

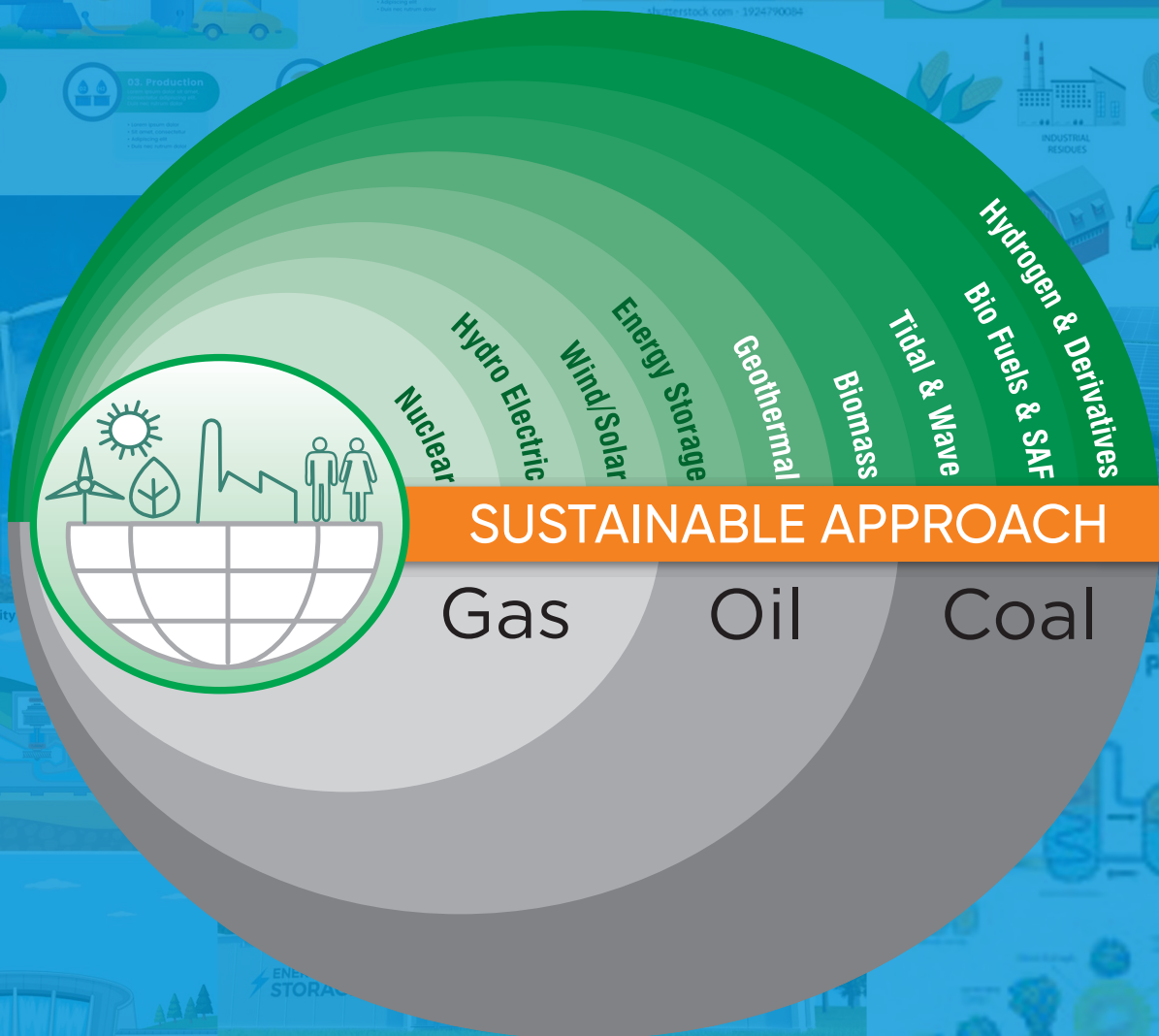
SEPTEMBER 2024

VIEWPOINT

OFFICIAL QUARTERLY MAGAZINE OF CEAI

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ENERGY TRANSITION





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Message from Chief Editor

Dear Fellow Consulting Engineers & Readers,

Today, the world is heavily dependent on energy, particularly in the form of electrical power, across all spheres of human activities. This dependency drives the consumption and subsequent depletion of the natural fuel resources. While energy is an irreplaceable requirement, the flip side is that it is a major contributor towards climate change on account of the very huge amounts of carbon being released in the process of either generating electrical power or heat or other forms for utilisation in residential, commercial, agricultural, industrial and transportation purposes. The aim of the Energy Transition is to achieve Net Zero Carbon emissions. India is progressing not only for replacing fossil fuels for electrical power generation but also in reducing their use in two other crucial sectors like industrial and transportation.

Energy Transition, in its holistic sense, involves not just the transition of energy utilisation but also allied activities such as process changes, retraining and upskilling personnel, securing finance for the transition, appropriately disposing of or reusing the plant equipment & tools from the replaced processes and above all guiding and educating the persons who need to steer the transition.

CEAI has been championing the cause of sustainability. It has held seminars over the years to apprise the professionals about the need for frugality in design albeit ensuring safety, reliability, and robustness so that what is built or produced is fit for the purpose intended for its design life. The Government of India has made commitments and has laid down policies and procedures to meet its Sustainability Development Goals, the Climate Change measures, and the Energy Transition targets. It is now up to all Professional Engineers to adopt the principles and practices which are imperative to meet the requirements. They must collaborate with the Government to ensure a better future for the generations to come.

Professional Engineers - Energy Transition For A Better Posterity

Happy Reading & Learning

A P Mull



Message from Guest Editor

As we stand at the crossroads of an unprecedented global mandate for sustainable energy, the transition and the urgency to decarbonise industries and economies has never been more pronounced. This issue explores the multifaceted challenges and innovative solutions that define the path towards a sustainable, low-carbon future. The issue presents and discusses the critical topics and emerging technologies that are shaping this transformative era. At the heart of this transition lies the pivotal role of renewable energy sources, particularly solar and wind, in reshaping the energy landscape. These resources are now more cost-effective and scalable than ever before, driving the shift away from fossil fuels. However, the intermittent nature of solar and wind energy necessitates innovative solutions for energy storage. Several types of devices and technologies are used for energy storage such as batteries, hydrogen storage, pumped hydro storage, flywheel, compressed air energy storage, supercapacitors, etc.

India has a broader goal to achieve 50% of installed capacity through non-fossil power by 2030. As of May 2024, non-fossil sources contribute about 43% of India's total installed power generation capacity, which amounts to approximately 180 GW, out of a total of 418 GW – this includes hydro, solar, wind, biomass, waste to energy, small hydro and nuclear power. In the Union Budget for 2024-25, the Government of India has placed significant emphasis on promoting the energy transition. It has identified pumped storage projects as a means to enhance energy storage and support the integration of renewable energy sources. Additionally, the budget includes viability gap funding for offshore wind (a potential unused so far), and also for battery storage projects. The comprehensive approach aims to ensure grid stability and support the increasing share of renewable energy in India's power mix.

In parallel, there is a global as well as national push towards nuclear energy, which has long been a cornerstone of reliable power generation. The Government of India has allocated significant funding for the development of Bharat Small Reactors (BSRs) in the 2024-25 budget. The government would partner with the private sector(s) to develop these reactors, which are based on India's existing Pressurized Heavy Water Reactor (PHWR) technology. It is now being reimagined to produce clean hydrogen—a versatile fuel that could revolutionize sectors from transportation to heavy industry. The potential of nuclear (pink) hydrogen is immense, offering a pathway to significantly reduce carbon emissions in areas that are difficult to electrify. The synergy between nuclear power and hydrogen production represents a key opportunity in the collective quest for deep decarbonization. BSRs are ideal to replace old fossil units replacing main plant while same BoP (Balance of Plant) may continue to be used.

The National Hydrogen Mission under MNRE (Ministry of New and Renewable Energy) envisions the Indian government's objective to establish India as a global hub for the production, usage, and export of Green Hydrogen and its derivatives, with a target of producing 5 million metric tonnes of green hydrogen per annum by 2030. In line with this objective, the government is actively promoting the green hydrogen initiative through the Strategic Interventions for Green Hydrogen Transition (SIGHT) program. In its initial phase, two distinct financial incentive mechanisms have been proposed with a budget allocation of ₹17,490 crores, extending up to 2029-30. The subsidies cover the first three years of production output, offering up to INR 50 (US\$0.6) a kilogram of hydrogen

(kg-H₂) for the first year, INR 40 (US\$0.48) in the second year, and INR 30 (US\$0.36) a kg-H₂ in the third year. These incentives focus on supporting the manufacturing of electrolyzers and the production of Green Hydrogen.

Bioenergy also plays a crucial role in energy transition, offering a renewable and sustainable alternative to fossil fuels. Whether through advanced biofuels or biomass power generation, bioenergy can contribute significantly to reducing greenhouse gas emissions, especially in sectors like transportation, agriculture and waste management. Sustainable Aviation Fuels (SAF) are being developed to provide sustainable solutions for air transport. Further, the optimisation and decarbonisation of electrically driven motors in industrial applications present a major opportunity for energy efficiency gains.

The carbon capture technologies for existing facilities offer a pragmatic approach to mitigating emissions from industries that are currently reliant on fossil fuels. These technologies will be critical in bridging the gap as we transition to a cleaner energy system, ensuring that existing infrastructure can be a part of the solution rather than a part of the problem. India has set an ambitious target to reduce its carbon emissions by 1 billion tonnes by 2030. This goal is part of a broader strategy to combat climate change and transition to more sustainable energy sources.

The integration of Environmental, Social, and Governance (ESG) frameworks into business practices is increasingly recognised as essential in navigating the Energy transition. ESG considerations guide companies in managing risks, seizing opportunities, and ensuring long-term sustainability in a rapidly changing world.

In this issue, the themes are explored in depth, providing insights and analysis on the innovations and strategies that will drive the energy transition forward. The road ahead is challenging, but with determination, collaboration, and a commitment to sustainable progress, India can achieve a future where energy is not only abundant and affordable but also clean and resilient

Let us all embark on this journey together!

Dr. Sakthivel. S

Deputy General Manager- Technology Team
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About CEAI

Consulting Engineers Association of India (CEAI) is the apex body of consulting engineers in India having membership of organisations as well as individuals. The membership represents large, medium and small consultancy companies/ organisations both in the private and public sector and eminent individual consultants. EPC organisations are also members of CEAI since they have planning and design engineers, apart from construction management consultants.

CEAI is the Member Association, of the International Federation of Consulting Engineers, commonly known as FIDIC, the acronym for *Fédération Internationale Des Ingénieurs-Conseils*, representing the Consulting Engineering Fraternity in India. FIDIC has membership of more than 100 Member Association of various countries and is headquartered in Geneva.

CEAI was incorporated in 1996, with the merger of two leading national associations Association of Consulting Engineers (India) {ACE(I)}, incorporated in 1960 and National Association of Consulting Engineers {NACE}, incorporated in 1976. Thus, CEAI has, behind it six decades of accumulated knowledge and experience.

- CEAI promotes the interest and works to enhance the status of the consulting engineering profession in India
- CEAI advocates global networking and co-operation
- CEAI's activities include:
 - Quality development of Consultants.
 - Productivity enhancement.
 - Promotion of ethical practices.
 - Facilitation and interaction with government and other authorities/ bodies to streamline and improve the system of engagement of consultants.
- Regional Centres in Jaipur, Bengaluru, Kolkata and Mumbai to broad base activities.

Aims & Objectives

- Promote the professional interest and establish the rights and privileges of the status of consulting engineering profession in India
- Represent the consulting engineering profession within India and abroad. Connect the members locally and globally.
- Disseminate among the members information on all matters pertaining to engineering, especially knowledge and information related to consulting engineering profession by way of holding Conferences, Seminars, Courses, Workshops, Field/ Site Visits, etc. and thus assist in Continuing Education for the Professional Development of Members.
- Act as the principal champion for consulting engineering profession through constantly informing and educating the public and lawmakers about key engineering issues and making it possible to have the voice of the profession heard by the policy makers.
- Promote adoption of equitable forms of contracts and other documents used in consulting engineering practice.

Vision

- To represent, promote and enhance the status of consulting engineers in India as an honoured and dignified profession for nation building and propagate Indian engineering consultancy globally.

Mission

- Promote interests of the consulting engineering profession nationally and internationally.
- Promote sustainable, safe and sound engineering practices.
- Upgrade engineering knowledge and skill.
- Propagate code of professional ethics, safety, health and environment.

Values

- Commitment with tenacity to high ethical values, integrity, professionalism and achieving technical excellence and inclusive development.

Code OF Ethics

- CEAI has adopted a Code of Ethics, to which all members must abide. It is not just for the quality of the jobs they work on, but for the safety and well-being of the public at large.
- CEAI is the profession's most respected voice on the practice of ethical engineering.
- The code specifies the responsibilities of Consulting Engineers towards the society as well as the profession, to refrain from performing services unless competent to do so, to act in the legitimate interest of client, to be impartial, to maintain ethical relations with other consultants.

Energy Transition - A Holistic Approach from Energy Generation to Consumption Phases



Shantanu S Apte
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Abstract

Energy Transition is not merely changing to low or no-polluting energy sources; it must be based on a holistic understanding of the environmental impacts during the various energy phases. This paper articulates the environmental impact of conventional and not-so-conventional energy sources during five phases such as generation, transport, refining/processing, distribution, and consumption. The Consulting Engineering community can play a crucial role in the energy transition journey.

Introduction

Energy Transition is a multi-faceted subject and consists of important phases from generation, storage, transmission, and distribution to usage. Each of these phases need to be studied carefully to understand and then mitigate the adverse environmental impact.

The Consulting Engineering (CE) community is knowledgeable in the fields of core technology, environmental regulations, rules, and standards. Thus, it can and should play an important role in the sustainability transition efforts¹.

Energy is at the core of the progress that humans have

achieved over thousands of years. From resources including muscle power, the taming of animals, the sun, the water streams, and the wind, to the modern era energy sources like coal, oil, gas, and nuclear energy have evolved progressively. The advent and rapid developments in mastering the art of electricity generation, transmission, distribution, and usage have exponentially changed the energy landscape. Earlier, energy usage was restricted to the location of the energy sources, but progressively the distant locations with no access to the energy sources could be supplied electricity by laying thousands of kilometres of electricity transmission lines.

Energy Transition needs to address not only the changes in the sources of energy but also its effective usage to minimise or eliminate the adverse impacts on the environment. There is a dire need to look at the environment and ecology, not from the narrow perspectives keeping humans at the centre but through holistic consideration of the entire ecosystems of plants, animals, and other living and non-living entities that co-habit the planet Earth. This paper discusses Energy Transition from a holistic perspective.

It is not enough to reduce the CO₂ emission in one phase while it manifests in another phase. Such a

narrow approach would never help achieve the energy transition goals. There are some low-hanging fruits in sectors like heating and cooling where it is possible to achieve 86% CO₂ reduction compared to the levels in 1990, by adapting to existing technological advancements. Energy saving is required on both demand and supply side. It is essential to ensure that the demand is optimised by careful need assessments. Collaboration across different stakeholders is necessary to integrate local and regional energy plans with national-level plans².



Stages of Energy

The energy stages, applicable to the traditional sources are:

- i. **Exploration and Production** – In this initial stage, the sources of energy are identified and production from the raw form to the next suitable form is devised. Coal is mined, oil and gases are extracted from the earth's core, etc. Such sources need to be converted into suitable forms to make it convenient to transport.
- ii. **Transportation** – Depending upon the solid, liquid, gases, or in the form of electricity, the energy needs to adapt suitable transportation mechanisms like road, rail, sea transport, or transmission through pipelines or transmission lines.

- iii. **Refining or Processing** – The transported energy sources need further refining and processing like refining of oil in the refineries or gas processing at the seaport. Such processing is an essential intermediary stage.
- iv. **Distribution** – The last mile distribution mechanism is crucial to finally provide energy to the end customer in the form that is most suitable for consumption. It may mean transporting petroleum products, oil, gas, etc. from the container and making those available through retail stations, distributing gas through pipelines, or providing electrical substations with necessary infrastructure for electricity distribution.
- v. **Consumption** – That is the stage where the end-user utilises the energy to serve individual needs. They include petrol, diesel, or CNG for automobiles or electricity for lighting, heating, cooling, or operating factory machines for material processing and production.

Environmental Impacts during Five Energy Stages

Though the energy transition literature predominantly concentrates on the exploration and production stage, each of the stages mentioned above- needs careful attention to minimise the adverse environmental and ecological impacts. The subsequent sections discuss a few energy sources and their environmental impact during each of the five energy stages.

Stage 1: Exploration and Production

The aspects that need critical attention in each of them are discussed. Table-1 summarises the impacts during the exploration and production phase of the three energy sources viz. Oil & Gas, Hydroelectric, and Nuclear.

Table-1: Impacts during Exploration and Production

Exploration and Production	Impact	Description
Oil and Gas	Pollution	Air, Soil, Water
	Ecosystem Damage	Construction of roads, buildings, and pipelines affecting natural habitats for the fauna and flora
	Oil Spills	Affects marine, riverine and land life; the vapours affect the air
	Acid Rains	Contributes to long-term adverse environmental impact
	Groundwater Contamination	Poses serious long-term challenges to humans and non-humans
Hydroelectric	Reservoir	Large portion of fertile land is lost forever
	Fish Migration	Change in water flow affects fish population
	Water Quality	Large mass of water accumulation leads to changes in temperature, pressure, and overall hydro ecosystem
	Erosion of Soil	Accumulation and change of water flow has geological impact
Nuclear	Radioactive Waste Management	This is a crucial and critical aspect that needs very methodical and careful management but still has a long-term environmental impact on contamination of soil and water sources.
	Thermal Load on Sea	Affects marine life and ecosystems
	Accident Possibilities	Devastating impacts on lives
Coal	Air Pollution	Emission of particulate matter, sulphur dioxide (SO ₂), and nitrogen oxides (NO _x)
	Water Contamination	Acid mine drainage and toxic wastewater contaminating local water sources
	Habitat Destruction	Surface mining operations displace ecosystems, forest, and wildlife
	Carbon emissions	Significant contributor to greenhouse gases, driving climate change
	Waste Management	Production of large amount of coal ash and mining waste, difficult to dispose off safely

Thus, different choices of energy sources pose different environmental challenges that have short, medium, and long-term impacts. As knowledge and understanding about global warming is increasing significantly, so is the need to carefully study the impacts of energy sources. The traditional ways of addressing the impact need an urgent relook.

The environmental impact is beyond CO₂ emissions. Though hydropower is a form of clean energy, it must be noted that the storage of huge quantities of water adversely impacts plants, animals and the human habitations that get displaced. It impacts not only the ecology submerged by the backwater, but it also affects the downstream ecology. The construction of dam's

results in less amount of water flow through the rivers and that alters the plant and animal lives downstream too. Thus, saying that hydropower is a form of clean energy is not necessarily true. On the other hand, it is a renewable source. Hence a balance needs to be struck on a case-to-case basis.

Stage 2: Transportation

The produced form of the energy needs to be transported to the point of consumption through various means. The transportation process itself consumes and wastes some portion of energy. Various aspects of transportation of coal, oil & gas, and electricity generation through various energy sources are given in Table 2.

Table-2: Impacts during Transportation

Transportation	Impact	Description
Coal	High energy consumption during transport	Transporting coal over long distances requires significant energy, resulting in overall loss.
	Air pollution due to diesel-powered trains/ trucks	Emissions from vehicles contribute to air pollution.
	Wear and tear on roads and railways	Large quantum of coal transportation leads to infrastructure degradation.
	Coal dust release during transport	Dust can affect air quality and health of nearby communities, as well as the flora and fauna.
Oil & Gas	Risk of leaks and spills	Oil and gas pipelines may leak, causing environmental damage.
	Energy used to maintain pressure in pipelines	Pumping oil and gas require continuous energy input, leading to losses.
	Risks associated with oil tankers	Accidents or spills at sea can have devastating environmental effects.
	High costs of building and maintaining pipelines	Large investment is needed for safe and efficient transport.
	Costs of building and maintaining the storage facilities	Large investment is needed for safe storage
Nuclear	Energy loss during transmission	Energy dissipates as heat in power lines, leading to losses.
	Construction of transmission lines affects landscapes	Building infrastructure can disrupt ecosystems and land use.
	Regular maintenance required for grid stability	Continuous monitoring and repairs are necessary to prevent outages.
	Potential health concerns	Proximity to high-voltage lines may raise concerns about long-term health effects.
Solar and Wind	Large area required for solar and wind farms	Transporting energy from remote solar/wind farms requires extensive infrastructure.
	Variability in energy supply	Transmission requires managing fluctuations in solar/wind energy output.
	Losses in DC to AC conversion and transmission	Converting and transmitting solar energy can result in energy loss.
	High initial investment for transmission infrastructure	Setting up transmission lines for solar/wind energy can be costly.

Thus, even if clean energy sources like nuclear, solar, and wind are chosen to generate electricity, the transport stage exerts various adverse environmental impacts. Merely changing the source of energy to a 'clean source' without paying attention to its means and method for transporting it cannot result in holistic

improvements. The need to create vast road, rail, and water-based transportation networks makes a lasting impact on the environment.

Many times, it is thought that electrical power transmission is clean as it is free of adverse effects of

pollution caused by oil and gas. This argument is also not right. The large infrastructure needed to transport such huge power through gigantic transmission towers, associated transmission lines and switchgear adversely impacts the environment. The transmission losses generate heat resulting in temperature rise in nearby areas. It also has the harmful impact of electromagnetic waves that can affect the navigation of migratory birds.

Stage 3: Refining/ Processing Stage

For bulk transportation, the energy needs to be converted to make it suitable for distribution to the

end customer in forms that are more convenient to suit different distribution channels and their application. Such channels themselves need energy consumption to operate and hence have an impact on the environment.

Table-3 outlines the key impacts associated with the refining and processing stages necessary to make oil, gas, coal, and electricity suitable for distribution. Each type of energy presents unique challenges in terms of environmental impact, energy consumption, and infrastructure demands.

Table-3: Impacts during Refining or Processing

Impact During Refining/ Processing	Impact	Description
Oil	Emissions from refineries	Refining crude oil releases pollutants such as CO ₂ , SO ₂ , and NO _x into the atmosphere.
	Contamination from spills and discharge	Wastewater and accidental spills during refining can contaminate local water sources.
	High energy demand for refining	The refining process requires significant energy input, contributing to overall energy consumption.
	Production of hazardous waste	Refining produces hazardous by-products that require careful management and disposal.
	Large-scale refineries require extensive infrastructure	The construction and operation of refineries impact local ecosystems and communities.
Gas	Release during processing	Processing natural gas can result in methane leaks, a potent greenhouse gas.
	High water demand for cooling and processing	Processing facilities require large amounts of water, affecting local water resources.
	Energy-intensive processing	Compressing and liquefying natural gas (LNG) requires substantial energy, leading to efficiency losses.
	High-risk processing environment	Gas processing facilities must manage the risks of explosions, which can have severe consequences.
	Land use and habitat disruption	The development of large gas processing plants affects local environments and land use.

Impact During Refining/ Processing	Impact	Description
Coal	Emissions from processing plants	Processing coal, such as washing and drying, releases dust and pollutants into the air.
	Runoff from coal processing	Wastewater and runoff from coal preparation plants can contaminate local water bodies.
	Production of coal slurry and tailings	Coal processing generates solid waste that requires proper disposal to prevent environmental harm.
	High energy use in processing	The preparation and cleaning of coal before it is used for combustion consume significant energy.
	Impact of coal processing facilities	The construction and operation of coal processing facilities can lead to land degradation and loss of habitat.
Electricity	Waste heat from substations	Large substations emit waste heat, affecting local temperatures and ecosystems.
	Potential health concerns	High-voltage substations and load dispatch centers generate electromagnetic fields that may have health impacts.
	Losses in electricity transformation and transmission	Converting and transmitting electricity from power plants to substations results in energy losses.
	Land use for substations and transmission lines	The infrastructure required for electricity distribution impacts local ecosystems and landscapes.
	High demand for materials for substations	The construction of substations and load dispatch centers requires large quantities of concrete, steel, and other materials.

The refining or processing of the energy to make it suitable for distribution and consumption demands huge infrastructure and energy. This applicability and impact of this stage for each energy source could be different. Careful attention is needed to the fact that the so-called energy transition does not merely move adverse environmental impacts from one phase to another. In the case of electrical power, the need for load dispatch centers is felt to maintain the demand-supply balance to ensure grid stability. Such huge

infrastructure exerts adverse environmental impacts too. Besides, the processing or refinement stage itself needs energy.

Stage 4: Distribution

Energy needs to be as close as possible to the form that is suitable for consumption/ usage. Distribution is typically a last-mile network to reach the customer/ user. The challenges related to oil & gas distribution and electricity distribution are given in Table-4.

Table-4: Impacts during Distribution

Impact During Distribution in Densely Populated Areas	Impact	Description
Oil	Environmental contamination	Leaks in pipelines can cause significant soil, water, and air pollution, posing serious health risks to nearby communities, flora and fauna.
	High risk of accidents	Transporting oil via trucks or rail through densely populated areas increases the risk of accidents, potentially leading to large-scale spills and fires.
	Wear and tear on urban infrastructure	Frequent movement of heavy transport vehicles can degrade roads and urban infrastructure, leading to increased maintenance costs and traffic disruptions.
	Risk of explosions or fires	The volatile nature of oil makes it a significant fire and explosion hazard in densely populated areas, requiring stringent safety measures.
	Air and noise pollution	Distribution activities can lead to increased air and noise pollution, adversely affecting the health of populations especially in built up areas.
Gas	Risk of gas leaks and explosions	Leaks in gas pipelines pose a severe explosion risk, particularly in densely populated areas, potentially leading to catastrophic damage and loss of life.
	Aging urban infrastructure	Urban gas distribution networks may rely on aging pipelines, increasing the risk of leaks and infrastructure failures in densely populated areas.
	Evacuation and emergency response challenges	High population density and narrow roads make evacuation and emergency response more complex in case of gas leaks or explosions.
	Energy consumption for distribution	Compressing and distributing gas through pipelines in urban areas requires significant energy, contributing to overall system inefficiency.
	Air and noise pollution	Gas distribution infrastructure, including compressors and pipelines, can contribute to localised air and noise pollution in urban areas.
Electricity	Energy loss in dense urban grids	High energy demand and complex grid networks in densely populated areas can lead to increased energy losses during distribution.
	Risk of power outages	The concentration of electricity demand in densely populated areas can strain the grid, increasing the risk of power outages and requiring robust grid management.
	High costs for maintaining urban grid	The distribution of electricity in urban areas requires extensive and costly infrastructure, including substations and underground cables, which need regular maintenance and upgrades.
	Electrocution and fire risks	Dense populations increase the risk of accidents, such as electrocution or electrical fires, necessitating stringent safety standards and rapid response mechanisms.
	Urban congestion and visual clutter	Electricity distribution infrastructure, such as overhead power lines and substations, can contribute to urban congestion and may face opposition due to their impact on the cityscape.

The distribution of the energy has several safety and aesthetic issues apart from the environmental issues. Collaborative housing (co-housing) is a group of households that come together to manage their living environment. Through extensive field studies, Tummers (2017) ³ states that such collaboration helps manage peak and off-peak demands. The study elaborated benefits of such collaborations to help energy transition.

The distribution channels need a huge infrastructure

and that itself consumes energy. It also affects the local landscaping and skylines. The surge in demand for battery charging stations due to the increase in electrical vehicles is not yet fully understood.

Stage 5: Energy Consumption

The journey of energy ends by meeting the end consumer needs. The various aspects that affect the environment and the suggestions to reduce those impacts are summarised in Table-5.

Table-5: Energy Consumption Stage

Impact During Energy Consumption	Impact	Description
Oil	Emissions from combustion	Burning oil products, such as in vehicles or heating systems, releases CO ₂ , NO _x , SO ₂ , and particulates into the atmosphere.
	Respiratory and cardiovascular issues	Prolonged exposure to emissions from burning oil can lead to serious health problems, including asthma and heart disease.
	Finite oil reserves being consumed	Continued reliance on oil for energy depletes finite natural resources, contributing to long-term energy insecurity.
	Used oil and filters	Improper disposal of used oil and filters can lead to environmental contamination.
	High carbon emissions	The carbon footprint associated with oil consumption is significant, contributing to global climate change.
Gas	CO ₂ and methane emissions	Burning natural gas for heating, cooking, or electricity generation releases CO ₂ , and methane leaks during use are potent greenhouse gases.
	Potential CO and NO ₂ emissions	Incomplete combustion of natural gas in homes can lead to the buildup of carbon monoxide (CO) and nitrogen dioxide (NO ₂), affecting indoor air quality.
	Finite natural gas reserves	Like oil, natural gas is a finite resource, and its continued use depletes reserves, posing future energy security challenges.
	Risk of explosions or fires	The use of natural gas in homes and industries carries risks of leaks, which can lead to explosions or fires if not properly managed.
	Lower than oil, but still significant	While natural gas has a lower carbon footprint compared to oil, it still contributes to global greenhouse gas emissions.
Electricity	Depends on generation method	The environmental impact of electricity consumption varies depending on the source—fossil fuels, nuclear, or renewables. Fossil fuel-based electricity contributes to CO ₂ emissions, while renewables have a lower impact.

Impact During Energy Consumption	Impact	Description
	Potential health concerns	Continuous exposure to electromagnetic fields (EMFs) from appliances, especially near high-power devices, may have long-term health effects.
	E-waste from electrical appliances	The disposal of old or broken electrical appliances contributes to e-waste, which can contain hazardous materials.
	Varies by source	The carbon footprint of electricity consumption depends on the energy mix of the grid; fossil fuel-based electricity has a higher footprint.
	Strain on the grid	High electricity demand, especially during peak hours, can strain the grid, leading to potential blackouts and increased emissions from backup power sources.

Worldwide, the building sector accounts for close to 40 % of energy consumption. Bridging the wide knowledge gap between the experts and craftsmen working on the ground can help improve the efficiency and reduction of losses⁴.

Though Electrical vehicles as endpoint consumption could have zero discharge but it increases the carbon footprints in the preceding stages like the source of energy, transportation, processing, and distribution. Unless solar energy is generated and consumed locally to charge the EVs, the EVs cannot be truly considered as clean and green.

Summary

Energy transition is not a homogeneous activity, but it needs to answer how different actors create, maintain, and disrupt subprocesses of transitions. The transition must consider not only the technology but also institutions and individual actors. While the technological, legal, and environmental considerations related to energy transition could be better understood, the social and individual dynamics involved in the transition are not easy to understand⁵.

It is thus evident that the Energy Transition is not just about changing the energy source from oil and gas to solar, nuclear, wind, green ammonia, hydrogen, etc. but it needs a holistic approach to consider the impacts and mitigation plans.

Each of the 5 stages of the energy journey need continued and careful planning and long-term thinking to ensure that investment provides both short and long-term

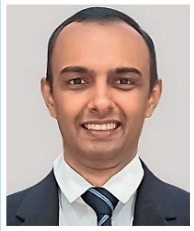
benefits without compromising on the environment. The Consulting Engineers armed with their sound knowledge and expertise in the various branches of engineering can educate and guide the stakeholders to adopt a broader outlook toward energy transition.

A holistic and multi-stakeholder-driven comprehensive planning can only help address the challenges of global warming. The individual stakeholder initiative by trying to maximise one's gains while doing its bit towards environmental protection would not be able to provide visible improvements. Joint efforts, at all levels, are necessary and essential.

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Navigating the Energy Transition: Climate Risks and Opportunities



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Abstract

The global energy transition, driven by the urgent need to mitigate climate change, presents significant risks as well as opportunities for businesses. This article explores the various climate-related risks - including physical, transition, litigation, and reputation risks - that firms in the business of generating energy face. It also delves into the opportunities arising from resource efficiency, energy innovation, new products and services, access to new markets, and resilience.

Keywords: Energy Transition, Climate Risks, Resource Efficiency, Energy Innovation, New Markets, and Resilience.

Introduction

The shift from fossil fuels to renewable energy sources is a critical response to the global climate crisis. For businesses, the energy transition is a double-edged sword, presenting both risks and opportunities. Understanding these factors is essential for firms to navigate the transition and thrive in a low-carbon economy strategically. This article aims to provide a detailed examination of the risks and opportunities associated with the energy transition.

Climate Risks

The transition to a low-carbon economy and the impacts of climate change pose several risks to businesses, which can disrupt operations, increase costs, and threaten the viability of business models, refer Figure-1.

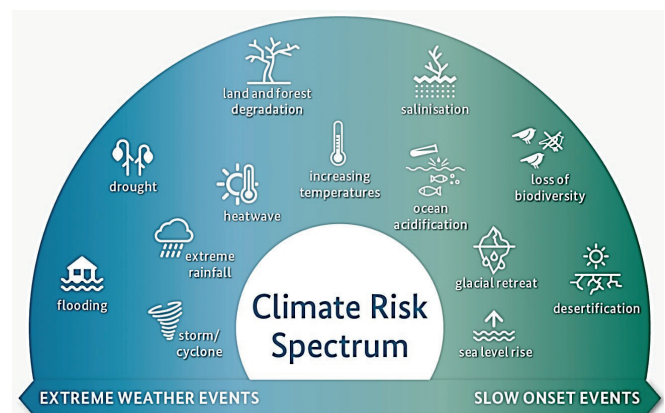


Figure-1: Climate Risk Spectrum (Source: weforum.org)

1. Physical Risk

Physical risks refer to the direct impacts of climate change on business operations, refer Figure-2. These risks can be categorized into long-term or gradual risks and short-term or stochastic risks.

Long-Term/Gradual Risks¹

- **Sea-Level Rise:** Rising sea levels can threaten coastal infrastructure, leading to increased maintenance costs and potential relocations. Companies with facilities in coastal areas may face operational disruptions and increased expenses to protect or move their assets.
- **Temperature Changes:** Higher temperatures contribute to the frequency and intensity of extreme weather events, such as hurricanes, heatwaves, droughts, and heavy rainfall. These events can cause significant damage to infrastructure, agriculture, and human settlements. Gradual temperature increases can affect agricultural productivity (i.e., reduced crop yields), energy consumption patterns (i.e., increased cooling costs), and worker health and productivity (e.g., health risks for outdoor workers).

- **Changes in Precipitation:** Altered precipitation patterns can impact water availability, leading to water shortages in some regions, which affects drinking water supplies, agriculture, and industry. Reduced water supply can lead to operational constraints and increased costs for water-intensive industries.

Short-Term/Stochastic Risks

- **Extreme Weather Events:** Sudden and severe weather events like hurricanes, floods, and wildfires can cause immediate and catastrophic damage to infrastructure and supply chains³. These events can lead to significant financial losses, operational downtime, and increased insurance costs.
- **Heatwaves:** Intense and prolonged heatwaves can increase cooling costs, strain energy systems, and impact the health and safety of workers¹. Businesses may face increased operational costs and productivity losses due to extreme heat.



Figure-2: Physical Risks (Source: climateworks.org)

2. Transition Risk

Transition risks arise from the shift to a low-carbon economy. They include regulatory changes, financial implications, and shifts in market dynamics, refer Figure-3.

Laws and Regulations^{4,5}

- Stricter environmental regulations and policies aimed at reducing greenhouse gas emissions can impose higher compliance costs on businesses. Companies may need to invest in cleaner technologies and processes to meet new standards.
- Introduction of carbon pricing mechanisms, such as carbon taxes or cap-and-trade systems, can increase operational expenses. Firms may face higher costs for emissions and need to adapt their business models accordingly.

Stranded Assets⁶

- Investments in fossil fuel-based assets may become obsolete or lose value as the world transitions to renewable energy sources. Companies with

significant investments in oil, gas, and coal may face financial losses if these assets can no longer be utilized.

Companies holding significant reserves of fossil fuels may face financial losses if these resources cannot be exploited. The devaluation of these assets can impact overall business valuation and financial stability.

Shift in Consumer Demand and Commodity Supply

- Increasing consumer preference for sustainable products can reduce demand for carbon-intensive goods and services⁷. Companies may need to adapt their product offerings to meet changing consumer expectations.
- Changes in the supply of critical commodities, such as rare earth metals used in renewable energy technologies, can affect production costs and availability⁴. Supply chain disruptions can lead to increased costs and challenges in sourcing necessary materials.

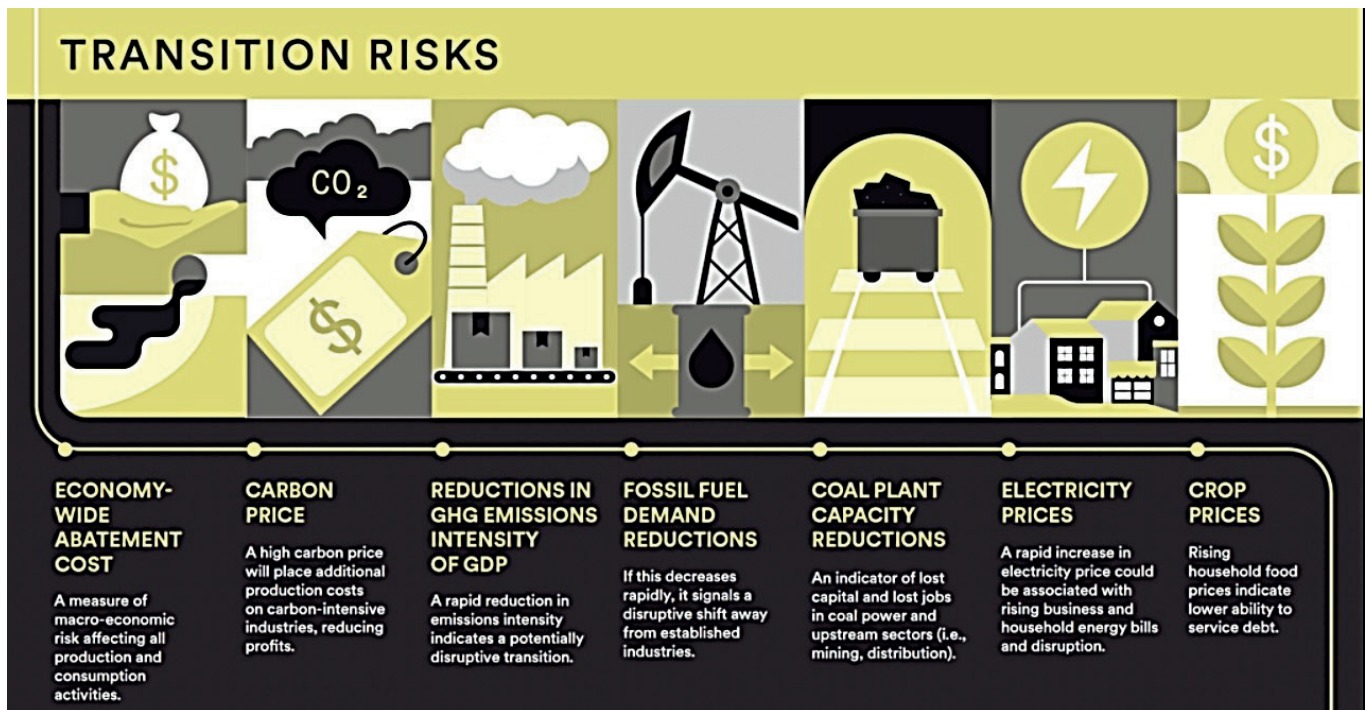


Figure-3: Transition Risks (Source: climateworks.org)

Cost of Transition⁶

- The financial burden of transitioning to sustainable practices and technologies can be substantial, requiring significant capital investment. Companies may face increased costs associated with research, development, and deployment of new technologies.
- Businesses may face increased costs associated with research, development, and deployment of new technologies. The transition to a low-carbon economy may require significant financial resources and strategic planning.

Speed of Transition⁴

- Rapid policy changes and technological advancements can create uncertainty and pressure businesses to adapt quickly.
- Companies may struggle to keep pace with evolving market demands and regulatory requirements.
- The speed of transition can impact business operations and require swift adaptation to remain competitive.

3. Litigation Risk

As awareness of climate change grows, so does the legal scrutiny of corporate environmental practices, refer Figure-4. Litigation risks can arise from various sources.

Litigation to Allocate Climate Responsibility/ Costs²

- Companies may face lawsuits aimed at holding them accountable for their contributions to climate change.
- Legal actions can seek compensation for damages caused by climate impacts, such as property destruction from extreme weather events.
- Litigation can lead to significant financial liabilities and reputational damage.

Litigation over Disclosure/ Greenwashing⁸

- Firms may be sued for failing to adequately disclose climate risks to investors and stakeholders.
- Legal actions can be taken against companies accused of greenwashing or making misleading claims about their environmental practices.

- Ensuring transparency and accuracy in environmental reporting is crucial to mitigate these risks.

Climate Bankruptcy²

- Companies facing substantial climate-related liabilities may enter bankruptcy proceedings.
- Legal processes can determine the allocation of responsibility and financial obligations for climate impacts.
- Climate bankruptcy can have significant financial and operational implications for affected firms.

Consumer Boycotts/Lost Sales for Poor Climate Performance³

- Negative public perception and consumer activism can lead to boycotts and loss of sales for companies with poor environmental performance.
- Reputational damage from climate-related litigation can impact market position and profitability.
- Maintaining a positive public image and demonstrating environmental responsibility are essential to mitigate these risks.

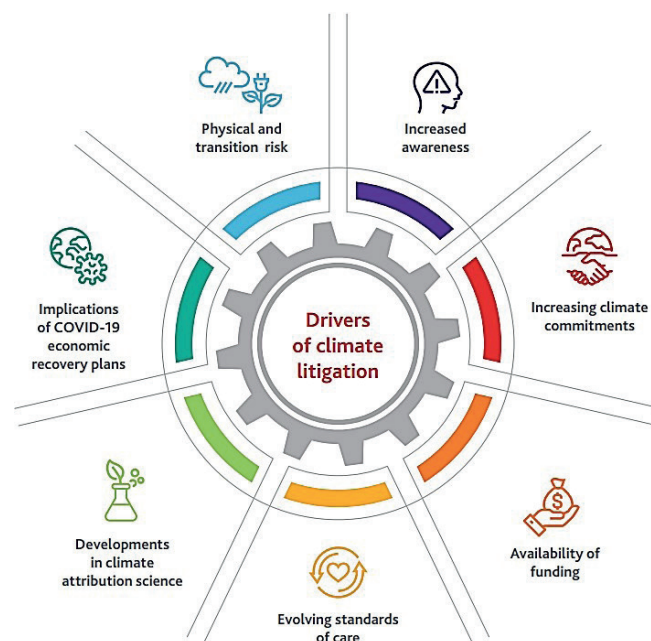


Figure-4: Seven Key Drivers of Climate Litigation (Source: The Geneva Association)

4 Reputation Risk

Reputation risk involves the potential damage to a company's brand and public image due to its environmental performance. Consumers, investors, and other stakeholders increasingly prefer businesses that demonstrate strong environmental stewardship, making sustainability a critical aspect of corporate reputation.

Examples:

- **Public Backlash:** Public backlash against companies perceived to be environmentally irresponsible³. Negative publicity and social media campaigns can harm a company's reputation and consumer trust.
- **Loss of Customers and Investors:** Loss of customers and investors due to poor environmental practices⁶. Companies with a poor environmental track record may struggle to attract and retain customers and investors.
- **Environmental Scandals:** Damage to brand image from environmental scandals or controversies³. High-profile incidents of environmental negligence

can have lasting impacts on a company's reputation and market value.

Climate Opportunities

While the energy transition presents significant risks, it also offers substantial opportunities for businesses to innovate, grow, and enhance their competitiveness. Companies that proactively embrace these opportunities can achieve long-term success and sustainability.

1 Resource Efficiency

Improving resource efficiency can significantly reduce operational costs, refer Figure-5. By adopting energy-efficient technologies and processes, firms can lower their energy consumption, reduce waste, and enhance overall productivity. Resource efficiency not only reduces costs but also minimizes environmental impact, aligning with sustainability goals.

Examples:

- **Energy Management:** Implementing energy-efficient lighting and Heating, Ventilation, and Air Conditioning (HVAC) systems to reduce energy

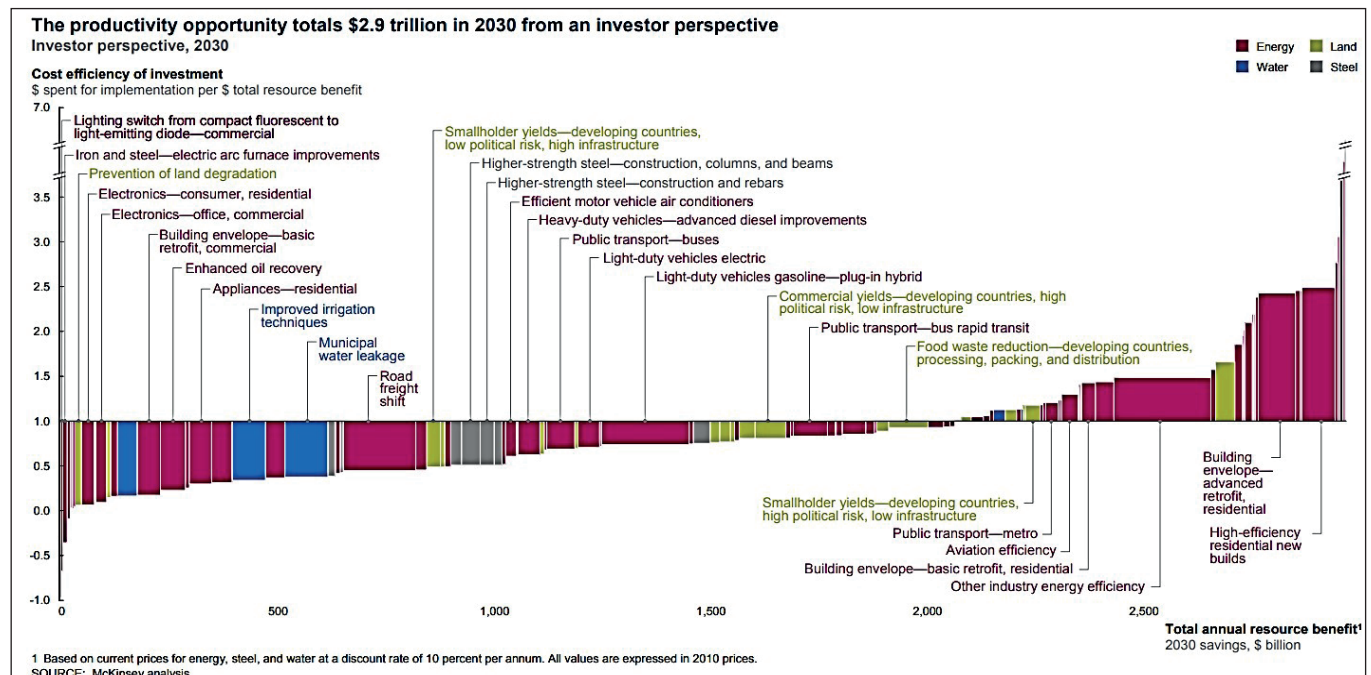


Figure-5: The potential microeconomic costs and benefits of illustrative resource-efficient technologies (Source: Dobbs et al. (2011), Exhibit 3, p. 13)

consumption⁴. Upgrading to energy-efficient equipment and optimizing energy use can lead to significant cost savings.

- **Water Management:** Utilizing advanced water treatment and recycling technologies to conserve water resources⁶. Efficient water management can reduce operational costs and enhance sustainability.
- **Waste Management:** Employing waste reduction strategies and recycling programs to minimize waste generation⁶. Reducing waste can lower disposal costs and improve environmental performance.

Technological Innovations

- **Heating and Cooling:** Developing more efficient heating and cooling systems that reduce energy consumption⁴. Innovations in HVAC technology can enhance energy efficiency and comfort.
- **Energy Generation:** Innovating in renewable energy generation technologies such as solar panels and wind turbines⁷. Investing in renewable energy can reduce reliance on fossil fuels and lower carbon emissions.

- **Electric Vehicles (EVs):** Advancing EV technology to improve energy efficiency and reduce emissions⁷. The adoption of EVs can lower transportation-related emissions and operating costs⁹.
- **Water Solutions:** Implementing cutting-edge water management solutions to enhance water use efficiency and sustainability⁶. Technologies such as smart irrigation and water recycling can improve resource efficiency.

2. Energy Innovation

Investing in energy innovation offers a competitive edge. Firms that develop or adopt cutting-edge renewable energy technologies can capitalize on new revenue streams, reduce dependency on fossil fuels, and enhance their sustainability credentials. Innovations in energy storage, smart grids, and renewable energy sources like solar and wind power present significant business opportunities. Figure-6 shows the spending on low-carbon energy R&D in International Energy Agency (IEA) member countries from 1970 till 2020.

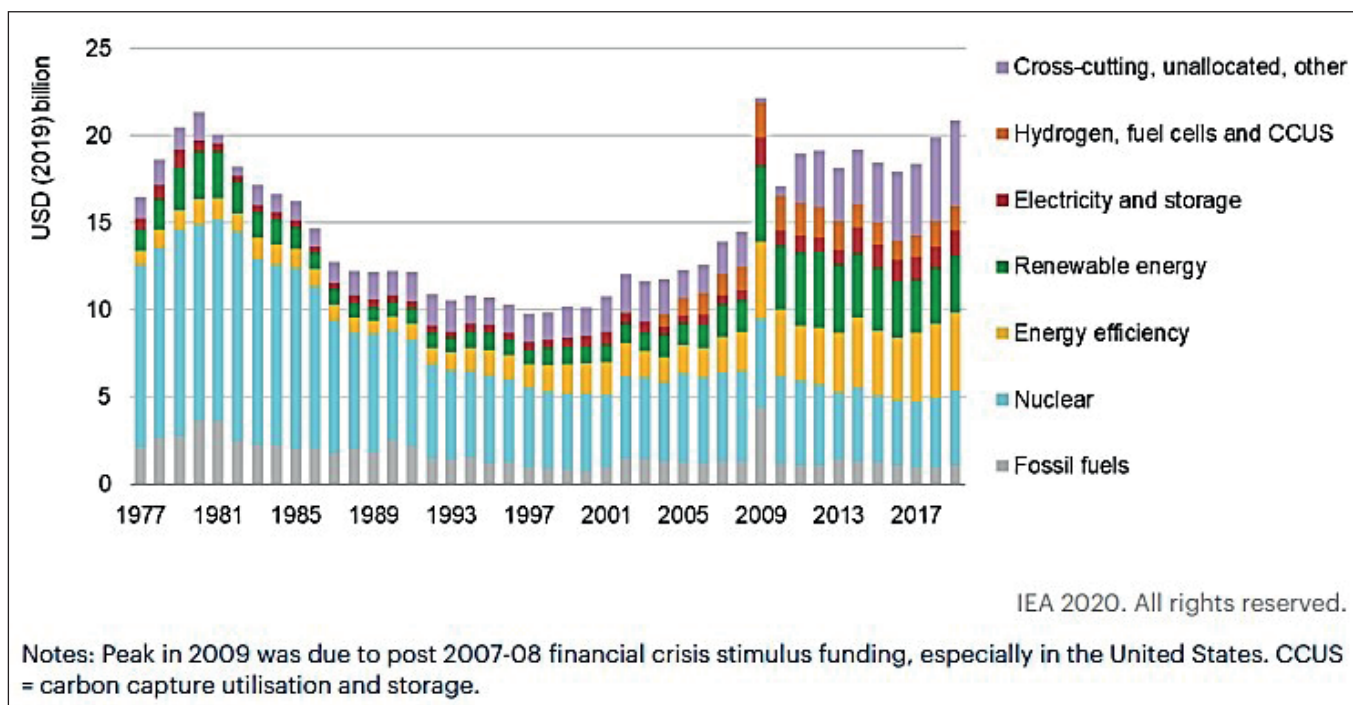


Figure-6: IEA public energy technology R&D and demonstration spending by technology (Source: IEA 2020)

Examples:

- **Low-Emission Alternative Energy Sources:** Exploring and investing in wind, solar, geothermal, and hydropower to reduce carbon emissions⁴. Diversifying energy sources can enhance energy security and sustainability.
- **Carbon Capture and Storage (CCS):** Developing CCS technologies to mitigate emissions from industrial processes and power generation⁴. CCS can help industries reduce their carbon footprint and comply with emissions regulations.
- **Improved Storage Capacity:** Enhancing energy storage solutions, such as advanced batteries, to store renewable energy more efficiently and ensure a stable energy supply⁷. Improved storage capacity can enable greater use of intermittent renewable energy sources.

3. New Products and Services

The transition to a green economy creates demand for new products and services. Companies can diversify their portfolios by offering sustainable products, renewable energy solutions, and green services, thereby tapping into emerging markets and customer segments. This not only meets the growing consumer demand for sustainability but also positions companies as leaders in the green economy.

Examples⁸

- **Reduced Carbon Footprint Products:** Developing and marketing products with a lower carbon footprint to meet consumer demand for sustainability. Sustainable products can attract environmentally conscious consumers and differentiate brands.
- **Supply Chain Emissions Reductions:** Implementing strategies to reduce emissions throughout the supply chain, from raw material sourcing to product delivery. Sustainable supply chain practices can enhance environmental performance and stakeholder trust.
- **Sustainable Services:** Offering services that

help other businesses and consumers reduce their environmental impact, such as sustainability consulting or renewable energy installation. Providing sustainable solutions can create new revenue streams and support environmental goals.

4. Creation of/ Access to New Markets

The shift towards sustainability opens new markets, particularly in regions prioritizing green growth. Firms that proactively enter these markets can benefit from first-mover advantages and establish themselves as leaders in the low-carbon economy. Emerging markets in renewable energy, electric vehicles, and sustainable agriculture present vast growth opportunities.

Examples:

- **Green Bonds:** Issuing green bonds to finance environmentally friendly projects and attract sustainability-focused investors⁷ as that can provide capital for sustainable initiatives and enhance corporate sustainability credentials.
- **Offsets:** Participating in carbon offset programs to mitigate emissions and enter the carbon trading market⁴ since that can help companies achieve targets for emissions reduction apart from generating additional revenue.
- **Public-Private Partnerships:** Collaborating with governments and other entities to promote infrastructure investments and develop sustainable networks, such as renewable energy grids and transportation systems^{5, 6}. Such partnerships can drive large-scale sustainable development and innovation.

5. Resilience

Building resilience against climate impacts ensures long-term business sustainability. Companies that invest in resilient infrastructure and adaptive strategies are better equipped to handle climate-related disruptions and maintain continuity. Resilient businesses can recover more quickly from extreme weather events and other climate impacts, reducing downtime and financial losses.

Examples:

- **Adaptive Capacity to Manage Risks:** Enhancing utilities and infrastructure to withstand extreme weather conditions and climate variability³. Investing in resilient infrastructure can protect operations and reduce recovery costs.
- **Diversified Supply Chains:** Reducing dependency on single suppliers or regions by diversifying supply chains to mitigate disruption risks⁶ which can enhance operational resilience and flexibility.
- **Business Continuity Planning:** Developing and implementing robust business continuity plans to ensure operations can continue in the face of climate-related disruptions³. and thus, minimize downtime and financial losses.

Conclusions

The energy transition is a pivotal moment for businesses worldwide. While it brings significant risks, it also presents unparalleled opportunities for innovation, growth, and sustainability. Firms that strategically navigate these changes can not only mitigate risks but also position themselves as leaders in the evolving low-carbon economy. Embracing resource efficiency, energy innovation, new products and services, access to new markets, and resilience will be key to thriving in this new landscape.

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Nuclear Hydrogen: Could It Be the Future of Clean Energy?



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Abstract

Hydrogen has the potential to alter transportation, industry, and energy storage for a sustainable, low-carbon energy future. This article analyzes nuclear energy and hydrogen production methods, environmental implications, and the associated problems. Nuclear-powered hydrogen production aligns with global climate change and sustainable energy programs.

Nuclear energy's synergy with hydrogen production offers emissions-free energy carriers, grid stability augmentation, and sectoral decarbonization beyond electricity generation. As climate change becomes more urgent, nuclear-powered hydrogen production must be explored. This review critically evaluates thermochemical water splitting, high-temperature electrolysis, hybrid systems, and nuclear heat for steam methane reforming. Environmental impacts include greenhouse gas emissions, nuclear waste handling, water use, and safety.

This article also lists research gaps, consolidates knowledge, and discusses nuclear hydrogen's potential as a sustainable energy source. It guides policymakers, researchers, and stakeholders through nuclear hydrogen's complex terrain by examining issues and potential directions. This critical study contributes to the discussion on nuclear energy's role in promoting

a sustainable hydrogen economy and a greener, more resilient energy future.

Keywords: Hydrogen production, Nuclear energy, Thermochemical water splitting, High-temperature electrolysis, Hybrid systems, Energy Transition

Introduction

As the world urgently seeks ways to cut down carbon emissions, hydrogen is emerging as a promising answer. Often called the “fuel of the future”, hydrogen could transform industries ranging from transportation to energy storage. However, producing hydrogen in a completely clean and sustainable manner is no simple task. This is where nuclear energy steps in - a potent yet often overlooked resource that could play a pivotal role in creating truly green hydrogen. In the earliest study on hydrogen production, a feasibility analysis was conducted using fission product waste heat in a three-phase approach. The first phase designed a system utilizing heat from radioactive wastes to generate saturated steam for producing electricity. The second phase used this electricity for water electrolysis to generate hydrogen. In the third phase, the produced hydrogen was assumed to be liquified and stored, and its combustion in a standard marine gas turbine was explored. The study, conducted in 1980, assessed various parameters, marking an early exploration of hydrogen production using fission product waste heat [1].

Thermo-chemical processes involving water and nuclear energy, especially from high-temperature reactors, offer a pathway for efficient hydrogen production. In studying nuclear-based hydrogen production using Cu-Cl cycles, the environmental impacts, specifically global warming potential (GWP) and acidification potential (AP), are assessed for different thermal output ratios and hydrogen plant efficiencies. Results indicate that adjusting the thermal output ratio and increasing the hydrogen plant efficiency significantly influence environmental impacts, showcasing the potential to reduce GWP and AP in the process [2].

Nuclear Energy to Clean Hydrogen

Nuclear energy is a dependable power source that produces significant amounts of electricity without releasing greenhouse gases. Traditionally, nuclear energy is used solely for generating electricity, but researchers are now investigating how it can also be used to produce hydrogen - a key fuel in the shift toward clean energy. Hydrogen made through nuclear energy could be vital in building a zero-emissions energy system. It has the potential to complement renewable sources like solar and wind, helping to stabilize the grid and reduce emissions across different industries, including transportation. There are several innovative methods for using nuclear energy to produce hydrogen. The most promising ones are:

1. Thermochemical Water Splitting

One of the earliest discussions on the potential application of high-temperature reactors for hydrogen production through thermo-chemical methods was in 1989 [3]. This method uses the heat generated by nuclear reactors to drive chemical reactions that split water into hydrogen and oxygen. High-temperature reactors, which operate at very high temperatures, are particularly good at this because they can achieve high efficiency, making the process both economically and environmentally sound.

Advances in hydrogen production technologies encompass the copper-chlorine (Cu-Cl) thermochemical water decomposition cycle [4], Sulphur-Iodine (S-I)

cycle or iodine-sulfur (IS) thermochemical process [5], and Very High Temperature Reactor (VHTR) integration [6]. Al-Zareer *et al.* proposed an integrated nuclear-based system combining electrical power and compressed hydrogen production via a four-step Cu-Cl water decomposition cycle and a Rankine Cycle. Using a supercritical water-cooled reactor, the system achieves energy and exergy efficiencies of 31.6% and 56.2%, producing 2.02 kg/s of hydrogen and 553 MW of power. Another study assessed hydrogen production scenarios for two planned nuclear plants in Turkey, estimating costs between 3.18 and 6.17 USD/kg H₂. Additionally, a Generation IV reactor-based system achieved 25.4% energy efficiency, producing 3.45 g/s of hydrogen and 467.2 kW of power. Finally, a Cu-Cl thermochemical cycle for nuclear fusion reactors showed high hydrogen production potential, with improvements in energy-cost performance being explored [7].

2. High-Temperature Electrolysis

Regular electrolysis uses electricity to split water into hydrogen and oxygen. High-temperature electrolysis, however, uses both electricity and heat from nuclear reactors. This combined approach requires less electricity (e.g., 37.5 kWh/kg-H₂), making it more efficient and cost-effective.

Previous studies on hydrogen production have explored various methods, focusing on sustainable and efficient approaches. In the late 1970s, researchers like R.N. Quade and K.F. Knoche laid the groundwork for using nuclear energy in hydrogen generation. Quade's 1977 [8] study highlighted the efficiency of high-temperature gas-cooled reactors (HTGRs) in hydrogen production from coal, while Knoche's 1978 [9] work emphasised nuclear process heat for coal gasification. Quade and Meyer further explored the potential of very high-temperature reactors (VHTRs) for large-scale hydrogen production in 1979, showcasing the capabilities of nuclear technologies [10].

In 1992, Hammache and Bilgen [11] introduced a thermo-chemical nuclear hydrogen production process based on sulfuric acid decomposition, addressing both

thermodynamic and engineering aspects. This marked the end of a research gap from 1979 to 1992.

Research in nuclear-powered hydrogen production revived in 2004. Fukushima and Ogawa [12] proposed a low-temperature hydrogen production method using dimethyl ether (DME) reforming, achieving an energy utilisation efficiency of around 50%. Filippov *et al.* [13] introduced a modular high-temperature helium-cooled reactor design with spherical fuel elements, demonstrating the potential for cost-effective hydrogen production and electricity generation with efficiency over 45%. These studies renewed interest in nuclear hydrogen production, presenting promising sustainable energy solutions.

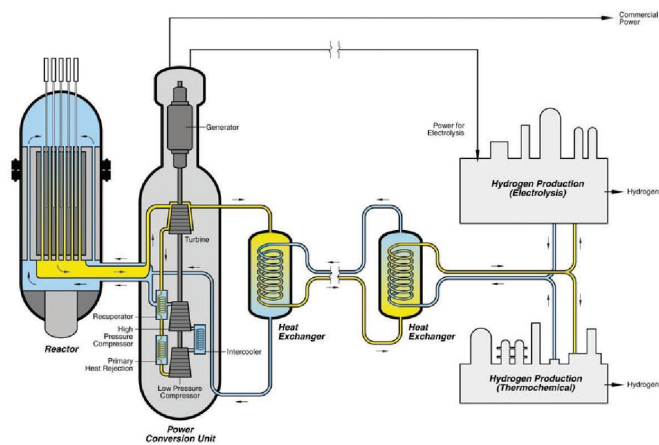


Figure-1: Concepts for producing hydrogen using nuclear energy include thermo-chemical processes and high-temperature electrolysis. [14]

A few latest advancements are listed below. Wang *et al.* [15] proposed an improved VHTR and Cu-Cl cycle-based nuclear hydrogen production system, noting that increasing the reactor pressure ratio enhances performance but faces energy loss challenges.

Myagmarjav *et al.* [16] developed a membrane reactor with a closed-end silica membrane for HI decomposition in the IS process, achieving over 60% conversion at 400°C and showing practical scale-up potential. Sanchez-Mora *et al.* [17] proposed a mathematical model for Zr oxidation in fuel rods during a BWR station blackout, providing results comparable to MELCOR and RELAP/SCDAP. Milewski *et al.* [18] investigated high temperature electrolysis (O=SOE and H+SOE)

for nuclear plant hydrogen generation, enhancing flexibility by 20% with minimal turbine modifications but facing efficiency and cost optimization challenges. Hercog *et al.* [19] analysed nuclear cogeneration with Cu-Cl and S-I thermochemical cycles, recommending the Cu-Cl cycle for its efficiency at lower temperatures and independence from electricity for hydrogen production.

3. Hybrid Systems

Some systems can switch between producing electricity and hydrogen, depending on what is needed. This flexibility makes them valuable for balancing the energy grid and ensuring a steady supply of power and hydrogen. Nuclear hybrid energy systems (NHES) offer potential in simultaneously producing electricity and hydrogen, with various hydrogen production technologies explored, highlighting economic challenges and technology readiness levels (TRLs) [20].

Challenges: Environmental Impact and Safety

While nuclear energy offers exciting possibilities for clean hydrogen production, it is not without its challenges. A few key concerns are:

- **Greenhouse Gas Emissions** - Although nuclear power itself doesn't emit carbon, the entire process starting from mining uranium to managing nuclear waste does result in some greenhouse gas emissions. When nuclear energy is used to produce hydrogen, especially through certain chemical processes, it can lead to a notable amount of CO₂ emissions.
- **Nuclear Waste** - Managing nuclear waste is a major issue. It remains radioactive for thousands of years and requires secure storage to prevent environmental contamination. Any expansion of nuclear energy into hydrogen production must include strong plans for dealing with this waste.
- **Water Use** - Both nuclear power plants and hydrogen production need a lot of water. This could create

challenges in areas where water is scarce. Efficient use of water and strategies to conserve it will be crucial if these technologies are to be scaled up.

- **Safety Concerns** - Nuclear power has a history of high-profile accidents, like Chernobyl and Fukushima, which have made people wary. Ensuring the safety of nuclear facilities is essential, especially if they are going to be used to produce hydrogen. This means adhering to strict safety protocols and continuously improving risk management strategies.

Economic and Policy Factors

The economics of nuclear hydrogen production is

another important factor to consider. Building and maintaining nuclear power plants is expensive, and getting the necessary permits can take years. However, advancements in reactor design and improvements in efficiency could make nuclear-produced hydrogen more competitive compared to other low-carbon hydrogen options. Government policies are also crucial in determining the future of nuclear hydrogen. In countries like France, where nuclear power is already a significant part of the energy mix, there's a strong case for leveraging this infrastructure for hydrogen production. Meanwhile, studies in Taiwan suggest that while renewables like wind and solar might be cheaper for hydrogen production, nuclear energy still has a role, particularly in providing a stable energy supply [32].

Table-1: Comparative Analysis of Nuclear Energy Studies: Highlights, Key Findings, and Recommendations

Authors	Highlights	Key Findings	Suggestions
Weingardt. J.J, Gauntt R.O. [21]	Nuclear safety analysis	Fuel behavior modeling	Emphasises safety aspects in nuclear systems; Improve fuel behavior modeling
Fukushima. K, Ogawa T. [12]	Nuclear hydrogen production	Iodine sulphur process	Explores nuclear hydrogen production via Iodine sulphur process; Consider advancements in the iodine sulphur process
Piera. M. et al. [22]	Nuclear hybrid energy systems	Integration of renewables and nuclear	Evaluates nuclear hybrid energy systems; Focus on the integration of renewables with nuclear
Sato.H.et.al., [23]	Nuclear reactor Design - Safety assessment	Examines nuclear reactor design and safety	Enhance safety assessments in reactor design
Sully A. et al., [24]	Energy system modeling	Control strategies for nuclear reactors	Studies control strategies for nuclear reactors in energy systems; Develop improved control strategies
Han S.J., Ahn K.I. [25]	Nuclear thermal energy	Hydrogen production, Investigates nuclear thermal energy for hydrogen production	Explore advancements in nuclear thermal energy
Woo T.H. [26]	Nuclear energy policies - Public perception	Analyzes public perception of nuclear energy policies	Improve public awareness and communication

Authors	Highlights	Key Findings	Suggestions
El-Emam R.S. et.al. [27]	Nuclear energy sustainability - Life Cycle Assessment	Assesses sustainability and life cycle of nuclear energy	Implement sustainable practices in nuclear energy
Wang K. et al. [28]	Nuclear waste management - Deep geological repositories	Explores deep geological repositories for nuclear waste	Focus on efficient nuclear waste management
Gao Q. et al. [29]	Advanced reactor design Heat exchanger optimization	Investigates advanced reactor design and heat exchanger optimization	Optimise heat exchanger designs
Gao Q. et al. [30]	Nuclear cogeneration- High-temperature steam electrolysis	Studies nuclear cogeneration for high-temperature steam electrolysis	Enhance high-temperature steam electrolysis
Gao Q. [31]	Thermochemical water Splitting - Multi objective optimization	Examines multi objectives. Optimisation in thermo-chemical water splitting	Focus on improving efficiency through optimization

Public Opinion Matters

Public perception plays a big role in whether nuclear hydrogen production will take off. For example, in South Korea, surveys show that public opinion on nuclear hydrogen is mixed. Factors such as where people live, their family size, age, and income all influence their views. Interestingly, education level and gender seem to have less impact on opinions. Addressing the public's concerns and building trust is essential for the widespread adoption of this technology [33].

Looking Ahead

Nuclear hydrogen production is a promising but complex solution to the global energy crisis. It offers the potential to produce large amounts of clean hydrogen, which is key to reducing carbon emissions and combating climate change. However, realising this potential means overcoming significant challenges, including environmental impacts, safety risks, and economic hurdles. Moving forward, continued research and development are crucial. There is need to focus on

making these processes more efficient, reducing costs, and ensuring the highest safety standards. Collaboration between policymakers, scientists, and industry stakeholders will be key to creating a supportive environment for innovation while addressing valid concerns about nuclear energy.

The journey toward a sustainable energy future is long and challenging, but nuclear hydrogen could be a vital part of the solution. By carefully navigating the complexities of this technology, the full potential of hydrogen as a clean and versatile energy source can be unlocked and the move closer to a greener, more resilient world be achieved.

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Wind Power in India - Opportunities & Challenges



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“We do not have a Planet- B”, sounds familiar? This is no longer just a discussion point in forums or an advertisement tagline for products; it is the need for the hour. The speed at which mankind has exploited Planet Earth means the days are not far off, when there will be no turning back. The heating rate of the Earth’s surface has doubled to 0.18°C per decade, especially after 1981, from 0.08°C per decade in the pre-industrial era. The need for energy is increasing exponentially, making the source of energy generation crucial. Renewable sources of energy generation are no longer a choice but the only option for energy security and consumption. Amongst the various sources of renewable energy, wind energy in India, although explored earlier, is now being implemented at a very fast pace.

Why Wind Power?

Energy security is not only the prime objective of every country, but individual entitlement to electricity has been accepted as a human right and basic necessity in some or other form by the UN and the Indian Constitution¹. However, the question is, at what cost?

Energy-related CO₂ emissions in 2023 reached 37.4 billion tonnes, increasing by 1.1% over last year, contrary to the reductions needed to align with the Paris Agreement.

According to the World Energy Outlook 2023 report², if the energy transition proceeds according to the Stated Policies Scenario (STEPS), the Earth's surface temperature will rise to 1.9°C by 2050 and 2.4°C by the end of the century. That is well above the threshold of 1.5°C, beyond which the Earth and its inhabitants will experience irreversible damage. Under the Announced Pledges Scenario (APS), the temperature increase would be 1.7°C by 2100, which is still unacceptable. Therefore, the only way to limit the Earth's surface temperature increase to 1.4°C by 2100 is to achieve Net Zero Emissions (NZE) by 2050.

Clean energy is the only way to balance energy security and mitigate global warming. Among the various established sources of clean energy (viz. solar, hydro, nuclear, geothermal, tidal and wind), this article emphasises the opportunities and challenges in the field of wind power in India. India, being geographically well-placed, has a lot of scope for wind energy. Not only is the wind potential high in some parts of India but being surrounded by sea from three sides also provides an advantage for the shipping of wind turbines and components as needed.

Opportunities

India holds immense potential for wind energy, making it a pivotal player in the global shift towards renewable energy. The country's geographical

diversity, with its extensive coastline and favourable wind patterns, provides an ideal environment for wind power generation. States like Tamil Nadu, Gujarat, Karnataka, Maharashtra, and Rajasthan have already established themselves as leaders in wind energy production, harnessing strong wind currents to generate significant electricity. The Indian government has set ambitious targets, aiming to achieve 100 GW of wind power capacity by 2030, further boosting investment and technological advancements in the sector. The introduction of competitive bidding processes has also driven down costs, making wind energy more economically viable. Moreover, India's strategic location with access to port facilities, the import and export of wind turbines and components, thus enhancing the supply chain efficiency. Initiatives such as the National Wind-Solar Hybrid Policy and the Green Energy Corridor project underscore the government's commitment to integrating wind energy into the national grid. Additionally, the potential for offshore wind farms along the coastlines opens new avenues for expansion. With continuous support from policy frameworks, technological innovation, and investment, India is poised to capitalize on its wind energy potential, contributing significantly to its energy security and sustainability goals.

Potential in India- Onshore & Offshore

India has high wind energy potential both in terms of on-shore and off-shore wind farms. When compared to solar, availability of wind is for a longer period throughout the year which makes it possible to have a higher Plant Load Factor (PLF) and more Capacity Utilization Factor (CUF). As shown in Figure-1 the wind potential increases substantially with the increase in height above the ground level, almost doubling with every 20m increase in height. On the offshore front, 7600 km of coastline creates a potential of 140 GW wind energy primarily in Tamil Nadu and Gujarat with 35 GW each.

Geographical Advantage and Developed Infrastructure

Being surrounded by sea on three sides, India is well connected with the world. Approximately 5700km of

navigational inland waterways, 7600 km of coastline and cheaper transport cost (less than half when compared to land transportation) is another advantage for India for transporting wind turbine components from within and outside the country to different sites. However, inland waterways in India are still underutilized; they should be explored more. Well-connected road network of 1.46 lakh km of National Highways and 1.79 lakh km of State Highway further simplifies the logistics for transportation of wind turbines and components.

Resource Availability- Land & Labour

India being the seventh largest country in the world in terms of land area, it provides ample opportunity for setting up of wind farms. Of the high potential wind sites, 47% capacity can be installed in the wasteland area, 52% in cultivable land and 1% in forest land considering the weightage availability of land of 80, 30 & 5% respectively derived through sensitivity analysis³. Apart from the high wind potential, ample land area, another important parameter that India is rich in, is skilled manpower. India is the second most populated country in the world with a population of close to 1.4 billion, and 50% of its population below the age of 25 and 65% below 35 years of age. With an average age of 29 years and with the presence of established education systems and skill institutes in India, manpower is a major advantage.

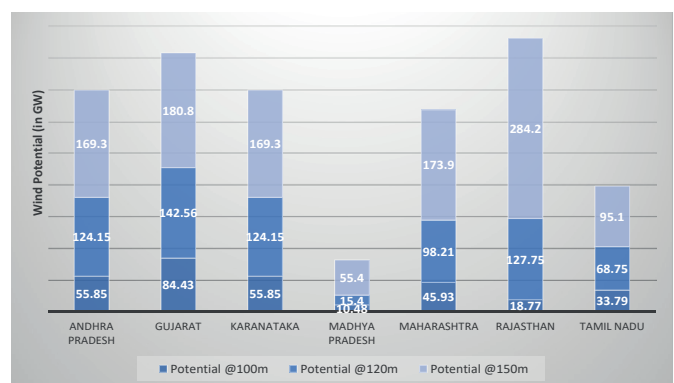


Figure-1: Wind Potential in India at different heights for onshore

Ambitious Target and Policy Push

In order to achieve the net zero target by 2070 and to ensure energy security, India has geared up to install

777GW⁴ by 2030, half of which is to be generated from renewable sources. Wind farms of approximately 100 GW capacity are to be installed by 2030. With the help of higher efficiency turbines, it is planned to provide 220- 280 TWh of energy. Government of India (GoI) is putting efforts to ease the policy, providing incentives, interest rebates on borrowing for renewable energy projects from time to time. Indian Renewable Energy Development Agency (IREDA) is extending loans at an interest rate of as low as 9.1% for wind and solar power projects, 90 basis point less than other renewable projects. To push for repowering of smaller wind farms, an additional rebate of 0.25% is extended by IREDA. State Nodal Agencies (SNA)/ Central Nodal Agencies (CNA) are being set up to coordinate with several regulatory bodies and approving authorities. Power evacuation infrastructures are being upgraded/ installed to pump power in and out of the grid. The Ministry of New and Renewable Energy (MNRE) and the National Institute of Wind Energy (NIWE) are working closely to bring in policy changes as and when called for to attract the developers and investors. The National Wind Atlas has been developed and is updated by NIWE to explore the wind potential across the country with updates in turbine technology. All the above steps by the GoI are not only attracting domestic but also foreign investors/ developers to set up wind farms in India.

Challenges

Wind energy in India faces several significant challenges. One major issue is the intermittent and variable nature of wind, which affects the reliability and stability of power generation. The lack of adequate grid infrastructure and connectivity in remote areas with high wind potential further complicates efficient energy distribution. Land acquisition for wind farms often encounters legal and social hurdles, including disputes with local communities and environmental concerns. Financial constraints also pose a barrier, as high initial investment costs and limited access to funding hinder the development of new projects. Additionally, the maintenance and supply chain logistics for wind turbines and components can be problematic due to India's

vast and diverse geography. Policy and regulatory uncertainties, including inconsistent government incentives and tariffs, add to the complexities faced by developers and investors. Addressing these challenges requires coordinated efforts from the government, private sector, and local communities to unlock the full potential of wind energy in India.

Manufacturing of Large Capacity Turbine

Till date large capacity turbines (5MW or more) are still not commercially manufactured in India. The Indian wind farms are still developed with 2X or 3X capacity machines. That is causing exploitation of high potentials by being underutilized. Currently Indian companies, M/s Suzlon and M/s Adani have made it to MNRE's Revised List of Models & Manufactures (RLMM) with capacity of 3.15 and 5.2 MW respectively. Although both have installed or are in the last phase of installation and are about to commission the higher rating turbines. Focus on increasing manufacturing capacity will be required to cater to the rapidly increasing demand. At the same time Indian companies need to optimize on cost to compete with global manufactures especially Chinese suppliers.

Rare Earth Mineral

Although the bulk materials used in manufacturing of wind turbines are steel, fibreglass resin or plastic, iron, copper, and aluminium it is the rare metals which can play a major roadblock in the supply chain. Rare earth includes neodymium, praseodymium, dysprosium and terbium and are called magnet elements. The first two elements impart strength to the magnet while the latter two make it resistant towards demagnetization at high temperature. This magnet is most commonly used in wind turbines and is a neodymium-iron-boron magnet. The alarming point is the geographical concentration of these rare earths. As of 2023, 60% production and close to 90% refining of these rare earths is concentrated in China⁵. The significance of these rare earths is evident from the increase in demand by 14% in the last 2 years alone. In order to achieve a NZE scenario supply of these minerals, they will be required in doubled the quantity from what is consumed today.

Acquisition of Land

While the presence of land is a boon, the acquisition of the land at the same time is a herculean task in India. Multiple ownership of land in a single wind farm makes its availability for wind farm development challenging. A major chunk of land still falls within cultivable land and in forest areas. Although, Right Of Way (ROW) required for Wind Turbine Generator (WTG) installation (on footprint basis) is just 5% as required for wind farm development other effects such as acoustics, migration of birds create challenges in wind farm micro-siting. Wind farms and associated infrastructure in or near cultivable land cause migration and killing of birds which in turn increase population of crop damaging insects which otherwise were consumed by birds. Death of slow reproducing birds like eagles is a damage which is critical for agriculture as these prey on mice and snakes present between the crops, which reproduce at very rapid rate and if left unattended are harmful for crops and human lives, thus the entire food chain is getting affected.

Power Evacuation

Once a project is commissioned and power is generated, then what? It is of no use until the power reaches the consumer. Therein lies the role of power evacuation infrastructure. Evacuation infrastructure needs to be upgraded/ installed at much higher rates with respect to the rate at which wind projects are being commissioned as it not only evacuates the power from wind farms but also from other sources of generation. Till 2000 smaller capacity turbines (less than 1 MW) were installed, that too in lesser numbers, and hence evacuation of power was possible at low voltage level and in a localized manner (33 kV or 66 kv). With the entry of high rating turbines (3 MW or more) and commissioning of bigger wind farms (200 MW and higher) spread across different states, power needs to be evacuated through Inter-State Transmission System (ISTS).

Conclusion

Of the available wind potential in the country, only 47 GW has been utilized so far in the onshore region, with 25GW of this capacity installed with WTG rating less than 2 MW. That leaves substantial room for further capacity addition and upgradation. On the other hand, offshore wind farms are not expected to make a significant impact until after 2030, providing ample time for infrastructure preparation in the offshore area. Research and development in the field of WTG will enable better utilization of wind potential, increasing efficiency to 35% or more, compared to the current average of 25% to 28%.

Technology such as bird diverters, as used for transmission lines, proper micro-siting, and measures such as painting of vane tips will help to reduce or avoid bird fatalities, garnering support from locals and farmers. With the rollout of industry-friendly and clear policies from the government, public-private partnership, establishment of a single window for all approvals, timely grid upgrade and foreign direct investment, India is poised to achieve its set target.

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Harnessing the Potential of Bioenergy: Overview and the Future of Sustainable Technologies



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Abstract

Organic matter, such as plants and animal manure, provides bioenergy which is a sustainable energy source. This review assesses the vital function of decreasing greenhouse gas emissions and alleviating climate change by offering a sustainable substitute for fossil fuels. Utilising bioenergy can reduce dependence on the limited resources and enhance energy stability. Furthermore, this article also covers the production of bioenergy, which can generate economic opportunities in rural areas and contribute to a more sustainable and robust energy system. Moreover, bioenergy exhibits versatility in its range of applications, encompassing the ability to fuel automobiles, provide heating for homes, and producing electricity. With the ongoing advancement of technology, the effectiveness and affordability of bioenergy production are improving, making it a more appealing choice for meeting energy needs. Investing in bioenergy research and infrastructure may simultaneously tackle environmental issues, promote job creation, and foster the establishment of a sustainable future for future generations. Bioenergy possesses the capacity to diminish the reliance on fossil fuels and mitigate greenhouse gas emissions, rendering

it an essential element in the shift towards a more environmentally friendly energy future. Furthermore, this study demonstrates that the use of bioenergy can enhance the variety of the energy sources and bolster energy security, thereby decreasing susceptibility to supply disruptions and price variations in the global energy market. By consistently investing in and developing bioenergy technology, nations across the globe can establish a more robust and environmentally friendly energy system that is advantageous to both the economy and the environment.

Keywords: Bioenergy; Biomass; Sustainability; Environment; Carbon.

Introduction

Bioenergy is generated from biomass, which is organic matter containing carbon that plants extract through photosynthesis¹. When this biomass is utilised for energy production, the carbon dioxide (CO₂) is emitted through combustion and re-enters the environment. Modern bioenergy is considered a nearly carbon-neutral fuel because the production of biomass results in the absorption of an equivalent amount of

CO₂. Renewable energy from this source is the most abundant worldwide, making up 55% of all renewable energy and contributing more than 6% to the total global energy supply². Bioenergy is a significant and renewable source of energy in the modern era. Its contribution to the overall energy demand in all sectors is currently five times greater than the combined contribution of wind and solar photovoltaic (PV) energy, even when the traditional usage of biomass is excluded³. Bioenergy is currently predominantly used for heating purposes, and although space heating is expected to shift towards electricity, bioenergy has the potential to significantly contribute to sectors that are difficult to electrify, such as aviation and shipping. Modern bioenergy excludes the conventional practice of using biomass in underdeveloped nations and rising

economies for cooking and heating with open fires or basic stoves, which significantly harms human health and the environment. The Net Zero Scenario (NZE) aims to meet the UN Sustainable Development Goal 7 on Affordable and Clean Energy by eliminating the use of traditional biomass by 2030^{4,5}.

To get on track with the NZE scenario, which requires deployment to increase by 8% per year between 2022 and 2030, additional efforts are required to expedite the deployment of modern bioenergy. At the same time, it is necessary to ensure that the production of bioenergy does not interfere with the existing processes. This paper provides an overview of the types of bioenergy, policy prospects with social innovation and the future of such technologies.

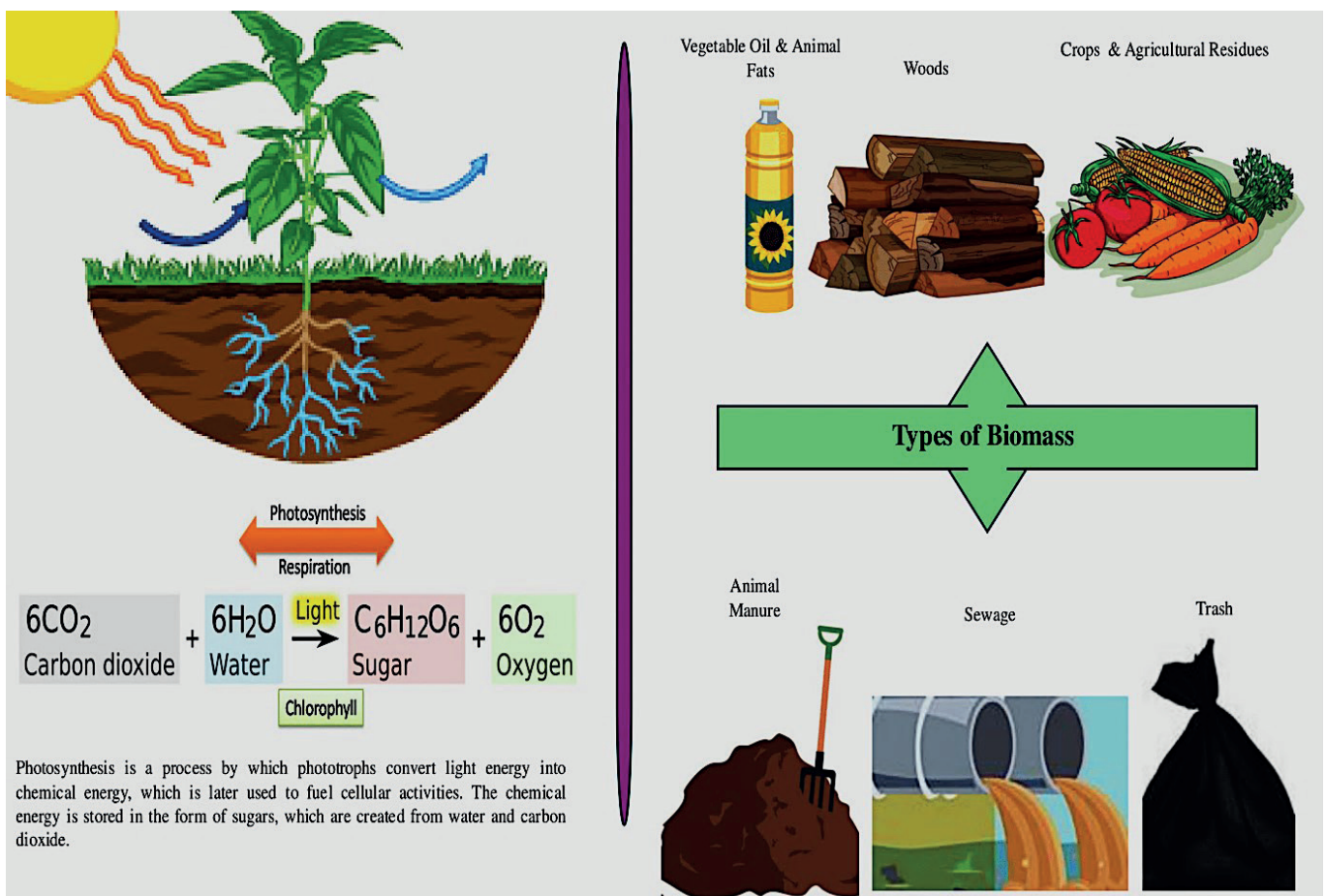


Figure-1: The term biomass refers to a renewable energy source originating from plants and plant-derived materials. Here plant-derived material can include animal manure, as it refers to plants consumed by animals with the product as manure. The same applies to the rest of the derivatives

Types of Bioenergy

In a manner comparable to that of petroleum, biomass is a diverse energy resource. In addition to turning biomass into biofuels for use in vehicles, it can also serve as a renewable alternative to fossil fuels in the production of bioproducts such as plastics, lubricants, industrial chemicals, and a wide variety of other products that are now generated from petroleum or natural gas⁶. Figure-1 provides an overview of biomass sources. Integrated biorefineries can create bioproducts in addition to biofuels, and they are designed to mimic the model of the conventional petroleum refinery. The revenue that is earned from bioproducts also delivers additional value, which helps to improve the economics of biorefinery operations and facilitates the production of biofuels that are more cost competitive. Some of its broad categories are given below.

Bioethanol and Biodiesel: Produced by fermenting plant resources such as corn, sugarcane, or switchgrass, and utilised as a fuel for transportation. Biodiesel is a renewable alternative to diesel fuel and is derived from vegetable oils or animal fats and utilised as a fuel source⁷.

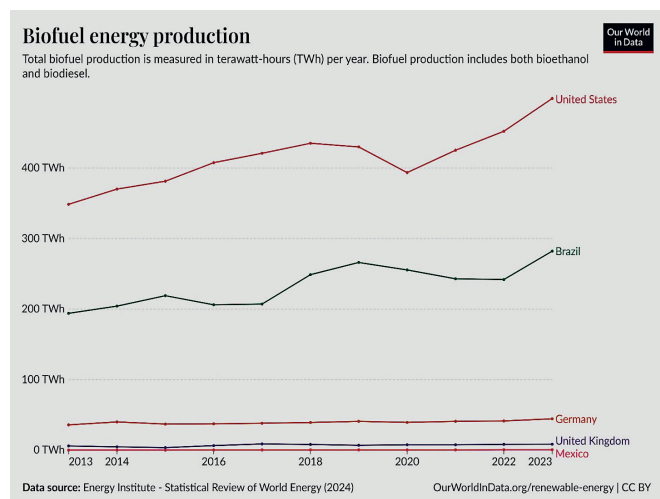


Figure-2: Biofuel output is quantified in terawatt-hours (TWh) annually. Biofuel production encompasses the manufacture of both bioethanol and biodiesel. Steady growth is observed in the ten-year period from 2013; USA and Brazil lead consistently.

The production trends for these two biofuels can be seen from the Energy Institute - Statistical Review

of World Energy published in 2024 and shown in Figure-2. In the last decade, a trend has been observed where there is consistent growth in the biofuel sector crossing 400 TWh for the United States and reaching 300 TWh for Brazil with other European countries progressing steadily. The analytics is created from Our World in Data platform⁸.

Biogas: It is mostly composed of methane and carbon dioxide, and is produced through the anaerobic digestion of organic materials such as food waste, agricultural waste, or sewage sludge. In the year 2023, the installed capacity of biogas energy around the globe reached approximately 21.4 gigawatts².

Biomass Energy: Fuel that is produced by the combustion of organic materials such as wood, waste from agriculture, or wastewater and is utilised for heating, electricity generation, or combined heat and power generation. The utilisation across continents is shown in Table-1.

Algal Bioenergy: Produced from algae, it can be transformed into a variety of energy products such as biofuels, biogas, or biomass through the process of conversion. According to the most recent study, the size of the global market for algae biofuel was estimated to be \$6151.87 million in 2022. It is anticipated that the market will rise at a compound annual growth rate of 13.45% during the forecast period, reaching \$13119.23 million by 2028⁹.

Synthetic Biology Bioenergy: The process involves modification of microorganisms to generate biofuels or other substances connected to energy. The global synthetic biology market was \$11.4 billion in 2022 and is predicted to reach \$35.7 billion by 2027, growing 25.6%. The growth is due to the demand for sustainable solutions, bio-based products, and genetic engineering advances¹⁰.

Landfill Gas Energy: Emissions of methane that have been captured from landfills and used for the generation of energy or for heating. The annual disposal of 1.5 billion tonnes of MSW in landfills generates nearly 75

billion Nm³ (normal cubic meter) of methane, which could generate 0.78 MW of power per tonne, generating 6500-10,000 MW h of electricity annually¹¹.

Municipal Solid Waste: An energy source that is produced through the combustion or anaerobic digestion of municipal materials. By the year 2050, it is anticipated that the amount of solid waste from municipalities generated will have increased from 2.1 billion tonnes in 2023 to 3.8 billion tonnes¹². In recent years, municipal solid waste-to-energy systems have garnered a substantial amount of attention due to their ability to generate renewable energy from waste.

Over the course of the past decade, bioenergy has been subjected to a great deal of scrutiny, and numerous nations have made major efforts to establish procedures that are environmentally responsible. Concerns regarding potential conflicts with food production, whether there is adequate land, and whether bioenergy can genuinely be delivered in a sustainable manner are at the focus of an ongoing debate that has put development on pause in some locations⁹. As was explained above, these concerns have caused development to be called into question.

That is because the bioeconomy poses complex questions to those who are responsible for formulating public policy. It is essential that scientific research be designed in such a way that it can provide the much-required direction and technologies that are responsible for bridging the knowledge gaps. It is necessary to integrate the sciences for bioenergy in order to reach the greatest benefits that it can offer, as well as to conduct a lot more in-depth analysis of the social and environmental benefits. Although a great deal of information has been disseminated regarding the potential drawbacks, there is a pressing need to make a more concerted effort to disseminate the instances of success and the best practices.

It is imperative that bioenergy be regarded as an essential component of the strategic planning process for a low-carbon economy. Further, if long-term policies are put into place, bioenergy has the potential

to make a significant contribution to the growth of the global bioeconomy. An understanding of the dynamics of costs and benefits along the entire production chain in integrated assessments, particularly about the social implications of bioenergy, can be of assistance in the assessment of risks and contribute to the development of appropriate financing schemes.

One example was created through the synergistic collaboration of the Below50 partnership, which comprises the World Business Council for Sustainable Development (WBCSD), the Roundtable for Sustainable Biomaterials (RSB), and Sustainable Energy for All or SE4ALL¹³. The goal of the global collaboration is to promote the best-of-breed of sustainable fuels that can achieve significant reductions in carbon emissions and to scale up their development and use.

Policy and Regulatory Considerations

One of the questions that needs to be answered is how to communicate to consumers the good environmental and socio-economic elements of using bioenergy, as well as how to evaluate the rising adoption of these clean energy options. It would be unethical to delay the pursuit of more sustainable energy development that includes bioenergy because of the global climate and environmental problems that are induced by the ongoing use of fossil fuels and inequitable development. The importance of replacing fossil fuels and the urgent necessity to do so, as well as the fact that bioenergy can help in the achievement of the objective, must be communicated through a concerted effort. There are numerous instances of effective communication tactics that can be utilised today.

Scaling up "best management practices" is something that needs to be done. Bioenergy has improved livelihoods in countries where access to energy was limited, improved forest protection by avoiding damages caused by traditional biomass extraction and use, modernised agricultural practices, improved rural development, and revitalised agricultural production. Bioenergy has also improved livelihoods in countries where there was limited access to energy¹². As the supply

chain becomes more stable and trustworthy, there are significant chances for new enterprises to emerge; but, to take advantage of those opportunities, advancements in logistics and coordination are required.

Accelerating the Development of Alternate Technologies:

The use of incentives that favour new technologies can be a useful approach for reducing the risk of becoming locked into legacy technology. Studies suggest that quotas, feed-in tariffs, and subsidies are all capable of being close to being economically optimal⁵. At this point in time, the most significant demand for incentives is probably not in the field of electricity generation; rather, it is more likely to be in the fields of energy storage (particularly long-term, big capacity), electricity transmission, and electrified heavy transportation.

When it comes to the energy that is used for heating, there is a continuing requirement for research and development to scale up low-carbon alternatives to

coal or charcoal. To encourage the electrification of the fleet of light duty vehicles, there is a continual need for incentives from the government. Furthermore, incentives are required to encourage the further development of direct air capture technologies, which have the potential to play a significant role in the reduction of negative emissions. In every one of these scenarios, incentives could come in a variety of forms, like as investments in research, tax credits, and regulations regarding government procurement. However, this is mostly plausible in the industrialised world. For instance, with a share of 75% of the worldwide market, Europe is the leader in the world when it comes to the production of heat from biomass in power plants¹⁴. It is essential to have a clear understanding that the term bioheat refers solely to the heat that is generated in heat-only and combined heat and power plants, and that this heat is primarily conveyed and delivered to end customers through district heating networks.

Table-1: Heat production and utility from biomass for the year 2020 (Malico et al., 2019). Values are in exajoules (EJ)

Continents	Municipality Wastes (EJ)	Industrial Waste (EJ)	Solid Biomass (EJ)	Biogas (EJ)	Biofuels (Liquids) (EJ)
Americas	0.02	0.02	0.04	0.004	0.000
Europe	0.27	0.003	0.55	0.05	0.004
Asia	0.01	0.19	0.04	0.00	0.000
Africa	-	-	-	-	-
Oceania	-	-	-	-	-

The direct utilisation of biomass for the generation of heat in end-use sectors is not included in this. An overview of the use of biomass for heating across continents is given in Table-1. All values in the table are in EJ or exajoules. 1 EJ equals 10^{18} Joules or is the equivalent of 174 million barrels of oil. The table shows the three continents that are currently tapping into this form of biomass energy.

Outlook on Bioenergy for the Future

The process of defining, developing, and monitoring sustainable practices for bioenergy is now taking place

in several nations and through multilateral efforts. It is important to mention that the ISO standard 13065 - Sustainability Criteria for Bioenergy, represented a significant early success. Numerous sustainable biomass production systems, such as agriculture, forestry, and bioenergy, as well as their supply chains to a wide range of goods, including a contribution of bioenergy in the form of solid, liquid, and gaseous fuels, have been investigated. Given that bioenergy constitutes a sizeable portion of the overall energy mix on a global scale. The existing policies and trends indicate that it is expected to increase over the course of the next decade or even longer. Most models and

scenarios anticipate that the size of bioenergy that can be produced in a sustainable manner while also providing net benefits to the climate has significant challenges which need to be overcome before it can become practical.

The best way to make use of biomass that is available as a waste product or because of good stewardship practices is to store it for an extended period, such as when it is used in the construction of structures. The second-best use is for energy, but only if the generation of that energy does not result in issues related to air or water pollution or water scarcity and preferably, if it is equipped with carbon capture and storage. Taking this into consideration, policymakers should carefully consider the incentives that are available for land-intensive bioenergy and instead offer incentives for the next generation of technologies that will make it possible to achieve a future with zero carbon emissions. Sustainable and modern bioenergy can be used for more than just home usage, small-scale local applications, or mini grids; it can also help electrify rural areas. Additionally, bioenergy offers options for biofuels in agriculture and transportation, high-temperature process heat for local industry, and large-scale electricity generation. Use of biomass for thermal and electrical generation has dual purposes: as a baseload to supply constant power and as a load-balancing mechanism. Modifications to energy storage, transmission capacity, frequency, and power flow management technologies are necessary for energy networks to accommodate increasing proportions of variable renewable energy sources.

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Energy Transition: Harnessing Biogas from Municipal and Agro Waste



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Abstract

The article aims to address the energy transition by focusing on the management of municipal solid waste, agro waste and its conversion into energy. Energy transition is the need of the hour due to Global warming. Conventional methods of energy production have to be minimized to prevent the build-up of greenhouse gases, which are driving global climate disruption and causing environmental challenges, including air and water pollution, that threaten our planet and way of life. The severe impacts of climate disruption are already evident, with rising temperatures leading to glacier melt, sea level rise, air pollution, wildfires, heatwaves, and extreme weather events. One of the major contributors to the Build-up of greenhouse gases is Power generation using fossil fuels. That effect is further accelerated by industrial development and urbanization, which lead to increased Power demand at more than 6 to 8 % on a year on year basis in the developing world. To mitigate these effects, it is essential to adopt alternative energy sources such as nuclear, solar, wind, hydro, tidal, geothermal and biogas. Among these, one sustainable approach to energy transition is harnessing biogas from agricultural waste and municipal solid waste through anaerobic digestion, as solid waste will continue to increase year

after year especially in urban areas. The approach will significantly reduce the harmful effects of methane emissions from municipal solid waste dumps and also provide bio- fertilizer as an alternative to chemical-based fertilizers.

Key words: Municipal Solid Waste, Agro waste, Anaerobic Digestion, Bioenergy

Introduction

The energy transition to renewable and low-carbon energy sources is essential for addressing greenhouse gas emissions and combating climate change. By shifting to those energy sources, CO₂ and other greenhouse gas (GHG) emissions can be significantly reduced, contributing to climate change mitigation. In addition, diversifying energy sources will reduce reliance on fossil fuels, enhancing energy security. Less dependence on fossil fuels also leads to lower air pollution, resulting in improved public health.

There is a strong push towards a cleaner environment through the energy transition to renewable sources. In India, this transition to alternative energy production is already moving ahead with full momentum, with the aim of reducing fossil fuel consumption, addressing

environmental challenges, and combating global warming.

Biogas production is playing a key role in replacing fossil fuels and controlling methane emissions by converting waste into energy and bio fertilizers. Biogas provides a cost-effective clean energy solution with significant potential, derived from abundant organic and agricultural waste. According to the 2020-21 annual report by the Central Pollution Control Board (CPCB), India generates 160,038.9 tonnes of solid waste per day (TPD) ¹. Of that, 50% is treated, 18.4% is landfilled, and 31.6% remains unaccounted for. Over the past five years, waste processing has increased from 19% to 49.96%, while landfilling has decreased from 54% to 18.4%.

India has the potential to produce 32 million tonnes of Compressed Bio Gas (CBG), but currently, only 0.06% of the potential is being realized.

Two primary methods have gained significant attention for converting municipal solid waste (MSW) into useful energy. This is by incinerating MSW in boilers to generate power using a steam-based cycle, and bio-methanization with anaerobic digestion to produce biogas and organic fertilizer. Recently, much more emphasis has been placed on recovering biogas for energy use, as it offers a cost-effective local solution with lower capital costs compared to steam-based power generation technologies. The approach is crucial for managing waste and significantly reducing greenhouse gas emissions, thus playing a vital role in mitigating climate change.

Waste-to-Energy: Turning Solid Waste into Power

Waste-to-Energy (WTE) is a process that converts municipal solid waste into electricity through combustion. The method not only helps to manage waste but also generates energy, providing the dual advantage of waste reduction and green power generation. However, WTE also has its shortcoming, especially air pollution from harmful emissions, high investment, and operational costs.

Compressed Biogas: Harnessing Energy from Organic Waste

Biodegradable organic waste, including agricultural residue, cattle dung, sugarcane press mud, municipal solid waste, poultry litter and sewage treatment plant waste can be converted into biogas through anaerobic decomposition. The biogas is then purified and compressed achieving a methane content of 90-97%, which is a clean and combustible fuel that can substitute compressed natural gas (CNG) during the energy transition, helping to reduce GHG emissions.

Biogas also has various applications - it can be directly burned for heating, utilized in gas engines to produce electricity, or upgraded to biomethane, which can be injected into the natural gas grid or used as vehicle fuel. The use of biogas not only decreases reliance on fossil fuels but also prevents methane emission from the municipal waste dump yard, a gas with a significantly higher global warming potential than carbon dioxide, from being released into the atmosphere.

In addition, CBG plants offer an environmentally friendly solution to crop residue burning, which has a major impact on air quality. The Solid Waste Management (SWM) Rules 2016, issued by India's Ministry of Environment and Forests, address waste management issues by promoting modern technologies like WTE and bio-methanization.

The digestate is converted into Bio-fertilizer and can replace chemical fertilizers to some extent.

Description of Biogas Technology

1. Characterization of MSW Feedstock

A waste characterization study must be conducted to assess the properties of the organic waste for designing the biogas plant. The evaluation will help to determine the bio- methanization potential of the organic waste that would be used as raw material for the plant. Typical Classification of Source Segregated Organic (SSO) Waste as obtained from one of the test results is given below in Table-1.

However, the analysis may change with different locations. The segregation should be done at the source in order to have minimum 85 % organic waste for optimizing the biogas production.

Table 1: Typical fractions of Source Segregated Organic (SSO) Waste

Source Segregated Organic (SSO) Municipal Solid Waste Constituents	
Waste Fractions	Approx. (%)
Food waste including Bone (Organic-1), SSO	87.80
Coconut shell (Organic-2)	0.55
Leaves (dry, wet and branches) (Organic-3)	0.73
Sugarcane waste (Organic-4)	0.18
Seeds (Organic-5)	0.70
Plastic/ rubber / insulation material	4.78
Cloth, jute bags, Paper/Cardboard	4.20
Inert (Stone/ Glass)	0.76
Metal (ferrous and nonferrous)	0.20
Wood and furniture waste	0.05
Other Sanitary Items/Napkin/Diaper	0.05

2. Pre-Treatment

Biogas generation relies on the microbial breakdown of substrate, which requires pre-treatment to make the substrate more accessible. That involves mechanical and microbial methods to reduce the complexity and the size, and thereby improving the efficiency of microbial digestion.

Mechanical pre-treatment includes shredding and crushing to standardize the size of organic waste and biomass, making it easier to handle and feed into digesters. Shredders cut waste into uniform pieces (15-20 mm), while crushers produce feed suitable for slurry making.

3 Anaerobic Digestion Process and Biogas Generation Process

Biogas is produced from anaerobic digestion of organic material. The process generates

combustible gas and nutrient-rich fertilizer under controlled conditions, such as temperature, pH, and C/N ratio (Carbon/Nitrogen).

Anaerobic digestion is a natural process where organic material decomposes in the absence of oxygen, producing biogas - a mixture primarily of methane (50-65%) and carbon dioxide (35-50%). The process is harnessed in biogas plants using feedstocks like manure, organic waste, and agricultural residues, which are fermented in sealed digesters to generate biogas and organic fertilizer. The process involves several microbiological steps, including hydrolysis, acidogenesis, acetogenesis, and methanogenesis, with microbes generating gas. The digestion process can be either mesophilic with digester temperature maintained between 37-43°C or thermophilic process with digester temperature maintained between 50-60°C.

During the Biogas productions the biological changes occur:

- In Hydrolysis Process**
Insoluble organic matter is broken down into simple sugars, fatty acids, and amino acids.
- In Acidogenesis Process**
Further break down of organic monomers of sugar, and amino acids into alcohol, aldehydes and volatile fatty acids (VFAs)
- In Acetogenesis Process**
Conversion of alcohol and volatile fatty acids (VFAs) into acetic acid, carbon dioxide (CO₂) and hydrogen (H₂).
- In Methanogenesis Process**
There are two pathways for methane production in methanogenesis process of anaerobic digestion. They are acetoclastic and hydrogenotrophic pathways. In Acetoclastic, the acetic acid is broken down directly to methane and carbon dioxide. This process is the dominant pathway in organic waste digestion. In hydrogenotrophic pathway the Hydrogen

(H₂) reacts with CO₂ to form methane and water. Figure-1 is a typical block diagram that is generally followed for biogas production by anaerobic digestion in most of the projects.

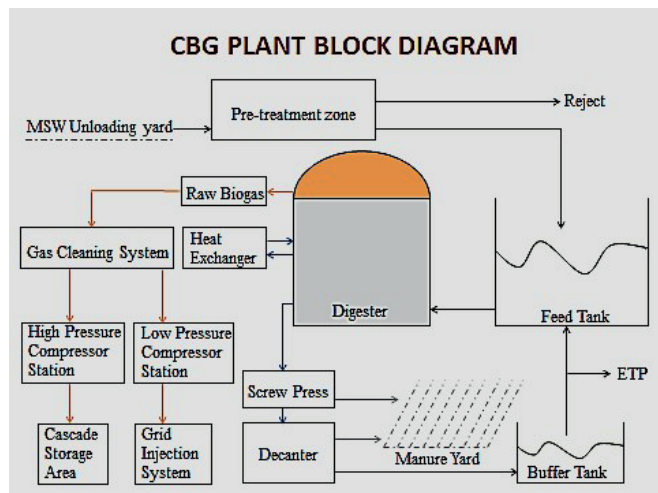


Figure 1: Typical Block Flow Diagram of CBG Plant

4. Biogas Purification and Upgradation

Biogas produced in the digesters is collected in a double membrane balloon. The collected raw biogas is first passed through a caustic scrubber where Hydrogen sulphide is removed. The purified CBG is further passed through a Vacuum Pressure Swing Adsorption system (VPSA system) where CO₂ is removed and the methane percentage increased to 96 %.

In the purification system the challenges are to be addressed. During caustic scrubbing for the removal of hydrogen sulphide (H₂S), sulphates are produced, and proper disposal of the same shall be addressed. To remove unwanted gases such as CO₂, N₂, O₂, H₂O, and residual H₂S, PSA (Pressure Swing Adsorption) or VPSA (Vacuum Pressure Swing Adsorption) systems are used. In the purification process the tower is filled with adsorption materials such as alumina, silica, activated carbon, and zeolite, which have the capacity to adsorb specific unwanted gases and allow high-purity methane to exit for further processing. It is essential to ensure the use of high-quality adsorption materials in the design to optimize performance and efficiency.

5. Biogas distribution

The upgraded biogas is distributed through a cascade system after being compressed to 250 bar(g) in a high-pressure compressor, or it is connected to the gas grid after compressing in a low-pressure compressor.

6. Byproduct as Manure

The digestate removed from the digester is passed through a screw press and decanter to reduce its water content. The solids extracted from the screw press and decanter are taken to the manure yard for the production of bio-fertilizer, used for farming, promoting sustainable farming and reducing the need for chemical fertilizers.

7. Compressed Biogas Composition

The composition of upgraded compressed biogas as specified in IS 16087: Biogas (Biomethane) – Specification, is reproduced in Table-2.

Table-2: Typical Composition of CBG

IS 16087:2016: Biogas (Biomethane) – Specification			
Sr. No.	Characteristic	UOM	Requirement
1	CH ₄ (minimum)	%	90.00
2	CO ₂ (maximum)	%	4.00
3	(CO ₂ + N ₂ + O ₂) (maximum)	%	10.00
4	O ₂ (maximum)	%	0.50
5	Total Sulphur (including H ₂ S), maximum	mg/m ³	20.00
6	Moisture, maximum	mg/m ³	5.00

The Indian standard IS 16087 specifies the methane percentage as minimum 90%. The technology that is being implemented in the present CBG projects is yielding methane percentage between 96 - 97%.

Power and Water Consumption

The power and water required for generating

Compressed Biogas (CBG) from municipal waste vary depending on the technology, capacity of the plant, and operational efficiency. Following are the Power consumption and Water Consumption based on the some of the running the plant:

1. Power Consumption

Power is required for the entire CBG generation process, including waste pre-processing, anaerobic digestion, biogas upgrading, compressing CBG, and effluent treatment, up to the bagging system. Typical specific power consumption ranges from 1.4 to 1.6 kWh per kg of CBG. This may vary based on the type of feedstock, pre-treatment requirements, and effluent treatment system.

2. Water Consumption

Water is required for preparing the feed for the digester and flushing of various equipment. Typical water requirement ranges from 4 to 8 liters per kg of CBG. Water consumption may vary based on the type of feedstock, moisture content of the feed stock, solid-liquid separation process, and the efficiency of the effluent treatment system.

Conclusion

The growing volume of MSW management has turned out to be a significant challenge and has major environmental impact. Traditional waste management practices, such as landfilling and incineration, have

harmed the environment, prompting efforts to reduce their use. In response, innovative approaches that convert waste into valuable products or energy are gaining momentum. These methods encompass both biological and thermochemical conversions, and extensive research over the past decade has led to enhanced yields of products and energy, along with reduced environmental impacts. These advancements also play a crucial role in supporting the broader energy transition by promoting sustainable waste-to-energy solutions.

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Holtec Experience

Holtec has been a front runner in building green energy projects. The company has engineered over 600 MW of green power from waste heat and are currently implementing projects with a biogas production overall capacity of approx. 98 tonnes per day. Holtec recognizes significant potential in this area as only less than 1% is realised at present.



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Sustainability Development Goal 13 (SDG 13) advocates adoption of rapid action to restrict climate change and related impacts. The Glasgow Climate Pact Agreement, 2021 reinforced the requirement with significant strides to be adapted for “transitioning towards clean energy and limiting impact of utilisation of fossil fuels” and thus enabling protection of the natural environment and tackling world-wide climate change. The main intent of the “Conference of Parties (COP) 26” summit was as per the Tag line “Uniting the World to Tackle Climate Change” was to attain “Net zero emissions” of carbon by the mid of the current century while maintaining a maximum global warming of 1.5 °C. This article spotlights Pumped Hydroelectric Energy Storage Systems which are often referred to as “Giant Water Batteries” which generate power and also store electric power as “Gravitational Potential Energy” of stored water in reservoirs.

Introduction

As part of the COP 26 Conference, the Government of India made the “Panchamrit” commitment regarding renewable energy and carbon emissions (Figure-1).

To provide impetus to that, a collaborative committee of the Ministry of Power and the Ministry of New and Renewable Energy of the Government of India has been

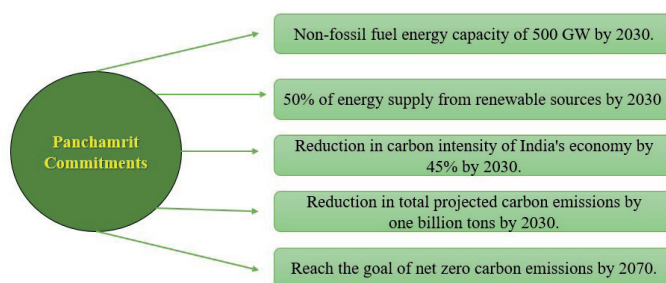


Figure-1: Five Nectar Elements – Panchamrit Commitments to Counter “Climate Change”

setup to formulate plans to enhance India’s Renewable Energy (RE) generation capacity to 500 GW by the year 2030. The committee is also endowed with the vital role of evaluating different technology options, find solutions for transmission issues, and energy storage requirements to achieve the intended 500 GW renewable energy mix target.

With increased thrust on power generation from renewable sources, there is an increased impetus on implementation of Solar and Wind plants, Biomass/ Co-Generation, Small Hydropower and Large Hydro power projects for renewable energy opportunities by harmonising energy storage from Pumped Storage Systems, Battery Storage Systems, Thermal/ Phase Transition Storage, Mechanical Storage, Hydrogen Electrolysis, etc. Large-scale augmentation of renewable energy necessitates conceptualisation and implementation of a suitable energy storage system for

plant peak operation generated energy and consumption of the same during plant non generating period based on demand.

The Ministry of New and Renewable Energy, Government of India issued draft guidelines in March 2023 for pumped hydro storage projects to generate over 18 GW of electricity to meet peak power demand and maintain grid stability, and also to meet the peak power demand by 2032. The draft Budget 2024 that was presented by the Finance Minister has also announced that a policy will be brought out to promote pumped storage projects for storage of electricity and facilitation to integrate them with renewable energy ensuring an effective energy mix solution to meet peak power demands.

Operating Principle

The working principle of Pumped Storage plants' is conversion of potential energy to electrical energy and vice-versa. When the energy demand is lower, the superfluous energy from the grid is generally used to pump water to a reservoir located at a higher elevation and when the power demand increases, the water is discharged from the reservoirs at higher elevation to lower elevation reservoirs through turbines and thus generate power. The elevation difference between the upper reservoir and lower reservoir is referred to as the 'Pressure Head'. Higher Pressure Head enable more efficient plant operation. The major components of Pumped Storage Systems are man-made reservoirs, natural water sources, pipelines and penstocks between the reservoirs and the Pump Turbine Generators (PTG) along with associated control systems.

PSPs are classified into two types- Open Loop PSP and Closed Loop PSP.

Open Loop PSP: It is a well-established technology, wherein stored water's gravitational (potential) energy is used to generate electricity. During low electricity demand or when there is adequate generation of power from renewable sources (e.g., Solar, Wind, biomass), water is drawn through the PTG system in pumping

mode from a lower reservoir to an upper reservoir using power from the grid. However, when the electricity demand is high, the water is allowed to flow from the upper reservoir to the lower reservoir through PTG in Turbine mode and generate electricity. Refer Figure-2. In general, the Open Loop PSPs have lower reservoirs connected to natural reservoir or naturally flowing water sources like rivers.

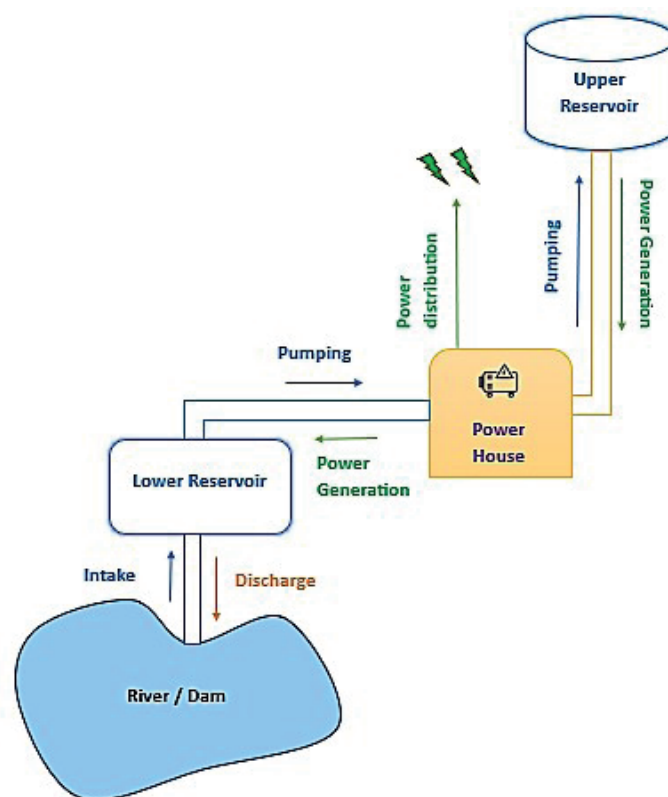


Figure-2: Open Loop Pump Storage System

Close Loop PSP: In the Closed Loop Pumped Storage plants operate utilising dedicated artificial man-made reservoirs. These systems generate electricity from Turbines operated by flowing water from upper to lower elevation reservoirs; store potential energy of water on pumping water from lower elevation reservoir to higher elevation reservoir (Figure 3)

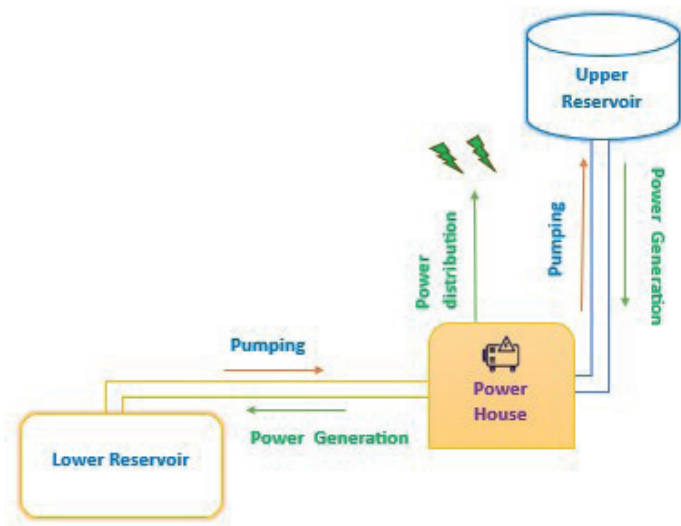


Figure-3: Closed Loop Pump Storage System

Role of PSP in Energy Transition

Energy transition involves increasing availability of Renewable Energy Sources (both variable and intermittent). India has pledged an ambitious commitment of 500 GW of renewable energy generation capacity by 2030. Wind and solar natural resources available in the country are being harnessed and those projects are in progress. Solar and Wind energy will be generated partially (i.e., day wise, seasonal, based on availability of Solar radiation and wind) and cannot be trusted entirely to meet the continuous daily and annual power requirements. In view of the unpredictable and intermittent energy generation from those sources, there is a need for a flexible power generation and storage system to cater to the fluctuating energy requirements (Base and Peak load power) keeping in mind efficiency and economics for ensuring grid stability. Energy mix from Solar and Wind renewable sources could pose challenges to grid stability. In addition to power availability there is the issue of, disturbances during peak load conditions owing to environmental instabilities. Nevertheless, PSPs address requirements of maintaining grid stability considering the fact that they can manage repeated start and stop with faster start up time and provide faster MW increase/ decrease option in comparison to other renewable sources. The PSPs are designed for MW scale power generation and large

amounts of energy storage. PSPs are implementable, effective, green, time-tested internationally proven and accepted systems supplementing clean and safe power generation. PSP's do not produce any harmful or bio toxic byproducts and thus do not pollute the atmosphere and are eco- friendly. Considering the guidelines and current trends in Energy transition in our country, PSPs are of prime importance to manage grid balance and, as reliable energy generation and storage solutions, empowering integration with wind and solar power catering to dynamic power supply demand.

Advantages of setting up PSPs are:

Proven technology

Addressing peak power shortage

Stabilizing the Grid

Long Term Asset creation: State-of-the-art Pump Storage facilities are generally designed for a duration of about 40 years. The country will gain from investment in such projects and also save precious natural resources.

Time of Day Tariff with Smart Metering: The Time-of-Day Tariff in combination with smart metering would be a reality implementation in the coming years. The Pump Storage Scheme enable maximizing revenue option, launching additional power at short notifications from anywhere across the grid.

Local Area Development by providing employment: PSP project execution would provide employment for technical staff and also to construction workers and associated supervisors during the construction stage.

Environmental & Social Benefits: PSPs facilitate large-scale development and integration with renewable energy projects (like Wind and Solar), thereby offsetting the detrimental effect of greenhouse gases on the environment. Hence, development of a proposed PSP would contribute to the national and global goal of combating climate change and help in achieving the United Nations Sustainable Development Goals (SDGs) to provide Clean, Affordable Energy for all.

Application Area: Worldwide Scenario and Indian Context

The growth in global hydropower generation plays an important role in the renewable energy sector. Conventional Hydropower Plants ranged from 7.2 GW to 1,237 GW and the Pumped Storage Hydropower Projects (PSH) from 6.5GW to 179GW in the year

2023 ¹. However, Hydropower generation and Pumped Storage Systems will rebound due to the increased thrust on Renewable Energy sources and sustainability initiatives.

In India ², the operational PSPs are generating 3305.60 MW as on date as listed below:

Operational PSPs in India (Above 25 MW Capacity)				
SI No.	Utilities/Stations	Developer	State	Capacity (MW)
1	Ghatgarh	MAHAGENCO	Maharashtra	250
2	Bhira	Tata Power Company	Maharashtra	150
3	N J Sagar	TSGENCO	Telangana	705.6
4	Srisaillam LBPH	TSGENCO	Telangana	900
5	Kadamparai	TANGEDCO	Tamil Nadu	400
6	Purulia	WBSEDCL	West Bengal	900
Total				3305.6

PSPs under design and detail engineering/ active construction activities include Tehri, Upper Sileru, Kundah Phase I, II, III and Pinnapuram projects totalling to 4050 MW with scheduled completion of the earliest project by 2024-25 and latest by 2028-29. India has an ambitious plan to set up PSPs with power generation capacity of up to 50760 MW by 2031-32 (Figure-4).

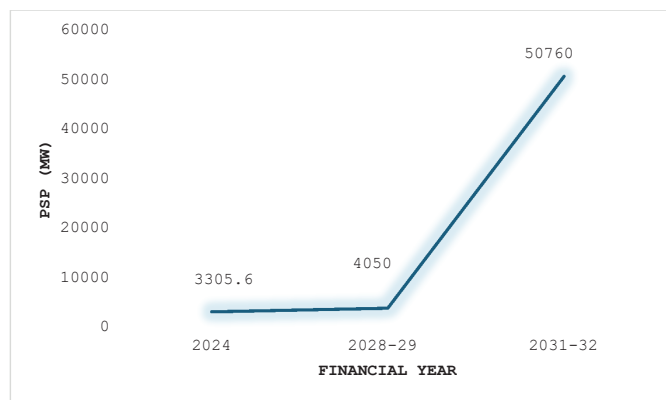


Figure-4: PSP Projected Growth in India

An overview of one of the ongoing projects under construction is presented in Figure-5. This Integrated Renewable Energy Project (IREP) in India is set to become the first of its kind world's largest Gigawatt-scale project with integrated Solar Power, Wind Power and Pumped Storage to provide Schedulable Power On Demand (SPOD). The project aims to deliver dispatchable and schedulable renewable energy to consumers across the country. Natural valley basins necessitating low height embankments will be used to construct two reservoirs. The reservoirs are isolated from the natural water systems with minimal catchment areas. Water for the pumped storage system will be initially drawn from the reservoir system and will be reused cyclically. Figure-6 shows the Aerial View, ongoing construction photographs.

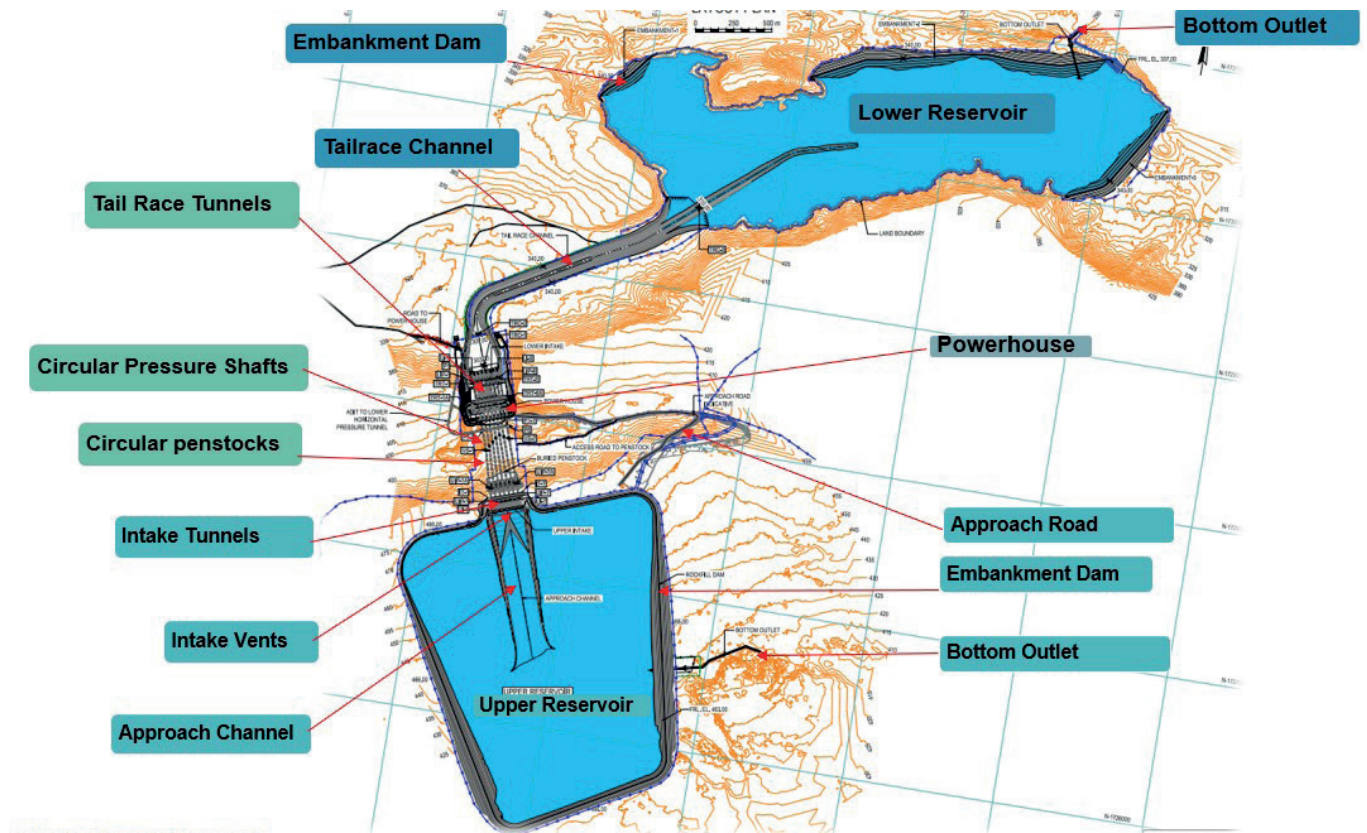


Figure-5: PSP Project Overview



Figure_6: Aerial Overview; Project photographs

Key Challenges

The most common challenges faced for implementation of PSPs are:

- Land acquisition
- Local and National level Regulatory compliances
- Clearances from Ministry of Environment and Forest
- Investment and Financing
- Geological and Environmental uncertainties
- Issues related to resurgence and reintegration of humankind and nature
- Site specific limitations
- Power evacuation concerns, etc.

These factors have contributed to delays in project execution and consequent plant commissioning resulting in increase in project cost and ineffective utilization which is vital for the intended power generation and storage application.

However, careful study and evaluation of key challenges during the Feasibility Study stage of the projects, adoption of corresponding risk mitigation measures and prudent decision making ensure successful project accomplishment. Reduced Regulatory clearance timelines, Structured land acquisition reforms and support from Government as well as public, creating realistic mission targets, optimum planning and on-time execution supplement building more PSPs to meet the ambitious international commitment of creating clean energy and storage systems.

Conclusions

Considering the large-scale enhancement in the installed capacities of Solar and Wind renewable energy plants, it is imperative to implement an appropriate energy storage system for absorbing and storing the excess energy generated during the plant peak operation and use the same during peak power requirement (mid-day and/ or evenings). At present, Pumped Storage Hydro Projects are the most sustainable alternative available globally or in India to accelerate large-scale energy or power storage. At present scenario other energy

storage systems have been found to be costlier and that justifies implementation of PSPs. In a few cases, PSPs with renewable energy generation plus energy storage are estimated to result in lower tariffs in comparison to a new thermal plant. There is growing interest from developers in PSPs.

Pumped Storage solutions present an economically viable and optimised scalable solution to provide Schedulable Power On-Demand (SPOD) with consideration of base and peak load capabilities. PSPs provide the required large volume energy storage (in terms of scale) and are designed for extended life cycle ensuring lowest cost of SPOD energy delivered during the project life cycle. Independent development of such Pumped Storage projects while maintaining the existing naturally available water eco system or irrigation systems is essential to sustainably energise the future needs and empowering the country's development whilst maintaining grid stability. In addition, the following socio-economic benefits are envisaged from PSP's:

The project will improve health care, primary education, women, and child welfare with periodic medical camps, and

Generation of job for local population.

The construction and continuous operation of PSP's would also lead to overall sustainable development in the project implemented region with direct and indirect contributions to improving the quality of life of the people.

Way Forward

With plans to develop PSP's, several optimisation and improvisation measures are being reviewed for adoption. Some of them are:

Possibilities of adding additional pumped storage systems in existing PSPs need to be studied for implementation. This prospect reduces the cost of setting up a new PSP while minimising undesirable environmental effects.

Possibility of using abandoned mines for PSPs to be explored.

Review and implementation of use of variable speed machines with adjustable speed to enable ramp up/ ramp down power generation to harmonise power requirement.

Digitalisation of PSP system assets to further improve efficiency, productivity, reduction in plant down time - operation & maintenance costs. Implementation of predictive and prescriptive analytics by adoption of Data Analytics, Machine Learning, Artificial Intelligence and Drones for Surveillance to reinforce Real Time Monitoring, Scheduled Plant Shutdown for Operation and Maintenance, timely Corrective/Preventive Action during disturbances leading to substantial reduction in equipment breakdowns and consequent plant shutdown.

Implementation of advanced digital strategy models for plant monitoring. Typical models are listed below:

- Model 1: PSP plants Owner monitors multiple PSPs of different capacities located at numerous distinct locations from a centralized PSP control room.
- Model 2: EPC (Engineering, Procurement, and Construction contractor) companies monitor the contracted PSPs located at different multiple locations from a single EPC PSP command center.

- Model 3: Each of the PSP original equipment supplier (OEM) monitors on real time basis their own equipment. OEMs would need to monitor plant's critical systems like PTG, Control Systems, Electrical Systems, etc. for the healthiness of respective supplied systems.

Acknowledgement

The author is grateful to TATA Consulting Engineers Limited for giving permission to submit this article.

TCE's Role in Energy Transition with Pumped Storage Systems: TATA Consulting Engineers Limited are involved in some of the Pumped Storage Projects initiated by the Government of India and private companies- with focus on Pre-Feasibility Reports, Feasibility Reports, Compendium, Planning and Implementation of PSP's.

TCE's multiple value addition suggestions in PSP for layout optimisation and powerhouse design have resulted in huge cost saving and are well appreciated by Plant Owners.

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Enhancing Energy Efficiency in Electric Motor Driven Pumping Systems for Sustainable Industrial Operations



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Abstract

Electric motor-driven systems are pivotal in the industrial sector, accounting for over 50% of global electricity consumption in industrial applications. This article delves into the pumping system which accounts as a major contributor to the electric-motor driven systems and covers the key strategies to optimize these systems with the aim of enhancing industrial efficiency and reducing carbon footprints. It discusses energy-saving alternatives, the indispensable role of energy audits, and the development of a comprehensive regulatory framework. The article also outlines the best practices for improving motor-driven system efficiency and offers actionable recommendations for integrating these practices into industrial operations. The goal is to achieve substantial reductions in carbon emissions while supporting global sustainability efforts, in line with the goal of Net Zero Emission by 2050.

Introduction

Electric motor-driven systems play a crucial role in industrial operations, representing a significant portion of global electricity use—more than 50% in industrial settings. As industries strive for greater sustainability and energy efficiency, optimizing these systems has

emerged as a critical focus. Improving the efficiency of motor-driven systems not only lowers operational costs but also contributes to reducing carbon emissions, aligning with the Global Sustainability Goals.

This article explores various strategies to enhance the efficiency of electric motor-driven pumping systems. It begins by examining the selection and implementation of energy-efficient equipment. It underscores the importance of comprehensive energy audits in identifying inefficiencies and areas for improvement. Additionally, the article discusses the creation of a robust regulatory framework to support efficiency measures and provides best practices for boosting motor-driven system performance. By implementing these strategies, industries can achieve notable efficiency gains and make strides towards a more sustainable future. Figure-1 illustrates the electricity demand from 2021, with projections extending to 2025. Figure-2 shows the breakdown of the electricity demand sector wise for the year 2021. It is inferred that 43% of the electricity is consumed by industrial operations, 27% by residential purposes, and 20% by commercial activities.

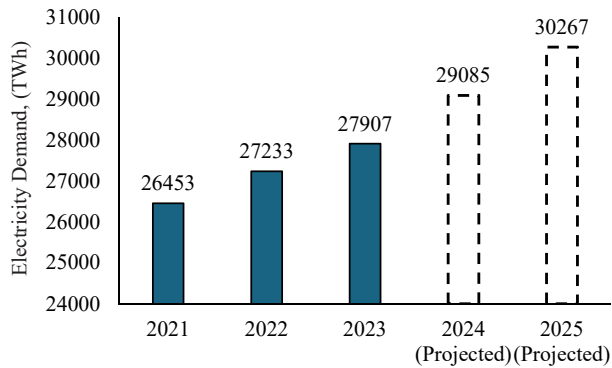


Figure-1: Electricity Demand - 2021 to 2025

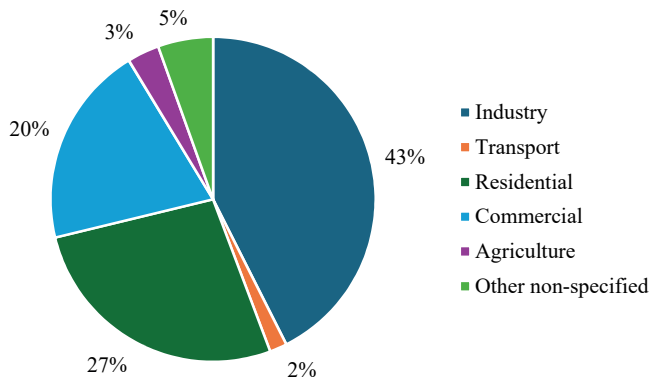


Figure-2: Electricity Demand - Sector wise in 2021

Role of Electrical Motor Driven Equipment in Industry

Electrical motor driven equipment is indispensable across a range of industrial sectors due to their reliability and versatility. They are integral to the operation of essential machinery and equipment, thereby enhancing the efficiency of industrial processes.

Given the critical role of electrical motor driven equipment, understanding their proper application, selection, operation, troubleshooting, maintenance, and energy conservation is crucial for industrial success. On a conservative estimate, energy savings of 15% to 25% can be achieved in pumping systems alone. Overall, electrical motors are essential for driving machinery across various industries, enhancing productivity and operational efficiency. On analyzing the scope of optimizing the equipment parameters to achieve greater efficiency for pumps, it is evident that energy

savings in this sector will be possible to a substantial amount. Figures-3 and 4 illustrate the energy balance of a typical pumping system and the lifecycle cost of pumps, respectively.

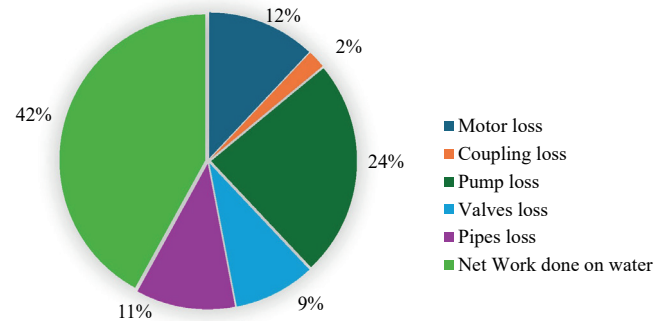


Figure-3: Energy Balance for Typical Pumping System

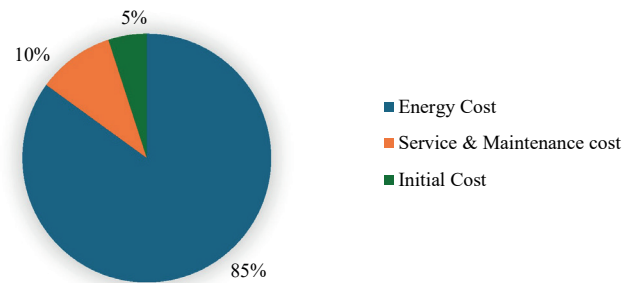
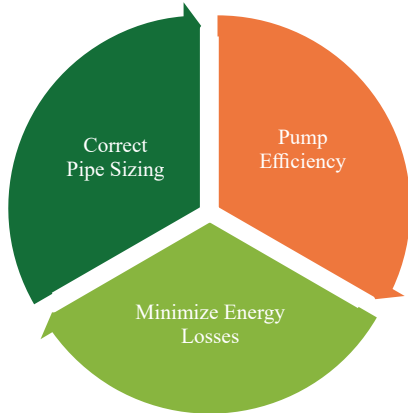


Figure-4: Typical Life Cycle Cost of Pumps

Challenges in Equipment Selection and Energy Optimization

Achieving energy optimization requires a thorough approach to equipment design and selection. The following parameters are critical when sizing equipment for optimal performance:

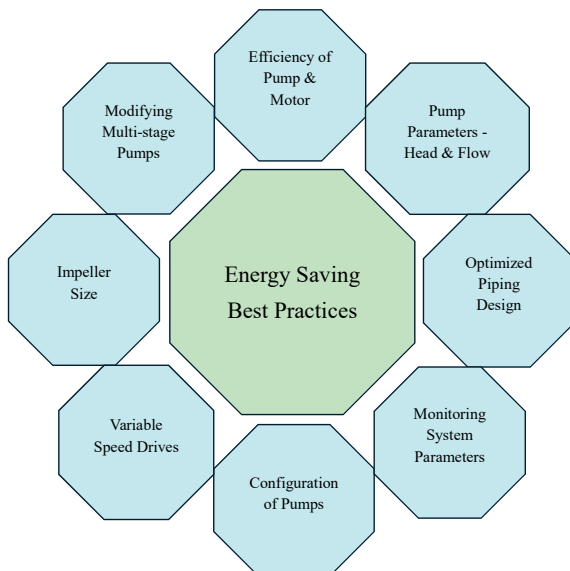
- **Pump Efficiency:** Selecting a pump model that maximizes efficiency is essential. Efficiency should be considered carefully during the selection process to avoid energy losses and ensure optimal performance.
- **Minimize Energy Losses:** Proper design and selection are necessary to minimize energy losses. This includes choosing equipment that matches the specific needs of the system and optimizing the overall design.



- **Correct Pipe Sizing:** Correct pipe sizing is crucial for maintaining efficiency and reducing energy losses. Well-designed piping systems can significantly impact the overall performance and energy consumption of the system.

Energy-Saving Opportunities and Best Practices

To maximize energy savings and improve the efficiency of motor-driven systems, several best practices should be followed:



- **Consider Pump Efficiency:** When selecting a pump, prioritize models with high efficiency. This consideration is essential for minimizing energy consumption and maximizing performance.

- **Match Pumps to Head Flow Requirements:** Ensure that pumps are selected to match the specific head flow requirements of the system which can be done using hydraulic analysis software. Mismatched pumps can lead to inefficiencies and increased energy consumption.
- **Choose High-Efficiency Motors:** Select motors that match the load requirements with high efficiency so that they consume less energy and contribute to lower operational costs.
- **Optimize Piping Design:** Proper piping design is crucial for minimizing energy losses by ensuring that the piping system is designed to reduce friction and improve overall efficiency.
- **Monitor System Parameters:** Regularly monitor important system parameters, including motor kilowatt (kW) usage, pump head, and flow temperature to help identify inefficiencies and areas for improvement.
- **Utilize Pumps in Series and Parallel:** Implementing pumps in series or parallel configurations can address system mismatches and variations in operating conditions. This approach allows for better adaptability and improved efficiency.
- **Employ Variable Speed Drives:** Use variable speed drives to accommodate variations in flow due to process requirements, since they enable more precise control and energy savings by adjusting motor speed according to demand.
- **Adjust Impeller Size:** If the head flow exceeds the requirements by 5% to 15%, consider trimming the existing impeller to a smaller diameter or replacing it with a smaller impeller. This adjustment helps optimize pump performance and reduce energy consumption.
- **Modify Multistage Pumps:** In multistage pumps, adding or removing stages can help adjust the delivered head and flow as needed. This modification allows for better alignment with system requirements and improved efficiency.

Importance of Comprehensive Energy Audits

Energy audits are critical for identifying inefficiencies and opportunities for improvement in motor-driven systems. A comprehensive energy audit involves evaluating the entire system, including equipment, processes, and operational practices. The audit helps pinpoint areas where energy is being wasted and provides actionable recommendations for enhancing efficiency.

Energy audits typically include:

- **Assessment of Equipment Performance:** Continuous Monitoring and Evaluating the performance of motors, pumps, and other equipment to identify inefficiencies and areas for improvement using IOT technologies.
- **Analysis of System Design:** Reviewing the overall system design, including piping, controls, and operational practices, to identify potential energy savings.
- **Identification of Energy-Wasting Practices:** Recognizing operational practices that lead to energy wastage and recommending changes to improve efficiency.
- **Implementation of Recommendations:** Developing and implementing strategies based on audit findings to enhance efficiency and reduce energy consumption.

Developing a Regulatory Framework for Efficiency Measures

A robust regulatory framework is essential for supporting the implementation of energy efficiency measures in industrial operations. Such a framework provides guidelines, standards, and incentives to encourage industries to adopt best practices and technologies for improving efficiency.

Key components of an effective regulatory framework include:

- **Standards and Guidelines:** Establishing clear standards and guidelines for energy efficiency in motor-driven systems set as benchmark for use

in industries, to help ensure that equipment and practices meet minimum efficiency requirements.

- **Incentives and Support:** Providing incentives and support for industries that invest in energy-efficient technologies and practices. This can include financial incentives, tax benefits, and technical support.
- **Monitoring and Reporting:** Implementing mechanisms for monitoring and reporting energy usage and efficiency improvements, to help track progress and ensure compliance with efficiency standards.
- **Training and Education:** Offering training and educational resources to industry stakeholders to enhance their understanding of energy efficiency and best practices.

Conclusion

Enhancing the efficiency of electric motor-driven systems is crucial for reducing energy consumption and lowering carbon footprints in industrial operations. By adopting energy-efficient equipment, implementing best practices, and conducting comprehensive energy audits, industries can achieve significant efficiency gains and contribute to global sustainability efforts.

A robust regulatory framework would support the implementation of efficiency measures, by providing the necessary guidelines, incentives, and support. By integrating these strategies into industrial operations, companies can realize substantial reductions in operational costs and carbon emissions, advancing towards a more sustainable and energy-efficient future. Through continued efforts and advancements in technology and practices, industries can play a pivotal role in mitigating climate change and achieving global sustainability goals.

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Hydrogen Detection Systems for Enhanced Safety in Hydrogen Infrastructure



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Abstract

Hydrogen is being increasingly recognised as a pivotal energy carrier in the transition towards a low-carbon economy. Its versatility, from fuelling vehicles to generating electricity, positions it at the forefront of clean energy solutions. However, hydrogen's unique properties (being colourless, odourless, and highly flammable) pose significant safety challenges. A critical aspect of hydrogen safety is the ability to detect leaks promptly and accurately to prevent potential explosions and fires. This article explores the various hydrogen detection technologies, their operational principles, advantages, and limitations, providing a comprehensive overview of their role in ensuring safety across hydrogen applications.

Key words: Hydrogen, Sensors, Detection, Safety, Application

Introduction

Hydrogen is playing an increasingly vital role in the global transition to clean energy, hence the importance of robust hydrogen detection technologies cannot be overstated. Hydrogen is a versatile and clean energy carrier, with applications ranging from fuel cells in electric vehicles to power generation, industrial

processes, and even as a potential aviation fuel. However, despite its environmental benefits, hydrogen presents unique safety challenges due to its physical and chemical properties. Hydrogen is colorless, odorless, and highly flammable, with a wide flammability range and low ignition energy. These characteristics make undetected hydrogen leaks a significant safety hazard, capable of leading to explosive incidents if not promptly addressed. Moreover, hydrogen has the smallest and lightest molecules, allowing it to easily escape from containment systems and disperse rapidly, making early detection even more critical.

The development and deployment of advanced hydrogen detection technologies are essential for ensuring the safe and reliable use of hydrogen across various industries. These technologies provide the first line of defense against potential hazards, enabling timely leak detection and preventing dangerous accumulations of hydrogen in enclosed spaces. Integrating these detection systems into hydrogen infrastructure, such as fuel cell vehicles, refueling stations, pipelines, and storage facilities, can mitigate the risks associated with hydrogen handling and use.

In addition to enhancing safety, effective hydrogen detection technologies are crucial for building public

trust in hydrogen as a viable and safe energy solution. As adoption of hydrogen grows, particularly in populated urban areas and sensitive industrial environments, ensuring the reliability of detection systems becomes increasingly significant. These technologies not only protect lives and property but also support the broader goals of decarbonization and the global energy transition by enabling the safe expansion of hydrogen applications.

Types of Hydrogen Detection Technologies

Several sensors are used to detect hydrogen, including catalytic combustion sensors, electrochemical sensors, semiconductor sensors and thermal conductivity sensors.

Catalytic Combustion Sensor: It is designed to detect hydrogen by facilitating its combustion on a heated catalytic surface. The combustion reaction induces a temperature rise, which is subsequently measured and correlated to the hydrogen concentration. Known for their high sensitivity and reliability, these sensors are extensively used in industrial environments where accurate hydrogen detection is crucial. Nonetheless, their performance can degrade in low-oxygen conditions, and that necessitates regular calibration and maintenance to ensure consistent accuracy and operational stability.

Electrochemical Sensor: It operates on the principle of hydrogen's electrochemical oxidation or reduction at an electrode surface, producing a current proportional to the hydrogen concentration. These sensors are

favoured for their high sensitivity and selectivity, offering precise measurements in many applications. However, they are prone to interference from other gases present in the environment, which can affect their accuracy. Therefore, careful consideration and calibration are required when deploying these sensors in mixed gas environments to avoid erroneous readings.

Semiconductor Sensor: It detects hydrogen by measuring changes in the electrical conductivity of metal oxide materials in response to hydrogen exposure. They are valued for their cost-effectiveness and ease of integration into various systems, making them suitable for widespread use. However, these sensors can experience issues with selectivity and drift over time, necessitating periodic recalibration to maintain accuracy. Despite these challenges, their affordability and adaptability make them a practical choice for numerous applications.

Thermal Conductivity: These sensors operate on the principle of heat conduction, to measure hydrogen concentration. Hydrogen concentration in the environment is monitored by measurement of parameters such as temperature, resistance, and voltage. Hydrogen concentration can be detected accurately across a continuous range from 4-100% by the sensor. It is resistant to humidity thereby it operates effectively from dry air conditions to condensation, thereby making it useful in all climatic conditions.

An overview of conventional hydrogen detection technologies is given in Table-1.

Table- 1: Overview of conventional hydrogen detection technologies ¹

Type	Principle	Characteristics	Advantages	Limitations
Catalytic Combustion Sensor	Detection of temperature changes in catalysts (e.g., Pd, Pt/ Al_2O_3)	- Low selectivity for hydrogen, fast response time - Response (90%): 5-10 sec	- Acceptable lifespan - Wide operational temperature range	- Not selective - High power consumption - Poisoning - Requires 5-10 % v/v O_2 - High maintenance

Type	Principle	Characteristics	Advantages	Limitations
Electrochemical Sensors	H ₂ oxidation at Platinum sensing electrode	• High resolution, high selectivity • Response (90%): ~ 30 sec	• Quite selective • Low power consumption • Poison resistant	• Some cross sensitivity to CO • Narrow temperature range • Short lifespan of 2 year
Semiconductor Sensor	Detection of changes in electron conductivity due to H ₂ oxidation	• High resolution, high selectivity • Response (90%): ~20 sec	• Commercially available • Acceptable lifespan	• Not selective • High power consumption • Sensitive to humidity and temperature
Thermal Conductivity Sensor	Detection of changes in gas thermal conductivity due to mixture	• Low resolution, high selectivity • Response (90%): 5-10 sec	• Quite selective • Poison resistant • Long term stability • Does not require O₂	• Not very sensitive • Cross-sensitive to helium • Requires heating

Emerging Hydrogen Detection Technologies

Fiber Optic Sensors: They offer significant advantages for hydrogen detection, including explosion-proof operation, high durability, corrosion resistance, and the ability to cover wide areas with compact and lightweight devices. The sensors operate by detecting changes in light interference caused by physical or chemical changes on the fibre's surface. Sensing elements can be located at discrete points (e.g., the fiber tip) or distributed along the fiber, responding to hydrogen chemically or detecting physical responses like acoustic signals. A common approach is the Fiber Bragg Grating (FBG) technique, where a palladium (Pd) or Pd alloy thin film on the fiber surface swells upon hydrogen adsorption, causing a wavelength shift that indicates the presence of hydrogen. This technology shows potential for remote monitoring and hydrogen pipeline surveillance.

Ultrasonic Sensors: Ultrasonic leak detectors identify hydrogen leaks by detecting the acoustic signals generated when pressurized gas escapes through an orifice. These sensors are optimized to recognize the ultrasonic signatures of leaks, differentiating them from operational noise based on the duration and intensity of the signal. While commercial ultrasonic systems exist, their application in hydrogen facilities is still limited. Current research aims to enhance

these systems by using multiple detectors to pinpoint leak sources. Another concept in ultrasonic detection involves measuring the speed of sound in a medium, as hydrogen's sound velocity is approximately four times faster than air's, enabling the detection of increased hydrogen concentrations.

Schlieren Imaging: It is a visualization technique that captures the differences in gas density within transparent media, producing real-time, two-dimensional images. This method is particularly useful for analysing hydrogen jets or flames, as well as mixtures of hydrogen with other gases. Although widely used in laboratory settings for device and system development, Schlieren Imaging has not yet been adopted for commercial hydrogen monitoring.

Memory-Based Sensors: A novel approach to hydrogen detection involves the use of semiconductor technology, specifically Resistive Random-Access Memory (ReRAM). ReRAM is a non-volatile memory technology that detects hydrogen by measuring changes in resistance due to redox reactions, with hydrogen acting as a reducing agent. The method enables the creation of light, small sensors with low power consumption. For example, a prototype developed by Nuvoton Technology consumes only 0.01 mW and detects hydrogen in the range of 0.1% to 4%.

Selection Criteria

There are several factors to be considered while selecting a hydrogen gas detector for an application.

a) The type of hydrogen gas detector, b) Sensitivity, c) Range, and d) Response time.

- a) **Type of Hydrogen gas detector:** Based on the application, the right type of hydrogen gas detector should be selected. Electro chemical sensors are the most commonly used type of sensors because of their accuracy and sensitivity.
- b) **Sensitivity:** The sensitivity of the hydrogen gas detector is another crucial factor to be considered. Sensitivity is defined as the smallest amount of hydrogen gas that can be detected. For high sensitivity application a detector with a low detection limit is required. If other gases are also present in the background, then a detector with higher detection limit is required to avoid false alarms.
- c) **Range:** The range of the detector depends on the area in which hydrogen leak detection is required to be measured. Large areas require detectors with high range and smaller areas require detectors with lower range.
- d) **Response time:** Response time is the time required for a detector to register a change in hydrogen gas concentration. Fast response time is to be considered for higher safety of the working personnel while for other applications slower response time may be sufficient.

Finally, the hydrogen gas detector should meet the industry safety standards and regulations as laid out by OSHA and NFPA.

Emerging Trends and Innovations in Hydrogen Detection

The field of hydrogen detection is rapidly evolving, with several emerging technologies showing promise. Nanomaterial based sensors, such as those incorporating graphene, offer enhanced sensitivity and

selectivity, potentially revolutionizing hydrogen safety in various applications.

Wireless and remote sensing technologies are also gaining traction, enabling continuous monitoring in remote or hazardous environments. These systems, often integrated with IoT platforms, provide real-time data and predictive analytics, enhancing overall safety and operational efficiency. The integration of hydrogen sensors with IoT and smart systems is another significant trend. By leveraging AI and machine learning, these systems can improve detection accuracy, predict potential failures, and optimize maintenance schedules, further enhancing hydrogen safety.

To support the future hydrogen economy, ongoing research is focused on enhancing hydrogen sensor performance by improving sensitivity, selectivity, response time, and reliability. Efforts are also directed at reducing sensor size, cost, and power consumption². Key requirements for hydrogen sensors include:

- Hydrogen detection concentrations range from 0.01-10 % and 1-100% for safety & Fuel cell applications respectively.
- Explosion-proof designs with protective housing shall ensure reliable and safe operation within the accuracy & sensitivity limits for a given application (Uncertainty < 5-10%).
- The most crucial environmental factors in the operation process are Pressure, Temperature and Relative humidity which are required to be maintained for a stable signal output with low noise.
- Additional factors include fast response and recovery times typically < 1second, low cross-sensitivity to other gases, long battery life typically > 5 years, low power consumption of the order of < 100mW, low cost, compact size, ease of operation and maintenance with extended service intervals and simpler system integration and interfacing.

Application

The areas where hydrogen is or could be used and the associated detection technologies are given in Table-2.

Table-2: Hydrogen applications and the associated detection technologies

Application	Technology	Details
Fuel Cell Electric Vehicles (FCEVs)	Contact Combustion Sensors	- Toyota's MIRAI features three hydrogen leak detection sensors: one located near the fuel cell stack and two at the hydrogen tanks. - These sensors detect hydrogen leaks by sensing temperature changes caused by the catalysed oxidation of hydrogen on the sensor's surface.
Off-Road Vehicles	Advanced Multi-Environment Sensors	- Hydrogen detection in off-road vehicles must use sensors that can withstand dust, extreme temperatures, and harsh operating conditions. - These sensors must ensure safety, even with large hydrogen storage volumes and the need for rapid refuelling.
Hydrogen Refuelling Stations (HRS)	Hydrogen Leak Detection and Flame Sensors	- HRSs have hydrogen leak and flame detection sensors placed in key areas like production facilities, compressors, storage tanks, and dispensers. - These sensors are crucial for reducing risks to the environment and surrounding communities.
Maritime (Hydrogen Carrier Ships)	Integrated Hydrogen Detection Systems	- LH2 carrier ships are equipped with hydrogen detection systems that meet the International Maritime Organization (IMO) IGF code requirements. - These safety systems include flame detection, emergency shutdown, fuel flow cut-off, and controlled airflow for tank connections to ensure safe operation.
Aerospace	Cryogenic Hydrogen Detection Systems	- Aerospace applications, especially zero-carbon aircraft using liquid hydrogen (LH2), demand highly sensitive hydrogen detection systems for safe operation under extreme conditions. - The safety requirements for hydrogen detection in aerospace far exceed those of other hydrogen applications due to the unique challenges posed by LH2.

Conclusion

Hydrogen detection technologies are an essential component of hydrogen safety strategies, enabling the safe and effective use of hydrogen across various industries. As the adoption of hydrogen continues to grow, the development and deployment of advanced detection technologies will play a critical role in mitigating risks and ensuring the safe integration of hydrogen into the global energy landscape. Future advancements in sensor technology, combined with smart systems and IoT integration, will further enhance the safety and reliability of hydrogen applications,

supporting the ongoing transition to a cleaner energy future.

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Abstract

The energy transition towards a more sustainable and environmentally friendly economy presents a complex challenge, often encapsulated by the ESG (Environmental, Social, and Governance) dilemma. This paper explores the intricate relationships and tensions between the three pillars of ESG across ten themes and thirty-three key issues, to offer a comprehensive analysis of how these factors influence the global shift towards renewable energy and sustainable practices.

Keywords : Energy Transition, ESG, Sustainability, Climate Change, Human Capital, Governance, Social Responsibility

Introduction

The energy transition refers to the global shift from fossil-based energy systems to renewable and sustainable energy sources. This transition is critical for mitigating climate change, reducing environmental impacts, and promoting sustainable development. However, this shift is fraught with challenges, particularly when viewed through the lens of ESG criteria¹. ESG encompasses a broad range of factors that companies and investors must consider ensuring responsible and sustainable operations². This paper addresses the ESG dilemma by examining key issues within the three pillars: Environment, Social, and Governance.

Environmental Pillar

Climate Change

i. Carbon Emissions

Carbon emissions from energy production are the primary driver of climate change. The energy transition aims to reduce these emissions by shifting to renewable energy sources such as wind, solar, and hydroelectric power. However, the transition itself can generate emissions, particularly during the manufacturing and deployment of renewable technologies. Addressing carbon emissions involves not only transitioning to renewable sources but also improving energy efficiency and adopting carbon capture and storage technologies. Moreover, policies such as carbon pricing and emissions trading systems can incentivize reductions in carbon emissions.

ii. Product Carbon Footprint

The product carbon footprint refers to the total Greenhouse Gas (GHG) emissions associated with the lifecycle of a product, refer Figure-1. In the context of energy, this includes emissions from the extraction, production, and consumption of energy. Reducing the carbon footprint of energy products is critical for achieving climate goals. Companies can achieve this by adopting more sustainable practices, improving supply chain efficiency, and utilizing low-carbon technologies. Life Cycle

Assessment (LCA) is a valuable tool for measuring and managing product carbon footprints, providing insights into where improvements can be made.

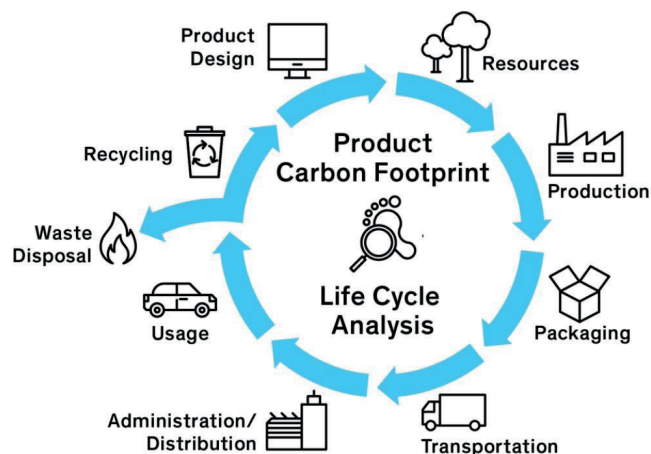


Figure-1: Product Carbon Footprint and Life Cycle Assessment (Source: myclimate.org)

iii. Financing Environmental Impact

Financing the energy transition involves substantial investment in renewable energy infrastructure. This raises questions about the sources of financing and the environmental impacts of these financial activities. Sustainable financing strategies, such as green bonds, are essential to ensure that the capital is directed towards projects that deliver positive environmental outcomes. Hence, investors and financial institutions are increasingly incorporating ESG criteria into their investment decisions, which can influence the flow of capital towards sustainable projects. However, challenges remain in ensuring that these financial products are genuinely sustainable and not merely "greenwashed".

iv. Climate Change Vulnerability

The vulnerability of energy infrastructure to climate change impacts, such as extreme weather events, poses significant risks. Transitioning to resilient renewable energy systems that can withstand climate-related disruptions is essential for long-term sustainability. This includes designing infrastructure to be more robust against extreme weather, diversifying energy sources to reduce reliance on any single type of energy, and investing in grid modernization to enhance flexibility and reliability. Additionally, integrating climate risk

assessments into planning and decision-making processes can help mitigate these vulnerabilities.

Natural Capital

i. Water Stress

Water is a critical resource for energy production, particularly for cooling processes in thermal power plants and for hydropower generation. The energy transition must consider water stress and prioritize technologies that minimize water usage. Renewable energy sources like wind and solar generally have lower water footprints compared to fossil fuels. Moreover, adopting water-efficient technologies and practices, such as dry cooling for thermal plants and closed-loop cooling water systems, can further reduce water use. Policymakers and companies must also consider the impacts of energy projects on local water resources and ecosystems.

ii. Biodiversity and Land Use

Renewable energy projects, such as wind farms and solar arrays, can impact biodiversity and land use. Balancing the need for clean energy with the preservation of ecosystems and biodiversity is a significant challenge. Strategic planning and siting of renewable energy projects can help minimize negative impacts on wildlife and natural habitats. Furthermore, adopting best practices for land use, such as co-locating solar panels with agriculture (agrivoltaics – refer Figure-2) or using previously disturbed lands, can mitigate biodiversity loss. Environmental Impact Assessments (EIAs) are also critical for identifying and addressing potential impacts on biodiversity.

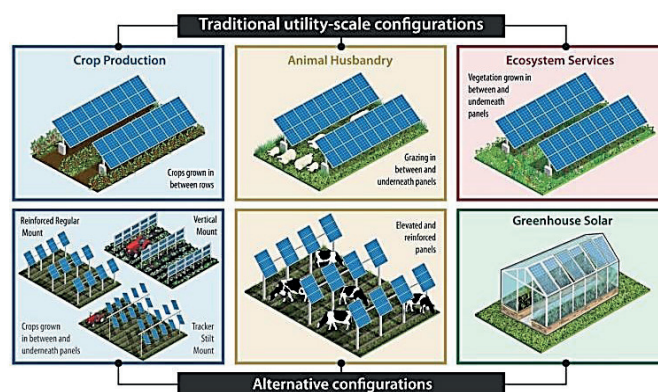


Figure-2: Types of Agrivoltaics Systems (Source: nrel.gov)

iii. Raw Material Sourcing

The shift to renewable energy requires raw materials such as lithium, cobalt, and rare earth elements, which are essential for technologies like batteries and wind turbines. Sustainable sourcing of these materials is crucial to avoid environmental degradation and social conflicts. This includes implementing responsible mining practices, improving recycling and reuse of materials, and developing alternative technologies that reduce dependence on scarce resources. Additionally, supply chain transparency and traceability can help ensure that raw materials are sourced ethically and sustainably.

Pollution & Waste

i. Toxic Emissions & Waste

Energy production and consumption generate toxic emissions and waste, including air pollutants and hazardous by-products. The energy transition must address these issues by promoting cleaner technologies and effective waste management practices. This includes transitioning away from coal and other high-emission fuels, adopting cleaner production processes, and implementing strict emissions controls. Additionally, proper handling, treatment, and disposal of hazardous waste, along with the development of waste-to-energy technologies, can help mitigate the environmental impacts of waste.

ii. Packaging Material and Waste

The production and deployment of renewable energy technologies involve packaging materials that contribute to waste. Sustainable packaging solutions are needed to reduce this environmental burden. Companies can adopt packaging materials that are recyclable, biodegradable, or made from renewable resources. Additionally, optimizing packaging design to reduce material use and implementing packaging take-back programs can further minimize waste. Collaboration across the supply chain is crucial for developing and adopting sustainable packaging practices.

iii. Electronic Waste

The proliferation of renewable energy technologies, such as solar panels and batteries, contributes to electronic waste. Proper recycling and disposal mechanisms are necessary to mitigate the environmental impact of e-waste. This includes developing efficient recycling processes, promoting the use of recyclable materials, and implementing take-back programs for end-of-life products. Policies and regulations that support e-waste management, as well as consumer education on proper disposal, are also essential for reducing the environmental footprint of electronic waste.

Environmental Opportunities

i. Opportunities in Clean Technologies

The energy transition presents opportunities for innovation in clean technologies, including energy efficiency, storage solutions, and advanced materials. These innovations can drive economic growth and environmental sustainability. Investment in research and development (R&D) for clean technologies is critical for advancing these innovations. Public policies and incentives, such as tax credits and grants, can also support the growth of clean tech industries. Moreover, partnerships between governments, academia, and the private sector can accelerate the development and deployment of new technologies.

ii. Opportunity in Green Building

Green building practices, which emphasize energy efficiency and sustainability, can significantly reduce the environmental impact of the built environment. Integrating renewable energy systems into green buildings further enhances their sustainability. This includes designing buildings to optimize energy use, utilizing sustainable materials, and incorporating renewable energy sources such as solar panels and geothermal systems. Green building certifications, such as LEED (Leadership in Energy and Environmental Design), can provide guidelines and standards for sustainable construction and operation, refer Figure-3³.



Figure-3: Applicability of LEED Across All Building Types and Phases (Source: usgbc.org)

iii. Opportunities in Renewable Energy

Investing in renewable energy sources, such as solar, wind, and geothermal, offers significant environmental benefits by reducing greenhouse gas emissions and reliance on fossil fuels. Renewable energy projects can also create jobs, enhance energy security, and promote sustainable development. To capitalize on these opportunities, it is essential to develop supportive regulatory frameworks, financial incentives, and infrastructure. Moreover, fostering community engagement and participation in renewable energy projects can ensure that the benefits are widely shared and that local needs are addressed.

Social Pillar

Human Capital

i. Labour Management

The energy transition affects labour markets, creating new jobs in renewable energy sectors while displacing workers in traditional fossil fuel industries. Effective labour management is needed to ensure a just transition that supports workers' rights and livelihoods. This includes providing retraining and reskilling programs for displaced workers, ensuring fair labour practices in new industries, and fostering inclusive labour policies.

Governments, companies, and labour organizations must collaborate to develop strategies that support a smooth and equitable transition for all workers.

ii. Health and Safety

Ensuring health and safety in the energy sector, particularly in high-risk environments such as offshore wind farms and solar installations, is crucial for protecting workers and communities. Implementing strict health and safety standards, conducting regular risk assessments, and providing appropriate training and protective equipment are essential for minimizing risks. Companies must also foster a culture of safety and prioritize the well-being of their employees. Regulatory oversight and enforcement are critical for ensuring compliance with health and safety standards.

iii. Human Capital Development

Investing in human capital development, including education and training programs, is essential for building a skilled workforce capable of driving the energy transition. This involves developing curricula and training programs focused on renewable energy technologies, sustainability, and innovation. Partnerships between educational institutions, governments, and the private sector can enhance the availability and quality of training programs. Additionally, promoting STEM (Science, Technology, Engineering, and Mathematics) education can help prepare the next generation of workers for careers in the renewable energy sector. Table-1 & Table-2 provide the Descriptive results of the Education and Innovation Index, as well as the Renewable Energy Share, for BRICS and OECD countries⁹.

Table-1: Descriptive Statistics (BRICS countries)

Country	Education and innovation index				Share of renewable energy			
	Mean	Std deviation	Min	Max	Mean	Std deviation	Min	Max
Brazil	45.24	3.41	41.30	51.20	28.91	1.50	26.90	31.29
China	64.47	2.12	61.50	66.70	5.17	0.35	4.73	5.98
India	33.74	2.04	30.80	37.30	6.60	0.76	5.85	8.18
Russia	49.96	4.23	41.30	54.40	9.52	1.47	7.35	11.61
South Africa	41.55	14.40	32.60	79.00	1.43	0.80	0.31	2.31
Total	46.99	12.31	30.8	79	10.33	0.90	9.36	11.87

Table-2: Descriptive Statistics (OECD countries)

Country	Education and innovation Index				Share of renewable energy			
	Mean	Std deviation	Min	Max	Mean	Std deviation	Min	Max
Australia	45.97	5.47	39.90	55.00	6.52	1.40	5.08	9.40
Austria	58.40	3.45	53.20	61.80	25.32	0.63	24.67	26.68
Belgium	56.61	4.36	48.10	61.50	5.31	1.43	3.77	8.62
Canada	51.05	4.27	43.50	58.10	20.66	0.40	20.08	21.42
Chile	42.53	4.88	34.00	50.60	16.65	1.85	14.29	19.65
Colombia	39.78	3.05	35.06	44.60	21.96	1.24	20.12	23.70
Czech Republic	58.05	1.94	54.60	61.21	5.50	0.46	4.67	6.44
Denmark	62.73	4.39	55.20	67.04	21.06	3.13	16.95	26.40
Estonia	53.69	4.48	48.20	63.70	6.23	2.10	4.01	10.47
Finland	61.36	3.35	56.90	64.35	17.40	1.61	14.74	20.19
France	56.49	1.99	53.50	59.70	7.15	1.04	5.89	9.38
Germany	62.93	3.13	58.00	68.80	11.90	2.20	9.24	15.75
Greece	46.90	2.85	43.00	49.88	10.97	1.85	7.45	14.41
Hungary	49.22	5.85	36.10	57.50	3.62	0.66	2.88	5.05
Iceland	58.14	3.30	51.80	62.10	44.65	0.65	43.63	45.37
Ireland	54.53	3.85	47.20	61.26	11.45	2.96	7.87	17.07
Israel	59.62	4.25	50.70	63.00	1.68	1.27	0.46	4.60
Italy	50.02	2.91	44.80	55.10	13.98	1.21	11.71	15.64
Japan	63.94	2.49	60.40	68.50	6.98	1.41	4.93	9.47
Latvia	47.08	2.81	43.20	50.50	17.72	2.29	15.20	22.46
Lithuania	49.55	3.63	43.00	54.40	8.01	1.55	5.21	10.04
Luxembourg	55.19	4.54	49.70	62.50	5.40	2.25	2.72	10.16
Mexico	38.14	4.57	31.20	43.90	5.82	1.09	4.50	8.29
Netherlands	58.59	2.30	54.00	60.70	4.74	1.77	3.33	8.72
New Zealand	49.25	5.41	43.40	57.80	26.52	0.47	25.96	27.21
Norway	62.46	4.97	53.20	66.72	40.59	0.47	39.91	41.40
Poland	52.47	4.28	44.50	58.32	5.28	0.71	4.40	6.64
Portugal	53.36	2.48	48.80	57.20	20.13	2.32	16.69	23.19
Slovenia	60.42	4.25	51.70	68.00	12.52	1.40	10.69	15.07
South Korea	73.40	6.09	58.90	79.00	1.77	0.61	1.02	2.89
Spain	47.29	3.84	42.60	54.00	13.67	1.22	11.93	15.54
Sweden	64.78	5.44	57.00	70.80	24.81	1.79	22.41	28.42
Turkey	60.90	4.17	54.30	64.90	21.01	0.90	19.95	23.06
United Kingdom	48.38	3.41	43.80	53.84	12.05	2.18	8.53	15.40
United States	59.16	4.77	53.20	66.51	9.01	3.25	4.37	14.64
Switzerland	57.19	3.55	51.40	62.28	6.72	0.93	5.64	8.39
Total	54.71	2.19	50.75	57.27	13.74	1.14	12.36	16.20

iv. Supply Chain Labour Standards

The renewable energy supply chain must adhere to high labour standards, including fair wages, safe working conditions, and the elimination of forced and child labour. Companies should conduct thorough due diligence to ensure that their suppliers and subcontractors comply with

labour standards. Transparency and traceability in the supply chain can help identify and address labour rights violations. Additionally, collaborating with industry initiatives and certification programs can support the implementation of ethical labour practices.

Product Liability

i. Product Safety and Quality

Ensuring the safety and quality of renewable energy products, such as solar panels and wind turbines, is critical for protecting consumers and maintaining public trust. This involves rigorous testing and certification processes, adherence to industry standards, and continuous monitoring of product performance. Companies must also establish robust quality control systems and respond promptly to any safety or quality issues that arise. Transparency in product information and clear communication with consumers are essential for building trust.

ii. Consumer Financial Protection

Protecting consumers' financial interests is crucial as the energy transition involves significant investments in renewable energy technologies and services. Consumer financial protection includes ensuring transparency in pricing and billing, preventing predatory lending practices, and providing clear and accurate information about financial products and services. Regulatory frameworks should be established to protect consumers from unfair practices and to ensure that they have access to affordable and reliable energy services. Additionally, financial education programs can help consumers make informed decisions about their energy investments.

iii. Privacy and Data Security

The increasing use of digital technologies in energy systems raises concerns about privacy and data security. Protecting sensitive information and ensuring cybersecurity are essential. This includes implementing strong data protection measures, conducting regular security audits, and complying with relevant regulations. Companies must also educate employees and customers about data security best practices and foster a culture of cybersecurity awareness. Collaboration with cybersecurity experts and participation in industry initiatives can enhance the overall security of energy systems.

iv. Responsible Investment

Responsible investment practices, which consider ESG factors, are crucial for directing capital towards sustainable energy projects that deliver positive social and environmental outcomes. This involves integrating ESG criteria into investment decision-making processes, conducting thorough due diligence, and engaging with portfolio companies to promote sustainable practices. Investors must also be transparent about their ESG policies and performance and engage with stakeholders to understand and address their concerns. Collaborative initiatives, such as the United Nations Principles for Responsible Investment (UNPRI), can support the adoption of responsible investment practices⁴. The Six Principles for Responsible Investment are shown in Figure-3.



Figure-3: Six Principles for Responsible Investment

v. Chemical Safety

The production of renewable energy technologies involves the use of chemicals that can pose risks to human health and the environment. Effective chemical safety regulations are needed to mitigate these risks. This includes implementing stringent safety standards for the handling, storage, and disposal of hazardous chemicals. Companies must also develop and adhere to comprehensive

chemical management plans, conduct regular risk assessments, and provide appropriate training to employees. Transparency in chemical use and proactive communication with stakeholders are also critical for managing chemical safety.

Stakeholder Opposition

i. Controversial Sourcing

The sourcing of materials and technologies for renewable energy projects can be controversial, particularly when it involves environmental degradation or social conflicts. Engaging stakeholders and ensuring transparent, ethical sourcing practices are essential. This involves conducting thorough impact assessments, consulting with affected communities, and implementing measures to mitigate negative impacts. Companies must also adhere to international standards and guidelines for responsible sourcing, such as the OECD Due Diligence Guidance for Responsible Supply Chains. Transparency and accountability in sourcing practices can help build trust and address stakeholder concerns.

ii. Community Relations

Fostering positive community relations is crucial for the successful implementation of renewable energy projects. This involves engaging with local communities early in the project planning process, addressing their concerns, and ensuring that they benefit from the project. Effective community relations can be achieved through transparent communication, participatory decision-making processes, and social investment programs. Building trust and fostering collaboration with local stakeholders can help mitigate opposition and ensure that projects are socially and environmentally sustainable. Companies must also consider the cultural, social, and economic contexts of the communities they operate in and tailor their engagement strategies accordingly.

Social Opportunities

i. Access to Finance

Ensuring access to finance for individuals and

businesses involved in the energy transition, particularly in developing countries, is essential for promoting inclusive and sustainable growth. This includes providing microfinance, loans, and grants to support renewable energy projects, offering financial education and training, and developing innovative financing mechanisms. Governments, financial institutions, and development organizations can play a crucial role in enhancing access to finance and fostering an enabling environment for sustainable energy investments.

ii. Access to Healthcare

Improving access to healthcare in communities affected by energy projects, particularly those exposed to environmental hazards, is crucial for promoting social welfare and resilience. This includes investing in healthcare infrastructure, providing medical services and support, and addressing health risks associated with energy production and consumption. Partnerships between energy companies, governments, and healthcare providers can enhance access to healthcare and improve health outcomes. In addition, by integrating health considerations into energy planning and decision-making processes can ensure that the health impacts of energy projects are adequately addressed.

iii. Opportunities in Nutrition & Health

Renewable energy projects can create opportunities for improving nutrition and health, particularly in rural areas by providing reliable electricity for refrigeration, cooking, and healthcare facilities. This includes supporting initiatives that promote clean cooking solutions, enhancing food storage and preservation, and improving access to clean water and sanitation. Renewable energy can also support the development of healthcare infrastructure, enabling the provision of essential medical services and improving health outcomes. Collaboration between energy companies, governments, and non-governmental organizations can maximize the health and nutrition benefits of renewable energy projects.

Governance Pillar

Corporate Governance

i. Board

Effective corporate governance, including diverse and independent Boards, is essential for ensuring that companies involved in the energy transition adhere to high ESG standards. This involves implementing governance structures that promote accountability, transparency, and ethical behavior. Diversity of Board Members which should *inter alia* include gender, ethnicity, and skill diversity, can enhance decision-making, and ensure that a broad range of perspectives is considered. Independent Board Members can provide objective oversight and help prevent conflicts of interests. Regular Board evaluations and training can also support effective governance.

ii. Pay

Executive compensation should be aligned with ESG performance to incentivize sustainable practices and long-term value creation. This involves linking a portion of executive pay to the achievement of ESG targets, such as reductions in carbon emissions, improvements in worker safety, and advancements in diversity and inclusion. Transparent and fair compensation practices can help attract and retain talent, promote ethical behaviour, and enhance corporate reputation. Shareholders and stakeholders should be engaged in the development and oversight of executive compensation policies.

iii. Ownership

Transparency in ownership structures and the alignment of ownership interests with long-term sustainability goals are critical for promoting responsible corporate behavior. This includes disclosing ownership information, ensuring that ownership interests are aligned with ESG objectives, and engaging with shareholders to promote sustainable practices. Institutional investors can

play a significant role in promoting responsible ownership by incorporating ESG criteria into their investment strategies and engaging with companies on sustainability issues.

iv. Accounting

Transparent and accurate accounting practices, including the disclosure of ESG-related risks and opportunities, are essential for informed decision-making and investor trust. This includes adopting standardized reporting frameworks, such as the Global Reporting Initiative (GRI) and the Task Force on Climate-related Financial Disclosures (TCFD), to ensure consistent and comparable ESG reporting^{5, 6}. Companies must also conduct regular audits and assessments of their ESG performance, identify and manage material ESG risks, and provide clear and comprehensive disclosures to stakeholders.

Corporate Behaviour

i. Business Ethics

Upholding high standards of business ethics, including integrity, transparency, and accountability, is crucial for maintaining public trust and ensuring the success of the energy transition. This involves developing and implementing codes of conduct, providing ethics training for employees, and establishing mechanisms for reporting and addressing unethical behaviour. Companies must also engage with stakeholders to understand their expectations and concerns and demonstrate a commitment to ethical business practices. Regulatory frameworks and industry initiatives can support the promotion of business ethics⁷.

ii. Tax Transparency

Tax transparency and responsible tax practices are important for ensuring that companies contribute fairly to public finances and support sustainable development. This includes disclosing tax policies and practices, avoiding aggressive tax planning, and

paying taxes in the jurisdictions where economic activities occur. Companies must also engage with tax authorities and stakeholders to promote fair and transparent tax practices. Regulatory frameworks and international initiatives, such as the OECD's Base Erosion and Profit Shifting (BEPS) project, can support the promotion of tax transparency and responsible tax behavior⁸.

Conclusions

The energy transition represents a complex and multifaceted challenge, requiring careful consideration of ESG factors to ensure a sustainable and equitable shift towards renewable energy. By addressing the key issues within the environmental, social, and governance pillars, stakeholders can navigate the ESG dilemma and promote a transition that delivers positive environmental, social, and economic outcomes. Collaborative efforts between governments, businesses, investors, and civil society are essential for achieving a just and sustainable energy transition.

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CEAI NEWS

SEMINAR ON “URBAN MOBILITY & EMERGING TECHNOLOGIES”

The seminar on *"Urban Mobility and Emerging Technologies"* held on 19th July 2024 in Bhopal, was a big success with participation of over 150 delegates

Mr. Rajendra Shukla, Hon'ble Dy. Chief Minister Government of Madhya Pradesh inaugurated the Seminar. Mr. Alok Sharma, Hon'ble Member of Parliament (Lok Sabha), graced the occasion as the Guest of Honour.



Shri R S Sharma, President, CEAI welcomed the dignitaries, the speakers and the participants and apprised the audience about CEAI and its activities. With regards to the seminar per se he said that a substantial percentage of India's population lives in cities and

towns; that number is growing and the exodus is putting pressure on the services in the urban areas. The habitants of the urban areas need to travel, from their place of residence for their work, studies, etc., and to other urban areas. A lot of their productive time is being spent on travel. To reduce the time spent on travelling, urban areas are being connected through expressways and better roads within the urban areas. However, reaching the destination and travel within the urban area was currently strenuous and time consuming.

To alleviate the day-to-day problems of mobility, new modes of transport such as Rapid Rail Transit, Metros Rails, and high-speed railways are coming up. In all those, technology is also changing very fast. Fossil fuels are giving way to electric vehicles. Huge investments are being made in the USA and other developed countries on Artificial Intelligence. Big changes await all in the near future when most gadgets would be equipped with AI.

Considering the importance of Urban Mobility, CEAI had decided to hold a Seminar to deliberate on the emerging technologies in the field.

CEAI had so far organized events in Delhi and cities like Kolkata and Mumbai, hence there was concern about moving out and venturing to smaller cities like Bhopal. However, CEAI's young and energetic Hon'ble Secretary took upon himself the responsibility and assured that he would be able to do it. That dream has come true as this seminar is being held today in a grand manner. Shri Navneet Sharma, CEO of Lion Engineering and Hon'ble Secretary CEAI, his entire team, all ably supported by his father Shri O.N. Sharma deserve a big applause.

Mr. R S Sharma added that during his over 50 years of professional experience both in government and private, he had observed that people are capable of implementing programmes but there are slips during planning. Most of the time they do short term planning and seldom think of future generations. People start thinking only when a crisis occurs.

Mr. Sharma continued and said that India has a glorifying history. Adding that the *Puranas* show that India had highly advanced technology in ancient times, he said that Indians could be world leaders even now, since they have the skills for it. It only requires able leadership, long term vision for the future and the determination to do big. He added that he was confident that the leaders both in the Centre as well as in the State of Madhya Pradesh were capable of doing that.

Moving on, Mr. Sharma said that the field of urban mobility was very vast and could not be covered in a day. It requires multiple seminars, and at times different audiences. Hence, the Seminar was covering RRTS for intra-city travel, and Metros for mobility within a city.

Mr. Sharma drew attention to non-motorised transport specially bicycles which he said were also a very important mode and need to be encouraged being the most environment friendly mode especially for small distances. Pedestrian movement also needs to be encouraged as it is good for general health. He added

that in developed countries such as the USA, every citizen whether young or old, healthy or handicapped travel on footpaths while going for shopping or outings. To encourage such habits in India, safe and seamless facilities need to be provided for all roads and streets. Both the modes had been included in the seminar.

Thereafter he said that the maximum number of fatalities on Indian roads involved pedestrians and two wheelers, hence serious work was required in that field. The movement of pedestrians and non-motorised transport would increase only when a safe environment is provided for them. Mr. Sharma pointed out that apart from other advantages those modes are most suitable from sustainability consideration, as these run purely on human energy.

Mr. Sharma pointed out that students are the future leaders, hence apart from the professionals in the field of design and construction, CEAI had invited students from local colleges and universities so that they would learn about the emerging technologies from the domain experts. To explain to them there were learned speakers, who have vast experience in teaching plus there were other delegates from whom they could learn.

In conclusion Mr. Sharma said that he expected that the participants would be greatly benefitted by the one-day Seminar and that CEAI would be willing to organize such seminars and training courses in future also for the benefit of the profession. He added that CEAI could help in designing pedestrian friendly roads and streets for the City of Bhopal on a sample basis which could then be replicated elsewhere.



Mr. Rajendra Shukla (Hon'ble Deputy Chief Minister, Government of Madhya Pradesh) congratulated CEAI for organizing the Seminar on Urban Mobility in Bhopal. He said that since traffic conditions were changing drastically, there was a need

to update technology to deal with the need of the hour i.e., a transportation system which would be readily accessible to people in a cost-effective manner. He added that as the population, businesses and per capita income

were rising, there was also an increase in the number of cars that were being driven on the roads. Therefore, the budget that they would present to the government would aim to improve the sustainability of the transportation system for the coming 50 years.



Mr. Alok Sharma, Hon'ble Member of Parliament, (Lok Sabha), while congratulating CEAI said that the seminar comprising skilled experts as well as students from different colleges and universities had verily come together. He spoke about the contribution of the new technology in urban mobility for a green economy and sustainability benefits for the present generation as well as those in the near future.



Mr. Navneet Sharma, CEO, Lion Group also welcomed and thanked the dignitaries, the speakers and the participants. Addressing the participants, Mr. Navneet Sharma said that since there was a lot of pressure on the habitants, accidents were increasingly occurring in the city and elsewhere in the country. The seminar on Urban Mobility was to discuss how and where new technology could improve the urban mobility systems and directly contribute to the improved lifestyle of the people. In the seminar, the speed and timing of the transportation system would be discussed, so that regular commuters for work or studies could consider using the public transportation system because of its lower cost and lesser travel time. He suggested that people should consider walking to their respective destinations since that would help to improve their health and also contribute to a much greener economy. He concluded by saying that the event also aimed at discussing working more on new and improved technologies to cope with the upcoming traffic conditions in a shorter span of time.

To sum up, the seminar aimed at discussing the importance of emerging technologies with active collaboration from country's policy makers, consultants, contractors, researchers and academics to decide a way

forward to support the government in achieving those targets set to become the world's 3rd economy.

The seminar was very well received. The participants were appreciative of the speakers and described them as 'Excellent', 'Very insightful', 'Informative', 'Amazing', 'Very lucid and very clear', 'forthright exposition of the issues', 'Very impactful', 'brilliant' and 'aptly brought out the underlying agendas', etc.



Welcome Address by President CEAI



*Welcoming of Chief Guest by
Mr. R S Sharma President CEAI*



*Presenting a Memento to Guest of Honour by
Shri O. N. Sharma Chairman Organising Committee*



*Shri Rajendra Shukla
Dy Chief Minister Madhya Pradesh, lighting the lamp*



*Shri Alok Sharma
Member of Parliament, Bhopal, lighting the lamp*



*Setting the Context by
Shri J V L Narayana Vice President CEAI*



*Shri Alok Sharma, Hon'ble Member of Parliament,
(Lok Sabha), Bhopal*



*Shri Rajendra Shukla, Hon'ble Deputy Chief Minister,
Government of Madhya Pradesh*



Session 1: RRTS Officers from NCRTC



Session 2: Bhopal Metro - Officers from MP Metro



Session 3: Non-motorised Transport and Pedestrian Mobility



General Manager Bhopal Metro



Mr. Sudhir Dhawan - Past President CEAI



S. Gangopadhyay – Former Director CRR



Organising Team



*Dr. P K Sarkar (Former HOD Transport Planning,
SPA Delhi)*



Participants



Participants

You Tube Link: [Seminar on “Urban Mobility & Emerging Technologies” \(youtube.com\)](#)

FIDIC Trainings

FIDIC Training (In-house) was organised with the support of National High Speed Rail Corporation for TCAP on 22nd & 23rd July 2024 at Ahmedabad, 25th to 27th July at Surat, 29th & 30th July at Mumbai and 31st July to 2nd August at Delhi.

Over 500 officers of NHSRC and TCAP including representatives of Contractors and Consultants participated. Mr. Bogdan Oprea, an international FIDIC Accredited Expert conducted the training on Module 1 and Module 2. At the closing session of each, CEAI thanked the officers of NHSRC, Mr. Bogdan Oprea and all the participants for their help and cooperation.



Felicitation of Directors NHSRCL by Chairman FIDIC Committee CEAI



Felicitation-MD NHSRCL by President CEAI



Shri JVL Narayana Vice President CEAI



Shri Vivek Gupta, NHSRCL



View of Participants



Training in Progress - Ahmedabad



Participants in Surat



Training in Progress - Mumbai, CEAI-FIDIC Training for NHSRC and TCAP – Officers and Staff

SEMINAR ON “QUALITY OF DESIGN AND CONSTRUCTION FOR SUSTAINABLE INFRASTRUCTURE”

A two day Seminar was organised on “*Quality of Design and Construction for Sustainable Infrastructure*” on 12th & 13th August 2024 at Le Meridien, New Delhi. It was an overwhelming success – more than 100 delegates attended it on both the days.

The seminar addressed the entire gamut of the quality of design and construction in a built environment covering Railways and Highway Elevated Transportation Structures, the Buildings sector and the Water sector.

The intent was to encourage the engineering fraternity to work towards achieving India’s aspiration to be a global engineering hub. The engineering consultancy sector should on its part work towards achieving a high degree of excellence in the quality of the engineering projects.

The Seminar aimed to address the challenges and opportunities for engineers to achieve quality along with sustainability in projects. It also showcased the best practices and solutions and advocated the adoption of digitalisation to meet the highest standards of Quality.

Mr. O P Goel former DG – Central Public Works Department (CPWD) was Chief Guest and Mr. Md Naimuddin, Additional Director General (Tech), CPWD was the Guest of Honour. Both of them set the stage with their insightful talks. While emphasizing on the importance of the timely seminar in view of burning issues in the quality of design and construction in the built environment, they also suggested that the seminar

should come out with some useful recommendations to adapt to the potential risks of climate change facing the globe.

There were six sessions; two each of which focused on the Transport, Buildings and Water sectors. There were expert speakers from the industry and The World Bank, with National and International experience. The presentations were of a high quality, educative and informative. The Seminar concluded with a panel discussion on Quality and Sustainable Infrastructure. The Q&A sessions had active participation by the delegates. Each sector was addressed by handpicked domain experts who not only focused on quality of design and construction in general but also the digital interventions and the action to be taken because of the climate change to mitigate the emergencies created by that.

In the transportation sector, bridges have in the recent past been fraught with unabated mishaps during construction and also of those in service. To compound the issue, India is on an unprecedented growth path led by numerous mega projects which has a direct correlation with the mishaps due to many factors. The challenges and the remedies for the issues that the mega projects present and the mitigation measures to obviate mishaps of bridges were the key takeaways, highlighted by the experts of the transportation sector.

The building sector experts dwelt on the challenges faced including those on account of climate change and suggested measures to alleviate them. They highlighted that digital interventions were not being exploited to

their potential in this sector. Digitalisation could bring in a sea change in this sector. Operational and Embodied carbon neutrality aspects were synthesized in detail. The key take away were the illustrations on the green airport design and construction.

As regards the water sector – the speakers stressed and enlightened on resilient water management, adoption and implementation of Circular Economy for water neutrality, Sustainable procurement strategy and improving efficiency in all aspects from extraction to recycling by digital interventions.

The panel discussions in the final session were the hallmark of the seminar. All the aspects of sustainability including quality of design and construction were once again brainstormed in the panel discussion and the takeaways were summed up by the panellists of various sectors. The testimony of overwhelming success of the seminar engagement of all the participants till the last minute. The Vote of Thanks was given by Mr. V N Heggade, Chairman – Technical Committee.



Lighting of the lamp by the Chief Guest



Welcome Address by President CEAI



R S Sharma, President CEAI Welcoming the Chief Guest and the Guest of Honour



Context Setting by Ms. Sayona Philip Chairperson, Quality and Ethics Committee



Keynote Address by Mr. K K Kapila



Vote of Thanks by Mr. V N Heggade



Address by Guest of Honour Mr. Md. Naimuddin



Inaugural Session



Address by Chief Guest, Mr. O P Goel



Session 1: Quality of Elevated Infrastructure



Session 2: Quality of Bridge Structures



Session 5: Sustainable Quality in Design and Construction



Session 3: Green Buildings



Session 6: Sustainability Considerations in an Infrastructure Project Life Cycle



Session 4: Quality of Built Assets



Valedictory Session



View of Audience



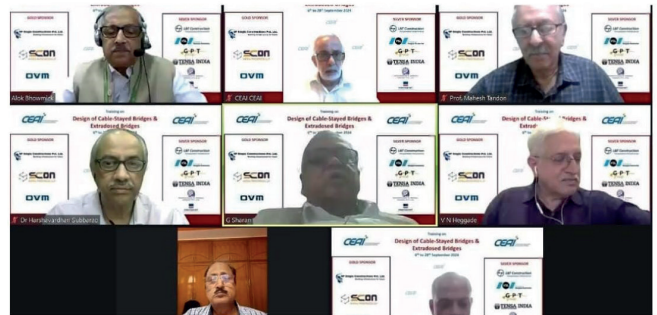
CEAI ACADEMY ONLINE TRAINING COURSE ON “DESIGN OF CABLE STAYED BRIDGES AND EXTRADOSED BRIDGES”

The online training course on “*Design of Cable-Stayed Bridges & Extradosed Bridges*” organised by CEAI-Academy, was a phenomenal success. The 24-hour training course, covering planning, design, construction, maintenance and monitoring of cable-supported bridges, was spread over 4 weeks and was held from 6th to 28th September 2024 on every Friday and Saturday between 4pm to 7 pm. The Course Coordinator was Er. Alok Bhowmick and the course was moderated by Er. V N Heggade.

The Course was inaugurated by Shri D. Sarangi, Director General (Road Development) and Special Secretary MORTH, Government of India and was graced by Shri G Sharan, Former DGRD and Convener of IRC B-9 Committee on Special Structure. Shri R S Sharma, President CEAI welcomed the participants and Mr Alok Bhowmick provided insights for the training course.

15 lectures were delivered by domain experts on the subject and at the end there was a panel discussion regarding the future of cable supported structures. The lectures were followed by an interactive Q&A session with participants queries answered by a panel of experts. The day wise break-up of the topics and the brief on each is given below.

- a) Day 1: Two Lectures - Broad Overview of the New Guidelines of the Indian Road Congress (IRC) on Cable Supported Bridges
Prof. Mahesh Tandon and Er. Alok Bhowmick



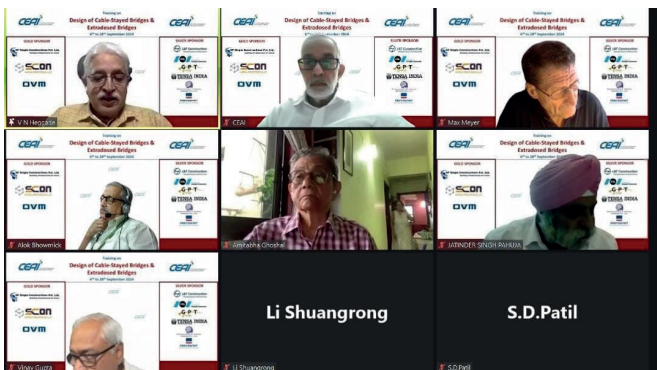
- b) Day 2: Two Lectures - Design Aspect of Cable Supported Bridges
Er. P G Venkatram



- c) Day 3: Two Lectures - Treatment of Wind Forces and Earthquake Induced Forces
Prof. Prem Krishna and Prof. Yogendra Singh



- d) Day 4: Two Lectures - Stay Cable Technology and its Durability Aspects
Er. Jatinder Singh Pahuja and Dr. Max Meyer



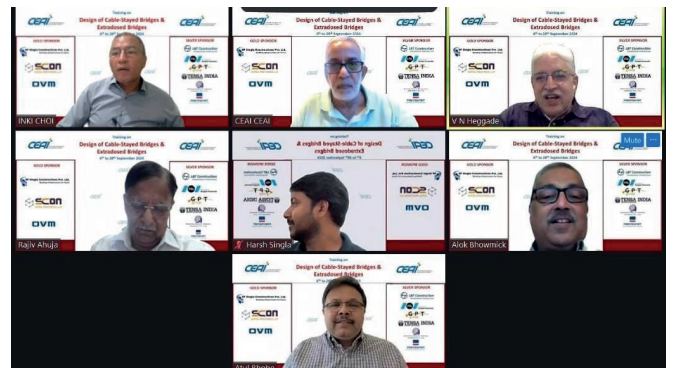
- e) Day 5: Two Lectures - Construction Aspects in Cable Supported Bridges
Er. Deepak Singla and Er. C Sankaralingam



- f) Day 6: Two Lectures - Inspection, Maintenance & Monitoring of Cable Supported Bridges
Er. Amitabha Ghoshal and Dr. Lakshmy Parameswaran



- g) Day 7: Three Lectures - Case Studies of Longest Span Cable Stayed Bridges and Extradosed Bridges
Er. Rajiv Ahuja, Er. Inki Choi and Er. V N Heggade



- h) Day 8: Panel Discussion and Proficiency Tests



There were over 300 participants for the online course from India, Nepal, and UAE; from Consulting Firms, Contracting Firms, Government Organisations, R&D Organisations and Students.

The training course was sponsored/ supported by firms representing contracting industry and stay cable system suppliers.

The Key Takeaways from the Training Course were:

Participants were given a broad overview about the content of the forthcoming IRC codes on Cable Supported Bridges. It covered all aspects of the design, construction planning, execution, maintenance and monitoring. Faculty who delivered the lectures were experts. Many of them are involved in the development of the IRC guidelines.

a. Key-Takeaways for Practicing Designers

The course traced the historical development of these bridge types, from their precursor to present practise. The lectures covered planning and conceptual design and preliminary design methods. Emphasis was laid on explaining the flow of forces in case of cable supported bridges and also explaining fundamental difference between girder bridges, extradosed bridges and cable stayed bridges. Design intricacies for Wind & Earthquake were covered in detail. Importance of construction-friendly design was emphasised. It was made clear to all the participants that design of cable supported bridges require high level of skill, experience and exposure. It is a multi-disciplinary activity requiring close interaction between contractors, temporary and enabling structure designer, stay cable system supplier, bearing and expansion joint supplier, etc.

b. Key-Takeaways for Engineers involved in Execution

Construction engineers were exposed to the challenges that needs to be faced in constructing cable supported bridges. Various alternative methodologies for construction were discussed and several real-life case studies from Indian projects were discussed to highlight the challenges. It was made clear by many of the speakers that

the structures are complex in nature, requiring highly specialised techniques for their execution. Such bridges require constant supervision by the contractor's senior staff since a very high degree of quality control is essential. The procedures that are practiced routinely for conventional bridges are not sufficient for Cable Supported Bridges. Only competent and experienced contractors, specialised sub-contractors, equipment suppliers and certified skilled operators should be involved in execution at site.

c. Key-Takeaways for Engineers involved in Construction Supervision (Owners, Authority's Engineer, Independent Engineers)

The course flagged the importance of supervision during execution, quality control and quality assurance for cable supported bridges. It was emphasised that teamwork is absolutely necessary for success in these types of complex structures. Owners must ascertain that the culture of checking and reviewing all field activities exists at the site of works, from start to finish. There were several lectures in the training course which emphasised the need to create special provisions for ensuring structured procedures for inspection, maintenance and monitoring of these types of bridges.

d. Key-Takeaways for Student

Students were exposed to the complexities involved in planning, design and construction of such bridges. They got a flavour about cable supported bridges, which are coming up fast in the country. They understood that it is a fascinating field of specialisation but a demanding field.

List of Participating Organisations

CONSULTANTS	GOVERNMENT DEPARTMENTS
Aartav Engineering Pvt Ltd	Central Railway
Aarvee Associates	Department of Roads, Bridge Branch
ADS Consultants	Indian Railways
AECOM India Pvt Ltd	Indian Railways Institute of Civil Engineering, Pune
AMAG Infrastructure Pvt Ltd	IRCON
Assystem India	Kerala Highway Research Institute
Aty Consult	Kerala Infrastructure Investment Fund Board
AYESA India Pvt Ltd	Kerala Public Works Department
B&S EC	MORTH
CASAD Consultants Pvt. Ltd.	National High Speed Rail Corporation Ltd
CDS Consult (India) Pvt. Ltd.	Public Works Department, West Bengal
Consulting Engineers Group	Public Works Road Department
Consulting Engineers Group Ltd.	PWD Maharashtra
COWI India Private Limited	PWD Odisha
DELFI Consulting Engineers (India) Pvt. Ltd.	PWD, Government of West Bengal
Dohwa	Railway Board
Force Structural Engineers Pvt Ltd	Staff Training College, Gujarat
GHD Pty Ltd	West Central Railway
HBS Infra Engineers India Private Limited	
ICT Pvt. Ltd.	EDUCATIONAL/ RESEARCH INSTITUTIONS
Indus Consultants Pvt. Ltd.	CAPA IC
Infinite Civil solution pvt ltd	CSIR - Central Road Research Institute
INFINITE Civil Solutions Pvt Ltd, Ahmedabad	ECR Hajipur
Infra Design Studio Pvt. Ltd.	Galaxy Global Group of Institutions
K&J Projects Private Limited	IIT Guwahati
LEA Associates South Asia Pvt Ltd	IIT Kanpur
Paragon Consultant	IIT Roorkee
SATRA Services and Solutions Pvt Ltd	IIT Delhi
Projects Consulting India Pvt Ltd	Indian Institute of Technology Mandi, India
RAMBOLL INDIA PVT LTD	Jadavpur University
RIE STRUCTURAL PVT LTD	Jamia Millia Islamia
Rithwik projects private limited	JNTU College of Engineering Hyderabad
Rodic Consultants Pvt. Ltd.	Motilal Nehru NIT, Allahabad UP
S2F Consultancy and Construction Pvt. Ltd.	MVR college of Engineering
SA Infrastructure Consultants Pvt. Ltd.	MVSR ENGINEERING COLLEGE
Samprisha Consultants	Quantam university
SMEC	R.G.P.V university

SPS CIVIL INFRA DESIGN PVT LTD	SCOE
Sri Infotech	SWR
Structcon Designs Pvt Ltd	VIT Vellore
STUP Consultants Pvt. Ltd.	VNIT Nagpur
Systra	WCTM, MDU
Tandon Consultants	XEN Design Ner
TATA Consulting Engineers Limited	Cube Highways Technologies Private Limited
Tech TANGENT Solutions Pvt Ltd	OVM
Theme Engineering Services Pvt.Ltd	
Transplex Infra Services Pvt. Ltd.	
FOREIGN DELEGATION	CONTRACTORS/ CONCESSIONAIRES
Consultant / Clients from Nepal and UAE	Afcons Infrastructure Ltd.
SPONSORS	AKC ANUV
S P Singla (GOLD)	Assystem India
Scon Infra Prestress LLP (GOLD)	Dineshchandra Infracon
Dineshchandra Infracon	GILCON PROJECTS SERVICES LIMITED
FREYSSINET India (SILVER)	GPT INFRAPROJECTS LIMITED
GPT Infra (SILVER)	L&T Construction
L&T (SILVER)	RUKY PROJECTS PRIVATE LTD
TENSA India (SILVER)	S.P.Singla Constructions Pvt. Ltd.
VSL India Pvt Ltd. (SILVER)	VR2 INFRA SOLUTIONS PVT. LTD.

OTHER NEWS, VIEWS, NOTES

REPORT OF THE VISIT OF PRESIDENT CEAI TO FIDIC GENEVA MEETINGS AND GIC 2024

a. 7th September 2024 FIDIC Directors and Secretaries (DNS) and Presidents Meeting 2024

In the earlier FIDIC events the DNS meeting had been held in the morning and the Presidents meeting in the afternoon. However, this year the DNS and the Presidents meetings were combined, but that had not been informed earlier. Since the flight itinerary of President CEAI precluded his attending in person, Mr. Gagan Anand, Member Governing Council CEAI was requested to attend the morning meeting. President CEAI attended a part of the afternoon meeting.

The Agenda and the Outline of the discussion held as reported by Mr Gagan Anand are attached.

The members present were divided into groups and discussions were held in the groups on the preidentified topics and subtopics.

b. 8th September 2024 FIDIC General Assembly Meeting (GAM) 2024

The meeting was chaired by the President FIDIC. The items as per agenda were taken up for discussion. All the agenda items proposed and circulated were approved by voice vote. President CEAI represented India in the GAM meeting.

Notable decisions are as below:

1. The accounts statement for 2023 were presented and passed.
2. The budget for 2024 were presented and passed.
3. The representative of Romania was declared elected to the Board by a comfortable margin vis-à-vis the representative from Pakistan.

4. The proposed fee structure which is 1.5% of gross revenue (average of latest three years) as proposed was accepted.

c. September 2024 FAP Meeting

In the absence of FAP President Mr Sudhir Dhawan, the meeting was chaired by Mr Prashant Kapila Regional Head FIDIC Asia. Only 5 delegates attended. The synopsis of discussions held are given below.

Synopsis of the FAP MEETING held on the sidelines of the GIC on 8th September (as circulated by Mr. Prashant Kapila)

Participants: India, Japan, Philippines, South Korea, Vietnam.

Consolidated List of the views expressed by the Participants.

- Regional Conferences must focus more on regional issues.
- There is a need for the Regional Conference to provide deep insights, on the local and regional issues presented.
- There needs to be greater interaction with MDB's/IFI's funding development projects in the region. A mechanism for this engagement must be developed.
- In the FIDIC Meeting held annually with ADB, the FAP Board Member should be a member of the delegation.
- Regional MA's must engage more with the FIDIC Academy & FCL Certification. FIDIC Academy provides 80:20 revenue sharing model for MA's. Regional MA's must engage with FIDIC Academy to effectively use this, to provide training for its member firms and their staff.
- There is a need for the region to have more
 - FIDIC Certified Trainers
 - FIDIC Certified Adjudicators
 - FIDIC Certified Professionals
- Enhanced business co-operation between Countries and MA's.

- MA's must try to engage other regional MA's when holding their conferences; to both increase collaboration besides tapping into good speakers from within the region.
- There needs to be a stronger and more concerted effort to increase membership both within FAP and also getting new MA's from the region to join FIDIC.
- Coordinated and concerted effort within FAP to support a balanced regional representation on the FIDIC Board. (Target 2- 3 Board members from the region at all times).

FIDIC Global Infrastructure Conference- 2024

9th and 10th September 2024

The theme of the conference was ***“Transforming Lives with Infrastructure - Investing in and Building a Better World for All”***

The conference was in the form of Panel Discussions. It comprised 7 sessions.

Panel Session 1:

Transforming Lives with infrastructure – Investing in and building a better world

Panel Session 2: Show me the money- De risking and Leveraging infrastructure

Panel Session 3: Decarbonising Infrastructure- towards a sustainable future

Panel Session 4: Focus on the developing world- the specific challenges of emerging markets and developing economies

Panel Session 5: The Politics of Infrastructure - Influencing Governments and persuading politicians

Panel Session 6: Global Infrastructure - Showcase

Panel Session 7: Leading the way - a view from Industry Leaders

The Sessions were chaired mostly by the FIDIC Board Members. Session 1 was chaired by Mr. Manish Kothari (Rep Sheladia Consultant, USA) and Session 4 was chaired by Mr. Prashant Kapila.

Prominent persons from Consulting Firms and Industry participated in the Panel Discussions.

In case the proceedings of the Conference are made available by FIDIC the same will be shared with members of CEAI, as they may be of interest to some.

FIDIC AWARDS

FIDIC Member Association Excellence Award 2024

- CEAI was declared as winner in the Category of MA Excellency in Consultancy Service- “Showcasing value initiative-Consulting Engineer-CEAI Compendium” in bringing out the *CEAI Compendium* depicting key engineering projects in the 75 years of Independence and was conferred with the FIDIC Member Association Excellence



Award 2024 during the Gala Dinner of the FIDIC Global Infrastructure conference held from 8th to 10th September 2024 in Geneva.

Mr. R S Sharma, President CEAI received the award on behalf of CEAI.

- India also received another award which was given to the Dedicated Freight Corridor Corporation of India (DFCC) for ‘East-West Connectivity of Dedicated Freight Corridors in India’ as **Highly Commended** in the **Megaproject category**.

Mr. Ajit Kumar Mishra GM, DFCC and his colleague Mr. Ajay Kumar and Mr. Prashant Kapila received the award. Project Name: East-West Connectivity of Dedicated Freight Corridors in India.

REPORT ON ADB’S BUSINESS OPPORTUNITIES SEMINARS IN MUMBAI AND KOLKATA

CEAI was a Supporting Partner for the Asian Development Bank’s (ADB’s) Business Opportunities Seminars which were held in Mumbai on the 7th and in Kolkata on the 27th September 2024.

In Mumbai, Mr. A P Mull Member GC and Past President CEAI made a presentation about CEAI. He covered the various seminars, workshops, courses, webinars, etc. organised by CEAI including training on FIDIC Contracts by FIDIC Accredited Trainers and stressed that it is the only authorised body in India which can give a certificate for Training on FIDIC Contracts conducted in the country. He invited all Professionals connected with Engineering Projects to join CEAI. He also informed the audience that CEAI along with ECI and other associations was pursuing for the enactment of legislation for the Profession of Engineering.

Mr. Amitabha Datta, Past Chairman Eastern & Northeastern Region made the presentation in Kolkata and also stressed on FIDIC Training and invited professionals to join CEAI and strengthen the engineering fraternity.

Both the seminars were well attended and there was good interaction with all present.



Mr. A P Mull making a presentation about CEAI at the seminar in Mumbai



Mr. Amitabha Datta making a presentation about CEAI at the seminar in Kolkata



View of the dais at the seminar in Kolkata



View of audience at the seminar in Mumbai



Representatives of Organising & Partnering Organisations in Mumbai



Organisers, Partners and Participants at the seminar in Kolkata

MEMBER NEWS

- Dr. Ajay Pradhan, Member Governing Council and Past President of CEAI, has been Appointed as Member of FIDIC Integrity Management Committee.
- Mr. Gagan Anand, Member Governing Council, CEAI has been appointed as Member of the FIDIC Contracts Committee, Geneva for a term of 3 years.
- Mr. Amitabha Ghoshal's article on "*Why Bridges Keep Falling in India*" was published as the lead article on the Editorial page of the New Indian Express, of 3rd July 2024. Mr. Ghoshal is a Member of the Governing Council and a Past President of CEAI. Following that, a newspaper from Bengaluru initiated an interview with Mr. Ghoshal on the subject.
- Dr Harshavardhan Subbarao, CEAI Member has been elected as President of the International Association for Bridge and Structural Engineering (IABSE) at its meeting on 24th September 2024 in Costa Rica.
- Mr Sunil Srivastava, CEAI Member has been appointed as Member of the Supervisory Board of Uzbekistan Railways.

CEAI Congratulates them.

CEAI NATIONAL AWARDS 2024

CEAI has announced the *CEAI National Awards 2024*, recognising Excellence in Engineering Consultancy Services.

Categories of the Awards

For Organisations:

Excellence in Engineering Consultancy Services (separate awards for two groups based on average turnover in consultancy services over the last 3 years)

- Group 1: Average turnover up to ₹50 crores
- Group 2: Average turnover above ₹50 crores
- Categories:
 - Category A: Excellence in Project Engineering
 - Category B: Excellence in Engineering Innovation

For Individuals:

Achievement Awards in Consultancy Services

- Categories:
 - Category A: Excellence in Project Engineering
 - Category B: Excellence in Engineering Innovation

Nomination Details:

- Open to all organisations and professionals, regardless of CEAI Membership.
- Brochure and Nomination Forms (may be obtained from CEAI Secretariat)

- Last date for receipt of nominations: October 31, 2024

CEAI invites your participation in the prestigious CEAI National Awards 2024.

FORTHCOMING EVENTS OF CEAI

- Conference on "*Recent Development of Laws and their Impact in Construction Industry*" on 18th October 2024 at Taj President, Cuffe Parade, Colaba, Mumbai.
- SEPC-CEAI Global Services Export Conclave on "*Design, Engineering, Construction, Space, Energy (incl. Nuclear) and Defence*" is scheduled on 29th October 2024 in New Delhi
- "*Construction Law Course*" on 8th, 9th, 10th and 16th November 2024 in New Delhi.

OBITUARY



With heavy heart, we have to inform that Mr. Jeffrey Aloysious Nambiar, Director, Chempro Expertise Pvt Ltd departed from this earth on 10th August 2024, while he was in Hallstatt, Austria on a vacation with his family.

Mr. Jeffrey was a member of a number of committees of CEAI. He participated actively in all meetings and contributed immensely. CEAI will miss him badly.

Jeffrey Nambiar represented Chempro in the Committees of the Consulting Engineers Association of India. He was the Hon. Secretary & Treasurer of CEAI's Western Region Centre ever since its inception over 14 years ago and strived along with the others to make it a vibrant centre for CEAI, organising seminars, courses, workshops, lectures, webinars, etc. and also share his knowledge and experience for the benefit of fellow professionals.

The Members of CEAI-Western Region Centre will always have very good memories of the time that they spent together with Jeffrey at meetings, organising events and at the event itself conducting them fruitfully. His dealings and conduct were always ethical. His dedication and unflinching contributions to CEAI and the engineering fraternity that he represented will be remembered.

CEAI conveys its deepest condolences to his family members and prays that his noble soul rest in peace.

VIEWPOINT

The theme for the December 2024 issue of CEAI's quarterly magazine ***“ViewPoint”*** is ***“Recycling & Reuse of Building Materials in the Construction Industry”***.

The December 2022 issue was on ***“Circular Economy towards Sustainability”*** hence this issue could be considered as a sequel to that.

Discussions and mandates based on sustainable considerations and to combat climate change are the norm. However, how much has really changed or in the process of being changed needs to be measured and tracked. While there is a tremendous amount of new construction being done there are also a very large number of facilities being dismantled and demolished. The questions that arise are -Is the dismantled and demolished materials a waste or can they be recycled and reused? The answer to both would be that a large quantum can be recycled and reused. The dismantled material could be used as is or modified for reuse. A lot of material if demolished carefully could be processed and reused. All permissions for re-construction or even new construction need to be mandated to do so. Some sectors could very easily and successfully utilise demolished material.

While the theme for this issue is Building Materials however, the same logic applies to all manufactured items as well. In the IT industry, while it is necessary for it to come up with new technology, but that should not make the older items or technology obsolete for a period of about 25-30 years. It should be possible to continue to use them or modify them for continued use.

A number of consulting engineers and smaller organisations are engaged in the works which address and adopt practices of sustainable development incorporating recycle and reuse of materials or could address the issue. Many do not receive the recognition they deserve since their works do not get publicized. CEAI's ViewPoint provides an opportunity to all those engaged in such activities to share case studies of their achievements, how they addressed the challenges faced, practical issues experienced and the solutions to those, etc. in the various disciplines of engineering. Photographs, charts, diagrams, drawings, etc. would benefit readers for a better appreciation of the issues encountered and the manner in which they were addressed.

The articles for an issue need to reach CEAI at least 3 weeks prior to the end of the month of the ViewPoint issue. Articles need to be in Times New Roman 12 with single line spacing with before and after 6 pt and normal

margin, on A4 size. A recent clear and bright passport size photograph of the author(s) is to be sent along with the article. For details of formatting please refer to “*Format for Articles for CEAI Viewpoint*” on CEAI’s website, under ‘Publications’.

We urge all Professionals to use CEAI’s ViewPoint to showcase the capabilities and achievements of the Engineers in India plus educate and guide new engineers.

The themes for 2025 will be decided by the Publication Committee that will be formed after the new Governing Council is elected for the term 2025-2026.

The articles for an issue need to reach CEAI at least 3 weeks prior to the end of the month of the ViewPoint issue. Articles need to be in Times New Roman 12 with single line spacing with before and after 6 pt and normal margin, on A4 size. A recent clear and bright passport size photograph of the author(s) is to be sent along with the article. For details of formatting please refer to “*Format for Articles for CEAI Viewpoint*” on CEAI’s website, under ‘Publications’.

Advertisement in ViewPoint

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VIEWPOINT

ViewPoint is circulated to all CEAI Members, FIDIC, Ministries of the Government of India, Public and private Sector Undertakings, Construction Firms, Contractors, Consultants, Foreign Missions and Funding Institutions in India and other organisations related to or dealing with the engineering profession. Thus, all stakeholders partnering development and progress are its readers.

Support from CEAI members and stakeholders are sought for increasing the number of advertisements so that ViewPoint gains in its stature as a unique Technical Publication for the fraternity and the public at large to spread information about how Consulting Engineers are helping society for improving the quality of life and doing so sustainably. The rates for advertisements in **VIEWPOINT** with effect from 1st January 2023 are given below:

Item	Rate Per issue* (Rs)	Discounted rate at 10% for 2 consecutive issues* (Rs)	Discounted rate at 20% for 4 consecutive issues* (Rs)
Back Cover	25,000.00	45,000.00	80,000.00
Inside Front Cover	18,000.00	32,400.00	57,600.00
Inside Back Cover	18,000.00	32,400.00	57,600.00
Full Page (Colour)	12,000.00	21,600.00	38,400.00
Full Page (Colour), if a specific page position is required.	14,000.00	25,200.00	44,800.00
Full Page (B&W)	8,000.00	14,400.00	25,600.00
(such advertisements will be taken up for printing only when there are 4 or multiple of 4 advertisements for an issue)			

Notes: *GST @ 5% or as prescribed will be added to the above rates.

Tech Quiz

1. What is the non-fossil fuel-based electricity installed capacity target for India by 2030?
 - a. 25%
 - b. 50%
 - c. 75%
 - d. 100%
2. What type of technology is suitable for Small Bharat Modular Reactors (SMRs)?
 - a. Pressurized Heavy Water Reactor
 - b. Boiling Water Reactor
 - c. Tokamak
 - d. Fast Breeder Reactor
3. How much total hydrogen is consumed in India?
 - a. 6.7 MMTPA
 - b. 3.0 MMTPA
 - c. 70 MMPTA
 - d. 1 MMTPA
4. Where is hydrogen being used currently?
 - a. Ammonia production
 - b. Desulphurisation & Hydrotreating process
 - c. Steelmaking
 - d. All the above
5. Which of the following is an example of a first-generation biofuel?
 - a. Algae-based biofuel
 - b. Ethanol from corn
 - c. Biodiesel from waste cooking oil
 - d. Synthetic biofuel from gasification
6. What is a major advantage of using biofuels over fossil fuels?
 - a. Higher energy content per unit volume
 - b. Unlimited availability
 - c. More complex refining process
 - d. Lower greenhouse gas emissions
7. Which of the following technologies is commonly used for capturing CO₂ from industrial emissions?
 - a. Amine-based solvent absorption
 - b. Direct Air Capture (DAC)
 - c. Electrolysis
 - d. Photocatalysis
8. Which fuels are used in hydrogen fuel cells?
 - a. Hydrogen
 - b. Methanol
 - c. Ammonia
 - d. All of the above
9. What is the primary objective of the Environmental Governance Society (EGS) framework?
 - a. Enhancing corporate profitability through environmental policies
 - b. Promoting sustainable development and responsible environmental management
 - c. Ensuring governmental control over environmental resources
 - d. Increasing public awareness about environmental issues
10. Which of the following principles is commonly included in the Environmental Governance Society (EGS) framework?
 - a. Transparency and accountability
 - b. Economic growth at any cost
 - c. Limited stakeholder involvement
 - d. Short-term environmental goals

The first person who mails the correct answers to CEAI info@ceai.org.in will get a congratulatory mail and will be acknowledged by publishing the persons photograph in the next issue.

Contributed by Dr. Sakthivel. S

Answers to Tech Quiz June 2024 issue

1. (e), 2. (b), 3. (c), 4. (a), 5. (e), 6. (d), 7. (e), 8. (b), 9. (e), 10. (d).



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INFRASTRUCTURE: GPT Infraprojects is one of India's leading EPC companies, serving customers in the Railways, Highways, Power and Urban Infrastructure sectors.

CONCRETE SLEEPERS: One of the pioneers in the concrete sleeper business in India, with a geographical footprint in eight countries.

HEALTHCARE: GPT Healthcare is one of the fastest growing hospital chains in Eastern India, through its state-of-the-art hospitals, clinics, and residential medical services.

CASTINGS: One of the leading railway track fitting manufacturers in the country, exporting its products to ASEAN countries.



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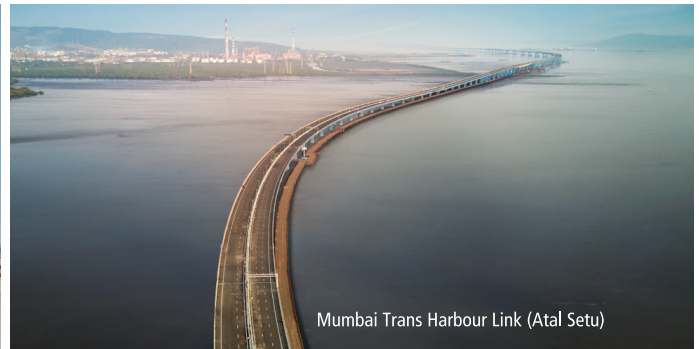
1.8 GWp Solar PV IPP Project, Sudair, Saudi Arabia



Mansourah-Massarah Gold Project, Saudi Arabia



Shri Ram Janmabhoomi Mandir, Ayodhya



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VSL India undertakes Specialist Package sub-contracts for Segmental Pre-cast bridges which includes Design, Supply & Operation of Launching Gantries for Span Erection, Supply of Casting moulds and Post Tensioning. VSL India also undertakes Supply & Installation of its Proprietary VSL SSI 2000 Stay cable System on Stay Cable Bridges and is one of the most widely used stay cable system in the country. In addition, VSL India undertakes Diaphragm Walls Construction for Underground Metros, Heavy Lifting Operations, Post-Tensioning on Various structures like Wind towers, Nuclear/LNG Tanks, Repair and Retrofitting works.



Okha-Beyt Dwarka Bridge, Gujarat

VSL India has successfully demonstrated its quality, competitiveness, speed & accuracy on various such package contracts executed on long segmental bridges like Bangalore Hosur Elevated Project-Bangalore, Devenahalli-Hebbal Elevated Highway-Bangalore, Hindon Elevated Road Project-Ghaziabad, Gangapath Bridge-Patna & Mumbai-Trans Harbor Link (PKG-2)-Mumbai to name a few.



Anjikhad Stay Cable Bridge, Jammu



Gangapath Bridge, Patna



Mumbai-Trans Harbor Link (PKG-2), Mumbai

VSL India is a leader in Cable Stay Supply & Installation and has successfully installed Stay Cables on iconic bridges like Bandra Worli Sea Link-Mumbai; Atal Setu-Jammu; The Veer Kunwar Singh Setu-Bihar; Karim Nagar Stay cable bridge-Telangana to name a few.



Chennai Metro Diaphragm Walls, Chennai

VSL India is presently engaged in construction of highly challenging projects like New MG-Setu Bridge-Patna; Anjikhad Stay Cable Bridge-Jammu; Okha-Beyt Dwarka Bridge-Gujarat; Mumbai Pune Missing Link Stay cable bridge-Mumbai; Diaphragm walls for CMRL-Chennai.



Heavy Lifting of LG at MTHL (PKG-2), Mumbai

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The FIDIC Conditions of Contract are being used the world over where multi-lateral development banks provide the funding. And in large complex Government projects.

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It covers the identification of project risks, their allocation, and the various causes of claim which can emerge over a construction contract and the way FIDIC addresses those. It details the way to handle claims – preparation, submission, assessment, determination under FIDIC Contracts, and how disputes are prevented or otherwise resolved.

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