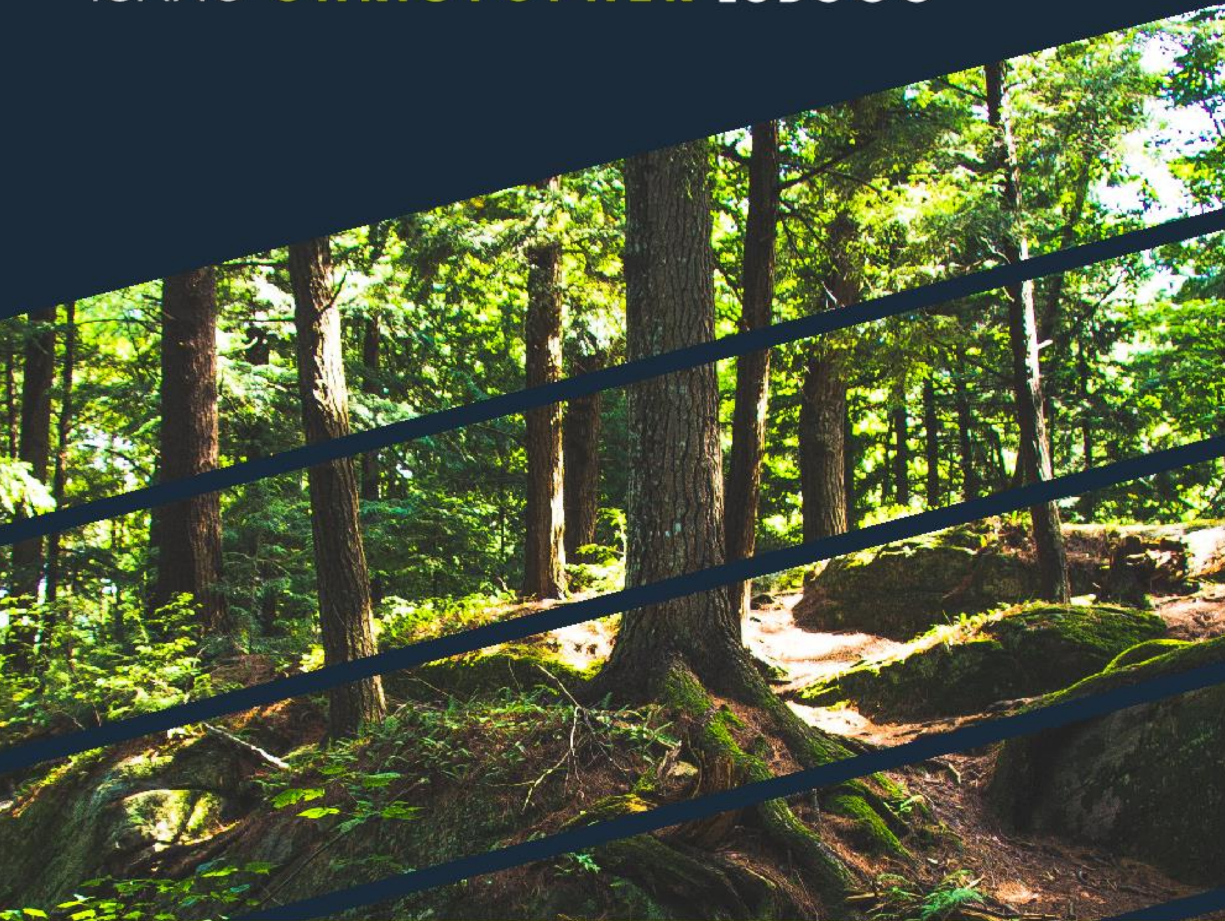
FIRST EDITION

SUSTAINABLE ENVIRONMENTAL LAW

ISAAC **CHRISTOPHER** LUBOGO



Sustainable Environmental Law

The Future for Uganda

Isaac Christopher Lubogo

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Table of Contents

Sustainable
Environmental Law

Dedication..vii

Sustainable Development Goals (SDGS) 8
Energy Poverty...8
Causes of Energy Poverty...9
Intermeddling Factors and different perspectives. 11
Challenges to defining and measuring energy poverty 12
Composite Indices 13
Government Intervention. 20
Effects of Governmental Interventions. 22
Mitigations. 33
Improved success 33
Successful interventions 34
Environmental impacts 37
Sustainable options.. 37
Challenges 38
Government intervention 39
Education interventions and behaviour change techniques......................... 40
Non-technological interventions 44
Challenges 44
Sustainable and Environmental development effects. 45

Energy Conservation..46
Energy conservation opportunities by sector 47

Global Impact 52
Energy conservation by countries 52
Mechanisms to Promote Conservation 57
Non-Governmental Mechanisms 62
Benefits 70
Appliances 70
Building design 71
Industry 76
Transportation 77
Energy conservation 80
Rebound Effect 80
Sustainable energy 81
Sources Of Energy 87
The Ultimate Source of Energy 88
Classification of energy sources 90

Renewable Energy Sources 92
Drivers and benefits 94
Power generation 95
Solar Energy. 96
Methods of solar energy 102
Heat Transfer. 108
Propulsion 109
Solar Pumping System 130
Hydro Energy 131
Geothermal energy 134
Geothermal Heating. 137
Bioenergy 142

Non-renewable energy sources 156

Renewable Energy in Africa. 169

Utilization of biogas.. 179

Combustion 183

Renewable energy use 195

Wind Energy 199

Horizontal Axis Single Blade Wind Mill 204

Sustainability As Amajor Requirment 208

Global Warming 212

Impacts of Global Warming To Uganda 213

Unconventional resources 221

Conventional Resources in Respect to Gas 222

Unconventional Resources in Respect to Gas 223

Importance of unconventional resources to the future of our industry ... 223

Benefits of non-conventional energy resources 226

Reducing Nitrous Oxide Emissions 242

Blue Economy 249

Terms of the economy 250

Blue Economy Development Framework 260

Fossil Fuel 270

The Role of Fossil Fuels in a Sustainable Energy System 273

Butane Gas 279

Clean Energy 281

Climate Change 283

Impacts of Climate Change 289

Reducing and recapturing emissions 293

Economic of climate change 294
Shale Gas 296
Shale Oil 299
Conventional Oil 301
Tidal Energy 302

References 310

Dedication

Oh God, Even my God my High Tower, my refuge, my Redemeer, my only source of hope. This and many more is for you Oh God of the mighty universe.

Sustainable Development Goals (SDGS)

For the worldwide goal of preventing climate change while sustaining economic growth and permitting living standards to rise, meeting present and future energy demands sustainably is a crucial challenge. For health care, education, and economic development, it is crucial to have access to affordable, reliable energy, especially electricity. 790 million people in developing nations will not have access to electricity by 2020, and about 2.6 billion will cook with harmful fuels. Most of the United Nations 2030 Sustainable Development Goals, which address topics like gender equality and climate action, may be achieved by increasing energy availability in the least developed nations and making energy cleaner. By 2030, all people must have access to "cheap, dependable, sustainable and contemporary energy for all," including access to electricity and facilities for clean cooking.

ENERGY POVERTY.

Lack of access to modern energy services is known as energy poverty. It refers to the condition where a lot of people in poor nations and some individuals in rich countries have their well-being badly impacted by extremely low energy usage, the use of dirty or polluting fuels, and a lot of time spent gathering fuel to meet their basic needs. Currently, 2.6 billion people employ unsafe and ineffective cooking methods, while 759 million people live without reliable access to power. Although increasing access is only one component in efforts to eliminate energy poverty, it is inversely correlated with access to contemporary energy services. Fuel poverty, which largely concentrates on the issue of affordability, is different from energy poverty. Brenda Boardman's book Fuel Poverty: From Cold Homes to Affordable

Warmth, which was published, gave rise to the phrase "energy poverty" (1991). The need to create governmental policies to alleviate energy poverty as well as research its causes, symptoms, and social repercussions was sparked by the term "energy poverty," which refers to the junction of poverty and energy use. In Boardman's book, when energy poverty was first mentioned, it was defined as not having enough electricity to heat and cool dwellings. Electricity poverty is now recognised as the outcome of many systemic injustices that make it difficult for people to obtain modern energy at a reasonable cost. Because energy poverty is a private experience within homes, is peculiar to cultural contexts, and dynamically changes based on the time and place, it is difficult to quantify and, thus, to analyse. The World Economic Forum's Energy Poverty Action programme states that "Access to energy is essential for raising quality of life and is a vital requirement for economic growth. Energy poverty is still pervasive in the developing world ". This led to the United Nations (UN) launching the Sustainable Energy for All Initiative and declaring 2012 as the International Year for Sustainable Energy for All, which placed a significant emphasis on lowering energy poverty. Through Goal 7 of the Sustainable Development Goals, which aims to "provide access to affordable, dependable, sustainable, and modern energy for all," the UN further highlights the significance of energy poverty.

CAUSES OF ENERGY POVERTY.

Energy Sources.

The majority of emerging nations have significant rural populations, and the rural areas in such nations lack a modern energy infrastructure. They have relied primarily on conventional biomass, including wood fuel, charcoal, crop residue, wood pellets, and similar materials. Due to a lack of modern energy infrastructure, including power plants, transmission lines, and underground pipelines to deliver energy resources like natural gas and petroleum, which require advanced technologies and have extremely high upfront costs and are therefore beyond their capacity in terms of both money and technology. Even while some emerging nations, such as the BRIC bloc, have financial clout and energy-related technical levels that are comparable to those of industrialised nations, conventional biomass still dominates in the majority of developing nations. The International Energy Agency (IEA) predicts that while traditional biomass use would decline in many nations, it is projected to rise along with population expansion in South Asia and sub-Saharan Africa. Renewable energy projects that address energy poverty can be helpful for low-carbon development plans.

Energy Ladder.

An energy ladder illustrates how energy use has improved as household income has increased. In general, home energy consumption would become cleaner and more cost-effective as income rose, such as when switching from traditional biomass to electricity. Low-income and underdeveloped households are prone to use inexpensive, locally accessible, but inefficient fuel, placing them at the bottom of the energy food chain. The World Health Organization estimates that over three billion people worldwide are on these lower rungs and rely on coal and biomass fuels, such as crop waste, dung, wood, and leaves, to supply their energy demands. These people are disproportionately concentrated in Asia and Africa; for example, 95 percent of the people in Afghanistan, 95 percent in Chad, 87 percent in Ghana, 82 percent in India, 80 percent in China, and so on, use these fuels. We would anticipate that households would switch to higher quality fuel options as wages improve. But it has been a very gradual process. In fact, according to the World Bank, the percentage of biomass used for all forms of energy has stayed stable at around 25% since 1975.

Energy Prices Increases and Poverty.

Increases in energy prices are frequently necessary for economic and environmental reasons, even though they occasionally make households poorer. According to a 2016 study assessing the expected effects of an energy price reform on poverty and distribution in Armenia, a large natural gas tariff increases of about 40% led to an estimated 8% of households switching to wood as their primary source of heating, and it also drove an estimated 2.8% of households into poverty, or below the national poverty line. This study also discusses the methodological and statistical assumptions and limitations that come into play when estimating the causal effects of energy reforms on household poverty. It also explores potential impacts of such reforms on non-financial human welfare, which is more challenging to statistically quantify. High Energy, a study by Oldham. Jules, (2011) Scottish Council for Single Homeless, demonstrated how having utilities set up before moving in, being aware of different payment options and metre types, and being able to access the right tariff to suit their financial needs can make the difference between a new tenancy succeeding or failing when people leave homelessness.

Intermeddling Factors and different perspectives.

Domestic Energy Poverty.

When a household lacks access to or cannot afford to purchase the essential energy or energy services needed to meet daily needs, the situation is referred to as domestic energy poverty. These specifications may vary from one location or country to another. Lighting, culinary energy, and household heating or cooling are the most frequent requirements. Other authors take into account a variety of energy requirements, ranging from "basic energy needs" related to human survival and highly impoverished conditions. All of the aforementioned activities (cooking, heating, and lighting) , as well as energy for fundamental services related to health, education, and communications, are referred to as "basic energy demands," which are necessary for achieving basic living standards. "Energy needs for productive uses" refers to situations where a user also needs the energy to meet basic needs; "Energy for recreation" refers to situations where a user has met all of the requirements for the previous categories but still needs energy to enjoy life. Up until recently, energy poverty definitions only took into account the bare minimum amount of energy needed. However, a newer school of thought holds that in addition to energy quantity, definitions of energy poverty should also evaluate the quality and cleanliness of the energy consumed. An example of one of these definitions is as follows:

(a) “A person is in 'energy poverty' if they do not have access to at least: (a) the equivalent of 35 kg LPG for cooking per capita per year from liquid and/or gas fuels or from improved supply of solid fuel sources and improved (efficient and clean) cook stoves.and

(a) 120kWh of energy per person per year is required for illumination, access to the majority of fundamental services (drinking water, communication, enhanced health services, improved education services, and others), as well as some value-added to local production.

An "improved energy source" for cooking is one that requires less than 4 hours of fuel collection time per week per household, complies with WHO air quality recommendations (maximum CO concentration of 30 mg/M3 for exposures lasting 24 hours and less than 10 mg/M3 for exposures lasting 8 hours), and has an overall conversion efficiency of more than 25%.”

Challenges to defining and measuring energy poverty

Energy services cannot be quantified in a tangible way, and there is no agreed-upon definition of what constitutes essential energy services, making it difficult to identify and quantify energy poverty. The various ways that humans use energy, such as for lighting, cooking, space heating, and refrigeration, are known as energy services.

Composite Indices

Energy Development Index (EDI)

The Energy Development Index (EDI), first developed by the International Energy Agency (IEA) in 2004, seeks to gauge a nation's transition to contemporary fuels. The weighted average of the following four variables is used to calculate it: "1) Per capita commercial energy consumption as an indicator of the overall economic development of a country; 2) Per capita electricity consumption in the residential sector as a metric of electricity reliability and customers' ability to afford it; 3) Share of modern fuels in total residential energy sector consumption to indicate access to modern cooking fuels; and 4) Share of population with access to modern energy sources. (The Human Development Index (HDI) served as the inspiration for the EDI.) The EDI gives a metric that provides an understanding of the national level of energy development because it is calculated as the average of indicators that quantify the quality and quantity of energy services at a national level. However, this also implies that the EDI is ill-suited to describe energy poverty at the home level.

Multidimensional Energy Poverty Index (MEPI)

Depending on how severely they are affected by energy shortage, determines whether a person is energy rich or poor. Seven variables are used to classify different levels of energy deprivation: "access to light, contemporary cooking fuel, fresh air, refrigeration, recreation, communication, and space cooling." If a person goes through a specified amount of energy shortages, they are said to be low on energy.

The MEPI is computed by averaging the average degree of energy deprivation among the energy poor and multiplying that number by the proportion of people who were classified as energy poor relative to the overall sample size. The MEPI's ability to account for both the quantity and severity of energy poverty among its many advantages. On the other hand, because it gathers data at the home or person level, it is more challenging to comprehend the larger national context.

Energy Poverty Index (EPI)

The Energy Poverty Index (EPI), created by Mirza and Szirmai in their 2010 study to assess energy poverty in Pakistan, is determined by averaging a household's energy deficiency and energy annoyance. The frequency of buying or collecting a source of energy, the distance travelled from the household, the mode of transportation used, the participation of household members in energy acquisition, the amount of time spent collecting energy each week, the household's health, and the participation of children in energy collection are all indicators of energy inconvenience. Lack of enough energy to meet essential home demands is referred to as an energy shortage. This rating gives more weight to the usability of energy services than to their accessibility. The EPI collects data at a micro level, like the MEPI, which aids in a better understanding of energy poverty at the household level.

Intersectional Concerns.

Energy poverty, like other challenges of economic justice, frequently makes already poor groups more vulnerable.

Climate Change

The production and use of energy accounted for 70% of greenhouse gas emissions in 2018. There is a chance that greenhouse gas emissions will rise correspondingly as more nations strive to switch to modern energy services and make energy accessible to more people. [Reference needed] 50 percent of the lowest emitting nations contribute only 0.74 percent of all historic greenhouse gas emissions, while 5 percent of countries historically account for 67.74 percent of total emissions. As a result, there are significant systemic hurdles that restrict people from obtaining and using energy services, which are reflected in the highly unequal distribution, production, and use of energy services. Additionally, poorer countries are being urged more strongly to invest in renewable energy sources rather than replicating the energy development trends of wealthy countries.

Health

Women are typically in charge of obtaining traditional biomass for energy because of traditional gender norms. In the kitchen, women also spend a lot of time cooking. Women who spend a lot of time gathering energy resources have less time for other pursuits, and the physically taxing work causes chronic weariness in them. Additionally, women and kids who stay close to their mothers to assist with household duties run the risk of being exposed over time to the indoor air pollution that is brought on by burning traditional biomass fuels. They face health risks from combustion-related substances such benzene, carbon monoxide, and particulates. This causes a lot of acute respiratory infections in women and children as well as lung cancer, asthma, and other illnesses. "Unsustainable biomass use has devastating effects on human health. According to the World Health Organization, exposure to indoor air pollution is to blame for 4% of the world's disease burden and over two million extra deaths from cancer, respiratory infections, and lung illnesses, mostly affecting women and children.

In comparison, each year more people die from biomass pollution-related causes than from tuberculosis (1.6 million) and malaria (1.2 million)." Energy-poor households are more likely to rely on traditional biomass, like wood and cow dung, to meet their energy needs, which is another link between energy poverty and health. Black carbon is released into the environment when wood and cow dung are burned, though, because of incomplete combustion. A potential health risk is black carbon.

Gender

Energy has a huge impact on women and girls' health, educational, and employment chances in underdeveloped nations because they are typically in charge of providing the main source of energy for households. Women and girls have less time to pursue school, recreational activities, and employment since they spend a large amount of time searching for fuel sources such wood, paraffin, dung, etc. Additionally, because they are the main family members in charge of cooking and other domestic tasks in the home, women and children are disproportionately impacted by using biomass as a fuel for heating and cooking. 85 percent of the 2 million deaths from interior air pollution are attributable to women and children because they are more susceptible to the indoor air pollution caused by burning biomass. Because of their comparatively low incomes compared to the high cost of energy services, women in industrialised countries are more likely to experience energy poverty.

For instance, of the 5.6 million French households who were unable to effectively heat their houses, 38 percent were headed by women. Because of structural differences between men and women in financial resources and ability to invest in energy-saving measures, older women are particularly vulnerable to experiencing energy poverty.

Development

"Energy offers services to fulfil a variety of fundamental human requirements, especially heat, drive (for things like water pumps and transportation), and light. Access to energy services is crucial for the provision of modern business, industry, commerce, and public services like modern healthcare, education, and communication. Indeed, many poverty indicators, including infant mortality, illiteracy, life expectancy, and total fertility rate, are directly correlated with the lack of adequate energy services. By encouraging people to move into cities in search of better living conditions, inadequate energy access also accelerates urbanisation in developing nations.

Long-term studies have shown a direct correlation between rising energy use and rising living standards. It's not obvious, though, whether rising energy consumption is a prerequisite for economic expansion or vice versa. There is still a strong direct correlation between energy consumption and economic development in underdeveloped nations, even though wealthy countries are already starting to divorce their energy consumption from economic growth (via structural reforms and improvements in energy efficiency)."

Education

Education is a very effective tool for reducing the effects of energy poverty, which has many different dimensions. Because they may be unable to study for as long as they would want without reliable energy sources after sundown, pupils with limited electrical access may have lower academic standards. Furthermore, having reliable access to energy allows female children, who are typically responsible for gathering fuel for their home, to devote more time to studying and attending school. In primary schools in sub-Saharan Africa, 90% of the students are without power. Only 2% of schools in Burundi and Guinea and 8% of schools in the Democratic Republic of the Congo (DR Congo) are electrified, respectively (43 percent of whom are under 14 years). According to these figures, about 30 million kids are attending school without electricity in the DRC alone. In order to increase human capital, which in turn helps people become more productive members of society and contribute to economic progress, education is a crucial factor. As emerging countries amass more money, they can spend in constructing cutting-edge energy infrastructure, giving households more options to pursue cutting-edge energy sources and reducing energy poverty.

Regional Comparisons.

Energy poverty is a complicated issue that takes into account the subtleties of a region's culture, time, and place. Although there are basic patterns in how energy poverty is experienced and mitigated between the Global North and South, the phrases "Global North/South" are generalisations and sometimes insufficient to capture the specifics of energy poverty.

Africa

Due to its growing urbanisation and expanding metropolitan centres, Africa faces some particularly difficult energy poverty issues. Urbanization has historically sparked more extensive shifts to contemporary energy services, according to trends in urbanisation in Asia. However, a rise in money is necessary for access to modern energy services in cities, and this is difficult to find in the economies of many African cities. Due to this, just 25% of Africans who live in metropolitan areas have access to power. Additionally, access to electricity has not grown proportionally as Africa's population has grown. Despite a population increase of 150 million individuals between 1970 and 1990, only 50 million people acquired access to electricity. The greatest obstacle to energy access for those living in urban areas is the high price compared to their generally low earnings. The urban poor spend 10–30% of their income on energy, compared to the non–poor who spend only 5-7%.

Global South

Due to inadequate energy infrastructure, weak energy service markets, and insufficient family incomes to cover the cost of energy services, the Global South suffers from a severe lack of access to modern energy sources. The capacity of a region to switch to modern energy sources is influenced by a complex web of political, economic, and cultural issues, according to recent research, therefore reducing energy poverty may take more than simply improving power infrastructure. Because better energy availability helps people to employ more of their skills, energy poverty is closely related to many sustainable development goals.

For instance, having more access to clean energy for cooking helps women's health by lowering the indoor air pollution caused by burning traditional biomasses; farmers can use telecommunication networks to find better prices for their crops; people have more free time to engage in leisure activities and other pursuits, which can increase household income from the time saved from searching for firewood and other traditional biomasses; etc. Energy poverty is generally viewed through the lens of another way to promote sustainable development in regions within the Global South because of the influence energy poverty has on sustainable development.

Global North

In the Global North, where the conversation centres on households' access to energy sources to heat, cool, and power their homes, energy poverty is most frequently characterised as "fuel poverty." High energy expenses, poor household incomes, and inefficient equipment are the main causes of fuel poverty. a global viewpoint Additionally, because of their financial situation and lack of access to energy-saving devices, older persons are more likely to experience fuel poverty. Between 50 and 125 million people live in fuel poverty, according to the European Fuel Poverty and Energy Efficiency (EPEE). Fuel poverty shares many complexities with energy poverty, making it challenging to describe and quantify. One of the few nations that defines fuel poverty as when a household spends 10% or more of its income on heating and cooling is the United Kingdom (UK) and Ireland. By employing three indicators checking for leaking roofs, energy bill arrears, the ability to pay for proper heating, and mould in windows another EPEE investigation discovered that 1 in 7 families in Europe were on the verge of fuel poverty. Low earnings, inadequate insulation in homes, and high energy costs all enhance a person's susceptibility to fuel poverty. As weather patterns become more extreme, there is increased pressure from climate change, which raises the need for fuel to heat and cool homes. Since cold weather can exacerbate respiratory and cardiovascular conditions, it is important to be able to provide enough heating during cold weather.

Facing Energy Poverty.

Energy is crucial for both public health and economic prosperity. Governments in developing nations should work to combat energy poverty since it has a detrimental effect on both public health and economic growth. As developing countries governments take steps to minimise social expenses and boost social benefits by progressively bringing modern electricity to their people in rural places, the number of people who currently use it should rise. Governments in the developing countries, however, have had trouble promoting the dissemination of modern energy, such as electricity. An enormous sum of money must initially be invested in order to develop the energy infrastructure that will produce and supply electricity to every home.

Additionally, developing nations have been unable to obtain contemporary energy due to a lack of advanced technologies. Due to these significant obstacles, it is challenging for the governments of developing nations to contribute to the efficient growth of the energy sector without outside assistance. Building a solid future energy infrastructure and institutions in developing nations requires international cooperation. Even though their energy status hasn't changed much in recent years, current international aid programmes are making a significant contribution to closing the gap between developing and industrialised nations when it comes to the use of modern energy. When compared to the absence of international cooperation, closing the gap will take less time with international aid.

According to the World Bank, financial aid should be given to individuals in need rather than acting as a general subsidy for fossil fuels.

GOVERNMENT INTERVENTION.

The term "economic interventionism," often also referred to as "state interventionism," refers to an economic policy stance that favours government intervention in the market process in order to address market imperfections and advance the welfare of the populace. An economic intervention is a step that a government or international organisation takes in a market economy to influence the economy in ways other than the usual ones—regulating fraud, upholding contracts, and offering public goods and services. Economic intervention can be used to achieve a range of political or economic goals, including fostering economic development, raising employment levels, boosting wages, increasing or decreasing prices, promoting income equality, controlling the money supply and interest rates, boosting profits, and addressing market inefficiencies.

The phrase "intervention" is generally employed by proponents of laissez-faire and free market capitalism, and it implies that government action is essentially exogenous to the economy and that, from a philosophical standpoint, the state and economy should be kept apart. State-owned firms that function as market entities do not constitute an intervention; the term refers to capitalist market-based economies when government activities interfere with the forces of the market through laws, subsidies, and price controls. Mixed economies are generally described as capitalist market economies with significant levels of state intervention.

The Political Standpoint.

Due to the law of unintended consequences, the conviction that government is incapable of successfully managing economic matters, and other factors, liberals and other proponents of the free market or laissez-faire economics typically see government interventions as negative. Modern liberals in the United States and modern social democrats in Europe, however, are more likely to embrace interventionism since they view state economic interventions as a critical strategy for advancing more income equality and social welfare. To further foster social order and stability, numerous center-right groups, including Gaullists, paternalistic conservatives, and Christian Democrats, embrace governmental economic interventionism. The power and riches of a nation or its citizens can be protected by economic interventionism, which is usually backed by national-conservatives. This is especially true when benefits are given to sectors of the economy that are considered as being crucial to the nation. When the prospective benefits surpass the external costs, such government actions are typically made.

A developed welfare state, on the other hand, makes capitalism more tolerable for the average worker, thereby perpetuating the continued existence of capitalism to the detriment of society, according to Marxists, who frequently feel that interventions in the form of social welfare policies might interfere with the goal of replacing capitalism with socialism. Interventionism, which is backed by social democrats and social liberals, is frequently criticised by socialists as being unworkable and likely to lead to further economic distortion in the long run. While interventions may temporarily address specific problems, they exacerbate distortions and reduce the effectiveness of the capitalist system. According to this viewpoint, the only long-term answer is the replacement of capitalism with a socialist economy because any attempt to fix capitalism's flaws would cause economic inefficiencies elsewhere.

EFFECTS OF GOVERNMENTAL INTERVENTIONS.

There is much debate concerning the effects of government economic intervention.

Although regulatory agencies don't always shut down markets, as was the case in Latin America's efforts at economic liberalisation by states and various organisations (including the International Monetary Fund and World Bank), "financial liberalisation and privatisation coincided with democratisation." According to one study, a growing "dispersion of regulatory agencies" arose following the "lost decade," and these actors got busy reshaping the economies in Latin America. Latin America had experienced hyperinflation and a debt crisis throughout the 1980s (during 1989 and 1990). These foreign parties constrained the state's economic clout and legally obligated it to cooperate. The renewal and intervention appeared to have stopped after numerous initiatives and years of unsuccessful attempts to get the Argentine authorities to comply. Significantly growing privatisation and the creation of a currency board were two crucial intervention factors that sparked economic growth in Argentina. This is an example of how international organisations, like the World Bank and the International Monetary Fund, promote openness to boost foreign investment and economic growth in various regions, including Latin America.

Theoretically, in Western nations, government officials must consider the costs and benefits of an intervention on behalf of the populace or they will be forced to act by third parties. Stakeholders' discretion and self-interest, as well as their many interpretations of progress and development theory, govern interventions for economic development. To demonstrate this, consider the fact that during the financial crisis of 2007–2008, the government and international organisations did not support Lehman Brothers, causing the company to declare bankruptcy. Days later, as American International Group began to teeter on the brink of collapse, the government spent tax dollars to prevent catastrophe. These businesses have overlapping interests with the state, therefore they have an incentive to lobby for regulatory measures that won't impede their ability to amass wealth. Abenomics is a form of intervention in Japan, where Prime Minister Shinzō Abe wants to bring back the nation's past glory within a globalised economy.

Government Interventions in the USA.

In 1970, the Clean Air Act was expanded by President Richard Nixon to require both state and federal regulation of industries and automobiles. Additional changes were made in 1977 and 1990. The National Environmental Policy Act of 1969 (NEPA), which mandates that the government take the environment into account when making decisions, was one of the first contemporary environmental protection laws passed in the United States. One of the most often applied environmental regulations in the country is still NEPA. There are several pollution-control laws that apply to such particular environmental media as air and water in addition to NEPA. The Clean Air Act (CAA), Clean Water Act (CWA), and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), sometimes known as Superfund, are the most well-known of these laws. The Resource Conservation and Recovery Act (RCRA), the Toxic Substances Control Act (TSCA), the Oil Pollution Prevention Act (OPP), the Emergency Planning and Community Right-to-Know Act (EPCRA), and the Pollution Prevention Act are just a few of the numerous other significant pollution control laws (PPA). There are many different types of pollution control laws in the United States, and many of the environmental laws established by Congress are focused on pollution prevention. Before their impact is completely seen, however, they frequently need to be updated and enlarged. Congress must find or establish an agency for each pollution-control statute since the laws are typically too broad to be administered by current legal authorities.

The United States government intervened during World War I and required that machinery production take the place of vehicle production in order to win the war. By requiring American automakers to create electric vehicles like the Chevrolet Volt, the government may step in to reduce the country's reliance on foreign oil. Jennifer Granholm, the governor of Michigan, stated: "We need help from Congress," namely in the form of reauthorizing the tax incentives that lower the cost of plug-ins for consumers and the manufacturing tax credit for sustainable energy. Government-mandated carbon fees may be used to advance technology and lower the cost of vehicles like the Volt for consumers. However, according to existing legislation, carbon pricing would only marginally increase the price of gasoline by a few cents, which would have little impact on fuel consumption. The White House has taken credit for putting a down payment on the American battery industry that may lower battery prices in the coming years. Washington is starting to invest in the auto manufacturing industry by partially providing $6 billion in battery-related public and private investments since 2008. Opponents now hold the opinion that the carbon dioxide emissions tax the US government implemented on new cars is unfair to customers and appears to be a revenue-raising fiscal intervention rather than preventing environmental harm. A national fuel tax ensures that everyone pays the same amount of tax, with the amount paid by each person or business being based on the quantity of emissions they produce. They would have to pay more the more they drove. The National Treasury has declared that minibuses and midibuses will be specifically exempt from the emissions tax on cars and light commercial vehicles, which went into effect on September 1, 2010, despite the fact that the motor manufacturers favour this tax. The reason for this exclusion is that these taxis are also used for public transportation, a claim that tax opponents dispute.

George W. Bush pledged to invest $2 billion over 10 years in research and development projects to promote clean coal technologies during the 2000 presidential campaign. Bush's budget request for fiscal year 2008 included $426 million for the Clean Coal Technology Program, which his supporters claim shows that he kept his pledge. The Energy Policy Act of 2005, passed by Congress under his administration, provided financing for the development of a carbon-capture technology that would enable coal to have its carbon removed and buried after burning. As part of a plan to lessen American reliance on foreign energy and cut carbon emissions, the coal industry received $9 billion in subsidies under the act. Included in this were $6.2 billion for brand-new power plants, $1.1 billion in tax credits for the installation of pollution-control equipment, and a further $1.1 billion for the cost-effectiveness of coal. The measure also permitted "non-traditional" coal processing to be redefined, allowing coal firms to avoid paying $1.3 billion in taxes annually. Examples of this include spraying coal with diesel or starch. After 2020, when the cost of the permits would increase to further reduce consumers' demand for CO2-intensive goods and services, the Waxman-Markey plan, also known as the American Clean Energy and Security Act, would aim significant CO2 reductions. In 2050, the Act aims to cut CO2 emissions by 83 percent from 2005 levels. According to an EPA assessment, the cost of the permit would increase from around $20 per tonne in 2020 to more than $75 per tonne in 2050.

According to the Office of Management and Budget (OMB), four coal tax preferences—expensing of exploration and development costs, percent depletion for hard mineral fossil fuels, royalty taxation, and domestic manufacturing deduction for hard mineral fossil fuels—were expected to be significantly reduced between 2011 and 2020 if the budget was approved by Congress. The Obama administration's proposed budget for fiscal 2011 would eliminate about $2.3 billion in coal subsidies over the following ten years.

International efforts

A third of the world's population, China and India, have rising economies, and other developing countries exhibit comparable patterns in rapid economic and demographic expansion. Modern energy sources are increasingly needed as a result of modernization and industry. Expanding their energy infrastructure to meet the rising energy demands of their expanding populations is a challenge for emerging countries. More people in developing nations will have extremely difficult access to modern energy services if deliberate policy-making and action are not taken.

Intervention strategies used by international development organisations have not always been effective. "International collaboration must be based on a select few, well-known components of energy policy, such as institutional assistance, capacity development, support for local and national energy programmes, and strong ties to utility/public sector leadership. Africa is deficient in utilising its abundant human and material resources for its people's welfare, while having everything needed to alleviate poverty. The ability to deploy technology, absorb and distribute funding, provide transparent regulation, implement peer review processes, and communicate and monitor pertinent information and data are all included in this."

European Union

In 2013, the European Economic and Social Committee (EESC) issued an official opinion on the subject urging Europe to concentrate on energy poverty indicators, analysis of energy poverty, consideration of an energy solidarity fund, economic analysis of member states' energy policies, and consumer education campaigns. Several million individuals in Spain are said to live in energy poverty, according to a 2016 survey. A few fatalities have resulted from these circumstances, and the public is outraged at the contrived and "absurd pricing structure" used by electrical companies to boost their profits. The average interior air temperature of impoverished families in Cyprus was found to be below the acceptable threshold for comfort in 2017, and their heating energy usage was found to be lower than the national average for the clusters classified by high and partial deprivation. Due to their inability to purchase it, low-income households are unable to meet and maintain the interior thermal needs.

Global Environmental Facility

"The Global Environmental Facility (GEF), an international financial organisation that lends money to developing nations for capital projects, was founded in 1991 by the World Bank Group to address global environmental issues in collaboration with other international organisations, the private sector, etc., particularly by funding various projects in developing nations. The GEF awards funding to developing nations and nations whose economies are transitioning for initiatives addressing persistent organic pollutants, international waterways, ozone depletion, land degradation, and biodiversity. By tying together regional, governmental, and international environmental issues and fostering sustainable livelihoods, these programmes help the environment worldwide. For more than 2,800 projects in more than 168 emerging and transitioning economies, the GEF has allocated $10 billion, plus an additional $47 billion in cofinancing. More than 13,000 small awards totaling $634 million have been awarded by the GEF directly to community-based and civil society organisations through its Small Grants Programme (SGP). The UN Development Programme, UN Environment Programme, World Bank, UN Food and Agriculture Organization, UN Industrial Development Organization, African Development Bank, Asian Development Bank, European Bank for Reconstruction and Development, Inter-American Development Bank, and International Fund for Agricultural Development are the ten organisations that make up the GEF partnership. The Scientific and Technical Advisory Panel provides technical and scientific advice on the GEF's policies and projects."

Climate Investment Funds

The Clean Technology Fund (CTF) and the Strategic Climate Fund are two Trust Funds that make up the Climate Investment Funds (CIF), each of which has its own governance structure, goals, and scope (SCF). The CTF encourages financial investments to start the transition to clean technologies. The CTF aims to close a gap in the global financial system by providing development financing at more favourable rates than those offered by

Multilateral Development Banks (MDBs) on a large enough scale to encourage developing nations to incorporate locally appropriate mitigation measures into their plans for sustainable development and investment choices. The SCF acts as an umbrella fund to assist targeted initiatives with dedicated funding to trial novel strategies with the potential for scaled-up, transformational action directed at a particular climate change challenge or sectoral response. The Program for Scaling-Up Renewable Energy in Low-Income Countries (SREP), which was approved in May 2009, is one of SCF's target programmes. Its goal is to show the economic, social, and environmental viability of low-carbon development pathways in the energy sector by generating new business opportunities and expanding access to energy through the use of renewable energy.

Energy Poverty and Cooking.

Lack of access to clean, contemporary fuels and cooking technologies is one aspect of energy poverty. More than 2.6 billion people in poor nations will be regularly cooking using fuels including wood, animal dung, coal, or kerosene by the year 2020. The World Health Organization (WHO) estimates that 3.8 million people die each year as a result of severe home air pollution brought on by burning these kinds of fuels in open flames or conventional stoves. This pollution also exacerbates other health, socioeconomic, and environmental issues.

Making clean cooking facilities widely accessible and reasonably priced is a top goal for global sustainable development. If the WHO-defined thresholds for carbon monoxide and fine particulate matter emissions are not reached, cooking facilities are regarded as "clean."

Electricity, liquid petroleum gas (LPG), piped natural gas (PNG), biogas, ethanol, and solar heat are all regarded as clean fuels for stoves and other equipment. Improved cook stoves that burn biomass more effectively than conventional stoves are a crucial stopgap measure in places where it is more difficult to implement cleaner technology. The ecology and gender equality would both benefit greatly from having clean cooking facilities available to everyone.

Shortfalls of Traditional Cooking Fuels.

By 2020, more than 2.6 billion people in developing nations would still cook with polluting biomass fuels like wood, dried dung, coal, or kerosene, which not only contribute considerably to outdoor air pollution but also dangerous indoor air pollution. According to the World Health Organization (WHO), cooking-related pollution kills 3.8 million people per year. According to the Global Burden of Disease report, 1.6 million people passed away in 2017.

Numerous of the hundreds of chemicals found in solid fuel smoke are harmful to human health. Carbon monoxide (CO), small particulate matter, nitrous oxide, sulphur oxides, a variety of volatile organic compounds, including formaldehyde, benzene, and 1,3-butadiene, and polycyclic aromatic compounds, such as benzo-a-pyrene, are among the substances whose effects on human health are believed to be both immediate and long-term.

Household air pollution (HAP) exposure roughly doubles the chance of developing paediatric pneumonia and is to blame for 45% of all pneumonia-related fatalities in children under the age of five. New research indicates that HAP increases the chance of low birth weight and cataracts, which are the main causes of blindness in lower-middle-income nations. In developing nations, cooking over open flames or using improper stoves is the main cause of burn injuries among women and children.

Women, who are probably in charge of cooking, and young children are most affected in terms of health. Women and children are particularly at danger when gathering fuel because it frequently takes 15 or more hours per week, which limits their time for paid labour, paid leisure, and education. Because they frequently have to travel great distances to collect cooking fuel, women and girls are more likely to experience physical and sexual abuse. Many kids, especially girls, may choose not to go to school in order to assist their mothers with gathering firewood and preparing meals. Excessive harvesting of wood and other flammable materials can result in serious local environmental harm, including desertification.

Traditional cooking facilities

Cooking is traditionally done over a three-stone fire or on a mud stove. The three-stone fire is the most affordable stove to construct since it just requires three suitable stones that are the same height and can support a cooking pot over a fire. Instead of exiting through a chimney, smoke is vented into the house.

Traditional cooking methods waste fuel by allowing heat to escape into the outside air. Burns and scalds are risks associated with using an open fire. Adults and children in particular are vulnerable to slipping or stepping into the flames while using the stove indoors, which increases their risk of getting burned. Additionally, spilling boiling water unintentionally could result in scorching, and blowing oxygen onto a fire could release burning embers and harm eyes.

Household Air Pollution.

Important source of indoor air pollution, known as household air pollution (HAP), is the use of cooking and heating appliances in developing nations.

For home cooking and heating, three billion people in poor nations rely on biomass fuel, which comes in the forms of wood, charcoal, dung, and crop residue. Millions of people, mostly women and children, face major health hazards since a large portion of cooking is done indoors in unventilated spaces. Combustion and building materials are the main causes of indoor pollution. IAP exposure was blamed for 4.3 million fatalities worldwide in 2012, almost all of which occurred in low- and middle-income nations. With 1.69 million and 1.62 million deaths, respectively, the Western Pacific and South East Asian regions carry the worst burden. Africa sees about 600,000 fatalities, followed by the Eastern Mediterranean by 200,000, Europe by

99,000, and the Americas by 81,000. High-income nations account for the remaining 19,000 fatalities. Although the pace of reliance on biomass fuel is decreasing, this resource will eventually run out due to population expansion, putting the environment at even greater risk. Numerous research have looked into the air pollution produced by traditional domestic solid fuel burning for space heating, lighting, and cooking in developing countries during the past few decades. It is already well-established that the indoor burning of solid fuels (biomass, coal, etc.) by inefficient, frequently improperly vented combustion equipment causes higher exposure to home air pollutants throughout most of the developing world. This is brought on by the combustion devices' poor combustion efficiency and the high intensity of the emissions. Additionally, they are frequently released right into populated areas. Typical incomplete combustion products found in smoke from traditional household solid fuel combustion include fine and coarse particulate matter (PM2.5, PM10), carbon monoxide (CO), nitrogen dioxide (NO2), sulphur dioxide (SO2), and a number of organic air pollutants (such as formaldehyde, 1,3-butadiene, benzene, acetaldehyde, acrolein, phenols, pyrene, benzopyrene, benzo(a)pyr About 6–20% of the solid fuel used in a typical solid fuel stove is transformed into hazardous pollutants (by mass). Factors determining the amount include fuel type and moisture content, stove type, and operation, which influence the precise quantity and relative composition. Although various pollutants can change over time, the majority of measurements have been made on carbon monoxide (CO) and particulate matter (PM), the two main byproducts of incomplete combustion and the ones thought to offer the biggest health hazards. There have been numerous reports of indoor PM2.5 exposure levels in the hundreds to thousands of micrograms per cubic metre (g/m3) range. Similarly, it has been determined that CO exposure levels can reach up to 1000 mg/m3 (milligrammes per cubic metre). A recent study of 163 households in two rural Chinese counties found that the geometric mean indoor PM2.5 concentrations for homes using a variety of different fuel types and stove configurations were 276 g/m3 (combinations of different plant materials, including wood, tobacco stems, and corncobs), 327 g/m3 (wood), 144 g/m3 (smoky coal), and 96 g/m3 (smokeless coal) (e.g., vented, unvented, portable, fire pit, mixed ventilation stove).

Consequences of HAP.

Health implications

The intensity of emissions that frequently result from the use of biomass fuels, particularly wood, dung, and agricultural residue, has been the subject of numerous applied research initiatives in rural Kenya. Women and children are exposed to smoke for up to seven hours a day in enclosed spaces as a result of the incomplete combustion of solid fuel. These emissions differ with the amount of airflow inside the house, the season, and the day of the week. Exposure in substandard housing can be up to 100 times higher than acceptable safety standards. One kilogramme of burning wood produces small soot particles that can block and irritate the bronchial passages since many Kenyan women use a three-stone fire, the worst offender. Aldehydes, benzene, and carbon monoxide are among the hazardous gases present in the smoke. Various diseases have been linked, with varied degrees of evidence, to exposure to IAP from the combustion of solid fuels. The two main conditions brought on by smoking are chronic obstructive pulmonary disease (COPD) and acute lower respiratory infections (ALRI). IAP is also thought to contribute to cataracts, blindness, lung cancer, TB, preterm births, and low birth weight.

Women and gender

In most households, especially in rural areas and in refugee camps, women and girls are primarily in charge of gathering wood for cooking. This makes them more susceptible to violent crimes like rape, assault, and beatings that result in physical harm. Improved cookstove initiatives in refugee camps have demonstrated considerable decreases in fuelwood collection times as reported by women. This time could be used in more productive ways, such as attending school or income generating. In addition, eliminating the necessity for women to gather fuelwood considerably lowers the number of reported rapes that occur while gathering firewood. The use of biomass combined with ineffective cooking equipment creates a web of environmental and social issues that are directly related to the UN Millennium Development Goals. The majority of deaths from household air pollution (HAP), which has been demonstrated to have an impact on close to three billion people worldwide, are also women and girls. In Nigeria, it has been demonstrated that using cleaner ethanol stoves instead of conventional kerosene/firewood ones can reduce the risk of unfavourable pregnancy outcomes due to HAP.

Mitigations.

Early interventions

Unfortunately, it is difficult and requires constant improvement to find an economical way to handle the multiple consequences of IAP, including enhancing combustion, reducing smoke exposure, improving safety and saving labour, reducing fuel costs, and addressing sustainability.

Although the effectiveness of these historical initiatives to improve cook stoves to conserve firewood is questionable, they were primarily focused on reducing deforestation without regard for IAP beginning in the 1950s. The results of numerous attempts varied. For instance, new stove designs in Kenya produced higher CO2 and SO2 emissions while dramatically reducing particle emissions. Flues to evacuate smoke were delicate and difficult to build.

Improved success

Smoke hoods are one of the more effective modern interventions, however they function similarly to flues in extracting smoke and are found to lower IAP levels more effectively than residences that only used windows for ventilation. A chimney, enclosing the fire to preserve heat, creating pot holders to enhance heat transfer, dampers to control air flow, a ceramic insert to prevent heat loss, and multi-pot systems to enable cooking different dishes are some features of recently upgraded stoves.

The use of stoves is currently recognised as one of the least expensive ways to accomplish the dual goals of lessening the health burden of IAP and, in some locations, lessening environmental stress from biomass harvesting. An interdisciplinary strategy that involves numerous stakeholders has helped with the installation of interventions, including better cook stoves. These initiatives have found that in order to make sure that intervention programmes are successful, significant socioeconomic factors must be addressed. Numerous intricate problems show that better stoves are more than just a way to save fuel.

Successful interventions

The Kenya Smoke and Health Project (1998–2001), which involved fifty rural homes in two different locations, Kajiado and West Kenya, is one successful intervention that is represented by the information that follows. Due to their various climatic, geographic, and cultural significance, these regions were chosen. The main goal of this project was community participation, and as a result, individuals participated said the outcomes greatly exceeded their expectations. Men were actively involved in the project in West Kenya as well as regional women's groups. The project gained wider acceptance as a result of including the end users, and it also produced the additional benefit of generating local employment.

Three major interventions were explored and widely publicised: placing smoke hoods above the cooking area, widening windows, or installing an upgraded cook stove like the Upesi stove. Smoke hoods are free-standing appliances that pull smoke out of the house by acting like chimneys or flues. They can be used over conventional open flames, and this study found they significantly reduce IAP levels. The smoke hood models were created locally using sturdy manila paper that was then transferred to heavy-gauge galvanised sheet metal. The artisans who were taught by the project as a result received additional employment options.

Practical Action and East African partners created the clay Upesi stove, which is kiln-fired and built of wood and agricultural waste. This stove provided a number of advantageous qualities because it was created and customised for local requirements. Not only does it reduce household smoke exposure and fuel-wood consumption by about half, but it also uplifts local women by giving them jobs because they make and sell the stoves. As a result of the introduction of this enhanced stove, these women's groups have access to technical training in production and marketing, experience higher wage earnings, and have better social standing.

Numerous advantages were attained, including better health, which was crucial for everyone of the affected communities. They also reported better sleep, fewer headaches and exhaustion, as well as reduced eye discomfort, coughing, and dizziness. The smoke hoods boosted safety by preventing goats and kids from falling into the fire, reducing soot contamination, and keeping snakes and rodents out of the house. Windows made it possible to see livestock from inside, and better interior lighting resulted in less of a need for kerosene. Overall, a number of small changes that are taken for granted in contemporary western homes considerably improved the indoor environment. Women can earn more money thanks to increased indoor lighting because they can work on their beading near the window when the weather prevents them from doing it outside. Increased illumination for homework is advantageous for kids as well. The project led to the development of interpersonal bonds among the women, and men better supported their wives' initiative when the outcome benefited them as well. The awareness that sustainable domestic energy resources are "essential to decreasing poverty and hunger, improving health...and enhancing the lives of women and children" has led to more effective current initiatives to improve stoves, notwithstanding the limited success of earlier ones. Giving the locals accessible, affordable options is the best short-term objective for reducing rural poverty. Stoves can help with this intervention, and using cleaner fuels will have further advantages.

Other parts of the world have seen success with comparable improved-stove initiatives. It was discovered that the improved stoves put in place as part of the Randomized Exposure Project of Pollution Indoors and Respiratory Effects (RESPIRE) study in Guatemala are well-liked by the populace and have a positive impact on mothers' and kids' health. In addition to experiencing less back pain and eye discomfort, mothers in the intervention group also reported lower blood pressure. Small particles and carbon monoxide levels were also found to be lower in intervention families. Asthma prevalence among kids in these homes was also lower. This original pilot project has developed into CRECER (Chronic Respiratory Effects of Early Childhood Exposure to Respirable Particulate Matter), which will try to follow kids in intervention households for a longer period of time in order to ascertain whether the improved stoves also contribute to better health over the lifespan. With some success, India's National Program on Improved Chulhas has pushed at-risk populations to utilise better stoves. This initiative, which was started in the middle of the 1980s, offers financial aid to families in order to persuade them to buy the more durable chulhas and have a chimney put in. According to a 2005 study, women are less likely to get cataracts while using stoves with chimneys. There is minimal data from intervention trials and most of the information from India is more of a characterization of the problem.

With hundreds of millions of upgraded stoves built since the project's inception in the early 1980s, China has been particularly effective at promoting their use. By the late 1990s, approximately 75% of poorer, rural homes had "better kitchens," thanks to the government's very deliberate targeting of these communities. A 2007 analysis of 3500 homes revealed that intervention homes had improved indoor air quality, as seen by decreased levels of carbon monoxide and tiny particle pollution in the air. Although the initiative in China included extensive intervention, it is unknown if its success could be duplicated because the cost of stoves was highly subsidised.

Environmental impacts

Utilizing inefficient energy technology, such as the combustion of biomass, has negative repercussions beyond mortality and disease load. More than 90% of the energy demands of rural households in Kenya are met by biomass, with around one-third coming in the form of charcoal and the remaining from firewood. Firewood for habitation and charcoal for urban use are two examples of biomass energy mostly derived from savannah woods. A minor portion is obtained from nearby communities' closed and protected forests, which are typically located in regions with dense populations. While it is problematic to gather biomass in sensitive places, it is now known that land conversion and agricultural expansion account for the vast bulk of biomass clearing. Due to periodic shortages of traditional fuel-wood, about 38% of families in "high agro-ecological zones" consume agricultural waste. Crop residue and animal waste used for household energy production has a negative impact on soil quality and livestock and agricultural productivity. In the end, these resources are unavailable as organic fertiliser, livestock feed, and soil conditioners, not to mention their "cumulative implications on national food security". The majority of farmers are however aware that agricultural waste and dung play a significant role in preserving soil fertility even when they are not burned for energy. Making briquettes is among the most effective ways to use crop waste and dung for residential energy. The process of shaping the material into a doughnut improves combustion efficiency, which helps to reduce emissions. This procedure can be carried out locally and only requires a basic instrument.

Sustainable options

Only when biomass combustion is done sustainably is it possible to burn it on a large scale. If wood fuel sources are to remain sustainable and renewable over the long term, regeneration is of utmost importance. The development of energy crops (trees and bushes), which would also increase farmer income, could be one attempt at sustainable solutions in Kenya. As the root systems and leaf litter would improve soil stability, this method would assist agriculture or rangeland vulnerable to erosion and flooding. The most sustainable choice would be regenerative cultivars because planting and tilling do not disturb the stability of the soil. However, with careful management of the forest resources, this could be a workable alternative. Some individuals see this solution as a way to further abuse forests. Energy efficiency and emissions in the home are two criteria that can be used to evaluate fuels and cook burner technology. Even with dirty fuels, highly effective stoves can help the environment to some extent (such as firewood and biomass). More of the fuel's heating value is converted into usable cooking energy with more efficient stoves, so less fuel needs to be produced, transported, and burned to deliver the same amount of cooking, according to a study comparing the environmental, social, and economic life cycle impacts of cooking fuels. Liquid and gas fuels that are burned in highly effective stoves are additional sustainable choices. For instance, ethanol generated from cellulosic/non-food feedstocks (wood, agricultural waste) has less of an impact on the environment over its whole life cycle than ethanol produced from materials containing sugar and starch. Even though LPG is generated from non-renewable fossil fuels, it still has less of an adverse effect on the environment than traditional fuels; as a result, even while it is not a sustainable alternative, it has significantly less of an influence on emissions than conventional fuels.

Challenges

Supply

On the supply side of the market for cook stoves and fuels, there are trade-offs between efficiency and sustainability. Although creating cook stoves that use effective and clean fuel sources is ideal from an environmental standpoint, this is frequently not a practical option because of difficulties in expanding the production and consumption of these fuels. For instance, electric stoves are mentioned as "clean" domestic alternatives to biomass that emit no emissions. The generation of electricity in India and China, countries that are heavily reliant on coal for electricity generation, still causes considerable environmental problems, and ambient air pollution in communities close to power plants continues to constitute a health risk. Additionally, only homes in a country or region that are connected to the electric grid will have access to electricity for domestic energy consumption, excluding a substantial portion of rural populations.

Demand

On the demand side, there are obstacles to establishing an atmosphere that makes buying cook stoves possible. To promote widespread behaviour change, as will be detailed below, culturally sensitive behaviour change methods (BCTs) must be incorporated into demand interventions. The high upfront costs of upgraded stoves are the other deterrent to cook stove programmes that do not include paternalistic good provision. The target end-users of these upgraded technologies are frequently consumers at the bottom of the economic pyramid, yet they do not have access to conventional forms of consumer finance and credit because they lack collateral or are isolated. These problems are being addressed by new business model innovations and the expansion of microfinance institutions (MFIs), however scaling up presents difficulties for MFIs.

Government intervention

There is a compelling justification for government involvement given the negative externalities connected to unclean cook stove technology, including the harm done to women and girls, the lack of environmental sustainability, and the increased risk of diseases like HAP. Direct subsidies with a focus on health and climate implications, such as those in the carbon market, could be one type of action. Public goods like consumer finance access and consumer education are examples of helpful initiatives. To build an efficient and sustainable supply chain, subsidies are needed for R&D into cleaner technologies and fuels, as well as for the establishment of baseline criteria and testing frameworks for cleanliness and efficiency (also provision of a public good).

Developments

Significant advancements in energy-efficient cooking techniques, like the Wonderbag, can drastically lower the amount of fuel needed for cooking in a home. Technology advancements have made it possible to employ more environmentally friendly cooking methods with conventional fuels, such as the BioLite Home Burner, a biomass stove that cuts emissions by up to 95% and fuel consumption by 50%.

Suppliers of cook stoves have also been able to "dramatically improve both manufacturer and end-user economics, while attaining high levels of health and environmental advantages," because to innovations in business models. For instance, Rwanda's Inyeneri, a for-profit energy provider, functions more like a "cooking fuel utility firm." Its strategy effectively handles a variety of issues with stove adoption, such as the unreasonably high upfront costs of stoves, the propensity of consumers to combine new and traditional cooking methods, and the lack of commercial sustainability of these businesses.

Furthermore, advances in mobile technology have made it possible for businesses like Pay Go Energy in Kenya and Kopa Gas in Tanzania to get around the financial barriers that low-income users experience, such as the high upfront cost of stoves and the difficulty of buying fuel in tiny quantities (a form of the poverty penalty). As seen by the accomplishments of the USAID-funded Renewable Energy Microfinance and Microenterprise Program, MFIs have also started to focus on access to clean energy (REMMP).

Education interventions and behaviour change techniques

By using behaviour change approaches that make individuals aware of the risks and inspire a readiness to change cultural and lifestyle behaviours, educational intervention can help reduce exposure to smoking. This could have a substantial impact on reducing exposure to IAP. One component of influencing demand that can be accomplished through targeted social marketing efforts is behaviour change. These campaigns often fall into one of two categories: mass-market campaigns or specialised local and household approaches that involve demonstrations and follow-up visits. Studies demonstrate that major marketing campaigns do in fact raise consumer knowledge of the dangers of indoor air pollution, but they frequently fail to stimulate demand for improved stoves.

These factors include intra-gender issues, felt needs, cultural significance of food, and religious and cultural beliefs. When designing these interventions, it is important to keep in mind that "consumer needs and preferences are complex and are influenced by many contextual and social factors that require a deep understanding of culture, going beyond technology and economics." China, which distributed 172 million upgraded cookstoves between 1980 and 1995, provided proof of one effective government initiative. The participation of local consumers, notably women, in the design and fieldwork processes led to this effort's greater success.

Primary intervention for children

90% of children under the age of five spend their time at home. Particulate particles breathed from indoor air pollution is to blame for 50% of pneumonia deaths in children under the age of five worldwide. Solid fuels were employed for cooking in a lot of homes all around the world. Both carbon monoxide and fine particulate particles are released in high quantities by these fuels. Inhaling these chemical irritants can result in a variety of lung diseases, such as acute pulmonary infection or pulmonary epithelial carcinoma.

Modern Energy in Kenya.

With the knowledge that consumption is linked to indoor air pollution and environmental deterioration, Kenya has demonstrated a willingness to take on biomass energy challenges as of 2004. The United Nations Development Programme suggests creating an organisation that will only deal with biomass energy and creating rules for modern biomass, such as cleaner fuels like wind, solar, and small-scale hydropower, as well as sustainable firewood and charcoal. The most practical near-term possibilities, as opposed to a complete switch to nonsolid fuels, are improved cook stoves that use domestic energy more efficiently. Transitioning to contemporary, cleaner fuels and alternative energy sources within a broad international and national policy and economic agenda is the foundation of long-term solutions. As seen by present attempts in Zambia to build policy to promote biofuels, government support for long-term solutions is conceivable.

In terms of installed solar power systems per person, Kenya is the global top (but not the number of watts added). Each year, Kenya sells more than 30,000 tiny solar panels with a power output of 12 to 30 watts. The PV system may be used to charge a car battery for as low as $100 for the panel and wiring, which can then supply power to light a fluorescent lamp or a tiny television for a few hours each day. Every year, more Kenyans switch to solar energy than connect to the nation's electrical grid.

Clean cooking Facilities.

Clean fuel can refer to a type of fuel used for cooking and lighting as well as a type of fuel used for transportation. The Sustainable Development Goal 7 is to "Ensure access to cheap, dependable, sustainable and modern energy for all" in reference to cooking. The WHO normative guiding rules for indoor air quality include specific fuel recommendations (i.e. against unprocessed coal and kerosene) and emission rate targets that define clean fuel. One element of sustainable energy is clean fuel.

Making clean cooking facilities widely accessible and reasonably priced is a top goal for global sustainable development. Cooking facilities are deemed "clean" by the World Health Organization if their carbon monoxide and fine particulate matter emissions are below a set threshold.

Electricity, liquefied petroleum gas (LPG), piped natural gas (PNG), biogas, ethanol, and solar heat are all clean fuels for stoves and other equipment. If properly used and the pellets have low enough levels of moisture, the best-in-class fan gasifier stoves that burn biomass pellets can be categorised as clean cooking facilities. However, these stoves are not commonly accessible. As of 2016, no commonly accessible biomass burner complies with the suggested emissions thresholds for usage in indoor households. In addition to conventional electric stoves, electricity can be used to power equipment like rice cookers and extremely efficient induction burners. Even when connected to coal power sources, electric induction stoves are often more environmentally friendly and less expensive than liquified petroleum gas (LPG). 770 million people still lack access to electricity as of 2019, and for many more, it is either unaffordable or unreliable.

Waste, including human waste and animal manure, is transformed into a methane-rich gas using biogas digesters, which burns cleanly. In regions where each family has at least two large animals to give dung and a reliable supply of water is also available, biogas systems are a viable technology. Solar cookers collect and concentrate the sun's heat when sunshine is available.

Improved Cooking Stoves.

Improved cook stoves (ICS) can be used as a stopgap measure on the way to clean cooking because they are often more fuel-efficient than conventional stoves. Less than 30% of those who use a biomass stove to cook as of 2009 do so with an ICS. Because the link between pollution levels and effects on the body has been proven to be non-linear for some illnesses, like childhood pneumonia, the efficiency advantages of ICS may not always translate into considerable reductions in health hazards. This implies, for instance, that a reduction in exposure of 50% would not result in a halving of the health risk. In terms of blood pressure, shortness of breath, emissions of cancer-causing compounds, and cardiovascular disorders, ICS use was associated with small improvements in 2020, according to a systematic study, but not with changes in pregnancy outcomes or child health. The World Health Organization promotes additional study to create low-emission, cost-effective, long-lasting, and user-friendly biomass stove technology.

Non-technological interventions

Household air pollution exposure can be reduced by 20 to 98 percent through behavioural modification treatments that aim to lower children's exposures. Cooking outside, spending less time in the kitchen, keeping the door open while cooking, avoiding leaning over the fire while preparing meals, staying away while carrying children when cooking, and keeping the kids away from the cooking area can all significantly reduce your exposure to indoor air pollution (IAP). Changes to the surroundings, such as using a chimney, curing fuel wood before use, and using a lid when cooking, can help lessen negative effects. Collaborations with festivals, religious gatherings, and medical outreach clinics are all possibilities for educating communities about lowering exposure to indoor air pollution in homes. Community health professionals are a valuable resource for teaching people in communities about how to lessen the consequences of indoor air pollution.

Challenges

A practise known as "fuel stacking" or "stove stacking" is common among users of clean stoves and fuels who also frequently use conventional fuels and stoves. For instance, a recent research in Kenya discovered that households that use LPG as their primary fuel consume 42% more charcoal than those that use charcoal as their primary fuel. Clean cooking facilities may not significantly reduce household air pollution when stacking is practised, which could have an adverse effect on health outcomes. There are several reasons to keep using traditional fuels and stoves, including the inconsistency of the fuel supply, the high cost of fuel, the flexibility of the stoves for various pots and cooking styles, and the necessity of making lengthy trips for stove repairs.

The population has barely kept up with efforts to increase access, and existing and projected policies will still leave 2.4 billion people without access in 2030.

Sustainable and Environmental development effects.

Even if fossil fuels are used as substitute fuels, switching to cleaner cooking methods is predicted to either modestly increase greenhouse gas emissions or decrease emissions. There is proof that converting to LPG and PNG has less of an impact on the environment than burning solid fuels, which releases methane and black carbon. Up to 58 percent of the world's black carbon emissions come from the burning of household solid fuels. "The costs of establishing nearly universal access to electricity and clean fuels for cooking and heating are anticipated to be between 72 and 95 billion USD per year through 2030 with modest effects on GHG emissions," the Intergovernmental Panel on Climate Change noted in 2018. The UN Sustainable Development Goal 7's first objective is to "Ensure universal access to affordable, dependable, and modern energy services by 2030," and one of its components is universal access to clean cooking. The achievement of other Sustainable Development Goals, such as eradicating poverty (Goal 1), promoting health and wellbeing (Goal 3), achieving gender equality (Goal 5), and acting on climate change, will be made easier by advancements in clean cooking (Goal 13). According to SDG 7, Indicator 7.1.2 measures the "Proportion of the population that relies primarily on clean fuels and technology." - The indicator is determined as the proportion of the total population who report using any type of cooking, heating, or lighting, divided by the number of persons utilising clean fuels and technology. In this context, the term "clean fuel" refers to fuels that meet the emission rate targets and particular fuel recommendations (i.e., refrain from using raw coal and kerosene) included in the normative WHO standards for indoor air quality.

Energy Conservation

The effort to lower energy consumption by utilising fewer energy services is known as energy conservation. This can be done by either increasing the efficiency with which energy is used (using less energy for a constant service) or by decreasing the quantity of service required (for example, by driving less). The idea of eco-sufficiency includes energy conservation. Buildings using energy conservation measures (ECMs) use less energy overall, which improves environmental quality, national security, individual financial security, and savings. On the hierarchy of sustainable energy, it is at the top. By avoiding future resource depletion, it also reduces energy expenditures.

By minimising waste and losses, enhancing efficiency through technological advancements, and improving operation and maintenance, energy can be conserved. The stabilisation of population growth can also help to reduce energy use globally.

Only the transformation of energy from one form to another is possible, such as the conversion of heat energy into vehicle motive power or the kinetic energy of water flow into electricity in hydroelectric power plants. To change energy from one form to another, however, requires the use of machines. When this machine is operating, the wear and friction of its parts result in significant energy losses and substantial associated expenses. By using green engineering techniques to lengthen the component life cycles, it is possible to reduce these losses.

Since 1991, December 14 has been designated as National Energy Conservation Day. The cornerstone of many sustainable energy initiatives is energy efficiency, which refers to using less energy to deliver the same goods or services or to delivering equivalent services with fewer commodities. According to the International Energy Agency (IEA), boosting energy efficiency might result in 40% of the greenhouse gas emission reductions required to meet the targets of the Paris Agreement.

By making equipment, vehicles, industrial processes, and buildings more technologically efficient, energy can be saved. Another strategy is to utilise less materials, such as through improved building design and recycling, whose creation consumes a lot of energy. Another option to save energy is to make behavioural adjustments like switching to videoconferencing instead of business travel or travelling inside cities on foot, bicycle, or public transportation rather than by car. Building codes, performance criteria, carbon pricing, and the creation of energy-efficient infrastructure are a few examples of government policies that can be used to increase efficiency. An approximation of the energy efficiency of economic output is provided by the global economy's energy intensity, or the amount of energy spent per unit of gross domestic product (GDP). Per US dollar of GDP in 2010, there were 5.6 megajoules (1.6 kWh) of global energy intensity. According to UN targets, between 2010 and 2030, energy intensity should drop by 2.6 percent year. This objective hasn't been reached recently. For instance, only 1.1% of energy intensity was lost between 2017 and 2018. Efficiency gains can have the unintended consequence of making consumers spend their money on more energy-intensive goods and services. For instance, consumer behaviour patterns like choosing larger vehicles and residences have largely countered recent technical efficiency increases in transportation and construction.

Energy conservation opportunities by sector

Buildings

Existing buildings

Conducting an energy audit is one of the key approaches to increase energy saving in buildings. A building, process, or system's energy use and flows are inspected and analysed as part of an energy audit with the goal of minimising energy input without adversely effecting output. This is often carried out by qualified experts and may fall under any of the national initiatives already mentioned. Homeowners may now perform somewhat complex energy audits on their own thanks to recent developments in smartphone apps.

Energy consumers, both commercial and residential, can see the effects of their energy use in their workplaces or homes thanks to building technologies and smart metres. Modern real-time energy metering can support individuals in their efforts to save energy.

Energy Service Companies (ESCOs) with expertise in energy performance contracting are frequently used by companies installing ECMs in their commercial buildings. Since the 1970s, this industry has existed and is now more widespread than ever. A set of rules have been developed by the US-based group EVO (Efficiency Valuation Organization) for ESCOs to follow when assessing the savings realised by ECMs. The International Performance Measurement and Verification Protocol is the name of these rules (IPMVP).

In order to provide a more thorough awareness of the environment, dataloggers can also be added to precisely track the interior temperature and humidity levels. More fine-tuning of the interiors can be undertaken if the data collected is then compared with the users' impressions of comfort (for example, in increasing the temperature where AC is used to prevent over-cooling).

New buildings

When a structure is designed with passive solar principles, its windows, walls, and floors are constructed to absorb, store, and distribute solar energy as heat in the winter and reject it in the summer. Because it doesn't employ mechanical or electrical components, like active solar heating systems do, this is known as passive solar design or climatic design.

Making the most of the local climate is essential when planning a passive solar building. The positioning of windows and the type of glass, as well as thermal insulation, thermal mass, and shading, must all be taken into account. The easiest buildings to use passive solar design approaches are those that are newly constructed, however older structures can be modified.

Transportation

In the United States, suburban infrastructure developed at a time when fossil fuels were readily accessible, which resulted in living arrangements that are reliant on mobility. Zoning changes that permit higher urban densities, along with plans for walking and bicycling, can significantly lower the amount of energy used for transportation. Since many Americans don't commute to work every day, there is a tremendous chance to save energy by working remotely.

A decrease in greenhouse gas emissions is one of the environmental effects. Madrid's city centre saw a 38 percent decrease in nitrogen oxide levels and a 14.2 percent decrease in carbon dioxide after restricting access for cars. A decrease in greenhouse gas emissions is one of the environmental effects. In Madrid, nitrogen oxide levels decreased by 38% while carbon dioxide levels increased after restricting access for cars to the city core.

Consumer products

An energy audit is a common first step for homeowners installing ECMs in their residential structures. This is one technique for homeowners to determine which parts of their homes are utilising and perhaps wasting energy. The Building Performance Institute (BPI) or the Residential Energy Services Network accredits residential energy auditors (RESNET). Homeowners have three options for doing an audit: hiring a pro, doing it themselves, or using a smartphone.

To maximise energy savings while reducing inconvenience to building residents by coordinating improvements, energy conservation initiatives are frequently integrated into larger guaranteed Energy Savings Performance Contracts. Some ECMs have lower implementation costs but produce greater energy savings. Lighting initiatives have historically been an excellent example of "low hanging fruit" that might be utilised to motivate the execution of more significant HVAC system modifications in large complexes. In order to increase energy efficiency, smaller structures may combine window replacement with contemporary insulation utilising cutting-edge construction foams. Energy dashboard projects are a new category of ECM that depend on occupant behaviour modification to reduce energy use. Case studies (like the one for the DC Schools) show that energy savings can increase by 30% when applied as part of a programme. Open energy dashboards may even be implemented without charge to increase these savings in the appropriate situations.

The cost reductions of energy-efficient items are frequently not well known to consumers. The energy savings that may be achieved by switching out an incandescent light bulb with a more contemporary substitute is a notable illustration of this. Many customers choose inexpensive incandescent light bulbs when buying light bulbs, failing to consider their higher energy costs and shorter lifespans when compared to contemporary compact fluorescent and LED lights. The extended lifespan and low energy use of these energy-efficient options can help consumers save a lot of money, despite their greater initial cost. Due to advancements in semiconductor technology, the cost of LED bulbs has also been gradually declining over the last five years. Numerous LED bulbs on the market are eligible for utility subsidies, which further lower the cost to the user. According to calculations made by the U.S. Department of Energy, the widespread use of LED lighting over the next 20 years may save the country $265 billion in energy bills.

When there are more affordable products and technology using today's fossil fuels, the research one must conduct to conserve energy is frequently too time-consuming and expensive for the typical customer. With the use of eco-labels that make it simple to compare variations in energy efficiency while shopping, certain governments and NGOs are striving to simplify this complexity.

It is crucial to comprehend and connect with people's current difficulties in order to offer the information and support individuals require to devote money, time, and effort in energy conservation. For instance, some merchants assert that lighting that is bright encourages buying. Health studies, however, have shown that the typical over-illumination found in many office and retail settings often causes an increase in headache, tension, blood pressure, weariness, and worker error. Natural daylighting has been found to boost employees' productivity levels while consuming less energy.

Any home appliance that produces heat will increase the load on the cooling system in warm areas where air conditioning is used. The home is heated by appliances like stoves, dishwashers, laundry dryers, hot water, and incandescent lighting. These gadgets emit less heat for the air conditioner to remove when they are low-power or insulated. Utilizing a heat sink that is colder than the typical air heat exchanger, such as geothermal or water, can help the air conditioning system operate more efficiently.

Heating water and air is a significant requirement for residential energy use in cold areas. Utilizing various technology allows for significant energy reductions. For warming air or water, heat pumps are a more effective option than electrical resistance heaters. There are several effective dryers to choose from, and hanging clothing out to dry uses only time and no electricity. Compared to conventional hot-flue models, the efficiency of natural gas (or biogas) condensing boilers and hot-air furnaces is increased. By using a time switch, standard electric boilers can be programmed to only operate during the times of the day when they are required. As a result, far less energy is used. A semi-closed-loop system may be used in showers. In bathrooms, laundry rooms, and kitchens, new architecture using heat exchangers can absorb heat from wastewater or exhaust air.

The most important aspect affecting a home's efficiency in both warm and cold climate extremes is its airtight, thermally insulated design. Although it can be labor-intensive to retrofit insulation into an existing home, it helps to reduce the movement of heat into or out of the house.

Global Impact

Globally, energy efficiency works in the background to increase energy security, reduce energy costs, and bring nations closer to achieving their climate goals. The IEA estimates that debt and equity account for about 40% of the global market for energy efficiency. ECMs can be introduced right away and compensated for using savings made over the course of the project thanks to an energy performance investment. Although there are laws permitting businesses to provide energy savings performance contracts in all 50 states, Puerto Rico, and Washington, D.C., the degree of success depends on the approach taken, the state's level of engagement, and other considerations. To save costs by reducing waste and increasing productivity, homes and businesses are embracing energy-efficiency measures including insulation, low-energy lighting, and even high-tech energy dashboards.

Energy conservation by countries

Asia

Even while energy efficiency is projected to be crucial in efficiently reducing energy demand, only a small portion of its economic potential is currently being utilised in Asia. To promote a variety of energy-efficiency projects across many sectors, governments have introduced a number of incentives, including cash grants, low-cost credit, tax exemptions, and co-financing with public-sector money. Governments in the Asia-Pacific area have put in place a variety of information provision and labelling systems for industrial, commercial, and residential structures, appliances, and transportation. Informational campaigns can simply disseminate information (such as fuel-economy labels) or actively work to influence behaviour (like Japan's Cool Biz campaign, which promotes setting air conditioners at 28 degrees Celsius and allowing staff to dress informally in the summer).

European Union

The European Union (EU) made a commitment to reduce its yearly primary energy usage by 20% by 2020 at the end of 2006. [37] Long awaited is the "European Union Energy Efficiency Action Plan." Energy efficiency is addressed in Directive 2012/27/EU.

The Boiler Efficiency Directive establishes minimum standards of efficiency for boilers using liquid or gaseous fuels as part of the EU's SAVE programme, which aims to promote energy efficiency and encourage energy-saving behaviour. Energy savings in Europe might reach 67% of the baseline scenario for 2019 in 2050, which would result in a demand of 361 Mtoe under the "energy efficiency first" societal trend scenario. The absence of a rebound effect is a requirement since, in the absence of one, the savings are limited to 32 percent and, in the event that techno-economic potentials are not realised, energy use may even rise by 42 percent.

India

In 1978, the Indian government established the Petroleum Conservation Research Association (PCRA), a group dedicated to advancing energy efficiency and conservation in all spheres of life. PCRA has recently organised mass media campaigns for print, radio, and television. According to a third-party effect assessment study, the PCRA's major initiatives have increased public awareness to the point that crores of rupees' worth of fossil fuels have been saved, along with reducing pollution. The promotion of energy conservation and efficiency is the responsibility of the Bureau of Energy Efficiency, a 2001 creation of the Indian government.

Community Natural Resources Management is responsible for protecting and conserving natural resources (CNRM).

Iran

Ali Khamenei, Iran's supreme leader, had frequently criticised the management of energy and excessive fuel use.

Japan

Energy conservation has been a problem in Japan since since the 1973 oil crisis. Since all oil-based fuel must be imported, renewable energy sources are being created domestically. In every sphere of Japanese life, energy efficiency is promoted by the Energy Conservation Center. The efficient use of energy for businesses and research is being implemented by public entities. It consists of initiatives like the Top Runner Program. The most efficient new appliances are made the standard in this project after they undergo regular efficiency testing.

Lebanon

Since 2002, the Lebanese Center for Energy Conservation (LCEC) has worked to encourage the development of energy-saving technologies and the use of renewable energy among consumers in Lebanon. Although it continues to receive support from the United Nations Development Program (UNDP), as stated in the Memorandum of Understanding (MoU) signed between MEW and UNDP on June 18, 2007, it was initially established as a project funded by the International Environment Facility (GEF) and the Ministry of Energy and Water (MEW) under the management of the United Nations Development Programme (UNDP).

Nepal

Up until recently, Nepal concentrated on harnessing its vast water resources to generate hydropower. Government initiatives did not prioritise demand-side control or energy saving. The joint implementation of the "Nepal Energy Efficiency Programme" was agreed upon in 2009 as part of bilateral development cooperation between Nepal and the Federal Republic of

Germany. The Water and Energy Commission Secretariat is the primary agency in charge of carrying out the implementation (WECS). The program's objective is to promote energy efficiency in government policy, in rural and urban homes, and in business. The Federation of Nepalese Chambers of Commerce and Industry (FNCCI) founded the Energy Efficiency Centre under his umbrella to promote energy saving in the private sector because the nation does not have a government body that promotes energy efficiency. A nonprofit organisation called the Energy Efficiency Centre provides energy audits services to various sectors. The Deutsche Gesellschaft für Internationale Zusammenarbeit's Nepal Energy Efficiency Program also provides funding for the Center. According to a 2012 research, Nepalese companies may save 160,000 megawatt hours of electricity annually and 8,000 terajoules of thermal energy (such as coal, diesel, and furnace oil). These reductions equate to a potential 6.4 billion Nepalese Rupee reduction in annual energy costs. The Nepal Economic Forum 2014 led to the declaration of an economic reform agenda in the priority sectors, concentrating on energy conservation among other things. The Nepali government committed to introducing incentive programmes in the budget for the fiscal year 2015/16 for industries that practise energy efficiency or deploy efficient technologies as part of the energy reform strategy (incl. cogeneration).

New Zealand

The government agency in New Zealand in charge of promoting energy conservation and efficiency is called the Energy Efficiency and Conservation Authority. The Energy Management Association of New Zealand, a membership-based organisation that represents the country's energy services industry, offers training and accreditation services to guarantee the reliability and credibility of energy management services.

Nigeria

The Lagos State Government in Nigeria is promoting energy conservation among Lagos residents. Under the auspices of the Ministry of Energy and

Mineral Resources, the Lagos State Electricity Board (LSEB) implemented the "Conserve Energy, Save Money" campaign in 2013. By influencing their behaviour with do-it-yourself advice, the programme aims to educate Lagosians about the importance of energy conservation. Rapper Jude "MI" Abaga, who served as the campaign ambassador, and Lagos State Governor Babatunde Raji Fashola took part in a conference video call on energy saving in September 2013.

The public was also invited to assess their household energy use and learn how to conserve money using a consumer-focused energy app at experience centres set up by LSEB at malls throughout Lagos State during the month of October, which is the official energy conservation month in the state. Solar lamps and energy-saving bulbs were distributed as well to get Lagosians started on energy conservation.

The Kaduna Power Supply Company (KAPSCO) in Kaduna State implemented a scheme to replace all of the light bulbs in all public buildings with energy-saving bulbs. Additionally, KAPSCO is starting a project to replace all traditional streetlights in the Kaduna Metropolis with LEDs, which use a lot less energy.

Sri Lanka

For the generation of daily power, Sri Lanka now uses fossil fuels, hydropower, wind power, solar power, and dendropower. Regarding energy management and conservation, the Sri Lanka Sustainable Energy Authority is actively involved. The majority of enterprises are being urged to use renewable energy sources and to make the best use of the energy they already have.

Turkey

By 2023, Turkey wants to cut its energy use as a percentage of GDP by at least 20%. (energy intensity).

United Kingdom

Promoting energy efficiency in the UK is the responsibility of the Department for Business, Energy, and Industrial Strategy.

United States of America.

Currently, China consumes more energy than any other country, with the United States coming in second. The U.S. Department of Energy divides the nation's energy use into four main categories: transportation, housing, commerce, and industry.

About half of all energy used in the US is used in the transportation and residential sectors, which are mainly under the control of individual users. Business organisations and other facility managers decide how much energy is used for commercial and industrial purposes. Energy use in all four sectors is significantly influenced by national energy policy.

Mechanisms to Promote Conservation

Governmental mechanisms

Policies promoting energy efficiency may be put in place by national, regional, and municipal governments.

Mandatory energy standards

Governments promote energy efficiency as a public good primarily through energy standards. Examples include energy regulations for buildings and cars, which set minimum standards for the energy efficiency of a vehicle, structure, appliance, or other type of technical equipment. There can be limitations on the sale or rental of the vehicle, structure, appliance, or equipment if it does not adhere to these criteria. These are known as "minimum energy efficiency standards" (MEES) in the UK, and they were implemented for privately leased housing in 2019.

Mandatory energy labels

Numerous nations demand that the energy efficiency of a vehicle, structure, or piece of equipment be labelled. Customers and consumers are able to see the energy implications of their decisions thanks to this, but it does not limit their options or control the products that are available for purchase.

Additionally, it does not make the best energy-saving choices readily available or allow for simple option comparison (such as the ability to filter by energy efficiency in online businesses) (such as energy-conserving options being available in the frequented local store). (Nutritional information about food might serve as an example.)

The approach of labels involves a trade-off between financial considerations and higher cost requirements in effort or time for the product selection from the many available options, which are frequently unlabelled and don't have any EEEC-requirement for being bought, used, or sold within the EU, according to a trial of estimated financial energy costs of refrigerators alongside EU energy-efficiency class (EEEC) labe ` `ls online. Additionally, in this one research, the labelling was ineffective at influencing purchases in favour of more environmentally friendly products.

Sustainable Standards and Certification.

Producers, manufacturers, traders, retailers, and service providers can demonstrate their commitment to excellent environmental, social, ethical, and food safety practises by earning sustainability standards and certifications on a voluntary basis. In the world, there are more than 400 similar standards.

The introduction of Ecolabels and standards for Organic food and other items in the late 1980s and early 1990s marked the beginning of the trend. The triple bottom line of economic prosperity, social equality, and environmental quality is used in most benchmarks. A standard is typically created by a wide range of specialists and stakeholders in a given industry and provides a set of guidelines or standards for how a crop should be produced ethically or sustainably. For example, this may include respecting human rights and paying fair wages on a coffee or tea plantation, or using responsible fishing methods that don't harm marine biodiversity. Sustainability standards typically include a verification process, also known as "certification," to assess whether an enterprise complies with the standard. They also typically include a traceability process for certified products to be sold along the supply chain, which frequently results in a label that can be seen by consumers. In order to help smallholders or underprivileged producers reach the standard, certification programmes also put a strong emphasis on building capacity and collaborating with partners and other organisations.

The basic premise of sustainability standards is twofold;

a. They appeared in countries with lax national and international legislation but where action was sought by global consumer and NGO movements. For instance, protests by Global Exchange and other NGOs against Nike, Inc., Levi Strauss & Co. and other well-known businesses buying products made in "sweatshop" factories gave rise to social welfare standards like the SA8000 and others.

b. Leading companies may want to highlight the environmental or organic benefits of their products when selling to both customers and the B2B supply chain, which has caused the establishment of hundreds of ecolabels, organic, and other standards.

The Fairtrade movement, led by FLO International and showing enormous global sales growth for goods sourced ethically, is a prime example of a consumer standard. The Forest Stewardship Council's (FSC) standard for forest products derived from sustainably harvested trees is an example of a B2B standard that has expanded significantly in recent years.

The distinction between B2B and consumer sustainability standards is fuzzing, as seen by the growing desire for Fairtrade certification among top trade buyers and the growing consumer awareness of the FSC seal. As it became evident that consumer demand alone cannot drive the change of significant sectors and industries, the business-to-business focus of sustainability standards increased recently. Initiatives for certification aim to mainstream the adoption of improved practises and precompetitive industry cooperation in commodities such palm oil, soy, farmed seafood, and sugar. Major shops and companies are also beginning to commit to certification across their whole product offering or supply chain, as opposed to just one product line or ingredient.

According to the International Trade Centre Standards Map, there are currently 264 active VSS in 194 countries and 15 industrial sectors, and 457 ecolabels in 199 countries and 25 industry sectors. The number of sustainability standards has also increased over time.

It is crucial that there be means to judge the reliability and effectiveness of various projects given the rise of standards and certification as the primary tool for enhancing the sustainability of global production and trade as well as the private sector's leadership in this area. Clarity on which standards and ecolabels are producing actual social, environmental, and economic results is necessary for company and government purchasers, NGOs, and civil society organisations dedicated to sustainable production. The ISEAL Alliance has established itself as the leading source of information on best practises for sustainability standards, and its Codes of Good Practice stand as the most well-known examples of excellent standard-setting and implementation practises. ISEAL members establish their reputation and aim to increase their beneficial effects by adhering to these Codes and cooperating with other certification programmes.

The State of Sustainability Initiatives (SSI) project, facilitated by the United Nations Conference on Trade and Development (UNCTAD) and the International Institute for Sustainable Development (IISD) under the auspices of the Sustainable Commodity Initiative, was established in an effort to address the issues brought on by a proliferation of certification initiatives (SCI)

Energy taxes

Some nations utilise energy or carbon taxes to entice energy consumers to cut back on their usage. Carbon taxes can encourage consumers to switch from combustion-engine vehicles, jet fuel, oil, natural gas, and coal to energy sources that emit less carbon dioxide, such as solar, wind, hydroelectricity, or nuclear power. On the other hand, taxes on all energy usage can both lower overall energy use and a wider range of environmental effects associated with energy production. Every consumer in the state of California receives a base energy allowance that is subject to a modest tax under the state's system of tiers of energy taxation. If usage rises above that threshold, the levy is dramatically increased. Such initiatives aim to safeguard low-income households while increasing the tax burden on energy-intensive customers.

Because doing so would impede their economic development, developing nations in particular are less likely to enact policies that reduce carbon emissions. Instead of reducing their carbon emissions, these developing nations can want to promote their own citizens and economic development.

The following carbon tax advantages and disadvantages can help one understand some of the possible outcomes of a carbon tax policy.

Carbon tax advantages include:

- requiring polluting parties to cover the price of carbon emissions.
- Greater social efficiency is made possible since every citizen pays the full social cost.
- generates income that can be used to offset the effects of pollution.
- encourages businesses and customers to look for options that don't produce carbon (ex. solar power, wind power, hydroelectricity, or nuclear power).
- reduces the costs to the environment incurred by excessive carbon pollution.
- Carbon tax disadvantages include:

- Businesses contend that increased taxes can deter investment and economic expansion.
- A carbon tax may promote tax evasion since businesses may pollute covertly to avoid paying the tax.
- It could be challenging to calculate external costs and the appropriate carbon tax rate.
- Measuring pollution and obtaining the corresponding tax have administrative costs.
- Businesses might relocate their operations to nations without a carbon price.

NON-GOVERNMENTAL MECHANISMS

Voluntary energy standards

Using the Leadership in Energy and Environmental Design (LEED) voluntary building design guidelines is another way to promote energy efficiency. The US Green Building Council is in favour of this scheme. Energy-related topics are covered by the "Energy and Atmosphere" Prerequisite, which focuses on energy efficiency, renewable energy, and other things. See green construction.

Reactions against conservation

Former US President Donald Trump had proposed water management. A law he also passed that the Biden administration later reversed loosened limitations on shower head output power. Additionally, faster and more potent dishwashers were made possible by the Trump administration.

Origin of global standards

The United Nations Food and Agriculture Organization is the source of many of the international standards created to help drive sustainability goals and certification programmes (FAO). For certifying entities to follow, the FAO has established a number of standards. The FAO has published standards and guidelines in particular to improve the sustainability of forestry, fisheries, and agriculture. Some of the sustainability standards, including the Rainforest Alliance in the United States and Fairtrade certification in the Netherlands, were started by social movements in individual nations.

Other standards, such as Utz Certified (Ahold), Starbucks C.A.F.E. (Starbucks), and Nespresso AAA, were created by specific businesses using private criteria (Nespresso). Some standards have been introduced by alliances of private companies (also known as multistakeholder governance), development organisations, nongovernmental organisations, and other stakeholders, such as the Marine Stewardship Council, or MSC standard, created through a partnership between Unilever and the World Wildlife Fund. For instance, the German Agency for Technical Cooperation and Development worked with a coalition of major American coffee roasters, such as Kraft Foods, Sara Lee, and Nestle, to launch the Common Code for the Coffee Community (4C) (GIZ).

A number of local development projects involving NGOs, coffee roasters, and producers in various poor nations were a key enabler for the establishment of most global standards. For instance, based on pilot initiatives with Mexican farmers, the Fairtrade private standard was created. Using GIZ, significant coffee roasters, and regional producers, 4C expands on development initiatives in Vietnam, Colombia, and Peru.

Agriculture has the most commonly defined and implemented standards, with about 15-20% of cocoa and tea production adhering to significant international standards and 40% of world coffee production certified to one of the major schemes. Standards have also had an impact in the forestry and wild seafood industries, with certified production now accounting for more than 10% of global production. Some of the commodities in which certification is expanding quickly are cotton, palm oil, soy, biofuels, and farmed seafood. This is partly because important roundtables have been established to unite the entire industry. The mining and extraction of metals, such as gold, silver, aluminium, and oil and gas, as well as the production of cattle, electronics, plastics, and tourism, have just begun to see the emergence of standards.

Global standards by private corporations hold promise for effective social impact because evidence suggests that Corporate Social Responsibility (CSR) accepted voluntarily by firms can be more effective than CSR regulated by governments. In a paper published by MSI Integrity, a counterargument was presented that raised concerns about multistakeholder governance in the private sector, led by corporations, that "adopts weak or narrow standards" that "better serve corporate interests than rights holder interests" in the absence of governmental regulation.

The establishment of the ISEAL Alliance as a private organisation in 2002 marked the beginning of a cooperative effort between a group of sustainability standards organisations to adhere to best practises in standard implementation and to cooperate to increase the use of standards and certification globally.

Sustainability standards

To address issues of environmental quality, social equality, and economic prosperity in international trade and manufacturing processes, many sustainability standards have been developed. There are several notable variances in their historical origins, target adopter groups, geographical distribution, and emphasis on environmental, social, or economic issues, despite parallels in their fundamental goals and certification processes.

The degree of rigour of the standard is one of the key variances. Some standards provide a high bar for a given industry, encouraging good social and environmental practises and collaborating with industry leaders to raise sustainability standards consistently. Other standards operate at a more entry-level and are more concerned with eliminating the worst practises in order to have a significant percentage of an industry working gradually towards improved practises. There are many tactics between requirements to advance producers up this sustainability performance ladder. Another significant difference is that although some standards are wholly established with a regional or national focus, other standards can be implemented internationally (often with processes to verify local relevance and appropriateness).

The certification procedure and whether it is carried out by a first, second, or third party; the traceability system in place and whether it permits the segregation or mixing of certified and non-certified materials; and the kinds of sustainability claims that are made on products are possible additional differences between standards.

Fairtrade

A Dutch development organisation worked with Mexican farmers to create the Fairtrade label in the late 1980s. The initiative carries out development work and promotes its political vision of an alternative economy, with its major goal being to strengthen the position of small producers on the global market and give them access to it. The assurance of a minimum price and a social premium that go to the cooperative rather than the producers directly is the most distinctive aspect of the Fairtrade mark. Fairtrade recently included environmental goals in its certification process. In response to a report from The Institute for Multi-Stakeholder Initiative Integrity, Fairtrade International released a position statement in 2020 defending their usage of proprietary standards (MSI Integrity).

Rainforest Alliance

The Rainforest Alliance is dedicated to preserving rainforests and their biodiversity. It was founded in the late 1980s as a result of a social movement. The requirement to develop and implement a comprehensive strategy for the creation of a sustainable farm management system in order to support wildlife conservation is a significant component of the standard. By creating and securing sustainable livelihoods, another goal is to enhance the welfare of the workforce. A premium may be added to producer prices. But rather of securing a set floor price, the standard attempts to boost producers' financial standing through increased yields and cost-effectiveness.

UTZ Certified

The Dutch coffee producer Ahold Coffee Company co-founded UTZ Certified (formerly Utz Kapeh) in 1997. It strives to provide a free and open market for agricultural products that respect people and the environment. The UTZ Code of Conduct and the UTZ Traceability System are examples of instruments. With the help of the traceability system, products that have been approved can be tracked all the way from the producer to the consumer. The UTZ Code of Conduct places equal emphasis on social and environmental benefits, such as biodiversity conservation, waste management, and water utilisation (e.g. access to medical care, access to sanitary facilities at work).

Organic

IFOAM Basic Standards served as the foundation for the Organic standard's development in the 1970s. The major global umbrella organisation for the organic farming movement is called IFOAM, which stands for International Federation of Organic Agriculture Movements. Agrochemicals like pesticides and chemical-synthetic fertilisers are excluded from the IFOAM Basic Standards' framework of basic requirements. Additionally, the use of animal foods is highly controlled. The use of genetically modified organisms (GMOs) and genetic engineering are prohibited.

Sustainable Tourism

The tourism sector now has a wide range of sustainability criteria for various subsectors as a result of growing awareness. This covers criteria for eco-friendly lodging, eco-friendly tour operators, eco-friendly conferences and events, eco-friendly travel destinations, and more.

Leed

The US Green Building Council created the Leadership in Energy and Environmental Design standards in an effort to advance green building design in the country. Compliance with all environmental laws and regulations, occupancy scenarios, building permanence and pre-rating completion, site boundaries and area-to-site ratios, and the mandatory five-year sharing of whole building energy and water use data starting from the start of occupancy (for new construction) or date of certification (for existing buildings) are all requirements for LEED certification.

Other examples

Other standards include industry-specific programmes like the Roundtable on Sustainable Palm Oil (RSPO), standards for climate and development interventions like the Gold Standard, retailer-led sustainability certification programmes like GlobalGAP, corporate own-brand sustainability programmes like Starbucks' CAFE Practices, and national programmes like the Irish Food Board's "Origin Green" programme.

The FAO, UNEP, ITC, UNCTAD, and UNIDO collaborated to create the United Nations Forum on Sustainability Standards (UNFSS). The UNFSS is an impartial and trustworthy platform that aims to maximise the potential of "Voluntary Sustainability Standards" (VSS) as a means of achieving the SDGs by: facilitating emerging economies' access to profitable markets, encouraging informed dialogue among key stakeholders at the national and international level, and developing the capacities of producers and SMEs to increase opportunities in international trade.

Efficient energy use

Reduce the amount of energy needed to supply goods and services via efficient energy use, sometimes referred to as energy efficiency. This can help lessen the consequences of air pollution. For instance, insulating a building enables it to achieve and maintain thermal comfort with less heating and cooling energy. When compared to utilising conventional incandescent light bulbs, installing light-emitting diode bulbs, fluorescent lighting, or natural skylight windows minimises the amount of energy needed to achieve the same level of illumination. Application of universally known techniques to reduce energy losses or adoption of a more efficient technology or industrial process are the two main ways to increase energy efficiency.

The desire to increase energy efficiency is widespread. If the energy savings outweigh any additional costs associated with deploying an energy-efficient technology, reducing energy use can save consumers money on their energy bills. The issue of reducing glasshouse gas emissions is also seen to be solved by using less energy. The International Energy Agency estimates that greater energy efficiency in infrastructure, manufacturing, and transportation could reduce global energy consumption by one-third by 2050 and contribute to the reduction of glasshouse gas emissions. Eliminating government-sponsored energy subsidies, which in more than half of the world's nations encourage excessive energy use and inefficient energy use, is another crucial option.

According to the sustainable energy hierarchy, energy efficiency and renewable sources of energy are the two pillars of sustainable energy policy and are given top priority. Because it can be utilised to lower the amount of energy imports from other nations and may slow down the rate at which indigenous energy supplies are depleted, energy efficiency is also considered in many countries as having a positive impact on national security.

Without necessarily boosting energy consumption, energy efficiency has shown to be a profitable approach for developing economies. For instance, the state of California started enacting energy-efficiency measures in the middle of the 1970s, including tight building code and appliance standards. In the years that followed, California's per-person energy consumption roughly stayed the same while that of the US as a whole doubled. California adopted a "loading order" for new energy resources as part of its strategy, which prioritises energy efficiency, followed by renewable electricity sources, and new fossil-fired power plants. States like Connecticut and New York have established quasi-public Green Banks to assist building owners fund energy efficiency improvements that lower emissions and lower energy bills for consumers.

According to Lovin's Rocky Mountain Institute, "there are plentiful potential to save 70% to 90% of the energy and cost for lighting, fan, and pump systems; 50% for electric motors; and 60% in sectors like heating, cooling, office equipment, and appliances" in industrial settings. In general, it is possible to conserve up to 75% of the electricity used in the US today with efficiency techniques that are less expensive than the electricity itself. According to the US Department of Energy, improving home energy efficiency has the potential to save 90 billion kWh of energy.

This has been reinforced in several investigations. According to a report from the McKinsey Global Institute from 2006, "there are enough economically viable opportunities for energy-productivity improvements that could keep global energy-demand growth at less than 1 percent per year"—less than half the 2.2 percent average growth predicted through 2020 in a business-as-usual scenario. Reducing the amount of energy needed to produce something or increasing the quantity or quality of goods and services from the same amount of energy can both increase energy productivity, which measures the output and quality of goods and services per unit of energy input. Under the auspices of the United Nations Framework Convention on Climate Change, the Vienna Climate Change Talks 2007 Report unequivocally demonstrates "that energy efficiency may achieve meaningful emission reductions at minimal cost." For the purpose of calculating and reporting on energy savings and energy efficiency for nations and cities, international standards ISO 17743 and ISO 17742 offer a codified approach. Energy efficiency is different from a country's or region's energy intensity, which is the proportion of energy use to gross domestic product or another indicator of economic production. Climate, economic structure (e.g., services vs. manufacturing), trade, and the energy effectiveness of buildings, vehicles, and industry all have an impact on energy intensity.

Benefits

From the perspective of an energy user, the primary driver of energy efficiency is frequently just the desire to save money by reducing the price of acquiring energy. Furthermore, from the perspective of energy policy, there has been a long-term tendency towards a greater understanding of energy efficiency as the "first fuel," which refers to the capacity to substitute for or avoid the consumption of actual fuels. In fact, according to calculations by the International Energy Agency, the use of energy efficiency measures between 1974 and 2010 was able to reduce energy consumption in its member states by more than any given fuel, including oil, coal, and natural gas, combined.

Additionally, it has long been understood that energy efficiency has advantages beyond just lowering energy use. Some estimates of the value of these additional advantages, also known as multiple advantages, co-benefits, auxiliary advantages, or non-energy advantages, have their total worth even higher than the direct energy advantages. These numerous advantages of energy efficiency include things like lessening the impact of climate change, lowering air pollution and improving health, enhancing indoor comfort, enhancing energy security, and lowering the price risk for energy users. The choice experiment approach for enhancements that have a subjective component (such as comfort or aesthetics) and the Tuominen-Seppänen method for price risk reduction are two examples of techniques for determining the monetary value of these numerous benefits. The economic return on investments in energy efficiency can be demonstrated to be much higher than just the value of the energy saved when considered in the study.

Appliances

Freezers, ovens, stoves, dishwashers, clothes washers, and dryers all consume a lot less energy today than they did a few decades ago. By using their dryer less, people who instal a clothesline will use less energy overall. For instance, energy-efficient refrigerators today consume 40% less electricity than standard versions did in 2001. Then, 20 billion kWh of electricity would be saved yearly, cutting CO2 emissions by about 18 billion kg, if all families in Europe replaced their more than ten-year-old equipment with new ones. The equivalent numbers in the US are 17 billion kWh of electricity and 27,000,000,000 lb (1.2 1010 kg) of CO2. The replacement of outdated appliances is one of the most effective global initiatives to reduce emissions of glasshouse gases, according to a 2009 McKinsey & Company report. By turning off or switching appliances to a low-energy mode after a certain amount of time, modern power management systems also cut energy consumption by inactive appliances. Energy input labelling is used in several nations to indicate equipment that save energy.

Depending on how and when an appliance is utilised, energy efficiency might affect peak demand. For instance, when it's hot in the afternoon, an air conditioner requires more electricity. As a result, peak demand will be affected more by an energy-efficient air conditioner than off-peak demand. On the other hand, a dishwasher that is energy-efficient uses more electricity when people use it in the late evening. Peak demand could be minimally or not at all affected by this appliance.

To make new devices as energy-efficient as possible, tech companies over the period 2001–2021 swapped out the conventional silicon switch in an electric circuit for faster gallium nitride transistors. However, gallium nitride transistors are more expensive. This is a big shift in terms of reducing the carbon footprint.

Building design

Due to their significance as a significant energy consumer, buildings are a crucial area for energy efficiency improvements globally. The ability to create different indoor environments with the use of energy makes the issue of energy use in buildings complex. Lighting, heating, cooling, and ventilation are all energy-intensive building comfort measures.

As a result, rather than only aiming to consume as little energy as possible, a balanced approach to energy efficiency in buildings should be taken. It is important to consider factors like the indoor environment's quality and the effective utilisation of available space. As a result, there are a variety of ways to improve energy efficiency. They frequently contain passive measures, such improved insulation, that automatically minimise the demand for energy use. Many serve a variety of purposes, such as increasing the utilisation of natural light, which both improves indoor conditions and lowers energy consumption.

Location and surroundings are important factors in controlling a building's temperature and lighting. For instance, hills, trees, and landscaping can offer shade and reduce wind. Buildings in the northern hemisphere with south-facing windows and those in the southern hemisphere with north-facing windows allow more sunlight (and subsequently heat energy) to enter the structure, reducing energy demand by optimising passive solar heating. Heat loss can be decreased by 25 to 50% with a tight building design that includes thermally insulated walls, basement slabs, and foundations, energy-efficient windows, and well-sealed doors.

When compared to the most reflecting white surfaces, dark roofs can get up to 39 °C (70 °F) hotter. Some of this excess heat is transmitted inside the structure via them. According to US studies, buildings with lighter-colored roofs require 40% less energy to cool than those with darker roofs. In more sunny climates, white roof systems save more energy. Modern electronic heating and cooling systems can reduce energy usage and increase occupant comfort.

The demand for artificial lighting can be decreased by strategically placing windows and skylights, as well as by utilising architectural features that reflect light into a building. One study found that using natural and task lighting more frequently can boost productivity in workplaces like schools and offices. In comparison to incandescent light bulbs, compact fluorescent lamps use two thirds less energy and can last six to ten times longer. In spite of their greater initial cost and payback times as short as a few months, newer fluorescent lights generate a natural light and are economical in most applications. Only 10% of the energy needed by incandescent lighting is used by LED lamps.

Low-cost passive infrared sensors can be used in energy-efficient building design to turn off lights in empty spaces like restrooms, hallways, or even office spaces after hours. In order to account for natural light and cut down on consumption, lux levels can also be monitored using daylight sensors connected to the building's lighting plan to turn on/off or lower the lights to pre-defined levels. Building management systems integrate all of this into a single, centralised computer to regulate the building's power and lighting needs.

It has been demonstrated that variable heat gains brought on by insulation and air conditioning efficiency can have load-shifting effects that are not uniform on the electricity load in a study that merges a home bottom-up simulation with an economic multi-sector model. The report also emphasised how improved household efficiency affects the power industry's decisions about the size of its power producing capacity.

Energy use and efficiency in buildings can be significantly impacted by the choice of space heating or cooling technologies. For instance, switching from an older, 50% efficient natural gas furnace to a new, 95% efficient furnace will significantly lower energy use, carbon emissions, and winter natural gas costs. Even more economical and energy-efficient ground source heat pumps are possible. In order to "pump" heat into a building against its natural flow from hot to cold, these systems employ pumps and compressors to transport refrigerant fluid around a thermodynamic cycle. The goal is to transfer heat from the local ground's huge thermal reservoir into the building. As a result, heat pumps typically consume four times less electrical energy than direct electrical heaters to produce the same quantity of heat. A ground source heat pump also has the ability to chill the air by moving heat from the building to the ground in the summer, which is a benefit. The drawback of ground source heat pumps is their large initial capital expenditure; however, because they use less energy, they often pay for themselves within five to ten years.

The commercial sector is gradually adopting smart metres to show employees and for internal monitoring needs the building's energy usage in a dynamic presentable format. In order to improve the energy efficiency of an existing building, power quality analysers can be used to measure utilisation, harmonic distortion, peaks, swells, and interruptions among other things. These metres frequently use wireless sensor networks for communication.

Green Construction a developing method, known as XML, which is a part of the Building Information Modeling efforts, is centred on the creation and maintenance of green buildings. Several energy simulation engines use it as input. But as current computer technology has advanced, there are now many building performance simulation software on the market. When deciding the simulation tool to utilise for a project, the user must take into account the tool's accuracy and dependability as well as the building data they will be using as input for the programme. The results of building performance simulations were evaluated using an artificial intelligence approach developed by Yezioro, Dong, and Leite. They discovered that more precise simulation tools have the best simulation performance in terms of heating and cooling electricity consumption within 3% of mean absolute error.

The US Green Building Council (USGBC) created the Leadership in Energy and Environmental Design (LEED) grading system to encourage environmental responsibility in building design. Based on a building's compliance with the following criteria: Sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, and innovation in design, they currently offer four levels of certification for existing buildings (LEED-EBOM) and new construction (LEED-NC). A tool to monitor building performance against LEED parameters and a potential route to recertification, the LEED Dynamic Plaque was created by USGBC in 2013. The following year, the council worked with Honeywell to automatically update the plaque, giving a view of performance that was almost real-time, by pulling information on energy and water use, as well as indoor air quality, from a BAS. One of the first structures to use the live-updating LEED Dynamic Plaque is the USGBC office in Washington, D.C.

When compared to typical energy retrofits, deep energy retrofits use a whole-building study and construction procedure to save a lot more energy. Both residential and non-residential (or "commercial") buildings can benefit from deep energy retrofits. A large increase in the building's value may emerge from a deep energy retrofit, which typically produces energy savings of 30% or more over the course of one or more years. A significant energy retrofitting project on the Empire State Building was finished in 2013. The project team, which included participants from Jones Lang LaSalle, Johnson Controls, Rocky Mountain Institute, Clinton Climate Initiative, and will have saved $4.4 million and 38 percent of yearly energy use. For instance, the 6,500 windows were converted on-site into super windows, which let light in but keep heat out. On hot days, air conditioning operational expenses were decreased, which immediately saved $17 million of the project's construction cost and helped pay for some additional upgrades. [39] The Empire State Building is the tallest LEED-certified structure in the United States after receiving a gold Leadership in Energy and Environmental Design (LEED) certification in September 2011. Recent deep energy retrofit work on the Indianapolis City-County Building resulted in a 46 percent yearly energy reduction and a $750,000 annual energy savings.

Deep energy retrofits, as well as other sorts, that are carried out in residential, commercial, or industrial facilities are typically backed by a variety of financial options or incentives. Pre-packaged rebates are one type of incentive; the purchaser or user may not even be aware that the item being used has been "bought down" or rebated. For effective lighting goods, "Upstream" or "Midstream" buy downs are typical. Through the use of formal applications, other rebates are more explicit and transparent to the end user. Governments occasionally provide tax incentives for energy efficiency initiatives in addition to rebates, which may be provided through government or utility programmes. Some organisations provide rebate and payment assistance and facilitation services, allowing energy end users to take advantage of incentive and rebate programmes.

Cost-effectiveness analysis, or CEA, can be used to assess the financial soundness of investments in buildings' energy efficiency. A CEA computation will yield the value of energy conserved, often known as negawatts, in dollars per kWh. In a calculation like this, the energy is virtual because it was never used but rather conserved as a result of an energy efficiency expenditure. Thus, CEA permits comparing the cost of negawatts with the cost of energy, such as grid power or the least expensive renewable energy source. The advantage of the CEA approach in energy systems is that it eliminates the need to estimate future energy costs for the calculation, eliminating the main source of uncertainty in the evaluation of investments in energy efficiency.

Industry

In order to fuel a wide variety of industrial and resource extraction activities, industries demand a lot of energy. Large amounts of heat and mechanical power are needed for many industrial operations, and the majority of these resources are provided by natural gas, petroleum fuels, and electricity. Additionally, some companies produce fuel from waste materials that can be used to generate extra energy.

It is impossible to fully define the plethora of potential prospects for energy efficiency in business due to the diversity of industrial processes. The particular technologies and procedures employed at each industrial facility are crucial to many. However, there are a few procedures and energy services that are frequently employed in a variety of businesses.

For later usage inside their facilities, various companies produce steam and electricity. The heat that is created as a by-product when electricity is made can be captured and used for heating, heating processes, and other industrial uses. Compared to conventional electricity generation, which only converts about 30% of the fuel into usable energy, combined heat and power (also known as co-generation) can produce up to 90% of the energy.

More energy-efficient boilers and furnaces may run at higher temperatures. These innovations are more productive and create fewer pollutants.

Steam is produced by burning more than 45 percent of the fuel used by US factories. According to the US Department of Energy, by insulating steam and condensate return lines, preventing steam leakage, and maintaining steam traps, the typical industrial facility can cut this energy usage by 20%.

A variable speed drive enables the motor's energy output to match the necessary load even though electric motors typically operate at a fixed speed. Depending on how the motor is operated, this results in energy savings of 3 to 60 percent. Energy losses can also be decreased by using superconducting motor coils. Voltage optimisation may also help motors.

In a great number of different applications, industry makes use of pumps and compressors of all sizes and shapes. Although there are many elements that affect a pump or compressor's efficiency, it is frequently possible to increase it by establishing improved process management and maintenance procedures. Sandblasting, painting, and other power tools all utilise compressed air, which is frequently supplied by compressors. The US Department of Energy states that putting variable speed drives in compressed air systems and performing preventative maintenance to find and rectify air leaks can increase energy efficiency by 20 to 50 percent.

Transportation.

An automobile's estimated energy efficiency is 280 Passenger-Mile/106 Btu. The energy efficiency of a vehicle can be improved in a number of ways. Vehicle fuel efficiency can be enhanced by using superior aerodynamics to reduce drag. Composite materials are frequently utilised in automotive bodies since lowering vehicle weight can also increase fuel efficiency.

Improved tyres that reduce tyre to road friction and rolling resistance can reduce fuel consumption. Keeping tyres inflated at the recommended pressure can increase fuel economy by up to 3.3%. On older vehicles, replacing a clogged air filter can reduce fuel usage by as much as 10%. A blocked air filter has little impact on mpg in modern (1980 and above) cars with fuel-injected, computer-controlled engines, however replacing it may increase acceleration by 6–11%. Efficiency of a vehicle is also aided by aerodynamics. The amount of gas required to move a car through air depends on its design. The efficiency of the energy used can be impacted by aerodynamics, which involves the air around the car.

By enabling a smaller displacement engine, turbochargers can improve fuel efficiency. The Fiat TwinAir engine with an MHI turbocharger has been named "Engine of the Year" for 2011." The new 85 HP turbo engine has a performance index that is 30% higher and 23 percent more powerful than a 1.2-liter 8v engine. In addition to having performance on par with a 1.4-liter 16-valve engine, the two-cylinder engine uses 30% less fuel "below."

The fuel economy of an energy-efficient car can be twice that of a typical car. Innovative designs, like the diesel Mercedes-Benz Bionic concept car, have surpassed conventional vehicles' average fuel efficiency by four times, reaching 84 miles per US gallon (2.8 L/100 km; 101 mpg).

The rise of electric vehicles is the key trend in automobile efficiency (all-electric or hybrid electric). Internal combustion engines are more than twice as efficient as electric ones. Regenerative braking is a technique used by hybrid vehicles, such as the Toyota Prius, to recover energy that would otherwise be lost when braking. This technique is particularly effective in city driving. Increased battery capacity on plug-in hybrids also allows for short-distance driving without using gasoline; in this situation, energy efficiency is determined by the method used to generate the power (such as burning coal, using hydroelectricity, or using a renewable energy source). Plug-in vehicles can normally travel around 40 miles (64 km) on electricity alone before needing to recharge; if the battery is depleted, a gas engine engages, extending the range. The Tesla Model S sedan is the only high-performance all-electric vehicle now available on the market. Lastly, all-electric vehicles are also gaining in popularity.

Street lighting

300 million lights are used by cities all over the world to illuminate millions of streets. By dimming lights during off-peak hours or upgrading to LED lamps, some communities are attempting to lower the amount of energy used by their street lights. The energy consumption of LED bulbs is known to be reduced by 50% to 80%.

Aircraft

Through changes to aircraft and air traffic control, there are numerous approaches to reduce the energy consumption of aviation. Aerodynamic, engine, and weight improvements help aircraft. Efficiency is influenced by things like seat density and cargo load. Air traffic management systems may automate airport operations, from straightforward activities like HVAC and lighting to more difficult ones like security and scanning. They can also automate takeoff, landing, and collision avoidance.

Alternative Fuel.

Any materials or substances that can be utilised as fuels other than conventional fuels are referred to as alternative fuels, sometimes known as non-conventional or advanced fuels. Biodiesel, bioalcohol (methanol, ethanol, and butanol), chemically stored energy (batteries and fuel cells), hydrogen, non-fossil methane, non-fossil natural gas, vegetable oil, and other biomass sources are a few of the more well-known alternative fuels. These fuels' production efficiency varies significantly.

Energy conservation

Energy conservation is more extensive than energy efficiency since it includes proactive attempts to reduce energy usage, such as through behaviour change. Examples of energy conservation without efficiency improvements include turning on energy-saving computer settings, using cars less, air-drying your clothing rather than using the dryer, and reducing indoor heating in the winter. The distinction between energy conservation and efficient energy usage, like other definitions, can be ambiguous, yet both are significant from an economic and environmental standpoint. This is especially the case when measures are geared at the saving of fossil resources. Energy conservation is a task that calls for coordinated action from policy initiatives, technology advancement, and behaviour change. To address this issue, a large number of energy intermediary organisations, such as governmental or non-governmental organisations on a local, regional, or national level, are working on frequently publically financed programmes or initiatives. The subject of energy conservation has also caught the attention of psychologists, who have offered recommendations for implementing behaviour change to lower energy usage while taking technological and governmental factors into account.

A comprehensive collection of energy-saving apps is kept up to date by the National Renewable Energy Laboratory (NREL). Commercial property managers that plan and manage energy efficiency projects often utilise a software platform to undertake energy audits and to interact with contractors to understand their full range of possibilities. EnergyActio software, a cloud-based platform created for this, is described in the Department of Energy (DOE) Software Directory.

Rebound Effect

Enhancing energy efficiency will cut energy consumption and carbon emissions if the demand for energy services stays constant. The amount of energy consumption reduction that simple engineering models would have anticipated is not always achieved by efficiency improvements. This is so that more people can afford to utilise the energy services, which boosts consumption. For instance, consumers may decide to drive further because fuel-efficient automobiles make travel more affordable, nullifying some of the potential energy savings.

Similarly, a thorough historical examination of technology efficiency advancements has decisively demonstrated that economic expansion almost always outperformed energy efficiency advancements, leading to a nett increase in resource use and related pollution. Examples of the direct rebound effect include these.

The rebound effect's size has been estimated to be between 5 and 40 percent. At the household level, the rebound impact is probably less than 30% and may even be closer to 10% for transportation. If there is a 30% rebound effect, then energy efficiency measures should reduce energy usage by 70% of what engineering models predict. Lighting has been responsible for around 0.7 percent of GDP over various nations and hundreds of years, according to a 2010 study by Saunders et al., suggesting a 100% rebound impact. In contrast, several of the authors contend in a subsequent publication that improved illumination generally boosts economic welfare and has significant advantages. According to a 2014 study, the rebound effect for domestic lighting, especially for high-use bulbs, is rather low.

SUSTAINABLE ENERGY

The two primary components of a sustainable energy policy are thought to be energy efficiency and renewable energy. To stabilise and lower carbon dioxide emissions, both plans must be created simultaneously. In order for rising sustainable energy supply to significantly reduce the usage of fossil fuels, it is imperative that energy demand growth be slowed. Renewable energy production will chase a vanishing objective if energy usage increases too quickly. Similarly, reducing demand growth will only start to lower total carbon emissions unless clean energy resources come online quickly; a decrease in the carbon content of energy sources is also required. Thus, significant investments in efficiency and renewable are necessary for a sustainable energy economy.

Europe.

2020 and 2030 energy efficiency goals.

In 1998, the first energy efficiency goal for the entire EU was set. Over a twelve-year period, member states promised to increase energy efficiency by 1% year. A broad foundation for energy efficiency has also benefited from regulations pertaining to goods, industries, transportation, and structures. More work is needed to solve heating and cooling since more heat is lost during the manufacturing of electricity in Europe than is necessary to heat all of the continent's buildings. Overall, it is predicted that EU energy efficiency measures will save up to 326 million tonnes of oil annually by 2020.

By 2020, the EU established a goal to save 20% more energy than it did in 1990, but member states are free to choose their own strategies for doing so. A new energy efficiency target of 27% or higher by 2030 was adopted by EU member states during a summit in October 2014. The "Suppliers Obligations & White Certificates" are one tool utilised to reach the aim of 27 percent. Energy efficiency is a topic of discussion around the 2016 Clean Energy Package; however, the objective will likely remain a 30 percent increase above 1990 levels. Some claim that this won't be sufficient for the EU to achieve its goals under the Paris Agreement, which call for a 40% reduction in glasshouse gas emissions from 1990 levels.

Important organisations and programs:

- Building energy rating
- Eco-Design of Energy-Using Products Directive
- Energy efficiency in Europe (study)
- Orgalime, the European engineering industries association

Germany.

Aside from the financial crisis of 2007–2008, recent progress towards increased efficiency has been consistent. However, some feel that energy efficiency's role to Germany's energy revolution is still underappreciated (or Energiewende).

With an increase of 1.7% between 2005 and 2014, attempts to lower final energy consumption in the transportation sector have proven unsuccessful. Both road passenger and road freight transportation are to blame for this expansion. To record the highest numbers ever for Germany, both sectors increased the total distance traversed. Rebound effects were a major factor in the relationships between increased vehicle efficiency and both the distance travelled and the increase in vehicle weight and engine power.

The German federal government unveiled its National Action Plan on Energy Efficiency on December 3, 2014. (NAPE). Building energy efficiency, corporate energy conservation, consumer energy efficiency, and transportation energy efficiency are the topics covered. Both immediate and long-term actions are included in the policy. The introduction of competitive tendering for energy efficiency, raising funds for building renovation, the introduction of tax incentives for efficiency measures in the building sector, and the creation of energy efficiency networks in collaboration with business and industry are some of the key short-term measures of NAPE. A sizable contribution is anticipated from German industry.

The German government published a green paper on energy efficiency for public comment on August 12, 2016. (in German). It describes the likely obstacles and steps that will be necessary to cut Germany's energy use in the ensuing decades. Sigmar Gabriel, the minister of economy and energy, remarked during the document's unveiling that "we do not need to create, store, transfer, and pay for the energy that we conserve." The green paper lists options for sector coupling, such as employing renewable energy for heating and transportation, and prioritises the efficient use of energy as the "primary" answer. Other ideas include a flexible energy tax that increases as gas prices drop, encouraging fuel efficiency despite low oil prices.

Poland

In May 2016 Poland adopted a new Act on Energy Efficiency, to enter into force on 1 October 2016.

Australia

Through the Department of Industry and Science, the Australian federal government is actively driving the nation's efforts to improve energy efficiency. A National Strategy on Energy Efficiency was approved by the Council of Australian Governments, which speaks for all of Australia's states and territories, in July 2009. (NSEE).

The goal of this ten-year plan is to hasten the adoption of energy-efficient techniques nationwide and to get the nation ready for a low-carbon future. The NSEE addresses a number of different energy-related topics. However, the chapter on the energy efficiency strategy to be followed nationally emphasises four points in order to reach the targets for energy efficiency:

- To assist businesses and homes in making the switch to a low-carbon future
- To facilitate the use of efficient energy
- To improve the energy efficiency of building
- want nations to collaborate and set the standard for energy efficiency
- The National Partnership Agreement on Energy Efficiency is the overriding agreement that controls this plan.

This document addresses the need for funding the strategy in order for it to advance, as well as the roles played by the commonwealth and the various states and territories in the NSEE. It also explains these roles and provides for the development of benchmarks and measurement tools that will transparently show the nation's progress in relation to the stated goals.

Departments and events:

- Department of Climate Change and Energy Efficiency
- Department of the Environment, Water, Heritage and the Arts
- Sustainable House Day

Canada

As a major component of the Pan-Canadian Framework on Clean Growth and Climate Change, Canada's national climate strategy, the Canadian government unveiled Build Smart - Canada's Buildings Strategy in August 2017.

The five objectives set forth in the Build Smart strategy strive to significantly improve the energy-efficiency performance of both new and existing Canadian buildings.

Beginning in 2020, the federal, provincial, and territory governments will collaborate to create and adopt model building regulations that are progressively more stringent, with the aim of having all provinces and territories adopt a "net-zero energy ready" model building code by 2030.

By 2022, the federal, provincial, and territory governments will collaborate to create a model code for pre-existing structures, with the intention of having the provinces and territories adopt it.

The goal is for the labelling of building energy use to be mandated by the federal, provincial, and territorial governments as early as 2019.

In order to achieve the highest level of efficiency that is both technically and economically feasible, the federal government will set new requirements for heating equipment and other important technologies.

The provincial and territorial governments will encourage energy efficiency enhancements, speed up the adoption of high-efficiency equipment, and adapt their programmes to local conditions in order to sustain and expand efforts to retrofit existing buildings.

The strategy outlines a variety of initiatives the Canadian government will take and financial commitments it will make to help it achieve its objectives. The BC Energy Step Code, a policy that supports the federal government's objectives to achieve nett zero energy readiness, has only been developed by one of Canada's ten provinces and three territories, British Columbia, as of early 2018. If they so choose, local British Columbian governments may employ the BC Energy Step Code to encourage or mandate an increased level of energy efficiency in new construction over and above what is required by the base building code. The rule and standard serve as a technical road map to assist the province in achieving its goal that by 2032, all new structures will operate at a level that is nett zero energy ready.

United States

The second-largest energy consumer worldwide is the United States. The U.S. Department of Energy divides the nation's energy use into four main categories: transportation, housing, commerce, and industry. The future fuel and electricity demand over the next few decades will be influenced by energy efficiency prospects, according to 2011 Energy Modeling Forum research covering the United States. The US economy is already on track to use less energy and produce less carbon, but clear regulations will be required to achieve the climate targets. These regulations include a carbon tax, requirements for energy-efficient furniture, structures, and automobiles, as well as rebates or lower upfront prices for new, more expensive, energy-efficient technology.

Programs and organisations:

- Alliance to Save Energy
- American Council for an Energy-Efficient Economy
- Building Codes Assistance Project
- Building Energy Codes Program

- Consortium for Energy Efficiency
- Energy Star, from United States Environmental Protection Agency
- Industrial Assessment Centre
- National Electrical Manufacturers Association
- Rocky Mountain Institute

Sources Of Energy

There is a variety of sources that provide us energy for different purposes. You must be familiar with coal, petrol, diesel kerosene and natural gas. Similarly, you must have also heard about hydroelectric power, wind mills, solar panels, biomass etc.

Fossil Fuels – Conventional Source of Energy

A fossil fuel is a fuel formed by natural processes, such as anaerobic decomposition of buried dead organisms, containing energy originating in ancient photosynthesis. Millions of years ago the remains of dead plants and animals were buried under the ground. Over the years by the action of heat from the Earth"s core and pressure from rock and soil, these buried and decomposed organic materials have been converted into fossil fuels.. Fossil fuels contain high percentages of carbon and include petroleum, coal, and natural gas. Coal, crude oil and natural gas are common examples of fossil fuels. They are used to run the vehicles, cooking, lighting, washing, to generate electricity, for making plastics and paints etc.

Energy from the Atom – Nuclear Energy

Nuclear power is the use of nuclear reactions that release nuclear energy to generate heat, which most frequently is then used in steam turbines to produce electricity in a nuclear power plant. Nuclear power can be obtained from nuclear fission, nuclear decay and nuclear fusion. The atoms of a few elements such as radium and uranium act as natural source of energy. In fact, atoms of these elements spontaneously undergo changes in which the nucleus of the atom disintegrates. The energy stored in the nuclei of atoms can be released by breaking a heavy nucleus such as uranium into two lighter nuclei. The splitting of the nucleus of an atom into fragments that are roughly equal in mass with the release of energy is called nuclear fission.

When a free neutron strikes a Uranium (235) nucleus at a correct speed, it gets absorbed. A Uranium (235) nucleus on absorbing a neutron becomes highly unstable and splits into nuclear of smaller atoms releasing huge amount of energy in the process. During this process, a few neutrons are also released.

These neutrons split other nuclei of the Uranium (235). The reaction continues rapidly and is known as the chain reaction. In this process a large amount of energy is released. This energy is used for boiling water till it becomes steam. Steam so generated is used to drive a turbine which helps in generating electrical energy.

The Ultimate Source of Energy

Solar energy is energy derived from sun in the form of solar radiation. It is hardness by either direct sources (like solar cooker, solar steam systems, solar dryer, solar cells, etc.), or indirect sources (biomass production, wind, tidal, etc.). The output of the sun is 2.8 x 1023 Kwy-

The energy reaching the earth is 1.5x 108 Kwy-1. It is used for drying, cooking, heating, generating power etc.

Wind Energy

Wind power is another alternative energy source that could be used without producing by-products that are harmful to nature. Like solar power, harnessing the wind is highly dependent on weather and location. However, it is one of the oldest and cleanest forms of energy and the most developed of the renewable energy sources. There is the potential for a large amount of energy to be produced from windmill.

Biomass Energy

Organic material made from plants and animals (microorganisms). Biomass has an existing capacity of over 7,000 MW. Biomass as a fuel consists of organic matter such as industrial waste, agricultural waste, wood, and bark. Biomass can also be used indirectly, since it produces methane gas as it decays or through a modern process called gasification. Methane can produce power by burning in a boiler to create steam to drive steam turbines or through internal combustion in gas turbines and reciprocating engines.

Geothermal Energy

Geothermal energy is energy derived by tapping the heat of the earth itself like volcano, geysers, hot springs (etc.). These volcanic features are called geothermal hotspots. Basically, a hotspot is an area of reduced thickness in the mantle which expects excess internal heat from the interior of the earth to the outer crust. The heat from these geothermal hotspots is altered in the form of steam which is used to run a steam turbine that can generate electricity.

Ocean Tidal and Wave energy

Tidal power or tidal energy is a form of hydropower that converts the energy obtained from tides into useful forms of power, mainly electricity.

Wave energy, also known as ocean energy is defined as energy harnessed from oceanic waves. As the wind blows across the surface of the ocean, it creates waves and thus they can also be referred to as energy moving across the surface of the water

- Tides are defined as the rise and fall of sea level caused by the gravitational pull of the moon and the sun on the Earth. They are not only limited to the oceans, but can also occur in other systems whenever a gravitational field exists.
- Ocean thermal energy (OTE)is the temperature differences (thermal gradients) between ocean surface waters and that of ocean depths.

Energy from the sun heats the surface water of the ocean. In tropical regions, surface water can be much warmer than deep water. This temperature difference can be used to produce electricity and to desalinate ocean water

CLASSIFICATION OF ENERGY SOURCES

Based on usability

- Primary resources: -Primary sources can be used directly, as they appear in the natural environment: coal, oil, natural gas and wood, nuclear fuels (uranium), the sun, the wind, tides, mountain lakes, the rivers (from which hydroelectric energy can be obtained) and the Earth heat that supplies geothermal energy.
- Secondary resources: - They are derived from the transformation of primary energy sources: for example, petrol that derives from the treatment of crude oil and electric energy obtained from the conversion of mechanical energy (hydroelectric plants, Aeolian plants), chemical plants (thermoelectric), or nuclear (nuclear plants). Electric energy is produced by electric plants, i.e, suitable installations that can transform primary energy (non- transformed) into electric energy.

Based on transaction

i) Commercial Energy: -The energy sources that are available in the market for a definite price are known as commercial energy. By far the most important forms of commercial energy are electricity, coal and refined petroleum products.

ii) Non-Commercial Energy: -The energy sources that are not available in the commercial market for a price are classified as non-commercial energy. Non-commercial energy sources include fuels such as firewood, cattle dung and agricultural wastes, which are traditionally gathered, and not bought at a price and used especially in rural households. These are also called traditional fuels. Non-commercial energy is often ignored in energy accounting.

Based on energy storage or cycling time involved

a. Renewable energy (inexhaustible) is mostly biomass based and are available in unlimited amount in nature. Since these can be renewed over a relatively short period of time, energy sources that are replenished more rapidly are termed as renewable. These include firewood or fuel wood from forest, Petro plants, plant biomass i.e., agricultural waste like animal dung, solar energy, wing energy, water energy in the form of hydro- electricity and tidal energy and geothermal energy etc.
b. Non-renewable energy (exhaustible) is available in limited amount and develop over a longer period of time. As a result of unlimited use, they are likely to be exhausted one day. These include coal, mineral, natural gas and nuclear power. Coal, petroleum and natural gases are common sources of energy being organic (biotic) in this origin. They are also called fossil fuels.

Based on traditional use

a. Conventional energy sources: - The sources of energy which have been in use for a long time, e.g., coal, petroleum, natural gas and water power. They are exhaust able except water and cause pollution when used, as they emit smoke and ash.
b. Non-conventional energy sources: - The resources which are yet in the process of development over the past few years. It includes solar, wind, tidal, biogas, and biomass, geothermal. They are inexhaustible, pollution free, easy to maintain and less expensive due to local use.

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Renewable Energy Sources

Since they often improve energy security and generate significantly fewer glasshouse emissions than fossil fuels, renewable energy sources are crucial to the development of sustainable energy. When places with high ecological value are used for wind or solar farms or bioenergy production, these projects can occasionally generate serious sustainability issues, such as threats to biodiversity.

While solar and wind energy are expanding quickly, hydropower is the main source of renewable electricity. In most nations, the least expensive new power generation capacity options are photovoltaic solar and onshore wind. Decentralized renewable energy sources like solar-powered mini-grids are probably the least expensive way to provide electricity by 2030 for more than half of the 770 million people who do not now have access to it. The share of renewable energy in the global energy supply is one of the United Nations' goals for the year 2030.

Energy that is derived from resources that can be regenerated naturally over time and are therefore considered to be renewable. It comes from a variety of sources, including the sun, wind, rain, tides, waves, and geothermal heat. Despite the fact that the majority of renewable energy sources are sustainable, some are not. For instance, certain biomass sources are deemed unsustainable at the rate at which they are being used. Renewable energy is frequently used to power stand-alone power systems, air and water heating and cooling systems, and electricity generation for a grid. Around 20% of the energy used by people worldwide, including roughly 30% of electricity, comes from renewable sources. Traditional biomass accounts for about 7% of energy usage, but this is decreasing. Modern renewable sources of heat, such solar water heating, account for over 4% and over 6% of total energy use, respectively.

Over 10 million people are employed by sectors related to renewable energy globally, with solar photovoltaics being the largest. With a big portion of the world's newly installed power capacity being renewable, renewable energy systems are quickly becoming more efficient and affordable, and their percentage of overall energy consumption is growing. The least expensive electricity for new construction is typically generated by onshore wind or photovoltaic solar.

With some producing more than half of their electricity from renewable sources, many countries already rely on renewable energy for more than 20% of their energy needs. In the 2020s and beyond, it is anticipated that national renewable energy markets will continue to expand rapidly. A few nations use renewable energy exclusively to produce all of their electricity. In contrast to fossil fuels, which are concentrated in a small number of countries, renewable energy resources are spread throughout a large geographic region. Energy security, climate change mitigation, and economic benefits are all significantly increased with the deployment of renewable energy and energy-efficient technologies. However, hundreds of billions of dollars in fossil fuel subsidies are impeding the development of renewable energy. Strong popular support has been found for renewable energy sources like solar and wind power in international opinion polls. However, the International Energy Agency stated in 2021 that more effort is required to expand renewables if we are to achieve nett zero carbon emissions, and it advocated for generation to increase by around 12% a year to 2030.

Large-scale renewable energy technology projects are typical, but they are also suitable for rural, isolated, and developing nations, where energy is frequently essential for human growth. Since the majority of renewable energy technologies produce electricity, electrification is frequently implemented with renewable energy since it has various advantages, including the ability to transmit heat or items effectively and being clean at the point of consumption. Additionally, electrification using renewable energy is more effective and thus results in large reductions in the need for primary energy. Nearly half of the increase in renewable electricity in 2021 came from China. Norway, recognised for producing hydroelectricity, used 45 percent of its entire energy supply from hydro sources in 2021.

Drivers and benefits

In contrast to fossil fuels, which are used up faster than they can be replaced, renewable energy is always being produced. In contrast to other energy sources, which are mostly found in a small number of nations, renewable energy resources and major prospects for energy efficiency are spread across a large geographic region. Significant improvements in energy security and economic gains could be achieved by the quick adoption of renewable energy sources, energy efficiency measures, and technical energy source diversification. The cost of the technologies that support many of these renewable energy sources, such solar and wind power, has decreased economically. In certain circumstances, switching to these sources will be less expensive than continuing to use the current, inefficient fossil fuels. Additionally, it would enhance public health, lower the number of premature deaths brought on by pollution, and cut associated health expenditures, which may save trillions of dollars annually. Environmental pollution includes air pollution brought on by the burning of fossil fuels. Quantified health benefits can greatly offset the costs of implementing decarbonization techniques, according to numerous assessments of these initiatives. After almost another billion years, the predicted increase in solar heat is expected to make the Earth's surface too hot for liquid water to exist. At that point, renewable energy sources that derive their energy from the sun, either directly or indirectly, such as hydro and wind, are expected to be able to supply humanity with energy.

Concerns about climate change, along with the ongoing decline in the price of some renewable energy machinery, like wind turbines and solar panels, are driving greater the usage of renewables. The industry fared better than many other industries in the global financial crisis thanks to new government expenditures, regulations, and policies. The International Renewable Energy Agency estimates that by 2019, renewables' overall share of the energy mix (including power, heat, and transportation) must increase six times faster in order to keep the rise in average global temperatures during the current century "well below" 2.0 °C (3.6 °F) compared to pre-industrial levels.

Scale

A few million houses were using modest solar PV systems as of 2011, and many more were being served by micro-hydro systems set up as mini-grids. Update required More than 166 million families rely on a new generation of more effective biomass cookstoves, and over 44 million homes use biogas produced in household-scale digesters for lighting and/or cooking. Ban Ki-moon, the eighth Secretary-General of the United Nations, has stated that developing countries can achieve new heights of prosperity through the use of renewable energy. At least 30 countries in the globe already have more than 20% of their energy supply coming from renewable sources. Even while many nations have different policy goals for longer-term proportions of renewable energy, these tend to be limited to the power sector, with the European Union setting a target of 40% of total electricity generated by 2030.

Uses

In four areas electricity production, hot water/space heating, transportation, and rural (off-grid) energy services—renewable energy frequently replaces traditional fuels.

Power generation

More than a quarter of electricity is generated from renewables as of 2021.

Heating and cooling

In several nations, most notably China, which currently accounts for 70% of the global total, solar water heating is a significant contributor to renewable energy (180 GWth). The majority of these systems are found on multi-family apartment buildings, and they provide about 50–60 million Chinese homes with their hot water needs. Over 70 million households throughout the world have access to solar water heating systems that partially suit their demands. Additionally expanding is the use of biomass for heating. Biomass energy is now used more widely than oil in Sweden. Heat pumps are becoming more and more important since they supply both heating and cooling while also flattening the energy demand curve. Additionally expanding quickly is renewable thermal energy. Renewable sources account for about 10% of the energy used for heating and cooling.

Transportation

Increased use of electric vehicles is one strategy to reduce transportation's carbon footprint (EVs). Less than 4% of transportation energy comes from renewable sources, despite this and the usage of biofuels like biojet. Heavy transport occasionally makes use of hydrogen fuel cells.

SOLAR ENERGY.

The Sun, a clean, abundant energy source in many areas, is the planet's main energy source. The Earth receives around 170,000 terawatts of solar energy continuously, which is roughly 10,000 times what is needed to power the world. Every day, the sun radiates an enormous amount of energy. This energy comes from within the sun itself. Like most stars, the sun is a big gas ball made mostly of hydrogen and helium. The sun produces energy in a process called nuclear fusion. The high pressure and temperature in the sun “score cause hydrogen atoms to split apart. Four hydrogen nuclei combine or fuse, to form one helium atom, producing radiant energy in the process.

The sun radiates more energy in one second than the world has used since time began. Only a small portion of this energy strikes the earth, one part in two billion. Yet this amount of energy is enough to meet the world's needs, if it could be harnessed. About 15 percent of the radiant energy that reaches the earth is reflected back into space. Another 30 percent is used to evaporate water, which is lifted into the atmosphere and produces rainfall. The radiant energy is also absorbed by plants, landmasses and the oceans.

Around 3% of the world's electricity was generated by solar energy in 2019, primarily through photovoltaic solar panels (PV). The panels are either put in utility-scale solar parks or mounted on top of buildings. Solar photovoltaic cell prices have significantly decreased, resulting in a significant increase in global capacity. The price of power from new solar farms is comparable to, or in many locations less expensive than, the price of electricity from coal plants. Solar photovoltaic energy is one of the primary sources of energy generation in a sustainable mix, according to various forecasts of future energy use.

The majority of solar panel components can be easily recycled, however in the absence of regulation, this is not usually done. Panels generally include heavy metals, thus dumping them in landfills could endanger the environment. A solar panel can produce as much electricity as was required to make it in less than two years. Recycling resources instead of mining them requires less energy.

In concentrated solar power, a field of mirrors concentrates sunlight, which then heats a fluid. A heat engine uses the resulting steam to generate electricity. Since some of the heat from concentrated solar energy is normally retained so that electricity may be produced when needed, concentrated solar energy can facilitate dispatchable power generation. Solar thermal heating systems are employed for the production of hot water, building heating, drying, and desalination, in addition to the production of electricity.

Solar power is the process of turning sunlight's renewable energy directly into electricity through photovoltaics (PV), indirectly through concentrated solar power, or a mix of both. The photovoltaic effect is used by photovoltaic cells to convert light into an electric current. A vast region of sunlight is focused to a hot spot using concentrated solar power systems, which are frequently used to power a steam turbine.

From the calculator powered by a single solar cell to rural dwellings powered by an off-grid rooftop PV system, photovoltaics was initially only employed as a source of electricity for small and medium-sized applications. In the 1980s, the first commercial concentrated solar power facilities were created. Grid-connected solar PV systems have increased more or less exponentially since that time as the cost of solar electricity has decreased. Gigawatt-scale solar power plants and millions of installations have both been and are being constructed. By 2020, solar PV will offer the cheapest source of electricity ever, having quickly established itself as a practical low-carbon technology.

In 2021, solar energy will produce 4% of the world's electricity, up from 1% in 2015, the year the Paris Climate Agreement was signed. Utility-scale solar has the lowest levelized cost of electricity, along with onshore wind. According to the International Energy Agency's "Net Zero by 2050" scenario, solar energy would account for nearly 20% of global energy consumption and be the main source of electricity by 2021.

Solar energy is the radiant heat and light from the Sun that is captured by a variety of technologies, including solar architecture, solar thermal energy (including solar water heating), and solar power to produce electricity.

It is a crucial source of renewable energy, and depending on how solar energy is captured, distributed, or transformed into solar power, its technologies are often classified as passive solar or active solar. Utilizing photovoltaic systems, concentrated solar electricity, and solar water heating are examples of active solar approaches. A building's orientation towards the Sun, the use of materials with favourable thermal mass or light-dispersing qualities, and the creation of naturally ventilated rooms are all examples of passive solar approaches.

Solar energy is a very alluring source of electricity because of how much of it there is. Since 2021, solar energy has been less expensive than fossil fuels.

The International Energy Agency stated in 2011 that "Long-term gains will be enormous from the development of clean, cost-effective solar energy technology. By relying on a domestic, limitless, and largely import-independent resource, it will boost sustainability, cut pollution, and lessen the expenses associated with combating global warming. These benefits apply everywhere ".

At the upper atmosphere, the Earth's surface gets 174 petawatts (PW) of solar energy. The remainder is absorbed by clouds, oceans, and land masses, while around 30% is reflected back to space. At the Earth's surface, the solar light spectrum is primarily distributed in the visible and near-infrared regions, with a minor portion in the near-ultraviolet. The majority of people on earth reside in regions with annual insolation rates of between 3.5 and 7.0 kWh/m2/150 to 300 watts/m2.

The Earth's land surface, seas, which make up around 71 percent of the planet, and atmosphere all absorb solar radiation. Convection, or atmospheric circulation, is brought on by warm air rising with ocean water that has evaporated. Water vapour condenses into clouds at high altitudes where it is colder, completing the water cycle by causing rain to fall on the Earth's surface. Convection is accelerated by the latent heat of water condensation, which results in atmospheric phenomena including wind, cyclones, and anticyclones. The surface is kept at an average temperature of 14 °C via sunlight absorption by the oceans and land masses. Green plants use photosynthesis to transform solar energy into chemically stored energy that is used to make food, wood, and the biomass that is used to create fossil fuels.

About 3,850,000 exajoules (EJ) of solar energy are annually absorbed by the Earth's atmosphere, oceans, and land masses. This utilised more energy in a single hour in 2002 than the entire planet did in a whole year. About 3,000 EJ of biomass are captured annually through photosynthesis.

Because of constraints imposed by geography, time fluctuation, cloud cover, and the land that is accessible to humans, the quantity of solar energy that humans may potentially consume is different than the amount of solar energy that is present close to the planet's surface. According to the Carbon Tracker Initiative, in 2021, 450,000 km2 of land—or about the same size as Sweden, Morocco, or California (0.3 percent of the planet's total surface area)—would be required to provide all of our energy from solar sources alone.

Geographical factors have an impact on solar energy potential since places closer to the equator receive more sun radiation. However, in locations further from the equator, the adoption of photovoltaics that can track the Sun's position can significantly boost the solar energy potential. Because there is less solar radiation on the Earth's surface at night for solar panels to capture, time fluctuation affects the potential of solar energy. As a result, solar panels are only able to absorb so much energy per day. Because clouds obscure the Sun's incoming light and lower the amount of light available to solar cells, cloud cover can affect the potential of solar panels.

Furthermore, as solar panels may only be installed on ground that is otherwise unoccupied and ideal for solar panels, the availability of land has a significant impact on the amount of solar energy that is available. Solar panels can be installed on roofs since many individuals have found that they can use this method to harvest energy directly from their homes. Lands that are not currently used for enterprises and where solar plants can be built are other regions that are excellent for solar cells.

The ability to catch, process, and distribute sunlight allows solar energy to be harnessed at various levels around the world, primarily based on distance from the equator. Solar technologies are classified as passive or active depending on how they do this. All renewable energies, with the exception of geothermal and tidal power, obtain their energy either directly or indirectly from the Sun, even though solar energy primarily refers to the use of solar radiation for practical purposes.

In order to transform sunshine into useful outputs, active solar approaches use photovoltaics, concentrated solar power, solar thermal collectors, pumps, and fans. Techniques for passive solar design include choosing materials with advantageous thermal characteristics, planning areas with natural air circulation, and taking into account a building's orientation with respect to the Sun. Passive solar technologies lessen the need for alternative resources and are typically regarded as demand-side technologies, whereas active solar technologies enhance the energy supply and are classified as supply side technologies.

Taking into account elements like insolation, cloud cover, and the amount of land that can be used by people, the United Nations Development Programme, UN Department of Economic and Social Affairs, and World Energy Council published an estimate of the annual amount of solar energy that humans could use in 2000. According to the calculation, the potential for solar energy on a worldwide scale range from 1,600 to 49,800 exajoules (4.4 1014 to 1.4 1016 kWh) annually.

Solar Water Heating.

Solar energy is energy derived from sun in the form of solar radiation. It is hardness by either direct sources (like solar cooker, solar steam systems, solar dryer, solar cells, etc.), or indirect sources (biomass production, wind, tidal, etc.). The output of the sun is 2.8 x 1023 Kwy1. The energy reaching the earth is 1.5x 108 Kwy-1. It is used for drying, cooking, heating, generating power etc.

Water is heated using a solar thermal collector and sunlight in a process known as solar water heating (SWH). For solutions in various climates and latitudes, a range of designs are offered at differing costs. For household and some industrial applications, SWHs are frequently employed.

A working fluid that enters a storage system for later use is heated by a sun-facing collector. SWH are both passive and active (pumped) (convection-driven). They either use water alone, water and a working fluid, or both. They are heated either directly or with the use of light-focusing mirrors. They can run on their own or in combination with electric or gas heaters. Mirrors may focus sunlight into a smaller collector in large-scale setups.

China, the United States, and Turkey dominate the market for solar hot water (SHW), which has a thermal capacity of 472 GW as of 2017. By capacity per person, Barbados, Austria, Cyprus, Israel, and Greece are the top five countries.

Methods of solar energy

Solar energy collectors

Solar energy collectors are special kind of heat exchangers that transform solar radiation energy to internal energy of the transport medium. The major component of any solar system is the solar collector. This is a device which absorbs the incoming solar radiation, converts it into heat, and transfers this heat to a fluid (usually air, water, or oil) flowing through the collector. The solar energy thus collected is carried from the circulating fluid either directly to the hot water or space conditioning equipment or to a thermal energy storage tank from which can be drawn for use at night and/or cloudy days. There are basically two types of solar collectors: no concentrating or stationary and concentrating. A nonconcentrating collector has the same area for intercepting and for absorbing solar radiation, whereas a sun-tracking concentrating solar collector usually has concave reflecting surfaces to intercept and focus the sun's beam radiation to a smaller receiving area, thereby increasing the radiation flux.

Centrating collectors (Focussing plate collectors)

For applications such as air conditioning, central power generation, and numerous industrial heat requirements, flat plate collectors generally cannot provide carrier fluids at temperatures sufficiently elevated to be effective. They may be used as first-stage heat input devices; the temperature of the carrier fluid is then boosted by other conventional heating means. Alternatively, more complex and expensive concentrating collectors can be used. These are devices that optically reflect and focus incident solar energy onto a small receiving area. As a result of this concentration, the intensity of the solar energy is magnified, and the temperatures that can be achieved at the receiver (called the "target") can approach several hundred or even several thousand degrees Celsius. The concentrators must move to track the sun if they are to perform effectively.

Concentrating, or focusing, collectors intercept direct radiation over a large area and focus it onto a small absorber area. These collectors can provide high temperatures more efficiently than flat-plate collectors, since the absorption surface area is much smaller. However, diffused sky radiation cannot be focused onto the absorber. Most concentrating collectors require mechanical equipment that constantly orients the collectors toward the sun and keeps the absorber at the point of focus. Therefore; there are many types of concentrating collectors.

Types of concentrating collectors

There are four basic types of concentrating collectors:

- Parabolic trough system
- Parabolic dish
- Power tower
- Stationary concentrating collectors

Parabolic trough system

Parabolic troughs are devices that are shaped like the letter “u”. The troughs concentrate sunlight onto a receiver tube that is positioned along the focal line of the trough. Sometimes a transparent glass tube envelops the receiver tube to reduce heat loss. These solar collectors use mirrored parabolic troughs to focus the sun's energy to a fluid- carrying receiver tube located at the focal point of a parabolically curved trough reflector. The energy from the sun sent to the tube heats oil flowing through the tube, and the heat energy is then used to generate electricity in a conventional steam generator. The temperature attained by the collector is 100-3000C. Many troughs placed in parallel rows are called a "collector field." The troughs in the field are all aligned along a north south axis so they can track the sun from east to west during the day, ensuring that the sun is continuously focused on the receiver pipes. Individual trough systems currently can generate about 80 MW of electricity

Parabolic dish systems

A parabolic dish collector is similar in appearance to a large satellite dish, but has mirror- like reflectors and an absorber at the focal point. It uses a dual axis sun tracker. The radiation received on the collector is reflected towards the concentrator. The concentrator, which is coated with absorber coating, is heated up with concentrated radiation. The temperature attained with this type of collector is more than 3000C.

Power tower system

A heliostat uses a field of dual axis sun trackers that direct solar energy to a large absorber located on a tower. To date the only application for the heliostat collector is power generation in a system called the power tower

Power tower system

A power tower has a field of large mirrors that follow the sun's path across the sky. The mirrors concentrate sunlight onto a receiver on top of a high tower. A computer keeps the mirrors aligned so the reflected rays of the sun are always aimed at the receiver, where temperatures well above 1000°C can bereached.High-pressure steam is generated to produce electricity.

Origins.

Prior to 1900, a black-painted tank put on a roof was the first solar collector documented in the United States. The first "batch water heater," as they are now known, was made in 1896 by Clarence Kemp of Baltimore, who encased a tank in a wooden box. In Maadi, Egypt, Frank Shuman constructed the first solar thermal power plant in the world. It used parabolic troughs to power a 45–52-kilowatt (60–70 horsepower) engine that pumped 23,000 litres (6,000 US gal) of water per minute from the Nile River to nearby cotton fields.

In the 1920s, Florida and Southern California used flat-plate collectors for solar water heating. After 1960, but especially after the 1973 oil crisis, interest in North America increased.

Australia, Canada, China, Germany, India, Israel, Japan, Portugal, Romania, Spain, United Kingdom, and the United States all use solar energy.

Mediterranean

The countries with the highest per capita use of solar water heating systems, which power 30% to 40% of houses, include Israel, Cyprus, and Greece.

In Israel, flat plate solar systems were developed and put to widespread use. Due to a fuel scarcity in the 1950s, the government outlawed heating water from 10 p.m. to 6 a.m. The NerYah Company, Israel's first commercial solar water heating company, was founded by Levi Yissar in 1953 after he constructed the nation's first solar water heater prototype. By 1967, 20% of the population was utilising solar water heaters. Israel mandated the installation of solar water heaters in all newly constructed homes in 1980 as a result of the energy crises of the 1970s (except high towers with insufficient roof area). As a result, Israel surpassed all other countries in the world in terms of household solar energy use, with 85% of homes using solar thermal systems (3% of main national energy consumption), which is predicted to save the nation 2 million barrels (320,000 m3) of oil annually.

Spain became the first nation in the world to mandate the installation of photovoltaic power generation in new structures in 2005. In 2006, it became the second nation (after Israel) to mandate the installation of solar water heating systems.

Asia

Systems started to be sold in Japan from 1960.

Starting with MRET in 1997, Australia has a mix of national and state laws for solar thermal.

The cost of basic versions in China, where solar water heating systems are widely used, starts at about 1,500 yuan (US$235), or about 80% less than in Western nations for a given collector size. There are at least 30 million households in China with one. The popularity is a result of the heaters' effective evacuated tubes, which enable them to work even in overcast conditions and at extremely low temperatures.

Freeze protection

Freeze protection techniques shield the system from harm caused by the freezing transfer fluid's expansion. When the pump fails, drainback systems remove the transfer fluid from the system. Antifreeze, such as propylene glycol, is frequently used as the heat transfer fluid in indirect systems.

In some direct systems, collectors can be manually drained when freezing is suspected. This strategy is popular in regions where freezing temperatures do not occur frequently, but because it depends on a human operator, it may not be as reliable as an autonomous system. Freeze-tolerance is a third kind of freeze protection where silicone rubber water pipes for low pressure simply expand when it freezes. European Solar Keymark certification has been granted to one such collector.

Overheat protection

All non-"drainback" systems can experience high fluid temperatures in the collectors and storage after a day or two of no hot water use. A "drainback" system's pumps shut off when the storage tank reaches the correct temperature, stopping the heating operation and protecting the storage tank from overheating.

Some active systems purposefully circulate hot water through the collector at times when there is little sunshine or at night, losing heat, to chill the water in the storage tank. Due to evacuated tube collectors' higher insulation, this works best in systems with direct or thermal storage piping and is essentially useless in those with other types of collectors. Any type of collector could still get too hot. The operation of temperature and pressure relief valves is ultimately what keeps high pressure, sealed solar thermal systems operating. Low pressure, open vent heaters often feature an open vent and easier, more dependable safety controls.

Structure and Working

Simple ideas include a straightforward glass-topped insulated box with a flat sheet metal solar absorber attached to dark-coloured copper heat exchanger pipes, or a group of metal tubes encircling a glass cylinder that has been evacuated (near vacuum). A parabolic mirror can focus sunlight on the tube in industrial applications. A hot water storage tank holds heat. With solar heating systems, the volume of this tank must be larger to account for inclement weather and the fact that the solar collector's ideal ultimate temperature is lower than that of a normal immersion or combustion heater. Water can serve as the heat transfer fluid (HTF) for the absorber, but in active systems, a separate loop of fluid containing anti-freeze and a corrosion inhibitor often heats the tank via a heat exchanger (commonly a coil of copper heat exchanger tubing within the tank). Due to its high heat conductivity, resistance to water and atmospheric corrosion, ability to seal and join by soldering, and mechanical strength, copper plays a significant role in solar thermal heating and cooling systems. Both receivers and primary circuits use copper (pipes and heat exchangers for water tanks).

The "drain-back" idea is another low-maintenance idea. All of the plumbing is slanted to allow water to drain back to the tank; anti-freeze is not necessary. The tank runs at atmospheric pressure because it is not pressurised. Before freezing can happen, flow reverses as soon as the pump goes off, and the pipes become empty.

Passive (also known as "compact") and active (also known as "pumped") systems make up residential solar thermal installations. To ensure that hot water is constantly accessible, both commonly have an auxiliary energy source (electric heating element or connection to a gas or fuel oil central heating system) that is activated when the water in the tank drops below a minimum temperature setting. In cooler climates, a hot water system can operate year-round using solar water heating and backup heat from a wood stove chimney, eliminating the need for fossil fuels or electricity to supply the additional heat needed by a solar water heating system.

When a solar water heating system is used in conjunction with a hot-water central heating system, the solar heat will either be concentrated in a pre-heating tank that feeds into the tank heated by the central heating or the solar heat exchanger will replace the lower heating element while the upper element will still be present to provide supplemental heat. But at night and in the winter, when solar gain is smaller, there is a greater requirement for central heating. As a result of better matching of supply and demand, solar water heating for washing and bathing is frequently a better use than central heating. A solar hot water system may supply up to 85% of the energy for home hot water in certain areas. Domestic concentrating solar thermal systems are one possible example of this. Solar combisystems, which supply both hot water and space heating, account for 15 to 25% of the home heating energy in many northern European nations. Large-scale solar heating may supply between 50 and 97 percent of the annual heat needed for district heating when paired with storage.

Heat Transfer.

Direct.

Potable water is pumped through the collectors using direct or open loop systems. They are reasonably priced. Issues include:

- Unless they contain a heat export pump, they provide minimal or no overheat prevention.
- Unless the collectors are freeze-tolerant, they provide minimal or no protection against freezing.

If an ion-exchange softener is not used, scale will build up in collectors in locations with hard water.

The market for SWH was opened up to colder locations with the introduction of freeze-tolerant designs. Older models suffered damage in freezing temperatures when the water converted to ice, rupturing one or more components.

Indirect

Heat is transferred from the "heat-transfer fluid" (HTF) fluid to the potable water in indirect or closed loop systems using a heat exchanger. The most typical HTF is a mixture of antifreeze and water, usually with non-toxic propylene glycol. The HTF heats up in the panels before moving on to the heat exchanger, where it heats the potable water. Overheat and freezing prevention are often provided via indirect systems.

Propulsion

Passive

The working fluid is circulated by passive systems using heat-driven convection or heat pipes. Although less expensive and requiring little to no maintenance, passive systems are less effective. Major issues include freezing and overheating.

Active

Pumps are used by active systems to circulate water and/or heating fluid. As a result, a far greater variety of system configurations is possible.

Pumped systems cost more to buy and keep running. They are more controllable and perform more effectively, though.

The controllers in active systems offer features including communication with a backup gas or electric water heater, computation and reporting of energy savings, safety features, remote access, and educational displays.

Passive direct systems

A tank that serves as both storage and a collector is used in an integrated collector storage (ICS or batch heater) system. Thin, rectilinear tanks known as batch heaters have a glass side that faces the midday sun. They are straightforward and less expensive than plate and tube collectors, but if installed on a roof, they might need bracing to support 400–700 lb (18–320 kg) lbs of water. They also lose a lot of heat at night because the side facing the sun is largely uninsulated, and they are only appropriate in moderate climates.

In contrast to an ICS system, a convection heat storage unit (CHS) system's storage tank and collector are physically apart, and convection is used to transport heat between the two. Standard flat-plate type or evacuated tube collectors are frequently used in CHS systems. Convection needs to be above the collectors in the storage tank for it to function correctly. Since the storage tank can be completely insulated, heat loss is considerably prevented with CHS systems compared to ICS systems. Since the panels are positioned below the storage tank, cold water remains at the bottom of the system, preventing convection from being caused by heat loss.

Active indirect systems

In order to avoid freezing damage, pressurised antifreeze systems use a mixture of antifreeze (usually always low-toxic propylene glycol) and water for HTF.

Antifreeze systems have shortcomings despite being good at preventing freeze damage: The components of the solar loop start to disintegrate if the HTF becomes too hot because the glycol breaks down into acid and no longer offers freeze protection. Regardless of the storage tank's temperature, systems without drain back tanks must circulate the HTF to keep it from deteriorating. If a tempering valve isn't fitted, the tank's high temperatures can lead to severe burns, increased scale and silt build-up, and thermostat failure if the tank is being utilised for storage.

Depending on the temperatures it has seen, the glycol/water HTF needs to be updated every 3 to 8 years.

Despite propylene glycol's low toxicity, certain jurisdictions need more expensive, double-walled heat exchangers.

The HTF flows hot water from the storage tank into the collectors at low temperatures, such as below 40 °F (4 °C), resulting in significant heat loss even if it contains glycol to avoid freezing.

A drainback system is an active indirect system in which a pump is used to circulate the HTF (often pure water) through the collector. The open drainback reservoir that is a part of the non-pressurized collector piping is housed in conditioned or partially conditioned space. When the pump is not in use, the HTF stays in the drainback reservoir and returns there when it is (emptying the collector). The drainback tank must receive the whole collector system, including the pipes, via gravity. Systems with drainbacks are not susceptible to freezing or overheating. In order to increase efficiency and save pumping costs, the pump only runs when it is necessary for heat collecting and not to protect the HTF.

Solar energy applications

Energy from sun can be categorised in two ways: in the form of heat and light. We use the solar energy every day in many different ways. When we hang laundry outside to dry in the sun, we are using the solar heat to dry our clothes. Plants make their food in the presence of sunlight. Animals and humans get food from plants. Fossil fuels are actually solar energy stored millions and millions of years ago.

Some of the major applications of solar energy are as follows

- Solar water and air heating
- Heating and cooling of buildings
- Salt production by evaporation of seawater
- Solar distillation
- Solar pumping
- Solar drying of agricultural and animal products
- Solar furnaces
- Solar cooking
- Solar refrigeration
- Solar electric power generation through Photo voltaic cells
- Solar thermal power production
- Industrial process heat

Solar cooker

A 'solar cooker' is a device which uses the energy of direct sunlight to heat, cook or pasteurize food or drink. Many solar cookers currently in use are relatively inexpensive, low-tech devices, although some are as powerful or as expensive as traditional stoves, and advanced, large-scale solar cookers can cook for hundreds of people.

Because they use no fuel and cost nothing to operate, many nonprofit organizations are promoting their use worldwide in order to help reduce fuel costs (especially where monetary reciprocity is low) and air pollution, and to slow down the deforestation and desertification caused by gathering firewood for cooking.

Solar cooking is a form of outdoor cooking and is often used in situations where minimal fuel consumption is important, or the danger of accidental fires is high, and the health and environmental consequences of alternatives are severe.

Types of solar cooker

a. For household cooking: Box type solar cooker
b. For community cooking: Concentrator type solar cookers

Box Type solar cooker

The solar rays penetrate through the glass covers and absorbed by blackened metal trays (Boxes) kept inside the cooker (Fig.9.1). The upper cover has two glass sheets each 3 mm thick fixed in the wooden frame with 20 mm distance between them. This prevents the loss of heat due to re radiation from blackened surface. The loss due to convection is minimized by making the box air-light by providing a rubber strap all round between the upper lid and the box. Insulating material like glass wool saw dust or any other material is filled in the space which minimizes heat loss due to conduction. When this type of cooker is placed in the sun, the blackened surface starts absorbing sunrays and temperature rises. The food in the trays is cooked. The temperature of cooking depends upon the intensity of radiation. The size of a box type cooker is 50×50×12 cm. Overall dimensions of the latest model are 60×60×20 cm. This type of cooker is termed as family solar cooker as it cooks sufficient dry food materials for a 49 family of 5 to 7 people. The temperature attained is about 100ºC. With the addition of single glass reflector, 15-20ºC more temperature is obtained and the cooking time is reduced.

Box Type solar cooker

Concentrator type solar cooker for community cooking

It works on the principle of solar energy concentration using a Reflecting Parabolic Solar Concentrator. A parabolic solar concentrator is used for concentrating solar radiation on a focal area where the cooking vessel is placed.

Parts of the concentrator type solar

- Part A - Solar Concentrating Disc (Primary Reflector) - The disc which helps in concentrating solar energy to a focal point
- Part B- Automatic Tracking System - With the help of a simple automatic mechanical tracking system the solar disc rotates in the direction of the movement of the Sun to give continuous and accurate solar energy concentration.
- Part C - Secondary Reflector - This is provided opening in the north-facing wall of the kitchen or the cooking place just below the cooking vessel. This reflector receives the concentrated solar radiation and reflects it on to the bottom of the cooking vessel.
- Part D- Cooking vessels

Merits of solar cooker

- No requirement of cooking gas or kerosene, electricity, coal or wood.
- No need to spend on fuel, as solar energy is available free.
- No loss of vitamins in the food: Food cooked in solar cooker is nutritious. About 10-20% of protein retention is more as compared to that in conventional cooking. Vitamin thiamine retention is about 20 to 30% more whereas vitamin A is retained 5 to 10% more when food is cooked in solar cooker.
- No orientation to sun is needed
- No attention is needed during cooking.
- No fuel, maintenance and recurring cost.
- Simple to use and fabricate.
- Solar cooking is pollution free and safe.
- Solar cookers come in various sizes. Based on the number of family members, the size of the cooker can be chosen.
- All cooking activities (like boiling, roasting) can be done using a solar cooker.

- There are government schemes which offer subsidies to purchase solar cookers.

Demerits of solar cooker

- Adequate sunshine is required for cooking: Cooking can be done only when there is sunshine.
- Takes longer time to cook food than the conventional cooking methods
- All types of foods can't be cooked.

Solar water heater

A solar water heating unit comprises a blackened flat plate metal collector with an associated metal tubing facing the general direction of the sun. The plate collector has a

transparent glass cover above and a layer of thermal insulation beneath it.The metal tubing of the collector is connected by a pipe to an insulated tank that stores hot water during cloudy days. The collector absorbs solar radiations and transfers the heat to the water circulating through the tubing either by gravity or by a pump. This hot water is supplied to the storage tank via the associated metal tubing. This system of water heating is commonly used in hotels, guest houses, tourist bungalows, hospitals, canteens as well as domestic and industrial units.

It consists mainly of:

- A thermal panel (solar collector) installed on the roof;
- A tank to store hot water;
- Accessories, such as a circulating pump to carry the solar energy from the collector to the tank, and a thermal regulator.

Small capacity domestic solar water heaters are also available in simpler design, in which the functions of the collector and storage tank are combined in one unit. The hot water is used for domestic purposes or meeting the needs of industries and commercial establishments. Solar water heating systems can be classified into two categories:

1) Natural circulation (thermo-syphon) system
2) Forced circulation system

Natural circulation water heating system

Basic elements of a solar water heating system are: (i) flat plate collector, (ii) storage tank, (iii) circulation system (iv) auxiliary heating system and (v) control of the system is shown in Fig.9.3 natural circulation system consists of a tilted collector, with transparent cover plates, a separate, highly insulated water storage tank, and well-insulated pipes connecting the collector and storage tank. The bottom of the storage tank is at least a foot higher than the top of the collector, and 52 no auxiliary energy is required to circulate water through it. Circulation occurs through natural convection, or thermo-siphoning. When water in the collector is heated by the sun, it expands (becomes less dense) and rises up the collector, through a pipe and into the top of the storage tank. This forces cooler water at the bottom of the tank and flow out from storage tank by gravity, enter into the bottom of the collector through pipe provided at the bottom of the storage tank. This water, in turn, is heated and rises up into the tank. As long as the sun shines the water will quietly circulate, getting warmer. After sunset, a thermo-siphon system can reverse its flow direction and loss heat to the environment during the night. To avoid reverse flow, the top heater of the absorber should be at least 1 foot below the bottom of the storage tank. To provide heat during long, cloudy periods, an electrical immersion heater can be used as a back up for the solar system.

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heater of the absorber should be at least 1 foot below the bottom of the storage tank. To provide heat during long, cloudy periods, an electrical immersion heater can be used as a backup for the solar system.

Natural circulation water heating system

Forced circulation water heating system

The forced circulation water heating system is suitable for supplying hot water to community centers such as hostels, hotels etc., and industries. Large array of flat-plate collectors are then used and forced circulation is maintained with a water pump. The restriction to keep storage tank at a higher level is not required, as done in the case of natural circulation water heating system. Depending on the size of storage tank, a group of flat plate collectors are selected and connected together. The storage tank is maintained with cold water fully by connecting to a make-up water tank which is provided with ball-float control mechanism. The pump for maintaining the forced circulation is operated by an on-off controller which senses the difference between the temperature of water at the exit of collectors and a suitable location inside the storage tank. When the temperature in the storage tank is reduced, the thermal controlling system operates the pump and cold water is pumped to the collectors. The cold water gets heated up in the collector and the flow to the storage tank. If the temperature of water in the storage tank reaches to a predetermined value, the pump automatically stops the pumping water from the tank to collector. If the temperature of hot water falls, the pump starts working and water flows to collector. In the absence of solar energy, the auxiliary heater operated by electrical power is used. The auxiliary heater has to be kept in the storage tank

Solar Drying

One of the traditional uses of solar energy has been for drying of agricultural products. The drying process removes moisture and helps in preservation of the product. Traditionally drying is done on open ground. The disadvantages associated with the traditional system of drying are slow process, uncontrolled drying, quality deterioration, and losses due to birds, rodents and insects. Drying under solar cabinet or convective dryers can be done faster and in a controlled condition.

Advantages of Solar Drying System

- Better Quality of Products are obtained
- It reduces losses and better market price to the products.
- Products are protected against flies, rain and dust;
- Product can be left in the dryer overnight during rain, since dryers are waterproof.
- Prevent fuel dependence and reduces the environmental impact
- It is more efficient and cheaper.

Disadvantages of Solar Drying System

- Quality of products are not obtained in some cases
- Adequate solar radiation is required.
- It is more expensive
- Require more time for drying.

Different types of solar dryer

Direct type solar dryer/ cabinet dryer:

A cabinet type solar dryer is suitable for small scale use. The figure 10.1 shows simplest type of cabinet dryer. Here moisture is removed from top; air enters into cabinet from below and leaves from top. The dryer consists of an enclosure with a transparent cover. This is open to the sun drying type of dryer only difference is food product is covered with the glass cover. The material to be dried is placed on the perforated trays. The solar radiation entering the enclosure is absorbed in the product itself and the surrounding internal surfaces of the enclosure. As a result, moisture is removed from the product and the air inside is heated. Suitable openings at the bottom and top ensure a natural circulation. Temperature from 50-80ºC is attained and drying time ranges from 2-4 days.

When sun light falls on the surface of glass then three things happen, first is some light is absorbed, some light is reflected back from the glass, and some light is transmitted. As part of radiation absorbs by surface of crop which causes increase in temperature. The glass cover reduces direct convective losses to the ambient and which plays important role in increasing temperature of agricultural product and cabinet temperature. Products like dates, apricots, grapes, chillies, turmeric etc., can be dried in a cabinet dryer. There are some disadvantages of cabinet dryer like, drying time required is large due to natural convection of air flow hence low heat and moisture transfer coefficient. Hence efficiency is low.

Indirect type of solar dryer/Convective dryer: For large scale drying, convective dryer is used. In this dryer, the solar radiation does not fall on the product to be dried. Air is heated separately in a solar air heater and then forced into the chamber in which the product to be dried is placed. A blower circulates the air from the heater to the grain hopper.

This type of dryer differs from direct dryer by heat transfer and vapour removal. In this method atmospheric air heated in flat plate collector. Then this hot air from flat plate collector is flow in the cabin where products are placed. The moisture from this type of dryer is removed by convection as well as by diffusion. These dryers are suitable for food grains, tea, tobacco, spices etc. In India about 10,000m2 of collector area for drying various kinds of crops and food products and for drying timber have been installed in about 50 industries.

Convective dryer

Space cooling and refrigeration system

Space cooling is one of the promising applications of solar energy to provide comfortable living conditions (air-conditioning) or of keeping a food product at low temperature to increase its shelf life. Since the energy of the sun is being received as heat, the obvious choice is absorption refrigeration system, which requires most of its energy input as heat.

A diagram of a simple solar operated absorption refrigeration system. The water heated in a flat plate collector array, is passed through a heat exchanger called the generator where transfer of heat takes place to a solution (absorbent + Refrigerant), which is rich in refrigerant. Refrigerant vapour boiled off at a high pressure and goes to the condenser where it is condensed into a high-pressure liquid. The high-pressure liquid is throttled to a low pressure and temperature in an expansion value and passes through an evaporator coil. Hence, the refrigerant vapour absorbs heat and cooling is obtained in the space surrounding this coil. The refrigerant vapour is now absorbed back into a solution mixture withdrawn from the generator. The refrigerant concentration is weak in this solution and pumped back into the generator, there by completing the cycle. The common refrigerant absorbent liquids are ammonia-water, water- lithium bromide. The later is used in air conditioning.

Solar Pond

The solar pond is a simple device for collecting and storing solar heat. The solar pond combines solar energy collection and sensible heat storage. Solar ponds are also called solar salt ponds. The solar pond works on a very simple principle. It is well-known that water or air is heated they become lighter and rise upward e.g. a hot air balloon. Similarly, in an ordinary pond, the sun"s rays heat the water and the heated water from within the pond rises and reaches the top but loses the heat into the atmosphere. The net result is that the pond water remains at the

atmospheric temperature. A solar pond, on the other hand, is designed to reduce convective and evaporative heat losses. The solar pond restricts this tendency by dissolving salt in the bottom layer of the pond making it too heavy to rise.so that useful amounts of heat can be collected and stored. A greater salt concentration at the bottom than at top causes bottom water to have greater density and remains at the bottom and is also hotter. The solar energy is absorbed in deep layers and is usually trapped.

Applications of solar ponds

- Heating and cooling of buildings
- Power generation
- Agricultural crop drying
- Desalination
- Industrial process heat
- Production of renewable liquid fuels

Limitations of solar ponds

- Need for large land area
- Require sunny climate
- Availability of brackish water

Types of Solar Ponds

There are two main categories of solar ponds: nonconvecting ponds, which reduce heat loss by preventing convection from occurring within the pond; and convecting ponds, which reduce heat loss by hindering evaporation with a cover over the surface of the pond.

Convecting Solar Ponds

Convecting solar ponds trap heat by stopping evaporation rather than by stopping convection. The structure consists of a large bag of water with a blackened bottom, foam insulation below the bag, and two layers of plastic or glass glazing on top of the bag; the design allows convection but prevents evaporation. The Sun heats the water during the day. Then, at night, hot water is pumped into heat-storage tanks

Non-convecting Solar Ponds

Solar ponds are of two types: non-convecting and convecting. The more common non- convecting solar pond reduces heat loss by preventing convection (the transfer of heat from one place to another by the movement of fluids) with the addition of a concentration of 20–30 percent salt to the bottom level (lower convective zone) of the pond. When saturated with high amounts of salt in the form of concentrated brine, the temperature of the bottom level rises to about 100 °C (212 °F) as heat from the Sun is trapped. The middle level (non-convective zone) receives a lower amount of salt than the bottom level. Because it is lighter than the bottom level but heavier than the top level, the water in the middle level is unable to rise or sink. The middle level, therefore, halts convection currents and acts as an insulator, trapping sunlight in the bottom level. In the top level (upper convective zone), where there is little salt, the water remains cold. Fresh water is added to that level, and saline water is drained. Finally, heat from the bottom level is transferred to pipes circulating through the pond to extract thermal energy. The salt gradient pond is the most common type of non-convective solar pond.

Salinity Gradient Solar Pond (SGSP)

A solar pond is mass of shallow water about 1 – 1.5 m deep with a large collection area, which acts as a heat trap. It contains dissolved salts to generate a stable density gradient. Salts have been dissolved in high concentrations near the bottom, with decreasing concentration towards the surface. The salts most commonly used for salt gradient ponds are sodium chloride and magnesium chloride. Part of the incident solar radiation entering the pond surface is absorbed throughout the depth and the remainder which penetrates the pond is absorbed at the black bottom. Convective losses can be eliminated by initially creating a sufficient strong salt concentration gradient with convection suppressed, the heat is lost from the lower layers only by conduction. Because of its relatively low thermal conductivity, the water acts as an insulator and permits high temperatures (over 90°C) to develop in the bottom layers. The solar gradient pond consists of three layers.

In the top layer, vertical convection takes place due to effects of wind evaporation. There is no membrane or glazing covering this pond. The next layer, which may be as much as about one meter thick, contains an increasing concentration of salt with increasing depth. This layer is nonconvective. The bottom layer is a convective layer of essentially salt concentration, which provides thermal storage. Non-convective pond of this type has been known to heat water to the boiling point.

Solar Photovoltaic systems

The most useful way of harnessing solar energy is by directly converting it into DC electricity by means of solar photo-voltaic cells. Energy conversion devices which are used to convert sun light to electricity by the use of photo-voltaic effect are called solar cells. A typical photovoltaic cell consists of semiconductor material (usually silicon) having a on junction. Sunlight striking the cell raises the energy level of electrons and frees them from their atomic shells. The electric field at the on junction drives the electrons into the n region while positive charges are driven to the p region. A metal grid on the surface of the cell collects the electrons while a metal back-plate collects the positive charges.

Solar photo-voltaic cells

Photovoltaic is a well-established, proven technology with a substantial international industry network. And PV is increasingly more cost-effective compared with either extending the electrical grid or using generators in remote locations. The cost per peak watt of today's PV power is about $7. Local supply conditions, including shipping costs and import duties, vary and may add to the cost. PV systems are very economical in providing electricity at remote locations on farms, ranches, orchards and other agricultural operations. A "remote" location can be as little as 15 meters from an existing power source. PV systems can be much cheaper than installing power lines and step-down transformers in applications such as electric fencing, area or building lighting, and water pumping – either for livestock watering or crop irrigation.

Solar cells can be manufactured from different semiconductor materials and their combinations. The voltage generated by a solar cell depends on the intensity of solar radiation and the cell surface area receiving the radiations. The maximum achievable power is about 100 W/m2 of solar cell surface area. The main types of solar cells are monocrystalline silicon cells, poly crystalline silicon cells, amorphous silicon cells, gallium arsenide (GaAs), and Copper indium Di selenide (CID) cells.

At present, silicon solar cells occupy 60% of the world market. Basic types of silicon solar cells are: (i) Mono crystalline silicon solar cells, (ii) poly crystalline silicon solar cells,and (iii) thin film or Amorphous silicon solar cells.

Mono crystalline silicon solar cells

A silicon solar cell of size 10cm×10cm produces a voltage of 0.5V and power output of 1 W at a solar radiation intensity of 1000 W/m2. The solar cells are formed into modulus by enclosing in an air tight casing with a transparent cover of synthetic glass. This modulus possesses high efficiency between 15 and 18% and are used in medium and large size plants.

Poly crystalline silicon solar cells: The higher efficiency of solar module is 12 to 14%.

Thin-film solar cells: The crystalline solar cells are labour and energy intensive in manufacturing. The thin film cells are produced from amorphous silicon. It has the capacity to absorb more solar radiation due to irregular atom arrangement. The efficiency is 5 to 8%. These are very cheap to manufacture. Cell efficiency is defined as the ratio of electric power output of the cell, module, or array to the power content of sunlight over its total exposed area. The maximum theoretical efficiency of solar cells is around 47 percent.

Advantages of photovoltaic solar energy conversion

- Absence of moving parts.
- Direct conversion of light to electricity at room temperature.
- Can function unattended for long time. Low maintenance cost.
- No environmental pollution.
- Very long life. Highly reliable.
- Solar energy is free and no fuel required.

Can be started easily as no starting time is involved

- Easy to fabricate. These have high power-to-weight ratio, therefore very useful for space application.
- Decentralized or dispersed power generation at the point of power consumption can save power transmission and distribution costs.
- These can be used with or without sun tracking.

Limitations of photovoltaic solar energy conversion

- Manufacture of silicon crystals is labour and energy intensive.
- High cost.
- The insolation is unreliable and therefore storage batteries are needed.
- Solar power plants require very large land areas.
- Electrical generation cost is very high.
- The energy spent in the manufacture of solar cells is very high.

The initial cost of the plant is very high and still requires a long gasification period. Solar cells can be manufactured from different semiconductor materials and their combinations. The voltage generated by a solar cell depends on the intensity of solar radiation and the cell surface area receiving the radiations. The maximum achievable power is about 100 W/m2 of solar cell surface area. The main types of solar cells are monocrystalline silicon cells, poly crystalline silicon cells, amorphous silicon cells, gallium arsenide (GaAs), and Copper indium diselenide (CID) cells.

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- Can be started easily as no starting time is involved Solar lantern

A solar lamp also known as solar light or solar lantern, is a lighting system composed of an LED lamp, solar panels, battery, charge controller and there may also be an inverter. The lamp operates on electricity from batteries, charged through the use of solar photovoltaic panel. It is a simple application of solar photovoltaic technology, which has found good acceptance in rural regions where the power supply is irregular and scarce. Even in the urban areas people prefer a solar lantern as an alternative during power cuts because of its simple mechanism. Solar Lantern is made of three main components - the solar PV panel, the storage battery and the lamp. The lamp, battery and electronics all placed in a suitable housing made of metal, plastic or fiber glass. The operation is very simple. The solar energy is converted to electrical energy by the SPV panel and stored in a sealed maintenance-free battery for later use during the night hours. A single charge can operate the lamp for about 4-5 hours. The lantern is basically a portable lighting device suitable for either indoor or outdoor lighting, covering a full range of 360 degrees. Solar-powered household lighting can replace other light sources like candles or kerosene lamps. Solar lamps have a lower operating cost than kerosene lamps because renewable energy from the sun is free, unlike fuel. In addition, solar lamps produce no indoor air pollution unlike kerosene lamps. However, solar lamps generally have a higher initial cost, and are weather dependent.

Applications and uses

Emergency and/or house lighting, table lamp, camping, patrolling (streets, farms), Hawker / Vendor Stalls, non-electrified remote places: Adult education, mass communication. Easy and convenient alternative to kerosene / petromax / gas.

Solar Street Light

Solar street lights are raised light sources which are powered by solar panels generally mounted on the lighting structure or integrated in the pole itself. The solar panels charge a rechargeable battery, which powers a fluorescent or LED lamp during the night. The system is provided with battery storage backup sufficient to operate the light for 10-11 hours daily. Solar street lights are designed for outdoor application in un-electrified remote rural areas This system is an ideal application for campus and village street lighting.

Advantages of solar street lights

Solar street lights are independent of the utility grid. Hence, the operation costs are minimized.

- Solar street lights require much less maintenance compared to conventional street lights.
- Since external wires are eliminated, risk of accidents is minimized.
- This is a non-polluting source of electricity
- Separate parts of solar system can be easily carried to the remote areas
- It allows the saving of energy and also cost.

Disadvantages of solar street lights

- Initial investment is higher compared to conventional street lights.
- Risk of theft is higher as equipment costs are comparatively higher.
- Snow or dust, combined with moisture can accumulate on horizontal PV-panels and reduce or even stop energy production.
- Rechargeable batteries will need to be replaced several times over the lifetime of the fixtures adding to the total lifetime cost of the light.

Solar Fencing

Like a normal electric fence, a solar-powered electric fence can be used to protect livestock, pets, or land from wildlife and pests. However, unlike normal electric lines or battery- powered fences, a solar electric fence charger uses a small solar photovoltaic (PV) panel to collect and convert sunlight into energy, which is then stored in the battery so that it can charge the fence.

The Solar module generates the DC energy and charges the Battery. The output of the battery is connected to Energizer or Controller or Charger or Fencer. The energizer will produce a short, high voltage pulse at regular rate of one pulse per second. The live wire of the energizer is connected to the fence wire and the earth terminal to the Earth system. Animal / Intruder touching the live wire creates a path for the current through its body to the ground and back to the energizer via the earth system and completes the circuit. The Energizer has to be set up with its earth terminal coupled to an adequate earthing or grounding system. The live terminal is coupled to the live insulated wires of the fence. Energizer will send an electric current along an insulated steel wire The shock felt is a combination of fence voltage and pulses time or energy.

The basic building blocks of a power fence are: Energizer, Earthing (Grounding System) and 3. Fence system

- Energizer: Most important part of the system. The energizer is selected depending on the animals to be controls, length of the fence and number of strands. Takes input from DC battery. Main function of the energizer is to produce short and sharp pulses of about 8000 volts at regular intervals. The power input is from the DC energy from battery.
- Earthing (Grounding System): The earth or ground system must be perfect to enable the pulse to complete its circuit and give the animal an effective shock. Soil is not a good conductor so the electrons spread out and travel over a wide area, inclining towards moist mineral soils.

Features of Solar Power Fencing:

- Easy Construction.
- Power fence can be erected to target species only.

- Low maintenance.
- Long lasting because of minimal physical pressure.
- All domestic and wild animals can be controlled economically.
- Makes strip grazing and back fencing easy.
- Encourages additional subdivision, giving increased production.
- Modification of system to control a variety of animals is very easy.
- Aesthetically pleasing.
- Discourages trespassers and predators.
- Not harmful. It gives a short, sharp but safe shock to the intruder.
- Perimeter protection

SOLAR PUMPING SYSTEM

Water pumping is one of the simplest and most appropriate uses for photovoltaic. From crop irrigation to stock watering to domestic uses, photovoltaic-powered pumping systems meet a broad range of water needs.

The solar water pumping system (Fig.12.1) is a stand-alone system operating on power generated using solar PV (photovoltaic) system. The solar cells in a PV module are made from semiconductor materials. When light energy strikes the cell, electrons are knocked loose from the material's atoms. Electrical conductors attached to the positive and negative sides of the material allow the electrons to be captured in the form of a D.C. current. The power generated by solar cells is used for operating DC surface centrifugal mono-block pump set for lifting water from bore / open well or water reservoir for minor irrigation and drinking water purpose.

Performance of Solar pumping system

The Solar PV Water Pumping System should provide a minimum of 85 liters of water per watt peak of PV array used per day under average daily solar radiation conditions of 5.5 KWh/sq. on a horizontal surface, from a total head of 10 metres (Suction head up to a maximum of 7 metres). For Deep Well Pumps, the water discharge should be a minimum of 28 liters of water per watt peak of PV array capacity used per day from a total head of 30 metres. In case of High Head, Deep Well Pumps, the water discharge should be a minimum of 17 liters of water per watt peak of PV array capacity used per day from a total head of 50 metres. Use of a tracking system to enhance the availability of solar radiation to lift desired quantity of water is desirable. It should be specified whether the minimum water output is achieved directly or through tracking of PV Array. The actual duration of pumping of water on a particular day and the quantity of water pumped could vary depending on the location, season, etc.

Advantages of solar pump sets

- No fuel cost-uses abundantly available free sun light
- No conventional grid electricity required
- Long operating life
- Highly reliable and durable- free performance
- Easy to operate and maintain
- Eco-friendly
- Saving of conventional diesel fuel

Advantages of solar energy

- Almost limitless source of energy
- Does not produce air pollution

Disadvantage of solar energy

- Expensive to use for large scale energy production
- Only practical in sunny areas
- It is intermittent in nature

HYDRO ENERGY

Water-moving energy is converted into electricity at hydroelectric facilities. From a peak of over 20% in the middle to late 20th century, hydropower produced 17% of the world's electricity in 2020. A reservoir is built behind a dam in conventional hydropower. A very flexible and dispatchable electrical supply is offered by conventional hydropower plants. To meet demand peaks and make up for times when wind and sun are scarce, they can be paired with solar and wind energy. Run-of-the-river hydroelectricity often has less of an environmental impact than reservoir-based projects. However, the river's capacity to flow depends on the weather, which might change daily and seasonally. Reservoirs provide adjustable electrical output and water quantity management for flood control, as well as drought security for agriculture and drinking water supply.

Although levels of emissions differ greatly between projects, hydropower is among the energy sources with the lowest levels of glasshouse gas emissions per unit of energy produced. Large dams in tropical areas frequently produce the most emissions. When biological stuff that is flooded into the reservoir decomposes, carbon dioxide and methane are released into the atmosphere. Hydroelectric dam energy production may be impacted by deforestation and climate change. Large dams can cause local environmental harm and evictions depending on where they are built; a failed dam could endanger the local population.

Electricity generated from hydropower is known as hydroelectricity or hydroelectric power. Nearly 4500 TWh of the world's electricity was produced by hydropower in 2020, which was more than all other renewable energy sources combined and more than nuclear power. Numerous safe and reliable electrical grids depend on hydropower because it can deliver significant quantities of low-carbon electricity on demand. It is also a flexible source of electricity with a dam and reservoir because the quantity of electricity produced by the station may be adjusted up or down in seconds or minutes to meet shifting energy needs. After it is built, a hydroelectric complex leaves no direct waste behind and almost always emits a lot less glasshouse gas than fossil fuel-powered energy plants. However, they can produce a significant amount of glasshouse gases when built in lowland rainforest regions where flooding a section of the forest is necessary.

A hydropower complex's construction may have a large negative impact on the environment, especially if arable land is lost and residents are uprooted. They also interfere with the river's natural ecology, changing habitats, ecosystems, and patterns of siltation and erosion. Dam collapse can be disastrous even though they can reduce the hazards of flooding.

Origins.

Since ancient times, hydropower has been used to grind flour and carry out other duties. The energy source required to kick off the Industrial Revolution in the late 18th century was hydraulic power. Richard Arkwright's combination of water power, the water frame, and continuous production played a significant role in the development of the factory system, with modern employment practises, in 1771. In the mid-1770s, French engineer Bernard Forest de Bélidor published Architecture Hydraulique, which described vertical- and horizontal-axis hydraulic machines. The hydraulic power network was created in the 1840s to produce and deliver hydropower to final consumers. The electrical generator was created by the late 19th century and could now be linked with hydraulics. Development would also be fueled by the rise in demand brought on by the Industrial Revolution. William Armstrong created the first hydroelectric power system in the world in 1878 at Cragside in Northumberland, England. In his art gallery, it was utilised to power a solitary arc lamp. In the vicinity of Niagara Falls, the previous Schoelkopf Power Station No. 1 started generating electricity in 1881. The Vulcan Street Plant, the first Edison hydroelectric power plant, opened for business on September 30, 1882, in Appleton, Wisconsin, with an output of roughly 12.5 kilowatts. In the United States and Canada, there were 45 hydroelectric power plants by 1886, and there were 200 in the United States alone by 1889.

The Warwick Castle water-powered generator house, used for the generation of electricity for the castle from 1894 until 1940 Commercial enterprises built numerous small hydroelectric power plants in the mountains close to urban centres at the turn of the 20th century. Over a million people attended the international exhibition of hydropower and tourism in Grenoble, France. The Federal Power Act was passed into law in 1920, at which point hydroelectricity accounted for 40% of all power generated in the US. The Federal Generating Commission was established by the Act to oversee hydroelectric power plants on federal lands and waters. The connected dams' other functions, such as flood control, irrigation, and navigation, evolved as the power stations' size increased. Large-scale growth required federal support, which led to the founding of nationally controlled organisations like the Tennessee Valley Authority (1933) and the Bonneville Power Administration (1937). Furthermore, the Bureau of Reclamation, which had started a number of irrigation projects in the western US in the early 20th century, was now building significant hydroelectric projects, such the 1928 Hoover Dam. The Flood Control Act of 1936 designated the United States Army Corps of Engineers as the top government flood control organisation, and it participated in the development of hydroelectricity by building the Bonneville Dam in 1937.

Throughout the 20th century, hydroelectric power plants grew steadily in size. White coal was used to describe hydropower. In 1936, the 1,345 MW first Hoover Dam power station was the greatest hydroelectric power station in the world; however, in 1942, the 6,809 MW Grand Coulee Dam surpassed it. The Three Gorges Dam in China, with a capacity of 22.5 GW, exceeded the Itaipu Dam in South America, which had a capacity of 14 GW when it first opened in 1984. Over 85% of the electricity in some nations, such as Norway, the Democratic Republic of the Congo, Paraguay, and Brazil, would eventually come from hydroelectric sources.

GEOTHERMAL ENERGY.

Geothermal energy is created by drawing on the heat stored in the earth's crust and using it to create electricity or heat buildings and water. Geothermal energy use is centred in areas where heat extraction is cost-effective; high temperatures, heat flow, and permeability are required (the ability of the rock to allow fluids to pass through). Steam generated in subsurface reservoirs is used to generate electricity. In 2020, fewer than 1% of the world's energy came from geothermal sources.

Due to the constant replenishment of thermal energy from nearby hotter regions and the radioactive decay of naturally existing isotopes, geothermal energy is a renewable resource. The glasshouse gas emissions of electricity generated by geothermal energy are typically less than 5% of those of power generated by coal. Geothermal energy needs appropriate protection to prevent water contamination, generates toxic emissions that can be captured, and poses a risk of causing earthquakes.

Electricity produced by geothermal energy is known as geothermal power. Dry steam power plants, flash steam power plants, and binary cycle power plants are among the technologies now in use. In 26 nations, geothermal energy generation is currently in use.

Geothermal power capacity as of 2019 is 15.4 gigawatts (GW), of which 3.68 GW, or 23.9 percent, are installed in the United States. Global geothermal power capacity is anticipated to reach 14.5–17.6 GW by 2020, growing at an average annual rate of 5% over the three years to 2015. The Geothermal Energy Association (GEA) estimates that just 6.9% of the world's total potential has been used up to this point based on the geologic information and technology the GEA publicly discloses, despite the IPCC reporting geothermal power potential to be in the range of 35 GW to 2 TW. El Salvador, Kenya, the Philippines, Iceland, New Zealand, and Costa Rica are among the nations that derive more than 15% of their electricity from geothermal sources.

Because the amount of heat extracted is negligible in comparison to the heat content of the Earth, geothermal energy is regarded as a sustainable, renewable energy source. Less than 5% of conventional coal-fired plants' glasshouse gas emissions, or 45 grammes of carbon dioxide on average per kilowatt-hour of energy, are produced by geothermal electric stations.

By 2050, geothermal energy has the potential to supply 3-5 percent of the world's energy needs for both power and heating. Economic incentives are predicted to make it possible to satisfy 10% of world demand by the year 2100.

History and development

Geothermal energy was taken into account as a generating source in the 20th century as a result of the demand for electricity. On July 4, 1904, near Larderello, Italy, Prince Piero Ginori Conti tested the first geothermal power generator. Four light bulbs were successfully ignited. The first commercial geothermal power station in the world was later constructed there in 1911. Italy was the world's only industrial producer of geothermal electricity until 1958, despite experimental generators being erected at Beppu, Japan, and the Geysers, California, in the 1920s.

When the Wairakei station was put into service in 1958, New Zealand surpassed the United States as the second-largest industrial generator of geothermal electricity. The first station to employ flash steam technology was Wairakei. Net fluid production has exceeded 2.5 km3 over the previous 60 years. A number of formal hearings about environmental consents for expanded expansion of the system as a source of renewable energy have raised the issue of subsidence at Wairakei-Tauhara.

The Geysers in California, operated by Pacific Gas and Electric, became the first productive geothermal electric generating facility in the country in 1960. The first turbine generated 11 MW of nett electricity and operated for more than 30 years.

Following the energy crisis of the 1970s and significant changes in regulatory laws, the binary cycle power station was initially demonstrated in 1967 in the Soviet Union and then introduced to the United States in 1981. Utilizing resources that were previously recoverable at considerably lower temperatures is now possible thanks to technology. In Chena Hot Springs, Alaska, a binary cycle station that produced electricity from fluid with a record-low temperature of 57 °C (135 °F) went online in 2006.

Up until recently, only high-temperature geothermal resources that were close to the surface were used to build geothermal power plants. Enhanced geothermal systems may be made possible over a much wider geographic area with the development of binary cycle power plants and advancements in drilling and extraction technology. While demonstration projects in France's Soultz-sous-Forêts and Germany's Landau-Pfalz are already in operation, Basel, Switzerland's earlier attempt was abandoned since it caused earthquakes. In Australia, the United Kingdom, and the United States of America, additional demonstration projects are being built.

Because geothermal fluids are at a lower temperature than steam from boilers, geothermal electric stations have a low thermal efficiency of 7–10%. This low temperature inhibits the ability of heat engines to extract useable energy during the production of electricity in accordance with the principles of thermodynamics. Unless it can be immediately and locally utilised, such as in greenhouses, lumber mills, or district heating, exhaust heat is lost. Although it doesn't have the same impact on operating expenses as it would in a coal or other fossil fuel plant, the system's efficiency does have an impact on the station's viability. Electricity generation needs high-temperature geothermal fields and sophisticated heat cycles to produce more energy than the pumps use. Geothermal power's capacity factor can be fairly high — up to 96 percent has been demonstrated — because it does not rely on variable sources of energy, unlike, for instance, wind or solar. However, the IPCC reports that in 2008, the average capacity factor across the globe was 74.5 percent.

Geothermal Heating.

The direct utilisation of geothermal energy for some heating applications is known as geothermal heating. Since the Paleolithic period, people have utilised geothermal heat in this manner. In 2004, 270 PJ of geothermal heating were directly used in almost 70 different nations. The installed geothermal heating capacity as of 2007 was 28 GW, which accounted for 0.07 percent of the world's primary energy consumption. Since there is no energy conversion required, thermal efficiency is excellent, but capacity factors are often low (about 20 percent) because heat is primarily required in the winter.

Geothermal energy comes from three sources: radioactive decay of minerals, heat held within the Earth since the planet's birth, and solar energy absorbed at the surface. In areas where volcanic activity increases near to the Earth's surface and tectonic plate borders, the majority of high temperature geothermal heat is gathered. These sites have ground and groundwater with temperatures higher than the application's target temperature. Though the temperature of the undisturbed ground is consistently at the mean annual air temperature below 6 metres (20 feet), even cold ground retains heat that can be retrieved with a ground source heat pump.

Geothermal heat can be used for a wide range of purposes, such as heating homes, greenhouses, swimming pools, and bathing areas. The majority of geothermal applications use hot fluids that range in temperature from 50 °C (122 °F) to 150 °C (302 °F). For various uses, different temperatures are suitable. The temperature range for the agricultural sector for direct geothermal heat use is 25 °C (77 °F) to 90 °C (194 °F), while the temperature range for space heating is 50 °C (122 °F) to 100 °C (212 °F). As they remove and "amplify" the heat, heat pipes reduce the temperature range to 5 °C (41 °F). Geothermal energy is often produced using geothermal heat that is hotter than 150 °C (302 °F).

In 2004, room heating accounted for more over half of direct geothermal heat use, and spas accounted for a third. The remaining material was put to use in a number of industrial processes, including desalination, household hot water production, and agricultural uses. Snow is melted by geothermal plants located beneath roads and pavements in the cities of Reykjavik and Akureyri. It has been proven that geothermal desalination works.

Geothermal systems frequently take advantage of economies of scale, distributing space heating power to numerous buildings and perhaps entire cities. District heating is a method that has been used for a long time in cities all over the world, including Reykjavik, Iceland; Boise, Idaho; and Klamath Falls, Oregon.

According to the European Geothermal Energy Council (EGEC), 280 geothermal district heating facilities with a combined capacity of roughly 4.9 GWth were running in Europe alone in 2016.

Extraction.

Geothermal resources are present in some areas of the planet, including large swaths of the western United States. Iceland, some regions of Japan, and other geothermal hotspots across the world experience comparable conditions. These locations allow for the direct piping of water or steam from natural hot springs into radiators or heat exchangers. As an alternative, the heat may come from deep wells that are drilled into hot aquifers or from waste heat produced by co-generation from a geothermal electricity plants. Direct geothermal heating is practical across a wide geographic area since it is more effective than geothermal electricity generation and has fewer strict temperature requirements. Air or water may be routed through earth tubes or downhole heat exchangers, which serve as heat exchangers with the ground, if the shallow ground is hot but dry.

Geothermal energy is also used to produce steam under pressure from deep geothermal deposits. At 2,100 metres, the Iceland Deep Drilling Project hit a magma pocket. In the hole, a cemented steel case was built with a puncture towards the magma at the bottom. The first magma-enhanced geothermal system in the world, IDDP-1, produced 36 MW of energy using the high temperatures and pressure of the magma steam.

It is still warmer than the winter air in regions where the shallow earth is too cold to immediately offer warmth. Under 10 metres of depth, seasonal changes in ground temperature totally vanish because of the thermal inertia of the shallow earth, which traps solar energy generated during the summer. A geothermal heat pump may extract the heat more effectively than a traditional furnace can produce it. Practically everywhere in the world, geothermal heat pumps are economically feasible.

In theory, geothermal energy (usually cooling) can also be extracted from existing infrastructure, such as municipal water pipes.

Ground-source heat pumps

A ground-source heat pump (GSHP) can offer both room heating and cooling in areas without high temperature geothermal resources. These systems use a heat pump, much like a refrigerator or air conditioner, to propel the transfer of heat from the ground to the building. No matter how cold the source, heat may be taken, but a warmer source allows for greater efficiency. A ground-source heat pump makes use of the shallow ground or ground water, which normally has temperatures between 10 and 12 degrees Celsius (50- and 54-degrees Fahrenheit), as a source of heat. An air source heat pump, in contrast, extracts heat from the air (colder outside air), requiring more energy.

Through underground closed pipe loops, GSHPs move a carrier fluid (often a solution of water and small concentrations of antifreeze). If sufficient acreage is available for deep trenches, a "horizontal loop field" is built around six feet below the surface. Single-home systems can also be "vertical loop field" systems with bore holes 50–400 feet (15–120 m) deep. When a fluid circulates underground, it absorbs heat from the earth and, upon returning, the warmer fluid goes through a heat pump that draws heat from the fluid using electricity. The cycle is continued by injecting the newly chilled fluid back into the ground. The house is heated using the heat that is extracted as well as heat that is produced as a by-product by the heat pump device. When the ground heating loop is included in the energy equation, a structure can get a lot more heat than it could if electricity had been utilised only for heating.

The same method can be used to circulate cooled water around the house to cool it during the summer by switching the direction of heat flow. Instead of transferring the heat to the warm outside air as an air conditioner does, the heat is expelled to the somewhat cooler ground (or groundwater). As a result, a greater temperature differential is covered by the heat pump, increasing efficiency and consuming less energy.

With the help of this technology, ground source heating is now feasible economically everywhere. Ground-source heat pumps with a combined 15 GW capacity are thought to have retrieved 88 PJ of heat energy for space heating in 2004. The capacity of ground-source heat pumps is increasing about 10% annually.

History.

At least since the Palaeolithic era, hot springs have been used for bathing. The earliest spa ever discovered is a stone pool on Mount Li in China, constructed during the Qin dynasty in the third century BC, on the same location as the Huaqing Chi mansion. Around 0 AD, district heating for baths and homes in Pompeii was provided by geothermal energy. Romans seized Aquae Sulis in England in the first century AD and exploited the hot springs there to supply public baths and underfloor heating. The first commercial usage of geothermal energy can be seen in the admission costs for these baths. A 1,000-year-old hot tub that was constructed by one of the island's first settlers has been discovered in Iceland. In Chaudes-Aigues, France, the oldest geothermal district heating system still in use dates back to the fourteenth century. In 1827, geyser steam was used to extract boric acid from volcanic mud in Larderello, Italy, marking the start of the first industrial exploitation.

Direct geothermal energy was used to power the nation's first district heating system in Boise, Idaho, in 1892. Klamath Falls, Oregon, followed suit in 1900. Boise greenhouses were heated by a deep geothermal well in 1926, while greenhouses in Tuscany and Iceland were heated by geysers about the same period. In order to heat his home, Charlie Lieb created the first downhole heat exchanger in 1930. In 1943, Icelanders started heating their homes with steam and hot water from the geysers.

Heinrich Zoelly patented the concept of employing a heat pump to extract heat from the ground in 1912. By the time of this invention, Lord Kelvin had already created the heat pump in 1852. However, the geothermal heat pump was not successfully used until the late 1940s. Robert C. Webber's homemade 2.2 kW direct-exchange system was likely the first, however sources dispute on the precise year of his creation. The Commonwealth Building in Portland, Oregon, was heated with the first geothermal heat pump invented and tested by J. Donald Kroeker in 1946. At 1948, Ohio State University professor Carl Nielsen created the first residential open loop version in his residence. The 1973 oil crisis caused the technology to gain popularity in Sweden, and since then it has progressively gained recognition on a global scale. The economic viability of the heat pump was significantly increased in 1979 with the invention of polybutylene tubing. Over a million geothermal heat pumps with a combined 12 GW of thermal capacity were installed worldwide as of 2004. In the US and Sweden, respectively, 27,000 and 80,000 units are installed each year.

BIOENERGY.

Renewable organic material from plants and animals is known as biomass. It can be burned to generate heat and energy or transformed into biofuels like ethanol and biodiesel that can be used to fuel automobiles.

The term biomass is also generally understood to include human waste, and organic fractions of sewage sludge, industrial effluents and household wastes. The biomass sources are highly dispersed and bulky and contain large amounts of water (50 to 90%). Thus, it is not economical to transport them over long distances, and conversion into usable energy must takes place close to source, which is limited to particular regions.

Depending on the source and cultivation methods of the biomass feedstocks, the climate impact of bioenergy varies greatly. For instance, burning wood for energy emits carbon dioxide. If the cut trees are replaced by young trees in a well-managed forest, the new trees would absorb carbon dioxide from the atmosphere as they grow, considerably reducing the emissions. However, the planting and growing of bioenergy crops has the potential to destroy natural ecosystems, deteriorate soils, and use up water resources and artificial fertilisers. Unsustainable harvesting practises account for about one-third of all wood used as fuel. Harvesting, drying, and transporting bioenergy feedstocks often demand large amounts of energy; greenhouse gases may be produced during these activities. When compared to using fossil fuels, the effects of land-use change, agriculture, and processing sometimes lead to higher overall carbon emissions from bioenergy.

Less acreage may be available for food production if it is used to cultivate biomass. Around 10% of motor gasoline in the US has been replaced with corn-based ethanol, which consumes a sizable percentage of the harvest. As these forests are essential carbon sinks and habitats for a variety of species, clearing them for palm oil production for biodiesel has had major social and environmental consequences in Malaysia and Indonesia. In comparison to other renewable energy sources, generating a given amount of bioenergy needs a lot of area since photosynthesis only collects a small portion of the energy from sunlight.

While second-generation biofuels made from trash or plants other than food minimise rivalry with food production, they may also compromise local air quality and conservation areas. Algae, trash, and plants raised on soil unsuited for growing food are some somewhat sustainable sources of biomass. If the biomass source is municipal or agricultural waste, it can be disposed of by burning it or turning it into biogas.

Emissions from biofuel power plants can be captured using carbon capture and storage technology. This procedure, known as bioenergy with carbon capture and storage (BECCS), has the potential to remove atmospheric carbon dioxide on a net basis. Depending on how the biomass material is cultivated, processed, and transported, BECCS may also produce net positive emissions. Large tracts of cropland would need to be converted in order to implement BECCS at the scales outlined in various climate change mitigation routes.

Plant-based biomass is used as a fuel to generate heat or electricity. Examples include wood and its byproducts, energy crops, agricultural trash, and household, farm, and industrial garbage. Some people conflate the terms "biomass" and "biofuel" because biomass can be utilised directly as fuel (such as wood logs). Others combine two terms into one. Biofuel is a liquid or gaseous fuel that is utilised for transportation, according to government agencies in the US and the EU. The Joint Research Centre of the European Union uses the term "solid biofuel" and defines it as unprocessed or processed organic material of biological origin used as fuel, such as firewood, wood chips, and wood pellets.

In 2019, 57 EJ (exajoules) of energy were produced from biomass, compared to 190 EJ from crude oil, 168 EJ from coal, 144 EJ from natural gas, 30 EJ from nuclear, 15 EJ from hydro and 13 EJ from wind, solar and geothermal combined. Approximately 86% of modern bioenergy is used for heating applications, with 9% used for transport and 5% for electricity. Most of the global bioenergy is produced from forest resources. Power plants that use biomass as fuel can produce a stable power output, unlike the intermittent power produced by solar or wind farms.

The most significant source of renewable energy, according to the IEA (International Energy Agency), is bioenergy. I The IEA also claimed that increased deployment of bioenergy is urgently needed because the current rate of deployment is well below the levels necessary in future low carbon scenarios. Traditional bioenergy is phased out by 2030 in the IEA's Net Zero by 2050 scenario, and the share of modern bioenergy in the total energy supply rises from 6.6 percent in 2020 to 13.1 percent in 2030 and 18.7 percent in 2050. The International Renewable Electricity Agency (IRENA) predicted in 2014 that the amount of energy produced from biomass would double by 2030, with just a negligible contribution from traditional bioenergy. Most of the IPCC's mitigation pathways involve considerable contributions from bioenergy in 2050, according to the IPCC, which claims that bioenergy has a significant climate mitigation potential if done properly (average at 200 EJ.) Researchers have criticised the usage of bioenergy for having high initial carbon intensity, poor emission savings, and/or extended lag times before having a positive climate impact.

Lignocellulosic (non-edible) biomass (such coppices or perennial energy crops), agricultural waste, and biological waste are the raw material feedstocks with the most future potential. These feedstocks also have the quickest time to help the environment. Since the conversion of chemical energy to heat energy is more efficient than the conversion of chemical energy to electrical energy, producing heat is typically more "climate friendly" than producing electricity. It is also more difficult to replace the heat from biomass combustion with heat from alternative renewable energy sources because these are either more expensive or have a limit on the highest temperature of steam they can produce. Given that solid biofuel production is more energy efficient than liquid biofuel, solid biofuel is probably more environmentally benign than liquid biofuel.

Biomass categories

Biomass is categorized either as biomass harvested directly for energy (primary biomass), or as residues and waste: (secondary biomass):

Biomass harvested directly for energy

The main biomass types harvested directly for energy is wood, some food crops and all perennial energy crops:

Woody biomass harvested directly for energy consists mainly of trees and bushes harvested for traditional cooking and heating purposes (mostly in developing countries.) 25 EJ per year is spent on traditional cooking and heating globally. The IEA argues that traditional bioenergy is not sustainable and in its Net Zero by 2050 scenario it is phased out already in 2030. Short-rotation coppices and short-rotation forest are also harvested directly for energy and the energy content provided is 4 EJ. These crops are seen as sustainable, and the potential (together with perennial energy crops) is estimated to at least 25 EJ annually by 2050.

Sugar-producing plants, like sugarcane, starch-producing plants, like corn, and oil-producing plants are the primary food crops that are collected for energy (e.g. rapeseed). Rapeseed and corn are annual crops, while sugarcane is a perennial. Bioethanol and biodiesel are both produced from crops that also provide sugar, starch, and oils. While the EU produces the most biodiesel, the USA produces the most bioethanol. The annual global production of biodiesel and ethanol contains 2.2 and 1.5 EJ of energy, respectively. The term "first-generation" or "conventional" biofuel refers to fuel produced from food crops and has a relatively low reduction in emissions.

Biomass in the form of residues and waste

By-products from biological material gathered primarily for non-energy reasons include residues and garbage. Wood residues, agricultural leftovers, and municipal/industrial trash are the three most significant by-products:

By-products from forestry operations or the wood processing sector include wood residues. In the absence of collection and utilisation for bioenergy, the wastes would have either decomposed in landfills or on the forest floor, or they would have been burned alongside roads in forests or outside of wood processing plants, producing emissions as they did so.

The by-products of forestry operations, also known as logging residues or forest residues, include tree tops, branches, stumps, damaged or dying or dead trees, irregular or bent stem sections, thinnings (small trees removed to encourage the growth of larger trees), and trees cut down to lessen the risk of wildfires. Logging residue extraction levels vary from region to region, however there is growing interest in utilising this feedstock because to its high sustainable potential (15 EJ annually). In the EU, wood stems make up 68 percent of the overall amount of forest biomass, while stumps, branches, and tips make up 32%.

The term "wood processing residues" refers to the by-products of the wood processing industry, which include cut-offs, shavings, sawdust, bark, and black liquor. The overall yearly energy content of wood processing leftovers is 5.5 EJ. Wood pellets have a total energy content of 0.7 EJ and are mostly derived from wood industry waste. Wood chips have a total energy content of 0.8 EJ and are produced from a variety of feedstocks.

Agricultural residues that are used as fuel have an energy content of about 2 EJ. Agricultural residues, however, have a lot of unrealized potential. Straw makes up the greatest portion of the estimated 78 EJ yearly energy content in the production of agricultural wastes worldwide (51 EJ). Between 18 and 82 EJ have been calculated by others. According to IRENA, between 37 and 66 EJ of sustainable and commercially viable agricultural residue and garbage will be used in 2030. Industrial trash generated EJ, whereas municipal garbage created EJ. EJ was also produced by industrial and urban wood waste. According to estimates, wood waste has a sustainable potential of 2–10 EJ. By 2050, the IEA advises a sharp rise in waste utilisation, to 45 EJ yearly.

Sometimes referred to as "second-generation" or "advanced" biofuel, this fuel is produced from perennial energy crops, residues, and garbage (i.e., non-edible biomass). Sometimes referred to as "third-generation" biofuel, algae is harvested for energy. Commercial manufacture of biofuel from algae has not yet taken place due to high costs.

Sustainable Biofuel.

Biofuel that has been produced sustainably is known as sustainable biofuel. It is not based on fossil fuels like petroleum. It entails not using plants that are used to produce food to produce fuel instead, which would disrupt the global food supply.

Sustainability standards

In 2008, the Roundtable for Sustainable Biofuels released its proposed standards for sustainable biofuels. This includes 12 principles:

- "Biofuel production shall follow international treaties and national laws regarding such things as air quality, water resources, agricultural practices, labor conditions, and more.
- Biofuels projects shall be designed and operated in participatory processes that involve all relevant stakeholders in planning and monitoring.
- Biofuels shall significantly reduce greenhouse gas emissions as compared to fossil fuels. The principle seeks to establish a standard methodology for comparing greenhouse gases (GHG) benefits.
- Biofuel production shall not violate human rights or labor rights, and shall ensure decent work and the well-being of workers.
- Biofuel production shall contribute to the social and economic development of local, rural and indigenous peoples and communities.
- Biofuel production shall not impair food security.
- Biofuel production shall avoid negative impacts on biodiversity, ecosystems and areas of high conservation value.
- Biofuel production shall promote practices that improve soil health and minimize degradation.
- Surface and groundwater use will be optimized and contamination or depletion of water resources minimized.
- Air pollution shall be minimized along the supply chain.
- Biofuels shall be produced in the most cost-effective way, with a commitment to improve production efficiency and social and environmental performance in all stages of the biofuel value chain.
- Biofuel production shall not violate land rights".

The European Union and the United States are two famous examples of regions and nations that have enacted laws or implemented guidelines to encourage the development and use of sustainable biofuels. The most comprehensive mandated sustainability criterion in effect as of 2010 is the EU Renewable Energy Directive from 2009, which calls for 10 percent of transportation energy to come from renewable sources by 2020.

By 2017, according to the EU Renewable Energy Directive, lifecycle greenhouse gas emissions from biofuel consumption must be at least 50% lower than those from using gasoline or diesel (and 35 percent less starting in 2011). Additionally, "lands with high biodiversity value, carbon-rich or wooded land, or wetlands" should not be used to gather the feedstocks for biofuels.

Similar to the EU, the United States requires certain levels of lifecycle greenhouse gas reductions relative to similar fossil fuel consumption under the Renewable Fuel Standard (RFS) and the California Low Carbon Fuel Standard (LCFS). According to the RFS, lifecycle emissions must be reduced by 50% for at least half of the biofuels that must be produced by 2022. By 2020, the LCFS performance standard mandates a minimum 10 percent decrease in emissions per unit of transport energy. Currently, only greenhouse gas emissions are covered by U.S. and California rules, but California intends to "extend its policy to include other sustainability challenges related with liquid biofuels in the future."

New sustainable rules for sugarcane ethanol were also enacted by Brazil in 2009, including "zoning regulation of sugarcane expansion and social protocols."

Motivation

Due to reasons including rising oil prices and the need for greater energy security, biofuels—liquid fuels made from plant materials—are now available on the market. But many of the first-generation biofuels currently available have come under fire for having negative effects on the environment, food security, and land use.

Supporting the development of second, third, and fourth generation biofuels is a difficulty. New cellulosic technologies are a part of second-generation biofuels, along with responsible economic and policy tools to support sustainable biofuel commercialization. The ethical commercialization of biofuels offers a chance to improve long-term economic prospects in Asia, Latin America, and Africa.

Biofuels should not be viewed as a "magic bullet" to reduce transportation emissions because of their limited capacity to replace fossil fuels. They do, however, present the possibility of more market competition and a lowering of oil prices. Increased use of fossil fuels will be lessened, notably in the transportation sector, thanks to a robust supply of alternative energy sources. A sustainable transportation strategy must also incorporate more effective fuel usage.

Biofuel options

Because there are so many different types of biofuels accessible, the development and usage of biofuels is a complicated topic. Currently, the starch, sugar, and oil feedstocks from crops like wheat, maize, sugar cane, palm oil, and oilseed rape—which include these crops—are used to make biofuels like ethanol and biodiesel. Some researchers worry that a significant shift to biofuels from these crops would put their use for food and animal feed in direct competition, and they assert that in some parts of the world, the economic consequences are already evident. However, other researchers argue that there is room for a significant amount of biofuel to be produced from conventional crops given the land that is available and the vast amounts of idle and abandoned land.

The cellulose in specialised energy crops (perennial grasses like switchgrass and Miscanthus giganteus), forestry products, by-products of food production, and home vegetable waste are just a few of the sources used to make second generation biofuels today. By increasing production efficiency and lowering the environmental effect of manufacturing biofuels from both existing food crops and cellulosic sources, conversion process improvements will increase the sustainability of biofuels. The discovery of a strain of Clostridium bacteria known as "TU-103" by Tulane University's alternative fuel research scientists in the late summer of 2011 is one promising advancement in biobutanol production technology. The "TU-103" organism can convert almost any type of cellulose into butanol and is the only known strain of Clostridium-genus bacteria that can do so in the presence of oxygen. According to university experts, the solid waste from one of the plains zebra at the Audubon Zoo in New Orleans was most likely the source of the "TU-103" Clostridium bacteria strain.

In The Courier-Mail in 2007, Ronald Oxburgh made the following argument about the ethical and immoral aspects of producing biofuels: "Produced responsibly they are a sustainable energy source that need not divert any land from growing food nor damage the environment; they can also help solve the problems of the waste generated by Western society; and they can create jobs for the poor where there were none previously. When they are produced recklessly, they at best provide no benefits for the climate and, at worst, have negative social and environmental effects. Therefore, biofuels are essentially similar to any other product. The Nobel Prize-winning chemist Paul J. Crutzen found that the production of biofuels releases nitrous oxide (N2O) emissions, which means that they cause more global warming than the fossil fuels they are meant to replace.

The Rocky Mountain Institute claims that good biofuel production methods would improve soil fertility while not interfering with the production of food or fibre or creating water or environmental issues. A key factor in the potential of biofuels to provide sustainable solutions is the choice of the land on which to cultivate the feedstocks. The reduction of biofuel competition for prime cropland is a crucial factor.

Biofuels are distinct from fossil fuels in that their carbon emissions are transient, but they are comparable to fossil fuels in that they both cause air pollution. Airborne carbon particles, carbon monoxide, and nitrous oxide are produced when raw biofuels are burned to create steam for heat and power. According to the WHO, air pollution caused 3.7 million premature deaths globally in 2012.

Marine Energy

The smallest portion of the energy market is occupied by marine energy. It includes wave power, which is still in the early stages of development, as well as tidal power, which is reaching maturity. 90% of the world's production is accounted for by two tidal barrage systems, one each in France and South Korea. The effects of larger devices are less well understood, even though a single marine energy device poses negligible environmental harm.

The energy carried by ocean waves, tides, salinity, and temperature variations is referred to as marine energy or marine power (also known as ocean energy, ocean power, or marine and hydrokinetic energy). The world's oceans generate a massive amount of kinetic energy, or energy in motion. It is possible to use some of this energy to create electricity that can be used to run businesses, residences, and transportation.

The phrase "marine energy" refers to both tidal and wave power, which are both derived from the kinetic energy of huge volumes of flowing water. Even though wind turbines are installed over water, offshore wind energy is not a type of marine energy because wind power is generated by the wind.

The oceans are close to many, if not the majority, of the world's most densely populated areas and hold a huge quantity of energy. A significant quantity of new renewable energy might be produced globally using ocean energy.

Global potential

Changes in ocean temperatures, salt content, movements of tides, currents, waves, and swells have the potential to produce 20,000–80,000 terawatt-hours (TWh/y) of power per year. Indonesia, an archipelago with 35% of its land covered by water, has a theoretical ocean energy potential of 727 GW and a recognised capacity of 49 GW.

Forms of ocean energy

Surface waves, fluid movement, salinity gradients, and temperature variations all occur in the oceans, which are a huge and mostly untapped source of energy.

Projects utilising the following tools are part of marine and hydrokinetic (MHK) or marine energy development in American and foreign waters:

- Wave power converters in open coastal areas with significant waves;
- Tidal turbines placed in coastal and estuarine areas;
- In-stream turbines in fast-moving rivers;
- Ocean current turbines in areas of strong marine currents;
- Ocean thermal energy converters in deep tropical waters.

Marine current power

Temperature, wind, salinity, bathymetry, and the Earth's rotation all work together to produce strong ocean currents. The fundamental force behind winds and temperature variations is the Sun. Ocean currents may be good places to place energy extraction equipment like turbines because there are only minor variations in current speed and stream position with no changes in direction. Many parts of the world's climate are significantly influenced by ocean currents. Although little is known about how reducing ocean current energy may affect the surrounding ecology, this could pose a serious environmental threat. Due to the presence of more diversified populations of marine organisms that use ocean currents for migration, the standard turbine problems with blade striking, entanglement of marine organisms, and auditory effects may be exacerbated. Longer power lines may be needed because of locations that are farther offshore since their electromagnetic output may have an impact on the maritime environment.

Osmotic power

The pressure-retarded reverse osmosis method and related conversion technologies can be used to capture energy from the salinity differential at river mouths where fresh water and salt water mingle. A system based on electrochemical reactions is also being developed, as is one that uses freshwater upwelling through a turbine submerged in seawater.

Significant research was conducted between 1975 and 1985, and the findings about the economy of PRO and RED plants varied. It is significant to note that smaller-scale studies into the production of salinity power are being conducted in nations including Japan, Israel, and the United States. Norway and the Netherlands, where small pilots are tested, are where most of the research is done in Europe. The energy produced by the differential in salt concentration between freshwater and saltwater is known as salinity gradient energy. Given that it does not directly manifest itself in nature as heat, waterfalls, wind, waves, or radiation, this energy source is difficult to comprehend.

Ocean thermal energy

The temperature of water normally ranges from the surface, warmed by the sun, to deeper levels, where the sun cannot reach. The tropical waters where this disparity is largest are where this technology is most useful. To power a turbine that can either produce electricity or desalinate water, a fluid is frequently vaporised. Systems can be hybrid, closed-cycle, or open-cycle.

Tidal power

The power generated by moving bodies of water a common method of producing hydroelectric power. There are three basic types of tidal power generation: tidal stream power, tidal barrage power, and dynamic tidal power.

Wave power

The Sun's solar energy causes temperature differences that lead to wind. When there is more space for them to build up, the waves produced by the interaction of the wind and the water's surface are larger. Due to the worldwide wind direction, the west coast of both hemispheres has the highest wave energy potential between 30° and 60° latitude. The four most popular methods—point absorber buoys, surface attenuators, oscillating water columns, and overtopping devices—should be distinguished when assessing wave energy as a technology type.

With encouraging moves being made toward commercial viability, the wave energy sector is approaching a key turning point in the growth of the industry. The more sophisticated device creators are currently moving past single unit demonstration devices and on to array development and multi-megawatt projects. Major utility companies' support is now being seen in partnerships within the development process, which opens the door for further funding and, in some cases, worldwide cooperation.

Wave energy technology can be found both near-shore and offshore, to put it simply. Additionally, wave energy converters can be made to function in deep, middle, or shallow water depending on the water depth. The placement of the device and the intended resource characteristics will determine the core device design.

Marine energy development

In the generation of wave and tidal (marine) power, the UK is at the forefront. In order to spur the growth of the marine energy sector in the UK, the world's first test facility for marine energy was established in 2003. The European Marine Energy Centre (EMEC), which is based in Orkney, Scotland, has assisted in the installation of more wave and tidal energy equipment than in any other location in the world. The centre was built with funding totaling about £36 million from the Scottish Government, Highlands and Islands Enterprise, the Carbon Trust, the UK Government, Scottish Enterprise, the European Union, and the Orkney Islands Council. It is the only accredited wave and tidal test centre for marine renewable energy in the world, and it is capable of testing multiple full-scale devices at once in some of the most challenging weather conditions while generating electricity for the country.

On the wave site, clients have tested at the facility include Aquamarine Power, AW Energy, Pelamis Wave Power, Seatricity, Scottish Power Renewables, and Wello; on the tidal site, clients have tested at the facility include Alstom (formerly Tidal Generation Ltd), ANDRITZ HYDRO Hammerfest, Kawasaki Heavy Industries, Magallanes, Nautricity, Open Hydro, Scot renewables Tidal Power, and Voith.

Leading the €11 million FORESEA (Funding Ocean Renewable Energy through Strategic European Action) project, which offers funding assistance to ocean energy technology developers to access Europe's top-notch ocean energy test facilities, EMEC will welcome a number of wave and tidal clients to their pipeline for on-site testing.

Along with offering a wide range of consultation and research services, EMEC also tests devices and is closely collaborating with Marine Scotland to simplify the approval procedure for marine energy companies. In order to promote the growth of a worldwide marine renewables economy, EMEC is at the forefront of the development of international standards for marine energy and is forming alliances with other nations.

Non-renewable energy sources

Fossil fuel switching and mitigation

There are advantages to switching from coal to natural gas in terms of sustainability. Natural gas has life-cycle greenhouse gas emissions that are around 40 times higher than those from wind or nuclear energy but significantly lower than those from coal for a given unit of energy produced. When used to create electricity, natural gas emits about half as many emissions as coal, and when used to generate heat, it emits around two-thirds as many emissions. Methane leaks during the extraction and transportation of natural gas might be reduced, which would lessen the influence on the climate. Compared to coal, natural gas creates less air pollution.

In the near term, switching from coal to natural gas cuts emissions, but in the long run, it does not offer a path to net-zero emissions. In the case of new fossil infrastructure, which commits to decades of carbon emissions or must be wiped off before it turns a profit, developing natural gas infrastructure runs the danger of carbon lock-in and stranded assets.

Carbon capture and storage can greatly reduce the greenhouse gas emissions of fossil fuel and biomass power plants (CCS). The majority of studies make the working assumption that CCS can collect between 85 and 90 percent of a power plant's carbon dioxide (CO2) emissions. The uncaptured emissions from a coal-fired power station would still be much higher than the emissions from nuclear, solar, or wind energy per unit of electricity produced, even if 90% of the emitted CO2 were caught. Because CCS would make coal plants less effective, they would need more coal, which would increase the pollution from coal mining and transportation. The cost of CCS is highly influenced by how close a site is to geology that is suited for storing carbon dioxide. With only 21 large-scale CCS plants operating globally as of 2020, the technology's use is still quite limited.

Nuclear Energy.

Since the 1950s, nuclear energy has been employed as a low-carbon source of baseload electricity. Around 10% of the world's electricity is produced by nuclear power reactors in more than 30 nations. Nuclear energy was the second-largest source of low-carbon energy as of 2019, behind hydropower, and it produced over a quarter of it. The lifecycle greenhouse gas emissions of nuclear power, which also include uranium mining and processing, are comparable to those of renewable energy sources. Compared to the main renewable energy sources, nuclear power utilises less land per unit of energy produced and does not contribute to local air pollution. Despite being a non-renewable resource, there is enough uranium ore to power nuclear fission facilities for hundreds to thousands of years. However, the amount of uranium deposits that can currently be economically exploited is limited, and uranium production would struggle to keep up during the growth phase. A rise in nuclear power supply is often seen in climate change mitigation routes consistent with ambitious goals.

Nuclear waste, the spread of nuclear weapons, and accidents have raised questions about whether nuclear power is sustainable. Nuclear power facilities produce fissile material that can be used to make bombs, and radioactive nuclear waste must be maintained for thousands of years. Nuclear energy has historically resulted in fewer fatalities per unit of energy produced than fossil fuels due to accidents and pollution, and its mortality rate is comparable to that of renewable energy sources. Nuclear power plant construction is frequently politically challenging due to public opposition.

The idea of developing new nuclear power reactors faster and cheaper has been around for a while, but the costs are still high and the timelines are lengthy. In an effort to solve the shortcomings of conventional plants, numerous new nuclear energy sources are now being developed. Fast breeder reactors are capable of recycling nuclear waste, which can greatly lower the quantity of waste that needs to be disposed of in the earth. However, they have not yet been widely used on a commercial scale. For nations without a significant uranium supply, nuclear energy based on thorium (rather than uranium) may be able to offer greater energy security. Compared to current big reactors, small modular reactors may offer the following benefits: They ought to be easier to construct quickly, and their modular design would enable cost savings through experiential learning. Nuclear fusion reactors, which would produce negligible waste and pose minimal explosion risk, are being developed by a number of nations. Even while fusion power has advanced in the lab, the multi-decade timeframe required to bring it to commercialization and then scale implies that it won't help achieve the 2050 net zero objective for climate change mitigation.

Nuclear Power Debate.

The pros and cons of deploying nuclear reactors to produce electricity for civilian use have long been the subject of heated debate. As more and more reactors were constructed and brought online, the nuclear power debate reached its zenith in the 1970s and 1980s and in certain nations "reached an intensity unequalled in the history of technology conflicts." Following that, the nuclear sector focused on safety, produced jobs, and public apprehensions mostly subsided.

The severity of the nuclear power discussion increased in the 2010s and beyond as a result of increased public knowledge of climate change and the crucial role that carbon dioxide and methane emissions play in warming the earth's atmosphere. In addition to a generation of young physicists and engineers working to bring a new generation of nuclear technology into existence to replace fossil fuels, nuclear power advocates and those most concerned about climate change highlight nuclear power's dependable, emission-free, high-density energy. On the other hand, sceptics argue against the continued use of the technology by citing nuclear disasters like the death of Louis Slotin, the Windscale fire, the Three Mile Island accident, the Chernobyl disaster, and the Fukushima Daiichi nuclear disaster, as well as rising acts of international terrorism.

Nuclear energy proponents contend that nuclear power is a clean, sustainable energy source that generates enormous amounts of electricity continuously without damaging the environment or releasing carbon emissions that contribute to global warming. By reducing reliance on imported fuels and exposure to price concerns related to resource speculation and Middle Eastern politics, nuclear power usage creates a large number of well-paying employment and promotes energy security. In contrast to the enormous quantity of pollution and carbon emissions produced by burning fossil fuels like coal, oil, and natural gas, supporters of nuclear power argue that it almost produces no air pollution. In the modern world, we need energy that is available all the time to power our homes, businesses, transit systems, and computer networks. Even with availability to solar and wind energy, utilities must burn fossil fuels to maintain the energy grid's dependability in the absence of nuclear power because such sources are erratic. A nation's "ambitious" Nationally Determined Contributions (NDCs) to cut carbon emissions in accordance with the Paris Agreement, which was signed by 195 countries, can only be met with nuclear power, according to supporters of the technology. They stress that there are few dangers associated with waste storage, and that stockpiles can be minimised by using waste to make fuel for more modern reactors. When compared to the other major types of power plants, nuclear power has an exceptional operational safety record and, through reducing pollutants, actually saves lives every year.

Nuclear power has many risks for both humans and the environment, according to opponents, who also cite research that raise the possibility that it may never be a viable energy source. These dangers stem from uranium mining, processing, and transportation-related illnesses, mishaps, and environmental harm. Nuclear power opponents also worry about nuclear plant sabotage by terrorists, the diversion and misuse of radioactive fuels or fuel waste, as well as naturally occurring leakage from the unresolved and insufficient long-term storage of radioactive nuclear waste. These concerns are in addition to those related to the proliferation of nuclear weapons. Additionally, they assert that because reactors are such intricate devices, many things may and do go wrong, and there have been numerous catastrophic nuclear accidents. According to critics, new technologies cannot decrease these risks. They also contend that nuclear power is not a low-carbon electricity source when all the energy-intensive stages of the nuclear fuel chain, from uranium mining to nuclear decommissioning, are taken into account.

History.

President John F. Kennedy said that nuclear power was a "step on the long road to peace" and that by using "science and technology to achieve significant breakthroughs," we could "conserve the resources" to leave the world in better shape. This was said at the 1963 ground-breaking for what would become the largest nuclear power plant in the world. The Atomic Epoch, he recognised, was a "dreadful age," and "when we broke the atom apart, we changed the course of world history," he added. Ten years later, in

Germany, local opposition and anti-nuclear organisations stopped the development of a nuclear power plant in Why. The effective use of civil disobedience to stop the construction of this plant was a turning point in the anti-nuclear power movement since it led to the establishment of numerous organisations not only in Germany but also internationally. After the partial meltdown at Three Mile Island and the Chernobyl Disaster, the public's attitude about nuclear power increased and became even more negative. However, pro-nuclear power organisations have emphasised the potential of nuclear energy to cut carbon emissions, the fact that it is a safer option to methods of production like coal, and the fact that the media has exaggerated the overall danger connected with nuclear power.

Electricity and energy supplied

Global nuclear power output increased gradually but steadily until 2006, when it reached a peak of 2'791 TWh. After that, it began to decline, reaching its lowest level of production in 2012, primarily as a result of Japanese reactors being shut down for a whole year. Since then, output from newly connected reactors has increased, reaching pre-Fukushima levels in 2019. At that time, the IEA referred to nuclear power as "historically one of the greatest suppliers of carbon-free electricity," with 452 reactors producing 2'789 TWh of electricity in total. The nuclear reactor fleet of the United States generated 800 TWh of low-carbon power that year, with an average capacity factor of 92 percent.

Energy security

Nuclear energy provides energy independence for many nations; for instance, France's Messmer plan was primarily motivated by the 1970s fossil fuel crises. Embargoes haven't had much of an impact on nuclear power, because uranium is mined in nations that are prepared to export, including Australia and Canada. Political support for nuclear power often declines during times of cheap fossil fuel and renewable energy prices while rising during times of high fossil fuel and underwhelming renewable energy. Another "nuclear renaissance" was reported to have occurred in the late 2020s as a result of growing interest in combating climate change, low-carbon energy, and the global energy problem.

Sustainability

Since the 1950s, nuclear energy has been employed as a low-carbon source of baseload electricity. Around 10% of the world's electricity is produced by nuclear power reactors in more than 30 nations. Nuclear energy was the second-largest source of low-carbon energy as of 2019, behind hydropower, and it produced over a quarter of it.

The lifecycle greenhouse gas emissions of nuclear power, which also include uranium mining and processing, are comparable to those of renewable energy sources. Compared to the main renewable energy sources, nuclear power utilises less land per unit of energy produced and does not contribute to local air pollution. Despite being a non-renewable resource, there is enough uranium ore to power nuclear fission facilities for hundreds to thousands of years. However, the amount of uranium deposits that can currently be economically exploited is limited, and uranium production would struggle to keep up during the growth phase. A rise in nuclear power supply is often seen in climate change mitigation routes consistent with ambitious goals.

Nuclear waste, the spread of nuclear weapons, and accidents have raised questions about whether nuclear power is sustainable. Nuclear power facilities produce fissile material that can be used to make bombs, and radioactive nuclear waste must be maintained for thousands of years. Nuclear energy has historically resulted in fewer fatalities per unit of energy produced than fossil fuels due to accidents and pollution, and its mortality rate is comparable to that of renewable energy sources. Nuclear power plant construction is frequently politically challenging due to public opposition.

The idea of developing new nuclear power reactors faster and cheaper has been around for a while, but the costs are still high and the timelines are lengthy. New nuclear energy technologies are being developed in an effort to overcome the limitations of conventional facilities. Fast breeder reactors are capable of recycling nuclear waste, which can greatly lower the quantity of waste that needs to be disposed of in the ground, although they have not yet been widely used in commercial settings. For nations with a limited supply of uranium, nuclear power based on thorium (as opposed to uranium) may be able to offer greater energy security. Compared to current big reactors, small modular reactors may offer the following benefits: They ought to be easier to construct quickly, and their modular design would enable cost savings through experiential learning. Nuclear fusion reactors, which would produce negligible waste and pose minimal explosion risk, are being developed by a number of nations. Even while fusion power has advanced in the lab, the multi-decade timeframe required to bring it to commercialization and then scale implies that it won't help achieve the 2050 net zero objective for climate change mitigation.

Reliability

The United States fleet of nuclear reactors produced 800 TWh zero-emissions electricity in 2019 with an average capacity factor of 92%. The average capacity factor globally in 2010 was 80.1 percent. The frequency of crucial SCRAMs every 7,000 hours was 0.6, the unplanned capacity loss factor was 1.6 percent, and the global average capacity factor was 86.8% in 2005. The capacity factor, which includes all planned maintenance/refuelling downtime as well as unforeseen losses, is calculated as the net power produced divided by the maximum amount that can be operated at full capacity at all times. Accordingly, the scramrates translate into an abrupt and unscheduled shutdown occurring about 0.6 times per year for each given reactor in the globe since the 7,000 hours roughly represents how long any given reactor will remain critical in a year. The amount of power lost as a result of unforeseen rushes and delayed restarts is represented by the unplanned capacity loss factor.

Waste heat disposal becomes a problem at high ambient temperatures since nuclear power facilities are essentially heat engines. Because of the increased stress on air conditioning and refrigeration systems as well as the reduced hydropower capacity, droughts and extended hot spells can "cripple nuclear power output." A power reactor could need to run at a lower power setting or perhaps shut down in such extreme heat. In Germany in 2009, eight nuclear reactors had to be shut down at once on hot summer days due to equipment overheating or waterways overheating. Significant fish deaths caused by overheated discharge water have in the past harmed livelihoods and sparked public concern. All thermal power facilities, including coal, gas, nuclear, and CSP, are affected by this problem equally.

New nuclear plants

Since there are opposing viewpoints on this matter and multibillion-dollar investments depend on the choice of an energy source, the economics of new nuclear power plants is a contentious subject. In general, nuclear power facilities have high capital costs during construction but low direct fuel costs (with much of the costs of fuel extraction, processing, use and long-term storage externalized). As a result, assumptions about nuclear plant construction timelines and capital funding are crucial for comparisons with other power generation techniques. Costs associated with plant decommissioning and nuclear waste storage must also be included in cost calculations. The economics of nuclear power, on the other hand, may be favoured by policies to reduce global warming, such as a carbon tax or carbon emissions trading. The rise of the electricity demand has slowed recently, and funding has become more challenging, which hinders huge projects like nuclear reactors, which have high upfront costs, lengthy project cycles, and a wide range of risks. Some potential funders have withdrawn from a number of long-running projects in Eastern Europe, including Belene in Bulgaria and the extra reactors at Cernavoda in Romania. A significant economic deterrent to nuclear projects is the consistent availability of inexpensive gas.

Who bears the risk of future uncertainty must be considered in the economic analysis of nuclear power? The majority of the risks related to construction costs, operating performance, fuel price, and other factors were borne by consumers rather than providers in all currently operational nuclear power plants, which were all created by state-owned or regulated utility monopolies. These risks, as well as the risk of cheaper competitors entering the market before capital expenditures are recovered, are now borne by plant suppliers and operators rather than consumers in many countries, which results in a radically different assessment of the economics of new nuclear power plants.

Due to rising demands for on-site spent fuel management and enhanced design basis hazards in the wake of the 2011 Fukushima Daiichi nuclear accident, costs are projected to rise for both existing nuclear power plants and new nuclear power plants. The high upfront costs of new nuclear power plants have been mostly attributed to the highly customised designs of major plants, although these costs can be reduced by using standardised, reusable designs (as did South Korea). The cost of new renewable energy is expected to rise as the grid becomes overloaded with intermittent sources and land use and energy storage become the main obstacles to their expansion, even though new nuclear power plants are more expensive than new renewable energy in terms of upfront investment. Due to uniform design and substantially lower complexity, a fleet of compact modular reactors can also be significantly less expensive than an equivalent single conventional size reactor. The International Energy Agency recommended for the development of a global nuclear power licencing framework in 2020 due to the current legal need that each plant design be granted a separate licence in each country.

Cost of decommissioning nuclear plants

Long after the facility has finished producing its last useable amount of electricity, the cost of energy inputs and environmental expenses associated with nuclear power plants still exist. Decommissioning is necessary to get uranium enrichment plants and nuclear reactors back to a secure enough state to be used for other purposes. Reactors must be disassembled, split into small parts, and placed in containers for final disposal after a cooling-off phase that could continue for an entire century. The procedure costs a lot of money, takes a long time, could be dangerous for the environment, and creates new opportunities for human mistake, accidents, or sabotage. Despite these dangers, the management and disposal of civil nuclear waste, according to the World Nuclear Association, "has not resulted in any severe health or environmental problems, nor has it posed any substantial risk to the general public, in over 50 years of civil nuclear power experience."

The overall amount of energy needed for decommissioning may be up to 50% higher than that required for initial construction. The average cost of decommissioning is between $300 million and $5.6 billion. The most expensive and time-consuming decommissioning takes place at nuclear plants that have had a catastrophic accident. There are 13 reactors in the United States that have been permanently shut down and are currently undergoing decommissioning; none of them have finished the procedure.

Current UK plants are expected to exceed £73 billion in decommissioning costs.

Environmental effects

Mercury, nitrogen oxides, sulphur dioxide, and other pollutants linked to the combustion of fossil fuels are not directly produced by nuclear power generation. In order to produce the same quantity of energy, nuclear power requires substantially less space due to its extremely high surface power density (thousands of times less when compared to wind or solar power).

Uranium mining, radioactive effluent emissions, and waste heat are the main environmental implications of nuclear power. Less than 1% of the total background radiation in the world comes from the nuclear business, including all previous nuclear weapon testing and nuclear catastrophes.

Nuclear and wind power have the best benefit-to-cost ratios, according to a 2014 multi-criteria analysis of impact factors crucial for biodiversity, economic sustainability, and environmental sustainability, and the study urged environmental movements to revaluate their stances on nuclear power and evidence-based policy making. Climate scientists Ken Caldeira, Kerry Emanuel, James Hansen, and Tom Wigley wrote an open letter in 2013 with the same message, and many additional people later added their signatures.

840 m3 of water (up to 90% of the water is recycled) and 30 tonnes of CO_2 are used in uranium mining for every tonne of uranium extracted. A PWR nuclear power plant's energy return on investment (EROEI) ranges from 75 to 100, which means that the whole amount of energy invested in the facility is repaid in two months. Nuclear power plants typically emit 12 gCO_2eq/kWh of greenhouse gases over their entire lifetime. One of the most competitive energy sources out there is both of these indications. Nuclear power ranks second only to wind in terms of lifecycle emissions, according to the Intergovernmental Panel on Climate Change (IPCC), and is lower than solar power. Nuclear power is listed as a source with very low lifecycle emissions by the US National Renewable Energy Lab (NREL).

Nuclear power has a median density of 240 W/m2, which is 34 times greater than solar power's (6.63 W/m2) and 130 times greater than wind power's (1.84 W/m2), meaning that when the same amount of power is to be generated by nuclear or renewable sources, the latter will use tens to hundreds of times more land surface for the same amount of power produced.

Greenpeace and some other environmental groups have come under fire for disseminating unfounded assertions about nuclear power's contribution to CO_2 emissions. Their impact has been attributed to the "shocking" findings of a 2020 poll conducted in France, when 69 percent of respondents thought nuclear power contributed to climate change. For instance, Greenpeace Australia asserted that nuclear power "does not significantly reduce carbon output," which is a blatant denial of the IPCC life-cycle assessment. In 2018, Greenpeace Spain disregarded the findings of a report from the University of Comillas that it had purchased, which showed that scenarios involving nuclear power had the lowest CO_2 emissions. Instead, Greenpeace Spain supported a different scenario involving fossil fuels, which had significantly higher emissions.

Nuclear power uses 100 m2/GWh of land over its entire life cycle, which is equivalent to half of solar power and tenth of wind power (direct and indirect mining and waste storage included). The primary argument against on-shore wind farms is space utilisation.

Extinction Rebellion UK spokesperson Zion Lights called on her fellow environmentalists to accept nuclear power as one of the "scientifically assessed solutions for addressing climate change" in June 2020. She defended nuclear power as a necessary component of the energy mix alongside renewable energy sources.

The first women-only pressure group promoting nuclear power as a component of climate change mitigation strategies was established in the US in July 2020 through the Good Energy Collective. In an open letter to the president of the European Commission in March 2021, 46 environmental organisations from the European Union urged him to boost the proportion of nuclear power as the most practical approach to lessen the EU's dependency on fossil fuels. The letter also denounced "multifaceted misinformation" and "rigged nuclear information, with opinion influenced by fear," which lead to the closure of reliable, low-carbon nuclear power plants.

Renewable Energy in Africa.

Renewable energy technology is frequently used in the developing countries of Africa. Many countries currently use small-scale geothermal, wind, and solar energy systems to power both urban and rural areas. Because it is so expensive to transmit electricity from huge power plants, these methods of energy production are especially helpful in remote areas. Many of the issues that Africans deal with on a daily basis might be solved with the help of renewable energy applications, especially if they are done sustainably and with human rights as a top priority.

For the purpose of reducing poverty and fostering economic development, access to energy is crucial. Access to abundant, dependable, and affordable energy is necessary for communication technologies, education, industrialization, agricultural advancement, and the construction of municipal water systems.

Avoiding fossil fuels

Most African nations would gain greatly in the long run by avoiding the impending economic issues that rich countries are currently facing by investing in the long-term energy solutions that alternative energy sources allow. Although fossil fuels in many ways offer a straightforward, user-friendly energy source that fueled the industrialization of the majority of modern nations, there are now a number of problems connected to their widespread use, including some of the most challenging and significant global political, economic, health, and environmental issues. The unsustainable rate at which these fossil fuels are being used has led to the impending energy crisis, and the demand for fossil fuels worldwide is likely to continue to rise over the next decades, aggravating already pressing issues.

The vast majority of people in Africa, especially those who reside in rural areas, don't have a viable choice to expand and link the existing grid networks because there are too many issues with this. The only workable way to meet the demand for rural electrification is through distributed generation employing renewable energy technology. African countries are moving toward energy decentralisation, with many considering different frameworks, like District Energy Officers, as stated in a document with recommendations for District Energy Officers for the country of Malawi.

Renewable energy resources

The Sun is the source of energy for solar, wind, and hydroelectric power. The Sun has the ability to meet all of our present and future needs for energy because it emits more energy in a second (3.827 1026 J) than is accessible in all fossil fuels on earth combined (3.9 1022 J). Solar energy generation produces no direct emissions and doesn't require refuelling, so African countries can use it to safeguard their citizens, the environment, and their future economic growth. They have a variety of options to achieve this.

Solar resources

Among all the continents of the world, Africa receives the most sunlight, thanks in large part to the vast Sahara Desert and other regions that are always sunny.

Compared to other continents, it has significantly more solar resources. While rain forests are significantly more cloudy yet still receive a fair amount of global solar radiation due to their proximity to the equator, desert regions are distinguished as having the greatest sunlight.

Over 85% of the surface of Africa receives at least 2,000 kWh/ (m2 year) from solar resources, which are distributed fairly evenly across the continent.

According to recent research, the European Union could meet its entire energy needs with a solar power plant that covered just 0.3% of North Africa. The state of Maine's land area is equivalent to this one.

In 2016, the Moroccan solar energy facility in Ouarzazate was finished.

Solar power in Africa

The "Sun continent" or the continent with the greatest solar influence is often referred to as Africa. The "World Sunshine Map" shows that Africa experiences more hours of bright sunshine annually than any other continent because it is home to several of the planet's sunniest regions.

Solar power penetration in Africa's energy industry is still quite low, despite the continent's vast solar potential.

Solar potential

Africa's desert and savannah regions stand up as the biggest cloud-free area on Earth, omitting the substantial portions of tropical rainforests (the Guinean Forests of West Africa and part of the Congo Basin). Even outside of deserts (such as the Sahara, Namib, and Kalahari), Africa is primarily known for its beautiful skies; nonetheless, the areas around the equator are significantly cloudier than the tropics and subtropics.

World sunshine records are mainly celebrated in the eastern Sahara and northern Africa. As the sun shines brightly for approximately 4,300 hours every year, or 97 percent of the possible total, the region has among of the highest mean annual durations of bright sunshine. The greatest solar radiation measurements were over 220 kcal/cm2, and this region also has the highest mean yearly solar radiation readings.

Another benefit of the landmass's low latitude is that a large portion of it is located in the intertropical region, where sunshine is always intense and strong. The region's north, south, and to a lesser extent, east, all have a significant amount of huge, sun-drenched dry and semi-arid stretches. The continent is made up of around two fifths desert, which is always sunny.

The large solar potential of Africa is the result of the interaction of all these geographic and climatic factors. Due to the number of daylight hours, much of Africa might potentially be powered by solar energy without the need for extensive grid infrastructure.

Over 85% of Africa's land area receives a worldwide solar horizontal irradiation of at least 2,000 kWh/m2, making the distribution of solar resources there very consistent (m2 year). Additionally, it is thought that Africa has theoretical solar energy reserves of 60,000,000 TWh/year, or nearly 40% of the world's total, making it the continent with the greatest solar energy potential.

Pay-as-you-go Solar

Pay-as-you-go Solar systems open up loans to less affluent customers in rural Africa, enabling them to invest in residential infrastructure. The off-grid pay-as-you-go solar power strategy, now known as Pay Go, which in some countries, like Malawi, where a business called Yellow is electrifying the population quicker than grid electricity, has shown to be the most consistent method of overcoming this significant barrier to development. Customers of the Pay Go system can make payments from remote regions without a smartphone or internet connectivity by using mobile money technologies.

Solar photovoltaics

With industry projections predicting that the continent's yearly PV market would climb to 2.2 GW by 2018, falling solar equipment costs were anticipated to greatly enhance solar installations. The equatorial and subequatorial climate zones, which are typically found in the western part of Central Africa near the equator but extend as far north and south as the 8th or 9th parallel in both hemispheres, are systematically linked with almost permanent cloud cover and only intermittent bright sunshine. Future installations for harvesting solar energy in Africa will typically not be found within these climate zones. The Republic of the Congo, Equatorial Guinea, Gabon, Rwanda, Uganda, Burundi, Liberia, Sierra Leone, and Senegal are thus the only countries entirely located in this wet-humid zone, making them the least solar-power-friendly on the entire continent. All other African countries, however, enjoy more than 2,700 hours of bright sunshine annually on at least a portion of their respective territories. Due to their vast landmasses and affordable costs, many of the continuously sunny African countries, such as Egypt, Libya, Algeria, Niger, Sudan, South Africa, and Namibia, might rely on developing their enormous solar resources.

With 1329 MW installed by 2016, South Africa is the continent's top in solar energy. In South Africa, solar energy is expanding quickly. The largest in the nation and among the greatest in Africa were several 75 MW PV installations and two 100 MW CSP plants apiece. The construction of a minigrid on Robben Island has been announced by South Africa; the addition of PV and battery storage is expected to cut fuel consumption in half.

In Garissa, Kenya, a city near the equator where the sun is said to shine for over 3,144 hours a year on average, a 50 MW photovoltaic power plant is being developed. It is anticipated to produce roughly 76,473 MWh per year.

The government of Ghana intends to grow solar power in the nation from 22.5 MW in 2017 to 300 MW in 2020. A 155 MW photovoltaic power facility is also planned.

On the continent, numerous small-scale modular solar power projects are being put in place at the village and home levels. Sub-Saharan Africa led all other regions in 2015 in terms of off-grid solar product purchases.

Solar thermal power

Aiming to install 2,000MW of solar power by 2020, the Kingdom of Morocco's solar plan, one of the largest solar energy projects in the world and projected to cost $9 billion, was unveiled in November 2009. With the

500MW phase one sun power complex in Ouarzazate being the first to be completed, five locations have been chosen for the development of solar power plants combining a range of technologies, including concentrated solar power, parabolic trough, as well as photovoltaics. The 160 MW Noor I, the first phase of the 500 MW project, which employs parabolic trough concentrated solar power technology, went online in 2016. Morocco, the only nation in Africa with a power cable connection to Europe, hopes to profit from energy exports to that continent. Desertec was one such effort.

Both parabolic trough and power tower kinds of solar thermal plants have been developed in South Africa. For solar PV and solar thermal energy in 2017, it ranked first in Africa.

Wave and wind resources

Africa has a sizable coastline with vast and underutilised wind and wave energy resources in the north and south. In many countries in eastern Africa, geothermal power has the potential to supply significant amounts of electricity.

Compared to solar resources, wind resources are far less evenly distributed, with the best places being adjacent to topographical funnelling features around coastal regions, mountain ranges, and other natural channels in the north and south. The western coast of Africa has significant wind resources available, totaling more than 3,750 kW/h, which will meet projected energy demand in the future. Wind resource availability in Central Africa is below average.

Geothermal resources

Although geothermal energy is primarily centred in eastern Africa, the continent is home to numerous scattered locations with strong geothermal potential. The East African Rift, which spans multiple nations in East Africa, including Eritrea, Ethiopia, Djibouti, Kenya, Uganda, and Zambia, and is approximately 5,900 kilometres long, has significant potential for geothermal energy.

Biogas

Most organic materials undergo a natural anaerobic digestion in the presence of moisture and absence of oxygen and produce biogas. The biogas so obtained is a mixture of methane (CH_4): 55-65% and Carbon dioxide (CO_2): 30-40%. The biogas contains traces of H_2, H_2S and N_2. The

calorific value of biogas ranges from 5000 to 5500 Kcal/Kg (18.8 to 26.4 MJ /m^3).

Digestion is biological process that occurs in the absence of oxygen and in the presence of anaerobic organisms at temperatures (35-70ºC) and atmospheric pressure. The container in which, this process takes place is known as digester.

Types of biogas plants

Biogas plants basically are two types

Floating dome type

- The floating-drum plant with a cylindrical digester (KVIC model)

Fixed dome type

- The fixed-dome plant with a brick reinforced, moulded dome (Janata model)
- The fixed-dome plant with a hemisphere digester (Deenbandhu model)

Floating dome type

Floating-drum plants consist of an underground digester and a moving gas-holder. The gas- holder floats either directly on the fermentation slurry or in a water jacket of its own. The gas is collected in the gas drum, which rises or moves down, according to the amount of gas stored. The gas drum is prevented from tilting by a guiding frame. If the drum floats in a water jacket, it cannot get stuck, even in substrate with high solid content.

Drum: -In the past, floating-drum plants were mainly built in India. A floating-drum plant consists of a cylindrical or dome-shaped digester and a moving, floating gas-holder, or drum. The gas-holder floats either directly in the fermenting slurry or in a separate water jacket. The drum in which the biogas collects has an internal and/or external guide frame that provides stability and keeps the drum upright. If biogas is produced, the drum moves up, if gas is consumed, the gas-holder sinks back.

Size: -Floating-drum plants are used chiefly for digesting animal and human feces on a continuous feed mode of operation, i.e., with daily input. They are used most frequently by small to middle-sized farms (digester size: 5-15m3) or in institutions and larger agro-industrial estates (digester size: 20-100m3).

KVIC type biogas plant

This mainly consists of a digester or pit for fermentation and a floating drum for the collection of gas. Digester is 3.5-6.5 m in depth and 1.2 to 1.6 m in diameter. There is a partition wall in the centre, which divides the digester vertically and submerges in the slurry when it is full. The digester is connected to the inlet and outlet by two pipes. Through the inlet, the dung is mixed with water and loaded into the digester. The fermented material will flow out through outlet pipe.

The outlet is generally connected to a compost pit. The gas generation takes place slowly and in two stages. In the first stage, the complex, organic substances contained in the waste are acted upon by a certain kind of bacteria, called acid formers and broken up into Renewable Energy small-chain simple acids. In the second stage, these acids are acted upon by another kind of bacteria, called methane formers and produce methane and carbon dioxide.

Fixed-dome type plants

A fixed-dome plant consists of a digester with a fixed, non-movable gas holder, which sits on top of the digester. When gas production starts, the slurry is displaced into the compensation tank. Gas pressure increases with the volume of gas stored and the height difference between the slurry level in the digester and the slurry level in the compensation tank.

1. Mixing pit, 2. Digester, 3. Gasholder, 4. Displacement pit, 5. Gas pipe

a) Function - A fixed-dome plant comprises of a closed, dome-shaped digester with an immovable, rigid gas-holder and a displacement pit, also named 'compensation tank'. The gas is stored in the upper part of the digester. When gas production commences, the slurry is displaced into the compensating tank. Gas pressure increases with the volume of gas stored, i.e. with the height difference between the two slurry levels. If there is little gas in the gas-holder, the gas pressure is low.

b) Digester - The digesters of fixed-dome plants are usually masonry structures; structures of cement and ferro-cement exist. Main parameters for the choice of material are:

- Technical suitability (stability, gas- and liquid tightness)
- Cost-effectiveness
- Availability in the region and transport costs
- Availability of local skills for working with the particular building material.

Fixed dome plants produce just as much gas as floating-drum plants, if they are gas-tight. However, utilization of the gas is less effective as the gas pressure fluctuates substantially. Burners and other simple appliances cannot be set in an optimal way. If the gas is required at constant pressure (e.g., for engines), a gas pressure regulator or a floating gas-holder is necessary.

Gas Holder - The top part of a fixed-dome plant (the gas space) must be gas-tight. Concrete, masonry and cement rendering are not gas-tight. The gas space must therefore be painted with a gas-tight layer (e.g., 'Water-proofer', Latex or synthetic paints). A possibility to reduce the risk of cracking of the gas-holder consists in the construction of a weak-ring in the masonry of the digester. This "ring" is a flexible joint between the lower (water-proof) and the upper (gas-proof) part of the hemispherical structure. It prevents cracks that develop due to the hydrostatic pressure in the lower parts to move into the upper parts of the gas-holder.

c) Types of Fixed Dome Plants

d) Janata mode, The design of this plant is of Chinese origin but it has been introduced under the name “Janata biogas plant” by Gobar Gas Research Station, Ajitmal in view of its reduced cost. This is a plant where no steel is used, there is no moving part in it and maintenance cost is low. The plant can be constructed by village mason taking some pre-explained precautions and using all the indigenously available building materials. Good quality of bricks and cement should be used to avoid the afterward structural problems like cracking of the dome and leakage of gas. Substrates other than cattle dung such as municipal waste and plant residues can also be used in janata type plants.

e) The plant consists of an underground well sort of digester made of bricks and cement having a dome shaped roof which remains below the ground level is shown in Fig 3.5. At almost middle of the digester, there are two rectangular openings facing each other and coming up to a little above the ground level, act as an inlet and outlet of the plant. Dome shaped roof is fitted with a pipe at its top which is the gas outlet of the plant. The principle of gas production is same as that of KVIC model. The biogas is collected in the restricted space of the fixed dome; hence the pressure of gas is much higher, which is around 90 cm of water column

f) Deenbandhu Model

g) Deenbandhu model biogas plant was developed by AFPRO (Action for Food Production, New Delhi) in 1984. The world Deenbandhu is meant as the friend of the poor. This plant is designed on the principle that the surface area of biogas plants is reduced (minimized) to reduce their installation cost without sacrificing the efficiency of the plant. The design consists of segments of two spheres of different diameters, joined at their bases. The structure thus formed act as the digester as fermentation chamber as well as the gas storage chamber. The higher compressive strength of the brick masonry and concrete makes it preferable to go in for a

h) structure which could always be kept under compression. A spherical structure loaded from the convex side will be under compression and therefore, the internal load will not have any residual effect on the structure.

i) The digester is connected with the inlet pipe and the outlet tank. The upper part above the normal slurry level of the outlet tank is designed to accommodate the slurry to be displaced out of the digester with the generation and accumulation of biogas and is called outlet displacement chamber. The size of these plants is recommended up to 6 m3 per day. The different components

UTILIZATION OF BIOGAS

Biogas generated from anaerobic digestion processes is a clean and environmentally friendly renewable fuel. But it is important to clean, or upgrade, biogas before using it to increase its heating value and to make it useable in some gas appliances such as engines and boilers. Biogas can potentially be used in many types of equipment, including:

- Internal Combustion (Piston) Engine – Electrical Power Generation, Shaft Power

- Gas Turbine Engine (Large) – Electrical Power Generation, Shaft Power
- Microturbine Engine (Small) – Electrical Power Generation
- Stirling Heat Engine – Electrical Power Generation
- Boiler (Steam) Systems
- Hot Water Systems
- Process Heaters (Furnaces)
- Space or Air Heaters
- Gas Fired Chiller - Refrigeration
- Absorption Chiller - Refrigeration
- Combined Heat and Power (CHP) - Large and Small Scale – Electrical Power and Heat
- Fuel Cells – Electrical Power, Some Heat

There are a variety of end uses for biogas. Except for the simplest thermal uses such as odor flaring or some types of heating, biogas needs to be cleaned or processed prior to use. With appropriate cleaning or upgrade, biogas can be used in all applications that were developed for natural gas. The three basic end uses for biogas are:

a. Production of heat or steam

The most straightforward use of biogas is for thermal (heat) energy. In areas where fuels are scarce, small biogas systems can provide the heat energy for basic cooking and water heating. Gas lighting systems can also use biogas for illumination. Conventional gas burners are easily adjusted for biogas by simply changing the air-to-gas ratio. The demand for biogas quality in gas burners is low, only requiring a gas pressure of 8 to 25 mbar and maintaining H2S levels to below 100 ppm to achieve a dew point of 150 degrees C.

b. Electricity Generation or Combined Heat and Power (CHP)

Combined heat and power systems use both the power producing ability of a fuel and the inevitable waste heat. Some CHP systems produce primarily heat, and electrical power is secondary (bottoming cycle). Other CHP systems produce primarily electrical power and the waste heat is used to heat process water (topping cycle). In either case, the overall (combined) efficiency of the power and heat produced and used gives a much higher efficiency than using the fuel (biogas) to produce only power or heat. Other than high initial investments, gas turbines (micro-turbines, 25-100 kW; large turbines, >100 kW) with comparable efficiencies to spark- ignition engines and low maintenance can be used for production of both heat and power. However, internal combustion engines are most commonly used in CHP applications. The use of biogas in these systems requires removal of both H2S (to below 100 ppm) and water vapor.

Vehicle fuel

Gasoline vehicles can use biogas as a fuel provided the biogas is upgraded to natural gas quality in vehicles that have been adjusted to using natural gas. Most vehicles in this category have been retro-fitted with a gas tank and a gas supply system in addition to the normal petrol fuel system. However, dedicated vehicles (using only biogas) are more efficient than these retro- fits.

Biomass

Unsustainable biomass fuel use threatens biodiversity and increases the likelihood of further landscape damage or annihilation. South Africa aside, the sub-Saharan region uses 86 percent of Africa's biomass energy. It is important to encourage energy efficiency wherever energy access is available since even when other types of energy are available, they are not harnessed or used effectively.

However, there is an urgent need to address the existing levels of respiratory sickness from burning biomass in houses. Biomass acquired in Africa is mostly used for energy through burning. When comparing the costs of biomass and fossil fuels, it is much more cost-effective to develop the technology for burning biomass than it is to use fossil fuels. Some of the common technologies used to transform biomass fuels into greener energy include gasification and anaerobic digestion systems.

Biomass Conversion

Biomass can either be utilized directly as a fuel, or can be converted into liquid or gaseous fuels, which can also be as feedstock for industries. Most biomass in dry state can be burned directly to produce heat, steam or electricity. On the other hand, biological conversion technologies utilize natural anaerobic decay processes to produce high quality fuels from biomass. Various possible conversion technologies for getting different products from biomass is broadly classified into three groups viz. (i) thermo-chemical conversion, (ii) bio-chemical conversion and (iii) oil extraction.

Thermo-chemical conversion includes processes like combustion, gasification and pyrolysis. Combustion refers to the conversion of biomass to heat and power by directly burning it, as occurs in boilers. Gasification is the process of converting solid biomass with a limited quantity of air into producer gas, while pyrolysis is the thermal decomposition of biomass in the absence of oxygen. The products of pyrolysis are charcoal, condensable liquid and gaseous products.

Combustion, gasification and pyrolysis are all thermochemical processes to convert biomass into energy. In all of them, the biomass is heated to evaporate water and then to cause pyrolysis to occur and to produce volatiles.

Thermal conversion processes for biomass involve some or all of the following processes: Pyrolysis: Biomass +heat charcoal, gas and oil Gasification: Biomass +limited oxygen fuel gas

Combustion: Biomass +stoichiometric O2 hot combustion products

Combustion

Combustion is a process whereby the total or partial oxidation of carbon and hydrogen converts the chemical energy of biomass into heat. This complex chemical reaction can be briefly described as follows:

Burning fuel = Products from reaction + heat

During the combustion process, organic matter decomposes in phases, i.e., drying, pyrolysis/gasification, ignition of volatile substances and charcoal combustion. Generally speaking, these phases correspond to two reaction times: release of volatile substances and respective combustion, followed by charcoal combustion.

Wood, agricultural residues, wood pulping liquor, municipal solid waste (MSW) and refuse derived fuel are examples of feed stocks for combustion. Combustion requires high temperatures for ignition, sufficient turbulence to mix all of the components with the oxidant, and time to complete all of the oxidation reactions. The moisture content of the feedstock should be low and pre-drying may be necessary in some cases.

Biomass combustion starts by heating and drying the feedstock. After all of the moisture has been removed, temperature rises for pyrolysis to occur in the absence of oxygen. The major

products are hydrogen, CO, CO2, CH4 and other hydrocarbons. In the end, char and volatile gases are formed and they continue to react independently. The volatile gases need oxygen in order to achieve a complete flame combustion. Mostly CO2 and H2O result from complete combustion. When combusting biomass in a furnace, hot gases are released. They contain about

85% of the fuel's potential energy. The heat can be used either directly or indirectly through a heat exchanger, in the form of hot air or water. Boiler used for biomass combusting transfers the produced heat into steam. The steam can be used for producing electricity, mechanical energy or heat.

Gasification

Gasification is a process whereby organic matter decomposes through thermal reactions, in the presence of stoichiometric amounts of oxidising agents. The process generates a combustible gas mix, essentially composed of carbon monoxide, hydrogen, carbon dioxide, methane, steam and, though in smaller proportions, other heavier hydrocarbons and tars. The process is aimed at converting the energy potential of a solid fuel into a gas product, whose energy content has the form of chemical energy with the capacity to generate work.

Gasification is carried out in two steps. First, the biomass is heated to around 600 degrees. The volatile components, such as hydrocarbon gases, hydrogen, CO, $CO2$, $H2O$ and tar, vaporize by various reactions. The remaining by-products are char and ash. For this first endothermic step, oxygen is not required. In the second step, char is gasified by reactions with oxygen, steam and hydrogen in high temperatures. The endothermic reactions require heat, which is applied by combusting some of the unburned char. Main products of gasification are synthesis gas, char and tars. The content depends on the feedstock, oxidizing agent and the conditions of the process. The gas mainly consists of CO, $CO4$, $H2O$, $CH4$ and other

hydrocarbons. The synthesis gas can be utilized for heating or electricity production. It can also be used for the production of ethanol, diesel and chemical feed stocks.

Pyrolysis

In pyrolysis, biomass is heated in the absence of air. The process results liquid, solid and gaseous fractions, mainly gases, bio-oil and char. The gases and the bio-oil are from the volatile fraction of biomass, while the char is mostly the fixed carbon component. In the first step, temperature is increased to start the primary pyrolysis reactions. As a result, volatiles are released and char is formed. Finally, after various reactions, pyrolysis gas is formed. The main product of slow pyrolysis, a thousand of years old process, is char or charcoal. In slow pyrolysis biomass is heated to around 500 degrees for 5 to 30min.Fast pyrolysis results mainly in bio-oil. The biomass is heated in the absence of oxygen and the residence time is 0, 5 to 5s. Vapours, aerosols and char are generated through decomposition. After cooling, bio-oil is formed. The remaining non condensable gases can be used as a source of energy for the pyrolysis reactor. Calculated by weight, fast pyrolysis results in 60%-75% liquid bio-oil, 15%-25% solid char, and 10%-20% non-condensable gases.

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Types of gasifiers, producer gas and its utilization

Gasification of wood and other agricultural cellulosic residues was a common practice at the beginning of this century to produce low calorie fuel gas. Gasifiers can be suitably used for thermal decomposition of a wide range of feed materials from forestry products, agricultural residues, and aquatic biomass to municipal solid wastes.

However, some important points which should be taken into consideration while undertaking any biomass gasification system:

- A gasifier itself is of little use. It is used either to generate a combustible gas to provide heat or to generate a fuel gas which can be used in an internal combustion engine as a petroleum oil substitute.

- Some of the gaseous, liquid and solid products of combustion are not only harmful to engines and burners, but also to human beings. That is why these gases are not used as cooking gas.
- A gasifier must have an effective gas cleaning train if the gas is to be used for internal combustion engines. A maximum limit of 5-15 mg solids and tar per kg of gas may be allowed for the use of the gas in an internal combustion engine.
- A gasification system may not be of much advantage to generate a combustible gas, as far as fossil fuel savings, economies and ease of operation are concerned.

Types of gasifiers

Gasifiers are generally classified on the basis of the physical conditions of the feed stocks in the reactors. The gasifiers may be grouped into the following types:

- Dense phase reactors
- Lean phase reactors

(a) Dense phase reactors

In dense phase reactors, the feedstock fills most of the space in the reactor. They are common, available in different designs depending upon the operating conditions, and are of three types: downdraft, updraft, and cross-draft.

i) Downdraft or co-current gasifiers

The downdraft (also known as co-current) gasifier is the most common type of gasifier. In downdraft gasifiers, the pyrolysis zone is above the combustion zone and the reduction zone is below the combustion zone. Fuel is fed from the top. The flow of air and gas is downwards (hence the name) through the combustion and reduction zones. The term co-current is used because air moves in the same direction as that of fuel, downwards. A downdraft gasifier is so designed that tar, which is produced in the pyrolysis zone, travels through the combustion zone, where it is broken down or burnt. As a result, the mixture of gases in the exit stream is relatively clean. The position of the combustion zone is thus a critical element in the downdraft gasifier, its main advantage being that it produces gas with low tar content, which is suitable for gas engines.

Updraft or counter-current gasifier

In updraft gasifiers (also known as counter-current), air enters from below the grate and flows upwards, whereas the fuel flows downwards. An updraft gasifier has distinctly defined zones for partial combustion, reduction, pyrolysis, and drying. The gas produced in the reduction zone leaves the gasifier reactor together with the products of pyrolysis from the pyrolysis zone and steam from the drying zone. The resulting combustible producer gas is rich in hydrocarbons (tars) and, therefore, has a higher calorific value, which makes updraft gasifiers more suitable where heat is needed, for example in industrial furnaces. The producer gas needs to be thoroughly cleaned if it is to be used for generating electricity.

Cross-draft gasifier

In a cross-draft gasifier, air enters from one side of the gasifier reactor and leaves from the other. Cross-draft gasifiers have a few distinct advantages such as compact construction and low cleaning requirements. Also, cross-draft gasifiers do not need a grate; the ash falls to the bottom and does not come in the way of normal operation.

b) Lean phase reactors

Lean phase gasifiers lack separate zones for different reactions. All reactions – drying, combustion, pyrolysis, and reduction – occur in one large reactor chamber. Lean phase reactors are mostly of two types, fluidized bed gasifiers and entrained-flow gasifiers.

i) Fluidized bed gasifiers

In fluidized bed gasifiers, the biomass is brought into an inert bed of fluidized material (e.g. sand, char, etc.). The fuel is fed into the fluidized system either above-bed or directly into the bed, depending upon the size and density of the fuel and how it is affected by the bed velocities. During normal operation, the bed media is maintained at a temperature between 550

°C and 1000 °C. When the fuel is introduced under such temperature conditions, its drying and pyrolyzing reactions proceed rapidly, driving off all gaseous portions of the fuel at relatively low temperatures. The remaining char is oxidized within the bed to provide the heat source for the drying and devolatilizing reactions to continue. Fluidized bed gasifiers are better than dense phase reactors in that they produce more heat in short time due to the abrasion phenomenon between inert bed material and biomass, giving a uniformly high (800–1000 ºC) bed temperature. A fluidized bed gasifier works as a hot bed of sand particles agitated constantly by air. Air is distributed through nozzles located at the bottom of the bed.

Entrained-flow gasifiers

In entrained-flow gasifiers, fuel and air are introduced from the top of the reactor, and fuel is carried by the air in the reactor. The operating temperatures are 1200–1600 °C and the pressure is 20–80 bar. Entrained-flow gasifiers can be used for any type of fuel so long as it is dry (low moisture) and has low ash content. Due to the short residence time (0.5–4.0 seconds), high temperatures are required for such gasifiers. The advantage of entrained-flow gasifiers is that the gas contains very little tar.

Producer gas applications

The producer gas obtained can be used either to produce heat or to generate electricity.

Thermal applications

Producer gas can also be burnt directly in open air, much like Liquid Petroleum Gas (LPG), and therefore can be used for cooking, boiling water, producing steam, and drying food and other materials.

- Dryer: The hot gas after combustion can be mixed with the right quantity of secondary air to lower its temperature to the desired level for use in dryers in the industries such as tea drying, cardamom drying etc.
- Kilns: Firing of tiles, pottery articles, limestone and refractories, where temperatures of 800–950 °C are required.
- Boilers: Producer gas can be used as fuel in boilers to produce steam or hot water.

Power applications

Producer gas can be used for generating motive power to run either dual-fuel engines (which run on a mixture of gas and diesel, with gas replacement of up to 85% of diesel) or engines that run on producer gas alone (100% diesel replacement). In general, the fuel-to electricity efficiency of gasification is much higher than that of direct combustion: The conversion efficiency of gasification is 35%–45% whereas that of combustion is only 10%– 20%. Generated electricity can be fed into the grid or can be used for farm operations, irrigation, chilling or cold storage, and other commercial and industrial applications.

Conditions and requirements for implementation

Biomass gasifier needs uniform-sized and dry fuel for smooth and trouble-free operation. Most gasifier systems are designed either for woody biomass (or dense briquettes made from loose biomass) or for loose, pulverized biomass.

Woody biomass:

- Pieces smaller than 5–10 cm (2–4 inches) in any dimension, depending on design
- Bulk density of wood or briquettes: less than 250–300 kg/m3

Loose biomass:

- Pulverized biomass, depending on design
- Moisture content up to 15%–25%, depending on gasifier design
- Ash content below 5% preferred; with a maximum limit of 20%
- Bulk density of loose biomass is less than 150 kg/m3

Horizontal integration potential

As there are systems available from less than 1 watt to several megawatts, solar and wind energy are incredibly scalable. This enables the electrification of a home or community to be started with a small amount of initial funding. Additionally, it enables dynamic and gradual scalability as load demands rise. A level of functional redundancy is also provided by the component layout of a wind or solar project, enhancing system dependability. A multi-panel solar array can continue to operate normally even if one of its panels is destroyed. The failure of one wind tower in a multi-tower setup similarly does not result in a system-level failure.

Solar and wind energy projects offer a safe, dependable, and economical solution since they generate power close to where it is needed. These systems are more secure and less prone to assault because transmission equipment is avoided. In areas prone to warfare, this trait may be crucial. The installation, operation, maintenance, and repair of wind and solar power systems are all straightforward. Rural people in isolated and other low-density locations that are impossible to service with conventional grid-based systems can get all of the electrical energy they need from wind and solar resources, which are plentiful enough to do so.

Finance

Costly items include photovoltaic panels, wind turbines, deep cycle batteries, metres, sockets, cables, and connectors. Renewable energy will continue to be pricey for persons who make less than US$1 per day, even after accounting for the relative differences in purchasing power, material costs, opportunity costs, labour costs, and overhead. Government subsidies have been used to finance the implementation of rural development programmes in a number of rural electrification projects in the past. It is challenging for for-profit businesses to complete rural electrification projects; in economically depressed areas, these initiatives must be run at a loss due to practical considerations. There are a number of theories as to how particular African countries could mobilise the funding for such initiatives.

Potential funding sources

Through emissions trading credits, European nations that use oil refined in African nations can support the price of individual, village, or community-level alternative energy systems. It has been suggested that a specific number of carbon credits or green credits would be produced for each unit of carbon of African origin that the European market consumed. Then, the European partners might either directly provide parts, components, or systems, as well as an equivalent amount of investment capital, or they may lend credits to support the distribution of renewable energy services, expertise, or equipment.

International aid intended to fight poverty could be transferred to fund renewable energy initiatives. Funding for rural electrification can be viewed as the main strategy for combating poverty because of the crucial role that electrification plays in fostering economic and social development. Access to electricity is necessary for the operation of computers, computer networks, radios, and televisions. Funding the electric infrastructure for such systems has a direct impact on their development because information services enable the multiplication of educational resources. In this sense, having access to communications and education helps to significantly lower poverty. Additionally, multinational initiatives that provide goods and services rather than cash are more resilient to issues caused by resource misappropriation in less stable regimes.

UNEP has created a loan scheme to encourage the market for renewable energy with enticing return rates, cushion the expense of initial deployment, and encourage consumers to think about and buy green technology. Following the success of a UNEP-sponsored solar loan programme that helped 100,000 people finance solar power systems in developing nations like India, UNEP began similar programmes in other developing regions of the world like Africa. Projects in Tunisia, Morocco, and Kenya are already operational, and many more in other African countries are in the pipeline. In Africa, draught National Climate Awareness Plans, publications in regional languages, radio programmes, and seminars have all been adopted as a consequence of UNEP assistance to Ghana, Kenya, and Namibia. Another major UNEP initiative, the Rural Energy Enterprise Development (REED) initiative, focuses on business development and seed funding for clean energy entrepreneurs in developing nations in West and Southern Africa.

The South African Government established the South African Renewables Initiative (SARi) to create a finance structure that would facilitate the development of a critical mass of renewables in South Africa through a combination of foreign grants and loans and local investment. With four rounds of allocations already completed, this initiative has been extremely successful and is now known as the REIPPP (Renewable Energy Independent Power Producer Program). Round 1 saw the allocation of 19 projects, round 2 saw the allocation of 28, Round 3 saw the allocation of 17, and Round 4 saw the allocation of 26 projects. A total of R194 billion (US$16 billion) has been spent in this scheme, which includes the allocation of more than 6100MW. It is significant to emphasise that there are no government subsidies for this initiative; instead, the complete funding for this investment comes from banks and private organisations.

Energy sector regulators as facilitators

The legitimacy of the organisations creating and carrying out RE policies affects the ability to finance RE initiatives. This puts a heavy responsibility on African energy regulators, who may have a small professional team and a track record of only a decade or so. Regulators make rules (micro policies) that are secondary to the overall government RE policy and rely on some state transfer of authority. However, there are times when the sector regulator can take the initiative on behalf of utility and customer concerns by offering information, reports, and public remarks that support the need for caution in the development of public policy regarding RE.

Many organisations are undoubtedly concerned in clean and renewable energy. In order to coordinate policies, incentives, and administrative procedures when various authorities are involved, coordination is necessary (including licencing and permitting). Regulators' responsibility to resolve particular cases or disputes is, of course, inherent in and incidental to their ability to make policy. This micro policy-making function results from the fact that it is unreasonable to expect macro RE policy to foresee every area of policy that will need to change for the regulatory process to be completely functional. With its constantly evolving technologies and shifting public (and political) attitudes, the field of renewable energy bears special attention to this point. There will be gaps that need to be filled, and the regulators are best equipped to do so in emerging nations due to their functional responsibilities, technical know-how, and practical experience. The energy sector regulator therefore significantly affects the uptake of RE in Africa and other regions through the design of purchasing power auctions, the establishment of feed-in tariffs, and other tools encouraging RE.

Renewable energy use

Solar power

In Africa, there are several large-scale solar power facilities being built, including ones in Algeria and South Africa. The greatest potential for solar power technology in Africa may be to provide power on a smaller scale and to use this energy to help with day-to-day needs like small-scale electrification, desalination, water pumping, and water purification. Although solar power technology has the potential to supply energy to large numbers of people and has been used to generate power on a large scale in developed nations, this is not necessarily true in Africa.

The 8.5MW plant at Agahozo-Shalom Youth Village, in the Rwamagana District, Eastern Province of Rwanda, is the region's first utility-scale solar farm. In order to accommodate and educate Rwandan genocide victims, it leased 20 hectares (49 acres) of property from the village. The facility generates 6% of the nation's total electricity supply and makes use of 28,360 solar panels. The project was developed with financing and expertise from the US, Israel, the Netherlands, Norway, Finland, and the UK.

In Africa, there are numerous instances of modest grid-connected solar power plants, such as the photovoltaic 250 kW Kigali Solaire station in Rwanda. The 96MW(DC) Jasper Solar Energy Project, the 75MW(DC) Lesedi PV Project, and the 75MW(DC) Letsatsi PV Project, all developed by the American company Solar Reserve and finished in 2014, are just a few of the projects that have been developed under the South Africa Renewable Energy Independent Power Producer Procurement Program.

Power Up Gambia, a non-profit organisation operating in The Gambia, supplies electricity to Gambian healthcare institutions, offering a dependable supply of power for lighting, diagnostic tests, therapies, and water pumping. Using solar energy for schools, health clinics, and community charging stations, the West African non-profit organisation Energy for Opportunity (EFO) also instructs photovoltaic installation programmes at regional technical colleges. The majority of its efforts to date has been in Sierra Leone. Its solar-powered Community Charging Stations in particular have been acknowledged as a creative strategy for supplying electricity to rural people in the area.

There are some ideas to construct solar farms in the North African deserts to provide electricity for Europe. The Desertec project sought to produce renewable power in the Sahara Desert and distribute it over a high-voltage system for export to Europe and domestic use in North Africa. It was funded by numerous European energy corporations and banks. Ambitions aim to supply up to 15% of continental Europe's electricity. 2GW of solar-generated electricity would be sent from Tunisia to the UK as part of the TuNur project.

Solar water pumping

The lack of access to clean drinking water is one of the most serious and deadly issues that many third world nations are currently confronting. Using a combination of solar powered well pumping, a water tower or other holding tank, and a solar powered water purifier, solar powered solutions can assist ease this issue at a low cost. Once installed, these technologies will contribute to the provision of clean water for drinking and agricultural use while requiring little maintenance and having low operating costs. A community will be better able to weather drought or famine if there are large enough reservoirs for the water that has been pumped and filtered using solar-powered technology. This reservoir water could be used to irrigate community gardens and fields, increase crop yields, and benefit human and animal consumption. Many viruses and bacteria can be removed from groundwater and runoff using a solar-powered water purifying system. These gadgets, which filter water from wells or runoff, could aid in improving sanitation and reducing the spread of waterborne diseases. Due to its forward-thinking and comparatively well-funded agriculture department, which includes the Kenya Agricultural Research Center, which finances and oversees numerous projects looking at experimental techniques and technologies, Kenya may be an excellent choice for testing out these systems.

The low cost of operation and maintenance, as well as the capacity to function without fuel, make solar-powered systems more affordable to maintain over time, even though their initial cost may be higher than that of conventional fossil fuel. After the initial equipment purchase and setup, a small rural village could operate a system like this indefinitely and it would offer clean drinking water for very little money. It may at least help with the water supply and ease the strains of daily existence in a larger population. Only the amount of water present in the water table can prevent this technology from pumping hundreds of gallons of water every day. Solar-powered water pumping and purification devices have the potential to help rural Africans meet one of their most fundamental demands for survival with a minimum of training in operation and maintenance. These small-scale solar technology applications seem promising, and more field tests are being conducted by groups like KARI and the several businesses that make the necessary products. Solar power is an excellent contender to bring the advantages of technology to the arid plains of Africa when combined with sustainable farming methods and resource conservation. Gathering runoff rainwater during the wet season for use later in a drought would supplement the well water. SEARNET, an information-sharing network for Southern Africa, teaches farmers how to collect and store rainwater. Some farmers report improved yields and extra harvests as a result. Greater sustainability of water resources has been achieved in the nations of Botswana, Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda, Zambia, and Zimbabwe as a result of this new network of farmers exchanging ideas with one another. This water could be passed through a purifier to produce water fit for drinking or for use by livestock or in agriculture.

Examples

In order to make up for the land that was lost to oil drilling, a solar-powered water pump and holding system was put in place in Kayrati, Chad, in 2004.

The photovoltaic panel array in this system powers a common well pump. The pumped water is kept in a water tower where it is under pressure until it is delivered to nearby dwellings. This example of leveraging revenues to raise the standard of living in rural areas uses oil revenue to create infrastructure.

Similar functions are carried out by hundreds of solar water pumping stations in Sudan, involving several applications of diverse pumping and storage methods. 250 solar water pumps have been erected in Sudan over the previous ten years, about. There has been significant advancement, and the current generation of systems appears to be trustworthy and economical under some circumstances. A solar array of about 800 Wp is needed for a photovoltaic pumping system to pump 25 cubic metres per day. Since the entire system includes the cost of modules, the pump, the motor, the piping, the wiring, the control system, and the array support structure, such a pump would cost US$6000. In the Sudanese state of Kordofan, PV water pumping has been effectively promoted. It has better economics than diesel pumps and eliminates the need to keep a steady supply of fuel on hand. The breakdown of pumps, not the failure of the PV devices, is the only cause of maintenance issues with PV pumping.

An Australian business created and produced the Solar Water Purifier, a low-maintenance, low-cost device that can filter enormous volumes of water, including seawater, to levels that are better than the World Health Organization's requirements for human consumption. UV light and evaporation are how this device operates. The black plastic layer beneath the top layer of glass receives light through the glass. The water and the black plastic both absorb sun radiation's heat. As the water evaporates and trickles down the levels, this plastic layer is made up of a network of connected troughs that segregate it. As the water passes through the apparatus, it is also exposed to UV light for a long time, which destroys several bacteria, viruses, and other diseases. This gadget can filter up to 45 litres of water each day from a single array in a sunny, equatorial region like much of Africa. For increased capacity, additional arrays may be chained together.

In order to help people, drink water free of pathogens and disease-causing microorganisms, The Water School now uses SODIS sun disinfection in target areas of Kenya and Uganda. A UV procedure called SODIS eliminates waterborne pathogens by destroying them. With more than 20 years of research, the SODIS system's science has been established.

Wind power

The largest wind farm on the planet is the Koudia Al Baida Farm in Morocco. In Tarfaya and Tangier, two other sizable wind farms are being built.

In Marsabit County, Kenya is constructing the Lake Turkana Wind Power (LTWP) wind farm. The project will enhance the country's electricity supply while generating jobs and lowering greenhouse gas emissions as Africa's largest wind farm. 310 MW of wind energy will be generated by LTWP at full capacity.

The Gambia's Batokunku village saw the construction of the region's first wind turbine in January 2009. The 2,000-person town receives electricity from the 150-kilowatt turbine.

Wind Energy

Wind is simple air in motion. It is caused by the uneven heating of the earth‟s surface by the sun. Since the earth‟s surface is made of very different types of land and water, it absorbs the sun‟s heat at different rates. Energy derived from wind velocity is wind energy. It is a non- conventional type of energy, which is renewable with suitable devices. This energy can be used as a perennial source of energy. Wind energy is obtained with the help of wind mill. The minimum wind speed of 10kmph is considered to be useful for working wind mills for agricultural purpose. Along the sea coast and hilly areas, wind mills are likely to be most successful in Karnataka, Maharastra and Gujarat. The wind energy over earth is estimated to be 1.6×107 M.W, which is equivalent to the energy consumed. But the wind energy is available in dilute form. The conversion machines are large. The wind energy varies from time to time and place to place. Due to this reason some storage facility is required. The kinetic energy of wind is converted into useful shaft power by wind mills. General applications of wind mills are pumping water, fodder cutting, grain grinding, generation of power etc. In India, wind speed lies between 5 kmph-20 kmph. The high wind velocity is seasonal. The wind energy, if used for power generation, it will be uncertain to generate power. In India, wind power can be used for lifting water in rural areas for drinking and for irrigation purpose.

Factors affecting the wind

- Latitude of the place
- Altitude of the place.
- Topography of the place 4. Scale of the hour, month or year

Suitable places for the erection of wind mills

- Off-shore and on the sea coast: An average value is 2400 kWH/m2/year
- Mountains: An average value is 1600 KWH/m2/year
- Plains: An average value is 750 KWH/m2/year

Places unsuitable for wind mills

- Humid equatorial region- there is virtually no wind energy
- Warm, windy countries, wind energy may not be usual because of the frequency of cyclones

Types of wind mills

There are two types of wind machines (turbines) used today based on the direction of the rotating shaft (axis): horizontal–axis wind machines and vertical-axis wind machines. The size of wind machines varies widely. Small turbines used to power a single home or business may have a capacity of less than 100 kilowatts. Some large commercial sized turbines may have a capacity of 5 million watts, or 5 megawatts. Larger turbines are often grouped together into wind farms that provide power to the electrical grid.

Vertical axis wind mills

a) Savonius or S type wind mill (low wind velocity)

b) Darrius wind mill (high wind velocity)

Horizontal axis wind mills

c) Single blade wind mills

d) Double blade wind mills

e) Multi blade wind mills

f) Bicycle multiblade type i.e., Sail type

Vertical axis wind mills

Vertical axis machines are of simple design as compared to the horizontal axis. The axis of rotation of vertical axis wind turbine is vertical to the ground and almost perpendicular to the wind direction. These turbines can receive wind from any direction. Hence complicated yaw devices can be eliminated. The generator and the gearbox of such systems can be housed at the ground level, which makes the tower design simple and more economical. Moreover, the maintenance of these turbines can be done at the ground level. The major disadvantage of vertical axis machines is that, these turbines usually not self-starting. Additional mechanism may be required to push and start the turbine, once it is stopped.

Vertical axis wind mill

a) Savonius wind mill

It works on the principle of cup anemometer. This machine has become popular, since it requires low wind velocity for operation. It consists of two half cylinders, which are mountedon a vertical axis perpendicular to the direction of wind, with a gap at the axis between the two cylinders. Two half cylinders facing each other forming an „s" shaped cross-section. Irrespective of the wind direction, the rotor rotates such as to make the convex sides of the buckets head into the wind. From the rotor shaft, we can tap power for our use like water pumping, battery charging, grain winnowing etc.

The main action of the wind is very simple, the force of the wind is greater on the cupped face than on rounded face. A low pressure is created on the convex sides of drums. Torque is produced by the pressure difference between the two sides of the half cylinders facing the wind. This design is efficient but requires a large surface area. A savonius wind energy conversion system has a vertical axis which eliminate the expensive power transmission system from the rotor to the axis. Since it is a vertical axis machine it does not matters much about the wind direction. The machine performs even at lower wind velocity ranges (i.e., 8 kmph).

b) Darrieus wind mill

Added advantage with this mill is that it supports its blades in such a way that minimizes bending stresses in normal operation. It requires less surface area as compared to Savonius type. In this machine, the blades are curved and attached to the hubs on the vertical shaft at both ends to form a cage-like structure. The blades look like an egg beater. Darrieus rotors have three symmetrical aerofoil blades, both ends of which are attached to a vertical shaft. Thus, the force in the blade due to rotation is pure tension. This provides a stiffness to withstand the wind forces it experiences.

The blades are made lighter than in the propeller type. When rotating, these aerofoil blades provide a torque about the central shaft in response to a wind direction. This shaft torqueis transmitted to a generator at the base of the central shaft for power generation. Both Savonius and darrieus type rotors run independently of the direction of wind because they rotate about a vertical axis. Major advantage of darrieus wind mill is that the rotor blades can accept the wind from any point of the compass. The machine can be mounted on the ground eliminating the tower structures. Disadvantage is that, it may experience lower velocity wind when compared to tower mounted conventional wind energy conversion system.

Horizontal axis type wind mills

Horizontal axis wind turbines have their axis of rotation horizontal to the ground and almost parallel to the wind stream. Most of the commercial wind turbines fall under this category. Horizontal axis machines have some distinct disadvantages such as low cut-in speed and easy furling. In general, they show relatively high-power coefficient. However, the generator and gearbox of these machines are to be placed over the tower which makes its design more complex and expensive. Depending on the number of blades, horizontal axis wind turbines are further classified as single bladed, two bladed, three bladed and multi bladed.

Horizontal axis wind mill

The horizontal type wind mills have thin cross-section or more efficient thick cross- section of aerofoil blade. The blade is designed such that the tip of the blades makes a small angle with the plane of rotation and almost at right angles to the direction of wind. In a modern wind turbine, the velocity of blades is six times the wind velocity. Ideally, the blade should be twisted, but because of construction difficulties this is not always achieved. The horizontal axis wind mills generally have better performance. These are mainly used for electric power generation and pumping water.

Horizontal axis propeller type wind mill with single blade

In this type of machine, a long blade is mounted on a rigid hub. Induction generator and gear box are arranged

hub, large blade root bending moments may occur due to tower shadow, gravity and sudden shiftsin the wind directions. To reduce rotor cost, use of low-cost counter weight is recommended for balancing long blade centrifugally.

Horizontal Axis Single Blade Wind Mill

a) Horizontal axis - two blade wind mill

In this type of design, rotor drives a generator through a step-up gear box. The blade rotor is designed to be oriented downwind of the tower. The components are mounted on a bedplate, which is attached on a pintle at the top of the tower. The rotor blades are continuously flexed by unsteady aerodynamic, gravitational and inertial loads, when the machine is in operation. If the blades are made of metal, flexing reduces their life due to fatigue loading. With rotor, the tower is also subjected to above loads, which may cause serious damage. If the vibrational modes of the rotor happen to coincide with one of the natural modes of vibration of the tower, then the mill may get damaged. Due to high cost of blades, the rotor with more than two blades is not recommended. Rotors more than two, say 3 or 4 blades would have slightly higher coefficient. Horizontal axis two blade wind mill

b) Horizontal axis-multi blade type wind mill

This type of design for multi blades made from sheet metal or aluminum. The rotors have high strength to weight ratios and are strong enough to with stand a wind speed of 60 Kmph. This type of wind mills has good power coefficient, high starting torque, simple and are low in cost.

c) Sail type wind mill

It is recent development in wind mills. The blades are made by stretching out triangular pieces of canvas cloth or nylon or plastics (Fig.13.9). There is also variation in the number of sails used. It runs at 60 to 80 rpm.

Construction details and application of wind mills

Construction details

There are two classes of windmill, horizontal axis and vertical axis. The vertical axis design was popular during the early development of the windmill. However, its inefficiency of operation led to the development of the numerous horizontal axis designs.

Of the horizontal axes versions, there are a variety of these including the post mill, smock mill, tower mill, and the fan mill. The earliest design is the post mill. It is named for the large, upright post to which the body of the mill is balanced. This design gives flexibility to the mill operator because the windmill can be turned to catch the most wind depending on the direction it is blowing. To keep the post stable a support structure is built around it. Typically, this structure is elevated off the ground with brick or stone to prevent rotting.

The post mill has four blades mounted on a central post. The horizontal shaft of the blades is connected to a large break wheel. The break wheel interacts with a gear system, called the wallower, which rotates a central, vertical shaft. This motion can then be used to power water pumping or grain grinding activities.

The smock mill is similar to the post mill but has included some significant improvements. The name is derived from the fact that the body looks vaguely like a dress or smock as they were called. One advantage is the fact that only the top of the mill is moveable. This allows the main body structure to be more permanent while the rest could be adjusted to collect wind no matter what direction it is blowing. Since it does not move, the main body can be made larger and taller. This means that more equipment can be housed in the mill, and that taller sails can be used to collect even more wind. Most smock mills are eight sided although this can vary from 6 to 12.

Tower mills are further improvements on smock mills. They have a rotating cap and permanent body, but this body is made of brick or stone. This fact makes it possible for the towers to be rounded. A round structure allows for even larger and taller towers. Additionally, brick and stone make the tower windmills the most weather resistant design.

While the previous windmill designs are for larger structures that could service entire towns, the fan-type windmill is made specifically for individuals. It is much smaller and used primarily for pumping water. It consists of a fixed tower (mast), a wheel and tail assembly (fan), a head assembly, and a pump. The masts can be 10-15 ft (3-15 m) high. The number of blades can range from four to 20 and have a diameter between 6 and 16 ft (1.8-4.9 m).

Raw Materials

Windmills can be made with a variety of materials. Post mills are made almost entirely of wood. A lightweight wood, like balsa wood, is used for the fan blades and a stronger, heavier wood is used for the rest of the structure. The wood is coated with paint or a resin to protect it from the outside environment. The smock and tower mills, built by the Dutch and British prior to the twentieth century, use many of the same materials used for the construction of houses including wood, bricks and stones.

The main body of the fan-type mills is made with galvanized steel. This process of treating steel makes it weather resistant and strong. The blades of the fan are made with a lightweight, galvanized steel or aluminum. The pump is made of bronze and brass that inhibits freezing. Leather or synthetic polymers are used for washers and O-rings.

Application of wind energy:

a) Mechanical application: mainly (water pumping) multi-blade windmill used for water pumping shown below:

water pumping system using wind mill

b) Electricity generation: Wind turbines vary in size and type. They are commercially available for electricity generation. Size of wind turbines (400 Watt-5 MW)

c) Industrial Applications

The number of dedicated industrial applications for wind power continues to grow. Small wind power systems are ideal for applications where storing and shipping fuel is uneconomical or impossible. Wind power is currently being used for the following applications:

- Telecommunications
- Radar
- Pipeline control
- Navigational aids
- Cathodic protection
- Weather stations/seismic monitoring
- Air-traffic control

Wind machines in industrial applications typically encounter more extreme weather than home power systems and must be designed to be robust with very minimal maintenance.

Several wind farms are already operating in the country commercially as a result of the South African REIPPP. The Eastern, Northern, and Western Cape provinces currently have these wind farms in operation. Ten farms are reportedly currently operational or under construction, and 12 more have received approval via the fourth round of the REIPPP.

Geothermal power

The Great Rift Valley's geothermal potential has only so far been fully utilised by Kenya. Three operational geothermal plants and twenty potential drilling sites have been designated for survey in Kenya, which is thought to have 10,000 MWe of geothermal energy potential. The largest geothermal power plant in the continent, Olkaria II, is located in Kenya, which was the first nation in Africa to utilise geothermal energy in 1956. Kengen also runs Olkaria I. Olkaria III is a different facility that is privately owned and run.Ethiopia has one binary-cycle plant, but because to insufficient operational experience, it does not use all of its potential energy output. Zambia has various areas set aside for construction, however due to a lack of funding, their projects have stopped. Although they have not built any kind of power plant, Eritrea, Djibouti, and Uganda have conducted preliminary exploration for prospective geothermal sources.

African agricultural enterprises have made use of geothermal energy. The greenhouse at the Oserian flower farm in Kenya is powered by a number of steam wells that Kengen abandoned. In addition, steady greenhouse temperatures are maintained using the heat generated by the geothermal process. Additionally, the heat can be used for cooking, reducing the reliance on wood burning.

Finance

Future geothermal plant exploration and construction are expensive for developing nations. Drilling possible locations alone can cost millions of dollars and have a zero-energy return if the heat and steam are inconsistent. It may take years for geothermal energy investments to pay off in terms of return on investment compared to fossil fuels, but in the long run, geothermal energy is more advantageous due to its low maintenance costs and renewable nature. Kenya enjoys substantial financial support from the World Bank as a pioneer in geothermal energy and a successful user of it. Conferences on development are held there between officials from the African governments and the UN Environment Program.

Sustainability As Amajor Requirment

Sustainability is defined by the United Nations as "filling the requirements of the present without compromising the ability of future generations to meet their own needs" (the Brundtland Commission of the UN popularised the phrase in 1987). When everyone, everywhere can meet their basic needs forever, that is when sustainability truly exists.

According to the definition of sustainability provided above, sustainable energy is defined as energy that satisfies current demands without endangering the ability of future generations to satiate their own needs. Finding clean, self-renewing energy sources rather than resources that can run out of fuel is the goal of sustainable energy.

We will never run out of or exhaust sustainable energy. It never runs out. Many energy sources can be categorised as sustainable. In addition to the three sources that are most frequently thought of—wind, solar, and water there are geothermal and bioenergy as well. The technique of generating energy from biological materials like straw, dung, and other agricultural leftovers is known as bioenergy. Geothermal energy is generated by the internal energy systems of the Earth, such as geysers.

Through increased energy efficiency and conservation, energy sustainability can also be attained. Although the most widely used energy sources, such as coal and natural gas, may be adequate for our current needs, at the pace we're utilising them, we'll burn through them and leave nothing for our children. Then, future generations will be compelled to find new ways to produce energy, which is something we may currently be doing.

Sustainable energy is not only continuously replenished by nature, but it also doesn't pollute the environment because it doesn't generate any greenhouse gases or other pollutants.

Generally speaking, fossil fuel sources are much less sustainable than renewable energy sources like wind, hydroelectric power, solar, and geothermal energy. However, some renewable energy initiatives, like the logging of forests to make biofuels, can seriously harm the environment. There has been debate over the place of non-renewable energy sources in sustainable energy. The sustainability of nuclear power has been questioned because to worries about radioactive waste, nuclear proliferation, and accidents despite the fact that its past death rates are comparable to those of wind and solar. Natural gas is an environmentally preferable alternative to coal, and it has a lesser climatic impact, but it may delay the transition to more sustainable solutions. Power plants can be designed with carbon capture and storage systems to reduce their carbon dioxide (CO2) emissions, but these systems are expensive and are rarely used.

85 percent of the world's energy needs are met by fossil fuels, and the energy sector is also to blame for 76 percent of greenhouse gas emissions. Around 2.6 billion people in developing nations use polluting fuels like wood or charcoal to cook, and 790 million do not have access to electricity. A system-wide revolution of the way energy is produced, delivered, stored, and used is necessary to reduce greenhouse gas emissions to levels commensurate with the 2015 Paris Agreement. The burning of biomass and fossil fuels is a significant cause of air pollution, which is thought to be responsible for 7 million fatalities annually. As a result, the shift to a low-carbon energy system would also significantly improve human health. There are ways to achieve the climate goals of universal access to energy and clean cooking while also benefiting the health and economy of poor nations.

The world quickly phased out coal-fired power plants, produced more electricity from clean sources like wind and solar, and shifted toward using electricity instead of fuels in sectors like transportation and building heating, according to proposed climate change mitigation pathways that are compatible with keeping global warming to 2 °C (3.6 °F). Many pathways describe a growing role for hydrogen fuel derived from low-emission energy sources for some energy-intensive technologies and processes that are challenging to electrify. Electrical networks need to be flexible through infrastructure like energy storage to support higher percentages of variable renewable energy. Buildings and transportation systems would need to be modified to employ renewable energy sources while also conserving energy if significant reductions in emissions were to be achieved. Some essential technologies for removing energy-related greenhouse gas emissions are still in the early stages of development.

8.5 percent of the electricity used worldwide in 2019 came from wind and solar energy. This proportion has increased significantly as expenses have decreased and are anticipated to continue decreasing. According to the Intergovernmental Panel on Climate Change (IPCC), between 2016 and 2035, the global energy system will need to receive investments totalling 2.5 percent of the world's gross domestic product (GDP). Government policies that support the transition of the energy system should be well thought out in order to reduce greenhouse gas emissions and enhance air quality. They frequently improve energy security as well. The construction of infrastructure to promote electrification and environmentally friendly transportation is one of the policy measures, along with carbon pricing and renewable portfolio standards. Funding research, development, and demonstration of new clean energy technologies is also an important role of the government.

Environmental Impact.

Climate change, air pollution, biodiversity loss, the discharge of chemicals into the environment, and water scarcity are just a few of the environmental issues that the existing energy system exacerbates. As of 2019, burning fossil fuels provides 85% of the world's energy needs. As of 2018, 76 percent of yearly greenhouse gas emissions created by humans were a result of energy production and consumption. Achieving this objective will demand that emissions be decreased as soon as feasible and achieve net-zero by the middle of the century. The 2015 worldwide Paris Agreement on climate change intends to limit global warming to well below 2 °C (3.6 °F) and preferably to 1.5 °C (2.7 °F).

The burning of biomass and fossil fuels is a significant contributor to air pollution, which is thought to be the cause of 7 million fatalities annually. The primary source of pollutants that react with atmospheric oxygen to form acid rain is the combustion of fossil fuels in factories, power plants, and automobiles. The second most common reason for non-infectious disease deaths is air pollution. More than the World Health Organization's recommended limits of air pollution are present where 99 percent of the world's population resides.

Nearly all indoor air pollution, which is thought to be the cause of between 1.6 and 3.8 million annual fatalities, is brought on by cooking with polluting fuels like wood, animal dung, coal, or kerosene. It also considerably increases outdoor air pollution. Women, who are likely to be in charge of cooking, and young children are more at risk for health repercussions.

Beyond combustion by-products, environmental effects also exist. Marine life is harmed by oil spills, which can also start fires that emit harmful fumes. Approximately 10% of the world's water supply is used for energy generation, primarily for cooling in thermal energy facilities. This increases the scarcity of water in dry areas. Water is also needed in significant quantities for the extraction of oil and for the production of bioenergy. Desertification and other major local environmental harm can result from over collection of wood and other combustible materials for burning.

UNECE published a lifecycle analysis of the environmental effects of various electricity generation technologies in 2021, considering the following: resource use (minerals, metals); land use; resource use (fossils); water use; particulate matter; photochemical ozone formation; ozone depletion; human toxicity (non-cancer); ionising radiation; human toxicity (cancer); eutrophication (terrestrial, marine, freshwater); ecotoxicity (freshwater); acidification; climate change.

Global Warming

On June 29, 2021, Lytton BC tipped over 49.6° C, and rural, Canadian town was suddenly one of the hottest places on the planet. Twenty-four hours later the town was gone, razed to the ground by wildfire. It is difficult to imagine a clearer signal that our world is becoming more unpredictable, and if we do not change course quickly, more unliveable.

Impacts of Global Warming To Uganda

Over the past fifty years, warming is of approximately 0.5°C throughout the entire continent of africa, accompanied by a change in the characteristics of extreme climatic events. Compared to the pre-industrial period, anthropogenic global warming has reached 1.1°C, or between 0.8°C and 1.2°C locally and is continuing at a rate of 0.2°C per decade. If nothing is done, this will reach 1.5°C between 2030 and 2052.

However, this climate change is not uniform, even across the African continent, In northern Uganda, periods of drought are expected to be increasingly long, although most models predict an increase in heavy rainfall with increased flood risks in urban areas. In the eastern Uganda particularly in Bududa, heavy rains could cause landslides that would affect populations living in makeshift dwellings. While in the northern Uganda, droughts will become increasingly frequent with longer and more intense heatwaves. In central Uganda, most models agree on a significant decrease in rainfall. However, these impacts will be reduced if the temperature increase is limited to 1.5°C rather than reaching 2°C.

Priority projects for global warming mitigation and adaptation

Most of the proposed solutions, which are related to water, sustainable agriculture and renewable energy sources, do not incorporate biodiversity, ecosystems and their services. The widespread degradation of terrestrial ecosystems reduces their carbon capture potential and makes them a major source of greenhouse gas emissions.

On this point, Africa holds a strong hand, hence the need to re direct with actions to protect natural forests, restore wetlands and promote sustainable agricultural practices, but the challenges remain enormous, the challenge is to increase access to energy while limiting the use of fossil fuels and to improve agricultural yields to ensure food security for a growing population without negatively impacting the soils and biodiversity.

Obstacles to the implementation of these global warming adaptation and mitigation solutions are encountered in Uganda

There is a problem with the availability of financial resources and access to green funds, projects are very complicated to set up: States need to be supported so that they can mobilize more funding. Secondly, project monitoring, evaluation, reporting and verification systems are difficult to develop and operate. In the long term, this hinders the mobilization of additional resources.

To solve this problem, the regulatory legislative framework must be better adapted to the local context of each country. The value of carbon dioxide must also be increased, especially when it is captured by a vulnerable community or country, and funding for projects to reduce greenhouse gas emissions must therefore be increased accordingly.

Also, there is a significant need for expertise that is relevant to local contexts. The sustainability of many of the projects being funded for the introduction of renewable energy is not guaranteed. For example, the African Development Bank's major "Desert to Power" initiative, which aims to reinforce electrification throughout the Sahelian belt, intended to mobilize a huge amount of funding without necessarily taking into account all the parameters of its implementation. There is a lot of desert dust in this region and a considerable amount of water will be needed for washing the solar panels, yet water is, or will be, in short supply. In some villages, people end up returning to diesel because it guarantees constant access to power. Importing technologies is therefore not sufficient, but reflecting on the sustainability of the proposed solutions in an African context is essential for the State that is getting into debt, for the populations that will use these solutions and for the donors that finance them.

Virtuous initiatives in global warming mitigation and adaptation

Unlike adaptation actions, which have short- and medium-term effects, the impacts of mitigation actions are only visible in the long term. They attract little attention. One solution is to target actions that are both beneficial for mitigation and adaptation, and especially economically viable actions.

For example, the second-hand cars and motorcycles that flood into the Ugandan market cause a significant amount of pollution. This has an impact on the regional climate but also on the health of the populations and has an enormous cost, financing an air quality management policy will help reduce greenhouse gas emissions and improve people's well-being while reducing the State's public health spending.

Similarly, to reduce charcoal use and deforestation, it is important to maintain butane gas subsidy policies and ensure that they benefit rural households. At the same time, income-generating activities other than logging need to be identified.

Butane gas subsidy

subsidized butane gas is used for irrigation and household tasks, A proposed reform of the system of butane subsidies could substantially increase energy costs for some consumers, potentially increasing energy poverty and pushing some rural consumers toward cooking on open fires, this means a subsidy swap replacing subsidies to fossil fuels with renewable energy could allow the removal of fossil fuel subsidies and promote a transition to clean energy. Two technologies solar irrigation pumps and solar thermal collectors could potentially offset the use of butane and reduce the cost of butane subsidies. However, policies are needed to overcome high upfront costs. This report reviews how butane subsidies can be reformed, how the impacts on consumers can be managed and how some of the savings can be reallocated to promote a transition to clean energy.

The IPCC report shows that there are many synergies, but also points out sources of tension between achieving the SDGs and keeping global warming below 1.5°C.

The agenda 2030 Declaration states that: "Climate change is one of the greatest challenges of our time and its impact may prevent some countries from achieving sustainable development." In Africa more than anywhere else, synergies between climate action and sustainable development must be created.

Climate change could compromise the development of African countries with low adaptive capacities. SDG 13 on combating climate change expresses this intrinsic link but lacks constraints. It does not set a temperature threshold, years for peak emission levels or a quantified mitigation target. On the operational level, there is a risk of numerous declarations being made without any real ambition to stay below the 2°C threshold.

Attaining SDG 6 on clean and accessible water for all may be jeopardized by increased investment in sectors that extract water for other uses, such as irrigation (by the growing number of agribusinesses), mining and hydropower. These are development choices that sometimes-run counter to Agenda 2030, creating pronounced inequalities.

The African continent has thus become a laboratory for change in response to global warming, Investing in environmental education from an early age. This will allow the younger generation in Africa to feel involved in preserving the environment for future generations.

For a long time, there has been a gulf between the sustainable development options suggested at the international level and the local African realities. The consensus is moving toward solutions that are not specific to Africa. African expertise and knowledge, derived from contextualized research, are not fully integrated into these international reports. This is a loss for universal scientific knowledge and it handicaps the promotion of inclusive African solutions at the international level.

However, Africa possesses solid expertise, It is time for a paradigm shift in order to propose solutions for Uganda, developed by Africans. First of all, this requires the development of closer links between the group of African negotiators and the African scientific community which contributes to international reports on climate, biodiversity, soil degradation and desertification. Everyone should work together in synergy to take better account of new research results, raise the profile of African concerns and evaluate contextualized solutions.

The end of this year, world leaders are expected to come forward with updated, more ambitious national climate plans under the Paris Agreement. Though buried deep within the legalese of the Paris, Agreement, this point of process is both a critical test and a once-in-a-lifetime opportunity.

Research from the New Climate Economy shows that bold climate action could deliver at least $26 trillion in global economic benefits between now and 2030. It could also generate over 65 million new low-carbon jobs by 2030, a number equivalent to the combined workforces of the United Kingdom and Egypt today; avoid over 700,000 premature deaths from air pollution compared with business-as-usual; and generate an estimated $2.8 trillion in government revenues in 2030 through subsidy reform and carbon pricing alone.

Delivering the benefits of a new climate economy requires ambitious action across key economic systems, creating the conditions for the phaseout of coal and rapid scale-up of renewables in the energy sector; investing in shared, electric, and low-carbon transport in cities; scaling up sustainable food and land use systems, including forest landscape restoration; targeting investment to resilient water infrastructure; and reducing emissions from key industrial value chains, such as plastic.

However, if the world fails to step up climate action, continuing on our current climate trajectory could force 100 million people into extreme poverty by 2030. Africa is the most-exposed region to the adverse effects of climate change despite contributing the least to global warming.

The region is already disproportionately feeling the impacts related to a changing climate. Devastating cyclones affected 3 million people in Mozambique, Malawi, and Zimbabwe in the spring of 2018. GDP exposure in African nations vulnerable to extreme climate patterns is projected to grow from $895 billion in 2018 to about $1.4 trillion in 2023 nearly half of the continent's GDP.

If fairness was the only goal, the impetus to act would lie solely with developed economies. Make no mistake, the big emitters absolutely must step up their domestic climate action, and quickly. But building the new climate economy is also a once-in-a-lifetime opportunity that Uganda as a nation should prioritize and claim a stake in.

This opportunity is why, despite historically negligible carbon emissions, despite only accounting for 2 percent of world coal demand, and despite the lack of leadership from some developed countries, many African countries are now making serious efforts to transition towards low-carbon technologies, low-carbon and resilient infrastructure, and low-carbon tax systems.

Morocco has built the world's largest concentrated solar facility to help achieve the country's goal of 52 percent renewable energy mix by 2030. The advanced 6,000-acre solar complex, Noor, serves as a clean energy source for around 2 million Moroccans, and provides pivotal job opportunities as the country transitions away from the fossil fuel industry. The solar complex is also offering training programs for women for entrepreneurial and agricultural activities and is recruiting women in decision-making roles to guide project activities.

South Africa's Carbon Tax Act, which places specific levies on greenhouse gases from fuel combustion and industrial processes and emissions, came into effect in June 2019. By 2035, the carbon tax could reduce the country's emissions by 33 percent relative to the baseline. Furthermore, South Africa's recent renewable energy auctions have led to solar and wind prices lower than those of the national utility or from new coal plants. Often regarded as the continent's clean energy trailblazer, much of what has been learned through South Africa's renewable energy procurement process can influence similar developments across Africa.

In Nigeria, which struggles with electricity access for a majority of its population, has set a renewable energy target of 30 percent by 2030. This goal underscores the potential for both grid-based and decentralized renewable energy investments to deliver energy access and climate change benefits simultaneously. Notably, off-grid solutions like M-Kopa and Lumos that deliver electricity to thousands of households on the continent and mini-grids are important options in both unserved rural areas and underserved urban areas. Natural resource-rich African countries, like Nigeria, should see renewables as a central part of achieving universal energy access while setting themselves on a pathway for low-carbon and resilient development.

The biggest energy companies see this future too and are working to diversify their global portfolios. As of September 2019, the world's major oil companies had made about 70 clean-energy deals, putting them on track to surpass the total for 2018. Shell, for instance, has invested in Solar Now, which sells high-quality solar solutions in Uganda and Kenya. Since its inception in 2011, Solar Now has supplanted 210,000 tons of greenhouse gas emissions. More African countries should insist upon being recipients of this 21st century investment.

While the private sector is driving the shift into renewables, state-owned enterprises (SOE) in the energy sector in Africa and globally are lagging behind. African governments need to support reform in the SOE sector by, for example, introducing competitive procurement for electricity supply. This strategy could open African institutions and markets to emerging opportunities in the renewable sector, and even drive down the price of renewables. Efforts such as South Africa's Renewable Energy Independent

Power Producer Procurement (REIPPP) program and the World Bank and International Finance Corporation's Scaling Solar program have resulted in solar prices as low as $0.05/kilowatt-hour.

With an abundance of solar, wind, and geothermal resources, African countries already have a comparative advantage in renewables. The falling costs of green technologies provide a propitious moment to be on the delivery end of the new energy revolution. And while it may seem counterintuitive, Africa's most oil- and gas-rich countries should be leading the energy revolution. Beyond the energy sector, food and land use systems including the agriculture and forestry sectors are integral to sub-Saharan Africa's economy, accounting for 70 percent of livelihoods and almost one-quarter of regional GDP. In fact, new business opportunities in sustainable food and land use systems could deliver $320 billion each year by 2030 across sub-Saharan Africa. These opportunities include $120 billion in forest ecosystem services and restoration of degraded land, $100 billion in increased agricultural yields, and $100 billion in supply chain efficiency improvements and enhanced value-adding capacity. Concerted landscape restoration efforts in Ethiopia's Tigray region, for example, are enhancing farmers' resilience, water availability, and livelihoods. Such sustainable food and land use approaches can deliver multiple co-benefits, from reducing rural poverty, to boosting food security and improving population health, to protecting and regenerating natural capital.

Africa's transition to a new climate economy is underway in many places. The question is: Will developed countries create a tail-wind or a head-wind? How they answer this question will determine whether Africa is positioned to fully capitalize on this opportunity. While it may not be polite to say so, African countries need money both to build a cleaner more prosperous future for themselves and to avoid the worst impacts of climate change created largely by others.

The pending replenishment of the Green Climate Fund (GCF) acts as both a mechanism and a barometer for this challenge. The good news is that in

October 2019, 27 countries confirmed their pledge to the GCF's replenishment, bringing the total raised so far to $9.7 billion. The GCF is critical for maintaining momentum behind the Paris Agreement by supporting developing countries to enhance their climate action. But, so far, some major contributors have been silent. We need to hear from them. African leaders cannot do this alone. And nor should they. Whether driven by opportunism or a sense of moral justice, the world's developed and emerging economies must take action at home and help Africa deliver.

UNCONVENTIONAL RESOURCES

Unconventional resources are resources, generally oil or natural gas resources, that do not appear in traditional formations and must use specialized extraction or production techniques to obtain fuel from the deposit. For oil and gas, conventional deposits are porous and permeable rocks below ground that contain tiny connected pore spaces that contain oil or natural gas. Generally, these resources are locked in geological structures where extraction is not economically or technologically feasible, however with technological advancements these can turn into viable fossil fuel reserves.

Unconventional resources are being utilized more and more as decades of oil and natural gas production have resulted in extensive use of conventional resources. Because of this, new technologies are constantly being introduced that allows for the more economic extraction of non-traditional oil and gas that may have been previously impossible to obtain. Development of these unconventional resources has significant economic potential as a large portion of oil and gas resources is estimated to exist in unconventional deposits.

Unconventional Oil

Unconventional oil is a very specific type of petroleum obtained by methods that are different from the extraction technique of using a traditional well. This type of oil is seen as being costlier and more difficult to extract and refine, as well as being more environmentally harmful. In general, unconventional oil is heavier and requires more processing and upgrading. Unconventional oil includes shale oil, oil sands and extra-heavy oil (natural bitumen deposits). In total, only about 3% of 2009's oil production came from unconventional oil sources. Although it is more difficult and costly to extract unconventional oil, it is becoming more common as the demand for oil is increasing and more research is being done to see how unconventional oil can be made simpler and more cost-effective to produce.

Unconventional Natural Gas

Unconventional natural gas is simply natural gas obtained by methods that are different from traditional extraction. Unconventional natural gas can refer to tight gas - natural gas locked in low-permeability rocks, shale gas - natural gas locked in shale, or coal bed methane natural gas contained in coal. The extraction of natural gas from these deposits can be an issue, as arguments about the environmental impact of hydraulic fracturing can be brought up. Additionally, the water use in the extraction of coal bed methane can be an environmental concern.

Lingo, jargon, verbiage, whatever you want to call it, every industry has its own. The oil and gas industry are no different. “Conventional” and “unconventional” are terms used across the industry that many may not have a clear understanding of conventional resources.

Conventional Resources in Respect to Gas

By definition, the word conventional means to conform, or adhere to accepted standards. So unconventional would be to not conform to these standards or not be bound to the conventional rule. In the US, conventional sources of energy are oil, natural gas, and coal. They are conventional resources because they are the standard that was set and the world has stuck to it hence, they have become conventional ways that power our everyday lives.

Unconventional Resources in Respect to Gas

What is considered to be unconventional energy sources are wind, tidal, solar, nuclear, and geo-thermal. Occasionally, these sources are also referred to as renewable energy. They are used all over the world. These sources are not the standard, because they are still relatively new compared to oil and gas.

There is conventional and unconventional oil and gas as well. The difference between the two is not so much about the chemical compositions, but more to do with the geological formations around the resources and how those resources are taken out of the ground.

In a nut shell; conventional oil and gas- easy to produce, unconventional oil and gas-more difficult to produce. And by produce, I mean everything in production; discovering, drilling, processing, transporting, refining, and storing. For over 100 years, the sole focus of our industry has been to find oil reservoirs, set up shop in the location and drill straight down to the conventional sandstone, and retrieve the resources. New technologies have allowed companies to be able to drill down and over (horizontal) to unconventional shale, tight sandstone, or coal beds to retrieve these resources.

Today, shale gas is the fastest growing unconventional resource here in the United States and worldwide. With advances in horizontal drilling technology and the constant need for a clean burning energy source, no doubt we will be hearing about it for a while.

Understanding how it is defined and what it applies to will hopefully help you understand the differences between a conventional shale play and an unconventional shale play.

Importance of unconventional resources to the future of our industry

Unconventional resources (tight/shale gas, tight oil, and oil sands) play an ever-increasing role in our energy supply and I only see that role increasing.

The bottom line is this: The world will need more energy under all scenarios. Even if renewables play a larger role and conservation is taken seriously (and I hope it is), the world's emerging economies will require sustained use of oil and gas for the foreseeable future. Because oil and gas from conventional reservoirs is declining (the "easy oil" is gone), the role of unconventional in the future energy mix will be major.

Our planet's endowment of unconventional oil and gas is orders of magnitude larger than the conventional deposits that were the primary targets of exploration and production for the past 150 years. Unconventional deposits can be grouped into three general categories:

1) unconventional reservoirs, which comprise source rocks and ultraright sandstones and carbonates; 2) unconventional fluids, including heavy oil, bitumen, and sour/acid gases;

3) hydrocarbons "locked in rocks," such as methane hydrates and oil shale (an immature source rock). Today, the primary targets of exploration and development investment in most countries are within categories 1 and 2, and these types of targets are also becoming increasingly important around the world.

The extraction of oil and gas from source rocks and ultraright sandstones and carbonates represents a breakthrough on the scale of that achieved when most countries first went offshore shortly after World War II. The newfound ability to extract hydrocarbons from source rocks has opened a vast new suite of opportunities that contains technically recoverable resources of thousands of billions of barrels of oil equivalent. While some still wonder about the commercial viability of unconventional reservoirs, it is worth noting that the Bakken formation in North Dakota and Montana today produces more oil on a daily basis than the Prudhoe Bay field in Alaska, which had been North America's top oil producer for almost three decades. Also, the Eagle Ford Shale in south Texas may surpass the Bakken in the not-too-distant future to claim the top spot. There seem to be a continued breakthroughs offshore in both the deep-water and Arctic operating areas While these reservoirs may not be "unconventional," the operating environments and required technology are just as impressive. Shell probably has the largest number of deep-water fields under multiple rounds of development drilling campaigns, and it appears the world is pushing forward with plans to drill in the offshore for example in Beaufort and Chukchi seas in the US Arctic. Thus, the world faces the challenge of drilling deep, high-angle wells through depleted zones in deep water as well as new wells in the shallow waters of the Arctic. In the planning phase, 4D as well as ocean bottom seismic are enabling most countries to fully understand the subsurface and properly plan these wells.

Drilling the wells is enabled by the use of full rotary drilling systems with full measurement-while-drilling evaluation and pressure sampling capability; expandable casing systems to maintain hole size; and managed pressure drilling systems, coupled with low rheology, synthetic-based mud systems, to minimize, if not eliminate, costly loss of drilling fluid. On the completion side of the business, efficient frac-and-pack and high-rate water pack completions are keys to achieving low skin completions that can hold up and deliver the needed production rates and volumes.

There are still enormous quantities of unconventional resources for which there are no viable commercial development options. For example, methane hydrate deposits, which are believed to contain hundreds of thousands to millions of trillion cubic feet of natural gas, are not today commercial, but could someday be developed if a technology breakthrough occurred. While commercialization is likely decades away, ConocoPhillips, in partnership with the US Department of Energy, will soon test an experimental technique on the North Slope of Alaska that pumps CO2 into a hydrate reservoir—liberating the methane and sequestering the CO2—which physically replaces methane molecules within the hydrate's ice lattice. If this technology, or another method for extracting natural gas from hydrates, can be commercialized, then the age of hydrocarbons could be extended not just into the 22nd century, but perhaps to the year 3000 or beyond. We also expect considerable advances in converting organic matter in immature source rocks into oil, which would greatly expand the options available for producing liquid fuels.

When the topic of "unconventional resources" comes up, onshore oil and gas tends to dominate the conversation, However, an analogous "unconventional offshore" play is in the deep-water basins and sub-salt play along with the offshore Arctic. I feel that development of these areas will continue to pay dividends well into the future and throughout the careers of the next generation of oil and gas professionals. source rocks, as their name implies, were considered important only because they were where oil and gas were generated. Nobody saw them as being viable reservoirs on a large scale

Unconventional energy resources, as explained, are those energy resources that do not occur in discrete oil or gas reservoirs held within stratigraphic and/or structural traps of sedimentary basins. As defined, such energy resources include coal, coalbed methane (CBM), tight gas and liquids, bitumen and heavy oil, uranium (U), thorium (Th), and associated rare earth elements of interest to industry, and geothermal. Current North American and global research and development activities are summarized for each of the unconventional energy resource commodities in separate topical sections of this report.

Natural resources like wind, tides, solar, biomass, etc generate energy which is known as "Non-conventional resources". These are pollution free and hence we can use these to produce a clean form of energy without any wastage.

Benefits of non-conventional energy resources

As the consumption of energy grows, the population depends more and more on fossil fuels such as coal, oil and gas day by day. There is a need to secure the energy supply for future since the prices of gas and oil keep rising by each passing day. So, we need to use more and more renewable sources of energy. For the effective exploitation of non-conventional sources, there has been an establishment of a separate department namely "Department of non-conventional sources of energy" by the government of India.

Renewable resources provide energy in four important areas like:

- Electricity generation
- Water heating or cooling
- Transporting
- Rural

Classification of Energy Sources

Energy sources can be divided into two types based on how quickly can they be replenished:

- Conventional sources of Energy
- Non-conventional sources of Energy

When we cannot reuse a source of energy after using it once we call them "conventional sources of energy" or "non-renewable energy resources". They are the most important conventional sources of energy. These include coal, petroleum, natural gas and nuclear energy. Oil is the most widely used source of energy. Coal, petroleum and natural gas account for about 90% of world's production of commercial energy and hydroelectric and nuclear power account for about 10%.

Well, we all are aware that nucleus of an atom is very small. But do you know the enormous amount of nuclear energy we can obtain from one tiny nucleus of an atom? And how do we obtain this energy? Let us learn more about nuclear energy, and how is it different from other forms of energy.

Scientists obtain nuclear energy in two ways:

- Nuclear fusion: This reaction involves the combination or fusion of two light elements to form a heavier element and energy is released.

- Nuclear fission: Fission of nuclei of some heavy elements like uranium is called nuclear fission.

It is can also produce electricity. Nuclear power is used in nuclear reactions that release nuclear energy to generate heat, which is then used in steam turbines to produce electricity in the nuclear power plant. Today nuclear power provides almost 20% of world's electricity. Nuclear power is the fourth largest source of electricity in India after thermal and hydroelectric, and it is a renewable source of energy. Did you know that sun's energy is generated by the nuclear fusion reaction? The heat and light that we get from the sun are all due to the continuous reaction.

Nuclear energy comes either from nuclei conversions which are spontaneous or from nuclei conversions. As mass and energy change, these conversions also change. Equivalence of the mass-energy is described by Einstein's formula E = mc2

What does this mean? If nuclear energy is generated, a small amount of mass transforms into pure energy such as thermal energy or radiant energy.

Example: The energy equivalent of one gram of mass is equivalent to:

- 89.9 terajoules
- 25.0 million kilowatt-hours
- 21.5 billion kilocalories
- 85.2 billion BTUs

and the energy released by the combustion of the following:

- 21.5 kilotons of equivalent energy.
- 568,000 US gallons of automotive gasoline.

Releasing energy

Nuclear reactors

Power plants use nuclear reactors for generation of electricity. A nuclear reactor produces and controls the release of energy from splitting the atoms of uranium. Heat from the nuclear fission then passes to a fluid which runs through turbines. Most reactors are working on the principle of fission. Except for the reactor itself, a nuclear power station works like coal or gas power stations. A typical reactor may contain about 165 tonnes of fuels. This fuel contains 157 fuel assemblies constituting over 4,50,000 fuels rods. When control rods are lifted the fission starts and makes heat. Generally, fuel assembly contains energy for nearly 4 years of operation at full power.

Nuclear Energy Renewable Energy

The uranium in rocks all over the world but power plants for same are very rare. Unlike solar energy and wind energy, uranium is a non-renewable source of energy. The problem with uranium is its confinement. So nuclear energy is not a renewable source of energy. All the nuclear energy we are ever going to get is locked up in the strong and weak nuclear forces in the atoms of the earth. Fission by itself is rare enough that we could never get useful energy out of it, but the neutrons can be absorbed by other atoms, making those atoms unstable and causing further fission.

Disposal of nuclear reactions

Mutations and DNA alterations may occur in the living cells if the handling of radioactive material doesn't occur with adequate precautions. The radiations of radioactive materials are invisible due to which our sense organs cannot feel the radiations. Precautions such as lead jackets are necessary for the workers in nuclear laboratories. When the workers store these waste products which are dangerous for long periods, they must be careful. The spent fuel is highly radioactive and so one has to carefully store it for many years or decades. This also adds to the cost, Sources of Energy Classificationton of Energy Sources Fuel Woods Conventional sources of Energy, Coal , Oil , Fuel Wood, Thermal Power plant , Nuclear Energy .

Basically, used by the rural people for cooking food. Major disadvantage is causing deforestation

Deforestation can be avoided by planting more trees. Non-Convectional sources of Energy, Solar Energy, Wind Energy, Tidal Energy, Geothermal Energy, Biomass Coal Thermal Power Plant Nuclear Energy How is nuclear energy obtained? Thermal Power Plant Nuclear Power Plant. Most abundantly available convectional source of energy. Formed when organic manner converts into lignite and then into anthracite. Used for heating houses, as fuels for boilers in steam engines and thermal plants. Power stations burn fossil fuels to produce steam. Steam is fed into the turbine to generate electricity. Most abundantly used conventional source of energy. Petroleum is a mixture of hydrocarbons and cycloalkanes. Crude petroleum is refined and purified to obtain petrol, diesel, lubricating oil, plastic etc. Natural gas is very useful in household sector. It causes less air pollution as compared to other fossil fuel. One of the most environmentally friendly energy sources as the green- house gas emission is very low. Small amount of radioactive substance can produce a lot of energy. Major hazard is the storage and disposal of spent or used fuel. There is always a risk of accidental leakage of nuclear radiation. Nuclear energy is produced by nuclear fission or fusion reactions. Nucleus of heavy atom (Uranium) is bombarded with low energy neutron. The heavy atom or the target atom then splits into lighter nuclear types of non-convention sources

- Solar Energy
- Wind Energy
- Tidal Energy
- Geothermal Energy
- Biomass

Solar Energy

Solar energy is harnessed by converting solar energy directly into electrical energy in solar plants. Photosynthesis process carries out this process of conversion of solar energy. In photosynthesis, green plants absorb solar energy and convert it into chemical energy. Solar energy is an essential energy of all non-conventional sources but its usage amount is very less. It is the most important non-conventional source of energy and it gives non-polluting environment-friendly output and is available in abundant.

Uses of Solar energy

- A solar cooker directs the solar heat into secondary reflector inside the kitchen, which focuses the heat to the bottom of the cooking vessel. It has a covering of a glass plate. They are applicable widely in areas of the developing world where deforestation is an issue, and financial resources to purchase fuel are not much.
- Solar heaters also use solar energy to heat water instead of using gas or electricity.
- Solar cells also use solar power to generate electricity from the sun.

Wind energy

Wind energy describes the process by which wind is used to generate electricity. As the wind increases, power output increases up to the maximum output of the particular turbine. Wind farms prefer areas, where winds are stronger and constant. These are generally located at high altitudes. Wind turbines use wind to make electricity. There is no pollution because no fossil fuels are burnt to generate electricity. One of India's largest windmill farms is in Kanyakumari which generates 380mW of electricity.

Biomass energy

Biomass is the organic matter that originates from plants, animals, wood, sewage. These substances burn to produce heat energy which then generates electricity. The chemical composition of biomass varies in different species but generally, biomass consists of 25% of lignin, 75% of carbohydrates or sugar. Biomass energy is also applicable for cooking, lighting, and generation of electricity. The residue left after the removal of biogas is a good source of manure. Biomass is an important energy source contributing to more than 14% of the global energy supply.

Tidal energy

Tidal power is a form of hydropower that converts the energy of tides into electricity. In areas where the sea experiences waves and tides, we can generate electricity using tidal power. India may take up "ocean thermal level conversion" by which it will be able to generate 50,000mW of electricity to meet the power requirements.

Geothermal energy

Geothermal energy is the heat energy that we get from hot rocks present in the earth's crust. So Geothermal wells release greenhouse gases trapped within the earth and but these emissions are much lower per energy unit than the fossil fuels. This energy generally involves low running costs since it saves 80% on fossil fuels. Due to this, there is an increase in the use of geothermal energy. It helps in reducing global warming and does not create pollution.

As the fossil fuels are one of the most the biggest pollutants on the planet, demand for the non-conventional sources is developing. These sources not only instigate greenhouse effects but also reduce the dependence on oil and gas. Therefore, in order to meet the energy demand of the increasing population, the scientists are developing methods for us to tap into various non-conventional sources of energy, which are not only renewable but also non-polluting.

Unconventional hydrocarbon applications have been growing rapidly in recent years. Unconventional oil can be produced from oil sands, oil shale, extra heavy oil, gas to liquids (GTL), and other liquids. Conventional fossil energy will not be enough to meet the continuously increasing need for energy in the future. In this case, renewable energy sources will become important. Conventional oil sources are currently preferred because they are less expensive than unconventional sources. New technologies are being developed to reduce unconventional oil production costs.

Methane emissions

FID Total VOC

Protea's Flame Ionisation Detector (FID) analysers are used to give quick, accurate measurement of Total VOC concentration in a range of applications such as emissions and process control.

FID Principal

Within the FID analyser chamber is a Hydrogen (H2) flame burning in an electrical field. The flame is fed by high purity fuel gas (Atmos FID can use H2 gas or a H2/He mix) and a hydrocarbon (HC)-free combustion air. The sample gas to be analyzed is then also fed into this flame.

The hydrocarbons within the sample gas are "cracked" in the flame and the resulting HC fragments are then ionized. An ion current in the order of 10-14A is generated in the electric field; this electric current is related to a DC amplifier and gives the detection of the HC content.

The measuring method requires that the measuring signal is proportional to the number of non-oxidized carbon atoms in the sample gas. Carbon atoms that are pre-oxidized are only partially measured. This phenomenon is expressed by the response factor (RF) of various hydrocarbons. Protea can provide a complete response factor list for the Atmos FID.

FID Total VOC Analyser is designed for Continuous Emissions Monitoring (CEM) of gaseous VOC emissions from a wide range of sources.

FTIR and FID Integration

Atmost FID is a Flame Ionisation Detector (FID) analyser from Protea that can give Total VOC (TVOC) measurement in stack emissions and process applications.

Methane Pro

The Methane Pro is an optical gas imaging (OGI) camera that detects methane gas in the camera coverage region. It offers large coverage regions, low false alert rates, ultra-fast response time, 24/7 detection in non-extreme weather conditions, as well as extremely low power consumption. It allows access to any historical and real-time data via the cloud, empowering decision makers of all levels

Examples of Greenhouse Gases

- Carbon Dioxide
- Methane
- Nitrous Oxide
- Fluorinated Gases

Total U.S. Emissions in 2020 = 5,981 Million Metric Tons of CO2 equivalent (excludes land sector). Percentages may not add up to 100% due to independent rounding. Larger Gases that trap heat in the atmosphere are called greenhouse gases. This section provides information on emissions and removals of the main greenhouse gases to and from the atmosphere. For more information on the other climate forcers, such as black carbon, please visit the Climate Change Indicators: Climate Forcing page.

- Carbon dioxide (CO_2): Carbon dioxide enters the atmosphere through burning fossil fuels (coal, natural gas, and oil), solid waste, trees and other biological materials, and also as a result of certain chemical reactions (e.g., manufacture of cement). Carbon dioxide is removed from the atmosphere (or "sequestered") when it is absorbed by plants as part of the biological carbon cycle.
- Methane (CH_4): Methane is emitted during the production and transport of coal, natural gas, and oil. Methane emissions also

result from livestock and other agricultural practices, land use and by the decay of organic waste in municipal solid waste landfills.

- Nitrous oxide (N_2O): Nitrous oxide is emitted during agricultural, land use, and industrial activities; combustion of fossil fuels and solid waste; as well as during treatment of wastewater.

Fluorinated gases: Hydrofluorocarbons, perfluorocarbons, sulphur hexafluoride, and nitrogen trifluoride are synthetic, powerful greenhouse gases that are emitted from a variety of household, commercial, and industrial applications and processes. Fluorinated gases (especially hydrofluorocarbons) are sometimes used as substitutes for stratospheric ozone-depleting substances (e.g., chlorofluorocarbons, hydrochlorofluorocarbons, and halons). Fluorinated gases are typically emitted in smaller quantities than other greenhouse gases, but they are potent greenhouse gases. With global warming potentials (GWPs) that typically range from thousands to tens of thousands, they are sometimes referred to as high-GWP gases because, for a given amount of mass, they trap substantially more heat than CO_2.

Whereas each gas's effect on climate change depends on three main factors, how much is in the atmosphere? The answer is simple, concentration, or abundance, is the amount of a particular gas in the air. Larger emissions of greenhouse gases lead to higher concentrations in the atmosphere. Greenhouse gas concentrations are measured in parts per million, parts per billion, and even parts per trillion. One part per million is equivalent to one drop of water diluted into about 13 gallons of liquid (roughly the fuel tank of a compact car.

Duration they stay in the atmosphere

Each of these gases can remain in the atmosphere for different amounts of time, ranging from a few years to thousands of years. All of these gases remain in the atmosphere long enough to become well mixed, meaning that the amount that is measured in the atmosphere is roughly the same all over the world, regardless of the source of the emissions.

Impact to the atmosphere

Some gases are more effective than others at making the planet warmer and "thickening the Earth's blanket."

For each greenhouse gas, a Global Warming Potential (GWP) was developed to allow comparisons of the global warming impacts of different gases. Specifically, it is a measure of how much energy the emissions of 1 ton of a gas will absorb over a given period of time, relative to the emissions of 1 ton of carbon dioxide (CO_2). Gases with a higher GWP absorb more energy, per pound emitted, than gases with a lower GWP, and thus contribute more to warming Earth.

Carbon Dioxide Emissions

Properties of Carbon Dioxide

Chemical Formula: CO_2Lifetime in Atmosphere: Global Warming Potential (100-year): 1

Carbon dioxide (CO_2) is the primary greenhouse gas emitted through human activities. In 2020, CO_2 accounted for about 79% of all U.S. greenhouse gas emissions from human activities. Carbon dioxide is naturally present in the atmosphere as part of the Earth's carbon cycle (the natural circulation of carbon among the atmosphere, oceans, soil, plants, and animals). Human activities are altering the carbon cycle–both by adding more CO_2 to the atmosphere and by influencing the ability of natural sinks, like forests and soils, to remove and store CO_2 from the atmosphere. While CO_2 emissions come from a variety of natural sources, human-related emissions are responsible for the increase that has occurred in the atmosphere since the industrial revolution.

The main human activity that emits CO_2 is the combustion of fossil fuels (coal, natural gas, and oil) for energy and transportation. Certain industrial processes and land-use changes also emit CO_2. The main sources of CO_2 emissions in the world today are described below.

- Transportation. The combustion of fossil fuels such as gasoline and diesel to transport people and goods was the largest source of CO_2 emissions in 2020, accounting for about 33% of total. CO_2 emissions and 26% of total greenhouse gas emissions. This category includes domestic transportation sources such as highway and passenger vehicles, air travel, marine transportation, and rail.
- Electricity. Electricity is a significant source of energy and is used to power homes, business, and industry. In 2020, the combustion of fossil fuels to generate electricity was the second largest source of CO_2 emissions, accounting for about 31% of total CO_2 emissions and 24% of total. greenhouse gas emissions. The types of fossil fuel used to generate electricity emit different amounts of CO_2. To produce a given amount of electricity, burning coal will produce more CO_2 than natural gas or oil.
- Industry. Many industrial processes emit CO_2 through fossil fuel consumption. Several processes also produce CO_2 emissions through chemical reactions that do not involve combustion, and examples include the production of mineral products such as cement, the production of metals such as iron and steel, and the production of chemicals. The fossil fuel combustion component of various industrial processes accounted for about 16% of total CO_2 emissions and 13% of total U.S. greenhouse gas emissions in 2020. Many industrial processes also use electricity and therefore indirectly result in CO_2 emissions from electricity generation.

Carbon dioxide is constantly being exchanged among the atmosphere, ocean, and land surface as it is both produced and absorbed by many microorganisms, plants, and animals. Emissions and removal of CO_2 by these natural processes, however, tend to balance, absent anthropogenic impacts.

Since the Industrial Revolution began around 1750, human activities have contributed substantially to climate change by adding CO2 and other heat-trapping gases to the atmosphere.

In the United States for example, the management of forests and other land (e.g., cropland, grasslands, etc.) has acted as a net sink of CO2, which means that more CO2 is removed from the atmosphere, and stored in plants and trees, than is emitted. This carbon sink offset is about 14% of total emissions in 2020 and is discussed in more detail in the Land Use, Land-Use Change, and Forestry section.

Emissions and Trends

Carbon dioxide emissions in the United States as an example decreased by about 8% between 1990 and 2020. Since the combustion of fossil fuel is the largest source of greenhouse gas emissions in the United States, changes in emissions from fossil fuel combustion have historically been the dominant factor affecting total U.S. emission trends. Changes in CO2 emissions from fossil fuel combustion are influenced by many long-term and short-term factors, including population growth, economic growth, changing energy prices, new technologies, changing behavior, and seasonal temperatures. In 2020, the decrease in CO2 emissions from fossil fuel combustion corresponded with a decrease in energy use as a result of decreases in economic, manufacturing, and travel activity in response to the coronavirus pandemic, in addition to a continued shift from coal to less carbon-intensive natural gas and renewables in the electric power sector.

Reducing Carbon Dioxide Emissions

The most effective way to reduce CO2 emissions is to reduce fossil fuel consumption. Many strategies for reducing CO2 emissions from energy are cross-cutting and apply to homes, businesses, industry, and transportation, EPA is taking common sense regulatory actions to reduce greenhouse gas emissions.

Atmospheric CO2 is part of the global carbon cycle, and therefore its fate is a complex function of geochemical and biological processes. Some of the excess carbon dioxide will be absorbed quickly (for example, by the ocean surface), but some will remain in the atmosphere for thousands of years, due in part to the very slow process by which carbon is transferred to ocean sediments.

Global Warming Potential

In 2020, methane (CH4) accounted for about 11% of all U.S. greenhouse gas emissions from human activities. Human activities emitting methane include leaks from natural gas systems and the raising of livestock. Methane is also emitted by natural sources such as natural wetlands. In addition, natural processes in soil and chemical reactions in the atmosphere help remove CH4 from the atmosphere. Methane's lifetime in the atmosphere is much shorter than carbon dioxide (CO2), but CH4 is more efficient at trapping radiation than CO2. Pound for pound, the comparative impact of CH4 is 25 times greater than CO2 over a 100-year period.

Globally, 50-65% of total CH4 emissions come from human activities. Methane is emitted from energy, industry, agriculture, land use, and waste management activities, described below.

- Agriculture. Domestic livestock such as cattle, swine, sheep, and goats produce CH_4 as part of their normal digestive process. Also, when animal manure is stored or managed in lagoons or holding tanks, CH_4 is produced. Because humans raise these animals for food and other products, the emissions are considered human-related. The agriculture sector is the largest source of CH_4 emissions in the United States. For more information[1],. While not shown in the figure and less significant, emissions of CH_4 also occur as a result of land use and land management activities in the Land Use, Land-Use Change, and

[1] see the Inventory of U.S. Greenhouse Gas Emissions and Sinks Agriculture

Forestry sector (e.g. forest and grassland fires, decomposition of organic matter in coastal wetlands).

- Energy and Industry. Natural gas and petroleum systems are the second largest source of CH_4 emissions in the United States. Methane is the primary component of natural gas. Methane is emitted to the atmosphere during the production, processing, storage, transmission, and distribution of natural gas and the production, refinement, transportation, and storage of crude oil. Coal mining is also a source of CH_4 emissions[2]..

- Waste from Homes and Businesses. Methane is generated in landfills as waste decomposes and in the treatment of wastewater. Landfills are the third-largest source of CH_4 emissions in the United States. Methane is also generated from domestic and industrial wastewater treatment and from composting and anaerobic digestion.[3]Methane is also emitted from a number of natural sources. Natural wetlands are the largest source, emitting CH_4 from bacteria that decompose organic materials in the absence of oxygen. Smaller sources include termites, oceans, sediments, volcanoes, and wildfires.

Emissions and Trends

Methane emissions in the United States decreased by 17% between 1990 and 2020. During this time period, emissions increased from sources associated with agricultural activities, while emissions decreased from other sources including landfills and coal mining and from natural gas and petroleum systems.

[2] see the Inventory of U.S. Greenhouse Gas Emissions and Sinks sections on Natural Gas Systems and Petroleum Systems

[3] see the Inventory of U.S. Greenhouse Gas Emissions and Sinks Waste chapter.

Reducing Methane Emissions

There are a number of ways to reduce CH4 emissions. Some examples are discussed below. EPA has a series of voluntary programs for reducing CH4 emissions, in addition to regulatory initiatives. EPA also supports an international partnership encouraging global methane reduction strategies.

Nitrous Oxide Emissions

In 2020, nitrous oxide (N2O) accounted for about 7% of all U.S. greenhouse gas emissions from human activities. Human activities such as agriculture, fuel combustion, wastewater management, and industrial processes are increasing the amount of N2O in the atmosphere. Nitrous oxide is also naturally present in the atmosphere as part of the Earth's nitrogen cycle and has a variety of natural sources. Nitrous oxide molecules stay in the atmosphere for an average of 114 years before being removed by a sink or destroyed through chemical reactions. The impact of 1 pound of N2O on warming the atmosphere is almost 300 times that of 1 pound of carbon dioxide.

Globally, about 40% of total N2O emissions come from human activities.2 Nitrous oxide is emitted from agriculture, land use, transportation, industry, and other activities, described below.

- Agriculture. Nitrous oxide can result from various agricultural soil management activities, such as application of synthetic and organic fertilizers and other cropping practices, the management of manure, or burning of agricultural residues. Agricultural soil management is the largest source of N2O emissions in the United States, accounting for about 74% of total U.S. N2O emissions in 2020. While not shown in the figure and less significant, emissions of N2O also occur as a result of land use and land management activities in the Land Use, Land-Use Change, and Forestry sector (e.g. forest and grassland fires, application of synthetic nitrogen fertilizers to urban soils (e.g., lawns, golf courses) and forest lands, etc.).

- Fuel Combustion. Nitrous oxide is emitted when fuels are burned. The amount of N2O emitted from burning fuels depends on the type of fuel and combustion technology, maintenance, and operating practices.
- Industry. Nitrous oxide is generated as a by-product during the production of chemicals such as nitric acid, which is used to make synthetic commercial fertilizer, and in the production of adipic acid, which is used to make fibbers, like nylon, and other synthetic products.
- Waste. Nitrous oxide is also generated from treatment of domestic wastewater during nitrification and denitrification of the nitrogen present, usually in the form of urea, ammonia, and proteins.

Nitrous oxide emissions occur naturally through many sources associated with the nitrogen cycle, which is the natural circulation of nitrogen among the atmosphere, plants, animals, and microorganisms that live in soil and water. Nitrogen takes on a variety of chemical forms throughout the nitrogen cycle, including N2O. Natural emissions of N2O are mainly from bacteria breaking down nitrogen in soils and the oceans. Nitrous oxide is removed from the atmosphere when it is absorbed by certain types of bacteria or destroyed by ultraviolet radiation or chemical reactions.

Emissions and Trends

Nitrous oxide emissions in the United States decreased by 5% between 1990 and 2020. During this time, nitrous oxide emissions from mobile combustion decreased by 61% as a result of emission control standards for on-road vehicles. Nitrous oxide emissions from agricultural soils have varied during this period and were about the same in 2020 as in 1990.

Reducing Nitrous Oxide Emissions

There are a number of ways to reduce emissions of N2O, discussed below.

Unlike many other greenhouse gases, fluorinated gases have no significant natural sources and come almost entirely from human-related activities. They are emitted through their use as substitutes for ozone-depleting substances (e.g., as refrigerants) and through a variety of industrial processes such as aluminium and semiconductor manufacturing. Many fluorinated gases have very high global warming potentials (GWPs) relative to other greenhouse gases, so small atmospheric concentrations can have disproportionately large effects on global temperatures. They can also have long atmospheric lifetimes in some cases, lasting thousands of years. Like other long-lived greenhouse gases, most fluorinated gases are well-mixed in the atmosphere, spreading around the world after they are emitted.

Many fluorinated gases are removed from the atmosphere only when they are destroyed by sunlight in the far upper atmosphere. In general, fluorinated gases are the most potent and longest lasting type of greenhouse gases emitted by human activities.

There are four main categories of fluorinated gases hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF6), and nitrogen trifluoride (NF3). The largest sources of fluorinated gas emissions are described below[4].

- Substitution for Ozone-Depleting Substances. Hydrofluorocarbons are used as refrigerants, aerosol propellants, foam blowing agents, solvents, and fire retardants. The major emissions source of these compounds is their use as refrigerants for example, in air conditioning systems in both vehicles and buildings. These chemicals were developed as a replacement for chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) because they do not deplete the stratospheric ozone layer. Chlorofluorocarbons and HCFCs are also greenhouse gases;

[4] Note: All emission estimates from the Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2020

however, their contribution is not included here because they are being phased out under an international agreement, called the Montreal Protocol. HFCs are potent greenhouse gases with high GWPs, and they are released into the atmosphere during manufacturing processes and through leaks, servicing, and disposal of equipment in which they are used. Newly developed hydrofluoroolefins (HFOs) are a subset of HFCs and are characterized by short atmospheric lifetimes and lower GWPs. HFOs are currently being introduced as refrigerants, aerosol propellants and foam blowing agents. The American Innovation and Manufacturing (AIM) Act of 2020 directs EPA to address HFCs by providing new authorities in three main areas: to phase down the production and consumption of listed HFCs in the United States by 85% over the next 15 years, manage these HFCs and their substitutes, and facilitate the transition to next-generation technologies that do not rely on HFCs.

- Industry. Perfluorocarbons are produced as a by-product of aluminium production and are used in the manufacturing of semiconductors. PFCs generally have long atmospheric lifetimes and GWPs near 10,000. Sulphur hexafluoride is used in magnesium processing and semiconductor manufacturing, as well as a tracer gas for leak detection. Nitrogen trifluoride is used in semiconductor manufacturing. HFC-23 is produced as a by-product of HCFC-22 production and is used in semiconductor manufacturing.
- Transmission and Distribution of Electricity. Sulphur hexafluoride is used as an insulating gas in electrical transmission equipment, including circuit breakers. The GWP of SF6 is 22,800, making it the most potent greenhouse gas that the Intergovernmental Panel on Climate Change has evaluated[5].

[5] To find out more about the role of fluorinated gases in warming the atmosphere and their sources, visit the Fluorinated Greenhouse Gas Emissions page.

Emissions and Trends

Overall, fluorinated gas emissions in the United States have increased by about 90% between 1990 and 2020. This increase has been driven by a 284% increase in emissions of hydrofluorocarbons (HFCs) since 1990, as they have been widely used as a substitute for ozone-depleting substances.

Emissions of perfluorocarbons (PFCs) and sulphur hexafluoride (SF6) have actually declined during this time due to emission-reduction efforts in the aluminium production industry (PFCs) and the electrical transmission and distribution industry (SF6).

Reducing Fluorinated Gas Emissions

Because most fluorinated gases have a very long atmospheric lifetime, it will take many years to see a noticeable decline in current concentrations. There are, however, a number of ways to reduce emissions[6].

Natural-gas production in the United States has increased 46% since 2006, but there has been no significant increase of total US methane emissions and only a modest increase from oil and gas activity, according to a new NOAA study.

Natural-gas production in the United States has increased 46% since 2006, but there has been no significant increase of total US methane emissions and only a modest increase from oil and gas activity, according to a new study by the National Oceanic and Atmospheric Administration (NOAA).

The finding is important because it's based on highly accurate measurements of methane collected over 10 years at 20 long-term sampling sites around the country in NOAA's Global Greenhouse Gas Reference Network, said lead author Xin Lan, a Cooperative Institute for Research in Environmental

[6] Study Finds US Methane Emissions Flat Since 2006 Despite Increased Oil and Gas Activity

Sciences scientist working at NOAA[7] . The study did not attempt to quantify oil and gas methane emissions or methane emissions overall but sought only to identify whether emissions were increasing by looking at enhancements in methane atmospheric concentration.

The new analysis showed increases in methane emissions from oil and gas activity of 3.4% ±1.4% per year—or up to 10 times lower than some recent studies that derived their methane trend by measuring levels of another petroleum hydrocarbon, ethane. Overall, though, methane concentrations in US air samples were shown to be increasing at the same rate as the global background, meaning there was no statistically significant increase in total methane from the US.

Sources of Methane

Methane is a component of natural gas, but it can also be generated by biological sources, such as decaying wetland vegetation, as a by-product of ruminant digestion, or even by termites. Ethane is a hydrocarbon emitted during oil and natural gas production and is sometimes used as a tracer for oil and gas activity. By measuring ethane, which is not generated by biologic processes, scientists had hoped to produce an accurate estimate of petroleum-derived methane emissions.

However, those studies assumed that the ratio of ethane to methane in natural gas produced by different oil and gas regions is constant. Instead, Lan said, the new NOAA analysis shows that ethane-to-methane ratios are increasing, and that has led to major overestimations of oil and gas emission trends in some previous studies.

[7] "We analysed a decade's worth of data, and, while we do find some increase in methane downwind of oil and gas activity, we do not find a statistically significant trend in the U.S. for total methane emissions," said Lan. The study was published in Geophysical Research Letters

The quest to understand methane releases and leaks associated with oil and natural gas production has taken on a high profile in recent years as production has surged to historic levels in the US. Methane is 28 times more potent than carbon dioxide in trapping heat in the atmosphere over 100 years. It exerts the second-largest influence on global warming among anthropogenic greenhouse gases behind carbon dioxide.

Global methane levels were nearly stable from 1999 through 2006 but since then have increased significantly. Some studies have suggested that the US oil and natural gas emissions have large contributions to the post-2007 increases. Previous NOAA research suggests the global methane increase has been dominated by biogenic emissions.

10 Years of NOAA Data Lan led an analysis of data collected by a research team from NOAA's Earth System Research Laboratory in Boulder, Colorado, and Lawrence Berkeley National Laboratory in Berkeley, California, that studied air samples collected from aircraft flights at 11 sites and nine tall towers that are part of NOAA's Global Greenhouse Gas Reference Network. Sampling with aircraft and tall towers allows scientists to analyse the different concentrations of gases close to the ground, where emissions occur, as well as higher up in the atmosphere where the influence of recent surface emissions is minimal, to help scientists understand their fate. The sampling sites were established in locations where sampling would capture well-mixed air masses and avoid samples dominated by local sources.

Three of the five sampling sites located downwind of oil and natural gas production areas did show varying increases in methane, ethane, and propane. This could be caused by a different makeup of the underlying oil and gas resource or different activity levels driven by the price of oil, natural gas, and other hydrocarbons, Lan said.

Lan's study is one of the first to explore trends in methane data from sites established by the 2004 North American Carbon Program, a multiagency research program focused on carbon sources and sinks in North America and its adjacent oceans, said Arlyn Andrews, chief of the NOAA Global Monitoring Division (GMD) Carbon Cycle Group.

"With 20 sites across the country, one can make enough measurements to evaluate aggregate emissions at large regional scales," she said. "If we had more sampling sites, we would be able to provide more specificity about methane sources in regions dominated by agriculture and oil and gas. These study results show the value of measurements taken by GMD's high-quality air sampling network over more than a decade. "Canada Takes the Lead on Methane Emissions, In the fight against climate change, one of the most damaging greenhouse gases is also one of the least regulated. Unless new strategies are developed to measure and reduce atmospheric methane, the targets set by the Paris climate agreement are unlikely to be met.

In the fight against climate change, carbon dioxide attracts the bulk of regulators' attention. But while long-lived CO2 is a key contributor to rising temperatures, it is not the only culprit. Other short-lived super pollutants are also warming the planet, and none is in greater need of regulation than methane.

According to the Intergovernmental Panel on Climate Change, methane is 86 times more potent than CO2 as a heat-trapping gas over a 20-year period, and is responsible for about a fifth of the warming caused by humans. If the international community is to have any chance of meeting targets set by the Paris climate agreement and keep global warming well below 2°C above preindustrial levels, the control of methane must be a high priority. At the moment, however, that is not happening on a global scale, and only a handful of countries led most recently by Canada have committed to managing methane.

A recent report by the US National Academy of Sciences (NAS) called methane an "intriguing" policy problem, because there is no dominant cause. Recent spikes in emissions have been attributed to a variety of sources, including forest fires and fermentation in rice fields.

Blue Economy

Blue economy is a term in economics relating to the exploitation, preservation and regeneration of the marine environment. Its scope of interpretation varies among organizations. However, the term is generally used in the scope of International development when describing a sustainable development approach to coastal resources. This can include a wide range of economic sectors, from the more conventional fisheries, aquaculture, maritime transport, Coastal, marine and maritime tourism, or other traditional uses, to more emergent spaces such as coastal renewable energy, marine ecosystem services (i.e. blue carbon), seabed mining, and bioprospecting.

The blue economy is the "sustainable use of ocean resources for economic growth, improved livelihoods, and jobs while preserving the health of ocean ecosystem." European Commission defines it as "All economic activities related to oceans, seas and coasts. It covers a wide range of interlinked established and emerging sectors." The Commonwealth of Nations considers it "an emerging concept which encourages better stewardship of our ocean or 'blue' resources." The Centre for the Blue Economy says "it is now a widely used term around the world with three related but distinct meanings- the overall contribution of the oceans to economies, the need to address the environmental and ecological sustainability of the oceans, and the ocean economy as a growth opportunity for both developed and developing countries."

A United Nations representative recently defined the Blue Economy as an economy that "comprises a range of economic sectors and related policies that together determine whether the use of ocean resources is sustainable. An important challenge of the blue economy is to understand and better manage the many aspects of oceanic sustainability, ranging from sustainable fisheries to ecosystem health to preventing pollution. Secondly, the blue economy challenges us to realize that the sustainable management of ocean resources will require collaboration across borders and sectors through a variety of partnerships, and on a scale that has not been previously achieved. This is a tall order, particularly for Small Island Developing States (SIDS) and Least Developed Countries (LDCs) who face significant limitations." The UN notes that the Blue Economy will aid in achieving the UN Sustainable Development Goals, of which one goal, 14, is "life below water".

World Wildlife Fund begins its report Principles for a Sustainable BLUE ECONOMY with two senses given to this term: "For some, blue economy means the use of the sea and its resources for sustainable economic development. For others, it simply refers to any economic activity in the maritime sector, whether sustainable or not."

As the WWF reveals in its purpose of the report, there is still no widely accepted definition of the term blue economy despite increasing high-level adoption of it as a concept and as a goal of policy-making and investment.

Terms of the economy

Ocean economy

A related term of blue economy is ocean economy and we see some organizations using the two terms interchangeably. However, these two terms represent different concepts. Ocean economy simply deals with the use of ocean resources and is strictly aimed at empowering the economic system of ocean. Blue economy goes beyond viewing the ocean economy solely as a mechanism for economic growth. It focuses on the sustainability of ocean for economic growth. Therefore, blue economy encompasses ecological aspects of the ocean along with economic aspects.

Green economy

The green economy is defined as an economy that aims at reducing environmental risks, and that aims for sustainable development without degrading the environment. It is closely related with ecological economics. Therefore, blue economy is a part of green economy. During Rio+20

Summit in June 2012, Pacific small island developing states stated that, for them, "a green economy was in fact a blue economy".

Blue growth

A related term is blue growth, which means "support to the growth of the maritime sector in a sustainable way." The term is adopted by the European Union as an integrated maritime policy to achieve the goals of the Europe 2020 strategy.

Blue justice

Blue Justice is a critical approach examining how coastal communities and small-scale fisheries are affected by blue economy and "blue growth" initiatives undertaken by institutions and governments globally to promote sustainable ocean development. The blue economy is also rooted in the green economy and the UN Sustainable Development Goals. Blue Justice acknowledges the historical rights of small-scale fishing communities to marine and inland resources and coastal space; in some cases, communities have used these resources for thousands of years. Thus, as a concept, it seeks to investigate pressures on small-scale fisheries from other ocean uses promoted in blue economy and blue growth agendas, including industrial fisheries, coastal and marine tourism, aquaculture, and energy production, and how they may compromise the rights and the well-being of small-scale fisheries and their communities.

Potential of blue economy

On top of the traditional ocean activities such as fisheries, tourism and maritime transport, blue economy entails emerging industries including renewable energy, aquaculture, seabed extractive activities and marine biotechnology and bioprospecting. Blue economy also attempts to embrace ocean ecosystem services that are not captured by the market but provide significant contribution to economic and human activity. They include carbon sequestration, coastal protection, waste disposal, and the existence of biodiversity.

The 2015 WWF briefing puts the value of key ocean assets over US$24 trillion. Fisheries are now overexploited, but there is still plenty of room for aquaculture and offshore wind power. Aquaculture is the fastest growing food sector with the supply of 58 percent of fish to global markets. Aquaculture is vital to food security of the poorest countries especially. Only in the European Union the blue economy employed 3,362,510 people in 2014. The World Bank specifies three challenges that limit the potential to develop a blue economy.

- Current economic trends that have been rapidly degrading ocean resources.
- The lack of investment in human capital for employment and development in innovative blue economy sectors.
- Inadequate care for marine resources and ecosystem services of the oceans.

Sectors

- Aquaculture (fish farms, but also algaculture)
- Maritime biotechnology
- Bioprospecting
- Fishing
- Desalination
- Maritime transport
- Coastal, marine and maritime tourism (Blue Tourism)[1]
- Mineral resources
- Offshore oil and gas
- Offshore wind power (also tidal and wave)
- Shipbuilding and Ship repair[11]
- Carbon sequestration
- Coastal protection

- Waste disposal
- Existence of biodiversity
- Ocean development

The Blue Economy .which uses the term differently, namely for "solutions for environmental problems that are based upon simpler and cleaner technologies".

The oceans as a huge economic system.

Our oceans are not only the largest ecosystem in the world, but also a huge economic system - a blue economy. The need for more sustainability in this area becomes more visible every day. Not only because oceans and seas must be in good ecological and chemical conditions in order to develop their economic - and social - potential.

The oceans as providers for ecological services

Our oceans make up 97% of the world's water resources. This magnitude makes our earth appear as a blue planet from space. Oceans and seas provide half of the oxygen we need for life on this planet. Our seas contain 80% of all life forms, provide food for almost half of the world's population and are important resources for human mental and physical health. Oceans are involved in a complex web of economic interactions - the Blue Economy, sometimes also called Ocean Economy.

The economic power of today's global Blue Economy is immense. It includes all industries and sectors that have to do with oceans, seas and coasts in the broadest sense, regardless of whether the activities take place on or in the sea or on land. These include: shipping, fishing, (renewable) energy production, ports, shipyards, aquaculture, algae production, tourism as well as research, development and education.

Endangered balance of the ocean ecosystem

The economic fields of activity have a cumulative effect on the marine environment, the largest ecosystem on our planet. The consequences of its use and exploitation have become increasingly extensive for decades, compounded by climate change and greenhouse gas emissions. Garbage slicks, plastic and oil spills are visible from afar. Added to these are the invisible burdens of microplastics, chemicals, nutrients and underwater noise. The loss of biodiversity and natural habitats as well as health risks for the food chain are consequences, Climate and oceans are also closely linked. Oceans are the main carbon sink on earth, meaning they absorb and store man-made CO2. This process, which is positive on the one hand, has a major disadvantage, however. The absorbed CO2 dissolves in the water and triggers acidification. This leads to damage to sensitive ecosystems such as coral reefs, which support almost a quarter of marine life.

The road to a sustainable blue economy the potential of the Blue Economy to ensure and improve human well-being and social justice are enormous. The risks are no less far-reaching if the ecological services of the oceans, seas and coasts continue to be used or exploited with primarily economic interests with concepts, approaches and measures, mankind has taken on the protection of the oceans. Companies, institutions and organizations that contribute to the restoration, protection or maintenance of productive and resilient marine ecosystems and promote the availability of clean water and sanitation facilities have become important stakeholders in the Blue Economy. By 2030, the area of marine protection areas is to be expanded from the current 11% to 30%. The United Nations have enshrined the protection of the oceans and seas in Goal 14 - Life Below Water - of the Sustainable Development Goals. The UN Decade of Ocean Research for Sustainable Development started in 2021, because there is a lot we don't yet know about this huge ecosystem and the consequences of human interference. At the European level, too, ocean and water protection and the necessary sustainability of the Blue Economy are coming into focus, not least with the Green Deal.

Some conferences have been held and they represent an important opportunity to take stock of both the opportunities – and the challenges which the Blue Economy concept presents, in the context of SDG14 - Life Below Water.

As the single largest natural asset on the planet which represents some 99% of the earth's living volume, the ocean delivers numerous benefits to humanity.

- The ocean is responsible for the oxygen in every other breath we take. It supplies 15 percent of humanity's protein needs.
- It helps to slow climate change by absorbing 30 percent of carbon dioxide emissions and 90 percent of the excess heat trapped by greenhouse gases.
- It serves as the highway for some 90 percent of internationally traded goods, via the shipping sector.
- If the ocean were a country, at several trillion dollars per year of economic activity, the ocean would rank 7th on the list of largest nations by GDP.
- It is the source of hundreds of millions of jobs, in fisheries, aquaculture, shipping, tourism, energy production and other sectors.
- It is also the source of some 30 percent of the world's oil and gas resources but this equation must change if we are to succeed in the necessary transition to a low carbon development pathway.
- Millions of the world's poorest people depend heavily on the ocean and coastal resources for their sustenance and livelihoods.
- Small-scale fishing provides about half of the world's harvested seafood – but provides 44 times as many jobs per ton of fish as industrial fisheries do!

For the United Nations Development Programme (UNDP), the Blue Economy paradigm is a natural next step in the overall conceptualization and realization of sustainable human development. It mirrors our long-accepted definition of sustainable development as one that meets the needs of the present without compromising the ability of future generations to meet their own needs. Simply put, it is the utilization of ocean resources for human benefit in a manner that sustains the overall ocean resource base into perpetuity.

As for terrestrial ecosystems, marine ecosystems can only provide their myriad ecosystem services to humanity if they are governed and managed sustainably through an effective ocean and coastal governance. UNDP's Ocean Governance Programme works towards helping countries achieve this - from local level through initiatives like the Global Environmental Facility's (GEF) Small Grants Programme, to regional efforts such as UNDP's Large Marine Ecosystems programme, and global efforts on sustainable shipping in cooperation with the International Maritime Organization (IMO) and GEF.

In simplest terms, there are two elements for the Blue Economy. The first is the necessity of protecting – and restoring where needed – the existing ocean resource base that already supplies food and livelihoods to billions of people. Depleted fish stocks that are permitted to recover can ultimately deliver higher, sustainable fish yields and associated jobs. If protected and restored, coastal ecosystems such as coral reefs and mangroves can deliver increased coastal protection benefits from storm surges and sea level rise. Coastal areas that reduce nutrient pollution and eliminate hypoxic areas can, in turn, enjoy higher fish yields and increased tourism revenue.

The other side of the Blue Economy is where opportunities may exist for enhanced or new sustainable economic activity derived from the ocean. Progress and prospects for ocean-related energy, such as offshore wind and tidal energy, appear promising. Opportunities also exist to 'monetize' the value of highly effective coastal carbon stocks such as mangroves and seagrasses into carbon finance markets, or 'blue carbon.' Globally, aquaculture has been growing at a compounded rate of almost 9% since 1980, and now supplies nearly half of the world's consumed fish protein. However, much of it remains unsustainable in terms of pollution and impacts on species diversity, making this a critical Blue Economy opportunity to introduce more sustainable practices, such as integrated multi-trophic aquaculture. With support from GEF and UNDP, the IMO and the global shipping sector are taking pro-active steps to minimize the sector's contribution to climate change through improved energy efficiency, which can, in turn, enhance the sector's profitability, a true-Blue Economy approach.

This week's Sustainable Blue Economy Conference represents a unique opportunity for stakeholders at all levels, public and private, to share ideas and opportunities, create innovative new partnerships, and work together towards turning the Blue Economy concept into tangible actions, which will deliver sustainable economic development.

Blue Economy Definitions According to the World Bank, the blue economy is the "sustainable use of ocean resources for economic growth, improved livelihoods, and jobs while preserving the health of ocean ecosystem." European Commission defines it as "All economic activities related to oceans, seas and coasts. It covers a wide range of interlinked established and emerging sectors." The Commonwealth of Nations considers it "an emerging concept which encourages better stewardship of our ocean or 'blue' resources." Conservation International adds that "blue economy also includes economic benefits that may not be marketed, such as carbon storage, coastal protection, cultural values and biodiversity." The Centre for the Blue Economy says "it is now a widely used term around the world with three related but distinct meanings- the overall contribution of the oceans to economies, the need to address the environmental and ecological sustainability of the oceans, and the ocean economy as a growth opportunity for both developed and developing countries."

A United Nations representative recently defined the Blue Economy as an economy that "comprises a range of economic sectors and related policies that together determine whether the use of ocean resources is sustainable. An important challenge of the blue economy is to understand and better manage the many aspects of oceanic sustainability, ranging from sustainable fisheries to ecosystem health to preventing pollution. Secondly, the blue economy challenges us to realize that the sustainable management of ocean resources will require collaboration across borders and sectors through a variety of partnerships, and on a scale that has not been previously achieved. This is a tall order, particularly for Small Island Developing States (SIDS) and Least Developed Countries (LDCs) who face significant limitations." The UN notes that the Blue Economy will aid in achieving the UN Sustainable Development Goals, of which one goal, 14, is "Life Below Water".

By efficient management, the sustainable exploitation of resources in oceans, seas, lakes and rivers—also known as the blue economy could contribute up to $1.5 trillion to the global economy, according to the Organisation for Economic Cooperation and Development, an intergovernmental organization comprising of 36 countries.

With the theme "Blue Economy and the 2030 Agenda for Sustainable Development," the conference[8], convened and hosted by Kenya, with Canada and Japan as cohosts, looked at new technologies and innovation for oceans, seas, lakes and rivers as well as challenges, potential opportunities, priorities and partnerships.

Africa has 38 coastal and island states and a coastline of over 47,000 km, and hence presents an enormous opportunity for the continent to develop the sectors typically associated with the blue economy, says Cyrus Rustomjee, a blue economy expert and a senior fellow at the Centre for International Governance Innovation.

Nairobi Blue Economy conference was dedicated to realizing the untapped potential found in our oceans, seas, lakes and rivers.

"Expanding fisheries, aquaculture, tourism, transportation and maritime and inland ports can help to reduce African poverty and enhance food and energy

[8] Experts, government officials, environmental activists, policy makers and academics converged in Nairobi, Kenya, for the Sustainable Blue Economy Conference.

security, employment, economic growth and exports, ocean health and sustainable use of ocean resources," says Dr. Rustomjee.

He notes that more than 12 million people are employed in fisheries alone, the largest of the African blue economy sectors, providing food security and nutrition for over 200 million Africans and generating value added estimated at more than $24 billion, or 1.26% of the GDP of all African countries, of concern at the Nairobi conference was the current wanton and large-scale exploitation of the world's waters, especially in developing countries.

President Uhuru Kenyatta of Kenya expressed concern over the "massive pollution of our water bodies; the evident overexploitation of water resources and their related bio diversities, as well as the specific challenge of insecurity, more so in the high seas." Pre-conference advocacy by Kenya, Canada and Japan, the main organisers of the event, focused on many issues central to Africa's development, including food security for vulnerable groups and communities, malnutrition, sustainable food production and gender equality in blue economy industries. Kenya's Foreign Affairs Cabinet Secretary, Monica Juma, said the discussions were "dedicated to realizing the untapped potential found in our oceans, seas, lakes and rivers; and focused on integrating economic development, social inclusion and sustainability which promotes a blue economy that is prosperous, inclusive and sustainable." While emphasizing the importance of unlocking the full productive potential of Africa's waters, Ms. Juma said she especially hoped to see increased participation of women and youth in all areas of the blue economy. A recurring theme at the conference was that the blue economy could boost a country's economic growth and environmental protection and, by extension, help achieve the Sustainable Development Goals of the 2030 Agenda.

Overall, the conference presented "immense opportunities for the growth of our economy, especially sectors such as fisheries, tourism, maritime transport, offshore mining, among others, in a way that the land economy has failed to do."

The strategic importance of the blue economy to trade is clear, notes the International Maritime Organization, a specialised agency of the United Nations responsible for regulating shipping. For instance, up to 90% of global trade facilitation by volume and 70% by value is carried out by sea.

One challenge is that the oceans and seas absorb about 25% of the extra carbon dioxide emissions added to earth's atmosphere through the burning of fossil fuels. Oil and gas remain major sources of energy, with approximately 30% of production carried out offshore.

Before the event in Kenya, the organisers highlighted current challenges within the blue economy, including a lack of shared prosperity, maritime insecurity and unsustainable human activities around and in oceans, seas, lakes and rivers, including overfishing.

Other challenges are pollution, invasive species and ocean acidification, which lead to biodiversity loss and compromise human health and food security. In addition, a weak legal, policy, regulatory and institutional framework and poorly planned and unregulated coastal development exacerbate existing challenges.

To address these problems, participants called on leaders and policy makers to implement appropriate policies and allocate significant capital to sustainable investment in the sector to boost production, inclusiveness and sustainability.

The Nairobi conference drew global attention to the blue economy; the challenge is ensuring concrete actions follow the vigorous discussion.

Blue Economy Development Framework

Growing the Blue Economy to Combat Poverty and Accelerate Prosperity The world counts numerous coastal and island countries with lower and lower-middle income levels, for whom oceans represent a significant jurisdictional area and a source of opportunity. In those countries, innovation and growth in the coastal, marine and maritime sectors could deliver food, energy, transport, among other products and services (see box below), and serve as a foundation for sustainable development. Diversifying countries' economies beyond land-based activities and along their coasts is critical to achieving the Sustainable Development Goals and delivering smart, sustainable and inclusive growth globally.

In Europe for example, the blue economy represents roughly 5.4 million jobs and generates a gross added value of almost €500 billion a year. Components of the Blue Economy Type of Activity Ocean Service Industry Drivers of Growth Harvest of living resources Seafood Fisheries Food Security Aquaculture Demand for Protein Marine biotechnology Pharmaceuticals, chemicals R&D for healthcare and industry Extraction of non-living resources, generation of new resources Minerals Seabed mining Demand for minerals Energy Oil and gas Demand for alternative Renewable energy sources Fresh water Desalination Demand for fresh water Commerce and trade in and around the oceans Transport and trade Shipping Growth in seaborne trade; Port infrastructure and services International regulations Tourism and recreation Tourism Growth of global tourism Coastal Development Coastal urbanization Domestic regulations Response to ocean health challenges Ocean monitoring and surveillance Technology and R&D R&D in ocean technologies Carbon Sequestration Blue Carbon Growth in coastal and ocean protection and conservation activities Coastal Protection Habitat protection and restoration Waste Disposal Assimilation of nutrients and wastes

Additional growth of the blue economy is possible in a number of areas, especially: fisheries, aquaculture, mariculture, coastal tourism, marine biotechnology, and ocean energy. While some of these sectors will require little encouragement and additional governance, others need more and better planning to achieve their full potential and return more sustainable outcomes. Ambitious governance reform supported by the World Bank in Morocco for instance, helped the country develop its aquaculture sector to generate jobs, especially for women, in rural areas where employment prospects are challenging. Providing technical knowledge of marine ecosystems, legal certainty and security to attract private investment have been key success factors in that instance. Significant contributions of marine and freshwater ecosystems include: Food security, nutrition and health: Fish contributes over 16 percent of the animal protein consumed by the world's population and percent of all protein consumed, with 1 billion people relying on this source of protein.

Fish is also a particularly critical source of nutrition. Even in small quantities, provision of fish can be effective in addressing food and nutritional security among the poor and vulnerable populations around the globe. Livelihoods: FAO estimates that fishers, fish farmers and those supplying services and goods to related industries assure the livelihoods of as many as 660–820 million people worldwide. In addition, women play a critical role in fishery supply chains – it is estimated that women account for 15 percent of people directly engaged in fisheries and up to 90 percent of jobs in secondary activities (particularly in fish processing, whether in the formal or informal sector).

Oceans and coasts also form the foundation for extensive employment in tourism - one of the top five industries in most small island states. Mitigation of climate change: Oceans constitute a major sink for anthropogenic emissions, absorbing 25 percent of the extra CO2 added to Earth's atmosphere by burning fossil fuels. 'Blue carbon' sinks like mangrove forests, sea grass beds and other vegetated ocean habitats are up to five times as effective as tropical forests at sequestering carbon. Homes and shelter: Roughly 40 percent of the world's population lives within 100 kilometres of the coast. Healthy coastal ecosystems provide protection from natural hazards, coastal erosion and rising sea levels particularly in small island developing states (SIDS) and low-lying, exposed delta regions. Sustainable economic growth: A large number of developing coastal and island nations depend on tourism and fisheries for a significant part of their gross domestic product and public revenues. Aquaculture is projected to continue to grow rapidly and if done sustainably, can serve as a major source of food and a cornerstone of the blue economy. Advances in seaweed production hold promise for replacing fishmeal and animal feeds with plant materials produced with less pollution.

Tourism, and particularly nature-based tourism, also provides an important path towards the sustainable development of marine and coastal ecosystems. Coastal tourism is a key component of small island state economies. The value of nature-based tourism is expected to increase over time as the supply of pristine natural assets declines while demand, which seems impervious to economic shocks, increases with rising GDPs.

Trade: Seafood is the most highly valued internationally traded food commodity in the world, with 36 percent of all fish produced exported in 2013-2014. At US$139 billion in 2013, the export value of fish is more than double that of the next most traded commodity – soybeans. More than half of the fish trade originated from the waters of developing countries. Challenges undermining the blue economy the potential to grow the blue economy is limited by a series of challenges. For much of human history, aquatic ecosystems have been viewed and treated as limitless resources and largely cost-free repositories of waste. These resources, however, are far from limitless and we are increasingly seeing the impacts of this approach. The narrow coastal interface is oversubscribed by myriad sectors, and increasingly impacted by climate change. Rising demand, ineffective governance institutions, inadequate economic incentives, technological advances and insufficient management tools have led to inefficiently regulated or unregulated competition among users. This in turn has resulted in excessive use, and in some cases irreversible change, of valuable aquatic resources and coastal areas. In this increasingly competitive space, the interests of those most dependent and vulnerable (for example small-scale artisanal fishers) are often marginalized. Most significant human impacts have been from:

- Overfishing as a result of technological improvements coupled with poorly managed access to fish stocks and rising demand. The FAO estimates that approximately 57 percent of fish stocks are fully exploited and another 30 percent are over-exploited, depleted or recovering. Fish stocks are further exploited by illegal, unreported and unregulated fishing, responsible for roughly 11 to 26 million tons of fish catches annually, or US$10-22 billion in unlawful or undocumented revenue.

- Habitat degradation due largely to coastal development, deforestation, mining, and unsustainable fishing practices as well as pollution, in the form of excess nutrients from untreated sewerage, agricultural run-off and marine debris such as plastics. Coastal erosion also destroys infrastructure and livelihoods.
- Climate change related phenomena -- both slow onset events like sea level rise and more intense and frequent weather events. Long term climate change impact on ocean systems is fraught with uncertainty, but it is clear that changes in sea temperature, acidity, and major oceanic currents, among others, threaten marine life and habitats.
- Unfair trade: Exclusive Economic Zones (EEZ), zones in which a state has special rights over exploration and use of marine resources, are crucial to the economies of island states, and often dwarf their corresponding land mass and government's administrative capacity. (In Tuvalu, for instance, the size of the EEZ is more than 26,000 times that of the land mass.) Moreover, much of the value from international seafood trade does not remain in developing countries of origin, let alone in fishing communities.
- Ad hoc development: Unplanned and unregulated development in the narrow coastal interface and near shore areas have led to significant externalities between sectors, suboptimal siting of infrastructure, overlapping uses of land and marine areas, marginalization of poor communities, and loss or degradation of critical habitats. Despite a range of actors and large investments, current attempts to overcome these challenges have mostly been piecemeal, with no comprehensive strategy (for example fisheries governance; improving ports; marine litter efforts). Even when one sectoral policy achieves some success, these results are often

undermined by externalities from activities in another sector. Often, for example, coastal zone management efforts, or support to coastal fishers, are undermined by unbridled sand mining, ill-sited ports or aquaculture farms or unregulated tourism development.

In coastal zones, declines in mangrove forest habitat resulting from wood harvest, sea level rise, and changes in sediment and pollutant loading from river basins combined with land reclamation for agriculture or infrastructure negatively impact fisheries by reducing or degrading spawning and feeding habitats. Loss of mangrove forests, for example, threatens profits from seafood harvests exceeding US$4 billion per year. In Belize, mangrove-rich areas produce an average of 71 percent more fish biomass than areas with few mangroves. How can we overcome these challenges effectively, and at scale? A more systematic approach, based on a better understanding of nationally defined priorities, social context and resource base, can guide sustainable and inclusive blue growth. Countries increasingly recognize that they need more knowledge about the biophysical characteristics, carrying capacity, synergies or trade-offs between sectors to ensure an efficient and sustainable management of different activities. Marine and coastal spatial planning and integrated maritime surveillance are needed to give authorities, businesses and communities a better picture of what is happening in this unique space.

Digital mapping of maritime and coastal space and natural assets can form the basis for cross-sector analysis and planning in order to prevent conflicts and avoid externalities. Similarly, the growing science of data-limited stock assessments can provide critical information needed for improved fisheries management. In places such as South Africa and Indonesia, mobile technology is being tested to gather previously unavailable data, for example on fishery landings and fish stock health. Integrated coastal zone management can enhance the protection of coastal and near shore resources while increasing the efficiency of their uses. Coastal zones are among the most productive areas in the world, offering a wide variety of valuable habitats and ecosystems services that have always attracted humans and human activities. Coastal zones are also among the areas most vulnerable to climate change and natural hazards. Risks include flooding, erosion, sea level rise as well as extreme weather events. These impacts are far reaching and are already changing the lives and livelihoods of coastal communities. Unlike sectoral approaches that can lead to disconnected decisions, inefficient resource use and missed opportunities, integrated coastal zone management (ICZM) seeks to coordinate the application of different policies affecting the coastal zone and maritime activities. ICZM is an iterative process which includes a variety of approaches, from mapping, delineation and demarcation of the hazard lines and coastal sediment cells, to building the capacity of agencies, institutions and communities to make informed decisions about growing the blue economy within the carrying capacity of its living natural resource base. Growing the blue economy requires assessing the value of marine resources. Not only are marine living resources poorly measured and understood, they are also rarely valued properly.

In Mauritania, for instance, a study showed that the value of fisheries and other renewable marine resources was much greater than that of the minerals upon which the Government had previously based most of its marine resource management decisions. Understanding that in comparison with mineral resources, marine living resources are a) of much higher total value, and b) renewable, the Government adopted an alternative approach to development based on realizing the long-term potential for blue growth.

New data can also sway decision-makers. Well managed, the goods and services produced from aquatic ecosystems could make a much greater contribution to reducing poverty, building resilient communities, fostering strong economies and feeding over 9 billion people by 2050. For example, the World Bank's 2016 Sunken Billions Revisited study shows that fisheries properly managed, with a significant reduction in overfishing, could provide an additional US$83 billion to the global economy each year. That amount represents about two-thirds of official development assistance in 2012 and almost 30 times the annual net benefits currently accruing to the fisheries sector. Investing in change to grow the blue economy Armed with data and political goodwill, countries have different options to tap into the growth potential of the blue economy. The World Bank sees four key entry points for creating comprehensive change: investments in governance, technology, markets, and finance. Investing in improved governance will create a pipeline of investable opportunities to grow the blue economy in a way that benefits national economies and local communities, while protecting resources for future growth.

Effective governance is an essential condition to promote sustainable management of aquatic resources and environment, and ensuring biodiversity and ecosystem resilience, which in turn contribute to building community resilience against various shocks, including climate change. Effective governance will also help create an enabling environment for responsible private sector investments throughout the value chain by reducing risks and providing incentives for innovation. Finally, effective governance will enhance the contribution of fisheries, aquaculture and mariculture to the macro-economy, which will help improve the visibility of the sector and consequently resource allocation. Governance enhancements should include a focus on including and empowering local communities. Analysis and results of fisheries rebuilding efforts around the world have demonstrated that when local communities and fishers have a voice in setting policy and management guidelines, these rules are much more likely to be followed and create lasting change. Empowering local communities also means clarifying tenure and resource access privileges, but in order to be effective, these must be accompanied with the capacity and resources to take advantage of these clear rights.

The use of science, data and technology is critical to underpin governance reforms and shape management decisions. Without credible information on the state of the resource in a given fishery, and how quickly a population can be expected to grow and recover, it is impossible to design effective and defensible fisheries conservation and management measures. Similarly, for aquaculture to be sustainable, its environmental impacts must be measured, understood and limited. Without data, it is impossible to discern the impact of any management changes. This basic knowledge about the status and potential for recovery of a fishery or the sustainable expansion of aquaculture is essential for decision-making and to facilitate private investment. Improving market infrastructure and access can create more sustainable outcomes that benefit the poor. Building on market demand for sustainable seafood can create incentives for good practices and drive new investment opportunities related to sustainably managed fisheries and aquaculture. Buyer demand for sustainable seafood in Western Europe and North America has driven substantial change in large fisheries that supply these markets. There is ample opportunity to use this same market demand to drive a shift towards best practices in developing world fisheries. This also helps reduce the risk, real and perceived, of investing in fisheries and aquaculture. Another critical step is to coordinate among investors, public funding agencies, and philanthropic donors to develop new deal structures that sequence or layer investments so that those with greater risk tolerance can begin to engage with fisheries. With improved governance and incentives that align natural capital with investment capital, responsible finance can secure returns and contribute significantly to building the blue economy. To date, the transition to more sustainable fisheries has been largely funded by development agencies and philanthropic sources of money. However, these types of capital alone cannot support the rate and scale of fisheries reform that is required on a global level. A growing number of investors are looking for opportunities that support positive social and environmental impacts. Good governance, including sustainable harvest levels, secure tenure, and robust monitoring and enforcement are required to reduce risk and encourage the development of bankable investments.

Rethinking the blue economy Most recently, the World Bank has been working with the government of Oman and community stakeholders to create a vision and implementation plan for a profitable world-class fisheries sector that is ecologically sustainable and a net contributor to Oman's economy. In Indonesia, the WBG is helping the government evaluate the potential economic contributions of investing in improved governance of fisheries and aquaculture. The Bank is also helping its clients rethink adaptation to climate change through a two-prong approach. First, we are developing a series of policy reform efforts designed specifically to encourage implementation of integrated coastal zone management in Morocco, Vietnam and Sri Lanka. In addition, the Bank is spearheading a major initiative on adaptation to coastal erosion aggravated by climate in West Africa, including through national and regional policy dialogues, and green infrastructure.

The Global Program on Fisheries (PROFISH), a multi-donor trust fund housed at the Bank, strengthens the WBG offer by supporting improved fisheries and aquaculture. PROFISH focuses on improving environmental sustainability, human wellbeing, and economic performance in the world's fisheries and aquaculture, with a focus on the welfare of the poor in fisheries and fish farming communities in the developing world. To date, PROFISH investments of US$4.5 million in research, analysis and technical support have generated US$1 billion in World Bank lending; created ALLFISH, which leveraged US$1.5 million from the Global Environment Facility, into US$8.5 million of private sector investments into sustainable seafood supply chains; and facilitated a US$10 million IFC investment in aquaculture, a return on investment of 727 percent. PROFISH builds its interventions on three pillars: 1. Governance: Reform policies, build public sector capacity, align economic interests with long-term sustainability, and promote conditions that encourage business growth in a sustainable seafood sector. Public-private dialogue, stakeholder inclusion and strategic partnerships with donors, technical expertise, the private sector and clients help shape the fisheries agenda and position fisheries as central to today's development challenges – poverty alleviation, climate change, and food security.

Science and data: Generate state-of-the art scientific knowledge to inform sustainable fisheries and aquaculture policy and investment. Predictive analytics, technical assistance and financing to leverage investment in fisheries across the World Bank Group and major donor portfolios. Markets and finance: Reduce waste, improve fish value chains, increase market access, and drive new investment opportunities in sustainably managed fisheries and aquaculture through innovative financing mechanisms. This brings together public and commercial finance, philanthropic capital and private equity to invest cooperatively in projects that create jobs, grow local economies and generate positive social impacts to scale up sustainable solutions in the fisheries sector.

FOSSIL FUEL

A fossil fuel is a hydrocarbon-containing material formed naturally in the earth's crust from the remains of dead plants and animals that is extracted and burned as a fuel. Fossil fuels are a non-renewable source of energy. Most of the energy used by us is obtained by the burning of fossil fuels. These fossil fuels are used up at a faster rate. They cannot be regrown at a scale compared to their consumption. With the increased demand for the production of various energies, fossil fuel energy is declining. It is difficult to replace them. That is why they are known as a non-renewable source of energy The main fossil fuels are coal, crude oil and gas. Fossil fuels may be burned to provide heat for use directly (such as for cooking or heating), to power engines (such as internal combustion engines in motor vehicles), or to generate electricity. Some fossil fuels are refined into derivatives such as kerosene, gasoline and propane before burning. The origin of fossil fuels is the anaerobic decomposition of buried dead organisms, containing organic molecules created by photosynthesis. The conversion from these materials to high-carbon fossil fuels typically require a geological process of millions of years.

The theory that fossil fuels formed from the fossilized remains of dead plants by exposure to heat and pressure in Earth's crust over millions of years was first introduced by Andreas Libavius "in his 1597 Alchemia [Alchymia]" and later by Mikhail Lomonosov "as early as 1757 and certainly by 1763". The first use of the term "fossil fuel" occurs in the work of the German chemist Caspar Neumann, in English translation in 1759.The Oxford English Dictionary notes that in the phrase "fossil fuel" the adjective "fossil" means "[o]btained by digging; found buried in the earth", which dates to at least

1652,before the English noun "fossil" came to refer primarily to long-dead organisms in the early 18th century.

Aquatic phytoplankton and zooplankton that died and sedimented in large quantities under anoxic conditions millions of years ago began forming petroleum and natural gas as a result of anaerobic decomposition. Over geological time this organic matter, mixed with mud, became buried under further heavy layers of inorganic sediment. The resulting high temperature and pressure caused the organic matter to chemically alter, first into a waxy material known as kerogen, which is found in oil shales, and then with more heat into liquid and gaseous hydrocarbons in a process known as catagenesis. Despite these heat-driven transformations, the energy released in combustion is still photosynthetic in origin.

Terrestrial plants tended to form coal and methane. Many of the coal fields date to the Carboniferous period of Earth's history. Terrestrial plants also form type III kerogen, a source of natural gas. Although fossil fuels are continually formed by natural processes, they are classified as non-renewable resources because they take millions of years to form and known viable reserves are being depleted much faster than new ones are generated.[

In 2019, 84% of primary energy consumption in the world and 64% of its electricity was from fossil fuels. The large-scale burning of fossil fuels causes serious environmental damage. Over 80% of the carbon dioxide (CO2) generated by human activity comes from burning them: around 35 billion tonnes a year, compared to 4 billion from land development.[7] Natural processes on Earth, mostly absorption by the ocean, can only remove a small part of this. Therefore, there is a net increase of many billion tonnes of atmospheric carbon dioxide per year. Although methane leaks are significant,[9]:52 the burning of fossil fuels is the main source of greenhouse gas emissions causing global warming and ocean acidification. Additionally, most air pollution deaths are due to fossil fuel particulates and noxious gases. It is estimated that this costs over 3% of global GDP and that fossil fuel phase-out would save millions of lives each year.

Recognition of the climate crisis, pollution and other negative impacts caused by fossil fuels has led to a widespread policy transition and activist movement focused on ending their use in favor of energy. However, because the fossil fuel industry is so heavily integrated in the global economy and heavily subsidized, this transition is expected to have significant economic impacts. Many stakeholders argue that this change needs to be a just transition and create policy that addresses the societal burdens created by the stranded assets of the fossil fuel industry.

International policy, in the form of United Nations Sustainable Development Goal 7: Affordable and Clean Energy, Sustainable Development Goal 13: Climate Action and the Paris Climate Agreement, is designed to facilitate this transition at a global level. In 2021, the International Energy Agency concluded that no new fossil fuel extraction projects could be opened if the global economy and society wants to avoid the worst impacts of climate change and meet international goals for climate change mitigation

Advantages:

Fossil fuels can generate a large amount of electricity at a single location.

They can be found very easily.

They are cost-effective.

Transportation of oil and gas can be done easily through pipelines.

They have become safer over time.

Despite being a finite resource, it is available in plenty.

Disadvantages

Fossil fuels emit carbon dioxide when burnt which is a major greenhouse gas and the primary source of pollution. This has contributed to global warming.

They are a non-renewable resource, i.e., once used they cannot be replaced.

Combustion of fossil fuels makes the environment more acidic. This has led to unpredictable and negative changes in the environment.

Harvesting of fossil fuels also causes fatal diseases among the people. For e.g., the coal miners often suffer from Black Lung Disease. The natural gas drillers are constantly exposed to chemicals and silica which is dangerous for their health.

The Role of Fossil Fuels in a Sustainable Energy System

climate change is one of the greatest challenges of our time. Equally important, however, is the need to ensure access to energy for quality of life and for economic development. It is therefore critically important to address climate change as part of the sustainable development agenda. Ongoing progress in the development of new technologies has brought confidence and hope that these objectives will be met in the energy system. Dramatic price reductions and technological advancement of wind generators and solar photovoltaics have shown that these renewable energy resources can be important players in global electricity systems, and that the long-anticipated breakthrough in cost-effective storage technology would shift primary energy mixes substantially[9].

These developments have led invariably to an assumption that we are "done" with fossil fuels across the energy system, that there is no need for further development of new resources, and that we have to stop using them as soon as possible. This assumption has also led to a perception of "good" renewables-based technologies in global energy systems today, on the one hand, and "bad" fossil fuels-based technologies, on the other. The reality is that this debate is much more nuanced and requires more thorough investigation. Carbon capture and storage (CCS) technology and managing methane emissions throughout the fossil energy value chain can help meet

[9] December 2015, No. 3 Vol. LII, Sustainable Energy

ambitious CO2 emission reduction targets, while fossil fuels remain part of the energy system. This will thereby allow fossil fuels to become "part of the solution", rather than remain "part of the problem". All technologies have a role to play in an energy system guided by rational economics

Fossil fuels comprise 80 per cent of current global primary energy demand, and the energy system is the source of approximately two thirds of global CO2 emissions. Inasmuch as methane and other short-lived climate pollutant (SLCP) emissions are believed to be severely underestimated, it is likely that energy production and use are the source of an even greater share of emissions. Further, much of the biomass fuels are currently used around the world in small scale heating and cooking. These are highly inefficient and polluting, especially for indoor air quality in many less-developed countries. Renewable biomass used in this way is a problem for sustainable development[10]. If current trends continue, in other words, if the current share of fossil fuels is maintained and energy demand nearly doubles by 2050, emissions will greatly surpass the amount of carbon that can be emitted if the global average temperature rise is to be limited to 2oC. That level of emissions would have disastrous climate consequences for the planet. There are a number of emission reduction opportunities for the energy sector, notably reducing the amount of energy consumed and reducing the net carbon intensity of the energy sector by fuel switching and by controlling CO2 emissions.

The need to reduce emission does not preclude the use of fossil fuels, but it does require a significant change in direction; business as usual is not consistent with decreasing emissions in global energy systems. Energy efficiency and renewable are often positioned as the only solutions needed to meet climate goals in the energy system, but they are not enough. Including an expansion of the use of CCS will be essential, and this technology is expected to result in 16 per cent of annual emissions reduction by 2050. This assertion is supported by the Fifth Assessment Synthesis Report of the

[10] bid

Intergovernmental Panel on Climate Change, which estimates that limiting energy sector emissions without CCS would increase the cost of climate mitigation by 138 per cent.

Renewable cannot be used uniformly across the energy system to replace the use of fossil fuels today, mostly because of the variance in the ability of different energy subsectors to switch from fossil fuels to renewable. For example, in some industrial applications such as cement and steel production, emissions come from both the energy use and the production process. Alternative technologies that can replace current production techniques are not yet available at the scale needed, so it is expected that these techniques will persist in the short to medium term. In these cases, CCS can provide a solution consistent with current demands and give the time needed to develop future alternative approaches.

Scenarios that foresee the use of CCS are in all cases associated with a significant transformation of the energy system in response to climate change. Hence, such scenarios are not "business-as-usual", and show a significant decrease in total global fossil fuels consumption, as well as a significant increase in efficiency across electricity production and industrial processes. This transformation of the energy system is supportive of all technologies that are instrumental for the development of a sustainable energy system.

In this vein, the United Nations Economic Commission for Europe (UNECE) member States endorsed a set of recommendations on CCS in November 2014 following extensive consultations with experts from around the world. The recommendations emphasize that an international climate agreement should:

Accept a broad array of fiscal instruments to encourage CCS.

- Address capturing and storing carbon dioxide from all industrial sectors, including cement, steel, chemicals, refining and power production.

- Ensure that Governments work together to sponsor and support multiple demonstration projects at scale.
- Allow carbon dioxide injected into reservoirs for enhanced hydrocarbon recovery to be treated and calculated as storage if stored permanently.

These recommendations, if implemented, allow United Nations Member States that still depend heavily on fossil fuels to engage in global efforts to reduce the consequences of climate change, instead of being seen as only contributing to the problem. The technology has been proven at scale in Canada, Norway and the United States of America, and there are some 40 projects at various stages of development around the world today. Near-term efforts on CCS are essential to improve efficiency, reduce costs and better map storage options in order to ensure that this technology is available for large-scale deployment starting in 2025.

CO2 emissions are not the only issue that needs to be addressed in the use of fossil fuels. The fossil fuel value chain, across natural gas, coal and oil production and use, is estimated to emit 110 million tons of methane annually. This represents a large share of all methane emissions. As a powerful greenhouse gas, methane emissions must be significantly reduced.

Methane is a primary component of natural gas, with some emitted to the atmosphere during natural gas production, processing, storage, transmission and distribution. It is estimated that around 8 per cent of total worldwide natural gas production is lost annually to venting, leakage and flaring, resulting in substantial economic and environmental costs. During the geological process of coal formation, pockets of methane get trapped around and within the rock. Coal mining-related activities (extraction, crushing, distribution, etc.) release some of the trapped methane. As with coal, the geological formation of oil can also create large methane deposits that are released during drilling and extraction. The production, refinement, transportation and storage of oil are also sources of methane emissions, as is incomplete combustion of fossil fuels. No combustion process is perfectly efficient, so when fossil fuels are used to generate electricity, heat or power vehicles, they all contribute as sources of methane emissions.

The key challenges for methane management are to monitor and record emissions accurately using the best monitoring and measurement technology and then to apply the best fixes to minimize leaks and emissions. This will offer economic benefits, while decreasing health impacts, increasing safety and reducing global warming. The multiple benefits of managing methane emissions are compelling, but still more work is needed to demonstrate adequate progress in this space.

Addressing the issue of sustainable energy requires the engagement of the broadest possible group of stakeholders, while ignoring the role of fossil fuels will have a negative effect. Many developing countries have large untapped fossil fuel resources that they intend to use to develop their respective economies. Insisting that they incur significant costs and forego the use of these resources in favor of renewable is likely to create unneeded tensions. The argument is made that the developed world built its existing economies on fossil fuels and still heavily relies on them. Rather than a "non-fossil" only agenda, a more pragmatic approach that encourages all to use the broad range of resources available to them (i.e., energy efficiency, renewables and fossil fuels in a sustainable manner) will create a more balanced approach.

The other stakeholder group that is often vilified is the private sector, especially actors in the fossil fuel industry. In fact, the private sector holds the expertise and often the financial resources to support the needed change to the inclusive green economy that the world is seeking. Using the balance sheets of the big players along with their knowledge and know-how can facilitate the transition; treating them like pariahs will make the journey harder and more expensive[11].

The persistent critical challenge is to ensure an improved quality of life and economic growth, while reducing the environmental footprint of the energy

[11] ibid

sector. The transition to a sustainable energy system is an opportunity to improve energy efficiency from source to use, minimize environmental impacts, reduce energy and carbon intensities, and correct energy market failures. Seizing the opportunity will require coordinated policy review and reform across many sectors. The UNECE region has the potential for competitive economic advantage compared to other regions of the world, given the relatively modest distances between energy supply sources and energy demand centers. Full integration of the region's energy markets within an efficient framework would significantly improve the technical, social, economic and environmental contribution that energy could make[12].

Building a sustainable energy system for the future in the UNECE region will involve a substantial transition from what is in place today. Improving efficiency relates not only to consumer-level energy issues (such as energy-efficient housing, vehicles and appliances), but also to upstream energy efficiency in production/generation, transmission and distribution. It is an opportunity to accelerate the change from the traditional model of selling energy commodities to one of providing energy services based on innovation.

The development of smart energy networks with common rules of operation provides an important opportunity to enhance the collaboration among technologies, thereby enhancing the cost-effective penetration of the broadest range of low-carbon technologies and improving the resilience of the energy system. Fossil fuels will be part of the global energy system for decades to come—whether we like it or not. It will continue to underpin social and economic development around the world. From that perspective, it is essential that we have an open and transparent discussion on the role of fossil fuels in sustainable energy systems globally in the creation of practical climate strategies. It is especially important to engage emerging economies and developing countries in the context of the twenty-first session of the Conference of the Parties (COP21) to the United Nations Framework

[12] ibid

Convention on Climate Change. This could change the political dynamics and help to shape a strong climate agreement in Paris.

Butane Gas

Butane is an alkane with the formula C_4H_{10}. Butane is a gas at room temperature and atmospheric pressure. Butane is a highly flammable, colorless, easily liquefied gas that quickly vaporizes at room temperature. The name butane comes from the root but- (from butyric acid, named after the Greek word for butter) and the suffix -ane. It was discovered by the chemist Dr. Walter Snelling in 1912.It was found dissolved in crude petroleum in 1864 by Edmund Ronalds, who was the first to describe its properties.

Butane is one of a group of liquefied petroleum gases (LP gases). The others include propane, propylene, butadiene, butylene, isobutylene, and mixtures thereof. Butane has a lower energy density but burns more cleanly than gasoline and coal. Butane and Propane were simultaneously discovered in 1912 by an American chemist, Dr. Walter Snelling. Snelling identified these gases as components in gasoline and found that if they were cooled, they could be stored in a volume-reduced liquified state in pressurized containers.

Spectrum of the blue flame from a butane torch showing CH molecular radical band emission and C_2 Swan bands

When oxygen is plentiful, butane burns to form carbon dioxide and water vapor; when oxygen is limited, carbon (soot) or carbon monoxide may also be formed. Butane is denser than air.

When there is sufficient oxygen:

$$2\ C_4H_{10} + 13\ O_2 \rightarrow 8\ CO_2 + 10\ H_2O$$

When oxygen is limited:

$$2\ C_4H_{10} + 9\ O_2 \rightarrow 8\ CO + 10\ H_2O$$

By weight, butane contains about 49.5 MJ/kg (13.8 kWh/kg; 22.5 MJ/lb; 21,300 Btu/lb) or by liquid volume 29.7 megajoules per liter (8.3 kWh/l; 112 MJ/U.S. gal; 107,000 Btu/U.S. gal).

The maximum adiabatic flame temperature of butane with air is 2,243 K (1,970 °C; 3,578 °F).

n-Butane is the feedstock for DuPont's catalytic process for the preparation of maleic anhydride:

$$2\ CH_3CH_2CH_2CH_3 + 7\ O_2 \rightarrow 2\ C_2H_2(CO)_2O + 8\ H_2O$$

Butane, like all hydrocarbons, undergoes free radical chlorination providing both 1-chloro- and 2-chlorobutanes, as well as more highly chlorinated derivatives. The relative rates of the chlorination is partially explained by the differing bond dissociation energies, 425 and 411 kJ/mol for the two types of C-H bonds.

Uses

Normal butane can be used for gasoline blending, as a fuel gas, fragrance extraction solvent, either alone or in a mixture with propane, and as a feedstock for the manufacture of ethylene and butadiene, a key ingredient of synthetic rubber. Isobutane is primarily used by refineries to enhance (increase) the octane number of motor gasoline.[12][13][14][15]

For gasoline blending, n-butane is the main component used to manipulate the Reid vapor pressure (RVP). Since winter fuels require much higher vapor pressure for engines to start, refineries raise the RVP by blending more butane into the fuel n-Butane has a relatively high research octane number (RON) and motor octane number (MON), which are 93 and 92 respectively

When blended with propane and other hydrocarbons, the mixture may be referred to commercially as liquefied petroleum gas (LPG). It is used as a petrol component, as a feedstock for the production of base petrochemicals in steam cracking, as fuel for cigarette lighters and as a propellant in aerosol sprays such as deodorants.

Pure forms of butane, especially isobutane, are used as refrigerants and have largely replaced the ozone-layer-depleting halomethanes in refrigerators, freezers, and air conditioning systems. The operating pressure for butane is lower than for the halomethanes such as Freon-12 (R-12), so R-12 systems such as those in automotive air conditioning systems, when converted to pure butane, will function poorly. A mixture of isobutane and propane is used instead to give cooling system performance comparable to use of R-12. Butane is also used as lighter fuel for a common lighter or butane torch and is sold bottled as a fuel for cooking, barbecues and camping stoves. The global market for butane canisters is dominated by South Korean manufacturers. In the 20th century the Braun (company) of Germany made a cordless hair styling device product that used butane as its heat source to produce steam As fuel, it is often mixed with small amounts of mercaptans to give the unburned gas an offensive smell easily detected by the human nose. In this way, butane leaks can easily be identified. While hydrogen sulfide and mercaptans are toxic, they are present in levels so low that suffocation and fire hazard by the butane becomes a concern far before toxicity. Most commercially available butane also contains some contaminant oil, which can be removed by filtration and will otherwise leave a deposit at the point of ignition and may eventually block the uniform flow of gas.

The butane used as a solvent for fragrance extraction does not contain these contaminants and butane gas can cause gas explosions in poorly ventilated areas if leaks go unnoticed and are ignited by spark or flame. Purified butane is used as a solvent in the industrial extraction of cannabis oils.

Clean Energy

Clean energy is energy that is produced through means that do not pollute the atmosphere. It can also refer to renewable energy sources that do not create environmental debt: using up resources that cannot be replaced or severely damaging the environment so that future generations must solve problems created today.

Renewable energy is energy that is collected from renewable resources that are naturally replenished on a human timescale. It includes sources such as sunlight, wind, rain, tides, waves, and heat. Although most renewable energy sources are sustainable, some are not. For example, some biomass sources are considered unsustainable at current rates of exploitation. Renewable energy often provides energy for electricity generation to a grid, air and water heating/cooling, and stand-alone power systems. About 20% of humans' global energy consumption is renewables, including almost 30% of electricity. About 7% of energy consumption is traditional biomass, but this is declining. Over 4% of energy consumption is heat energy from modern renewables, such as solar water heating, and over 6% electricity.

Globally there are over 10 million jobs associated with the renewable energy industries, with solar photovoltaics being the largest renewable employer. Renewable energy systems are rapidly becoming more efficient and cheaper and their share of total energy consumption is increasing, with a large majority of worldwide newly installed electricity capacity being renewable. In most countries, photovoltaic solar or onshore wind are the cheapest new-build electricity. Many nations around the world already have renewable energy contributing more than 20% of their total energy supply, with some generating over half their electricity from renewables. A few countries generate all their electricity using renewable energy. National renewable energy markets are projected to continue to grow strongly in the 2020s and beyond. Studies have shown that a global transition to 100% renewable energy across all sectors – power, heat, transport and desalination – is feasible and economically viable. Renewable energy resources exist over wide geographical areas, in contrast to fossil fuels, which are concentrated in a limited number of countries. Deployment of renewable energy and energy efficiency technologies is resulting in significant energy security, climate change mitigation, and economic benefits. However renewables are being hindered by hundreds of billions of dollars of fossil fuel subsidies. In international public opinion surveys there is strong support for renewables such as solar power and wind power. But the International Energy Agency said in 2021 that to reach net zero carbon emissions more effort is needed to increase renewables, and called for generation to increase by about 12% a year to 2030. Renewable energy technology projects are typically large-scale, but they are also suited to rural and remote areas and developing countries, where energy is often crucial in human development. As most of the renewable energy technologies provide electricity, renewable energy is often deployed together with further electrification, which has several benefits: electricity can move heat or objects efficiently, and is clean at the point of consumption. In addition, electrification with renewable energy is more efficient and therefore leads to significant reductions in primary energy requirements. In 2021, China accounted for almost half of the global increase in renewable electricity

Climate Change

Climate change includes both global warming and its impacts on Earth's weather patterns. There have been previous periods of climate change, but the current changes are distinctly more rapid and not due to natural causes.[13] Instead, they are caused by the emission of greenhouse gases, mostly carbon dioxide (CO_2) and methane. Burning fossil fuels for energy production creates most of these emissions. Certain agricultural practices, industrial processes, and forest loss are additional sources.[14] Greenhouse gases are transparent to sunlight, allowing it through to heat the Earth's surface. When the Earth emits that heat as infrared radiation the gases absorb it, trapping the heat near the Earth's surface and causing global warming. Due to climate change, deserts are expanding, while heat waves and wildfires are

[13] IPCC SR15 Ch1 2018, p. 54: These global-level rates of human-driven change far exceed the rates of change driven by geophysical or biosphere forces that have altered the Earth System trajectory in the past...

[14] Our World in Data, 18 September 2020

becoming more common.[15] Increased warming in the Arctic has contributed to melting permafrost, glacial retreat and sea ice loss.[16] Higher temperatures are also causing more intense storms, droughts, and other weather extremes. Rapid environmental change in mountains, coral reefs, and the Arctic is forcing many species to relocate or become extinct.[17] Climate change threatens people with food and water scarcity, increased flooding, extreme heat, more disease, and economic loss. Human migration and conflict can be a result.[18]

The World Health Organization (WHO) calls climate change the greatest threat to global health in the 21st century.[19] Even if efforts to minimise future

[15] IPCC SRCCL 2019, p. 7: Since the pre-industrial period, the land surface air temperature has risen nearly twice as much as the global average temperature (high confidence). Climate change... contributed to desertification and land degradation in many regions (high confidence).; IPCC SRCCL 2019, p. 45: Climate change is playing an increasing role in determining wildfire regimes alongside human activity (medium confidence), with future climate variability expected to enhance the risk and severity of w

[16] IPCC SROCC 2019, p. 16: Over the last decades, global warming has led to widespread shrinking of the cryosphere, with mass loss from ice sheets and glaciers (very high confidence), reductions in snow cover (high confidence) and Arctic Sea ice extent and thickness (very high confidence), and increased permafrost temperature (very high confidence).

[17] EPA (19 January 2017). "Climate Impacts on Ecosystems". Archived from the original on 27 January 2018. Retrieved 5 February 2019. Mountain and arctic ecosystems and species are particularly sensitive to climate change... As ocean temperatures warm and the acidity of the ocean increases, bleaching and coral die-offs are likely to become more frequent.

[18] Cattaneo et al. 2019; UN Environment, 25 October 2018.

[19] IPCC AR5 SYR 2014, pp. 13–16; WHO, Nov 2015: "Climate change is the greatest threat to global health in the 21st century. Health professionals have a duty of care to current and future generations. You are on the front line in protecting people from climate impacts – from more heat-waves and other extreme weather events; from outbreaks of infectious diseases such as malaria, dengue and cholera; from the effects of malnutrition; as well as treating people that are affected by cancer, respiratory, cardiovascular and other non-communicable diseases caused by environmental pollution

warming are successful, some effects will continue for centuries. These include sea level rise, and warmer, more acidic oceans.[20]

Many of these impacts are already felt at the current 1.2 °C (2.2 °F) level of warming. Additional warming will increase these impacts and may trigger tipping points, such as the melting of the Greenland ice sheet. Under the 2015 Paris Agreement, nations collectively agreed to keep warming "well under 2 °C". However, with pledges made under the Agreement, global warming would still reach about 2.7 °C (4.9 °F) by the end of the century. Limiting warming to 1.5 °C will require halving emissions by 2030 and achieving net-zero emissions by 2050.[21] Making deep cuts in emissions will require switching away from burning fossil fuels and towards using electricity generated from low-carbon sources. This includes phasing out coal-fired power plants, vastly increasing use of wind, solar, and other types of renewable energy, and taking measures to reduce energy use. Electricity will need to replace fossil fuels for powering transportation, heating buildings, and operating industrial facilities. Carbon can also be removed from the atmosphere, for instance by increasing forest cover and by farming with methods that capture carbon in soil. While communities may adapt to

[20] IPCC SR15 Ch1 2018, p. 64: Sustained net zero anthropogenic emissions of CO_2 and declining net anthropogenic non-CO_2 radiative forcing over a multi-decade period would halt anthropogenic global warming over that period, although it would not halt sea level rise or many other aspects of climate system adjustment.

[21] IPCC SR15 Ch2 2018, pp. 95–96: In model pathways with no or limited overshoot of 1.5 °C, global net anthropogenic CO_2 emissions decline by about 45% from 2010 levels by 2030 (40–60% interquartile range), reaching net zero around 2050 (2045–2055 interquartile range); IPCC SR15 2018, p. 17, SPM C.3:All pathways that limit global warming to 1.5 °C with limited or no overshoot project the use of carbon dioxide removal (CDR) on the order of 100–1000 GtCO2 over the 21st century. CDR would be used to compensate for residual emissions and, in most cases, achieve net negative emissions to return global warming to 1.5 °C following a peak (high confidence). CDR deployment of several hundreds of GtCO2 is subject to multiple feasibility and sustainability constraints (high confidence).; Rogelj et al. 2015; Hilaire et al. 2019

climate change through efforts like better coastline protection, they cannot avert the risk of severe, widespread, and permanent impacts. [22]

Multiple independent instrumental datasets show that the climate system is warming. The 2011–2020 decade warmed to an average 1.09 °C [0.95–1.20 °C] compared to the pre-industrial baseline (1850–1900). Surface temperatures are rising by about 0.2 °C per decade, with 2020 reaching a temperature of 1.2 °C above the pre-industrial era.[23] Since 1950, the number of cold days and nights has decreased, and the number of warm days and nights has increased. [24]

There was little net warming between the 18th century and the mid-19th century. Climate information for that period comes from climate proxies, such as trees and ice cores.[25] Thermometer records began to provide global coverage around 1850. Historical patterns of warming and cooling, like the Medieval Climate Anomaly and the Little Ice Age, did not occur at the same time across different regions. Temperatures may have reached as high as those of the late-20th century in a limited set of regions.[26] There have been prehistorical episodes of global warming, such as the Paleocene–Eocene Thermal Maximum. However, the modern observed rise in temperature and CO_2 concentrations has been so rapid that even abrupt geophysical events in Earth's history do not approach current rates.[27]

Evidence of warming from air temperature measurements are reinforced with a wide range of other observations. There has been an increase in the

[22] IPCC AR5 SYR 2014, p. 17, SPM 3.2

[23] IPCC AR5 WG1 Ch2 2013, p. 162

[24] PCC SR15 Ch1 2018, p. 57: This report adopts the 51-year reference period, 1850–1900 inclusive, assessed as an approximation of pre-industrial levels in AR5 … Temperatures rose by 0.0 °C–0.2 °C from 1720–1800 to 1850–1900; Hawkins et al. 2017, p. 1844

[25] IPCC SR15 Ch1 2018, p. 57: This report adopts the 51-year reference period, 1850–1900 inclusive, assessed as an approximation of pre-industrial levels in AR5 … Temperatures rose by 0.0 °C–0.2 °C from 1720–1800 to 1850–1900; Hawkins et al. 2017, p. 1844

[26] IPCC AR5 WG1 Ch5 2013, p. 386; Neukom et al. 2019a

[27] IPCC SR15 Ch1 2018, p. 54.

frequency and intensity of heavy precipitation, melting of snow and land ice, and increased atmospheric humidity.[28] Flora and fauna are also behaving in a manner consistent with warming; for instance, plants are flowering earlier in spring. Another key indicator is the cooling of the upper atmosphere, which demonstrates that greenhouse gases are trapping heat near the Earth's surface and preventing it from radiating into space. Sea ice reflects 50% to 70% of incoming solar radiation while the dark ocean surface only reflects 6%, so melting sea ice is self-reinforcing feedback.[29]

The response of the climate system to an initial forcing is modified by feedbacks: increased by self-reinforcing feedbacks and reduced by balancing feedbacks. The main reinforcing feedbacks are the water-vapor feedback, the ice albedo feedback, and the net effect of clouds. The primary balancing mechanism is radiative cooling, as Earth's surface gives off more heat to space in response to rising temperature. In addition to temperature feedbacks, there are feedbacks in the carbon cycle, such as the fertilizing effect of CO_2 on plant growth.[30] Uncertainty over feedbacks is the major reason why different climate models project different magnitudes of warming for a given number of emissions.[31] As the air is warmed by greenhouse gases, it can hold more moisture. Water vapor is a potent greenhouse gas, so these further heats the atmosphere. If cloud cover increases, more sunlight will be reflected back into space, cooling the planet. If clouds become higher and thinner, they act as an insulator, reflecting heat from below back downwards and warming the planet.[103] The effect of clouds is the largest source of feedback uncertainty.[32]

[28] Kennedy et al. 2010, pp. S26, S59–S60; USGCRP Chapter 1 2017, p. 35.

[29] Thermodynamics: Albedo". NSIDC. Archived from the original on 11 October 2017. Retrieved 10 October 2017.

[30] IPCC AR5 WG1 2013, p. 14

[31] Wolff et al. 2015: "the nature and magnitude of these feedbacks are the principal cause of uncertainty in the response of Earth's climate (over multi-decadal and longer periods) to a particular emissions scenario or greenhouse gas concentration pathway."

[32] IPCC AR6 WG1 Technical Summary 2021, p. 58,59: clouds remain the largest contribution to overall uncertainty in climate feedbacks

Another major feedback is the reduction of snow cover and sea ice in the Arctic, which reduces the reflectivity of the Earth's surface. More of the Sun's energy is now absorbed in these regions, contributing to amplification of Arctic temperature changes. Arctic amplification is also melting permafrost, which releases methane and CO_2 into the atmosphere. Climate change can also cause methane releases from wetlands, marine systems, and freshwater systems.

Overall, climate feedbacks are expected to become increasingly positive.[33] Around half of human-caused CO_2 emissions have been absorbed by land plants and by the oceans.[34] On land, elevated CO_2 and an extended growing season have stimulated plant growth. Climate change increases droughts and heat waves that inhibit plant growth, which makes it uncertain whether this carbon sink will continue to grow in the future.[35] Soils contain large quantities of carbon and may release some when they heat up. As more CO_2 and heat are absorbed by the ocean, it acidifies, its circulation changes and phytoplankton takes up less carbon, decreasing the rate at which the ocean absorbs atmospheric carbon.[36] Overall, at higher CO_2 concentrations the Earth will absorb a reduced fraction of our emissions.[37]

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[33] IPCC AR6 WG1 Technical Summary 2021, p. 58: Feedback processes are expected to become more positive overall (more amplifying of global surface temperature changes) on multi-decadal time scales as the spatial pattern of surface warming evolves and global surface temperature increases.

[34] NASA, 16 June 2011: "So far, land plants and the ocean have taken up about 55 percent of the extra carbon people have put into the atmosphere while about 45 percent has stayed in the atmosphere. Eventually, the land and oceans will take up most of the extra carbon dioxide, but as much as 20 percent may remain in the atmosphere for many thousands of years."

[35] PCC SRCCL Ch2 2019, pp. 133, 144

[36] USGCRP Chapter 2 2017, pp. 93–95

[37] IPCC AR6 WG1 Technical Summary 2021, p. TS-122, Box TS.5, Figure 1

Impacts of Climate Change

Environmental effects

The environmental effects of climate change are broad and far-reaching, affecting oceans, ice, and weather. Changes may occur gradually or rapidly. Evidence for these effects comes from studying climate change in the past, from modelling, and from modern observations. Since the 1950s, droughts and heat waves have appeared simultaneously with increasing frequency. Extremely wet or dry events within the monsoon period have increased in India and East Asia. The rainfall rate and intensity of increasing. Frequency of tropical cyclones has not increased as a result of climate change. Historical sea level reconstruction and projections up to 2100 published in 2017 by the U.S. Global Change Research Program·

Global sea level is rising as a consequence of glacial melt, melt of the ice sheets in Greenland and Antarctica, and thermal expansion. Between 1993 and 2020, the rise increased over time, averaging 3.3 ± 0.3 mm per year. Over the 21st century, the IPCC projects that in a very high emissions scenario the sea level could rise by 61–110 cm. Increased Ocean warmth is undermining and threatening to unplug Antarctic glacier outlets, risking a large melt of the ice sheet and the possibility of a 2-meter sea level rise by 2100 under high emissions.

Climate change has led to decades of shrinking and thinning of the **Arctic Sea** ice. While ice-free summers are expected to be rare at 1.5 °C degrees of warming, they are set to occur once every three to ten years at a warming level of 2 °Higher atmospheric CO_2 concentrations have led to changes in ocean chemistry. An increase in dissolved CO_2 is causing oceans to acidify. In addition, oxygen levels are decreasing as oxygen is less soluble in warmer water. Dead zones in the ocean, regions with very little oxygen, are expanding too. Greater degrees of global warming increase the risk of passing through ‘tipping points’ thresholds beyond which certain impacts can no longer be avoided even if temperatures are reduced. An example is the collapse of West Antarctic and Greenland ice sheets, where a temperature rise of 1.5 to 2 °C may commit the ice sheets to melt, although the time scale of melt is uncertain and depends on future warming. Some large-scale changes could occur over a short time period, such as a shutdown of certain ocean currents like the Atlantic Meridional Overturning Circulation (AMOC).Tipping points can also include irreversible damage to ecosystems like the Amazon rainforest and coral reefs.

The long-term effects of climate change include further ice melt, ocean warming, sea level rise, and ocean acidification. On the timescale of centuries to millennia, the magnitude of climate change will be determined primarily by anthropogenic CO_2 emissions. This is due to CO_2's long atmospheric lifetime. Oceanic CO_2 uptake is slow enough that ocean acidification will continue for hundreds to thousands of years. These emissions are estimated to have prolonged the current interglacial period by at least 100,000 years. Sea level rise will continue over many centuries, with an estimated rise of 2.3 meters per degree Celsius (4.2 ft/°F) after 2000 years.

Nature and wildlife

Recent warming has driven many terrestrial and freshwater species poleward and towards higher altitudes. Higher atmospheric CO_2 levels and an extended growing season have resulted in global greening. However, heatwaves and drought have reduced ecosystem productivity in some regions. The future balance of these opposing effects is unclear. Climate change has contributed to the expansion of drier climate zones, such as the expansion of deserts in the subtropics. The size and speed of global warming is making abrupt changes in ecosystems more likely. Overall, it is expected that climate change will result in the extinction of many species.

The oceans have heated more slowly than the land, but plants and animals in the ocean have migrated towards the colder poles faster than species on land. Just as on land, heat waves in the ocean occur more frequently due to climate change, harming a wide range of organisms such as corals, kelp, and seabirds. Ocean acidification makes it harder for organisms such as mussels, barnacles and corals to produce shells and skeletons; and heatwaves have bleached coral reefs. Harmful algal blooms enhanced by climate change and eutrophication lower oxygen levels, disrupt food webs and cause great loss of marine life Coastal ecosystems are under particular stress. Almost half of global wetlands have disappeared due to climate change and other human impacts.

Humans

The effects of climate change on humans have been observed worldwide. They are mostly due to warming and shifts in precipitation. Impacts can now be observed on all continents and ocean regions, with low-latitude, less developed areas facing the greatest risk. Continued warming has potentially "severe, pervasive and irreversible impacts" for people and ecosystems. The risks are unevenly distributed, but are generally greater for disadvantaged people in developing and developed countries.

Food and health

The WHO has classified climate change as the greatest threat to global health in the 21st century. Extreme weather leads to injury and loss of life, and crop failures to undernutrition. Various infectious diseases are more easily transmitted in a warmer climate, such as dengue fever and malaria. Young children are the most vulnerable to food shortages. Both children and older people are vulnerable to extreme heat. The World Health Organization (WHO) has estimated that between 2030 and 2050, climate change would cause around 250,000 additional deaths per year. They assessed deaths from heat exposure in elderly people, increases in diarrhea, malaria, dengue, coastal flooding, and childhood undernutrition. Over 500,000 more adult deaths are projected yearly by 2050 due to reductions in food availability and quality. Climate change is affecting food security. It has caused reduction in global yields of maize, wheat, and soybeans between 1981 and 2010. Future warming could further reduce global yields of major crops. Crop production will probably be negatively affected in low-latitude countries, while effects at northern latitudes may be positive or negative. Up to an additional 183 million people worldwide, particularly those with lower incomes, are at risk of hunger as a consequence of these impacts. Climate change also impacts fish populations. Globally, less will be available to be fished. Region's dependent on glacier water, regions that are already dry, and small islands have a higher risk of water stress due to climate change.

Livelihoods

Economic damages due to climate change may be severe and there is a chance of disastrous consequences. Climate change has likely already increased global economic inequality, and this trend is projected to continue. Most of the severe impacts are expected in sub-Saharan Africa, where most of the local inhabitants are dependent upon natural and agricultural resources, and South-East Asia. The World Bank estimates that climate change could drive over 120 million people into poverty by 2030.

Current inequalities based on wealth and social status have worsened due to climate change. Major difficulties in mitigating, adapting, and recovering to climate shocks are faced by marginalized people who have less control over resources. Indigenous people, who are subsistent on their land and ecosystems, will face endangerment to their wellness and lifestyles due to climate change. An expert elicitation concluded that the role of climate change in armed conflict has been small compared to factors such as socio-economic inequality and state capabilities.

Low-lying islands and coastal communities are threatened by sea level rise, which makes flooding more common. Sometimes, land is permanently lost to the sea. This could lead to statelessness for people in island nations, such as the Maldives and Tuvalu. In some regions, the rise in temperature and humidity may be too severe for humans to adapt to. With worst-case climate change, models project that almost one-third of humanity might live in extremely hot and uninhabitable climates, similar to the current climate found in the Sahara. These factors can drive environmental migration, both within and between countries. More people are expected to be displaced because of sea level rise, extreme weather and conflict from increased competition over natural resources. Climate change may also increase vulnerability, leading to "trapped populations" who are not able to move due to a lack of resources.

Reducing and recapturing emissions

Scenarios of global greenhouse gas emissions. If all countries achieve their current Paris Agreement pledges, average warming by 2100 would still significantly exceed the maximum 2 °C target set by the Agreement.

Climate change can be mitigated by reducing greenhouse gas emissions and by enhancing sinks that absorb greenhouse gases from the atmosphere. In order to limit global warming to less than 1.5 °C with a high likelihood of success, global greenhouse gas emissions needs to be net-zero by 2050, or by 2070 with a 2 °C target This requires far-reaching, systemic changes on an unprecedented scale in energy, land, cities, transport, buildings, and industry. The United Nations Environment **Programme** estimates that countries need to triple their pledges under the Paris Agreement within the next decade to limit global warming to 2 °C. An even greater level of reduction is required to meet the 1.5 °C goal. With pledges made under the Agreement as of October 2021, global warming would still have a 66% chance of reaching about 2.7 °C (range: 2.2–3.2 °C) by the end of the century.

Although there is no single pathway to limit global warming to 1.5 or 2 °C, most scenarios and strategies see a major increase in the use of renewable energy in combination with increased energy efficiency measures to generate the needed greenhouse gas reductions. To reduce pressures on ecosystems and enhance their carbon sequestration capabilities, changes would also be necessary in agriculture and forestry, such as preventing deforestation and restoring natural ecosystems by reforestation.

Other approaches to mitigating climate change have a higher level of risk. Scenarios that limit global warming to 1.5 °C typically project the large-scale use of carbon dioxide removal methods over the 21st century. There are concerns, though, about over-reliance on these technologies, and environmental impacts. Solar (SRM) is also a possible supplement to deep reductions in emissions. However, SRM would raise significant ethical and legal issues, and the risks are poorly understood.

ECONOMIC OF CLIMATE CHANGE

The economics of climate change concerns the economic aspects of climate change; this can inform policies that governments might consider in response. A number of factors make this and the politics of climate change a difficult problem: it is a long-term, intergenerational problem[38] benefits and costs are distributed unequally both within and across countries; and both the scientific consensus and public opinion on climate change need to be taken into account.

Effects of climate change may last a long time, such as sea level rise which will not be reversed for thousands of years. The long time scales and uncertainty associated with global warming have led analysts to develop "scenarios" of future environmental, social and economic changes.[39] These scenarios can help governments understand the potential consequences of their decisions. The impacts of climate change include the loss of biodiversity, sea level rise, increased frequency and severity of some extreme

[38] IPCC (2001), Watson, R. T.; the Core Writing Team (eds.), Climate Change 2001: Synthesis Report (PDF), Contribution of Working Groups I, II, and III to the Third Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, ISBN 978-0-521-80770-8 (pb: 0-521-01507-3

[39] Webster, M.; et al. (December 2002), Report 95: Uncertainty Analysis of Climate Change and Policy Response (PDF), Cambridge MA, USA: Massachusetts Institute of Technology (MIT) Joint Program on the Science and Policy of Global Change, Joint Program Report Series, pp. 3–4, retrieved 20 January 2022

weather events, and acidification of the oceans. Economists have attempted to quantify these impacts in monetary terms, but these assessments can be controversial. The two main policy responses to global warming are to reduce greenhouse gas (GHG) emissions (climate change mitigation) and to adapt to the impacts of global warming (e.g., by building levees in response to sea level rise). One of the responses to the uncertainties of global warming is to adopt a strategy of sequential decision making. This strategy recognizes that decisions on global warming need to be made with incomplete information, and that decisions in the near term will have potentially long-term impacts. Governments may use risk management as part of their policy response to global warming. For instance, a risk-based approach can be applied to climate impacts which are difficult to quantify in economic terms, e.g., the impacts of global warming on indigenous peoples.

Analysts have assessed global warming in relation to sustainable development. Sustainable development considers how future generations might be affected by the actions of the current generation. In some areas, policies designed to address global warming may contribute positively towards other development objectives, for example abolishing fossil fuel subsidies would reduce air pollution and thus save lives. Direct global fossil fuel subsidies reached $319 billion in 2017, and $5.2 trillion when indirect costs such as air pollution are priced in. In other areas, the cost of global warming policies may divert resources away from other socially and environmentally beneficial investments (the opportunity costs of climate change policy). More recent studies suggest that economic damages due to climate change have been underestimated, and may be severe, with the probability of disastrous tail-risk events being nontrivial. Carbon-intensive industries and investors are expected to experience a significant increase in stranded assets with a potential ripple effect throughout the world economy. To achieve deep reductions in greenhouse gases and slow global warming, the financial system and the world's economies will have to adapt.[40]

Shale Gas

Shale gas is natural gas that is found trapped within shale formations.[41]Shale gas has become an increasingly important source of natural gas in the United States since the start of this century, and interest has spread to potential gas shales in the rest of the world. Some analysts expect that shale gas will greatly expand worldwide energy supply.[42] In 2000 shale gas provided only 1% of U.S. natural gas production; by 2010 it was over 20% and the U.S. Energy Information Administration predicted that by 2035, 46% of the United States' natural gas supply will come from shale gas.[43] China is estimated to have the world's largest shale gas reserves.[44] Shale gas was first extracted as a resource in Fredonia, New York, in 1821,[45] in shallow, low-pressure fractures. Horizontal drilling began in the 1930s, and in 1947 a well was first fracked in the U.S.[46] Federal price controls on natural gas led to shortages in the

[40] Battiston, Stefano; Monasterolo, Irene; Riahi, Keywan; van Ruijven, Bas J. (28 May 2021). "Accounting for finance is key for climate mitigation pathways". Science. 372 (6545): 918–920. doi:10.1126/science.abf3877. PMID 34016742. S2CID 235072507. Retrieved 21 January 2022.

[41] U.S. Energy Information Administration". Eia.gov. Retrieved 6 August 2013

[42] "New way to tap gas may expand global supplies". The New York Times. Retrieved 6 August 2013.

[43] Stevens, Paul (August 2012). "The 'Shale Gas Revolution': Developments and Changes". Chatham House. Retrieved 15 August 2012

[44] Staff (5 April 2011) World Shale Gas Resources: An Initial Assessment of 14 Regions Outside the United States US Energy Information Administration, Analysis and Projections, Retrieved 26 August 2012

[45] KEN MILAM, EXPLORER Correspondent. "Name the gas industry birthplace: Fredonia, N.Y.?". Aapg.org. Retrieved 6 August 2013.

[46] A Comparison between Shale Gas in China and Unconventional Fuel Development in the United States: Water, Environmental Protection, and Sustainable Development, Farah, Paolo Davide; Tremolada, Riccardo in Brooklyn Journal of International Law, Vol. 41, No. 2, 2016, June 2016.

1970s.[47] Faced with declining natural gas production, the federal government invested in many supply alternatives, including the Eastern Gas Shales Project, which lasted from 1976 to 1992, and the annual FERC-approved research budget of the Gas Research Institute, where the federal government began extensive research funding in 1982, disseminating the results to industry. The federal government also provided tax credits and rules benefiting the industry in the 1980 Energy Act.[48] The Department of Energy later partnered with private gas companies to complete the first successful air-drilled multi-fracture horizontal well in shale in 1986. The federal government further incentivized drilling in shale via the Section 29 tax credit for unconventional gas from 1980–2000. Micro seismic imaging, a crucial input to both hydraulic fracturing in shale and offshore oil drilling, originated from coalbeds research at Sandia National Laboratories. The DOE program also applied two technologies that had been developed previously by industry, massive hydraulic fracturing and horizontal drilling, to shale gas formations,[49]which led to micro seismic imaging.

Although the Eastern Gas Shales Project had increased gas production in the Appalachian and Michigan basins, shale gas was still widely seen as marginal to uneconomic without tax credits, and shale gas provided only 1.6% of US gas production in 2000, when the federal tax credits expired.[50] George P. Mitchell is regarded as the father of the shale gas industry, since he made it commercially viable in the Barnett Shale by getting costs down to $4 per 1 million British thermal units (1,100 megajoules).[21] Mitchell Energy

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[47] Zhongmin Wang and Alan Krupnick, A Retrospective Review of Shale Gas Development in the United States Archived 19 March 2015 at the Wayback Machine, Resources for the Futures, Apr. 201

[48] Stevens, Paul (August 2012). "The 'Shale Gas Revolution': Developments and Changes". Chatham House. Retrieved 15 August 201

[49] KEN MILAM, EXPLORER Correspondent. "Proceedings from the 2nd Annual Methane Recovery from Coalbeds Symposium". Aapg.org. Retrieved 6 August 2013.

[50] Zhongmin Wang and Alan Krupnick, A Retrospective Review of Shale Gas Development in the United States Archived 19 March 2015 at the Wayback Machine, Resources for the Futures, Apr. 2013

achieved the first economical shale fracture in 1998 using slick-water fracturing.[22][23][24] Since then, natural gas from shale has been the fastest growing contributor to total primary energy in the United States, and has led many other countries to pursue shale deposits. According to the IEA, shale gas could increase technically recoverable natural gas resources by almost 50%.[51] The Obama administration believed that increased shale gas development would help reduce greenhouse gas emissions.[52]A 2013 review by the United Kingdom Department of Energy and Climate Change noted that most studies of the subject have estimated that life-cycle greenhouse gas (GHG) emissions from shale gas are similar to those of conventional natural gas, and are much less than those from coal, usually about half the greenhouse gas emissions of coal; the noted exception was a 2011 study by Howarth and others of Cornell University, which concluded that shale GHG emissions were as high as those of coal.[53]More recent studies have also concluded that life-cycle shale gas GHG emissions are much less than those of coal,[54] among them, studies by Natural Resources Canada (2012),[55] and a consortium formed by the US National Renewable Energy Laboratory with a number of universities (2012).[56]

Some 2011 studies pointed to high rates of decline of some shale gas wells as an indication that shale gas production may ultimately be much lower than is

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[51] "International Energy Agency (IEA). "World Energy Outlook Special Report on Unconventional Gas: Golden Rules for a Golden Age of Gas?"" (PDF). Retrieved 6 August 2013.

[52] Arthur Berman (8 February 2011). "After the gold rush: A perspective on future U.S. natural gas supply and price". Theoildrum.com. SS

[53] David J. C. MacKay and Timothy J. Stone, Potential Greenhouse Gas Emissions Associated with Shale Gas Extraction and Use, 9 September 2013. MacKay and Stone wrote (p.3): "The Howarth estimate may be unrealistically high, as discussed in Appendix A, and should be treated with caution."

[54] James Conca, Fugitive Fracking Gets Bum Rap, Forbes, 18 February 2013.

[55] Natural Resources Canada, Shale gas, 14 December 2012.

[56] Jeffrey Logan, Garvin Heath, and Jordan Macknick, Elizabeth Paranhos, William Boyd, and Ken Carlson, Natural Gas and the Transformation of the U.S. Energy Sector: Electricity, Technical Report NREL/TP-6A50-55538, Nov. 2012.

currently projected.[57] But shale-gas discoveries are also opening up substantial new resources of tight oil, also known as "shale oil".[58]

Shale Oil

Conventional production establishes the basic costs of drilling a well. You need a rig, drill stem, casing, the crew, and all the other pieces that go into a vertical well. The difference with shale oil is that, instead of drilling just past the target deposit, the wells will take a 90-degree turn in the deposit and run alongside it horizontally. These wells go thousands of feet down to reach the deposit, but they also run thousands of feet horizontally. This type of well takes more time to drill, which means higher labor costs and more basic inputs like drill stem. Once the well is drilled and perforated, millions of gallons of water, proppants (materials, like sand, introduced to keep the fracture open), and chemicals are pumped down the hole to fracture the formation and allow the oil to flow back into the pipe to be pumped out. Millions of gallons mean a lot of hauling, with either added capital and labor costs for the trucks or, more likely, an oil service firm contract for the fluid hauling. All of this adds to the cost of the well.

Some new shale oil wells in the U.S. may have a break-even point of less than $30 a barrel despite the higher drilling and fracking costs. However, the average break-even point for new wells ranges from $46 to $58, depending on the site, with the higher-cost wells coming in at $90 a barrel

With these costs paid upfront for a comparatively short production life compared to a conventional well, it makes sense for the shale oil industry to suspend new wells when world oil prices dip and ramp up when the prices are

57 David Hughes (May 2011). "Will Natural Gas Fuel America in the 21st Century?" Post Carbon Institute.

58 Syed Rashid Husain. "Shale Gas Revolution Changes Geopolitics." Saudi Gazette. 24 February 2013. [2] Archived 18 April 2013 at archive.today

strong. That means there are a lot of shale oil deposits sitting idle when crude oil prices are hovering around $50 a barrel.

Is shale gas conventional or un convetional?

The terms 'conventional' and 'unconventional' gas are often misunderstood and have taken on different meanings in different reports relating to the gas industry.

For the purpose of this Inquiry, 'unconventional' gas is found in source rocks such as coal and shale where the gas has been trapped in place. This is different from 'conventional' gas, which migrates into porous, permeable rocks and is trapped under a seal.

Conventional gas can typically be developed with a limited number of wells due to the accumulation of the hydrocarbons in a confined area with well-connected pore spaces within the source rock enabling effective drainage from strategically placed wells. The gas will flow to the surface under its own pressure driven by a water table (or aquifer) underneath an expanding pressurised gas cap overlying the gas

By contrast, with unconventional gas, the source rocks that hold the gas have much lower porosity (that is, the void spaces between the grains that make up the rock are very small) and much lower permeability (that is, the interconnectedness of the pore spaces to allow the gas to move through the rock is very low). Therefore, in order to make the gas flow, artificial stimulation, such as hydraulic fracturing, must be used. Improvements have been made to the production of conventional gas and many of these techniques have been refined and applied to unconventional gas. Horizontal drilling and hydraulic fracturing have been used for decades on conventional reservoirs but better efficiency and accuracy has allowed this technology to be used in unconventional gas reservoirs making them economically viable. Shale gas formations are "unconventional" reservoirs i.e., reservoirs of low "permeability." Permeability refers to the capacity of a porous, sediment, soil or rock in this case to transmit a fluid. This contrasts with a "conventional" gas reservoir produced from sands and carbonates (such as limestone). The natural gas contained in shale reservoirs has the same primary chemical composition as the natural gas contained in conventional reservoirs – normally up to 95% methane. The main difference is in the geological and physical properties of the reservoirs in which the natural gas is stored rather than the composition of the gas itself. Shale reservoirs are often classified as 'unconventional' because they contain oil and natural gas that were generated in the shale itself, and because they do not naturally have sufficient permeability to allow the oil and gas to flow at commercial rates.

Unconventional gas generally occurs in very low permeability reservoirs (normally less than 0.1 millidarcy [mD]) with smaller, fewer or less interconnected pores, where fluids can barely flow. Shale gas reservoirs have especially low permeabilities, on the order of 0.001 mD.

Conventional Oil

Conventional oil production generally refers to the pipe and pump production off a vertical well. This means a hole has been drilled straight down into a deposit and a pump jack is put on it to help pull the deposit to the surface where it can be sent on for further refining. The cost-per-barrel of conventional deposits varies, with Saudi Arabia able to produce oil the most cheaply, sometimes under $10 a barrel.2 In the Middle East, non-producing onshore fields can produce oil for less than $20 per barrel with an average of $31.1

Of course, conventional can be a misleading term because oil production methods tend to be called conventional if they've been in use for a long time. For example, offshore drilling can be viewed as pipe and pump production, just with the small matter of an ocean between the drilling rig and the first layer of rock. There are also a number of processes, including perforation, that are now a part of every well. Perforation is the use of explosives to blow holes in the sides of the pipe to allow the hydrocarbons to flow in. Because this can cause debris to shift and slow the flow, acids or fracturing (if legal) are then used to open up the deposit around the perforated section of the pipe. So even conventional wells can be using the techniques developed for unconventional deposits to increase their production. But in general, a conventional deposit will yield oil with a number of vertical wells pumping from different points on the deposit. The problem is that in North America at least, there are not many untapped conventional deposits left.

Tidal Energy

Tidal energy is a form of power produced by the natural rise and fall of tides caused by the gravitational interaction between Earth, the sun, and the moon. Tidal currents with sufficient energy for harvesting occur when water passes through a constriction, causing the water to move faster. Using specially engineered generators in suitable locations, tidal energy can be converted into useful forms of power, including electricity. Other forms of energy can also be generated from the ocean, including waves, persistent ocean currents, and the differences in temperature and salinity in seawater. Tidal power or tidal energy is harnessed by converting energy from tides into useful forms of power, mainly electricity using various methods.

Although not yet widely used, tidal energy has the potential for future electricity generation. Tides are more predictable than the wind and the sun. Among sources of renewable energy, tidal energy has traditionally suffered from relatively high cost and limited availability of sites with sufficiently high tidal ranges or flow velocities, thus constricting its total availability. However, many recent technological developments and improvements, both in design (e.g. dynamic tidal power, tidal lagoons) and turbine technology (e.g. new axial turbines, cross flow turbines), indicate that the total availability of tidal power may be much higher than previously assumed and that economic and environmental costs may be brought down to competitive levels. Suitable locations for capturing tidal energy include those with large differences in tidal range, which is the difference between high tide and low tides, and where tidal channels and waterways become smaller and tidal currents become stronger.

Because water is denser than air, tidal energy is more powerful than wind energy, producing exponentially more power at the same turbine diameter and rotor speed. Tidal power is also more predictable and consistent than wind or solar energy, both of which are intermittent and less predictable. This makes tidal energy an intriguing renewable energy source to pursue. The challenge is in making it commercially feasible to capture and convert the energy into usable power at scale, as well as finding uses of tidal energy where costs are less sensitive than national grid electricity.

To fully harness tidal energy as a significant and ongoing source of clean energy, it is critical that researchers explore ways to assist in developing technologies and methods that increase its viability for broad commercial application. The industry is largely just emerging, with complex barriers to overcome before it can sustainably grow and thrive.

Tidal energy can be generated in four methods.

A) **Tidal stream generator**

Tidal stream generators make use of the kinetic energy of moving water to power turbines, in a similar way to wind turbines that use the wind to power turbines. Some tidal generators can be built into the structures of existing bridges or are entirely submersed, thus avoiding concerns over aesthetics or visual impact. Land constrictions such as straits or inlets can create high velocities at specific sites, which can be captured using turbines. These turbines can be horizontal, vertical, open, or ducted.[11]

B) **Tidal barrage**

Tidal barrages use potential energy in the difference in height (or hydraulic head) between high and low tides. When using tidal barrages to generate power, the potential energy from a tide is seized through the strategic placement of specialized dams. When the sea level rises and the tide begins to come in, the temporary increase in tidal power is channeled into a large basin behind the dam, holding a large amount of potential energy. With the receding tide, this energy is then converted into mechanical energy as the water is released through large turbines that create electrical power through the use of generators.[59] Barrages are essentially dams across the full width of a tidal estuary.

C) **Dynamic tidal power**

Dynamic tidal power (or DTP) is a theoretical technology that would exploit an interaction between potential and kinetic energies in tidal flows. It proposes that very long dams (for example: 30–50 km length) be built from coasts straight out into the sea or ocean, without enclosing an area. Tidal phase differences are introduced across the dam, leading to a significant water-level differential in shallow coastal seas – featuring strong coast-parallel oscillating tidal currents such as found in the UK, China, and Korea. Induced tides (TDP) could extend the geographic viability of a new hydro-atmospheric concept 'LPD' (lunar pulse drum) discovered by a Devon innovator in which a tidal 'water piston' pushes or pulls a metered jet of air to a rotary air-actuator & generator. The principle was demonstrated at London Bridge June 2019. Plans for a 30 m, 62.5kwh 'pilot' installation on a (Local Authority) tidal estuary shoreline in the Bristol Channel are underway.

D) **Tidal lagoon**

A new tidal energy design option is to construct circular retaining walls embedded with turbines that can capture the potential energy of tides. The created reservoirs are similar to those of tidal barrages, except that the location

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[59] Evans, Robert (2007). Fueling Our Future: An Introduction to Sustainable Energy. New York: Cambridge University Press.

is artificial and does not contain a pre-existing ecosystem.[60] The lagoons can also be in double (or triple) format without pumping[61] or with pumping[62] that will flatten out the power output. The pumping power could be provided by excess to grid demand renewable energy from for example wind turbines or solar photovoltaic arrays. Excess renewable energy rather than being curtailed could be used and stored for a later period of time. Geographically dispersed tidal lagoons with a time delay between peak production would also flatten out peak production providing near baseload production at a higher cost than other alternatives such as district heating renewable energy storage. The cancelled Tidal Lagoon Swansea Bay in Wales, United Kingdom would have been the first tidal power station of this type once built.[63] Tidal energy represents a significant opportunity to increase the world's renewable power generation capacity. As countries continue to develop, and the global population and its reliance on energy grows, so does the demand on power systems to provide additional clean energy resources. Tidal energy could potentially supply a significant percentage of future electricity needs if barriers, including robustness of devices, environmental challenges, and the cost-effectiveness of its commercial application, can be successfully navigated. Tidal energy is best captured in areas with high tidal ranges and strong currents. There are several ways to harness it.

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[60] "Tidal – Capturing tidal fluctuations with turbines, tidal barrages, or tidal lagoons". Tidal / Tethys. Pacific Northwest National Laboratory (PNNL). Archived from the original on 16 February 2016. Retrieved 2 February 2016

[61]Hydrological Changing Double Current-typed Tidal Power Generation" (video). YouTube. Archived from the original on 2015-10-18. Retrieved 2015-04-15

[62] "Enhancing Electrical Supply by Pumped Storage in Tidal Lagoons" (PDF). Archived (PDF) from the original on 2015-09-24. Retrieved 2014-03-13.

[63] Elsevier Ltd, The Boulevard, Langford Lane, Kidlington, Oxford, OX5 1 GB, United Kingdom. "Green light for world's first tidal lagoon". renewableenergyfocus.com. Archived from the original on 18 August 2015. Retrieved 26 July 2015.

Tidal turbines can be installed in places with strong tidal activity, either floating or on the sea floor, individually or in arrays. They look and operate much like wind turbines, using blades to turn a rotor that powers a generator, but must be significantly more robust given their operating environment and, as tidal turbines are much smaller than large wind turbines, more turbines are required to produce the same amount of energy. Multiple tidal demonstration projects are under way in the United States.

Turbines placed in tidal streams capture energy from the current, and underwater cables transmit it to the grid. Tidal stream systems can capture energy at sites with high tidal velocities created by land constrictions, such as in straits or inlets. When fully operational, the MeyGen project in Scotland will be the largest tidal stream generating station in the world, with up to 398 MW generation capacity.

Tidal barrages are like dams built across tidal rivers, bays, and estuaries to form a tidal basin. Turbines inside the barrage enable the basin to fill during incoming tides and release through the system during outgoing tides, generating electricity in both directions. It operates much like a river dam in capturing the power in surrounding water. Two of the world's largest tidal power stations are barrages in South Korea and France, with 254 MW and 240 MW electricity generation capacity, respectively. The next largest in Canada has much lower generation capacity at 20 MW. Tidal lagoons are like barrages in using man-made retaining walls to partially contain a large volume of incoming tidal water, with embedded turbines to capture its energy. They also rely on a large tidal range to generate power. Unlike barrages, tidal lagoons could be placed along natural coastline for continuous power generation as the tide changes and designed to minimize their environmental footprint. Though the energy output from tidal lagoons is unproven, with no current examples in operation, a few are under development in China, North Korea, and the United Kingdom. Due to the environmental challenges, they pose, tidal barrages and lagoons are not the focus of tidal energy development efforts in most areas of the world.

The predominant application for tidal energy has been the generation of electricity for use on shore via the national power grid. There is also potential value in tidal energy to serve the needs of other existing or emerging ocean industries (e.g., aquaculture, ocean mineral mining, oceanographic research, or military missions), as captured in DOE's Powering the Blue Economy Initiative. The "blue economy" is defined as the sustainable use of ocean resources for economic growth, improved livelihoods, and jobs, while preserving the health of ocean ecosystems.

Benefits of tidal energy

Tidal energy is a clean, renewable, sustainable resource that is underutilized and represents significant opportunity to meet growing global energy needs, both now and in the future. Water is hundreds of times denser than air, which makes tidal energy more powerful than wind. It is more efficient than wind or solar energy due to its relative density and produces no greenhouse gases or other waste, making it an attractive renewable energy source to pursue.

Also beneficial is the relative predictability and reliability of continuous tides, especially compared to other renewable energy sources like wind and solar, which are affected by the variability and uncertainty of atmospheric forcing. Low tide and high tide cycles are easy to predict and rarely experience unexpected changes.

To realize the benefits of tidal energy on a commercial scale, it will be important for researchers to identify new technologies and methods that significantly lower installation and maintenance costs, reduce environmental effects, and increase the suitability of more locations. There are a few tidal projects in operation; however, the industry is growing slowly due to barriers to entry and lack of supply chain.

Limitations of tidal energy

Tidal energy as an industry remains limited by a few significant barriers, cost being its most challenging. Developing tidal arrays and connecting them to the power grid requires extensive and costly engineering and manufacturing work. While there are numerous tidal technologies being tested that may improve affordability, none have emerged as a market leader that could help establish supply chains and begin reducing installation and maintenance costs.

Tidal energy technologies have been slow to develop, and some industry participants have exited the market. Suitable locations for tidal energy facilities are inherently limited, given that not all coastal bays and tidal channels experience the conditions required for effective power generation. And among those limited locations, some are not near the grid, requiring further investment to install lengthy undersea cables for transmitting generated electricity.

In addition to cost and geographic limitations, there is also significant concern about environmental effects. Constructing and operating tidal energy arrays based on massive underwater structures may change the ambient flow field and water quality, as well as negatively affect sea life and their habitats, potentially threatening collisions by marine animals and fish with rotating turbine blades and affecting marine animal navigation and communication with underwater noise. This may cause some sensitive species to shy away from electromagnetic fields from power cables or changes to their habitats. Achieving cost reductions, developing devices that can endure ocean forces, and minimizing environmental effects to improve tidal energy's commercial viability is and must be the primary focus of research investments in this area.

Recent advances in tidal energy

Tidal power arrays of varying sizes are being developed or have been deployed recently around the world, with much focus on energy generation from tidal streams or currents. A tidal stream array located in the Pentland Firth in Scotland the body of water between the Scottish mainland and the northern islands is the newest to begin operating and is the first of its kind. The

MeyGen tidal energy project began phased operations in 2018, and its first four turbines had generated and delivered more than 35 gigawatt-hours of power to the grid by the end of 2020. At full deployment, 61 turbines submerged on the seabed will generate up to 400 MW of energy from high-speed currents in the area.

There are multiple projects under way in Wales, an emerging hotspot for the industry. This development will include a top center for marine engineering, which was approved by the United Kingdom and Welsh governments in 2020 and will include among its assets a 90-kilometer demonstration zone to enable the deployment of future tidal energy generation technologies.

There are other test sites and technology deployments at various stages in countries including Scotland, France, Japan, Korea, China, Canada, and the United States as developers bring forward new and improved tidal current technologies that show promise for clearing key hurdles to commercial viability. The ability to assess the performance and environmental effects of new technologies in real sea conditions is critical to sustainable industry advancement.

Engineers are working to improve tidal energy generation technologies to increase their energy production efficiency, reduce biofouling, decrease their environmental effects, and find a path to commercial profitability.

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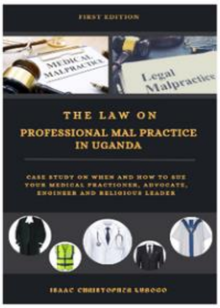

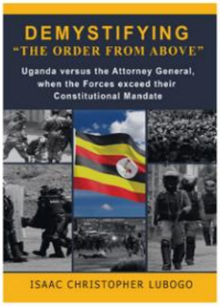

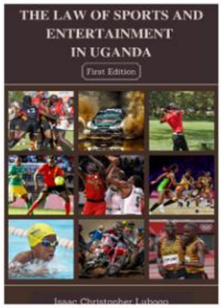

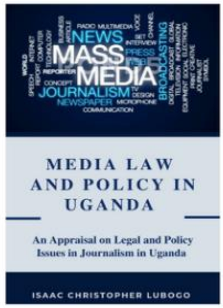

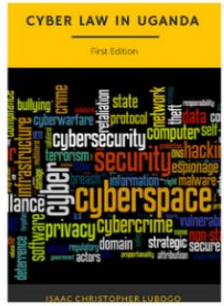

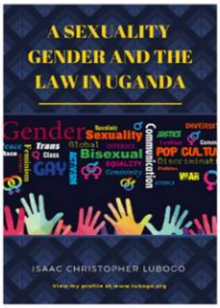

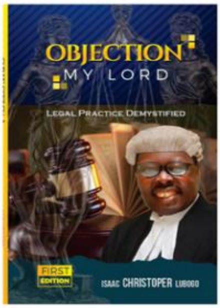

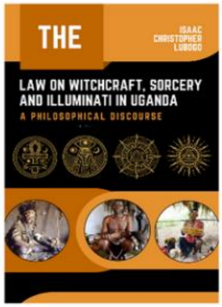

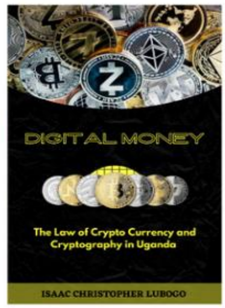

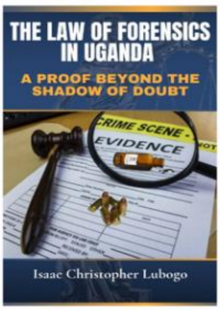

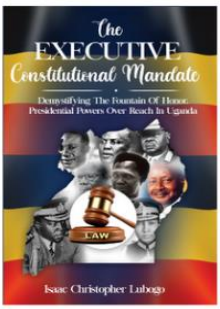

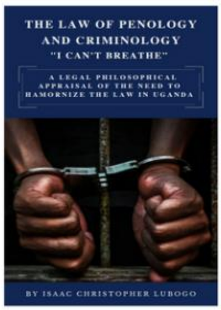

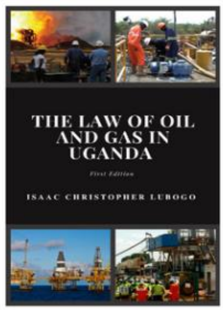

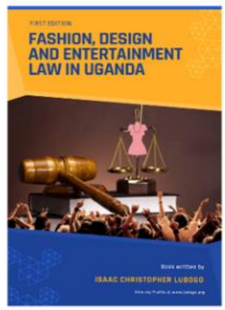

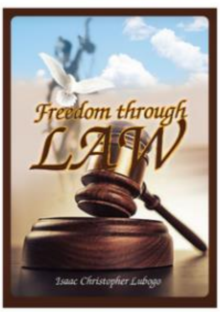

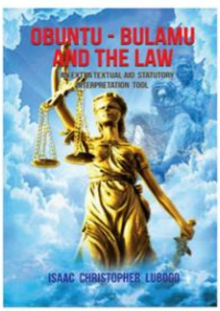

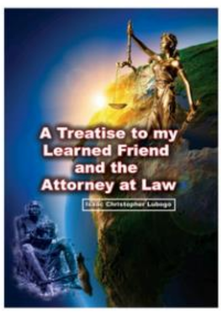

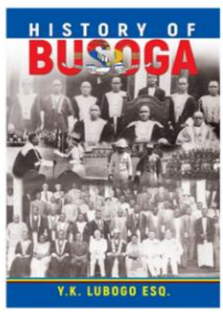

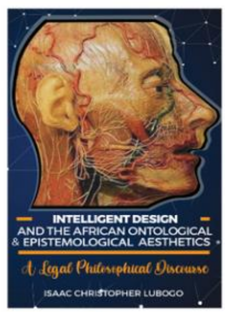

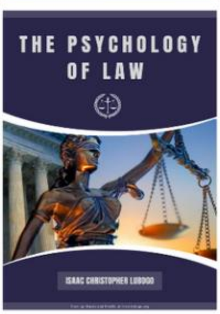


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ABOUT THE BOOK

The book is designed to acquaint readers with the development and key principles of Uganda's environmental policy and legislation particularly in novel areas of renewable energy and clean energy, The book tackles renewable energy, nuclear energy, geothermal energy, wind energy, solar energy, waste residual energy, (land fill) residual biomass.

The book further looks, at the doctrines of rebus sic stantibus, which establishes permanent sovereignty over natural resources, it also focuses on Jus cogens as a right to expropriate, as an expression of their sovereignty in order to safe guard natural resources and therefore seeks to engage pacta sunt Servanda (whatever is carried out on our environment should be carried out in good faith) it also address how measures implemented to limit greenhouse gas emissions must consider smart utilization of available limited resources through integrated energy systems and the utilization of waste energy systems and the utilization of waste energy streams. This reference considers the main concepts of thermal and conventional energy systems through detailed systems description, analyses of methodologies, performance assessment and optimization and illustrative examples and case studies.

The book examines producing power and heat with cooling, freshwater, green fuels and other useful commodities designed to tackle rising greenhouse gas emissions in the atmosphere.

With worldwide energy demand increasing and the consequences of meeting supply with current dependency on fossil fuels, investigating and developing sustainable alternatives to the conventional energy systems is a growing concern for global stakeholders.