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Sustainable energy: a solution to climate change

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ABSTRACT

Energy crisis and climate change are very grave issues faced by the humanity. Various anthropogenetic activities impact climate on a huge scale, in that way the risk in affecting the future is very high.Science implies a strong probability that, if emissions continue persistently, earth will experience a radical alteration of its climate. We report the adversative effect of greenhouse gases produced by burning of fossil fuels. Also, the consumption pattern of energy in India as well as worldwide has been assessed. The most recent stabilization scenarios, assessed by this chapter includes greenhouse emission mitigation strategies, technology needs, structural changes and possible policy controls, comparative benefits of advanced technology with that of conventional technology. Such solutions alongside the issues are very helpful for mitigating present and future energy crisis.

Key words: *Climate change, Green House gases, Methane, Energy*

Introduction

Energy system decarbonization has a large role in mitigation of climate change (Cronin *et al.,* 2018). Due to climate change, the energy system components are adversely affected, because of long-term changes in parameters of climate, variability and extreme weather events (Salinger *et al.,* 2000). Impacts of climate change is expected throughout the energy system. When we look at this issue on basis of demand, because of rapid rise in temperature, there is a change in the demand in patterns of heating and cooling. But if we look at this issueon basis of supply, it depends on the availability of crops for bioenergy feedstocks; increasing cost and availability of fossil fuels due to melting sea ice and permafrost; the efficiency of photo-voltaic (PV) panels, thermo-electric power plants and transmission lines due to rising temperatures; technology downtime due to changes in the frequency and intensity of extreme weather events (Panteli and Mancarella, 2015).

These physical effects have implications on the reliability, cost and local environmental impacts of energy supply. Furthermore, some impacts may result in an increased use of fossil fuels or reinforced infrastructure, and thereby increasing greenhouse gas (GHG) emissions; for example, reductions in the efficiency of power stations, reductions in renewable energy resources or increased risks of storm damage to coastal infrastructure. These would undermine efforts to decarbonize the energy sector. To ensure mitigation, adaptation options should be comprehensively examined.It is imperative that climate change impacts are thoroughly accounted for the models which are used to examine the feasibility, costs and implications of energy system decarbonization pathways. Further exploration of the climate and its impacts on the energy system is highlighted in the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR6, 2021). In our present study, we have taken stock of the literature quantifying the impacts, assessed how that understanding is being used in energy system models and identified key research priorities.

The Energy Crisis

The challenges now facing the world's energy systems are arguably far greater than those of the 1970s energy crisis, and most available evidence suggests that theywill get more daunting in future.

The vulnerabilities of our current energy system stem mostly from its reliance primarily on fossil fuels which are nonrenewable, depleting resources that, when burned, release climate-changing greenhouse gases (Godson *et al.,* 2013). The fight against climate change implies a rapid, dramatic shift in world energy source–a shift that would be extremely challenging and unprecedented, and that would also require levels of investment measured in the tens of trillions of dollars. However, even if world leaders do nothing to respond to the climate threat, depletion will continue to eat away at the world's oil, gas, and coal reserves. The quality of fossil fuel resources is diminishing at a rapid pace, which can be seen from its last few years data (Perez *et al.,* 2014).

The two challenges, climate change and the effects of depletionwill require action if we want to avoid economic and environmental calamity. Such action would entail the replacement not only of energy production infrastructure, but also of much of our energy usage infrastructure, which was designed to take advantage of the specific capabilities of fossil fuels.

A study is needed to justify our current reliance on fossil fuels and its shift towards renewable energy. A shift to renewable energy for electricity generation implies an efficiency opportunity. It's a known fact that wind and solar energy produce electricity directly, implying a steep reduction in wasted energy, and electric motors are highly efficient compared to internal combustion engines. Overall, the transition will represent a back-and-forth between the costs of making a renewable energy system like the current one and the costs of adapting our energy usage patterns to the inherent qualities and characteristics of renewable resources.

Only 20 percent of final energy globally is used in the form of electricity (Kondziella and Bruckner, 2016). The alteration transition to wind and solar electricity would require many technologies that use energy to be electrified, or powered with renewables in different ways. Some substitutions will be relatively easy, such as trading natural gas space heaters for electric air-source heat pumps. Some will be difficult, such as finding ways to fuel aviation and shipping with renewable power.

An all-renewable economy may be very different from the economy we know today. Indeed, what is required is nothing less than a near complete redesign of industrial systems and a substantial downsizing of energy usage in industrialized nations. If policies and leadership to accomplish these goals are not forthcoming, the eventual result will be dire. Nations will simply burn whatever fossil fuels can be extracted affordably, wrecking the global climate while their economies collapse (probably in stages) because of declining thermodynamic efficiency and to snowballing environmental impacts. The energy dilemma would be more critical to our future, but there is little evidence that it is being taken seriously.

Total energy consumption worldwide

It can be denoted as the total energy produced and actively used by the humankind. It doesn't include energy gained from eating food, thereby, the amountof direct burning of biomass is poorly reported.Consumption of energy worldwide has deep consequences for humanity's political and socio-economic provinces; as it is the fountain of civilization.

Institutions such as the International Energy Agency (IEA), the U.S. Energy Information Administration (EIA), and the European Environment Agency (EEA) record and publish energy data periodically (Kappatos, 2021). Understanding of world energy consumption and Improved data may reveal patterns and systemic trends, which could encourage movement towards collectively useful solutions and help frame current energy issues.

The concept of total primary energy supply (TPES) is closely associated with energy consumption, which – on a worldwide level – is the sum of energy production minus storage changes (Heun and Brockway, 2019). Since energy storage changes over the years are inconsequential, for energy consumption estimation, TPES values are often used. Nevertheless, TPES ignores effectiveness of conversion, overplaying those forms of energy which have poor conversion effectiveness (e.g.coal,gas and nuclear) and devaluing those forms that has been already described for in transformed forms (e.g. hydroelectricity or photovoltaics). IEA, in 2018 reported that 14281.89 Mtoe was the total primary energy supply.Coal was the main cause of energy with the maximumapplication from 2000–2012. The usage of oil and gas also had considerable evolution, tailed by renewable energy. Renewable energy grew at a rate faster than the other time in history during this era. The demand for nuclear energy decreased, in part due to nuclear disasters (Three Mile Island, 1979; Chernobyl, 1986, and Fukushima, 2011). Recently, consumption of coal has declinedto renewable energyconsumption. Coal dropped from about 29% of the worldwide total primary energy consumption in 2015 to 27% in 2017, and non-hydro renewables were up to about 4% from 2%.

In 2011, expenditures on energy totaled over US$6 trillion, or about 10% of the world gross domestic product (GDP) (Tang, 2021). Europe spends almost one-quarter of the world's energy expenditures whereas North America does 20%, and Japan 6%.

An overview of India's energy system

India consumes a lot of energy and stands third in world consumption because of its increasing incomes and standard of living. Since 2000, energy consumption has doubled whose 80% is still being met by coal, oil and solid biomass (Pachauri and Jiang, 2008). India's energy use and emissions are less than half the world average, on a per capita basis; as can be made out by vehicle ownership, steel and cement output. India is re-entering a dynamic period of energy consumption post 2020's covid slump. It is expected that in the next few years, many Indian households will be buying electrical appliances on huge scale. As per population is concerned, India will soon become world's most populous country and to meet its electricity demand, it will need a power system equivalent to that of European Union's present day power system.

Climate Change and Renewable Energy

Solar energy is abundant and offers significant potential for near-term (2020) and long-term (2050) global climate change mitigation. Even though solar power generation represents alittle fraction of total energy consumption, markets for solar technologies are growing rapidly. Potential deployment scenarios range widely—from a marginal role of direct solar power in 2050 to at least one of the major sources of energy supply. Solar energy is the most abundant of all energy resources. Indeed, the rate at which solar energy is intercepted by the earth is about 10,000 times greater than the speed at which humankind consumes energy (Kaur and Kumar, 2015). Opting for such home improvements can allow one to scale back almost 70% of one's overall contribution to pollution. This is a big number considering that most people are highly dependent upon non-renewable energy sources that have grave contributions to overall amounts of pollution. The internal thermal energy of the Earth flows to the surface at a rate of 44.2 terawatts (TW) by conduction, and is replenished at a rate of 30 TW by decay of minerals (Zohuri, 2018). These power rates almost doubles humanity's current energy consumption from all primary sources, but most of this energy flow isn't recoverable. Geothermal utilization is commonly divided into two categories, i.e., electricity production and direct application If the electricity that drives the heat pump is produced from a renewable energy source like hydropower or geothermal energy, the emission savings are even higher. The total CO_2 reduction potential of heat pumps has been estimated to be 1.2 billion tons per year or about 6% of the global emission (ISEO). The IPCC's Fourth Assessment Report (AR4), 2007 states that hydropower could contribute 17% of global electricity supply by 2030. The estimated reduction potential of Micro/ Mini hydro as a CDM project is 2.3 plenty of CO_2 equivalent per kilo watt of generated power per annum. According to the International Energy Agency (IEA, 2010), 1.4 billion people have no access to electricity. A decentralized electricity supply can be provided by SHP in those rural areas that have adequate hydropower technical potential. This opportunity of carbon market may support in further development and promotion of the technology in the rural areas of the country, which will not only increase access to decentralized energy but also supports in the sustainable development. Wind power, as an alternate to fossil fuels, is plentiful, renewable, cosmopolitan, clean, produces no greenhouse emission during operation and uses little land. As of 2021, there is now 743 GW of wind power capacity worldwide. According to the IEA's estimate, wind energy generationwill lead to 600g/kWh of the carbon dioxide. The most ambitious scenario by the Global Wind Energy Council (GWEC) shows that, with growth rates much less than the 30%, the wind sector has experienced over the past decade, global wind energy capacity increased from 121GW during 2008 to over 1,000GW by 2020 and is estimated 400 GW by 2030. This would result in annual CO_2 savings of more than 1.5 billion tons in 2020 and 3.2 billon tons in 2030 (GWEC, 2017).

Climate change mitigation

Global warming and its related effects need measures so that they can be mitigated. Thisusually includes decrease in discharges of greenhouse gases (GHGs). 70% of GHG emissions is caused due to fossil fuels. To substitute these fossil fuels with clean energy sources is very challenging and costly. Although green energy resources like solar and wind energy is competing with fossil fuels but still more efforts are to be made to make them more reliable, cheap and portable since these requires energy storage and extended electrical grids. Climate change can also be reduced by rapid plantation of more and more trees (afforestation), prevention of destruction of existing forests and grasslands, using public transport, using electric vehicles, reducing the use of plastic, making environmental laws more strict, spreading awareness in community about climate change and its drastic affects.

Nearly all countries are part of the United Nations Framework Convention on global climate change (UNFCCC). Stabilization of atmospheric concentrations of GHGs at a level that might prevent dangerous human interference with the climate system is the ultimate objective of the UNFCCC (Gao *et al.,* 2017). Parties to the UNFCCC, in 2010, decided that heating in future, should be restricted to below 2 °C (3.6 °F) relative to the pre-industrial level. This was confirmed with the Paris Agreement 2015.

With the special report on heating of 1.5 °C, the International Panel on global climate change has emphasized the advantages of keeping heating below this level, suggesting a worldwide collective effort which will be guided by the 2015 United Nations Sustainable Development Goals. Emissions pathways with limited or no overshoot would require far-reaching and rapid transitions in energy, urban, land and infrastructure including industrial systems, buildings and transport.

But the present path of global greenhouse emission doesn't appear to be restrictive heating to under 1.5 or 2 °C. However, the benefits of keeping temperature change under 2 °C exceed the costs globally (Rogelj *et al.,* 2015).

Greenhouse gas concentrations and stabilization

Currently, CO_2 is adding to the atmosphere by human activities faster than natural processes can remove it. According to a US study of 2011, alleviating atmospheric CO_2 concentrations would require human caused CO_2 emissions to be limited by 80%.

The IPCC works with the concept of a fixed carbon emissions budget. If emissions remain on the present level of 42 $GtCO_2$, the carbon allow 1.5 °C might be exhausted in 2028 (Ohlendorf *et al.*, 2018). The rise in temperature thereto level would occur with some delay between 2030 and 2052. Even if it had been possible to realize negative emissions within the future, 1.5°C must not be exceeded at any time to avoid the loss of ecosystems.

After leaving room for emissions for making of food for 9 billion people and still to limitthe rise in temperature below 2°C worldwide, the emissions from transport needs to be reduced while the energy production needs to peak soon within the developed world until zero emissions are gotby 2030.

Sources of greenhouse gas emissions

With the Kyoto Protocol, the reduction of just about all anthropogenic greenhouse gases has been addressed. These gases are nitrous oxide (N_2O), carbon dioxide (CO_2), methane (CH_4), and fluorinated gases (F-Gases): the hydrofluorocarbons (HFC), perfluorocarbons (PFC), and sulfur hexafluoride (SF_6). Their heating potential (GWP) depends on their lifetime within the atmosphere. Methane features a relatively short atmospheric lifetime of about 12 years but a high immediate impact. Areduction of about 30% below current discharge levels would cause aequilibrium in its atmospheric concentration for methane, while for N_2O, an emissionreduction of around 50% would be required (Howarth, 2014). Estimations largely depend on the ability of oceans and land sinks to absorb GHGs. The risk of retaliated heating results in high uncertainties within the determination of GWP values.

Carbon dioxide (CO_2)

- Burning fossil fuel: oil, gas and coal are the main driver of anthropogenic heating with annual emissions of 34.6 $GtCO_2$ in 2018.
- Cement production is estimated 1.5 $GtCO_2$
- Land-use change (LUC) is the imbalance of deforestation and reforestation. Estimations are very uncertain at 3.8 $GtCO_2$. Wildfires cause emissions of about 7 $GtCO_2$
- Flaring: In petroleum production vast amounts of associated gas are commonly flared as waste or unusable gas.

Methane (CH_4)

- Burning fossil fuel (33%) also accounts for many of the methane emissions including gas distribution, leakages and gas venting.
- Cattle (21%) account for 2 thirds of the methane emitted by livestock, followed by buffalo, sheep and goats.
- Human waste and waste water (21%): When biomass waste in landfills and organic substances in domestic and industrial waste water are decomposed by bacteria in anaerobic conditions, substantial amounts of methane are generated.
- Another agricultural source is rice cultivation (10%): In flooded rice fields, where methane is produced by anaerobic decomposition of organic materials.

Nitrous oxide (N_2O)

- Most emissions by agriculture, especially meat production: cattle (droppings on pasture), fertilizers, animal manure.

F-Gases

- Switchgear within the power sector, semi-conductor manufacture, aluminum production and an outsized unknown source of SF_6.

Causes of Energy Crisis

Global energy consumption is increasing and soon humankind will face a scarcity of fossil fuels in the approaching decades. Therefore, the accessibility of reserves is a vital source of apprehension and where they are being over exploited needs to be thoroughly researched.

Overconsumption

Due to increase in population the demand for energy is also increasing day by day. For fulfilling this energy demand more minerals are needed to be extracted from earth's crust which not only leads to deforestation but resources are also overexploited which ultimately affects climate and causes global warming. Since more unconventional resources are utilized to produce more energy,hugeamount of harmful gases are produced like CO_2 which causes greenhouse effect and ultimately leads to global warming making climatic conditions worse.

Over population

The data for population, are to be put into viewpoint because they are based on current consumption, while it is clear that it will increase considerably. Energy requirements are and will be augmented by the demographic data- the world's population will reach nearly 10 billion people by 2050 - and financial boom of developing areas will take place. International Energy Agency (IEA) reports, that the global energy demand could surge by more than 50% by 2030 in the absence of public guidelines.

Aging Infrastructure

It is considered to be another reason for energy shortage and scarcity because of the poor infrastructure of power creating apparatus. Outmoded equipmentis used by most of the energy producing companies that confines energy making. There is a need to upgrade the infrastructure and set a high standard of performance.

Energy Waste

This mainly comes from the redundant energy resource usage. Energy waste defines the wastage of energy sources, in particular fuels and electricity. Subsequently, the reduction of waste is a massive source of energy reserves, which necessitates actions mutually on an individual and collective level.

Effects of Energy Crisis

Environmental

Rise of greenhouse gas emissions such as carbon dioxide (CO_2) can be seen because of fast use of conventional energy sources resulting in global warming and damaging the atmosphere and biodiversity. Consequently, the environmental crisis is closely linked to the energy crisis.

Economic and Socio- Political

Energy security is one of the major apprehensions of the main economic hubs of the planet. Actually, energy conditions the likelihood of growth, which is essential for the economy and expansion of the market. Therefore, on the global economy level, energy crisis could have a drastic impact. Also, an energy scarcity develops, when energy markets fail. Subsequent economic factors and energy scarcities may create socio-political issues.

Conclusion

Properly designed climate change policy can be part and parcel of sustainable development, and the two can be mutually reinforcing. Sustainable development path can reduce GHG emissions and reduce venerability to global climate change. Projected climate change can exacerbate poverty and undermine sustainable development, essentially in least developed countries. Hence global mitigation efforts can enhance sustainable development prospects in part by reducing the risk of adverse impacts on climate change. Mitigation also can provide co-benefits, like improved health outcomes. Mainstreaming global climate change mitigation is thus an integral a part of sustainable development.

Energy crisis and environmental concerns raised the necessity for the new biofuels. Biodiesel is a clean alternative to fossil fuel. A green approach for biodiesel production through enzymatic biodiesel production has gained a lot of attention due to the drawbacks of chemical methods. Promising enzymatic processes are established for biodiesel production. The main obstacle for the industrialization of enzymatic process would be overall cost of production. Production cost could be reduced by increasing the productivity or by increasing the catalytic efficiency of lipases. Immobilization and genetic engineering methods appear to be an attractive way to obtain more active, stable, and reusable lipases in different reaction systems. Operational parameters like water content, temperature, solvent, acyl acceptors, and so on plays key role in transesterification process. Along with all these technical operational conditions, novel bioreactor designing has also promising challenges in order to make biodiesel a great potential commercial fuel in future.

Conceptions of energy security differ between energy importers and energy exporters. Definitions that emphasize affordability and access are traditionally associated with energy importers, but fossil-fuel exporters, such as Russia, are more concerned with security of demand and price stability. For importers, renewable energy may clash with affordability currently, but can reduce dependence on suppliers and increase energy security through energy independence. This can sometimes produce compatibility between energy-security and climate-protection objectives, but can also emphasize exploitation of fossil-fuel resources, which does not help to achieve climate-change objectives.

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