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Hon'ble Power Minister of India Shri RK Singh Inaugurates

BuildELEC IntELECT DistribuELEC 2024

Hon'ble Cabinet Minister of Power and New & Renewable Energy,
Shri RK Singh

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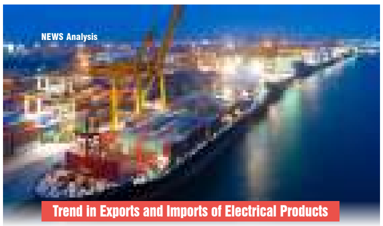

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Dear Friends,

As the world moves towards sustainability and environmental awareness, IEEMA is also **advancing** towards growth. With our country's population and urban areas set to expand, as highlighted by Power Minister Shri RK Singh at BID 2024, our businesses need to scale up to meet the increasing demand. He discussed the power sector's future in 2024, including demand trends, challenges, and investment areas, indicating significant growth potential.

Our events, BID 2024 (DistribuELEC, Intelect, and BuildELEC), **launched** early this year, have set the tone for the next 11 months. **Coinciding** with India's major power reforms, these events align with the country's shift from power deficit to surplus.

India's Progressive Growth Path

The power sector experienced a surge in 2023, with significant profits in power equipment, renewables, and smart metering, and even traditional power firms seeing substantial gains. Minister Shri RK Singh's vision and direction have laid a strong foundation for our sector, positioning it to lead other industries in the nation.

Electric Vehicle Industry Insights

According to the IEEMA Vision 2040 report, one of the driving **factors** for electricity demand will be e-mobility.

Globally, the push for electrical mobility is driven by a vision **toward** sustainability. The Indian automotive industry, contributing 7.5% to GDP and 49% to manufacturing GDP, supports 32 million families. In 2023, India imported 87% of its oil needs, with 40% used in transportation, leading to a $158.4 billion import bill, plus an additional $16.5 billion for vehicle components. EV penetration is expected to increase 8-fold by 2030, from 5% to over 40%. India, the world's 4th largest CO2 producer, with transportation contributing 13.5% of total emissions, sees EVs as crucial for sustainable development and the Make in India initiative. The

EV sector is leveraging global supply chain stabilization, export incentives, and technological advances, potentially reaching over $100 billion in revenue by 2030. Success in this area **hinges on** strategies across product development, distribution, customer prioritization, software, and charging infrastructure. The increase in EVs has boosted the demand for public chargers in cities and highways, with infrastructure development dependent on local transformer loads and associated costs. This edition of **the IJ** presents some insights **into** the growth of EVs in India.

Budgetary Recommendations

In February, the nation awaits **the Union** Budget. Aligned with the Government of India's vision, our recommendations for the 2024 budget aim to enhance domestic production, increase export potential, and improve quality and safety standards. We have proposed removing basic customs duty on crucial imports like CRGO Steel, mandatory BIS certification for key components, and no custom duty on raw materials for major exported equipment. We suggest including RODTEP for exports against advanced authorization licenses to boost competitiveness. To support domestic manufacturing, we recommend increasing basic custom duty on specific low-voltage components.

Under Aatmanirbhar Bharat, we have requested the removal of inverted **duty structures and a reduction in** compliance burdens. We advocate for the PLI scheme for critical imports and the use of insurance security bonds **over** bank guarantees. IEEMA also seeks budget allocations for IoT innovation, QBCS adoption, and government support for technology and investment collaborations. We aim to reduce unnecessary imports of domestically available equipment and components.

Lots to look forward to...

Hamza Arsiwala

Dear Members,

We at IEEMA had an electrifying start to 2024 with the culmination of yet another successful edition of Distribuelec, Buildelec and Intelect – BID in Mumbai. We had the privilege and honour of hosting Shri RK Singh, Hon'ble Cabinet Minister (Power, New & Renewable Energy) and other prominent officials from the industry at the marquee event. The Minister discussed the electricity sector's growth, challenges, and future direction, emphasizing its key role in sustainable development and in reducing India's CO2 emissions.

Speaking at the event Shri RK Singh said "We have set a huge ambition in energy transition and plan to have 500 GW of non-fossilbased electricity installed capacity by 2030. We have installed a Renewable Energy capacity of 1,79,570MW (43% of our total capacity) and another 99,000MW is under installation. My Ministry has rolled out the plan for 500 GW Generation as well as a transmission system for evacuation of this power,"

BID-2024 edition was the largest-ever trifecta in terms of size, scale, engagement and potential business opportunities generated. With over 250 exhibitors, 50,000+ business visitors footfall, 200+ international & 100+ domestic hosted buyers, 30,000+ B2B meetings, 20+ new product launches and estimated business enquiries of about USD 1 Bn. BID-2024 was a resounding success. This edition also spotlighted the green energy segment and new energy landscape in close alignment with the government's vision for growth.

The February edition of IEEMA journal covers BID 2024 in detail, including a summary of the Minister's speech and show highlights.

We also focus on E Mobility & Charging Infrastructure, with various authors exploring the topic. The cover story, "The Zip Zap Zoom of E Vehicles," includes insights about the E Mobility and Charging Infrastructure Division. It features two case studies: one on EV technology advancement and another on energy conservation through alternative fuels. Guest writers like Sachin Pilkhane and PK

Bhattachayya discuss various aspects of E mobility and infrastructure.

Additionally, it includes the first runner-up paper from the TRAFOTECH Conference 2024 about asset management of distribution transformers, by Debashis Sikder & Prachi Sharma.

As we move ahead, we will keep a close track of the Union Budget in February, which presents opportunities to boost domestic manufacturing, expand exports, and implement quality and safety standards. Our budget proposals align with the Indian government's objectives, and we are confident that the government will take steps in the direction that will bring cheer to India Inc. and give the booster shot to drive the next wave of growth.

February 2024 will be another exciting month for us as we gear up to host E3 in Kolkata, Insulec and Tech IT in Mumbai. I welcome you all to be a part of these events and engage with industry stakeholders and make the most of these opportunities.

Thank you!

Charu Mathur

BUILDELEC INTELECT

Honourable Minister of Power Shri R. K. Singh launches BUILDELEC

The 3rd Edition of IEEMA - Indian Electrical & Electronic Manufacturers' Association's three-day flagship exhibition BuildELEC and DistribuELEC was launched on Tuesday January 17, Honourable Minister of Power, New & Renewable Energy, Government of India, Shri R. K. Singh. Eminent dignitaries from the industry including Dr. Praveer Sinha the CEO & Managing Director of The Tata Power Company Limited, Shashi Amin, CEO - Cable Division, Apar Industries Limited, Hartek Singh, Director, Hartek India Pvt Ltd, Hamza Arsiwala, President of IEEMA, Charu Mathur Director General of IEEMA, Vikram Gandotra, Vice President and Sunil Singhvi President Elect, IEEMA, among others were present on the occasion.

The Inaugural Session began with a Ganesh Vandana, after which the the President of IEEMA, Hamza Arsiwala, expressed his delight about the event, highlighting its role as a pivotal platform for industry leaders, utilities, manufacturers, and technology providers to come together. He said, DistribuELEC aims to address critical aspects of the electrical industry, including Smart Grids, Outage Management, Demand Management, Metering,

DISTRIBUELEC 2024

& Renewable Energy

INTELECT DISTRIBUELEC 2024

MicroGrid, Storage, Substation, Energy Efficient Buildings, and Feeder Automation.

BuildELEC focuses on electrical solutions for residential and commercial buildings, showcasing smart electrical technologies and equipment. The event Intelect, is a conference dedicated to intelligent electricity distribution and consumption, offering insightful discussions on the future direction of the industry. Arsiwala said, “The fact that BID 2024 has more than doubled in size from the previous edition, is a testament of the growth Indian Electrical Equipment industry is seeing, as a result of the power reforms and the fast pace of transformation that the power sector is undergoing for the past 9 years."

Dr. Praveer Sinha from Tata Power set the mood of the exhibition when he said, “It is a great honour and pleasure to be present to celebrate the power sector’s work and I say this because the last 4 years have been a very difficult period.” He noted how challenges in the supply chain arose during Covid19, “when we had a review meeting to figure out how power is generated, transmitted and supplied when all are working from home. There was not a single day without power, so I must congratulate all those present here for this great feat!”

Union Cabinet Minister of Power and New & Renewable Energies, Shri RK Singh inaugurating BuildELEC Intelect DistribuELEC 2024

In the past three years the demand for power has gone up, he said and noted that before Covid19, the peak was 180 GW and demand was 1 trillion units. "In the last 3 years we have seen that the demand has gone up to 210GW while last year it was 241GW; "and meeting this peak demand of 241GW in a country like India without any disruption of supply in my opinion is a big achievement of the government. This year we are expecting the peak demand to go up substantially and numbers that are being talked of are 260GW - 270GW."

Referring to the efforts of the Chief Guest of honour Shri RK Singh, he said, "One activity I know that the honourable minister involves personally in is 'power generation'," in that, he plans many review meetings just to ensure how the coal supply takes place at various power plants, discusses gas supply and issues related to imported coal supply, etc. and further complimented the Indian power sector for doing exceedingly well.

The minister listening intently to IEEMA Presidium

Introducing the cabinet minister as 'the leader who leads from the front', he concluded by setting a brilliant context to the much anticipated industry event. The Director General of IEEMA, Charu Mathur welcomed Shri RK Singh to address the august gathering.

Even before completing his opening remark: "It is a family gathering.....," the Minister's samcharcha was met with a thunderous applause, and he continued, "It is a family gathering..., and as the head of the family, it has incumbent upon me to anticipate the future, so that you can prepare for it and it is my job to tell you that this is what is going to happen so that you are prepared for it. We as a family have been very successful, so it is time to celebrate."

Commenting on the reason why the Indian economy is the world's largest economy, growing at the fastest rate in the world, he said, "It is to a large extent because of us, because without electricity, there is no growth."

The minister mentioned that when he joined the ministry he saw "a perverse outlook in the field of transmission, for example the outlook 'let the load come, then we shall provide for the transmission,' I felt was utter nonsense!"

"The matter of the fact is that the load will come after you provide the transmission, because without electricity there is no industrialization," he noted. He said that he had to struggle to change the old ideas to progressive ones.

They achieved that aim to bring about a change, but the range to which it was achieved, was humungous. "In 2014 when I joined office, the peak demand was a mere 130 odd gigawatts whereas today, we have already reached a peak demand of 243 thousand GW; an increase of 80%."

The minister in the middle of passionate speech

"We have increased our established capacity by about almost 71% - 72% and our established capacity is about 426 GW, which used to be 270 GW - 280GW when I took office." The ministry has added about 180,000 to 190,000 MW of generation capacity.

"The growth we spurted was due to our high expectations. We added capacity, we added 190,000 circuit km transmission line, and worked upon the distribution lines by expending at least 2 lakh crores and reached 4000 substations from 3000, 80 lakh new transformers, etc. Other than the fact that we connected every home in every village approximately, 90 million homes with electricity and because of this the demand increased. All this added to the increase in demand that we see now.

"The rate of growth in the last 3-4 months was about 20% - 22% but last year we had expected 9% and this year we expected to grow at 10%.

"We will keep growing, our country will keep growing and that is what we have to prepare for. And we have to make this growth possible. Economists had said that we would grow at a rate of 7% for the next 3 decades. I am expecting that installed capacity for 2030-31 will be 500GW. I expect demand to grow, and a few people tell me that the demand will be 366,000 GW by 2030, whereas I think the peak demand will be around 400,000GW.

Shashi Amin, Chairman of BuildELEC and CEO, Cable Division, APAR Ltd

When we started off, the event was one-fourth the size it is today; then it grew two-times when we went to Delhi. Though in Bengaluru we did not perform very well, today into the 3rd edition, we have recorded more than 6000 unique visitors. The exhibition has seen seven times increase in size, volume and we have upped its quality as well.

It is up to us to take BuildELEC DistribuELEC to the next level in the future with a bigger space and a unique identity apart from ELECRAMA.

"When consumption doubles, everything will double. Just imagine we will have to double the number of transformers, double the length of lines and that is the challenge before us and an indicator of growth and have to grow fast.

"There is one thing I want to say," said the minister, "we should grow not because of any 'imported' elements, but we should grow cent-percent by making in India. We have to grow fast, and India is a growing market. Europe and US have reached a static 2% rate of growth, whereas we are at a level not below 7%.

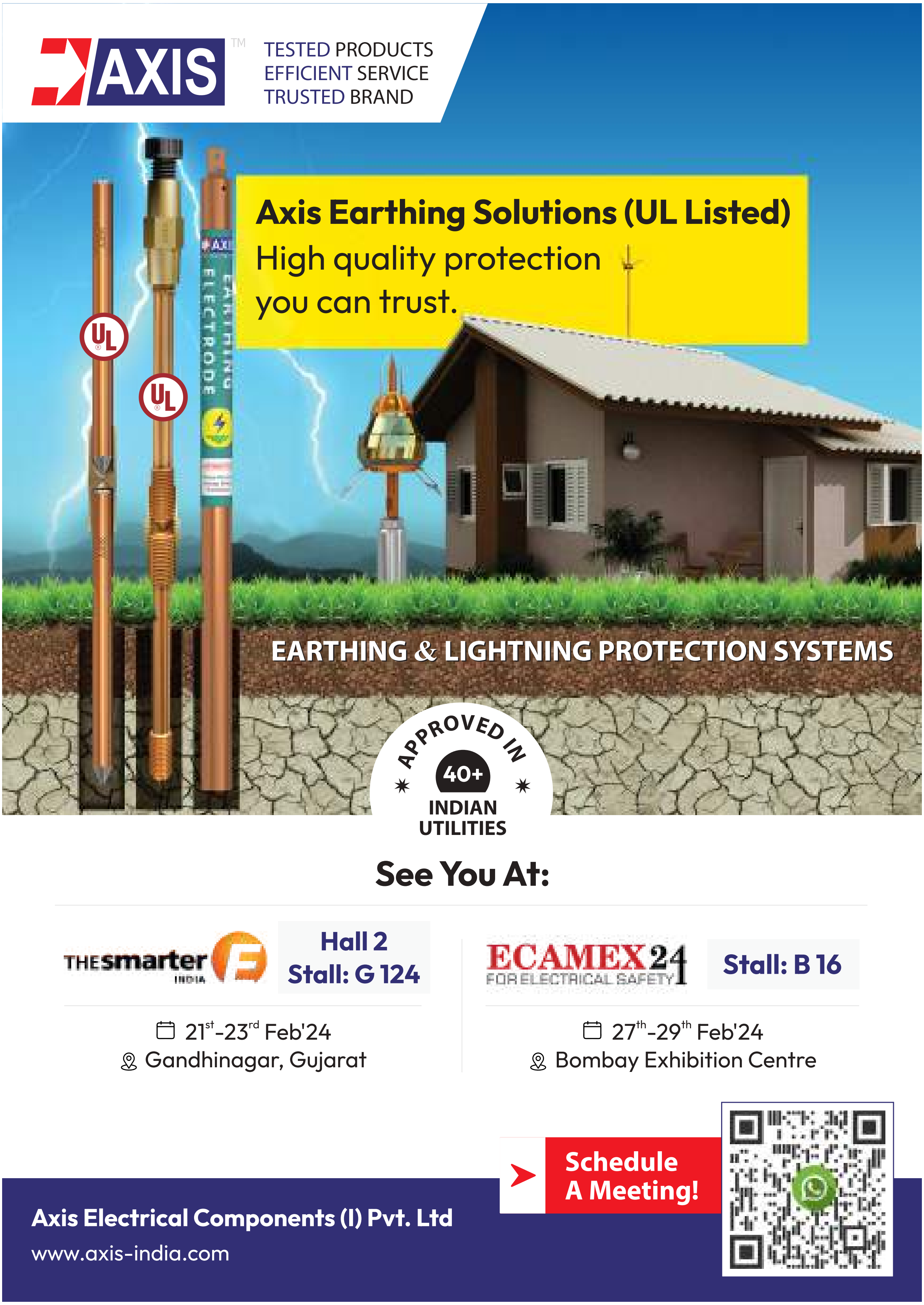
The minister reassured the industry that there is a huge opportunity in India to make the right investment and not only to make in India to be sufficient to India alone, but also assured the 200 buyers in the audience, that India can be a global leader in manufacturing and design of electrical equipment.

Commenting on thermal capacity he said, "When I took office, we had 26,000 MW of thermal capacity under construction, I have increased that to 80,000 MW, so apart from that 26,000 MW was under construction. Now from the 26,000 GW, I have bid out about 12,000 GW of more thermal capacity and about 20,000 MW are under clearances, so after a few years I will have 80,000 MW of thermal capacity under construction.

Commenting on renewable energy, he said, "I already have 99,000 MW of renewable energy capacity under construction, and I am going to bid out 50,000 MW of energy capacity every year.

Commenting upon hydro, he said, "Hydro was dead when I joined. Now I have 18,000 hydro under construction, because we have an installed capacity of 46,000 MW of hydro and about 13,000 hydro under clearances.

IEEMA Director General, Charu Mathur in conversation with Hartek Singh



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The minister is thronged by media

"We keep adding transmission lines," he remarked. "We have changed the rules to make it more viable and simpler and done that across the sector. I had added a huge quantum of transmission lines but that was not enough, so I am trying to keep pace and it turns out that we have run out of connectivity! So basically, we have to add more transmission capacity, that too in a hurry! Here, I see the future in HBDC made in India. Do that!

"We will have to make underwater cables here, because we are going to have 35,000 MW of offshore wind. This too will be rolled out rapidly, as we will come out with some bids that are going to accelerate. And, as we do not want to import them, so we start making them here.

"I was in consultation with Hamza, where we discussed about launching a policy which will force people to make in India and buy in India, because I am the market and I don't want to buy things abroad, and I want to buy things made in India. So, we will come up with a policy, if you have any inputs give me that policy.

"That is the direction that you need to go. You need to go in the direction of storage, in the direction of reverse oil pumps, because you have 40,000MW of pumped hydro under various stages of clearances, and I want to add more pumped hydro, so that's the direction, reverse, turbine, pump, etc…

"Basically, I am going to double everything as there is a demand and I am putting into place policies that will ensure that the demand will continue to grow.

A very pertinent point addressed by the honourable minister was concerning distribution. "I have seen the tendency of distribution companies to not sign long term PPS and depend on the market. That will not do; thus, I have brought in a rule that states that everybody who has a distribution licence has a responsibility to tie up enough capacity to meet the demand of the area which it is licenced to serve. I have put that into the rules.

Dr. Praveer Sinha, CEO & MD Tata Power Company

Imteyaz A. Siddiqui, Chairman Intelect

Shashi Amin, Chairman, BuildELEC


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This will be assessed by a committee headed by the chairperson of the CEA. We are here to serve the people and we cannot have an attitude which I call the 'Hangover Attitude', the colonial attitude, where, if there is a shortage of electricity, I'll not buy electricity, but I will do load shedding. I have made rules that you cannot do load shedding and if wilfully done, you will be penalised. I am carrying out inquiries and going to carry out my first prosecution.

"The load has to be translated into demand and that has to be translated into PPS. I will make sure that PPS will come, people need 24X7 electric supply and we are almost there… but you are not then there will be penalties. You cannot do load shedding, people need 24X7 supply!

Losses of discoms have also come down. "We have brought it down from 27% to 15% and now are going to bring it down to 12%. Those who consume power have to pay for it, there could be subsidy, but power is not free, I keep saying that.

"That is why we have the prepaid option, if you do not pay, power is cut off and that is a rule. In the future it will all be prepaid, and it will be smart prepaid.

"I am not in favour of spending millions of dollars that are coming into the system. I want the capacity to develop here. We are the only manufacturers of the world, in my opinion.

"The shares of all my companies have doubled and tripled, so all those who bought shares of any power company a year back, their values have multiplied, two and three times. This is the only country where all the bills are paid and up to date, infact even the legacy dues have also been cleared off.

"This system will continue, because we have built it to the software; we can do things, we can grow, grow rapidly, and this is a sector

"Yes Minister!"

that has to grow rapidly; because you and me; we lead the growth. "Without us, nothing will come up; no industry will come up. We shall add a capacity at a pace unheard of and we are doing that.

"Earlier our capacity was based on modules coming in from China to no good. Now I have 50,000 MW of manufacturing capacity of modules. The cell manufacturing capacity will go up. In a couple of years, the entire value chain from poly silicon to modules will be made here. We already have bid it out. Soon we shall be the biggest manufacturers of polysilicon, wafers, cells, modules.

Hartek Singh, Chairman, DistribuELEC and Director Hartek India Pvt Ltd

After considering the needs of the industry, some internal research, we found that there was a need to have a platform in the power electrical sector to display electrical goods upto 33kv class voltage. Vendors and exhibitors used to get lost in all the classes not able to search for their need, not able to sell their products to their targeted audience. BuildELEC and DistribuELEC presented a focussed opportunity to a delighted result beneficial to all in the bargain.

Here we present quality and not just fluff. IntELECT has its own class and the magic of these three iconic events presenting intelligent, smart and focussed solutions all under one roof!

The Inaugural Panel of the 3rd Edition of BuildELEC DistribuELEC 2024

Launch of the Exhibitor's Directory

"We are already one of the biggest manufacturers of wind equipment; we will also become one the largest manufacturers of offshore wind equipment and of course, we are going to emerge as a leader in Green Hydrogen. I already have 7 million tonnes of green hydrogen planned in different places by different industries and all this not being done by the public sector nor by public investment.

"Every bid I hold is hotly contested, every major fund is already invested here, for good reason, as they get good returns and every major fund in the world is investing here, because we are the ones who are growing.

"Where else do you see the growth? In China the growth has dampened, the growth is here, in India and it will continue to be here for the next 3 decades, now you have to prepare for it. You have to be prepared to grow at a rate which you have not seen.

"That's the future of our country, not only in this sector but in all sectors, but we must lead. If we don't grow, India will not grow, that is how critical this sector is; but we shall grow…and as we grow, our industry will grow and we shall export. The price and quality of our make will be unparalleled, because elsewhere the industry will be dying out. This is where the growth is, this is where the demand is, and this is where the industry will be growing.

After this passionate delivery the minister concluded his address to the 200 buyers listening with great eagerness, with these remarks, "I see you all multiplying to twice thrice the present size. You have to multiply to twice and thrice the present size, because my demand is going to double and triple. The demand is huge, but it is exciting; and it is this challenge which keeps people alive, keeps us alive and we've never missed on a challenge yet, so we'll not miss on this challenge yet, so this is the biggest challenge in India and I am up to it, wish you too all the best!"

IEEMA DG Mathur commended the inspiring words of the minister and added "Aaj Bharat aatmanirbhar hai, toh kal poora vishwa aatmanirbhar banega!"

IEEMA Quality Cell Launch: A Commitment

One of the most important component of the power supply for the reliability of power supply is the quality of the equipment and safety practices. IEEMA Quality cell is headed by the board of IEEMA and chaired by the senior quality professionals of IEEMA membership. The aim of the cell is to create awareness among industry, users and members about safety and quality practices.

Sunil Singhvi VP of IEEMA informed, "We will do benchmarking with the auto industry etc, and encourage

A house-full audience in attendance

the industry to adopt best manufacturing practices. This initiative will reduce wastage and make us more competitive on the global scale. In the second phase the cluster programme will be launched where small clusters of members will help each other improve their quality and take their product on a global scale."

The objective of IEEMA Quality Initiative is to establish quality and safety as a 'way of life'. Implementation activities include awareness and advocacy programmes, training programmes, stringent quality and safety standards, collaboration and partnerships. The campaign will include an Industry Pledge followed by establishing a quality and safety forum, factory visits for sharing best practices, newsletters, social media campaigns, pan India campaigns for industry clusters.

Caught smiling, DG of IEEMA, Charu Mathur

ELECRAMA 2025 Dates Announced

The dates of the next edition of ELECRAMA – Powering the Future of Energy 2025 were launched with much fanfare as February 22 to 26, 2025. The Minister then launched BuildELEC and DistribuELEC Show Directory. Hartek Singh, Director of Hartek India Pvt Ltd, presented the vote of thanks and accompanied the dignitary to the exhibition area. BuildELEC and DistribuELEC displayed a wide array of electrical solutions, smart technology, equipment for building intelligent structures and was inaugurated with a ribbon cutting ceremony. This exclusivity of this event was in the fact that it featured a panoramic range of products, technologies, and services covering the spectrum from 220V to 33KV.

DistribuELEC 2024 serves as a testament to India's remarkable power reforms, which have transitioned the country from a power deficit to a surplus. The event displayed traditional electrical equipment such as transformers, cables, capacitors, switchgear, meters, insulators, and conductors, as well as cutting-edge advancements in distribution automation, control systems, energy efficiency, demand response, advanced metering, communications technologies, cybersecurity, and electrical fire safety.

3rd Edition of BuildELEC & DistribuELEC Exhibition

RBSM - Meet 2024

Khalid from Gulf Cooperation Symbols Cont. Co., Bahrain said that he had met 12 companies for products that he was looking for. He said business was getting better after Covid19 and especially in the Gulf area, business is booming as Saudi has more projects.

Enriczar T. Tia, Senior VP along with his colleague MarUlysses M. Relacion, Senior Assistant VP of Davao Light and Power Co., Inc were of the opinion that DistribuELEC is a more focussed event with more suppliers and vendors to find exactlty what we are looking for. There is one issue though that we would want to bring to light and that is the fact that Indian standards need to be acceptable globally just like US standards are. Top companies for business for us include Schneider, CG Power, Transformers & Rectifiers among others.

Jasman form Nepal said that it was wonderful to meet different types of manufacturers. "It was interesting!" Top companies he would want to do business included CG Power as Co-partners, Yamuna for product and quality and Dynamic cables for cables.

Patrick Mufiki from Africa said, "It was quite a huge tour for me." Companies and products are good, promising business opportunities are available. "It was worth my while being here." Top companies for him included Scope, Secure and Transformer – RTS Power Corporation Ltd.

6th Edition of INTELECT 2024

Transformative Journey – Reliable, Sustainable and Safer Prosumer Ecosystem

The inaugural panel of IntELECT had Imteyaz A Siddiqui, Chairman, IntELECT and Director & Regional Area Sales Manager-SA & GCC, Altanova India Pvt. Ltd., Neeraj Yadav, Vice President – International Marketing, Stelmec Limited and Chairman RBSM, Vikram Gandotra, Vice President IEEMA, Hamza Arsiwala, President IEEMA and Charu Mathur, Director General IEEMA.

Imteyaz Siddiqui set the context of the conference by saying that “knowledge is power, but when the knowledge is about electricity and energy, it becomes very powerful knowledge” and welcomed all the guests to the session of acquiring powerful knowledge.

The 6th Edition of IntELECT was curated to increase knowledge, learning from the cream of the industry and acquire and accept those practices which have helped them in evolving successfully. He extended a warm welcome to all and acknowledged the efforts of the organiser.

Charu Mathur, DG, IEEMA, took on the podium and expressed how IntELECT has become an interesting platform for exchanging ideas and technologies as well as engage in interesting topics at the forums.

Niraj Yadav, Chairman, RBSF extended a warm welcome to all to “WeKonnect Reverse Buyer Sellar Meet” happening in Mumbai, as part of the 6th Edition of IntELECT. IEEMA organised IntELECT in association with the Ministry of Commerce & Industry, Government of India.

“At IEEMA we have a vision to achieve an export of 25BN worth of electrical equipment by 2030,” informed Yadav. “In that context, we achieved USD 11.8BN last tear so we grew at a CAGR of about 11.5%; that is, we grew at about USD 6BN - USD 11BN. To facilitate the same IEEMA has planned many activities including the RBSM.

“At RBSM, we have over 200 buyers who have travelled from all over the world, including the Middle East, Africa, Latin America, ASEAN, Asia-Pacific, SAARC nations.” Yadav informed that they had received 800 applications in all, from which 200 were screened and 70 out of these belonged to Utilities.

Yadav extended a warm welcome to all international delegates from the Utilities from SAARC countries including Bangladesh, Sri Lanka, Nepal, Bhutan, South Africa and African countries like Malawe, Zimbabwe, Kenya, Uganda, Ghana, Laos and others. Over 2000 one-on-one meetings were scheduled between the 200 plus buyers with over 200 exhibitors in the span of one-and-a-half days converting into strong businesses and meaningful relationships. “This activity in turn will improve IEEMAs target to increase Indian exports,” he concluded.

Hamza Arsiwala, the president of IEEMA welcomed the global RBSM delegates to Mumbai, the vibrant, commercial capital of India. He said it was heartening to see delegates travel to India who would benefit from not only the event but the visit to the city. He said it

The proud Chairman of the 6th edition of Intelect Conference


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Inaugural Session in progress

was an honour to be amongst a distinguished group of experts, industry leaders and policy makers – all united by a common purpose to promote innovation, quality, safety and sustainability.

Arsiwala "The pursuit of green energy and decarbonization emerges, as a strategic imperative net-zero targets; this transition involves a fundamental restructuring of the energy landscape emphasising the adoption of the noble resources such as solar, wind and hydro-electric power. Decarbonization within the energy sector optimizes processes, enhances energy efficiency and unexplored carbon technologies. The net zero targets, set a clear trajectory to balance carbon emissions for all offset measures marking a paradigm shift towards sustainability."

Imteyaz Siddiqui, Chairman, IntELECT and Director & Regional Area Sales Manager-SA & GCC, Altanova India Pvt. Ltd

Knowledge is power, but when the knowledge is about electricity and energy, it becomes very powerful knowledge. We curated this edition of IntELECT to increase our knowledge, learn from the best minds of the industry, acquire and accept those practices which have helped the successful entrepreneurs and businessmen achieve their goals. I am proud that the 6th edition of IntELECT was a thumping success!

The two days of conference will have discussions with CEOs of utilities, high level panel discussions on safety, sustainability, reliability, modernization, 7innovations in the distribution system, fire safe and sustainable buildings for a safe future, prioritizing safety measures, adhering to stringent quality standards and investing in modern technologies.

"Together we must resolve, we can and shall build – a robust and resilient power grid that meets the demands of the future," said the president and added that this platform serves as a platform to bring together the brightest of minds, and strongly recommended that all introspect, explore, think out of the box and simply have fun over the next few days. In conclusion he said, "This is 'the India story', the decade is for India, to conduct business, work and herald exciting times for all!"

Charu Mathur, the Director General of IEEMA was called upon the dais to give away the Start-up Awards. Matur invited the delegates to visit the start-up pavilion at the exhibition and encourage them. She said that the previous day, she had witnessed a 'SharkTank in IEEMA' wherein twelve Start-ups were giving pitches and a jury had gruelling questions for each enterprise. Mathur announced Baud and Cappatery as winners of the Runners Up prize while Trinano bagged the First Prize in the Start-up ElectraVerse Sparks Contest.

Signing of an International MOU

Memorandum of Understanding was signed between Indian Electrical & Electronics Manufacturers' Association (IEEMA) and Ho Chi Minh City Association of Mechanical and Electrical Enterprises (HAMEE). General objectives of the association include collaboration and cooperation at various levels, information exchanges, joint exercises, education and training.

The Inaugural concluded with a Vote of Thanks by the Vice President of IEEMA, Vikram Gandotra.

A Keynote Address was delivered by Shaikh Sahid Hossain, Chief Revenue Officer enlightening the audience about industry 2.0 and way ahead followed by a Q&A session. The highly anticipated event, the CEO Session followed next.

Indian Electrical & Electronics Manufacturers' Association (IEEMA) and Ho Chi Minh City Association of Mechanical and Electrical Enterprises (HAMEE) signed a Memorandum of Understanding

The CEO Session

The most awaited CEO Session in progress.

Moderated by Krishnakumar Ramanathan, Head of Strategy & Business Excellence – Asia Pacific and Middle East, Siemens Large Drives, the panel included renowned dignitaries like Dr Saket Kumar. Managing Director UHBVN; Kushal N Desai, Chairman & Managing Director, APAR Industries limited; Robert Demann, Executive Vice President and Head Smart Infrastructure Siemens Ltd; Uday Singh, Managing Director and CEO of Schneider Electric.

Ramanathan began the session by putting forth the very serious theme of carbon emission and net zero to the panellist. Noting the problem of 'very long-term goals', Ramanathan quipped that these goals would manifest almost after their lifetimes were through! However, the repercussions were evident in nature and splashed across the news. Noting how countries are severely lagging in their environment commitments, he listed three challenger he said are firstly, building critical awareness beyond tree planting, etc; secondly investing in technology over time and the third big question he asked was pertaining economic viability. The session had brilliant inputs from each panellist and concluded with a Q&A.

Questions and answers at the CEO Session moderated by Krishnakumar Ramanathan

A session on Advanced Technologies for DISCOM Modernization was followed by a special session on Demystifying QCO's on Fire Survival & Solar Cables. The second day had sessions on Energy Systems Integration, Resilient Prosumer Infrastructure and New Dimensions to Modern Infrastructure. You can log on to youtube Day1 @ #BID 2024 to recreate the experience and know expert panellists' views and Day2 @ #BID2024.

A panel discussion in progress

DistribuELEC & BuiildELEC Stall Design Winners

One of the most looked forward to activity at the event was the best stall prize. The esteemed just consisted of JG Kulkarni, Harshwadan P Parikh and DPK Udas. The prizes were handed over to the winners by R. Prakash, Vice President, Easun MR Tap Changers P Ltd. In the space category of 9sqm - 12sqm (Shell Scheme) Linkk Busway Systems (M)SDN BHD bagged the first prize and A. Eberle Systems Pvt Ltd was placed runner's up; in the 15sqm – 24sqm space category, SCOPE T&M Pvt Ltd took the first place, while MODUTEC Ready Panels Pvt Ltd won the runner's up; in the 27sqm – 48sqm space category, Cyanconnode Pvt Ltd won the first prize and The Motwane Mfg Co Pvt Ltd bagged the runner's up prize; in the 54sqm – 84sqm space category, Secure Meters won first prize and Ashida Electronics Pvt Ltd won the runner's up prize; and finally the first prize in the last category of 120sqm – 150sqm was bagged by Siemens Ltd while CG Power & Industrial Solutions Ltd won the runner's up.

The three days of DistribuELEC and BuildELEC and two days of IntELECT ended on a high note with a scintillating performance from Ambili Menon followed by cocktails and networking.

Innovate to Elevate- Curated Session on Inclusive Growth for MSMEs

Hamza Arsiwala, President, IEEMA set the context for the panel after extending a warm welcome to the government officials and dignitaries on the stage. He said, "MSMEs have a very important role to play and our industry is strengthened through the MSMEs that are present and working from pockets of India like Jamnagar, Jalandhar, Coiambatore and other. The industry is scaling up on their strengths which include quality, safety, reliability among others."

Dr Kamal Golia set the context for the session welcoming each panellist of the session which included Dr Anupam Srivastava, Dr Nadeem Lobal.Cobal, Sanjeev Kumar, Rajesh Sharma, Hamza Arsiwala Shaji K and Sanjay Kulkarni, Vice Chair, WRC. Shaji K, Manager CGFMSE was the first to make a presentation about the Credit Guarantee Scheme and explained how it was formed when there was a 20 lakh crore credit gap that needed to be plugged in due to many reasons. He introduced Credit Guarantee Fund Trust for Micro and Small Enterprises. Rajesh Sharma, Assistant General Manager, SIDBI, Mumbai explained about purpose-based financing and introduced a subsidy scheme by the GoI called SPICE and SIDBI initiatives. Sanjeev Kumar in his address emphasised that excellence comes through standardization. He spoke at length about the advantages of GeM or the Government market interface stating that GeM overview reduces government to human transaction thus minimising chances of corruption in practices and that except Sikkim all states have GeM.

Anupam Srivastava, Assistant Director of MSME & Facilitator of SME DFO, Mumbai MSME said that udyam registration and holding an udyam aadhaar was mandatory to gain benefits of various governmental schemes. Sanjay Kulkarni delivered the vote of thanks.

Shaji K, Manager CGFMSE

Rajesh Sharma, Assistant General Manager, SIDBI, Mumbai

Anupam Srivastava, Assistant Director of MSME & Facilitator of SME DFO, Mumbai MSME

Kamal Golia, Chairman SME Division IEEMA & Vice Chairman BID

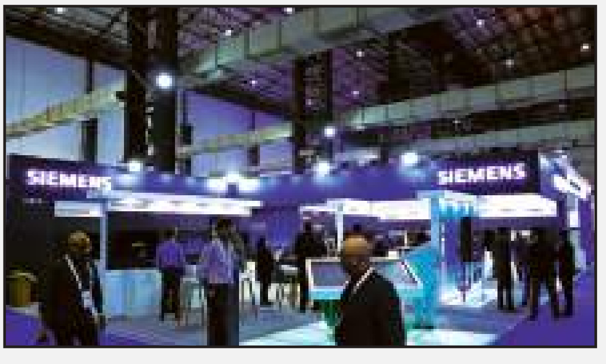
START-UP Pitch Session Winners

DBSM Session 2024

Team EEMA

Acknowledging the Sponsors

Sponsors for BuildELEC Intelect DistribuELEC 2024 included RR Kabel as Theme Partner for Safety; Schneider Electric India Pvt Ltd as Platinum Partner; Secure Meters Ltd, Polycab India Ltd, Atlanta Electricals Pvt Ltd. as Diamond Partners; Siemens Ltd as Lanyard & Batch Partner, Apar Industries Ltd as Registration Partners; MSEDCL as Host Utility Sponsor and Stelmec as DBSM Kit Sponsor. IEEMA Electraverse Sparks' Winning Profiles and Product Launches will be featured in the upcoming edition of IEEMA Journal.



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कंडक्टर्स
- बेयर और इंसुलेटेड कॉपर कंडक्टर्स
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The ZIP ZAP ZOOM of E Vehicles

Electric Mobility and vehicles are slated to be the frontrunners in the future of transportation globally; what with 'environment' on every agenda, plan policy, technology and design. Read on to get a bird's eye view of the state of the EV industry

The ideation of electric vehicles marks the unique horizon metaphorically that of the bright skies overlooking the power sector and the deep and misterios seas of the automation sector. A marriage of two huge industries holding a growth potential to reach a future where electricity could convert to monopolize the entire automation segment, by default!

One can easily consider 2023 as a milestone for EVs with the complementary and indispensable charging infrastructure component that has witnessed unprecedented surge in demand and relevance to the environmentally conscious world. Universally there is a substantial shift towards sustainable and eco-friendly transportation. Join us as we research about the key factors, market dynamics, and the global impact of this brand new, Boss Baby of the electric industry – EVs.

To make the transition towards the adoption of electrical mobility the Government of India has introduced a set of fiscal and non-fiscal incentives like tax breaks, subsidies, and access to dedicated lanes and an ambitious target of reaching 30% all new vehicles sold in India by 2030. FAME, or Faster Adoption and Manufacturing of (Hybrid and) Electric vehicles, is currently

India's flagship scheme for promoting electric mobility. Currently in its 2nd phase of implementation, FAME-II is being implemented for a period of 3 years, eff. 1st April 2019 with a budget allocation of 10,000 Cr. Every state offers incentives for EVs which you can access at https:// e-amrit.niti.gov.in.

Timeline of E-Mobility Adoption in India

i) In 1994 India's first electric vehicle, the REVA was launched;

ii) In 2010, the Ministry of New and Renewable Energy (MNRE) launched the Alternate Fuels for Surface Transportation Programme with a budget of INR 95 crore;

iii) In 2012 the National Electric Mobility Mission 2020 (NEMMP 2020) policy set a target of having 6-7 million electric vehicles on the road by 2020;

iv) In 2015 the Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles (FAME) scheme was announced;

v) In 2019 FAME revised;

vi) In 2021 PLI SCHEME,

vii) In 2022 FAME scheme revised;

viii) In 2022, NITI Aayog released a draft policy on Battery Swapping;

xi) 2023 FAME II

FAME Scheme (I&II)

In the year 2015, the Department of Heavy Industry (DHI) developed the National Electric Mobility Mission Plan (NEMMP) 2020 under which the Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles India Scheme also called the FAME India Scheme was formulated to promote the manufacturing of electric and hybrid vehicle technology and ensure its sustainable growth.

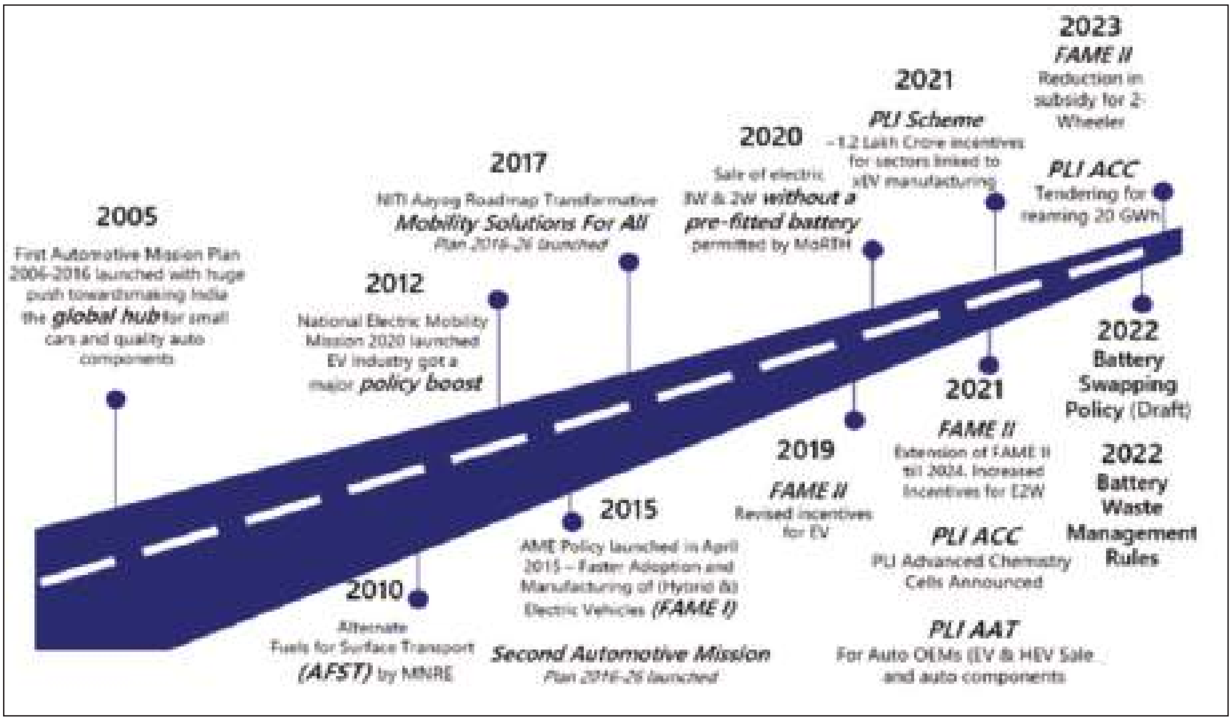
Phase-I saw the creation of a demand for electric vehicles through incentives and grants for various vehicle segments. It resulted in about 2.78 lakh supported EVs via demand incentives.

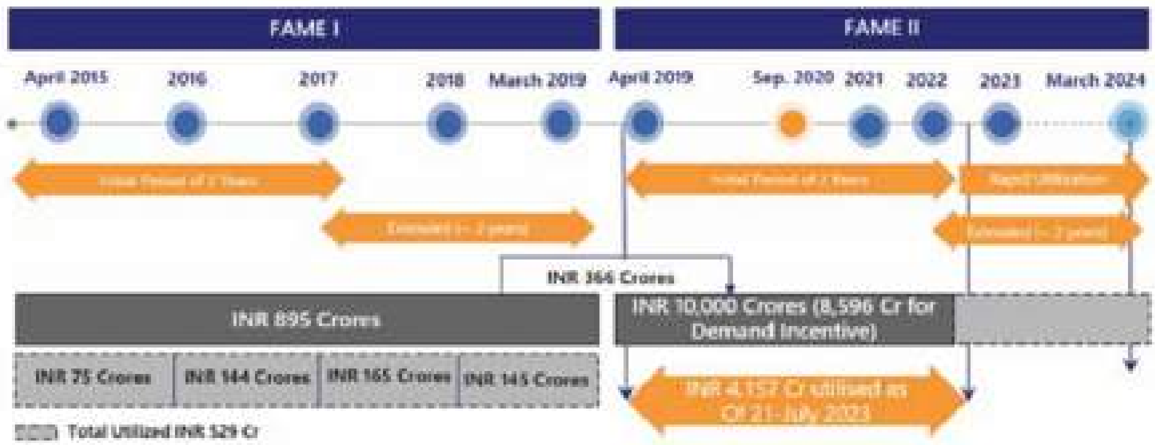
Phase-II of the FAME India Scheme, approved with an outlay of INR 10,000 Crore, aims to support demand for EVs by supporting 7,000 e-Buses, 5 lakh e-3 Wheelers, 55,000 e-4 Wheeler (Commercial purposes) and 10 lakh e-2 Wheelers (including commercial & private).

Starting from June 2023, for 2-wheeler subsidy is capped at INR 10,000 per kWh with cap of 15% of exfactory, while for other segments expect e-buses the cap is limited to 20% of the ex-factory price. e-Buses have higher incentive value of INR 20,000 per kWh.

Of the allocated INR 10,000 Cr, INR 8,596 Cr is for demand incentives with additional INR 366 Cr carry-forwarded from FAME-I primarily for e-buses and INR 1,000 Cr for development of charging infra.

As of 21st July 2023, INR 4,157 Cr for demand incentives has been exhausted. With announcements of INR 800 Cr for setting up fast charging stations approved a significant chunk of budget for charging infra is also expected to be utilised.





Source: PIB Notifications

Total Approximate Incentives	Approximate Size of Battery
Two wheelers: Rs 15000/- per kWh upto 40% of the cost of Vehicles	**Two wheelers:** 2 kWh
Three wheelers: Rs 10000/- per kWh	**Three wheelers:** 5 kWh
Four wheelers: Rs 10000/- per kWh	**Four wheelers:** 15 kWh
E Buses: Rs 20000/- per kWh	**E Buses:** 250 kWh

Performance Linked Incentives Scheme

PLI ACC:

GoI approved the PLI scheme for ACC battery manufacturing in February 2022, with an INR 18,100 crore outlay over five years (2023-2028) to establish 50 GWh local battery production.

This scheme encouraged domestic manufacturing of ACC batteries and components for the EV industry. Eligible companies will receive a 25% incentive on incremental investments and sales, expected to attract over INR 60,000 crore investments and generate over 50,000 jobs.

In the initial round of allotment Rajesh exports, Ola electric and Reliance New Energy emerged as winners with combined capacity of 30 GWh.

PLI Auto & Auto Components:

In March 2022, GoI approved the PLI scheme for auto and auto components, offering financial incentives of up to 18% to boost domestic manufacturing of advanced automotive technology (AAT) products and attract investments in the automotive value chain.

The PLI Scheme has well-defined targets for local domestic investments added with 50% minimum localisation to be qualified for any incentive.

With an INR 25,938 crore outlay over 2022-2027, eligible OEM Champions will receive incentives ranging from 13-16% of determined sales value for BEV & FCEV vehicles.

For Component Champion, 8-11% of determined sales along with an additional 5% for BEV & FCEV vehicle components. The scheme is anticipated to draw over INR 80,000 crore investments and generate over 7 lakhs jobs in the industry.

Growing Consumer Awareness

A growing awareness about environmental issues spurring an eco-friendly revolution and a rise of electrical vehicle sales. The rise in the brand value, demand and sales reflects impressive advancements in the EV technology and infrastructure. There is a reported surge in sales, driven by technological advancements, supportive policies, and environmental consciousness. Some of the main factors for the growing popularity of EVs is not only the fact that they are environmentally friendly, but also more cost-effective, reliable, and convenient than their fossil-fuel counterparts. International Energy Agency (IEA), reports that by 2023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Can EVS Resolve These Problems?

EVs could avoid 1.5 gigatons of CO2 emissions on an annual basis.

EVs are known to keep the air pollution free by avoiding tailpipe emissions of harmful pollutants such as nitrogen oxides, particulate matter, and volatile organic compounds. These poisonous gases are known to impact public health by causing congestion and smog.

Advantage EVs

EVs offer an enhanced convenience of the driving experience as they have a simpler and more efficient drivetrain than internal combustion engines, which translates into faster acceleration, smoother handling, and quieter operation.

Since EVs have a higher energy density than batteries they store more energy in a smaller space allowing a wider range and flexibility in vehicle design. Additionally, EVs can be charged at home or at work without hassles related to petrol and diesel vehicles.

EVs lower the total cost of ownership for drivers and commercial vehicle operators. With a lower fuel and maintenance cost than conventional vehicles, EVs do not require oil changes, spark plugs, or even filters. Electricity as a fuel, costs lesser and offers more stability in pricing than gasoline or diesel, especially since renewable sources such as solar or wind have appeared on the scene.

Attractive incentives and subsidies offered by governments and utilities encourage EV sales. In the US, EV buyers can claim a federal tax credit of up to $7,500, while in China, EVs are exempt from purchase taxes and license plate fees. In India a direct discount is provided to the user on the cost of the electric vehicle, financial incentive where the amount is reimbursed later, discounted interest rates while availing loan, road tax exemption at the time of purchase is waived off, one time as also the registration fee applicable on new vehicle purchase is excused. Income tax benefits, scrapping incentives upon de-registering old petrol and diesel vehicles, interest-free loans, top-up subsidies, special incentives on electric three-wheelers, etc. are offered.

Global EV Policies

There is a contrast in the area of focus in the policy directions with EV penetration at different levels across geographies. According to IEA, in 2022, 90% of EV sales in Light Duty Vehicles (LDV) that include passenger and commercial vehicles were covered in EV-related policies. Countries like China, Europe, US

Policy Area	Indonesia	India	Japan	USA	Germany	China	Norway
LDV Support	△→○ Subsidy announced for e2W/e3W from '23.	○ Subsidy for private e2W. None for private cars	○→⊙ Increased subsidy Scheme	○ ACC II Rule. Tax Credits for Private cars	⊙→○ BEV Subsidy phase-out till 2025	⊙→○ National Incentive Phased out in 2022	⊙→○ VAT Re-introduced. Reduced Tolls. Special Lanes still in place
HDV Support	△ Subsidies for 134 e-Buses in pipeline	○ Subsidy for e-Buses (Public Transport) FAME-II	⊙ $1Bil subsidy under IRA for HDV	○→⊙ $1Bil subsidy under IRA for HDV, Global MoUs	⊙ 80% of the additional cost of HDV veh covered	○ Targets for EV buses & trucks.	○ Targets for EV buses & trucks.
Charging Infra	△ Ease of regulations for setting up charging infra	○ Capital Subsidy for Charging Infra.	○→⊙ $1.5 Bil under NEVI. IRA tax credit	○→⊙ $1.5 Bil under NEVI. IRA tax credit	○→⊙ Add. Budget for EV Chargers	⊙ State-wise subsidies for charging points	○ «Charge Right» for people in buildings
Manufacturing	○ EV in national mfg. plan. Export ban for downstream processing of minerals	⊙ Strong localisation push (PLI) Battery mfg. support	○ Push around Battery mfg. 100 GWh by '30. Investment into magnets	△→○ IRA to promote local mfg.	○→⊙ EU: Green Deal Industrial Plan, Critical Raw Materials Act	⊙ Regional production targets, supply chain support	○→⊙ EU: Green Deal Industrial Plan, Critical Raw Materials Act

△: Low, ○: Medium, ⊙: High

and promising ambitions in markets like India, around ~50% of the global sales in LDV sales are targeted to be Zero-Electric-Vehicles by 2035.

Global Policies Related to Charging Infrastructure

According to IEA, the number of electric LDVs per public charging point and kW per electric LDV, 2022

Most growing and advanced EV penetration markets like **China** have strong policies incentivising the set-up of charging stations, with regions like Shenzhen targeting over 790,000 slow chargers and 43,000 fast chargers by 2025.

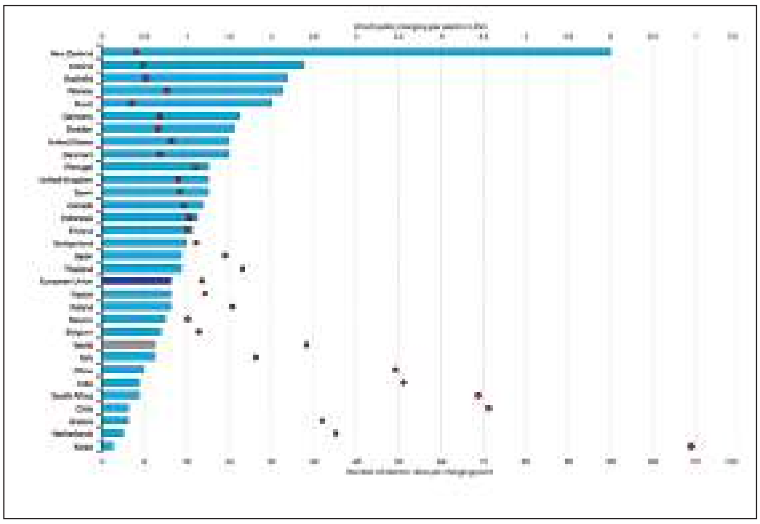
Despite reducing purchase incentives in **Germany**, investment into charging infra, especially for High Duty Vehicle (HDVs), is amped up.

Japan has policy & budget outlays for setting up both hydrogen refilling 14 Electric Mobility: Strengthening Eco-System Towards Vision 2030 stations and charging stations. Japan plans to construct over 150,000 charging stations by 2030, with 20% being fast-charging stations.

The **US** also has a strong policy push for charging infra with $1.5 Billion under National Electric Vehicle Infrastructure (NEVI) program. Coupled with the NEVI program is Inflation Reduction Act (IRA) which provides tax credits for setting up charging stations. California has been the leading region in the US with funding schemes, especially for Medium-Heavy Duty Truck charging stations.

India also has strong charging infra policies, with FAME-2 providing capital subsidy at a central level and various state-level policies supporting via tax incentives and ease of regulations.

Apart from support for charging infra, India and China are 2 countries giving significant importance to battery swapping in policy. Chinese standard for battery swapping was published in 2021 and is part of national NEV strategy. Several cities and provinces in China also provide financial support for swapping stations which has led to China having ~2,000 battery swap stations



India's G20 Vision Towards EV & Environment

India's G20 Presidency in 2023 presented an exceptional opportunity for the country to spearhead a collective approach to tackle multiple, complex, and interconnected challenges, while placing, front and centre, the aspirations and needs of the developing world. The COVID-19 pandemic, supply chain disruptions, climate change, food and energy security risks, geopolitical tensions, inflation, and a looming debt crisis all contribute to economic slowdown and uncertainty in global economic growth. India had set "*Vasudhaiva Kutumbakam*" or "One Earth - One Family - One Future" as the theme for its G20 Presidency, rightly aiming to instil a sense of unanimity essential for addressing these global challenges collectively and effectively. India's Prime Minister further envisions India's G20 agenda to be "inclusive, ambitious, actionoriented, and decisive."

Key focus areas of G20 Included:

1. **Climate action**: India has made climate action a key focus of its G20 presidency. The country has called for a collective effort to reduce greenhouse gas emissions and transition to a clean energy future.
2. **Economic recovery**: India is also using its G20 presidency to promote economic recovery from the COVID-19 pandemic. The country has called for measures to boost global trade and investment, and to support small and medium-sized businesses.
3. **Global health**: India is also committed to global health. The country has called for a coordinated response to the COVID-19 pandemic, and for measures to strengthen global health systems.

Multiple groups have been created to address these themes like "Expert Group on Climate Action": responsible for developing recommendations on how to accelerate the transition to a clean energy future. "Business Forum": a platform for businesses to engage with the G20 on issues of economic growth and development. India is using its G20 presidency to promote carbon neutrality, alternate powertrains, and electric vehicles in a number of ways.

India hosted a G20 Ministerial on Clean Energy Transition: This ministerial meeting brought together ministers from G20 countries to discuss ways to accelerate the transition to a clean energy future. India also launched the G20 Action Plan on Electric Vehicles: This plan outlines a number of measures that G20 countries can take to promote the adoption of electric vehicles and announced the launch of the G20 Green Hydrogen Task Force to promote the development and deployment of green hydrogen.

by end of 2022. India also introduced draft EV battery swap policy in 2022 which is targeted towards e-2W and e-3W.

Crucial Raw Material Supply Chain Update & Disruption

Major economies are increasingly looking into developing strategic stockpiles of critical minerals due to the Russia Ukraine war scenario highlighting the vulnerability of minerals like nickel, and also due to the fact that the downstream material processing, battery manufacturing, and permanent magnets for motors are areas predominantly controlled by China. The 30 key minerals identified in the inter-ministerial report "Critical Minerals for India" led by Ministry of Mines includes EV battery specific minerals like lithium, nickel, cobalt and graphite. To strengthen India's position in the supply chain of the critical minerals, the report has recommended:

- Establishing Centre of Excellence for Critical Minerals (CECM) new research and analytical infrastructure for critical mineral demand
- Collaboration with international agencies, KABIL (Khanij Bidesh India Limited) for strategic acquisitions of minerals
- Preparation & monitoring of exploration strategy under Ministry of Mines via CECM

Outlook

Notwithstanding the snail pace of the consumer demand for electric vehicles, news about the "demise of EVs" are greatly exaggerated. S&P Global Mobility's 2024 global sales forecast has projected battery electric passenger vehicles to be on track to post 13.3 million units worldwide for 2024 and accounting for an estimated 16.2% of global passenger vehicle sales.

Challenges in Electric Vehicle Charging Infrastructure Development in India

As the world races towards a sustainable future, India is making strides in adopting electric vehicles (EVs) to curb pollution and reduce dependence on fossil fuels. However, the transition to electric mobility is not without its challenges, and one significant hurdle lies in the development of a robust EV charging infrastructure. In this article, we will explore some of the key issues related to EV charging infrastructure in India.

Power: One of the primary challenges faced in setting up EV charging stations is ensuring a reliable power supply to these locations. In many areas, especially remote or underserved regions, establishing a consistent and adequate power source can be challenging. Moreover, the cost of establishing the power supply for the necessary charging infrastructure can sometimes account for as much as 30-40% of the total cost, posing a significant barrier during the initial investment.

A dedicated policy or rate for providing power to establish EV charging infrastructure could serve as a catalyst to ensure sufficient power for these stations. This issue requires a collaborative effort between the government, power distribution companies, and private stakeholders to ensure a seamless and reliable power supply.

Ravin Mirchandani

Ravin is the chief dream merchant at Quench EV Chargers. He has done his MBA from Queensland university in Melbourne, Australia.

Clarity on government-installed charging station: While the Indian government has taken steps to promote the installation of EV charging stations, there is a need for standardized guidelines and regulations for these facilities. In the past there have been multiple projects where the charging standard involved in the project was based on vehicles that are not common in the industry. Lack of clarity on standards for charging stations can lead to inconsistency in infrastructure quality, compatibility issues, and hinder interoperability. A well-defined set of standards will not only streamline the development process but also instill confidence among EV users regarding the reliability and safety of the charging infrastructure.

Financing models: The capital expenditure required to set up EV charging infrastructure constitutes a significant barrier. Charging stations involve high upfront costs for equipment, installation, power and land acquisition. The absence of clear and attractive financing models discourages private investors, businesses and individuals from venturing into this sector. The industry must explore innovative financial mechanisms, incentives, and partnerships to make investments in EV charging stations financially viable and attractive for stakeholders.

While India is on the path to embracing electric mobility, addressing the challenges associated with EV charging infrastructure is imperative for the success of this transition. Collaborative efforts involving the government, private sector, and communities are crucial to overcoming these obstacles.

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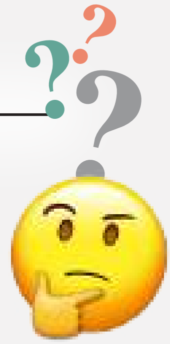

"EV Chargers will be a US$ 2 billion size market by 2030 and will include exports. Energy as Service provided by CPO's is slated to be a US$ 4 - 5 billion size industry by 2030 and include Real Estate, Software, APP's, Digital Payments."

Mustafa Wajid
Chairman, IEEMA E-Mobility and Charging Infrastructure
(Managing Director & CEO MHM Holdings Pvt. Ltd)

Mustafa Wajid, the Chairman of IEEMA E Mobility and Charging Infrastructure Division has an optimistic outlook when he says, "I expect electric 2W to achieve over 50% penetration, electric 3W more than 80% penetration, passenger cars over 25%; eBuses 80% by 2030. Read on to know his thoughts in his own words….

1.0 Inception and evolution of the e-mobility market in India.

1.1 The Indian context in which the E-Mobility must be seen is not just the environmental aspects but also that India's imports of petroleum crossed US$ 200 billion in FY23. As the Indian economy transitions to a middle income level in the coming years the need for fueling transportation shall increase dramatically.

1.2 Recognising this possible scenario, the GoI has over the last decade instituted various policies backed by fiscal support to accelerate adoption of EV's – ex: FAME 1, FAME2, PLI's etc.,

1.3 2018-19 was a notable year in which a variety of EV's were thus launched by a variety of companies in India. Despite the fallout of the pandemic, the range & types of EV's on offer has significantly increased.

1.4 In parallel GoI's initiative to push for E-Buses for public transport has now resulted in several thousand buses being deployed both in urban India & on Inter-City routes.

1.5 Many more are likely to be deployed going forward.

1.6 Niti Aayog has also launched a dedicated initiative… "E-Fast" to transform the logistics sector by use of electrified transportation.

2.0 Environmental concerns addressed through e-mobility & concerns that are created due to the adoption of e-mobility.

2.1 Minimising/Eliminating harmful tailpipe emissions from automobiles are an absolute necessity if environmental concerns are to be addressed.

2.2 There are broadly 3 approaches that can be adopted – with different environmental concerns.

2.2.1 Battery Powered EV's – The environmental concerns created are primarily about recycling of batteries – an area that is evolving rapidly.

2.2.2 Hybrid Powered Automobiles (Combining battery power with traditional Internal Combustion Engines - ICE) – same as above but significantly less as battery sizes are much smaller.

2.2.3 Hydrogen Powered Automobiles – 2 types

2.2.3.1 Fuel Cell Powered – Recycling of exhausted fuel cells is an environmental concern & various efforts are on to address this.

2.2.3.2 Hydrogen ICE – The NOx emissions from combustion have to be dealt with - https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/how-hydrogen-combustion-engines-can-contribute-to-zero-emissions

3.0 Conservation of energy – here are some basic facts:

3.1.1 One litre of petrol has about 9.6kWh of energy. A petrol scooter in typical Indian urban conditions can possibly give you 40-50km/litre. Taking the higher number this implies that we get about 5km/kWh

3.1.2 An electric scooter of a similar size gives about 30km/kWh in similar conditions.

3.1.3 Hence its energy efficiency is way above an ICE vehicle.

3.1.4 Similar conclusions can be reached if you compare similar passenger cars.

4.0 Status of charging infrastructure development in India and issues related to it.

4.1 Personal EV's – are typically charged at home using the EV Charger supplied along with the EV by the EV OEM – This is considered quite adequate given the available range & the typical usage of km/day

4.1.1 However, when such users need to travel longer distances it is necessary to have access to EV Charging facilities on the highways as well as at the destination. A number of CPO's (Charge Point Operators) are now providing such facilities.

4.2 Urban Commercial Vehicles – Typically fleets – have captive EV Charging solutions including in some cases battery swapping

4.3 Urban Public Buses – The E-Bus operators have enabled E-Bus charging facilities at the bus depot's.

4.4 Intercity Buses – same as 4.3 but typically at start & end destinations.

4.5 Intercity Trucks – An evolving area.

5.0 Issues relating to supply chain and distribution in the sector.

5.1 The primary challenge is to localise the supply chain for battery cells. GoI has already announced PLI's for this. In addition, several large investments have been announced to set up domestic production of battery cells.

5.2 The next challenge is to localise the rest of the EV Power train, i.e.

5.2.1 Battery Packs

5.2.2 Motor Drive Systems

5.2.3 Vehicle Control Units

5.2.4 Switchgear & Protection – Products & Systems

5.2.5 Cable & Wiring Harnesses

5.2.6 Software

5.2.7 Various domestic suppliers have emerged over the last few years & localisation percentage is increasing.

6.0 Consumer acceptance, creating attraction or ways to spread awareness about e-mobility.

6.1 In urban India customer/user acceptance levels of light electric vehicles (2W & 3W) has significantly increased since 2019. Much more needs to be done to ensure better product-market fit in terms of pricing, financing etc., However production of electric 2W alone has reached about 1 million nos/annum & is likely to grow rapidly.

6.1.1 The e-rickshaw & the electric 3W segment has also gained customer acceptance.

6.2 The passenger electric car segment has seen many new launches by reputed EV OEM's & sales are growing. However, the price point of such EV's is still significantly higher than comparable ICE cars – hence this segment is still evolving.

6.3 E-Buses have gained customer acceptance & we can expect this segment to grow much bigger in the coming years as the unit economics & total cost of ownership are quite favourable when compared to traditional diesel buses.

6.4 E-Trucks – An evolving area – still in a nascent stage.

7.0 Integration of EV charging infrastructure with distribution grid.

7.1 AC Chargers are typically rated as 3.3/7.4/11/22 kW. The incoming supply needed is either 230V, 50Hz, Single phase – or – 415v, 50Hz, 3 Phase. These are thus capable of being seamlessly integrated into the standard low voltage distribution network.

7.2 DC Chargers typically start at 30-50kW & can go upto 360kW. DISCOMS generally specify that at these power levels incoming supply will need to be given at 11kV or higher. Hence integrating such high-capacity chargers will need an upstream power infrastructure, i.e. a transformer with the required switching & protection systems. Another aspect is that an EV Charging station may have several chargers in one location. Hence the Power Supply & its management will need to broadly follow the same practices as in an electrical substation.

8.0 Current status of the EV-technology in India.

8.1 World class for electric 2W & 3W.

8.2 Passenger Cars – Tech is well developed but compromises being made on features & performance so as to optimise costs for Indian market conditions – Ex: Range, Acceleration, Autonomous/Assisted Driving etc.

9.0 Global EV market in terms of technology, status of investment, technology, R&D in the sector & background for policy making in relation to EV infrastructure.

9.1 Generally speaking, India is not lagging behind in EV technology, but we have to face the reality that our median ICE passenger car price is about Rs. 8L whereas EV's are more expensive.

9.2 Hence it is an affordability issue – not a technology issue.

9.3 However, India needs to significantly strengthen its supply chain capabilities for the EV Sector – particularly in battery cells.

9.4 Much has been done by GoI – refer FAME policies, GST reductions, Road Tax Exemptions etc.,

10.0 Key policies of a few foreign countries with an already established EV market.

10.1 Western countries (EU & North America) have adopted a double-edged policy – one being the levy of emission taxes on ICE vehicles; and another is enabling subsidies for electric cars.

10.1.1 It is important to note that the median price of an ICE passenger car in such countries is around US$35,000 – hence the price barrier for adoption of EV's is much lower.

10.2 China has followed the same logic as the western countries with an additional measure – In certain large cities there are now rules that you have to purchase your number plate for an ICE car – this is quite expensive. However, this rule is not applicable if you are buying an EV

10.3 Components used within EV's are governed by a variety of standards – SAE, UL, IEEE, IEC, BIS etc., - depending on which market the OEM is addressing.

10.4 The same is true for EV Charging Infra.

11.0 My vision for the future of the EV and Charging infrastructure market in India.

11.1 Expectations are as follows:

11.1.1 Electric 2W – 50%+ penetration by 2030

11.1.2 Electric 3W – 80%+ penetration by 2030

11.1.3 Passenger Cars – 25% penetration by 2030

11.1.4 E-Buses – 80%+ penetration by 2030

11.1.5 Trucks – Too early to say…

11.2 E V Charging Infra market – has three constituents

11.2.1 EV Chargers – a US$ 2 billion size in 2030 (including exports)

11.2.2 Energy as Service – Provided by CPO's – A US$ 4 to 5 billion size in 2030

11.2.2.1 Which will also include Real Estate, Software, APP's, Digital Payments.

"India will become a global leader in the design and manufacture of Electric Vehicles" Sundaresan SA

Sundaresan SA
An entrepreneur and a technology innovator, designing products and processes for over three decades: a mechanical engineer, he currently is Head – New Technologies at Ashok Leyland.

IEEMA ThinkTank voices the concerns, transformational ideas and most valuable outlook from thought leaders of the Power Industry

The 'Why' Of E Mobility

Tail pipe emissions are eliminated through adoption of e-mobility. If the power used to charge the electric vehicles is renewable energy, then overall emissions are eliminated. Even if the power comes from fossil fuel plants, the resulting emissions can be tackled much better through centralized capture and treatment facilities, with the impact on the environment lesser than if they were generated by individual internal combustion engine-driven (ICE) vehicles.

But concerns about the impact of mining of the critical minerals required – Lithium, Cobalt, etc., amount of energy consumed in manufacturing the electric vehicle aggregates and the treatment of batteries at the end of their life need more attention and action. Reports discuss about the distance an electric vehicle must cover before it's impact on environment is less that of an equivalent ICE vehicle.

Policy Solutions & 'How' Answered

FAME: Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India (FAME India) Scheme in 2015 to promote adoption of electric/ hybrid vehicles (xEVs) in the country. At present, Phase-II of FAME India Scheme is being implemented for a period of 5 years w.e.f. 01st April, 2019 with a total budgetary support of ₹10,000 crore. Battery Electric Vehicle and Strong Hybrid vehicles are supported under the FAME-II Scheme

National Electric Mobility Mission Plan (NEMMP)

PLI Scheme

- Production Linked Incentive (PLI) scheme for manufacturing of Advanced Chemistry Cell (ACC) in the country in order to bring down prices of battery in the country
- Electric Vehicles are covered under Production Linked Incentive (PLI) scheme for Automobile and Auto Components, which was approved on 15th September 2021 with a budgetary outlay of ₹ 25,938 crore for a period of five years. Hydrogen fuel cell based vehicles which are Zero Emission Vehicles (ZEVs) are covered under Auto and Auto component PLI Scheme

PMP

- Public charging infrastructure
- Battery swapping policy
- Special emobility zone
- National Electric Bus Program
    - GST on electric vehicles has been reduced from 12% to 5%; GST on chargers/ charging stations for electric vehicles has been reduced from 18% to 5%.
    - Ministry of Road Transport & Highways (MoRTH) announced that battery operated vehicles will be given green license plates and be exempted from permit requirements.
    - MoRTH issued a notification advising states to waive road tax on EVs, which in turn will help reduce the initial cost of EVs.
    - Model Building Bylaws 2016 amended to establish charging stations and infrastructure in private and commercial buildings.

Charging Infrastructure

For medium and heavy electric vehicles, the supply chain is still predominantly import oriented. The low volumes, and the heavy investment required are delaying faster indigenization.

Consumer Connect

When it comes to commercial vehicles, the high cost of electric vehicles has prevented widespread adoption. Financial viability is a key requirement for any technology to be accepted in commercial vehicles, and there is still a lot of doubt regarding this for electric vehicles. Though calculations show better Total Cost of Ownership (TCO) over the lifetime of the vehicle for certain applications, doubts about the unknowns – the maintenance costs, life of the battery, and the resale value of the vehicle prevent fleet owners from investing in electric vehicles. We will need real world data, and white papers for these customers to feel confident about the viability.

Current Status of EV-Technology

In heavy commercial vehicles, India is on par with the rest of the world when it comes to integration technology at the vehicle level. In terms of controls and software – the Battery Management Systems, Motor Controllers, Vehicle Supervisory Controls, India is one step ahead of the rest of the world. However, when it comes to the aggregates, while in terms of design, India is at the same level, but in terms of manufacturing, we are nowhere near – whether it comes to the cells, battery packs, large motors, and the power conversion devices such as DC-DC converters and the inverters.

We lag mainly in the manufacturing technologies of both the subsystems and the components. We are catching up in manufacturing large battery packs and have started setting up cell manufacturing plants. We need to catch up with the state-of-the-art yields and productivity norms in this crucial sector. Technology partnership along with investment in indigenous R&D are key. The current focus on bringing semiconductor manufacturing to India will hopefully succeed and if the industry focusses on meeting global requirements from India, then the volumes can justify investing in the manufacture of aggregates such as motors and power conversion devices. We also need to invest in indigenous development and manufacture of both the manufacturing as well as testing equipment required in this sector.

Investment & R&D

While investment is happening at a vehicle level, investment in aggregates is lagging.

Significant work is happening at application level (TRL 7 and above), but very little below that. We thus don't have a pipeline of technologies.

My Vision & Outlook about the Future of EV

India will become a global leader in the design and manufacture of Electric Vehicles of all sizes and shapes. Especially in the heavy commercial vehicles sector, India understands the requirements of emerging markets, and design products better suited to these markets. Indian OEMs collaborate to compete – collaborate on standards, interoperability, and non-differentiating technologies, and compete to offer differentiated products – collaborate to increase the pie, and then compete to grab a bigger share of the pie rather than simply fighting to grab a bigger share of the pie and actually making the pie smaller through aggressive competition.

For example, agreeing on making the batteries interoperable can reassure customers that they are not at the mercy of the original OEM when it comes to battery replacement. This can also lower the costs of development for battery pack manufacturers bringing down the overall costs. OEMs and battery pack manufacturers can still differentiate – in the round-trip efficiency, life and reliability of the battery packs, and command the loyalty of the customers, as well a premium. ■

"Recycling EV batteries, developing skilled manpower, enhancing awareness among consumers" are key concerns, states Dr Amitabh Saran

Dr. Amitabh Saran
Ph.D. in Computer Science and a published author of numerous papers and books covering software engineering and distributed computing. A co-inventor in over 26 global patents, Dr Saran has over three decades of industry experience with institutions like TCS, Philips, NASA, & Hewlett-Packard, TriVium, BuzzInTown and is the Founder/ CEO of Altigreen Propulsion Labs.

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My Suggestions to the GoI

- Rationalizing GST rates for electric vehicles essential components; currently GST on electric vehicles stands at 5% whereas majority of its components are between 18% and 28%. The Government should bring these components under the same umbrella of 5%;
- Government should consider extending FAME timeline, given that this sector is at a nascent stage;
- Central policy of waiver of road tax and registration fee for electric vehicle buyers (currently a state govt choice given by selected states like Maharashtra, TN etc);
- Central government support on creating charging infra and incentivising, may be Capex support for ramping up network;
- Reduction of custom duty on Lithium cells will help manufactures to bring down battery cost;
- EV sector is driven by extensive research and development; hence additional tax deduction should be considered for companies spending on research and development activities relating to electric vehicles and their components.

Point of Concern

Recycling EV batteries is a concern. Altigreen has explored eco-friendly ways to dispose of batteries through Strategic Tie-up to make sure our growth is environmentally responsible. However central standards should be made as part of the policy.

Q. Pinpoint required developmental upgrades – especially in quality and standards in the functioning of EV Sector at large.

Needed Quality & Standard Upgrade

- Our industry is committed to continuous improvement. We urge a focus on research and development to enhance the overall quality of electric three-wheelers. This includes investing in advanced materials and technologies to make the vehicles more durable and efficient.
- Government can mandate a Quality Control Order, in specific areas, to ensure compliance with the defined standards of EV battery, Ac/DC charging etc.
- As EV sector is exponentially growing, India will play a vital role to become export house of EV products. Mandatory compliance with Indian Standards (BIS) should be a good next step.
- Setting higher standards for safety and performance is paramount. Collaborating with industry experts to establish and enforce these standards will not only ensure customer satisfaction but also contribute to the overall credibility of the EV sector.

Other Important Issues of Concern

- Developing skilled manpower for the EV industry is essential. Collaborating with educational institutions and government bodies to introduce specialized courses and training programs will ensure a steady workforce equipped to meet the growing demands of the sector.
- Enhancing awareness among consumers about the benefits of electric three-wheelers is vital. Initiatives to educate the public on the environmental and economic advantages will contribute to a informed and receptive market. ■

Electric Vehicle Technology & Advancement

In an era marked by pressing environmental concerns and a growing need for sustainable transportation solutions, this article aims to provide a comprehensive understanding of the core elements that underpin the EV revolution. This article explores the fundamental aspects of electric vehicles (EVs), shedding light on their history, types, key components, performance characteristics, challenges, and future prospects.

This article endeavors to achieve three primary objectives: first, to chronicle the historical evolution of electric vehicles from their early beginnings to their resurgence in contemporary times; second, to categorize and dissect the various types of EVs, including Battery Electric Vehicles (BEVs), Plug-In Hybrid Electric Vehicles (PHEVs), Hybrid Electric Vehicles (HEVs), and Fuel Cell Electric Vehicles (FCEVs); and third, to assess the performance attributes of EVs, including acceleration, range, energy efficiency, and their environmental impact.

Introduction

Electric vehicles have a rich history, dating back to the early 19th century, and have witnessed a remarkable revival in recent years. Battery Electric Vehicles (BEVs) have emerged as a dominant force in the market, capitalizing on advancements in battery technology. EVs offer superior energy efficiency and have a significantly reduced carbon footprint compared to internal combustion engine vehicles. However, challenges such as range anxiety and the need for robust charging infrastructure remain to be addressed.

Fig.1: Electric Vehicle (Image source: The Open University)

The future of EVs appears promising, with ongoing research focusing on improving battery technology and charging infrastructure. *(Refer Figure 1)*

In recent years, the growing importance of electric vehicles (EVs) has become evident, driven by increasing environmental concerns and the imperative for sustainable transportation solutions. Electric vehicles and their pivotal role in achieving sustainable transportation solutions is well known to everyone. *(Refer Figure 2)*

Figure 2: Electric Vehicle

Traditional internal combustion engine vehicles **(ICEVs)** have long been associated with adverse environmental impacts. The combustion of fossil fuels in ICEVs leads to the emission of pollutants, including carbon dioxide (CO2), nitrogen oxides (NOx), and particulate matter. These emissions contribute significantly to air pollution, climate change, and associated health problems. As awareness of these issues has heightened, there is a pressing need to transition to cleaner and more sustainable alternatives.

Electric vehicles represent a paradigm shift towards sustainable transportation. Their propulsion systems rely on electricity, often sourced from renewable energy, making them inherently cleaner and more environmentally friendly. By reducing reliance on traditional fossil fuels, EVs offer a tangible solution to mitigate air pollution and decrease greenhouse gas emissions.

One of the key advantages of electric vehicles is their potential to reduce carbon footprints significantly. Unlike ICEVs that directly burn fossil fuels, EVs produce zero tailpipe emissions. Even when accounting for electricity generation, EVs can be more carbon-efficient, especially in regions with a substantial share of renewable energy in their power grids.

Electric vehicles exhibit higher energy efficiency compared to traditional internal combustion vehicles. Electric motors are inherently more efficient in converting electrical energy to mechanical power than internal combustion engines. This efficiency translates into reduced energy consumption and lower overall environmental impact. (Refer Figure 3)

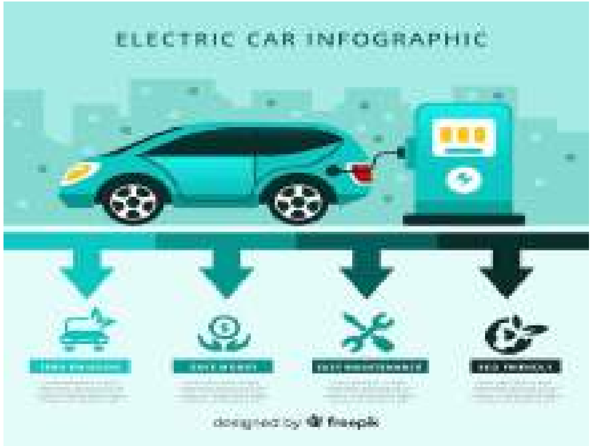

Fig.3: Electric Car Infographic (*Image source: freepik)*

Governments worldwide are recognizing the environmental imperative of transitioning to electric mobility. Many countries are implementing policies and offering incentives to encourage the adoption of electric vehicles. These measures include tax incentives, subsidies, and investments in charging infrastructure, fostering a conducive environment for the growth of the EV market.

The automotive industry has witnessed a paradigm shift with major manufacturers making substantial commitments to electric mobility. Established automakers are investing heavily in research and development of electric vehicles, and new entrants are emerging, focused solely on electric mobility. This industry trend further underscores the growing importance of EVs in the broader landscape of sustainable transportation.

History and Evolution of Electric Vehicles

The history of electric vehicles (EVs) is a **compelling narrative that dates back** to the early 19th century, **marked by innovative minds exploring the potential of electric propulsion.**

In the early 1800s, inventors like Thomas Davenport and Robert Anderson laid the groundwork for electric vehicles with the creation **of primitive electric motors.** However, it was in the **mid-19th century that substantial progress occurred**. In 1834, Thomas Davenport, an American blacksmith, built a small, non-practical electric vehicle—a model car powered by a small electric motor. Following this, the Scottish inventor Robert Anderson developed a crude electric carriage around 1832.

The late 19^{th} century saw the involvement of the iconic inventor Thomas Edison in electric vehicle development. Edison, known for his innovations in electric lighting and power systems, worked on electric vehicles with the

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hope that they would become the dominant mode of transportation. He even predicted that electricity would replace gasoline as the primary fuel for automobiles.

Electric vehicles gained some popularity in urban areas **during the late 19th and early 20th centuries**. Electric taxis, particularly in cities like New York and London, were a common sight. These early electric taxis were favored for their quiet operation and absence of noxious emissions, making them attractive for city transportation.

Despite initial success, **electric vehicles faced challenges such as limited** range, long charging times, and the high cost of batteries. The emergence of the internal combustion engine and the discovery of vast petroleum reserves led to the dominance of gasoline-powered vehicles. Gasoline vehicles offered longer ranges and quicker refueling, **contributing to their widespread adoption.**

The latter half of the 20th century **witnessed sporadic attempts** to revive interest in electric vehicles, **driven by concerns about air pollution and dependence on fossil** fuels. However, these efforts **often faced technological and economic challenges that hindered mass adoption.**

The early 21st century marked a significant resurgence of interest in electric vehicles. **Advances in battery technology, coupled with environmental concerns and efforts to reduce greenhouse gas emissions, led to a renewed focus on electric mobility.** Companies like Tesla played a pivotal role in popularizing high-performance electric vehicles and challenging traditional automotive norms.

The revival of electric vehicles (EVs) in recent years marks a transformative period in the automotive industry, characterized by technological breakthroughs, growing environmental consciousness, and a shift towards sustainable transportation.

Reasons of Emergence of Electric Vehicle Industry

A pivotal player in the revival of electric vehicles has been Tesla, led by entrepreneur Elon Musk. **Tesla's introduction of the Roadster in 2008 marked a significant milestone, demonstrating that electric vehicles could be high-performance, desirable, and competitive with traditional combustion engine vehicles**. The success of Tesla's subsequent models, particularly the Model S, Model 3, and Model X, reshaped perceptions of electric vehicles and set new standards for range, acceleration, and technology.

One of the key enablers of the **electric vehicle resurgence has been advancements in battery technology. Lithium-ion batteries, with their high energy density and declining costs, became the standard for electric vehicles**. Ongoing research and development efforts focus on enhancing battery performance, durability, and affordability. Solid-state batteries and other emerging technologies hold promise for further improving the efficiency and range of electric vehicles.

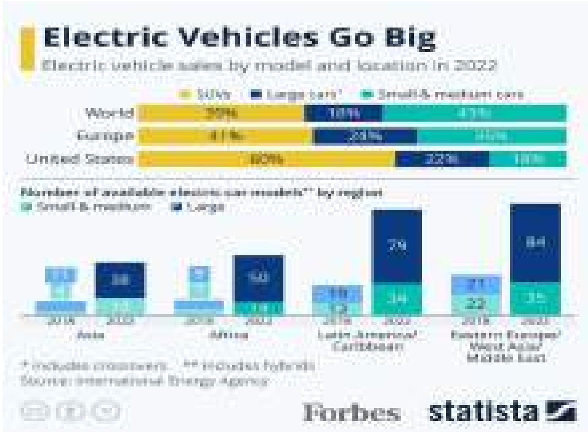

Fig.4: Electric Car Sales (Image source: Forbes)

Major automotive manufacturers globally began committing to electric mobility. **Traditional automakers, recognizing the inevitability of an electric future, have announced ambitious plans to transition their fleets to electric power**. Countries and cities have set targets to phase out internal combustion engine

vehicles, signaling a global commitment to electric mobility as a key component of sustainable transportation. (Refer figure 4)

The development of a **robust charging infrastructure is crucial** for the widespread adoption of electric vehicles. Governments, businesses, and electric utilities have been investing in expanding charging networks, **including fast-charging stations along** highways and charging points in urban areas. This infrastructure expansion addresses the challenge of range anxiety and enhances the practicality of electric vehicles for daily use.

The market for electric vehicles has diversified, with an increasing range of models catering to different consumer needs. In addition to high-end luxury electric cars, there are more affordable options, electric SUVs, and electric trucks entering the market. This diversification contributes to a broader adoption of electric vehicles across various demographics.

Electric vehicles often integrate cutting-edge technologies, including advancements in autonomous driving. The intersection of electric mobility and autonomous technology is shaping the future of transportation, offering potential benefits in safety, efficiency, and urban mobility.

Types of Electric Vehicles

In this section, the focus shall be on different types of electric vehicles available in the markets.

Battery Electric Vehicles (BEVs)

Battery Electric Vehicles (BEVs) represent a category of electric vehicles that rely solely on electric energy stored in rechargeable batteries for propulsion. Unlike hybrid vehicles, BEVs do not have an internal combustion engine and operate entirely on electric power. Here's an in-depth explanation of the concept, key components, and advantages of Battery Electric Vehicles:

BEVs operate on the principle of electric propulsion, where an electric motor is powered by energy stored in high-capacity rechargeable batteries. These batteries are typically **lithium-ion batteries** due to their high energy **density, efficiency, and relatively light weight.** The electric motor converts electrical energy from the battery into mechanical energy to drive the vehicle's wheels. (Refer figure 5)

Key Components

1. **Battery Pack:** The heart of a BEV is its battery pack, which stores and provides electric energy. Modern BEVs use advanced lithium-ion battery packs that **offer a high energy-to-weight ratio.**
2. **Electric Motor**: BEVs are equipped with one or more electric motors responsible for converting electrical energy from the battery into mechanical energy to drive the wheels. Electric motors are known for their **efficiency and instantaneous torque delivery.**
3. **Power Electronics:** Power electronics components, such as inverters and converters, are crucial for managing the flow of electrical energy between the battery and the electric motor. They ensure **efficient energy conversion and control** the speed and torque of the motor.
4. **Charging System**: BEVs come with onboard charging systems that facilitate the charging of the battery pack. Charging can be done using various methods, including standard AC charging, fast DC charging, and, increasingly, ultra-fast charging technologies.
5. **Regenerative Braking System:** BEVs often feature regenerative braking systems, **which capture and convert kinetic energy during braking into electrical energy.** This energy is then fed back into the battery, improving overall energy efficiency.

Advantages

1. **Zero Emissions**: BEVs produce zero tailpipe emissions, contributing to a reduction in air pollution and mitigating the environmental impact of transportation.
2. **Energy Efficiency**: Electric motors are inherently more efficient than internal combustion engines, leading to higher energy efficiency and reduced energy consumption.
3. **Reduced Operating Costs**: BEVs have fewer moving parts than traditional vehicles, resulting in lower maintenance costs. Additionally, the cost of electricity for charging is often lower than the cost of gasoline.
4. **Quiet Operation**: BEVs operate quietly compared to internal combustion engine vehicles, reducing noise pollution in urban environments.
5. **Lower Carbon Footprint**: The overall carbon footprint of BEVs depends on the energy sources used for electricity generation. In regions with a high share of renewable energy, BEVs can have a significantly lower carbon footprint compared to traditional vehicles.
6. **Government Incentives**: Many governments offer incentives such as tax credits, rebates, and access to carpool lanes to promote the adoption of BEVs.

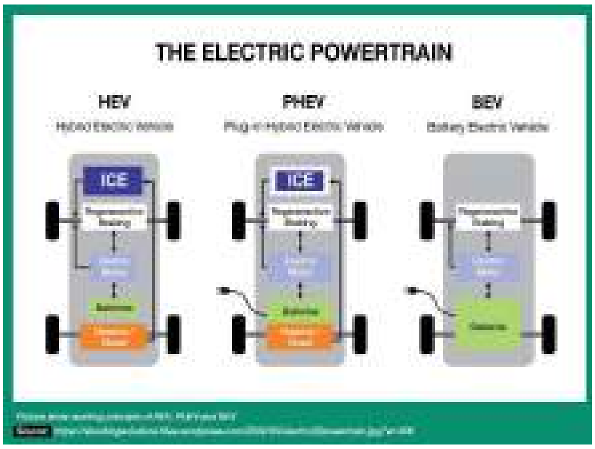

Fig.5: Different Types of Electric Cars & Components

Plug-In Hybrid Electric Vehicles (PHEVs)

Plug-In Hybrid Electric Vehicles (PHEVs) represent a hybrid vehicle category that combines features of both conventional internal combustion engine vehicles and Battery Electric Vehicles (BEVs). PHEVs are equipped with a rechargeable battery that can be charged via an external power source (plugged in), and they also have an internal combustion engine (ICE). This hybrid nature allows PHEVs to operate in electric-only mode, gasoline-only mode, or a combination of both. Here's a detailed exploration of PHEVs, their hybrid characteristics, and how they differ from BEVs:

Hybrid Nature

PHEVs are characterized by their dual powertrain systems—a combination of an electric motor and an internal combustion engine. This hybrid architecture allows PHEVs to switch seamlessly between electric and gasoline-powered modes, providing flexibility and extending the vehicle's overall range. (Refer figure 5)

Key Components

1. **Electric Motor:** PHEVs are equipped with an electric motor powered by a rechargeable battery. The electric motor can propel the vehicle independently or work in conjunction with the internal combustion engine for enhanced performance.
2. **Internal Combustion Engine**: Unlike BEVs, PHEVs have an internal combustion engine, usually fueled by gasoline. The internal combustion engine can be used to provide additional power, especially when the battery charge is depleted.
3. **Battery Pack**: PHEVs feature a rechargeable battery pack that can be charged using an external power source, typically a standard electrical outlet or a dedicated charging station.
4. **Power Electronics:** Power electronics components manage the flow of energy between the electric motor, the battery, and the internal combustion engine. They optimize energy usage and control the seamless transition between electric and hybrid modes.
5. **Regenerative Braking System**: Similar to BEVs, many PHEVs incorporate regenerative braking systems to capture and convert kinetic energy during braking into electrical energy for the battery.

Differences from BEVs

1. **Dual Power Sources:** The primary distinction lies in the dual power sources of PHEVs. While BEVs rely solely on electric power, PHEVs can operate using both electric and gasoline power.
2. **Extended Driving Range:** PHEVs have an extended driving range compared to BEVs due to the presence of the internal combustion engine. This makes PHEVs suitable for longer trips, even when there are no charging stations available.
3. **Gasoline Backup:** In PHEVs, the internal combustion engine serves as a backup power source, providing additional range and eliminating concerns related to range anxiety, a common consideration for BEV owners.
4. **Flexibility in Charging**: PHEVs offer flexibility in charging. They can be charged via an electric outlet like a BEV, but they can also rely on the internal combustion engine for power, eliminating the need for immediate recharging.
5. **Reduced Dependency on Charging Infrastructure**: PHEVs are not as dependent on charging infrastructure as BEVs since they can operate using gasoline. This can be advantageous in areas where charging infrastructure is limited.

Hybrid Electric Vehicles (HEVs)

Hybrid Electric Vehicles (HEVs) represent a category of vehicles that integrate both an internal combustion engine (ICE) and an electric motor. **Unlike Plug-In Hybrid Electric Vehicles (PHEVs), HEVs do not have a plug-in option for external charging**; instead, they generate electric power through regenerative braking and the internal combustion engine. Here, we'll delve into the working principles of HEVs and their efficiency. (Refer figure 5)

Main Components

1. **Electric Motor**: HEVs are equipped with an electric motor powered by a small onboard battery. This electric motor assists the internal combustion engine during acceleration and can operate the vehicle at low speeds.
2. **Internal Combustion Engine (ICE):** HEVs also have a conventional internal combustion engine, typically fueled by gasoline. The internal combustion engine provides additional power during high-speed driving or when additional power is needed.
3. **Regenerative Braking:** HEVs use regenerative braking, a technology that captures and converts kinetic energy during braking into electrical energy. This captured energy is then stored in the battery for later use by the electric motor.
4. **Automatic Start/Stop:** Many HEVs feature automatic start/stop systems, which shut off the internal combustion engine when the vehicle comes to a stop, such as at traffic lights. The engine restarts automatically when the driver presses the accelerator.
5. **Power Split Device (PSD):** HEVs often incorporate a power split device, also known as a **hybrid transmission**. The power split device manages the distribution of power between the internal combustion engine, the electric motor, and the wheels. It allows for seamless transitions between electric-only, gasoline-only, and combined power modes.

Main Advantages

1. **Fuel Efficiency**: HEVs are designed to optimize fuel efficiency by utilizing the electric motor during low-speed driving and in situations where the internal combustion engine may be less efficient. The electric motor assists the internal combustion engine, especially during acceleration, reducing the overall fuel consumption.
2. **Regenerative Braking Efficiency**: The regenerative braking system improves overall efficiency by recapturing energy that would otherwise be lost as heat during braking. This

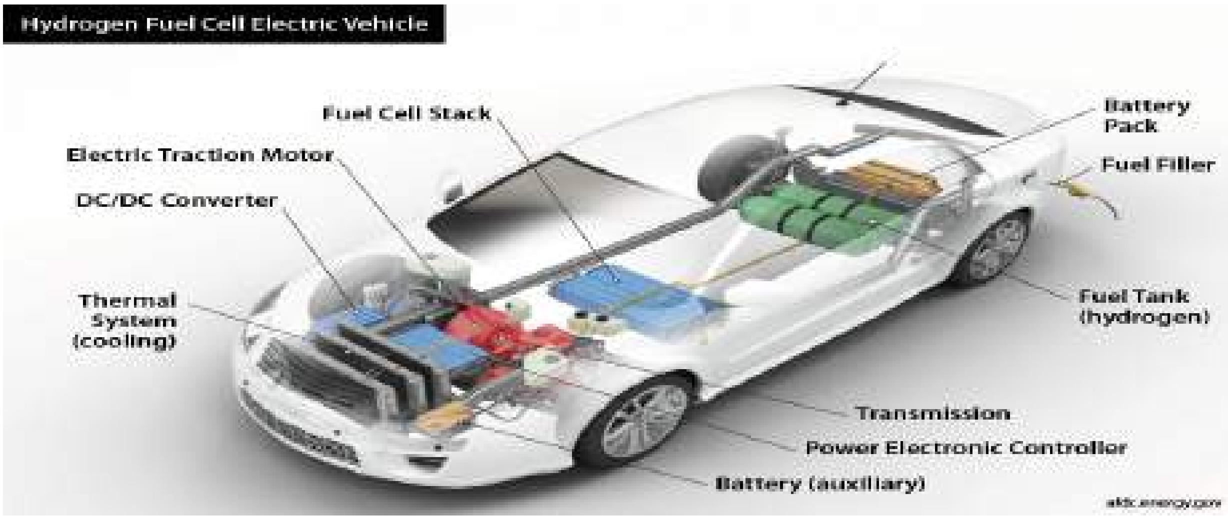

Fig.6: Fuel Cell Electric Car & Components (Image source: afdc.energy.gov)

recovered energy is stored in the battery and used to assist the vehicle during subsequent acceleration.

3. **Automatic Start/Stop Efficiency**: The automatic start/stop feature reduces idling time, especially in city driving conditions, enhancing fuel efficiency by shutting off the engine when the vehicle is stationary.
4. **Optimized Power Distribution:** The power split device ensures that the internal combustion engine and the electric motor work together efficiently, utilizing each power source for optimal performance based on driving conditions.
5. **Reduced Emissions:** By using the electric motor during low-speed and stop-and-go driving, HEVs can reduce emissions in urban environments. The electric mode, particularly in city driving, allows for zero-emission operation.

Fuel Cell Electric Vehicles (FCEVs)

Fuel Cell Electric Vehicles (FCEVs) represent an innovative category of electric vehicles that utilize hydrogen as a fuel source to generate electricity through a chemical reaction in a fuel cell. FCEVs are distinct from other electric vehicles in their reliance on hydrogen rather than conventional electric charging. Here, we'll introduce FCEVs, emphasizing their use of hydrogen fuel cells. (Refer figure 6)

Hydrogen Fuel Cell Technology:

1. **Fuel Cell Stack**: At the heart of FCEVs is a fuel cell stack, which contains multiple individual fuel cells. Each fuel cell consists of an anode, a cathode, and an electrolyte membrane. The most common type of fuel cell for FCEVs is the **proton exchange membrane fuel cell (PEMFC).**
2. **Hydrogen Fuel**: FCEVs store hydrogen in high-pressure tanks onboard the vehicle. The hydrogen fuel is then fed into the anode side of the fuel cell.
3. **Chemical Reaction:** In the fuel cell, hydrogen molecules (H2) undergo a chemical reaction at the anode, splitting into protons (H+) and electrons (e-). The protons pass through the electrolyte membrane to the cathode, while the electrons are forced to travel through an external circuit, generating electrical current.
4. **Electricity Generation:** As the electrons move through the external circuit, they create an electric current that powers the electric motor of the vehicle. At the cathode, the protons and electrons combine with oxygen from the air, forming water (H2O) as the only byproduct.
5. **Efficiency and Zero Emissions:** The efficiency of the fuel cell process is high, and the only emission is water vapor, making FCEVs a clean and environmentally friendly option.

Key Characteristics of FCEVs

1. **Zero Tailpipe Emissions**: FCEVs produce zero tailpipe emissions, as the only byproduct of the hydrogen fuel cell reaction is water vapor. This feature makes FCEVs a promising solution for reducing air pollution and greenhouse gas emissions.
2. **Quick Refueling:** FCEVs can be refueled with hydrogen in a matter of minutes, providing a refueling experience similar to traditional gasoline vehicles. This quick refueling time contributes to the convenience of FCEVs.
3. **Long Range**: FCEVs typically have a longer driving range compared to battery electric vehicles (BEVs) and can cover substantial distances on a single tank of hydrogen.

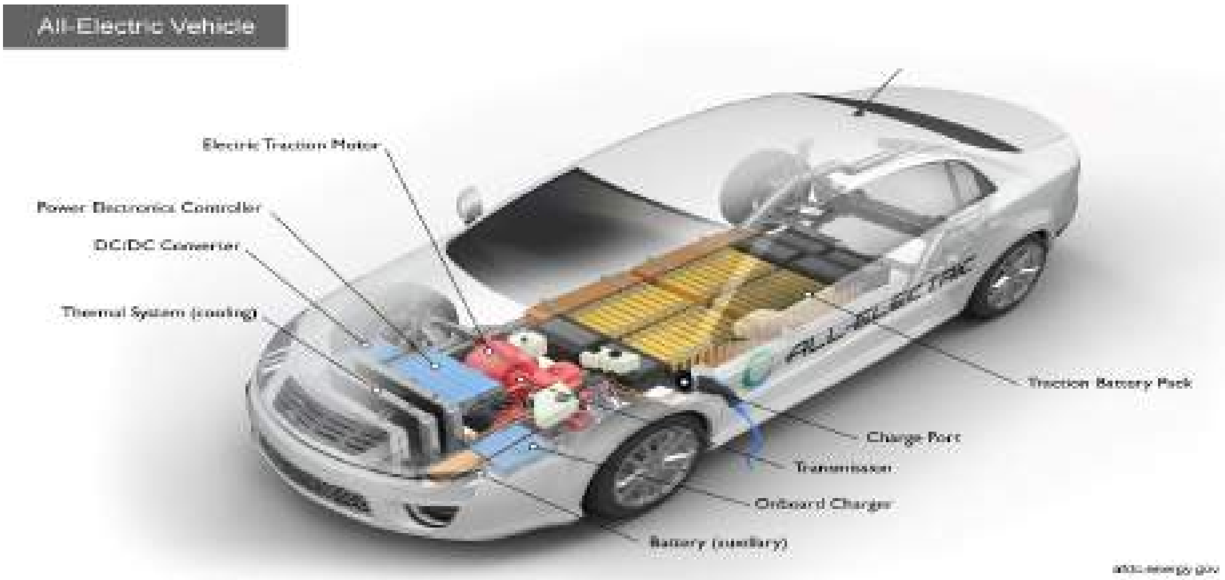

Fig.7: Electric Car Components (Image source: AFDC.energy.gov)

4. **Versatility in Applications:** FCEVs find applications beyond passenger vehicles, including buses, trucks, and even some trains. The versatility of hydrogen fuel cells makes them suitable for a range of transportation needs.
5. **Challenges**: Despite their advantages, FCEVs face challenges related to the availability of hydrogen infrastructure, production methods, and cost. Establishing a comprehensive hydrogen refueling network remains a key consideration for the widespread adoption of FCEVs.

Key Components of an Electric Vehicle

Electric Motors

Electric motors are the heart of an electric vehicle's propulsion system, responsible for converting electrical energy from the vehicle's battery into mechanical energy to drive the wheels. The primary types of electric motors used in electric vehicles are typically alternating current (AC) motors, with the most common being the three-phase induction motor and the permanent magnet synchronous motor.

Electric motors operate based on the principles of electromagnetism. When electric current flows through a coil or winding within the motor, it generates a magnetic field. The interaction between this magnetic field and the field produced by permanent magnets (in the case of synchronous motors) or induced currents (in the case of induction motors) creates a rotating force.

The rotational motion produced by the electric motor is transferred to the vehicle's wheels through a transmission system. This rotational energy propels the vehicle forward.

Electric motors are known for their high efficiency compared to internal combustion engines. They can convert a large percentage of electrical energy from the battery into mechanical energy, contributing to the overall energy efficiency of the electric vehicle.

One notable feature of electric motors in EVs is **regenerative braking**. During braking or deceleration, the electric motor operates in reverse, acting as a generator. It converts kinetic energy back into electrical energy, which is then fed back into the battery for storage. This regenerative braking system enhances energy efficiency and extends the vehicle's range. (Refer figure 7)

Batteries

Batteries serve as the energy storage **powerhouse in electric** vehicles (EVs), providing the necessary power for electric motors and other vehicle systems. The types of batteries used in EVs have a significant impact on performance, range, and overall efficiency. The most prevalent battery technology in EVs is lithium-ion (Refer figure 8), but other types are also considered. Let's delve into the characteristics of these batteries:

Lithium-Ion Batteries

1. **Chemistry**: Lithium-ion batteries use lithium ions as the charge carriers. Most Li-ion batteries share a similar design consisting of a metal oxide positive electrode (cathode) that is coated onto an aluminum current collector, a negative electrode (anode) made from carbon/graphite coated on a copper current collector, a separator and electrolyte made of lithium salt in an organic solvent. The most common chemistry variants include lithium cobalt oxide ($LiCoO_2$), lithium

manganese oxide (LiMn2O4), lithium iron phosphate (LiFePO4), and others.

2. **Energy Density:** Lithium-ion batteries are known for their high energy density, which means they can store a significant amount of energy in a relatively small and lightweight package. This characteristic is crucial for extending the driving range of electric vehicles.

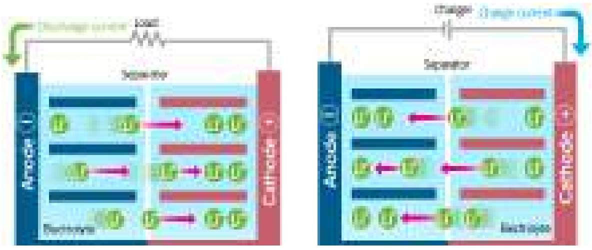

Fig.8: Lithium-Ion Battery Charging & Discharging

3. **Voltage Stability**: Lithium-ion batteries exhibit stable voltage characteristics throughout most of their discharge cycle, providing consistent power to the electric motor and contributing to the overall efficiency of the vehicle.

4. **Fast Charging:** Lithium-ion batteries are capable of fast-charging, allowing EVs equipped with these batteries to replenish a substantial portion of their charge in a relatively short time. Fast-charging capability enhances the practicality of EVs for daily use.

5. **Long Cycle Life:** Lithium-ion batteries generally have a long cycle life, meaning they can undergo numerous charge-discharge cycles before experiencing a significant decrease in performance. This longevity contributes to the durability of EVs.

6. **Thermal Management**: Proper thermal management is crucial for lithium-ion batteries to ensure safety and performance. Advanced battery management systems (BMS) in EVs monitor and regulate the temperature of the battery cells to prevent overheating and optimize performance.

7. **Cost Considerations:** While the cost of lithium-ion batteries has significantly decreased over the years, it remains a notable factor in the overall cost of electric vehicles. Ongoing research focuses on further reducing the cost of production and enhancing the efficiency of lithium-ion batteries.

Other Battery Technologies:

1. **Solid-State Batteries:** Solid-state batteries are a next-generation technology that replaces the liquid electrolyte in traditional batteries with a solid electrolyte. These batteries offer potential advantages such as higher energy density, faster charging, and enhanced safety. However, they are still in the early stages of development and commercialization.

2. **Nickel-Metal Hydride (NiMH) Batteries:** While less common in modern EVs, NiMH batteries have been used in some hybrid vehicles. They offer a decent energy density but are bulkier and heavier compared to lithium-ion batteries.

3. **Lithium-Sulfur Batteries:** Lithium-sulfur batteries are being explored for their potential to provide higher energy density than traditional lithium-ion batteries. Research is ongoing to address challenges related to cycle life and overall stability.

Power Electronics

Power electronics play a pivotal role in the operation of electric vehicles (EVs) by controlling and managing the flow of electrical energy between the battery, electric motor, and other components. The importance of power electronics in EVs lies in their ability to optimize energy efficiency, control motor performance, and ensure the safe and reliable operation of the vehicle.

Energy Conversion and Inversion:

A. **DC-AC Inverters:** Electric motors in EVs require alternating current (AC) to operate, while batteries provide direct current (DC) electricity. Power electronics, specifically DC-AC inverters, are responsible for converting the DC power from the battery to AC power for the electric motor. This conversion is crucial for the seamless operation of the electric drivetrain.

B. **AC-DC Converters**: During regenerative braking or when charging the battery, power electronics facilitate the conversion of AC power generated by the electric motor or received from an external power source (such as a charging station) into DC power for storage in the battery.

Motor Control

A. **Variable Frequency Drives (VFDs):** Power electronics, in conjunction with sophisticated motor control algorithms, enable precise control of the electric motor's speed and torque. This level of control is essential for achieving optimal performance, efficiency, and responsiveness in various driving conditions.

B. **Regenerative Braking Control:** Power electronics govern the regenerative braking process by efficiently capturing and converting kinetic energy during braking into electrical energy. This energy is then fed back into the battery for later use, enhancing overall energy efficiency.

Battery Management

A. **Battery Charging Control:** Power electronics control the charging process of the battery, ensuring that it occurs within safe voltage and temperature ranges. This includes managing the charging rate during different charging stages, such as fast charging or slow overnight charging.

B. **Discharge Control:** Power electronics regulate the discharge of energy from the battery to the electric motor, maintaining optimal conditions to prolong the battery's life and performance.

Thermal Management:

Cooling Systems: Power electronics generate heat during their operation. Efficient thermal management systems, integrated with power electronics, ensure that components remain within safe temperature limits. This involves cooling mechanisms such as liquid cooling or air cooling to prevent overheating and maintain optimal efficiency.

Efficiency Optimization

Power Factor Correction: Power electronics contribute to power factor correction, improving the efficiency of energy transfer between the power source (battery or external grid) and the electric motor. High power factor is essential for minimizing energy losses and ensuring a more effective use of electrical power.

Safety Features

Fault Detection and Protection: Power electronics systems incorporate safety features, including fault detection and protection mechanisms. In the event of anomalies or failures, these systems can quickly respond to protect the vehicle's components and ensure the safety of occupants.

Charging Methods & Infrastructure

Charging infrastructure is a key component in the widespread adoption of electric vehicles (EVs). The availability, accessibility, and efficiency of charging methods **significantly impact the convenience and practicality of electric mobility**. Let's explore the different charging methods and the infrastructure needed for EVs:

Charging Methods

Level 1 Charging (Standard Household Outlet):

- Voltage: 120 volts (AC)
- Power Output: Typically 1 to 2 kilowatts (kW)
- Charging Time: Slow, suitable for overnight charging
- Application: Level 1 charging is commonly used with a standard household outlet. While it is the slowest method, it is convenient for overnight charging at home. **(Refer figure 9)**

Level 2 Charging (Residential and Public Charging Stations):

- Voltage: 240 volts (AC)
- Power Output: Typically 7 to 22 kW
- Charging Time: Faster than Level 1, suitable for home and public charging stations
- Application: Level 2 charging is suitable for both residential and public charging. It is faster than Level 1 and is commonly used at home or at workplaces.

DC Fast Charging (Public Charging Stations):

- Voltage: 480 volts (DC) or higher
- Power Output: Varies, but can range from 50 kW to 350 kW or more
- Charging Time: Rapid charging, provides a significant amount of charge in a short time
- Application: DC fast charging is designed for public charging stations and is suitable for long-distance travel. It enables quick charging stops, providing a substantial charge in a matter of minutes. (Refer figure 9)

Fig.9: Electric Car Charging Station – Residential & Public

Charging Infrastructure

1. **Home Charging Stations**: Many EV owners prefer to install Level 2 charging stations at home. Home charging is convenient, especially for overnight charging. Home charging stations are often hardwired into the electrical system and offer faster charging compared to a standard household outlet.

2. **Workplace Charging Stations**: Installing charging stations at workplaces encourages EV adoption by providing employees with a convenient and reliable charging option during the workday. Level 2 charging stations are commonly deployed in workplace charging setups.

3. **Public Charging Stations:** Public charging stations are crucial for enabling long-distance travel and providing charging options in urban areas. These stations can offer both Level 2 and DC fast charging, catering to the diverse needs of EV users.

4. **Charging Networks:** Charging networks, operated by companies or utilities, play a role in connecting charging stations and providing services such as payment processing, charging station location information, and real-time status updates. This enhances the user experience and contributes to the growth of the charging infrastructure.

Challenges and Future Developments:

1. **Infrastructure Expansion:** A critical challenge for EV adoption is the need for an expanded and well-distributed charging infrastructure. Continued investments in infrastructure expansion are essential to support the growing number of electric vehicles on the road.
2. **Standardizing charging:** connectors and protocols is crucial to ensure interoperability among different EV models and charging stations. Efforts to establish global charging standards aim to create a seamless charging experience for users.
3. **Ultra-Fast Charging**: Ongoing research and development focus on ultra-fast charging technologies, with charging stations capable of delivering power in the range of 350 kW or more. Ultra-fast charging aims to reduce charging times further and enhance the practicality of EVs for all users.
4. **Innovations in Wireless Charging:** Wireless charging technologies are being explored to eliminate the need for physical cables. These systems use electromagnetic fields to transfer energy between a charging pad on the ground and a receiver on the vehicle, simplifying the charging process.

Conclusion

The history of electric vehicles is characterized by a series of innovations, setbacks, and revivals. The early developments laid the foundation for contemporary electric mobility, and the ongoing advancements suggest a promising future for electric vehicles as a sustainable and mainstream mode of transportation.

The various types of EVs, including Battery Electric Vehicles (BEVs), Plug-In Hybrid Electric Vehicles (PHEVs), Hybrid Electric Vehicles (HEVs), and Fuel Cell Electric Vehicles (FCEVs) w.r.t. the performance attributes of EVs, including acceleration, range, energy efficiency, and their environmental impact have been discussed.

The increasing prominence of electric vehicles is intricately linked to the urgent need to address environmental concerns and transition towards sustainable transportation models. The alignment of EVs with clean energy principles, coupled with government initiatives and industry commitments, positions electric vehicles as a crucial component in the global pursuit of a greener and more sustainable future.

Battery Electric Vehicles represent a clean and efficient mode of transportation, offering numerous advantages in terms of environmental sustainability, energy efficiency, and cost-effectiveness. The increasing popularity and advancements in battery technology are contributing to the continued growth of BEVs in the automotive market.

The development and expansion of charging infrastructure are critical factors in the widespread adoption of electric vehicles. The availability of diverse charging methods, along with a well-connected and accessible infrastructure, contributes to the overall success of electric mobility. Ongoing advancements in charging technologies and infrastructure development will continue to shape the future of electric vehicle charging.

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Energy Conservation in Transportation:

Promoting Sustainable Mobility through Alternative Fuels and Electric Vehicles

This technical paper examines the role of alternative fuels, electric vehicles (EVs), and sustainable transportation modes in achieving energy conservation and promoting sustainable mobility.

The transportation sector is a significant contributor to greenhouse gas emissions and energy consumption. To address these challenges, the adoption of alternative fuels, such as biofuels and natural gas, along with the widespread use of EVs, has gained momentum. Additionally, promoting sustainable transportation modes, including public transportation, walking, and cycling, can significantly contribute to energy conservation. This paper explores the technical aspects, environmental benefits, and policy implications associated with these measures, providing insights into achieving a more energy-efficient and sustainable transportation system.

Keywords : Energy; Transportation; Alternative Fuels; Electric Vehicles.

Introduction

The transportation sector is one of the largest consumers of energy, accounting for a significant portion of global oil consumption. The reliance on fossil fuels for transportation has led to concerns about energy security, as many countries are dependent on oil imports, making them vulnerable to price fluctuations and geopolitical tensions.

Furthermore, transportation-related emissions contribute significantly to climate change, leading to global warming and its associated impacts, such as rising sea levels, extreme weather events, and disruptions to ecosystems. The detrimental effects of climate change have spurred a global call for action to reduce greenhouse gas emissions and transition to more sustainable practices.

The significance of energy conservation in transportation can be understood from various perspectives:

1) Climate Change Mitigation

2) Air Quality Improvement

3) Energy Security

4) Economic Benefits

5) Technological Advancements and Innovation

6) Sustainable Development

7) Global Cooperation

Energy conservation in transportation is a multi-faceted approach that involves a combination of policies, technological advancements, and individual actions. By implementing these strategies, we can reduce energy consumption, lower emissions, and work towards creating a more sustainable transportation system.

Alternative Fuels for Energy Conservation

Alternative fuels are non-conventional sources of energy that can be used to power vehicles. They often produce fewer greenhouse gas emissions compared to conventional fossil fuels. Each alternative fuel has its advantages and challenges. Some are already in widespread use, like ethanol blends in gasoline or electric vehicles. Others are still in the development and research stages due to cost, infrastructure, and scalability concerns. The adoption of alternative fuels often depends on factors like government policies, technological advancements, and public awareness of environmental issues. Some common alternative fuels include:

Biofuels

These are fuels derived from biomass, such as plants, algae, or agricultural waste. The two most common types of biofuels are ethanol and biodiesel. Biofuels can be used in conventional vehicles with minor modifications and offer reduced carbon emissions compared to fossil fuels.

Ethanol:

Ethanol is a renewable and relatively clean-burning alternative fuel that has gained attention as a potential replacement or supplement to gasoline in the transportation sector. Often made from corn, sugarcane, or other crops, ethanol is used as an additive in gasoline or as a standalone fuel in certain flex-fuel vehicles.

Ethanol is produced from crops, which can be grown annually, making it a renewable and sustainable source of energy thus enhancing energy security for countries that can produce it locally. Compared to gasoline, ethanol generally results in lower net greenhouse gas emissions, mainly because the carbon dioxide released during combustion is offset by the carbon dioxide absorbed by the plants during growth. This cycle is known as the carbon-neutral cycle. In addition, it is compatible with existing vehicles with minor modifications, especially in blends like E10 (10% ethanol and 90% gasoline) and it has a higher-octane rating than gasoline, which can lead to better engine performance and efficiency when used as an additive in gasoline or in high-compression engines designed specifically for ethanol. The production of ethanol from crops can provide economic benefits to rural communities by creating jobs and supporting agricultural industries.

However, there are some considerations associated with ethanol as an alternative fuel. Its production is energy intensive, and it can lead to competition for land and resources with food production, potentially affecting food prices and availability.

Existing vehicles can use E10 blends; the availability of flex-fuel vehicles (capable of running on higher ethanol blends like E85) is limited, which hampers the broader adoption of higher ethanol blends because this will require modifications to existing infrastructure to accommodate higher ethanol blends.

Biodiesel

Biodiesel is another important alternative fuel that has gained attention as a renewable and environmentally friendly option for the transportation sector. Produced from vegetable oils or animal fats, biodiesel can be used as a diesel fuel replacement or blended with traditional diesel. Biodiesel offers several advantages as an alternative fuel.

Biodiesel can be replenished through farming and agricultural practices, making it a renewable energy source as well as providing energy security. It has lower lifecycle greenhouse gas emissions compared to traditional diesel fuel because of its carbon-neutral cycle. Biodiesel is biodegradable and less toxic than petroleum-based diesel, reducing the environmental impact in case of spills or leaks. It can be used in existing diesel engines with little to no modifications and it has excellent lubrication properties, which can lead to reduced engine wear and potentially longer engine life.

However, biodiesel as an alternative fuel also faces some challenges and considerations. The availability of feedstocks for biodiesel production, such as vegetable oils and animal fats, can be influenced by land use considerations, including competition with food production and concerns about deforestation and habitat destruction. In addition, its production requires huge energy particularly in the form of heat and electricity. It has slightly different properties than traditional diesel, which can impact storage and fuel quality. Moreover, biodiesel performance poorly in cold weather due to increased viscosity and potential gelling, which can affect fuel flow and engine performance in colder climates.

Natural Gas

Compressed Natural Gas (CNG) and Liquefied Natural Gas (LNG) are forms of natural gas that can be used as transportation fuels and it is cleaner-burning fossil fuels compared to gasoline and diesel. It primarily consists of methane and is considered a cleaner-burning option, making it an attractive choice for various applications.

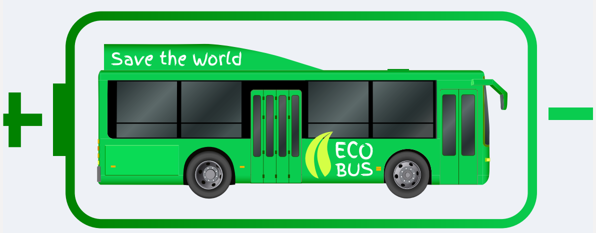
Natural gas vehicles emit fewer pollutants and greenhouse gases like sulfur dioxide and particulate matter compared to coal and oil, resulting in reduced air pollution and improved air quality. Apart from transportation natural gas can be used in a wide range of applications, including electricity generation, heating, and cooking with higher energy efficiency than those using coal or oil, leading to lower fuel consumption and operating costs. Natural gas reserves are abundant in many regions, providing a stable and domestically sourced energy supply that reduces dependency on foreign oil.

The existing natural gas infrastructure, including pipelines and distribution networks, allows for efficient delivery and use of fuel. Natural gas power plants can provide a stable and reliable source of electricity, serving as a complement to intermittent renewable energy sources like solar and wind.

Challenges and Considerations of Natural gas include methane emissions (primary component of natural gas) because it is a potent greenhouse gas. Leakage during extraction, transportation, and distribution can offset its climate benefits. While natural gas is cleaner than coal and oil, it is still a fossil fuel, and it may not be sufficient for achieving deep decarbonization goals necessary to combat climate change. Its extraction through hydraulic fracturing (fracking) raises environmental concerns, including water pollution and habitat disruption. It can be used as a transportation fuel, the infrastructure for CNG and LNG is not as widespread and may require huge investments.

LPG: Liquefied Petroleum Gas (LPG)

LPG (liquefied petroleum gas) is considered an important alternative fuel. Liquefied Petroleum Gas (LPG), also known as autogas, is a mixture of propane and butane. LPG is produced during natural gas processing and crude oil refining and is stored and transported in a liquefied state, which makes it highly portable and convenient to use.



As an alternative fuel, LPG offers several advantages. LPG combustion produces lower levels of greenhouse gases and air pollutants in comparison, and it has higher energy content per unit volume compared to gasoline, which can result in better fuel efficiency and longer driving range for vehicles using LPG as fuel. Apart from transportation it can be used in a wide range of applications, including heating and cooking. LPG is produced domestically, reducing dependence on imported oil and enhancing energy security. LPG can be easily integrated into existing fuel distribution systems, making it a viable option with minimal modifications. LPG has built-in safety features, including odorants that add a distinct smell for leak detection, and the fuel has a narrow flammability range, making it safe when handled correctly. LPG is often more cost-effective than other fuels, which can lead to savings for consumers and businesses, especially in regions where it is readily available. It can serve as a transitional fuel during the shift to more sustainable energy sources, providing a cleaner and more environmentally friendly option while renewable technologies continue to develop.

While LPG has numerous advantages as an alternative fuel, it is essential to address some challenges and considerations, such as safety precautions, proper handling and storage, and the need for continued efforts to diversify energy sources and promote the use of renewable and low-carbon alternatives. It has limited refueling infrastructure, baring bi-fuel or dedicated LPG vehicles, converting existing gasoline vehicles to run on LPG can be costly, and vehicle owners might be hesitant to make the switch. LPG-powered vehicles may have a slightly shorter range compared to gasoline or diesel vehicles. LPG refueling may take longer compared to gasoline or diesel refueling, as the tank has to be filled slowly to prevent over-pressurization. LPG tanks are bulkier and heavier than gasoline or diesel tanks, which can affect vehicle design and reduce cargo space in some cases. While LPG emits fewer greenhouse gases and pollutants compared to gasoline and diesel, it is still a fossil fuel and contributes to carbon emissions. Proper handling and storage of LPG are crucial to ensure safety.

Hydrogen

Hydrogen as a fuel can be used in fuel cell electric vehicles (FCEVs) or it can be combusted directly in internal combustion engines. In FCEVs, hydrogen reacts with oxygen in a fuel cell to produce electricity, powering the vehicle with zero tailpipe emissions. Hydrogen can be produced from various sources, including water electrolysis using renewable energy, natural gas (via steam methane reforming), biomass, and other renewable resources. The main byproduct of hydrogen fuel use is water vapor, making it a clean alternative. Hydrogen is considered one of the most promising and versatile alternative fuels for the future. It is the lightest and most abundant element in the universe, making it a potential clean and renewable energy carrier.

Here are some key characteristics and advantages of hydrogen as an alternative fuel:

1. **Clean and Zero Emissions:** When hydrogen is used in fuel cells to generate electricity, the only byproduct is water vapor, making it a zero-emission energy source. When used in combustion engines, it produces minimal emissions, especially if produced using renewable energy sources.
2. **Versatile Energy Carrier:** Hydrogen can be used in a wide range of applications, including transportation (fuel cell vehicles), electricity generation, heating, and industrial processes.
3. **Energy Efficiency:** Hydrogen fuel cells have higher efficiency than internal combustion engines, and they can convert a greater proportion of the energy content in hydrogen to electricity.
4. **Energy Storage:** Hydrogen can serve as an energy storage medium, allowing excess renewable energy to be converted into hydrogen during periods of low demand and used later when demand is high.
5. **Energy Independence:** Hydrogen can be produced domestically from various sources, reducing dependence on imported fossil fuels and enhancing energy security.
6. **Potential for Large-Scale Use:** Hydrogen has the potential to be used on a large scale to decarbonize various sectors, including transportation, industry, and power generation.

Challenges and Considerations:

However, there are several challenges and considerations associated with the widespread adoption of hydrogen as an alternative fuel:

1. **Production Methods and Costs:** The most common method of hydrogen production involves using natural gas, which generates carbon dioxide as a byproduct. Producing hydrogen using renewable energy sources, like electrolysis, can be more expensive and require further technological advancements to be cost-competitive.
2. **Infrastructure Development:** The existing infrastructure for hydrogen production, storage, and distribution is limited, and establishing a robust hydrogen infrastructure is a significant challenge.
3. **Storage and Handling:** Hydrogen has a low energy density by volume, which makes it challenging to store and transport efficiently. Developing safe and cost-effective storage solutions is essential.

4. **End-Use Efficiency:** Converting hydrogen into usable energy (e.g., electricity or mechanical power) involves energy losses in the process, affecting overall system efficiency.
5. **Safety Concerns:** Hydrogen has unique safety considerations, as it is highly flammable and can cause explosion risks if not handled properly.
6. **Technological Advancements:** Advancements in fuel cell technology and hydrogen production methods are ongoing to improve efficiency, reduce costs, and address safety concerns.

Synthetic Fuels

Synthetic fuels, also known as synfuels or renewable fuels or e-fuels or power-to-liquids fuels, are a category of alternative fuels that are produced through chemical processes using non-petroleum feedstocks. They are produced by gasification or the Fischer-Tropsch process where carbon-based feedstocks like coal or biomass are converted into liquid fuels by capturing CO2 emissions and combining them with renewable energy to create synthetic hydrocarbon fuels. These fuels can be used in existing ICE vehicles, aircraft, and ships, offering a potential alternative to fossil fuels. Synthetic fuels can be produced from a variety of sources, including biomass, natural gas, and carbon dioxide captured from the atmosphere.

Here are some common types of synthetic fuels and their characteristics:

1. Synthetic Gasoline: Synthetic gasoline is produced through processes like gasification or Fischer-Tropsch synthesis. It is chemically similar to conventional gasoline and can be used as a drop-in replacement or blended with regular gasoline.
2. Synthetic Diesel: Synthetic diesel is produced using similar processes to synthetic gasoline but is tailored to have properties similar to petroleum diesel. It can be used in existing diesel engines without any modifications.

3. Bio-Synthetic Fuels: These are synthetic fuels produced from biomass, such as agricultural residues, energy crops, or algae. Bio-synthetic fuels are considered renewable and have the potential to reduce greenhouse gas emissions compared to conventional fossil fuels.
4. E-Fuels (Power-to-X Fuels): E-fuels are synthetic fuels produced using renewable electricity to convert carbon dioxide and water into hydrocarbons. They include power-to-gas (P2G) and power-to-liquid (P2L) processes. E-fuels have the advantage of potentially using excess renewable energy and providing a means of energy storage.
5. Carbon-Recycled Fuels: These synthetic fuels are produced using captured carbon dioxide from industrial processes or directly from the atmosphere, reducing the net carbon emissions when used.

Advantages of Synthetic Fuels:

- Reduced Greenhouse Gas Emissions: Synthetic fuels, especially those produced from renewable sources or carbon-recycled methods, can have significantly lower greenhouse gas emissions compared to conventional fossil fuels.
- Compatibility with Existing Infrastructure: Synthetic fuels are designed to be compatible with existing engines, pipelines, and fueling infrastructure, allowing for easier adoption.
- Energy Security: By reducing dependence on traditional petroleum-based fuels, synthetic fuels can enhance energy security, especially if produced from domestically available feedstocks.
- Technological Compatibility: The production of synthetic fuels often involves advanced technologies, which can drive innovation and economic development in the energy sector.

Challenges and Considerations:

- Production Costs: The production of synthetic fuels can be more expensive compared to traditional fossil fuels, which can impact their competitiveness and widespread adoption.
- Feedstock Availability: The availability and scalability of feedstocks, such as biomass or renewable electricity, can be limiting factors for large-scale synthetic fuel production.
- Energy Intensity: The processes involved in synthetic fuel production may require significant energy inputs, which can affect the overall energy efficiency of the fuels.
- Infrastructure Development: Scaling up synthetic fuel production would require significant investment in new infrastructure and facilities.
- Competition with Other Alternatives: Synthetic fuels face competition from other renewable energy options, such as electric vehicles and hydrogen, in the transition to a low-carbon energy future.
- In conclusion, synthetic fuels hold promises as a cleaner and potentially more sustainable alternative to traditional fossil fuels. Their ability to reduce greenhouse gas emissions and compatibility with existing infrastructure make them an attractive option for transitioning to a low-carbon energy system. However, addressing challenges related to feedstock availability, production costs, and infrastructure development is essential to realizing their full potential as an alternative fuel source.

Hydrocarbon Fuels from Non-Petroleum Sources

Some researchers are working on producing traditional liquid fuels, such as gasoline and diesel, from non-petroleum sources like algae or certain types of waste. Hydrocarbon fuels from non-petroleum sources, also known as drop-in fuels or advanced biofuels, are a class of alternative fuels that share similar chemical properties with traditional petroleum-based fuels but are derived from non-fossil, renewable sources. These fuels are considered promising options for reducing greenhouse gas emissions and achieving energy security while minimizing the need for significant changes to existing infrastructure and vehicle technology.

Here are some key examples of hydrocarbon fuels from non-petroleum sources:

1. **Hydroprocessed Esters and Fatty Acids (HEFA):** HEFA fuels are produced through the

hydroprocessing of vegetable oils, animal fats, or algae-derived oils. The process involves hydrogenation to remove oxygen, resulting in a fuel that is chemically similar to conventional diesel and jet fuel.

2. **Renewable Diesel:** Also known as green diesel or hydrotreated vegetable oil (HVO), renewable diesel is produced from various feedstocks like vegetable oils, animal fats, and waste oils. It can be used as a drop-in replacement for petroleum diesel in existing engines.
3. **Alcohol-to-Jet (ATJ) Fuel:** ATJ is a synthetic jet fuel produced from alcohols, such as ethanol or butanol, through a series of chemical processes. It meets the specifications of traditional jet fuel and can be used in existing aircraft without modifications.
4. **Gas-to-Liquid (GTL) Fuels:** GTL fuels are derived from natural gas through a process called Fischer-Tropsch synthesis. They include synthetic gasoline, diesel, and jet fuel, which can be used as direct replacements for their petroleum counterparts.
5. **Isobutanol:** Isobutanol is an alcohol fuel that can be used as a gasoline additive or blended with gasoline. It offers certain advantages, such as higher energy content and compatibility with existing engines and infrastructure.

Advantages of Hydrocarbon Fuels from Non-Petroleum Sources:

- Reduced Greenhouse Gas Emissions: These fuels can significantly reduce greenhouse gas emissions compared to conventional fossil fuels, especially when produced from renewable feedstocks or waste materials.
- Compatibility with Existing Infrastructure: Hydrocarbon fuels from non-petroleum sources are designed to be used in existing engines and fueling infrastructure without the need for extensive modifications.
- Energy Security: By diversifying fuel sources and reducing dependence on fossil fuels, these advanced biofuels can enhance energy security and reduce reliance on imported oil.
- Drop-in Capability: The drop-in nature of these fuels means they can be easily integrated into existing distribution systems and fueling stations, reducing the need for new infrastructure.
- Economic Opportunities: The production of advanced biofuels can create economic opportunities in the agricultural and biotechnology sectors, as well as in research and development.

Challenges and Considerations:

- Feedstock Availability and Cost: The availability and cost of sustainable and abundant feedstocks are essential for large-scale production of these fuels.
- Energy Intensive Production: Some production processes may require significant energy inputs, which can impact the overall carbon footprint and energy efficiency of these fuels.
- Competition with Conventional Fossil Fuels: Advanced biofuels may face competition with low-cost petroleum-based fuels, especially during periods of low oil prices.
- Scale-Up and Commercialization: Scaling up production and commercializing these fuels on a large scale can present technical and financial challenges.

Electric Vehicles (EVs) for Energy Conservation

Electric vehicles are becoming increasingly popular as a sustainable mode of transportation. They are powered by electricity, reducing or eliminating tailpipe emissions. As the electricity grid becomes cleaner and renewable energy sources are used for charging, the environmental benefits of EVs become even more significant. EVs are vehicles that run on electricity stored in rechargeable batteries, eliminating the need for conventional internal combustion engines (ICEs) and reducing or eliminating tailpipe emissions. Key points about EVs include:

Electric Vehicles (EVs) play a significant role in energy conservation and sustainability. They offer numerous benefits that contribute to reducing energy consumption and mitigating environmental impacts. Here are some ways in which EVs contribute to energy conservation:

1. **Energy Efficiency:** EVs are more energy-efficient compared to internal combustion engine vehicles. They convert a higher percentage of energy from

the grid into vehicle movement, while conventional vehicles waste a significant portion of energy as heat during combustion. This increased efficiency translates to less energy consumption per mile driven.

2. **Regenerative Braking:** EVs use regenerative braking technology, which captures and stores energy during braking. This process converts the vehicle's kinetic energy back into electrical energy, which is stored in the battery and can be used to power the vehicle again, reducing overall energy waste.
3. **Reduced Dependence on Fossil Fuels:** By using electricity as their primary energy source, EVs help reduce the demand for fossil fuels, including gasoline and diesel. This reduces the need for oil extraction, refining, and transportation, resulting in lower associated energy consumption and environmental impacts.
4. **Utilizing Renewable Energy:** Charging EVs with electricity generated from renewable energy sources, such as solar, wind, hydro, or geothermal, further enhances their environmental benefits. It promotes the use of clean and sustainable energy for transportation, contributing to overall energy conservation efforts.
5. **Grid Load Management:** Smart charging technologies enable EVs to charge during off-peak hours when electricity demand is lower. This practice optimizes the use of existing electricity infrastructure, avoids strain on the power grid during peak hours, and helps conserve energy resources.
6. **Energy Storage and Grid Stabilization:** EV batteries can be used as energy storage systems when connected to the grid. During periods of high electricity demand, EVs can release stored energy back into the grid, helping to stabilize it and support the integration of intermittent renewable energy sources.
7. **Long-term Efficiency Improvements:** The ongoing development and advancements in EV technology are leading to more efficient electric drivetrains and batteries, which will further enhance energy conservation in the transportation sector.
8. **Waste Reduction:** EVs have fewer moving parts and require less maintenance than conventional vehicles, reducing the energy and resources required for manufacturing and maintenance.
9. **Lifecycle Energy Analysis:** Studies have shown that, even when accounting for the energy required to manufacture and recycle batteries, EVs have a lower overall energy footprint over their lifetime compared to conventional vehicles.

By embracing electric vehicles and supporting their widespread adoption, society can move towards a more sustainable and energy-efficient transportation system. However, to fully maximize the energy conservation potential of EVs, it is essential to continue promoting renewable energy sources, improving battery technologies, expanding charging infrastructure, and encouraging sustainable practices in vehicle manufacturing and recycling.

Battery Electric Vehicles (BEVs)

Battery Electric Vehicles (BEVs) are a key driver for energy conservation and sustainability in the transportation sector. BEVs are powered solely by electricity stored in onboard batteries. They produce zero tailpipe emissions and offer a longer range with advancements in battery technology. BEVs offer numerous benefits that contribute to energy conservation and reduced environmental impact.

Here are some ways in which BEVs promote energy conservation:

1. **Energy Efficiency:** BEVs are more energy-efficient compared to internal combustion engine vehicles. They convert a higher percentage of energy from the grid into vehicle movement, while conventional vehicles waste a significant portion of energy as heat during combustion. This increased efficiency translates to less energy consumption per mile driven.
2. **Reduced Dependence on Fossil Fuels:** By using electricity as their primary energy source, BEVs help reduce the demand for fossil fuels, including gasoline and diesel. This reduces the need for oil extraction, refining, and transportation, resulting in lower associated energy consumption and greenhouse gas emissions.
3. **Utilizing Renewable Energy:** Charging BEVs with electricity generated from renewable energy sources, such as solar, wind, hydro, or geothermal, further enhances their environmental benefits. It promotes the use of clean and sustainable energy for transportation, contributing to overall energy conservation efforts and lowering carbon emissions.
4. **Regenerative Braking:** Like other electric vehicles, BEVs use regenerative braking technology, which captures and stores energy during braking. This process converts the vehicle's kinetic energy back into electrical energy, which is stored in the battery and can be used to power the vehicle again, reducing overall energy waste.
5. **Smart Charging and Grid Integration:** BEVs can be charged during off-peak hours when electricity demand is lower. Smart charging technologies enable optimized charging times, which helps

balance the load on the power grid, reducing strain during peak hours and further conserving energy resources.

6. **Grid Stabilization and Energy Storage:** BEV batteries can serve as energy storage systems when connected to the grid. During periods of high electricity demand, BEVs can release stored energy back into the grid, helping to stabilize it and support the integration of intermittent renewable energy sources.

7. **Long-term Efficiency Improvements:** Ongoing advancements in battery technology and electric drivetrains are leading to more efficient BEVs, which will further enhance energy conservation and extend the driving range of electric vehicles.

8. **Lifecycle Energy Analysis:** Studies have shown that, even when accounting for the energy required to manufacture and recycle batteries, BEVs have a lower overall energy footprint over their lifetime compared to conventional vehicles.

9. **Reduced Noise Pollution:** BEVs are quieter than internal combustion engine vehicles, reducing noise pollution, especially in urban environments.

Plug-in Hybrid Electric Vehicles (PHEVs)

Plug-in Hybrid Electric Vehicles (PHEVs) are another important option for energy conservation in the transportation sector. PHEVs combine an electric motor and an internal combustion engine. They can run on electricity for shorter distances, and the combustion engine provides additional range. Alternatively, PHEVs may have a larger battery pack that can be charged through an external power source. PHEVs offer lower emissions compared to conventional vehicles.

PHEVs offer several benefits that contribute to energy conservation and sustainability:

1. **Reduced Fuel Consumption:** PHEVs can operate in electric-only mode for shorter trips, reducing the need for gasoline or diesel consumption. This mode allows for lower energy consumption and fewer greenhouse gas emissions, particularly during city driving.

2. **Energy Efficiency:** PHEVs benefit from the energy efficiency of electric vehicles during electric-only operation. They can take advantage of regenerative braking to recapture energy during deceleration, contributing to reduced energy waste.

3. **Extended Driving Range:** Unlike battery-only electric vehicles, PHEVs have the flexibility to use their internal combustion engine for longer trips, providing extended driving range without the need for frequent recharging.

4. **Smart Charging and Grid Integration:** PHEVs can take advantage of off-peak charging times when electricity demand is lower. Smart charging technologies enable optimized charging schedules, which can help balance the load on the power grid and promote efficient energy use.

5. **Utilizing Renewable Energy:** When charged with electricity from renewable sources, such as solar or wind, PHEVs can significantly reduce their environmental impact and promote the use of clean energy in transportation.

6. **Lower Tailpipe Emissions:** During electric-only operation, PHEVs produce zero tailpipe emissions, leading to improved local air quality and reduced pollution in urban areas.

7. **Energy Storage and Grid Support:** PHEV batteries can serve as energy storage systems when connected to the grid. They can provide grid support by releasing stored energy during peak demand periods, contributing to grid stability and renewable energy integration.

8. **T ransitioning Option:** PHEVs serve as a transitional option for consumers who may have range anxiety or limited access to charging infrastructure. They allow drivers to experience the benefits of electric driving while having the security of a backup internal combustion engine.

9. **Incentive for Electric Infrastructure:** The increasing adoption of PHEVs can incentivize the development of charging infrastructure, benefitting the broader transition to electric mobility.

10. **Behavioral Impact:** PHEVs can raise awareness about electric driving and sustainability, encouraging drivers to make more energy-conscious choices.

EV Charging Infrastructure

EV charging infrastructure plays a crucial role in the adoption and successful integration of electric vehicles (EVs) into the transportation system. Different charging technologies, such as Level 1, Level 2, and DC fast charging, offer various charging speeds and capabilities, impacting energy conservation and the convenience of charging for EV owners.

Here's an overview of these charging technologies:

1. **Level 1 Charging:**

- Charging Speed: Level 1 charging is the slowest charging option. It typically provides charging at a rate of 120 volts (V) and 15 amperes (A), resulting in a power output of around 1.4 kilowatts (kW).
- Charging Time: Level 1 charging is the least energy-efficient and requires the longest time

to charge an EV fully. It can take several hours to charge a depleted battery, depending on the battery size and state of charge.

- Use Case: Level 1 charging is often used with standard household outlets, making it accessible to all EV owners. It is suitable for overnight charging when the vehicle is parked for an extended period.

2. **Level 2 Charging:**

- **Charging Speed:** Level 2 charging operates at 240 volts (V) and can provide charging rates ranging from 3.3 kilowatts (kW) to 19.2 kilowatts (kW), depending on the charging station's capacity and the EV's onboard charger.
- **Charging Time:** Level 2 charging is significantly faster than Level 1 charging and can fully charge an EV in a few hours, depending on the battery size and state of charge.
- **Use Case:** Level 2 charging is commonly installed in residential, workplace, and public charging stations. It is ideal for daily charging needs and can provide convenient charging options for EV owners.

3. **DC Fast Charging (DCFC):**

- Charging Speed: DC fast charging is the fastest charging option available for EVs. It operates at much higher power levels, ranging from 50 kilowatts (kW) to over 350 kilowatts (kW), depending on the charging station and the EV's compatibility.
- Charging Time: DC fast charging can provide an 80% charge in a matter of minutes, making it suitable for long-distance travel and quick charging needs.
- Use Case: DC fast charging is primarily used for highway charging stations and charging infrastructure along major travel routes. It is designed for fast and convenient charging during road trips.

Energy Conservation Considerations:

- Level 1 charging is the least energy-efficient option, as it operates at a lower power output. It may not be the most sustainable choice for drivers seeking to minimize their energy consumption and carbon footprint.
- Level 2 charging offers a good balance between charging speed and energy efficiency. It is suitable for daily charging needs, including overnight charging at home or workplace charging stations.
- DC fast charging is the most energy-intensive option due to its high charging power. While it is essential for long-distance travel and enhancing the convenience of charging, its widespread deployment should be balanced with considerations of grid capacity and overall energy demand.

- In conclusion, the availability and deployment of diverse EV charging technologies are crucial for supporting the widespread adoption of electric vehicles. A mix of Level 1, Level 2, and DC fast charging infrastructure caters to various charging needs, enabling energy conservation while ensuring the convenience and accessibility of EV charging for drivers. As EV technology continues to evolve, advancements in charging infrastructure and charging speeds will further enhance the energy conservation benefits of electric mobility.

Sustainable Transportation Modes for Energy Conservation

Sustainable transportation modes are those that have a reduced impact on the environment and contribute to long-term ecological balance by promoting efficient and low-carbon options for moving people and goods. Embracing these modes can significantly contribute to energy conservation and create a more sustainable transportation system. They aim to minimize energy consumption, greenhouse gas emissions, and other negative environmental effects associated with transportation.

Here are some examples of sustainable transportation modes:

1) **Public Transportation:** Efficient and well-planned public transportation systems, such as buses, trams, subways, and trains, can move large numbers of people efficiently reducing the overall energy consumption and emissions compared to individual car trips. They provide a more sustainable alternative to private cars, as they have the potential to transport a large number of people in a single journey, reducing traffic congestion and emissions. Investing in and improving public transportation networks encourage more people to use sustainable modes of travel.

Carpooling and Ride-Sharing:

Carpooling and ride-sharing services promote the sharing of vehicles, reducing the number of cars on the road. By maximizing vehicle occupancy, these services help decrease traffic congestion and emissions per passenger, making them more sustainable than single-occupancy vehicles. Another example is

Car-sharing programs and MaaS platforms that offer flexible mobility options without the need for individual vehicle ownership. These services can lead to fewer vehicles on the road and promote sustainable transportation choices.

Rail Transport:

Rail systems, including trains and light rail, are an energy-efficient mode of transportation for long-distance travel and commuting between cities. Trains have a lower carbon footprint compared to airplanes or cars, especially when powered by electricity from renewable sources. High-speed rail systems are an energy-efficient alternative to air travel for medium-distance travel between cities. They can significantly reduce energy consumption and greenhouse gas emissions compared to flights.

Water Transport:

Water-based transportation, such as ferries and boats, can be a sustainable option for both passengers and cargo. Water transport generally consumes less energy and produces fewer emissions compared to road or air transport for similar distances. Freight transport by waterways is generally more energy-efficient than trucks, especially for long-distance hauls. Utilizing these modes for freight transportation can significantly reduce energy consumption and emissions.

Micro-mobility:

Micro-mobility refers to small, lightweight transportation modes, typically including electric scooters, electric bikes, and other micro-mobility solutions like segways. They are suitable for short trips and can be a sustainable alternative to car use, especially in urban areas. These modes can help alleviate congestion and reduce the environmental impact of short trips.

Eco-Driving Practices:

Encouraging eco-driving practices, such as maintaining proper vehicle maintenance, driving at moderate speeds, and avoiding aggressive acceleration and braking, can improve fuel efficiency and energy conservation.

2) Active Transportation: Walking and Cycling:

Walking and cycling are highly sustainable modes of transportation that do not rely on fossil fuels, and they produce zero emissions and promote physical activity. They are particularly suitable for short trips within urban areas. Promoting pedestrian and cyclist-friendly infrastructure, such as sidewalks, bike lanes, and dedicated paths, encourages people to opt for these energy-efficient modes for shorter trips.

Energy conservation

Energy conservation can be achieved through the use of alternative fuels and the adoption of sustainable transportation modes such as electric vehicles (EVs). Here's how they contribute to energy conservation:

1. **Efficient Energy Use:** Alternative fuels and EVs offer higher energy efficiency compared to conventional vehicles. Internal combustion engines are relatively inefficient, with a significant amount of energy lost as waste heat. In contrast, electric motors used in EVs are more efficient, converting a higher percentage of energy from the battery to power the vehicle. Alternative fuels like biofuels and natural gas can also be produced with higher energy conversion efficiency compared to extracting and refining fossil fuels.
2. **Reduced Energy Losses:** EVs and alternative fuel vehicles can minimize energy losses during operation. In conventional vehicles, energy is wasted through idling, braking, and inefficiencies in the engine. EVs, with regenerative braking, can recover and store energy that is typically lost as heat during braking. This regenerative braking technology improves overall energy efficiency by reusing energy that would have otherwise been wasted.
3. **Renewable Energy Integration:** Electric vehicles have the advantage of being compatible with renewable energy sources such as solar and wind power. By charging EVs with electricity generated from renewable sources, the transportation sector can reduce reliance on fossil fuels and transition to a cleaner energy mix. This integration promotes sustainable energy use and conservation.
4. **Reduced Energy Waste in Refining and Distribution:** Alternative fuels like biofuels and synthetic fuels can be produced from renewable sources, reducing the energy wasted in extracting, refining, and distributing fossil fuels. Additionally, since these fuels can be produced locally, the energy required for transportation and distribution is minimized, further conserving energy.
5. **Shift to Public Transportation and Active Modes:** Sustainable transportation modes, such as public transportation, walking, and cycling, contribute to energy conservation by reducing the overall number of vehicles on the road. Public transportation systems are designed to transport a large number of passengers efficiently, using less energy per person compared to individual vehicles. Walking and cycling require no energy consumption, relying solely on human power.
6. **Efficient Urban Planning:** Sustainable transportation systems promote compact and mixed-use urban planning, which reduces the need for long-distance travel. By creating walkable neighborhoods with easy access to amenities and public transportation, energy consumption associated with commuting and transportation can be significantly reduced.

7. **Smart Mobility Solutions:** Integrated mobility systems, incorporating ride-sharing, carpooling, and advanced traffic management technologies, optimize transportation efficiency. By utilizing data-driven solutions and intelligent routing, these systems can reduce congestion, travel times, and unnecessary energy consumption.

Policy and Regulatory Considerations

Indian government has implemented several policies and regulatory measures to promote energy conservation in the transportation sector. These initiatives aim to reduce fossil fuel consumption, greenhouse gas emissions, and air pollution while encouraging the adoption of cleaner and more sustainable transportation modes. Here are some key policy and regulatory considerations for energy conservation in transportation in India:

1. **National Electric Mobility Mission Plan (NEMMP):** The NEMMP was launched in 2013 to promote the adoption of electric vehicles (EVs) and reduce dependence on imported fossil fuels. It aims to achieve 30% electric vehicle penetration in the country by 2030 and has various incentives and subsidies for EV manufacturers and buyers.
2. **Faster Adoption and Manufacturing of Electric Vehicles (FAME) Scheme:** Launched under NEMMP, FAME India is a financial incentive program to promote the manufacturing and adoption of electric and hybrid vehicles in various vehicle segments, including two-wheelers, three-wheelers, and buses.
3. **Bharat Stage Emission Standards:** India has adopted the Bharat Stage (BS) emission standards, similar to Euro emission norms, for vehicles. The implementation of stricter BS emission standards aims to regulate vehicular emissions and improve air quality.
4. **Fuel Efficiency Standards:** India has introduced Corporate Average Fuel Efficiency (CAFE) standards for vehicle manufacturers to improve fuel efficiency and reduce greenhouse gas emissions. These standards mandate specific fuel efficiency targets for different vehicle categories.
5. **Green Tax:** The Indian government has proposed a Green Tax policy, intending to discourage the use of older and polluting vehicles while promoting the adoption of cleaner vehicles.
6. **National Smart Cities Mission:** The Smart Cities Mission encourages the development of smart and sustainable transportation infrastructure in selected cities, with an emphasis on public transportation, non-motorized transport, and intelligent traffic management.
7. **Public Transportation Expansion:** The government is investing in the expansion and improvement of public transportation systems, including metro rail, buses, and suburban rail networks, to encourage people to shift from private vehicles to more energy-efficient modes of transport.
8. **Promotion of Biofuels:** The Indian government has set targets for blending biofuels, such as ethanol and biodiesel, with conventional fuels to reduce fossil fuel consumption and promote energy security.
9. **National Mission on Transformative Mobility and Battery Storage:** Launched in 2019, this mission aims to drive clean, connected, shared, sustainable, and holistic mobility initiatives, including EV adoption, setting up charging infrastructure, and promoting domestic battery manufacturing.
10. **Roadmap for Hydrogen Fuel:** The government is exploring the use of hydrogen as an alternative fuel and is developing a roadmap to promote hydrogen-based transportation solutions.
11. **Green Urban Mobility Scheme (GUMS):** Launched to provide financial support for implementing urban transport projects, GUMS encourages the adoption of clean and energy-efficient public transportation solutions in urban areas.

Recommendations

Energy conservation in transportation is a critical aspect of sustainable development and reducing greenhouse gas emissions. Policymakers, industry stakeholders, and researchers play essential roles in shaping the future of transportation towards energy efficiency and environmental sustainability. Here are some recommendations for each group:

1. Policymakers:

- **Incentive Programs:** Implement and expand incentive programs for the adoption of electric vehicles (EVs) and other low-carbon transportation options. These can include tax credits, subsidies, reduced registration fees, and other financial incentives.
- **Regulatory Measures:** Enforce and strengthen fuel efficiency standards for vehicles, emission limits, and clean air regulations. Set ambitious targets for the transition to electric mobility and renewable energy in transportation.
- **Investment in Infrastructure:** Allocate funding for the development of charging stations, public transportation networks, bicycle lanes, and pedestrian-friendly infrastructure. Support the expansion of electric vehicle charging infrastructure to make it more accessible to all.

- **Research and Development Support:** Provide funding and support for research and development in areas like battery technology, hydrogen fuel cells, and sustainable biofuels to accelerate technological advancements in the transportation sector.
- **Sustainable Urban Planning:** Promote sustainable urban planning that prioritizes public transportation, cycling, and walking to reduce the need for private vehicle use.

2. Industry Stakeholders:

- **Vehicle Manufacturers:** Continue investing in research and development to improve the energy efficiency of vehicles, reduce vehicle weight, and increase battery range for electric vehicles.
- **Charging Infrastructure Providers:** Collaborate with policymakers and other stakeholders to build a robust and reliable charging infrastructure network that can support the growing fleet of electric vehicles.
- **Public Transportation Companies:** Invest in cleaner and more energy-efficient buses and trains. Improve public transportation services to encourage more people to use sustainable modes of travel.
- **Logistics and Freight Companies:** Adopt sustainable practices, such as using electric trucks for last-mile deliveries, optimizing routes, and employing alternative fuels for freight transport.

3. Researchers:

- **Battery Technology Advancements:** Conduct research to enhance battery technology, such as increasing energy density, reducing charging times, and improving battery life for electric vehicles.
- **Alternative Fuels:** Explore and develop advanced biofuels, synthetic fuels, and hydrogen-based technologies for various transportation applications.
- **Data Analytics and AI:** Use data analytics and artificial intelligence to optimize traffic flow, design efficient transportation networks, and promote energy-efficient driving practices.
- **Life Cycle Assessments:** Conduct life cycle assessments to analyze the overall environmental impact of different transportation modes and technologies, taking into account manufacturing, use, and end-of-life considerations.

Collaboration and cooperation among policymakers, industry stakeholders, and researchers are crucial for successful energy conservation efforts in transportation. By working together, these groups can accelerate the transition to a more sustainable and energy-efficient transportation system, contributing to a greener future for the planet.

Future Direction and Emerging technologies

As the world continues to prioritize sustainability and energy conservation, the transportation sector is witnessing rapid advancements in technologies and innovative solutions to promote energy-efficient and low-carbon mobility. Some future directions and emerging technologies in energy-conserving transportation include:

1. **Electrification:** The shift towards electric mobility is expected to continue, with the development of more efficient and longer-range batteries, faster-charging infrastructure, and improved electric drivetrains. This includes the growth of battery electric vehicles (BEVs) and the adoption of electric buses, trucks, and even airplanes.
2. **Autonomous Vehicles:** Self-driving vehicles have the potential to improve energy efficiency by optimizing driving patterns, reducing traffic congestion, and enabling platooning, where vehicles drive close together to reduce aerodynamic drag.
3. **Vehicle-to-Grid (V2G) Technology:** V2G technology allows electric vehicles to return stored energy to the grid during peak demand periods. It can enhance grid stability, promote renewable energy integration, and offer financial incentives for EV owners.
4. **Hydrogen Fuel Cell Vehicles:** Hydrogen fuel cell vehicles use hydrogen to generate electricity and have the advantage of fast refueling and longer driving ranges compared to battery-powered EVs. Advances in fuel cell technology and hydrogen infrastructure could make these vehicles more viable for certain applications.
5. **Sustainable Aviation:** The aviation industry is exploring alternative fuels and electric propulsion systems for aircraft to reduce greenhouse gas emissions and noise pollution.

6. **Lightweight Materials and Design:** The use of lightweight materials, such as carbon fiber composites, and aerodynamic design improvements can reduce vehicle weight and improve fuel efficiency.
7. **Biofuels and Synthetic Fuels:** Advanced biofuels and synthetic fuels produced from renewable sources or carbon capture technologies can offer low-carbon alternatives for existing internal combustion engine vehicles.
8. **Smart Traffic Management:** The integration of smart traffic management systems and real-time data can optimize traffic flow, reduce congestion, and improve fuel efficiency for all vehicles on the road.
9. **Mobility-as-a-Service (MaaS):** MaaS platforms offer integrated and on-demand transportation services, encouraging the use of shared mobility options and reducing the need for private car ownership.
10. **Renewable Energy Integration:** Integrating renewable energy sources, such as solar and wind, into charging infrastructure and transportation hubs can ensure that EVs are charged with clean energy.
11. **Urban Planning and Sustainable Infrastructure:** Smart urban planning that prioritizes walking, cycling, and public transportation, along with sustainable infrastructure development, can encourage energy-efficient transportation choices.
12. **Vehicle Connectivity and Data Analytics:** Connectivity and data analytics can help optimize vehicle performance, predict maintenance needs, and enable energy-efficient driving practices.
13. **Circular Economy for Electric Vehicle Batteries:** Developing a circular economy approach for electric vehicle batteries, including recycling and reusing battery materials, can minimize waste and improve resource efficiency.

These emerging technologies and future directions are part of a comprehensive effort to transform the transportation sector into a more sustainable and energy-conserving system.

Conclusion

Energy conservation in transportation is crucial for environmental sustainability, energy security, and economic growth. Transitioning to cleaner transportation practices combats climate change and enhances resilience.

- Shifting to sustainable transportation requires EVs, supportive policies, charging infrastructure, battery tech advancements, and renewable energy for charging.
- Hydrogen offers zero-emission potential and energy storage, but overcoming production, infrastructure, storage, and safety challenges is vital for broad adoption in a sustainable energy landscape.
- Non-petroleum hydrocarbon fuels cut emissions, boost energy security, and diversify sources. Addressing feedstock availability, cost, and large-scale production is crucial for sustainability.
- Embracing Battery Electric Vehicles (BEVs) and renewable energy promotes energy conservation. Enhancing battery tech, charging infrastructure, and sustainable manufacturing, along with policy support, accelerates the transition.
- Sustainable transportation prioritizes energy conservation, emissions reduction, and a cleaner future. Electric vehicles, public transportation, active modes, and government support are essential for this transition.

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Natural Disaster Management & Power Restoration

IEEMA columnist Dr. Deepak Lakhapati in his regular column illustrates his experiences from Oman where he restored power lines and tackled other issues related to the damage caused by cyclones, storms and hurricanes

Global warming, environmental changes is of highest concern globally. We are witnessing frequent cyclonic condition resulting in lot of damages to power infrastructure, uprooting of trees, damage to housing, evacuation of affected families and unfortunate loss of innocent people. Some of the recent cyclones have given transmission line engineers, lessons to protect future power infrastructure globally.

Ministry of Power, Central Electricity Authority in India have recently revised the regulations for designing transmission towers coming under coastal region as a preventive measure from blackouts. Similarly, many countries have investigated criticality of their power infrastructures adequacy to mitigate the situations. Some of the examples are given in the article.

Cyclonic damage due to GONU in Oman and Power Restoration of transmission network

MUSCAT, 03 June 2007 – The Country declared red alert warning for the CYCLONE GONU, the strongest tropical storm hit the region with winds of 160 kms an hour. Weather officials said the Cyclone was strongest to hit the peninsula since 1977.

Cyclone GONU reached Oman's Eastern coast producing strong winds and waves on June 5, 2007. The streets of Muscat were almost deserted, thousands of residents were evacuated from Eastern Coastal areas. The Army, Police and Civil defense troops were mobilized and about 18,000 people were evacuated across the Country.

The 132 kV double circuit transmission line which links Madinat Sultan Qaboos with Jahloot Circuits 1 & 2 was down. This caused electrical shutdown on Jahloot Grid station, which feeds the entire Welayat Al Amerat and Welayat Qurayat region, which has more than 40 villages and 5 major towns.

Picture 1: Tropical Cyclone Gone with storm category

Picture 2: Cyclonic advancement of Gonu towards Oman.

Picture 3: Over 4-5 meters of water waves hitting the city of Muscat.

Picture 4: Strong wing speeds hitting the costal trees.

Picture 5: Entire city experienced flooding of roads and houses

Picture 6: Damage to all major highways & roads

Picture 7: Damages to many of the heavy vehicles

The impact was so devastating, that the country still shivers at its name.

Cyclonic winds created waves of the height of over 4-5 meters hitting the city and many tall trees got uprooted. Most of the infrastructure of the city of Muscat was badly damaged, heavy flooding in the city.

The whole country was ripped apart- from their highways to roads to the airport. Transmission lines had collapsed, leaving the country in pure darkness, including the King's palace itself.

Most of the transmission line towers suppling power to the city were washed away due to high intensity of floods. Even the access to check the damage was not available.

There was no back up power nor alternative transmission lines which can temporarily divert the power. After the water levels receded the MEW's team went for the inspection to assess the damage. It was concluded that the main damaged transmission line will need much longer time to re-construct, hence it was decided to construct a temporary line using the wooden poles and restore power using one circuit.

In this moment of crisis, transmission line EPC company was called in by MEW and the asked to extend support in reinstate power at the King's residence and the city at the earliest.

Immediately the construction crew was diverted from another project site. All materials required for the construction was shifted to locations. We had to do the temporary foundations and protect by stone pitching surrounded at the base of wood pole. A frame with three wooden poles and a tie wooden beam fixed at the top was made as a structure used for power evacuation.

Frame by Frame at shorter spans were erected day and night, by then all insulators, conductor and other hardware fittings were kept ready for installation.

Picture 8: Collapse of major bridges, flyovers made the life almost standstill.

Picture 9: Complete Tower Collapse

Picture 10: Many of towers of the transmission line had Collapsed.

Picture 11: removal of undamaged insulators for future use

Picture 12: Inspection of the damaged towers to get a firsthand information by MEW officials

Picture 13: Inspection of the damaged towers to get a firsthand information by MEW officials

Picture 14-17: Installation of wood poles for temporary restoration of power.

Picture 18: Final commissioned line & restoration of Power.

Restoration of electricity was done with day & night efforts within 7 days which was very much appreciated by the Utility

This crisis helped us develop a direct relationship with the primary utility of Oman- Ministry of Electricity and Water. We advised the ministry over upgradation of their power lines from 132 kV to 400 kV lines.

I stayed at Oman, we worked 16 hours a day, and I can't be thankful enough to workmen for having cooperated to such an extent and working late into the nights. It was solely because of them, that we succeeded with best possible solution and the line was charged successfully bringing the life back to normal in 7 days.

"*Take away is to extend out-of-way support to customers during an Emergencies. Power restoration in One week during Gonu cyclone was well appreciated by MEW and consultants*"

Cyclonic damage in India and remedial actions

Environmental changes globally are becoming a strong reason for frequent cyclonic condition resulting in lot of damages to power infrastructure, uprooting of trees, damage to housing and evacuation of affected families. Some of the recent cyclones have given us lessons to protect future power infrastructure.

Central Electricity Authority have recently revised the regulations for designing transmission towers coming under coastal region as a preventive measure from blackouts.

Following are the worst hit cyclones in recent past in India where it took quite long to restore infrastructure back to normal life.

A) Cyclone Tauktae (2021): Classified as an extremely severe cyclone, Tauktae landed on the southern coast of Gujarat on May 17, 2021, while India was battling a fierce second wave of COVID-19. Winds of up to 185 kmph, making it the "strongest tropical cyclone" in at least two decades to impact the west coast of India.

B) Cyclone Amphan (2020): Amphan, the first super cyclone over the Bay of Bengal after Odisha's super cyclone of 1999, made landfall on May 20, 2020, near the Sundarbans in West Bengal. Amphan was the costliest tropical cyclone on record in the North Indian Ocean, with reported economic losses in India of approximately USD 14 billion and 129 casualties across India and Bangladesh.

C) Cyclone Fani (2019): Fani struck the eastern coast of India on May 3, 2019, near Puri in Odisha at a wind speed of 175 kmph. The extremely severe cyclonic storm claimed 64 lives and caused substantial damage to infrastructure, including houses, power lines, agricultural fields, communication networks and water supply systems.

D) Cyclone Vardah (2016): Vardah made landfall near Chennai on December 12, 2016. It was categorised as a very severe cyclonic storm. Vardah claimed 18 lives in Tamil Nadu and caused extensive damage to infrastructure, uprooted trees, and disrupted power supply in Chennai and neighbouring areas.

Pictures 20-22 : devasting situation due to cyclones in India

Texas, USA- Power Crisis due to unprecedented winter storms

In February 2021, the state of Texas suffered a major power crisis, which came about during three severe winter storms sweeping across the United States between 10th to 20th of FEB 2021. The storms triggered the worst energy infrastructure failure in Texas state history, leading to shortages of water, food, and heat. More than 4.5 million homes and businesses were left without power, some for several days. At least 246 people were killed directly or indirectly.

Principally natural gas infrastructure but also to a lesser extent wind turbines, had caused the grid failure, with a drop in power production from natural gas more than five times greater than that from wind turbines. The limited number of ties made it difficult for the state to import electricity from other states during the crisis. Many of the Transmission lines had collapsed, huge damage to the infrastructure, many of the houses were under water, most cars were fully under water.

Last few decades, utilities in USA were having the old transmission system and no major new transmission lines were built.

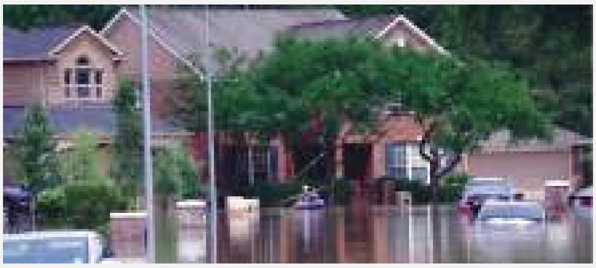
Texas Power Crisis have shaken up the Utilities in USA for immediate steps for building new transmission lines to strengthen the existing grid.

Picture 23: Transmission lines badly collpased creating black outs

Picture 24: Transmission lines badly collpased creating black outs

icture 25: Transmission lines badly collpased creating black outs.

Picture 26: Houses ,Car parks flooded.



Picture 27: Houses ,Car parks flooded

Most Talked about a damage to Infrastructure due to Hurricane Katrina, USA

Katrina began on August 23, 2005, with the merger of a tropical wave and the remnants of Tropical Depression Ten. Early the following day, the depression intensified into a tropical storm and headed generally westward toward Florida. On August 25, two hours before making landfall at Hallandale Beach, Katrina entered the Gulf of Mexico on August 26 and rapidly intensified. The storm strengthened into a Category 5 hurricane over the warm waters of the Gulf of Mexico.

Before weakening to a high-end Category 3 hurricane at its second landfall on August 29 over southeast Louisiana and Mississippi.

The largest loss of life in Hurricane Katrina, 80% of the city, as well as large areas in neighboring, were flooded for weeks. The flooding destroyed most of New Orleans's transportation and communication facilities, leaving tens of thousands of people who did not evacuate the city prior to landfall with little access to food, shelter, and other necessities.

Hurricane Katrina was a devastating category 5 hurricane that caused 1,836 fatalities and damage estimated between $97.4 billion to $145.5 billion in late August 2005, particularly in the city of New Orleans and its surrounding area

Picture 28: Heavy flooding, collapse of infrastructure

Picture 29: Satellite image of storm.

Picture 30: All the houses have been submerged.

Conclusion

From the above examples, one can notice that the whole world is experiencing the effect of Global warming, environmental changes, and its consequences. All out efforts are required for reducing an impact by, more tree plantations, reducing the pollution levels, renewable power generation replacing old traditional generating plants etc.

Detailed study is required to assess the adequacy of existing transmission grids, alternative back up plans in case of cyclonic uncertainties, strengthening the transmission networks to make it more equipped to sustain the cyclonic conditions.

Asset Management of Distribution Transformer Fleet

by Analysis of Winding Failure

Distribution Transformers, as defined in the standard[1], are transformers with capacity under 2500kVA and operating at voltage levels lower than 33kV. These are often located near load centers and form an essential part of utilities' connect with the consumers. With changing power scenario, utilities are now giving impetus to minimizing failure of Distribution Transformers in order to minimize downtime and prevent loss of revenue, all this while optimizing the capital and revenue expenditures. This has caused a paradigm shift in the maintenance practices from the conventional periodic maintenance to 'Asset Management'. In this regards, the approach of CESC Limited, a power generation and distribution company, has been highlighted for its operations in Kolkata & Howrah, India.

Keywords- Distribution Transformers (DTRs), Asset Management, Winding Failure, Core Coil Assembly (CCA)

Introduction

As per the latest figures by CEA[2], the total DTR population in the country is about 1.3 crore, with a failure rate nearing 10% annually. This includes circumstances when the DTRs could be either repaired at site or had to be replaced on account of failure. A 10% failure rate would mean a failure of about 13 lacs DTRs annually. On the contrary developed countries are having a failure rate of about 2%. This presents a huge potential of saving.

In the context of the paper and with regard to CESC's operations, the term 'Failure' has been used to indicate those cases where on-site repair couldn't be carried out and the DTR had to be replaced. This is because the redundancy in most cases LT network allows load shifting allows on-site repair of DTRs with minimum downtime. However, in the event of 'Failure', the cost involved in replacement and refurbishment of DTRs is significantly large owing to larger footprint and capacity. Following are some characteristic features of the DTR population of CESC Limited:

1. Over 8500 in number and mounted on pole structures/ outdoor plinths.
2. Comprises of DTRs with capacity 315kVA, 400kVA & 500kVA.
3. Comprises of both dry-type & oil cooled DTRs.
4. Equipped with AMR-enabled / Smart meters.
5. Fed through an HT network of insulated underground cables.

The utility over time has evolved its practices to suit its characteristic population of DTRs, with the current focus being overall health alleviation through 'Asset Management'.

Necessity of Asset Management for Distribution Transformer

The population of Distribution Transformers in any utility is huge. In CESC's context, these are over 8500 in number and scattered over the entire licensed area.

Since the per unit cost of these assets is relatively less, opting for a Time Based Maintenance (TBM) / Preventive Maintenance (PM) is often uneconomical. This calls for a shift from the conventional 'Maintenance' philosophy to the 'Asset Management' philosophy. 'Asset Management' encompasses measures targeted at the overall health alleviation of the entire population and enhancement of the capability of assets to survive anomaly.

Identification of such measures requires the analysis of failures to make informed decisions regarding the proposed changes.

Analysis As An Integrated Part Of Asset Management

Taking the Asset Management philosophy forward, every decommissioned DTR is brought back to the utilities own godown for necessary inspection. Only after thorough inspection process further action is finalized based on the winding & accessories condition. In case of core / winding failure, which is irreparable at own works, is then goes through further investigation to identify the root cause of the failure.

The root causes and its historic statistical data is then analyzed further to identify the following-

i) Relation of the root cause to installation, operation & maintenance practice.

ii) Annual contribution & overall contribution of the root cause to DTR failure.

iii) Other / secondary effects and possibilities of condition monitoring.

These information acts as "Asset Knowledge Enablers" of "DTR Asset Management Process".

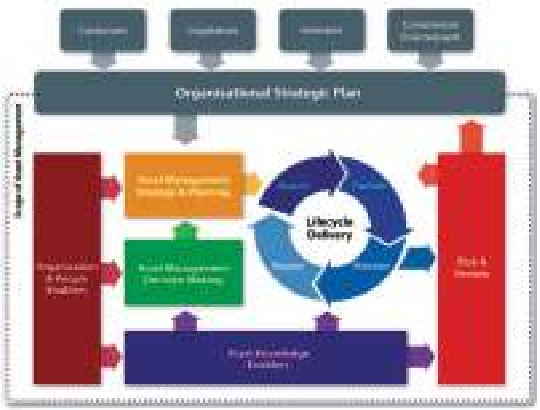


Figure 1: Asset Management Process

This "Asset Knowledge Enabler" helps to upgrade / modify the overall asset management process through

i. Modified DTR specification.

ii. Modified installation and O&M practice.

iii. Modified condition monitoring methods.

iv. Modified asset retirement policy.

Causes Of Dtr Failure And Impressions On Core Coil Assemly (Cca)

The analysis of failures overtime has presented conclusive evidences of failure due to the following reasons. In some of these events, a repetitive impression is observed on the CCA.

Natural Ageing- DTRs after running for >25 years under optimal conditions are susceptible to failure owing to natural degradation of paper insulation. Under such circumstance paper insulation of the entire winding appears equally brittle and failure initiates from the HV winding through inter-turn short circuit within coils.

Figure 2: Failure due to natural ageing

Direct Water Ingression- Water ingression is common through holes on rusted conservator tops & loosened / damaged gaskets on transformer tank. Water being denser than oil tends to settle at the bottom and gets absorbed by the paper insulation of the bottom coils making the locus of failure centralized at the bottom coils of HV winding.

Figure 3: Failure due to direct water ingression

Figure 4: Rusted Conservator Top causing water ingression

Overloading- This accounts for failures where the DTRs failed while operating under overload. The loading status is confirmed through the Smart Meters placed with the DTRs. Such failures occur when the hottest-spot temperature rise exceeds the limiting value for that particular class of insulation. These are more common in dry-type transformers as compared to oil-type DTRs due to the low overload withstand capability of the Dry-type DTRs[3]. The failure is located towards the top coil and initiates from the LV winding as expected due to the natural circulation of oil/air from bottom to top with the top being the hottest.

Figure 5: Failure due to overload

Accelerated ageing- Following factors contribute to the accelerated ageing[4] of paper insulation:

i. High Moisture inside DTR- Occurs while operating in largely humid environment with saturated breathers. With high moisture content, the high rate of pyrolysis can lead to faster deterioration of solid insulation. The solid insulation aging rate can go up to 25 – 30 time higher with respect to the natural speed. Additionally bubble formation or condensation may cause acute insulation failure.

ii. Overheating- Can be caused by short term overloading / choked cooling circuit / oil leakage from bushing / oil pilferage leading to falling of oil level below radiator levels resulting in loss of circulation of oil. Under each of these circumstances, the locus of failure is towards the top coil.

Figure 6: Accelerated ageing on account of low oil level

In-tank Flash- In tank flash is often associated with flashover at accessories placed inside the main tank like tap-link board, Riser connections, HT isolator (special cases in CESC Ltd.) etc. In situations where these cause irreparable damage to the windings / paper insulations. In most of the cases, the high temperature generated by the in-tank flash damages the insulating papers. In some cases molten coppers / other metallic particles falls into the active winding resulting to subsequent failure.

Figure 7: In-tank flash caused by tap-link board failure.

Mechanical failure- Mechanical failure occurs due to poor short-circuit withstand capability[5] of CCA and occurs while feeding a fault in close vicinity of the downstream network. This is often accompanied by axial and radial deformation of windings/ core or both. In most of the cases, the tapped winding gets affected first.

Figure 8: Failure after repeated fault in LT feeder

Winding hotspot - Improper brazing at coil/tap connections leads to hotspot. Failure in such cases is localized with melted copper.

Figure 9: Failure due to Hotspot at coil connections

Core Failure- Use of high loss core leads to melting of varnish and short circuit between laminations, further increasing the losses. Eventually, this leads to failure of LV winding.

Figure 10: Core Displacement

Apart from this there are certain manufacturing defects like zigzag placing of coil spacers, use of poor grade of conductor, winding of coils with insufficient pressure etc. that may lead to failure in the long run. Ingression of external entities through explosion vent, falling of rust particles from rusted conservator tops etc. might also lead to failure.

Another very common cause of failure is due to lightening impulse/ surges. However, in CESC's context, this isn't significant as almost the entire HV distribution network comprises of insulated underground cables.

Modifications of DTR Asset Management process based on individual Identification and / or Statistical Analysis

The adopted methodology for DTR asset management process modification can be explained through the following process flow-diagram.

Presently during inspection of site returned DTRs it is concluded first if the core / winding is damaged or not. In case of accessories failure only, the DTR is repaired within the own works. On the contrary, if the core / winding is damaged, the said DTR goes through detailed investigation to confirm primary root cause before being sent to the repairer for necessary repairing.

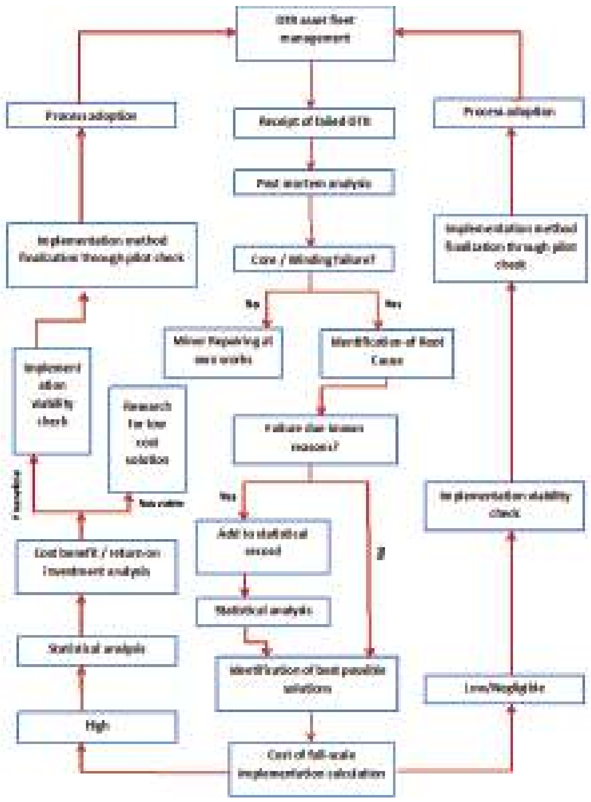


Figure 11: Process Flow Diagram

After identification of primary root cause & subsequent statistical analysis, possible preventive actions & their cost of implementation is finalized. If the cost of implementation is found to be low then subsequent viability check, pilot implementation is done. If found to be sustainable then this is incorporated into the DTR asset management process. On the other hand, if the cost of implementation if found to be high, then the cost benefit analysis is done. If the Return on Investment (ROI) is acceptable, the process is adopted to be a part of fleet management through viability check & pilot implementation.

As an outcome of the improved asset management practice, the percentage failure contribution of different root causes varies with time.

Examples and Experience Sharing

Modified radiator position

Accelerated aging of DTR winding caused by cooling circuit choked was one of the major concerns. The primary cause was oil leak from DTR bushing resulted into oil level below bushings. Therefore, in a DTR if the top radiator header is above the bushing level, the natural oil circulation gets affected when the oil level drops below bushing level. In order to prevent such incident both new & repairing spec mandated the top radiator header below bushing level since 2005.

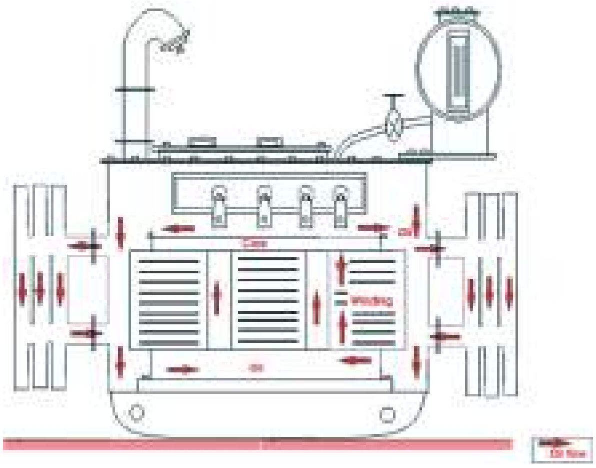


Figure 12: After Modification

Modified location of conservator pipe & vent pipe

A significant quantity of DTR found failing due to rust / foreign particles falling of the core coil assembly (CCA) through conservator pipeline and vent pipe. To prevent this, the conservator pipeline and vent pipe has been specified to be placed at a corner of the main tank top cover. Additionally, the conservator pipeline aperture at the main tank top cover is equipped with a deflector plate.

Figure 13: Conservator & Vent Pipe

On-site painting of DTRs

Substantial number of DTR failed during rainy seasons due to water ingression inside main tank. In most of the cases, the water penetrated through hole on metallic parts developed due to rusting. In order to prevent such incidents, following process has been incorporated-

a. New / repaired DTR painting quality check.

b. Identification of rusted DTRs through condition monitoring.

c. On-site painting of rusted DTRs.

Evolution of tap-link board & shift to tap-less winding

In tank flash leading to damage of windings was observed to be resulting from a short circuit at tap link board or sludge accumulating and creating a short circuit path. In order to prevent this, the design was modified to keep the tap-link board at an angle to prevent sludge accumulation. It was also observed that tap-leads coming out of common conduit were more prone to failure, following which singly insulated tap-leads with support. However, with significantly reduced tap changing requirement, the utility opted for a tap-less design aiming at better coil binding strength and an elimination of all tap-link board related failures.

Apart from these, the utility focused on developing a robust manufacturing & refurbishment quality control process that includes:

a. Design review

b. Material quality inspection

c. Stage inspection

d. Routine tests & type tests

The impact of these changes could be visualized in terms of the lowered failure rate, i.e., less than 0.4% of the entire population in 2022-23 from about 1.2 % in 2012-13. Contribution of different factors towards failure have also changed allowing the utility to prioritize the actionable areas and measures.

Parameters	2012-13	2022-23
Natural Ageing Only	6%	28%
Water Ingression	22%	19%
Overloading	31%	9%
Accelerated ageing	17%	9%
Manufacturing Defect	3%	9%
In-tank Flash	8%	6%
Mechanical Failure	3%	6%
Winding Hotspot	2%	6%
Foreign object	7%	6%
Core Insulation Failure	1%	0%

Modern Solutions for Additional Impact

With the evolving technological scenario, the utility has shifted its focus to data driven solutions. In order to enable this, the first step has been incorporation of Smart Meters to the entire DTR population. This in turn has facilitated a geographical mapping of sources and identification of the ones operating beyond their capacity and the ones running underloaded. With proper network planning, the utility has been able to lower the failures occurring on account of overload. Apart from this, it has been able to build an extensive asset management system to track the entire lifecycle of the asset including its operation and maintenance. The inputs are being used for taking decisions regarding on-site repair/ replacement/ refurbishment of the asset.

Additional projects like 'IoT based Remote Monitoring' of certain parameters like oil level, temperature & humidity inside various chambers have been implemented at strategic locations with the aim of preventing failures due to high moisture ingression etc.

Conclusion

According to the latest figures, the winding failure percentage of the utility in the past few years has been significantly low, less than <0.4% of the entire population. One of the aspects that has contributed to this, certainly has to be its approach towards the postmortem analysis of failed DTRs and subsequent follow-up for alleviation of root-causes. Switching from the conventional 'Maintenance' philosophy to 'Asset Management' has kept its operations economical even with no significant revision in tariffs over the past few years.

In the recent 'CEA Guidelines on O&M of Distribution Transformers', these practices have been reiterated.

Thus, it can be concluded that postmortem analysis of DTR winding failure must not be considered as a separate entity in the asset lifecycle but an integrated part of the essential 'Asset Management'.

Path Forward

With significant availability of past data, the utility is aiming to develop solutions for 'AI & ML Based Dynamic Health Indexing of DTRs' that not only accounts for the operating conditions of DTRs like loading, actual age etc. but also additional inputs like the performance of DTRs of a particular make & lot. This will enable failure prediction with greater accuracy allowing the utility to plan its expenditure & investments. A primary model in pilot from has been developed and its accuracy is being monitored.

Since the field presents huge potentials of saving, greater efforts need to be put in to extract those.

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Guest Article

Importance of Electrical Safety in eMobility

The authors elucidate upon safety as an imperative element to the concept of eMobility

In India electrical safety monitoring solution in electrical systems in general was always an option and add-on suiting the budget. It was not an integral part of electrical systems design and was at the mercy of mandatory regulations and legislations. It was and is in many instances considered as an additional cost and kept in abeyance.

However, with exposure to global quality requirements, international industrial standard recommendations and with experience in real life electrical hazards and accidents there is a change in attitude and perception. Further complexity in design calls for inclusion of electrical safety monitoring solutions as an integral part of electrical systems design, installation and maintenance. eMobility ecosystem which includes eVehicles and charging infrastructure including storage batteries by its intrinsic electrical power use come under the purview of requirement of mandatory reliable electrical safety solution for asset and human safety.

Importance of electrical safety in e-mobility

Electrical safety is crucial in e-mobility because electric vehicles (EVs) are powered by high-voltage batteries and electric motors, which pose a potential electrical hazard to drivers, passengers, and maintenance personnel and loss of infrastructure property. Safety measures must be in place to prevent electric shock, fire, and other hazards associated with high-voltage systems. Also continuity of power supply is of utmost importance for ensuring availability of the system.

Battery safety

The high-voltage batteries used in EVs are potentially dangerous, and any damage or malfunction can cause a fire or explosion. Therefore, the battery must be designed, manufactured, and tested to ensure its safety. Additionally, proper installation, maintenance, and storage are necessary to prevent accidents.

Charging safety

EV charging infrastructure requires proper installation design including grounding and protection from electrical faults. Safe charging stations must be installed in accordance with local regulations and international standards to avoid electric shock or fire.

Vehicle safety

The high-voltage electrical system in an EV must be designed to prevent electric shock to occupants in the event of an accident. Further insulation faults and leakages may cause fires endangering the life of occupants and loss of asset. Safety features such as automatic disconnect of the battery in the event of a collision and monitoring of insulation of high-voltage components can help prevent accidents.

Maintenance Safety

Maintenance personnel must be properly trained to handle high-voltage electrical systems, and safety protocols must be in place to prevent accidents during repairs or maintenance.

In summary, electrical safety is critical in e-mobility to ensure that EVs are safe for drivers, passengers, maintenance personnel, and the environment. Proper design, installation, and maintenance of high-voltage systems can help prevent accidents and ensure the safety of all stake holders.

e-Mobility Electrical Installation Design

The electrical power system design with its ground/chassis referencing plays a crucial role in the inherent safety of EV and charging infrastructure. The type of ground referencing of electrical power source with respect to ground/chassis plays an important role in ensuring safety. There are 2 major types of grounding used in electrical installation. Grounded and Ungrounded. In grounded system the electrical power source reference pole is connected to ground/chassis. In an ungrounded system the electrical power source is not connected in any way to ground/chassis and totally floating and insulated from ground/chassis.

The use of ungrounded system is the cornerstone in the electrical design of e-Vehicle and charging infrastructure in eMobility ecosystem. Ungrounded electrical system if designed intelligently is inherently safe against electrical hazards namely electrical shock and fire. Further ungrounded system increases continuity and availability of electrical system. For encashing the benefit of ungrounded system the first insulation to ground fault should be monitored, detected and annunciate to user. For this function some form of high accuracy and sensitive online insulation leakage monitoring system should be deployed. IEC standards recommend the use of such insulation monitoring device for 24x7 monitoring of insulation in the eV and their chargers.

Which is the best insulation monitoring method in E vehicles?

There are several insulation monitoring methods used in electric vehicles (EVs) to ensure electrical safety. The best method for insulation monitoring in an EV depends on factors such as the type of vehicle, the electrical system, and the specific safety requirements.

Some commonly used insulation monitoring methods in EVs:

Legacy cheap passive method

old passive method historically originated in telephone DC power distribution system and later spread into various electrical installations mostly DC supplies. It uses a voltage divider series resistance circuit connected across the 2 poles of power source with the midpoint connected to ground/chassis. The voltage unbalance between each pole with respect to ground is monitored for any insulation fault. However this passive method is not very accurate and sensitive to high resistance insulation faults for advance prediction and does not detect symmetrical faults. Further this passive measurement technology is susceptible to electrical noises and does not provide reliable and stable reading and causes spurious alarms. Not recommended by current IEC standards.

Online insulation monitoring

online insulation monitoring continuously measures the insulation resistance of the electrical system and provides real-time information about the condition of the insulation. This active measurement method is more sophisticated and can detect high resistance faults earlier than passive insulation monitoring or any

other method of Insulation monitoring. Further this Online insulation monitoring is commonly used in high-voltage systems where the consequences of insulation failure can be severe. Recommended by current IEC standards.

Is Online insulation monitoring better than passive insulation monitoring in e vehicles

Online and passive insulation monitoring are two methods used in electric vehicles (EVs) to detect insulation faults and ensure electrical safety.

Passive insulation monitoring involves periodically measuring the insulation resistance in terms of unbalance voltage of the electrical system circuit with respect to ground and to detect any changes, which can indicate an insulation fault. However, in the case of symmetrical faults, this will not show any faults as the system is still balanced thereby leading to a potential hazard of electric shock, fire, and other associated hazards. This method is commonly used in low-voltage telephone electrical systems and pure AC/DC distribution system without any nonlinear loads and electrical noises and is relatively simple and inexpensive. Not reliable for predictive monitoring.

On the other hand, online insulation monitoring continuously measures the insulation resistance of the electrical system with respect to earth for both asymmetrical and symmetrical including high resistance faults and provides real-time information about the condition of the insulation. This is a widely used method in the European and US market considering the safety of man and machine.

Overall, the best method of insulation monitoring in EVs is online insulation monitoring as it takes care of all the electrical design and installation issues in modern nonlinear electrical systems with presence of high EMI/EMC noises. However, it is expensive compared to all others methods but worth its price considering human and asset safety. As per ARAI, the choice of method depends on the specific requirements of the vehicle's electrical system and the level of electrical safety needed to be based on the voltage levels. However, in general with high voltage, it is desired to have online insulation monitoring taking into account human and asset safety.

What is the importance of Electrical safety in E mobility and its impact on man & machine?

Electrical safety is of utmost importance in E-mobility, as it directly impacts both man and machine. Here are a few reasons why:

Protection of human life: Electric vehicles (EVs) and electric charging stations carry high-voltage electricity, which can be dangerous if not designed properly. In case of an electrical fault, this voltage can cause electric shock, burns, or even death. Proper safety measures need to be in place to prevent such accidents from happening.

Protection of the vehicle

Electric vehicles and their components are sensitive to electrical faults, which can lead to damage to the vehicle's battery, motor, or other electrical components. Proper safety measures ensure that these components are protected, preventing expensive repairs or replacements.

Regulatory compliance

Many countries have specific safety standards that electric vehicles and charging stations must adhere to. Complying with these standards not only ensures safety but also helps manufacturers avoid legal liabilities and financial penalties.

Public perception

Safety is a critical factor in building public trust in electric vehicles. Any accidents or incidents involving electric vehicles can damage the public perception of EVs and slow down their adoption.

Overall, electrical safety in E-mobility is crucial for protecting both human life and the vehicles themselves. By implementing proper safety measures, manufacturers can ensure the safety of their customers and build public trust in electric vehicles.

Benefits of using an Online insulation monitoring system

Early detection of insulation faults

Insulation faults can occur in the electrical components of E-vehicles, such as the battery or motor, and eV Chargers which can lead to unsafe conditions or component failure. Online insulation monitoring can detect these faults early on, allowing for timely repair or replacement before they cause further damage.

Improved safety

Insulation faults can create hazardous conditions for E-vehicle occupants and charger users and surrounding individuals. Early detection and resolution of these faults through online insulation monitoring can prevent accidents and increase overall safety.

Reduced maintenance costs

Insulation faults can cause costly repairs and replacements if left unaddressed. Online insulation monitoring can catch faults early on, reducing the need for extensive repairs or component replacements and lowering overall maintenance costs.

Increased vehicle efficiency

Insulation faults can cause electrical systems to operate less efficiently due to leakages, leading to reduced vehicle performance and range. Online insulation monitoring can identify and correct these faults, improving the efficiency of the vehicle and maximizing its range.

Fire safety

Insulation leakage and faults may initiate fire in case of short circuits endangering the life of occupants in eVehicles and protect against damage of eV. Similarly it will enhance fire safety of eVehicle chargers.

Data tracking and analysis

Online insulation monitoring systems can provide data on the insulation resistance and overall health of the electrical components of the vehicle. This data can be tracked and analysed over time, providing valuable insights into the performance and maintenance needs of the vehicle.

Overall, online insulation monitoring in E-vehicles and e-vehicle chargers can offer numerous benefits, including improved safety, reduced maintenance costs, and increased efficiency. By identifying insulation faults early on, E-vehicle owners can ensure their vehicles operate safely and efficiently over the long term. ■

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Effect of Site Conditions on Performance of Energy Efficient Motors

The authors elaborate upon how correct selection and actual site conditions on motor performance affects the level of energy efficiency in the performance of motors

The E&E industry today is well aware that the use of energy efficient motors is imperative for optimum utilization of energy for its operations.

We are now at a stage when all users are aware of the benefits of using energy efficient IE3/ IE4 motors and are ready to upgrade to motors of higher efficiencies. However, in order to achieve planned goals of energy saving through the use of such motors, it is important for users to understand the effect of correct selection and actual site conditions on motor performance. Failing to do so could nullify the benefits offered by the adoption of energy efficient motors.

This paper covers the impact of site conditions on the starting and running performance of 3-phase induction motors. The paper considers abnormal operating conditions such as variations and unbalance in electrical supply conditions as well as variation in loading of induction motor, to explain their impact on the motor performance.

The declared performance parameters of motors, like efficiency, power factor, speed, current, starting torque and starting current, refer to rated supply conditions and at rated load. Very often it is observed that the motors are not operated on rated supply condition of voltage and frequency and are often under loaded. It is necessary to understand the impact of these variations on motor performance, especially efficiency, to ensure optimum utilization of motors.

Abnormal conditions often prevalent in industry are:

A) High/ Low supply voltage

B) High/ Low supply frequency

C) Combined voltage and frequency variation

D) Unbalance in supply voltage

E) Harmonics in supply for VFD operation

F) Partial load operation

G) High site ambient temperature

The Indian standards on 3-phase motors allow voltage variation of $\pm$10% and frequency variation of $\pm$5% in supply conditions. The allowed combined variation of voltage and frequency is limited to $\pm$10%.

High/Low supply voltage

When the motors operate on under-voltage, they draw higher current for a given load torque. This reduces motor efficiency, increases I^2R losses and the heat generated in the motor.

Figure -1 shows the variation in full load efficiency with respect to supply voltage.

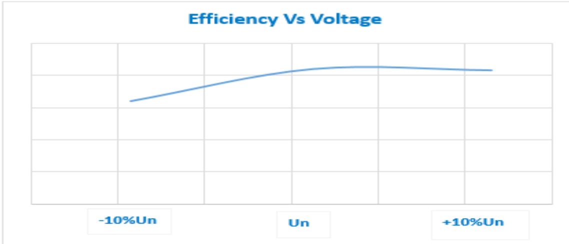

Figure-1 – Efficiency vs Voltage

Thus the full load efficiency reduces for under-voltage. This also results in drop in starting torque and motor speed. Over-voltage leads to drop in power factor and increase in starting current of the motor due to increased flux densities in yoke, teeth and air gap.

Table-1 and Figure -2 shows the effect of supply voltage variation on other performance parameters – power factor, speed (RPM), starting torque and starting current of a 15 kW 4 pole motor.

	PF	RPM	T_s / T_n	I_s / I_n
Rated voltage (Un)	0.83	1465	220%	650%
-10% of Un	0.86	1457	176%	542%
+10% of Un	0.78	1471	268%	744%

Table-1

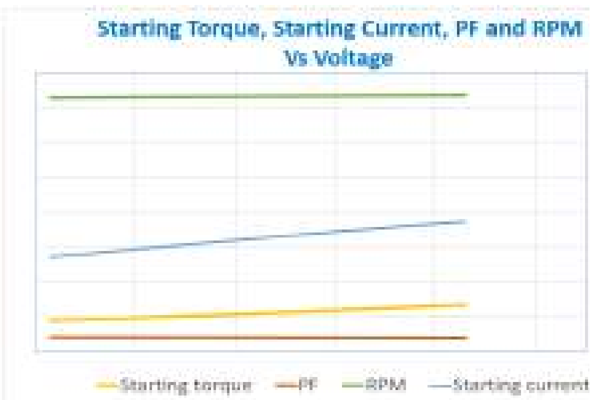

Figure 2

High/Low supply frequency

Table-2 shows effect on motor performance when operated on frequency lower or higher than its rated frequency. Operation on lower supply frequency reduces full load efficiency and power factor.

	Eff	PF	RPM	T_s / T_n	I_s / I_n
Rated frequency (fn)	92.1	0.83	1465	220%	650%
-5% of fn	91.8	0.81	1391	233%	660%
+5% of fn	92.15	0.84	1539	208%	633%

Table-2

Figure-3 shows variation of performance values with respect to supply frequency.

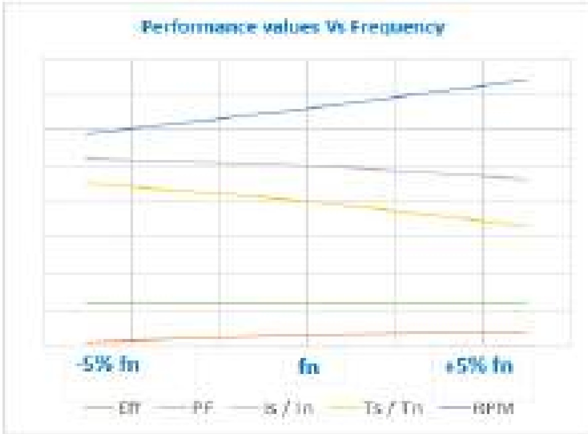

Figure-3

Combined voltage and frequency variation

The effect of combined voltage and frequency variation on motor performance is illustrated in Table-3.

	Eff	PF	RPM	T_s / T_n	I_s / I_n
Rated voltage & frequency	92.1	0.83	1465	220%	650%
-5% Un and -5% fn	91.8	0.84	1388	209%	614%
-5% Un and +5% fn	92.5	0.85	1534	187%	581%
+5% Un and -5% fn	92.0	0.79	1395	258%	711%
+5% Un and +5% Fn	92.3	0.82	1542	234%	685%

Table-3

Unbalance in supply voltage

The voltage unbalance refers to supply conditions wherein the line-to-line voltages are not same in all the phases. This results in unbalanced currents in stator windings. This condition induces circulating current leading to higher stator I^2R losses, higher slip, higher rotor copper losses, increased heating and reduction in motor efficiency. The increased temperature rise and reduced torque greatly influences output of the motor.

Under these conditions, in order to maintain safe operation of the motor, it becomes necessary to reduce the load on motor by a factor (deration factor) as given in Figure-4. The unbalance in supply system also induces torque pulsation and increased vibrations.

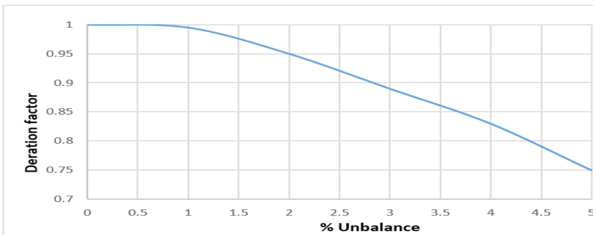

Figure 4

Table-4 shows tested value of line current, motor losses and temperature rise of a mid-sized motor. The voltage unbalance of 5% can cause current unbalance of the order of 25% to 31%.

Voltage	Line Currents (A)	Current unbalance	Total losses (W)	Temp. rise (°C)
Un, Un, Un	45, 45, 45	0%	2326	65
-5%Un, Un, +5%Un	36, 42, 64	31%	2677	94

Table-4

Harmonics in supply for VFD operation

Harmonics in supply source has several effects on induction motor performance.

Presence of harmonics in supply, results in higher losses in motors by 15-20%, resulting in heating of motor. The load on motor is to be de-rated or reduced as per Figure-5.

Deration factor for harmonics

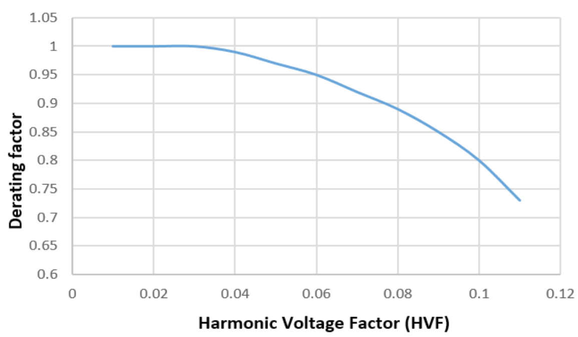

Figure 5

Presence of harmonics also leads to reduction of torque and torque pulsation

The HVF (Harmonic Voltage Factor) is defined as follows:

$$\sqrt{\sum_{n=5}^{n=\infty} \frac{U_n^2}{n}}$$

n is order of odd harmonics, not including those divisible by 3.

V is per unit magnitude of voltage at n^{th} harmonic frequency.

Partial load operation

The efficiency of the induction motor varies with the load on the motor. For an appropriately designed motor, the efficiency may remain same for 60% to 100% of rated load; however, it reduces considerably for motor loaded for 50% or below. The curve-5 is a typical efficiency vs load curve for a high efficiency motor.

The selection and the margin between motor kW and load BkW are important considerations for understanding energy consumption. It is recommended to select the motor kW such that motor load remains between 60% to 85% rated motor kW.

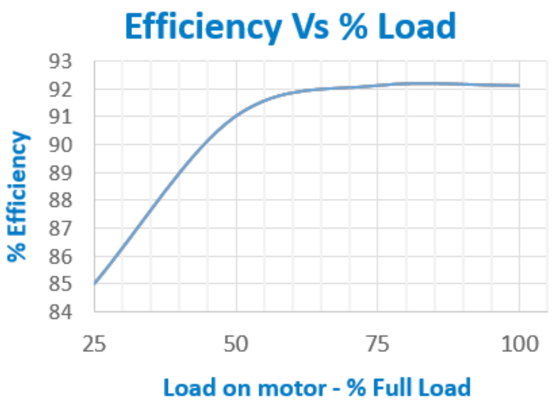

Figure 6

High site ambient temperature

The stator winding in 3-phase motors are normally made of copper. The increase in ambient temperature increases resistance of the motor winding. This leads to increased I^2R losses and reduced efficiency.

It is generally established that operation on ambient temperature higher than designed ambient temperature considerably reduces the insulation life. Going by approximation, every 10°C rise in winding temperature can reduce insulation life by 50%.

Conclusion

Based on the above study, it is clear that site supply and load conditions play a major role in achieving desired performance in motors. The user should continuously monitor and control the site conditions in order to maximize the operational efficiency of their processes.

It is our experience that several times customers and users of high efficiency motors do not get the expected energy savings. On investigation, we found that the actual site supply conditions were quite different from the specified values. In such cases, users should decide to use custom made motors meeting their specific site conditions to ensure best results. ■

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Solutions For E-Mobility

The author presents a study of the topology in a charging station

E-mobility, the shift towards electric vehicles, is no longer a futuristic mirage but a rapidly approaching reality. However, among various challenges, the challenge "charging infrastructure or charging station" hamper its widespread adoption. Electric Vehicle Supply Equipment (EVSE) or charging station is a piece of equipment that supplies electrical power to an electric vehicle (EV) to recharge the vehicle's batteries. EVSE systems include the electrical conductors, related equipment, software, and communications protocols that deliver energy efficiently and safely to the vehicle.

The charging stations are of two types: AC charging stations and DC fast chargers. In AC charging station, power is supplied to the onboard charger with an AC to DC converter (mounted on electric vehicle). The DC charging station may be of different levels. Level 1 chargers has power rating upto 15 kW with voltage levels greater than or equal to 48 V. Level 3 chargers have power rating upto 400 kW with voltage levels in the range of 200 to 1000 V. The DC charging station is directly interfaced with the battery of the vehicle bypassing the onboard charger. Figure 1 shows a typical block diagram of a DC charging station.

DC fast charger consist of two stages i.e. AC to DC converter stage (Rectifier) and DC to DC converter stage (Chopper). There are number of topologies and circuits to achieve the required AC to DC conversion. Below discussed are few topologies along with their merits and demerits based on the simulation results in Matlab Simulink and circuit.

A. Topology 1: SCR based full bridge controlled rectifier:

This topology consists of a three phase, 6 pulse SCR based rectifier. A three phase transformer is used to isolate the three phase source from the power converter. A PID loop can be used to strictly follow the current in CC and voltage in CV profiles which will directly affect the SCR firing angle. Benefits of this topology includes ease of implementation, no need of a DC-DC converter stage, robustness of the design, SCRs capability to handle large amounts of voltage and currents and reduced complexity in firing of SCRs.

Simulation results shows more than 3% ripple in battery current and low input power factor. Another demerit of this topology is that pulse charging scheme cannot be adopted as SCR remains conducting till zero crossing of the input ac signal.

B. Topology 2: Twelve pulse diode bridge rectifier followed by full bridge DC – DC converter:

In this topology, three phase AC is rectified by using a 12 pulse diode bridge rectifier. Three phase isolation transformer with two secondary windings (one in delta and other in star connection) is used to generate twelve pulse. The two diode bridges are connected in series in order to reduce the current stress. The rectified DC voltage is processed by the inverter bridge, high frequency transformer, high speed diode stack and filter to obtain the required charging voltage.

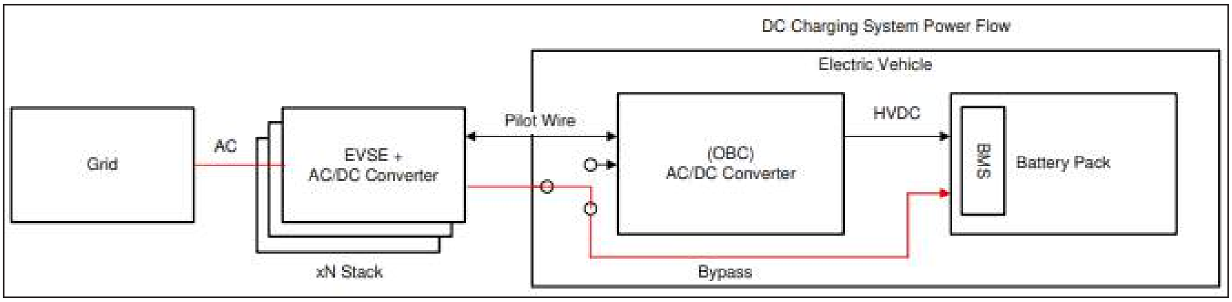

Figure 1: DC charging station

In this topology current ripple gets reduced to less than 0.5% as it has better control derived by high switching frequency of full bridge DC-DC converter. Input current harmonics are also low due to inclusion of 12 pulse diode bridge rectifier. But the design requires high frequency transformer and high frequency diodes to operate. Also there are two transformers which makes it costlier.

C. Topology 3: Six pulse Thyristor bridge rectifier followed by full bridge DC – DC converter:

In this power scheme instead of diode bridge which is uncontrolled rectifier, a six pulse SCR based controlled rectifier is used for the rectification stage. The DC to DC full bridge converter part remains same as above topology.

Here as per the battery voltage requirement, the DC voltage can be changed (which was fixed in the previous topology) by varying the firing angle of the SCR. Thus it gives a two way control. But the input current has more harmonics and input power factor is low compared to previous topology. In this topology in order to have control over DC link voltage, SCR bridge is used at the primary stage. input power factor is low due to 6 pulse thyristor bridge.

D. Topology 4: Twelve pulse diode bridge rectifier followed by midpoint clamped three level buck converter:

In this power scheme a 12 pulse diode bridge rectifier is utilized to generate the rectified DC voltage. The next stage here comprises of a three level buck converter. This three level buck converter with the help of two capacitors reduce the voltage stress on each switch by half. A dual PID loop is implemented in the simulation. The outer PID loop maintains the battery charging voltage and the inner current loop maintains maximum current. Depending on the current requirement the duty cycle of the two IGBT's are adjusted.

This topology has following advantages:

- Less number of switches
- Higher input power factor due to 12 pulse rectifier
- Reduced current stress on the rectifier diodes as two rectifiers stages are connected in series
- Reduced voltage stress on buck converter IGBTs as voltage across them is halved by the use of midpoint clamped capacitors
- Reduced inductor size
- Control part is simplified as only two IGBTs are to be controlled
- Economical design

In this topology due to the use of 12 pulse diode bridge rectifier input power factor is high. Also due to the use of midpoint clamped three level buck converter the current and voltage stress is reduced by half as each power switch is exposed to half the voltage which leads to more economical design.

Based on the comparison of all the topologies it can be concluded that topology 4 comprising of twelve pulse diode bridge rectifier followed by midpoint clamped three level buck converter is the most suited for EV charging application due to reduced voltage and current stress, thermal stress, reduced complexity and better control over battery parameters.

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Compensation Methodology for Operating a Thermal (Coal) Generating unit below 55% Minimum Power Level

Introduction

Penetration of large-scale renewable generation in the grid is bringing a new set of challenges in the power sector. The inconsistency and intermittency of solar & wind power has to be managed by other sources of generation in order to ensure the grid security, reliability and stability. Thus, huge flexible power is required for the balancing of grid from sources like pump storage system, thermal power plants, battery storage system etc. Thermal generation capacity constituting about 54% of total installed capacity is the dominant part of power generation in the country and more than 70% of country's energy demand is being met from thermal generation, Thus, lowering of minimum power loadof existing coal-fired power plants along with ramp rate capability (ie flexible operation)is very much essential for handling the instability & intermittency of renewable generation and ensuring security, reliability of power supply. Further, the cost of flexible power from thermal fleet is very less compared to power from battery storage system.

In this context CEA has also notified a Regulation regarding Flexible operation of coal based Thermal Power Generating Units on 30.1.2023.

Measures required for achieving lower Minimum Power Load

For achieving minimum power load (40%) and higher ramp rate, Coal based power plants may require few modifications by way of improved control systems etc and also required to be compensated for the loss of life and increased variable cost due to regular part load operation.

The primary focus of the utility shall have to be on the existing control system optimization and improvements in some of the areas like achieving automated control operation which includes proper tuning of operation so as to avoid temperature and pressure excursions. Control optimization shall also include main/ reheat steam temperature control, boiler feed water recirculation control, flue gas temperature control. Better combustion control include, optimum fuel to air ratio, fuel to load coordination, furnace pressure control, burner tilt control and proper flame monitoring at low loads are essential. Condition monitoring of boiler and turbine, flame monitoring is crucial from the safety point of view. To reduce the running cost of the unit at low loads, the optimization of auxiliaries is also important. The above measures are essential for a unit and may require anestimated capital investment of Rs 10 crores. In case of very old units which have not upgraded their plant control and instrumentation system previously, the estimated capital investment will beRs 30 crores depending on the retrofit.

Proposed Compensation

The compensation mechanism has been prepared based on the studies carried out by various agencies(CEA's report "Flexibilisation of coal fired power plants"published in Feb 2023). The power plant needs to be compensated for both fixed cost due to infusion of capital investment,increased O & M cost, variable charges due to efficiency loss at part load operation and additional oil consumption due to increasedEquivalent Forced Outage Rate (EFOR).

A. Fixed Cost

a) Capital Expenditure

One-time expenditure to be incurred in retrofitting of various measures to make the plant capable of low load operation.

i. In case of old units (commissioned before 01.01.2004) which have not upgraded their plant control and instrumentation system previously, capex requirement may around Rs 30 crores for each unit.

ii. It is estimated that measures essential, to operate at 40% load may require anestimated capital investment of aroundRs 10 crores for each unitcommissioned on or after 01.01.2004and except units covered under para3(a)(iv).

iii. Unit will be eligible for increased fixed tariff irrespective of actual operationonce measures are implemented and exhibits desired low load operation.Considering five (5) years payback period the impact has beenestimated as under Table-I.

Table-I

		For units in Para 3(a)(ii)		For units in Para 3(a)(i)	
Unit Size (MW)	Recovery period (years)	Total Capital cost (Rs Cr)	Increase in fixed charge per annum (Rs. Cr.)	Total Capital cost (Rs Cr)	Increase in fixed charge per annum (Rs. Cr.)
200	5	10	2.55	30	7.65
500	5	10	2.55	30	7.65
660	5	10	2.55	30	7.65
800	5	10	2.55	30	7.65

iv. As per theRegulation 8 (11) of Central Electricity Authority (Technical Standards for Construction of Electrical Plants and Electric Lines) notified on 20.08.2010,pulverised fuel combustion-based steam generator shall not require oil support above 40% unit load.

Therefore, measures/ retrofits are not required in these units for operation upto 40% load. However, as per the OEM few measuresare requiredto be implemented for regular 40% load operation of subcritical units though the same (40%) was demonstrated during PG test.Considering above it is proposed a maximumcapital investment of Rs.6 crores may be allowed to the **subcritical generating units** where investment approval received on or after 01.01.2011 and the impact is calculated as underTable-II:

Table-II

		For units in Para 3(a)(iv)	
Unit Size (MW)	Recovery period (years)	Capital cost (Rs Cr)	Increase in fixed charge per annum (Rs. Cr.)
200/250	5	6	1.53
500	5	6	1.53
600	5	6	1.53

v. Power plant may be penalised proportionally (Fixed cost) for not exhibiting low load operation at least 85% of time when asked for.

b) O&M cost due to increased Life Consumption (damage costs):

Flexible operation also leads to a higher rate of deterioration of plant's components. This is observed in increased failure rate and more frequent replacement of components. The impact on life of components increases with increase in number of flexible operation instances and also with number of start stops the unit undergoes in a year. As a result, the operation and maintenance cost are significantly higher in units operated on a daily or weekly start-stop basis.Based on CEA Report "Flexibilization of coal fired power plants" the increase in annual O&M cost has been considered as 9%, 14% and 20% of O&M Cost at 50%, 45%, 40% loading respectively **(Table-III).**

The increase in O&M cost shall be allowed on the basis of plant actual low load operation.Unit will be eligible for full compensation if the unit participated in flexible operation minimum 310 days (85% days) in a year.For less than 310 days low load operation compensation may be calculated proportionately.

Table-III

Capacity (MW)	Loading (%)	Increase in O&M (%)	Proposed increase in O&M cost (Rs Cr.)
200	<55 to 50	9.00	6.58
	<50 to 45	14.00	10.23
	<45 to 40	20.00	14.62
500	<55 to 50	9.00	11.23
	<50 to 45	14.00	17.47
	<45 to 40	20.00	24.97
660	<55 to 50	9.00	13.34
	<50 to 45	14.00	20.76
	<45 to 40	20.00	29.66
800	<55 to 50	9.00	14.55
	<50 to 45	14.00	22.64
	<45 to 40	20.00	32.35

B) Variable Cost

a) Cost due to increase in Net Heat Rate: It has been observed that the extent of deterioration in Net Heat Rate depends on the percentage unit loading. Units running minimum power load below 55% shall be additionally compensated in Electricity Charge Rate (ECR) to the extent of Net Heat Rate (NHR) deterioration. Based on the actual study/test conducted at few coal based power plants andHeat Balance Diagram (HBD) reports of major OEMs (BHEL/GE/Siemens) on unit size Net Heat Rate degradation, compensation has been proposed in variable part of tariff considering coal price Rs 2000.00 per ton (estimated average cost of coal at pithead plants), Rs. 3300.00 per ton (estimated average cost of coal at non-pithead plants) and is as in Table-IV

Table-IV

Capacity (MW)	Loading (%)	Net Heat Rate increase (%)	Variable Tariff increase (%) at coal price Rs 2000/ton	VariableTariff increase (%) at coal price Rs 3300/ton	Proposed variable Tariff increase (%)
200	<55-50	10.00	9.88	9.94	9.91
	<50-45	13.00	12.84	12.92	12.88
	<45-40	16.00	15.81	15.90	15.86
500	<55-50	10.90	10.76	10.83	10.80
	<50-45	13.60	13.44	13.51	13.48
	<45-40	16.00	15.81	15.90	15.86
660	<55-50	8.70	8.59	8.64	8.62
	<50-45	11.90	11.75	11.82	11.79
	<45-40	14.60	14.42	14.50	14.46
800	<55-50	8.60	8.49	8.54	8.52
	<50-45	12.00	11.84	11.92	11.88
	<45-40	15.00	14.81	14.90	14.86

The variable cost of any plant has been estimated using the formula given below:

Variable Expense (Rs/kwh) = Coal Cost (Rs/kwh) + Oil Cost (Rs/kwh)

Coal Cost (Rs/kwh) =

$$\textbf{Coal Cost (Rs/MT)} \times \left[\frac{\text{Station Heat Rate (kcal / kwh)} - \dfrac{\text{Oil CV (kcal / l) x Specific Oil Consumption (ml / kwh)}}{1000}}{\text{Fuel Calorific Value (kcal / kg)}} \right]$$

$$\textbf{Oil Cost (Rs/kwh)} = \frac{\text{Oil Cost (Rs / kL) x Specific Oil Consumption (ml / kwh)}}{10^6}$$

$$\text{Variable Charge at bus bar (Rs/kwh)} = \frac{\text{Varible Expense (Rs / kwh)}}{(1- \dfrac{\text{\% Aux Consumption}}{100})}$$

b) Cost due to additional oil consumption for additional EFOR (Equivalent Forced Outage Rate): Based on Electric Power Research Institute study report the additionalEFOR due to regular low load operation of thermal generating units may increase specific oil consumption from 0.5 ml/kWh to 0.7 ml/kWh. Therefore, it is proposed to compensate 1.0 paisa/ kWh on account of EFOR.

Note : EOFR – Equivalent Forced Outage Rate is defined the percentage of scheduled operating time that a unit is out of service due to unexpected problems or failures and can no reach full load capacity due to component/ equipment failures.

Likely increase in paisa/ kWh on account of proposed compensation

Sample calculation on basis of the compensation mechanism proposed above and various assumptions are given in Annexure-I.:

i. Total likely increase in tariff considering capital investment of Rs. 30 crores, increase of O&M cost, variable cost and EFOR cost is given in Table-A.

ii. Total likely increase in tariff considering capital investment of Rs.10 crores,increase of O&M cost,variable cost and EFOR costis given in Table-B.

iii. Total likely increase in tariff considering capital investment of Rs. 6 crores, increase of O&M cost, variable cost and EFOR cost is given in Table-C,This is only applicable for subcritical unit'swhere investment approvalreceived on or after 01.01.2011.

Table-A. Likely Incremental Tariff (Rs 30 crores capital investment)

Unit Size (MW)	Loading %	Coal price Rs 2000.00 per ton	Coal price Rs 3300.00 per ton	Fixed Tariff increase (Paisa/kWh)		EFOR compensation (Paisa/kWh)	Total tariff (fixed & variable) increase (Paisa/kWh)	Total tariff (fixed & variable) increase (Paisa/kWh)	Proposed total tariff (fixed & variable) increase (Paisa/kWh)
		Variable Tariff increase (Paisa/kWh)	Variable Tariff increase (Paisa/kWh)	due to increased O&M cost	due to increased capital cost		Coal price Rs 2000.00 per ton	Coal price Rs 3300.00 per ton	
200	<55 to 50	13.68	22.57	6.70	7.68	1	29.06	37.95	33.51
	<50 to 45	17.78	29.34	10.42	7.68	1	36.88	48.44	42.66
	<45 to 40	21.89	36.11	14.88	7.68	1	45.45	59.67	52.56
500	<55 to 50	14.66	24.20	4.57	3.07	1	23.30	32.84	28.07
	<50 to 45	18.30	30.19	7.11	3.07	1	29.48	41.37	35.43
	<45 to 40	21.53	35.52	10.16	3.07	1	35.76	49.75	42.76
660	<55 to 50	11.17	18.42	4.12	2.56	1	18.85	26.10	22.48
	<50 to 45	15.27	25.20	6.40	2.56	1	25.23	35.16	30.20
	<45 to 40	18.74	30.92	9.14	2.56	1	31.44	43.62	37.53
800	<55 to 50	10.65	17.57	3.70	1.92	1	17.27	24.19	20.73
	<50 to 45	14.86	24.52	5.76	1.92	1	23.54	33.20	28.37
	<45 to 40	18.58	30.65	8.23	1.92	1	29.73	41.80	35.77

Table-B. Likely Incremental Tariff (Rs 10 crores capital investment)

Unit Size (MW)	Loading %	Coal price Rs 2000.00 per ton	Coal price Rs 3300.00 per ton	Fixed Tariff increase (Paisa/kWh)		EFOR compensation (Paisa/kWh)	Total tariff (fixed & variable) increase (Paisa/kWh)	Total tariff (fixed & variable) increase (Paisa/kWh)	Proposed total tariff (fixed & variable) increase (Paisa/kWh)
		Variable Tariff increase (Paisa/kWh)	Variable Tariff increase (Paisa/kWh)	due to increased O&M cost	due to increased capital cost		Coal price Rs 2000.00 per ton	Coal price Rs 3300.00 per ton	
200	<55 to 50	13.68	22.57	6.70	2.56	1.00	23.94	32.83	28.39
	<50 to 45	17.78	29.34	10.42	2.56	1.00	31.76	43.32	37.54
	<45 to 40	21.89	36.11	14.88	2.56	1.00	40.33	54.55	47.44
500	<55 to 50	14.66	24.20	4.57	1.02	1.00	21.25	30.79	26.02
	<50 to 45	18.30	30.19	7.11	1.02	1.00	27.43	39.32	33.38
	<45 to 40	21.53	35.52	10.16	1.02	1.00	33.71	47.70	40.71
660	<55 to 50	11.17	18.42	4.12	0.85	1.00	17.14	24.39	20.77
	<50 to 45	15.27	25.20	6.40	0.85	1.00	23.52	33.45	28.49
	<45 to 40	18.74	30.92	9.14	0.85	1.00	29.73	41.91	35.82
800	<55 to 50	10.65	17.57	3.70	0.64	1.00	15.99	22.91	19.45
	<50 to 45	14.86	24.52	5.76	0.64	1.00	22.26	31.92	27.09
	<45 to 40	18.58	30.65	8.23	0.64	1.00	28.45	40.52	34.49

Table-C. Likely Incremental Tariff for units where investment approval received on or after 01.01.2011 (Rs 6 crores capital investment)

Unit Size (MW)	Loading %	Coal price Rs 2000.00 per ton	Coal price Rs 3300.00 per ton	Fixed Tariff increase (Paisa/kWh)		EFOR compensation (Paisa/kWh)	Total tariff (fixed & variable) increase (Paisa/kWh)	Total tariff (fixed & variable) increase (Paisa/kWh)	Proposed total tariff (fixed & variable) increase (Paisa/kWh)
		Variable Tariff increase (Paisa/kWh)	Variable Tariff increase (Paisa/kWh)	due to increased O&M cost	due to increased capital cost		Coal price Rs 2000.00 per ton	Coal price Rs 3300.00 per ton	
200	<55 to 50	13.68	22.57	6.70	1.54	1	22.92	31.81	27.37
	<50 to 45	17.78	29.34	10.42	1.54	1	30.74	42.30	36.52
	<45 to 40	21.89	36.11	14.88	1.54	1	39.31	53.53	46.42
500	<55 to 50	14.66	24.20	4.57	0.61	1	20.84	30.38	25.61
	<50 to 45	18.30	30.19	7.11	0.61	1	27.02	38.91	32.97
	<45 to 40	21.53	35.52	10.16	0.61	1	33.30	47.29	40.30
660	<55 to 50	11.17	18.42	4.12	0	1	16.29	23.54	19.92
	<50 to 45	15.27	25.20	6.40	0	1	22.67	32.60	27.64
	<45 to 40	18.74	30.92	9.14	0	1	28.88	41.06	34.97
800	<55 to 50	10.65	17.57	3.70	0	1	15.35	22.27	18.81
	<50 to 45	14.86	24.52	5.76	0	1	21.62	31.28	26.45
	<45 to 40	18.58	30.65	8.23	0	1	27.81	39.88	33.85

- No additional capital investment is required in the unit size of 660MW and 800 MW units for operating them at 40% load.

Annexure-I

Assumptions

1. General:

i. Auxiliary power consumption (APC): 6.5%,

ii. Average PLF: 60%,

iii. PAF: 100%,

iv. Debt to equity ratio: 70:30,

v. Return on equity: 15.5%,

vi. Interest on loan:10%,

vii. Depreciation rate:5.28%,

viii. Specific oil consumption: 0.5 ml/kWh,

ix. Price of oil-: Rs 35/lt,

x. GCV of oil: 10000 kcal/lt,

xi. GCV of Coal:3800 kcal/kg.

xii. Landing cost of coal

a) Rs.2000.00 per ton (estimated average cost of coal at pithead plants)

b) Rs. 3300.00 per ton (estimated average cost of coal at non-pithead plants)

ii. Weighted average cost of capital for annuity calculations : 10%

2. Unit size 200 MW

O&M Cost Rs 36.56 lakh/MW, Heat rate 2430 kcal/kWh.

3. Unit size 500 MW

O&M Cost Rs 24.97lakh/MW, Heat rate 2390 kcal/kWh

4. Unit size 660 MW

OO&M Cost Rs 22.47lakh/MW, Heat rate 2280 kcal/kWh.

5. Unit size 800 MW

O&M Cost Rs 20.22 lakh/MW, Heat rate 2200 kcal/kWh.

The Reliable Rearguard - V20 Series - Type 2 Surge Arrester

The V20 type 2 arrester series for surge protection according to VDE 0100-443 (IEC 60364-4-44) is designed for buildings without an (external) lightning protection system and is used in the main distribution board and in sub-distributions/control cabinets of the building. With a total dissipation capacity of 60 kA (20 kA/pole), the V20 surge protection devices are also suitable for use in systems with increased safety requirements in accordance with IEC 61643. The V20 arresters offer a system fuse of 160 A without a separate back-up fuse.

Dol Mobility Product Portfolio

DOL Mobility Pvt Ltd., specialized in producing one of the best High-Speed drivetrains in India has launched carefully engineered drive trains suiting to the Indian environment and driving conditions.

Indian weather conditions, road conditions and the relatively rough usage of the vehicles need a robust design. While designing, DOL Mobility gave a special attention to:

Optimum quantity of active material such as copper & the magnets to produce the extra torque and power

High Grade copper and steel for higher efficiency

Heavy duty shafts and aluminum structural parts to bear the rugged road conditions

High quality bearings and termination lugs & connectors for longer life expectancy

Specially engineered seals and sealants to provide high grade ingress protection

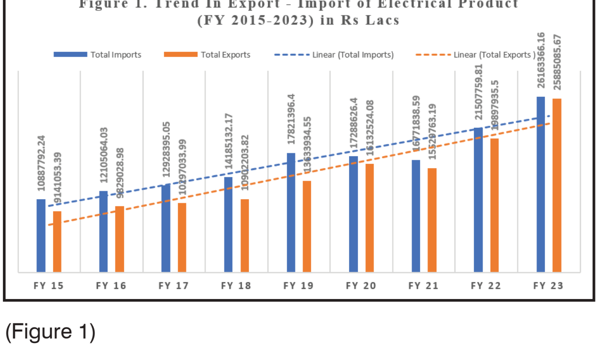
Trend in Exports and Imports of Electrical Products

IEEMA's research wing offers a bird's eye-view of the trends that dominated in the EXIM Sector over the past decade

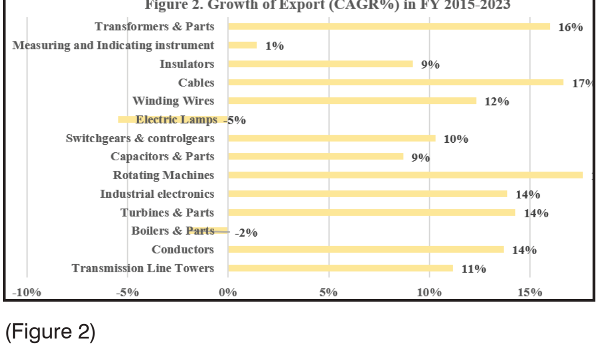
The Indian electrical sector has a diverse, mature, and powerful industrial base and a robust supply network that is fully prepared to fulfil domestic demand and any capacity expansion. According to a Technavio analysis, the electrical equipment industry in India, with a market size rise of USD 52.97 billion, is poised for remarkable growth. This growth potential is driven by several factors, including an increase in residential and commercial construction projects, an increased reliance on renewable energy sources for power generation, and significant expenditures in the power sector[1]. The sector's increasing contribution to India's trade is another factor that makes the sector even more important.

Electrical equipment sector has emerged a major sector for India's foreign trade over the period. Review of trade data reveals that exports of electrical products have increased by almost 3 times from INR 91,410,53.39 Lacs in 2015 to INR 258,850,85.67 Lacs in 2023 (Figure 1). This is despite the fact that exports have not been consistent across years and product segments. Data also reveal that the top five destinations for India's export are the United States of America, the United Kingdom, Bangladesh, UAE, and the Netherlands.

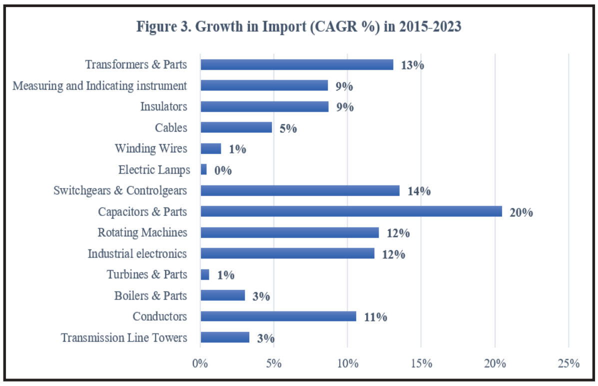
The pattern of exports of electrical products also indicates that while growth in export of electrical products was marginal during FY 2015 to FY 2018, in the later years beginning FY 2019, it realized significant growth. As per the growth of exports for different electrical products, major exported products that contributed to the growth include Rotating machines, Cables, Transformers and parts (Figure 2).



(Figure 1)



(Figure 2)



(Figure 3)

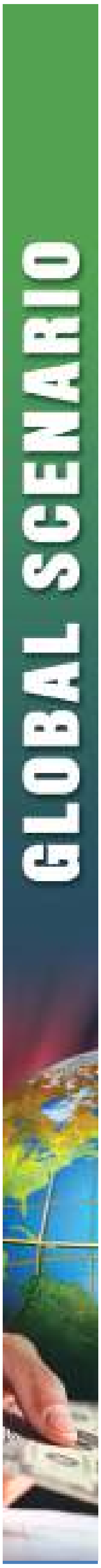
Some of the products' categories showed downward trend during the seven-year period. These include Electric Lamps and Boilers & parts. This decline could be because of decline in demand of these products in the importing countries, or it could have also been caused by improved trade and investment relationships of importing countries with India's competitors.

In the case of imports of electrical products, data shows that imports have increased approximately 2.5 times from INR 108,877,92.24 Lacs in 2015 to INR 261,633,66.16 Lacs in 2023. As per the growth of

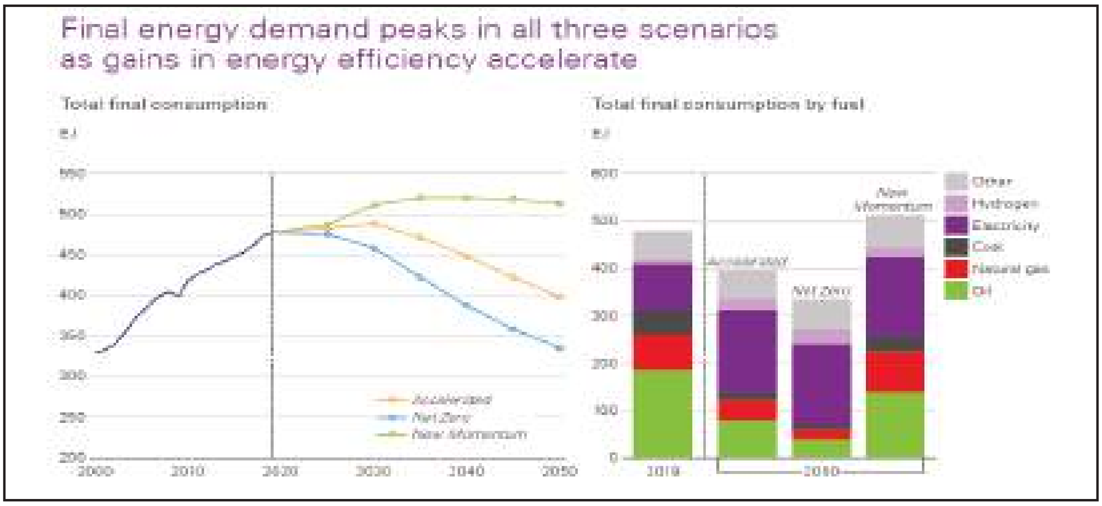
imports for different electrical products, major imported products which have contributed to this growth include Capacitors & parts, Switchgears & Controlgears and Transformers and parts. The top five importing countries are China, Germany, Singapore, Japan, and the United States of America.

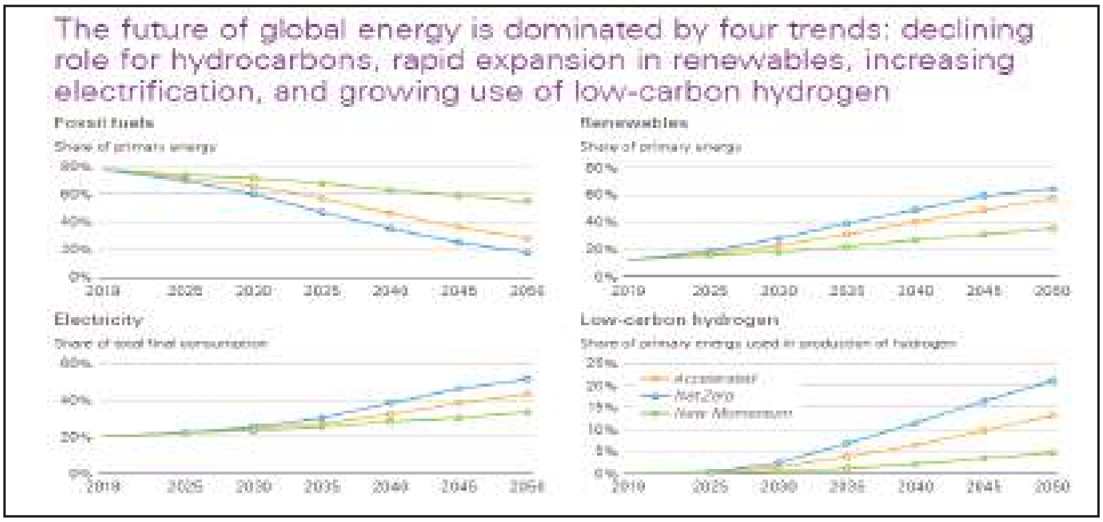
Reference

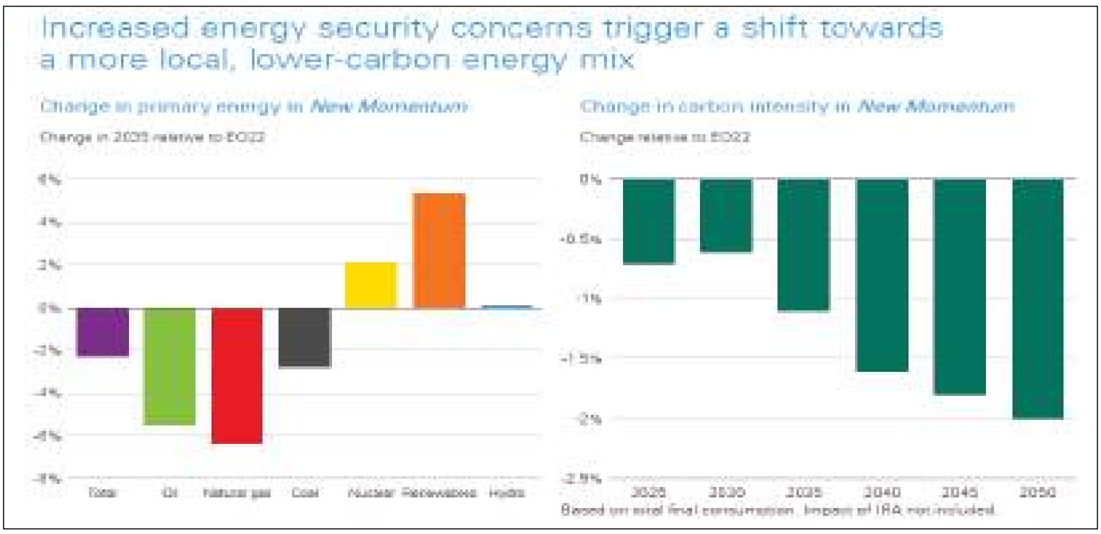
1) https://www.technavio.com/report/electrical-equipment-market-in-india-industry-analysis?utm_source=LinkedIn&utm_medium=Social&utm_campaign=LinkedInArticle_19thOct_Top+SKU&utm_term=2023&utm_content=IRTNTR41598



Global Energy Outlook 2023







Source: BP Energy Outlook 2023

INDIAN SCENARIO

India's Energy Outlook 2023

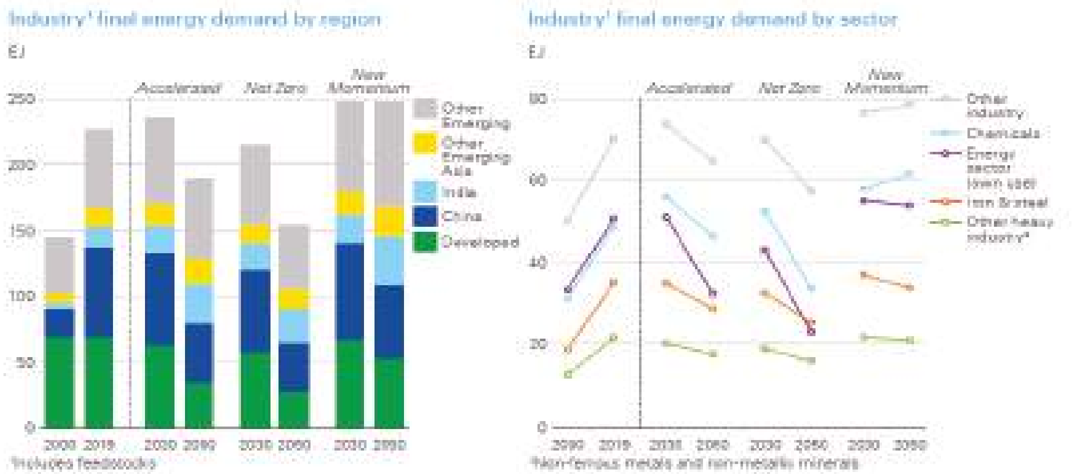
Insights from the Accelerated, Net Zero and New Momentum scenarios – India

	Level in 2050				Shares in 2050 (%)				Change 2019-2050 (% p.a.)		
	2019	Accelerated	Net Zero	New Momentum	2019	Accelerated	Net Zero	New Momentum	Accelerated	Net Zero	New Momentum
Primary energy consumption by fuel (EJ)											
Total	42	88	88	94	100	100	100	100	2.5	2.4	2.6
Oil†	10.0	9.3	4.7	16	24	11	5.4	18	-0.2	-2.4	1.6
Natural gas	2.1	8.5	6.4	10	5.1	9.6	7.3	11	4.6	3.6	5.2
Coal	19	8.3	5.0	31	45	9.4	5.7	33	-2.8	-4.1	1.7
Nuclear	0.4	5.9	6.8	2.6	1.0	6.6	7.7	2.8	9.0	9.6	6.2
Hydro	1.4	4.5	5.0	2.0	3.5	5.1	5.7	2.1	3.7	4.1	1.0
Renewables (incl. biofuels)	9.1	52	60	31	22	59	68	33	5.8	6.3	4.0
Primary energy consumption (native units)											
Oil† (Mb/d)	5.3	5.0	2.6	8.7							
Natural gas (Bcm)	59	238	177	280							
Total final consumption by sector (EJ)											
Total	30	54	47	66	100	100	100	100	1.9	1.4	2.5
Transport	4.6	12	11	12	15	21	24	19	3.1	2.8	3.2
Feedstocks	1.9	3.6	2.9	4.2	6.3	6.5	6.1	6.6	2.0	1.3	2.6
Buildings	9.7	12	9.9	16	32	22	21	25	0.7	0.1	1.7
Industry	14	27	23	33	47	50	49	50	2.1	1.6	2.7
Generation											
Electricity (TWh)	1,723	7,314	8,638	6,467					4.8	5.3	4.4
Hydrogen (Mt)	4.6	26	57	18					5.6	8.5	4.6
Production											
Oil† (Mb/d)	1.0	0.4	0.3	0.4					-2.9	-3.8	-3.0
Natural gas (Bcm)	27	86	59	132					3.8	2.6	5.3
Coal (EJ)	13	5.7	3.4	19					-2.5	-4.1	1.3
Emissions											
Carbon emissions (Gt of CO_2e)††	2.8	1.9	0.7	5.1					-1.2	-4.5	2.0
CCUS (Mt of CO_2)	0	261	736	3.9							

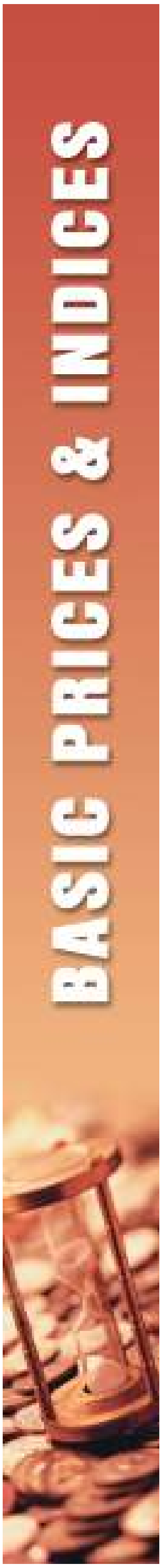
EJ = exajoules

† Oil supply includes crude oil, shale oil, oil sands, natural gas liquids, liquid fuels derived from coal and gas, and refinery gains, but excludes biofuels. Oil demand includes consumption of all liquid hydrocarbons but excludes biofuels. †† Carbon emissions include CO_2 emissions from energy use, industrial processes, natural gas flaring, and methane emissions from energy production.

Energy demand in industry peaks despite continued growth in India and other emerging Asian economies



Source: BP Energy Outlook 2023

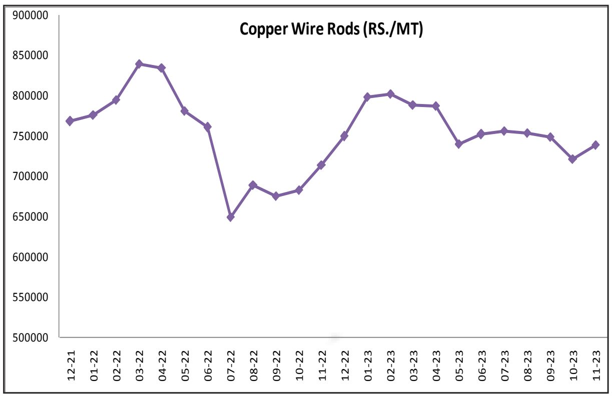


Basic Prices and Index Numbers

	Unit	as on 01.11.23
IRON, STEEL & STEEL PRODUCTS		
BLOOMS (SBLR) 150mmX150mm	TLT	49684.00
BILLETS (SBIR) 100MM	TLT	50837.00
CRNGO Electrical Steel Sheets M-45,C-6 (Ex-Rsp)	RM	109.91
CRGO Electrical Steel Lamination		**578213.00**
NON-FERROUS METALS		
Electrolytic High Grade Zinc	TLA&H	241900.00
Lead (99.97%)	CABLE	206700.00
Copper Wire Bars	SWGR	721875.00
Copper Wire Rods	CABLE	738675.00
Aluminium Ingots - EC Grade (IS 4026-1987)	TLA&H	226696.00
Aluminuium Properzi Rods - EC Grade (IS5484 1978)	CABLE	
Aluminium Busbar (IS 5082 1998)	SWGR	295000.00
OTHER RAW MATERIALS		
Epoxy Resin CT - 5900	SWGR	736.00
Phenolic Moulding Powder	SWGR	110.00
PVC Compound - Grade CW- 22	CABLE	150825.00

QE/PVC/39

	Unit	as on 01.11.23
PVC Compound Grade HR - 11	CABLE	151825.00
Transformer Oil Base Stock (TOBS)	TOBS	105397.00
OTHER IEEMA INDEX NUMBERS		
IN-BUSDUCTS (BASE July 2000=100) FOR THE MONTH September 2023		336.50
IN - BTR - CHRG (BASE JUNE 2000=100)		
IN - WT (BASE JUNE 2000=100)		354.27
Wholesale price index number for 'Insulators' (Base 2011-12 = 100) for the month September 2023		126.70
Wholesale price index number for 'Manufacture of Basic Metals (Base 2011-12 = 100) for the month September 2023		143.00
Wholesale price index number for' Fuel & Power (Base 2011-12 = 100) for the month September 2023		153.10
All India Average Consumer Price Index Number For Industrial Workers (Base 2016=100) September 2023		137.50
# Estimated, NA: Not available		

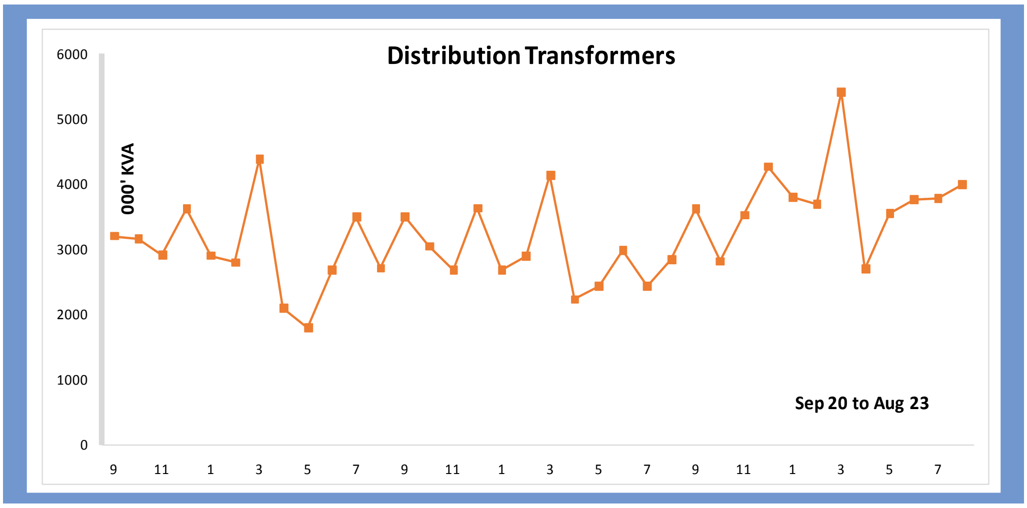


The basic prices and indices are calculated on the basis of raw material prices, exclusive of excise/C.V. duty wherever manufactures are eligible to obtain MODVAT benefit.

These basic prices and indices are for operation of IEEMA's Price Variation Clauses for various products. Basic Price Variation Clauses, explanation of nomenclature can be obtained from IEEMA office.

Every care has been taken to ensure correctness of reported prices and indices. However, no responsibility is assured for correctness. Authenticated prices and indices are separately circulated by IEEMA every month. We recommend using authenticated prices and indices only for claiming price variation.

Source : IEEMA



Name of Product	Accounting Unit	Production		
		For the Month Aug 23	From Sept 22 to Aug23	Highest Annual Production
Electric Motors				
AC Motors - LT	000' KW	1618	18100	17744
AC Motors - HT	000' KW	393	5034	5273
DC Motors	000' KW	31	356	618
Switchgears				
Contactors	000' Nos.	1512	15171	15211
Motor Starters	000' Nos.	200	2081	2427
SDF	000' Nos.	58	691	752
Circuit Breakers DIN Rail Mounted	000' Poles	17696	213915	213362
Circuit Breakers - LT	Nos.	448558	5288927	4850300
Circuit Breakers - HT	Nos.	6440	70274	77659
Custom Built Product	Rs. Lakhs	20793	295465	452536
HRC Fuses & Overload Relays	000' Nos.	1343	17005	17246
Power Cables	**KM**	85393	872839	855297
Power Capacitors - LT & HT *	000' KVAR	4564	56778	57368
Transformers *				
Distribution Transformers	000' KVA	4004	45068	58341
Power Transformers	000' KVA	16163	166823	234922
Instrument Transformers *				
Current Transformers	000' Nos.	120	1183	1042
Voltage Transformers	Nos.	21476	201393	177288
Energy Meters *	000' Nos.	2469	28692	25973
Transmission Line Towers *	000' MT	78	913	1250

* Weighted Production

Source : IEEMA

\# NA – Not Available

IMPACT NEWS
Local 2 Global

NATIONAL NEWS

CERC Issues Draft Central Electricity Regulatory Commission Regulations 2023

The CERC issued Draft Central Electricity Regulatory Commission (Terms and Conditions of Tariff) Regulations, 2024 for stakeholder comments. It outlines the regulations that will be in effect from April 1, 2024, to March 31, 2029. It covers various aspects of the tariff structure, including components of the tariff, provisions for true-up of tariffs, determination of tariffs after the implementation of revised emission standards, scheduling, metering, accounting, billing, and payment of charges. The regulations aim to provide a framework for the determination of tariffs for the supply of electricity from thermal and hydro generating stations, as well as for the transmission of electricity on inter-State transmission systems. It also specifies the process for determining tariffs and the sharing of capacity charges for thermal generating stations among beneficiaries.

Chapter 1 details a preliminary of 88 pointers followed by Chapter 2 that lists the date of commercial operation. Chapter 3 deals with the Procedure of Tariff Determination and Chapter 4 on Tariff Structure. Chapter 5 talks about Capital Structure and Chapter 6 touches upon Computation of Capital Cost. Chapter 7 deals with Computation of Additional Capital Expenditure and Chapter 8 Is on Computation of Annual Fixed Cost. Chapter 9 deals with the Computation of Input Price of Coal and Lignite from Integrated Mine and Chapter 10 details about the Components of Energy Charge, while Chapter 11 is called Computation of Capacity Charges and Energy Charges with formulae for calculating the same are shared. Chapter 12 specifies the Norms of Operation and Chapter 13 reveals aspects of Scheduling, Accounting And Billing for the same, chapter 14 deals with methods of Sharing Of Benefits and finally Chapter 15 notes Miscellaneous Provisions.

The entire report is worth a read and available on https:/ cercind.gov.in dated Jan 4, 2024.

Cabinet approves signing of a Memorandum of Understanding (MoU) between India and United States for International Development/ India (USAID/India) for supporting Indian Railways to achieve Mission Net Zero Carbon Emission

The Union Cabinet chaired by the Prime Minister, Shri Narendra Modi, today was apprised of signing of Memorandum of Understanding between India and United States for International Development/India (USAID/India) on June 14, 2023 for supporting Indian Railways to achieve Mission Net Zero Carbon Emission by 2030.

The MoU provides a platform for Indian Railways to interact and share the latest developments and knowledge in the railway sector. The MoU facilitates utility modernization, advanced energy solutions and systems, regional energy and market integration and private sector participation and engagement, training and seminars/workshops focusing on specific technology areas like Renewable Energy, energy efficiency and other interactions for knowledge sharing.

Earlier, USAID/India had also worked with IR focused on deployment of rooftop solar across railway platforms.

The MoU signed by Indian Railways with United States Agency for International Development/India is for enabling energy self-sufficiency with the following understanding:

i. Both the Participants intend to jointly work broadly on the following key activity areas with details to be agreed separately:

   a) Long-term energy planning including clean energy for Indian Railways.

   b) Develop an Energy Efficiency Policy and Action Plan for Indian Railway Buildings.

   c) Planning for clean energy procurement to achieve Indian Railway's net-zero vision.

   d) Technical support for addressing regulatory and implementation barriers.

   e) Bid design and bid management support for system-friendly, large-scale renewable procurement.

   f) Supporting Indian Railways in the promotion of e-mobility.

   g) Collaboratively host event, conferences, and capacity-building programs in the mentioned identified areas.

ii. Either participant may request in writing a revision, modification or amendment to all or any part of this MoU. Any revision, modification or amendment approved by the Participants will form part of the revised MoU. Such revision, modification or amendment will come into effect on such date as may be determined by the Participants.

iii. This Memorandum of Understanding is effective as of the date of signing and is expected to continue for a period of five year or until the effective end of South Asia Regional Energy Partnership (SAREP) whichever period is shorter.

Impact:

The MoU has been signed to support India Railways in achieving Mission Net Zero Carbon Emission (NZCE) by 2030. This will help Indian Railways to reduce dependence on imported fuel such as Diesel, Coal etc. Deployment of Renewable Energy (RE) plants will give fillip to RE technology in the country. This will help in development of local ecosystem which subsequently gives boost to local product development.

Expenditure involved:

Technical assistance for the services under this MoU is intended to be provided by USAID under the SAREP initiative. This MoU is not an obligation of funds or a commitment of any kind, and it is non-binding. This does not involve any financial commitment from Indian Railways.

Cabinet approves signing of Memorandum of Understanding between India and Guyana on cooperation in the hydrocarbon sector

The Union Cabinet chaired by the Prime Minister, Shri Narendra Modi has approved the signing of Memorandum of Understanding (MoU) between the Ministry of Petroleum & Natural Gas, Government of India and the Ministry of Natural Resources, Republic of Guyana on cooperation in the hydrocarbon sector.

Details of the MoU:

The proposed MoU covers the complete value chain of hydrocarbon sector including sourcing of crude oil from Guyana, participation of Indian companies in Exploration and Production (E&P) sector of Guyana, cooperation in the areas of crude Oil refining, capacity building, Strengthening bilateral trade, collaboration in natural gas sector, collaboration in developing regulatory policy framework in oil & gas sector in Guyana; Cooperation in the area of clean energy including biofuels as well as renewables sector including solar energy etc.

Impact:

The MoU on cooperation in hydrocarbon sector with Guyana will strengthen bilateral trade, foster investment in each other countries and help diversifying source of crude oil, thus augmenting the energy & supply security of the country. It will also provide opportunity to Indian company to participate in E&P sector of Guyana, gaining experience by working with global oil & gas companies in upstream projects, thus fostering the vision of "Aatmanirbhar Bharat".

Implementation strategy and targets:

This MoU shall enter into force on the date of its signature and will remain in force for a period of five years and shall be automatically renewed thereafter on a quinquennium basis unless either Party gives the other Party a written notice three months in advance of its intention to terminate this Understanding.

Background:

In recent times, Guyana has gained significant salience in the oil & gas sector becoming the world's newest oil producer. The new discoveries of 11.2 billion barrels of oil equivalent, amounts to 18% of total global Oil & Gas discoveries and 32% of discovered oil. As per OPEC World Oil Outlook 2022, Guyana is projected to see a significant ramp-up in production, with liquids supply growing from 0.1 mb/d in 2021 to 0.9 mb/d in 2027.

Further, as per BP Statistical Review of World Energy 2022, India is the world's 3rd largest energy consumer, 3rd largest consumer of oil and 4th largest refiner and the fastest-growing major economy with rising energy needs. BP Energy Outlook and International Energy Agency estimate that India's energy demand would grow at about 3% per annum till 2040, compared to the global rate of 1%. Further, India is likely to account for approximately 25-28 per cent of the global energy demand growth between 2020-2040.

With a view to give a further impetus to ensure energy access, availability, affordability to citizen underpinned by energy security of the country, India is focusing on fostering new partnership in hydrocarbon sector, both through diversification of crude oil sources and through acquiring quality overseas assets. This dilutes dependencies on a single geographical/economic unit and increase India's strategic maneuverability.

Noting the significance of Guyana and given the renewed momentum to the bilateral relationship in hydrocarbon sector, and the number of possible areas of cooperation, it is proposed to enter into an MoU with Guyana on cooperation in the hydrocarbon sector.

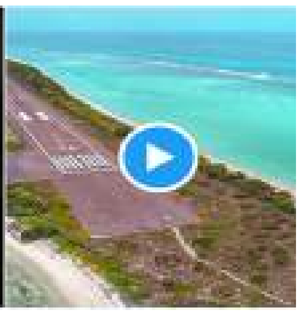
New Solar Power Scheme (for PVTG Habitations/Villages) Under PM JANMAN

STORY:

The President has sanctioned the implementation of A New Solar Power Scheme (for particularly Vulnerable Tribal Groups(PVTG) Habitations/Villages under Pradhan Mantri Janjati Adivasi Nyaya Maha Abhiyan (PM JANMAN) during 2023-24 to 2025-26. Implementation guidelines of the scheme can be found at https:/cdnbbsr.s3waas.gov.in.

Kavaratti's First On-grid Solar Power Plant with state-of-the-art Battery Energy Storage System projected to save Rs. 250 crores, reduce diesel consumption by 190 lakh litres and offset 58,000 tonnes of carbon emissions

In a historic milestone for Lakshadweep, **the Prime Minister Shri Narendra Modi dedicated to the nation on January 3, 2024, the solar power plant at Kavaratti,** which is the region's first on-grid solar project with state-of-the-art Battery Energy Storage System (BESS) technology. Together, these two installations of Solar Energy Corporation of India Limited (SECI) have a combined solar capacity of 1.7 MW and an advanced 1.4 MWh battery storage facility.

A matter of monumental stride towards sustainable energy solutions for the archipelago, the solar power plant will help reduce dependency on the Diesel-based Power Generation plant at Kavaratti. The Lakshadweep Energy Development Agency (LEDA) will now harness power from these solar plants, marking a pivotal shift from diesel-based power to a sustainable, eco-friendly energy source for the region.

Over the anticipated technical lifespan, the initiative is projected to yield commercial savings of approximately Rs. 250 crores. The substantial reduction of diesel consumption by up to 190 lakh litres and the offsetting of 58,000 tonnes of carbon dioxide emissions underscore its profound significance in promoting green energy and fostering a cleaner and more sustainable future for Lakshadweep.

The Engineering, Procurement & Construction (EPC) expertise for the project has been provided by SunSource Energy.

Solar Energy Corporation of India Limited (SECI), a Miniratna Category-I Central Public Sector Unit under the administrative control of the Ministry of New and Renewable Energy (MNRE), Government of India, is engaged in promotion and development of various renewable energy resources, especially Solar and Wind energy, renewable energy (RE) - based storage systems, trading of power, R&D as well as RE-based products like Green Hydrogen, Green Ammonia and RE-powered electric vehicles.

The company is one of the nodal agencies for implementation of a number of schemes of MNRE. The company also has a Category 1 power trading license and is active in this domain through trading of Solar/ Wind/Hybrid/RTC/BSES power from projects set up under the schemes being implemented by it.

REC Limited and Bank of Baroda join hands to finance Power, Infrastructure and Logistics Projects

REC Limited has signed a Memorandum of Understanding (MoU) with Bank of Baroda in order to facilitate joint sanctions of loans to fund power, infrastructure and logistics projects in the country over the next three years. Recognizing the pressing need to fortify these critical domains, REC Limited and Bank of Baroda unite with a shared vision of advancing sustainable growth and bolstering the nation's infrastructural backbone. By pooling resources and expertise, both entities endeavor to champion initiatives that will invigorate economic development and enhance accessibility to essential services nationwide.

The MoU was signed on January 3, 2024 in the presence of Chairperson and Managing Director (CMD), REC Limited, Shri Vivek Kumar Dewangan and Managing Director & CEO, Bank of Baroda, Shri Debadatta Chand along with Executive Director, Bank of Baroda, Shri Lalit Tyagi.

Commenting on the collaboration, Mr. Dewangan said: "This landmark agreement signifies a collaborative effort to accelerate the realization of pivotal projects crucial to the nation's progress. This partnership marks a significant stride in our commitment to fostering inclusive development. By harnessing synergies between REC's expertise in the power sector and Bank of Baroda's financial prowess, we aim to catalyze transformative projects that will positively impact communities and drive socio-economic progress."

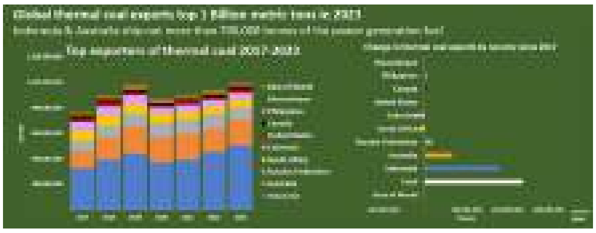
Managing Director & CEO, Bank of Baroda, Shri Debadatta Chand said: "This MoU will enable Bank of Baroda and REC to jointly finance Power (including renewable power), Infrastructure and Logistics projects. With the Indian economy on a strong growth path, we will see a rise in capital expenditure and private investment and an increasing need for collaborative and innovative financing structures."

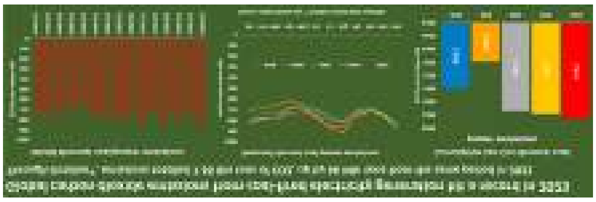
POWER INDUSTRY

Worldwide electricity generation from coal hit record highs in 2023, while thermal coal exports surpassed 1 billion metric tons for the first time as coal's use in power systems continues to grow despite widespread efforts to cut back on fossil fuels.

Coal-fired electricity generation was 8,295 terawatt hours (TWh) through October, up 1% from the same period in 2022 and the highest on record, according to environmental think tank Ember.

Total thermal coal exports were 1.004 billion metric tons for the whole year, up by 62.5 million tons or 6.6% from 2022, ship-tracking data from Kpler shows.





The continued expansion in coal use and emissions provides a stark reminder to climate trackers that the high-polluting power fuel remains integral in key power systems even as solar, wind and other clean energy sources are deployed at a record rate.

Growing Asian Concentration

The footprint of coal mining and exports and its use in power generation is overwhelmingly concentrated in Asia, as many other parts of the world including Europe and North America have adopted measures to phase down the use of coal for power.

But even as the geographical area of coal use and trade is shrinking, the outright volumes of extraction, exports and consumption in power plants remains on a rising trajectory.

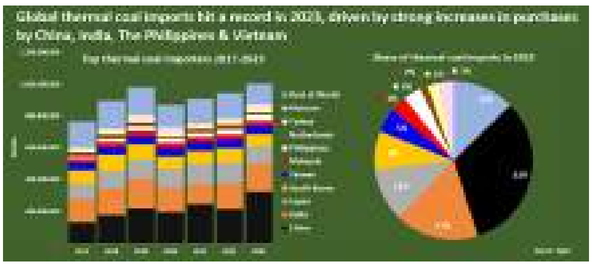
Indonesia was the top thermal coal exporter in 2023, shipping out a record 505.4 million tons for the year, up 54 million tons or 12% from 2022's levels.

For the first time, Indonesia accounted for more than half of all thermal coal shipments within a calendar year in 2023, Kpler data shows.

Australia was the second largest thermal coal exporter, shipping out 198 million tons, up 12.5 million tons (7%) from the year before.

Russia, South Africa and Colombia were also notable exporters, shipping 103 million tons, 60 million tons and 51 million tons respectively last year.

On the import side, China was the top thermal coal buyer, taking delivery of a record 325 million tons, which is 109 million tons more than 2022's total.



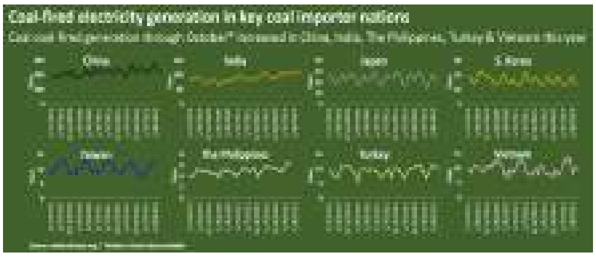
India was the second biggest importer (172 million tons), followed by Japan (109 million tons), South Korea (80 million tons) and Taiwan (51 million tons).

Other notable importers included the Philippines (37 million tons) and Vietnam (31 million tons), both notching up strong double-digit percentage increases in year-on-year imports.

Locked in Generation

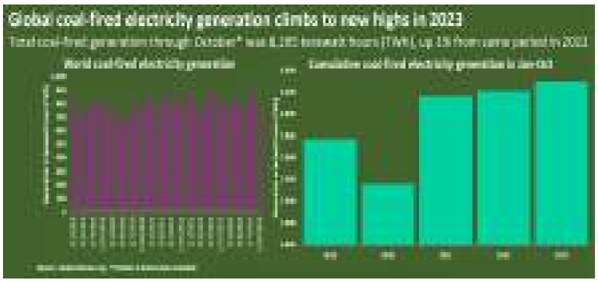
In major coal importing nations, coal-fired electricity generation increased on the year in China, India, the Philippines, Turkey and Vietnam, Ember data shows.

Coal-fired output declined by 8.2% in Japan and by 4% in South Korea, but those reductions were nearly offset by the increase in Vietnam alone last year.



Globally, around 82% of all coal-fired electricity generation occurred within Asia in 2023, up from an average of around 75% in 2019, according to Ember.

Asia's share of coal use and imports should continue to climb as other regions further reduce coal consumption.



But total volumes of Asia's coal imports and consumption for power generation also look set to continue climbing, especially in major and fast-growing economies such as China, India, Vietnam, the Philippines and Indonesia, where cheap power sources remain critical for industry competitiveness.

Those same countries are also committed to steep increases in the deployment of renewable energy sources, but over the near term they look just as liable to continue steering total coal use and emissions to further heights. The opinions expressed here are those of the author, a columnist for Reuters. News reporting by Gavin Maguire and edited by Tom Hogue. ■

INDEX TO ADVERTISERS

India's EV Dream !

By Kamakshi Fernandes

Electrifying vehicles to ensure a smooth ride for us humans and more so for environmental enthusiasts, should ideally translate to modes of transport that are not only economically viable, but truly close to nature. So EV should ideally stand for environmentally-friendly vehicles.

The humble bullock cart must return. Not only would the family of cows and bullocks benefit, the environment too would be saved, shepherds would get employment, the local municipality would be relieved from so many duties and the national finance minister too would benefit. Let us see how.

The humble bullock cart would ensure that animals too occupy roads, hitherto dominated mostly by smoke emitting metal structures of various brands and sizes, colours and intimidating shapes. So, with the brand new transport opportunity of having a bullock cart on the road, there would be a mandatory need for green patches at every juncture of the road so that the bullock could snack upon some fresh and crispy grass. This would ensure to be a cost effective option instead of expending upon expensive fuels like petrol, diesel or electricity, as is being considered now.

As we know speed kills, so the humble bullock cart would ensure a decent long and healthy lifespan, saving us from the gory road accidents reported by newspapers. Assuming the cartwheel of the cart is 125 cms is diameters, it would take 10 rounds per 4 seconds to cover a distance of 22.5 kms in an hour approximately. Not bad, as with the current traffic conditions, we move at a pace of 1 inch per hour, slower than the slowest snail.

All gas stations would convert to parks. There would be no problems of parking spaces as bullocks would only need to be left free while the carts were tied. Every office complex would have a shepherd to look after the bullocks, creating new employment opportunities. Come rain, sun, cold, the bullocks would never abandon us humans leaving us to die in nature's fury. We could easily rely on the animals to reach us safely and soundly home.

The hi-fi, the CEOs, millionaires and billionaires could travel on elephants, horseback or a horse cart like the ones shown in the televised versions of Ramayana and Mahabharata. In a desert region they could use camel carts and in snowy places reindeers could pull sledges. Some countries have dogs, goats, donkeys and other beasts of burden pulling carts. All animals could get employment and for international guests we could consider going to the zoo to procure rare breeds of

animals to carry them on their backs. Our PM to be pulled by 3 lions, the President by tigers. Global delegates would be offered services by their national animal like a zebra would carry delegates from Botswana, giraffe for Tanzania, leopard for Rwanda, the American bison for American delegates and the likes.

Other sectors that could emulate the truly environmentally-friendly vehicles or EVs would be the paint industry, by scrapping usage of artificial synthetic colours offer consumers environment-friendly version of cowdung; the national postal department could use pigeons while airmail could train the falcon for a global reach, flamingos and seagulls traveling intercontinental are other options.

Even after the demise of the animal it would be useful and environmentally friendly, unlike the metal (and now plastic) smoking boxes running on the road ending their lives in junk yards. Every part of the animal is used to create products after its life span comes to an end – bones, skin and horns are used to make biodegradable designer consumer products on a large scale.

The message is loud and clear - employ your natural resources smartly and with discretion, such that they contribute to not only the environment, but also the economy. And more so, being a Mumbaikar, I feel the bullock carts racing on the roads can yield higher results if the road is called Dalal street.

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