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India's power grid of 21st century: Challenges and opportunities

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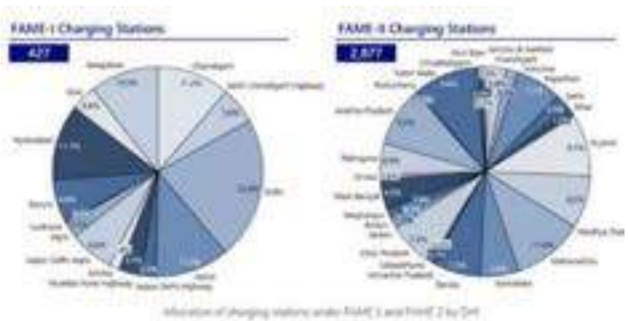
1.1 CURRENT SCENARIO

National Mission for Electric Mobility (NMEM2020)

Government of India approved the NMEM2020 in 2011 and subsequently was unveiled in 2013. As part of the mission DHI has formulated a scheme namely – **FAME India** implemented over a period of 6 years, till 2020.



In 2010, the Ministry of New and Renewable Energy proposed a 20% subsidy for electric vehicles through a scheme called the Alternate Fuels for Surface Transportation Programme. This resulted in a big leap in sales of electric vehicles, mostly in the e-bikes segment.

1.1.1 Charging Infrastructure

Currently the EV composition in India is largely dominated by 3-wheelers. Following it is the 2-wheeler section. And the last one is the 4-wheeler section (majorly due to high cost.) Still the growth of EV's in India is very good.

1.1.2 Major Challenges

1) <u>High initial investments:</u>

Setting up the EV charging station is quite high in cost. To set up the EV charging infrastructure, some requirements need to be fulfilled like proper location, land, right vendor, grid power stability, remittance of power, varieties of charger types, cables, and other auxiliaries.

Here the government must step-in and provide subsidies and invest in EV companies.

2) <u>Multiple Types of Charging Connectors:</u>

There are a variety of charger plugs for different companies. So, a charging station must have all the types of plugs to cater vehicles of different companies and different charging requirements (in terms of time).

3) <u>Location of EV Charging Station</u>

To set up the Electric Vehicle charging station, the location of the charging station is a major challenge which should be such that it is easily visible, accessible, save time, and charging queue can be minimized. For that, location should be having characteristics of ample parking space, approachable, feasible to set up, convenient waiting area, etc. so the consumer can utilize the ideal time to charge their EVs.

4) <u>Technical Safety at EV charging stations</u>

Setting up the EV charging stations requires specialized technical safety. Voltage fluctuations, over current, frequency mismatch, and ground fault are major concerns. To overcome Voltage fluctuations, stabilizers, proximity sensors, and control pilot sensors need to be integrated to keep a check on it. Otherwise, it may damage the expensive components. By designing some hardware components properly, many issues like power issues, heat dissipation, grounding, voltage measurement can be fixed.

5) Software Related Challenges

The vehicle owners should have access to some real-time status of a charging station (like availability of plugs, expected queue time, etc) Finding the availability of the charging slot is one of the most important tasks, for this, it is very helpful to develop such software, it makes life easier and saves time. Let's take an example of India's one of the top companies in the EV charging station sector: Fortum India. They have developed an application based on real-time data called Fortum charge and drive. It enables the EV consumer to locate chargers and start/stop charging, manage payments, contact customer support, charging history, digital receipts, fleet management.

1.2 Innovations to be Adopted

Initial phase of EV adoption (0% - 30%):

As there would be very less investments initially, there would be very less charging stations, so in order to utilize effectively and spread awareness among citizens The government has to utilize the charging stations for charging Public Transport and few Startups have to initially invest in infrastructure and EV deployment and smartly using them, so that more people get attracted to buy EVs.'

EV adoption (30% - 50%):

There would be enough infrastructure built by this time and in order to reduce load on Grids one can look into battery swapping and also, we can implement integration with Renewable Energy Resources and integration to Offshore Wind farms.

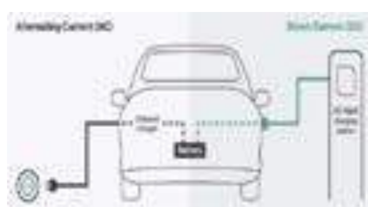
EV adoption (50% - 100%):

As of now there are many EVs' and there would be very much load on Grid and Energy Discrepancies might happen, so Following innovations might help in Decreasing load on Grid and ensuring balance in Energy.

Bidirectional Charging:

It allows energy to flow both ways: from the grid into the car, and from the vehicle to the grid (V2G) or to your home (V2H). This offers a major breakthrough in charging technology compared to traditional one-way chargers that can 'only' power your car.

In the future due to the increase in the number of electric vehicles, there might be a scenario in which the grid lines might be bearing heavy loads and there might be high chances of energy fluctuations and power cuts, in such cases energy can be reused from electric vehicles and load will be ultimately stabilized on grid lines.



Wireless charging:

With a high-powered wireless EV charging system, vehicles can automatically charge while parked in selected pick-up/drop-off locations – an ideal solution to keep taxis or autonomous vehicles perpetually charged. The system requires no physical charger-vehicle connection; it consists of multiple charging plates installed underground that engage automatically. No charging station is required, delivering more convenience and less clutter in the public space.

Electrified Roads:

Electrified roads use overhead power lines to power larger electric vehicles, such as lorries, however these are not suitable for passenger cars. In July, the Department for Transport awarded funding to a project led by Costain to explore how long-range trucks can be electrified using overhead power cables on motorways across the UK.

Pop-up and Lamp post chargers:

One of the downsides of expanding EV charging infrastructure is that the chargers can clutter streets and pavements. However, two similar innovations could reduce this clutter: pop-up pavement chargers and lamp post chargers.

London-based EV charging company Urban Electric Networks has developed an on-street charging device, the UEone, which retracts into the ground when it's not being used. It can be activated remotely using a smartphone app. The company tried six pop-up fast chargers in Oxford in 2019-20, which proved a big success.

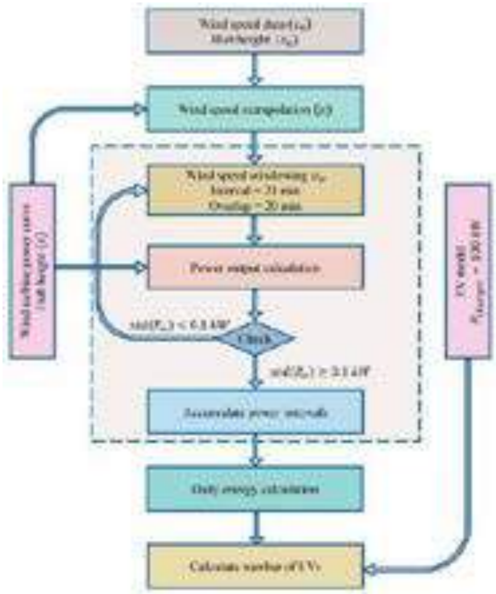
Electric Vehicle Fleets:

EV fleets represent a particularly promising segment of the potential market for charging services, which can help fleet operators reduce their costs by procuring and managing energy in efficient ways.

Renewable Energy Powered EV infrastructure:

There are two ways to utilize wind energy to charge EVs as a source. The first one is via the electricity grids, where energy storage is required for both wind and the grid. The second could potentially be an off-grid solution to avoid expensive energy storage equipment, power conversion equipment, and conversion stages because a direct current (DC) bus system can be used in the second case.

The wind-powered EV charging station is strongly dependent on the availability of constant power supply from wind turbines, which limits the station in terms of providing smart charging compared with an immediate charging scenario. Excess wind power that is not used for fast charging can be injected into the utility grid. The (re-)scheduling of the charging events is triggered whenever the charging system predicts stable wind energy that falls within user-defined EV charging specifications (energy volume and charging duration). All-time intervals (the holding time of EV for charging) were statistically analyzed, and the intervals that did not show stable or enough power within the EV charging standards were filtered. Finally, the cumulative daily wind energy and the estimated number of EVs that the station could handle were obtained from the remaining charging intervals.



Research reveals that during the daytime when the solar radiation is at its peak, solar power can be easily stored in the car batteries for future usage. The idea of a "green" charge has enabled people to understand the significance of maximizing the cost of EVs throughout the irradiation period. A research scholar has introduced a concept in which **EVs can be charged during the day at the parking areas situated, for instance, within the workplaces. In addition, EVs can be re-energized entirely during the working periods to realize the solar-to-vehicle (SV2) approach. Furthermore, the research also illustrates that energy generated in each parking area is essential in the extra generation of adequate electricity for transportation requirements for the EVs operator**.

1.3 Market Policies at various implementation phase

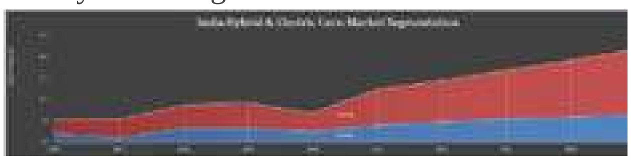
Initial phase of EV adoption (0 – 30%):

The major focus during this phase is to implement public transports like buses, encouraging private entities (like Ola, Uber etc.). Many top battery manufacturers, such as Amara Raja Batteries, have used these incentives as a cue to direct future investments toward green technology, particularly lithium-ion batteries. Leading businesses such as OLA Electric Mobility Pvt, Ather Energy, and Mahindra Electrics are rapidly expanding their market presence in response to the opportunity that India's EV industry affords. The facility of Ather Energy is said to have a production capacity of 0.11 million two-wheelers per year. Ola Electric, the unicorn Indian ride-hailing start-up, also announced in March 2021 that it would build the world's largest electric scooter plant in Hosur (about a two-and-a-half-hour drive from Bengaluru) over the next 12 weeks at a cost of US$330 million, with the goal of producing 2 million units a year. Ola Electric plans to increase production to 10 million vehicles per year by 2022, accounting for 15% of the global e-scooter market. Meanwhile, Ola Electric reportedly sold INR 11 billion (US$149.26 million) in electric two-wheelers over a two-day purchasing window, indicating market demand in India. Greaves Cotton announced its debut into the multi-brand electric car retail industry under the brand name

AutoEVMart on September 9, 2021. According to rumors, this platform would provide consumers a diverse selection of electric vehicles, ranging from Ampere Electric to other EV companies. As a result, AutoEVMart will act as an electric vehicle marketplace in India, offering e-two-wheelers and e-three-wheelers, as well as EV accessories. Greaves Cotton envisions first-of-its-kind multi-brand retail stores for clean tech or electric mobility in Bengaluru.

Also selecting a few major cities for pilot projects to showcase the viability of the idea to the general public which in turn makes them much more confident and aware of the economic and environmental benefits by adopting EV.

Investing in Research & Development of battery technologies.



EV adoption (30% - 70%):

Adoption of EV among the general public would be the key area of focus in this phase.

The charging time and the congestion it causes is another major challenge and proper implementation of Battery Swapping Policy and some improvements in the battery technology due to investment in R&D in previous phase.

To increase the public share in the EV sector various incentives can be provided by the government in the form of direct subsidies to private manufacturers and sellers. Economic benefits in the form of reduced taxes, no tolls, reducing cost of vehicle registration.

We can also look up to the Norway's "The polluter pays principle" which calculates the taxes on a particular vehicle by a combination of CO2 and NOx emissions. This type of tax system is progressive in nature making vehicles with higher emissions expensive and those with less emissions affordable.

Another thing is to increase public awareness on the long-term benefits of EV in comparison to the initial cost in the form of less maintenance cost and less fuel charges.

EV adoption (70% - 100%):

In the final phase of implementation, various policies with restrictions on ICE vehicles can be brought up. Thus, demotivating the further purchase of conventional ICE vehicles and also bringing up scrapping policies to reduce the ICE vehicles share on the road and the increase the EV sector share.

	Volkswagen Golf	Volkswagen e-golf
Import price	22 046	33 037
CO2 tax (133 g/km)	4 548	-
NOx tax	206	-
Weight tax	1 715	-
Scrapping fee	249	249
25% VAT	5 512	-
Retail price:	34 076 €	33 286 €

The Chinese government announced various **subsidies** to promote sales of e-vehicle by private parties and industrial organisations. The Government offers subsidies for fuel cell electric trucks and buses.

Tax exemption: The Chinese government exempts electric vehicles from consumption and sales taxes. It also waives 50% of vehicle registration fees for electric vehicles

Various strategies were introduced to address the initial barriers of cost and charging limitations. Some strategies include battery swapping, battery leasing, electric car leasing and fast charging. The Chinese government also laid down research and development strategy under PPP to develop all the technologies for example, fuel cell technology and traction motors.

Norway
The progressive tax system makes most EV models cheaper to buy compared to a similar petrol model, even if the import price for EVs is much higher. This is the main reason why the Norwegian EV market is so successful compared to any other country.

Q2. What should be the solar policy? Should integration happen at transmission or distribution level? Utility scale or residential?

2.1 Integration of Solar Energy at various levels

Distribution/ Transmission level

The distribution level involves building solar energy resources near the load site itself, which helps cut down on the various transmission losses.

Transmission level refers to the integration at the transmission stage where electricity is going to be provided through various transmission lines from a remote solar plant instead of generating it near the load site itself.

We believe integration at the Distribution level will be more beneficial. Below are some advantages of the Distribution level:

First, let us look at an example of Sweden.

- Sweden is transforming home to power stations. They are promoting use of solar panels which in turn helps increase the renewable energy penetration.
- Sweden had started enforcing policies to increase renewable energy usage at a very early stage. This is now reaping its benefits.
- This proves how it is necessary to start working in the direction of increasing renewable energy usage. Solar is a very reliable energy as India lies in the Tropical region.

Environmental

- **The use of CHP, made possible** through the decentralizing of electricity production, also increases the overall heat and power system's efficiency and thereby reduces harmful greenhouse gas emissions.

Economic

- **Distributed generation sources often have lower capital costs per project**, this is because distributed generation uses lands on rooftops and near the load site whereas integration requires huge amounts of land, and hence involves a lot of land costs too.
- **Lower losses through the lengthy transmission of electricity** there are a lot of losses involved during transmission These can be cut short by integration at the distribution level.
- **Distributed generation projects provide planning flexibility** due to their small size and short construction lead times, compared to larger central power plants.

Social

- **A decentralized system, particularly through the use of isolated, off-grid units and mini-grids, are suitable in rural areas** where the population density is low. Decentralized approaches can achieve rural electrification faster.
- **It will employ far more people** than a centralized one, employing small businesses and technicians to maintain and install systems wherever they are needed.
- **It gives power to the people**, by providing them proper control on generation of electricity.
- **It provides market space for lots of technologies** as now many small plants will be built near the load site. This will help avoid any kind of monopoly of big companies.

RESIDENTIAL / UTILITY SCALE

- Division of solar energy integration into Utility-scale and residential scale is done based on the size of the generating source.
- We believe establishing small sources for generating solar energy will be better. This would help facilitate distributed generation. Residential scale generation also includes solar panels put up at rooftops.
- Residential scale generation like generating from solar panels at rooftops will be more efficient as it doesn't require any extra land. Currently seeing the increase in land rates, utility-scale projects are becoming infeasible financially.
- Building at a residential scale facilitates distributed generation in which energy generation happens near the load site. This helps cut down on the immense transmission loss.
- **A residential scale solar system utilizes unused space on rooftops and in yards** to generate power, whereas a utility-scale system requires the development of new land, destroying habitats while generating no more power.
- **A residential scale solar strategy will increase employment** as now more technicians and experts will be required to install solar panels/plants in every region.
- **A residential scale solar strategy gives power to the people**, as now people are in control of the electricity generated.

SOLAR POLICY

Currently in India there are many policies in place to incentivize the citizens to adopt renewable energy such as solar, wind energy. Some of the current policies in solar energy are:

- National Electricity Policy 2005: - The policy allowed preferential tariff for electricity produced from renewable energy sources.
- Tariff Policy 2006: - The mechanism of Renewable Energy Portfolio (RPO) to fix a minimum percentage of purchase of energy consumption by the States from renewable energy sources and giving special tariff for solar energy among others were its main contribution.
- There are many other policies such as Integrated Energy Policy 2006, Generation based Incentives (GBI) for Solar, Renewable Energy Certificates (RECs) etc.
- As we can see That most policies of government are that they are applicable only when you have a renewable energy source. But we believe that the transition takes place when there is a help at initial level like investment for a renewable source.
- Many countries that are highly advancing in renewable energy are helping people to start their own renewable source by funding them at initial stage.
- In India there are many good companies that are interested in renewable energy market but are feared of risk of entering a new sector where no grounding has been done.

- Our idea is to encourage these companies into revolutionizing the renewable energy market in India. This can be done in many ways ,one of the ways to increase interest in this companies are by decreasing the risk factor on entering into this field mainly loss of investment.
- Indian government can take a forward step and start encouraging private investment in different companies that globally established but are afraid of risks in India. Taking shares in this type of companies helps not only the companies and the project of increasing renewable energy but also gives profit to Indian government as the success achieved by these companies can be reflected as dividends in shares to Indian government.
- Since this is a public private cooperation working with all stakeholders helps lowering the cost of loan standards and lower transaction costs. Altogether they are can be 25% lower project cost than the original project cost forecast.
- Finally, the project can be successful in dispersing risk effectively, with the public partners taking on much of the political, financial, and commercial risk and the private partners taking on the construction and performance risks.
- Until now, we have discussed that how government can help industries that are interested in helping India to make transition to renewable energy source. But we believe there can be a steep change of curve when we help every ordinary man to be a part of this revolution.
- We already have many policies that helps every owner get the profit from the returns of the plant, for example Generation based Incentives (GBI) for Solar, Renewable Energy Certificates (RECs) etc. These policies help owner get profit when the owner have a plant.GBI,REC are the incentives provided in different forms by government to every owner of a plant.
- But as we discussed in above having a distribution level transition is much more effective than a transmissional level transition.
- As per discussion we have made policy for great companies by buying equity shares in their companies in a similar way government can help every individual who are willing to use renewable sources for electricity (like rooftop solar PV) by giving loans for the investment.
- Government can also help in form of tax returns by giving a credit varying from 10% to 30%, But also restricting the use of this tax returns if the source of the owner stopped working before a fixed period of time.
- This policy makes the people not only the consumers but also producers for their own and helps maintaining the load that can cause for grid.
- We believe policies that are mentioned above will have a major impact on the current renewable energy source market mainly solar market.

Q3. What should be the strategy for battery energy storage? Should the approach be more towards large utility scale storage or more distributed approach at residential level?

3.1 Introduction

The electrolytes and plates of a battery store energy in the form of chemical energy. Storage is accomplished by altering the nature of substances under the influence of an electric current. When the battery is fully charged and used, reverse chemical processes occur, and the electrolytes and plates return to their pre-charged state. The charging and discharging capacity of the battery, which is the rated energy storage in Ah at the nominal terminal voltage, is determined by the nature and quantity of electrolytes and plates.

The lithium-ion battery is distinguished from other frequently rechargeable batteries such as Ni-Cd, Ni-MH, and Lead-acid batteries by its high energy density, long service life, high energy and power density, and environmental friendliness.

Batteries, for example, are electric devices that demand a lot of electricity. A high number of batteries are required for energy storage systems (BESSs) and electric vehicles (EVs). A battery pack is made up of batteries that are connected in series and parallel. Costs, stability, uniformity, and safety are all affected. The applications are hampered by these issues. Lithium-ion batteries are a type of lithium-ion battery.

The battery pack consists of large numbers of batteries in series and parallel. In the process of using these batteries, the battery cells' performance (SOC (State of charge), RUL (Remaining useful time), OCV (Open circuit voltage) are inconsistent. The performance inconsistencies are caused by the inconsistencies of the battery parameters. It has a great impact on the efficiency and longevity of the battery pack. Compared with the single battery, its service life is greatly reduced. Therefore, optimizing the battery parameters consistency is of great significance to improve the performance of the battery pack.

Battery sorting means that by using some methods, the batteries that have the same performance will be put together to improve the consistency of batteries and to reduce the negative impact of initial differences among batteries, so as to improve the use efficiency of the batteries and prolong their service life. This section describes different methods in sorting lithium-ion batteries. Battery sorting includes single parameter sorting methods, multi-parameter sorting methods, dynamic character sorting methods and model sorting methods. However, these methods still have many drawbacks, such as low accuracy, time-consuming, sensitive to the collected data, poor applicability and so on.

3.2 Advantages of BESS Technologies

Energy Generation from renewable sources like solar PV is not always correlated with electricity demand. For example, in cold climate countries electricity demand peaks typically happen in the evenings when there is no solar energy.

There are different solutions for increasing the consumption of renewable sources like solar PV onsite, or so called "self-consumption", which can maximize the benefits of distributed energy generation and minimize the electricity bills of the PV owner.

One of the common solutions is to export extra electricity from solar PV to the grid.

However, in large-scale penetration of distributed solar PV, the export of electricity from many buildings to the distribution grid at peak generation times will cause contingencies and grid imbalances, resulting in additional costs for the system.

Moreover, the value of self-consumption of solar electricity for the private owner is typically much higher compared to the gains from exporting electricity to the grid, as export tariffs are typically lower than purchasing electricity prices.

Therefore, the private owner of solar PV prefers to find different ways to increase their self-consumption, e.g., by storing electricity via electrical energy storage (EES) systems such as batteries.

EES such as batteries can balance the mismatch between onsite renewable source like solar PV generation and electricity demand by storing electric energy at hours of low demand in daytime and discharging that to meet evening peaks.

The strategy for battery energy storage systems should be more towards large utility scale storage than distributed approach at residential level.

3.2 Advantages of Large-Scale storage system

Large scale storage systems are more beneficial to customers.

Large scale storage systems have low maintenance cost compared to distributed residential storage systems.

Large utility scale storage systems can be established at remote places, which cannot affect safety issues of residential people.

3.3 Disadvantages of Residential Approach

According to cost criteria the large utility scale storage is more beneficial to customers than distributed residential level storage systems.

The cost of batteries is still at the start of their learning curves, which diminishes the financial viability of investment in such distributive residential level BESS, from a private owner's perspective

The customer can get more benefit if the BESS is connected to the grid.

But connection of BESS to grid has some limitations like balancing services etc.,

For example, the requirement for an energy storage technology for providing balancing services in Finland is a minimum power output of 5 MW. These requirements leave many distributed technologies such as PV-EES systems with a typical size of a few Kilowatts unqualified for entering such marketplaces.

Aggregators, who are often third-party corporations profiting from control and transaction fees, may aggregate and coordinate the available capacity of numerous small-scale distributed technologies to overcome such hurdles to entry.

Therefore, the owner of a renewable source generation like (PV)-EES system can operate their asset either independently mainly for managing their own generation and demand or, alternatively, they could offer their available storage capacity to be coordinated with other small-scale EES units to participate in wholesale electricity markets through aggregators.

BESSs can be "aggregated" to provide the grid with a variety of services, such as operational flexibility and peak shaving.

Under centralized coordination, power users can save between 4 and 8% when using no technology, 3-11 percent when using electricity storage alone, 2-5 percent when using stand-alone solar PV, and 0-2 percent when using PV-battery combination.

The study reveals that the growth of the Battery energy storage system, as well as the scheduling coordination regime, has a significant influence on the consumer's yearly savings. Distributed coordination results in 4–11% lower savings than centralized coordination, whereas the system's evolution accounts for 1–27% of the difference in savings. In situations with massive utility-scale storage and renewable capacity, the biggest savings are realized.

Q4. What sort of market policies or regulations will be needed to move from current scenario of ~30% renewable penetration to a scenario of 60%, 70% or 80% renewable integration while facilitating complete electrification of vehicles to make sure there is good return on investment for EV charging infrastructure and DER owners who help in accelerating the energy transition?

4.1 Introduction

Government can set up renewable energy plants and allow private entities to set up plants like solar plants and can help private entities by giving subsidies, some relief on import tax for foreign companies. This will increase the renewable energy and lower the use of energy from fossil fuels.

Examples of different countries

France:

Public EV charging incentives in France

Purchase and Grid connection Grant:

Up to €2700- (AC) and €11100,- (DC) (both public use) + up to 75% connection costs for the purchase, installation and grid connection of publicly accessible charging points on roads.

Charging Hub Grant:

€ 100.000 per station (0.5-0.99 Mega Volt-Amp (MVA))

€ 160.000 (1-1.99 MVA)

€ 240.000 (>2 MVA)

Up to € 75.000 related to the grid connection for the purchase, installation and grid connection costs for deployment of hubs near metropoles or national roads.

Austria:

A subsidy of up to €30,000 is available to companies and public entities for the purchase and installation of DC charging stations designed to accommodate heavy goods vehicles.

A subsidy of between €300 and €15,000 is available to companies for the purchase and installation of publicly accessible charging stations.

Denmark:

A tax reduction of around 1DKK (€0.13) per kWh applies to companies that provide electric vehicle charging on a commercial basis.

4.3 Policies that can be adopted by the government

EV Incentives: Provide incentives at the state and national levels to reduce the upfront cost and total cost of ownership of electric vehicles.

Scrappage Policy: Develop and implement a policy that encourages the scrapping of vehicles older than 15 years.

Emission Requirements: Commit to implementing BSVI and CAFE requirements over the long term to help domestic Original Equipment Manufacturers (OEMs) compete in international markets.

Leverage R&D on Battery Technologies: Make in India encourages in-house development of cutting-edge lithium-ion batteries.

Develop a framework that promotes renewable energy trade and balancing between resource surplus and deficit states by creating ancillary marketplaces to pool Renewable Energy Power.

Lower interstate renewable energy transmission charges to promote regional balancing and allow renewable energy surplus states to find clients in renewable energy deficit states.

Providing an acceptable level of service support for flexible generation - gas, hydropower, and biomass - to grow their output capacity through feed-in tariffs.

Increase intra- and interstate grid infrastructure investments to accelerate the integration of anticipated renewable capacity.

Ensure that Renewable Power Obligation (RPO) objectives are met in various states, including the application of appropriate sanctions and enforcement methods.

The NCEF should provide financial assistance to states in order to strengthen intra-state transmission corridors for lines that are not included in the Green Corridor projects.

Existing power purchase agreements (PPAs) in India, which account for 90-95 percent of total renewable energy generation, are a significant impediment to greater power system flexibility from both interstate commerce and power plant flexibility. As a result, states should think about developing alternate resource sufficiency procedures and implementing financial PPAs. In the long run, India could benefit from the implementation of sophisticated electricity markets.

Providing states with the required technical and financial help to build world-class forecasting techniques for solar and wind-based energy sources. Launch an urban road-improvement initiative to promote more accessible walking, cycling, and electric micro mobility solutions, which will give clean, safe transportation options. This will result in a large number of new jobs being created in metropolitan areas.

Promote the development of electric freight lines in order to accelerate the electrification of the medium and heavy-duty truck sectors. Create a plan to **rethink and restore public transportation trust**, including greater bus procurement, the adoption of e-buses and innovative bus designs, the construction of bus corridors and bus rapid transit systems, and the digitalization of public transportation.

Grant subsidies for EV home charging infrastructures to homeowners to elevate faster and cheaper installation of charging infrastructures, and provide an alternative revenue stream to homeowners.

Q5. What sort of energy market policies will help with accelerating energy transition? Will transactive energy framework help customers to get additional revenue/ incentivize quicker adoption of advanced technology?

5.1 Energy Market Policies

Policies that can be implemented in future in India: -

One of the policies that can be implemented in India to increase the growth of renewable energy is by using a non-conventional renewable energy law that is implemented by Chile. The government issued a law that every energy provider should make 5% of their total energy production to renewable energy production in span of 5 years. Later from that every year there should be increase of 0.5% of their total production to renewable energy.

Another policy that can be implemented in India is to make the individual enthusiastic to support in production of renewable energy by starting a policy like policy maintained in US (solar investment tax credit (ITC)).

US government has given credit called solar investment tax credit which increased from 10% to 30 % from 2005 to 2009.This credit however can be taken away if the plant is not maintained for minimum of 5 years. The owner can take the tax credit in the first year in which the plant is operational.

How we can implement to increase production on distribution level?

Indian government can pass a policy stating any owner having a rooftop solar PV or a plant can have a tax benefit according the area of his solar panels.

We can also increase credit amount like us which makes them to buy from credit which in return helps government too.

Another policy implemented in US that can be applicable for India is The U.S. Department of Energy’s (DOE),1705.

Established in 2009 as a part of the American Recovery and Reinvestment Act, has successfully increased innovation and investment in utility scale PV and CSP

The DOE established the Financial Institution Partnership Program, which identified qualified private lenders eligible to participate.

Borrowers applied for loans directly with eligible lenders, with DOE reviewing all applications. Approximately $13 billion in loans, about 80% of all loan guarantees under the program, went to solar investments.

How can be implemented in India?

This policy cannot be implemented to individuals but can be implemented to a group of people belonging to same area or apartments, residencies etc.

About 80% of this loan should be guaranteed that it is going to be in solar investment.

Giving loan for construction increases profit for government and also creates a new renewable energy source for development.

Another policy that can be implemented in India is by India sharing equity shares with companies that are ready to develop a solar plant in India.

cost of investment was further reduced through participation of the government as an equity partner and international financial institutions, which decreased the cost of capital.

By decreasing the project risk many will be private developers are attracted to participate in the effort resulting a success in making energy transition.

5.2 Transactive Market

Yes, a transactive energy framework will help customers to get additional revenue/to incentivize quicker adoption of advanced technology.

This also increases the customer participation in the total process making them not just consumers but prosumers (producers + consumers).

WHY Transactive Energy?

Transactive energy systems provide a way to maintain the reliability and security of the power system while increasing efficiency by coordinating the activity of the growing number of distributed energy resources.

The new renewable energy sources which are being added to the grid are a bit unpredictable. This makes the generation source quite variable. This is one of the major issues of renewable energy sources.

We believe that over time the old model of the generation following load will be superseded by a future model of load responding to supply.

During the transition between these two paradigms, the new problem is one of finding a means to manage that variability most efficiently, while maintaining system balance, stability, supply security, and reliability.

This is where a common transactive market model can serve its purpose.

Another issue with solar power is about incentivization to the public. It is true that in long run, using solar panels at their home is beneficial, but we need to provide them direct profit/incentive to spend money to install the required equipment like solar panels in the first place.

The below proposed transactive model provides a method for the public to trade the energy they generate for money in an exchange market. This increases customer satisfaction and in turn motivates/incentivizes them to build more renewable energy sources.

5.3 Model

First, let us establish the transactive market model (reference NRJcoin Virtual currencies). This transactive model works in the system where there is a smart grid system in place already. This would require investments and a lot of modification in the present grid system which will be attained gradually.

Prosumers in the smart grid trade locally produced renewable energy using a specific unit of virtual currency (let's say solar money, in short, $sol) the value of which is determined on an open currency exchange market. $sol is generated by injecting energy into the grid, this creates a trading paradigm between energy generated and money.

There are many advantages of using a virtual currency. IT will be free of inflation. It will also be decentralised hence no monopoly can be done in this. Due to all these points, we propose a model with virtual currency instead of fiat currency.

A prosumer let's say A generates renewable energy and feeds x amount back into the grid. Then the amount of $sol paid to him will be calculated by a specific function ‘f. So the prosumer will be paid with f(x) $sol coins.

This f depends on the present rate of energy depending on supply and demand. Every 15 minutes each street-level substation independently determines the rates for energy consumption and for production for all dwellings in that neighbourhood. This helps maintain the balance between the supply and demand and the rates provided for it.

The consumer is paid in this virtual currency by the local substation for generating x amount of energy and also will be paid by the administration managing this coin so that there is an inflow of new currency and to avoid any kind of deflation. All this amount of energy generated and fed back to the grid is done based on the smart meters installed in every residential place.

ANNEXURE

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Abbreviations:

1. **2W -** Two-Wheeler
2. **3W -** Three-Wheeler
3. **4W -** Four-Wheeler
4. **AC -** Alternating current
5. **BESS -** Battery Energy Storage System
6. **BSVI -** Bharat Stage Emission Standards VI
7. **CAFE -** Corporate Average Fuel Economy
8. **CERC -** Central Electricity Regulatory Commission
9. **CHP -** Combined Heat and Power
10. **CSP -** Concentrating Solar Power
11. **DC -** Direct Current
12. **DG - Distributed** Generation
13. **DOE -** Department of Energy
14. **EES -** Electrical Energy Storage
15. **EV -** Electric Vehicles
16. **FAME -** Faster Adoption and Manufacturing of Hybrid and Electric vehicle
17. **FiT -** Feed-in-Tariff
18. **GBI -** Generation based Incentives
19. **ICE -** Internal Combustion Engine
20. **ITC -** Investment Tax Credit
21. **MASEN -** Moroccan Agency for Solar Energy
22. **MDAS -** Meter Data Acquisition System
23. **MDMS -** Meter Data Management System
24. **MWh -** Megawatt-hour
25. **NCEF -** National Clean Energy Fund
26. **NMEM2020** - National Mission for Electric Mobility 2020
27. **OCV -** Open Circuit Voltage
28. **OEM -** Original Equipment Manufacturer
29. **PPA -** Power Purchase Agreement
30. **PPP -** Public-private partnership
31. **PV -** Photovoltaic
32. **R&D -** Research and Development
33. **REC -** Renewable Energy Certificates

34. **RLDC -** Regional Load Dispatch Centre
35. **RPO -** Renewable Power Obligation
36. **RTS -** Roof-Top Solar
37. **RUL -** Remaining Useful Time
38. **SAM -** System Advisor Model
39. **SOC -** State of Charge

Distribution of EV Charging Stations

We choose to analyse the choice criteria that have a substantial impact on the number of charging stations when calculating the demand quantity of charging stations.

1. The ownership of electric cars.
2. The mileage of electric cars.
3. The charging characteristics of the battery.
4. Two charging ways of electric cars.

Electric vehicle daily charging demand measurement

Variables comment

D1	The car's daily fast charging demand	N1	The number of fast charging vehicles
L1	The average annual mileage of a fast charging car (km)	H1	The number of days a fast-charging car travels in a year.

M_1	Endurance mileage for fast charging vehicles (km)	α_1	The proportion of fast charging vehicles
β	The usage rate of fast charging vehicle (in %)	D_2	The EV's daily destination charging demand (kw/h)
N2	The number of days a destination charging car travels in a year.	B1	Average charge per fast charge (kw/h)
WBi	The demand charge per day in per community (kw/h)	PBi	The number of users who use the destination charge in the per community
EC	The number of charging stations (range)		

For this estimate, the charging demand vehicle is primarily a Tesla private car, which has two charging modes: rapid charging and destination charging. The sum of the electricity required for these two charging modalities should be the total amount of power distributed in the charging station.

The computation of the charging demand vehicle is primarily done by Tesla private car, with two charging modes: rapid charging and destination charging. The sum of the electricity required for these two charging modes should be the total quantity of power distribution at the charging station.

Measurement of daily charging demand for quick charging.

a. Quick charge mode can meet the needs of rapid plug-in electric vehicle charging, also provide quick charge for some other types of electric vehicles to provide emergency charging demand.

$$D_1 = N_1 * L_1 / H_1 * \alpha_1 * \beta$$

a. Destination charging mode - The destination type charging car can be used in the public places such as business circle, station and residential area, and it can use the space prediction method to predict the daily demand charge of charging users. Most government vehicles and private cars are taking conventional charging ways, and the charge amount of the vehicles on the weekend is bigger than that of working days.

$D_2 = F_2 * N_2 * \alpha_2 * \beta$

By analysing the above formulas, it is found that the average driving distance of the destination plug-in vehicle is about 60km per day, and it can continue to travel 120km after charge. And the average charging frequency is 0.5 times per day.

Measurement of Total Demand for Electric Vehicle Charging Stations

The total distribution of the public charging station consists of two parts, one is to meet the charging demand of the inbound vehicle, and the other is to meet the operational needs of the station.

$$W = W_1 + W_2$$

Fast charging car users daily charge demand:

$$W_1 = D_1 * B_1 = N_1 * L_1 / H_1 * \alpha_1 * \beta * B_1$$

M

Electric car users show a regional distribution, the user's charge demand will be different if the land type is different. Therefore, the daily charging of electric vehicles on the basis of land nature of the region.

$$^{N}W_2 = \sum W_{2i} * P_{2i} * R_{2i} * api$$

After determining the total charging demand, we can obtain the demand range of charging station.

$$Ec = \varepsilon * W / Ic * tEc = \varepsilon * W / Ic * t$$

Variable Comment Variable Comment

γt γo	Electric vehicle charging station service radius(γt refers to station in city; o to the countryside)	Dt Do	Unit price charging column can serve the total amount of vehicles (t refer to station in city; o to the countryside)
C(t,o)	Number of charging stations in the city or countryside	p	External influence coefficient (innovation coefficient)
q	Coefficient of influence (imitation coefficient)	Zi	The optimal results
ηi	Electric car charging station revenue	μ	Operation and construction costs.

When the capital is the same, it is necessary to have the maximum service radius and meet the maximum charging demand if you want to get the optimal construction namely charging station service ability is the strongest.

$$Max(D_m) = D_t * C_t * + D_o * C_o$$
$$Max(R_m) = g_t * C_t * + g_o * Co$$

While the constraints conditions are

$$C_t + C_o \leq 1$$
$$C_t \geq 0$$
$$C_o \geq 0$$

The bottlenecks which could constrain emission cuts:

Summary:

Bottleneck effect means, the consequences of an action or other factors slows down the same action.

- The Paris Agreement requires that countries reach global peaking of greenhouse gas (GHG) emissions as soon as possible to achieve a climate-neutral world by mid-century. The HLDE's goal was to accelerate and scale up action to achieve universal access to clean, affordable energy by 2030 and net-zero emissions by 2050.

- To achieve the net-zero emissions by 2050, all countries should use the renewable resource instead of fossil fuels.

- The energy generation technologies that use the renewable resources like wind turbine and solar panels etc., are already ready to achieve the universal access to clean, affordable energy by 2030 and net-zero emissions by 2050.

- but to reach the goal, we need to large number of wind farms and solar farms which requires millions of tones of raw materials to be mined.

- For example, batteries in EV (Electric vehicles) depend on cobalt, lithium and nickel; neodymium and other rare-earth elements make the magnets for electric generators and motors; the veins and arteries of the green economy run with copper.

- The supply chains on which this all depends pose at least two big problems.

1. The first one is of concentration.

- The mining and processing of minerals needed for renewables is far more geographically concentrated than the drilling of oil and gas; that should be troubling to anyone with a sense of how the distribution of fossil fuels has influenced history and geopolitics.

2. The second problem concerns underinvestment, particularly in metals.

- Revenues from coal, the dirtiest fossil fuel, continue to exceed those from the minerals that today's technologies for providing a cleaner future require (see chart 2). Investment in new projects for lithium, nickel and copper were rising before the pandemic, but at less than $25bn the figure in 2019 was only about 5% of the amount invested on upstream oil and gas. And mines require sustained effort; it can take well over a decade to get one up and running

Method for Electrical Energy Can be Captured as liquid air

- For the Past few times, We are Using Wind and Solar Energy as a Joule.

- If Somedays Wind may not Blow or Sun may not Shine then we will use A coal or Gas Power station as a Source of Energy.
- Lithium-ion batteries, the workhorse of applications from mobile phones to electric cars are, Reliable, Scalable, and Well Understood.
- Liquid Air can fulfill the demand for lithium-ion batteries to make the availability at low price.
- At -196^{o}C Air liquefied and occupy $(1/700)^{th}$ Volume as Gases at Room Temperature.
- Using a Device, Dearman Engine, liquid Air is Forcefully Expanded.
- Cryogenic Energy Storage main proponent, Highview Power-A firm in London, Can store 15 MW-hr.
- The Trick, Dr. Ding says, is to Capture, Probably in oil or salt, the heat generated as the air is compressed prior to its liquefication. Some Heat can be used to boost the warming of liquid as it enters the Derman engine.
- Rest of the Heat can be used to power a piece of refrigerator called an absorption chiller. This will help us to reduce the amount of electricity used to liquefy air.