TCEXpresssion

TATA CONSULTING ENGINEERS LIMITED

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Energy Transition Pathways

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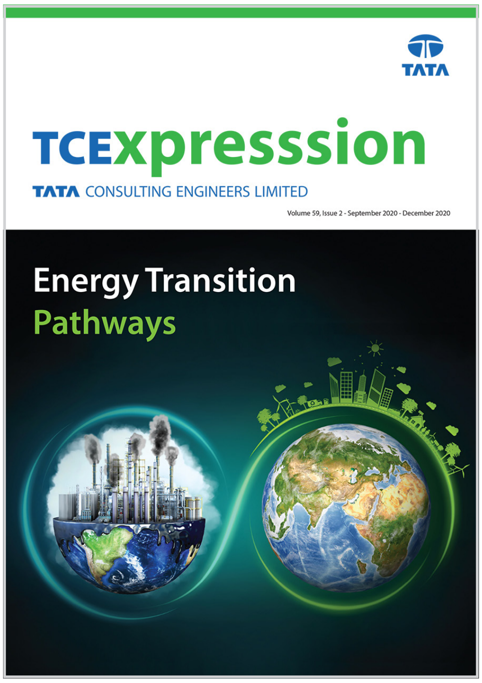


EDITOR'S NOTE

Dear Readers,

This edition of TCExpression, Energy Transition Pathways, explores the need and solutions for transitioning towards clean and sustainable energy.

As the world evolves its thinking and options, we tried to get you our perspective on how Energy Transition impacts various sectors and how each industry can mitigate the negative impact.

I wish to thank Dr Rajashekhar R Malur and Mr Atul Choudhari for helping us put together the content and Ms Shruti Deshpande for the beautiful design.

Please do feel free to share your thoughts and feedback with us on tceconnect@tce.co.in

Happy Reading!
Alpna Singh

REFLECTIONS

Amit Sharma
Managing Director

I am delighted to present this issue of TCExpressions, primarily as it deals with a subject close to my heart, ***"Energy Transition"***; a pathway toward globally transforming the energy sector from fossil-based to zero-carbon, at the very core of which is the need to reduce energy-related CO2 emissions to limit climate change.

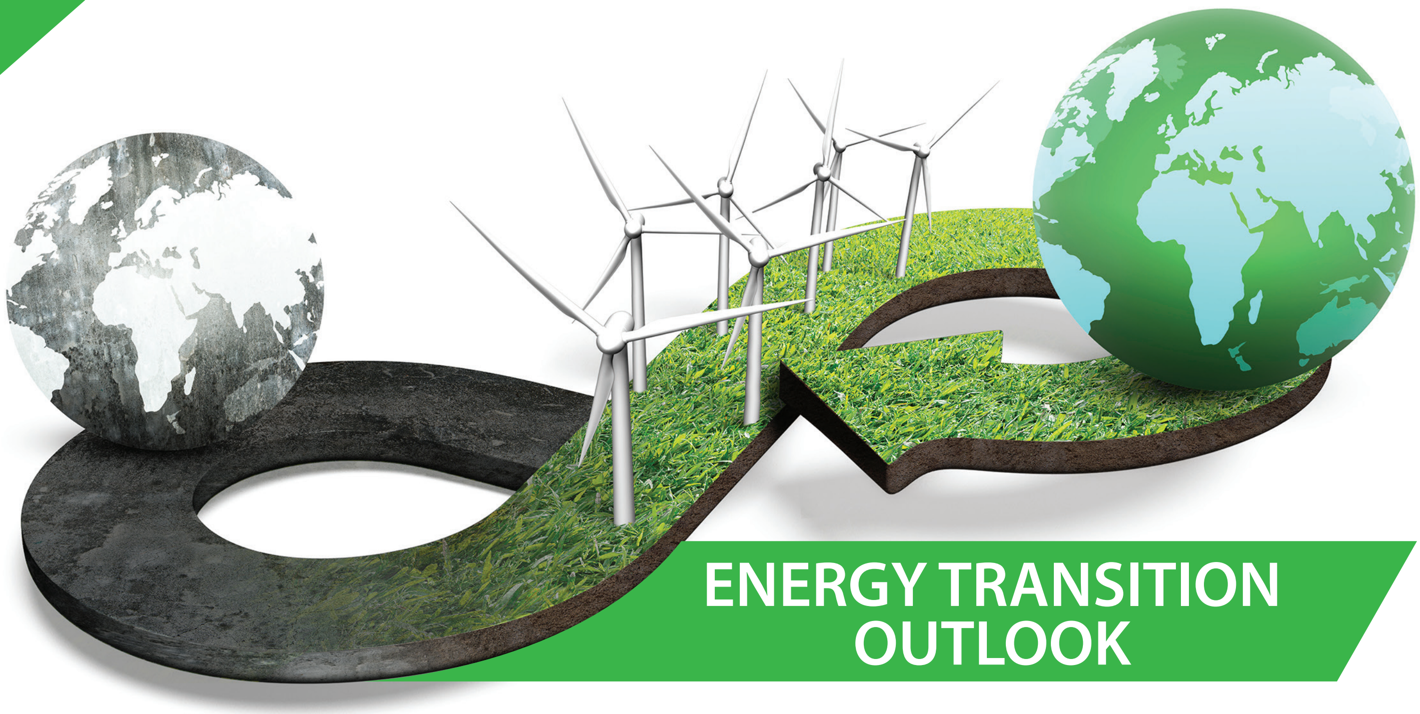
Decarbonising the energy sector requires immediate action on a global scale. While the global energy transition is underway, further action is necessary to reduce carbon emissions and mitigate climate change. Further, this energy transition will be enabled by smart information technology and policy frameworks.

I am pleased to inform you that Tata Consulting Engineers (TCE) has geared up a team of experts who have worked on sectoral Energy Transition needs and actions. You will read more about it in this issue. You will also get to read about hydrogen, the fuel of the future, which is all set to play a significant role in the Energy Transition.

2020 is finally behind us. It was an eventful year that showed the world to live frugally, be self-sufficient, and be agile - all three key to survival. I am proud of the team for staying current to provide value-added services to all our clients.

I wish to thank my entire TCE team and all our customers for their trust and patronage. I hope you enjoy reading this issue and get to learn more about energy transition; we will be glad to connect with you and understand how it affects you specifically and assist you in the journey.

Happy Reading!



Global energy demand grew at a compounded annual growth rate of 3% p.a. between 1950 to 2000 mostly spurred by growth in the Western world. The growth rate continued at 2% between 2000 to 2015 on the backdrop of accelerated industrialisation in China. However, during this time, concerns over climate change and adverse impacts due to rising Greenhouse gas (GHG) emissions started to alter the energy vision, leading to the birth of energy transition. A landmark agreement of restricting global temperature rise to less than 2°C above the pre-industrial level by 2050 was adopted in Paris by 190 state parties in 2015. Many countries made a conscious effort to effect changes in the energy mix commensurate with a reduction in carbon-intensive fuel dependence. It is also expected that the growth in global energy demand will fall by less than 1% per year between 2015 to 2030 and further halve to 0.5% per year between 2030 to 2050[1,2].

The Emission Scenario

The energy sector is the most significant contributor to human activity related GHG emissions at 73% of 49.4 Gt CO_2e as of 2016 data. Within this sector, heat and electricity are responsible for 30% (15 Gt CO_2e), transport accounts for 15% (7.9 Gt CO_2e), and manufacturing and construction at 12% (6.1 Gt CO_2e) of total emissions[3]. Figures 1 and 2 show the sector-wise GHG emissions.

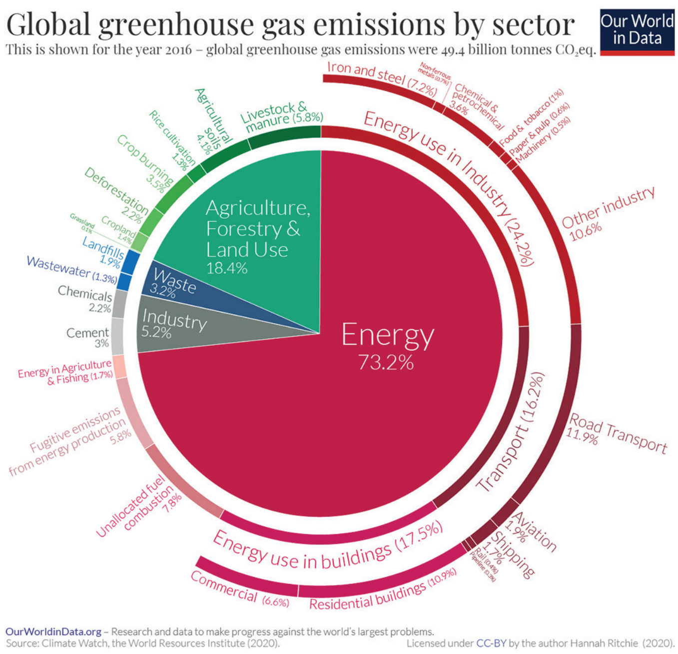


Fig. 1: Sector-wise emission of Greenhouse Gases[4]

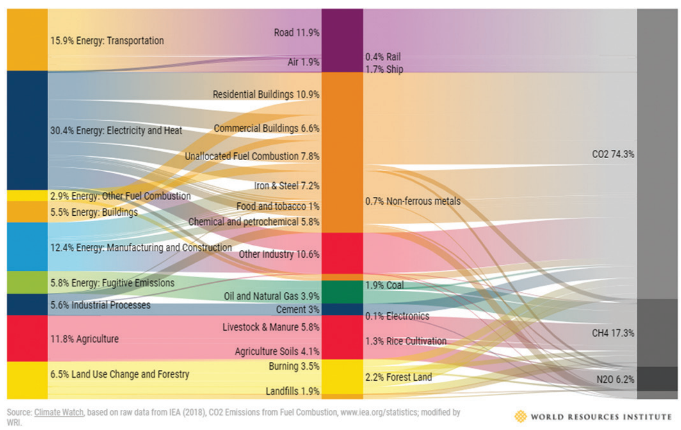


Fig. 2: Greenhouse Gas Emissions in 2016 by sector/ end-use/ gas emission[5]

1 Fueling the energy transition | McKinsey
2 Global Energy Perspective 2021: Energy landscape | McKinsey
3 4 Charts Explain Greenhouse Gas Emissions by Countries and Sectors | World Resources Institute (wri.org)

4 Emissions by sector - Our World in Data
5 https://www.wri.org/resources/data-visualizations/world-greenhouse-gas-emissions-2016

Path to Decarbonisation

To achieve deep decarbonisation of the global economy, it has become imperative to look for alternate energy sources, transitioning to greener sources.

The transportation sector is a significant contributor (16%) towards GHG emissions. These emissions are primarily due to burning fossil fuel for cars, ships, trucks, planes, trains, etc. Conventionally, over 90% of the transportation fuel is derived from petroleum resources – mainly Kerosene, Gasoline and Diesel. The energy transition must prioritise decarbonising transportation sector. Electric battery vehicles or Hydrogen fuel cell-based vehicles are the hot alternatives being actively considered by world economies.

Electricity production is another large (28.2% per cent of 2018 GHG emissions) contributor to the GHG emissions. Approximately 63% of the electricity is obtained by burning fossil fuels, mostly natural gas or coal. Study shows that the electricity demand is increasing seven times faster than demand growth of other fuels and in 2050 the total demand is expected to be double that of all other fuels put together1. Figure 3 depicts the rising electricity demand.

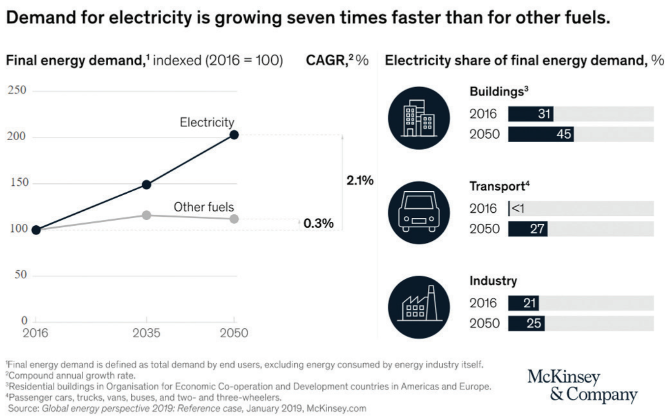


Fig. 3: Rise in Electricity demand

The growth of electricity demand will be driven by fuel mix changes in transport, industry and construction sectors, with renewables replacing oil and gas. Digitisation of industries would further increase electric power demand for handling increased demand from data capture, storage and processing. With the current efficiency improvement of energy generation, it is unlikely that the goal of 1.5°C temperature reduction looks achievable; GHG emissions are likely to reduce from current levels by 25% till 2050 reaching a 3.5°C pathway, refer Figure 4.

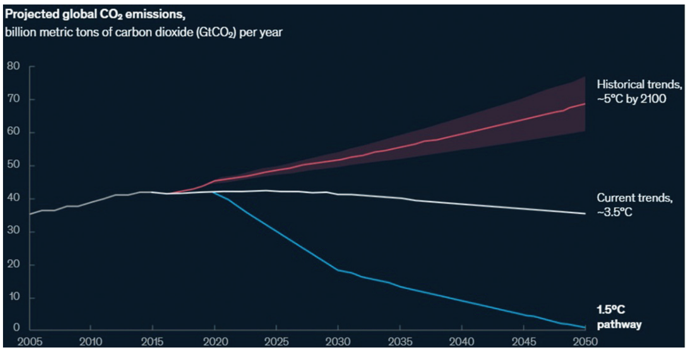


Fig. 4: Projected CO_2 emissions[6]

Another large share of GHG emissions is attributed to the industry (24%). Industrial GHG emissions primarily arise due to fossil fuels' combustion used as an energy source and greenhouse gas emissions from specific chemical reactions necessary to produce goods from raw materials. The industry sector is mainly considered ***'hard sector'*** to decarbonise because several large GHG contributors in the industrial (Eg. Steel, Cement, Petrochemicals, etc.) need a high temperature. Further, specific process requirements must be satisfied, making the switch to renewables difficult; moreover, a fifth of the industrial sector's carbon dioxide emissions are solely from the processes itself rather than the type of energy used. Slow progress in research and innovation on alternate approaches towards decarbonising the industrial sector also hamper progress.

Technological innovations provide a rational approach to achieving a low carbon economy. Technical solutions are always leading part of the puzzle in energy transition approaches. These could include use of zero-carbon or renewable energy sources, Adopting to the new alternate pathway, CO_2 capture from significant industries such as power, steel, cement, etc. in addition to efficiency improvements. However, technological advancements must be supplemented by proper policy support from the states, which can accelerate deployment of the emerging technology. Strategically designed policies incentivise faster adoption of emerging low carbon technologies and make more investments in such cleaner technologies more feasible or profitable.

The present policies for decarbonisation would only be able to keep emissions stable till 2050. Reductions in developed economies would be offset by industry growth in developing economies leading to increased use of coal, oil and gas-based power for transport and power generation[1].

6 The 1.5-degree challenge | McKinsey

Amongst the conventional carbon-based fuels coal demand peaked in 2014 and is declining by 40% from 2019 to 2050; oil demand is expected to peak in 2029 and gas demand in 2037, as shown in Figure 5.

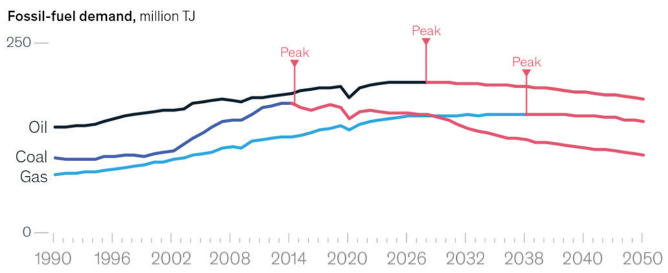


Fig. 5: Demand for Fossil fuels and peaking of demand[2]

The New Energy Scenario

Figure 6 shows the current mix of the global energy system and the contribution to CO2 emission from each sector. Fossil fuels dominate the energy system, and these are also a significant contributor to carbon emissions.

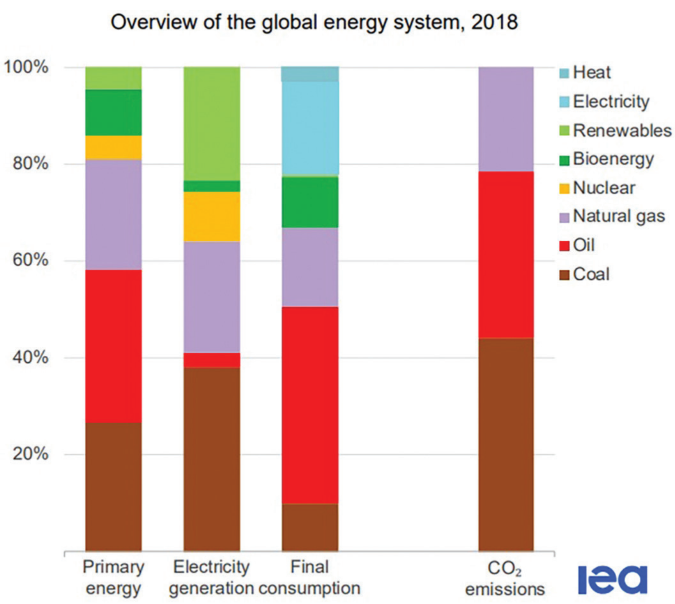


Fig. 6: Overview of Global Energy Mix and CO_2 emissions[7]

The International Energy Agency Assessment indicates that ***global energy demand is set to drop by 5% in 2020, energy-related CO_2 emissions by 7%, and energy investment by 18%. The impacts vary by fuel. The estimated falls of 8% in oil demand and 7% in coal use stand in sharp contrast to a slight rise in renewables' contribution. The reduction in natural gas demand is around 3%, while global electricity demand looks set down by a relatively modest 2% for the year.***

The global megatrends indicate wind and photovoltaic together will meet more than half of the world's electricity demand by 2050. All countries would also substantially increase the proportion of renewable energy in their total energy use by 2050. Renewables and batteries would form 80% of the market in new power capacity. It is expected that oil demand would continue to increase until 2035 and gradually decrease until 2050 to match and stabilise the current levels. Hydrogen economy would start gaining market share slowly from 2030 onwards.

The Energy Transition Path

There are three pillars to energy transition – generation, storage and efficiency; the related technologies converge to provide an integrated solution. The road to achieving climate change goals on the energy transition pathway essentially adopts the following tracks[8]:

- Electrification of transport – 15% of CO_2 emissions each year are from vehicle exhausts, and a reduction will require a widespread shift to electric vehicles
- Electrification of buildings – 7% CO_2 emissions come from cooking and heating in buildings and 20% from space and water heating, as shown in Figure 7.

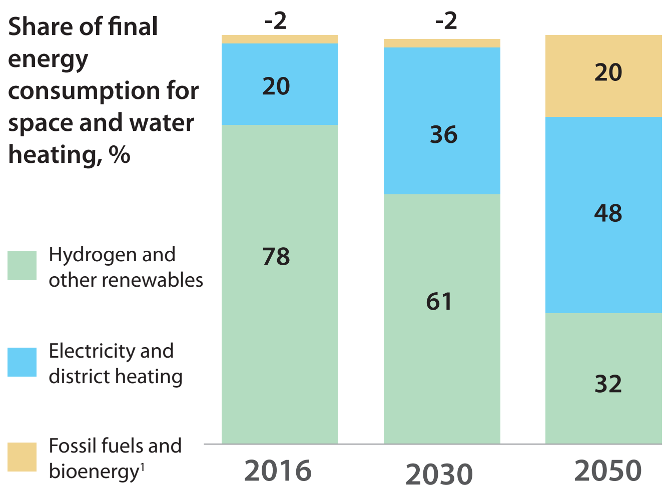


Fig. 7: Energy for Buildings[6]

- Reduce methane emissions – oil, gas and coal mining generates most methane, the second most potent GHG making up 40% of annual emissions. Reduction in demand, gas leakages and improving gas recovery are some measures that can be adopted to achieve fugitive methane emission of 40% of the current level in 2030 and 10% in 2050.

7 The Oil and Gas Industry in Energy Transitions – Analysis - IEA

8 The 1.5-degree challenge | McKinsey

- Improvements in industrial processes – 40% emission from metals, mining, chemical, and other processes need to be reduced to 2/3rd of 2016 levels by 2050. This can be achieved by adopting a circular economy, improving efficiency and optimising operations.
- Electrifying industrial processes – the most considerable emission reduction will come from the electrification of industrial heat process that can reduce 65% of the fossil fuel caused CO2 emissions. This is mostly applicable for low and medium temperature-based industries like construction, food, textiles, and manufacturing.

Decarbonisation of Power and Fuel:

Renewables – Approximately two-thirds of the current global power generation is from fossil fuel sources of coal and natural gas, generating 40% of the total CO2 emissions. Increase in wind power to five times and solar power to eight times the current levels would be required to achieve decarbonisation targets by 2030.

Hydrogen – Electrification alone may prove inadequate for decarbonising industries like steel making. These industries would require the use of low-carbon hydrogen generated from renewable power sources ("green" hydrogen) or by using natural gas with carbon capture ("blue" hydrogen). Figure 8 shows the increasing role of hydrogen.

Final global demand for hydrogen on 1.5ºC pathway, exajoules

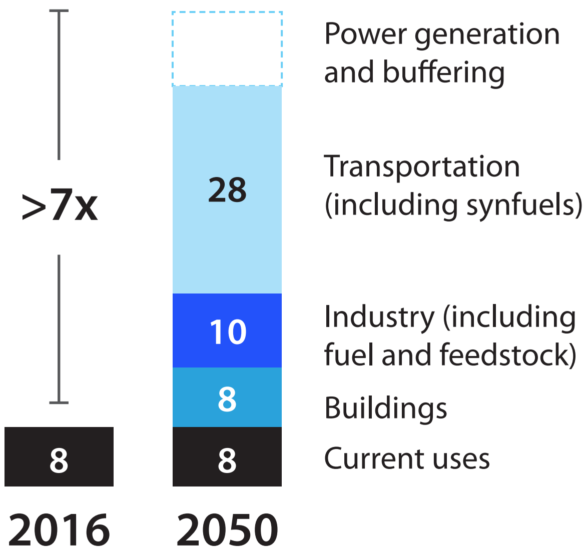


Fig. 8: Hydrogen demand growth[6]

Bioenergy – Industries like aviation, marine transport, and cement manufacturing are challenging to decarbonise through electrification or hydrogen. In these sectors, fossil fuels can be replaced with bioenergy using a sustainable conversion of biomass or waste to energy and feedstock, contributing 3% of total CO2 reduction by 2050. Figure 9 shows the growth of bioenergy in the mix.

Top uses of bioenergy by 2050, % of each industry's 2016 CO_2 emissions reduced via bioenergy

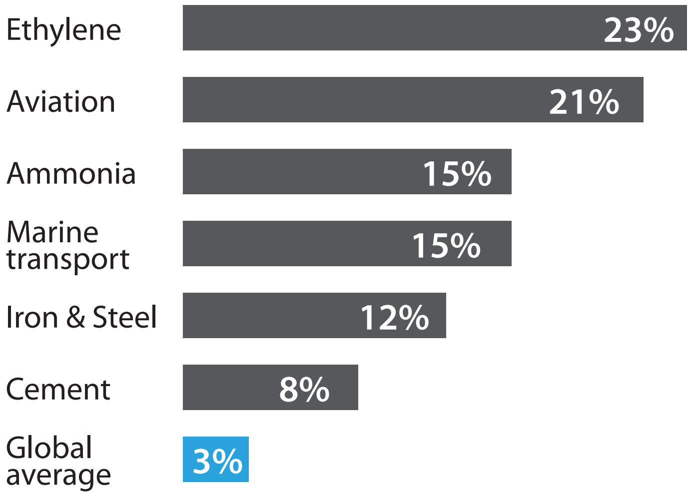


Fig. 9: Demand growth for Bioenergy[6]

The overall picture of energy transition is shown in Figure 10. The overall consumption increases two-fold by 2050, mostly through electrification and green hydrogen in the mix. Renewables are projected to become cheaper than fossil fuel-powered plants in the coming decade.

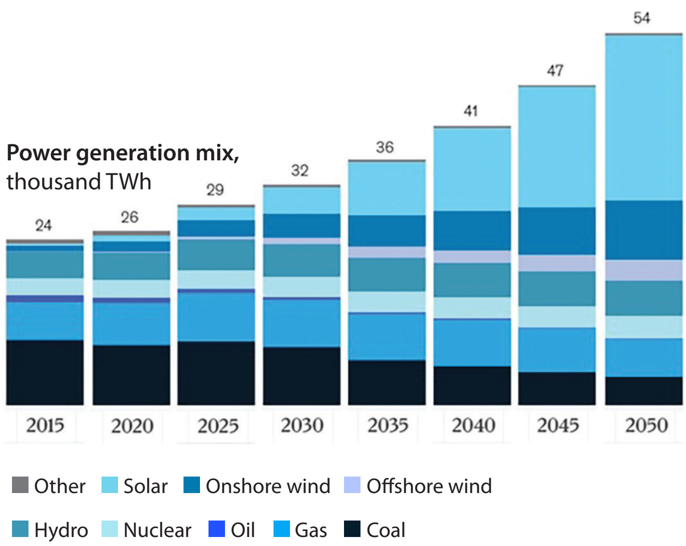


Fig. 10: Change in the power generation Mix[2]

Evaluating New Technologies for Energy Transition

International Energy Agency (IEA)[9] has developed different methods and tools to assess the various technologies' effectiveness for an energy transition based on scenario analysis. The Sustainable Development Scenario (SDS) targets rise in global temperature of 1.8°C in 2070 with a probability of CO_2 emission reaching net-zero as 66%. Negative CO_2 emissions after 2070 would enable reaching the target of restricting temperature rise target of 1.5°C by 2100. Such negative emissions have also been studied in 88 scenarios by the Intergovernmental Panel on Climate Change (IPCC).

The Energy Technology Perspectives Model 2020 (ETP 2020) by IEA uses a combination of scenario techniques to evaluate the energy sector's performance in the long term. The technologies that have been studied and developed have advanced to extensive prototype testing with known performance and cost parameters. The ETP model has four parts covering energy conversion, industry, transport and buildings. Using this model, outcomes can be studied for use cases of construction, industry, and transport against variations in energy supply.

In the SDS, electrification of transport, industry and building sectors would reduce emissions in 2070 by 40%. Adopting hydrogen, bioenergy and synthetic fuels derived from hydrogen would result in further 20% reduction and deploying carbon capture utilisation and storage (CCUS) systems can contribute 15%. Innovation in new and existing technologies can bring about the implementation of these strategies for decarbonisation. The technology readiness is shown in Figures 11 and 12.

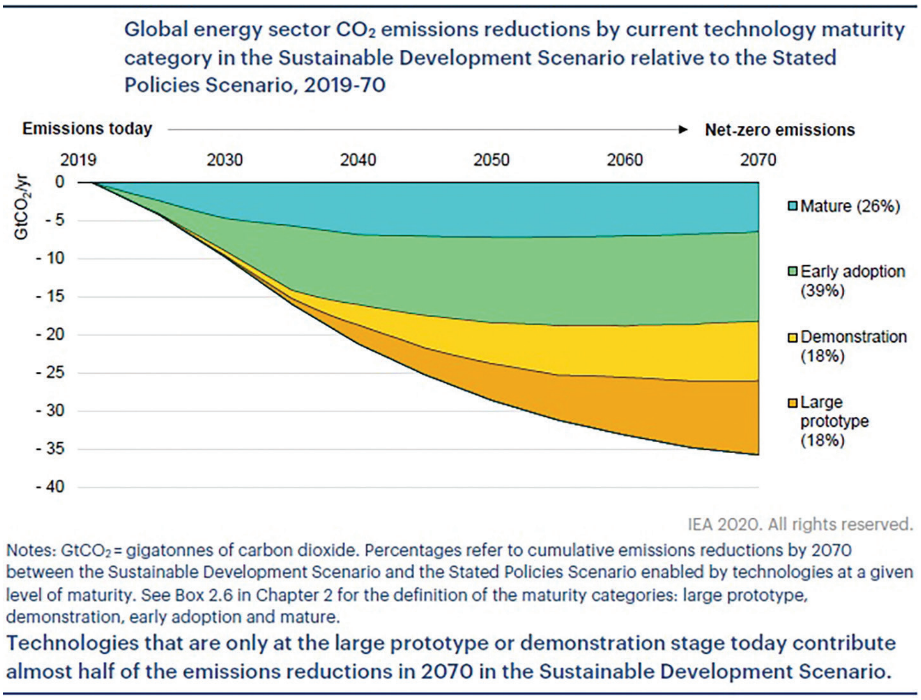


Fig. 11: Technology readiness for CO_2 emission reduction[9]

Fig. 12: Maturity of Technology for Energy Transition[9]

9 Making the transition to clean energy – Energy Technology Perspectives 2020 – Analysis - IEA

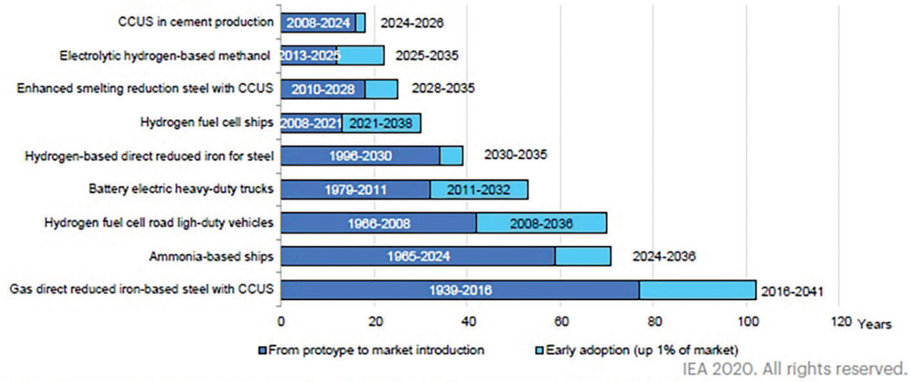
Records show that implementing new energy technologies has taken between 20 to 70 years to progress from prototype to commercialisation and gain at least 1% of the national market, refer Figure 13. However, with the stiff targets for decarbonisation in a relatively shorter span of three decades, the entire cycle of technology maturation, commercialisation and market adoption must be operated on a much faster time scale. This will require strong policy support, more generous sharing of knowledge and improving synergy between different agencies.

Impact of COVID19 on Energy Transition

The COVID19 crisis has overshadowed the world economy in much of 2020 and continues into 2021, showing an appreciable downfall in energy demand curves. Studies project that growth to pre-COVID19 levels may resume in one to four years, but the growth path would change. Demand for electricity and gas would register higher growth; oil demand would rise at a slower rate while coal demand would continue to fall further. The increase of remote working and travel reduction can reduce oil demand by 2 million barrels per day by 2035.

The response to the pandemic crisis has shown hope for a decarbonised future for energy. Healthcare and economic stimulus support has been swift, and the present scenario points towards a contained spread of the virus and returns to a growth path. The agile response to this black swan event shows that appreciation of the catastrophic scenario and supportive policy decisions can implement new technology on an accelerated track. Applying this same concept to the cause of energy transition can achieve the desired decarbonisation targets and meet the agreed demand for climate change.

Time to materiality for selected technologies in the Sustainable Development Scenario



Notes: Time period from market introduction to materiality relates to global deployment projections in the Sustainable Development Scenario. Pace of deployment of a given technology depends not only on observed historical patterns for analogous examples, but also on how competitive it is on cost and performance compared with alternative available low-carbon technologies delivering an equivalent service, as well as the effectiveness of policies to stimulate uptake.

Sources: Matsunaga, Tatsuya and Kuniaki (2009); Zemships (2008), Molino et al. (2018); European Cement Research Academy (2012); Brohi (2014); TATA Steel (2017); Kohl and Nielse (1997); Ballard (2019); Kraftwerk Forchung (2013), Nuber, Eichberger and Rollinger (2006).

Bringing new clean energy technologies to market on a large scale after the first prototype can take from 20 years to more than 80 years in the Sustainable Development Scenario.

Figure – 13: Timespan for technologies to achieve market share[9]

Concluding Remarks

In response to the Paris 2015 agreement, rapid changes are being witnessed globally, especially the way energy is used. Technology can deliver solutions to combat global warming; however, the approach requires careful selection and policy support. Engineering companies and expertise would help the industries in conducting detail energy transition studies and framing suitable roadmap for adopting select technologies to meet the given industrial process's specific goals.

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INDUSTRIAL ENERGY TRANSITIONS

World over, we are passing through a significant energy transition and are witnessing the industrial revolution like never before. Sustainability, Green Initiatives and environmentally conscious approach is the key to a circular economy. The current pandemic has been a catalyst to accelerating these areas for many reasons; from the environment to social to geopolitical to the simple realisation, nature needs more respect. The underlying theme in the current transition period is a better appreciation of our future generation's responsibility and care towards the planet and its resources.

While the economic cycles are becoming shorter, the basic demands of developed-developing nations are normalising, and the gap is diminishing. The so-called equalisation is also exponentially increasing the negative impact of industrial growth and its future sustainability.

Revisit Lifecycle Energy Demand:

Energy and resources drive growth. The demand for resources is also undergoing a shift, almost as if new elements from the periodic table are now needed, which were rare and reserved for exotic use only a few decades ago. Nevertheless, the most significant change is being felt on the energy mix regarding its quantity and quality. It is quite strange that while the world has utilised the high energy density sources such as coal and oil, we are now compelled to seek low energy and intermittent energy sources like solar, wind and geothermal. We are now finding means of storage, transmission and distribution of the energy generated from these sources to meet similar metrics and continuity as those of high energy density sources. However, this rule's exception is nuclear energy - both fusion and fission, which have too high energy densities.

Though it is essential to find solutions concerning the 'Energy Density and Continuity' challenge, it is also equally imperative to think about the overall energy footprint regarding the materials used in mitigating the challenges. While Hydrogen has one of the highest energy densities in the order of 120-150 GJ/tonne (Nuclear energy is the exception as it has many times higher energy density than Hydrogen), its low volumetric density is a matter of concern which results in a low energy per unit volume, hence Hydrogen storage is an issue. Similarly, the solar photovoltaic cells are an attractive source for renewable power generation, but it requires a large land quantum. Same is also applicable for bio-fuels initiating concerns over food vs fuel.

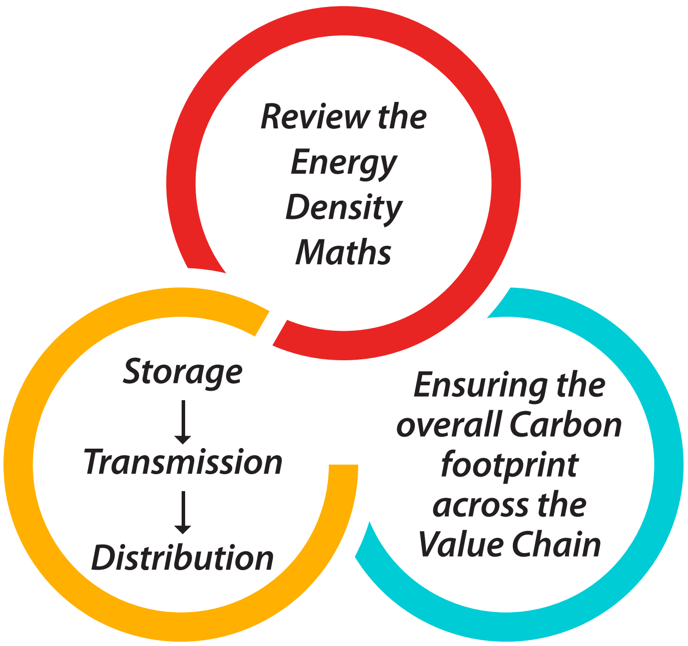
It is essential to evaluate the energy requirements of the complete product lifecycle. For example, Aluminium is a lighter material than steel and, hence, possibly better for automotive applications, but can this reason be considered a green and sustainable solution? The energy required to produce a tonne of Aluminium (approx. 300 GJ/ton) is almost six times compared to

Iron/Steel (approx. 50 GJ/ton). Similarly, while Solar PV is default and preferred choice to replace thermal power plants, the energy required to produce one tonne of electronic-grade silicon (approx. 7600 GJ/ton) is almost 15 times compared to iron in making of turbines.

The initial energy transition journey may have to adopt renewable sources; for example, green Hydrogen by water electrolysis route can utilise electricity generated from renewable sources. But for being ***"GREEN"*** needs a holistic perspective in the long term seeking sustainable and low carbon energy sources. Extending the logic further, the cost of pumped/battery storage and its energy maths in terms of material and losses at each stage of its flow – from generation to storage to conversion needs to be accounted. Hence, energy transitions must consider a holistic life cycle management to account for energy needs from the cradle to the grave.

Energy Transition Approach:

Energy transition will systematically require the following phases.



Value chain in the energy transition process is a bit complex. One needs to anticipate the shift in the value chain that may occur either due to ongoing industrial revolution or due to expected exponential maturity in technology that may change the value-chain landscape. Hence, it is necessary to adopt a strategy to interconnect the various value chains, considering the current one's anticipated changes.

Finally, we need to justify any transition with financials and business case, keeping in mind the volatility and shorter economic cycles demanding faster returns (gone are the days of 20 years payback periods) else incentives, policies, penalties, and offsets may fail to provide long term sustainable usage. However, these ingredients must be a catalyst to accelerate the energy transition in the initial stages. Technology development (linear or rapid) and maturity phase requires policy support to kick start the energy transitions, e.g. cost of bioethanol manufacturing is presently 30-40% higher than the price at which ethanol is being sold in the market. Green Hydrogen currently costs approx three times than the blue Hydrogen. So, policy support to incentivise green Hydrogen or bioethanol may help accelerate the transitions.

Recommended Approach for Energy Transition:

From the industry perspective and professional consultants' lenses, a holistic approach to clients across O&G, Metals, Mining, Infra, Power, etc. must be provided. We need to keep these factors in mind and have a framework that helps clients achieve their vision and roadmap for the energy transition to a low carbon future or low carbon energy source.

Changes are indeed the most exciting playgrounds for visionaries, scientists, engineers and pioneers – but they take time; for example, it took the wood to Coal to Oil-based, and then gas energy sources almost 80-100 years each time to gain a 50% mix. Solar/wind/nuclear are much recent and still in single or lower double % regarding overall energy composition.

It would be pertinent to note that this energy transition will be much faster and rapid and may take maybe 30 years due to the exponential pace of technological innovation and advancement, maturity and a more global collaborative effort unlike the past when it was more siloed and concentrated. While energy transition may start in respective value chains, it requires a cross value-chain approach across industries to reap enhanced and overall benefit based on uniqueness.

- While modernisation is inevitable and maybe linear or rapid due to disruptive technologies, the focus will be on integrating the technological advancements with the old technology to ensure low carbon footprint, including gas balance, steam balance, and energy balance.

- Energy transition initiatives may reduce material requirement and complexity (from 10,000 moving parts and BOM and supply chains to say 100-500 parts – more electrical and less mechanical) and be cost-effective in the Automobile industry. Similar drivers shall be identified in other sectors such as Power, Process, Steel, Infra, etc.
- A specific focus is required on visibility/ consideration of the carbon footprint across the value chain, including the manufacturing/ processing equipment and operations with a view on Capex/Opex, i.e. Total Cost of ownership and operations.
- While utilisation of waste or recycled material is a process, it needs to be integrated across value-chains to enhance recycling and improve carbon footprint by optimising the waste footprint.
- A robust modular and repeatable framework may be adopted to assess each system/process shop/ plant - and this applies across all industries, but in varied proportions and may involve different timelines and phases.

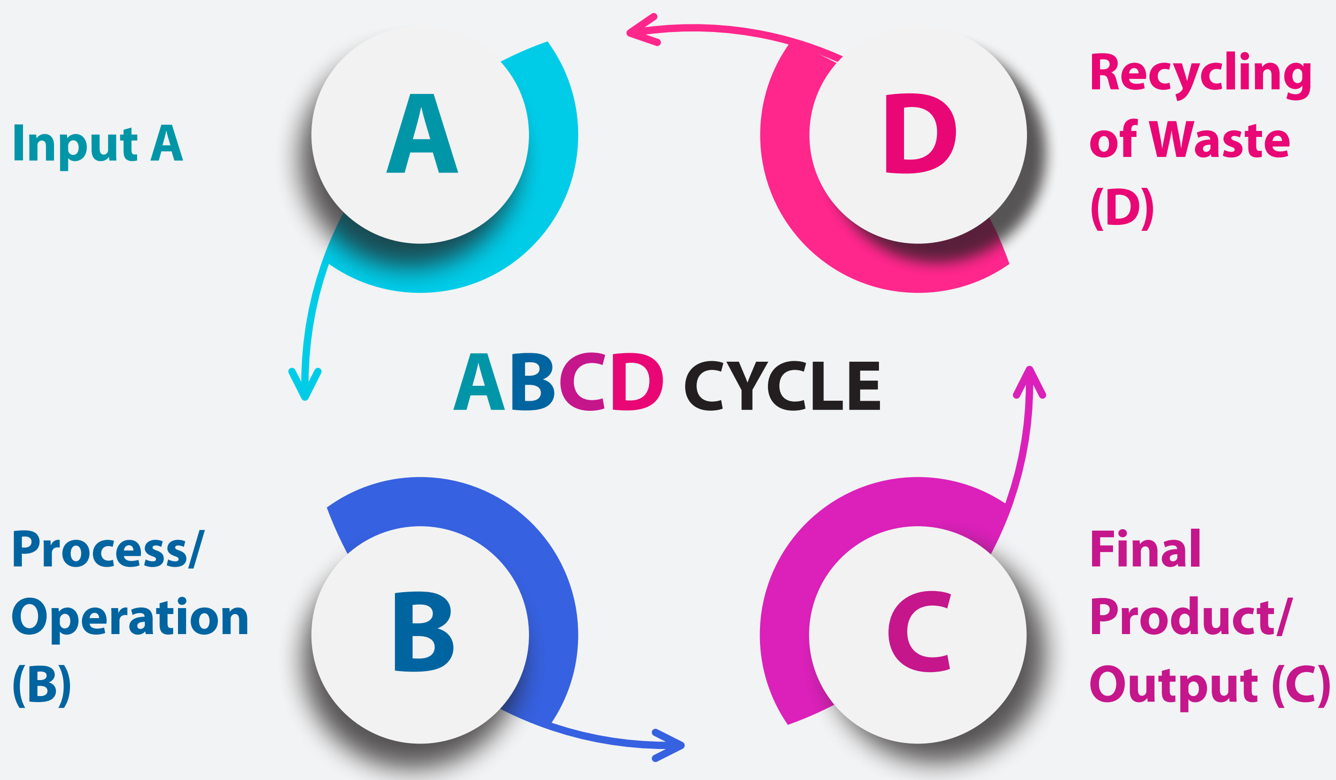
Simple ABCD Model for Energy Transition:

We visualise the entire energy transition process as a simple ABCD cycle. Typically, this model depicts the plant operations in a simplified way. Raw materials (***A*** of the ABCD Model) are processed using specific technologies or operations (***B*** of the ABCD Model) to make desired products (***C*** of the ABCD Model), and the value chain is completed after recycling (***D*** the ABCD Model) the product back to the process.

Some of the energy transition themes (given below) that can go through the ABCD Cycle need to be reviewed holistically, as explained earlier, to develop a strong business case.

A: Look for alternate feedstocks to make the same product. Ensure that the alternate feedstock consumes lesser energy during its manufacture/lifecycle. Prefer ***'Green Feedstock'*** with true ***GREEN*** footprint pre and post-production. Use research and innovation to promote energy transitions by locating newer and affordable green synthesis pathways.

It is essential to evaluate energy density maths of the



alternate source and its production. The per capita energy (in terms of land, people or weight etc.) needs careful evaluation while selecting the energy transition techniques.

B: Improvements in operational efficiencies and energy optimisation opportunities should be considered, especially using cutting-edge digital technologies to improve efficiency under varying loads vs constant peak loads.

Pull and Push strategy: Ability to seamlessly change the production volume and mix and maintain high efficiencies in both Pull and Push Strategy.

Peak Capacity operations vs Flexibilisation, i.e. stable & efficient operating level ensures the optimum cost of the operation

Inter-Connected / Enhanced Transmission & Distribution / Hybrid Grid Infrastructure

C: Better quality of products which can last longer. Energy transitions to reduce the demand for the product by making long-lasting and superior quality products.

D: Less Wastage (Recycling) driven by both efficiencies and circularity mindset, i.e. optimum utilisation of resources

Concluding Remarks:

Energy transition road map will be unique to every organisation. It requires prioritisation across the different areas of operations within the organisation, aligned with transition roadmap of an organisation keeping existing laboratory scale efforts and their technology readiness (TRL) levels so that a parallel program can be drawn for the future.

Industry partnerships or Consortiums or conglomerate may have to be sought for a collaborated effort focusing on internal efficiencies and agility to develop a strong business case and justify the cost. A startup, innovation ecosystem with the help of pilots and experimentations and support from the government, academia and industry may accelerate the energy transition.

Our approach in this journey shall be to work with clients, academic institutions and industry partners to have a holistic view of the industry/sector energy map. The transition needs to ensure that any efficiency and optimisation or flexibilisation (as regards production volume and product mix) are enabled by rewiring the enterprise and connecting the legacy (for asset sweating) with the digitalisation. Digitalisation needs a parallel business case and shall be an integral part of Energy transition, else without the digital glue, integration and rewiring will be suboptimal.

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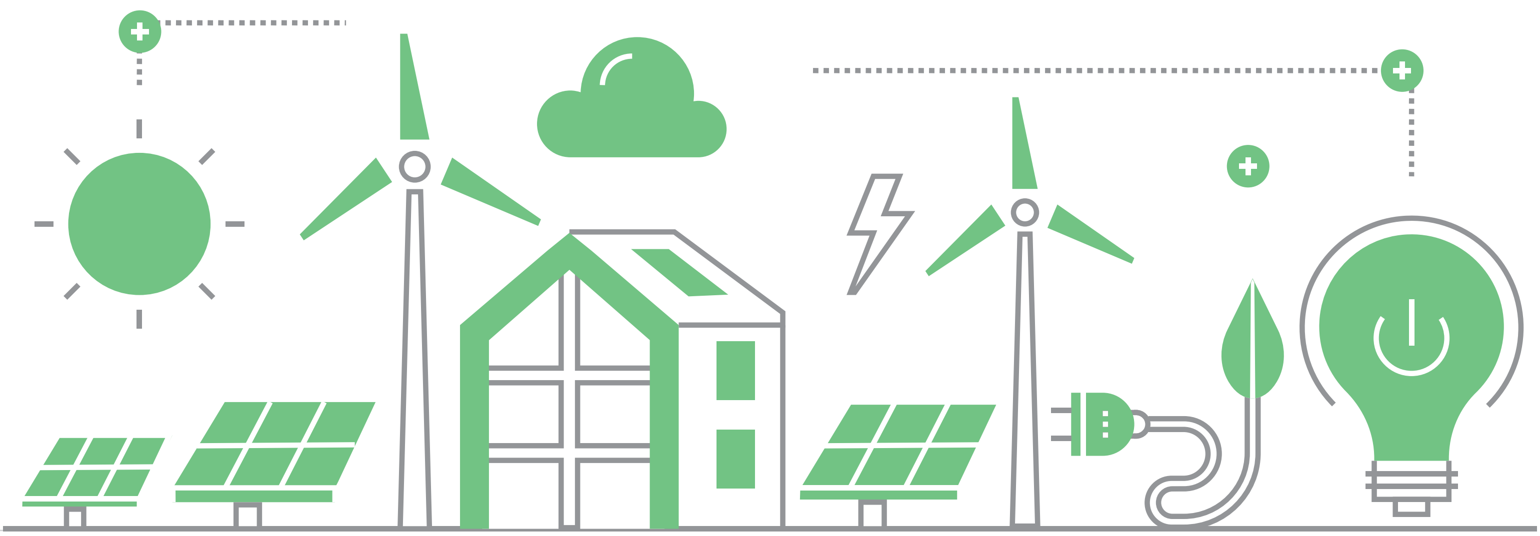
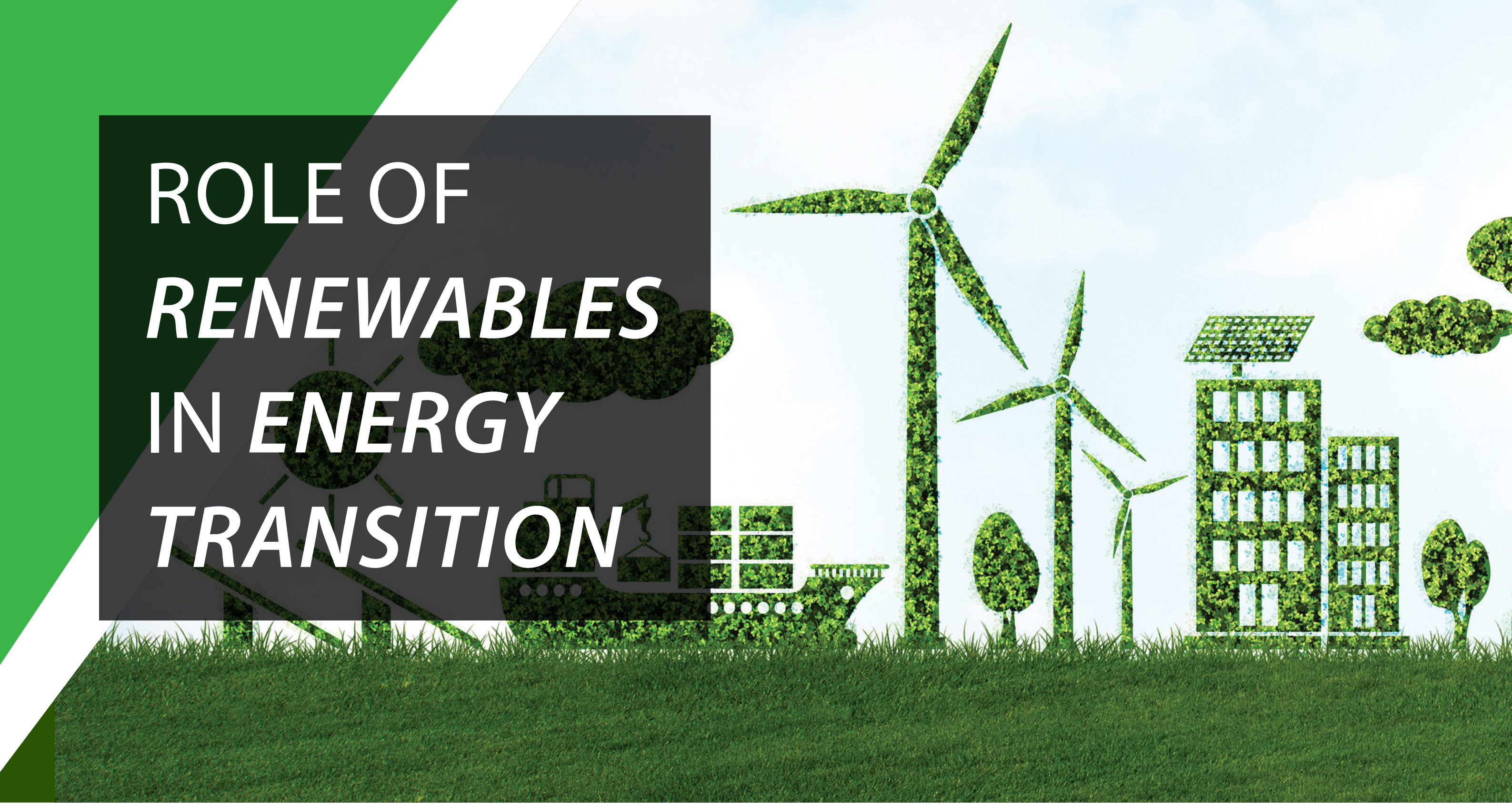




ROLE OF *RENEWABLES* IN *ENERGY TRANSITION*

The World Economic Forum defines an effective energy transition as ***"a timely transition towards a more inclusive, sustainable, affordable and secure energy system that provides solutions to global energy-related challenges, while creating value for business and society, without compromising the balance of the energy triangle"***[1]

As per Intergovernmental Panel on Climate Change (IPCC), United Nations body for assessing the science related to climate change; human activity is likely responsible for about 1˚C of the global warming above pre-industrial levels. They predict that global warming is likely to reach 1.5˚C between 2030 and 2052 if current activities continue[1]. The carbon budget will get depleted in 10-17 years[2] in order to limit global warming within 1.5 ˚C, with the current emission levels. Hence, there is an urgent need to limit CO_2 emissions.

The power generation sector and transportation sector are the two main sectors which account for about 50% of the total CO_2 emissions[1]. Hence, these areas must be looked at critically for implementing the energy transition. However, it does not take away the required attention from the remaining sectors such as iron & steel, cement, heavy transportation, aviation and shipping, where solutions are still evolving.

In the following sections, the discussion on these two significant sectors focuses on how renewables can play a crucial role in the energy transition.

Power Generation:

Fossil fuels continue to negatively impact air, soil and water pollution and contribute to direct CO_2 emissions. Hence, renewable energy forms the critical component of a low carbon economy both in the generation and in the end-use application.

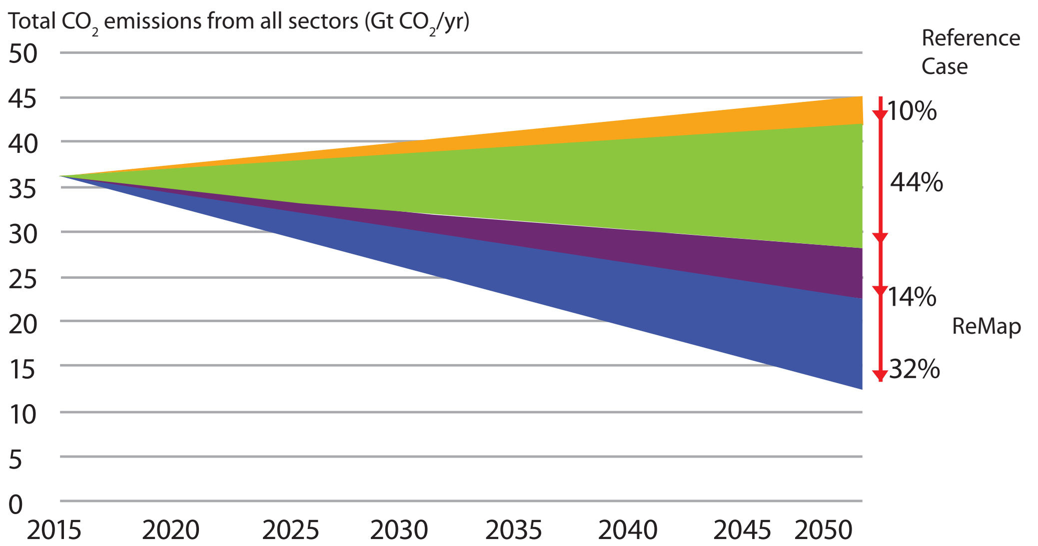
Sustainability is one of the key drivers of the current energy transition that the world is going through. The energy sector is changing its landscape with more renewable generation share boding well for a sustainable future. Solar PV and Wind projects make headlines world over for higher capacities and record-low costs, making them the natural choice for broader adoption, thus paving the way for a smoother and a sustainable energy transition.

1 Fostering effective energy transition, 2020 edition, World Economic forum
2 World Economic Forum, Energy transition 101-Getting back to basics for transitioning to a low carbon economy

2019 has been a record year witnessing drastic change towards sustainability and the emissions from the energy sector has remained more or less flat[1]. While coal-based generation's contribution has reduced by 3%, the renewable-based generation has increased more than the electricity demand growth[1]. Researchers say that global carbon emissions have dropped by an estimated 2.4 billion metric tons this year due to the coronavirus-induced lock downs[3]. Though this is welcome, there is every chance that this value will rebound once we return to normalcy post covid unless urgent action is taken.

Reducing energy-related CO_2 emissions to limit climate change is pivotal to the global energy transition. Renewable energy and the adoption of energy efficiency measures can achieve up to 90% of the required carbon reductions, with two-thirds coming from renewable energy alone[4].

It is good news that many of the finance sector asset managers and non-finance sector organisations, including oil and coal companies, are investing in renewable assets as a step towards meeting their carbon neutrality goals.



CO_2 emissions reductions

- Others
- Renewable energy
- Electrification with renewables
- Energy efficiency

Figure 1: Primary CO_2 emission reduction potential by technology 2015-2050[3]
(Renewable energy: 44%, Electrification with renewables: 14%, Energy efficiency: 32% & others: 10%)

Notes: Includes energy, non-energy use, process and fugitive CO_2 emissions; the Reference Case is most likely case based on current and planned policies and expected market developments; the REmap case is a low-carbon technology pathway that goes beyond the Reference Case for an energy transition to decarbonise the energy system in line with the goal in Paris Agreement of limiting global temperature rise to less than 2°C above pre-industrial levels with a 66% probability; yr = year.

3 IRENA Global Renewable Outlook 2020 & Climate policy

4 https://www.dw.com/en/global-carbon-emissions-down-by-record-7-in- 2020/a-55900887 Global Carbon Budget 2020

This should get amplified in the coming years to visualise a perceptible change in the energy sector demography. It is expected that investment from significant Oil and Gas companies will increase tenfold from 2020 to 2050[5].

As per IEA's Market Update on Renewables, Nov 2020 renewables used in electricity generation has shown resilience during Covid and is poised to grow by 7% by the end of the year[5]. Renewable equipment manufacturers and developers have seen better growth in their share value than their other energy sector counterparts[5]. This is commendable considering the present economic uncertainties related to covid and has only reinforced the investors' faith in the renewable sector.

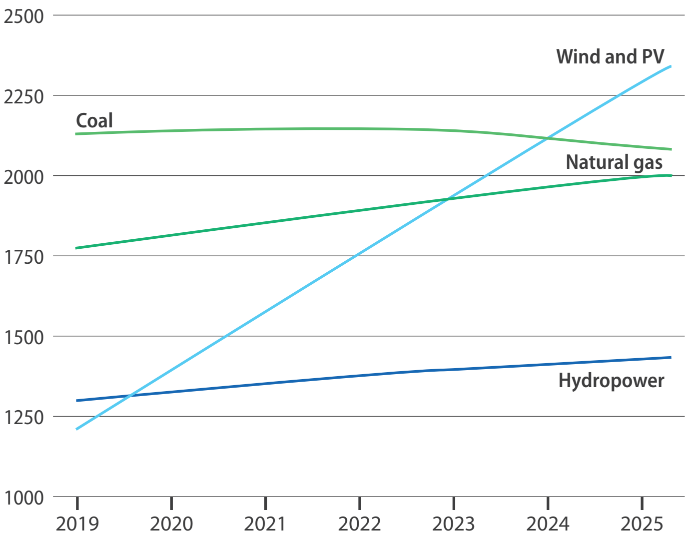


Figure 2: Total projected Installed Power Capacity by fuel and Technology 2019-2025[5]

By 2025, it is not only predicted that the renewable capacity additions will be 95% of the total reserves but also that renewables will surpass coal to become the largest source of electricity. Hydropower would continue to supply half of the renewable power followed by Solar and Wind.

Unlike dispatchable Hydropower, Solar and Wind need to be complemented by energy storage systems to provide continuous power supply. Hence, energy storage systems such as Pumped storage and Battery energy storage system play an essential role in the energy transition by not only supporting renewables reach the desired levels but also in maintaining grid stability.

5 IEA Renewable Market Update, 2020

Pumped storage provides various grid services such as reactive power support, frequency control apart from black-start capabilities. Hence, it becomes the preferred large-scale energy storage solution for ensuring grid stability with increased renewable penetration and can act as a catalyst in the global energy transition.

Better power system flexibility can be achieved by integrating battery energy storage with renewables, in addition to other benefits such as better ramp rate, energy shifting, investment deferral in any distribution system, etc. According to a report by Rocky Mountain Institute, battery storage is expected to enable renewables penetration of 16 to 20% by 2025[6]

Along with renewables, necessary focus needs to be given to improving the energy efficiency of existing assets, which will help in reducing the CO_2 emissions and electrification of many end-use applications, including transportation segment.

Transportation:

Light vehicles emit greenhouse gases and also cause air pollution, smog and other health-related issues. Though with improved emission norms, it has reduced; still, there is much ground to be covered.

Globally, the light vehicle population is poised to increase from 1 billion as on date to about 2.5 billion by 2050, resulting in a tripling of energy utilisation and corresponding CO_2 emissions[7]. Significant disruption is required in the transportation sector to shift to a cleaner and low emissions trajectory to achieve the global targets on air quality and CO_2 emissions.

To reduce the CO_2 emissions from this sector, switching to electrification through battery-powered Electric Vehicles (BEV) and Hydrogen Fuel Cell powered Electric Vehicles (FCEV) are the options going forward. It is opined that BEVs will be more economical for the light vehicle segment while there is a need to go in for FCEVs for long-distance, heavy vehicle segment. Further discussions in this article are limited to BEVs (EVs).

According to the International Energy Agency, limiting the global temperature increase to less than 2°C will require at least 20% of all road transport vehicles be electrically driven by 2030 (approximately 300 million vehicles)[6].

6 https://science.thewire.in/economy/energy/can-battery-storage-propel-indias-energy-transition/
7 UN environment programme https://www.unenvironment.org/explore-topics/transport/what-we-do/electric-mobility/electric-light-duty-vehicles

By reaching 60% battery, electric and plug-in hybrid vehicles (electric and internal combustion engine) on the road, more than 60 billion tons of CO_2 could be saved between now and 2050[6].

IRENA analysis shows that EVs have significant growth potential:

- The number of electric passenger cars could increase from 2 million in 2016 to 200 million in 2030.
- Electric two/three-wheeled vehicles could outnumber four-wheeled vehicles, with as many as 900 million on the roads by 2030.
- Electric buses/ light-duty vehicles could exceed 10 million by 2030[8]

In 2017, Electric Vehicles Initiative (EVI) governments launched the EV30@30 campaign to speed up electric vehicles' deployment and target at least 30 per cent new electric vehicle sales by 2030[7]

There are studies which state that EV adoption in China could increase the smog generation by three to five times as compared to fossil-fuel driven vehicles primarily because of its dependence on fossil fuel-based generation[9]. This is true in many other countries, including India, where around 61.8% of installed capacity (as of November 30, 2020) is from fossil fuel-based generation[10]. The power required for EV charging should be derived from renewable sources to the maximum possible extent as fossil fuels will defeat the whole objective of carbon-free mobility.

However, with India poised to surpass it's Renewable Energy (RE) target of 175 GW by 2022, more renewable energy penetration is expected.

EVs can be considered as flexible energy demand that can be powered by renewable sources such as solar and wind as their charging can be aligned with the availability of the sources. Some utilities in the US offer customers incentives for adopting EV charging at stipulated time of the day when Solar / Wind resources are available.

EVs can act as important source/sink for the variable renewable energy sources. Introducing EV in a grid could lead to congestion in distribution lines and transformer overloading. However, these can be mitigated by resorting to their integration with distributed renewable energy sources.

Renewable integration with EV is more relevant in the case of distributed generation, where EV, along with the distributed generation together contribute to meeting the load demand and variations over the day. Since EVs are not only consuming power (Grid to Vehicle, G-V), they are also capable of supplying power to the grid (Vehicle to Grid, V-G) through their batteries and hence play an active role in grid management[11]. As power generated from renewable sources are not dispatchable on their own, in conjunction with EV, they together participate in better grid control. Hence EV and distributed renewable generation can be seen as complementing each other.

Way Forward

Though there can be regional / country-specific challenges, some of the common factors that can support increased renewable penetration are:

- Commitment from countries towards net-zero emissions
- Investments
- Adoption of sustainable policy by corporations/ organisations
- Supportive government policies to attract investment
- Power system flexibility
- Transmission corridor availability
- Supportive cutting-edge technologies
- Widespread adoption of energy storage solutions

8 IRENA https://www.irena.org/transport/Electric-Vehicles
9 World Resources Institute https://www.wri.org/blog/2019/11/4-emerging-ways-pair-electric-vehicles-and-renewable-energy#:~:text=EV%20charging%20can%20be%20paired,with%20or%20without%20managed%20charging
10 Ministry of Power website https://powermin.nic.in/en/content/power-sector-glance-all-india

11 Electric vehicles integrated with Renewable Energy sources for Sustainable mobility by Michela Longo, Federica Foiadelli and Wahiba Yaici

As Electric mobility provides ample avenues for linking renewables and the transportation sector, the following aspects can help in better RE penetration:

- Regulated EV charging so that they do not destabilise the grid
- Attractive tariff schemes to utilise maximum RE generation
- Better forecasting tools both for predicting RE generation and EV charging demand
- Improved scheduling tools for optimum load management
- Smart charging facility at the consumer end

In advanced countries such as the US and in Europe, many of these features are already in place and in India, as the Electric mobility is still in a nascent stage, these aspects can be incorporated taking learnings from other countries and may help in contributing for a faster and smoother transition to a low carbon economy.

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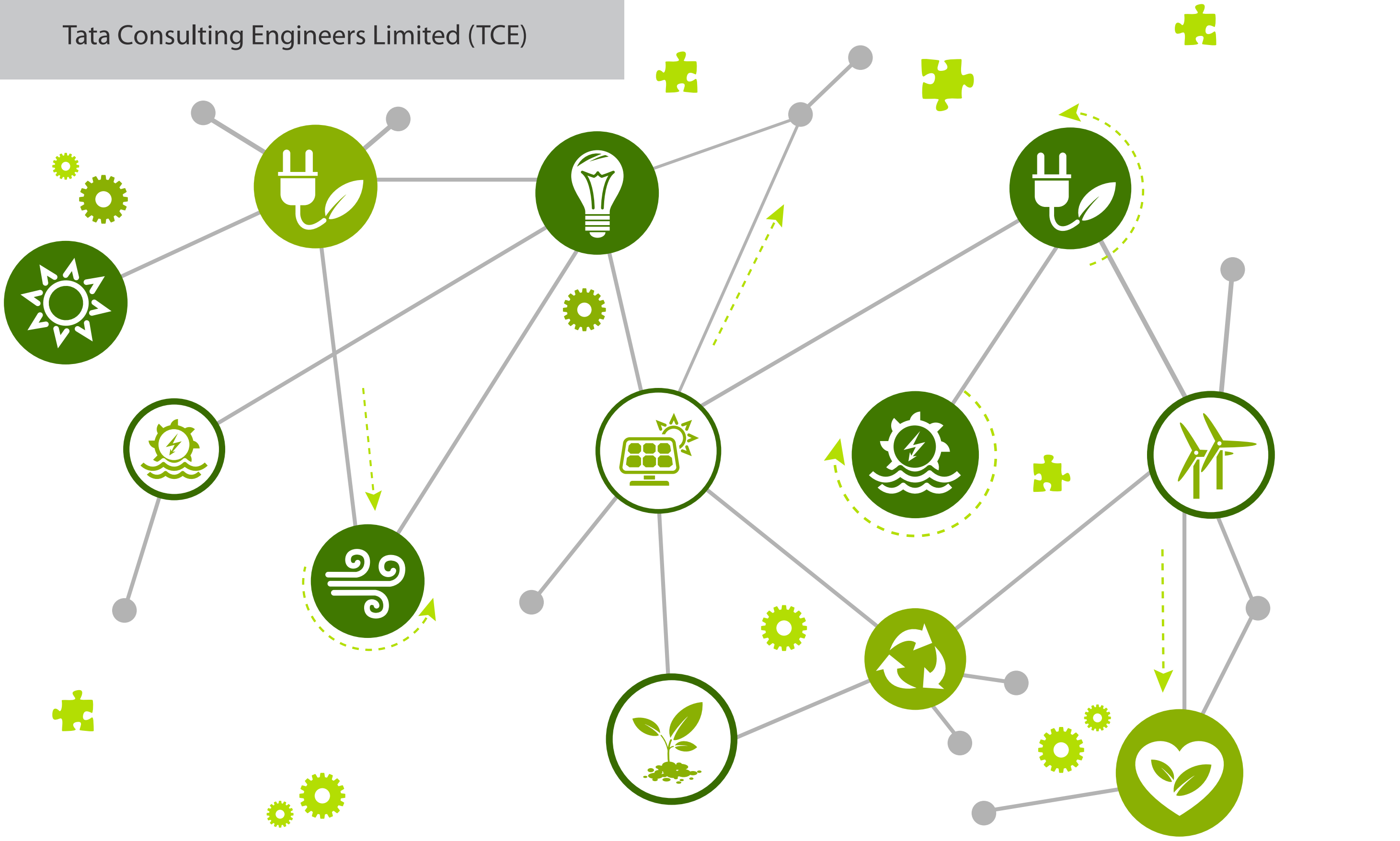


IMPACT ON THERMAL POWER PLANT DUE TO RENEWABLE PENETRATION & WAY FORWARD

The energy requirements and growth of the civilisation flourished through fossil fuels since the Industrial Revolution era reaching its pinnacle at the end of the 20th century. Subsequently, fossil fuel usage in power generation started declining and expected to settle almost at the installed capacity levels globally. The depleting fuel sources, difficulty securing long-term fuel supply agreements and ever-growing concerns of emissions and its impact on global warming from the release of greenhouse gases have led to this movement.

The drive to shift from fossil fuel-based power generation increased when the entire global community agreed to commit for limiting the global warming to well below 2°C under Paris agreement, on December 12th, 2015. Experts and the policymakers believe that this can only be achieved with significant decarbonisation of energy system over the long run.

It is expected that the implementation of the Paris Agreement will lead to the retirement of 80 per cent of the thermal power plant, globally by 2030. Further, falling of renewable energy prices and rising public resistance to set-up thermal power plants have also led to increased renewable capacity additions, forcing existing plants to operate at lower plant load factors, leading to reduced profits, forcing the private sector (IPP) exit.

This has led to a substantial reduction in investment for thermal power plants. Due to cheaper renewable sources and rising climate concerns, globally, the thermal power plants (predominantly coal-based) are losing visibility.

The renewable penetration in the grid, five states of India (Karnataka, Tamil Nadu, Rajasthan, Andhra Pradesh and Gujarat) face significant system integration challenges, as solar and wind shares rise above 15%.

In India, renewable energies, especially wind and solar technology, efficiency improvement measures, and how the existing power plant operates, are playing a fundamental role in reaching this goal. To achieve these carbon-free energy targets, Government of India plans to install 175 GW renewable energy with a daily net load swing of up to 80 GW by March 2022.

As per NITI Aayog, the total primary energy will increase almost three times between 2017 and 2042, equivalent to an annual growth rate of approximately 4%. However, coal will continue to remain predominant among all other commercial sources of energy in India. Considering the scale of demand in the country and abundant availability coal, it will remain the primary source for generating electricity, followed by hydro, gas, nuclear, and renewable energy.

However, coal usage will gradually transition towards clean coal technologies like supercritical (SC), and ultra-supercritical (USC) power plants, which will reflect in higher efficiency, more considerable power from coal with lesser coal consumption. Moreover, as compared to other fuels like oil and natural gas, which are mainly imported due to limited domestic resource availability, coal is available domestically in abundance. The older and smaller thermal power plants will retire and get replaced by larger SC / USC thermal power plants.

Further with the renewable penetration in the grid, five states of India (Karnataka, Tamil Nadu, Rajasthan, Andhra Pradesh and Gujarat) face significant system integration challenges, as solar and wind shares rise above 15%.

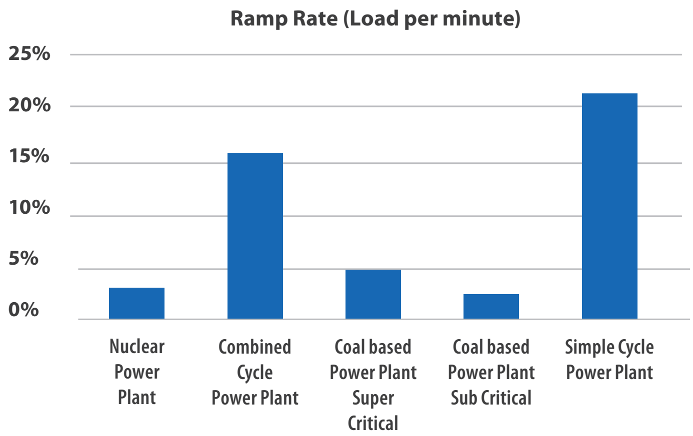
More states will experience higher shares of variable renewables, as solar power will be available during daytime and only when the sun is shining; and wind power is also dependent only when the wind blows. All these conditions create newer challenges and require significant change to the operation of the thermal power plants. This will create an opportunity for flexibility in the thermal power plant's operation and cleaner energy mix.

Considering the thermal power plant's percentage in the Indian power system, thermal power plants are the predominant source for the system flexibility. With its operating flexibility and lower loads and ramping rate, these plants can accommodate supply and demand variability and uncertainty.

There is a diverse range of strategies that can make existing conventional power plants more flexible. CEA has developed a road map for flexibilisation of thermal power plants, which underlines the importance of ramp rate (not a challenging factor, however, need to improve at least 1%/minute), financial framework (compensation for the increase in Capex and Opex due to change in the operating scenario) and revision of Grid Codes in terms of tariff structure. Considering this, there will be a considerable investment to develop thermal power plants to operate up to 30 to 40% load flexibly.

The other major factor for flexible operation of the grid is the operational philosophy (start-up and ramp-up characteristics) of the power plant. Gas-based combined cycle power plant with its high operationally flexible (high ramp rates & low start-up time) can suffice this requirement. The latest Indian grid code for RGMO (Restricted Governor mode of operation) mandates a speedy and sustainable response to the grid frequency fluctuations. Providing the primary frequency response will improve the grid stability, during daily load swing when renewables enter the grid. As per CEA, the required ramp rate in 2022 is 217 MW/min. (down) & 220MW/min (up).

The typical ramp rates of various type of units in India are depicted below.



Source: Gathered from various operating plant information

It may be noted that a simple cycle power plant has the highest ramp rate followed by a combined cycle power plant (CCPP) and coal-based power plant. The gas power plant in priority can support the daily swings as they possess higher ramping characteristics than the coal-based power plant.

The higher efficiency plants like supercritical units and advanced class combined cycle power plant would require operating at a baseload/maximum time. The subcritical power plant and stranded CCPP can take part in flexibilisation of the grid. The frequent load swings can be taken care of by the higher ramp rate turbines (Gas turbines/CCPP), while the steam turbine is used to operate at a fixed load condition.

Also, many R&D efforts are being deployed in developing hydrogen or hydrogen-based derived fuels viz., methanol/ammonia, and based combustion system for thermal power plants. The hydrogen generated from renewable power during lean power demand conditions can be stored and used in the thermal power plant when power demand peaks.

The capability to deliver a quick peak power is achievable through fuel combustion route. The hydrogen generated through renewable energy is termed as Green Hydrogen.

Further work around achieving Net Zero, without adding any more carbon to the atmosphere, is also underway. The carbon emissions, which is invariably generated through fuel combustion route presently, will be avoided. Using surplus renewable power, generating green hydrogen and synthesising with captured carbon from thermal power plants to make methanol or mix green hydrogen with nitrogen split from air to produce ammonia have all started. Small-scale testing of cofiring ammonia and coal is also being tried to reduce the existing power plant's carbon footprint.

While moving towards a cleaner energy mix, the following options are available for thermal power sector:

- Replacing the older thermal powerplant with new clean coal technologies like supercritical and ultra-supercritical power plants
- Operation of the stranded (8 GW) and stressed (16 GW) gas-based power plant to manage the Renewable energy variations, in India
- Shift to green hydrogen fuel or hydrogen-based derived fuels for use in thermal power plants, in future.

Having the dominant role in electricity supply, thermal power plants are critical for grid stability and economic growth. Due to stress on the environment impact, renewables may take over the larger share of power generation over the next few decades. However, this will not eliminate the addition of thermal power plant. The thermal power plants will continue to thrive in the grid, with its flexible nature and stabilising/sustaining the grid during the variation of renewable power generation.

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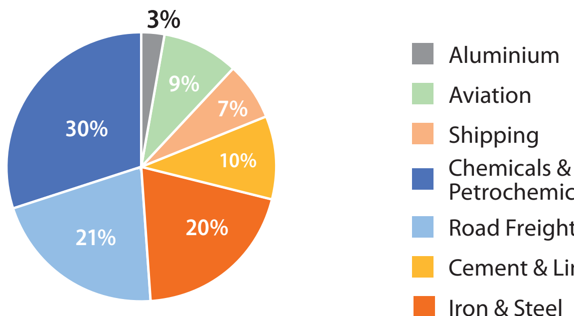
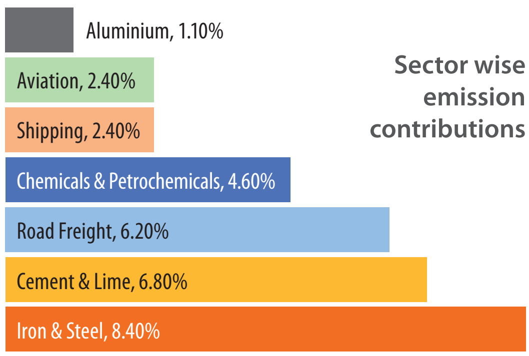
Energy Transition & Clean Technology In Metals: *IRON & STEEL*

The world is on a warming pathway of 2.8-3˚C, and the Paris accord, 2015 requires all nations to act aggressively to restrict temperature rise below 2°C above pre-industrial levels within this century. As of November 2020, the European Union and 194 countries, including India, signed the Agreement and expressed commitment to carbon neutrality. However, under current and planned policies, if fossil fuels such as oil, natural gas and coal would continue to dominate the global energy mix, the world would exhaust its energy-related "carbon budget" (CO_2) to keep the global temperate rise well below 2°C (with 66% probability) within 20 years.

Industry accounts for about 45% of the global energy consumption and 32% of total CO_2 emissions with varied contribution across seven major sectors:

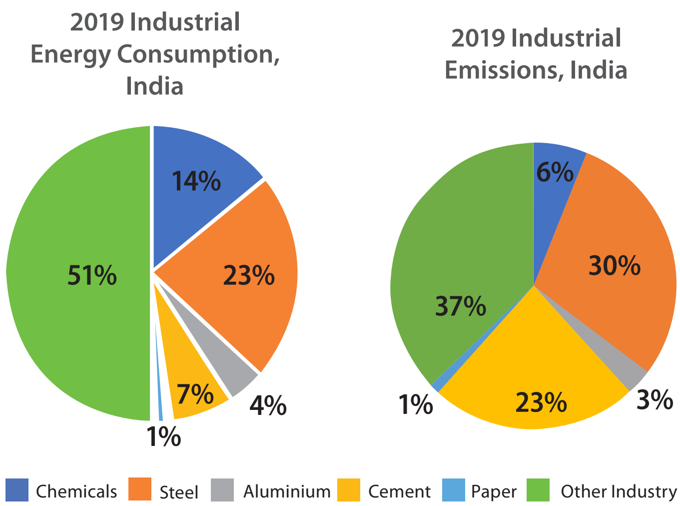


% Energy Consumption



Sector wise emission contributions

Figures below give the distribution in India:



Technologies are being deployed for a transition in energy systems starting with generation & use of renewable energy sources and moving towards hard to abate Energy-intensive and Emission-intensive industries such as Power, Metals (primarily Iron & Steel and Aluminium), Cement, Refineries.

Although aluminium takes a lower position in cumulative contribution, primary aluminium production is very energy-intensive. Emission intensity is around 4.8 tCO_2/t of aluminium against the global average of 2.2 tCO_2/t of crude steel. The energy source is primarily electricity. Majority of the power consumption is from inhouse power generation, primarily based on coal (~60%). Work on improvements in CO_2 emissions is in improved recycling, flexibility to adopt renewable power, and development of non-carbon consumables such as inert anodes.

At around 1.9 billion tons of global steel production per year and about 19 gigajoules (GJ) (0.45 tonnes of oil equivalent) of energy required per ton of crude steel, the industry emits around 2.6 Gt direct CO_2 emissions annually.

Similarly, Steel Industry stood highest as a single sector in industrial energy consumption and CO_2 emissions in India in 2019.

Consequently, steel players across the globe are increasingly facing a decarbonisation challenge. Three key developments drive this challenge:

- Changing customer requirements and growing demand for carbon-friendly steel products. A trend that has already been observed in various industries, including the auto industry.
- Further tightening of carbon emission regulations manifesting in carbon dioxide reduction targets and rise in carbon dioxide emission prices.
- Growing investor and public interest in sustainability. For example, the Institutional Investors Group on Climate Change, a global network with 250-plus investors, has raised expectations for the steel industry to safeguard its future in the face of climate change.

With substantial projected capacity additions (100 – 140 MT) by 2030-31 in India and high reliance on coal, green/clean technology is very relevant for iron & steel industry even in India.

Steel is mainly produced by two routes:

Iron ore-based steelmaking and Scrap-based steelmaking.

In total, 70% of the world steel is made BF-BOF route, where iron ore is reduced in Blast Furnace and then converted into steel in Basic Oxygen Furnace (BOF). Raw materials are mainly iron ore, coal, limestone and steel scrap. Electric Arc Furnace produces balance (EAF) wherein scrap steel, or Direct Reduced iron (DR) is mainly used as raw materials and electricity as the energy source. In FY2020, share or crude steel BF-BOF route was 44%, EAF- 26% and IF (Induction furnace) was 30% in India. Global average carbon emissions from above routes:

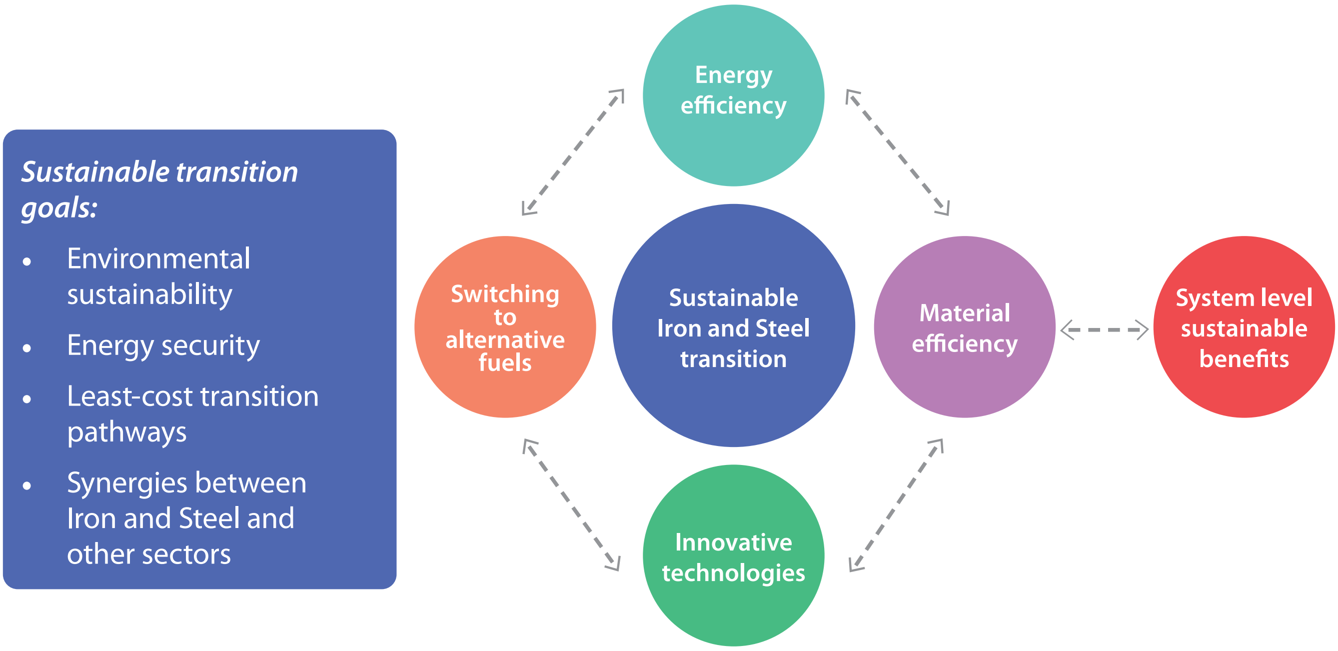
BF-BOF	*Natural Gas based DRI-EAF*	*Scrap based DRI*
CO_2 Emissions (Direct + Indirect*)		
2.2 t CO_2 / t cs (1 + 1.2)	*1.4 t CO_2 / t cs (1 + 0.35)*	*0.4 t CO_2 / t cs (0.04+0.35)*

**Indirect emissions include emissions from the required electricity and other energy imports. Coal-based DR kilns emit three times that of direct emissions by gas-based DRI.*

While energy intensity and carbon emissions are closely linked, the path towards energy transition in iron and steel sector can be divided into three segments:

- ***Reduce the energy intensity of current processes:*** Energy efficiency improvement with waste heat utilisation, Process efficiency improvement
- ***Replace fossil fuels for production***: Electrification and use of Renewable energy, low carbon Hydrogen, Biomass utilisation
- ***Develop new production pathways with low carbon footprint:*** Process intensification with hybrid technologies, Improved Scrap recycling and utilisation.

The path can be represented by the following figure also:



Available Technologies in Energy Transition and Decarbonising programmes for Iron & Steel Industries

The following section discusses the available technologies wherein Technical systems are either complete & qualified or very promising to have a significant impact in future:

- ***Technologies related to energy efficiency measures***
  Energy efficiency in industry has resulted in energy savings of around 40% per product unit (EEA, 2019). There is a remaining potential for estimated additional savings of 15-25% by 2050 using system design changes such as Coke Dry Quenching, Top Pressure Recovery Turbine, Waste heat recovery from different available sources, recuperative and regenerative burners, process improvements, etc. TCE has managed many such projects successfully.

- ***BF/BOF efficiency programs***
  Such programs improve efficiency and/or decrease production losses in different ways, for example
  - optimising the BF burden mix by maximising the iron content in raw materials to reduce the usage of coal as a reductant
  - increasing the use of fuel injection through, for example, pulverised coal injection (PCI), natural gas, plastics, biomass, or hydrogen (as an additional reagent on top), or
  - using coke oven gas in the BF as an energy source.

  These processes may decrease carbon dioxide emissions without eliminating them, but do not offer fully carbon-neutral steel production.

- ***Technologies dealing with electrification***
  There is a growing potential for emission reduction in the steel industry by switching from fossil fuels towards electricity, thanks to growing availability of strong transmission grid and economical renewable power including rooftop solar, waste energy utilisation, etc. supported by storage solutions.

  As indicated earlier, the EAF route is a well-established technology having substantially fewer emissions with a major share of indirect emissions. The use of electricity often offers considerable efficiency benefits, such as applying heat pumps for low-temperature heat. Several commercially available technologies can be implemented to substitute fossil fuels for heat demand: Electrode boilers, Electrical resistance heating, Heat pumps, Steam recompression, etc.

  However, the integrated steel plants run with an established gas and steam balance. Thorough knowledge and case to case basis study are required to evaluate the techno-economic benefits.

- ***Increase share of scrap-based EAFs***
  EAF producers are more environmentally friendly and flexible to demand ups and downs. Increasing the share of EAF-based steel production will play a key role in decarbonising the steel industry.

However, this role will be dependent on the regional availability of high-quality scrap. Therefore, it could be limited in regions with an inadequate supply of high-quality scrap, making other technologies a must.

Increasing demand for high-quality scrap will also lead to extra cost for EAF-based steel production.

- ***Transition to gas-based DR-EAF route***

  Another matured alternative is the gas-based DRI EAF route. In case a carbon-neutral reduction gas is used, such as green hydrogen, the steelmaking process can be mostly carbon-neutral and fueled by renewable electricity in the DR-EAF route.

  Currently, Iron ore can be reduced to iron by reduction with Natural Gas (NG). NG can play an interim role in the transition phase by implementing the DR/EAF production route.

  DRI-EAF route based on NG would result in a ~40% CO2 emission reduction compared to the BF-BOF route. In the long term, use of green hydrogen in place of NG will lead towards carbon neutrality. However, this is mainly dependent on the availability of required gases.

- ***Biomass reductants***

  This process uses biomass, such as heated and dried sugar, energy cane, or pyrolysed eucalyptus, as an alternative reductant or fuel. It is regionally dependent and mainly crucial in areas where the biomass supply is guaranteed, like in South America or Russia.

  In Europe, biomass availability is likely not enough to reduce carbon emissions on a large scale. This is used as reductant and may replace coal.

- ***Use of Hydrogen in Blast Furnace***

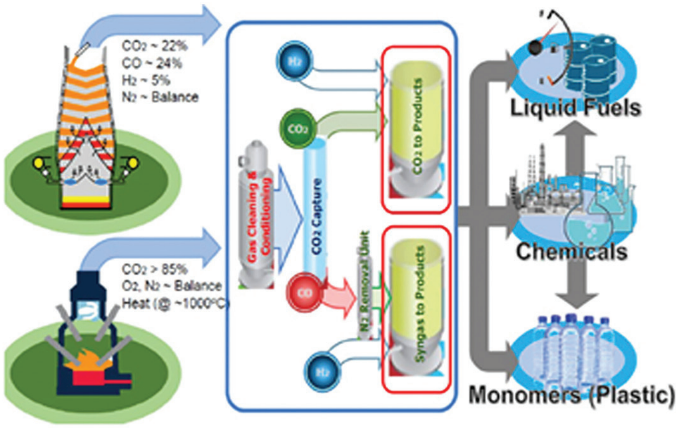
  Hydrogen reduction is not yet proven at industrial scale and is currently more expensive than the BF-BOF route. However, it also depends on the availability of hydrogen.

  Green Hydrogen generation requires intensive renewable electrical energy, and with the availability of economical solar & wind power, green hydrogen is expected to be affordable by 2030.

Following hydrogen-based technologies are promising and will have a huge impact once made commercially viable:

- ***HYBRIT:*** Direct reduction of iron into steel using hydrogen and renewable energy generates water as a by-product instead of carbon dioxide.
- ***COURSE-50:*** This involves reforming coke oven gas using catalysts and utilising unused heat to increase its hydrogen content (from 55% to 67%). This hydrogen-enriched gas is then used for the reduction of iron ore in the blast furnace.
- ***SUS STEEL:*** Based on hydrogen-based DR-EAF steel making (Hydrogen Plasma Smelting Reduction: HPSR process).
- ***SALCOS:*** The SALCOS technology uses hydrogen-based DR-EAF steel making
- ***FLASH OXIDE SMELTING:*** The process would use inexpensive NG (or hydrogen) to heat the ore and remove oxygen, in converting the ore into metal.

Technologies for Carbon Capture, Utilisation/ Storage (CCU/S)



In addition to the above shift in energy systems, carbon dioxide capture with permanent sequestration (CCS) / viable utilisation (CCU) prepares to play a significant role in defining the future energy systems.

New technologies such as the HIsarna process generate CO_2 rich emissions for economic capture other than 20% emission reduction by replacing Coke making and agglomeration processes. However, the commercial transformation will require time.

A summary of various available & emerging Technologies is tabulated below with broad segregation on technology readiness between a pilot and commercially availability:

TECHNOLOGIES ON ENERGY OPTIMISATION, REDUCTION OF EMISSION & DECARBONIZATION				
PROCESS	BF-BOF ROUTE		DRI -EAF/EIF ROUTE	
	PILOT	COMMERCIAL	PILOT	COMMERCIAL
Sintering	-	Waste heat recovery	-	NA
Sintering	-	High-Efficiency Coke Oven Gas Burner in Ignition Furnace	-	NA
Sintering	-	Increasing sinter bed depth	-	NA
Sintering	-	Improvement in segregated charging of sintering material	-	NA
Cokemaking	-	Coke Dry Quenching (CDQ)	-	NA
Cokemaking	-	Coal Moisture Control (CMC)	-	NA
Cokemaking	-	Automated Combustion Control of Coke Oven	-	NA
Cokemaking	-	Partial fuel substitution in the coking plant	-	NA
Ironmaking	COURSE 50	Top pressure recovery turbine (TRT)	SALCOS	Use of iron ore pellets in DRI kiln/ BF.
Ironmaking	FLASH OXIDE SMELTING	Preheating through WHR from Hot Stoves of Blast furnace	SUSEEL	Waste Heat Recovery from Sponge Iron kiln.
Ironmaking	HISARNA	Pulverised coal injection (PCI)	HYBRIT	-
Ironmaking	-	Injection of coke oven gas	-	-
Ironmaking	-	Recovery of blast furnace gas	-	-
Ironmaking	-	Stove flue gas recycling	-	-
Ironmaking	-	Use of iron ore pellets in DRI kiln/ BF	-	-
Steelmaking	-	Converter gas heat recovery device	-	Charge or scrap preheating
Steelmaking	-	Converter gas recovery device	-	Scrap densification or shredding
Steelmaking	-	Heat recovery from steelmaking slag	-	Coherent Jet Gas Injection Technology
Steelmaking	-	Increased use of recycled steel scrap	-	Improved process control
Steelmaking	-	-	-	Ultra-high-power transformers
Steelmaking	-	-	-	Waste heat recovery from EAF
Steelmaking	-	-	-	Ecological and Economical Arc Furnace
Steelmaking	-	-	-	Oxy-fuel burners or lancing
Steelmaking	-	-	-	Slag Foaming, Exchangeable Furnace and Injection Technology
Steelmaking	-	-	-	Hot Charging DRI
Steelmaking	-	-	-	Increased use of recycled steel scrap
Casting and Refining	-	Oxygen burners system for ladle preheating	-	Near net shape casting
Rolling	-	Regenerative burners in reheating furnace	-	Direct rolling
Rolling/ Furnace	-	Rotary Hearth Furnace (RHF) Dust Recycling System	-	Hot charging of slab
Rolling/ Furnace	-	-	-	Installing VVVF drives to electrical motors

Financial Improvements/ Government funds applicable in India

Current Indian Govt. policies and programmes that could enable progress towards low emission steel making are given below:

- ***PAT (Perform, Achieve, Trade) Scheme:***
  Aims to reduce industrial specific energy consumption using a market-based mechanism.

- ***Steel Scrap Recycling Policy:***
  Increasing the steel recycling rate is the primary goal of the Steel Scrap Recycling Policy (Ministry of Steel, 2019c), promoting the 6Rs: Reduce, Reuse, Recycle, Recover, Redesign and Remanufacture.

- ***Promotion of R&D in Iron & Steel Sector Scheme:***
  Regarding public-sector funding, the Indian government through the Ministry of Steel has supported several R&D projects under this with a total cumulative budget of more than USD 17 million over the past five years (Ministry of Steel, 2019a). Private companies in India such as SAIL, RINLS, Tata Steel, and JSW, invest cumulatively USD 83.3 million in R&D per year.

Conclusion and Way Forward

Metallurgical industries in General and Iron & Steel Industry in particular, are energy-intensive and generate a significant amount of Green House Gas. Innovative approaches in Energy optimisation, Waste heat recovery, Scrap recycling, Gas based EAF will support shift towards green. Carbon capture and utilisation/ storage and the use of green H2 for the reduction process offer prospective solutions. Still, adoption reality depends on the socio-economic thrust and availability of required resources, including a considerable quantity of renewable energy, technology maturity for commercial adoption.

Adopting the fast development in digitalisation, artificial intelligence and machine learning offers a considerable prospect in unfolding detailed information on the processes and optimisation in energy consumption. While coming years will bring out the techno-economically sustainable solutions, an open-minded, informed and progressive approach in developing the configuration for a greenfield project and prioritising the sustainability projects in a brownfield installation may be a key to adopt and align with future.

Each system needs to be evaluated in terms of Input, Internal Process, Output and Recycling capacity to arrive at a suitable carbon footprint, integrated into overall plant product. The plant's success appears to be dependent on effective collaboration across sectors of power, chemicals, digitalisation, automation, and environmental control measures, other than the core process optimisations & development.

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ELECTRICITY DISTRIBUTION SYSTEM IN INDIA

The Indian power sector is segmented mainly into Generation, Transmission, and Distribution sectors. The Distribution sector involves Distribution Companies (Discoms) responsible for the supply of electricity to the Domestic, Industrial, Commercial and Agriculture Consumers. In Power Sector, the distribution system is a weak link due to high Aggregate Technical & Commercial (AT&C) losses, erroneous metering, poor revenue realisation, and inadequate infrastructure maintenance.

All these factors have contributed to the poor financial health of the distribution utilities. As mandated in the Indian Electricity Act-2003, the State Electricity Boards (SEBs) were unbundled for independently handling Transmission, Generation & Distribution sectors and setting up the Central and State Electricity Regulatory Commissions. At present, 58 independent Discoms operating in India excludes SEBs, where the Generation, Transmission, and Distribution sectors are yet to be unbundled.

Distribution losses in India are around 35-40 %, which is very high compared to the Global standards. In 2015, to reduce distribution losses from 35%-45% to 15%, Government of India (GoI) launched UDAY scheme.

In May/Sept 2020, to revive the health of ailing Discoms a significant financial intervention by GOI of Rs 90,000 Cr was announced, which is expected to be enhanced to Rs 1,20,000 Cr through Power Finance Corporation (PFC) and Rural Electrification Corporation (REC)[1]. These initiatives will improve the financial health and operational efficiency of the Discoms.

Over the last 15 to 20 years, the Distribution sector's outlook has vastly improved due to various Regulations and Schemes introduced by the Central and State Governments.In the coming years, consumers' preference towards uninterrupted high-quality power supply and fast phase technological developments will drive the distribution sector's growth to new heights.

TCE with its vast experience in the power industry is all poised to take up the challenges and provide solutions to Discoms to improve the overall performance in the areas such as Due diligence, AT&C loss minimisation studies, smart metering infrastructure, digitisation, utility-scale battery energy storage system, renewable integration and IT-enabled services to the distribution utilities across the country.

1 ET Energy World (13 May 2020) and Press Trust of India (13 Sep 2020)

Government Policies and Regulations

Since independence, both Central and State governments have supported electrical sector with various schemes and initiatives to improve the overall health of Discoms but with limited success. This has resulted in a resource drain on the Indian economy.

The Electricity Act-2003, National Electricity Policy-2005 and National Tariff Policy-2006 have vastly helped improve the Indian power sector. The key initiatives/ programs in Distribution sectors such as Accelerated Power Development Reforms Program (APDRP)2002 and Restructured Accelerated Power Development and Reforms Program (R-APDRP) 2008 have primarily focused on improving necessary infrastructure, and IT-enabled services of Discoms.

National Smart Grid Mission (NSGM) 2012, Deendayal Upadhyaya Gram Jyoti Yojana (DDUGJY)2014, Pradhan Mantri Sahaj Bijli Har Ghar Yojana (SAUBHAGYA) 2017, Ujwal Discom Assurance Yojana) scheme – (UDAY) 2015 are focused on meeting the goal of "Power to All". All the schemes aim to ensure availability of 24×7 power at an affordable price and improve the financial health and operational efficiency of Discom.

In 2020, to revive the health of ailing Discoms a significant financial intervention by GOI, Rs 1,20,000 Cr would be infused through PFC and REC. The Draft Amendment Bill proposes Direct Benefit Transfer (DBT) for the economic viability of Discoms. Now, State Govt. can directly pay to end consumer under Direct Benefit Transfer and linking smart meters to provide DBT to consumers.

The government is continuously evolving various policies and regulations to bring commercial viability for Discoms. As in Delhi and Orissa's case, the Private players are encouraged through multiple models such as Public Private Participation (PPP).

In Maharashtra, Madhya Pradesh and Uttar Pradesh input-based distribution franchisee models are being considered. In May 2020, GoI announced that the Centre would privatise the power distribution companies in Union Territories (UT). This will bring private sector investment and result in improved operational efficiency, better service to consumers and financial health of Discoms in UTs.

Current Challenges

Aggregate Technical & Commercial (AT&C) losses in Distribution are as high as 35%, which are much higher than those in any developed country. Increasing share of renewable generations in the grid has impacted the traditional approach of Distribution system operation.

The power generated from wind and solar plants is intermittent in nature and difficult to schedule firm power. To take care of these variations, distribution utilities will tie-up with additional peaking generating stations with high variable cost.

The use of gas-based peaking generating stations for balancing purpose is uneconomical as it increases the power purchase cost of distribution licensees.

The decentralised market structure provides individual distribution entities to be more responsive in complying with grid discipline rules of balancing their generation and demand. The regulation has mandated volume limits on over drawl and under-drawl of electricity.

Distribution utilities are severely affected due to these grid discipline rules and pay a hefty penalty. In the coming decade, the need to modernise the grid will help the utilities meet the challenge of handling projected energy needs while maintaining a robust and resilient electricity delivery system.

TCE with its vast experience in the power industry is all poised to take up the challenges and provide solutions to Discoms to improve the overall performance in the areas such as Due diligence, AT&C loss minimisation studies, smart metering infrastructure, digitisation, utility-scale battery energy storage system, renewable integration and IT-enabled services to the distribution utilities across the country.

TCE Role in Electrical Distribution System in India

With its vast experience in Power Industry, TCE is all poised to take the challenge and provide solutions to Discoms across the country.

Focused Areas of Distribution System

Due Diligence

- *Privatisation of DISCOM*
- *Firming Management level Investment decision by developing Utility level SWOT analysis*

AT&C Loss Minimisation

- *Various Government initiatives are taken to improve the health of Distribution system*
- *Most of the Indian utilities have high AT&C losses*

Grid Automation

- *Improved system performance*
- *Reduced dependence on HR*

Smart Grids / Smart Meters

- *Various Government initiatives including smart cities*
- *Moving towards Digitalisation*

BESS

- *Managing a renewable mix*
- *Reducing Grid Penalties and enabling flexible operation*

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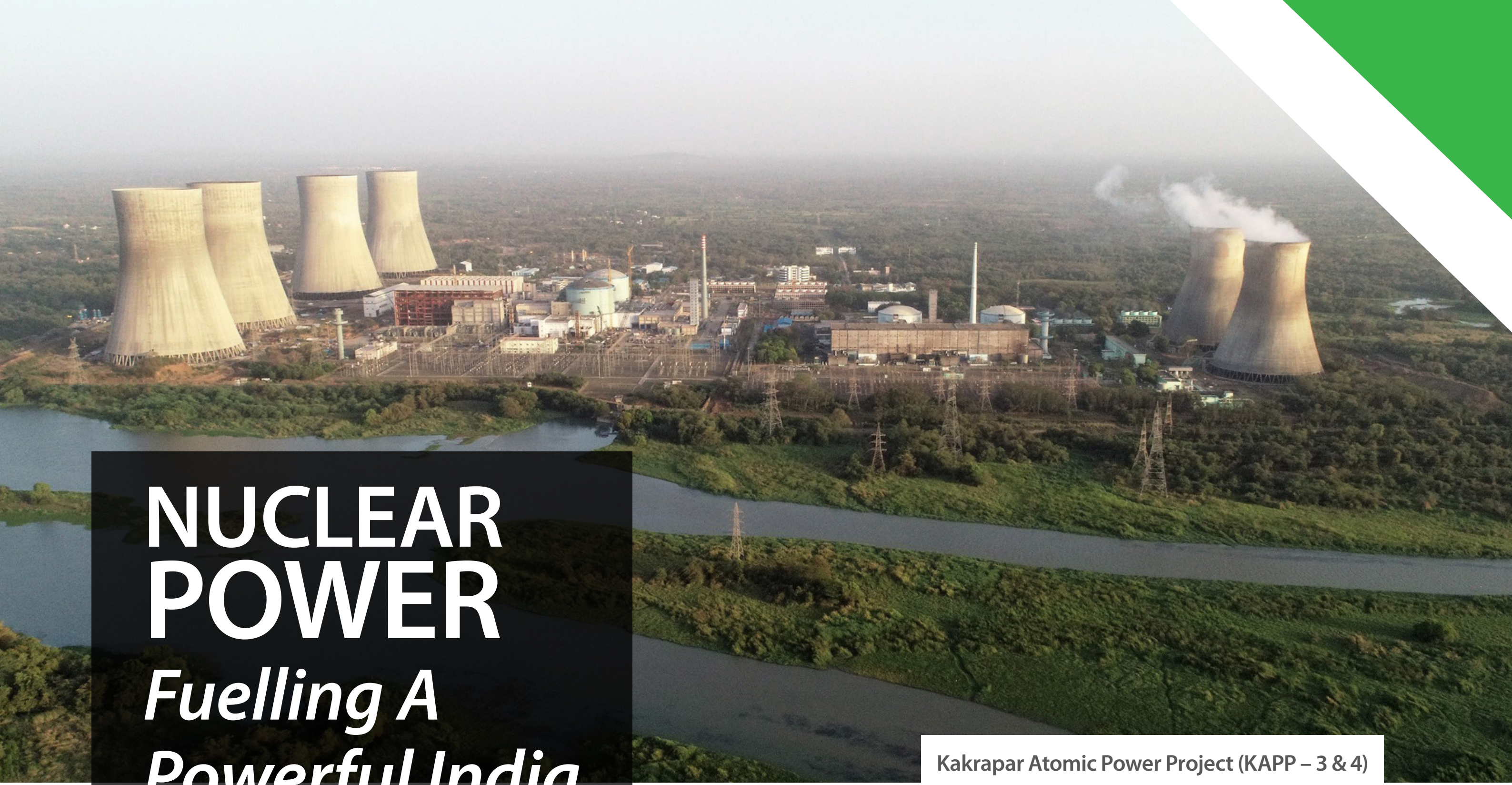

NUCLEAR POWER

Fuelling A Powerful India

Kakrapar Atomic Power Project (KAPP – 3 & 4)

Building "Brand India" on a global stage

Nuclear power generation plays a vital role in India's energy security and energy transition aspirations. India started its Nuclear energy program soon after independence by setting up the Indian Atomic Energy Commission in 1948 (Today's Department of Atomic Energy (DAE)), pursuing relentlessly to empower India with high technology and advanced scientific research in the nuclear field.
DAE has an ambitious plan, which puts India on a high pedestal in the global arena.

TCE has been continuously working for DAE and its various units for the past four decades in engineering nuclear power projects and associated infrastructure facilities. TCE's rich engineering experience covers complete plant engineering for nuclear power projects with boiling water reactors, pressurised heavy water reactors and fast breeder reactors (Fig.1). Also, TCE has extensive experience and capability to engineer nuclear fuel processing, fuel fabrication and waste management facilities.

Nuclear Power Plants - Engineering Capability

Special Capabilities

1. Integrated 3D/4D Engineering 2. Fire Hazard Anaysis 3. Plant Layout Studies 4. Advance Analysis (FEA/CFD/Blast Analysis) 5. Special component Design (Fuelling machine) 6. Industrial Automation & Remote Handling

Fig. 1: TCE's Nuclear Engineering Capability

TCE has achieved 85% market share in engineering services in the nuclear sector, thus becoming a trusted partner in implementing projects of national importance and strategic in nature.

Nuclear Power in India – Present Scenario

Nuclear power generation's total installed capacity in our country stands at 6780 MW as of December 2020, which is about 2% of the total installed power generation capacity. In terms of electricity generated, all operating nuclear plants added nearly 46 billion units of electricity to our national grid in FY20, which accounted for a little more than 3% of total electricity generated in our country in the corresponding period.

Presently, 22 nuclear power reactors are operating in India, and many units are under various stages of implementation. Government of India has an ambitious plan of tripling the installed nuclear power generation capacity in the next ten years. The Units No 1 & 2 in Tarapur Atomic Power Station (TAPS) had completed ***50 years of safe operation*** as of May 2019. Unit No. 1 of Kaiga Atomic Power Station (KAPS) had ***set a world record of 962 days of continuous operation.*** These benchmark performances reaffirm our highest safety standards of Nuclear power plant operation.

India's Long-Term Approach

India has an advantage in terms of the availability of nuclear fuel resource. Though the availability of Uranium is limited, we have an extensive resource of thorium. Kerala and Orissa's beach sands have rich monazite reserves, which contains about 8 – 10% thorium. Thorium can be used to produce nuclear energy, but not directly due to its physical properties. Thorium must be converted to U233 in a nuclear reactor so that it can be used as fuel.

India's nuclear power program (three-stage approach) is a long-term vision to meet our country's energy needs for several centuries, duly addressing the climate change challenges.

The three-stage process multiplies power generation potential by expanding the nuclear fuel base.

- We adopt pressurised heavy water reactors (PHWRs) with natural uranium 235 (U235) as fuel and heavy water as moderator & coolant in the first stage.
- In the second stage, we will adopt fast breeder reactors (FBRs) with depleted Uranium and plutonium obtained from recycled spent fuel from the stage 1 reactors with thorium as a blanket produce Uranium 233 (U233).
- In the third stage, we will be using breeder reactors (BRs) with U233 as fuel produced from stage 2 reactors. The power generation potential is enormously high and will be sustainable for many centuries.

A large amount of work has been carried out on several aspects of thorium fuel cycle viz. mining and extraction, fuel fabrication, evaluation of its properties, reprocessing and recycling.

Nuclear Power Projects under implementation

The indigenously designed 700 MW Pressurised Heavy Water Reactor (PHWR) is our nuclear power generation fleet's work-horse. The following projects with a cumulative capacity of 8200 MW are under various stages of implementation. Unit No. 3 of KAPP achieved its criticality in July 2020, and other units in KAPP and RAPP would be achieving criticality in a phased manner.

The construction work is in advanced stage in the Kudankulam project, and the first pour of concrete (FPC) has been achieved in GHAVP project recently.

Project	Reactor Type	Plant Capacity
Kakrapar Atomic Power Project (KAPP-3&4)	PHWR	2 x 700 MW
Rajasthan Atomic Power Project (RAPP-7&8)	PHWR	2 x 700 MW
Kudankulam Nuclear Power Project (KKNPP-3&4)	LWR	2 x 1000 MW
Gorakhpur Haryana Anu Vidyut Pariyojana (GHAVP-1&2)	PHWR	2 x 700 MW
Kudankulam Nuclear Power Project (KKNPP-5&6)	LWR	2 x 1000 MW

Fleet Mode Implementation
Shifting gears

To achieve a quantum leap in implementing nuclear power projects, NPCIL has announced fleet mode implementation of 10 numbers of 700 MW PHWR reactors (a fully indigenously developed design), thus enabling further addition of 7000 MW of power generation capacity within next ten years. Following are the proposed projects under fleet-mode implementation.

Project	Reactor Type	Plant Capacity
Kaiga Atomic Power Project (Kaiga-5&6)	PHWR	2 x 700 MW
Gorakhpur Haryana Anu Vidyut Pariyojana (GHAVP-3&4)	PHWR	2 x 700 MW
Chutka Nuclear Power Project (Chutka-1 &2)	PHWR	2 x 700 MW
Mahi Banswara Nuclear Power Project (Mahi 1&2)	PHWR	2 x 700 MW
Mahi Banswara Nuclear Power Project (Mahi 3 & 4)	PHWR	2 x 700 MW

Next stage reactors

Indian Government has set up a company, ***Bharatiya Nabhikiya Vidyut Nigam Limited (BHAVINI)*** to construct and commission fast breeder reactors in our country. ***BHAVINI is presently building 500MWe Prototype Fast Breeder Reactor (PFBR) at Kalpakkam.*** The PFBR is the fore-runner for future installations of Fast Breeder Reactors in our country. ***The PFBR is being built with the design and technology developed at the Indira Gandhi Centre for Atomic Research (IGCAR), Kalpakkam.***

India has developed two types of advanced reactors, namely, AHWR and AHWR300-LEU, to adopt a large scale utilisation of thorium for power generation in Stage-3 of the nuclear power program. These reactors are of 300 MW capacity and of boiling light water cooled and heavy water moderated reactor.

AHWR reactor will use Thorium-Plutonium or Thorium-Uranium233 as fuel, while AHWR-LEU reactor will use Thorium-Low enriched Uranium fuel.

Conclusion

India is poised to achieve significant growth in nuclear power generation in the years to come, and nuclear power generation capacity will reach to the tune of 25 GW by 2030. The second and third-stage nuclear power generation strategy will be accelerated to achieve long-term energy security. Nuclear power will play a significant role in realising the net-zero carbon commitment to be achieved in 2050, considering the lower carbon footprint.

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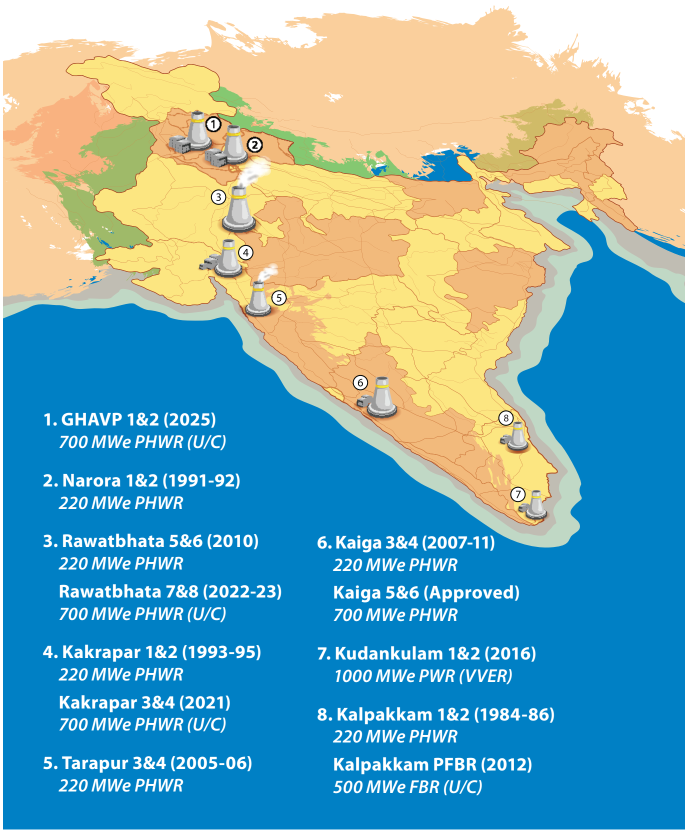


TECHNOLOGY DEVELOPMENT AND AUTOMATION FOR OPERATING NUCLEAR PLANTS

Engineering Assistance to **Periodic Safety Review of Operating Nuclear Plants, Plantlife extension studies,** is a growing business area in India and Globally as more plants are approaching their design life. This involves Deterministic and Probabilistic safety assessment of operating nuclear assets. ***TCE is currently the only Indian consultant assisting in this area for commercial-scale nuclear plants.***

TCE has successfully developed the Deterministic Safety Assessment (as a new service offering) and is engaged with clients including **NPCIL-PHWR, NPCIL-LWR and IGCAR.**

Deterministic safety assessment (as per Conservative Deterministic Failure Margin (CDFM) method) of any structure/component involves the following stages

- Performing Finite Element (FE) Analysis of the structure/component
- Digitising the As-built strength of various structures and components.
- Finding the margin available to assess the as-is condition of the components. (High Confidence of Low Probability of Failure (**HCLPF**) factor)

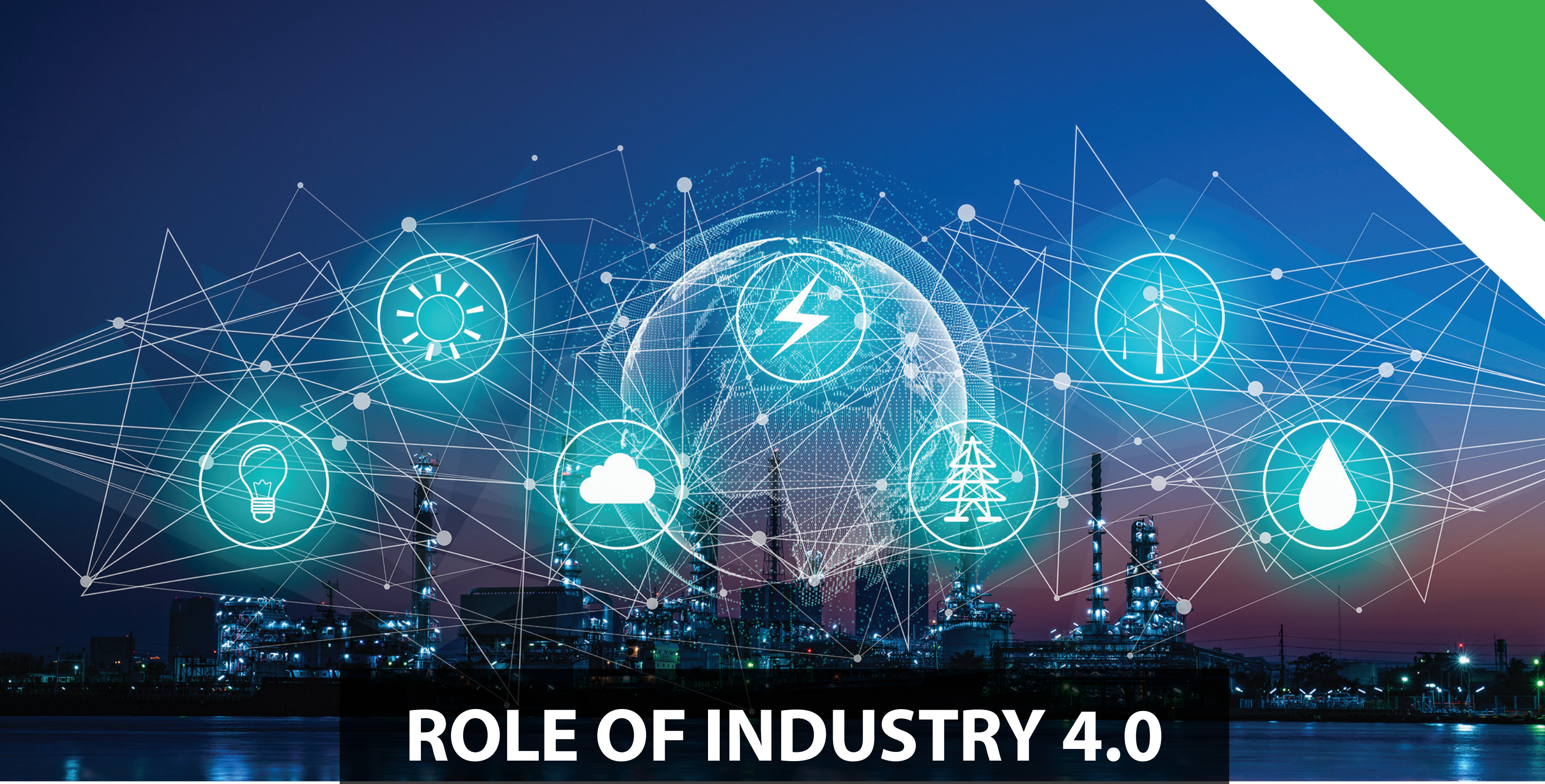
This involves handling massive volumes of as-built data and FE analysis results.

Anticipating the need for an automation-tool to optimise the process, an integrated **one-click** program, **"SMART", which integrates a suite of modules**, has been developed which extracts and links FE Analysis results (Demand), with as-built digital data of the plant (Capacity) to assess the Seismic Margin available, for various structural elements.

The advantage of having this technology and set of tools developed has helped TCE retain its position as a monopoly supplier in this area and working on repeat orders from DAE.

Since the automation is entirely **modular based on standard work-flows**, it is effortless to extend it for any other international design codes or accommodate any technological advances. ***TCE is currently expanding the tool for Russian SNiP codes for an ongoing Light Water Reactor project.***

The tool's efficiency was a significant challenge as the run-time had to be optimised for enormous data volume involving millions of numerical calculations. TCE mitigated this by adopting careful programming methods, including a modified numerical search method where the computational speed has been improved, apart from automating the process.

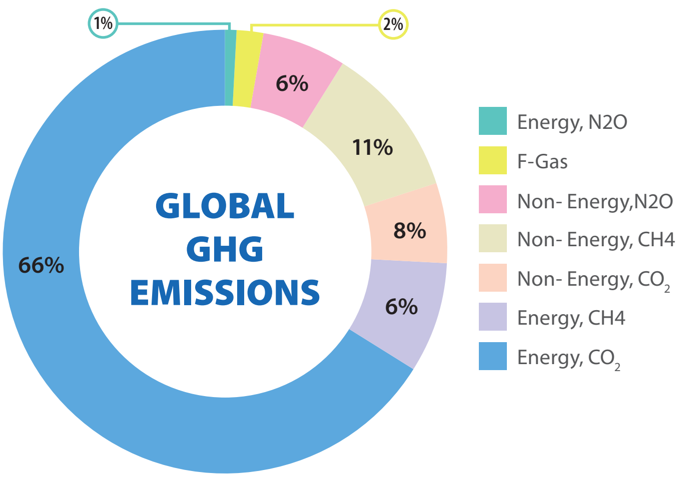


ROLE OF INDUSTRY 4.0 IN ENERGY TRANSITION

The energy industry is going through a significant transformation with Decarbonisation, Decentralisation and Digitalisation (3Ds) as central themes around this transition. It is touching every entity in the value chain; from energy-producing companies to the last mile consumers. The clean energy drive originates from the efforts to contain GHG emissions as part of the global climate change initiative. Digitalisation complements this drive by technologically enabling the transition. Decentralised production and energy consumption would significantly help reduce transmission losses and improve access to quality energy. The change is visible in energy production, consumption and the way it is transmitted and distributed. Digitalisation would accelerate each step of the transition by making them more efficient, flexible and reliable. Industry 4.0 technologies, Internet of Things (IoT) and Artificial Intelligence (AI) /Machine Learning (ML) can improve the efficiency of plants/industries and reduce fossil fuel consumption. This article covers the impact of Industry 4.0 technologies and digitalisation on energy transition.

Decarbonisation for Existence of Humanity

The Intergovernmental Panel on Climate Change (IPCC) of UN estimated that the human activities are responsible for about 1ºC of global warming by 2030 w.r.t the pre-industrial levels and are likely to reach 1.5º C by 2050 if the current activity levels continue. Global warming effects are visible in the past couple of years with many unpredicted, devastating climate events worldwide. Considering the need for firm action to limit global warming, Paris summit on Climate Change in 2015 reaffirmed the global warming target of 1.5ºC w.r.t base reference and legally binding agreement came into existence with acceptance of 195 countries.



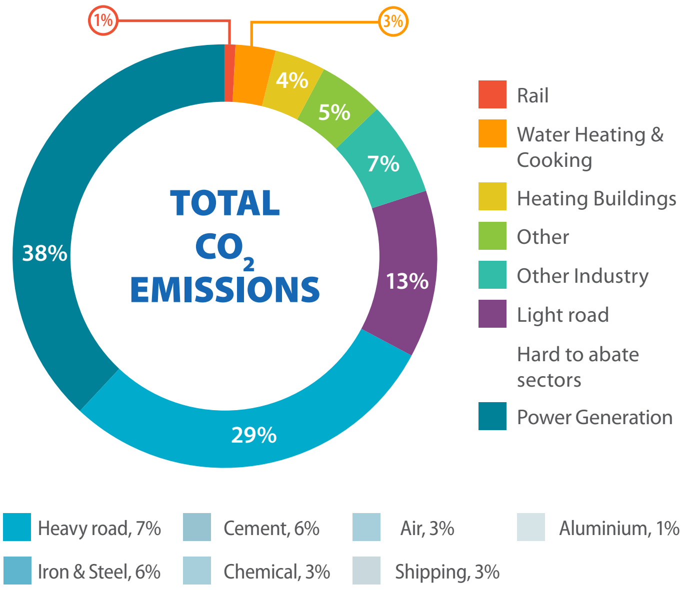
Source: WEF, Energy Transition 101, July 2020

Fig. 1

Significant technological and policy-related interventions are in various implementation stages to reduce emission levels and achieve carbon neutrality by 2050. The energy sector is the major contributor to GHG emissions. It corresponds to about 73% of the overall GHG emissions globally. Hence, a continued focus on the energy sector is essential to reduce emission levels. And about 66% of it is CO_2 emissions. Refer Fig. -1.

In Energy Sector, a significant share is from power generation, contributing about 38% of the total GHG emissions per 2014 statistics.

The clean energy drive has picked up considerable momentum in this background, and measurable decarbonisation targets and monitoring mechanisms are in place for the countries and institutions. Carbon neutrality is targeted by 2050, and about 45% reduction in CO_2 emissions than 2010 levels is required to achieve this goal.



Source: WEF, Energy Transition 101, July 2020

Fig. 2

Broadly, to meet the climate targets related to GHG emissions, there shall be a continuous reduction in usage of fossil fuels and an increase in dependency on renewable energy sources. The curtailment of fossil fuel can be achieved by shifting to renewable sources or improving fossil fuel-based plants/industries. The strategies that are being adopted for decarbonisation are aligned in this direction and major ones briefed below.

Use of Alternative, Low-Carbon Energy

The dependency on natural energy sources like solar, wind, tide, geothermal shall be increased instead of fossil fuels like coal, oil, natural gas etc. Hydrogen is also an alternative clean fuel. The energy production from these sources is also becoming cost-competitive due to scaling. IEA, in its 2020 report mentioned that the cost of capital for solar power is lower compared to coal-based power by about 2.6-5.0% in Europe and the US, 4.4-5.5% in China and 8.8-10.0% in India, mainly as a result of policies designed to reduce the risk of renewable investments. As per the report, solar electricity can be generated "at or below" $20 per megawatt-hour (MWh) in the best locations and with necessary policy and financial support.

Switching from fossil fuel to electricity in all transportation means can significantly reduce emissions. An average electric car and plug-in hybrid electric car using electricity emit less GHGs than a global average internal combustion engine driven car using gasoline over their life cycle. (Considering current global average carbon intensity of 518g of carbon dioxide equivalent per kWh). The alternative means for powering transportation would involve new materials (say for battery internals, motor winding etc.) and end processing. The GHG emissions generated in the life cycle of such new materials shall also be accounted while evaluating an alternative mean for mechanical power production in place of conventional fossil fuel-based engines.

Enhance Energy Efficiency

About 67% of the energy produced is lost on an average due to the inefficiencies in electricity generation, transport, heavy industry and buildings. For example, subcritical thermal power units have efficiencies between 33% and 37%; i.e. between 33% and 37% of the coal's energy is converted into electricity. Efficiencies for supercritical coal plants range from 37% to 40%. In ultra-supercritical units., generating efficiency ranges from 44-46% and the world's most efficient combined-cycle power plant in operation today, having an efficiency of about 63.08%. There is ample room for increasing the plants and processes' energy efficiency to use less fossil fuel for the same power generated. The fossil fuels still form about 84% of the global energy mix, and a small increment inefficiency can result in a significant reduction in CO_2 emission.

Building energy management systems also plays a crucial role in reducing global CO_2 emissions because of the scale at which it can influence. Efficient, smart, IOT powered building management systems can reduce energy consumption by about 20-30% in the longer run.

Further, there are "Hard to Abate "sectors wherein the CO_2 emission is unavoidable due to the nature of the process adopted like in Steel industry. These sectors' emission contributes to about 29% of the total CO_2 generated globally (Fig-02). These plants shall aim to increase the efficiency of the process to mitigate the emission levels.

Capture the Carbon

This measure is typically implemented when other options are not viable, either due to the limitation of process or higher cost. The present carbon capture & storage technologies can capture about 80-90% of the CO_2 emitted from conventional coal-based thermal plants. Carbon capture and storage facilities are becoming popular in Europe. However, it would still need policy support for implementation at scale. A nature-based approach, like reforestation, has also been adopted for carbon capture.

Decentralisation for Reducing T&D Loss and Improving Access

As per Energy Progress Report, 2019 published by UN, about 13% of the global population lack access to modern electricity. They are either far away from the power grids, or the modern grids are not affordable for specific regions. The growth of RE power and its decentralised nature ensures more sustained electrification, improving electricity's access rate.

The world average T&D losses stand at about 8.3% in 2014. In India, the Aggregate Technical and Commercial (AT&C) losses stand at 19.89% which is more than twice the world average. Longer distances between the power generation and load centres would add to the T&D infrastructure cost and AT&C losses. The decentralised nature of renewable energy generation and distribution will minimise the cost, AT&C losses and increase the power system's efficiency. Mini/ microgrids connecting RE power with battery storage or pumped storages are proven decentralised options for electrification.

Digitalisation can help achieve a more stable operation of such grids. Such decentralised, stable mini/micro girds would reduce blackouts' risk and improve quality power access. The decentralised RE dominated mini-grids can also support EV charging stations in remote, inaccessible locations

Digitalisation - Driving force for Decarbonisation& Decentralisation

Digitalisation enables and catalyses the energy transition by making it more efficient, flexible and reliable. It would be interesting to analyse in detail about how digitalisation helps decarbonisation and decentralisation of energy.

Digitalisation for Decarbonisation

Digitalisation plays a vital role in all three significant steps that are being undertaken towards decarbonisation. Switching to low carbon RE has a considerable challenge of managing the variability from RE sources. Accurate forecasting of the RE power, load management in short intervals of fluctuations, and electricity grid stability during unpredicted weather conditions are possible only using digital tools. Smart grids help manage RE sources' variability through demand-side management using smart meters and big data tools. AI/ML algorithms and big data tools are successfully being adopted worldwide to manage modern RE dominated grids.

In the Power sector, the digitalised process optimisation can lead to a 5% increase in the electricity output per unit of fuel input for all subcritical and supercritical coal-fired power plants. Further, about 5% reduction in O&M costs in power generation and electricity networks can be achieved from digitalisation as per IEA report of 2017. Digital tools are proven to be reliable means for Real-Time Analysis and Optimisation. This is a low hanging fruit to reduce emissions in the energy transition journey. Policymakers can explore incentivising the first digital tool deployments in the plants to accelerate such digital tools.

Most industrial plants are instrumented adequately and generate a large amount of digital data related to the complex processes. Analog to Digital Converters (ADC) is used to get the data converted to a digital format in analogue signals. The digital tools analyse the data quickly and provide the operator with useful insights and actionable information into the processes that otherwise would not be available to the plant operator. The digital tools can streamline the data ingestion of structured or unstructured data on a real-time basis using the Machine Learning (ML) pipelines. The performance optimisation/ improvement tools use AI/ ML-based hybrid algorithms and advanced analytics to yield desired results.

A plantwide performance optimisation covering all critical equipment and process is generally planned though a digital platform capable of customising process/ equipment, interfacing and data ingestion, data analytics and visualisation. Plant/ Fleetwide digital transformations are typically implemented through such digital platforms.

There are micro/ point solutions that run on open architecture and focus on specific process or equipment issues. Such point solutions can be implemented quickly and independently as required in a plant to take advantage of time and cost. Most of such point solutions are cloud or edge deployable and are offered in Software as a Service (SaaS) model.

An example of a point solution related to pump performance monitoring and diagnostics is given below (Fig-03). This digital tool can help the operator monitor the pump performance and analyse multiple influencing parameters in near real-time to ensure optimal performance levels throughout plant operation.

Courtesy : Tata Consulting Engineers Ltd

Fig. 3 Digital Point Solution for Pumps

Few of the capabilities of the digital tool on Real-Time Monitoring and Diagnostics of Pumps are listed below

- Anomaly detection based on historical behaviour
- Recognise deviated parameter and provide early warning alerts
- Predict the pump performance for different load conditions
- Provide insights into pump failures and factors influencing pump performance
- Help plan the maintenance actions

Digitalisation for Decentralisation

Decentralised energy generation and distribution would be sustainable only if stable quality power supply can be ensured. The variability in generation and demand, continuous monitoring requirement, lack of technical skill, etc. are challenging such decentralised mini-grids' stability. The digital tools are handy to manage this situation. Remote monitoring through cellular communication, smart sensors, AI/ML-based self-diagnostic features and correction features etc. are promising technologies that are being explored to ensure stable, quality power supply from the decentralised RE dominated grids.

Digitalisation – Key Enabler for Energy Transition

A fast-paced energy transition is the need of the hour, and it is possible only with digital intervention. "Design for Digitalisation" is becoming the norm for the industry which involves 'sensorising' critical processes to help build accurate digital twins, provision for big data ingestion, and process and data-based interventions for process optimisation. The challenges of EV dominated future transportation system can be well managed through the digitalisation of the vehicles and charging infrastructure. Smart grids become an essential component of managing the variability from RE sources and new types of consumers like EV. Building energy management systems is also becoming more intelligent, efficient, and deployed at scale to aid energy transition effort. In a nutshell, digitalisation is the most effective enabler in the journey towards a greener planet.

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THE SUN IS SHINING BRIGHTER ON THE SANDS

Middle East's Solar Revolution And Warfare

A lot is happening in the sunny and sandy fields of the Middle East. In a region where oil was the undoubted king, solar power is emerging as a strong leader. The region receives plenty of sunshine throughout the year, hence making solar an attractive option.

Why is the oil-rich Middle East that used to cater to its power demands from thermal power keen in switching to green solutions? Middle East Nations realised quite early that investments in renewable energy and abandoning fossil fuels for electricity generation is the key to future prosperity. These Nations also realised an eventual end to their oil reserves, thus leading to climate change initiatives and adopting global shift towards renewables.

At present, the region is at the forefront of the race to decarbonise energy production. According to the Middle East Solar Industry Association (MESIA), energy investment in the Middle East region could hit more than $1 trillion by 2023.

While oil may remain the primary economic engine for the Middle East for years to come, renewable energy is gaining substantial new interest and investment from both governments and private-sector energy firms within the region and worldwide. Prominent names like Acwa, Taqa, Masdar, EDF and Marubeni etc. have invested heavily in the region and may continue to do so in the future.

UAE, Saudi Arabia, Oman & Qatar have drawn aggressive plans for implementing large-sized projects in the region in various phases. Projects in range of 6GW plus are in the various stages of development and implementation in Saudi Arabia and 5 GW plus in UAE.

Another interesting point to note in these Solar projects is the "Price Wars" leading to significant players in the region outpricing each other by offering aggressive and record low prices. Each time a new bid is opened, a new record is being set.

One of the recent bids in Abu Dhabi for 2 GW Al Dhafra Solar Project saw a record low tariff of 1.35 cents/kWh. It was preceded by another project of Dewa at a tariff of 1.6953 cents/kWh. Another project in Qatar was awarded at a tariff of 1.6 cents/kWh, which was considered the lowest for a solar project.

These low bids are also backed with high-quality assurance, thanks to favourable tax regimes, assured long term power offtake agreements, besides projects locations closer to consumer centres resulting in lower transmission costs and losses.

A decade ago, solar generation costs were well above 30 cents per kWh. At present, the best solar projects in the Middle East can achieve drastically lower prices, thanks to continuous technology innovations that are driving down costs further.

Abu Dhabi, Dubai and Saudi Arabia have been passing the crown to achieve the cheapest renewable energy over the last several years now.

All these "Price Wars" are directly benefitting Middle East Nations and helping their economies in the long run. *In an interview, the Crown Prince of Abu Dhabi,* ***Sheikh Mohammed bin Zayed*** *appeared to embrace the change and said:* ***"In 50 years, when we might have the last barrel of oil… I can tell you we will celebrate that moment".***

TCE has been associated with more than 13GW of solar projects, including 4GW in the Middle East region working closely with some developers.

Energy Transition in the Middle East

- The Middle East has long been associated with high-polluting fossil fuels — but now set to become a global leader in the energy transition towards zero-carbon sources.
- The region that was reliant on its Natural reserves for several decades is increasing its stake in renewables over the past few years to limit the impacts of climate change.
- One of the key challenges the region faces is water scarcity, so need for regional governments to invest heavily in water, with the private sector's involvement.
- Given the region's abundant renewable energy resources, availability of investment capital, landmass and infrastructure, the Gulf states are in prime position to take the reins in the green hydrogen market, which is in early stages but much projected to be a growth area for the region.
- The region has taken steps to reiterate interest to policymakers in the region to implement projects like CO2-free hydrogen despite the lack of a regulatory framework for the licensing.
- Since Q2 of 2020, fossil fuel consumption and CO2 emission levels have plummeted, renewable energy has re-emerged at the forefront of discourse. Businesses have been subject to and will continue to face mounting pressure from the public, regulators, industry experts, organisations and governments to focus more heavily on ESG policies.
- With demand for energy continuing to rise in the region and increasing pressure from governments, investors and consumers to support the industry's decarbonisation, the energy transition is set to remain at the forefront of regional governments' priorities.

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HYDROGEN INFRASTRUCTURE

Development and Challenges

Satisfying energy demands forms an integral part of the development of the world. Growing concerns over climate change, especially finding an alternate means of energy sources to the present fossil fuels, has increased hydrogen interest. Hydrogen is a flexible and alternative energy carrier with potential applications across all energy sectors, significantly impacting economic and social development in the low-carbon economy. Hydrogen is considered a clean energy source and a viable alternative to fossil fuels to control emissions as it can be produced from renewable sources. Hydrogen has the potential to reduce India's dependence on oil imports as several fossil fuel-based applications can be replaced by Hydrogen.

Typically, Hydrogen has the highest mass-energy density amongst other commonly used fuels and has an advantage for using it as a fuel or for energy storage. However, exploitation of Hydrogen for using it as an alternate energy option requires the development of a new hydrogen infrastructure which primarily consists of ***(a) Production (b) Storage and (c) Distribution.*** Development of such an infrastructure poses several technological challenges that must be overcome before it can be employed economically and safely in various sectors on a commercial scale. This paper briefly highlights the issues associated with hydrogen infrastructure development.

Why Hydrogen

Hydrogen has the potential to transform the energy sector by contributing to a sustainable energy future. Global climate change and emission concerns can be addressed at both ends of the value chain, i.e., hydrogen production and hydrogen user. In both ways, Hydrogen can be used as a reinforcing catalyst to connect to the energy systems. First, technological advancements to hydrogen production methods may make it economically feasible by shifting the focus of hydrogen production from fossil fuels to production using a cleaner or renewable sources. Secondly, several applications that presently use fossil fuel as sources of energy can be replaced with Hydrogen.

Hydrogen in its pure form can be possibly used

- as a fuel for transportation
- for electricity generation
- as a combustion fuel in industrial boilers and furnaces, and
- in residential sectors for heating/cooling.

Instead of using Hydrogen as a pure component, it can be further utilised in methanol production or ammonia production or synthetic natural gas production, which can be used as alternative fuels.

Hydrogen has a wide application range. It has created interest amongst stakeholders of several industry sectors such as renewable electricity, industrial gas, automobiles, oil and gas, steel, carbon capture, etc. It is not only hydrogen producers but also includes those who use or could use, Hydrogen as a feedstock for various industrial applications. Due to the renewed interest amongst different industry sectors, it has become imperative for the governments to create a roadmap to develop hydrogen infrastructure.

Hydrogen can be helpful in various ways to achieve energy security. Hydrogen can be integrated into the electricity infrastructure, by converting electrical energy (supplied by renewable sources) to produce Hydrogen and then reconvert it back to electrical energy. Further, such conversion of electrical energy to hydrogen production enables Hydrogen promotion for fuel applications and helps reduce energy imports in the form of oil and gas. Fossil fuel-based hydrogen-producing processes can be amended to employ carbon capture technologies to produce Hydrogen cleanly. A right infrastructure must be developed for exploiting the use of Hydrogen as a low carbon energy source.

Hydrogen Users and Growth Potential

Majority of the Hydrogen is presently consumed for industrial applications. Petroleum refining processes account for one-third of hydrogen consumption. Other significant users are producers of Ammonia (27%) and Methanol (11%). A small percentage (3%) of Hydrogen is utilised in steel production using direct ore reduction technology.

The Hydrogen required in the middle distillate's desulphurisation process in petroleum refineries is mostly (60%) produced from natural gas. Considering stricter emission norms for automobiles, hydrogen demand for desulphurisation is expected to increase by 7% in the next ten years. However, with the electric vehicle revolution gaining momentum, this may dampen the market in the long term. Majority of the future hydrogen demand will arise from new applications such as transportation.

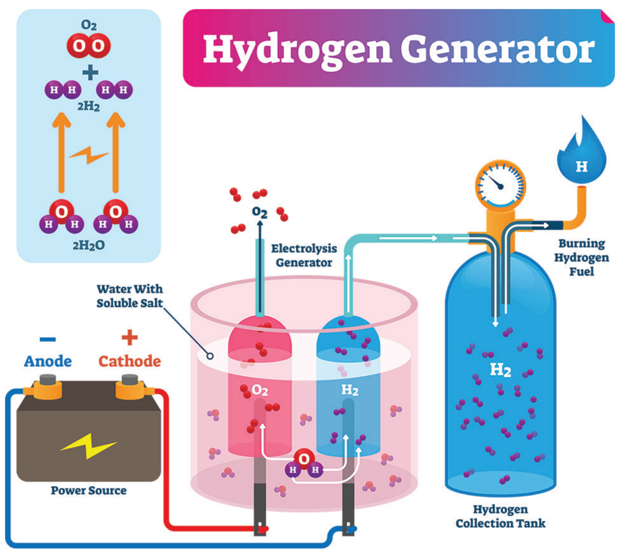
Future hydrogen demand and infrastructure development priorities mainly focus on Hydrogen's possible widespread use in the transportation sector. This suggests that research and development focus should be developing affordable hydrogen fuel cell technology to drive hydrogen growth.

Hydrogen can replace fossil fuels that are widely used for industrial combustion processes in furnaces and boilers. The hydrogen fuel cell has the potential to generate electricity on a small scale. It can be an alternative to replace diesel generators commonly used as a source for emergency power back up in industrial, commercial and residential installations.

Hydrogen Production

Currently, most of the Hydrogen (75%) produced globally uses natural gas as a feedstock. Another commonly used resource is coal, which accounts for 23% of the total Hydrogen produced. Today's total hydrogen production is about 70 Mt, and this contributes 830 Mt of carbon dioxide per year to the environment. With an increased interest in developing hydrogen-based economy, demand for Hydrogen is further expected to increase significantly. Therefore, it is evident that unless current technologies producing Hydrogen are targeted to minimise carbon dioxide emissions, the hydrogen-based economy in the future shall not help reduce carbon footprint and will not help address global climate change conditions. It is, therefore, necessary to develop options for producing Hydrogen without contributing to carbon dioxide emissions.

Another commercially available technology for hydrogen production is based on splitting of a water molecule by electrolysis. Water electrolysis methods contribute only 2% to the world hydrogen production.



Electricity is needed as an energy input to the water electrolysis process, and electricity can be economically produced using renewable sources. Therefore, water electrolysis using renewable energy sources can produce Hydrogen and reduce carbon footprint in hydrogen production. With technological advancements, electricity production costs from renewables are continuously declining, and more capacities are being added. Due to non-availability of renewable sources for 24 hours in a day, electricity produced from renewables often has energy storage requirements.

Hydrogen can be used for energy storage as well. There is significant scope for setting up dedicated renewable electricity generation facilities for environmentally clean hydrogen production and storage.

Another way of reducing carbon dioxide emissions from hydrogen production processes is carbon capture and sequestration (CCS) technologies. Natural gas-based or coal-based hydrogen production processes can amend the techniques to capture carbon dioxide.

Presently, the operating costs and CAPEX requirements for CCS technology are high due to which commercialisation of technology is yet to mature. ***Worldwide, CCS technologies are being rigorously researched, and developed economies are seriously promoting research, testing, marketing and implementation at select locations.***

Hydrogen production prices vary significantly between various regions due to the variable cost of resources used for making Hydrogen. Natural gas and coal are abundantly available at a lower price only in the select areas as its availability are not uniformly spread over the entire world. Similarly, costs for electricity generation vary widely between various regions. ***Raw material availability hence influences the cost of hydrogen production to a great extent. Hydrogen production using natural gas without carbon capture technology is presently the most economical route amongst all regions.*** Cost of hydrogen production through the electrolysis route depends on electricity production costs and overall, these methods are currently expensive compared with the natural gas-based production process without CCS. Suppose cost of electricity generation is between 10 US$ to 40 US$ and considering full load hours of 3000 – 6000 per annum. In that case, hydrogen production from water electrolysis can be cost-competitive compared to the production based on natural gas processes with CCS.

In short, CCS technologies are mandatory to produce clean Hydrogen, and renewable-based water electrolysis methods can become a financially attractive option for hydrogen production. This provides an essential direction for research efforts in future for developing hydrogen infrastructure. As Hydrogen is currently produced mainly in central processing facilities in select industrial areas, an extensive distribution network is needed for making it available across the country. Adaptation of CCS technologies will also help in the nationwide spread of hydrogen production locations and ensure Hydrogen availability.

Coal gasification process produces syngas which can be used for power generation. CCS technologies are usually integrated with coal gasification units; thus, they can produce clean electricity. Hydrogen production from syngas (obtained from coal gasification) can be enhanced using water gas shift technologies. Entire coal gasification unit can be further optimised and configured for a flexible switch between electricity generation and hydrogen production.

Biomass is another alternative source for hydrogen production. However, the limited availability of biomass and higher production costs are the significant barriers to mass-scale commercial production. Considering the difficulties in hydrogen storage and transportation due to its low molecular weight, it can also be converted into other chemicals such as synthetic natural gas, ammonia, jet fuel, etc. which can be used as fuels. This may not be an economical option at current price levels.

Hydrogen Storage

Hydrogen has high mass-energy content but is the smallest molecule (Mol Wt. 2), it has very low volumetric density and low volumetric energy. This peculiar characteristic of Hydrogen poses difficulty in its storage. Hydrogen is highly flammable material having a relatively more extensive range of explosion limits in air. Safety aspects thus form an integral part of the hydrogen storage technologies.

Hydrogen usually is available at 1 to 4 bar pressure when produced from electrolysis route and at roughly 20-30 bar when created from Steam Methane Reforming (SMR) route. Reducing Hydrogen's volume for transportation is achieved by increasing its density by compressing Hydrogen to a higher-pressure level and then storing in pressurised cylinders before transport.

An alternative method to increase the density of the fluid is to liquefy the gas. Liquified Hydrogen can be stored and transported in bulk volumes. Hydrogen can be stored in a liquid state. However, liquifying hydrogen calls for an operating temperature of (minus) −253° C. Liquefaction is an energy-intensive process and it would consume around 30% of the total energy content of Hydrogen. Another issue related to liquid hydrogen transport is loss due to heat gain and boil-off, leading to hydrogen/energy losses. Additionally, storage tanks need to be made up of expensive materials for operating at cryogenic temperature.

Both pressurised storage and cryogenic storage technologies require specialised materials of construction. Research is underway to find suitable lightweight and economical materials for storing Hydrogen under extreme pressure or temperature conditions.

Hydrogen storage in solids solution form using metal hydrides is an emerging technology. For this purpose, metals, intermetallic compounds, alloys, complex hydrides are being studied. Based on current research, it is now established that Hydrogen's absorption and release under hydrides of some metal alloys are possible. Hydrogen can be stored in solid form by using this technology. This technology requires less energy to operate. However, under these operating conditions, hydrogen density will be close to liquid Hydrogen density, making it heavier to handle. Hydrogen storage technology in solid form is at a nascent stage, and so far, it is limited to holding no more than about 1.8 % hydrogen by weight.

Comparison of various storage technologies and the associated challenges are stated in Table 1 below.

Storage Method	Advantages	Challenges
Pressurised Storage	Matured technology with high efficiency	Weight Reduction by way of using alternate materials
Cryogenic Storage	Higher liquid density and suitable for large quantities	Liquefaction costs are high. Boil-off gas management and expensive materials are required for cryogenic service
Metal Hydrides	Relatively high density, Modular operation	New technology and not commercialised. Temperature and energy requirements for desorption are high.

Table 1: Comparison of Hydrogen Storage Methods

Hydrogen Distribution

Typically, the following options are available for transportation, ensuring availability at the user point.

- Gas tankers/trailers
- Liquified tankers/trailers
- Hydrogen pipelines
- Onsite production

Gaseous Hydrogen can be transported in medium quantities in pressurised gas containers by road tankers. The hydrogen storage capacity of road tankers depends on storage pressure and materials of construction of road tanker. Compressed Hydrogen is generally shipped in road tankers at pressures up to 200-250 bars. In India, gaseous Hydrogen is transported using road tankers having pressures up to 172 bar.

Liquefaction of hydrogen results in a significant increase in its energy density enabling transportation of large quantities using road tankers or ships. Due to the density difference in the gaseous and liquid phase, liquid hydrogen road trucks can carry approximately ten times more Hydrogen than the pressurised transport mode. For longer distance distribution, liquified hydrogen transport is usually more cost-effective as it can significantly hold more Hydrogen than a pressurised gas tank. Liquefaction requires more energy and higher capital costs compared to the pressurised mode.

Hydrogen produced at any central processing facility can be transported to user point directly through pipelines. Pipeline transport mode is a technologically sophisticated method, and it's the most efficient method of hydrogen transportation in large quantities. Selection of materials of construction for Hydrogen requires careful attention as Hydrogen tends embrittlement. Hydrogen is also prone for corrosion due to presence of an active electron of Hydrogen. The blending of Hydrogen with natural gas can be studied further. This may help in boosting hydrogen usage. Cost of hydrogen pipelines depends upon CAPEX for pipes, the compression energy costs and the available pressure limit at the source.

Transmission pipelines use mild, low carbon steels as materials of construction. Liquid hydrogen pipelines are expensive due to extremely low-temperature requirement. It may also be beneficial to consider onsite hydrogen generation using smaller-scale equipment for eliminating transport cost.

For Hydrogen as transportation fuel, it is necessary to have a countrywide distribution network. The water electrolysis method is most suitable for onsite hydrogen generation for remote areas as it is more scalable and emission-free. Electrolyser produces a sufficiently high purity (nearly 100%) Hydrogen required for hydrogen-based vehicles. It could be cheaper to produce Hydrogen locally in refuelling stations far away from central hydrogen production facilities. However, there may be space constraints in the urban area for onsite hydrogen production.

Various issues for hydrogen transportation and associated challenges are presented in Table 2 below.

Transportation Mode	Issues	Challenges
Pressurised Container or Cylinders	Low capacity	Manufacturing of indigenous onboard cylinders, reduction in material weight
Cryogenic Road Tankers	Liquefaction costs	Development of indigenous cryogenic road tankers and boil-off gas management
Pipelines	Safety such as leak detection	Reduction in costs associated with materials of construction
Onsite Production	Economical technology	Reduction in the costs of electricity and electrolyser cells

Table 2: Issues with Hydrogen Transportation Methods

For large-scale consumer adoption of hydrogen-based transport vehicles, deployment of hydrogen refuelling stations (HRS) in primary markets is essential. Hydrogen refuelling station consists of hydrogen storage tanks, compressors with aftercoolers, and dispensers for delivering fuel. It is easy and fast to set up refuelling stations. By standardising the components, refuelling station costs can be reduced. Hydrogen refuelling stations shall be conceptualised and designed considering the risk of fire and explosion.

This must be by the regulations, standards and codes of practice of each country. The European Union has adopted two directives on safety and health, known as ATEX (Atmospheric Explosion) 94/9/EC and ATEX 99/92/E.

Other Challenges

Energy security and global climate change are the main drivers for the future growth of hydrogen infrastructure. It has created a favourable environment for investing and developing hydrogen infrastructure. However, several significant challenges must be addressed to obtain benefits of hydrogen-based clean energy systems.

Any new infrastructure development requires regulatory framework and policies to ensure risk-free investments by the users in hydrogen energy sectors. ***The government has a critical role in promoting technology innovations and its successful deployment in new infrastructure. Innovation and competition can help with cost reductions. It is necessary that all stakeholders (Producers, Users and Investors) work together to achieve long-term stability.***

Currently, hydrogen production systems are primarily based on fossil fuel availability, and a shift to the renewable source is needed. Presently, the efficiencies of hydrogen making technologies from renewable sources are low. Also, they are not available for implementation on a small scale. Most of the hydrogen production currently is achieved in central facilities due to the size of operations.

To expand and promote the use of Hydrogen as an alternative fuel to various applications, production technologies must be selected and developed suitably so that Hydrogen can be produced at near to user locations in economical and sustained manner. Small scale reforming technology, coal gasification, renewables, etc., need further research efforts.

Hydrogen storage requires special attention due to its low volumetric density. Essential criteria for hydrogen storage systems require considerations to energy requirements, methods to obtain high gravimetric and volumetric energy density, minimise emissions, safety in operation, long lifetime, etc.

Currently, compressed gas is the most favoured option in transportation solutions for onboard storage of Hydrogen. However, the gas compression process would consume 6 to 15% of Hydrogen's total energy content.

Compressed gas storage is favoured as it is a simple, reliable and proven technique. Hydrogen storage in solid form using metal hydrides is a promising alternative to pressurised or cryogenic storage method. A significant challenge in hydrogen storage system design is selecting alternate lightweight materials to withstand high storage pressures or low temperatures. Efforts are required to increase the energy efficiency of storage systems.

Research programs can reduce the energy associated with compression/liquefaction processes related to liquid hydrogen technologies. When Hydrogen is to be used for transportation, a challenge lies in minimising refuelling hydrogen cylinders' time similar to liquid fuel tank filling.

Transportation and distribution costs are the most critical factors that affect the Hydrogen economy. Pipeline transport mode is a technologically sophisticated and efficient method for supplying large hydrogen quantities. However, the selection of construction materials, optimum pressure level selections, leak detection, and safety issues need to be standardised.

Developing a full nationwide distribution network (similar to the natural gas grid) may require much time. To start with, regional networks can be considered for faster development. Availability of relevant codes and standards to address safety issues for infrastructure development plays a critical role. Standard policy for using existing natural gas pipelines for hydrogen service can be framed if spare capacity is available in existing natural gas pipelines.

The overall hydrogen infrastructure development program should address developing alternate technologies for production at both small and large scale, economical storage methods to enhance energy density, cheaper pipeline materials, and standard practices for leak detection and other safety issues.

Continuous research, industrial interest and investment, and the country's policy can overcome the above-listed challenges. The fully developed hydrogen value chain will be more complex and requires cross-sectoral investments, especially for new network infrastructure.

Concluding Remarks

Transition to a hydrogen-based economy faces several challenges. Availability of suitable and sustainable infrastructure plays a critical role in promoting Hydrogen for several industrial sectors

Hydrogen infrastructure development and the associated production, storage, distribution technologies must be further researched to achieve energy security and economic development objectives.

To summarise, challenges are:

- Available technologies for hydrogen production, storage and distribution need further development.
- The existing fossil fuel-based processes need to adapt to CCS methods to make them financially attractive.
- In the transportation sector, the costs of fuel cells need to be reduced further.
- Lightweight materials and alternate technologies for hydrogen storage need development.
- Countrywide pipeline networks need to be developed.
- Safety issues for hydrogen handling need to be resolved by framing appropriate codes and standards.

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Road Map to Environment-Friendly Power Generation in India

The Journey So Far:

In 2015 while India signed the Paris Climate Change Agreement, the country faced the challenge of becoming the world's highest emitter of SO_2 gases, producing over 15% of global emissions due to anthropogenic activities. The focus on India's environmental sustainability became urgent. To battle, climate change & increasing pollution levels, the government & regulatory authorities needed to address a significant contributor, i.e. 198.8 Giga-Watt (GW) coal-based Thermal Power Plants (TPPs) operating at pollution standards considerably lower than international benchmarks.

In December 2015, The Ministry of Environment, Forests & Climate Change (MOEF &CC) prescribed stringent environmental norms for power plant emissions (for pollutants like SO_2, NO_X, Hg, SPM) & specific water consumption guidelines, with an optimistic implementation deadline of 2 years for accelerating the compliance. These harmful gases (generated during coal combustion in a boiler) are liberated along with exhaust flue gas. Hence, meeting the stipulated emission levels called for retrofit/installation of Air Pollution Control (APC) systems to treat the flue gas before escaping to the atmosphere through stack.

The emission levels recommended by MOEF & CC are presented below:

Year	SPM	SO_2	NO_x	Mercury
Pre 2003	100 mg/ Nm^3	600 mg/Nm^3 for <500 MW 200 mg/Nm^3 for >500MW	600 mg/Nm^3	0.03 mg/Nm^3 for >500MW
2003-2016	50 mg/ Nm^3	600 mg/Nm^3 for <500 MW 200 mg/Nm^3 for >500MW	300 mg/Nm^3	0.03 mg/Nm^3
Post 2017	30mg/ Nm^3	100 mg/Nm^3	100 mg/Nm^3	0.03 mg/Nm^3

There was inevitable inertia & resistance to change during the power producers' initial stages because of the pertinent pain-points associated with implementing these norms. Stringent execution timelines, significant cost impact, increased auxiliary power consumptions, operation & maintenance issues and no clarity on the way forward and retrofit challenges like unit shutdowns, layout constraints, integration with existing systems, etc. were some such issues. In due time, the power producers, Government & regulatory authorities, consultants, OEM & EPC firms, financial institutions, and industry experts pitched in to address the various associated hurdles to the progress path.

Taking a cue from its legacy of being the first engineering consultant to introduce SO_2 abatement technology in India, way back in the 1980s, TCE geared up to contribute to the cause of achieving improved air quality, preventing climate change, and making the environment a better place to live in by leveraging its rich experience and knowledge of over five decades in the power industry. Exclusive in-house Design Suites were developed & automated for fuel/plant-specific emission analysis & accurate pollution control system design calculations. A dedicated & skilled cross-functional team was formed to pioneer projects and provide consultancy support to plant owners, EPCs, OEMs, regulatory authorities and other stakeholders in this domain.

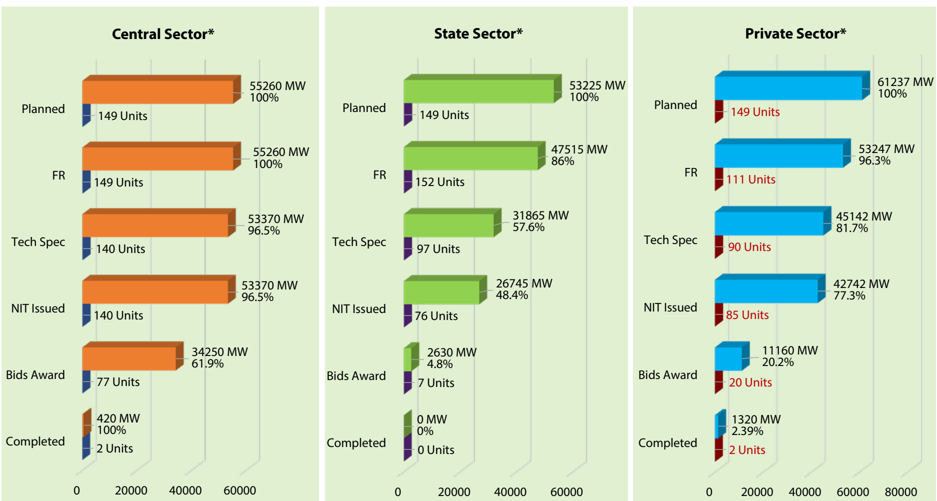
Mercury in domestic coal is present in a negligible amount, and hence most power plants do not require a separate technology for mercury control. SPM control systems like Fabric Filters, Electro-Static Precipitators (ESP) were already installed in the existing coal-based TPPs to meet the previous regulations, this technology (in only a few cases) required up-gradation/ modifications. NO_x emission control could be achieved through either Primary combustion NOx control or a combination of Primary and Post-combustion NO_x control technologies. Popular primary NO_x control methods involved reducing NO_x during the combustion process by installing Low NO_x burners in place of existing burners, combustion tuning & zoning, excess air optimisation & control, separated/coupled overfire air systems, or their combinations. Post Combustion control technologies like Selective Non-Catalytic Reduction (SNCR), Selective Catalytic Reduction (SCR), Hybrid SCR-SNCR, etc. can be used alongside Primary NOx control technologies to significantly reduce NO_x levels in the flue gas and is required for new power plants.

Hence, reducing SO_2 emissions is the epicentre for meeting the regulations. Central Electricity Authority (CEA) identified about 168 GW generating capacity comprising 444 units for compliance through the retrofit of Flue Gas Desulphurisation (FGD) systems. The implementation process of these regulations was segmented into a staged approach, with Stage-I being feasibility study & basic engineering, Stage-II is tendering/bidding process till order placement.

At the same time, Stage-III involves detailed engineering & site execution/ construction.

Some of the prevalent FGD technologies explored & analysed in India are Wet Limestone based, Sea Water-based, Dry/Semi-Dry based, Ammonia-based, Sorbent or Polymer-based FGD systems. Several other technology alternatives and the merits & demerits of these options were carefully evaluated to arrive at the optimal plant-specific technology solution. The crucial factors influencing the selection & design of FGD are fuel firing, site & layout specific aspects, GGH & stack configurations, suitable liners, water, performance parameters, implementation time and finally life cycle cost analysis (Capex + Capitalised OPEX).

Considering practical challenges, the deadline for compliance with environmental regulations was extended by MOEF & CC from 2017 to a more realistic schedule till 2022. CEA also developed a phased unit-wise schedule of FGD implementation for smoother execution & power supply reliability in consultation with the power producers. Considering market trends & cost of technology, retrofit, and the cumulative capital investment, these initiatives are estimated to cross over INR 1 Lakh Crores, one of the largest modern-day investments in the Indian power industry.



Source: CEA

The current status of FGD implementation is varying between the Central, State and Private Sectors with Central sector units taking the lead with over 60% of the Central TPPs completing stage-II (Tendering & Order Placement) and commencing Stage-III (Execution & construction).

Note: FGD's already commissioned/operating include NTPC Vindhyachal, CLP Mahatma Gandhi TPP, TATA Power Trombay Unit 5, Adani Power Mudra Units 7,8,9, Adani Power Udupi (partial), IL&FS Cuddalore TPP, JSW Energy Ratnagiri Plant (partial), Reliance Dahanu

Recent Developments & The Way Forward:

At the beginning of 2020, several power plants (about 48 GW) already missed the revised deadline for retrofitting the FGD system. CPCB also furnished notices to 15 coal-based plants (about 14000 MW & 31 units) for non-compliance of environmental regulations which might face closure.

Environmental penalty (Rs. 18 Lakhs/Unit/ Month) was to be imposed for continuing non-compliance of CPCB directions. However, currently, the Supreme Court of India has placed a stay order on environmental compensation issued to plants who challenged this penalty.

Supreme court rejected the petition filed by Association of Power Producers (APP) for blanket extension of deadlines for FGD installation, from 2022 to 2024. Central Electricity Regulatory Commission (CERC) issued the Draft Amendments to incorporate temporary increase of electricity tariff for FGD retrofit of Independent power producers, which was a significant development in the tariff-revision aspect. MOEF & CC have also allowed thermal power plants to use coal having more than 34% ash content. CERC recently mentioned in tariff paper that power producers should be permitted to recover 90% of additional CAPEX cost due to APC equipment retrofit over 25 years.

Due to security & defence escalations at the borders, Haryana government decided to annul two tenders of FGD project contracts with Chinese firms worth over INR 1000 Crores for 2x300 MW Yamunanagar TPP & 2x600 MW Rajiv Gandhi TPP in Hisar thus putting into effect the trade ban proposed by Indian Government. Many state & central sector power plants are expected to take similar measures as we advance, leading to a boost in indigenous manufacturing & domestic business. Citing transgression in border areas, cybersecurity threats & significant cash outflow, Power Ministry also imposed restrictions/ban on importing power equipment from China & few other countries, requiring the Government's necessary approval. Moreover, regulations have been introduced on Public Procurement from neighbouring countries and registration of bidders are now required under Competent Authority.

The FGD execution phase's progress is considerably lagging from the planned schedule, with very few Orders awarded especially in the Private and State sector. This progress further decelerated in the last few months due to the unprecedented Covid-19 pandemic and trade restrictions. At the current situation, completion of all FGD installations across India by 2022 is very unlikely to occur.

Limited domestic FGD technology suppliers/ Vendors are available in India, and many leading EPC contractors, sub-vendors are saturated because of ongoing parallel FGD projects. The restrictions imposed on the power equipment import from China could result in bottlenecks of supply chain & procurement process. There are challenges envisaged in sanction & granting of funds/loans for FGD retrofit from Financial Institutions, especially since many power plants currently fall under NPAs / stressed assets categories. Clarity is further required for addressing significant revenue losses to be incurred & power crisis during the unit shut down period. Market price fluctuations of CAPEX from unit/capacity wise benchmarked values provided by CEA are being observed, due to recently modified government policies related to tendering/ import and pandemic scenario. Other roadblocks to be taken care involve long-term procurement of reagent & unequal price escalations in the future, along with disposal/land requirement of a considerable quantity of byproducts, if it could not be sold.

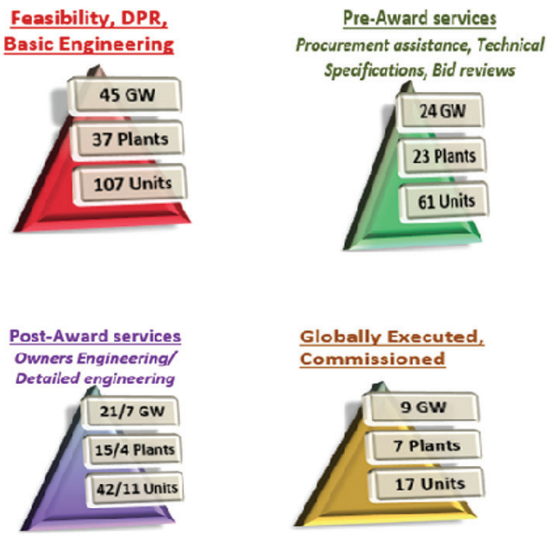
The Ministry of Power has recently recommended in a letter to MOEF & CC, to extend the deadlines for implementation emissions norms by two years (i.e. till 2024), for over 200 units comprising 100 GW generating capacity coal-based thermal power plants. Ministry is presently considering this matter alongside an evaluation of its implications on environment & public health. Further confirmation/amendments by MOEF &CC on the relaxation of deadlines are still awaited. Although the journey ahead is long with unavoidable obstacles in its path, the industry is marching steadily towards cleaner power generation, thus gaining better clarity & progressive elaboration.

Considering practical challenges, the deadline for compliance with environmental regulations was extended by MOEF & CC from 2017 to a more realistic schedule till 2022. CEA also developed a phased unit-wise schedule of FGD implementation for smoother execution & power supply reliability in consultation with the power producers. Considering market trends & cost of technology, retrofit, and the cumulative capital investment, these initiatives are estimated to cross over INR 1 Lakh Crores, one of the largest modern-day investments in the Indian power industry.

Our Key Milestones and Contributions:

TCE is now positioned as the Indian market leader in engineering consultancy in this field, extending services to 20+ customers/organisations, 40+ Thermal Power Plants, 120+ units and a cumulative of over 55,000 MW capacity of thermal power plants (coal-fired) in the domain of SO_2, SPM & NO_x emission control technologies.

TCE'S SERVICE EXPERIENCE



TCE'S CLIENTELE

TCE gained Intellectual Property Rights (IPR) for innovative FGD process (Patent No: 318817) and was also awarded the Best Innovative Project at the Tata Group level. TCE was also recognised as one of the Top 26 innovative companies in India.

TCE contributed to identifying gaps & suggesting improvements in draft Environmental Regulations furnished by MOEF & CC. The company supported thermal power sector by providing insights into the introduced environmental norms. We also sensitised & informed Customers on the necessity of implementation, target deadlines, pain-points, risks, and APC retrofits impacts. ***TCE conducted an extensive analysis, market research, reports, lectures, publications, training and developed standard documents, technology design suites, technical specifications, techno-commercial comparative analysis of various prevalent emission control systems.***

TCE played an instrumental role in executing these challenging brown-field projects requiring retrofitting pollution abatement systems in most coal-based power plants for the first time across India. The excellent feedback & appreciations/testimonials from multiple customers to provide comprehensive & customised solutions for their plant(s), & recommending right technologies, optimal designs, cost savings & value additions says it all. *TCE is involved in both Owner's Engineering (Concept to Commissioning) and Detailed Engineering services for EPC/OEMs.*

TCE suggested unique solutions to minimise the plant/unit shutdown time required for FGD & DeNOx system retrofit, thereby addressing associated power generation crisis preventing considerable revenue losses (ranging from INR. 24,000 - 50,000 / MW / Day) due to plant/unit shutdown. Apart from the conventional APC domains, TCE has also developed novel solutions for related crucial areas of water optimisation & treatment, Wet Stack, optimal coal blending solutions and 3D/4D Engineering of complete systems in digital platforms.

Author

Anmoy Kumar - Assistant Manager

Tata Consulting Engineers Limited (TCE)

SELECT CLIENT

“It is a moment of great pleasure and pride that even after facing all coronavirus odds, we have successfully completed upgradation of 2000 Nandghars. On this occasion, we wish to thank TCE and all our stakeholders as without their support this was not possible. Please convey my thanks to your team.”

“We would like to thank each one of you and your team members for your relentless support and dedication which facilitated us in submitting this very complicated Multi-Utility (First of its kind) bid on time with the highest quality. Despite these tough pandemic (COVID) times, TCE's team efforts to conclude this bid is commendable. Hoping to continue our association into the next phase after the successful award of the Project. We are receiving a very positive and credible response from the Client on our technical solution.”

“We appreciate the strong contribution of very good and timely work done by the whole team of TCE assigned for our Indonesian project site. Since COVID 19 spreads, though remote work by TATA team has continued, their performance level is very high even done remotely !!! Further, we very much appreciate decision by TCE that whole team will be remobilised to our site to support works at site under the condition of COVID 19. The TATA team has been very dedicated, customer centric and proactive throughout the engagement.”

“The TCE team has demonstrated exemplary patience and professionalism in supporting SUEZ WTS and our customers, despite all the constraints, in these challenging times. We are proud of the team and the support provided by the TCE management. While the challenges mentioned have not gone away, I am quite certain that, we will be able to weather the storm together and emerge stronger, continuing to build on this long-standing partnership.”

TESTIMONIALS

"We thank you, your company, for your steadfast support during the early stages of the COVID-19. Even though there was a lot of panic on the site, your team stayed steadfast and focused on delivering the results on their assigned work, in a highly professional manner. Your team displayed real professionalism and stood by us without giving room to fear but adopting all the safety measures pertaining to the control of COVID-19. We thank your team and your company for their professionalism and their support."

"Tata consulting Engineers Ltd (TCE) is engaged in performing a comprehensive energy audit at process plants of Indorama Ventures Limited. Till now the plants at Thailand, Indonesia & Nagpur have been covered and significant savings have been identified in electricity & coal consumption at these plants. TCE's services were found to be excellent in performing Energy Audits for these plants."


Jan 2021
India

Certificate of Recognition

This certificate is awarded to

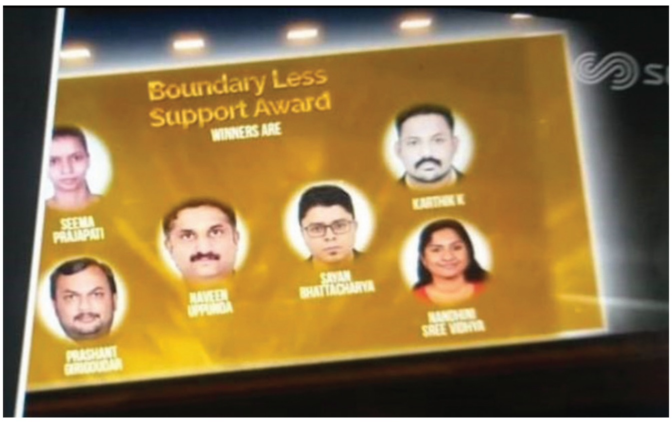
Gokul Surendran

TATA Consulting Engineers Limited.

For the fastest Project Delivery of Baroda- Bhayli NTI in the 2020 program.

Ronald Rosario
(Engineering Manager)

Rama Krishnan
(NDM Retail India)



SAMSUNG DET

Customer understands the importance of individual team members for the success of the project. Taking care of these valuable team members should be a high priority. Showing gratitude to team members year-round is essential, especially during these stressful and uncertain days amid the coronavirus pandemic. To show their gratitude/ caring towards the team members,

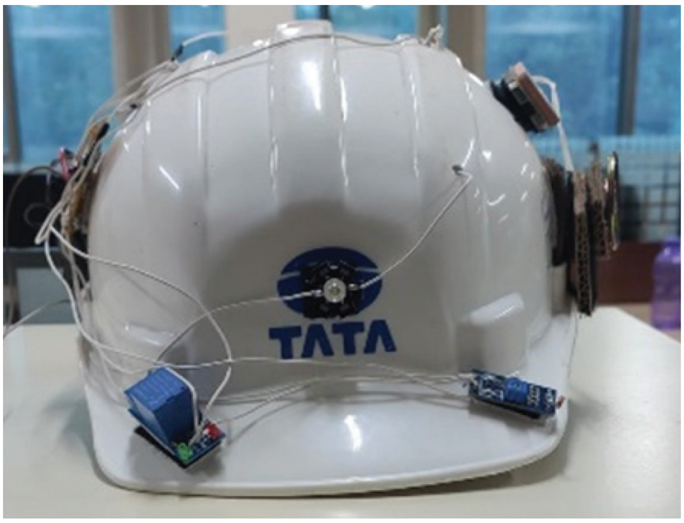
Samsung C&T Management sent KF 94 mask to each of the DET members working in the Bangalore office.

TCE Management thank the Samsung Team for their care and concern for TCE Employees.

INFRASTRUCTURE CLUSTER

SMART HELMET

In this world of fast-paced development, there is an increasing risk of safety to human lives. Here, in this article, we focus on a small segment of people, construction staff, mostly affected due to their involvement in a pot. These are the people who work in dangerous conditions risking their lives with minimal safety provided to them. With the development of a smart helmet, we propose to provide better protection to construction workers. Further, it will provide easier access to features that will help them work more efficiently. It may provide an opening to the future scope of integrating safety with IIoT.



Team Talks

As per the Young Engineers Development Program (YEDP) training schedule, he YEDP's were supposed to deliver four interdisciplinary model projects. A small task force of 8 trainees, was constituted to create a special project.

The YEDP's included were Ghana Thakur (Electrical HCBU), Rohan Jathar (I&C, HCBU), Akash Salunkhe (Electrical, HCBU), Unwan Kazi (Electrical, PMCBU), Akash Patel (Mechanical, HCBU), Dhruv Bhandari (Mechanical, PBU), Moksith Bohra V (Mechanical, PBU), and Siddharth Saini (Mechanical, DATBU, PM of Smart Helmet).

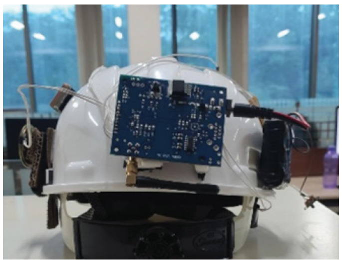
This project aims to use technology and make smart construction helmets to improve the chances of survival of workers who have met an accident. The helmet even helps report a potentially hazardous situation/element to the higher authorities quickly using technology. The benefits of a smart helmet will also encourage workers to wear their helmets on-site.

The helmet offers:

- Fall Detection and Emergency Communication – When the conditions of a fall or an accident are detected, a distress signal is sent to the Quick Response Team.
- Location tracking using GPS Module to determine the whereabouts of the wearer in the site.
- Integrated speaker-microphone and GSM module for communication – To provide quick communication between the wearer and on-site manager and vice versa.
- Integrated Power LED with an auto ON/OFF – Implementation of smart LED that will turn ON or OFF based on the ambient light level.

Working

Arduino being the brain of the project helps us run each module, i.e. GPS GSM LDR and ACCELEROMETER in sync as per cases. Accelerometer threshold value (2g) is fixed in the Arduino which continuously monitor the accelerometer value.



Let us take 2 cases:

- The worker jumps and starts to move
- The worker falls and is unconscious he doesn't move.

After the threshold value is reached, Arduino monitors the values of the accelerometer for 6 seconds. IF the accelerometer values continuously change, the system reads it as the person is moving and assumes he is fine; in this case, the distress signal is not sent.

IF the accelerometer values do not change for 6 seconds, the system assumes that the person is unconscious, and a distress signal is sent through the GSM module to the QRT team.

Secondly, if any worker on the site wants to communicate with the on-site manager, he can call him instantly by pressing the button. The system is designed as a two-way communication tool where the manager can also call a specific worker to communicate information.

Costing

A standard helmet generally costs around 300 to 500 rupees. The cost estimation for SMART Helmet prototype with locally available electronics costs around Rs. 3500 for a single prototype. But if mass-produced, the product's value will reduce by 1/3 rd of the current price, i.e. Rs. 1160 making it affordable.

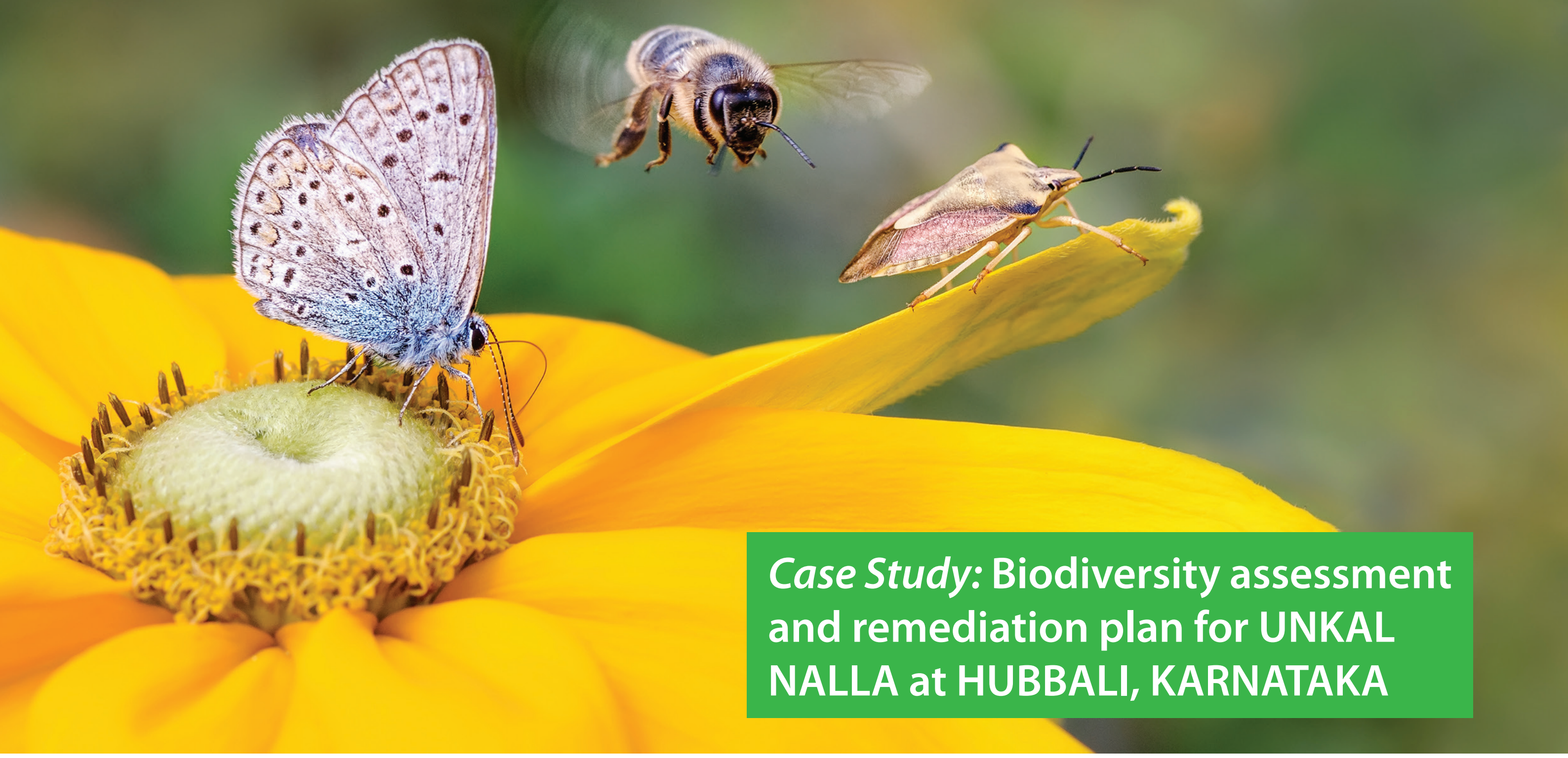
Future Scope

- Implementation of a camera and AR for communication and surveillance can also be incorporated. The workers can use the helmet to share real-time problems with the site manager instantly. The data from the camera can also help solve on-site issues instantly.
- The number of people entering and leaving the site can also be monitored by authorising entry only after issuing the SMART Helmet.
- With microchips and micro modules development, the helmet can aesthetically look good without losing its integrity, making it even more potent and lighter.

Author

Siddharth Saini - Engineer Trainee

Tata Consulting Engineers Limited (TCE)



Case Study: Biodiversity assessment and remediation plan for UNKAL NALLA at HUBBALI, KARNATAKA

The Unkal Nalla, a stormwater drain of Hubli city, originates at Unkal Lake as natural stormwater drainage and flows through Hubli city. The Nalla is currently very polluted as it receives sewage and industrial waste from various inlets. Also, solid-waste dumping, including slaughter waste, is being carried out at many locations of the Nalla.

Objective: This degraded state of the Nalla necessitated interventions to understand the current status and improve its overall condition. TCE carried out a biodiversity assessment study to understand the current needs and interventions to improve biodiversity.

Key Observation: Invasive species like Eichhornia crassipes (known for its invasiveness) & Alternanthera sessilis (known for drainage clogging) were an area of concern.

Recommendations for Biodiversity Conservation:

Considering the species richness & evenness, their density, movement, habitat requirement, IUCN status and possible impacts due to proposed Nalla rejuvenation project, mitigation measures were provided by TCE to avoid/reduce biodiversity loss and also improvement of low biodiversity areas. Mitigation measures include following:

- Removal of invasive plant species and plantation of native plants in the riparian area
- Maintaining existing green areas, including wetlands with aquatic plants.
- Regulating solid-waste dumping, including slaughter waste and improving water quality to enhance aquatic biodiversity indirectly controlling scavenging fauna populations like black kites, dogs & pigs.
- Development of butterfly garden and frog ponds to improve biodiversity
- Restriction on operation timings of fountains considering feeding movement of aquatic birds like River Terns in the area
- Considering the presence of Grey hornbills planting fruiting plants is also recommended

The entire study was planned considering IFC standards and outcome will help the client improve the condition of the Nalla by rejuvenating and developing a green mobility corridor project with minimum impact on biodiversity. The proposed project with suggested interventions will enhance local biodiversity and increase green area per individual in the city. This will also contribute to Sustainable Goal 6 (Clean Water and Sanitation), 11 (Sustainable Cities and Communities), 14 (Life below water) and 15 (Life on land).

Author

Alok Kumar- Deputy General Manager

Tata Consulting Engineers Limited (TCE)

'Zero' has now a value: Integrating Passive House Principles in Designing a Multi-family Residence

Ecofirst Services Limited, a Tata enterprise, is leading its way to technically assist GreenShape for their client neighbourhood development company attempting to build net-zero affordable housing under Washington DC City Council.

Project snapshot

Project Name: 3450 Eads NE Street

Project Location: Washington DC, USA

Year: Completed in September 2019

Scope of work: Assess and analyse the building performance for Passive House International certification (PHI-US) and identify potential areas for applying Energy Conservation Measures

Project Team & Authors:
Rakesh Bhatia (Project Mentor & Lead);
Vertika Srivastav (Project Manager)

Energy-efficient homes built with energy efficiency in mind, pose a significant number of benefits. Energy-efficient homes are less expensive to operate, more comfortable to live in, and more environmentally friendly. Inefficiencies that are not removed in the building process can pose issues for years. It is essential to inculcate the concept of energy efficiency in building design from the concept stage itself.

Energy-efficient building design involves constructing or upgrading buildings that can get the most work out of the energy supplied to them by taking steps to reduce energy loss such as decreasing the loss of heat through the building envelope ensured with airtightness.

Project Objective

- The client was keen to develop an energy-efficient, thermally & visually comfortable facility for all its occupants.
- The Washington DC City Council incentivises affordable housing by giving additional grants projects pursuing Passive House International or Net Zero Ratings.
- Later, the client approached Ecofirst as a speciality Sustainability consultant to design and assist in strategies and advisory services to their principal consultants for working towards these desired outcomes of Passive House International (PHI)/Net Zero under Living Building Challenge.

Methodology Adopted

To assure energy efficiency, a proper methodology was followed to help move all the stakeholders, i.e. Architects, MEP engineers, and the client, to achieve Passive House International (PHI)/Net Zero under Living Building Challenge.

The initial evaluation was done using ASHRAE 90.1-2016 international standards.

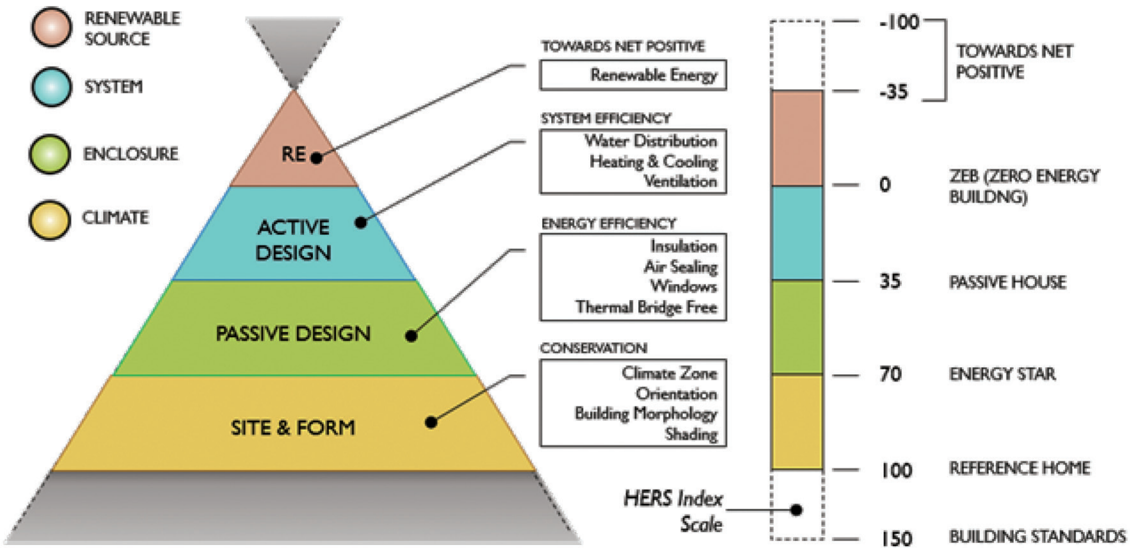


Figure 1 Design methodology to energy efficiency

Figure 1 outlines a 4-tier approach followed to attain energy efficiency. It also broadly outlines the process that needs to be adopted for moving towards the path of net-zero buildings. All buildings' performance was measured across their Energy use Intensity (EUI) and Home Energy Rating System (HERS) index. These two indices help to measure the performance and quantify them across benchmarking available via Energy Star.

The key players for providing energy-efficient buildings can be elaborated as:

- Site & Form: This starts at the schematic design phase of the building. It involves climate analysis, orientation, building morphology and design & impact of shading devices.
- Passive Design: If the passive design is done appropriately, less dependence on active systems is seen. The measures include insulation on the envelope, airtightness of the building, optimum selection for fenestration (windows) and ensuring materials that act as thermal breaks and reduce heat gains through conduction.
- Active Design: A less dependence is seen in this if proper measures have been implemented in the previous stage of Passive Design. However, while selecting dynamic systems (HVAC, interior lighting & equipment), high-efficiency systems should be chosen.
- Renewable Energy (Solar Photovoltaics): The key to its success is that Renewable Energy should be installed to produce as many units as the building is consuming to achieve net-zero.

Framework Developed for Assessment

After studying the project and interacting with stakeholders, an iterative process was carried out to achieve maximum savings compared to any regular conventional house in the Washington DC area. Based on this, following Energy Conservation Measures (ECMs) were suggested to ensure optimisation of the building's performance without compromising human comfort.

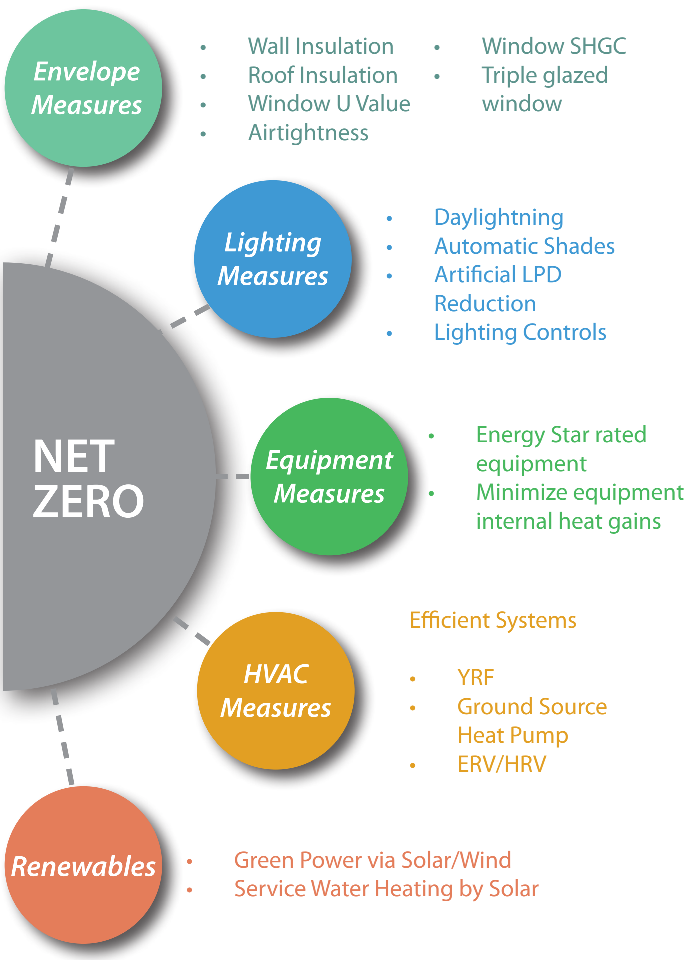


Figure 2 Measures pack for optimisation of the building

Figure 2 represents the process flow using which the building was simulated, and energy consumption was estimated. The ECMs pack include:

- Passive Design Strategy
  - ◊ Envelope Measures
- Active Design Strategy
  - ◊ Lighting Measures
  - ◊ Equipment Measures
  - ◊ HVAC Measures (Heating & Cooling)
- Renewable Energy using Solar Photovoltaic

Results and Findings

By incorporating passive & active measures, the facility could save 49% energy over the ASHRAE baseline. Further, the incorporation of RE resulted in 63% energy savings.

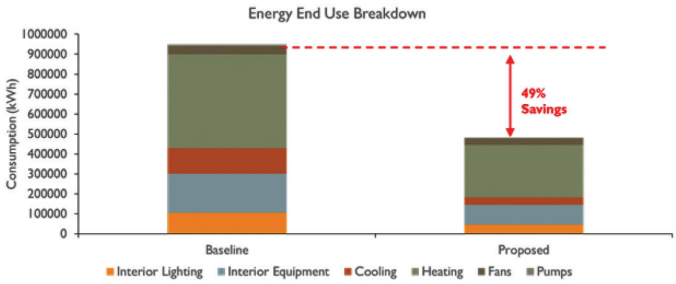


Figure 3 Results for Eads

Figure 3 represents the outcome that was achieved and conveyed to the client for better energy performance. Other suggested measures for optimising the building will require the adoption of the following measures:

- An airtight envelope with high R-value for Walls (R-75), Roof (R-54) and U-Value of 0.051 Btu/sqft hF & SHGC 0.5.
- Use of ground source heat pump for heating, cooling and service water heating
- Using pumps with 95% efficiency
- 50% reduction in lighting power density over ASHRAE baseline
- Use of energy star equipment.

Thus, through this analysis Ecofirst project team showcased the potential measures that can be taken for energy savings in Multi-family Residential Building to GreenShape for their client neighbourhood development company and the advantages of designing building towards net zero. This study will act as a case/ prototype to the council to further use for similar Multi-family Residential Buildings in the future. This will lead to a more sustainable development ensuring energy savings, occupant comfort and reduced carbon footprint.

IIT-HYDERABAD (PHASE-2)

Project Brief

IIT Hyderabad (IITH) is planned as a residential campus built on an area of 576 acres. The Phase-2 of campus development started in March '19. The Government of India has received a loan from Japan International Cooperation Agency (JICA) towards this Campus Development Project of IITH. TCE is the Project Management Consultant & responsible for pre-construction activities, Contract administration & variation management, Time management, construction supervision, EHS & Quality Management, and post-construction activities during the defect liability period.

The proposed built-up area is about 3,11,000 sqm, and TCE value additions are as under

- Deletion of two Electrical substations resulting in the saving of around INR 8.8 Cr.
- The depth of excavation level was reduced from 5.5 m to 3.5 m which saved the cost of excavation & concrete, the estimated cost-benefit of INR 15 Lakhs.
- TCE got back one building through backfilling, which can now be utilised for admin/stores purpose.
- Use of BLDC (Brushless DC motors) fans in place of Conventional fans, resulting in reduced capital cost & monthly electricity consumption.
- To avoid any water/stagnation ingress in electrical rooms, the floor level of electrical rooms was raised—a simple but effective solution to the problem.

TCE SmartSite App:

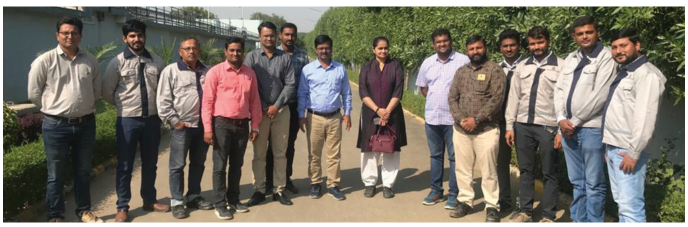
TCE took the initiative to make the construction and other related activities digital in this adverse pandemic condition, a step towards digitalisation. TCE team at IIT Hyderabad project has started working to make the best use of the TCE SmartSite, a digital platform to eradicate the paperwork involved in the construction site.

60 MLD VADAJ, AHMEDABAD STP

60 MLD Sewage Treatment Plant located at Vadaj, Ahmedabad won the Elets Water Innovation Award under the Innovation in Water Resource Management by an Urban Local Body (ULB) category.

The plant is based on Sequencing Batch Reactor (SBR) technology consisting of primary treatment unit and secondary treatment, including sludge digestion with mechanical sludge dewatering facility and chlorination system.

Tata Consulting Engineers (TCE) the Design Consultant, and Project Management Consultant (PMC) for the project is also the Design Consultant for the Ahmedabad Smart City.



TCS Sahyadri PARK 2 - WELCOME BLOCK

TCS Sahyadri PARK 2 was initiated in June 2019 by Harshal Buildcon. The welcome block being an incubation centre for TCS was required to start the operations early given the SEZ compliance and generate revenue before February 2020. TCE's scope as a PMC was to maintain Safety, Quality and Timelines for all activities such as Excavation, RCC, MS erection, Civil works, Decking, Façade, HVAC & Electrical HS & LS, STP, Access control, CCTV, DG, UPS, Finishing, Interiors, Statutory compliance and Handover.

Harshal Buildcon being a developing company, required hand-holding and guidance in safety, quality, scheduling, project tracking and billing at all project cycle levels adding to the challenge of achieving the project commitments.

Following are few of the unforeseen challenges in detail and how they were dealt with to complete the project before time and cost-saving.

Excavation & Backfilling

Challenges - The soil at the welcome block area was Black cotton. The required depth for excavation as per drawing and borehole data was avg. 2m. However, due to the huge quantity of black cotton soil and dumped garbage from around the area, the required strata were encountered only after 7m of excavation resulting in timeline delay and cost implications of 1.06 Cr for excavation and backfilling.

Solution - Majorly available moorum from inside the premises was used for saving time and cost. Additional resources were deployed for expediting the activity.

Extended Monsoons

Challenges - Monsoons in 2019 extended up to Sept, which affected the site activities with abysmal productivity.

Solution - The activity was not stopped, and the Vendor deployed additional resources to continue working relentlessly even during heavy rainfall. Planning and readiness to work in dry spell expedited the activity resulting in minimising the delay.

Value additions:

- Project completion within allotted Budget even after cost implications.
- Reduction in PCC thickness
- Approaching sub-vendors for expediting the procurement and execution processes.
- Close monitoring and daily tracking at all the fronts.
- MS shuttering for increasing productivity.
- Blockwork in place of shuttering for expediting concreting activity.
- Plumb concrete in place of backfilling for expediting PCC works.
- Hilti- cleat and lock anchor, HSUR arrangement for dry cladding, reducing time & cost.

FEW PROJECT HIGHLIGHTS

TUNGA RIVERFRONT DEVELOPMENT PROJECT

The City of Shivamogga is a typical example of the development of habitations along River banks. The old city of Shivamogga flourished on a 2.60 km stretch of the left bank of TUNGA RIVER. This 2.60 km stretch depicts the rich heritage of the city. This strip that houses the old city of Shivamogga is hardly 0.5 km wide & all monuments of heritage/historical value, & indicators of cultural & economic developments, which led to the blossoming of the new city Shivamogga are packed in this strip of land. The important landmarks in the town like Shivappa Nayaka Palace its fort, Ganapathi temple of Ramanna Shresti Park, Kote Marikamba temple and Mandakki Bhatti, are located on the riverside. During the year 2009-10, high flood protection retaining wall was constructed along the river's left bank (or North bank) to avoid flooding of this old city area and its monuments during monsoon season.

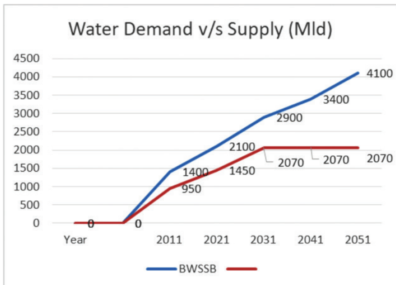
Between this 2.80 km long flood protection wall and the old city of Shivamogga, a narrow stretch of wasteland with moat along the fort wall to the tune of 6.5 Hectares is available and the same is proposed to be developed into a vibrant green and blue corridor integrating the heritage and cultural walk in the project. This flood protection wall lies between two main entry roads to Shivamogga city, and by developing it into a green wall, it will act as a gateway to the Western Ghats.

The vision behind this development proposal is to create a thriving public space along the river, which can enhance the city's image while simultaneously making it an essential part of its residents' everyday lives. Prosperous cities have been characterised by active public sectors along rivers, water bodies, and natural features, forming the centre of public life. These spaces owe their triumph to their tendency to adapt to satisfy the changing needs of society. In the case of Shimoga, the revitalisation of these spaces can improve quality of life and act as a stimulus for the development of the surrounding area and the city.

52nd Annual Convention 2020 IWWA

National Institute of Technology Patna (NIT) Patna and Indian Water Works Association (IWWA) organized 52nd Annual Convention of IWWA at Patna between 10th to 12th January 2020. The conference's theme was "Water Knowledge Summit: Driving efficiency and resiliency in water conservation and quality management in changing environment". The conference had good deliberations on water security, sustainable development, water quality, smart water and wastewater management systems, circular economy, integrated river basin management, climate change impacts, legal and socio-economic issues, and best practices in solid waste, environmental sanitation and improved water supply. ***Mr Dilip Sonwane, Group Sector Head – Built Environment*** *delivered an Expert talk on Improved intermittent water supply system.*

The water supply is intermittent in most of the cities in India. Some major cities have implemented source development programs and added bulk water to meet citizens' water requirements. However, the gap between supply and demand widens every decade due to increasing population, better living conditions, and increasing water demand.



Improving the water supply from present few supply hours to increased or better supply hours requires additional water sources. The sources of water are at longer distances requiring colossal investment and are limited in nature. The cities like Mumbai, Bangalore, and Chennai are getting water from 50 to 150 Kilometres away from the city, which calls for better water management practices, including demand and source-side management. The water losses are high in most of the cities in India. It forms a significant component of overall water demand for any development. Reducing the water losses results in increasing the available water at the consumer end and better supply hours. The water sources need to be planned considering the increase in water demand, available resources and possible water losses giving optimum solution considering huge costs involved in developing water resources. The cities need to plan the overall water demand scenario concerning leakage reduction program, resulting in better water supply hours and improved intermittent water supply.

PLANT ENGINEERING CLUSTER

SAFER OPERATION OF BOILERS IN THERMAL POWER STATIONS

A PERSPECTIVE

An accident occurred in an operating tower type boiler of 210 MW unit of a thermal power station on 7th May 2020. This unit has been in operation for a long time. Some of the technicians and workers present nearby reported to have got injured, and few sustained serious injuries. However, the investigation is yet to be completed.

A similar accident occurred in a 500 MW unit boiler in November 2017 during its trial operation and causing serious injuries and few casualties to people near the furnace. Both these incidents occurring on high-pressure boilers in a span of three years is a matter of concern. One boiler was newly commissioned while the other one was in operation for a long time. In this perspective, an attempt is made to bring out the possible causes that lead to boiler accidents and measures that can be taken to mitigate the same and ensures safe boiler operation.

Boiler Explosions:

A boiler explosion is a catastrophic failure. It carries dirt, debris and higher temperature gases in all directions at high speeds. It causes severe damage to everything in the vicinity. The explosive potential is always present, primarily if regular maintenance and repair are not performed. During an explosion, the sequence of events occurs very fast, leaving almost no time to act. Hence, prevention against these failures has always been of prime importance.

Boiler explosion at Groover shoe factory in Brockton, Boston, the USA in 1905 which killed 58 people and injured over 150 people triggered formulation of US national boiler code/ standard (by ASME) governing the safe design, construction, operation and maintenance of boilers.

Today, most of the national/international standards are primarily based on ASME boiler standards. A boiler explosion in Kolkata in 1863, triggered the Boiler regulation by British India, subsequently 'Indian Boiler Act 1923'[1].

As per National Fire Prevention Association (NFPA), boiler explosions in the US are caused by the operator error (47%), insufficient purge (39%), control failure (11%) and equipment failure (3%)[1].

Causes of Boiler Accidents:

Boiler accidents typically occur due to shortcomings in either design, control, operation or maintenance.

In earlier days, poor design, workmanship and low quality used to be the reasons for boiler accidents. The technological advancements in materials and automation, coupled with better safety standards, have improved the modern boilers' inherent safety and brought down the design-related accidents.

1 Compliance of Boiler Standards and Industrial safety in Indian Subcontinent -2018, by Akshoy Ranjan Pau.

However, few accidents are still occurring even today, mainly due to operational errors or poor maintenance.

Major boiler accidents normally can be expected due to sudden rise in furnace pressure beyond its design pressure which disturbs the furnace integrity and releases very high-temperature flue gases to the surrounding area. Formation of fuel-rich pockets in the furnace due to improper combustion followed by sudden combustion of the accumulated fuel pressurises the furnace to unacceptable levels.

However, these issues are addressed in the revised boiler safety standards by introducing boiler purge with robust automation controls, thus minimising possible accidents.

Rupture of tubes carrying high-pressure water, with the addition of flashed steam, sometimes increases flue gas volume beyond the induced draft (ID) fan's capacity and increases the furnace pressure.

Even though boiler tubes are well designed and fabricated, failures do occur, particularly when subjected to off-design fuel firing, poor operation & maintenance , improper feed water quality, and ageing, leading to reduced tube thickness, hot spots, or reduced material strength. Overheating tubes would reduce its material strength, and prolonged corrosion / erosion would reduce tube thickness and make the tubes susceptible to failure.

Corrosion can arise either from waterside (caustic attack, oxygen pitting, stress corrosion, etc.) or fireside (high-temperature oxidation, coal ash corrosion).

Accumulation of slag in tube surface due to ineffective wall blowing operation or firing off-design coal and falling large chunk of molten ash on water-filled bottom ash hopper also led to accidents in the past. Awareness and following of standard operating procedures can rule out such possibility. Spreading/accumulating pulverised coal near the boiler area, due to leaks from coal mills / fuel pipes coupled with poor housekeeping, could become a source of uncontrolled fire/explosion.

Boiler start-up from the cold condition is a critical task and more prone to accidents. Chances of incomplete combustion, accumulation of unburnt fuel in pockets and steep rise in SH metal temperatures are high.

However, it can be dealt with safely by following standard operating procedures.

Commissioning of a new boiler till completion of its reliable operation is a critical period and a challenge for operating personnel mainly due to non-availability of benchmark parameters, lack of knowledge of boiler behaviour and on-going tuning of control loops. Switching to coal firing during this period should therefore need extra care.

Mitigation of Boiler Accidents:

Modern boilers are designed as per the established codes that make them intrinsically safe. Hence, as discussed earlier, boiler accidents happen mainly due to improper operation, poor maintenance, or engineering judgment error. These aspects need to be strengthened to reduce probable boiler accidents.

The following actions are suggested to assist in mitigating the boiler accidents:

- Proper housekeeping is essential and should never be neglected
- Conduct regular safety audits
- Impart comprehensive training to operation and maintenance with particular emphasis on safety aspects. Such training should also include understanding boiler dynamics connected with off-design coal, improper operation that can lead to failures, poor performance, and at times accidents. Many times, operators do not get any warning of abnormal boiler behaviour as measurements of related parameters are not available. Using a predictive performance model can reveal such abnormalities in boiler operation and help operators take corrective actions.
- Tata Consulting Engineers (TCE) has developed such a boiler performance model. A brief about the model is given at the end of the article.
- Have an effective training mechanism to revisit the critical aspects of operation & maintenance periodically.
- Strictly follow the standard operating procedures (SOP)
- Whenever in doubt regarding the boiler operation's safety, bring the boiler to a safe condition by cutting the fuel, even if it means tripping the complete plant. This can be included in the SOP.
- Ensure all the available built-in checks and safety systems (protections, trip logics) are in place and are not bypassed
- Perform periodic calibration of critical instruments that are connected to the safety of the boiler
- Before boiler start-up, inspect the boiler and check for the build-up of any material/ash, misaligned tubes, damaged burners, malfunctioning of soot blowers to the extent possible
- Regularly monitor boiler parameters, identifying any deviations and quickly address problems before they pose a serious threat
- Check and maintain the boiler feed water quality to eliminate/ minimise scale formation and prevent tube failures
- Conduct life extension programme and periodical residual life assessment (RLA) studies to ensure safe operation of the boiler for relatively old boilers

Conclusion:

Recent boiler accidents on high capacity boilers equipped with automation controls reveal that a potential danger still exists in the form of an operational error, error of judgement or poor maintenance.

This article broadly looks at the most common causes of such accidents and mitigation measures that can be adopted to minimise accidents.

Author

Lakshmana Rao - Sr. General Manager

Tata Consulting Engineers Limited (TCE)

Mathematical Modelling of Boilers for Performance Evaluation: *Tata Consulting Engineers (TCE) developed boiler performance model*

Boiler design knowhow is available mainly with boiler designers/ manufacturers. Tata Consulting Engineers (TCE) has developed mathematical modelling of pulverised coal (PC) fired boilers, which is agnostic to any particular make.

The model evaluates and predicts boiler performance under variable operating conditions and can be used for troubleshooting and design review.

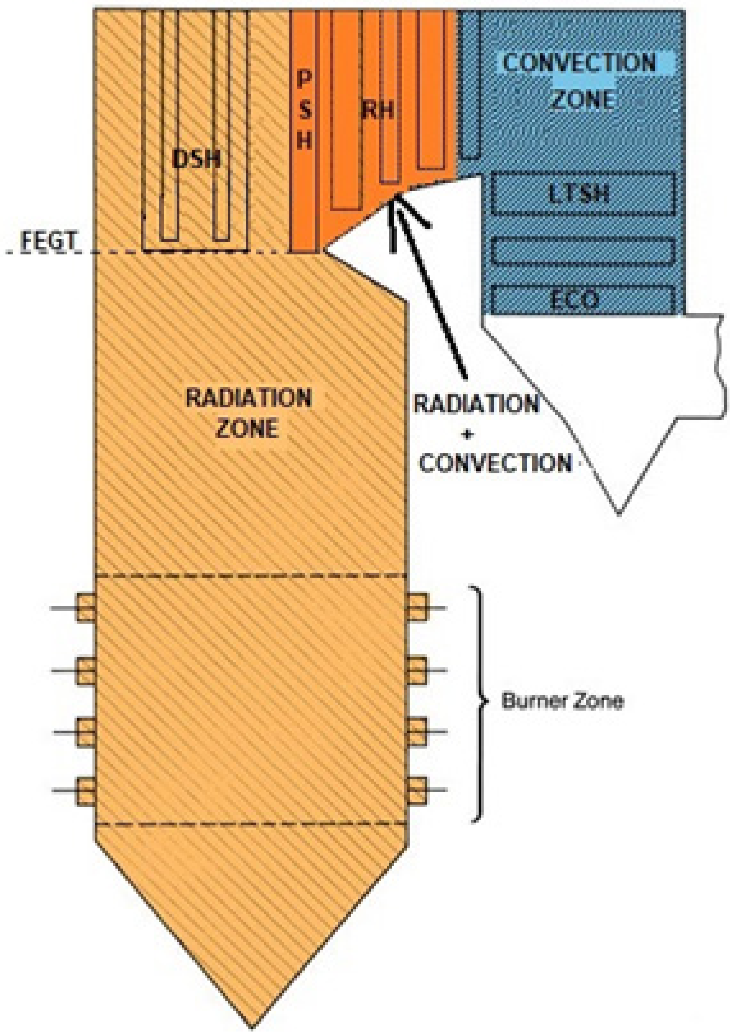
It uses available operating data on coal, water/ steam, air/ flue gas circuits. It derives intermediate parameters that are not available through direct measurements but essential for analysing boiler performance & health. Based on this data/information, it evaluates the boiler's overall performance and thus assists operators in achieving optimum performance while enhancing the life of the boiler components.

The model can perform the following:

- Evaluate the thermal performance of the boiler under varying load and change in fuel quality
- Evaluate SH/RH tube metal temperatures
- Evaluate the performance of air preheater
- Guide operator towards optimum boiler operation

The model can be used as a tool for a proactive operation strategy to improve boiler performance.

Schematic view of PC fired boiler



NUCLEAR MEDICINE

The word "Nuclear" conjures all sorts of negative images in people's mind nowadays. But PET scans, heart scan, bone scan and radiation therapy for cancer are all derived from our deep understanding of Radioisotopes and how we could use them safely and effectively. Radioisotopes are isotopes of elements which are radioactive. Lack of knowledge about radiation and radioisotopes in medicine is common regarding diagnostic tools, therapeutic medicines, and equipment sterilisation.

Uses of Radioisotopes

Diagnostic radiopharmaceuticals

Our body organs absorb different chemicals at different rates; for example, Iodine is absorbed more by the thyroid. A small amount of a specially created radioisotope is injected into the body. These get localised in specific organs, and the scans can detect that organ's dis/functionality. The technique can measure blood flow to the brain, functions of liver, lungs, heart, kidneys, bone growth assessment, etc.

This procedure's key element is that the radioisotope used should have a short half-life, a good gamma emitter, must be removed from the body through the normal biological process. The dose obtained from this should be minimal.

Globally used radioisotope for these procedures is Tc-99, which is used in almost 85% of nuclear medicine procedures. Tc-99 (Technetium) is an ideal isotope because

- Metabolic processes can be viewed within 6 hours, and it also reduces dosage to the body
- A good emitter of low energy electrons and gamma rays
- Technetium forms tracers that combine with active biological substances to collect in the tissue or organ of interest

Other radioisotopes used are rubidium-82, thallium-201 chloride, and fluoro-deoxy glucose (FDG) incorporating F-18 respectively for PET imaging by strontium-82, Myocardial perfusion imaging (MPI) for coronary artery disease and PET imaging.

Nuclear medicine therapy

Cancerous growth can be eliminated/reduced by using radiations. External irradiation is performed using a gamma beam from a radioactive cobalt-60 source by focusing on the cancerous tumour region. Internal radioisotope irradiation or Brachytherapy is used generally for thyroid and breast cancers wherein

Iodine-131 is used for thyroid, Iridium-192 for head & breast, iodine-125 or palladium-103 for prostrate. Localised targeting of tumours by this procedure effectively destroys cancerous cells, and overall radiation to the body is reduced. Targeted Alpha Therapy (TAT) using bismuth-213 & lead-212 are newer treatments for leukaemia, cystic glioma, & melanoma and treat pancreatic, ovarian, and melanoma cancers.

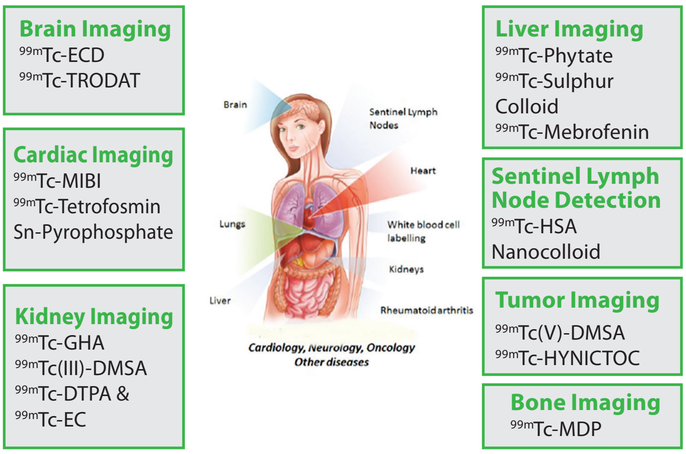
Boron-10 or gadolinium-157 are concentrated in malignant brain tumours, and the patient is irradiated with neutrons and protons. The Boron absorbs these particles and produces high energy alpha which kills the cancerous cells. This experimental development technique Neutron Capture Enhanced Particle Therapy (NCEPT) requires the terminally ill patient to be irradiated in a reactor facility.

Sterilisation

Co-60 source provides Gamma rays for cheap and effective sterilisation of disposable syringes, surgical instruments, surgical gloves, solutions, ointments, powders and biological preparations for heart valves, skin, tissue graft, bone, nerve. It is also used for bandages, plastic and rubber sheets, cotton wool, and burn dressings. Blood for transfusions kits is sterilised using Cs-137. Sterilisation provided by radiation has indefinite shelf life until it is exposed to air and can perform on fully packed items.

Production of Radioisotopes

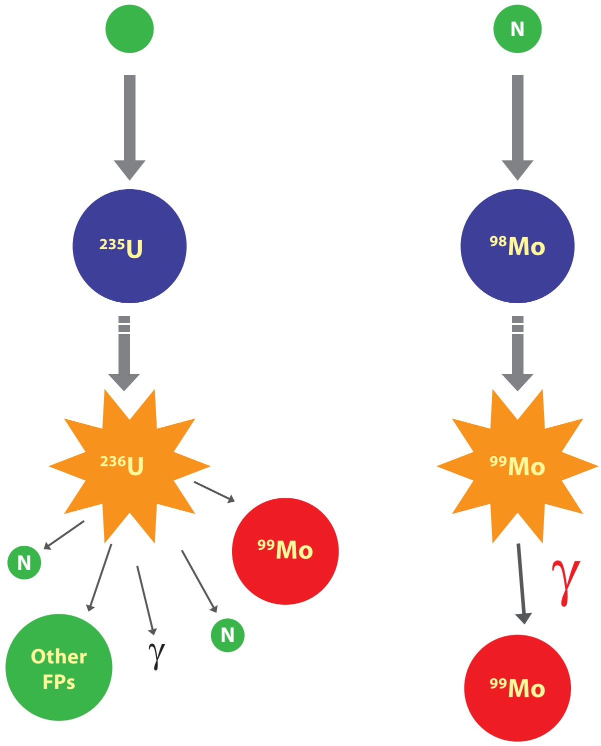
The Radioisotopes, as mentioned above, are all produced in Nuclear Reactors or Cyclotrons/ Accelerators. The most in-demand Isotope is Mo99 from which Tc99 is obtained. This is because as mentioned above used in over 85% of Nuclear procedures as shown below



Source: https://www.britatom.gov.in/sites/default/files/Publications/RPH_exhibit.pdf

There are three primary ways of creating Mo99

- Fission of uranium-235 (U-235) using HEU (Highly Enriched Uranium) targets and newer method LEU (Low Enriched Uranium) targets
- Neutron capture of molybdenum-98 (Mo-98)



Source: https://www.ncbi.nlm.nih.gov/books/NBK215146/

- Using ACCELERATOR

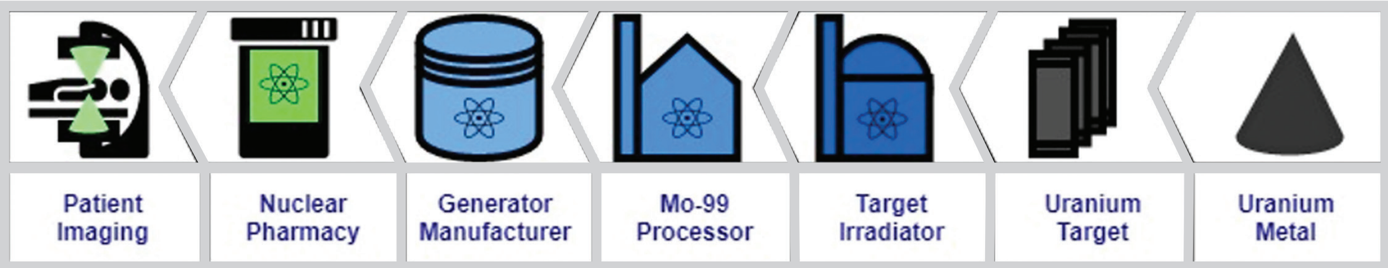
1. Photo-fission reaction: 238U(γ,fission)99Mo
2. Photonuclear reaction: 100Mo(γ,n)99Mo
3. Photo-neutrons generated from the e- beam for fission LEU in solution
4. D-T neutron generators to fission LEU in solution: 235U(n, fission)99Mo
5. Spallation neutron source production (ADS): 235U(n,fission)99Mo
6. Direct Tc-99m production by cyclotron: 100Mo(p,2n)99mTc

The fission method is used in 95% and 98% of Mo-99 production currently.

Global Supply Chain of Radio Isotopes

The supply chain consists of :

- Uranium target manufacturers
- Nuclear reactors for target irradiation
- Processing facilities that dissolve the irradiated targets to extract Mo-99
- Mo-99/Tc-99m generators manufacturers
- Radio-pharmacies to elute Tc-99m from the generators and prepare radiopharmaceutical doses
- Transport companies to ship to various participants involved in the supply chain



Source: https://www.oecd-ilibrary.org/sites/67dec9af-en/index.html?itemId=/content/component/67dec9af-en#wrapper

The most important factor of the supply chain is that Mo99 has a half-life of 66 hours, and Tc99 has a half-life of 6 hours which is time available for effective radioisotope utilisation.

Some of the Key Nuclear Reactors producing Mo99 Fission Products

Overview of Nuclear Research Reactor irradiators						
Reactor Name	**Country**	**Average no of Mo-99 production weeks/year**	**Maximum capacity per week (6-day Ci 99Mo)**	**Share of annual total world capacity**	**Type of Organisation[1]**	**Importance of Mo-99 irradiation to organisation[2]**
ANSTO (OPAL)	Australia	43	3 500	16%	Governmental	High
CNEA (RA-3)	Argentina	46	400	2%	Governmental	High
NCBJ (MARIA)	Poland	36	2 200	9%	Semi-governmental	Moderate
NECSA (SAFARI-1)	South Africa	44	3 000	14%	Semi-governmental	Very High
NRG (HFR)	Netherlands	39	6 200	26%	Semi-governmental/ commercial	High
RC Rez (LVR-15)	Czech Republic	30	3 000	10%	Semi-governmental/ commercial	High
Rosatom (RIAR and KARPOV)	Russian Federation	50	890	5%	Semi-governmental	Low
SCK-CEN (BR-2)	Belgium	21	6 500	15%	Semi-governmental	Moderate
University of Missouri (MURR)	United States	52	750	4%	**Independent non-profit**	Moderate

Source: https://www.oecd-ilibrary.org/sites/67dec9af-en/index.html?itemId=/content/component/67dec9af-en#wrapper

1 https://www.world-nuclear.org/information-library/non-power-nuclear-applications/radioisotopes-research/radioisotopes-in-medicine.aspx

2 Nuclear medicine in India: A historical journey- Anshu Rajnish Sharma

The number of research reactors producing Mo99 is on the decline, whereas the demand for the Mo99 is increasing. Many of these reactors are reaching their end of life, and replacement reactors are not being built.

Some of the leading processors' are listed below

Processor Name	Country	Average no of Mo-99 production weeks/year	Maximum capacity per week (6-day Ci 99Mo)	Share of annual total world capacity	Type of Organisation[1]	Importance of Mo-99 processing to the organisation[2]
ANM	Australia	43	3 500	18%	Governmental	Very High
CNEA	Argentina	46	400	2%	Governmental	High
Curium	Netherlands	52	5 000	32%	Commercial	High
IRE	Belgium	52	3 500	22%	Semi-governmental/ commercial	High
NorthStar	United States	52	750	5%	Commercial	High
NTP	South Africa	44	3 000	16%	Semi-governmental	Very High
Rosatom (RIAR and KARPOV)	Russian Federation	50	890	5%	Semi-governmental	Low

Source: https://www.oecd-ilibrary.org/sites/67dec9af-en/index.html?itemId=/content/component/67dec9af-en#wrapper

Both the reactors and processing involve a lot of engineering automation and careful handling of the highly radioactive elements. According to Transparency Market Research report titled, "Technetium-99m Market", the global Technetium-99m market was valued at **US$ 2.7 Bn** in 2019 and is projected to expand at a **CAGR of 3.5%** from 2020 to 2030. Radio-pharma players drive the growth of Technetium-99m market; clinical trials applications; ageing population increase; new drugs Testing; and an indication of disease mortality.

The stoppage of reactors or processing plants can impact the Molybdenum supply. Processing facilities need to be located close to the reactor to avoid delay in transit. So integrated Reactor Processors are essential to a successful Supply chain. Global Technetium-99m market includes GE Healthcare, Curium, Lantheus Medical Imaging, Inc., Mallinckrodt, Siemens Healthineers, Advanced Accelerator Applications, Bayer AG, Eckert & Ziegler, Advanced Cyclotron Systems, Inc., Sumitomo Heavy Industries, Ltd., Philips, and Jubilant Life Sciences Limited.

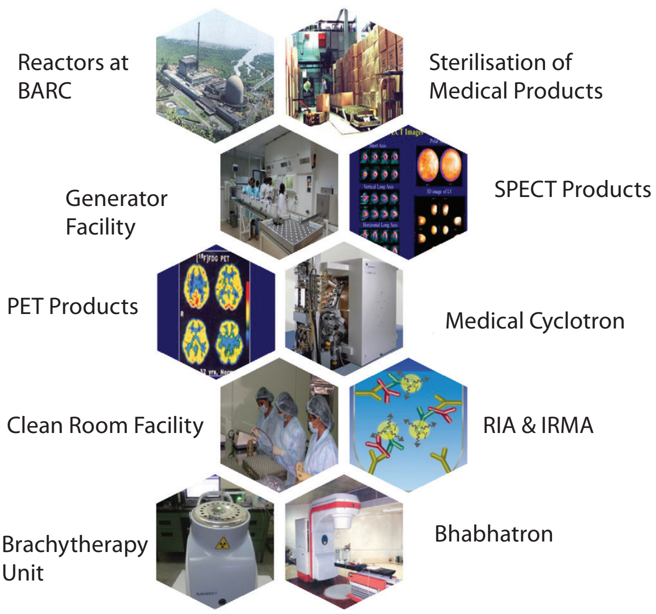
History and Radioisotope production in India

Dr Homi Jehangir Bhabha regarded as "Father of Indian Nuclear Program" spearheaded and established India's ambitious atomic energy program. In 1956, APSARA, the first research reactor in India became critical.

The second reactor, CIRUS, became operational in 1960. Indigenous production of radionuclides (131I, 32P, 51Cr) for medical applications were initiated in these reactors. The Isotope Division of Bhabha Atomic Research Centre since 1967 began the Commercial and supply of radioisotopes, radiopharmaceuticals to the hospitals in India.

The Board of Radiation and Isotope Technology (BRIT) was set up as an Industrial Unit of Department of Atomic Energy (DAE), commencing the commercial production on March 01, 1989.

BRIT products include Radiopharmaceuticals, Sealed Radiation Sources, Labelled Compound and Nucleotides, Gamma Chambers, Radiography Exposure Devices and Blood Irradiators. BRIT provides the following services - Isotope Application services, Radioanalytical services, Calibration and Dosimetry services and Radiation Processing Services besides Project Consultancy services for setting up Radiation Processing Plants in the private sector.



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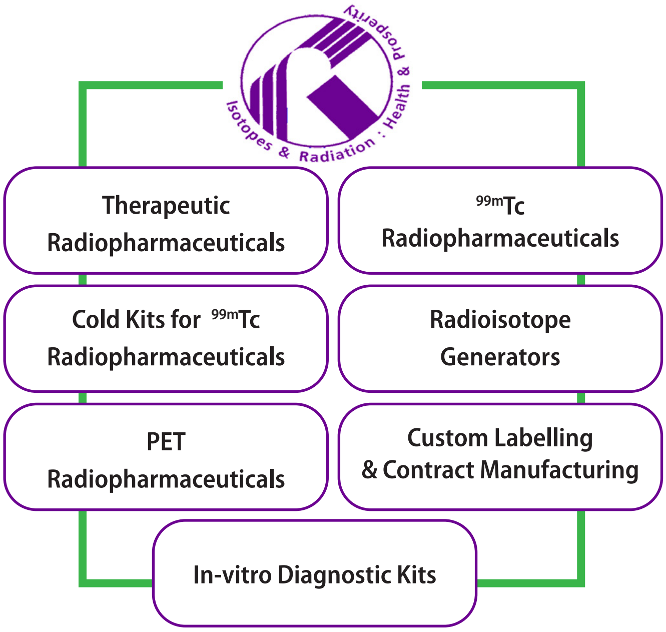

Source: https://www.britatom.gov.in/sites/default/files/Publications/RPH_exhibit.pdf

The figure provides an overview of the Radiopharmaceuticals produced at BRIT.

PET radiopharmaceuticals like below are produced and shipped to hospitals having PET camera in Mumbai and nearby areas.

- [18F]-FDG- Fluoro-deoxy-glucose injection used for Oncology, neurology, infection and cardiology, [18F]-FLT Fluoro-thymidine injection used for Oncologic applications
- [18F]-NaF Sodium fluoride injection used for Bone scintigraphy
- [18F]-FET Fluoro-ethyl tyrosine injection used for Brain gliomas
- [18F]-FMISO Fluoro-misonidazole injection used for Hypoxia imaging

BRIT also provides 3 types of 99Mo-99mTc generator for extraction / elution of 99mTc from radioactive parent 99Mo

- TCM 1 99Mo-99mTc COLTECH generator Alumina column generator
- TCG 99Mo-99mTc GELTECH generator Zirconium molybdate gel generator
- TCM 2 99Mo as sodium molybdate radiochemical Solvent Extraction Generator

Future of Radioisotopes in India

Mo99 production by BRIT in collaboration with INVAP

BRIT is building a Mo99 processing facility in collaboration with INVAP, Argentina. The production process of fission-based Mo is a sophisticated technology. It is almost a miniature "back end nuclear fuel cycle" of a nuclear power plant, handling large scale of activity, having many of isotopes, and all kind of radioactivity.

Indian Government reforms the Atomic Energy Regulation and allows for private participation

- Research reactor to be constructed in PPP mode (for medical isotopes)
- Irradiation tech for food in PPP Mode
- The nuclear sector-based Start-up ecosystem

Conclusion

The Government's step to reform the Atomic Energy Sector will facilitate nuclear medicine growth in India. A larger section of the patients would benefit from the availability of high-tech diagnostic procedures and medication at an affordable rate.

About Tata Consulting Engineers Ltd.

TATA Consulting Engineers Ltd. (TCE), a wholly-owned subsidiary of Tata Sons was established in 1962.
TCE has been associated with Indian Government's Nuclear establishment, Department of Atomic Energy (DAE) right from the inception of the first Indigenous Nuclear power plant to ***engineering over 7.15 GW of Nuclear plants.*** With vast experience in the design and engineering of Research Reactors like Dhruva, Bhavini and designing complicated Fuel handling machines, Automated Material Transfer inside Vacuum Glove Box, TCE is ready to support customers planning to build Research Reactors for Radioisotopes.

Author

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INDIAN CEMENT INDUSTRY

Building The Nation

India is the second-largest producer of cement in the world. India's cement industry is a vital part of its economy, employing more than a million people, directly or indirectly. Ever since it was deregulated in 1982, the Indian cement industry has attracted huge investments, both from Indian as well as foreign investors.

Indian advantage for Cement Industry

Robust Demand

- Government's Initiative to build
- 100 Smart Cities, AMRUT mission and Swachh Bharat Abhiyan.
- Pradhan Mantri Awas Yojana - Housing of all by 2022.

Long Term Potential

- Low per capita cement consumption as compared to other developing nations.
- Low threat from other substitutes.

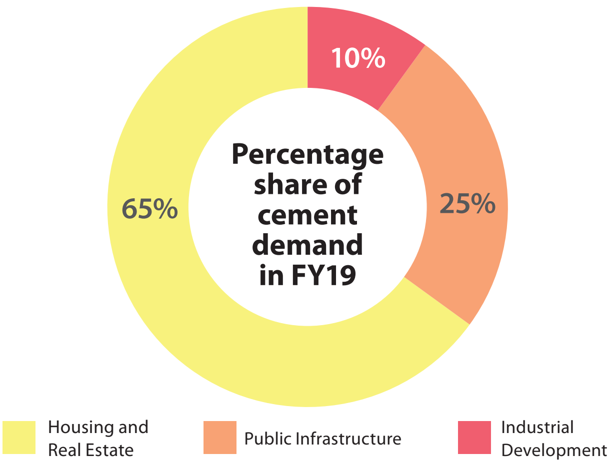
Attractive Opportunities

- Attractive opportunities in dedicated freight corridors, ports, highways, housing etc.

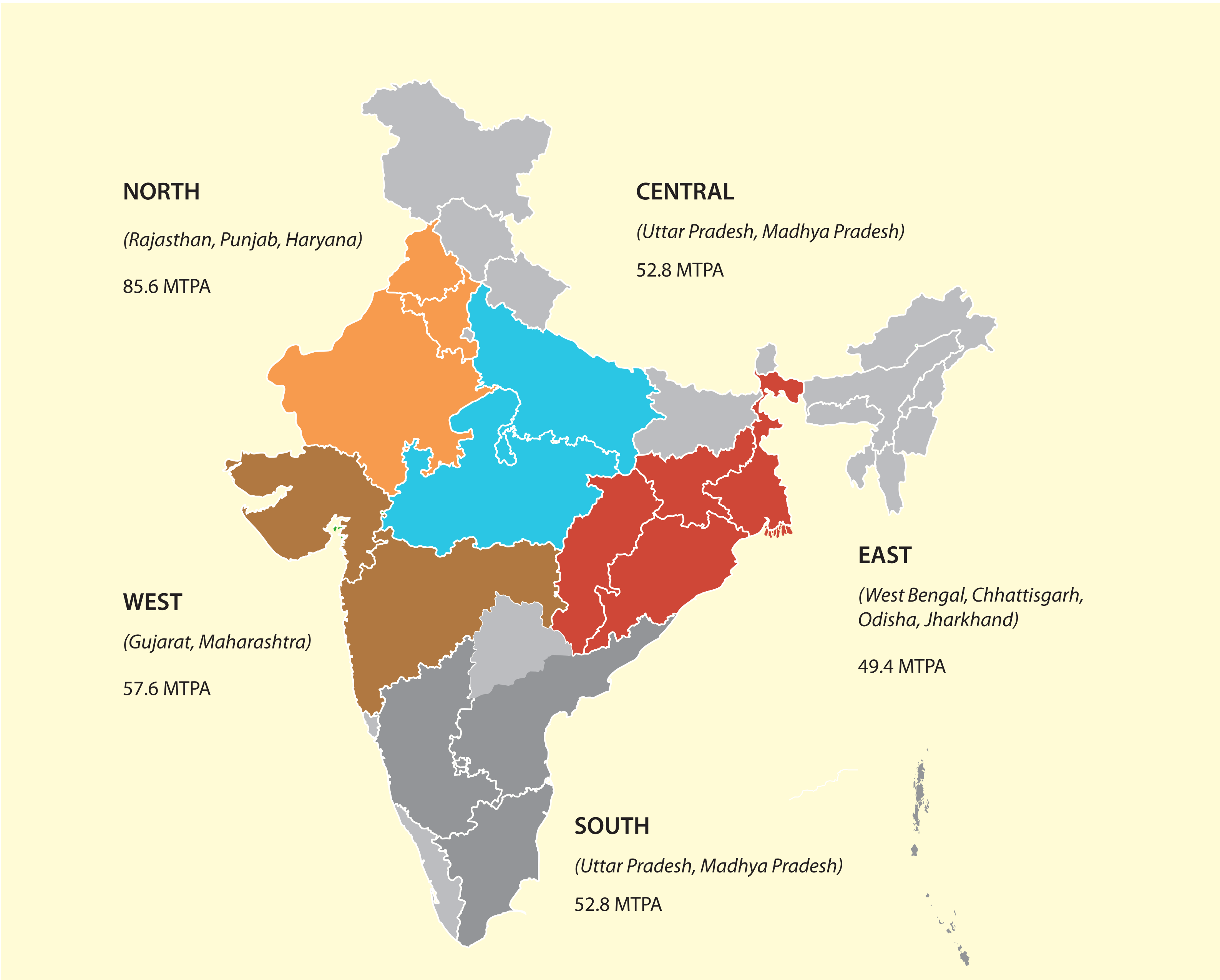
Increasing Investments

- National Infrastructure Pipeline (NIP) introduced projects for next five years
- Increasing FDI inflow in industries related to Manufacturing of cement.

The Cement industry demand is expected to achieve 550-600 million tonnes per annum continuously by 2025 because of the expanding requests of different divisions, i.e. housing, commercial construction and industrial construction. Expecting such developments in the country and aided by suitable government foreign policies (FDI), several foreign players such as Lafarge-Holcim, Heidelberg Cement, and Vicat have invested in the country in the recent past. A significant factor that aids this sector's growth is the ready availability of the raw materials for making cement, such as limestone and coal.



Cement Industry - Installed Capacities



The country is divided into five regions, w.r.t the installed capacities.

Successful use of alternate fuels in cement production - an emerging prospect

The Indian cement industry is now globally competitive with the lowest energy consumption and CO_2 emissions. Apart from fulfilling domestic cement requirements, the industry also exports cement and clinker to around 30 countries worldwide.

COMPANY/ PLANT	STRATEGY	BENEFITS
Madaras Cement's Alathiyur plant	Use bioenergy through burning of coffee husks and cashew nuts shells	Annual cost savings of US $1.7 million
India Cements Ltd.'s Dalavoi plant	Use Low Sulphur heavy Stock (LSHS) sludge as alternate fuel	Annual savings of US $6,500 approx
Ultra Tech's Gujarat Cement Works	Use tyre chips & rubber dust as alternate fuel	Reduction of about 30,000 tonnes of carbon emissions annually
Lafarge's Arasmeta plant	Substitue 10 per cent of coal used in kins with rice husk	Higher energy savings and lower carbon emissions

COVID-19 Impact

The Cement production in the country is slated to fall by 25-30 per cent this fiscal as COVID pandemic has sucked demand from end-user industries. This is the steepest fall for the industry in any year. Also, the Capacity utilisation in FY21 is seen at 40-45 per cent.

Cement production is mostly in-line with the infrastructure (housing, retail etc.) demand which is also poised to fall sharply due to the lockdown related restrictions.

Growth in the housing segment that forms 60%-65% of cement demand is likely to be affected given the impact of the slowdown in economic development on discretionary spending over the next year. A public health emergency of such a severe magnitude and the resultant downturn in the economy will put government finances under stress, limiting its ability to step-up capital expenditure thus impacting infrastructure growth, which forms nearly one-fourth of the total demand.

The COVID pandemic and the nationwide lockdown have come when construction activities are peaked and followed by the monsoon season. Again, the construction activity will be impacted, thereby affecting the cement industry's fundamental demand-supply dynamics.

Authors

Manoj Kumar - Sr. Vice President
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Tata Consulting Engineers Limited (TCE)

CHALLENGES

Weak demand in housing & infrastructure segment

Lack of funding and halting/temporary stoppage of various projects

WAY FORWARD

Target OPEX services

Major mergers and acquisitions ahead

Building relations and presence amongst cement players

FEW PROJECT HIGHLIGHTS

Rajasthan Rajya Vidyut Utpadan Nigam Ltd (RRVUNL)

2 X 660MW MW SURATGARH SUPERCRITICAL THERMAL POWER PLANT

M/s RRVUNL is installing a power plant at Suratgarh, Rajasthan. The site is near the canal fed by Indira Gandhi Nahar Priyojana. The 1320 MW capacity plant has 2 x 6600MW Unit # 7 & 8 subcritical units. The plant will receive washed coal from South Eastern Coal Fields Ltd. The Power generated will be evacuated with 2 Nos. 400 kV D/C lines, one to Jhunjhunu another to Bikaner.

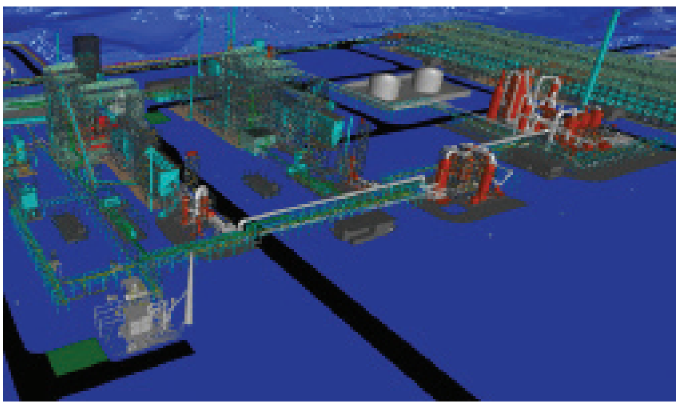
TCE is engaged in preparing the plot plan and detailed project report for the complete plant, Engineering and Procurement Management for various packages, Review of Contractor's drawing, review for the whole plant, Home Office based project management services, Construction Management and site supervision & commission services, Plant and equipment Inspection services and Witness and certification of performance Guarantee Test for the above packages.

The first unit was declared COD on 1st Dec 2020 for unit#7.

PT AMIN Copper Smelter Project Indonesia

The plant's size is 1.3 MTPA (dry basis) copper concentrate smelting and refinery with supporting facilities - a TCE first as an Engineer in the base metal Extraction.

Outotec and IKPT had earlier prepared the FEED document. As Owner's Engineer, TCE will independently review the FEED document and prepare the Bid bulletin for the prospective EPC bidders. TCE's present scope also includes Cost Estimation, Bid Adjudication and Assistance in EPC Contractor engagement.



FEW PROJECT HIGHLIGHTS

FEASIBILITY STUDY FOR STEEL PLANT & HOT STRIP MILL, EMIRATES STEEL, ABUDHABI, UAE

Scrap based steel making promoting recycling and moving towards carbon neutrality

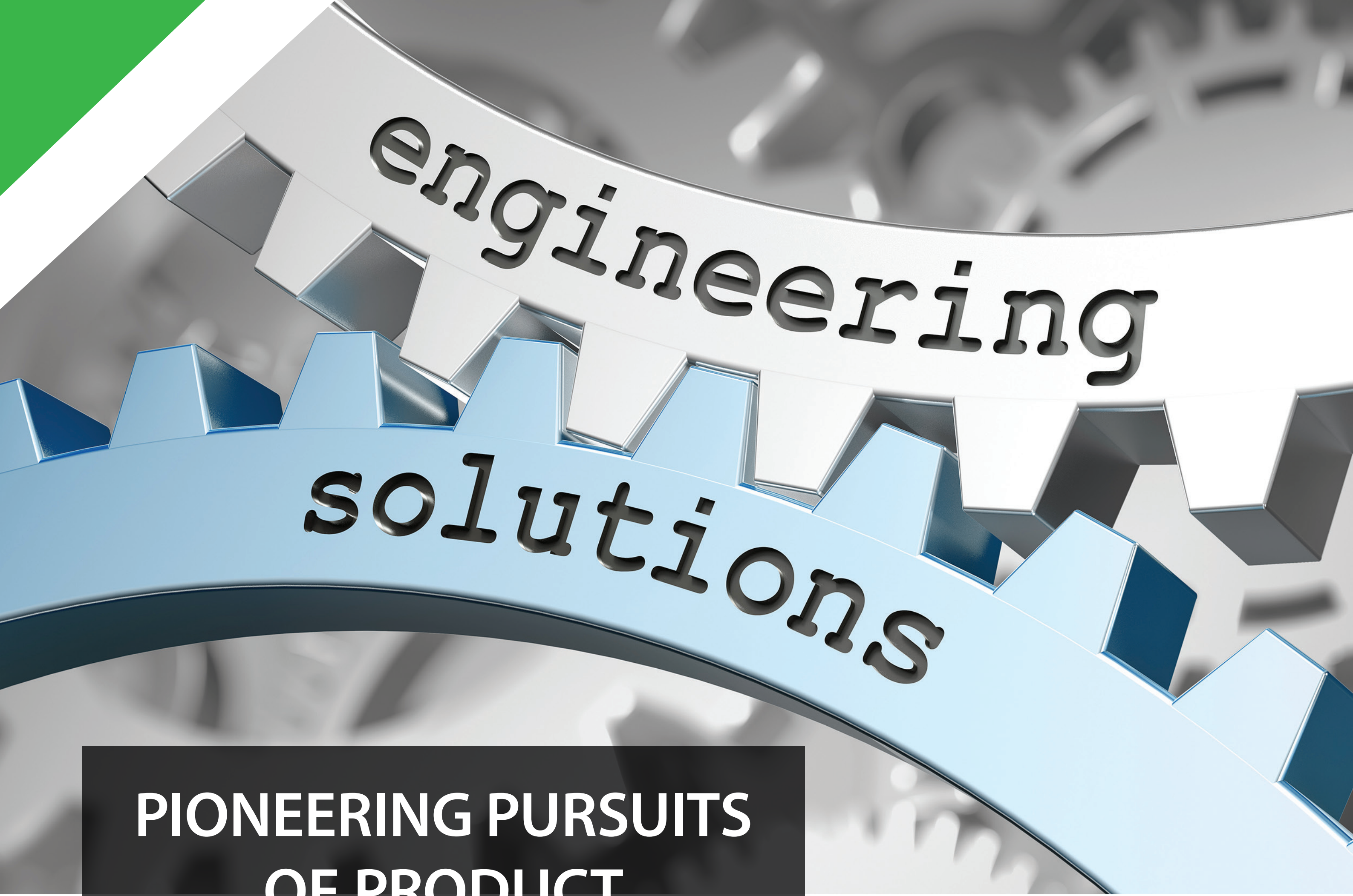
TCE was engaged for a bankable feasibility study for steel plant expansion and Hot strip mill at Emirates steel, Abu Dhabi, UAE. The study was conducted to install an EAF based steel melt shop using steel scrap exclusively for billet production to feed the exiting Rolling Mills.

A liquid steel capacity of 1.8 MTPA in the existing steel plant will be routed to a new thin slab casting and in-line rolling facility to produce Hot rolled coils. Necessary Jetty and handling facilities were envisaged for import, handling and processing of Scrap.

TCE envisaged the latest technology for both the new steel plant & Hot strip mill in its study. The optimised layout was prepared to take care of future expansion. The cost optimisation was done carefully to enable Emirates Steel as a Regional Player in Flat Market.

The projects as proposed enable optimisation of the Emirates Steel ISP (Integrated Steel plant) in terms of capacity, and product portfolio.

DIGITAL & TECHNOLOGY CLUSTER



PIONEERING PURSUITS OF PRODUCT ENGINEERING GROUP

Perhaps it is little known that today's Digital and Advanced Technologies Group started as special projects group incubated in 1968 with the nucleus of experienced engineers in Machine Design and Control Systems. The group was formed to cater to clients' needs, mostly government, in unique projects and products. The projects' nature required applying engineering from first principals and fundamentals, thus helping indigenous development of high technology products at a reduced cost, which helped substitute imports and save precious foreign exchange for the government during the country's critical development phase after independence. The team has done several pioneering works for industry, scientific establishments, Space and Nuclear Defence industry, Research organisations, and other Institutions of national importance.

One such project of National Importance where TCE demonstrated pioneering spirit is the team's work for Vainu Bapu Observatory of the Indian Institute of Astrophysics in Kodaikanal. Newly established Indian Institute of Astrophysics (IIA), headed by distinguished Astronomer, Vainu Babu, was looking for an optical telescope's indigenous fabrication in 1971. TCE helped IIA realise this dream. Extract from Biographical Memoirs of Vainu Babu is reproduced below where acknowledgement of TCE's support is specifically mentioned.

Harlow Shapley of Harvard University, where Babu studied astronomy, once lamented that although India had produced so many great theoretical astronomers, her observing facilities were practically nil. The Saha Committee in 1945, also realised this shortcoming and recommended acquiring a large telescope. But the high cost of a large telescope and the difficult foreign exchange situation prevented successful implementation of the recommendation. In 1971 when IIA was born, Babu, the founder-director, toyed with indigenously manufacturing one such telescope for a long time.

Fig.1 Indian Institute of Astrophysics Observatory in Kodaikanal

In 1972, Mr Hunter from a Canadian firm, M/s Dilworth Secord, Meagher & Associates visited Babu at Kodaikanal with Mr Jagannathan of Tata Consulting Engineers. They assured him of their help in designing and indigenising an optical telescope if such a project was undertaken. In 1973, Babu sent a proposal to the government of India and got the approval from the governing council with the condition that only the mirror block (2.5 M dia, 500mm thick weighing 4 tonnes) would be imported from Germany. Rest of the work like grinding of the block to parabolic concave mirror, design and construction of telescope mount, movement and control would all be carried out locally.

The governing council also declared that the new facility would be a national facility for all Indian astronomers. M/s Tata, Dilworth Secord, Meagher and Associates who worked on the feasibility report were awarded the design contract.

Babu was involved in the herculean task of managing the project's technical aspects while convincing the financial authorities about the advantages of embarking upon this venture. He convinced a leading group of scientists about the project's benefits, which helped him secure the financial assurance.

The project involved complex design and manufacture in civil works, mechanical engineering, electronics and computer science, and advanced technologies like optics, hydraulics and cryogenics.

TCE completed this complex project in 1984. Vainu Babu initiated the 2.3-metre (93-inch) aperture telescope designed and built within the country but did not live to see its completion as he passed away in 1982. On 6 January 1986, the observatory was renamed Vainu Babu Observatory and the 2.3-metre telescope as Vainu Babu Telescope. The telescope is so powerful that it can effortlessly spot a 25 paise coin kept forty kilometres away.

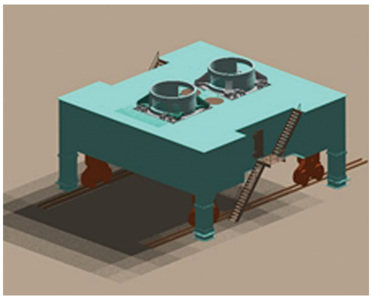
The telescope is used for deep-sky observations using a variety of focal plane instruments. The equatorially mounted horse-shoe-yoke structure of the telescope is ideal for low latitudes and permits easy observation near the north celestial pole. The telescope has an F/3.25 paraboloid primary of 2.3 m diameter with the prime focus image scale of 27 arcsec/mm and a Cassegrain focus image scale of 6.7 arcsec/mm. Even today the observatory attracts proposals from all over the country and sometimes from outside India and has helped Indian astronomers carry out several path-breaking research.

TCE is proud to have contributed to building this national asset. Subsequently, TCE secured and completed several astronomy and antenna related projects of national importance, some of them on a turnkey basis like

- 23 nos. 30 M dia parabolic arc Radio telescopic project in Ooty for National Centre for Radio Astronomy, TIFR
- 30 nos. 45 M dia parabolic dish steerable gaint meter wave radio telescope project for National Center for Radio Astronomy, near Pune. TCE even today offers AMC services for maintenance of dish antenna
- 14 m dia steerable dish antenna at ISRO Hassan Master control facility for tracking of large satellites launched for ISRO

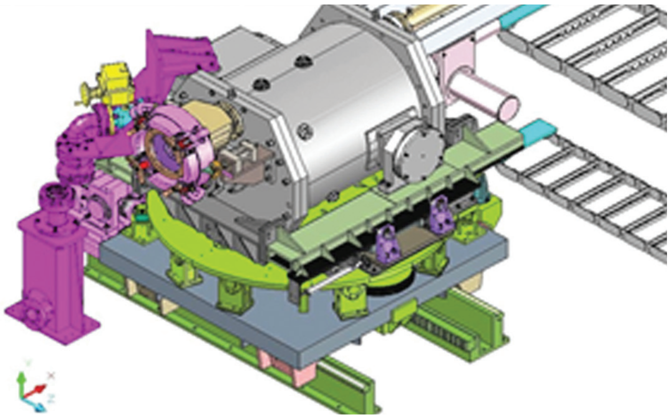
Apart from the above, our Product Engineering team completed several other projects of national importance some of which is listed below

- Mobile launch pedestal for PSLV and GSLV



- Design of Tokamak Fusion Reactor for BARC (Tokamak is a magnetic confinement device to demonstrate the fusion of hydrogen, deuterium and tritium)

- Mobile fuel transfer machine for NPCIL 740 MW Kakrapar Nuclear Power plant



The product engineering team is continuing the pioneering spirit and innovation culture at TCE. The company supports Government, Scientific establishment and Private sector players in providing indigenous product designs and solutions. Currently, the team is working on several such projects some of which is listed below

- TCE explores the possibility of involvement in the prestigious ***The Laser Interferometer Gravitational-Wave Observatory (LIGO)*** project in India, a large-scale physics experiment and observatory to detect cosmic gravitational waves and to develop gravitational-wave observations as an astronomical tool. India project will be built by the Department of Atomic Energy (DAE) and the Department of Science and Technology (DST), Government of India, with a Memorandum of Understanding (MoU) with the National Science Foundation (NSF), USA, along with several national and international research and academic institutions.
- Cryogenic engine test facility coming up in ISRO Mahendragiri
- The mobile launch vehicle for ISRO Gaganyan Program

TCE will continue the pioneering spirit and pursue many more complex and challenging assignments and establish an excellent reputation in niche machine designs, automation and advanced engineering analysis.

Author

S Vidyanand - President Digital Cluster
Tata Consulting Engineers Limited (TCE)

Technology Group Updates

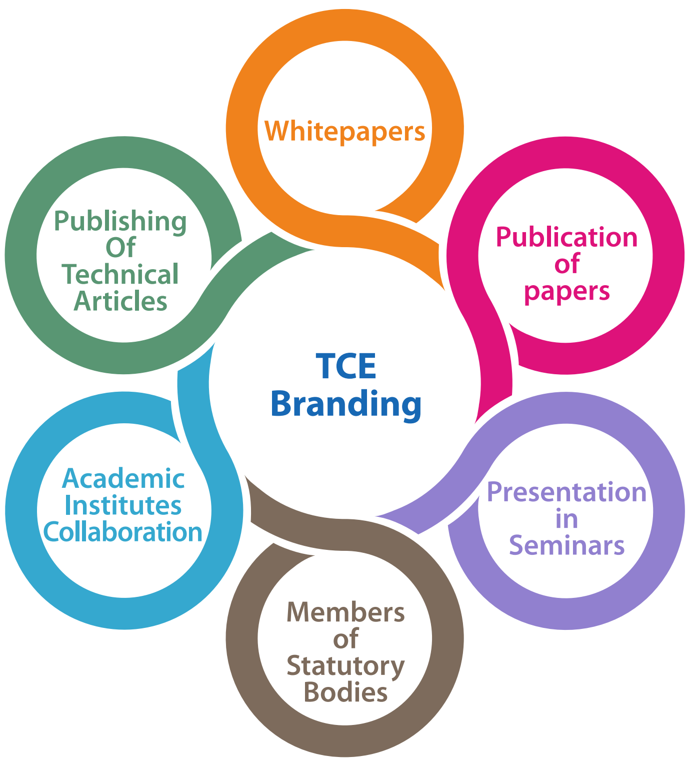
December 2020

TCE BRANDING

The technology group is actively involved in promoting the Brand. The branding effort highlights TCE's differentiated services, which helps improve TCE's image in the competitive market and win projects with enhanced revenue through the technically excellent offerings and new business areas.

The technical capability of an Organisation is reflected by the number of articles authored by the team. TCE has to its credit no. of articles published in various National and International Journals of repute. Conducting webinars on topics of interest to Industry as well as Academia has been an ongoing initiative.

The prevailing pandemic has significantly boosted webinars, making it a popular communication channel with the Industry and Academia. TCE has been part of several Industrial as well as Academic webinars.



TECHNICAL PUBLICATIONS

The Indian Engineering Congress organised every year by the Institute of Engineers is a flagship event that provides a broad platform to the engineering and technical fraternity in India and abroad for interaction and transfusion of knowledge furthering a new dimension for technological development. The 35th Indian Engineering Congress was a virtual event based on the theme "Engineering for Self-Reliance and Sustainable Goals".

TCE presented three papers at this event:

• Green Hydrogen: A Perspective

Dr S. Sakthivel, Shireesh S Swami, Atul Choudhari

Hydrogen is a clean-burning, emission-free fuel, which can be produced locally from any primary energy source, be it fossil or renewable. It has the highest energy density (120 MJ/kg), compared to gasoline (45 MJ/kg) and ensures energy security (i.e., produced from a variety of domestic sources). Hydrogen is emerging as an alternative clean fuel, particularly for hydrogen vehicles, alternative industrial feedstock, power generation and energy storage etc. Furthermore, hydrogen can be utilised in newer applications as fuel, reducing DRI agents and other metal processing, and energy storage. This article focuses on an overview of green hydrogen production methods, the landscape of electrolyser technology, cost analysis to understand the entire hydrogen value chain, including storage, transportation and distribution to the end-user. This article concludes that green hydrogen will penetrate the domestic market as renewable energy growth with lower prices and proactive policy frameworks encourages sustainable development to promote zero-emission ambition.

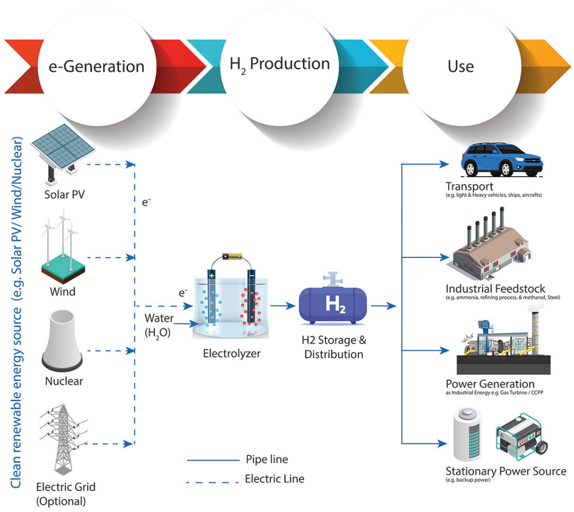


Fig.1 Flow scheme of green production via renewables and their applications

• Mitigating Covid-19 induced disruption to Steel use in Construction through Engineering solutions

Manos Kumar De

The construction industry is a significant contributor to economic development and a primary source of employment and materials consumption. Steel is one of the most versatile construction materials, and the construction industry is a significant source of demand for this material.

The economic havoc caused by the Covid-19 virus pandemic has severely affected the construction industry and the need for steel. The uncertainty associated with controlling and eradicating the disease has caused great distress to the established economic activities contributing to growth.

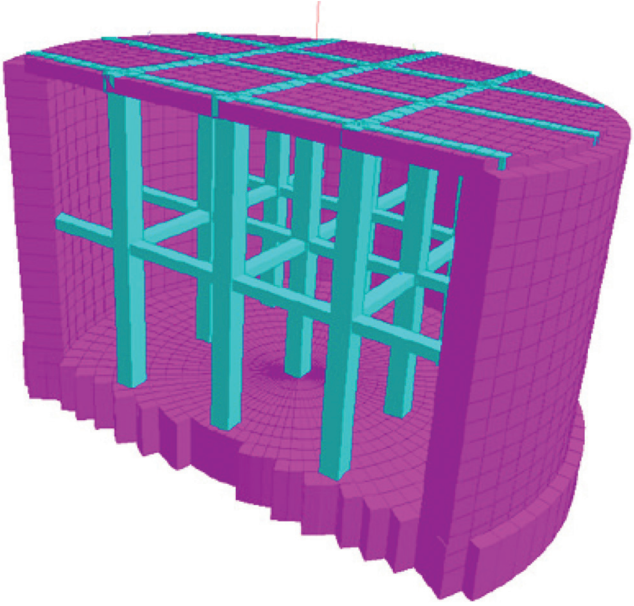
This article reviews the uncertainty imposed on the construction industry's future due to the pandemic induced disruption and the subsequent effect on the use of steel in the construction sector. It also reviews the factors that have driven down the sector's growth in the economic slowdown caused by lockdowns' imposition to arrest the virus's spread.

The measures planned to manage the risk and uncertainty caused due to this unprecedented phenomenon are studied. The article reviews the changing technologies that can revive the Industry and improve the steel demand in the new normal era, focusing on adopting digitalisation and mechanisation.

• Design Of Framed Foundation For Absorber In Flue Gas Desulphurization System

R L Dinesh, Ranjit P Kangralkar, Sandhya Krishnamurthy and Rohit Pantoji

The Flue Gas Desulphurization (FGD) system helps all operational and new thermal power plants meet the new guidelines laid by the Ministry of Environment Forest and Climate Change. FGD system provides "Environmental Sustainability" by reducing the SO2 gas emissions to the atmosphere, which cause respiratory infections, eye irritation, breathing difficulty, asthma and other health hazards. Absorber (scrubber) is the heart of the FGD system wherein the SO2 reacts with lime, and the concentration of SO2 emission reduces from the flue gas. Absorber structure needs to be supported on a rigid foundation. This paper describes a case study for selecting a type of foundation for absorber structure to provide a cost-effective and eco-friendly sustainable solution. This article concludes that using natural sand filling in the conventional FGD foundation system can be eliminated by using a framed type foundation, resulting in saving in natural resource and optimised solution.



Gaining Ground: CGD sector witnesses greater application of SSLNG

Shireesh Swami, published in CGD India, Dec '20, https://cgdindia.co/gaining-ground-cgd-sector-witnesses-greater-application-of-sslng/

India has ambitious plans to shift from an oil-based economy to a gas-based economy due to its near-zero-emission commitment. As natural gas is an environment-friendly and low-priced fuel. The newer initiatives and revised regulations help increase participation from public and private sectors in the CGD market.

Small scale (SS)LNG is an emerging alternative model in the LNG value chain, potentially creating considerable impact in the future due to its cost-effectiveness. Although SSLNG in India is still at a nascent stage, it offers immense potential to meet the growing demand for CGD. The SSLNG route eliminates right-of-way, rugged terrains, crossing water bodies and other issues related to laying pipelines and developing associated support infrastructure, resulting in faster project implementation and substantial cost savings than conventional CGD networks. In the future, the SSLNG model will surely gain momentum in line with the country's commitments to reduce carbon emissions and increase the share of cleaner fuels in the energy mix. This article covers the challenges to be overcome by all stakeholders involved in the LNG sector and the government's initiatives.

Criticality Of Power Distribution System In A Steel Plant

Anupam Roy, published in Electrical India, August '20, www.electricalindia.com

The steel plant is a continuous process plant with high capital expenditure. The power network should be designed keeping criticality at the centre. Any eventuality such as grid power failure, power equipment failure and internal power system disturbances due to low power quality can drive the processes into jeopardy. Such circumstances will result in colossal capital damage due to loss of production.

This paper discusses various alternative studies to select the most feasible power distribution network configuration in terms of reliability, flexibility, redundancy, and cost optimisation.

Process integration for energy efficiency and networking of unit operations

C Sailaja, Published in Chemical Industry digest, September '20, www.chemindigest.com

Process Integration involves analysing the entire plant rather than individual equipment to obtain an energy-efficient solution. It is a very challenging exercise to optimise a chemical plant for energy-efficient operation. It involves efficiently integrating different energy sources by implementing an energy management system and using the appropriate instrumentation to measure energy consumption. This paper addresses the design and operational issues to optimise the utility generation & distribution in any process plant in a cost-effective manner and reduce energy consumption.

Should You rely on your simulation results?

Atul Choudhari (Dy CTO), Petroleum Technology Quarterly, October '20, www.digitalrefining.com

Process Simulation is a useful and powerful tool to model chemical process flowsheets of varying complexities. Modern-day simulators are built with a comprehensive, pure component databank, an exhaustive library of thermodynamics systems, physical property estimation method, initial estimate generators and inbuilt algorithms for every unit operation with a user-friendly graphical interface. These simulators can solve and optimise virtually any flowsheet synthesis problem. However, despite the simulators sophisticated and rigorous modelling techniques, process simulations fail to represent real-life plant data. In most cases, the user shows blind faith in the inbuilt configurations and default selection of simulators' methods, introducing erroneous results for specific systems. Since simulators can generate multiple and sometimes conflicting solutions for the same set of external input data parameters, this raises doubts about their effectiveness and reliability. There are several reasons for simulation failure. This article covers various issues that may help users to derive meaningful results from simulations and thus enhance the reliability of their simulations.

Back To Basics: Introduction To Pinch Technology

Shreyas Choudhari, Atul Choudhari (Dy CTO), Chemical Industry Digest, September '20 www.chemindigest.com

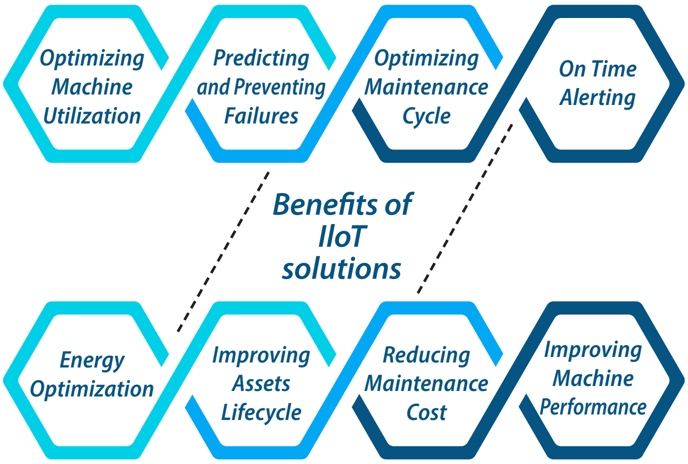
The Chemical Process Industry is one of the largest consumers of energy. Heat exchanger network design is a commonly used method for optimising the energy requirements. Pinch analysis is a systematic method that can be used to minimise the external energy requirements by utilising 'available energy' from the process streams to a maximum extent. Pinch analysis is usually carried out by using special software due to the advancements in software technologies. For reaping full benefits, this paper provides an overview and intends to go back to pinch technology basics, refresh and enhance users' understanding. A simplified and outline approach for energy optimisation using Pinch analysis is also presented.

Industry 4.0 Digital Technologies to optimise energy use in plants

Sunil Agarwal and Bharat Yadav, Published in Chemical Industry digest, September '20 –ww.chemindigest.com

Industry 4.0 is broader than the Internet of Things (IoT) and encompasses technologies such as Big Data analytics, Artificial Intelligence, and Machine Learning (ML). This article includes a brief introduction to the Industrial Revolution 4.0. and elaborates about the benefits of IIoT based solutions which are bringing a significant shift in the way businesses are looking at plant operations and reducing energy intensity.

Some typical applications across industries using smart solutions to improve plant productivity and efficiency are also identified.

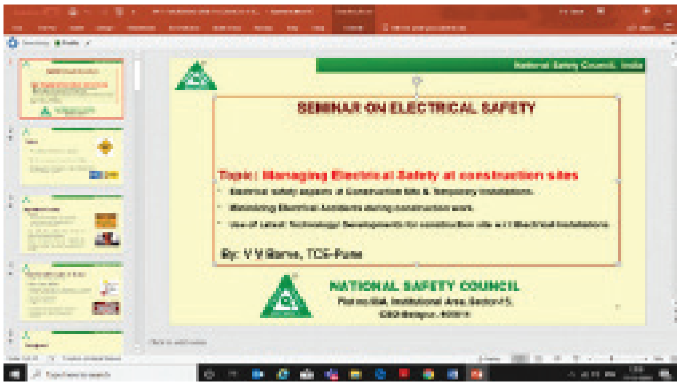


WEBINARS

1. Successful brownfield site development requires the planning of geotechnical tests, data collection, analysis, and field interpretation and laboratory results in a timely and cost-effective manner. The planning and scheduling needed to define potential criticalities and uncertainty in ground conditions allow designers to use resources effectively, optimise space constraints and develop response strategies for execution safety. The foundation system's decision and ground improvement required during the underground construction activity significantly impact brownfield project schedule and overall cost. The "Triad Approach" consists of planned geotechnical investigation combined with systematic foundation planning based on real-time data that optimally uses available resources and accounts for space and time constraints.

The paper on geotechnical site characterisation through "Triad Approach" for Coke Oven Project" at Tata Steel Ltd, Jamshedpur was presented by Manos Kumar De at the Indian Geotechnical Conference 2020 held between December 17th -19th.

2. Safety governs all aspects of life in different forms and to different extents. Safety is essential to protect people from fatalities and accidents, plants from damage and fire, and business sustainability. Electrical energy poses unique challenges as we can't see, hear or smell electricity. Yet, if an incident occurs, it can be fatal and costly. So electrical safety is of prime importance and identifying and controlling electrical hazards is an integral part of every safety program across all industries.

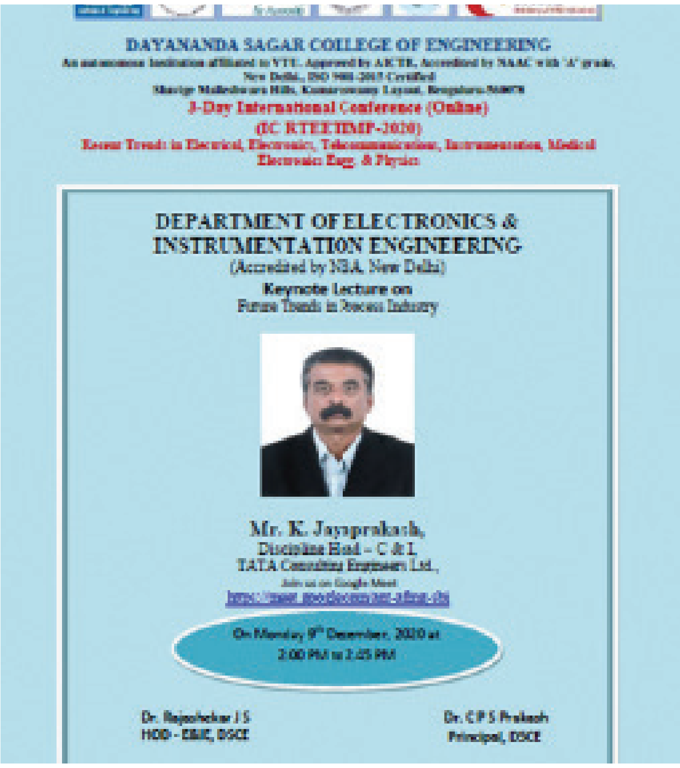


Mr V V Barve conducted a session on "Managing Electrical Safety at Construction Sites" during the virtual seminar on Electrical Safety conducted by National Safety Council, India on 12th December 20. It covered the electrical safety approach, electrical shock effects, types of injuries, common electrical hazards at the site, principles of site safety and precautions for temporary power distribution at site. Possibilities of accidents during the execution and testing/commissioning phase, including preventive measures, were also discussed.

The talk also covered the use of modern technologies for electrical safety like ultrasonic detection, e-alert safety helmet, smartwatch, prefab electrical systems, app-based safety monitoring, non-contact testers for measurements and the landscape of AR/VR/MR for electrical safety

3. An International conference on recent trends in Electronics, Electrical, Communication and Medical Instrumentation was organised by Dayanand college of engineering, Bangalore from 7th to 9th December 2020 (online). Participants included Engineers from IISc, Universities of Spain, Germany, Honeywell & Huawei.

K Jayaprakash gave a brief preview of technological factors driving the Digitisation and changes in all sectors like Smart sensors, Communication, Cloud, AI, & Cybersecurity. The topics covered included Digital twin, Asset management & Remote Monitoring applications in Process/ Power industry with benefits and challenges and a technical briefing on Microgrid and Wireless sensors applications in Smart cities



Technology Lecture Series Session 15 Engagement

Testimonials/ Comments from the audience

"The lecture was delivered and explained very nicely. It added value for me to implement in workplace."

"SiL studies being sought by more clients, the session helped to gain insights that can be applied in these studies."

"Very good subject knowledge which will be helpful."

"Overall good concept explained about SiL. I can use the same in critical projects."

146	Unique Participants
23	Unique Questions
7+	Bussiness Units and Functions

There is a Q & A section at the end of each lecture, followed by the participants' feedback. Testimonials with no. of participants, no. of questions and the attending BU's is circulated to all employees with each upcoming session.

KNOWLEDGE SHARING

Knowledge sharing is fundamental to a team's collective knowledge, intelligence and abilities. Virtual platforms have become essential means of working in the current circumstance and are excellent learning opportunities. As part of our culture of keeping abreast with the latest technology development, a lecture series was introduced as a part of the future fit sessions to address technical training needs and enhance the organisation's learnings.

The sessions conducted on a virtual platform by domain experts covered a wide range of trending and exciting topics. This series of lectures were hosted as live TEAM event starting 16th April 20. 34+ lectures have been conducted to date.

P R I D E - PROJECT INNOVATIONS IN DESIGN ENGINEERING

TCE has executed projects almost in all the industrial sectors and has built various state of the art plants and facilities demonstrating its rich experience and unique capabilities. All projects follow best in class engineering practices leading to many 'First of its Kind' applications. The PRIDE poster session allows showcasing and sharing achievements in building value to customers, TCE colleagues, and creating a sense of pride at being part of such a unique team.

At TCE, the customer is at the centre, and customer value depends on three factors – Quality, Cost and Timelines.

The poster sessions aim to meet the following objectives:

- Highlight the value additions aligned to Customer Goals
- Create a vibrant and collaborative environment that thrives on creativity, conceptualisation, value engineering and optimal design & engineering.
- Share the best engineering practices, expertise and strengths.
- Recognise projects and projects teams on
  - *Customer value through service quality, schedule adherence and cost reduction*
  - *Customer feedback and customer testimonials*
  - *Unique and innovative features, First of its kind (in India/world) design/application*
  - *Recognitions/Laurels earned in the form of awards and letters of appreciation*

> *"The poster must have value addition aligned to customer goals in numerical value*
>
> *Pride of project score = time or cost or quality improvement*
>
> *Customer value is dependent on three factors – Quality, Service and Price*
>
> *Customer Value Triad (Value of a product increases with its quality and service as the benefits increase)*
>
> *This will make the PRIDE poster complete"*
>
> Amit Sharma
> MD, TCE

The second knowledge sharing e-Pride session conducted virtually, involved 100 teams. Around 57 teams were shortlisted from the 100 entries. The finals was a live TEAM event, where the jury panel evaluated pre-recorded video of the team's presentation.

The winners from the different BU's:

PBU	
Winner: Piping layout for Cryogenic Engine Testing System	Namitha Hebbar, Vasanth Kumar, Harsha B.
Runner up-1: 60 MW Solar PV Plant	Shouvik Patari, Balaji S, Viswapriya, Kanumuri Bhavya, Nitin Adam
Runner up-2: Performance Guarantee tests evaluation tools	Venkata Ramana Sepena, Tailor Dharmendra, Patel Mohakkumar, Sreenath Janardhanan
MMBU	
Winner: Environment Program – Advanced Source Identification	Kaustav Das, Swadhin Acharya, Madhumita Mukherjee, Rajanish Tiwary, Atul Kulkarni
IBU	
Winner: Revival and Restoration of a Palace Complex	Aloke Roy, Prasad Dharasurkar, Nandini Mukhopadhyay, Sanghita Bhowmick
HCBU	
Winner: Secondary Tank farm Project for Oil PSU	Sandip De, Devendra Juvale, Reshma Palkar, Batchu Rao, Nitin Rajput, Peda Pasapu, Amit Shelar, Rupesh Koyande, Shantanu Jena
DATBU	
Winner: Design of SLV Integration Facilities	Shrishail Kore, Mandar Padgaonkar, R Swaminathan; Muhammad Thumseem, Mayuresh Darekar, Manoj Mane, Tushar Karandikar
PMCBU	
Winner: IT Building Construction Project -Dealing with COVID–19	Mahesh Sawant, Nishtha Gupta, Neel Kamdar, Rajeev Surendran, Shivam Khandelwal, Akash Danidhariya, Avani Kanabar

INDUSTRIAL AUTOMATION LANDSCAPE: *The Metamorphosis*

The industrial realm has encountered rising technology transformations, swift adoption of modern systems, low-cost computing, big data analytics and a persuasive network over the last decade. The concurrence of cutting-edge information, computing, and communication technologies propel automation and industrial applications to the so-called next industrial revolution – Industry 4.0. The synergy of technology-aided integration and joint alliance between people and machines across the factory floor and the supply chain is responsible for this revolution.

Today, every major industrial automation supplier is undergoing a strategic shift aligning itself to Digital Technology to address Industry 4.0. Most of them had their offerings, software or hardware, and leveraged their existing Industrial Automation and Control offerings (Software or Hardware) and expanded from there.

ABB has **ABB Ability; Emerson** has **Plantweb; Honeywell** has **Connected Plant; Rockwell Automation** has **Connected Enterprise; Schneider Electric** has **EcoStruxure; Siemens** has **MindSphere**, and the list goes on.

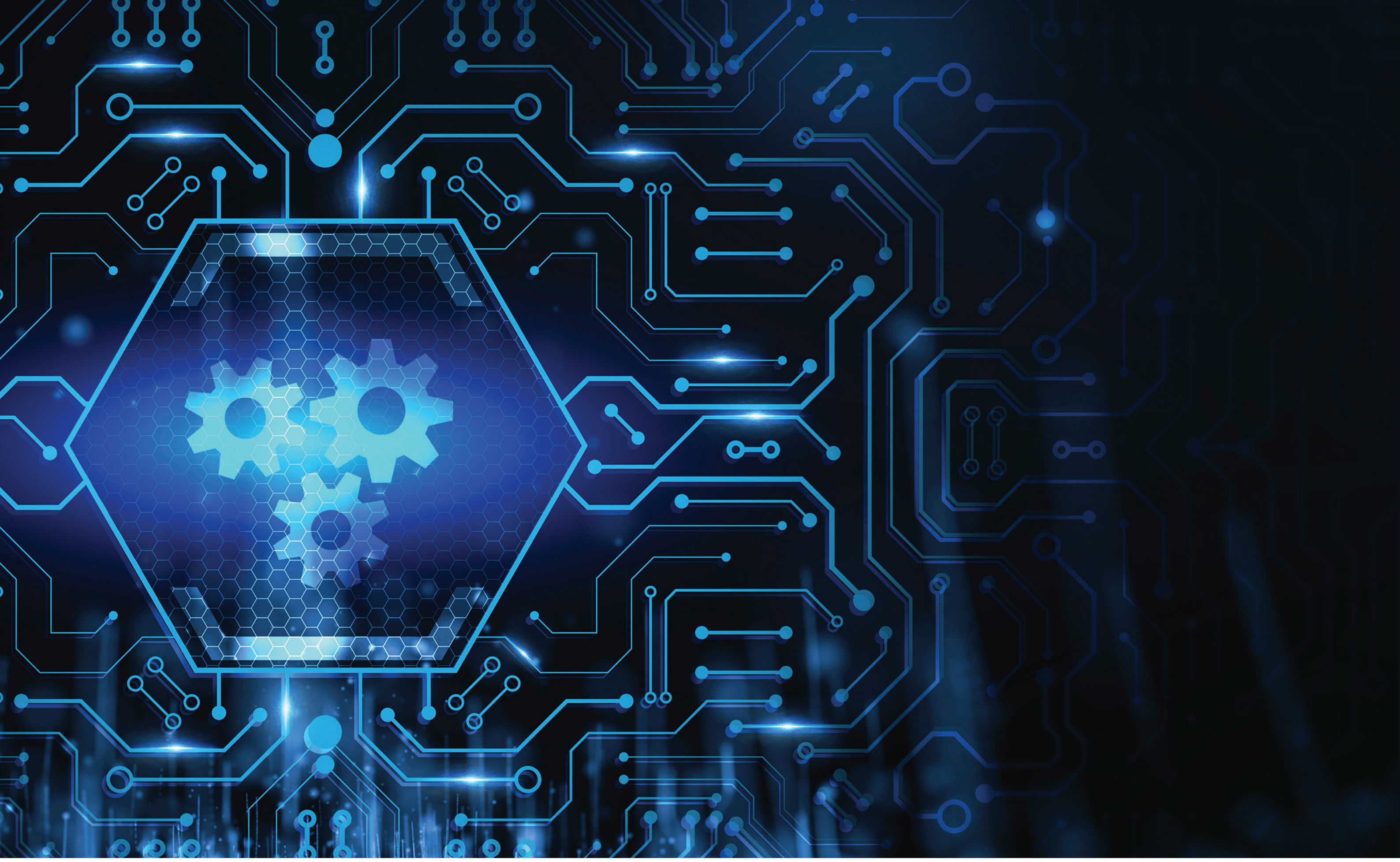
The common denominator is that all these companies are dedicated to the automation business and see Industry 4.0 as a considerable opportunity.

The trend of control systems, as depicted in Figure 1, can be summarised as Integrated, Connected and Intelligent. To achieve it, the Automation Solution providers are:

- ***Integrating vertically*** – From "Connected Equipment" to **"Connected Plants."**
- ***Integration horizontally*** – Especially **Horizontal integrations** towards Analytics, Predictive Maintenance and Enterprise Integration for improved business visibility.
- ***Focus on core & letting go of non-core*** – OEMs are focusing more on core solutions and increasing the space for **Partners** (EPCMs as System Integrators).

A few advancements by the Automation Solution Providers are highlighted below:

ABB acquired **GE Industrial Solutions** in 2017 for $2.6 billion to improve its reach in the North American market and get closer to end consumers. On the other hand, **ABB** shifted its Power Grids business to Hitachi. **Hitachi** acquired 80.1 % of **ABB's Power Grids** business recently for $6.85bn. ABB appears to have made substantial progress in becoming a more customer-focused and streamlined organisation.



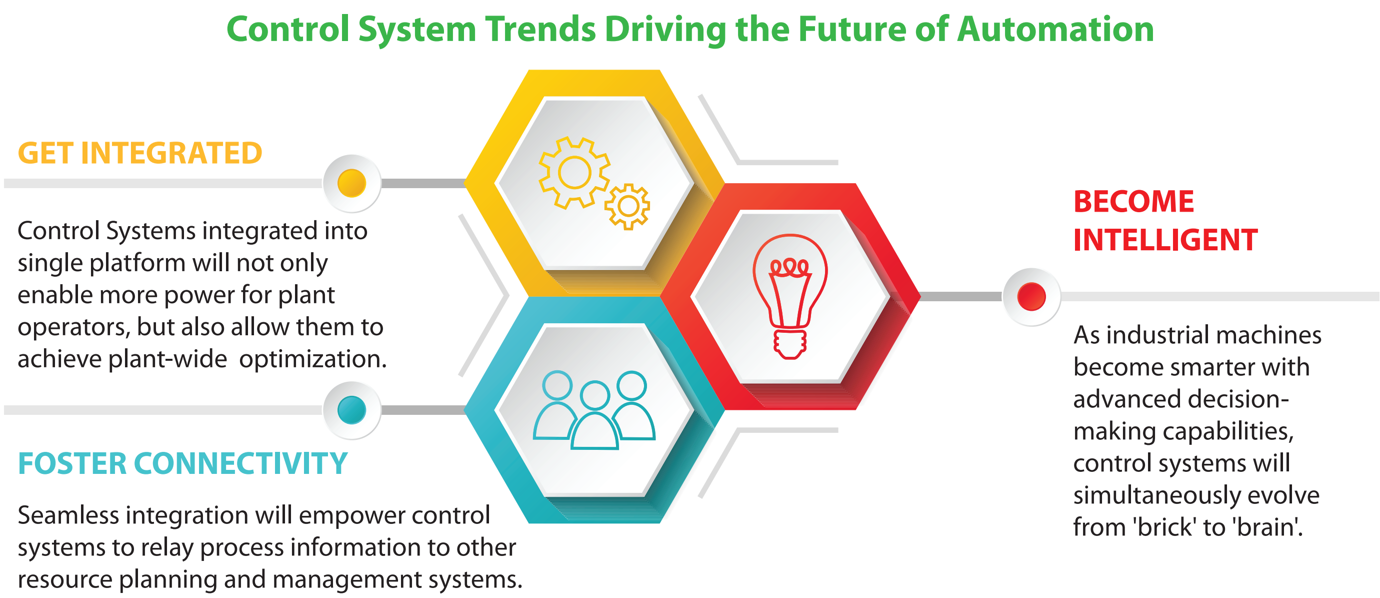


Figure 1

Emerson completed the purchase of **GE Intelligent Platforms** in 2019. The inclusion of Intelligent Platforms programmable logic controller (PLC) technologies will aid Emerson, a worldwide pioneer in automation for process and industrial clientele, to extend its competences in machine control and distinct applications.

Rockwell Automation acquired **Kalypso** (software delivery and consulting firm), **ASEM S.p.A.** (a leading provider of digital automation technologies based in Italy), **Avnet Data Security Ltd** (an Israeli-based cybersecurity provider) and systems integrator **MESTECH.** The acquisition of **MESTECH** (based out of Pune) enhances **Rockwell's** digital-change offer and spurs business in India.

Siemens will be restructuring into three primary business units and merging the Digital Factory and Process Industries and Drives divisions into one incorporated business. Its acquisition of Mendix in 2018 and its entry into the IoT integration services business expands its digitalisation portfolio. **Honeywell** has announced taking the Honeywell Homes product portfolio and ADI distribution business and producing a spinoff business called Resideo. Simultaneously, Honeywell itself intensifies focus on its PMT business, which is where its automation solutions dwell.

Amongst most automation suppliers, **AVEVA's** evolution is most unique. **Schneider Electric** accomplished its "reverse acquisition" of **AVEVA** in 2018. As part of the agreement, AVEVA merged with Schneider Electric's industrial software business to enlarge its selection of software products and services. Schneider Electric reported that joining its software with AVEVA gives it the "Power of Two," a hardware company with sturdy discrete, process and building automation and data centres combined with AVEVA's software.

AVEVA recently completed the $5 billion takeover of OSIsoft (US), a real-time industrial data software and services supplier. Through this, AVEVA makes a substantial aggressive mark in the Industrial Automation market.

Incorporating OSIsoft's PI System data management software with AVEVA's engineering, operations, and performance products will create an integrated data foundation that can push big data, cloud and AI-driven insights to build worthwhile business outcomes for customers. This combination aids AVEVA to grow and diversify the industries it serves and continue to increase its footprint in current and new markets and geographies. A significant addition by AVEVA to its comprehensive Asset Performance Management (APM) portfolio has already been the acquisition of the software assets of **MaxGrip** in 2019, which brought a strong RCM background. The solutions span engineering, operations and performance supporting the evolution of the industries that sustain our world.

Challenges foreseen for automation suppliers are giving tailor-made solutions for customers, pushing standardisation across customer processes, effective standardisation in data exchange protocol across suppliers, acquiring in-depth know-how of plant operations, and strategising a digital roadmap of the clients in this ever-changing technological and economic scenario. Lastly, incorporating and cultivating a multidiscipline solution while justifying the ROI in the shortest possible time will remain a predicament.

TATA Consulting Engineers (TCE) is a premier engineering consultant supporting its clients with integrated engineering solutions using the latest digital engineering suites. ***With engineering expertise and process domain capabilities, TCE serves as a" Problem solver to every client's unique needs".*** With its customer-centric and problem-solving approach, TCE is best equipped to partner both the clients and the automation solution providers to realise a collective Digital Roadmap for process industries.

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SHAPING THE FUTURE TOGETHER

Nidhi Mehandiratta
Head - HR, Ethics & CSR

In my twelve-year association with TCE, I have witnessed the business undergo many transformations leaving significant footprints on the sands of time. From contributing to Nation Building to putting India on the world map. As I look back at my TCE journey over the last decade, I am reminded of TCE's strong people-first ethos, which inspired me to join this venerable organisation. It is the very same inspiration that continues to drive me today and makes me immensely optimistic for the road ahead.

At TCE, we have always strived to stay the course on our purpose, which has helped us remain resilient in the face of changing macro-economic forces. This determined direction on our purpose is guided by the compass of our ethics and values that determines how we treat our employees, customers, partners and stakeholders.

Our drive for excellence as an organisation has always been a North Star for our people philosophy. It fills my heart with immense gratitude to take this legacy forward, and I am looking forward to play my part in contributing to the competitive excellence of TCE. People are our greatest asset, and hence our focus is on strengthening our culture of a highly engaged and high-performing workforce while partnering in business transformation.

The world is fast becoming digital, and an agile workforce is pivotal to TCE's growth story in this emerging era. The culture of innovation fostered here over the ages will help us sustain a robust growth trajectory and pivot and transform as necessary. We aim to take TCE's brand quotient to the next level to attract bright talent globally while continuing to provide a thrust to develop, motivate and retain talent in our journey of growth and be a preferred partner for our clients.

As TCEites, we are cognizant of our responsibility towards the society where we live and work, and I am optimistic that we will continue to take more significant strides in impacting communities across the globe and build a better tomorrow for our posterity in the time to come.

We value the voice of our people to help us help them better. We will continue to lend our ears to improve on our internal processes and systems through unlearning and relearning from our employees. At TCE-HR, we are looking forward to hearing more of your suggestions to jointly take TCE's employee experience and technical excellence to newer heights.

REINCARNATION OF HR

An Approach to Adapt & Embrace Uncertainties

Gone are the days when the bulk of human resource activity was confined to administrative tasks such as payroll processing etc. The accelerated transformation witnessed by the human capital in an organisation regarding their job portfolio to cater to unique business demand has necessitated a change in the HR function's role. Today, the HR function is no longer just an enabler. Instead, it is critical to chart the business strategy and company priorities and prepare the organisation for change. In effect, the HR function is at a phase of reincarnating itself, evolving into something much more substantial in the new workplace era.

The bottlenecks that many businesses encountered during this pandemic have made it challenging and critical for its survival in the long run. HR being a business-enabling function is required to innovate & align its People Practice strategies to identify real constraints, probe what makes it more challenging, explore resolutions with an open mind and choose the right option for quick results. To come out of this critical phase, the business must set a culture which promotes adaptability and embraces uncertainties.

In this setup, a company needs to leverage its core competencies, emphasise core values & encourage innovative solutions.

So what is driving this evolution in the HR function?

The scramble for talent

Chronic skills gaps combined with a mismatch between demand and supply of critical talent has been a crucial issue in an organisation while they get involved in resource planning in line with their business requirements. Majority of the Business leaders today can devote only a limited time to future workforce planning resulting in more than 50% looking to outsource all or part of their talent strategy & recruitment process in the next five years. To reach new heights in retention and engagement of knowledge-economy-millennial-workforce, HR has started aligning employee goals with business and corporate objectives through a combination of performance, reward, communication and tailor-made employee value proposition.

Technological advances

Today, the HR function has taken the opportunity to leverage technology & use the digital medium for acquiring, engaging & developing talent available in the industry. The growing use of data analytics has fostered even more profound change in the HR function. HR professionals are increasingly relying on analytics to help organisations make evidence-based decisions. Business leaders today use Big Data & Talent Analytics as part of their talent strategy. A more efficient workforce planning is the prime reason behind choosing talent analytics.

Importance of work-life balance

The dynamic social framework owing to career orientated professionals, nuclear families with both parents working coupled with responsibilities for children & ageing parents, has increased the emphasis on maintaining work-life balance. Good work-life balance act as a dominant factor to stay within their organisation over the next 12 months. Employees, especially the younger generation faced with long working hours, are beginning to demand different work arrangements from their employers to accommodate their lifestyle needs. There is growing recognition regarding the definite link between the work environment and employees' health and well-being.

HR's objective is to understand such critical issues related to work-life balance and develop innovative work-life programs to strengthen the employer-employee proposition. To be perceived as an employer of choice, many organisations are coming up with innovative work-life balance programs such as flexible working hours, an excellent creche facility for working mothers, specific health insurance policies for dependents etc.

Diverse, multi-generational workforce

The workplace of the future will get more diverse than ever before. India's demographics will continue to present some unique HR challenges as the tech-savvy, energetic, socially conscious and hard-working GenY will populate the workforce. Their work styles, culture and perspectives are different from traditional leadership styles and workplace cultures. Further, employees would come from a broad range of educational backgrounds, other regions, linguistic traditions, castes, communities, races and genders, adding another complexity layer. Going ahead, the HR function will have to play a critical role in designing a unified workplace that allows these varied groups of people to work together efficiently without compromising the organisation's core values.

Business Leaders agree that diverse teams always outperform teams with similar members.

Adherence to culture

Business leaders increasingly realise the importance of a compelling corporate culture in attracting new talent and retaining employees leading to HR function playing a pivotal role in influencing leadership to steer an organisation's culture in the right direction and align the business strategy.

Conclusion

To summaries, the dynamic business environment will necessitate HR as a Business Partner to explore opportunities and come out with an innovative option to cater to the changing organisation's needs. Besides, how well companies foresee, explore and align their human capital strategies during this crisis worldwide can make the difference between their success and failure. HR leaders need to vertically align to the business strategy, horizontally integrate the different functions of HR and contextualise the organisation's culture.

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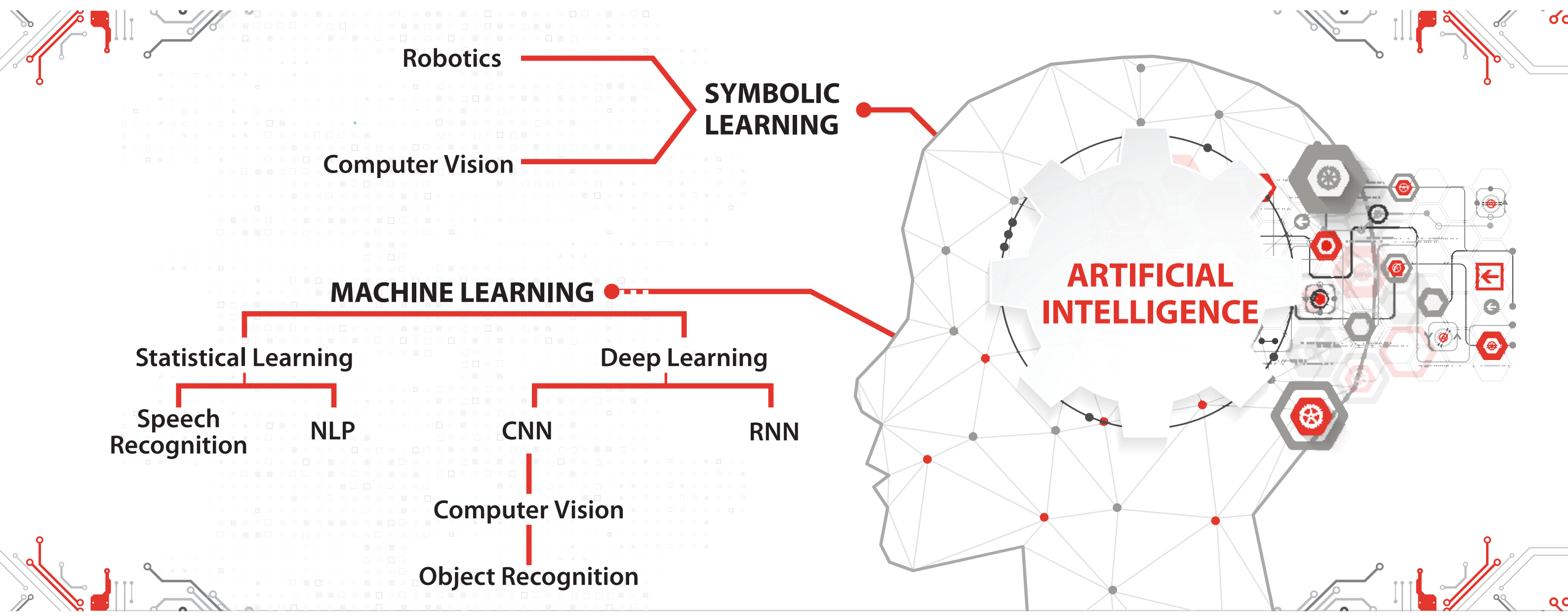
USE OF ARTIFICIAL INTELLIGENCE IN HR

Present And Future

Artificial Intelligence is a part of Computer Science, which creates a system to function independently and intelligently. Humans can understand and communicate through speech, which is Speech Recognition in AI. Similarly, we can write and read text; see through our eyes, process information; understand the environment, move fluidly; these in AI are the fields of NLP, Computer Vision, Robotics. We can recognise patterns and can group similar objects, which in AI is called Pattern Recognition. Machines too, process data and predict an outcome that is part of Machine Learning. The ability to mimic the brain and its working, gaining cognitive capability, is Neural Networks' field. Furthermore, complex networks are the area of Deep Learning. Machines can learn from big data to understand the pattern in different dimensions and can predict or classify.

We have seen different applications of Artificial Intelligence in our day to day life. We shop online, and e-commerce site shows or recommends products according to our buying pattern. Driverless cars can understand the road map, its patterns, the proximity of objects, and hurdles with the data used to train it. Nowadays, in Stock trading, AI understands its behaviour and pattern to predict its price. A Huge amount of MRI data of Cancer patients are used to provide the prediction of Cancer. Chatbots are a common sight in many websites. They answer the question based on data used to train them. Most of the computer games are also AI-powered. Reading or understanding an image with Robotics helps in Automation in Manufacturing. Today's security system can recognise whether a person is a friend or a foe with AI implementation.



Even sports are not far away, and AI has made it fair and better, whether a goal is legal or not in Football to whether the Batsman is out or not in Cricket.

THE NEED FOR ARTIFICIAL INTELLIGENCE – WHY?

The VUCA World is moving towards the need for agility, disruption, and information on hand. AI is reshaping, and revolutionising human lives in all spheres, so organisations adopt AI to enhance growth and improve productivity. This article shall study the AI technology's usefulness, impact on HR Management, relevance, its merit & demerits. Today, as all are aware of digital transformation and automation, AI shall find various requirements in these Human Resources work process areas.

AI is changing the lives in multiple walks of life, and its presence is growing in all industries and various sectors of industry.

The levels in which AI shall affect human life is

- Automation of mundane, tedious, time-consuming tasks
- Augment Human capabilities/abilities
- Amplification of the Human functions

AI empowers HR personnel with quality data and enables them to work efficiently, i.e. to attract and retain top talent. AI refers to a technology that can perform tasks otherwise performed by humans. These are not used in all functional areas, but only in a few functions where it is useful in many companies. In general, the following tasks can be replicated like: problem-solving, scheduling, training & reasoning, etc.

AI's benefits in HR and workforce shall not be seen immediately, but it is a journey. We can observe short term benefits in automation, medium-term benefits by augmentation, and long-term benefits in the enlargement of Human Tasks. Therefore, HR professionals need to begin experimenting with AI implementation benefits in the organisations and delivering value to the function. AI will not replace or reduce the HR roles instead will augment HR capabilities and create a collaborative environment.

Artificial Intelligence, along with it's two major components – Machine learning and Deep Learning, will enable Human Resources function to predict responses to such questions:

- Which candidates are likely to join?
- When would these candidates expect to join?
- Which employees are most likely to leave the organisation?
- Who is expected to be the most productive?
- What would be the expected future performance post-training is imparted?
- Who is most likely to be promoted?
- Who is the most likely candidate as a Successor to the role?

APPLICATION IN HR – HOW?

Organisations are trying to use AI in specific wherein they feel confident that it can assist the HR personnel, employee, and the organisation in improving productivity, efficiency, and reducing cost.

1. Recruitment and Onboarding

AI helps recruiters analyse large data points, identify and shortlist suitable candidates quickly for an interview. AI provides solutions to explore not only structured data but also unstructured data points.

As a Talent Acquisition solution, AI will help eliminate a significant percentage on candidates by scanning and analysing the profiles, thus reducing the time otherwise spent by the HR Team. This will help the recruiter in assessing and evaluating a smaller percentage of eligible candidates. As a result, AI would enhance the quality of decision making in hiring.

AI bots and assistance are used to provide a faster and efficient guide to the job applicant or candidate by matching the job requirement and responding to applicant queries through NLP tool. Thus, resulting in increased candidate engagement. The usage of AI in recruitment reduces candidate drop-off rates.

Another importance of AI is, it removes human bias during recruitment which can't be released during human evaluation. AI works on logic and reasoning, so screening the right candidates avoids unfair hiring practices and reduces human bias.

Sometimes AI is embedded in the system and tools to identify the suitable candidates. Once the candidates are shortlisted, the recruiter can follow the normal selection process of checking the ability, potential, and recruit appropriate candidates.

AI also helps in advertising the available position openings with the organisation, analyse interview outputs. The advanced technologies enable us to assess the likelihood of candidates joining the organisation; post Job Offer is made.

Onboarding

After hiring a qualified talent for the organisation, the next step is to fit them into a new environment and make them comfortable and productive at the earliest. It is the responsibility of HR to ensure that new employees adapt to the organisational environment by creating a digital onboarding structured, personalised program. It has been found that it is not easy to allow dedicated time to every new employee by HR.

So, by creating a customised digital onboarding procedure for each different position or skillset, it is seen that it's quite useful in making the new employees happy and comfortable. AI makes a significant contribution to improve the efficiency of employees and make them productive at the earliest. An important aspect is that the AI process shall be personalised to the extent and not familiar to all employees. The new employee who wants to interact with other employees and get organisation information will not know where to start. In this context, AI significantly contributes to enhancing and creating the first impression, thus building confidence in the new employee. AI chatbots are also used to answer all questions regarding organisation policies, rules & regulations. This is useful, so that employee gets only the required information and is not overwhelmed with excess details, thus making the onboarding process "just-in-time".

The right tool and the correct information at the start shall bring a positive impact on new employee productivity with increased engagement.

As noted above, the following functions are covered in digital onboarding by using AI.

- Providing clarity in roles and responsibilities to be performed
- Contact information for the employee to settle down within the system in the organisation
- Just in time, employee query resolution
- Verifications of the documents submitted by the new employees
- Responding to the infrastructure requests

2. Career Path & Retention

Internal Knowledge Management system with AI can be used as training modules by HR to provide new and existing employees to learn, upgrade their skills, and competency to the required levels. AI today is making considerable advances in big data technology. It can mobilise huge and variable data sets with several biographs, performance reviews, and historical data to improve the training and educative model.

After using AI to improve technical competency and expertise, many companies are now using dynamic analysis techniques. These are used to check employees' positive & negative feelings and biases, which shall measure employee sentiments, engagement, and role in the organisation. Two essential qualities of a successful professional are towards productivity and engagement. Therefore, to check these, organisations use emotional analysis techniques to monitor employee behaviour and performance indicators.

It is possible to get employees' unconscious level "of information using smart people analytics & digital IQs. In this analysis technique, people statements, moods, intentions in various social media platforms, and an internal social platform are consolidated compressively and validates human behaviour. This AI is also simulated with human and validated; these are inputs available to HR to evaluate and take corrective actions to reduce attrition. Software tools like monometers track employees' sentiments over a period, try to point out disgruntled employees to whom HR can speak, and sort out the issue to retain them.

Machine Learning algorithm can learn the behaviours of the people who have left the organisation, e.g., their productivity level, reasons for leaving, and other data sets. The algorithm can learn on this and predict who is likely to leave the organisation for the future. Thus, HR professionals can design a system and framework to retain the employees as a preventive measure or identify replacements in advance as a proactive measure resulting in saving money and time for the organisation.

3. Automation of Administrative Tasks

At the administrative end, AI can help automate many repetitive tasks and workloads, thus providing HR to focus on strategic decisions and reduce overhead costs. A lot of repetitive tasks often consume much time for HR professionals. For instance - questions regarding policy matters, basic do's and don'ts', issues related to leaves, appraisals, etc. These all can be quickly answered using an AI-powered employee help desk; wherein employee can feed the queries and receive an automatic response. Other applications in the future would include self-service kiosks for employees to generate their salary slips, Form 16, etc. Additionally, it can also allocate office space and equipment, allowing the HR staff to direct their time to more valuable productive tasks.

4. Transformation of Learning & Development

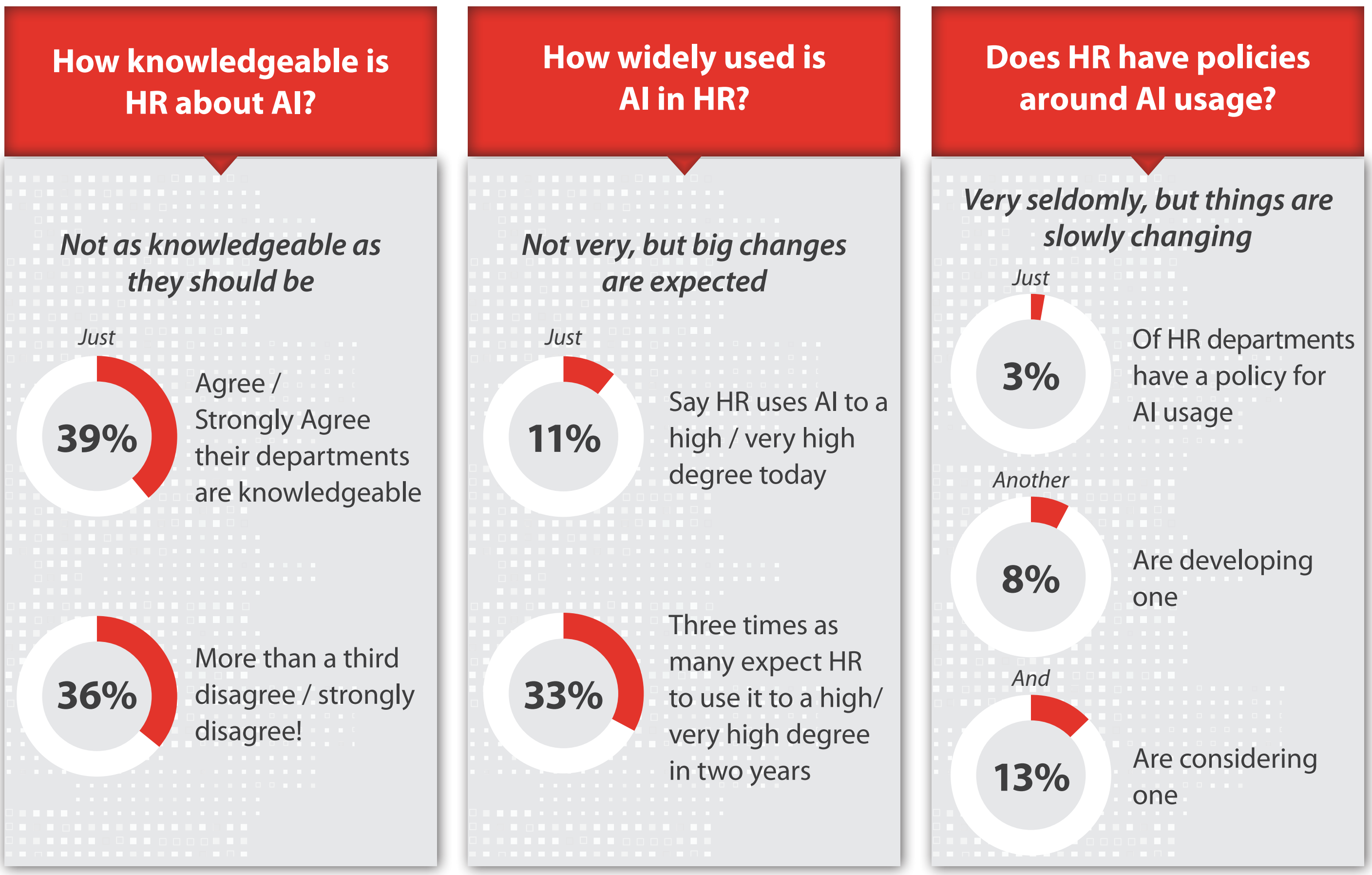
The presence of AI technologies like chatbots and virtual assistance everywhere would very soon disrupt the L&D function. The challenge is that the training programs must embrace the latest modules, learning approaches, and methodologies. With various available data, the AI can help capture insights on employees' behaviour, interests, and learning patterns, resulting in creating specific programs for each learner, thereby keeping the employee, motivated and engaged. Bots can help in creating personalised learning materials.

AI can also help in tracking learning progress, giving feedback, and guidance by the mentors. The available data can provide insights on learners' preferences, gaps in progress, and employee retention.

CURRENT SCENARIO

The HR Professionals need to enhance their knowledge of Artificial Intelligence and its impact. There is a need for increasing awareness of AI and related tools, creating policies around the usage of Artificial Intelligence in the HR Function. The hour's need is to know the types of analytics - descriptive, prescriptive, predictive, and optimisation.

How do we consume these analytics – visualisation, dashboards, enhancing current systems, etc. The need is to harmonise the data in different areas on the business and link it together with each function. Presently, it is imperative to know if we are willing to review the current processes and identify the gaps, ready to learn from those, willing to try and fail, gearing towards AI usage.

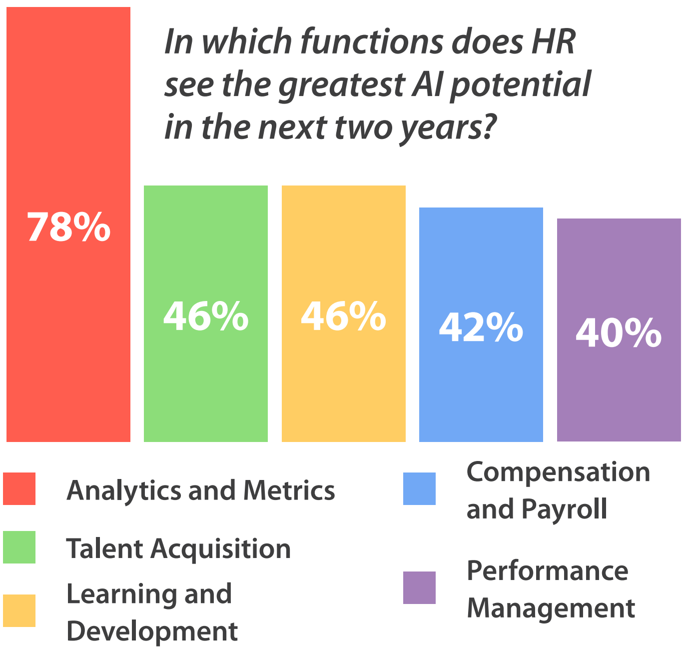


Citation Source - https://www.hr.com/en/resources

FUTURE PERSPECTIVE

The future is here now!

It is a journey that starts with the belief that AI will have a more considerable impact globally. The data strategy embarked upon and analytics capabilities being built in the organisations to lead us ahead. Financial Services has been leading this technology with tools like Robo-advisory and Sandbox, Bots, etc. In the Automotive Industry, e.g. BMW looked at the shop floor of enhancing their capabilities and smart manufacturing processes by leveraging AI technology. In Supply Chain Industry, e.g. Plant Logistics AI has been embedded for optimisation as continuous capability. In Energy Management Sector, e.g. Schneider Electric's predictive IoT Solutions, using Azure with ML capabilities to look up how they continuously tune up their models. This has helped lower worker safety incidents, lowering the costs of servicing and enhancing pumps' lifetime. Walmart at Intelligent Retail Labs uses AI for tests and learn innovative ideas. Amazon uses AI for customer preference recommendation, Swiggy uses for Route Optimization in delivery. AI has been used in Life Sciences and Diagnosis, e.g. TCS Labs, during COVID19, has analysed and synthesised molecules and used the AI model to evaluate various scenarios and problem-solving.



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In the HR Function, with the advent of Artificial Intelligence, the entire workforce is getting revolutionised. Intelligent tools would replace mundane jobs. Robots would assist and act as co-workers for repetitive tasks.

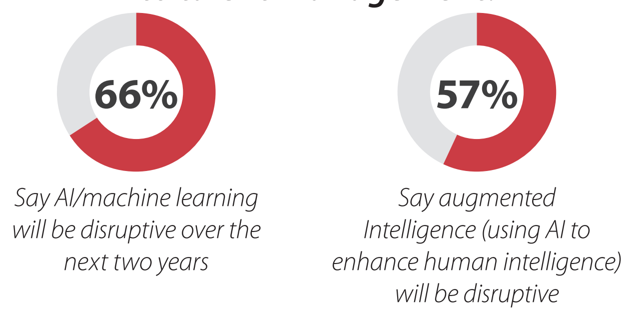
Amazon is the largest user of AI in Human Resource Management. IBM uses AI to check on the anger or violence problem about the job applicant. It uses a facial expression recognition technology to check on the candidate suitability with the organisation.

HR must utilise Artificial Intelligence as an enabler resulting in a better impact on the workforce. HR Professionals would utilise quality time to analyse patterns, predict the future, focus on strategic thinking, and use innovation for best practices. Embedding capabilities like predictive quality management, predictive process management, and current organisational processes, enhance the candidate experience and employee experience.

Intelligent Chatbots would enhance employee experience on queries and reduced response time. Gartner predicts a Virtual World of Exponential Change.

Impact and benefit of these above functions in AI

Does HR view AI as potentially disruptive to talent management?



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Deep-learning will transform the industries, and AI will significantly impact the global economic scenario. HR professionals clearly understand the impact of augmenting the human mind's amalgamation and machine learning for uninterrupted work processes and creating an intuitive work environment.

AI tools and machines can emulate human intelligence and provides many advanced responses based on data analytics. Point to ponder is, how AI impacts the department, which is based on human factors?

Though there is various AI usage in the HR function, one of the strategies could be to use this technology to analyse data for decision-making, resulting in enhanced employee experience and productivity with reduced operational costs.

BARRIERS & CHALLENGES

- While the need for AI is well understood, the concept is widely accepted, with its positive impact on the HR Function, but there are specific barriers in adopting AI.
- Talent Availability: there could be a shortage of the right skill set for implementing Artificial Intelligence tools in HR.
- Thought Process: old method vs new method. Linearity is always a challenge, are people geared up to break their processes and be prepared to disrupt the new systems.
- Integration: seamless integration with the old and new systems and other enabling functions, business units, etc.
- Data Privacy: the data must be available only to the concerned authorities or HR Members.
- Data Maintenance: like any other tools even AI technology requires machine learning, deep learning, and periodic updates and reviews.
- Financial: cost of digital tools and technologies could be a barrier for implementation.
- The results are in the Process to be proven.

CONCLUSIONS

Increased awareness of AI is growing gradually, AI's demands in all facets of life, all industries and, all functions, leveraging advanced analytics to leverage business challenges. It enables the HR Function to connect better, improve processes, and employee satisfaction with increased employee satisfaction.

Before deciding whether to implement AI solutions or not in HR, companies should analyse their business in-depth and evaluate the areas or sub-functions within HR that could be improved with AI technology. Overall the primary reason for implementing AI should always be enhancing or amplifying the employees' overall experience. This achievement can increase the organisation's productivity and reduced operational costs, resulting in enhanced employee engagement.

"The biggest workplace disruptor is next-generation automation technologies. The McKinsey Global Institute estimates that nearly half of all work could be automated with current technologies."

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DIGITAL TRANSFORMATION FOR FACILITIES MANAGEMENT

Digital Transformation is applying digital capabilities to processes, products, and assets to improve efficiency, enhance customer value, manage risk, and uncover new monetisation opportunities.

Facilities Management (FM), is a multidisciplinary field devoted to the proper operation of all aspects of buildings including Security, Cleaning, Landscaping, Health and Safety, Fire Safety, Maintenance, Testing & Inspection and Asset Management. It is mostly associated with office blocks, shopping complexes, arenas, schools, convention centres, hospitals and hotels etc.

The use of new technologies and full digital transformation in facilities management has some primary benefits—more customer touchpoints, visibility and data-driven decision making. When facility managers understand their existing operations, associated costs, and issues, they can present a more robust business case to expand the budget to address the maintenance backlog and other needs. Similar digital capabilities applications include implementing a preventive maintenance program, using data to make maintenance decisions, prioritising repairs, preventing minor issues from causing significant disruptions, and even identifying potential malfunctions before they are visible to the naked eye.

The top technologies enabling the digital transformation of facilities management include:

- Big Data Analytics
- The Internet of Things (IoT)
- Blockchain-based systems
- Artificial Intelligence
- Computerised maintenance management systems (CMMS)
- Energy management systems (EMS)
- Building automation systems (BAS)
- Interactive voice response systems (IVRs)

What new digital technologies are offering today is the ability to collect information from anywhere (a building, a piece of equipment, a vehicle, a process) create giant data silos and convert them into knowledge so that the appropriate action takes place towards a more efficient operation.

For example, we can build predictive models that will indicate where and when the next problem could occur using Artificial Intelligence.

Information can be stored into the cloud and accessed from anywhere through any device (workstation, tablet, mobile) from anywhere in the world centrally and decentralised, automatically routing predictive alerts to engineers and technicians to take specific actions.

Digital Transformation for FM should be people-oriented, customer-centric with innovative and streamlined communication channels. Digital transformation will transform your workers to knowledge workers who will use technology to collect data and use the fast array of tools to process big data, transforming them into meaningful information and taking action upon at the time and place of their collection. This includes performance monitoring, predictive maintenance, energy management and related dashboards.

Challenges in Facilities Management and how Digital Facility Management can make a difference

The typical challenges that FM companies often face are described as below:

- FM enterprises are under pressure to reduce costs and add value to their client organisations' core business, typically the building owner or developer.
- They need to achieve continuous operational efficiency improvement through service and technological innovation.
- FM enterprises are required to manage many safety-related issues. Failure to do so may lead to injury, loss of business, prosecution and insurance claims.
- There is a need for service delivery consistency by ensuring each service team member performs to the same standard and follows the same processes.
- Client organisations demand Proof of Service Delivery, Attendance and Health and Safety compliance via regular reports.

To meet the above challenges, Facility Managers would have to decide what their KPIs are. Depending on their most pressing needs, here is a snapshot of the top KPIs used by Facility Managers:

- Gross Facilities Management Costs per ft^2 of Floor Area
- Operational Costs per ft^2 of Floor Area
- Capital Costs per ft^2 of Floor Area
- Number of End User Complaints

Assuming these top KPIs are being measured regularly, it is possible to benchmark the results against a peer group. (Measurement is the first step that leads to control and eventually to improvement. If you can't measure something, you can't understand it. If you can't understand it, you can't control it. If you can't control it, you can't improve it.)

Goal: Increased Profitability KPI: Operational Costs per ft^2 of Floor Area

Mobile apps can ensure process compliance, which will lead to consistent service delivery, but how do you increase operational efficiency – getting more productivity from your service teams? This is where the Internet of Things and real-time intelligence relating to your function comes in.

Fixed rotas drive many service tasks and inspections. Cleaning, security and maintenance tasks are most often done in a pre-planned way based on standard time intervals. The challenge is to drive your service business dynamically, based on need rather than on fixed time intervals.

Internet of Things sensors placed on the assets being serviced or monitored provide this real-time data on the condition and performance of assets, be they mechanical or electrical equipment, buildings, facilities or environmental spaces.

IoT deployment also allows for a proactive service model to be put in place, increasing asset availability by up to 19%. Extending an asset's lifetime will reduce its lifetime cost.

Goal: Increased Profitability KPI: Capital Costs per ft^2 of FLOOR AREA

Another example of digital efficiency comes from measuring average hours per work order. Management can see which individuals and which teams are performing best. For example, with greater accountability and additional focussed training, it has been seen that average labour hours per HVAC work order decrease from 4 hours to 3.2 hours, resulting in a 19% productivity gain.

Goal: Service Excellence Consistency. KPI: % Number of End User Complaints

Service excellence is a crucial driver of customer retention and increased profitability.

Managers need to ensure that each service team member performs to the same standard and follows the same processes. Compliance in this regard has become much more feasible through technology by using mobile workflow apps. These intuitive mobile apps guide service teams through the elements of a service visit workflow, ensuring consistency each time. Mobile technology plays a significant part in ensuring that all incidents are attended to within the agreed SLA. All incident details are similarly recorded through on mobile, providing irrefutable proof of service. With reduced end-user complaints comes a decrease in churn and total customer satisfaction.

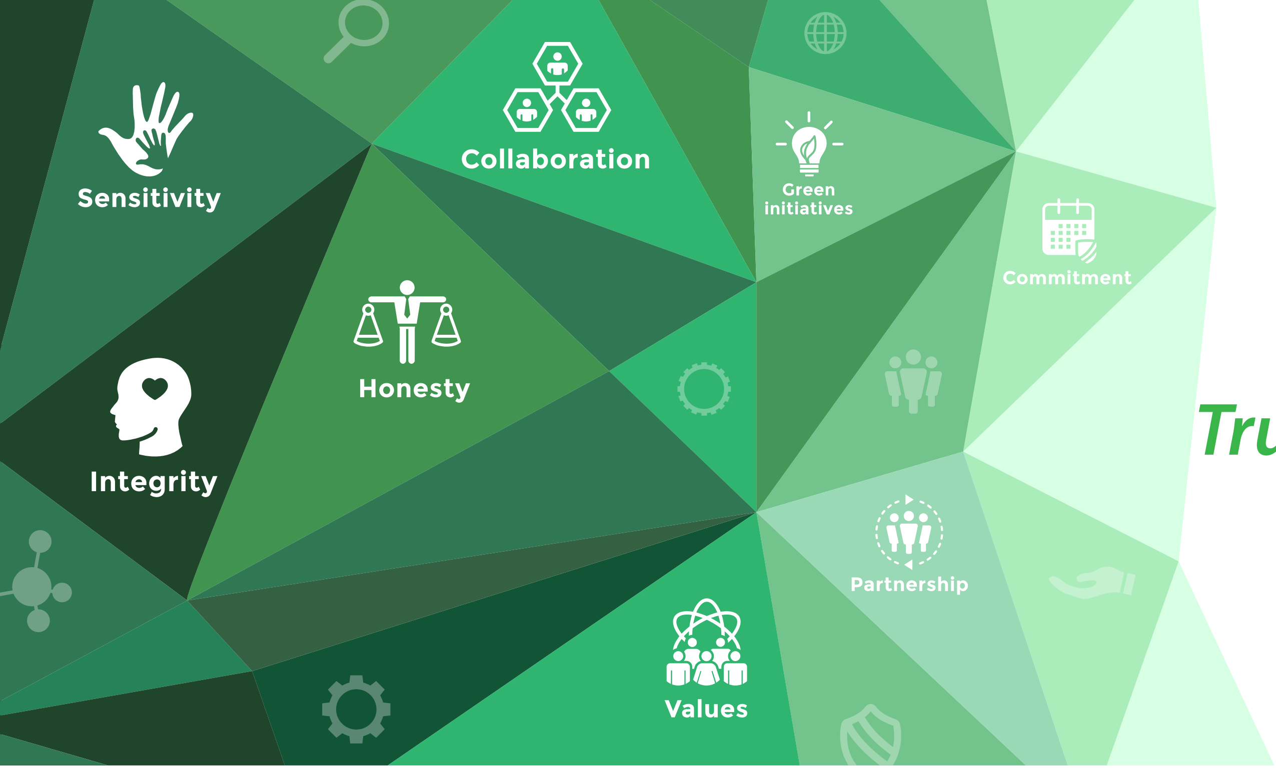
Conclusion

Again, Digital Transformation's essence is the convergence of three essential elements: People, Processes and Technology. Technology can and should be leveraged to deliver further transparency and accountability to people and ensure processes are streamlined and adhered to.

Author

Retd. Col. Anurodh Mishra
Associate Vice President

Tata Consulting Engineers Limited (TCE)



TCE *Trustcove*

Tata Consulting Engineers Limited (TCE) is a signatory to the Brand Equity & Brand Promotion Guidelines (BEBP), which ensures that the Tata Brand and the Group philosophy on ethics, transparency and accountability is applied across the Group companies day-to-day business.

TCE follows the ethical principles laid out in the Tata Code of Conduct (TCoC). These are institutionalised, formalised and practised by all TCE employees and our Business Partners.

The TCoC commits us to:

- Doing business conforming to the highest moral and ethical standards
- Good corporate citizenship
- The economic development of the communities, countries and regions we operate in; while respecting their culture, norms and heritage
- Not to compromise safety in the pursuit of commercial advantage
- Highest moral and ethical standards and be fair and transparent
- Respecting the dignity and human rights of all our stakeholders
- Avoid unfair discrimination of any kind and strive to balance the interests of our stakeholders
- Ensure that the statements that we make to our stakeholders shall be truthful and made in good faith
- Avoid engaging in any restrictive or unfair trade practices
- Ensure mechanisms are provided for our stakeholders to raise concerns and report actual or perceived violations of our Code
- Ensure an environment free from fear of retribution to deal with concerns raised or cases reported in good faith
- To demonstrate leadership commitment to the ethical standards set out in this Code
- Comply with the laws of the countries in which we operate and any other regulations which apply to us

For understanding TCoC, please refer to the Tata Code Of Conduct

We are committed to conducting our businesses, conforming to the highest moral and ethical standards. Accordingly, our Company policies are guided by principles of TCoC and are as below:

1. Anti-Bribery Anti-Corruption Policy (ABAC)
2. Anti-Money Laundering Policy (AML)
3. Gift Policy
4. Prevention of Sexual Harassment Policy (POSH)
5. Whistle Blower Policy

The above policies are designed to reiterate and articulate the Company's commitment to ethical practices and ensure that all employees and our Business Partners understand the scope and application of the TCoC entirely.

We have a robust mechanism to resolve any concern related to the TCoC. You can also write to ethics@tce.co.in for a better understanding of TCoC or for resolving ethical dilemmas.

Demystifying GREY

Imbibing TCoC among new and existing employees continued to be a focus area in 2020. It was further strengthened through focused communication during the "Ethics Week" in October '20. During this week, several communications, e-learning modules, and training programs were rolled out to cover TCoC, POSH, Gift and Hospitality, Whistle Blower Policy, ABAC, and AML policies for all stakeholders and third Party workforce and Supplier/Partners.

The senior management team actively participated in TCoC/POSH related communications at various forums such as BUMRM, COCs, DC Communication etc.

A Pulse Survey on Ethics was also conducted to measure the progress/effectiveness of the Location Business Ethics (LBE) framework. External subject matter experts also trained TCE ethics Counsellors and POSH IC members.

I am an ardent advocate of all matters related to Ethics at TCE!

Stay tuned as I, Dr. Owlivia passionately share my wisdom through stories, scenarios and exciting quizzes.

Watch this space for more!

Did you Know?

- **70%+** employees and associates participated in live **POSH** awareness session in Oct '20
- **100%** of employees are assigned e-learning sessions on **TCoC and POSH**
- For every 100 employees, we have at least **one Location Ethics Counsellor** to resolve ethical dilemmas and investigate ethical concerns
- All locations have a woman ethics counsellor so that women employees feel free to raise **TCoC / POSH** related concerns.
- All major construction sites (Domestic & Overseas) have dedicated **LECs / POSH members**
- Contact details of **LECs / POSH** members are available on the Company Intranet – **RHYTHM**
- There is a helpline for reporting on ABAC related matters, i.e. ***tceabac@tce.co.in***

TCEndeavour

CARE | SHARE | RESTORE

Under the CSR Brand, TCEndeavour, the company is working on the below primary focus areas:

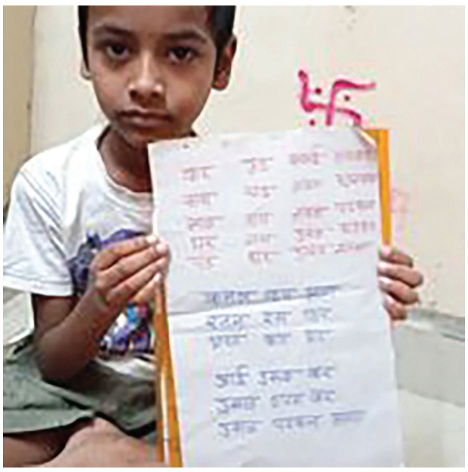
Sustainable Livelihood & Infrastructure

Education | Health and Hygiene

Sustainable Livelihood & Infrastructure

This is the first time that Malghar and Dapti village stored water in farm pond for irrigation using Solar pump. After pond filling 700 mango graft and 700 cashew grafts were planted by 35 farmers in individual plots. Also 4500 saplings of bamboo, teak, and acacia were planted on boundaries of these plots.

Education | Health and Hygiene



TATA VOLUNTEERING WEEK 14

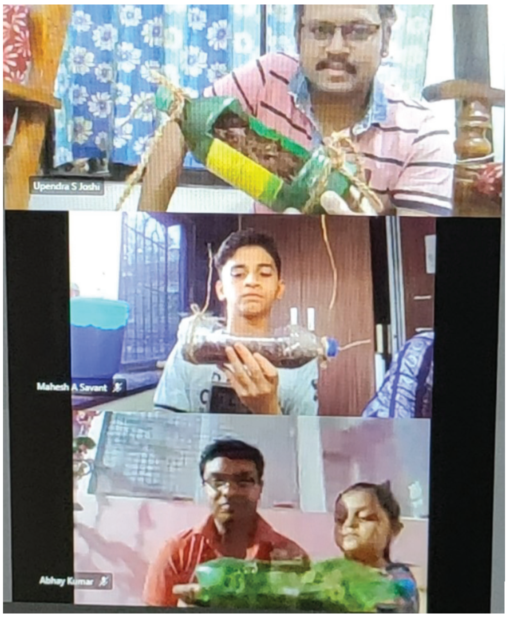
2307.9 Volunteering Hours | 481 Volunteers | 37 Programs | 2666 Lives Touched

Dream It Do It

Motivational activity for Differently Abled kids

Gandhi Jayanti Celebration

Tutorial preparation for Let's Dance

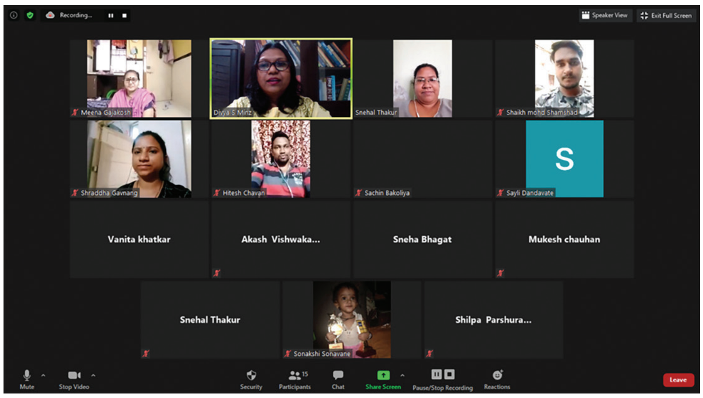


Making Planters from Pet bottles

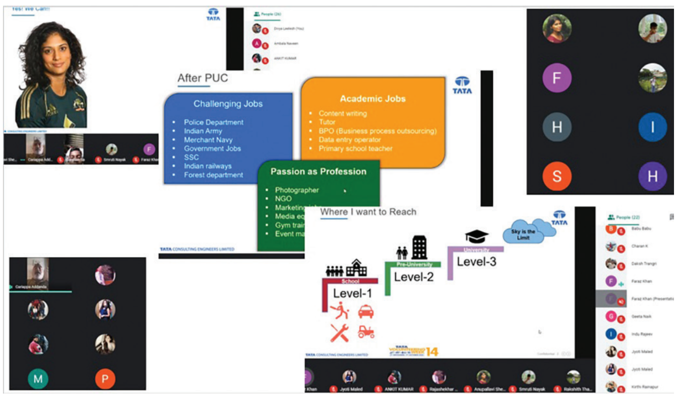
Kitchen Gardening Workshop

Nesting Campaign

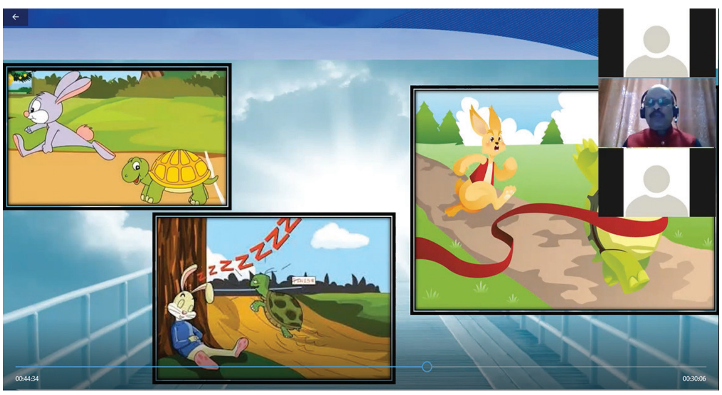
Vishwa Hindi Diwas



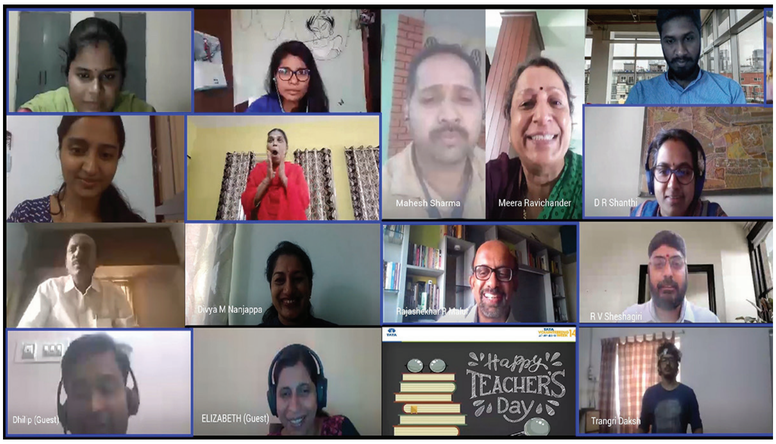
Career Counselling for Night School students



Career counseling for high school students



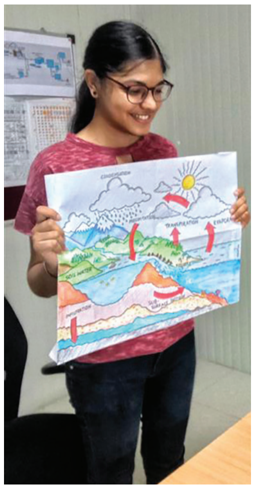
Session on Motivation



Stress Burster activity for Teachers

Motivational activity for Differently Abled kids

On The Chess Board



Water - Jal Hi Jeevan

COVID Awareness

All About Banking

Once upon a time

Teaching School Kids

Meet and Greet Teachers

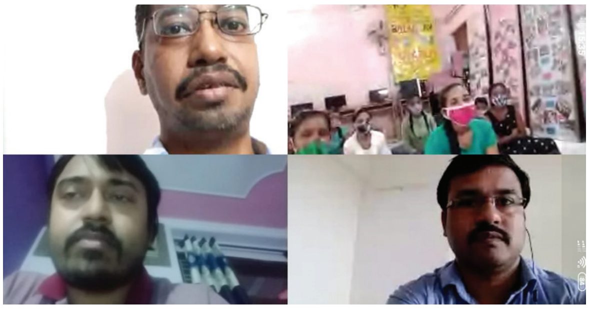
Visit to Orphanage Home

Awareness for Laborer's at Project Site, Pune

Saplings Plantation at SHP1,
Beda Village, Banaskanta

Virtual Tour of Bangalore

Meet and Greet Teachers



All About Banking

Connect with your Roots

Trees - Oxygen Factory of Earth

Covid-19 Awareness, General Construction Safety

Mask Making

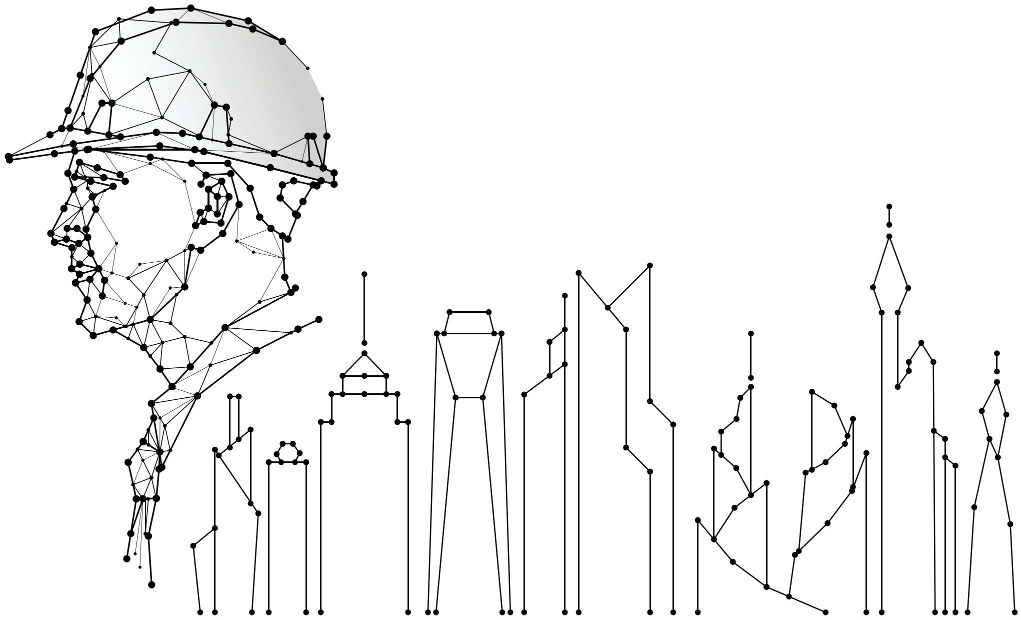
Tata group's FY20 Volunteering Performance Report

As per the Tata groups report, group has totalled 1.52 million volunteering hours last year (up from 1.44 million in the year before that) as per information shared by 59 Tata companies.

TCE stands stand at 9506 volunteering hours and per capita is at 3.2 which is more than group average 1.9

Company Name	Total employees	Total no. of volunteering hours	Per capita
Tata Motors Finance	6,600	4,635	0.7
Tata Power Group	6,486	1,10,722	17.1
Tata Elxsi	6,386	1,499	0.2
TACO Group	6,093	7,665	1.3
Infiniti Retail	5,691	5,759	1.0
Tata Capital	5,658	1,793	0.3
Tata Projects	5,343	16,785	3.1
Vistara	4,010	1,850	0.5
Air Asia	3,169	792	0.2
Tata Consulting Engineers	**2,935**	**9,506**	**3.2**
Tata Chemicals Group*	2,462	32,145	13.1
Trent Hypermarket	2,392	640	0.3
Ginger Hotels	2,339	7,319	3.1
Tata Starbucks	2,296	15,047	6.6
Tata Advanced Systems	2,238	1,139	0.5

TCE featured in International Association for Volunteer Effort (IAVE) magazine for its volunteering efforts



VISION

To be an internationally respected engineering consultant offering comprehensive solutions

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MISSION

Provide technically excellent and innovative solutions, for adding value for all stakeholders, and operate globally as professional consulting engineers

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CORE VALUES

- Customer Satisfaction and Loyalty
- Technical excellence with professional ethics
- Responsibility to society
- Employee dignity and self-respect
- Organisational and individual growth

TATA

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Engineering a Better Tomorrow Since 1962

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