UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

Discussion Paper

Best Practices in Electric Mobility

INCLUSIVE AND SUSTAINABLE INDUSTRIAL DEVELOPMENT

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Best Practices in Electric Mobility

Vienna, 2019

List of Abbreviation

2-W	Two Wheeler
AC	Alternating Current
ASEAN	Indonesia, Thailand, Malaysia, Singapore, Philippines, Vietnam, Brunei, Cambodia, Myanmar (Burma), Laos
AT&C	Aggregate Technical & Commercial
BEV	Battery Electric Vehicle
CARB	California Air Resources Board
CDFI	Community Development Financial Institution
CLMV	Cambodia, Laos, PDR, Myanmar and Vietnam
CPUC	California Public Utilities Commission
DC	Direct Current
EESL	Energy Efficiency Services Limited
EU	European Union
EUR	Euro
EV	Electric Vehicle
EVSE	Electric Vehicle Suplly equipment
GEF	Global Environment Facility
GHG	Greenhouse Gas
HEV	Hybrid Electric Vehicle
ICE	Internal Combustion Engine
IMPT	Indonesia, Malaysia, the Philippines, Thailand
JEVA	Japanese Electric Vehicle Association
LAPD	Los Angeles Police Department
LCO	Lithium Cobalt Oxide cathode
LDV	Light Duty Vehicle
LFP	Lithium-iron-phosphate
Li-ion	Lithium Ion
MBCDC	Multibank Community Development Corporations
MITI	Ministry of International Trade and Industry, Japan
NCA	Nickel-cobalt-aluminium
NMC	Nickel-manganese-cobalt
NMH	Nickel Metal Hydride
OEM	Original Equipment Manufacturer
PHEV	Plug in Hybrid Electric Vehicle
PHV	Plug-in Hybrid
PLDV	Passenger Light Duty Vehicle
PLEVs	Personal Light Electric Vehicles
PPP	Public Private Partnership
R&D	Research and Development
RE	Renewable Energy
RFID	Radio-Frequency Identification
RGGI	Regional Greenhouse Gas Initiative
ROEV	Roaming for EV Charging
TCO	Total Cost of Ownership
UK	United Kingdom
UNIDO	United Nations Industrial Development Organisation
US/USA	United States of America
USD	United States Dollar
VAT	Value Added Tax
ZEV	Zero Emission Vehicle

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Foreword

United Nations Industrial Development Organization (UNIDO) is implementing many programmes in association with Global Environment Facility (GEF) for development of electric mobility. The programmes have been running in China, South Africa and Malaysia under the 5th and 6th replenishment cycle of GEF. The objective of this paper is to provide a global assessment of practices, challenges, drivers and emerging best practices in major electric vehicle markets. The key leanings will form the inputs for designing further programmes in electric mobility by UNIDO and GEF.

At this stage some countries have gained considerable experience in encouraging and adopting electric mobility. There is however no country that has reached 100% electric mobility. For countries that are yet to start their journey in electric mobility, global experience in the sector will form the basis for designing programmes to encourage uptake of electric vehicles. Additionally, countries that have considerable electric vehicles deployed on their roads can learn from their counterparts.

The paper seeks to address the challenges that are faced by countries in employing EVs and setting up charging infrastructure. Exemplary programmes are discussed and best practices to overcome the barriers. We assess the key learnings for integrating the power sector with transport and incorporating electric mobility in the urban planning concept of transit oriented development.

The paper also presents case studies from the e-mobility programmes UNIDO is implementing in association with GEF in China, South Africa and Malaysia. The case studies have been developed through detailed study of programme documents and in depth interviews with local teams in the countries.

Executive Summary

The world is making significant inroads to convert their transport sector to electric. Rising GHG emissions, higher cost of crude oil and a reduction in battery costs have contributed to the rise of electric vehicles. The shift to electric mobility is crucial to reduce emissions and governments across the world need to take actions to encourage the adoption of EVs in every mode of transport.

In 2018, there were more than 5 million[1] EVs on the road, with a significant increase of 2 million EVs in the same year. China leads the world in volume of electric cars sold and Norway leads in the market share of EVs in the new vehicle sales. China and USA have the largest number of public EVSEs installations.

The transition to electric mobility is faced with many challenges that need to be addressed by all stakeholders. The barriers are across economic, regulatory, technical and informational domains as highlighted below.

Economic Barriers	Regulatory Barriers	Technical Barriers	Informational Barriers
Business viability issues High upfront EV cost	Characterization of EV charging activity Tariff related issues	Charger standards and protocol issues Grid stability issues Battery performance issues	Lack of awareness Range anxiety

Despite the challenges, there are many opportunities now to encourage EV adoption across the world. The developments in technology and changing government priorities have provided the required impetus to e-mobility. The drivers for e-mobility are presented in the following infographic:

Reduction in battery prices	Evolving battery technology	Evolving charging methods	Increase in Renewable Energy	Rising crude oil prices	Increasing government support

Changes in fuel and technology lead to many changes in the trade relations of countries. Co-operation between countries can lead to many green "free" trade agreements that will reduce the cost of imports between countries to encourage EVs. However, many countries with an automobile manufacturing base would want to protect their domestic industry by raising import duties. Oil rich countries will also have to find an alternate source of income with the reducing dependence on oil. In turn, requirement for cobalt, nickel, lithium and other minerals will increase, as they are key elements in batteries that are currently in circulation. The largest reserves of metals and minerals required for battery production are found in weak states with poor governance records, which can lead to instability in the countries.

The local and national government take many steps to encourage electric mobility. As a first step, the government should declare a well-defined roadmap or strategy that sets the mission and objectives for the country to achieve electric mobility. The roadmap should have clear and well-defined objectives for deployment of EVs and EVSE. The development of the roadmap should involve private and public stakeholders during the formulation period to create a holistic policy and ensure their active participation. For effective implementation, the government should follow by taking concrete legislative action and setting a stringent monitoring mechanism. The local government at the city and state level can take the programme further and supplement the initiatives taken at a central level. Due to the high capital cost of EVs, financial incentives are necessary. The most effective incentives reduce the upfront cost of EV and can be availed easily by consumers. Additionally, it is essential for governments to provide information about EVs and the associated benefits, incentives and policies to the end consumer.

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1 Global EV Outlook, 2019, IEA

The utilities are required to play an active role in providing a network of charging stations. In some regions utilities are not allowed to set up charging stations, however as in the case of California, allowing utilities to set up charging infrastructure has led to an increase in investment of EVSEs. A concern with the rising level of electric vehicles is that the pollution is being transferred to the power plants, since significant amounts of electricity is still produced by fossil fuel based thermal power plants. However, EVs can enable the transition to renewable energy as the batteries can act as storage for the power generated at by RE sources. Smart Charging can enable the bidirectional flow of current and help utilities manage EV load at times of peak demand. Countries should enable smart charging to take advantage of EVs in grid management. Additionally, countries should also allow the charging activity to not be considered as a resale of electricity but as a service to enable private sector investment in the sector.

Transit Oriented Development is a concept in urban development and planning that encourages public transport. It focuses on the creation of pedestrian oriented pathways with easy connectivity to transit services to the rest of the city from transport hubs such as metro stations and bus stands. Governments should enable electrifying public transport services, car fleets and personal use vehicles to electric at such hubs.

The technology of electric vehicles is constantly evolving, with faster charging methods and higher capacity batteries. It is important to ensure interoperability of the charging stations. This will ensure that all EV users have access to a robust charging network and there is less variability and easier adoption. Since EVSE business models are highly dependent on the utilization of the charging station, incentives must be provided in the short term till the business is viable for private players to invest. Additionally, there is no fixed EVs to EVSEs ratio in regions where there are a considerable number of EVs. It is essential for countries developing their plan to consider the residential and personal chargers while deciding on number of EVSEs. Without new business models emerging that create new relationships between private drivers, fleet managers, city managers, energy providers, the auto industry and central government, it will be difficult to scale up electric vehicles. Demand aggregation or bulk procurement is one of the most common model followed for adoption of electric vehicles for a public or private fleet. Outright purchase and collaborative procurement are some popular demand aggregation methods. In order to save the maintenance and operating hassle, some agencies also prefer leasing the vehicles in their fleet. Electric car sharing is also gaining popularity. It saves the hassle of owning a car (parking charges, fuel costs, etc.). In addition, since shared cars have greater utilisation percentage or average driving distance per day if compared to an owned car, the payback period for owning an electric car reduces significantly.

For charging infrastructure deployment, governments are employing several business models. In China, a government agency installed substantial number of fast charging stations in order to overcome the hurdle of range anxiety from the mind of EV owners. Battery swapping stations are also becoming a popular concept. Swapping stations provide reduced charging times as well as increased battery life.

Lastly, innovative financing mechanisms are required to mobilize the e-mobility ecosystem. Some of the common financing mechanisms for EVs and related charging infrastructure are Low interest rate loans, fee-bate mechanisms, green bonds, and microloans. Sometimes, multibank arrangement, operated by a group of banks to pool funding and provide lending, is also undertaken. Small business micro-loans can also be used to fund e-mobility ecosystem. Microloans are small-business loans offered at attractive interest rates to help businesses access capital for items like machinery or fixtures. These loans can facilitate funding for electric vehicle charging equipment and installation costs.

It is clear that governments need to take concrete action to encourage electric mobility to take advantage of the benefits of the technology. International co-operation is essential to the development of electric mobility. Experiences from across the world and the understanding gained from these experiences have to be incorporated in further programmes across countries.

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1. Overview of global electric mobility

Over the last few years, electric mobility has once again been the subject of lively discussions due to new, more powerful, rechargeable batteries and the high volatility on the oil markets. Strategic objectives such as reducing the dependency on oil, more efficient energy transformation, significant CO2 reductions and lowering local emissions from transport are important drivers of electric mobility. Electric mobility is therefore a prominent topic in environmental, economic and social terms. Electric mobility could prove to be the silver bullet for the mobility of tomorrow: vehicles that do not locally emit any pollutants or CO2 protect the environment and resources, especially if the electricity used comes from renewable energy sources. In addition, they run quietly. This could ensure that our cities remain livable

1.1. Electric Mobility Landscape

The total number of electric cars in the world has crossed the 5 million mark in 2018[2], with an increase of about 2 million e-cars in 2018 alone. China is the leader in electric car sales, followed by Europe and the United States. China has the largest fleet of electric LCV with 57% of the world's stock. Norway has the highest share of electric cars in its transport sector sales at 46%.

Other transport modes such as 2-W and buses are also becoming electric. In 2018, the global stock of 2-W was about 260 million and 460,000 electric buses were plying on international roads.

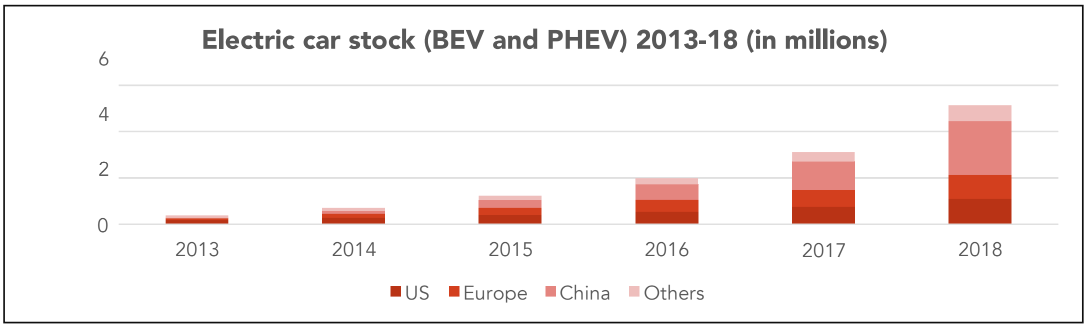


Figure 1. Electric car stock (BEV and PHEV) 2013-18 (in millions)

China and Japan have the maximum number of chargers installed to cater the available number of electric vehicles. China has around 130,508 AC chargers and 83,395 fast DC chargers installed as of 2017. The chart below provides a snapshot of number of publicly accessible AC and DC chargers by country for the year 2017. As evident from the graph, China has the highest number of AC as well as DC chargers, mainly due to government aggressive deployment policies and rebates. Whereas, countries such as Norway and Sweden focus on home based charging, hence the number of public chargers are very low.

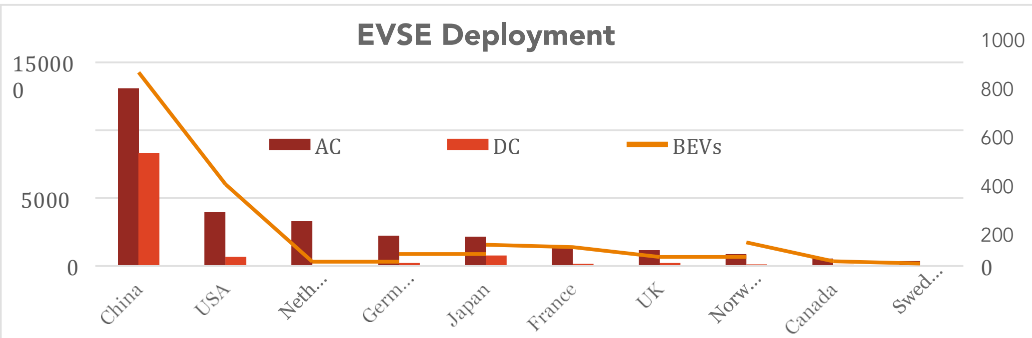


Figure 2. EVSE Deployment

2 Global EV Outlook, 2019, IEA

1.2. Key Barriers in EV adoption

Electric vehicle ecosystem is ready to proliferate in a major way; however, there is a long way to go before this paradigm shift in transportation sector becomes a reality. Electric mobility market is still in its infancy and point to many barriers for it to become a common mode of transportation. Barriers in EV adoption have been discussed below:

Economic Barriers

- Business viability issues
- High upfront EV cost

Regulatory Barriers

- Characterization of EV charging activity
- Tariff related issues

Technical Barriers

- Charger standards and protocol issues
- Grid stability issues
- Battery performance issues

Informational Barriers

- Lack of awareness
- Range anxiety

Figure 3. Key Barriers in EV Adoption

1.2.1. Economic Barriers

Purchase Price of EVs

EVs have a higher price tag than conventional ICE cars due to the high price of the battery. This is a significant hindrance for potential consumers.

Business Viability issues

EVs have a high cost of acquisition in comparison to conventional ICE cars. Even though EVs have very low operating costs, fleet operators that use traditional ICE vehicles will face higher capital cost to replace them with EVs. It is difficult to offer EVs at the same rate as ICE vehicles or even deploy the vehicles at a higher cost.

In the current scenario, it is challenging to construct a profitable business case for public EV charging stations for several reasons. These include high initial investments, low and uncertain near-term demand for public charging and high cost of electricity to public charging stations as compared to home charging. As the penetration of electric vehicles is very low, utilization of initial Charging Stations would also be low, resulting in negative Total Cost of Ownership (TCO) and revenues for the Charging Station Operators/ Owners.

1.2.2. Regulatory Barriers

Characterization of EV charging activity

The characterization of EV charging activity either as sale of electricity or service has been a point of contention. Internationally, majority of the countries have characterized EV charging as a service, and hence, have kept the market open for all the players without the requirement of obtaining any license from Government authorities.

Tariff issues

For public charging stations, the cost of electricity constitutes a major component of overall cost of charging electric vehicles. It may range from 30% to 60% of the overall cost depending upon the cost of various components, viz. cost of equipment, land cost and electricity tariff. If charging stations are charged the tariff applicable for commercial use (which is generally higher than the average cost of supply in order to subsidize various categories of consumers and high AT&C losses), it would force them to charge high rates from consumers. This would make electric vehicles less attractive than ICE vehicles at present scenario, as the initial cost of electric vehicles is already higher than the ICE vehicles.

1.2.3. Technical Barriers

Charger Standards and Protocols

There is a lack of single agreed charger standard in many countries, which result in lack of inter-operability.

Grid Stability related issues

Normal EV charging behavior will put extra load on the grid at peak hours. Charging profiles on traditional or 'unmanaged' EV charging stations (primarily residential and office premises) typically see peaks in the mid-day and early-evening periods, which overlap with peak loads on the grid. EV charging during peak demand hours carries the risks related to management of electricity distribution network. Hence, utilities are likely to become increasingly concerned with managing of charging activity of electric vehicles, to avoid any adverse impact on the electricity grid.

Higher EV uptake would need to be supported by strengthening of distribution & sub- transmission network. However, EVs can have a positive impact on grid stability, if EV charging is done during off-peak hours.

Battery Performance Issues

While Lithium ion batteries are the most suited to this application, there have been concerns about the safety of the battery in high temperatures and life cycle of the battery.

1.2.4. Informational Barriers

Awareness

There is lack of awareness about electric vehicles, their performance, the incentives and regulations in place for their use.

Range Anxiety

The range of e-cars is limited by the size of the battery, which is generally lesser than ICE cars. Range anxiety, is the one of the most significant barriers to the rapid uptake of electric vehicles.

2. Drivers for Electric Vehicles (EV) adoption

Globally, following major market drivers are responsible for the transition to electric mobility ecosystem across developed and developing nations. The studied key variables have been illustrated below:

- **Reduction in battery prices**
- **Evolving battery technology**
- **Evolving EVSE (Electric Vehicle Supply Equipment) technology**
- **Promotion of renewable energy**
- **Rising crude oil prices**
- **Government Support**

Figure 4. Drivers for EV adoption

2.1. Reduction in battery prices

The fairly higher cost of electric vehicles has held the market back from fully competing with conventional vehicles. The cost of batteries is the primary factor behind EVs' high sticker price. The battery cost contributes as high as 45-50% of total medium battery electric vehicle (BEV) cost.

The figure below illustrates cost breakdown of a fully electric vehicle. A Li-ion battery pack costs around 45% of the total cost of a battery operated electric vehicle (BEV)

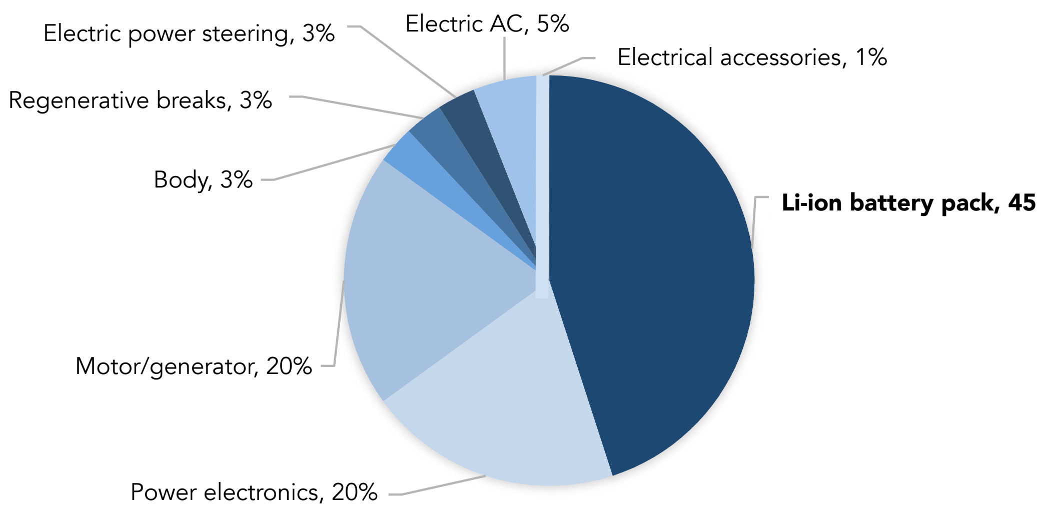


Figure 5. Cost breakdown of BEV

Source: IRENA, PwC analysis

However, in the last few years, battery prices have fallen much rapidly than expected. The battery prices have dropped around 73-75% since 2010 and so is their contribution in the overall BEV cost. The analysts forecast prices for lithium-ion battery modules to tumble below $200/kWh by 2019, enabling previously "uneconomical applications" such as battery storage enabled solar powered EV charging stations to surge.

The figure below presents BNEF (Bloomberg New Energy Finance) Li-ion battery price survey from 2010 to 2018.

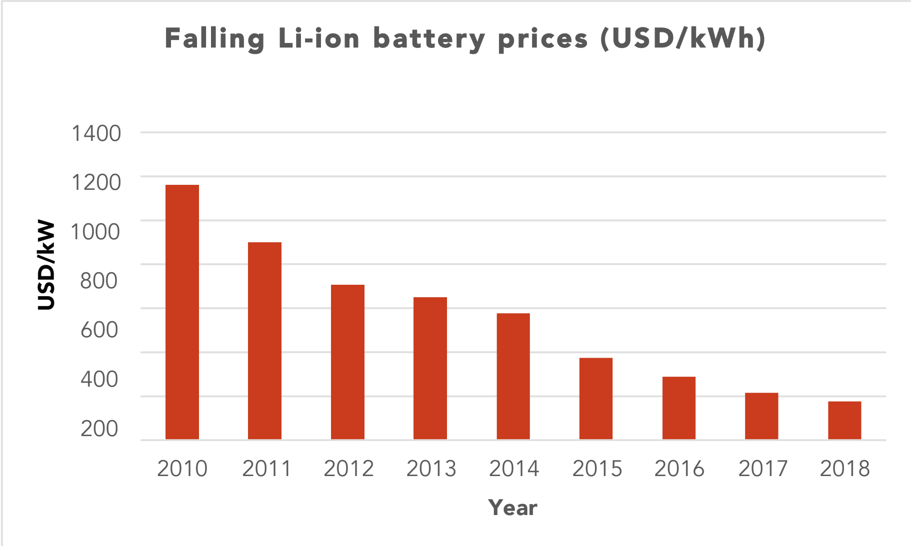
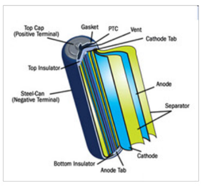
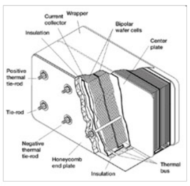
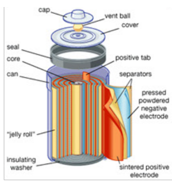
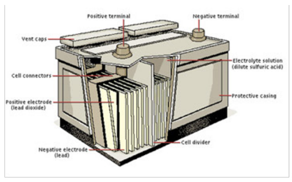


Figure 6. Falling Li-ion Battery Prices

2.2. Evolving battery technology

As the disruption took place in the Li-ion battery space, electric car market began to accept the newer technology. Battery OEMs moved from lead acid or Nickel Metal Hydride batteries towards the Li-ion technology for transportation purposes. The major reason behind the acceptance of Li-ion batteries was the manifold increase in their overall performance. The figure below presents a concise comparative analysis among different types of prevalent battery technologies used for powering electric vehicles.

	Lithium ion (Li-ion)	**Nickel Metal Hydride (NMH)**	**Nickel Cadmium**	**Lead Acid**
Advantages	▪ High energy density ▪ No memory effect ▪ Low discharge ▪ No maintenance ▪ Long lifespan	▪ Good energy density ▪ Low memory effect ▪ No environment issues ▪ Good safety ▪ Good lifespan	▪ Very good power density ▪ Rapid recharge ▪ Inexpensive ▪ Long lifespan	▪ Good power density ▪ No memory effect ▪ Low discharge (40%/year) ▪ Inexpensive, easy to manufacture
Disadvantages	▪ Safety (sensible to °C, overload) ▪ Stability ▪ Expensive	▪ Risk of overheating ▪ No use at -0°C ▪ High self discharge (3 months) ▪ Expensive	▪ Memory effect ▪ Low capacity ▪ High self discharge ▪ Environmental concerns	▪ Low energy density ▪ No fast charge (8-16 h) ▪ Short lifespan ▪ Environmental concerns ▪ Requires charged storage
Applications	▪ Hybrid / electric vehicles ▪ Mobile phones ▪ Laptops	▪ Yesterday's Hybrid vehicles ▪ Consumer electronics	▪ Low end consumer goods ▪ Standby power	▪ Conventional car batteries ▪ Emergency lighting ▪ Back-up power

Figure 7. Comparitive Analysis of Different Battery Types

Initially, Li-ion batteries were considered unsuitable for large-scale storage (required in electric vehicles) due to their limited capacity and therefore, suffered from having handful of suppliers. Slowly, over the years, as technology progressed and new Li-ion battery packs started to come in (Li-phosphate and Li-Nano phosphate batteries), suppliers started to take interest and slow ramp-up of the technology started. Li-ion also evolved as new market entrants such as NMH and other alternatives started to prosper. Finally, after 2016, Li-ion batteries were prepared to be used for transportation purposes due to their operational improvements and commercial affordability. The figure below explains the three stages of Li-ion battery development throughout the years.

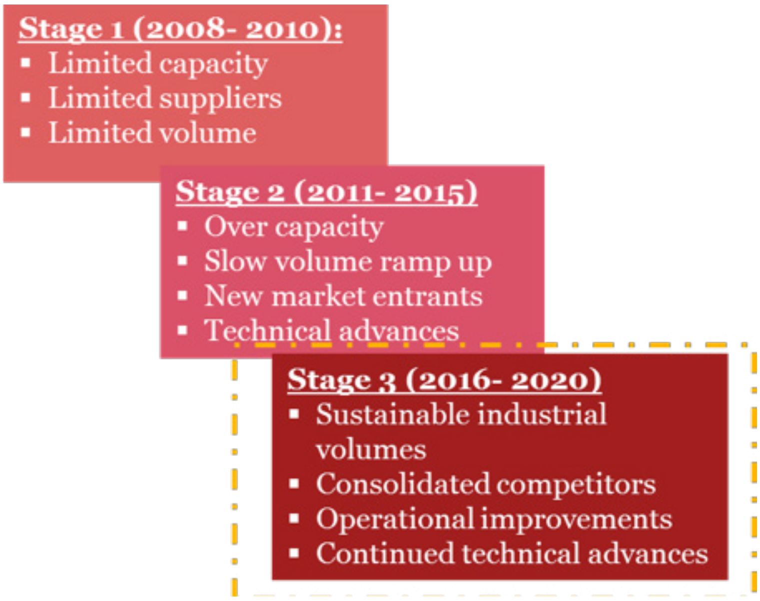


Figure 8. Stages of Li-ion Battery Development

The figure below illustrates how the Li-ion battery energy density increased as years passed.

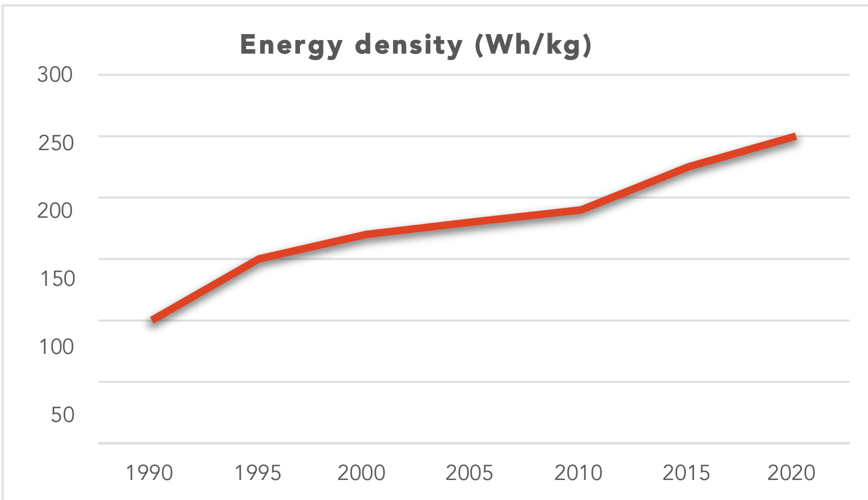


Figure 9. Li-ion battery energy density

Source: https://www.omicsonline.org/articles-images/advances-automobile-engineering-Lithium-ion-batteries-6-164-g003.png

2.3. Evolving EVSE (Electric Vehicle Supply Equipment) technology

Today's technology supports two charging methods: an alternating current (AC) on-board charger (slow and fast charging) and a direct current (DC) off-board charger (fast charging), as illustrated in the figure below.

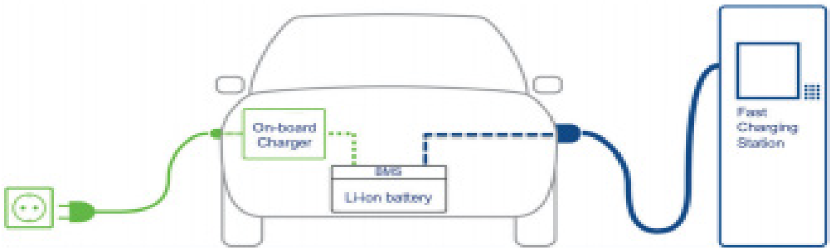


Figure 10. Charging Methods for EVs

At home or at work locations, vehicles are typically charged using an AC wall box, which takes about eight hours. When on the road, people can use public AC charge posts or DC fast chargers, depending on their needs and the type of electric vehicle. DC fast chargers typically cost more than AC slow chargers, but charging time per session is considerably lower in case of DC charging as DC chargers produce much more power. This difference in service capability results in higher overall return on investment from DC fast chargers. DC fast chargers also ensure efficient use of high-cost parking spaces in urban areas. Hence, deployment of fast charging network is one of the most critical factors in the faster deployment of electric vehicles.

Case Study: CHINA fast DC charger deployment

CAUSE

Many stakeholders in China, including the central government, local governments, and utilities, have been active in quickly building a fast DC charging infrastructure network in the country. In 2017, China had around 83,000 publicly accessible fast chargers and 130,000 publicly accessible slow chargers.

EFFECT

- Fast charging infrastructure deployment resulted in huge electric vehicle uptake.
- In 2017, China had the largest electric car stock i.e. 40% of the global total, with an auto market share of 0.2%.
- Electric cars sold in the Chinese market more than doubled the amount delivered in the United States, the second-largest electric car market globally.

Figure 11. Case Study: CHINA fast DC charger deployment

2.4. Promotion of renewable energy

Globally, energy transition towards renewable energy continues to move forward at a fast pace, owing to continuously slashing prices, technology enhancements and an increasingly supporting policy environment. Global renewable energy generation capacity reached 2,356 GW by the end of 2018. This represents a yearly growth of around 8%, according to new data released by the International Renewable Energy Agency (IRENA).

Renewable energy generated from hydropower plants comprises slightly lesser than half of the global renewable generation mix[3]. Wind and solar account for a majority of the remaining capacity. In fact, additional renewable energy capacity addition is in the form of wind and solar energy was 84% of new RE

3 IRENA, Renewable Capacity Highlights, 2019

capacity in 2018. The figure below provides the details of proportion of renewable electricity generation in global energy mix[4], ranging for a period of 15 years from 2001 to 2015.

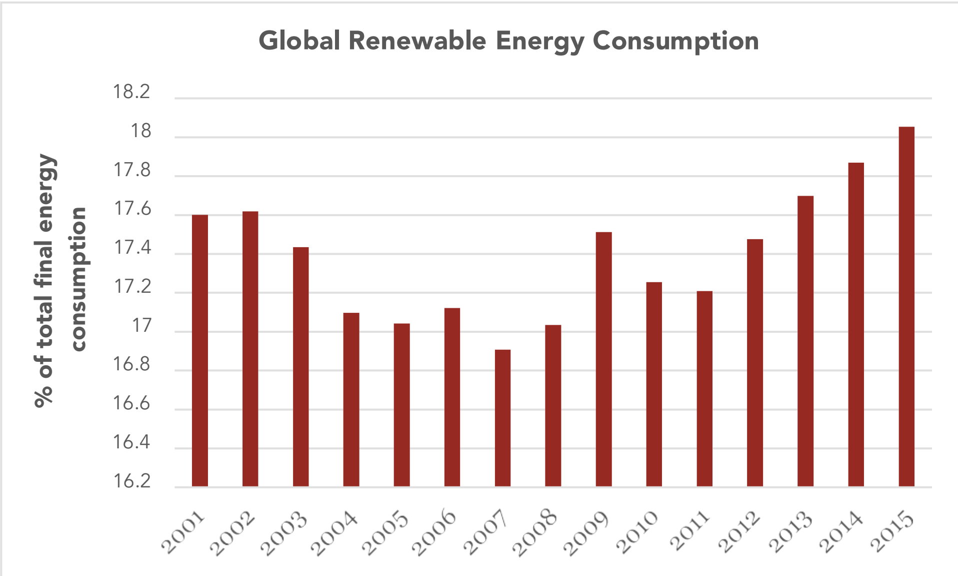


Figure 12. Global Renewable Energy Consumption

The growing renewable energy generation fits perfectly with the e-mobility ecosystem. Electricity used for powering the batteries can be fueled from renewable based energy to make the transport ecosystem carbon-free. Promoting renewable energy, thus, would give huge impetus to the electric vehicle deployment.

2.5. Rising crude oil prices

The recent spike in oil prices has given new momentum to global e-vehicles programmes that aim to reduce oil imports, cut emissions and boost energy security.

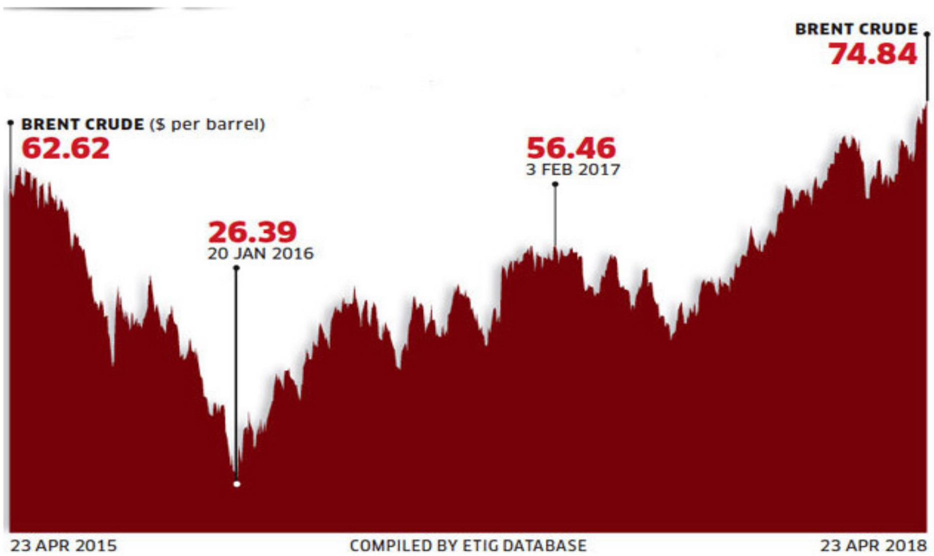


Figure 13. Historical Crude oil prices

4 World Bank Open Data

2.6. Government support

More than 160 countries have declared their Intended Nationally Determined Contributions (INDCs) to reduce GHG emissions as a part of the preparation for COP21 Paris Climate Conference in December 2015. Transport has been identified as a key sector for reducing emissions by a majority of the nations[5]. Additionally, there has been a focus on the vehicles and fuels utilized for transport with a heavy emphasis on converting to electric vehicles. Additionally, many initiatives such as EV30@30 by the Clean Energy Ministerial in which countries such as Canada, China, India, Finland and Norway have set an objective to reach a 30% sales share for EVs by 2030.

Since the introduction of electric vehicles, governments of different countries have taken various steps at national and local level for promoting electric mobility. The governments have adopted various programs and are increasingly working for development of electric vehicles and the associated charging infrastructure through subsidies, grants and public-private partnerships.

Opportunities for Electric Mobility in Small Island Developing States

Small Island Developing States (SIDS) are heavily dependent on fossil fuels for electricity generation and transport. SIDS are more vulnerable to changes in environment as they are small in size, less resources and might be easily affected by natural hazards.

SIDS can leverage the benefits of EVs to maintain the ecological balance and reduce costs. A detailed review of the opportunities that adoption of EVs would have on the state are highlighted below:

Island nations do not have large distances to be covered

- This eliminates the range anxiety of EVs

Reducing pollution

- With almost zero tailpipe emissions, EVs can drastically reduce the GHG emissions from transport

Reduce dependency on fossil fuels

- EVs will reduce the requirement of fossil fuels for transport, thus reducing the import of the same for the nations

Increasing Renewable Energy

- SIDS have to preserve the ecological balance and thus, EVs with technologies such as V2G and second life of batteries can reduce.
- SIDS usually have an abundance of Sun and Wind that can be utilized to produce electricity and the batteries can also work as backup during natural hazards/events.

Megapower, a company in Barbados has effectively managed to increase EVs in region, an eastern Caribbean island nation. The company provides EVs, charging infrastructure and solar energy to the region. They have sold more than 200 EVs and 50 charging stations in Barbados. They are integrating renewable energy into EV network by setting up solar carports which combines solar power with charging stations. They also sell used EV batteries that can be used for energy storage of renewable power.

Figure 14. Opportunities for Electric Mobility in Small Island Developing States

5 Transport in Nationally Determined Contributions (NDCs), GIZ

3. Geopolitical implications for Electric Vehicles (EV) adoption

A rapid transition to EVs would increase the risk of disruption, especially against the current backdrop of rising trade barriers and resource nationalism. EV adoption is likely to influence geopolitics through several interrelated mechanisms, including international trade, energy security and competition over strategic resources. EVs will also have second and third order effects with geopolitical or human security implications, in large part because of a declining tax base in oil producing countries. In each case, EVs have the potential to be a catalyst for greater cooperation, or a source of conflict.

3.1. International Trade

- **Rise of "Green" Free Trade Agreements:** EV costs must fall rapidly if sales are to grow to deliver a transport sector compliant to targets and mandates set by various countries. Fast growth requires an expansion of global supply chains, regulatory cohesion and market integration, which could prompt a rise in "green" free trade agreements.

- **Strategic trade tensions:** Countries with an automobile manufacturing base will need to accelerate their transition to electric mobility. In case they are not able to adapt to the new technology, they risk losing market share and car-making jobs. To protect domestic industries, they raise import tariffs on EVs, which will affect global trade and take up of EVs.

3.2. Energy Security

- **Reduction of revenue in oil states:** Electrification could result in reduced public revenues from oil in producing countries, many of which are in regions already at risk of instability. If oil declines and batteries rise as geopolitical drivers, the world will look very different.
- **Transnational energy infrastructure:** China is investing heavily in EVs and the Belt and Road initiative to reduce its reliance on the US for protection of oil supply chains. It is also a way to bring Chinese EVs and clean energy to the global market. The EU, China and Japan want to avoid the impact of volatile oil markets on economic growth. This could all lead to faster phase out of combustion vehicles.

3.3. Access to strategic resources

- **Increased competition for Rare-earth elements:** The need for cobalt, nickel, lithium and other minerals could lead to an increased competition for access to them.
- **Regional instability:** The largest reserves of metals and minerals required for battery production are found in weak states with poor governance records. Investment in resource extraction can lead to environmental degradation, civil unrest and instability.

3.4. Economic shocks and financial instability

The estimated oil revenue for the oil industry that will be wiped out by 2040 is USD 19 trillion, by the adoption of electric cars. Large-scale loss of oil industry revenue would mean lower tax revenues for governments reliant on the oil industry. Lower oil industry revenues leads to poor returns for institutional investors including pension funds. This is followed by decline in institutional investment in oil and the industry less able to raise capital.

4. Analysis of Policy Initiatives in Electric Mobility

The governments of many countries have recognized the benefits provided by electric vehicles and have implemented policies aimed at transitioning the base of their country's automobile sector from conventional fossil fuel to electricity. As the transition to electric mobility involves multiple stakeholders, the policies act as a guide for them to direct their actions to enable the uptake of electric mobility. The policy initiatives that have been implemented intend to overcome a range of barriers that are faced in the uptake of electric mobility such as high initial cost of vehicles, range anxiety, high charging times and consumer awareness. It is due to these policies that many countries have been able to successfully deploy electric vehicles. This section aims to discuss the key learnings of the policy initiatives of the governments of a few countries across the world

4.1. Key Learnings from Electric Mobility Roadmaps

As a first step towards the transition of the automotive sector to electric, many countries establish a national roadmap or policy to implement e-mobility. A national roadmap is a vision document that defines a set target and the proposed strategies to support the expansion of the EV market. The roadmap generally has the following components:

The need for electric mobility in the country	EV Targets	The initiatives and methodology required for EV and EVSE deployment	Barriers to electric mobility	Procurement programmes for EV and EVSE

Figure 15. Components of e-mobilty roadmaps

A few examples of electric mobility roadmaps are elaborated below:

Title	Country	Key Features
The National Electromobility Development Plan, 2009	Germany	The German Federal Government had laid out electromobility as a major component of the Integrated Energy and Climate Programme (2007). In lieu of achieving the intended targets, the National Electromobility Development Plan was developed in August 2009. The Plan represents Germany's approach to electric mobility as a cross sectoral initiative and involves all relevant industries to draft the plan. The plan envisages that Germany will become the lead market and provider of electro-mobility by 2020, and will have 1 million electric vehicles on the road by then. Proposed measures include financial incentives, R&D, development of an enabling framework, integration of renewables and standardization of technology.
2014 Automobile Industry Strategy	Japan	Though Japan has included electric vehicles in their strategic plans since the 1970s, the Automobile Industry Strategy sets out the latest roadmap for achieving electric mobility. The plan includes a target for 'next-generation vehicles' and 'electric vehicles' accounting for passenger vehicle market. It contains the strategy to promote 'next-generation' vehicles and development of research, development and human resources.

Zero-Emission Vehicle Executive Order, 2018	California, USA	The then Governer of California, Edmund G. Brown Jr. signed an executive order, commanding all state entities to work with private sector and all appropriate levels of government to put at least 5 ZEVs on on California roads by 2030 and 200 hydrogen fueling stations and 250,000 zero-emission vehicle chargers, including 10,000 direct current fast chargers, by 2025
National Environment Strategy 2020 and Action Plan	Lao PDR	The vision of EST Strategy is to "manage and promote the land transport to be convenient, connected, safe, modern, barrier free, sustainable and environment friendly." The first goal of the action plan is the promotion of goods and passenger transportation using electricity, domestic potential energies and low-emission energies.

Table 1. Electric Mobility Roadmaps

Set a well-defined Electric Mobility roadmap

As per International Energy Association, the policy pathway for sustainable transport begins with the planning stage that results in the development of the policy framework and action plan. The steps included in the planning stage are defined below:

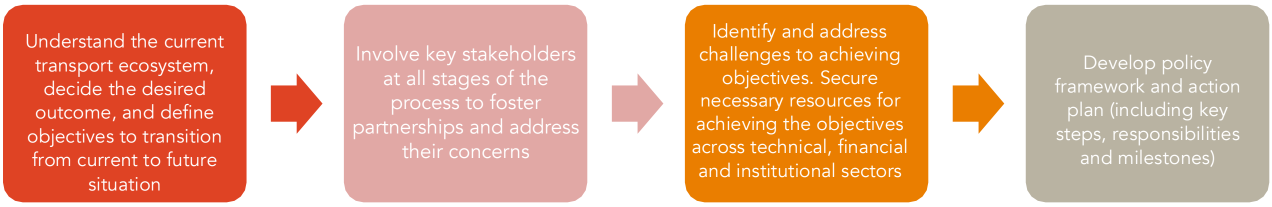


Figure 16. Planning Process for Policy Framework

Japan has been successful in implementing electric mobility roadmaps. The country had envisaged the need for electric mobility as early as 1976, when the Ministry of International Trade and Industry, Japan (MITI) established a basic market expansion plan for battery powered electric vehicles[6]. The plan was comprehensive and co-ordinated government departments, municipalities and companies in their efforts to achieve electric mobility. The plan was regularly reviewed and updated according to the market environment. The plan had a clear vision and strategy for all the stakeholders. The release of the plan was followed by swift action by the stakeholders, which resulted in the achievement of the set targets. For example, the government agencies initiated programmes to fund R&D of new technologies for 10 years over different phases, the Japanese Electric Vehicle Association (JEVA) initiated leasing programmes and OEMs initiated the development of HEVs and EVs.

In 2016, Japan's electric car charging points crossed the number of petrol stations in the country[7]. Japan has also been the home of the hybrid car Toyota Prius and the first mass produced EV, Nissan Leaf which has sold 360,000[8] units around the world since 2014. In 2018, Japan had sold a total of 49,750 BEV and PHEV cars of which approximately half were BEV.

California is leading the change to electric vehicles in the USA due to the actions of the local government. The local government has been aggressively targeting electric vehicle conversion in the state, which has led to the proliferation of EVs in the region.

On the other hand Germany has not been able to successfully implement its electric mobility policy. The German Federal Government had laid out electromobility as a major component of the Integrated Energy and Climate Programme (2007). In lieu of achieving the intended targets, the National Electromobility

6 Government policy and the development of electric vehicles in Japan, Max Ahman, 2004
7 https://www.theguardian.com/world/2016/may/10/japan-electric-car-charge-points-petrol-stations
8 Centre for Solar Energy and Hydrogen Research Baden-Württemberg

Development Plan was developed in August 2009. The plan represents Germany's approach to electric mobility as a cross sectoral initiative and involved all relevant industries to draft the plan. The plan envisages that Germany will become the lead market and provider of electromobility by 2020, and will have 1 million electric vehicles on the road by then. Proposed measures include financial incentives, R&D, development of an enabling framework, integration of renewables, standardisation of technology.

The case of Germany stresses the need for an **effective legislation**. In the absence of laws and initiatives by local authorities that are effective, it is difficult to implement a change in the transport sector. The Electric Mobility Act in Germany in 2015 provides for privileges such as special parking spots, lowering of charges, permitting the cars to be driven in the bus lanes among others. The decision on which privileges to be given is made by the local authority. It is learned that the incentives have been implemented in less than 1% of local authority areas[9]. Hence, the policy has not been utilized to its maximum potential and has impacted the adoption of electric mobility in the country.

Germany has delayed the target achievement of 1 million electric vehicles in the country to 2022 from 2020. Though the National Electromobility Development Plan has led the various government departments to take out policies, orders and laws to enable electric mobility in the country, the initiatives were delayed. The environmental bonus, that provides for an environmental subsidy of EUR 4,000 for BEVs and EUR 3,000 for PHEVs was implemented in 2016. A total of 131,000[10] electric vehicles were registered in Germany up till December 31, 2017.

In Lao PDR, a more focused approach is required from the government for proper implementation of the National Environment Strategy 2020 and Action Plan. The lack of appropriate strategies for each focal point leads to a lack of action plans and priority projects, especially those that can be implemented by the Lao Government.

4.2. Key Learnings of Policy Initiatives in deployment of Electric vehicles

Key Learning

It is essential for countries to set a clear and well defined roadmap or strategy for implementing electric mobility. The roadmap should be prepared in co-operation with the stakeholders and should assign roles and responsibilities to each of them. It should also be followed by concrete legislative action. The implementation of the strategies need to be monitored and evaluated at regular intervals to ensure that the goals are achieved.

The focus of this section is to discuss the key learnings of policy initiatives taken by governments that have been aimed at increasing the uptake of electric vehicles.

4.2.1. Local administration has to implement the national strategy

While the national government sets the vision and strategy for country to transform its transport sector, it is the local administration that can further stimulate action. The local administration can steer the deployment of EVs by directly implementing state and city level projects. The role of the local administration can be highlighted by the following roles:

9 Progress Report 2018 – Market ramp-up phase, German National Platform for Electric Mobility
10 Progress Report 2018 – Market ramp-up phase, German National Platform for Electric Mobility

Providing free parking and access to high capacity lanes	Providing additional financial and non financial incentives	Spreading awareness about electric mobility with the citizens	Setting up EV procurement programmes and mandates for themselves and their suppliers

Figure 17. Role of local administration

The state of California in the USA makes a case for exemplary action at a local level. A majority of electric vehicles in USA are deployed in California. The state has provided financial and non financial incentives that are in addition to the incentives by the federal government. They have set specific and clear targets for deployment of EVs in the state. The state has also set stringent emission norms for motor vehicles Many other states in the USA have adopted the regulations defined by the (CARB). The auto makers in the country have also agreed to adopt the stricter tailpipe emissions set out by the state[11].

The requirement of effective local administration action is also clear in the case of Germany, as elaborated in section 5.1, only 1% of the local authorities implemented the directives under the The Electric Mobility Act, 2015 leading to a slower uptake of electric vehicles than envisaged.

Key Learning

Since many actions that are envisaged in EV strategies are controlled by the local administration, it has to actively incorporate the set directives of the central government in its implementation. It is also suggested that the local government should identify further actions that will supplement the initiatives of the central government.

4.2.2. Involve stakeholders in policy formation and implementation

While the benefits of electric mobility are well known, it may not be in the business interest of the stakeholder to pledge future actions to achieve the targets set out by the state. For example, the purchase of electric buses may be an initiative by the environment ministry, but the procurement has to be the transport ministry that might not have the budget for new buses. Interacting with stakeholders will help the policymakers understand their needs and also receive feedback and input on the initiatives undertaken. The needs of some of the stakeholders are identified below:

EV Private Consumers	Fleet operators	Grid Distribution Companies	EVSE Operators	Car Sharing Operators
• EVSE Network	• Profitable business model and EVSE Network	• Avoid Congestion of the grid	• Profitable business	• Parking spaces from municipalities

Figure 18. Needs of EV stakeholders

An effective way to engage with stakeholders is to create a multi-stakeholder task force for electric mobility at the level of national and local administration. The task force can take part in all stages of the transition, i.e. planning, implementing, monitoring and taking corrective action.

11 https://www.wsj.com/articles/auto-makers-agree-to-stricter-california-tailpipe-emissions-standards-11564074757

Key Learning

In the process of deploying EVs, it is essential to involve all stakeholders in the planning and execution of the policies and programmes. Addressing the needs of the stakeholders and finding solutions to alleviate their concerns in a collaborative manner is necessary for successful implementation of national strategies.

4.2.3. Set clear targets for implementation of electric mobility

Many countries have defined their deployment targets for transitioning to electric mobility. The targets are well defined with timelines set for achieving the objectives. A few examples of targets set by countries are identified in the following table.

Target	City/ Country	Key Features
100% electric vehicle sales in LDV and public bus segments by 2025	Norway	In 2017, the Norwegian Parliament passed the goal for the country to phase out gasoline vehicles for passenger bus and car segments by 2025
1 million electric vehicles on road by 2020	Germany	As a part of the National Electromobility Development Plan, Germany has committed to having 1 million EVs deployed in the country by 2020
1 million EVs and PHVs by 2020	Japan	As a part of the EVs and PHVs roadmap to 2020 by Ministry of Economy, Trade and Industry (METI), Japan.
30% EV sales share by 2030	India	As a part of the EV30@30 campaign, India has signed up to achieve 30% EV sales share by 2030
1.5 million zero-emission vehicles (ZEVs) on California roads by 2025, on the path to 5 million ZEVs by 2030.	California	An executive order was signed by the Governor of California in January of 2018 to set a target and focus multi-stakeholder efforts on achieving the same.

Table 2. Examples of e-mobility targets

4.2.4. Incentives should be specific and easily available

Key Learning

In order to achieve the vision of the roadmap, an essential requirement is to set clear targets for roll out of EVs and EVSEs. The targets will help in directing actions of the state and other stakeholders towards the required scale of operations. Setting targets also acts as an effective tool to monitor the progress of the electric mobility in the country. Intermediate targets may also be set that will provide timely reality checks and required changes in the policy and initiatives may then be taken up accordingly.

A major challenge with electric vehicles is the high initial cost that restricts the rapid proliferation of the technology. In order to tackle this, countries provide incentives in many ways to bring the cost of acquisition of an electric vehicle similar to that of a conventional gasoline/ICE powered vehicle. The incentives can be segregated into the following categories:

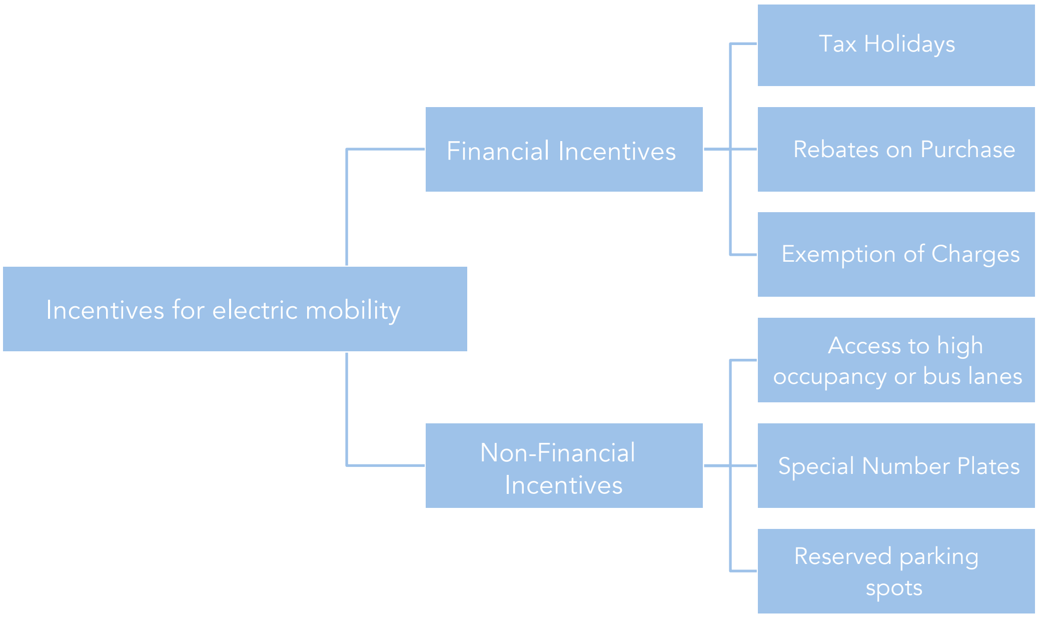


Figure 19. Types of Incentives for EVs

Financial incentives are a necessary to encourage the use of electric vehicles. These incentives will be necessary until the cost of electric vehicles are at par with ICE vehicles.

Norway is the global leader in the electric car market share with 46%[12] of its new car sales electric in 2018. The country's most effective initiative has been the provision of financial and non financial incentives. Norway offers a bouquet of incentives to a consumer purchasing an electric vehicle. These incentives are very effective in increasing the number of electric vehicles on the roads of Norway. A snapshot of the incentives are provided below[13]:

Title	**Key Features**
Exemption from registration tax, 1990	Norway charges an import or registration tax for all cars which can reach about EUR 10,000 or more depending on the CO2 emissions. BEVs are completely exempt from this tax.
Exemption from Road Tax, 1996	BEV's were charged a lower annual road tax in Norway
Exemption from 25% VAT on purchaxse, 2001 and lease, 2015	BEVs are exempt from paying 25% VAT charged at the time of purchasing or leasing an electric vehicle.
Reduced Company Car tax, 2000	To calculate tax for BEV used for as a company car, the cost was reduced to 50%. Since 2018, this has been reduced to 40%.
Free municipal parking	Local governments may decide the incentives from 2010, however most electric vehicles have free parking in the country. This may be subject to change given the growing number of EVs in the country
No charges on toll roads	Road tolls are mostly exempt for Electric Vehicles in Norway. The exemption may be phased out, however it will still continue to be less than 50% of the charge for ICE vehicles
No charges on ferries	BEVs are exempt from ferry charges.

12 Global EV Outlook, 2019, IEA
13 Incentives for Electric Vehicles in Norway, Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), Germany

Access to bus lanes	BEVs have access to bus lanes in most towns and cities of Norway. The programme was launched in 2003 in Oslo. However from 2015 it requires carpooling with at least one passenger during rush hour. From 2017, local governments can decide on incentives.
Introduction of special registration plates	The BEVs have different number plates that have a prefix 'EL' or 'EK' for easy identification of the vehicles.

Figure 20. Norway's Incentives for e-mobility

Key Learning

According to a study conducted on State Alternative Fuel Vehicle Incentives over a decade, the following key learnings need to be incorporated in the implementation of incentive programmes.

Specific goal of the programme:

- The goal needs to be defined clearly so that 'alternate fuel only' vehicles are incentivised rather than vehicles that have the capability of alternate fuel

Incentive should be the right amount:

- The incentive should alleviate the incremental cost of the electric vehicle. Smaller incentives such as fuel price discount and sales tax exemption are typically ineffective unless packaged with bigger incentives.

Grant based incentives are more effective:

- Compared to tax benefits, grant or rebate based incentives are more effective as they offer immediate benefits and certainty. However in leasing of electric vehicles, tax exemptions are known to be effective

Incentives that are easily availed are preferred:

- Incentives that are available at the time of purchase are more effective than incentives that refund the amount after undergoing procedures and applications

Phase out period:

- The incentives should be applied for 5 to 10 years to introduce the new technology till it becomes competitive. To cap the funds of the government, it is necessary to set a budget and a phase out period thereafter.

Monitoring:

- The incentives programme should be monitored regularly to assess the effectiveness. The programme should be updated as per the analysis if required.

4.2.5. Spread awareness about electric vehicles

As electric vehicles present a new technology to consumers, it is essential that there is accurate and reliable information about the technology that is reaching them. As a part of encouraging electric vehicles, many governments undertake awareness programmes to spread relevant information. Along with educating the prospective consumers about the benefits of electric vehicles, it is necessary to inform them about the incentives and advantages of purchasing an electric vehicle. The following methods of raising awareness are recommended.

Online Information

- It is beneficial to create a dedicated website to spread awareness about electric mobility
- In the UK, Go Ultra low provides information about all vehicles running on alternate fuels. It takes a few clicks to learn everything about the vehicles and laws in the country.
- Information can be provided on social networking sites like Facebook, LinkedIn, Instagram and twitter to targeted customers

Public Events

- In the USA, National Drive Electric Week is a weeklong annual event that has events all over the country.

Targeted Promotion Material

- Specific Government departments can create leaflets and brochures elucidating the programmes and the steps required to apply for certain privileges
- For example: the Utility can provide stepwise procedure to apply for an EV charger connection, the municipality can provide information for requirements to access free parking spots and access lanes

Labelling

- Many countries offer different number plates for electric vehicles with 'Zero Emission' signage

Figure 21.Methods of Raising Awareness for e-mobility

Governments can collaborate with OEMs to spread awareness about the vehicles as done in the 'Go Ultra Low' campaign in the United Kingdom. A sustained programme with multiple methods of outreach and funding from governments is most effective. A survey of battery electric vehicle owners in Norway proved that effective online sources of information were the EV association, blogs, media, dealers and friends.

Key Learning

A customer aware of the electric vehicle technology is more likely to purchase an EV. There are multiple ways to spread awareness about electric vehicles, but successful awareness campaigns involve multiple stakeholders from government and private sector. Specific government department specific information should also be readily available for consumers to avail the benefits.

4.3. Key Learnings of Policy Initiatives to support convergence of energy and transport sectors

Electric Mobility will lead to a paradigm shift in the 'refueling' of vehicles. Electric vehicle batteries are required to be charged periodically leading to the need for a robust charging network. The key role in this transition will be played by power utilities. Electric mobility is a great business opportunity for power utilities as a growing network of consumers will help increase revenues. The power utilities also play a key role in providing clean energy to electric vehicles. The GHG emission reductions that are associated with electric vehicles are dependent on the energy mix of the country. The higher share of renewable energy in the electricity generation can impact the GHG reduction obtained by using an electric vehicle. Electric vehicles also faciliate a shift to renewable energy as the batteries can store renewable power. In this section we analyse the policies that are required to maximize the convergence of energy and transport sectors.

4.3.1. Allow utilities to own EVSEs

In many countries, a utility is not allowed to own an EVSE. Thus, even though the number of electric vehicles are increasing, the utilities are not yet playing an active role in deployment of charging infrastructure in those countries. It is considered easier for a utility to install charging stations using taxpayer's money, without expecting a return in the near future. However, by allowing utilities to install charging infrastructure there has been some resistance from the private sector for hampering their profitability14. In the following example, the private sector has welcomed the decision to allow setting up charging infrastructure[15].

The California Public Utilities Commission (CPUC) in 2015 lifted a four year ban on utilities from investing in public charging infrastructure. The lifting of the ban was considered necessary to unlock potential investment and accelerate setting up of charging infrastructure for the state to meet its electric vehicle targets. Surprisingly, the decision was supported by the private industry as long as they would still be allowed to participate as it increased the overall EV market.

Key Learning

As heavy regulation may hamper the fast development of charging infrastructure, it may be preferable to allow utilities to install charging infrastructure in partnership with the private sector.

4.3.2. Reduce Carbon Emission of Power Sector

A lowering of carbon emission of the electricity sector will significantly improve the impact of electric vehicles on the environment. A number of governments have taken out regulations that will reduce the emissions from the electricity sector. The most effective policies for reducing emissions are highlighted in the following table.

Type of Initiative	Example
Renewable Portfolio Standards	A 45% reduction in CO_2 pollution has been achieved by The Regional Greenhouse Gas Initiative (RGGI) in 9 states of the USA[16]
Cap and Trade Programs	The European Union uses a cap and trade programme to restrict CO_2 emissions from power plants.
Carbon Tax	The Japanese government charges a tax per ton of CO_2 emitted

Table 3. Effective Policies for reducing carbon emmission

14 Alexander-Kearns & Cassady, 2016
15 https://www.greentechmedia.com/articles/read/california-utilities-are-back-in-the-ev-charging-game#gs.u22y63
16 RGGI, 2016

Key Learning

The emission reduction via EV's is directly related to the energy mix of the electricity sector in the country. Efforts to reduce carbon emissions at the point of electricity generation will further strengthen countries' endeavors to reduce emissions.

4.3.3. Enable Smart Charging

There is a risk that charging of electric vehicles will increase the peak demand of electricity. As a general practice an EV user will charge his vehicle when he returns from work. This is around the same time that electricity demand will peak from the residential sector. To avoid this, EVs may be encouraged to be charged during the day. Additionally, electric vehicles have an onboard battery that can be used for various grid stability processes. In addition to providing a backup for the grid, electric vehicles can also support RE integration into the grid. In the case of solar power, the electricity is generated during day time. To initiate a change in the behavior of the consumer, dynamic pricing is seen as an effective tool. Thus, the electricity at peak times may be offered at a higher price and when there is availability of RE power such as solar it may be charged at a lower rate to reduce the charging at peak times.

To enable such dynamic pricing and smart charging it is important that national legislations make the technology for it compulsory. In the United Kingdom, from July 2019, only charge points installed at home that utilize 'smart' technology will be eligible for funding from the government. Governments set the following requirements:

Two way electronic communications with a third party;	React to the communication by changing charging or discharging rate	Record and monitor the charge point's own energy usage	Comply with energy efficiency standards; and	Require protocols to be open

Figure 22. Requirements for Smart Charging

Key Learning

To leverage the advantages that the integration of the EV and energy sector has, it is essential for governments to remove any regulatory obstacles that would hamper the developments such as smart charging.

4.4. Key Learnings of Policy Initiatives to support Transit Oriented Development

Transit Oriented Development is a concept in urban development and planning that aims to encourage public transport. It focuses on transport hubs such as metro staions and envisages the creation of pedestrian oriented paths with easy connectivity to transit services to the rest of the city. The increase of public transport and new business models involve car sharing, electrifying fleets and mobility as a service. The key learnings in policy intitiaves to support transit oriented development are highlighted in this section.

4.4.1. Electrify Ride Hailing Services

Ride hailing services like Uber, Lyft, Didi and Ola are becoming the new modes of transport in many countries. They encourage sharing their services with multiple riders travelling together from point to point. Since they will form a significant portion of the shared mobility, governments must initiate action to encourage the services to shift their vehicles to electric. This can be carried out in the following ways:

Fleet Regulations	Financial Incentives	Exemption of Charges
States may come up with their version of fleet based ZEV regulation	**Ride hailing fleet specific financial incentives**	**Exemption of charges such as tolls and permissions that are levied on commercial vehicles**

Figure 23.Regulations for Electrifying Ride Hailing Services

In 2018, the state of California introduced a legislations that instructs state agencies to develop regulations that reduce the per passenger mile emissions of transportation network companies, which must include company-specific targets for electric vehicle adoption.

Key Learning

Shared mobility is the future of transport, electrifying the fleet presents multiple benefits to the fleets. It is essential for governments to take out emission based regulations for ride hailing services and encourage the use through multiple methods.

4.4.2. Allow electric vehicles in last mile connectivity

Most cities now have an intra-city metro network that connects the major locations in the cities. It is the travel from the metro stations to the destination that needs to be electrified. In South East Asian countries this sector is dominated by rickshaws or tuk-tuks. Legislation should be passed to ensure these vehicles are converted to electric. Additionally, personal light electric vehicles (PLEVs) that consist of electric kick scooters and mono-wheelers should be allowed to ply. Germany and UK are working towards legalizing PLEVs in the last mile of travel.

Key Learning

It is recommended that countries explore their last mile connectivity options and enforce regulations to electrify the sector and reduce emissions.

5. Analysis of infrastructure and technology requirements for Electric Vehicles adoption

An essential requirement of electric vehicles to be running effectively is a hassle free recharging facility. Range anxiety and lack of charging infrastructure can be a huge deterrent to uptake of electric vehicles[17]. In contrast to the conventional ICE vehicles, where refueling at a gas station is the only option, EVs can be charged in residences or offices. While slow charging at home may be convenient and common for EV users, it is the public charging infrastructure that can re-inforce the confidence in the consumers to shift to electric mobility. It has been proved that the availability of a strong network of EVSE in a country has been three times more effective than providing rebates and subsidies on the purchase of an electric vehicle[18]. In the following sections we analyse the infrastructure and technology requirements for electric mobility and required initiatives.

5.1. Enable Interoperability of Charging Stations

The development of electric vehicles has been fragmented across the world, which has led to the availability of multiple technologies for charging the vehicles. As the market for electric vehicles is developing, it is necessary to standardize the charging station protocols. Research has proved that in the absence of an effective charger network, even high subsidies on EVs cannot lead to market success[19]. While the standards for physical plugs have been accepted, the development of payment mechanisms, backend communication and power supply standards are less developed. This leads to EV consumers taking multiple memberships and using various payment mechanisms to access public charging networks. To enable ease of use, it is essential to establish a single platform for payments across the country and also allow interoperability of chargers. This requires considerable planning and consolidation. Netherlands has been able to integrate all its public chargers and some private charging stations so that they can be used and paid for with a single RFID card.

Interoperability Initiatives in USA	
Government Initiatives	**Private Sector Initiatives**
The State of California released the **Interoperability Electric Vehicle Charging Stations Open Access Act (California Senate, 2013)** which ensures interoperability of charging stations in the state. This has led to the state being a frontrunner in adopting electric mobility	The **Roaming for EV Charging (ROEV)** initiative is co-founded by BMW, Nissan, Chargepoint and EVgo t0 advance interoperability in the United States. The goal of the association is to provide drivers with accessible and convenient charging across stations and networks across North America

Table 4. Interoperability Initiatives in USA

Key Learning

With constantly evolving technology in charging infrastructure, it is required to ensure that the already installed infrastructure does not become obsolete. Additionally, it is equally important to provide ease-of-charging to early adopters and new consumers of electric mobility.

5.2. Financial incentives should be given in the short term

To build an effective EVSE network, many governments and local utilities provide rebates or tax incentives for installation of EVSE. EVSE incentives act as a key enabler for installation of charging infrastructure. These incentives are effective in spurring investment in the installation of EVSE.

17 Egbue & Long, 2012; Harrison & Thiel, 2017; Struben & Sterman, 2008
18 Yu, Li, & Tong, 2016
19 Harrison & Thiel, 2017

Global view of subsidies/incentives provided for EV Charging Infrastructure

Belgium	**Tax incentives** • When a private actor installs a charging point outside his house, it is entitled to **40% tax deduction** with a maximum of 260 Euros • **Additional deductibility of 13.5%** on the investment in Charging Infrastructure for companies under corporate tax law
Netherlands	**Tax incentive** • Customers and companies that create charging points on private space can get a **discount of 500 Euros per charging point** • The Rotterdam Electric Programme **supported the first 1.000 EV owners** with an electric charging point. On private property, a charging point is partly subsidized
Norway	**Local benefits ('non-fiscal incentives')** • EV users can use the public Charging Infrastructure for **free** • The Norwegian government has **granted 11,9 Million Euro for new recharging stations**
UK	**PIP (Plugged-in-places)** • Intended to support the development and consumer uptake of EVs by **creating electric car hubs in 6 key British city or city regions or hubs** with the installation of charging points at various locations
USA, California	**Rebates/subsidies** • **PEV Home Charger Deployment Program.** Provides incentives for residents who purchase new PEV and install Level 2 EV Charging Stations from qualified vendors • **PEV Charging Rate Reduction.** Southern California Edison (SCE) offers a discounted rate to customers for electricity used to charge EVs. Two rate schedules are available for PEV charging during on- and off-peak hours • **Commercial loans.** Small business loans up to $500,000 on the installation of EV Charging Infrastructure; rebate of 50% of loan under certain conditions.

Table 5. Global View of Subsidies/Incentives for EV Charging Infrastructure

Private players need to be incentivized to install charging stations as the utilization of public charging infrastructure is directly related to the number of electric vehicles plying in the country. As already established, countries need to set up an EVSE network to increase the uptake of electric vehicles. Thus, in the short term utilization of the chargers will be low and will not make a profitable investment for private players. In the long term, with an increase in electric vehicles, public charging infrastructure will become a profitable investment and will be implemented by the private sector. The government may also encourage private participation and innovative business models by inviting private players through tenders to set up charging infrastructure in the country, as done by the Netherlands through public procurement tenders for EVSE's that are open to all players.

Key Learning

It has been evident from the various incentive programmes for setting up charging infrastructure that they are necessary in the short term. Once the viability of various business models is established, these incentives may not be required for setting up charging networks.

5.3. Apt ratio of public EVSE to EVs needs to be decided

The ratio of electric vehicle chargers to the number of electric vehicles varies across the world. The number of EVSE's depends on the type of chargers available in residences and offices. In cities where there is an easy access to charging at home, there is a lesser requirement of public charging stations. An analysis of countries such as Norway, USA, Netherlands, China adopting large scale electric mobility suggests there is no uniformity in the ratio of EVSE to EVs.

According to an analysis done of several metropolitan areas in the following countries, the ratio of EV's to charge points was found out to be as follows:

China	Netherlands	California	Norway
3-11 EVs/Charge point	3-6 EVs/Charge point	25-30 EVs/Charge point	14-17 EVs/Charge point

Table 6. Ratio of EV's to EVSE

This clearly indicates that there is no pattern in the ratio of charging stations to EVs.

Key Learning

It is suggested that for countries looking to establish a target for EVSE, they should model their cities according to the markets with increased deployment of EVs. The plan for setting up public and private charging infrastructure in a city should incorporate the urban infrastructure available.

5.4. EVSE should be incorporated into the Building Code Regulations

EVSE's require robust electrical connections and infrastructure to be installed in existing building units. Reworking the electrical connection in multi-unit dwellings or commercial buildings is required while setting up the charging infrastructure, which is a tedious process. However, while constructing new buildings, it is easier to have the requisite electrical work installed. Thus, many countries have updated the regulations for new or refurbished buildings to incorporate the need for EVSE charging. The state of California has mandated that 3% of all parking locations in commercial buildings should have the infrastructure which includes a dedicated panel and circuit capacity for installation of EVSE in the 'California's Green Building Standards Code' in 2015.

Even in Europe, every new or refurbished building is required to incorporate a charging point from 2019 onwards. The incorporation of charging points in buildings is going to help in uptake of electric mobility.

Key Learning

Every country needs to build a plan for charging infrastructure ratio as defined in the previous section. Based on the requirement of chargers in public and private buildings, the building codes that the new and refurbished buildings need to adhere should have specific requirements for incorporation of charging points.

5.5. Characterization of the role of electricity

The characterization of EV charging activity either as sale of electricity or service has been a point of contention. Internationally, majority of the countries have characterized EV charging as a service, and hence, have kept the market open for all the players without the requirement of obtaining any license from Government authorities.

In Japan, there is a separate act called "Electricity Business Act". EV charging business is a part of specified supply section. The Electricity Business Act was fully liberalized in April 2016 after which all entities are allowed to engage in the retail electricity business including supplying electricity to low-voltage consumers, by registering as electricity retailers.

Most of the US states treat EV charging as a service. **Californian Public Utility** found that EV charging by stations did not constitute resale of electricity.

Key Learning

By classifying the activity of charging an EV as a resale of power can severely restrict the installation of EVSEs. Hence, it is essential that charging of EVs is defined as a service.

5.6. Smart Charging should be encouraged

Smart Charging is a way of vehicle grid integration that optimizes the charging of EVs considering the distribution grid constraints, incorporation of renewable energy and EV users flexibility. Smart Charging enables the management of EV loads by communicating with the grid. Under this method, the grid communicates with the EV to monitor and manage the charging process in the most beneficial manner. Thus, EV's cannot only assist in avoiding peaks on the local grid but can also support the integration of renewables in the grid.

Time of use pricing

- This is the simplest form of smart charging as it does not require any communication between the grid and the EV. The timing of charging in response to the rates via a smart charger on the EV or EVSE can be utilized to reduce peak demand and also reduce costs for customers.

Basic Control

- On/off of charging for grid congestion management

Unidirectional controlled (V1G)

- In this method, vehicles or charging infrastructure control the rate of charging

Vehicle to Grid

- In this form of smart charging, the utility utilizes the EV battery during discharge mode to reduce peak loads

Vehicle to Home/Building

- The EV is used as a back up power supply for the residential grid

Dynamic Pricing

- EVSE embedded meters and the prices reflect real time cost of energy and the grid at small intervals

The different types of smart charging that can be employed to reap the benefits are described as follows[20]:

Smart Charging Hub

In Germany, on the outskirts of Berlin, EUREF campus hosts international technology companies and research institutions. It has created a smart charging hub that is capable of V2G charging, which is connected with the solar and and smart grid thus enabling smart charging. The grid uses dynamic pricing.

Figure 24. Types of Smart Charging

Key Learning

Smart charging has emerged as one of the most effective way that the power of EVs can be harnessed and their impact on the grid can be reduced. It can be utilized to encourage renewable energy integration into power generation for many countries. The only disadvantage with smart charging is the effect on the battery life due to frequent charging and discharging. However many studies have proved that there is no visible impact of V2Gon battery life.

5.7. Battery Technology

Improvements in battery technology have been a key enabler to the electric mobility ecosystem. The EV market is currently dominated by lithium ion based batteries. The cost of the batteries at the end of 2018 were approximately USD 175/kWh from about USD 1,160/kWh[21]. While Li-ion batteries are the most commonly used batteries they have limitations on safety and future availability. A significant component of the Li-ion batteries is a lithium cobalt oxide cathode (LCO). Due to the increase in cost of cobalt, the battery chemistries for electric vehicles are moving towards nickel-rich chemistries.

A significant amount of R&D is being undertaken in the battery technology to improve energy density of batteries and reduce costs. While it is assumed lithium ion batteries will continue to dominate the market for sometime, the following battery sub chemistries are currently in use:

Battery Subchemistry	Uses
LFP (lithium-iron-phosphate)	75% of China's Fleet of buses use LFP subchemistries. LFP appears to have the best compromise between safety, cost and performance[22].
NMC (nickel-manganese-cobalt)	NMC is used in the batteries' of Nissan Leaf, BMW i3 and other EVs[23].
NCA (nickelcobalt-aluminium)	Though NCA has high energy and power density, but is not stable at high temperatures. Tesla uses NCA subchemistry in its cells that delivers an impressive specific energy of 3.4Ah per cell or 248Wh/kg[24].

Figure 25. Battery Subchemistry

Key Learning

There is a need to develop safe, high energy and low cost batteries to overcome range anxiety and reduce the purchase cost of EVs.

20 SMART CHARGING FOR ELECTRIC VEHICLES, IRENA
21 https://about.bnef.com/blog/behind-scenes-take-lithium-ion-battery-prices/
22 SMART CHARGING FOR ELECTRIC VEHICLES, IRENA
23 https://batteryuniversity.com/learn/article/electric_vehicle_ev
24 https://batteryuniversity.com/learn/article/electric_vehicle_ev

6. Analysis of Business Models

Without new business models emerging that create new relationships between private drivers, fleet managers, city managers, energy providers, the auto industry and central government, it will be difficult to scale up electric vehicles. Electric mobility business models can bring together three important sectors that have previously operated separately: auto industry, power sector and transport infrastructure. It is vital that new e-mobility business models are investigated, as the ecosystem for electric vehicles has to be developed. International experience can provide valuable lessons on the best practices governments can undertake to create business opportunities and provide financing in this sector. In this section, we analyze the key learnings learnt from business models across the world.

Some of the prevalent business models for electric vehicles procurement and charging business have been discussed below:

6.1. Bulk aggregation for fleets

Any entity (whether public, private or PPP) which procures electric vehicles or related infrastructure in large quantities can be identified as an EV aggregator. Bulk procurement provides an impetus for vehicle manufacturers, charging infrastructure companies, fleet operators, service providers, and the industry to gain efficiencies of scale and drive down costs. Three inter-linked aggregation strategies that might become prevalent in the current market in order to make aggregation collaborative and cost-efficient have been presented below:

Demand aggregation strategy	Product category
Aggregating the demand for public transport at city/ multiple city level	E-Rickshaws and Electric Buses
Aggregating the demand for private and commercial transport at city/multiple city level	Passenger Light Duty Vehicles [PLDVs] includ-ing passenger cars and taxis
Aggregating the demand for government officials	Vehicles for public sector establishments

Figure 26. Strategies for Demand Aggregation

Below are the cases for demand aggregation for procurement of electric vehicles and chargers.

Examples of efforts to encourage electrifying fleets through bulk procurement and aggregating demand

1. **Government fleets:** Energy Efficiency Services Limited (EESL) is a joint venture of four National Public Sector Enterprises, set up under Ministry of Power, Government of India. EESL issued tenders for procurement of 10,000 electric cars and 5,000 EV chargers. Upon procurement, EVs were leased out to Government organisations at rentals that are equal to the present rentals for petrol and diesel cars hired by these organisations. EV chargers were installed within the premises of such organisations. This bulk procurement resulted in bringing down the costs of EVs and chargers by more than 30%. EESL is now planning to deploy public chargers too.
2. **Police fleets:** The Los Angeles Police Department (LAPD) switched 260 fleet vehicles to EVs. Charging infrastructure deployment is being integrated with solar power generation.
3. **Public fleets:** The four largest cities on west coast, Los Angeles, Seattle, San Francisco, and Portland, purchased 24,000 electric vehicles for their municipal fleets. The city of New Bedford, Massachusetts, procured 23 Nissan EVs Nissan using state incentives and federal tax credit. The U.S. Navy Department also purchased 400-600 EVs from Ford Motor Company.

Figure 27. Examples of efforts to encourage electrifying fleets through bulk procurement and aggregating demand

Best model for procurement of EVs for fleets is yet to emerge. Instead, fleet aggregators are taking a variety of approaches towards EV procurement.

Outright Purchase: Outright purchase of vehicles is the most common model for adoption of vehicles in fleets.

Collaborative procurement: It refers to a process where more than one entity combine their EV procurements into a single bid request. In 2013, eight state governors (including New York) signed a MoU (Memorandum of Understanding) committing to coordinated action on state EV programs.

Closed-end leasing: In a closed-end leasing, lease term as well as monthly payments are fixed. The lessor sets limitations on mileage and wear-tear, & maintenance and repairs are built into the contract. At the end of the lease term, the lessee has no obligations to make additional payment, provided vehicle did not exceed maximum mileage or other terms. Lessor then takes responsibility of the vehicle.

Open-end leasing: Open-end leasing tends to be common in private fleets. Open-end lease places the risk for fluctuations in the vehicle's value on the lessee. At the end of the lease period, if vehicle sells for less than its depreciated value, the lessee must pay the difference. A significant determinant of costs for both open- and closed-end leases is the value at the end of the lease term. All else being equal, a vehicle that sells near its original purchase price will be less expensive to lease than one that depreciates more quickly.

Examples of EV leasing

The City of New Bedford is currently leasing 19 Nissan Leafs, which represents more than 25% of the city's "general use" fleet. The vehicles are leased through a dealer already on the state contract who offers a three-year lease term. This model works best for Bedford as it reduces administrative burden for local governments.

Figure 28. Examples of EV leasing

Key Findings

- Public fleet procurement can make EVs less expensive than gasoline vehicles.
- A volume purchase can encourage favorable pricing approaches and increase vehicle model availability.
- Increasing the annual mileage of vehicles can improve EV competitiveness.
- EVs can play a leading role in achieving the environmental goals of public agencies.

6.2. E-Car Sharing

In this business model, the car is used by subscriber for commuting, but during the rest of the day, it is available for regular carsharing customers. This way the utilization of each car increases, which is beneficial for all electric compared to ICE. Customers avoid the risk of vehicle ownership and cost of the car is distributed among multiple users. The residual value problem is also addressed by assuming that the car is retained within the business until its salvage value is zero. With a carsharing offer, which includes a suitable mix of electric and ICE cars any travel or distance need can be met. The carsharing offer works as a bundle of electric and ICE cars and hence can replace 100% of ICE car ownership.

Subscription fee is based on the daily driving distance of subscriber. When the daily driving distance is within 0-50 km, the subscription fee can easily compete with the cost of owning an ICE car. If daily range exceeds 50 km, the depreciation of the electric car will make subscription fee too high for it to be able to compete with ICE car ownership. If the distance limit in the battery warranty were increased to 120,000 km, the subscription fee would be able to compete with car ownership up to daily driving distance of 70 km.

Examples of electric car sharing

The Lithuanian electric car-sharing service, Spark has officially launched in Romania with deployment of 50 cars in Bucharest. The fleet consists of Nissan Leafs and Renault Zoes electric cars. The minimum rental time is 12 minutes. The service area, however, is Bucharest, so anybody outside the city's vicinity must bring the car back or else pay extra.

Figure 29. Examples of electric car sharing

6.3. State led charging models

Chinese Government used cities to test out local programs, which later resulted in a national initiative. China started systemic change through city-based pilots by initiating "Ten Cities, Thousand Vehicles" program in 2009. Different business models employed by different cities have been covered in brief below:

China's "Ten-cities, One-thousand vehicles" program

State Leadership Model: Beijing

- Reduced vehicle taxes and granted license plate lottery exemptions
- 3 EV industrial campuses were set up to promote R&D in EV technologies and attract leading automakers, battery makers, and other industry players
- Tie-ups and Joint Ventures between private and government entities e.g. Yanqing's (a district in Beijing) government set up a joint venture with BAIC Foton to deploy EV taxis

Platform-Led Business Innovation Model: Shanghai

- Adopted rental model borrowed from Bremen, Germany
- Set up international EV demonstration zone, called EVZONE, for testing and piloting the EV model; to test innovations in vehicle performance, route design, and charging facility distribution; and to provide site for auto manufacturer R&D collaboration. EVZONE to establish EV leasing stations in busy areas where consumers can lease an EV with a membership card

Shenzhen: Cooperative Commercialization Model

- Shenzhen government has fostered a financial leasing model with state-owned enterprises such as Potevio New Energy
- Potevio retained ownership of the bus battery (around $56,000), leased it to Shenzhen Bus Company, and offered loan guarantees for the bus capital cost. Moreover, because of support from the local government and BYD, Potevio was able to buy the batteries at a subsidized price

Flexible Rental Model: Hangzhou

- People could rent the car or the battery separately
- Provided free battery rental for three years or up to 60,000 km for people who purchase EV cars

Fast-Charging Model: Chongqing

- Unlike other pilot cities that adopted battery swapping (Shenzhen and Hangzhou) or slow charging stations (Beijing and Shanghai), Chongqing piloted more grid intensive fast-charging EV technology as Chongqing is near the robust Three Gorge Power Grid.
- In addition, battery-swapping stations need flat areas to be installed. Whereas, the city has mountainous areas and very few flat areas. Hence, Chongqing could not go for battery swapping stations.

Figure 30. China's "Ten-cities, One-thousand vehicles" program

6.4. Battery Swapping

This business model compensates the high cost component of the electric battery compared to the vehicle price. Charging times are also reduced by a substantial amount. In addition, due to controlled charging conditions, batteries last for longer charging cycles. Swapping requires a compatible interface between the vehicle and swapping station. The battery swapping provider has a contract with the customer, which contains the automated swapping of discharged to charged batteries for the electric vehicle. The swapping provider follows his/her own optimized charging strategies. Whereas, the customer possesses a battery for a temporary period.

Better Place battery swapping stations in Israel

- Better Place, an Israeli startup company tried to execute the concept of swappable electric car batteries.
- Consumer buys an electric car (Renault Fluence ZE sedan in this case), drive to a Better Place station and swaps empty battery with a fully-charged one in about the same time it takes to put gas in a conventional car
- Consumer pays for the electricity used per mile – Subscription model

Better Place initiative has failed over the years. The key reasons for failure are:

- Better Place only ever established a few dozen battery-swapping stations in Israel and Denmark due to high cost of robotic-based battery swapping.
- Batteries compatible only with Renault Fluence sedan cars
- Large Fluence sedans not popular among buyers in those countries, who tend to prefer smaller vehicles

Figure 31. Better Place battery swapping stations in Israel

Gogoro battery swapping stations in Taiwan

- Gogoro is a Taiwan-based company that develops and sells electric scooters and battery swapping infrastructure
- It has set-up GoStations, ATM-sized vending machines where depleted batteries can be readily swapped for fully charged batteries
- The electric scooters are also cloud connected and transmits the vehicle and battery data to the swapping stations
- It has sold over 34,000 scooters, which, combined with its rental efforts, have led to customers riding over 100 million kms to date — and saving an apparent 4.1 million liters of gasoline that would otherwise have been used.

Figure 32. Gogoro battery swapping stations in Taiwan

6.5. Second Life of Battery

An EV is required to be replaced when the capacity reduces to 70-80%. The batteries can still be utilized for energy storage systems. Used EV batteries can be used for rooftop solar storage, solar streetlight applications, backup power for telecom towers. This extends the useful life of the battery by another 10 years before they need to be disposed. Utilizing the second life of the battery also leads to a way for an EV owner to monetize the investment. A few applications of EV batteries after they have been completed their useful life for EVs are highlighted below:

Using Old EV batteries for energy storage

- Nissan, Eaton and The Mobility House have developed an energy storage system that makes the energy management of the Amsterdam Arena in Netherlands more efficient, sustainable and reliable
- The system uses Eaton's bidirectional inverters and the equivalent of 280 **Nissan LEAF batteries** stored in racks
- It will be used for back-up power during major events replacing diesel generators in the future, assisting utilities during periods of high demand and grid stabilization services

Recycling Old EV batteries to power street lights

- Nissan's "The Reborn Light" initiative uses old batteries from the Nissan Leaf electric vehicle to ease the burden on Japan's electrical grid
- The former car battery lives in the base of the light, powering an array of high-efficiency LEDs at the top
- The battery recharges each day, but it's not plugged into the electrical grid. Instead, Nissan uses solar panels on the light to ready the batteries for nighttime.

Used Electric Car Batteries in Data Centres

- A data center French web hosting company Webaxys is building in Normandy is using an energy storage system based on used batteries from EVs by Nissan Motor
- The system, designed by Nissan and Eaton, will help the facility take advantage of RE, whose intermittent availability requires energy storage for effective use
- GM is powering its data centers with old Chevrolet Volt EV batteries

Applications in Renewable Energy Storage using recycled batteries

- Second-life batteries from Renault electric vehicles will be used to store the fluctuating supply of energy produced by Porto Santo's solar and wind farms
- Stored as soon as it is produced, this energy is recovered by the grid as and when needed to meet local demand

Figure 33. Application for Second life of EV Batteries

7. Analysis of financing approaches

The financing of electric mobility is usually done in three main areas:

Financial Incentives	• Financial Incentives are provided to EV consumers for procuring EVs • The incentives are also provided to EVSE operators • Governments and Private Sector spend on conducting R&D
Procurement	• Procurement of EVs, EVSEs by governments, fleet operators
Policy	• Government and Multilateral agencies spend on policy preparation and implementation

Figure 34. Financing of e-mobility

Some of the common financing mechanisms for EVs and related charging infrastructure have been discussed below:

7.1. Global Financing Mechanisms

Global financing mechanisms such as the Global Environment Facility (GEF) and Green Climate Fund (GCF) consist of members across countries, international institutions, private sector and other organizations that provide grants and funding for programmes critical to conserving the environment. Reduction of GHG emissions is a focal point such programmes. A few areas in which the programmes are financed are elaborated below:

Promoting Innovation	**Policy Planning**	**Demonstration Projects**	**Capacity Building**

Figure 35. GEF Focal Areas

7.2. Low interest rate loans

These are the easiest type of financial instruments on the market for customers to understand. The terms and conditions are generally simple and allows for loan appraisal and comparison with other lending institutions. The low interest loan is easy to manage, as loans are the standard 'business as usual' type of finance provided to customers. The low interest loan is of particular interest to Charging Station Operators (CSOs) and other charging business as similar preferential instruments are not available from commercial banks due to perceived risks associated with EVs.

7.3. Revolving Loan Fund (RLF)

RLF is fundamentally a source of money from which low cost loans are made to borrowers consistent with standard, prudent lending practices. As the borrowers repay loans, the money is returned to the RLF to make additional loans. In that manner, the RLF becomes an ongoing or "revolving" financial tool. Governments can use RLF to finance the EV related projects. Public sector institutions have been the major borrowers of these RLFs globally. Typically, the interest and fees paid by the borrowers support RLF administration costs and the fund's capital base remains intact.

Case Study – USA

- In USA, the American Recovery and Reinvestment Act (ARRA) provided funding of $3.1 B for State Energy Programs (SEP).
- The ARRA legislation encouraged the creation of long term funding mechanisms such as RLF, in order to extend the impact of the ARRA funds. In this regard, many states applied for ARRA funding and have setup RLFs for financing EE projects.

Figure 36. Case Study – USA

7.4. Fee bate mechanism

Fee bates are special financing structures which generally present a revenue neutral policy regime to incentivize a positive technology like low carbon transport. Fee applied in the form of increased taxes and duties on ICE vehicles can be used to provide purchase incentives for electric vehicles.

California's "Clean Car Discount" program

- The program imposed a fee of up to $2,500 on new, high carbon emitting vehicles
- And then rebated the fee to buyers of new low emission vehicles

Figure 37. California's "Clean Car Discount" program

7.5. Green Bonds

Green Bonds are created to fund projects that have positive environmental and/or climate benefits. These are debt instruments that allow investors to invest in sustainable projects while offering issuers affordable funding to finance these projects. However, verification of the use of proceeds and its environmental impact must be strictly regulated and monitored by a third party.

Examples of green bonds

In March 2014, Toyota Financial Services, issued the automotive industry's first asset-backed green bond, USD 1.75 billion in securities backed with US dealer income stream, to fund conventional loans and leases on sales of its hybrid ZEV models in the USA. Since then, the company has issued two more green bonds, the latest in May 2016, for USD 1.6 billion. In March 2016, Hyundai Capital Services issued Korea's first green bond, for USD 500 million to finance the provision of loans and lease contracts for Hyundai and Kia hybrid and electric models. In May 2016, Chinese car manufacturer, Zhejiang Geely Holding Group issued USD 400 million in green bonds to build a factory north of London and finance manufacturing of zero-emission taxis by its subsidiary London Taxi Company. The bonds issued were oversubscribed six times, demonstrating the demand for these instruments.

Figure 38. Examples of green bonds

7.6. Collaborative fund

A collaborative fund between government and private automakers can be explored in order to finance the transition to electric mobility.

Japan's collaborative fund

- Four private automakers - Toyota Motor Corporation, Nissan Motor Co., Ltd., Honda Motor Co., Ltd., and Mitsubishi Motors Corporation announced a joint project to support the developments of EV charging infrastructure by providing additional subsidies to cover the remaining costs from government subsidies.
- These automakers formed a joint entity, which provided financial support for the one-third cost of the charging equipment. Remaining two-third subsidy was provided by the Government.

Figure 39. Japans Collaborative Fund

7.7. Multibank funding with a Loan-Loss Reserve

Current funding for electric vehicles comes from a mix of local, state, and national rebates, as well as cash and financing options from the conventional institutions, such as banks or financing arms of automobile manufacturers. Some local credit unions have also started to provide loans for EVs and related charging infrastructure, but still a gap in private funding remains. A multibank arrangement, operated by a group of banks to pool funding and provide lending, could help overcoming this barrier.

MBCDCs (Multibank Community Development Corporations) spread the risk among several lenders and are used to develop infrastructure and extend credit for small-business loans, real estate development, and affordable housing construction. A similar structure could be applied to fund loans for electric vehicles in underserved communities. It could also serve as a platform for education on EVs and clean-driving initiatives while it provides credit to the population it serves.

7.8. Small business microloans

Microloans are small-business loans offered at attractive interest rates to help businesses access capital for items like machinery or fixtures. These loans can facilitate funding for electric vehicle charging equipment and installation costs.

Examples of micro loans

One such micro lender is LiftFund, a highly regarded certified community development financial institution, or CDFI. CDFIs provide loans, financial education, and other financial services in underserved communities. LiftFund is a micro lender based in San Antonio, Texas, and was founded in 1994. The nonprofit now operates in 13 states—Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, Missouri, New Mexico, Oklahoma, South Carolina, Tennessee, and Texas. Its supporters include regional and national banks, chambers of commerce, philanthropic foundations, local governments, and business and civic leaders.

Figure 40. Examples of micro loans

8. Recommendations

The development of e-mobility presents both promising opportunities as well as challenges for the global community to reduce emissions from the transport sector. Electric mobility also acts as a key enabler for reducing carbon emissions in the energy sector. This section lists the recommendations for countries to uptake electric mobility.

8.1. National Roadmaps and Policies

Countries should set clear strategies in the form of a national roadmap to develop the electric mobility sector in their countries. The strategies set out need to be well defined, with clear targets that are designed to integrate electric mobility in the country with the current ecosystem and stakeholders.

Policies and initiatives designed to encourage electric vehicle deployment in the country need to have an active engagement of the local administration. They are the implementing agencies to lead the country towards lower emissions. It is also essential to engage with private and government stakeholders such as the automobile industry, power sector and municipalities at each stage of planning and implementation of the policies. Stakeholders may have interests that are conflicting with the objectives of the national government, which stresses the need to work out solutions for them without harming the sector. This can be done by setting up a task force on electric mobility that can guide the policy decisions in the country.

An effective method of deploying electric vehicles is by providing financial and non-financial incentives. The incentives need to be well targeted and should alleviate the incremental costs of acquiring an electric vehicle. The incentives should also be easily disbursed to the consumer by either reducing the upfront cost or being disbursed shortly after purchase. National and Local administrations need to spend considerable efforts to spread awareness about electric vehicles and the incentives provided by the government for them.

Electric mobility is a significant opportunity for power utilities. Integrating the two sectors will lead to significant synergies for the country. Utilities should be allowed to set up EVSEs and implement smart charging projects to incorporate renewable energy. Electric mobility should be incorporated in types of transport required under transit-oriented development such as last mile connectivity and ride hailing services.

8.2. Infrastructure and Technology

An integrated charging network is essential for the transition of the transport sector. One of the main challenges for the setting up of the charging stations is the multiple standards and communication methods available across the world. It is necessary to ensure interoperability of charging stations so that EV consumers have the ability the charge their electric car from any charger.

As is the case with electric vehicles, charging infrastructure needs to be incentivized too. Currently, due to high cost of public charging stations and lesser number of electric vehicles, it is not an attractive business investment. Governments need to incentivize the installation of charging stations till the cost economics of the operations are favorable to private players.

There is no set standard for the ratio of electric cars to public charging stations. Countries looking to establish a target for EVSE should learn from countries with similar urban infrastructure. Charging infrastructure connections should also be made a prerequisite in the building codes for new and refurbished buildings.
Many countries may classify EV charging as a re-sale of electricity, which may restrict the entry of private players in the business and might slow down the deployment of charging infrastructure. It is recommended to classify EV charging as a service and not a resale of electricity.

Smart Charging has many advantages and can encourage power utilities to reduce the carbon emissions from their operations. It is recommended that countries should allow the flow of bidirectional current between EV batteries and the grid. Battery technology is constantly evolving, and more research is required to create more sustainable and effective batteries.

8.3. Business Models for Deployment

Demand aggregation or bulk procurement is one of the most common model followed for adoption of electric vehicles for a public or private fleet. Outright purchase and collaborative procurement are some popular demand aggregation methods. In order to save the maintenance and operating hassle, some agencies also prefer leasing the vehicles in their fleet. It is also called GCC or Gross Cost Contract where the lessor has to pay a fixed agreed upon amount to the lessee in installments and lessee takes care of operation and maintenance of the vehicles.

Electric car sharing is also gaining popularity. It saves the hassle of owning a car (parking charges, fuel costs, etc.). In addition, since shared cars have greater utilisation percentage or average driving distance per day if compared to an owned car, the payback period for owning an electric car reduces significantly.

For charging infrastructure deployment, governments are employing several business models. In China, a government agency installed substantial number of fast charging stations in order to overcome the hurdle of range anxiety from the mind of EV owners. China experimented with 10 cities and deployed state-specific business models, playing on the state's strengths.

Battery swapping stations are also becoming a popular concept. There has been one very successful case of two-wheeler battery swapping in Taiwan i.e. Gogoro battery swapping stations. Swapping stations provide reduced charging times as well as increased battery life.

8.4. Financing Electric Mobility

Some of the common financing mechanisms for EVs and related charging infrastructure are Low interest rate loans, fee-bate mechanisms, green bonds, and microloans. Sometimes, multibank arrangement, operated by a group of banks to pool funding and provide lending, is also undertaken. Multibank funding spreads the risk among several lenders and are used to develop infrastructure and extend credit for small-business loans, real estate development, and affordable housing construction.

Small business micro-loans can also be used to fund e-mobility ecosystem. Microloans are small-business loans offered at attractive interest rates to help businesses access capital for items like machinery or fixtures. These loans can facilitate funding for electric vehicle charging equipment and installation costs.

It is clear that governments need to take concrete action to encourage electric mobility to take advantage of the benefits of the technology. International co-operation is essential to the development of electric mobility. Experiences from across the world and the understanding gained from these experiences have to be incorporated in further programmes across countries.

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