Draft Report

"Study on Infrastructure and Enabling Environment for Road Electric Transport in SAARC Member States"

Draft Version (V1)
Submitted to: SAARC Energy Centre (SEC)
Submitted by: India Smart Grid Forum (ISGF)

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Abbreviations

AD	Accelerated Depreciation
ADB	Asian Development Bank
ALCS	Afghanistan Living Conditions Survey
AMI	Advanced Metering Infrastructure
AMR	Automated Meter Reading
APSCL	Ashuganj Power Station Company Ltd.
AT&C	Aggregate Technical and Commercial
ASEAN	Association of Southeast Asia Nations
ATF	Aviation Turbine Fuel
BAU	Business As Usual
BBCSAP	Bangladesh Climate Change Strategy and Action Plan
BEA	Bhutan Electricity Authority
BERC	Bangladesh Energy Regulatory Commission
BESS	Battery Energy Storage System
BEV	Battery Electric Vehicle
BMS	Battery Management System
BPC	Bhutan Power Corporation Limited
BPC	Bangladesh Petroleum Corporation
BPDB	Bangladesh Power Development Board
CAGR	Compound Annual Growth Rate
CCS	Combined Charging System
CEA	Central Electricity Authority
CEB	Ceylon Electricity Board
COP	Conference of Parties
CPC	Ceylon Petroleum Cooperation
CPEC	China-Pakistan Economic Corridor
CPO	Charge Point Operators
DABS	Da Afghanistan Breshna Sherkat
DCFC	Direct Current Fast Charging
DCSD	Distribution and Consumer Services Directorate
DER	Distributed Energy Resources
DESCO	Dhaka Electricity Supply Company Limited
DHI	Druk Holding & Investments
DISCOM	Distribution Company
DMS	Distribution Management System
DOE	Department of Energy

DoR	Department of Revenue
DPDC	Dhaka Power Distribution Company
DR	Demand Response
DSM	Demand Side Management
DSO	Distribution System Operator
DT	Distribution Transformer
EDF	Électricité De France
EDP	Economic Development Policy
EGCB	Electricity Generation Company of Bangladesh
EM	Electric Motor
ERL	Eastern Refinery Ltd.
EV	Electric Vehicle
EVCC	Electric Vehicle Communication Controller
EVCS	Electric Vehicle Charging Station
EVI	Electric Vehicle Initiative
EVMM	Electric Vehicle Maturity Model
EVSE	Electric Vehicle Supply Equipment
FCEV	Fuel Cell Electric Vehicle
FCV	Fuel Cell Vehicle
GEF	Global Environment Facility
GENCO	Government owned generation companies
GHG	Greenhouse Gas
GIS	Gas Insulated Substation
GNH	Gross National Happiness
GNHC	Gross National Happiness Commission
GOI	Government of India
GUTS	Green Urban Transport Scheme
GWh	Gigawatt-hour
HEV	Hybrid Electric Vehicle
HPCL	Hindustan Petroleum Corporation Limited
HSD	High Speed Diesel
ICCT	International Council on Clean Technology
ICE	Internal Combustion Engine
IEA	International Energy Agency
IEC	International Electrotechnical Commission
IM	Induction Motor
INDC	Intended Nationally Determined Contribution

IOCL	Indian Oil Corporation Limited
IoT	Internet of Things
IPP	Independent Power Producer
IRENA	International Renewable Energy Association
ISO	International Organization for Standardization
JOCL	Jamuna Oil Company Ltd.
KERC	Karnataka Electricity Regulatory Commission
LCV	Light Commercial Vehicles
LDV	Light Duty Vehicle
LECO	Lanka Electricity Company
LEDS	Low Emission Development Strategy
LFP	Lithium Iron Phosphate
LIB	Lithium Ion Batteries
LMO	Lithium Manganese Oxide
LPG	Liquid Petroleum Gas
LTO	Lithium Titanate
LUCF	Land Use Change and Forestry
MERC	Maharashtra Electricity Regulatory Commission
MEW	Ministry of Energy and Water
MMT	Million Metric Tonne
MoU	Memorandum of Understanding
MPEMR	Ministry of Power and Energy & Mineral Resources
MPL	Meghna Petroleum Ltd.
MTPA	Million Tonnes Per Annum
MU	Million Units
MW	Mega Watt
MWSC	Malé Water and Sewerage Company Pvt. Ltd.
NAMA	National Appropriate Mitigation Action
NATRIP	National Automotive Testing and R&D Infrastructure Project
NCA	Nickel Cobalt Aluminium Oxide
NDRC	National Development and Reform Commission
NHPC	National Hydro Power Corporation

NMC	Nickel Manganese Cobalt
NPS	New Policies Scenario
NTPC	National Thermal Power Corporation
NWPGCL	North West Power Generation Company Ltd.
NWZPDC	North-West Zone Power Distribution Co.
O&M	Operation and Maintenance
OCPP	Open Charge Point Protocol
OEM	Original Equipment Manufacturer
PGCB	Power Grid Company of Bangladesh Ltd.
PHEV	Plug-in Hybrid Electric Vehicle
PLDV	Passenger Light Duty Vehicle
PMSM	Permanent Magnet Synchronous Motor
POCL	Padma Oil Company Ltd.
PPP	Public Private Partnership
PUCSL	Public Utilities Commission of Sri Lanka
REB	Rural Electrification Board
RTP	Real Time pricing
SAARC	South Asian Association of Regional Cooperation
SAE	Society of Automotive Engineers
SDG&E	San Diego Gas and Electric
SEB	State Electricity Board
SECC	Supply Equipment Communication Controller
SLSEA	Sri Lanka Sustainable Energy Authority
SOC	State of Charge
SPHS	Series/Parallel Hybrid System
SRM	Switched Reluctance Motor
STELCO	State Electric Limited Company
SynRM	Synchronous Reluctance Motor
TCO	Total Cost of Ownership
TERI	The Energy and Resources Institute
ToD	Time of Day
TOE	Tonnes of Oil Equivalent
USAID	The United States Agency for International Development

Executive Summary

The economies of the SAARC nations have grown over recent years, with growth in the industrial and service sectors. In parallel to economic growth, the countries have witnessed an increase in their contribution to climate change. Bangladesh, Pakistan and India were the largest GHG emitters in the SAARC region: 73.2 $mtCO_2$, 166.3 $mtCO_2$ and 2238.4 $mtCO_2$ respectively. While the cumulative GHG emissions of the other SAARC states was comparatively lower, the GHG emissions per capita remained high for these states, with Maldives in particular, registering 3.7 tons of CO_2 emissions per capita. The SAARC region is geographically extremely vulnerable to the adverse effects of climate change. In light of this, each of the SAARC nations have ratified the Paris Agreement (COP21) declaring Intended Nationally Determined Contributions (INDCs) to tackle climate change.

The transportation sector is observed to be one of the most energy intensive and polluting sectors in the SAARC region and continues to be one of the largest oil consuming sectors with transport fuels accounting for significant shares of the total petroleum and diesel consumption. The increased use of oil in the transport sector has also increased the import dependency of the SAARC states, which will not only increase GHG emission but will also have substantial impact on the energy security scenario of the countries.

Considering this, some of the governments of the SAARC states, such as Bhutan, Bangladesh, India, Nepal and Sri Lanka, have undertaken various initiatives and introduced policies towards transformation of the transportation sector by replacing the fossil fuel run vehicles with electric vehicles which are not only very efficient drive mechanisms. The dilemma for some of these nations (that do not have domestic “fuels” for electricity generation – Coal, Hydro, Gas) is the imported fuel consumption cannot be reduced substantially.

India Smart Grid Forum has conducted this study to identify and evaluate key enablers of electric vehicle implementation and assess the readiness of SAARC member countries in terms of policy, technology, commercial and institutional aspects. Based on the assessment, implementable recommendations have been provided to facilitate electric vehicle penetration in SAARC member states. An Electric Vehicle Maturity Model (EVMM) has been created to assess these parameters.

Chapter 1 provides the broad objective and scope of the study, that includes the assessment of EV infrastructure requirement and subsequent formulation of EV implementation plan for the respective SAARC member nations in order to ensure sustainable EV deployment in near future. The approach and methodology adopted for the assignment is based on comprehensive desk research on the EV infrastructure requirement, policy & technology adopted etc. in each of the SAARC member states along with the evaluation of international best practices followed and adopted by leading EV markets in the world, which are evaluated in the next chapters. This section further emphasized on the limitations or constraint faced by the ISGF team in conducting the research in terms of limited project budget, time frame, minimal client support, limited data availability etc.

In ***Chapter 2,*** we have assessed the detailed socioeconomic overview of the SAARC nations and the key drivers for Electric Vehicle deployment which shows that India, Bangladesh, Maldives, Pakistan and Sri Lanka, which are high energy intensive countries are mainly dependent on fossil fuels including oil, gas and coal to meet their majority of energy requirements. The transport sector which is one of the major drivers of SAARC economies, contributes almost 7% in the respective GDPs of the member states with a share of 7% in the overall primary energy consumption and contributes 6% to 27% of total GHG emissions for each SAARC member state. The low energy resource availability, small crude

oil refining capacity, increasing energy imports and primary energy consumption of the transport sector coupled with surging fuel prices, growing GHG emissions and the INDC commitments have been identified as the key drivers or the push factors for electrification of transportation sector in the SAARC member states.

Chapter 3 highlights the current status and forecast of EV implementation in the global context for the various vehicle segments considering two scenarios: i) The New Policies Scenario (NPS) and ii) The EV30@30 Scenario. This chapter also forecasts the price trajectories for batteries of the different vehicle segments. This section also evaluates the policy support provided by the countries leading in EV deployment, in terms of subsidies and incentives, which can then be modified and suitably adopted to address the potential implications on EV markets in the SAARC nations.

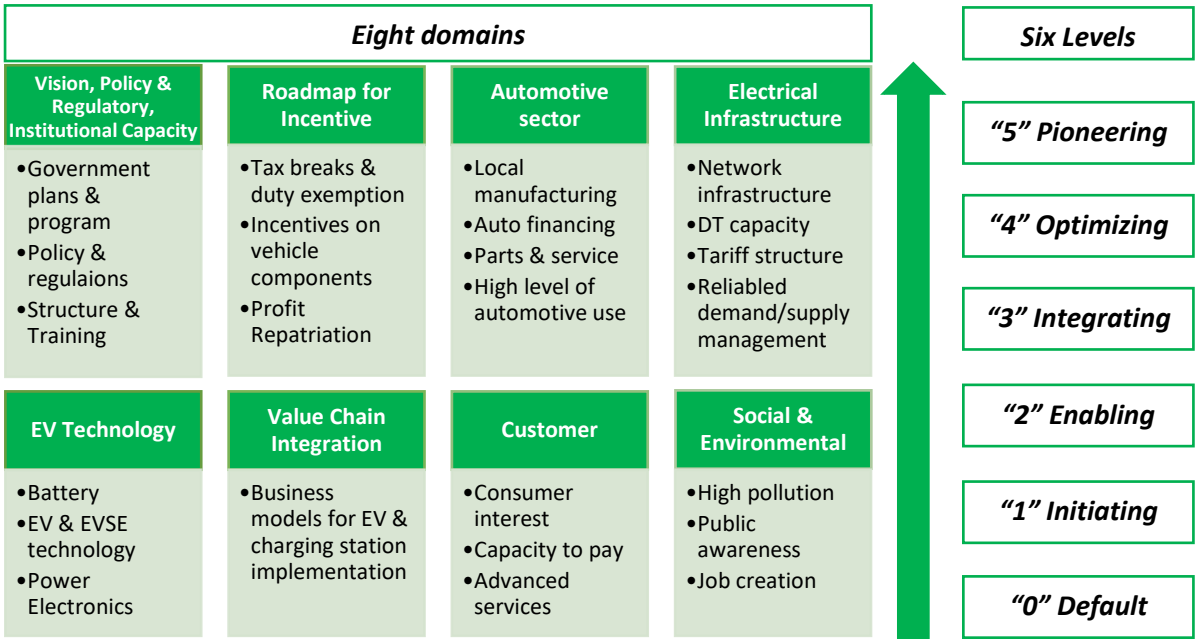
Chapter 4 discusses various components of EV ecosystem in terms of policy, technology and business models that have been adopted globally like types of electric vehicle, charging infrastructure and standards, battery types and chemistry, motors etc. This section also evaluated their technical specifications, characteristics, designs like specifications of DC charging standards like CHAdeMO, CCS2, GB/T etc., battery specifications of different lithium ion batteries and their pros and cons. In addition, various business models like aggregator model, integrated infrastructure model, independent e-mobility model and EV related policies innovative tariff structures adopted by various utilities across the world have also been evaluated to understand their requirement and benefits which will help us to analyse their fitment in the SAARC member states to accelerate the EV deployment process.

Chapter 5 discusses the EV rollout procedure for the top 3 global leaders, namely Norway, China and USA and evaluated the cases of Oslo, San Jose, San Francisco, Los Angeles, Shanghai, Shenzhen and Beijing in terms of metropolitan population, total electric vehicle sales, Electric vehicle share of total vehicle sales, electric vehicle sales share relative to country average, public electric vehicle charge points per million people, Grid CO_2 emissions, financial incentives, non-financial incentives, charging infrastructure etc. which have helped us to figure out the key factors responsible for successful EV deployment in these countries.

Chapters 6 to Chapter 13 assessed the existing scenario in terms of policy, automobile industry, EV initiative etc. in each of the SAARC member states and provided key recommendations related to above mentioned parameters based on ***Electric Vehicle Maturity Model Assessment***.

India Smart Grid forum has developed an ***Electric Vehicle Maturity Model (EVMM)*** to assess the readiness of each of the SAARC member states for EV adoption in terms of policy, infrastructure, technology, institutional structure, market dimensions, customer willingness etc. which will help the concerned stakeholders including concerned ministry, transport utilities etc. to identify and implement the required steps that need to be taken in phases to ensure sustainable EV adoption across the country.

The EVMM is structured across eight categories, including vision, policy& regulation, institutional capacity, automotive sector, electrical infrastructure, incentive roadmap, technology, value chain integration, customer, social and environmental and 6 Levels of maturity to assess the preparedness and measure the progress of the countries in the respective domains.



Based on the EVMM assessment, the recommendations advocate for various steps that need to be taken by the SAARC member states in different phases till 2030 for electrification of transport sector. Policy actions include the launching of national EV mission with strict implementation plan and fixed targets, setting up of nodal agency through the collaboration of relevant ministries, local municipalities and other stakeholders for overseeing the EV implementation process, attractive FDI policy, provision of incentive mechanisms like subsidised loans, reduced tax, creation of EV-only areas, etc. In addition, different business models for EV and charging infrastructure deployment as well as for developing the EV automotive market have also been recommended along with the activities that power utilities need to undertake to support the EV deployment process in terms of upgradation to the electrification infrastructure, effective grid management etc.

The electrification of the transport sector in SAARC member states will lead to direct benefits like reduced GHG emissions, improved air quality, creation of business opportunities in automotive sector and subsequent increase in employment opportunities, improved electrification rate, affordable transport etc. In addition, this will not only allow the member states to reduce their fuel imports but will also facilitate in diverging the usage of fuel in power generation, fertilizer industry etc., thus positively impacting the economies of the respective SAARC countries.

1. Introduction and Scope of the Report

1.1 Introduction

The concern for increase in greenhouse gases and need for a low carbon economy has been acknowledged by several countries which led to the signing of Paris Agreement in December 2015 envisaging limitation of global temperature rise to two degrees Celsius above pre-industrial levels by 2100. The Agreement was signed by 195 countries and ratified by 148 countries which also agreed to maintain and communicate National Determined Contributions (NDCs) along with action plans that it intended to achieve in the long term. Decarbonisation action plans that need to be adopted to address greenhouse gas (GHG) emissions and drive new economic opportunities, while improving the quality of life of the citizens in the cities, should address these three key prioritized decarbonisation pathways in energy generation, energy utilization and transportation sector. All these three sectors will influence significant rise in city-level carbon emissions in next five to ten years, primarily driven by accelerated urbanization and economic growth.

South Asian Association of Regional Cooperation (SAARC) countries comprising of India, Pakistan, Afghanistan, Nepal, Bhutan, Bangladesh, Sri Lanka and Maldives are currently experiencing an average GDP growth of 6.5% (except Afghanistan) and is set to increase to more than 7% by 2020 which will subsequently require a change in the energy consumption dynamics to ensure sustainable economic development. These countries are largely dependent on crude oil and oil products in terms of primary energy consumption with transportation sector being the highest contributor in consumption of oil products. Moreover, the increased dependency on crude oil and oil products has also led to increase in the import of these products ***e.g. Bhutan imported 170 million litres of oil and petroleum products in 2016, mostly for the transport sector and oil import is at the top spot in monetary terms among the import list in Maldives (USD 227 million)***. The increased use of oil in the transport sector along with import dependency will not only increase GHG emission but will also have substantial impact on the energy security scenario of the country.

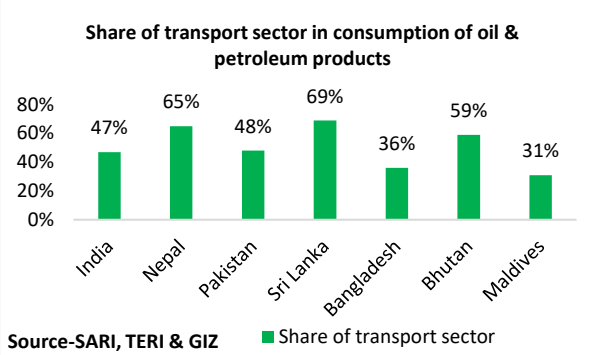


Figure 1 Share of transport sector in consumption of oil & petroleum products

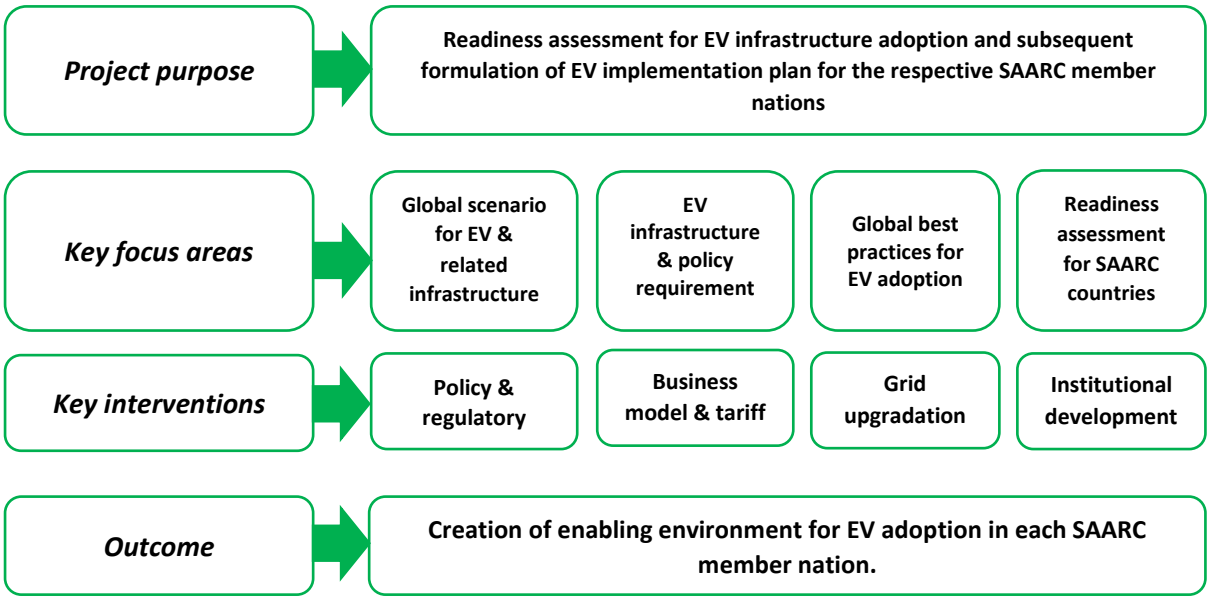
Share of transport sector in GHG emission	
Pakistan	11%
Bangladesh	6%
Sri Lanka	16%
Source - USAID	

Therefore, to address the issue of GHG emission and to ensure energy security, transportation sector need to undergo a significant transformation from oil based system to a more environment friendly electricity based system. SAARC countries as a party to the Paris Agreement have well acknowledged the contribution of transport sector and included adoption of Electric Vehicle as a prioritized action item in their NDCs.

1.2 Project Objective & Scope

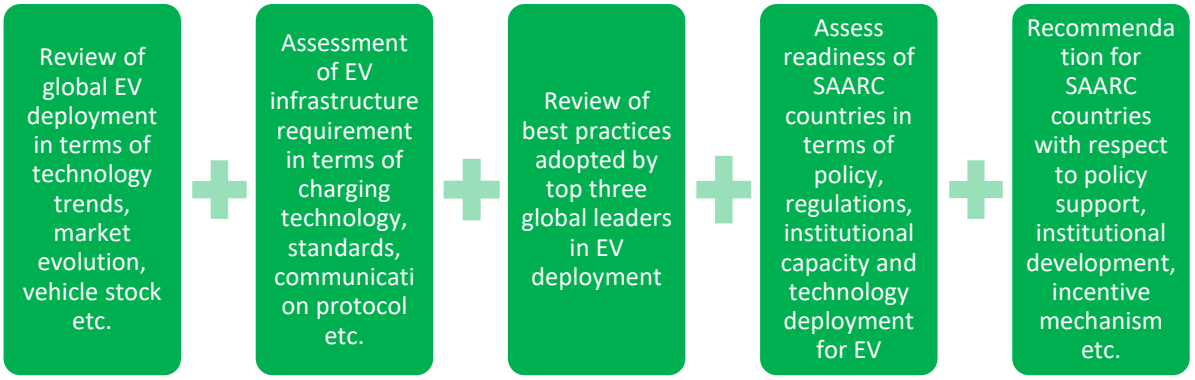
SAARC Energy Centre has awarded the project Study "Study on "Infrastructure and Enabling Environment for Road Electric Transport in SAARC Member States" to India Smart Grid Forum on 1st June 2018.

The objective of this study is to identify and evaluate key enablers of electric vehicle implementation and assess the readiness of SAARC member countries in terms of policy, technology, commercial and institutional aspects. Based on the assessment, implementable action points will be developed to facilitate electric vehicle penetration in SAARC member states.



1.3 Approach & Methodology

The proposed approach and methodology for the assignment is based on comprehensive desk research on the EV infrastructure requirement, global EV deployment strategies etc. in each of the SAARC member states along with the international best practices followed and adopted by leading EV markets, extensive work experience of the domain experts and knowledge base of the organisation. ***We have also leveraged the experience of our highly qualified experts and team to carry out extensive research and data collection activities which has been the key to successful completion of the below mentioned activities in the stipulated time frame.*** The overall approach and methodology are as follows:



1.4 Limitations

The broad scope of the study requires us to perform a detailed analysis in each of the vehicle segments e.g. two wheelers, three wheelers, buses etc. along with technology adoption, electrical infrastructure and manufacturing facility to identify the key activities that have already been undertaken and the ones that need to be carried out to facilitate the deployment of electric vehicle in a sustainable manner. This requires a huge amount of data and information pertaining to policy and regulations, government's plans & programs, electrical infrastructure, manufacturing scenario etc. Considering the requirement, the project faces certain limitations in terms of time, information availability etc. which are stated below:

- Limited time frame to complete the necessary detailed analysis considering each member state has different dynamics in terms of policy, economy, technology adoption, manufacturing etc. and has to be evaluated separately to identify and recommend the key steps that need to be undertaken by government and transport authorities in the coming years.
- Limited project budget defying the possibility of visiting each country, transport authorities and the utilities to gather the necessary information.
- More support is needed from the client, transport authorities of the member states and other stakeholders in terms of sharing relevant data, availability of information related to policy and regulations, government plans and programs, technology adoption etc. which are required to carry out the necessary assessment in each of the steps mentioned in the approach and methodology.
- Limited data from the primary sources and that too back dated data in the secondary sources and lack of its authenticity in many cases restricts the evaluation of various parameters in terms of precision and accuracy, thereby affecting the project time frame.

However, considering the above limitations, we have tried to carry out the necessary assessments with the authentic data available in the secondary sources provide the way forward for each member states and also to ensure project completion in the given time frame.

2. Introduction

The South Asian Association for Regional Cooperation (SAARC) is an intergovernmental organization aimed towards the social and economic development of its member nations through regional collaboration. It comprises of 8-member states namely Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka.

The current global scenario demands for sustainable economic growth while also considering the impending conventional energy crisis and climate change concerns. The SAARC countries have united on this forefront to address these issues so as to maintain and enforce the socioeconomic progress of their respective economies.

In regards to this, 'Electric Vehicle Infrastructure' (EV) has emerged as a leading technology that most of the developed and few of the developing nations have adopted and this study seeks to evaluate the necessity, suitability, feasibility and requisite actions that must be taken for EV deployment in SAARC to provide optimum results.

2.1 Socioeconomic Overview

The SAARC region is a highly diverse mix of ecologies given its geographic location between the Equator and the Tropic of Cancer. It occupies a total territorial area of about 5.13 million square kilometers (3.77% of the world total) with a population of 1.73 billion people (23.4% of the world population) as of 2017. SAARC also has the greatest population density worldwide. India has the lion's share of the region's population (74%) and area (64%). SAARC is facing an upsurge in population that has placed intense pressure on the natural resources and environment. Contributing to this is the region's rampant urbanization that is indicated through the increasing urban population—33% of the total in 2017. The region boasts of a largely untapped abundance of natural resources. The region's peculiar geographic and climatic conditions make it most vulnerable to the adverse effects of climate change.

Population

- Population of **1.73 billion** spread out over a region of **5.13 million sq. kms**

Urbanization

- High urbanization rate in SAARC. **33%** of total population is urban populace

Economic Growth

- SAARC economy registered a **GDP** of **$2.7 trillion** with a **7% growth rate**
- Highest GDP growth rate was for **India**: **7.6%**. **Afghanistan** posted a negative growth rate of **-2.4%**

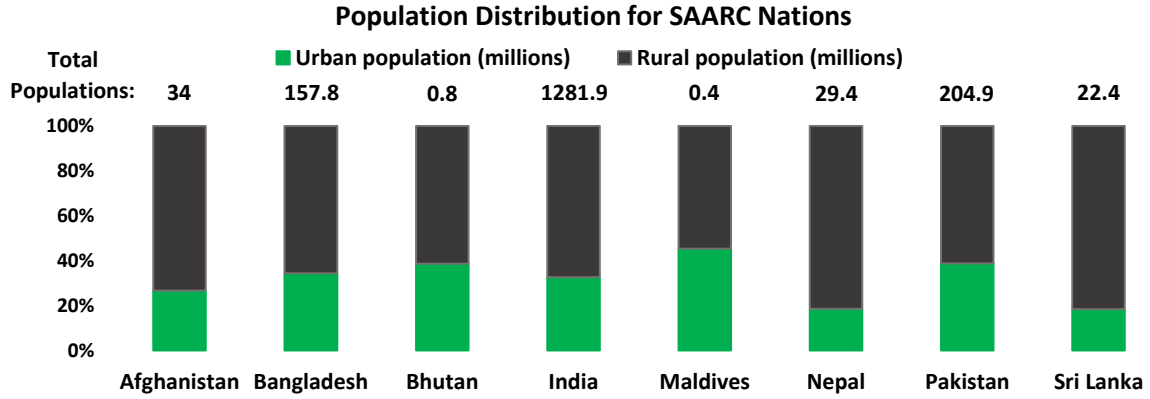
Sectoral share in GDP

- Despite being **agrarian** economies, **service sector** has **greatest share** in GDP for the SAARC nations

Source: (UNdata, 2017) (Various Statistical Yearbooks 2016-17) (CIA The World Fact Book, 2018)

Economic growth has flourished in recent years, with SAARC registering a GDP of $ 2.7 trillion with a 7% growth rate for the year 2016-2017. At 7.6%, India posted the highest GDP growth among the SAARC states, while Afghanistan had a negative growth rate of -2.4%. Agriculture, despite employing maximum portion of the workforce, has declined in its sectoral share for GDP while there has been a marked rise for the industry sector. The service sector leads in terms of GDP share in SAARC. Transport (a sub-sector of services), as one of the key drivers of economic growth, has risen significantly due to urbanization, industrialization and logistics requirements. The high energy intensity of these sectors

has placed great pressure on the energy sector of the respective member states to match supply with the demand.



Sources: (BP Statistical Review of World Energy June 2018) (CIA The World Fact Book, 2018) (IRADe)

Figure 2 Population Distribution for SAARC Nations

2.2 Energy Sector Profile

Given the developing phase of the SAARC economies, the region relies heavily on conventional sources of energy to meet energy demands. Energy demands have risen at a historic pace with the rapid growth of the service and industry sectors. Energy sector expansion has been a key part of the SAARC states' economic agendas, that has driven the exploration and exploitation of potential energy reserves, augmentation of electricity generation capacity and propelled fuel imports.

Energy Parameters	Afghanistan	Bangladesh	Bhutan	India
Primary Energy Source	Hydro	Gas	Hydro	Coal
Energy Imports	Electricity and fuel imports	Electricity and fuel imports	Exporter to India, small fuel imports	Electricity, Oil & Gas imports
Installed Electricity Capacity (GW)	0.585	16	1.62	344.7

Sources: (CIA The World Fact Book, 2018) (IRADe) (Various Statistical Yearbooks 2016-17)

Energy Parameters	Maldives	Nepal	Pakistan	Sri Lanka
Primary Energy Source	Diesel	Hydro	Gas	Hydro and Thermal
Energy Imports	Diesel imports	Electricity and fuel imports	Fossil fuel imports	Oil imports
Installed Electricity Capacity (GW)	0.36	1.07	33.1	4

Table 1 Energy Parameters for SAARC Countries

Sources: (CIA The World Fact Book, 2018) (IRADe) (Various Statistical Yearbooks 2016-17)

2.3 Transport Sector Profile

Transport (a sub-sector of services), as one of the key drivers of economic growth for the SAARC states, has risen significantly due to urbanization, industrialization and logistics requirements.

GDP	Registered Motor Vehicles	Primary Energy Consumption	GHG Emissions
•The transport sector for each SAARC country has a contribution of **at least 7%** in the respective GDPs.	•SAARC region has **over 238 million** registered motor vehicles. •**Sharp increase** in motor vehicles is forecasted in the near future.	•By the year 2015, the share of Transport sector in primary energy consumption stood at **7%.**	•The transport sector contributes **6% to 27%** of total GHG emissions for each SAARC state.

Sources: (Various Statistical Yearbooks 2016-17) (Energy Statistics Yearbook, 2015) (UNdata, 2017)

2.4 INDC Targets

The unique geographical location of the SAARC region leaves it highly prone to adverse effects of climate change. In response to the COP21, the SAARC member states have ratified the Paris Agreement and declared respective INDCs. The states of Afghanistan, Bhutan, Bangladesh, India, Maldives, Pakistan and Sri Lanka have set specific conditional and unconditional GHG emission targets based on either business as usual or projected scenarios.

Afghanistan

•"**13.6%** reduction in GHG emissions by **2030** compared to a business as usual (BAU) scenario, conditional on external support"

Bhutan

•"Remain **carbon neutral** where GHG emission will not exceed sequestration by forests, estimated at 6.3 million tons of CO_2"

Bangladesh

•"**5%** to **15%** (conditional) reduction in GHG emissions by 2030 compared to the BAU levels"

India

•"**33%** to **35%** reduction in the emissions intensity of its GDP by 2030 compared to 2005 level"

Maldives

•"**10%** up to **24%** (conditional) reduction in GHG emissions for the year 2030 compared to the BAU scenario"

Pakistan

•"Up to **20%** reduction in GHG emissions by 2030 compared to the projected GHG emissions"

Nepal

•"By 2050, Nepal to decrease fossil dependency of transport sector by **50%** and increase electric vehicles share to **20%** from 2010 level"

Sri Lanka

•"**4%** to **20%** (conditional) reduction in GHG emissions from energy sector, and **3%** to **10%** (conditional) from transport, industry, forests and waste by 2030 wrt BAU"

Sources: (Various INDCs)

Apart from the GHG targets, the SAARC states have also declared certain non-GHG targets that are aimed towards achieving COP21 goals. Behavior modification and opportunities for the establishment of renewable and alternative energy sources have been declared by Afghanistan for 25% of the rural populace. Bangladesh has developed a mitigation strategy 'Bangladesh Climate Change Strategy and Action Plan (BBCSAP)' and also stated additional mitigation actions in its INDC that include the development of "400 MW of wind-generating capacity by 2030," and "1000 MW of utility-scale solar power plant by 2030". Bhutan has committed to preserve forest cover for at least 60 percent of total land as per the Kingdom of Bhutan's Constitution. The current forest cover is 70.46% of total land, for which, sustainable forest management as well as conservation of environmental services are the steps that Bhutan has declared to implement. India itself has a detailed climate action plan that involves renewable energy deployment, grid modernization, etc. Nepal has set targets through its National Rural & Renewable Energy Programme and also that of 40% forest cover. Sri Lanka has set renewable integration and 32% forest cover target.

2.5 Why EV? - Key Drivers

2.5.1 Energy Resource Availability

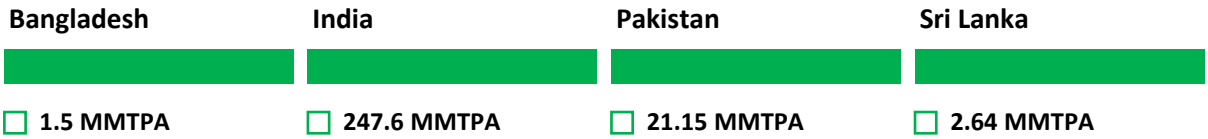
Despite being rich in natural resources, the supply of energy resources is dispersed in the SAARC region. Afghanistan, Bhutan, India and Nepal have an abundance of hydropower. India and Bangladesh possess sufficient deposits of coal. However, the other fossil fuel reserves of oil and gas, that service a significant portion of SAARC energy demands, are scarce. This poses a considerable strain on the available resources and a consequent overreliance on imports to meet the energy requirements of the SAARC economies.

Country	Proven Crude Oil Reserves (Million Barrels)	Proven Natural Gas Reserves (BCM)
Afghanistan	-	49.55
Bangladesh	20	196.1
India	4500	1200
Pakistan	350.6	542.5
Sri Lanka	150	-

Sources: (BP Statistical Review of World Energy June 2018) (CIA The World Fact Book, 2018) (IRADe)

Table 2 Energy Resource Availability for SAARC Countries

2.5.2 Crude Oil Refining Capacity



Sources: (Eastern Refinery Limited) (Petroleum Planning & Analysis Cell) (BP Statistical Review of World Energy June 2018) (export.gov)

Refining and storage capacities of crude oil in SAARC nations are smaller compared to the large consumption rates, leading to large expensive imports.

2.5.3 Energy Imports

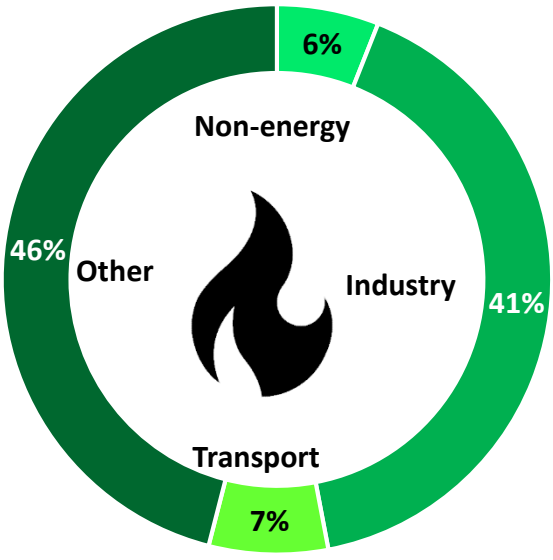
The energy reserves in the SAARC nations are insufficient to service their energy demands resulting in a rising trend in fuel imports, in particular, that of crude oil, natural gas, petrol and diesel. Petroleum constituted 15% of the total imports for Afghanistan that stood at USD 1008 million in 2016-2017. Bangladesh reported crude oil imports increase by 23.34% while petrol product imports rose by a rate of 27.34%. Diesel and petrol imports for Bhutan stood at USD 84.2 million and USD 25.6 million respectively. The bulk of India's imports comprised mostly of crude oil and petroleum products, which was approximately USD 77 billion with imports growth for petrol products and crude oil at 4.8%. Maldives spent $236 million on oil imports for 2016. Maldives imported 445036 mt of diesel and 47794 mt of petrol in 2016. The total petrol imports for Nepal were USD 181 million and total diesel imports were USD 600 million. Crude oil imported in July-March FY 2017 for Pakistan stood at 5.9 million tonnes and USD 1.84 billion and in July-February 2018, 60.4 million barrels of crude oil were imported. Petroleum imports for July-Feb 2018 stood at USD 4193.35 million. Expenditure on fuel imports grew by 30% to USD 3428 million for Sri Lanka. Sri Lanka imported 1591000 million tonnes of crude oil in 2017.

Oil Imports:
Fuel imports form the bulk of SAARC imports. Crude oil imports in Bangladesh rose by 23.79%. In 2016, 0.54 million metric tons of fuel were imported by Maldives. Pakistan imported 5.9 million tonnes of crude oil worth $1.84 billion during July-March FY2017. Oil imports increased by 30% to $3428 million in FY2017 for Sri Lanka. A likewise surge in crude oil imports has been observed for the other SAARC countries over the past decade.

2.5.4 Sector-wise Primary Energy Consumption

The energy sector forms the backbone of an economy and it is one of the prominent indicators of the nation's financial health. Primary energy consumption has jumped with the recent growth in industrial activity. As a result, augmentation of the energy sector has been a crucial point on the agenda of the SAARC countries to facilitate the transition from agrarian to industrial economy. Of the categories of energy consumption, a marked increase has been observed for the transport and electricity sectors. Transport noted 7% of primary energy consumption for the SAARC states in 2015 while the share of electricity stood at 10.4% in the year 2014.

Primary Energy Consumption by Sector (2015)

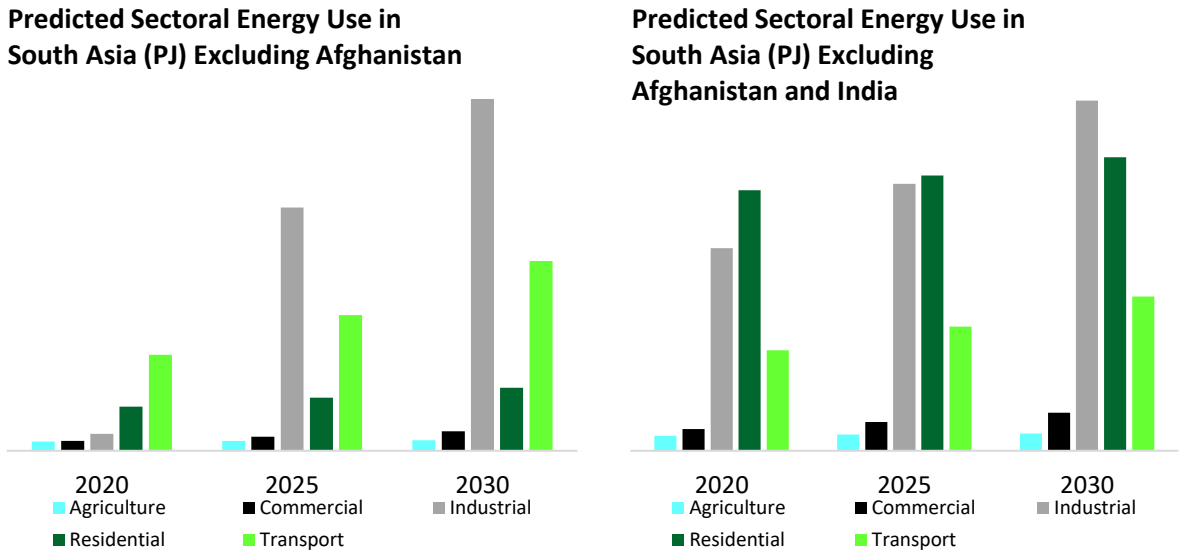


Sources: (Energy Statistics Yearbook, 2015)

Figure 3 Primary Energy Consumption by Sector for SAARC Countries (2015)

2.5.5 Future Energy Usage Pattern

With growing pace of economic growth, future energy demands are expected to rise exponentialy, in particular, that of transport, going by the present and historic trends. According to an ADB study, the total energy consumption in the South Asian region, excluding Afghanistan, would increase to 66,724.2 PJ in 2030 at an annual rate of 6.8%. The share for the transport sector will be 27% of the total energy consumption. The top three energy-intensive sectors in the SAARC region are: industry, transport, and residential sectors respectively. With energy use ratios of 6.6 and 8.8 respectively, transport and industrial sectors have displayed highest growth in regard to energy consumption.



Source: (ADB-Australia South Asia Development Partnership Facility)

Figure 4 Predicted Sectoral Energy Use in South Asia

2.5.6 Transport Sector Consumption of Imported Oil

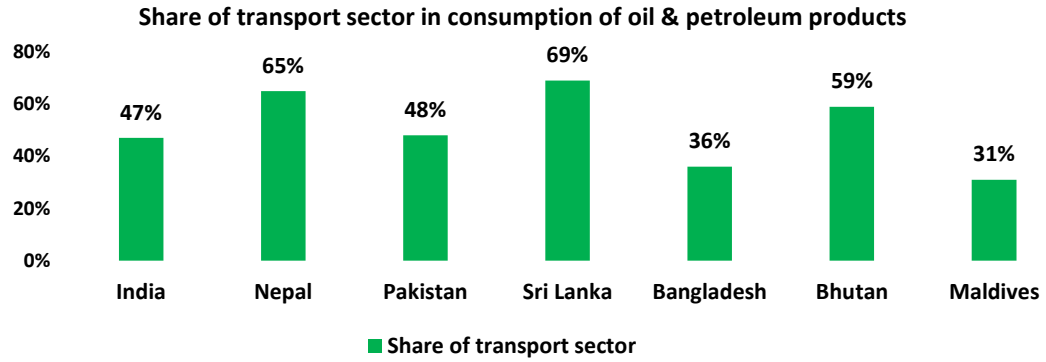


Figure 5 Share of transport sector in consumption of oil & petroleum products in SAARC Countries

Diesel and petrol ranked 1st and 5th respectively in Bhutan's top ten commodity imports for 2016. During July-February 2018, 60.4 million barrels of crude oil were imported and transport share was 60.4% in oil consumption. Goods transport vehicles from India, traversing on Bhutan roads consume a part of the total imported fuel. Tourist vehicles as well as other vehicles from India that refuel at the Bhutanese border towns are also included in the total fuel consumption. Approximately 127.54 million liters of diesel was imported by Bhutan in 2016, a year-on-year rise of nearly 4 percent. Petrol import

in 2016 increased by 6 percent to 359.60 million liters. The Maldives is almost fully dependent on imported fuels for generation of electricity, maritime transportation; aviation; road transport, cooking, producing water and for other uses. Maldives imported petroleum products worth 23% of its GDP in 2012. Under a BAU scenario, Maldives's dependency on these fuels is expected to grow rapidly in the future. For the first eight months of FY 2016-17, the share of total consumption of petrol products registered by petrol was 22.5%, by diesel was 67.5%, by kerosene was 1.1% and ATF was 9% for Nepal. With Sri Lanka being fully dependent on imports for its oil requirements, petroleum and petroleum related products are being imported throughout the year. In the year 2017, the total cost of import of petroleum products stood at USD 3,167 million which is around 11.9 percent of the total imports in the year 2017.

Petrol and diesel register on the **top ten import commodities** for the countries of **Bhutan, India, Maldives, Nepal and Sri Lanka.**

2.5.7 GHG Emissions from the Transport Sector

Global energy consumption by transport sector and the corresponding emissions are forecasted to multiple by one and a half times till 2030 after which, they will be more than twice till 2050 in a BAU scenario. The transport sector accounts for more than 50% of world oil consumption and nearly 25% of energy-related carbon dioxide emissions. According to a study conducted by ADB, a 3 to 5 times increase in carbon dioxide emissions from transportation sector in Asia till 2030 relative to 2000, in BAU scenario. 22% share of the total global CO_2 emissions in 2012 was contributed by the transport sector. Notably 16% of the 22% was contributed by the road transport sector. This is driven by the anticipated six to eight-fold increase in the number of light-duty vehicles and a large increase in the number of trucks, which could overwhelm even the most optimistic forecasts of improvements in vehicle fuel efficiency. In terms of GHG emissions in South Asia, the Asian Development Bank has estimated that the emissions will reach a staggering, 244.7 million tonnes of CO_2e in 2030, that is an increment more than four folds compared to the 2005 levels. Out of which, the transport sector contributed 15.9 million tonnes CO_2e in 2005. It has been estimated that the share of GHG emissions from transport sector will exceed 46.7 million CO_2e by 2030.

Overall GHG Emissions (2005): GHG emissions for SAARC region stood at approximately 80 million tons of CO_2e

GHG Emissions by Transport Sector (2005): The transport sectors of the SAARC nations cumulatively contributed 17.59 million tones CO_2e

Estimated GHG Emissions (2030): GHG emissions from transport sector by SAARC (exc. Afghanistan and India) will exceed 46.7 million CO_2e by 2030

Sources: (SYNODE ADVISORY Private Limited) **Sources:** (USAID)

Share of transport sector in GHG emission	
Pakistan	**11%**
Bangladesh	**6%**
Sri Lanka	**16%**

Table 3 Share of transport sector in GHG emission for SAARC Countries

2.6 Key Issues in SAARC to consider EV deployment

Depleting Fuel Reserves: Afghanistan, India, Pakistan, Bangladesh and Sri Lanka have exploited their already scant fuel reserves significantly. While further efforts have been made in oil and gas exploration, the results have been lukewarm, thus piling pressure on the SAARC states to import fuel.

- Bangladesh Petroleum Corporation (BPC) imports, acquires, stores and markets petroleum products. The current storage capacity of petroleum products is around 12.21 lakh MT. BPC has taken a project titled 'Installation of ERL Unit-2' to increase processing capacity of existing refinery from 15.00 lakh MT to 45.00 lakh MT to strengthen energy security of the country.
- Crude oil production target for India during 2017-18 (April-Oct) was 21.85 MMT against which actual production was 21.06 MMT which meets the target by only 96.38 percent. The production faced a shortfall majorly on account of dwindling production by old and marginal fields, lengthy delay project development of the western offshore as well as the unscheduled closure of refining plants, wells and pipelines.
- Diesel has the highest share of local consumption in Maldives, primarily utilized to generate electricity and for the purpose of transportation. Petrol has the second greatest contribution to fuel imports in Maldives. Petrol and diesel consumption for transport grew at 4.5% per year. The petrol energy consumption by cars at outer atolls jumped from 13% at 2010 and 2011 to 28% in 2012. As a result, the percentage share of energy consumption by motor bikes in outer atolls have declined. As in the Greater Male' Region, the majority of Diesel energy is consumed by heavy vehicles such as lorries, trucks and tractors. The total energy consumption for transport sector is 99,821toe for 2012, which is a jump of 11% compared to the 2010 levels.

Rise in fuel prices: Oil prices have fluctuated arbitrarily in the international markets over the past decade. There was respite for the SAARC states with oil prices drop in the last fiscal year however they have picked up pace and are expected to surpass previous levels. The issue of fuel prices offers a further grievance given that a number of the SAARC states still use the 'Administered Pricing Mechanism' and provide subsidies for petrol and diesel, making the SAARC states vulnerable to global price hikes.

- Bangladesh Petroleum Corporation (BPC) imports crude and refined oil every year according to the country's demand. There are fluctuations in refined and crude oil prices in international market. BPC was continuously incurring losses due to non-adjustment of oil price and custom duty in the domestic market in conformity with the increases in oil price in the international market. As a result, the Government had to give remarkable amount of subsidy for importing petroleum products. In recent years the price of oil has fallen in the international market. So, the Government did not require giving any subsidy in FY2015-16 and FY2016-17.
- The average crude oil prices for the Indian basket increased year-on-year by nearly 14 percent in 2017-18 (mid-January 2018). The average crude oil price is expected to reach US$ 56-57 per barrel in 2017-18 which could increase 10-15 percent further in 2018-19. This would negatively affect the GDP growth for India.
- Growing fuel imports in July-March FY2018 had a dampening effect on Pakistan's balance of payments. The import bill increased further owing to the recovery of world oil prices, thus stretching the current account deficit.

Increase in import: Soaring fuel imports have led to the widening of trade deficit, causing negative Balance of Payments (Current Account), which reflects poorly on the financial health of the economy and can be a major cause of detriment to sustaining economic growth. Maldives faces the additional challenge of storage for the imported fuel.

- The annual trade deficit for Afghanistan of around 33 percent of GDP is financed by foreign aid inflows. Data on foreign trade indicates that in 2016-2017, value of registered imports was USD 6534 million and that of exports was USD 596 million only. There was a decrease in the imports by USD 1189 million or 15.4% and an increase in exports by USD 25 million or 4.4% compared to the previous year. It is to be mentioned that total imports include USD 261 million of electricity imports.
- Import grew by 9.00 percent in FY2016-17 with import of crude oil growing by 23.79 percent and petroleum products by 27.34 percent for Bangladesh.
- Bhutan imports fossil fuels including diesel, petrol & LPG gas from India. Import of diesel grew by 4.46 percent in 2016 as compared to 4.11 percent in 2015. Petrol import grew by 6.14 percent in 2016 as compared to 8.28 percent in 2015, a decrease of almost 2 percent. Further, in terms of percentage share, diesel import accounts for 78 percent in 2016 while petrol accounts for 22 percent. Bhutan imported around 127.54 million liters of diesel in 2016 as compared to 122.10 million liters in 2015, an increase of around 4 percent. The import of petrol in 2016 increased to 359.60 million liters from 338.81 million liters in 2015, an increase of 6 percent.
- The Maldives relies almost entirely on imported fossil fuel to meet its energy demands. Maldives imported fuel of 506334 metric tons in 2015. This includes 12,385 metric tons of cooking gas, 389,968 metric tons of diesel, 38,683 metric tons of petrol and 65,299 metric tons of aviation gas.
- The total trade deficit soared by 47.6 percent reaching Rs. 580.34 billion for Nepal in the review period. The growth rate of petroleum products consumption, occupying nearly 20 percent share of total imports from India, is very high. The share of petrol, diesel, kerosene and ATF except that of LPG in the total consumption of petroleum products stood at 21.3 percent, 70.4 percent, 1.3 percent and 7.0 percent respectively in FY 2015/16.
- During July-March FY 2018, Pakistan had a current account deficit of US $12.0 billion which is predicted to go beyond US $15.0 billion at the current fiscal year end. The rise in overall import payments was mainly driven by higher purchases of fuel and capital equipment. This is understandable, given that Pakistan is transitioning from a low growth to higher growth economy and is therefore faced with supply-side bottlenecks in energy and infrastructure. Pakistan mainly depends upon oil and gas resources to fulfil energy requirements. Pakistan has to import large quantity of oil and oil-based products from Middle East countries especially from Saudi Arabia.
- With the country being fully dependent on imports for its oil requirements, petroleum and petroleum related products are being imported throughout the year in Sri Lanka. In the year 2017, the total cost of crude oil and refined products imports amounted to USD 3,167 million which is around 11.9 percent of the total imports in the year 2017. It is envisaged that the government needs to take required policy measures to mitigate the possible external risk of increasing trend of oil prices in future, resulted by the market forces, which may create more adverse macroeconomic impact to the country. The country's largest procurement is the procurement of Petroleum and related products by the Ceylon Petroleum Cooperation (CPC) where the total procurement value for the year 2017 is reported to US $ 2,008 Mn (Approximately Rs. 322 Bn). Since the expenditure incurred was on account of CPC, such expenditures were not reflected in

the public procurement expenditure of Rs.602 Bn due to the said expenditure was not on the account of National Budget.

Impact on budget: Imports, fluctuating fuel prices and ever-increasing imports have hurt the government expenditure through the allotment of copious amount of funds from the budgets of the respective SAARC states.

INDC commitment: The transport sector, that is highly energy intensive and with the greatest acceleration rate in GHG emissions, shows the most potential for meeting INDC commitments on fast track.

- Transport sector in the Maldives is considered as one of the most energy consuming sectors and it is estimated that 25% of GHG emissions in the Maldives are accounted for the transport sector. Furthermore, GHG emissions in the transport sector is increasing rapidly, mainly due to increased economic development and continued increase in aviation, sea and land transportation. In fact, the total registered vehicles have jumped more than 295% from 2007 to 2014, and the vessel registrations have increased by approximately 70% during the period 2005 to 2014. Taking this into account and countries obligations for international reporting, Maldives is a country striving for low carbon development. The sector emitted 304,186 tCO_2e in 2012, which is an increase of 10.7% by 29,596 tCO_2e compared to the 2010 levels. Furthermore, the transport sector contributes to approximately 25% of the overall GHG emissions in the Maldives. This rate is more or less consistent with the business as usual scenarios of the Maldives Low Carbon Development Strategy (2014) and the Maldives Carbon Audit of 2009. The Asian Development Bank has estimated that the emissions from the transportation sector of the Maldives will reach nine hundred thousand tCO_2e by 2020, which will inflate further by an additional one million tCO_2e to 1.9 million tCO_2e by 2030.11 This is a 624.6% increment compared to the GHG emissions in 2012. Mitigation through improved fuel economy can reach a savings amounts to US$10 million annually.

3. Global EV Outlook

Sales of Electric Vehicles

The electric vehicles market took off in the last few years with new electric cars sales crossing a record of 1 million units globally, in 2017 representing a growth of 54% over the previous year. China boasts the lion's share of electric car sales, accounting for approximately half of the global sales that is around 580000 units, vastly ahead of the United States, the second largest electric vehicle market. In terms of sales share however, Norway, Iceland and Sweden hold the top three spots, accounting for sales shares of 39%, 11.7% and 6.3% in their respective markets for the year 2017. Apart from electric cars, electrification of other transport modes has also picked up pace, in particular for two-wheelers and buses. In 2017, sales of electric buses were about 100000 and sales of two-wheelers are estimated at 30 million; China had the highest share for both electric two-wheelers and electric buses sales.

Global Electric Car sales registered a milestone of **1 million** in 2017

Global Electric Car Stock stands at over **3 million**

Growth Rate: **57%**

Largest Stock is in **China** - **40%** of global total

Global Electric Bus Sales were **0.1 million** for 2017

Global Electric Bus Stock stands at **0.37 million**

China has the highest share - over **99%**

Electric Vehicle Stock

The global electric car stock has been making an incremental growth of at least 1 million units per year since 2015, to the point that the total global electric cars stock stands at 3 million. China contributed to 40% of the world electric car stock in 2017. China has the maximum share of electric bus and electric two-wheeler stock in the world; the adoption of electric vehicles in Europe and India have also shown promising signs.

Global Electric 2 Wheeler Sales were **30 million** for 2017

Global Electric 2 Wheeler Stock stands at **250 million**

China has the highest share - over **99%**

Electric Vehicle Chargers

Charging infrastructure development plays a vital role in the electric vehicle (EV) adoption for a country. Electric cars which are owned by households or fleets prefer private chargers at residences and workplaces. Publicly accessible chargers are also an integral part of the EV supply infrastructure which includes both slow and fast charging outlets. Owing to land availability

There are almost **3 million private chargers** at residence and workplace, globally.

Public Slow Charger Outlets: **0.32 million**

Public Fast Charger Outlets: 0.11 million

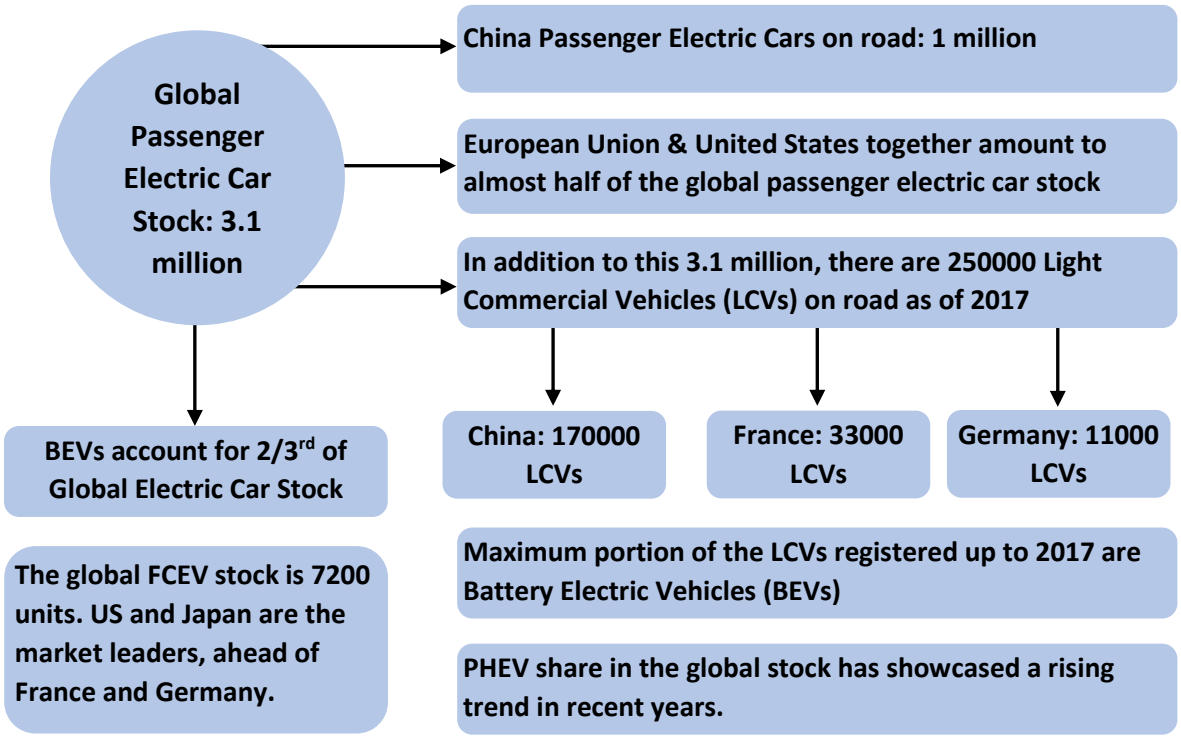
China has almost **0.36 million private chargers** for fleets

Source: (Global EV Outlook 2018)

constraints in urban areas, fast chargers have been identified as the viable option as compared to slow chargers. Fast chargers also enable EVs to travel longer routes. China, the European Union and the United States have considered this vital aspect for setting targets for charging station development and network density.

3.1 EV deployment status of various countries in different segments:

Cars and light commercial vehicles:



Source: (Global EV Outlook 2018)

Global electric car sales reached about 1.1 million units in 2017, displaying tremendous growth rate of 54%. China established itself as the electric car market leader with approximately 580000 electric cars sold in 2017. Japan and Germany displayed the most positive sales growth in 2017, twice the level of sales of the previous year. BEVs dominated the electric car sales in 2017 specifically in the Chinese, French and Dutch markets; PHEV shares were also observed to show an increasing trend, particularly in the Japanese, Swedish and the UK markets.

Two- and three-wheelers:
Electric two wheelers have recently begun to show notable rates of adoption over their traditional ICE counterparts. China is the front leader in electric two-wheelers adoption, with approximately 250 million units plying on road. These numbers have been sustained by annual sales of 30 million. This stock of electric two wheelers is nearly a hundred times greater than the existing global electric LDV population.

ASEAN, India and China have a cumulative 0.9 billion two wheelers on road, wich is nearly equal to the global stock of passeneger light duty vehicles (PLDVs).

Eighty percent share of the combined private passenger vehicles in these areas is occupied by two wheelers.

The number of three wheelers in China is approximately 50 million.

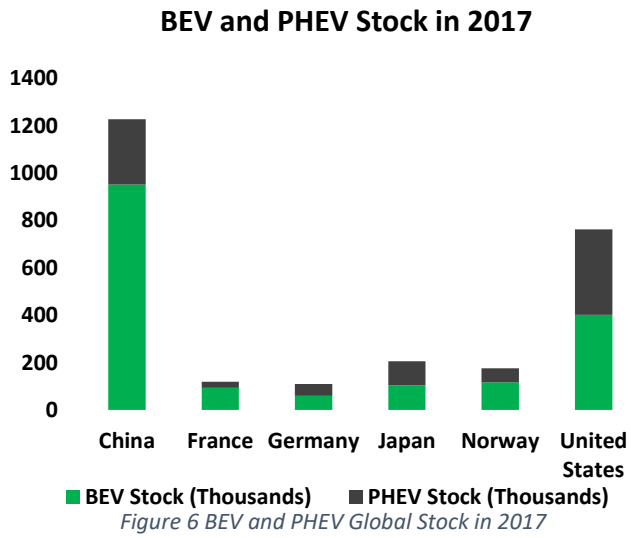


Figure 6 BEV and PHEV Global Stock in 2017

Electric Vehicle Deployment in South East Asian Countries: Indonesia, Thailand, Malaysia, Philippines and Vietnam have shown positive signs towards electric vehicle deployment in recent years; a report by the International Renewable Energy Association (IRENA) claims that the region could have 59 million electric two- to three-wheelers and 8.9 million electric four-wheel vehicles by 2025. This translates to an estimated 20 percent of passenger automobiles on the road. Presently, Thailand has a BEV and PHEV stock of 80 and 320 vehicles respectively.

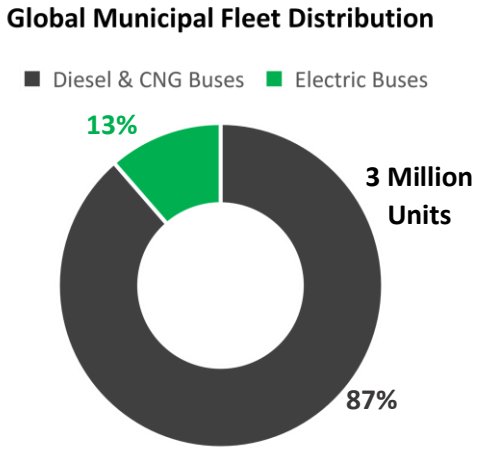


Figure 7 Global Municipal Fleet Distribution

Diesel and CNG dominate as the preferred fuel for the global bus fleets. With a growing number of cities committing to electrification of their respective bus fleets, the global electric bus market is undergoing rapid transformation. Pure electric buses have been observed to have greater market share globally as compared to the plug-in hybrid models. The C40 Fossil-Fuel-Free Streets Declaration has been signed by 13 cities, with the commitment to deploy only zero-emission buses post-2025.

China has managed to electrify 17% of the country's bus fleet. There are 2100 electric buses operating in Europe, of which 1560 buses are pure electric and the remaining are plug-in hybrids; the United Kingdom has the largest share of electric buses in Europe. The United States has an estimated national bus fleet of 70000 buses, of which 360 are electric buses.

3.2 Future growth patterns

The New Policies Scenario:
The IEA's World Energy Outlook defines the New Policies Scenario as its primary scenario that includes existing government policies and steps undertaken towards EV promotion, and also the expected impacts of proposed policies communicated through official targets and plans.

The EV30@30 Scenario:
The EV30@30 Scenario is in line with the ambitious targets set by Electric Vehicle Initiative nations as per the EV30@30 Campaign Declaration. According to the Global EV Outlook, "In this scenario, the EV30@30 target – the 30% market share of EVs for LDVs, buses and trucks collectively – is met at the global level. If accompanied by a reduction of the carbon intensity of power generation exceeding 50% by 2030, this goal is in line with the Paris Agreement, as growth in the market uptake of EVs continues after 2030."

3.2.1 Global results

The global stock of electric vehicles, excluding two and three wheelers, is projected to reach 13 million by 2020 and almost 130 million by 2030, as per the New Policies Scenario. The scenario predicts the EV sales to cross 4 million in 2020 and to 21.5 million till 2030. As per the EV30@30 Scenario, the global electric vehicle stock is expected to reach 228 million till 2030m majorly light duty vehicles (LDVs). Immediate changes in policy and implementation are required to ensure that these projected levels are reached.

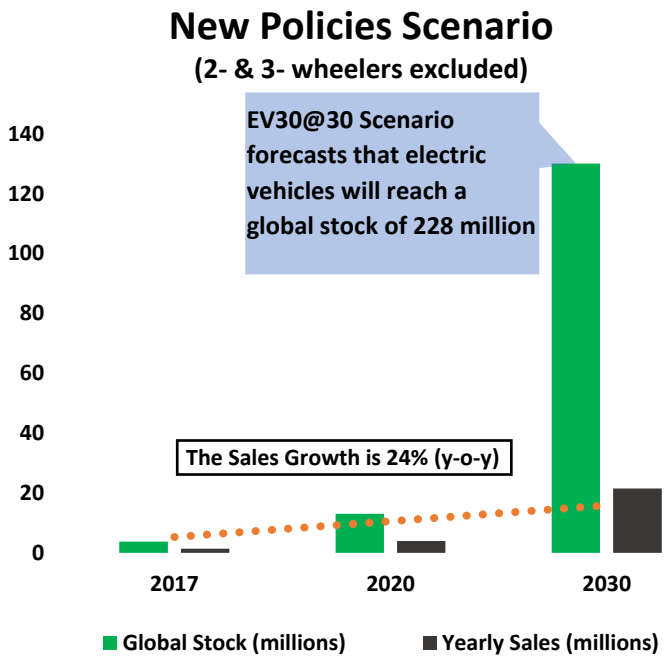


Figure 8 New Policies Scenario

3.2.2 Two- and three-wheelers

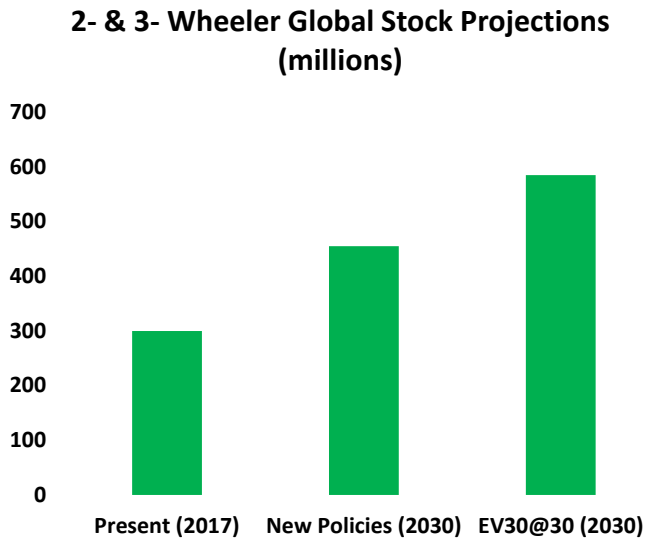


Figure 9 2- & 3- Wheeler Global Stock Projections (millions)

Electric two wheelers will occupy 39% of global two wheeler stock by 2030, according to the New Policies Scenario

According to EV30@30 Scenario, electric units will reach 50% of the global stock of two wheelers in 2030

China, India and ASEAN countries will be the dominant markets for electric two and three wheelers

The New Policies Scenario predicts the global electric two and three wheelers stock to rise to 455 million by 2030. The EV30@30 Scenario places this figure at an ambitious 585 million. India, China and the ASEAN nations are predicted to be the markets with maximum electric two and three wheeler penetration. These forecasts demonstrate a strong business case for electrification of two wheelers. The battery production market is expected to achieve economies of scale, thus bringing down the battery price and thus boosting the electric two wheeler market. The forecasts only include battery electric vehicles (BEVs) and not plug-in hybrids for two and three wheelers, owing to better suitability of BEVs for two and three wheeler operations.

3.2.3 Light-duty vehicles

The New Policies Scenario and the EV30@30 Scenario forecast that electric Light Duty Vehicles (Including Passenger Light-Duty Vehicles and Light Commercial Vehicles) will have the 2nd greatest share in terms of global electric vehicle stock by 2030.

New Policies Scenario

Year	Electric LDV Stock	Percentage of Electric LDV to Global LDV Stock	Electric LDVs Sale	Percentage of Global LDV market
2020	12 million	1%	3.9 million	3%
2030	125 million	6%	21 million	13%

Table 4 New Policies Scenario

The passenger light-duty vehicles segment is forecasted to have a 90% share of all-electric Light Duty Vehicles for 2020 as well as 2030.

The various local, national and supra-national policies are reflected in the growth trajectory for the electric vehicles. This growth facilitates economies of scale and promotes the development of enhanced technology, which subsequently drives down the cost of battery packs. As a result, this

creates opportunity for LDV prices to drop and for their performance to improve. Urban areas are expected to be the zones with maximum electric LDV uptake on account of favorable driving distances and charging points and conducive measures taken at the local and regional level for reduction in GHG emissions. Taxi and cab services are popular modes of transport in urban areas and have a high potential for electrification. High daily mileage and greater usage during traffic peak times make the business case for electrification of taxis particularly feasible. The New Policies Scenario forecasts that PHEVs and BEVs will have nearly identical share in the LDV stock and sales by 2020; in 2030, the ratio is expected to be in the favor of PHEVs. This is primarily due to variation in preference in different markets.

EV30@30 Scenario

Year	Electric LDV Stock	Percentage of Electric LDV to Global LDV Stock	Electric LDVs Sale
2030	**220 million**	**12%**	**38 million**

Table 5 EV30@30 Scenario

The New Policies Scenario forecasts that BEVs will have nearly 1/3rd share of electric LDVs by 2030. On the other hand, the EV30@30 Scenario predicts BEVs to have a greater share, nearly 60% of total electric by 2030.

The New Policies Scenario and EV30@30 Scenario diverge significantly in terms of the penetration rate for PHEVs and BEVs. This difference arises due to the assumptions of readily available charging stations, stricter standards for fuel-economy, policy incentives promoting EVs and stringent rules for internal combustion engine (ICE) vehicles. These factors also cause a rising share of electricity in PHEVs annual mileage. The EV30@30 Scenario indicates a greater BEV dependence due to quicker depreciation for ICE vehicles (including PHEVs), and also elevated taxes for petrol and diesel.

3.2.4 Buses

Both scenarios indicate swift developments for electrification of bus fleets, essentially through deployment of BEVs in cities. As of 2017, there is an estimated global stock of 370000 electric buses. In the New Policies Scenario, the number of electric buses touches 1.5 million units by 2030. The EV30@30 Scenario forecasts the electric bus count to reach 4.5 million units. These high market shares are based on cost benefits corresponding to high bus mileages and the opportunity to schedule their daily overnight charge. Electrification of buses in urban areas opens up opportunities to adapt their battery size to the requirements of the charging stations in the service area. The changeover to electric buses is quicker in the EV30@30 Scenario principally due to robust policy incentives and collaborated planning for EVSE implementation by the private and public stakeholders. This would fast track the establishment of 50 kW or more charging capacity with appropriate grid connections in urban regions. Intercity buses, that run on both PHEV and BEV technologies, are also included in these scenarios.

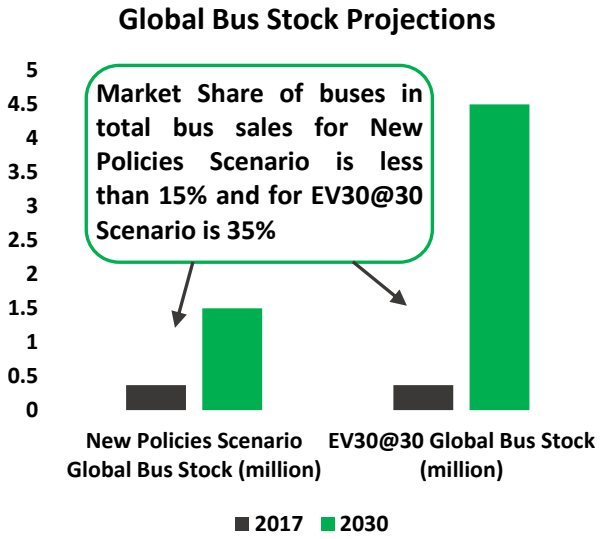


Figure 10 Global Bus Stock

Case Study: Electric Bus Revolution in Chinese cities

Subsidies have been the driving force for the significant bus sales in China. These subsidies were applied to BEV, PHEV and FCEV buses and were subsequently phased out over time. A number of national level schemes were introduced for supporting electric bus deployment on a pilot basis in a few select cities. Subsidies that fossil fuel transit operators enjoyed were also reduced. The battery prices for electric buses were subsidized in the cities of Shenzhen, Beijing and Tianjin to match those of regular buses. Shenzhen finished the electrification of its entire urban bus fleet (16359 buses) by the end of 2017. Shenzhen now aims to electrify its taxi fleet. A number of cities in China have set several more targets that include the electrification of public and logistic fleets, mail coaches, and sanitation trucks. Bus electrification targets have also been set in the Hebei province and the Jing-Jin-Ji region, improving electric bus sales since 2013. Depending on the area or locality the terms of incentive policies and targets are adapted accordingly. For example, in Beijing, the subsidies were calculated from the bus lengths however, in 2016 these were later derived from the unit-load energy consumption in Watt-hours per kilometre-kilogram (Wh/km kg).

3.3 Existing battery composition and price trajectory:

3.3.1 Current status:

The Lithium-ion battery technology hit the battery markets in the 1990s. In 2010, Li-ion batteries became a mainstay of the industry with a global production capacity of 100 GWh. While originally developed for smaller electronic applications, research in the past few years has made Li-ion battery packs viable for electric vehicle requirements. Over the past few years, the electric vehicle lithium ion battery packs have managed to achieve augmentation of manufacturing volumes, undergone cost reductions and enhancement in performance.

The battery packs available in the market, that are used for LDV applications have gravimetric energy density of 200 Wh/kg and volumetric pack energy density of 200-300 Wh/l. Quality EV batteries show little degradation in their "mileage per capacity" ratio over their designated lifespan. The existing Li-ion batteries have a retention rate of 80% of their original capacity and are able to bear 1000 cycle degradations.

3.3.2 Battery chemistry

Battery Cell Cathode Material	Battery Cell Anode Material
•Lithium Nickel Manganese Cobalt (NMC) •Lithium Nickel Cobalt Aluminium Oxide (NCA) •Lithium Manganese Oxide (LMO) •Lithium Iron Phosphate (LFP)	•Graphite •Lithium-titanate (LTO)

Benefit and Application of NMC, NCA and LFP Cathode Material
•NMC and NCA battery technologies have relatively greater energy densities. This factor makes both these chemistries conducive for light-duty vehicle application. •Electric buses and other heavy-duty electric vehicles require safe battery chemistry which has a longer lifecycle. Lithium Iron Phosphate batteries are hence preferred for these vehicles despite of their lower energy densities.
Benefit and Application of Graphite and LTO Anode Material
•Graphite dominates as the preffered anode material due to its unique features and cost-effectiveness. •LTO is also being used as the anode material specifically for heavy-duty uses, since it can be used to expand the cycle life of the battery.

The difference in the constituents and energy densities of the various battery chemistries determine the cost and performance of the battery packs. Ceteris paribus, the production cost of the battery is inversely proportional to the energy density of the battery. Similarly, lower the proportion of rare and expensive elements such as Nickel and Cobalt in the battery chemistries, the lower is the battery cost. Battery performance is also affected by the battery content. For example, an increase in the amount of Nickel in the NMC batteries causes a fall in thermal stability.

3.3.3 Battery size

EV battery pack prices witnessed significant drop from USD 800/kWh to USD 227/kWh for the period 2011-2016. Battery prices are predicted to drop further to about USD 140/kWh by 2022.

Vehicle Type	Market	Battery Size Range (kWh)
Small-size EVs	China	18.3 to 23
Mid-size EVs	Europe and North America	23 to 60
Large-size EVs	Global	75 to 100

Light duty battery electric vehicles generally have battery sizes between 20-100 kWh. The standard battery size for buses available globally, are generally 200 kWh and above. The battery size is generally inversely proportional to the specific cost. This is because greater size batteries have a greater cell to pack ratio. The BMS and cooling cost also gets diffused over the capacity, thus reducing the specific cost.

3.3.4 Price Trajectory

Light-duty vehicles

Cost reductions for batteries over the period to 2030 are likely to stem from three main drivers:	Battery sizes are expected to improve to serve longer all-electric driving ranges.
	Economies of scale will be achieved for battery manufacturing.
	Better battery chemistries will be developed with greater energy density and lower cobalt dependence.

Region	EV battery cost target till 2030 (USD/kWh)
European Union	93
People's Republic of China	116
Japan	92

Using the BatPaC model, the estimation for cost range of batteries varies between 155 USD/kWh to 360 USD/kWh. Battery packs for PHEVs will be costlier than BEVs on a per unit energy basis on account of their larger pack to cell ratio. Hence PHEV battery cost will be 1.2 times that of BEV batteries. An EV battery cost of 100 USD/kWh to 122 USD/kWh was derived by the BatPaC model. The assumptions include: "NMC811/graphite chemistry, production capacity: 7.5 to 35 GWh/year and battery capacity range: 70 to 80 kWh".

Two-wheelers

Electric two wheelers currently have a battery cost range of 240 USD/kWh to 550 USD/kWh. It is expected to decrease approximately 50-60% further below that of electric cars.

Electric two wheelers able to deliver sufficient mileage will have a battery size of 1.5 kWh to 4 kWh. Slow charging will be favoured over fast charging for the electric two wheelers. Electric two wheelers are expected to share the benefits of economies of scale with their light-duty vehicle counterparts in terms of battery cost, even surpassing the battery cost reductions of the LDVs.

Heavy-duty vehicles

HDVs cost range will not vary significantly compared with the cost range of electric LDVs.

Electric heavy-duty vehicles require battery packs with a longer lifecycle and the ability to sustain greater charging loads. LFP and LTO batteries are hence used for electric HDV application. In addition, HDV batteries must be developed to sustain high charging loads to enable reasonable charging times. The larger battery size leads to a decrease in the specific battery cost however the expensive battery chemistry compensate for this decrease. As a result, the battery cost for HDVs will most likely be similar to that of electric light duty vehicles.

3.4 Policy Support in terms of subsidies and incentives to accelerate EV deployment:

A number of countries have implemented various fiscal incentives including subsidies, tax benefits and others to encourage EV adoption. However, it has been observed that an optimum combination of fiscal as well as non-fiscal incentives need to be put in place in order to ensure the success of EV deployment. These non-fiscal measures include the development of charging infrastructure, creating greater consumer awareness, special EV parking spaces and stricter regulations.

The characteristics of purchase incentives are explored in the list below, focusing primarily on countries with higher-than-average EV market shares:

China

- Electric cars in China enjoy an exemption from acquisition tax and from the excise tax, normally based on engine displacement and price (Mock and Yang, 2014). The value of the incentives was in the range of 35000 Yuan renminbi (CNY) to CNY 60000 (USD 6000 to USD 10000) to purchase electric cars (Lutsey, 2015).

France

- France began offering in 2013 purchase incentives of 6300 euros (EUR) (USD 7100) for BEVs (cars emitting less than 20 gram of CO_2 per kilometre [g CO_2/km]) and EUR 1000 (USD 1100) for PHEVs (vehicles emitting between 20 g CO_2/km and 60 g CO_2/km) through its bonus/malus feebate scheme (MEEM, 2016a). Scrapping diesel vehicles allows a supplementary bonus of EUR 10000 (USD 11000) for BEVs and EUR 3 500 (USD 4 000) for PHEVs (MEEM, 2016b).

Japan

- Japan subsidies are based on the price difference between an EV and a comparable gasoline car, with a maximum of 850000 yen (about USD 7800). Mock and Yang (2014) indicated that incentives amounted to EUR 3000 to EUR 5 000 (USD 3300 to USD 5500) for typical BEVs and PHEVs.

Germany

- Germany, in 2016 announced that ICE production and sales will be stopped in 2030

United Kingdom

- In the United Kingdom, BEVs receive a purchase incentive up to 4500 pounds (GBP) (USD 6300) for cars and GBP 8000 (USD 11200) for light commercial vehicles; PHEVs below GBP 60000 (USD 84000) receive incentives equal to GBP 2500 (USD 3500) (GOV.UK, 2016a).

United States

- In the United States, EVs enjoy tax credits capped at USD 7500 at the national level. PHEV models with all-electric ranges (18 km to 40 km) receive credits of USD 2500 to USD 4000; BEV models and some PHEV models with relatively high all-electric range (e.g. Chevrolet Volt) receive the maximum USD 7500 credit (Lutsey at al., 2015). States also apply purchase incentives (AFDC, 2016). For instance, California offers incentives of USD 2500 for EVs and USD 5000 for FCEVs (or more for low-income consumers); Colorado offers an income tax credit of up to USD 6000; Rebates of USD 3000 and USD 2200 are provided on EV purchase by Conneticut and Delaware respectively. The average rebate across the various states on purchase of EV is estimated to be approximately USD 1000 for Battery Electric Vehicles as well as for Plug-In Hybrid Electric Vehicles.

Netherlands

- Netherlands, in 2016, cars emitting zero CO_2 at the tailpipe are exempt from paying registration tax. For other cars there is a differentiated taxation scheme with five levels of CO_2 emissions with progressively increasing taxation per g CO_2/km. PHEVs qualify for the first level (below 80 g CO_2/km) and pay EUR 6 per g CO_2/km. Diesels emitting more than 70 g CO_2/km Beyond one million electric cars also pay EUR 86 per g CO_2/km (EVI, 2016a and Energielabel, 2016). This kind of structure provides significant benefits for both BEVs and PHEVs compared with vehicles powered by ICEs, with a steep growth for models having ICEs with emissions ratings above 106 g CO_2/km. The condition for exemption from the registration tax has become stricter since 2013, when it started to be fully coupled with CO_2 emission performances (Energielabel, 2016).

Portugal

- In Portugal, BEVs are exempt from vehicle registration (about EUR 1250, or USD 1400) and circulation taxes (Saldopositivo, 2014). Scrapping existing vehicles for a selection of BEVs also entitles buyers to a bonus of EUR 4500 (USD 5000) (Apambiente, 2016; IMT, 2016). PHEVs are not eligible for specific incentives.

Sweden

- In Sweden, passenger vehicles with emissions levels lower than 50 g CO_2/km have been granted a 40000 kronor (roughly EUR 4000 or USD 4400) rebate since 2011.

3.4.1 Policy, Regulatory and Incentives Support for EV deployment in South East Asia:

The Big 3 – Thailand, Malaysia, and Indonesia – have established comprehensive EV policies that take a holistic approach to developing the entire EV ecosystem by promoting consumer demand and incentivizing private investments across the value chain. Smaller markets like the Philippines and Singapore do not have integrated roadmaps; they are, nevertheless, pushing the EV agenda through various automotive policies. For example, the Philippines has taken the modernization of its Jeepneys as the focus project to promote its EV program.

The Future of Electric Vehicles in South East Asia Position Paper by Frost & Sullivan recognizes the following incentives for encouraging people in South East Asia to switch from conventional vehicles to electric vehicles:

Tax waivers on cars	Charging Stations in Apartments	Priority Lanes for EVs	Free Parking	Toll Discounts

Apart from the number of incentives discussed, various policies have been suggested that can be adopted by policy makers to promote EV and VGI:

Special EV Tariff	Payment Settlement Mechanism	Robust EVSE Infrastructure
•Creating separate electricity tariff for EV charging that may be dynamic and concessional based on grid situation and use of differential pricing for different times of day and night. Differential pricing for EV charging may also help renewable energy integration – subsidised rates when surplus generation from RE resources on the grid.	•Developing payment settlement mechanisms for the EV aggregator/owner: An EV owner/aggregator may be charged with or incentivised on basis of net consumption (import-export). The payments for grid servicing can be done through cash or mobile/internet-based payment gateway (e.g. prepaid cards issued by Discoms/third parties, Credit/Debit cards, Mobile wallets, Reward points).	•An adequate infrastructure of charging stations, also called Electric Vehicle Supply Equipment (EVSE), is a key enabler for EV adoption and Vehicle to grid integration. An EVSE can be coupled with interoperable communication and networks, to enable operators and EVs with cost-effective management services and ease their integration with grid management systems. Such features will ensure utilities and owners to eliminate stranded assets, which can result from proprietary technologies. Open standards such as Open Charge Point Protocol (OCPP) for EVSE network management, can be used to manage this requirement. Technology integrators can access data to provide innovative solutions such the availability of the nearest charging station, charging costs, track energy usage, etc.

3.5 Potential Implications on EV Markets in SAARC countries

The automotive industries in the South Asian countries differ greatly from each other due to differences in their respective market demands. India is the leading nation in South Asia in automobile manufacturing. India has few domestic automobile manufacturers, prominent of which are Tata Motors, Mahindra & Mahindra and Hero MotoCorp; few foreign automobile manufacturers have also established their manufacturing factories in India such as Honda, Toyota, General Motors, Ford, BMW, Benz, Volkswagen and Hyundai. Apart from these companies, India also has a number of automobile accessories manufacturers. India achieved an annual automobile production volume of 4 million and a sales volume of more than 3 million in 2016. Pakistan has a few automobile manufacturing facilities; some of the other South Asian nations have automobile assembling plants. Bangladesh also has domestic manufacturing factories for two and three wheelers. As a result, Pakistan, Nepal, Bangladesh, Sri Lanka and Bhutan depend heavily on vehicle imports.[1] Similar circumstances have been observed for Maldives and Afghanistan. Electric Vehicle adoption would require the automotive industries in the respective SAARC nations to undergo transformation.

3.5.1 Automotive Manufacture

Except for India, the automotive manufacturing capacities of the other SAARC nations are presently quite modest. For EV adoption, these countries will have to establish and improve their automotive industries otherwise they will have to rely on expensive EV imports. For developing the EV industry, the countries will have to first promote FDI for EV manufacturing; collaborations or joint ventures can be setup between local car manufacturers, automobile dealers and automobile assembling companies. India has an electric vehicle manufacturers' association SMEV (Society of Manufacturers of Electric Vehicles) that acts as a knowledge sharing platform and also as collective voice for the manufacturers to address the government on vehicle manufacturing concerns such as prices, taxes, standards, etc. The other nations can encourage similar associations in their respective countries. The countries will have to setup a committee to identify and adopt or prepare the requisite standards for the EV equipment including EV components and the charging infrastructure; India has introduced Bharat Charger standards which may be considered by the SAARC nations for adoption. The nations will have to work towards developing various financial instruments and business models for promoting EV manufacturers; the countries can launch domestic electric vehicle manufacturing initiative or scheme for this purpose with a combination of funding allocation and technology development.

3.5.2 Skilled Labour Requirements & Infrastructure

The automobile manufacturing facilities in the SAARC nations will have to conduct training and capacity building programs to meet the skilled labour needs of EV manufacturing. One of the business models used for EV charging infrastructure involves the OEMs as the main operators. This would require the OEMs to train their personnel for both, electric vehicle as well as charging infrastructure operation and maintenance. Along with charging stations, the allied infrastructure such as transport facilities, electricity distribution and communication for information transfer will have to be built by the SAARC countries in order to nurture EV technology in their respective markets.

[1] Automobile Industry Forecast to 2021: India, Pakistan, Bangladesh, Nepal, Sri Lanka and Bhutan

3.5.3 Import Strategy

China, Europe and the United States at present are the hub for electric vehicle technology; until proper EV manufacturing facilities are established in the SAARC nations, they will have to rely on EV and EVSE imports from the aforementioned countries. Depending on the needs of the specific country, the import strategy can be designed and the imports can be phased out over time as the manufacturing capacity grows to a sufficient state in the given country. The basic import strategy outline that can be followed is: initially, the imports can include electric vehicles and the charging equipment, for which, relaxation on import duty can be provided; the next stage could include battery imports while the vehicle components and vehicle charging equipment is locally manufactured through JVs between foreign companies and local manufacturers. Lithium ion batteries are the market favourite for the latest editions of EVs launched globally and the R&D for these batteries is still in the developing phase, due to which it may take longer for battery manufacturing to pick up pace in the SAARC nations. Plus, battery manufacturing factories would themselves have depend heavily on rare mineral imports such as Lithium, Cobalt, Nickel, etc. Afghanistan, that has potentially large untapped reserves of Lithium, can become a net exporter of lithium or also an EV battery manufacturing hub in South Asia.

Number of Electric Vehicles

Some of the SAARC nations already have a few electric passenger cars, two wheelers, three wheelers and buses operating in various pockets, however these numbers are negligible compared to the fossil fuel cars. The public transport is the segment that should be targeted for electrification prior to moving on to other market segments; public sector buses, taxi fleets and three wheeler fleets are to be targeted as part of this segment. Electrification of two wheelers has large market potential in the SAARC states due to their high popularity in the region. Hybrid vehicles can be considered for the SAARC states, which can later be phased out and pure electric vehicles can be brought in for the four wheeler market segment. In the short to medium term, electric public transport is expected to be the main contributor to EV population in the SAARC countries.

4. EV Infrastructure & Policy Requirements

With advancements in technology and growing consumer awareness, electric vehicles have become more mainstream over the past few years. Given this trend, it is expected that EVs will be the largely preferred alternative in the future, overtaking demand for ICE vehicles.[2]

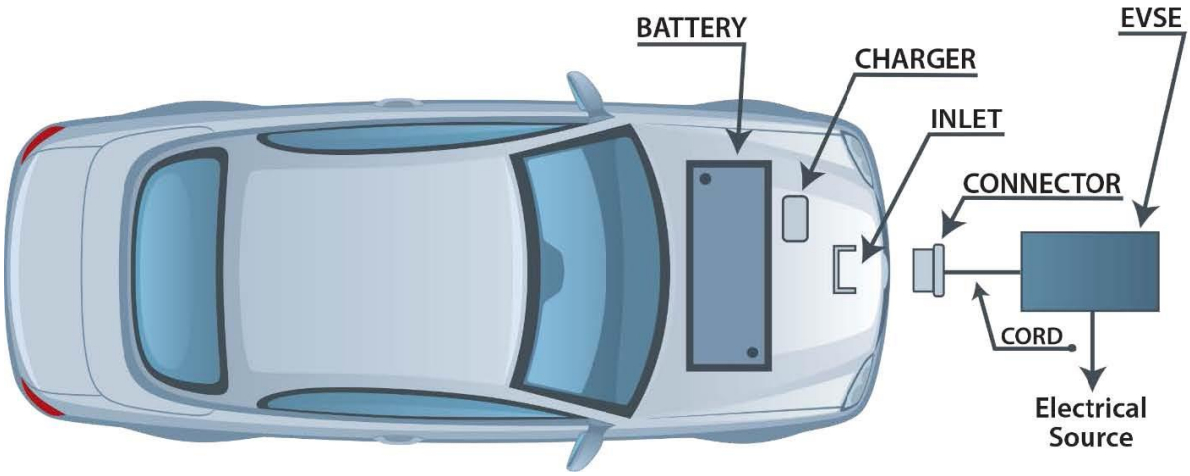


Figure 11 EV Components

4.1 EV Types[3]

The basic kind of EVs are called Battery Electric Vehicles (BEVs), which have only batteries as energy source. Hybrid Electric Vehicles (HEVs) on the other hand, use alternative energy sources along with electricity. The nomenclature for HEVs is such: vehicle with both electric engine and internal combustion engine are named HEVs; the vehicles with a combination of electric battery and capacitor are called ultra-capacitor-assisted EVs; the vehicles that combine fuel cells and batteries are called FCEVs. The classification of electric vehicles is as given:

4.1.1 Battery Electric Vehicle (BEV)

Battery Electric Vehicles are powered exclusively with electric battery packs. On account of this, the BEV mileage is directly proportional to the energy stored in the battery. The average range for BEVs is 100 to 250 km, while the latest models have a range of 300 to 500 km, on single charge. These ranges depend on a number of parameters including the battery specifications, region of operation and vehicle usage. In comparison to ICE vehicles, the BEVs have a longer refueling time. BEVs are eco-friendly, have simplistic design and reliable in operation. The BEV engines provide instantaneous and high torques, even at lower velocities. These vehicles are considered ideal fits for urban driving conditions. Nissan Leaf and Teslas are the most popular BEVs available in the market. In recent years, a few Chinese BEVs have also begun to capture greater market share.

4.1.2 Hybrid Electric Vehicle (HEV)

The HEVs have both, an internal combustion engine as well as an electric battery engine built within the vehicle. The electric propulsion system is employed in conditions of greater power demand. The internal combustion engine operates for longer drives. There is also an option to operate both engines

[2] Electric Vehicle Charging Technology Analysis and Standards

[3] A Comprehensive Study of Key Electric Vehicle (EV) Components, Technologies, Challenges, Impacts, and Future Direction of Development

simultaneously to improve the vehicle performance. Turbocharged cars are designed as HEVs in order to resolve issues of turbo lag. The HEV systems also have the ability to manage power gaps that occur between gear shifts and providing speed boosts when necessary. The internal combustion engines in the HEVs can also be used to replenish the car battery when required. Newer HEV models have also incorporated regenerative braking mechanism in their designs.

4.1.3 Plug-in Hybrid Electric Vehicle (PHEV)

Plug-in Hybrid Electric Vehicles, similar to HEVs, employ combination of internal combustion engine as well as electric battery engine. However, unlike HEVs, the electric power train is the primary engine, with the internal combustion engine being used mostly for as a backup, for providing boost and emergency charge to the battery or for "range-extension" purpose. PHEVs, as their name suggest, can be plugged into the power grid for charging purpose. Hence, they have lower fuel consumption, fewer GHG emissions and lower operating cost. Chevrolet Volt and Toyota Prius are the most common PHEV models available in the market.

4.1.4 Fuel Cell Electric Vehicle (FCEV or FCV)

Fuel cells act as the primary energy source for FCEVs. Hydrogen is the most commonly used fuel in modern FCEVs. Batteries or supercapacitors are used to store the extra electricity generated by the fuel cells. FCEVs available in the market mostly fit batteries in the vehicle. Water is produced as the waste in the FCEVs. This is discharged from the vehicle through tailpipes. FCEVs have the greatest potential for reducing GHG emissions. FCEVs have a refueling time that is nearly equal to that of ICE vehicles. However, fuel cells cost over $200 per kW, which is more than four times the ICE cost. Plus, the number of hydrogen-refueling stations is miniscule, partly due to high cost and safety concerns.

Technology/Protocol	BEV	HEV	PHEV	FCEV
Propulsion	Electric Motor	ICE/ Electric Motor	ICE/ Electric Motor	Electric Motor
Battery Charging	Plug-in	Regenerative Breaking	Plug-in	Fuel Cell Energy
Fuel	Electricity	Petrol/Diesel	Petrol/Diesel/Electricity	Hydrogen
Infrastructure	Electric Charging Facilities	Refueling Stations	Refueling Stations & Electric Charging Facilities	Hydrogen Production and Transportation facilities
Tailpipe Emissions	No	Low	Low	No
Features	• High efficiency • Oil independent • Commercially available	• Low emission • Better fuel economy than ICE vehicles • Commercially available • Long range	• Low emission • Better fuel economy compared to ICE vehicles depending on motor use and driving cycle • Commercially available	• High energy efficiency • Oil independent • Under Development
Challenges	• High cost compared to ICE vehicles • Lack of charging infrastructure • Relatively short range • Battery and battery maintenance	• High cost compared to ICE vehicles • Battery sizing and management • Longer Range	• High cost compared to ICE vehicles • Battery sizing and management • Lack of charging infrastructure • Longer range compared to conventional hybrids	• Fuel Cell cost, reliability, safety • Hydrogen infrastructure

Table 6 EV Technology Category-wise Comparison

4.2 Charging Infrastructure

The EV charging infrastructure comprises of the following:

- **Electricity supply infrastructure** - transformers, meters, panels, conduits and wires that is required to provide reliable electricity supply to the vehicle chargers.
- **Electric Vehicle Supply Equipment networking** requirements to enable efficient EV charging and other services among EVSE owners and EV drivers
- **EVSE and EV integration** for automated communications and EV identification
- **EVSE/EV communication** with electricity service provider and/or grid operators for effective monitoring and management of EV, as a grid resource

4.2.1 Charging Station Type (AC&DC), technical specifications, power requirement, standards followed globally for both AC & DC[4]:

There are two basic EVSE options for charging an electric vehicle: wired or conductive charging and wireless or inductive charging. Considering that the wireless charging is still in early stages of development and widespread acceptance, the focus is on wired charging. Wired charging is primary option wherein commercially ready solutions are widely available for EVs and EVSEs. The EVSEs are classified into several types and categorized by the current flows and the power ratings at which the EV batteries are charged. The EVSE current follows are categorized, as alternate current (AC) and direct current (DC) charging. Charging with AC is used for low- and medium-power charging at homes and offices or workplaces, and at public spaces. Charging with DC is used for fast-power and are called DC Fast Charging (DCFCs), while AC Pulse Charging (ACPC) is enabled through the deployment of Ultra Capacitors. The global deployments of public charging infrastructure are dominated by AC chargers and DCFCs. The advantage of Pulse Charging is that the grid power supply intake is much less even though the DC pulse charge (often less than a second) can be twice as much as DCFC levels. Considering that all EV batteries require DC power to be charged, the grid-supplied AC power has to be converted to DC. An AC/DC convertor is needed to charge the battery using grid power. In the AC EVSEs the converter is on-board the EV, while the DC EVSEs (DCFC) and the ACPC (AC Pulse Chargers) have integrated converters. At higher power DC charging levels, a more expensive converter is needed that is not a standard practice by majority of the car manufacturers. These converters are therefore incorporated in the EVSEs and DC power is delivered to the EV. The same is true of Pulse Chargers as well.

Power Levels	Grid Voltage/Current (in Amperes) Input	DC Power to Battery (kW)	Applicable Vehicles
AC Level 1	108-120/15-20	~1.4 to 2.4	2W, 3W, 4W
AC Level 2	208-240/>=30	~7.2 to 19	3W, 4W
DC Level 3 (DCFC)	400-800/>=120	>=50 (up to 150)	4W, LDV, HDV
AC Level (ACPC)	400/60	450-600	HDV

Table 7 EV Charging Types

The EVSE types vary for each type of EVs for example, 4 wheelers primarily use dedicated EVSEs in non-residential charging, while buses can be charged with overhead (pantograph based) charging.

[4] Implementation Plan for Electrification Of Public Transportation In Kolkata

While the power standards for EVSEs are mature for 3W, 4W and LDVs, the same is not true for bus charging infrastructure. It may be noted that battery chemistry variant dictates the limitations to the type of charging method (and hence chargers) that can be used. While this is taken care in the case of the AC Level-1 and AC Level-2 chargers (being on board the vehicle), in all other cases where the charger converter is external to the vehicle, the selection of third party chargers needs careful consideration of battery chemistry used in different types of EVs. AC Pulse Chargers cannot typically adjust their outputs to respect Demand Response (DR) signals nor VGI signals due to their internal "pulse booster circuitry designs which keep the battery "off-circuit" from the grid. These types of chargers are not widely used.

4.2.1.1 EVSE Power Standards

For both AC and DC charging, multiple plug designs and charging modes have been developed and have been deployed throughout the world. Some of the major charging standards followed around the world are described below:

a. Modes

The charging mode refers to power levels that charger and its connectors are rated for. IEC 61851-1 Committee on "Electric vehicle conductive charging system" has defined 4 Modes of chargers, concerning:

- Mode 1: slow charging from a household-type socket-outlet in AC
- Mode 2: slow charging from a household-type socket-outlet with an in-cable protection device in AC
- Mode 3: slow or fast charging using a specific EV socket outlet with control and protection function installed in AC
- Mode 4: fast charging using an external charger in DC

b. Plug Type

i. AC Charging Stations

Both 3 and 4 wheelers can primarily use the AC EVSEs, depending on the EV manufacturers' preferences. The IEC committee has defined three types of socket outlets:

- **IEC 62196-2 "Type 1"** - single phase vehicle coupler - reflecting the SAE J1772/2009 automotive plug specifications
- **IEC 62196-2 "Type 2"** - single and three phase vehicle coupler - reflecting the VDE-AR-E 2623-2-2 plug specifications
- **IEC 62196-2 "Type 3"** - single and three phase vehicle coupler with shutters - reflecting the EV Plug Alliance proposal

ii. DC Charging Stations

Both 4 wheelers and buses can primarily use the DC EVSEs, depending on the EV manufacturer's preferences, based on the battery chemistry. There are four different standards for DCFCs in practice today as briefed below:

CHAdeMO

To define a standard for DC charging, Japan set up the CHAdeMO association (Charge de Move) in 2010. CHAdeMO charging station can only be used for cars with a matching CHAdeMO inlet and that it is not possible to use alternative cables such as for AC charging. The plug design is however not (yet) recognized as such by the IEC even though its power and safety ratings comply with the IEC 62196

norms. A major drawback of the CHAdeMO standard is that it prescribes a separate vehicle inlet that is used for DC charging exclusively. The CHAdeMO equipment is typically rated for 125 A and 500 V DC, which translates to 62.5 kW, albeit recent updates allow the peak power charging upwards of 125 kW.

Combined Charging System (CCS)

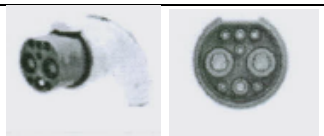
The Combined Charging System (CCS) or Combo was developed by the Society of Automotive Engineers (SAE) for EVs with DC charging requirements. Similar to CHAdeMO, the CCS-supported EVSE can only be used for cars with a matching CCS inlet. There are two versions of the CCS connector: (1) The U.S. version combines the Type 1 Yazaki AC design with the additional DC pins, and (2) The European version combines the DC pins with the Type 2 Mennekes AC design. Type 1 is available for sale rated up to 200 A and 600 V on the DC lines, which translates to 120 kW peak power at best. European Type 2 seems much more capable with 200 A and 850 V, which in theory gives 170 kW peak power.

GB/T

GB/T is a Chinese standard (20234), which can run up to 250 A and 750 V, which means that it is actually the most powerful DC fast-charger in the world with 187.5 kW capacity. This standard is yet to be accredited by the international standards development organisations.

Tesla SuperCharger

Tesla began its adventure from 90 kW level, then increased to 120 kW in North America. The connector in North America is unique. Tesla SuperChargers in Europe have a different connector which looks like Level 2 AC connector.

Charger Types & Sockets	Picture	Origin and Popular EV Models	Maximum Power Output and Communication Protocols
A. AC Chargers			
Type-1 with Yazaki Socket		Japan, USA (uses separate standard – JSAE 1772 due to 110 Voltage)	Up to 7.4 kW (32 Amps, Single Phase)
Type-2 with Mennekes Socket		Manual 3 phase AC at high power—SAE J-3068	Up to 44 kW (63 Amps, 3 Phase)
Type-3 with Le Grand Socket		France and Italy – some European cars	Up to 22 kW (32 Amps, 3 Phase)
B. DC Charger Types			
CHAdeMO		Origin from Japan; Most popular DC charger in the world; used in Japan, Korea and parts of USA and Europe; Nissan Leaf, Mitsubhi, Kia etc	Up to 400 kW DC charging (1000 Volts, 400 Amps); Control Area Network (CAN) for communication between EV and EVSE
GB/T		Used in China; as well as Bharat Chargers in India; Chinese Vehicles and Mahindra Electric in India	Up to 237.5 kW DC charging (950 Volts x 250 Amps); CAN for communication between EV and EVSE

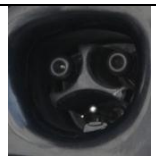
Tesla Super Charger	 	Tesla has its own supercharger. Tesla also sells adapter for connecting to a CHAdeMO charger	Up to 135 kW DC charging (410 Volt x 330 Amp); CAN for communication between EV and EVSE
C. Combined (AC and DC) Chargers			
SAE Combined Charging System (CCS)	   	CCS-1 and CCS-2 versions available; same plug used for both AC and DC charging; Most European Cars - Audi, BMW, Daimler, Ford, GM, Porsche, VW etc.	Up to 43 kW AC and up to 400 kW DC (1000 Volt x 400 Amp) Power Line Communication (PLC) for communication between EV and EVSE.

Table 8 EV Charger Types

For buses, the EVSE types can also be overhead or pantograph based. Considering that the battery capacities for buses are typically much larger than those of 3 or 4 wheelers, a significantly higher level of charging will be required. The U.S. Society of Automotive Engineers (SAE) is considering charging voltage (V) limits in the range of 500 V to 1500 V and current ampere (A) limits from 200 A to 350 A, which provides a maximum 350 kW DC charge. For buses, the following standards are under considerations:

- Manual 3 phase AC at high power—SAE J-3068
- Manual DC connection at high power—SAE J-1772
- Overhead or pantograph connection at high power—SAE J-3105

iii. AC Pulse Charging Stations

These chargers are typically deployed on heavy duty vehicles (buses and trucks) mostly through the use of pantograph style connectors due to the heavy pulsed charging currents involved. This method allows for charging en route (and not just at depots) as well due to its short duration. The cost of the charger is high due to its use of Ultra Capacitors and DC-DC pulse boosting converters.

International Standards

SAE International (Society of Automotive Engineers) has defined 240 V AC charging as level 2 and 500 V DC high current charging as DC fast charging (level 3). Level 2 chargers can be installed at home. A number of standards have been formulated for energy transfer, connection interface and communication for EV charging.

Country	Power Standards
Americas	SAE J1772 Level 1 and 2 for AC
	SAE J1772 Combo Coupler Standard (CCS) DC
	CHAdeMO (DC)
	Tesla Supercharger (DC)
Europe	SAE J1772 Level 1 and 2 for AC
	SAE J1772 Combo Coupler Standard (CCS) DC
	CHAdeMO (DC)
	IEC 61851
Asia (China)	GB/T (DC)
	IEC 61851

Table 9 International EV Charging Standards

In addition to SAE standards, the International Electrotechnical Committee (IEC) and CHAdeMo, industry association with a mission to set-up fast charging infrastructure too have developed standards.

Charging Level	Typical charging power	Voltage	Charging time	Suitable Location	Price (USD)
Level I	1.5 kW	120 V AC	6-8 hours	Homes, offices, parking areas	~550-600
Level II	6.6 kW	240 V AC	3-4 hours	Malls, railway station, airports	~5000
Level III	40 kW and above	500 V DC	<30 min	Petrol pumps	~25000

Table 10 Other International EV Charging Standards

4.2.2 Communication protocol between EV and EVSE and also between EVSE and the grid:

EVSE Communication Standards

While power standards are key to determine interoperability to charge different makes of EVs, with different makes of EVSEs, their management and use for services to respective owners is the key function of the standardization of communication standards. The figure below shows the communication requirements between EV and EVSE and EVSE/EV with the electric grid through electric utilities and EVSE service providers (EVSP). These communication standards are further described below.

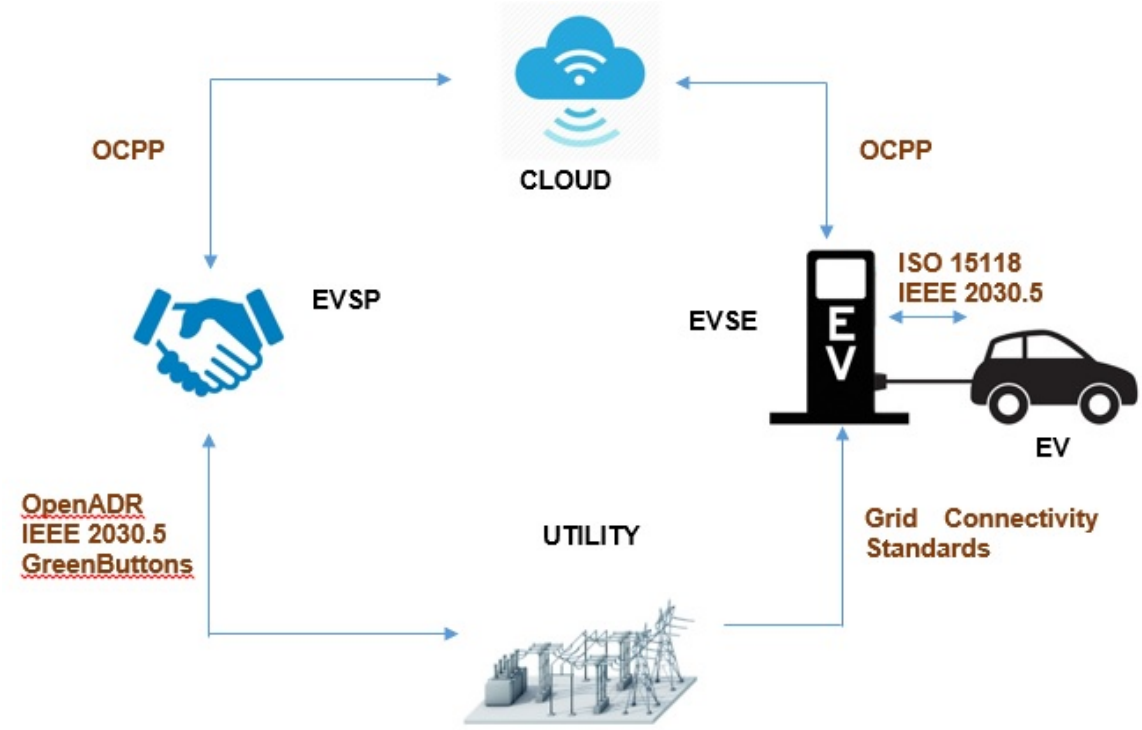


Figure 12 EVSE Communication Protocol

(EVSP: EVSE Service Provider; EVSE: Electric Vehicle Supply Equipment; OCPP: Open Charge Point Protocol)

Open Charge Point Protocol (OCPP)

EVSE communicate through the internet to management software for the purposes of operating and controlling the charging stations. The Open Charge Point Protocol (OCPP) is an internationally established open protocol for the communication between EV charging stations and charging station networks (akin to a cell phone service provider). OCPP tells the charging station to communicate and send data to a particular EVSE service provider (EVSP) or operating company's charging station management software. That charging station management software is the major component of an EV charging "network". An EV charging station network is necessary to monitor charging station up-time, control access to charging, enable payment processing, capture driver and usage data for reporting, and to integrate with enterprise software systems beyond the charging station network – including utilities, building management systems, HR systems, customer loyalty programs, and other charging station networks.

ISO 15118

ISO 15118 specifies the communication between Electric Vehicles (EV) and the Electric Vehicle Supply Equipment (EVSE). As the communication parts of this generic equipment are the Electric Vehicle Communication Controller (EVCC) and the Supply Equipment Communication Controller (SECC), ISO 15118 describes the communication between these components. The ISO 15118 can be applied to any vehicles that wishes to communicate with the supporting EVSE in a standardized fashion. ISO 15118 does not specify the vehicle internal communication between battery and charging equipment and the communication of the SECC to other actors and equipment (beside some dedicated message elements related to the charging). All connections beyond the SECC, and the method of message exchanging are considered to be out of the scope as specific use cases.

OASIS Energy Interoperation (or OpenADR 2.0)

OpenADR is commonly being used in peak load management programs in electric utilities. The last few years have seen an increasing uptake of this standard for fast demand response (DR) programs and auxiliary service which deploy DR resources within seconds to balance inconsistent generation from renewables. Distributed energy resources (DER) management and electric vehicle charging are also key aspects in many recent trials. OpenADR 2.0 can communicate event messages, reports, registration services, and availability schedules for price- and energy usage-based programs.

IEEE 2030.5 (or Smart Energy Profile)

IEEE 2030.5 is a standard for communications between the smart grid and electricity customers. The standard is built using Internet of Things (IoT) concepts and gives consumers a variety of means to manage their energy usage and generation. Information exchanged using the standard includes pricing, demand response, and energy usage, enabling the integration of devices such as smart thermostats, meters, plug-in electric vehicles, smart inverters, and smart appliances.

Energy Services Provider Interface (or GreenButton)

The GreenButton initiative is an industry-led effort that responds to a White House call-to-action to provide utility customers with easy and secure access to their energy usage information in a consumer-friendly and computer-friendly format. Customers are able to securely download their own detailed energy usage with a simple click of a literal “Green Button” on electric utilities’ websites. The GreenButton initiative was officially launched in January 2012. This ensures homes and businesses to securely access their own energy information in a standard common, machine-readable format.

4.2.3 Charger Costs

The costs of EVSEs are one of the critical components that needs to be considered to support scaled deployment of EVs. For Level 2 and DCFCs, which are widely deployed using CHAdeMO and CCS standards, the following are the early 2017 costs for the United States market. While the costs may be higher, the federal-, state-, and city-level incentives and funding allocation have reduced their costs significantly. A large component of the EVSE costs is the cost-recovery through innovative operational business models. The table shows typical costs in the United States for Level 2 and DCFC EVSE up to 150 kW. The hardware constitutes

Charger Type	Cost in USD
Level 2 AC Wall Mount (~7 kW)	900
Level 2 AC Ground Mount (~7 kW)	1350
Level 2 AC Ground Mount (~25 kW)	2410
DCFC Ground Mount (~50 kW)	31000
Level 3 DCFC ~75 kW	56000
Level 3 DCFC ~100 kW	78000
Level 3 DCFC ~150 kW	>95000

Table 11 EV Charger Costs

the majority of the EVSE costs and are in the range of 45% to 65% of the total costs, depending on the type and peak charging power level. The other costs include communications, installation, commissioning, and annual operation.

4.2.4 Battery Management System and its function[5]

Battery Management System (BMS)

The batteries in an EV have modular configuration with each battery comprising hundreds to thousands of individual battery cells. Each cell has a voltage ranging from 1.2 V to 3.6 V. These modular, high-energy battery pack requires intricate electronics and software to manage voltage, current levels and temperatures for each individual (module of) cells. This system is called the Battery Management System (BMS). The BMS also manages the state-of-charge (SOC) of the battery, and controls the maximum power level of the charger and the maximum regenerative breaking level. When an EV is connected to the EVSE a hand-shake is established between the EV and EVSE; and the BMS in the EV takes control over the charging process. The BMS is tightly integrated with the battery chemistry and its thermal properties. BMS determines the charging rate depending on the input voltage, current, ambient temperature; and the residual charge remaining in the battery.

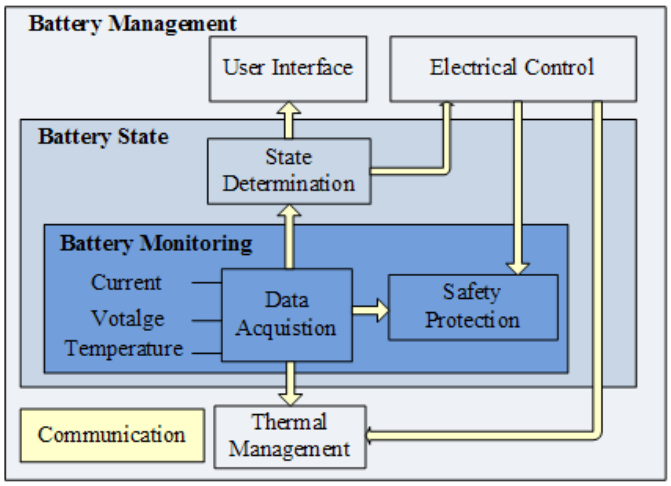
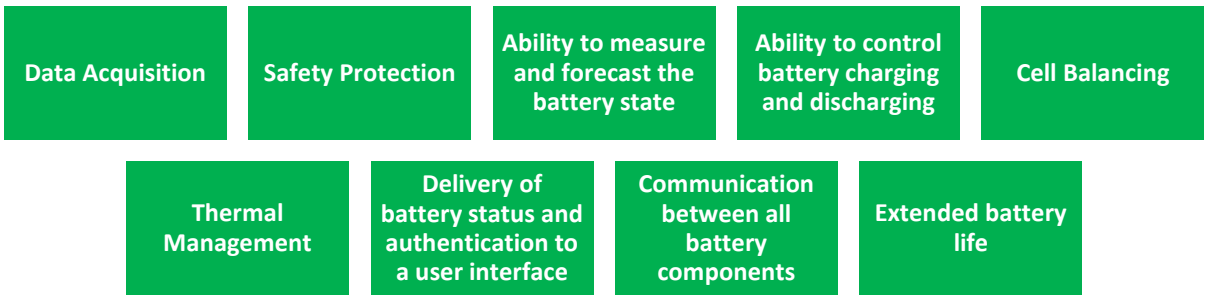


Figure 13 Battery Management System



4.2.5 Distribution system enhancement to support vehicle grid integration and innovative tariff structures[6]

The concept of vehicle to grid (V2G) makes a case for electric vehicles to act as both power loads during times of low power demand, and also as dynamic energy storage devices, feeding power back into the grid during peak demand hours. By utilizing the functionalities of smart grid, especially smart meters, EVs can be used as dynamic loads or dynamic storage systems.

[5] Smart Grid Handbook for Regulators and Policy Makers; Battery Management Systems in Electric and Hybrid Vehicles

[6] Emerging Technologies for Electric and Hybrid Vehicles

4.2.5.1 Typical Components for V2G

There are three basic components in a V2G model for recharging a vehicle or discharging energy from the vehicle to the electrical grid:

- Point of grid interconnection
- EVSE
- EV and the BMS (Battery Management System) that manages the operations

The vehicle has several important components that manage and regulate the charging and discharging functionality of the battery and the battery itself. A brief description of these components is given below:

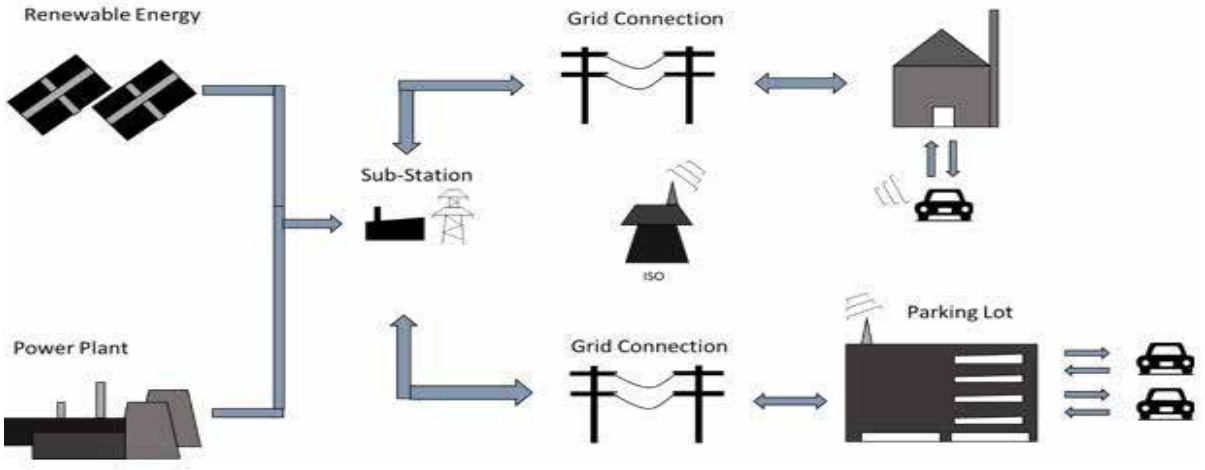


Figure 14 Vehicle to Grid Integration (V2G)

I. V2G Capable Vehicle

Most essential element is an electric or plug-in hybrid vehicle with the capability to connect and communicate with grid.

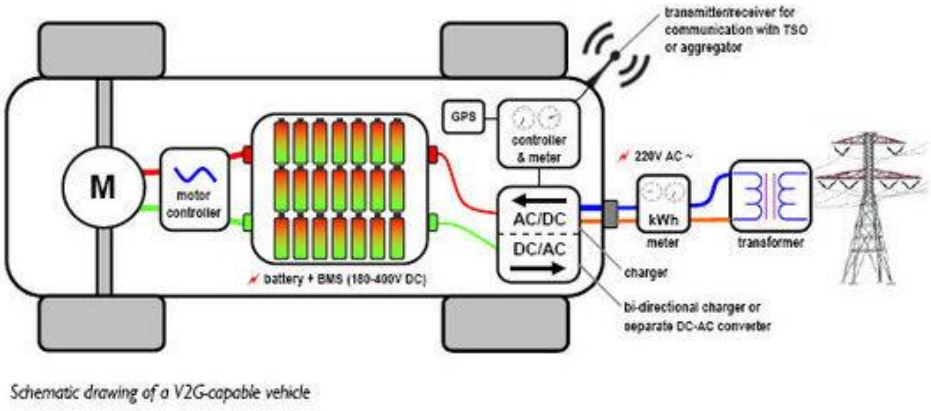


Figure 15 Vehicle to Grid Capable Vehicle

II. Battery

PHEVs have advanced batteries with a storage capacity of 4 to 15kWh, giving the vehicle an electric-only range of 15-80km. BEVs generally have 15 to 50kWh on board, for a range of 80-300km.The DC voltage of the batteries is generally between 180V and 400V DC.

III. Battery Management System (BMS)

The battery performance of an electric vehicle changes according to the different operation and environment variables. The BMS is designed to deliver optimum battery performance for the EV. It manages the state of charge, state of health, and state of life of the battery.

IV. Battery Charger (AC-DC) & Inverter (DC-AC)

The Battery chargers generally have an output voltage of 180-400 Volt DC. If they are rated for a standard 220V AC socket, their maximum (dis-)charge power in Europe is generally ±3.5kW while in the US, the residential socket output is 110V, and hence maximum power output is ±1.5kW. However, if a two-phase AC outlet is used, a much higher charge power can be drawn (15-20kW is the current norm). Most of the current research assumes that future chargers will have a (dis-)charge power level of 10-20kW, and that there will thus be dedicated EV charging connections installed in the house of (PH)EV owners. The BMS controls the maximum charge level of the charger, which is usually connected via a CAN-interface (Controller Area Network-interface). In order to achieve the V2G functionality, either the charger needs to be bi-directional, or a separate DC-AC inverter is required.

V. Controller, GPS & Electricity Meter

A communication signal is required to be sent to a remotely controlled regulation device (controller) to regulate the power taken from or fed into the grid by the vehicle. The signal can be provided in the following ways:

- via the cellular phone network
- via a radio signal
- via the 'Internet' (last part WLAN connection)
- via a 'smart meter' network (last part wirelessly, first part Internet or cellular phone network)
- via the power grid (TSO signals)

Ideally, a GPS device keeps track of where the vehicle is and an on-board electricity meter measures in- and outflow of electricity. However, in a less advanced V2G scenario, it is not the on-board meter that measures electricity consumed and generated by the vehicle, but a (smart) residential electricity meter.

4.2.5.2 Special Tariff for Electric Vehicles (EVS)

- Time-of-use (TOU) rate, where in the electricity rate varies with the hours of the day; charges a lower price for energy during certain hours of the day and higher during other hours. It could provide EV owners with an incentive to delay EV charging from the day-time peak hours, to overnight off-peak hours. For example, NV Energy, Nevada offers ToU rates having wide differentials for on- and off-peak power. Its summertime rate for northern Nevada varies from 40.7 cents/kWh for on-peak power (from 1 pm to 6 pm) and to 5.53 cents/kWh for off-peak power (from 10 pm to 6 am). In Europe, EDF in France offers off-peak discount; a special EV TOU rate is offered by RWE in Germany; and a day/night tariff is offered by EON in Germany. The effect of TOU rates in shifting the EV charging times to off-peak hours was supported by a study done by the California Public Utilities Commission.
- Real-time pricing (RTP) tariff dynamically sets prices based on the real-time marginal cost of energy. Although electricity tariffs provide indirect control of EV charging, detailed analyses of such schemes are scant. However, experience with such dynamic pricing arrangements for electric vehicle charging is still limited, and ongoing changes in technology, including the systems used to

control charging, contribute to uncertainties about how dynamic pricing will affect charging behaviour.

- Day-ahead hourly rate provides dynamic hourly rates for EV charging on a day-ahead basis. It allows the user to know optimum hours for charging his vehicle and gives the flexibility to minimize the charging cost predictably and reliably. This structure is being tested by San Diego Gas and Electric (SDG&E). However, one disadvantage of this structure would be that the customers may not be comfortable with the complexity of dynamic pricing, in which case aggregators will needed to aggregate the load and obtain the benefits of dynamic pricing.
- Managing the load through direct control: In this approach charging loads could be controlled directly by grid operators or utilities or aggregators of charging infrastructure within the defined parameters set by the user. This would give the flexibility to avoid overloading the distribution network and optimize all assets on the grid under a dynamic pricing regime. However, it would be infrastructure intensive and require Advanced Metering Infrastructure (AMI) to measure hourly or sub-hourly demand and to enable billing for dynamic pricing. It would also require high degree of communication between the network operators, aggregators, distribution utility and the EV user.

4.2.5.3 Innovative Tariff Structures in Other Countries

Tempo Electricity Tariff – Électricité De France (EDF), France

In France, electricity bills for residential and small business customers include a standing charge determined by the level of maximum demand (in kVA) nominated by the customer (puissance souscrite), and an energy usage charge based on the type of tariff chosen by the customer (type d'abonnement). In 1993, EDF introduced a new rate design, TEMPO tariff to its 120,000 residential customers. Thus, a residential and small business customer could choose from three types of electricity contract.

Option Base	Option Heures Creuses (Option HC)	Option Tempo
For lower usage, smaller homes with infrequent usage.	For the majority of houses occupied full-time with non-electric heating	For high use households with electric heating and full-time occupation, and for small business customers.
Simplest, with the lowest standing charge and a flat rate for electricity usage all the time throughout the day and year.	• Two-part time-of-use tariff with normal (heures pleines) and off peak (10 pm until 6 am each night) (heures creuses) rates. • Usually used in conjunction with a water heater operated by ripple control so that the heating element is switched on only during off-peak periods.	• Complicated tariff system with six rates of electricity pricing based upon the actual weather on particular days and on hours of use. • Each day of the year is colour coded. - Blue (jours bleus): low prices - White (jours blancs): medium prices

		- Red (jours rouges): high electricity prices. • The colour of each day is determined mostly by the electricity provider Électricité de France (EDF) based on the forecast of electricity demand for that day. • The French transmission network operator also has the ability to determine the day colour if there is significant congestion on the electricity network.

Figure 16 Tempo Electricity Tariff – Électricité De France (EDF), France

Tempo tariff has been successful but less than 20% of electricity customers in France have chosen Option Tempo. The Tempo tariff was designed specifically for the situation where EDF is a monopolistic generator and retailer of electricity. In July 2009, EDF discontinued the Tempo tariff for new customers and for customers who are on the tariff at their current residence and then move house.

Gulf Power's GoodCents Select

The Florida based Gulf Power Company employs Critical Peak Power Pricing mechanism, which is similar to a time-of-use rate most of the time, with the exception that on declared "critical-peak" days, a prespecified higher price is charged for a specific time period. GoodCents® SELECT is a residential advanced energy management system that allows consumers to program their central heating and cooling system, electric water heater and their pool pump to automatically respond to varying prices. There are three TOU prices for non-critical hours, and a CPP that can be invoked no more than one percent of the hours in a year. The Program showed Significant Real-Time demand reduction and customers could save up to 15% on electricity bill annually.

Real Time Pricing

Several utilities in US and Europe offer real time electricity tariffs for their consumers. Real-time pricing means that the electricity prices vary hour-to-hour and are determined from wholesale market prices using an approved methodology. Real-time pricing allows consumers to adjust their electricity usage by scheduling usage during periods of low demand with cheaper electricity price. Utilities of Illinois i.e. ComEd and Ameren offer real-time pricing programs in Illinois. For RTP, enabling technologies (e.g., smart meters) are usually involved to support the accuracy of measurements. The reason RTP highly relies on enabling technologies is that it has to be closely connected with wholesale market prices, as well as with consumer feedbacks (two-way communication required). Nova Scotia Power, Canada offers one-part Real Time Pricing (RTP) to customers who have loads of 2,000 KVA or 1,800 KW and over. The consumers are charged based on the company's actual hourly marginal energy costs, plus the fixed cost for on-peak and off-peak usage.

Peak Time Rebate

PTR refers to the payment that consumers can receive for reducing demand during peak periods on event days. It is inverse of CPP, where customers will be reimbursed for the amount of reduced power consumption during the critical peak period. Utilities such as San Diego Gas and Electric (SDG&E) ComEd offer PTR to their consumers.

4.2.6 Renewable and energy storage options for charging

With the large influx of distributed renewable energy in the grid, energy storage and electric vehicles are being looked at as viable options to balance RE power supply and consumer demand. The distributed renewable energy sources, particularly rooftop solar projects can be used to charge electric vehicles. Public parking spaces can be built with solar rooftop panels as sheds, which can charge electric vehicles. And through the concept of V2G, the charged electric vehicles can be used to inject electricity into the grid at times of excess power demand. Large scale energy storage projects at the distribution level can also be used as charging option for EVs. Usage of distributed RE and energy storage will help to improve the well-to-wheel efficiency of the electric vehicle, translating to fewer GHG emissions across the valuechain.

4.3 Battery & Motor

4.3.1 Battery specifications and technology trend:

Types of EV Batteries and their features[7]:

Battery Chemistry	Maximum C rate	Maximum Temperature (Degree C)	Life (Maximum Cycles)	Power Density (Wh/kg for cell)	Average Module Price (US$/kWh in 2018)
Lithium Ion Iron-Phosphate (LFP)	Up to 2C	40	1500-3000	100-130 Wh/kg	270
Lithium Ion- Nickel Manganese Cobalt (NMC)	C/2	40	1000-2000	230-250 Wh/kg	250
Lithium Ion- Nickel Manganese Cobalt (NMC)	3C	40	3000-4000	200 Wh/kg (for NMC 811)	400
Lithium Ion- Nickel Cobalt Aluminium (NCA)	2C	40	1000-1500	250-270 Wh/kg	230
Lithium Ion Titanate Oxide (LTO)	6C	60	7500-10000	50-80 Wh/kg	700

Figure 17 Types of EV Batteries and their features

[7] ISGF White Paper Electric Vehicle Charging Stations Business Models for India

Batteries are the most important component in an EV and constitute approximately 50-60% of the cost of the EV. Battery in an EV should be robust enough to handle high power, should have high energy capacity, should be stable and ideally be lightweight in order to reduce the deadweight in the vehicle which impacts the fuel efficiency. Today, Lithium Ion Batteries (LIB) are used in all EVs. There are different battery chemistries in the LIB family but the ones popular with most EV manufacturers are:

- Lithium Iron Phosphate Oxide ($LiFePO_4$) or simply called LFP for Lithium Ferro Phosphate
- Lithium Nickel Manganese Cobalt (LNMC) or popularly known as NMC
- Lithium Nickel Cobalt Aluminium (NCA)
- Lithium Titanate Oxide (LTO)

The commercially available electric vehicles with Li-ion batteries suffer from small driving range on single charge. As a result, lithium–air batteries (with specific energies reaching 3000 Wh/kg) are being developed that can deliver driving ranges comparable to that of petrol cars. The performance, durability and cost are key consideration in selection of batteries. All batteries cannot be fast charged. In the battery parlance the C-rate is used to refer the charging rate. 1C rate refers to full charging in one hour; 2C rate refers to full charging in 30 minutes; and 10C refers to full charging in 6 minutes. And C/2 means two hours to fully charge.

4.3.2 Motor technology specifications:[8]

The electric motor is the major driving force of the EV propulsion system. Under normal mode of operation, the motor sets the EV in motion. And when regenerative braking mechanism is applied, it behaves as a generator. Different motors have been designed over the years, on the basis of the driving requirements. The categorization of these electric motors is described below.

4.3.2.1 Brushed DC Motor

Brushed DC motors were used in the early electric vehicle models. They could deliver large torque even at lower speeds. However, these motors were discontinued mainly due to their weight, low efficiency and heating issues. Permanent magnets were used for the stator design while brushes were placed on the rotor. This structure made it very difficult to remove heat generated in the rotor center.

[8] A Comprehensive Study of Key Electric Vehicle (EV) Components, Technologies, Challenges, Impacts, and Future Direction of Development

4.3.2.2 Permanent Magnet Brushless DC Motor (BLDC)

The BLDC motors employ a permanent magnet as the rotor and an inverter is connected to the stator. The BLDC motors have greater efficiency than induction motors, compact size, fewer heating issues and deliver more reliable output. However, the torque is limited at higher speeds on account of back EMF produced in the motor stator windings. The inclusion of reluctance motors in combination with the PM motors are called PM hybrid motors. For achieving greater efficiency in the BLDC motor, the conduction angle of the power convertor is modulated. BLDCs are mostly installed in smaller vehicles that need a power output of at the most 60 kW.

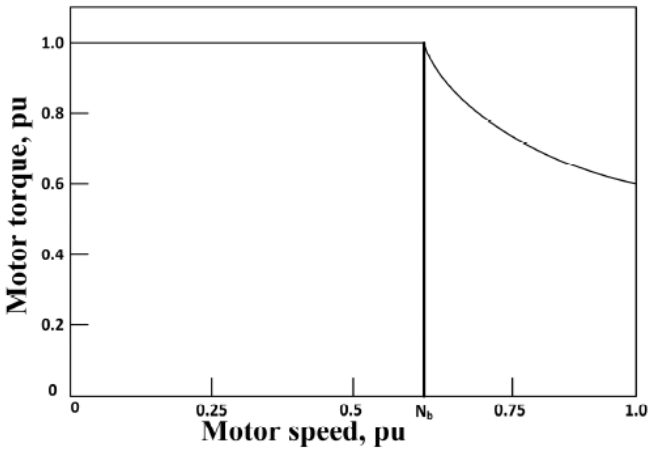


Figure 18 Permanent Magnet Brushless DC Motor: Motor Torque vs Motor Speed

4.3.2.3 Permanent Magnet Synchronous Motor (PMSM)

The PMSM motors can be driven at a variety of different speeds despite the lack of a gearing system. These motors are small and highly efficient, capable of delivering large torque even during driving conditions of lows speed. However, the motor loses stability when operated during in-wheel operations at high speeds. Most of the latest battery electric vehicle models use PMSMs.

4.3.2.4 Induction Motor (IM)

Induction motors have been used in both older as well as the latest EV designs. Induction motors employ commutator-less motor drive system. The existing EV models that run on induction motors use 3-phase, 4-pole AC motors with Cu rotors. Vector control and field orientation management are several techniques that are used to improve the speed output delivered by the induction motors in the electric vehicles.

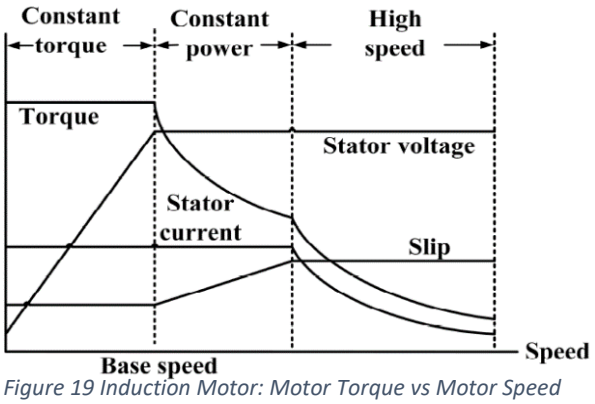


Figure 19 Induction Motor: Motor Torque vs Motor Speed

4.3.2.5 Switched Reluctance Motor (SRM)

SRMs are synchronous motors that are run using unipolar inverter-produced current. These motors have plain and durable design and can be driven at high speeds. They are also more affordable as well as safer than their PM counterparts. However, these motors create noise during operation and are very bulky. In certain driving conditions the SRM motors also display low efficiencies. As these motors do not require permanent magnets, which contain rare earth metals, modern research is underway to develop more efficient SRMs.

4.3.2.6 Synchronous Reluctance Motor (SynRM)

Synchronous Reluctance Motors are resilient, compact, fault tolerant and highly-efficient. These motors have a control structure framing like the PM motors. The applicability of SynRMs for EV are

limited on account of issues of controllability, low manufacturing and low power factor. New and enhanced design techniques, control systems and advanced manufacturing are being employed to improve the SynRM motors.

4.3.2.7 PM Assisted Synchronous Reluctance Motor

These motors do not face the issues of demagnetization caused due to overloading and high temperature. Through an appropriate efficiency optimization method, this motor can be built to deliver operational performance similar to IPM motors.

Power Comparison of different motors having the same size:

Motor Type	Power (kW)		Base Speed (rpm)	Maximum Speed (rpm)
	HEV	BEV		
IM	57	93	3000	12000
SRM	42	77	2000	12000
BLDC	75	110	4000	9000

Table 12 Power Comparison of different EV motors

Typical torque density values of some motors:

Motor Type	Torque/Volume (Nm/m$^{\#}$)	Torque/Cu Mass (Nm/kg Cu)
PM motor	28860	28.7-48
IM	4170	6.6
SRM	6780	6.1

Table 13 Typical torque density values of EV motors

Advantages, disadvantages and usage of different motor types

Motor Type	Advantage	Disadvantage	Vehicles used in
Brushed DC Motor	• Maximum torque at low speed	• Bulky structure • Low efficiency • Heat generation at brushes	Fiat Panda Elettra (Series DC motor), Conceptor G-Van (Separately excited DC motor)
Permanent Magnet Brushless DC Motor (BLDC)	• No rotor copper loss • More efficiency than induction motors • Lighter • Smaller • Better heat dissipation • More reliability • More torque density • More specific power	• Short constant power range • Decreased torque with increase in speed • High cost because of PM	Toyota Prius (2005)
Permanent Magnet Synchronous Motor (PMSM)	• Operable in different speed ranges without using gear systems • Efficient • Compact • Suitable for in-wheel application • High torque even at very low speeds	• Huge iron loss at high speeds during in wheel operation	Toyota Prius, Nissan Leaf, Soul EV
Induction Motor (IM)	• The most mature commutator-less motor drive system • Can be operated like a separately excited DC motor by employing field orientation control		Tesla Model S, Tesla Model X, Toyota RAV4, GM EV1
Switched Reluctance Motor (SRM) Synchronous Reluctance Motor (SynRM)	• Simple and robust construction • Low cost • High speed • Less chance of hazard • Long constant power range • High power density • Robust • Fault tolerant • Efficient • Small	• Very noisy • Low efficiency • Larger and heavier than PM machines • Complex design and control • Problems in controllability and manufacturing • Low power factor	Chloride Lucas
PM assisted Synchronous Reluctance Motor	• Greater power factor than SynRMs • Free from demagnetizing problems observed in IPM		BMW i3
Axial Flux Ironless Permanent Magnet Motor	• No iron used in outer rotor • No stator core • Lightweight • Better power density • Minimized copper loss • Better efficiency • Variable speed machine • Rotor is capable of being fitted to the lateral side of the wheel		Renovo Coupe

Table 14 Advantages, disadvantages and usage of different EV motor types

4.4 Business Models

Various business models for grid integration have been proposed and studied. The most common is aggregator model which is explained below:

I. AGGREGATOR MODEL

- The aggregator is the coordinator between system operator, EV owner and distribution utility. The aggregator collates EVs and create a potential source of energy that can be used by the utilities and system operator during the periods of high demand-supply gap.

II. OWNER MODEL

- Another possible model is to integrate large EV fleet through individual vehicle owners who then directly participate in the energy market. In this model, the EV owner will receive signals and directly manage the requests from utilities and system operators with the help of the two-way communication and control systems. This can be achieved by optimizing charging price so that the EV owner can minimize the charging cost at all times while reducing the stresses on the power grid. However, this integration scheme is not reliable and efficient because dealing with each individual EV owner increases the complexity in energy planning, security and control.

III. DISCOMS

- In this model, the DISCOMs shall be the owners and operator of charging facilities under a separate deregulated model. Several DISCOMs consulted have shown an interest in this business.

IV. BUS DEPOTS

- In this model, the STUs themselves shall be the owners and operators of charging facilities for their own buses as well as their franchisee private bus operators.

V. BATTERY SWAPPING

- In this model, the battery charging could be at public facilities or at their own captive industrial establishments from where charged batteries can be delivered at strategic locations within the city.

VI. FRANCHISEES AT PARKING LOTS AND MUNICIPAL FACILITIES

- In this model, the Franchisees of DISCOMs will own and operate charging facilities at premised allotted by City Governments/Municipalities or leased from the landlords.

4.4.1 Business Model suggestions specific to the SAARC states include:[9]

a. Electric utilities may be mandated to setup EVSE network in strategic locations in their service area under capex for grid upgrades (regulated asset)
b. City governments/Municipalities and Highway Authorities may be mandated to allot space for EVSE networks on long lease at concessional (or free) through transparent selection route avoiding creation of monopolies
c. Bundle EVSE as mandatory in new buildings through Building Codes for all categories of buildings exceeding certain built area - in this case the impact of EVSE infrastructure cost in the per square meter cost of the buildings will be negligible
d. EV manufacturers to contribute a certain percentage of the vehicle cost towards EVSE Fund which will be utilized to build EVSE network in respective cities/states
e. EVSE infrastructure may be clubbed with Highway construction cost – again it will have negligible impact on per kilometre cost of highways
f. In commercial centres, tourist places, religious places etc. the shop owners may be encouraged to invest in EVSE infrastructure and entry of petrol and diesel vehicles may be banned
g. Allot land and licenses to setup large EVSE stations at strategic locations which will also have following facilities:
    a. Café/ATMs
    b. Convenient Store/ Grocery/Vegetables Shops
    c. Health Club (Gym)
    d. Gaming Stations/Barbershops/Beauty Parlors/Massage Centres
    e. Air and Tire changing services

h. Public sector undertakings and large private companies (above certain turnover) may be mandated to setup (or contribute towards) EVSE infrastructure in their area of operation
i. Oil distribution companies may be mandated to create EVSE infrastructure nearer to their retail outlets (subject to clearances for operating at high voltages) on highways (with in cities it may not be possible owing to space limitations and high cost of land)
j. EV manufacturers consortiums may promote EVSE networks and collect monthly subscription from EV owners and pay to the EVSE owners and operators (Japanese model)
k. Fleet operators and car rental companies may be allowed to setup EVSE networks
l. Other incentives for EVSE infrastructure could include:
    a. Tax concessions
    b. Free or concessional land on long term lease
    c. Transparent allocation of EVSE locations preventing formation of monopolies

The private sector models for EV charging may face difficulties in business case on a small-scale basis; this is owing to large upfront capex and given the nascent stage of EV adoption, the return on investment for the private players is expected to be low in the early years, especially for EV charging in pocket locations. Without public utility support, the private sector models for EV charging may prove to be unviable in the short run. Hence it is recommended that the business models to be adopted for the SAARC states for EV charging should be either managed by the public utilities or through public-private-partnership arrangements in the initial years.

[9] ISGF White Paper Electric Vehicle Charging Stations Business Models for India

4.5 Policy Requirements

4.5.1 National and supra-national measures[10]

Effective policies and regulations are required to be devised for ensuring successful EVSE rollout. These need to determine proper EVSE deployment targets, division of responsibility for implementation and the financing mechanism. Well-developed policy framework facilitates the government in achieving an effective balance between the chicken-and-egg issue of charging infrastructure deployment and electric vehicle deployment.

4.5.1.1 EVSE deployment targets

Defining clear EVSE targets should be coordinated with the EV deployment targets. This enables phased adoption of EVs and strikes a demand-supply balance between the number of electric vehicles plying on-road and the supporting charging facilities. While this is the recommended approach, it is not a hard and fast rule, with many countries declaring only EV targets and in a few instances, targets for public charging infrastructure. Some examples are as given below:

China:

China has defined EV and EVSE deployment targets for 2020. It has declared to establish 12000 "battery swapping facilities". To facilitate charging of EVs, it will rollout half a million "public chargers" and nearly 4.3 million "private chargers".

EU:

The constituent members of the European Union were to set deployment targets for 2020, 2025 and 2030 iaccording to the AFI Directive. 20% of the members remain to declare their targets, as of 2017. Approximately 35% of public charging outlets (part of the 2020 target) have been established.

California: California has planned to pour USD 0.9 billion in funding for building a quarter million EV charging stations by 2025. 10000 of these charging stations will be "DC fast chargers".

4.5.1.2 Fiscal policies

Most of the recent government EV policies have focussed on providing fiscal incentives for charging infrastructure deployment. These include subsidies and tax incentives. These have come to overtake “promoting direct investment in charging stations”, as the favoured approach to EVSE deployment. While government spending on encouraging EVSE has increased extensively, the effectiveness of these fiscal policies has been limited.

4.5.1.3 Regulatory policies

Changes in the building code and regulations that mandate the installation of private EV charging infrastructure in apartment complexes, shopping complexes and parking facilities support EV deployment as public charging stations are not sufficient to meet the growing demand of the market. Various countries have introduced revisions to their existing building codes to compulsorily install charging infrastructure in new buildings that are being constructed in order to enable "EV-ready" parking.

[10] Global EV Outlook 2018

4.5.1.4 Regulatory frameworks on electricity distribution

The electric vehicle charging infrastructure falls under the regulations of the automotive sector, the transport sector, the electricity sector and other relevant sectors depending on the country. As the charging facilities are connected to the power grid, major part of operation, control, monitoring and ownership of the stations falls under the jurisdiction of the power sector, specifically the power distribution sector. Certain nations allow private companies to setup and operate charging stations however, it is always subject to monitoring by a nodal government agency.

Depending on the specific regulatory approach of a country, and whether by definition, the electric vehicle charging facility is considered a retailer or as distributor of electricity, the regulatory environment can either encourage or hamper investments. For example, in India, if EV charging operations are to be considered through petrol pump stations, the law that may cause hindrance is that of minimum safety distance: the petrol pumps are mandated to maintain a minimum safety distance of 9m from 66 kV transmission lines, 18m from 220 kV transmission lines and 26 metres from 400 kV transmission lines on both sides.

4.6 Potential Implications on Power Draw for EV charging in SAARC Countries

4.6.1 Weak distribution systems

Electric Vehicle charging infrastructure is constructed an operated at the distribution level of the power sector; in the developed nations, where EV rollout has gained momentum, the power distribution networks are widespread and robust, with low distribution losses, high reliability and quality electricity supply. In USA, private power sector utilities are responsible for 75% of electricity sales to final customers, with the remainder being sold by municipal utilities and cooperatives, leading to greater efficiency and reliability in power supply; the distribution system operators (DSOs) in Europe have started to modify their distribution systems to accommodate the non-linear loads of electric vehicles and also for distributed generation like rooftop solar panels, and for smart meters. The SAARC nations, on the other hand suffer from weak power distribution infrastructure and lack of quality power supply; while energy access has comparatively improved for these nations, the issue of continuous reliable power supply persists. While India, Pakistan and Sri Lanka have made significant progress in modernizing their distribution grids, more improvements are required to support large scale EV charging infrastructure deployment.

4.6.2 Distribution Transformer (DT) sizes and Residential power limitations

The standard DT size in USA and Canada is less than 200 kVA, typically 100 kVA and the number of consumers connected to a single DT is 15-20 or less; the DT sizes in India range from 10 kVA to 2500 kVA, of which the 250 kVA to 400 kVA range transformers are the most common; the number of customers connected to a single 250 kVA or 400 kVA transformer in India is in the hundreds. As a result, there is large connected load burden for DTs in India as compared to the North American nations. Frequent interruptions to electricity service have been observed due to DT failure on account of overloaded conditions, thus increasing the expenditure of the distribution companies on O&M as well as causing unavailability of continuous power supply to the consumers. Similar situation is observed in the other SAARC states. Given such nature of the distribution network in the SAARC states, residential electric vehicle charging will only add to the load on the DTs, increasing the probability of transformer failure and disruption of service and in consequence discouraging the concept of residential EV charging.

4.6.3 Limitations on simultaneous EV charging

Most of the present distribution networks in the SAARC nations are quite old in design, making them quite unequipped to withstand the large-scale integration as well as simultaneous charging of EVs. The electric vehicles are non-linear loads, causing harmonic distortions and voltage stability issues. In a study[11], it was discovered that the voltage profile of the node where several EV charging stations are connected, degrade to a certain point. Larger loads of EV charging stations cause severe degradation of the voltage profile of the weak buses of the system. This decrease the net life of the distribution network assets, hampering the case for simultaneous EV charging.

4.6.4 Potential solutions

The distribution networks need to be revamped and modernized in order to adapt to the requisites of EV adoption; the modernization will involve increasing the DT and feeder line capacities for the potential EV concentration centres as well as residential complexes and also the addition of voltage and harmonics stabilizing devices. By leveraging suitable technologies, communication and control strategies Discoms can defer the investment in distribution system upgrade and additional generation capacity on account of EVs. Intelligent chargers may be placed which will limit the simultaneous charging of electric vehicles and will avoid overloading of transformers. Ideally charging stations should be integrated with the Building Management Systems (BMS) where ever feasible and in-turn the BMS should be integrated with the Distribution Management Systems (DMS) of the Discoms.[12] The upcoming residential and commercial building designs can be upgraded through modifications and amendments to the Building Codes and Bylaws to accommodate EV charging infrastructure.[13]

[11] Impact of Electric Vehicle Charging Station Load on Distribution Network

[12] Recommendations for Electric Vehicle Policy and Charging Infrastructure for Incorporating in the NEMMP Framework and Policies

[13] Article: E-car charging stations could soon become mandatory in your residential building; Website: https://economictimes.indiatimes.com/industry/auto/auto-news/ev-charging-stations-may-become-must-in-buildings-parking-lots/articleshow/66353793.cms

5. Global Scenarios and Case Studies

Electric vehicle adoption is seen by a majority of the world as key to improving air quality and for tackling climate change issues. In this regard, Norway are considered as one of the prime movers of the electric vehicle revolution, with other European nations following suit. Given the significant market opportunity and environmental advantages of electric vehicles, China and USA have heavily promoted EV rollout, thus making them, alongside Norway, the dominant forces across the globe in the EV industry. In this chapter, the EV rollout developments for the global leaders of Norway, USA and China (ICCT: Electric Vehicle Capitals of The World) have been examined in terms of the deployment status, policies and incentives for EV promotion, business models, etc. so as to ascertain what may be applied to the respective SAARC nations.

5.1 Norway

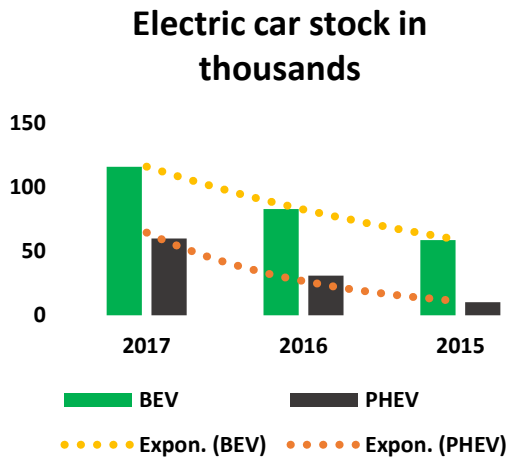


Figure 23 Electric car stock in Norway

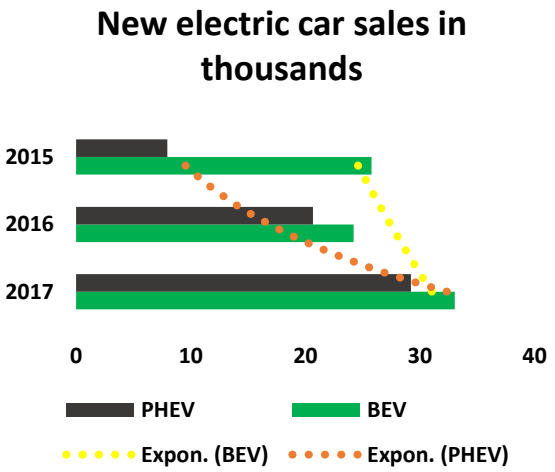


Figure 22 New electric car sales in Norway

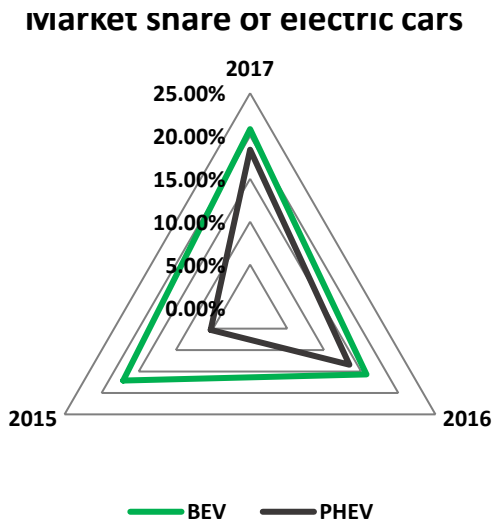


Figure 20 Market share of electric cars in Norway

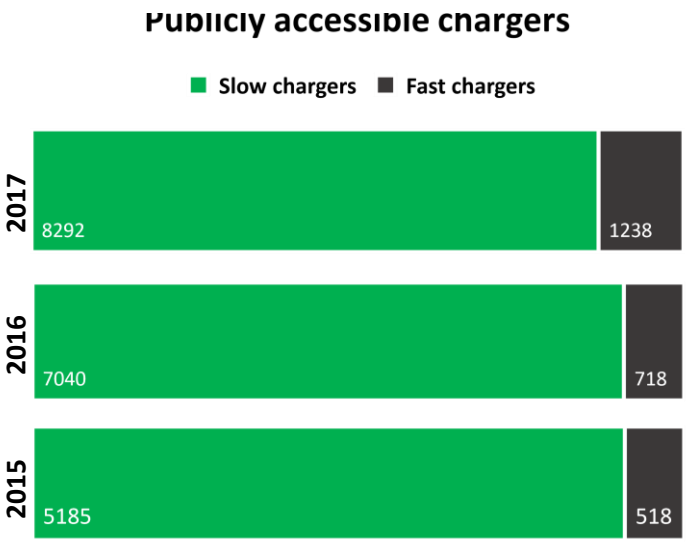
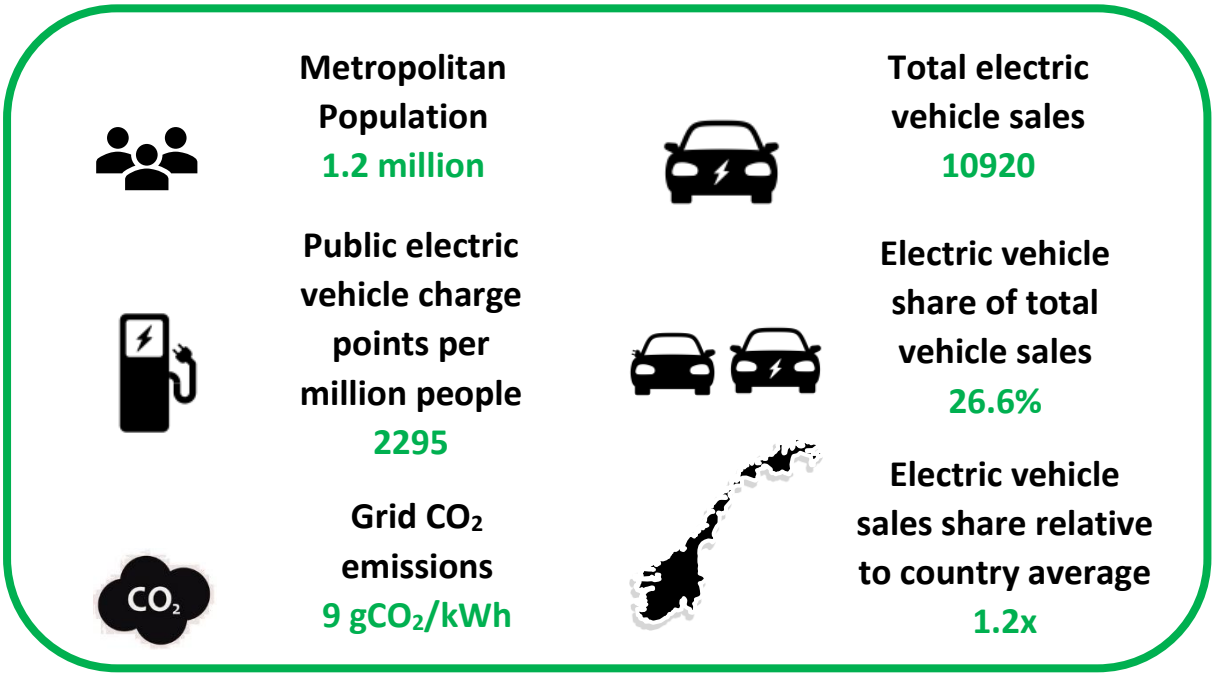


Figure 21 Publicly accessible chargers in Norway

Norway is a pioneer of the electric vehicle revolution, in its efforts to reduce GHG emissions.

The country generates most of its electricity through its hydropower plants. Norway has planned to harness this electricity to drive EV deployment and charging. Norway has set a 2020 target of reaching a CO_2 emission rate below 85 gm/km. This is applicable to the new passenger vehicles that will be launched. In order to facilitate these targets, Norway provided a number of progressive incentives for electric vehicle deployment that includes tax and toll exemptions, preferential parking benefits and the facility of free charging at certain EVSE stations. The government has also invested large funds for enabling charging infrastructure on highways.

5.1.1 Oslo, Norway (2015-2016)



The city of Oslo is the global leader in terms of electric vehicle market penetration. Oslo has set defined targets electric vehicle to reduce GHG emissions by 40% from transportation sector in its Climate Budget. The city has also implemented various passenger traffic restrictions in order to curb GHG emissions along with its electric vehicle initiative.

For promoting EV deployment the Oslo government has granted a number of fiscal incentives that include relaxation on import duties and purchase tax on EVs, and lowering or complete removal of taxes on toll and leasing. The city has also defined strict “low-emission zones”, provided free parking for EVs at municipal parking spaces, implemented subsidized EV charging tariffs and granted “special lane access” for e-buses.

Oslo has also invested heavily in public and private charging infrastructure installation and electric vehicle research, through collaborations with private sector companies and various research organizations.

5.2 United States of America

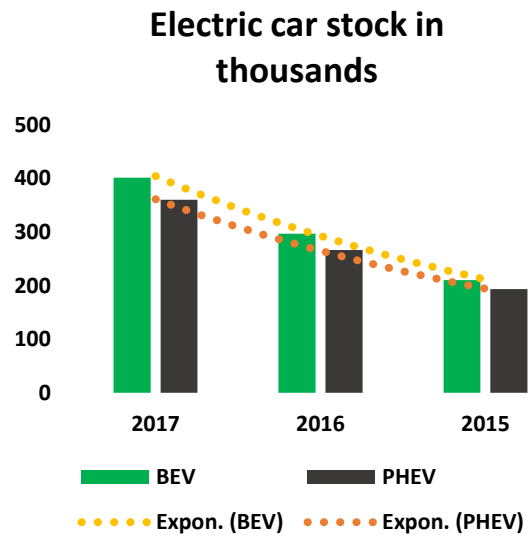


Figure 25 Electric car stock in USA

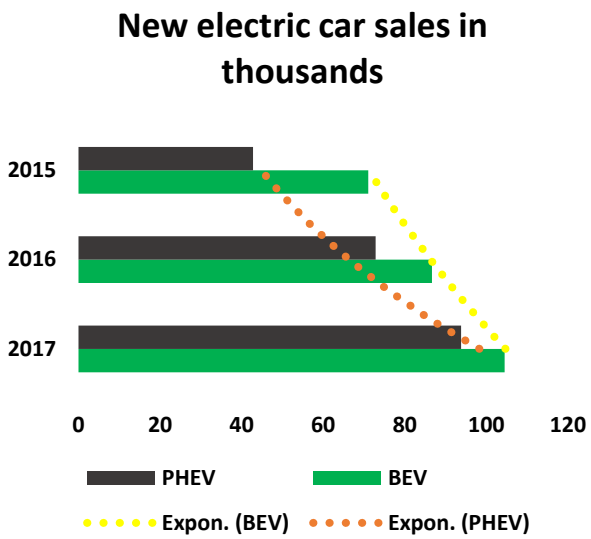


Figure 24 New electric car sales in USA

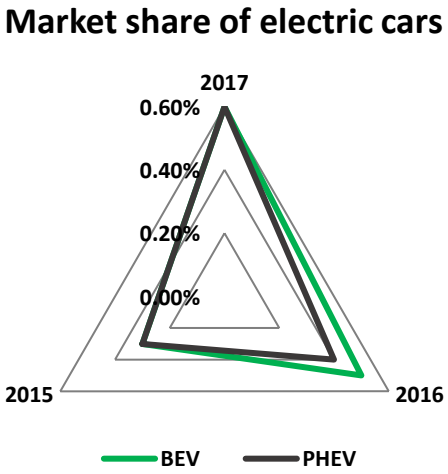


Figure 27 Market share of electric cars in USA

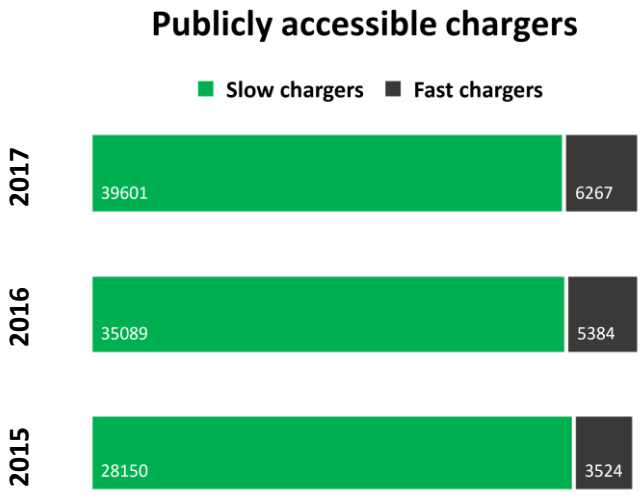
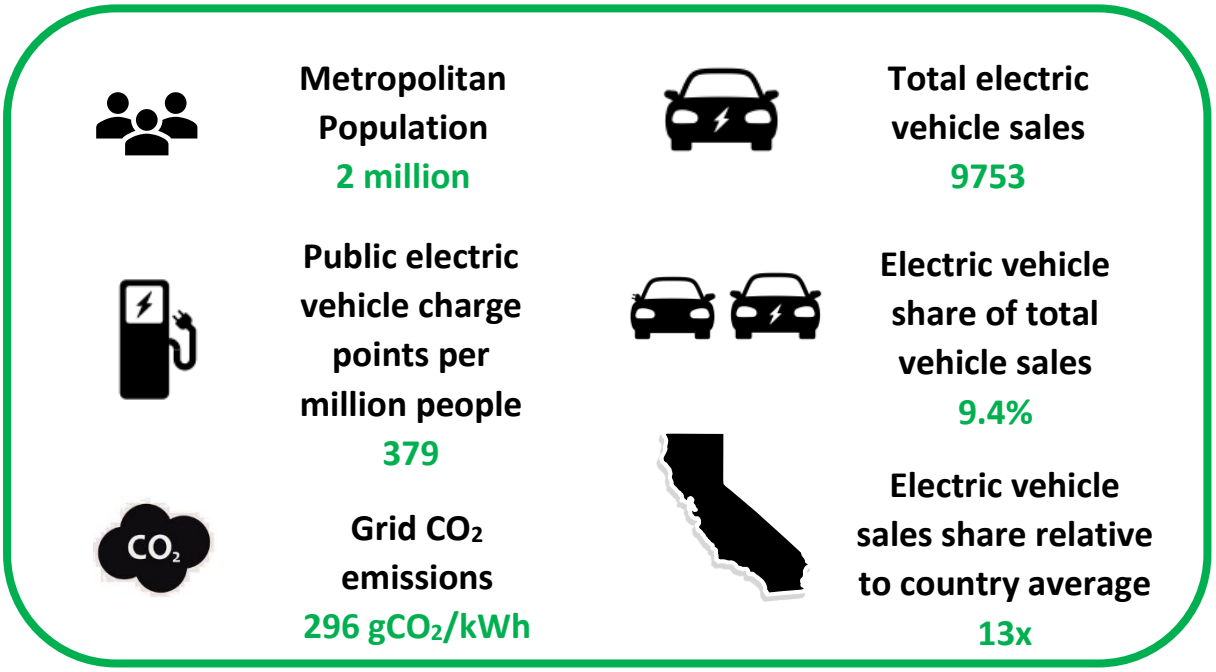


Figure 26 Publicly accessible chargers in USA

The United States has enacted numerous national and incentive programs to expedite EV adoption. The Department of Energy had released the EV Everywhere initiative which focused on R&D and consumer awareness to achieve cost and market parity for EVs till 2022. Different states in the US have announced their individual EV policy frameworks, of which California has been the most successful.

5.2.1 San Jose, California, United States of America (2015-2016)

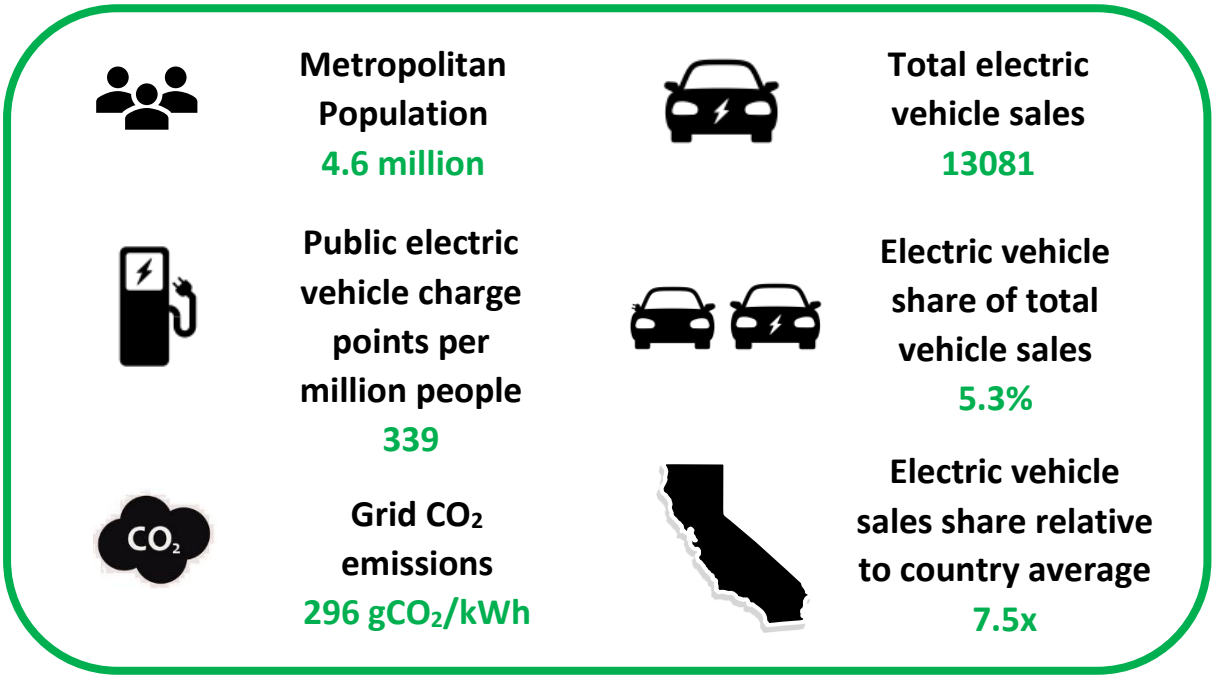


San Jose has witnessed the maximum adoption of electric vehicles as compared to any other city in the United States. San Jose has announced that it will completely transform its existing municipal fleet to alternative fueled vehicles by 2020. Support for EV deployment has come in the form of favorable state policies and also through EV interventions implemented by the local utility, 'Pacific Gas & Electric'.

California state offers a "federal tax credit" and "state rebate" on EV purchase of up to USD 7500 and USD 2500 respectively. EV manufacturing has also been incentivized at the state level. San Jose has also granted special parking perks, dedicated lane access to "high-occupancy vehicle lanes" and special EV tariff for encouraging electric vehicles uptake.

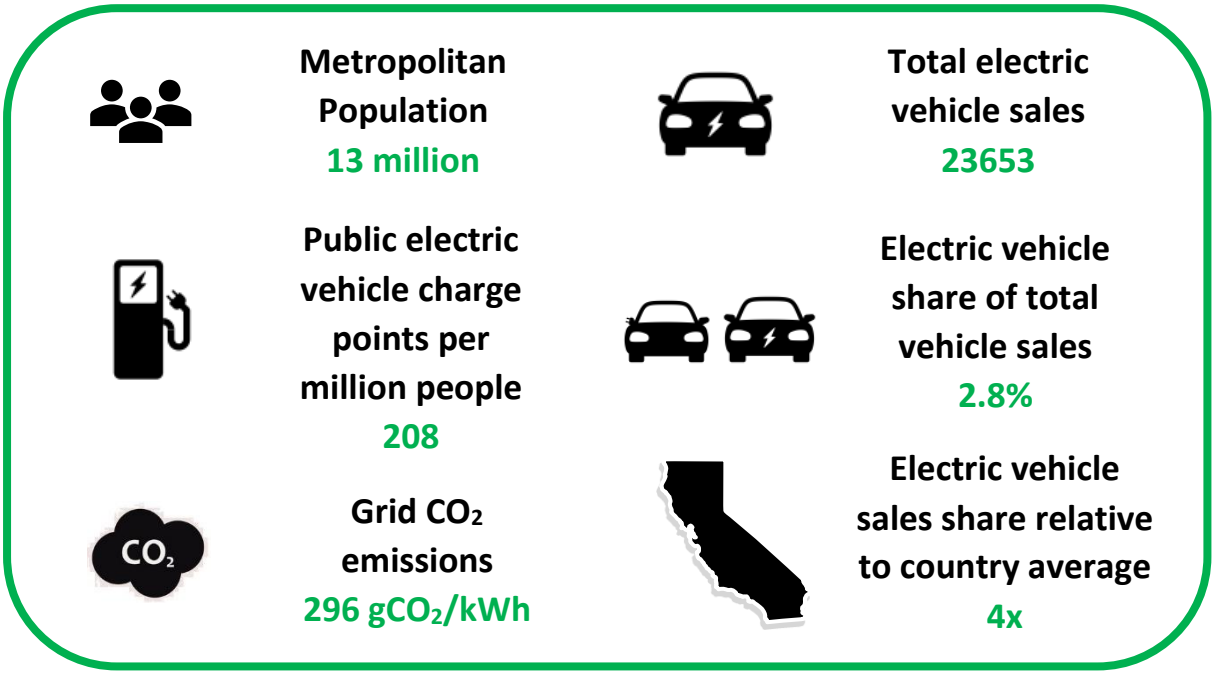
San Jose has also implemented regulations to promote low fossil fuel usage, installed charging infrastructure at public places as well as at office areas, and incentivized the installation of private charging stations. Various awareness programs such as "National Drive Electric Week" have been organized by the utilities and stakeholders for EV promotion.

5.2.2 San Francisco, California, United States of America (2015-2016)



San Francisco stands second only to San Jose in terms of electric vehicle penetration at the city level in the United States. Similar to San Jose, EV deployment in San Francisco has been bolstered by the various state level initiatives implemented. Apart from the vastly similar steps implemented at state and local level in both these cities, San Francisco has also concentrated on launching over three hundred e-trolley and hybrid buses along with the electrification of other vehicle fleets. The city has also developed a shared e-mobility program to serve the dual purpose of reducing passenger vehicle traffic and increasing EV usage. Various awareness programs such as “Best.Ride.Ever” and “National Drive Electric Week” have also been organized to educate the public on EV adoption.

5.2.3 Los Angeles, California, United States of America (2015-2016)



The Los Angeles boasts the greatest EV sales rate in the country. Similar to San Jose and San Francisco, Los Angeles has also benefitted from various state-level policies and also various local governance initiatives to promote EV adoption.

Apart from the various schemes that it shares with its sister cities, the Los Angeles government has mandated a "EV-ready building code" for setting up charging facility in new building constructions. A pilot plan is also in progress which will see investment of approximately $22 million to build EV public charging infrastructure within the city area. The city has developed a streamlined for obtaining "local-charging permits". The city has placed impetus on EV research by providing incentives to EV manufacturing. It has also participated in the "Drive the Dream", "Best.Ride.Ever" and "National Drive Electric Week" campaigns for EV promotion.

5.3 China

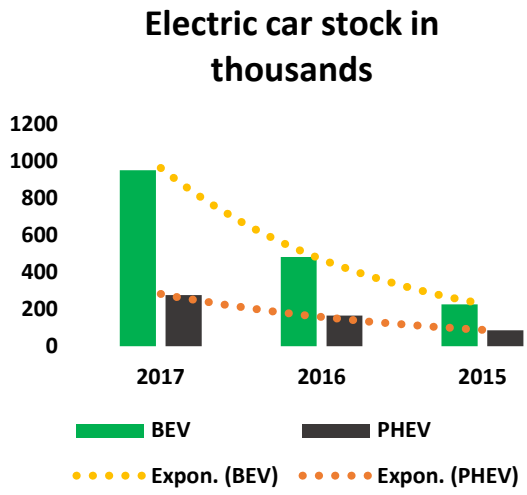


Figure 31 Electric car stock in China

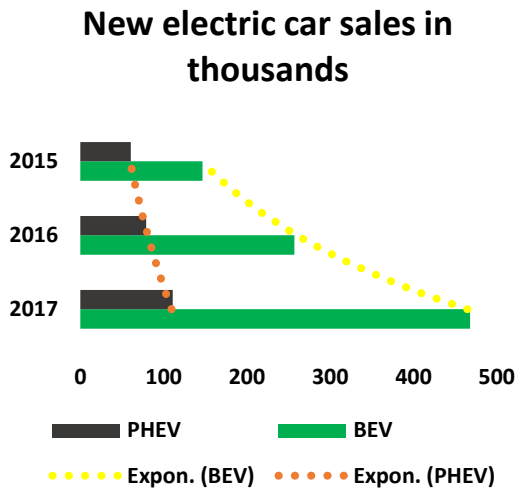


Figure 30 New electric car sales in China

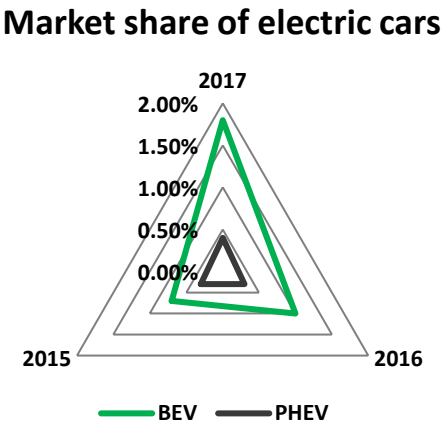


Figure 28 Market share of electric cars in China

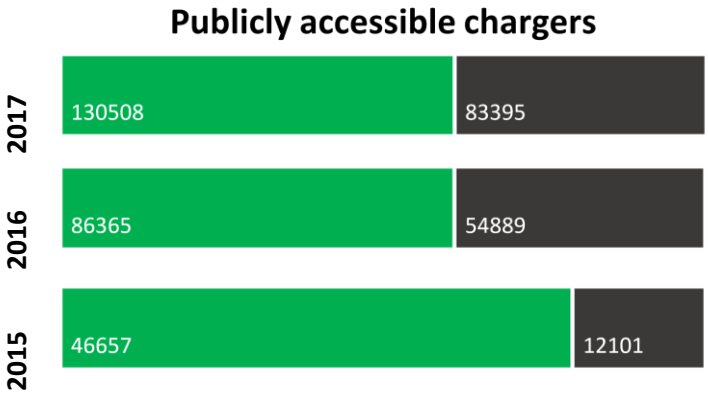


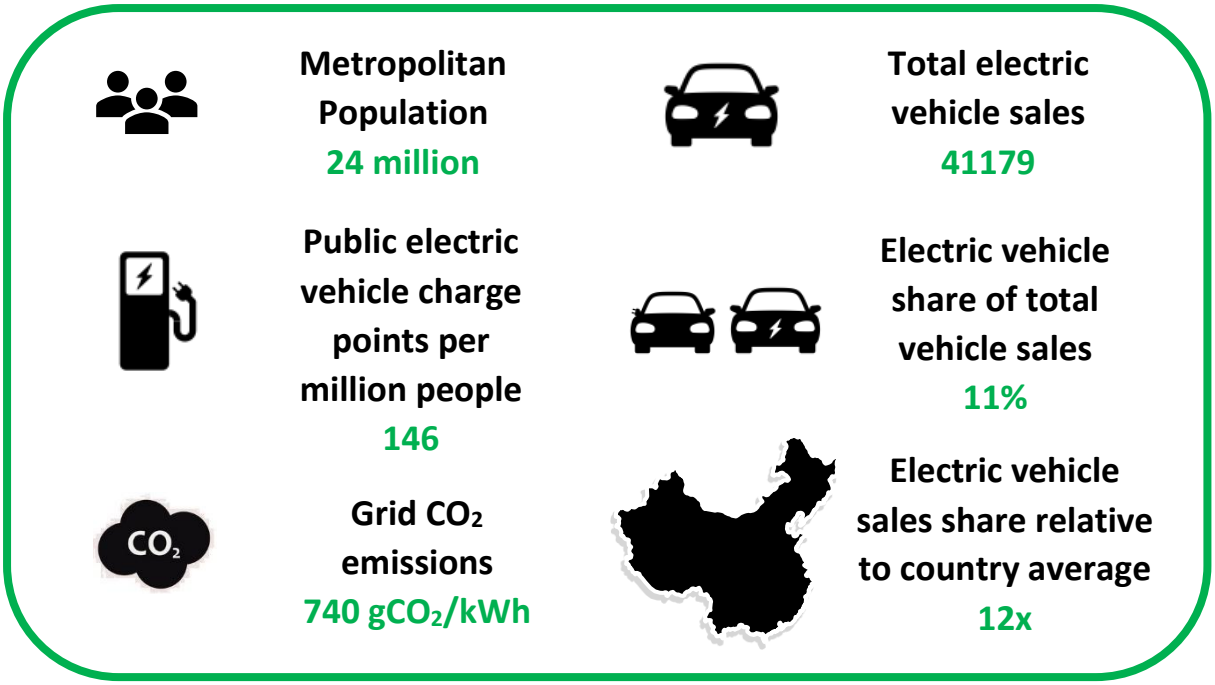
Figure 29 Publicly accessible chargers in China

China has the largest global electric vehicle stock. The country has announced and implemented number of central and state level policies and strategies to encourage EV uptake.

The electric utility State Grid Corporation has been involved in the construction of fast charging stations across the country. The country has laid down an aim of of constructing at least one charging station per every two thousand EVs. It also aims to establish charging facilities sufficient to cater to the requirements of 5 million EVs by 2020.

The “Ten Cities, Thousand Vehicles” program has grown to have a total of 25 cities. These pilot cities employed incentives, charging infrastructure, and other promotion activities to facilitate EV adoption. Many major cities have placed various restrictions on vehicle registrations to combat congestion and emission, for which relaxation has been provide to EVs.

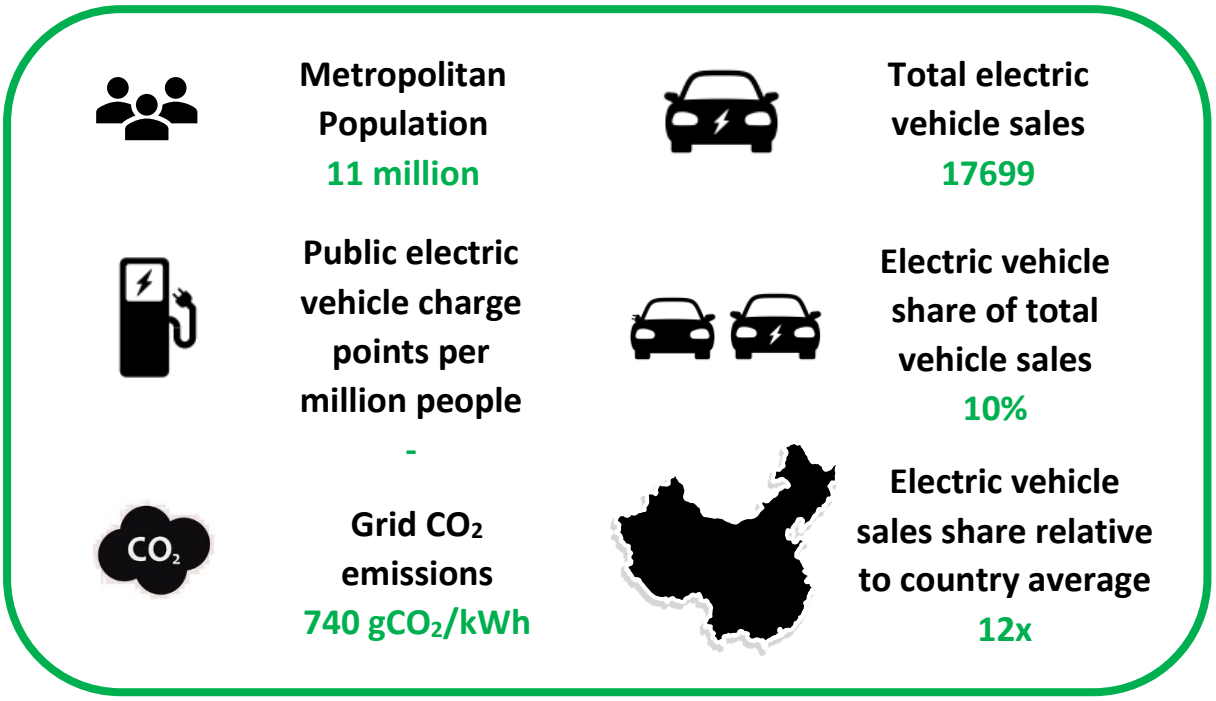
5.3.1 Shanghai, China (2015-2016)



Shanghai city holds the record for greatest EV adoption in the country. It ranks as the leading city globally in terms of EV sales. The EV revolution has been given impetus in Shanghai as it was conferred the status of "International EV Demonstration City" by the Chinese government. The city has a designated "EV Demonstration Zone" that is part of the Jiading District. The zone acts as a platform for congregation and communication between the EV stakeholders.

The city EV goals have been supported with a number of central and regional level subsidies and tax exemptions on EV purchase. The city government has established numerous public charging stations and has also planned to deploy fast charging stations in the near future. Subsidy has been made available to businesses that aspire to enter the EV charging scene. Shared e-mobility has been encouraged through programs like "EVCARD" and also through the electrification of public bus fleets.

5.3.2 Shenzhen, China (2015-2016)

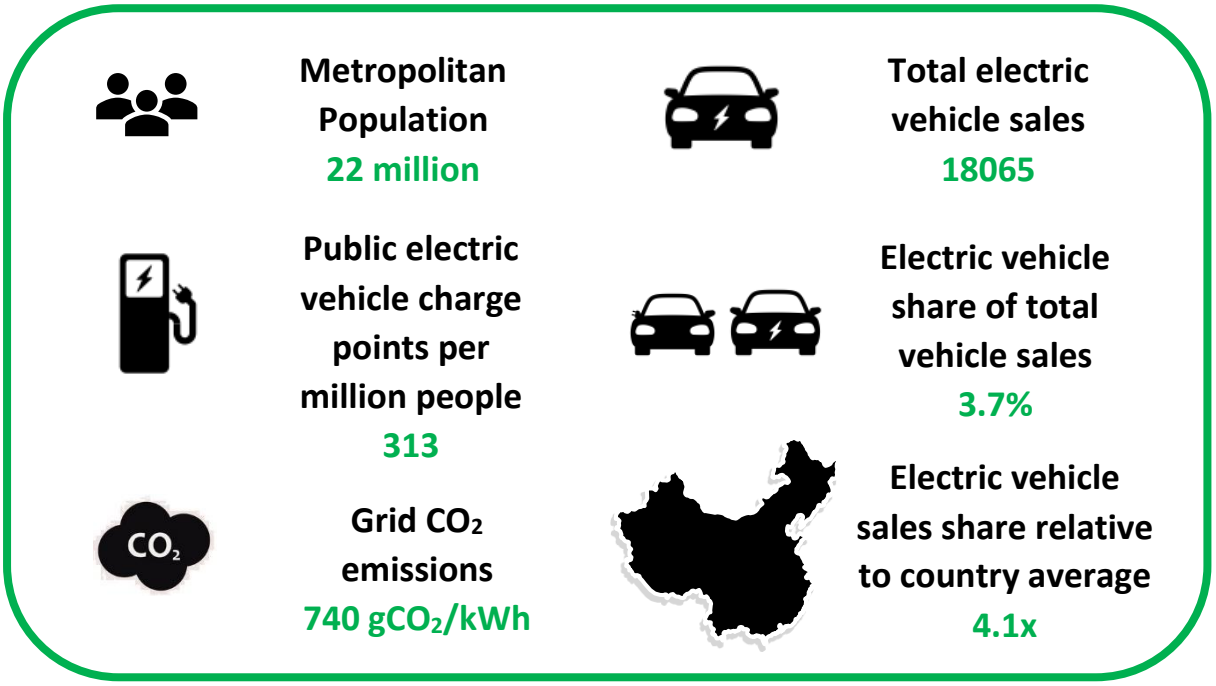


Shenzhen has organized a variety of local schemes for EV adoption and establishment of charging infrastructure. Close to 500 million yuan was spent by the Shenzhen government per year from 2009 to 2015 for subsidization of EV cars. The city has further committed to invest 5 billion yuan on charging facilities, EV purchase subsidies, and EV adoption policies, in 2015.

Apart from the fiscal incentives, Shenzhen has also provided other incentives such as preferential parking spaces and registration relaxations for encouraging EV uptake.

The city is one of the pioneers in the world for electrification of bus fleets. BYD, one of the leading EV manufacturers, is headquartered in Shenzhen.

5.3.3 Beijing, China (2015-2016)



Battery electric vehicles dominate the EV market in Beijing due to EV purchase subsidy that is not applicable to plug-in hybrid vehicle models. Beijing has placed restrictions on new vehicle registrations to reduce congestion and traffic in the city. Electric vehicles have been exempted from these restrictions.

The city has launched various consumer awareness campaigns, prominent of which is “Electric Vehicle into Community”. Beijing has established a “New Energy Vehicle Experience Center” which informs the public regarding new energy vehicles and permits test drives in BAIC electric vehicles. The city also has “Beijing New Energy Vehicle Promotion Center” and “Beijing Auto Museum” which hold EV test drive programs to raise awareness. Private and public car fleet electrification initiatives have also been implemented by the Beijing government.

5.4 EV Rollout Implication for SAARC Countries

5.4.1 Potential Barriers for EV rollout in SAARC

- In order to promote EVs, the SAARC states will have to bear large expenses for establishing EV charging infrastructure; given their relatively poorer economic status, the countries might have to rely on foreign aid and grants for this purpose. EVs are more expensive compared to the average fuel-driven vehicles deterring the price-sensitive consumers of the SAARC states from opting for EVs.
- The power sectors of most of the SAARC nations are plagued by the issues of insufficient electricity generation, weak transmission & distribution networks and inadequate electricity demand balancing, which critically affects the success of EV charging infrastructure that is heavily dependent on reliable and quality power supply.
- The SAARC nations lack proper regulatory clarity for EV adoption, discouraging private sector investment and entrepreneurship.
- EV adoption would also require appropriate technical expertise for EVSE setup, operation and maintenance activities, etc., which is not presently available in the SAARC states.
- Public awareness regarding EV technology remains low in the SAARC states, which can adversely affect EV uptake.

5.4.2 Market Formations

The EV markets in the SAARC countries are presently underdeveloped. Most of the automobile market share is captured by petrol, diesel or CNG run cars. Market formation for EVs in the SAARC nations can be explored through incentives to the consumers, EV manufacturers, EV dealers and the EV charging companies. The incentives can include fiscal incentives in the form of tax concessions, funding, discounts, etc. and also regulatory incentives such as encouraging public-private-partnerships for EV charging, EV electricity tariff, etc. Facilitating research and development and manufacturing initiatives for EV technology and corresponding standards would also drive the EV market formation for the SAARC states.

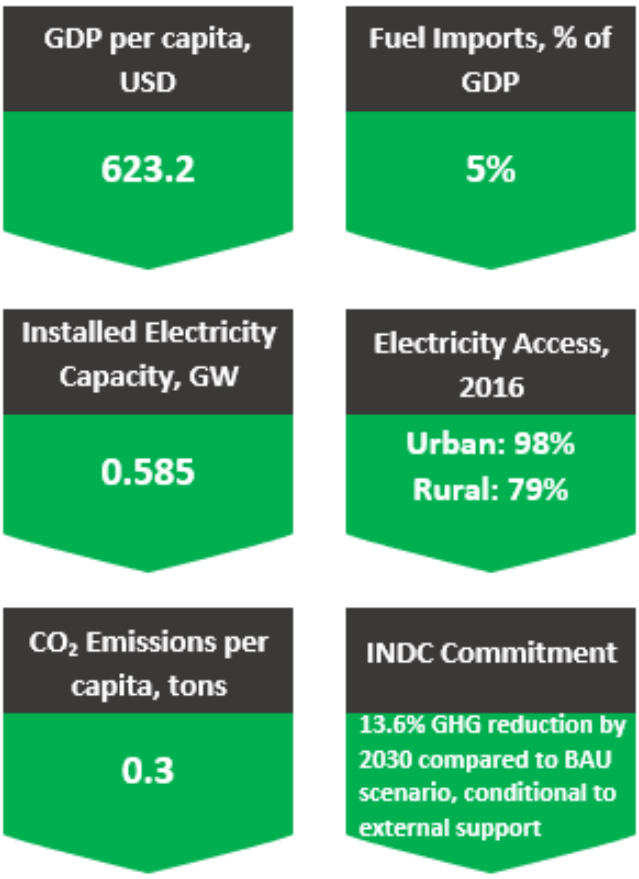
5.4.3 Public Transport

Public transport is the lifeline for transport services in the SAARC nations. The main sub-segments to be targeted can include the buses, taxi fleets and three wheelers, which are the most common means of transport in SAARC. Targeting these segments for electrification would serve the dual purpose of e-mobility as well as shared mobility. Electrified public transport would be more economically attractive to the consumers owing to lower expense and it will also bring down the per capita GHG emissions. For the purpose of electrification of public transport, the transport authorities, municipal corporations, power distribution companies and EV manufactures should be involved.

6. Afghanistan: EV Scenario

Afghanistan is a slow growing economy with a GDP growth rate of 2.6% in 2017; while the government has strived towards sustainable economic development, the country has been marred by frequent wars that have hindered the rate of progress. The nation depends on foreign aid and donations received through various bilateral grants from organizations such as ADB and the World Bank. The Afghan economy is driven primarily by the service sector, which accounts for 51.6% of GDP share. Like the other countries in the world, Afghanistan has begun to face the adverse effects of climate change; while Afghanistan is comparatively a low GHG emitter as compared to other nations, the localized effects of the pollution have been felt. The transport sector is one of the major sources for the GHG emissions in Afghanistan. Electric vehicle adoption would serve to address the issue of rising GHG emissions while also providing relief to the trade deficit caused by massive transport fuel imports.

6.1 Country Profile[14]



Despite political unrest, Afghanistan managed to achieved a GDP of USD 20.27 billion in 2017. Afghanistan has relied on the service sector for economic growth. In comparison, Agriculture and Industry sector have recorded lower GDP shares: 23% and 21% respectively.

The energy sector in Afghanistan is dependent on fuel and electricity imports as its lifeline for energy requirements and maintaining high electricty access. Despite its installed electricty capacity of 0.585 GW, the nation imports 70-80% of its power; expenditure on fuel imports amount to approximately 5% of the GDP.

With increasing energy consumption, the CO2 emissions have reached 9.8 million tons. The Afghan government hence ratified the COP21 Agreement and it also committed to decrease its GHG emissions by 13.6% till 2030, conditional to the availability of external support.

[14] Unstats; Afghanistan Statistical Yearbook 2016-17; CIA Factbook; SAARC Primary Findings; World Development Indicators

6.2 Electricity Generation and Distribution Network Profile

Generation: Ministry of Energy and Water (MEW) governs the power sector while Da Afghanistan Breshna Sherkat (DABS), is responsible for controlling & operating it**.** Afghanistan has an installed generation capacity of 650 MW of which 585 MW is active; 325 MW of the installed capacity is hydropower, 321 MW is thermal (including gas) while the remaining 139 MW is from renewables (solar and wind). Afghanistan's renewable energy potential is estimated to be greater than 300,000 MW, contituting of solar (222,849 MW), wind (66,726 MW), hydro (23,310 MW) and biomass (4,000 MW). There are nearly 3024 MW of projects that are planned till 2024.[15] In 2015-16, Afghanistan generated only 23% of its own power (1307 GWh) and imported 77% (5761 GWh) from Uzbekistan, Tajikistan, Iran and Turkmenistan.[16]

Distribution: Afghanistan has nine distribution zones serving a total of 1508008 customers. The low voltage and medium voltage distribution network lengths were 7497.1 km and 5920.92 km respectively in 2017. There were a total of 13639 distribution transformers with a cumulative capacity of 3484532 kVA. The average distribution losses in Afghanistan were 22.7%. The summer peak load and winter peak load for Afghanistan were 950 MW and 870.2 MW respectively in 2017-18. The gross electricity demand is forecasted to rise to around 18409 GWh and the peak load to about 3500 MW by 2032.[17] A number of distribution network expansion projects have been planned to augment the distribution capacity by 485.5 MW by 2024; in a first for Afghanistan, supply and installation of 7000 prepaid smart meters has also been proposed for the Herat district.

Kabul Electricity Tariff Rates:

Type	Level	USD/kWh
Apartments	0 – 200 kWh	0.033
	201 – 400 kWh	0.05
	401 – 700 kWh	0.08
	701 – 2000 kWh	0.12
	2001 and higher	0.13
Commercial	-	0.16
Government	-	0.18
NGOs	-	0.16
Registered Factories	-	0.09
Unregistered Factories	-	0.16

Table 15 Kabul Electricity Tariff Structure

EV Potential: Afghanistan has large renewable energy potential that can be tapped for providing electricity for EV charging.

[15] Renewable Energy Roadmap for Afghanistan RER 2032
[16] SAARC Primary Findings
[17] Islamic Republic of Afghanistan: Power Sector Master Plan

6.3 Transport Sector Profile[18]

Ministry of Transport is the chief governing body for the Transport sector in Afghanistan. Transport, Storage and Communication sector of Afghanistan recorded a 4.9 percent growth in 2016-17.

Transport & Storage sector contribution to GDP	**18.1 %**
Percentage of Gross Value Added by the Transport, Storage and Communication sector	**25.22%**

Afghanistan consumed a total of 3,619 TTOE in 2014, out of which the Transport sector accounted for 53.5%; the Road Transport sub-sector consumed the largest share of energy: 1617 TTOE.

95.3% of the total petroleum products consumption in Afghanistan in 2014 was for road transport.

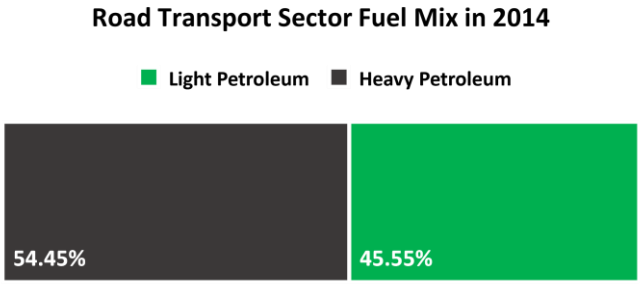


Figure 32 Road Transport Sector Fuel Mix for Afghanistan in 2014

Transport Sector Energy Consumption in 2014 in Thousand Tons of Oil Equivalent (TTOE)		
Road Transport	**Rail Transport**	**Air Transport**
1,617	**268**	**52**

Table 16 Transport Sector Energy Consumption for Afghanistan in 2014

Fuel, Vehicle and Vehicle Part Imports

- Petroluem product imports for the transport sector accounted for approximately **USD 1.008 billion**, which is **15%** of total imports and **5% of the GDP** in 2016-17.
- Due to lack of vehicle manufacturing facilities in Afghanistan, vehicle imports have risen considerably over the years. In 2016-2017, close to **USD 73 million** was cumulatively spent on bus, passenger car, motorcycle, other vehicles and battery imports.

GHG Emissions: As of 2011, the country emitted an estimated 35 million metric tons ($MtCO_2e$) of greenhouse gases. As of 2005, Afghanistan's GHG emissions originated from agriculture (52.5%), land use change and forestry (32.8%), and energy (7.3%). The transport sector ranked 4th, accounting for 5.8% of total GHG emissions. However, the current transport sector emissions has grown exponentially due to vast expansion in the fleet of registered motor vehicles has grown rapidly, at an average annual rate of 17% during the period since 2005, so that GHG emissions may have increased accordingly.

[18] Undata; Afghanistan Statistical Yearbook 2016-17, SAARC Energy Data Book; Afghanistan Transport Sector Master Plan Update (2017–2036) Asian Development

Number of Registered Vehicles by type in Afghanistan in 2016-2017	
Lorry	**3,15,194**
Bus	**1,06,616**
Milli Bus	**331**
Motorcycle	**2,70,185**
Passenger Car	**9,75,635**
Taxi	**1,81,238**
Rickshaw	**18,820**
Foreigner's Vehicles	**38,919**

The total number of registered vehicles in Afghanistan for 2016-17 is 1,906,938.

Nearly 700,000 vehicles operate within Kabul, the capital city of Afghanistan as of 2015.

Passenger cars are the most popular vehicle (51.2%), after which come lorries (16.5%), motorcycles (14.2%), taxis (9.5%) and buses (including milli bus) (5.6%).

Table 17 Number of Registered Vehicles by type in Afghanistan in 2016-2017

6.4 Status of EV implementation in Afghanistan

The Electric Vehicle revolution has not yet hit Afghanistan; The government has not introduced any policy or regulation for electric vehicles and there is no record of electric vehicle deployment as of now. Even the Afghanistan Transport Sector Master Plan Update (2017–2036) released by the Asian Development Bank for the Government of Afghanistan has focussed majorly on improvement of roads, railways, urban transport, civil aviation, trade logistics and all institutions related to transport infrastructure and operations, without mention of EVs. However, recently, ADB has partnered with a Hyderabad-based startup, Gayam Motor Works (GMW) for piloting an electric three-wheeler project in Kabul, which may instigate EV penetration in the Afghan market.[19]

6.5 Key Benefits of EV deployment in Afghanistan

Afghanistan is plagued by the ill effects of climate change, primarily due to the large GHG emissions recorded by its transport sector; Kabul is listed as one of the most polluted cities in the world owing to declining air quality from vehicle emissions. EVs would directly contribute to reducing the traffic congestion and poor air quality in the nation.

EVs will reduce the dependence of Afghanistan on expensive fuel imports and decrease the trade deficit for the country while at the same time diminishing the country's heavy reliance on foreign grants, donations and loans.

Provision of clean, affordable and comfortable transport facility for the Afghan population.

[19] Blogpost: Battery swapping can propel India's electric car revolution
Website: https://blogs.adb.org/blog/battery-swapping-can-propel-india-s-electric-car-revolution

6.6 Key Challenges for EV uptake in Afghanistan

The high investment cost of EVs and EVSE equipment is a major cause of detriment for EV adoption especially in Afghanistan; the country might require foreign funding for EV adoption.

The main focus of the government has been on improving transport infrastructure however there has been no mention of electric vehicle in any of the plans, policies and regulations released.

Afghanistan imports the major portion of its electricity from its neighbouring nations; while electricity access is high in the country, the unavailabilty of consistent, reliable and quality power supply persists and there is a significant latent electricity demand that is not met. EVs might add to the burden of electricty demand for the country, raising electricity imports. Plus, the region has hilly terrain and very cold climate that would also wold act as a detterent to EV uptake

Lack of public awareness and technical expertise regarding electric vehicles and their adoption, coupled with the political instability in the nation caused due to frequent wars and terrorism is a major hurdle for electric vehicles to kick off in Afghanistan.

6.7 ISGF Proposition for EVs in Afghanistan

Energy consumption in the industry sector amounted to 1,170 TTOE in 2014 while that of households was 448 TTOE and that of the agriculture segment was 9 TTOE. The transport sector, specifically the road transport sector, is the most energy intensive for Afghanistan, contributing to 44.7% of the energy demand in 2014; the GHG emission rate by the transports sector has paralleled the energy demand growth. This has had an adverse impact on the urban environment in terms of air quality. Kabul, the capital of Afghanistan and one of the swiftest growing cities in the world, has been ranked as one of the most polluting cities in the world.

ISGF has prepared a possible electric vehicle approach that Afghanistan can take to address the issue of climate change in the country. The target vehicle segments for electrification chosen are: Passenger Cars, Taxis, Buses (including milli buses) and Motorcycle; the targets have been chosen considering the share of registered vehicle population (passenger cars), push for shared mobility (taxis and buses) and the global success rate in e-mobility adoption (electric two wheelers). The approach considers three scenarios for vehicle electrification:

1. Scenario 1: 10% of the vehicles replaced with electric vehicles
2. Scenario 2: 50% of the vehicles replaced with electric vehicles
3. Scenario 3: 100% of the vehicles replaced with electric vehicles

Premises:

- Fuel prices in Afghanistan as of 22nd October, 2018:
  Petrol: USD 0.76
  Diesel: USD 0.72
- Commercial Electricity Tariff has been considered for EV public/private (p/p) charging: USD 0.16/kWh
- Residential Charging is considered for 201-400 kWh range (only for two wheelers aka 2Ws): USD 0.05
- The Nissan Leaf having 40 kWh battery and 400 km/single charge has been considered for passenger cars and taxi electrification; the Motorcycle segment is assumed to be of 100-125 CC capacity and the replacement electric 2W has comparable specifications; 100 kWh electric bus is considered for bus electrification with an energy efficiency of 130 kWh/100km.
- As given in the "*National Implementation Plan for The Stockholm Convention on Persistent Organic Pollutants"* by the Government of the Islamic Republic of Afghanistan, the ratio of diesel passenger cars to petrol passenger cars is taken as 73:27 (for taxi, the ratio is also assumed to be 73:27). The daily km covered for passenger cars, buses, taxis and motorcycles is taken as 30 km, 50 km, 60 km and 30 km respectively. The mileage (km/litre) for diesel cars (including taxi), petrol cars (including taxi), diesel buses, and motorcycles is taken as 20, 16, 1.5, and 35 respectively.
- the electric 2Ws are considered to have a 1.152 kWh battery, with a range of 70km/Charge (as per Hero Electric Optima Plus Electric Bike specifications).
- The GHG emission rate per vehicle type is assumed as follows:
  Petrol Passenger cars/taxis: 0.103 $kgCO_2e/km$
  Diesel Passenger cars/taxis: 0.103 $kgCO_2e/km$
  Buses (including millibuses): 0.015161 kg CO_2/pax-km (0.455 kg CO2/ km considering 30 passengers)
- Motorcycles: 0.029 $kgCO_2e/km$

Analysis results:

Scenarios	Annual GHG reductions (million tCO_2e)	Annual fuel imports reduction (million USD)	
		Diesel	Petrol
Scenario 1: 10% replacement	0.2	88.7	47
Scenario 2: 50% replacement	1.02	443.54	235.2
Scenario 3: 100% replacement	2.05	887.1	470.4

Table 18 ISGF Proposition for EVs in Afghanistan: GHG and Fuel Import Annual Reductions

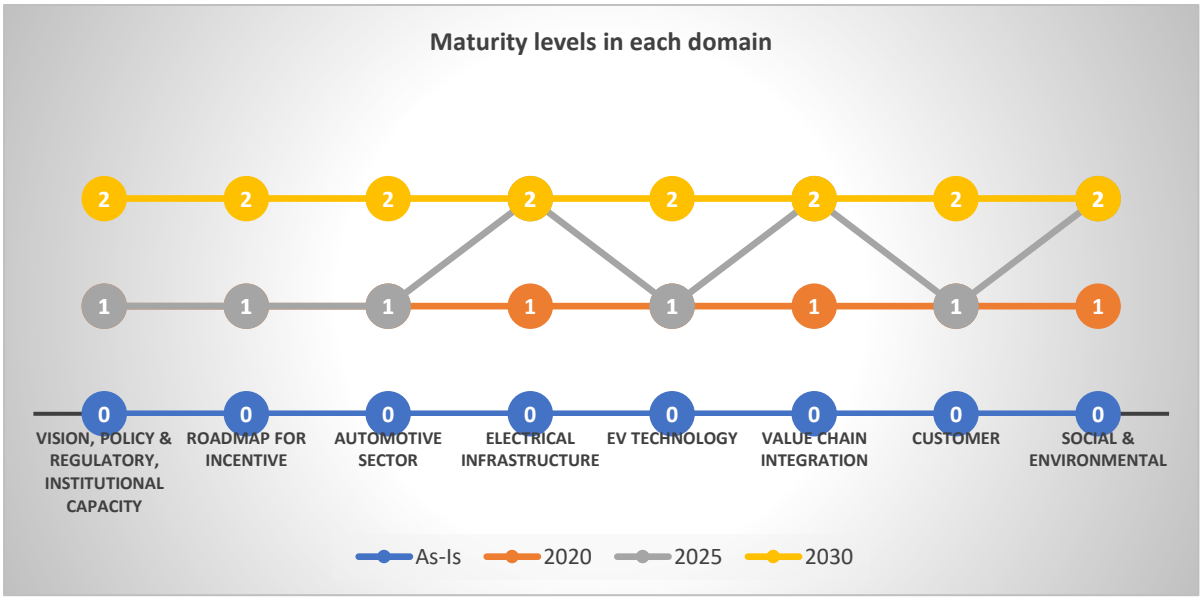
Complete electrification of the target vehicle population will result in 1,357.5 million USD reduction in the fuel consumption, which amounts to nearly 6.7% of the GDP; annual GHG emission reductions is estimated to be approximately 2.05 million tCO_2e. The monetary benefit for the different vehicle segments is listed as below:

Savings per diesel passenger car, % of current fuel expense	Savings per petrol passenger car, % of current fuel expense	Annual charging expense per electric passenger car (USD)	
55.6%	66.3%	144	
Savings per diesel taxi, % of current fuel expense	Savings per petrol taxi, % of current fuel expense	Annual charging expense per electric taxi (USD)	
46.7%	66.3%	288	
Savings per diesel bus, % of current fuel expense		Annual charging expense per electric bus (USD)	
56.7%		3,120	
Savings per motorcycle, % of current fuel expense (residential charging)	Savings per motorcycle, % of current fuel expense (p/p charging)	Annual residential charging expense per electric 2W (USD)	Annual public charging expense per electric 2W (USD)
96.2%	87.87%	7.4	23.7

Table 19 ISGF Proposition for EVs in Afghanistan: Annual Savings for Consumer

6.8 EVMM Assessment & Recommendations for Afghanistan

Based on the As-Is scenario (previous chapters), we have assessed[20] the existing conditions in each of the eight domains and identified the levels (as explained in Executive Summary) that they ought to attain in future years i.e. 2020, 2025 and 2030. We have also provided summary recommendations to ensure a sustainable EV adoption from one level to the next. A graphical representation showing the As-Is maturity level and the maturity level they need to attain in future is depicted below.[21]



[20] A detailed assessment requires stakeholder interviews

[21] "0" means default level which indicates that the basic minimum initiatives have been undertaken in this domain

Domain	By 2020	By 2025	By 2030
Vision, Policy & Regulatory, Institutional Capacity	***Target Maturity Level – 1*** • Current planning practice in Afghanistan follows a bottom-up approach with provincial authorities identifying the project. Planning in the transport sector needs to be improved and streamlined for which the new Ministry of Transport & Civil Aviation should be assigned as the apex body for transport planning and policy formulation in Afghanistan • Government must establish a road transport authority to facilitate implementation of transport sector policies, plans and programs in Afghanistan • Sustainable transport division focusing electric vehicle should be formed and should include members from Ministry of Transport & Civil Aviation, Ministry of Urban Development and Ministry of Public works which can facilitate in developing future deployment strategy for EV, planning for charging station installation, consumer awareness etc. • Government should seek grants, funds and foreign loans from development banks and other institutions for the purchase and deployment of electric three wheelers and buses in pilot projects	***Target Maturity Level – 1*** • Sustainable Transport Division along with Road Transport Authority should come up with a nation-wide mission on electric vehicle and a EV specific policy with a defined target and deadline, to send clear signal to both OEMs & consumers to invest in and adopt EV respectively • An EV cell within DABS also need to be formed for assessing grid impact and upgradation requirement for implementation of charging stations • The government should collaborate with the local municipal, provincial authorities and foreign development institutions for deploying pilot project on electric buses and three wheelers in major cities like Kabul, Herat, Mazar-i-Shariff, Kandahar etc. • Government should encourage adoption of electric two wheelers and four wheelers in urban areas, that presently have major vehicle share, by providing subsidy schemes with support from banks and international financial institutions. With gas as fuel and insufficient electricity production to meet the domestic demand, Afghanistan can opt for hybrid vehicles for a shorter period till the electricity supply is increased or convert its transportation system into electric so that the gas from the transportation sector can be utilized for incremental electricity generation	***Target Maturity Level - 2*** • Government should make electric vehicle mandatory in certain city centres, government offices, embassies and major market areas • Based on the success of pilot projects, the Government (Ministry of Transport & Civil Aviation) along with the municipalities, EV adoption city targets should be identified and implemented in a phased manner, primarily focussed on public transportation including buses and three wheelers followed by two and four wheelers by 2035 • Government should make mandatory the installation of charging stations in bus depots and terminus, parking lots and should request utilities to evaluate the same to promote the usage of electric buses for both intracity and intercity travel • Government to streamline the third party charging process by providing guidelines • Government should notify guidelines on electrification of railway in Mazar-i-Sharif, Herat and Faryab province

		• Tariff policy by recognising EV as a separate group of consumers to be developed and aspects of Time of Use pricing to be introduced to smoothen the load curve	
Roadmap for Incentive	***Target Maturity Level – 1*** • Subsidised import duty on the imported electric vehicle • Subsidized registration charges for one year for electric three and two wheelers • Subsidized parking charges for electric vehicle • Reduced property tax for businesses, hotels using electric vehicle and installing charging stations	***Target Maturity Level - 1*** • Government support for purchase and deployment of electric three wheelers and buses as per the targets for the respective cities as well as for the pilot projects for taxis • Low interest loans from banks on electric two and four wheelers • Government support (support from development banks, financial institutions) through subsidy on establishment of charging station by third party	***Target Maturity Level - 2*** • Subsidized registration charges for one year for passenger cars as well as subsidies on CAPEX through various schemes like 20% subsidy for first 5000 purchases and 10% on next 10,000 etc. • Duty free import of plant and machinery for setting up of assembly unit on one time basis
Automotive Sector	***Target Maturity Level - 1*** • Electric two wheelers and cars to be used on personal basis or for business purposes can be imported from India, China or Japan • Battery and charging stations to be imported from countries like India or China for the pilot projects	***Target Maturity Level - 1*** • Electric buses and electric three wheelers to be deployed on pilot basis need to be imported from countries like India and China with services for these vehicles provided by the OEMs for few initial years. Afghanistan is primarily a second-hand automobile market. Hence, the electric buses imported from China can include used electric buses • Used electric passenger cars and the corresponding battery and charging stations for pilot projects may be imported from India, China, etc. for electric taxi pilot project	***Target Maturity Level - 2*** • Afghanistan can set up small assembling units for electric two and three wheelers with foreign companies. • Servicing facility for charging stations can be provided by OEMs and local capacity development on O&M of charging stations through training and skill development
Electrical Infrastructure	***Target Maturity Level - 1*** • DABS to expand current installed electricity generation capacity of 585 MW by phase-	***Target Maturity Level - 2*** • Upgradation of electrical infrastructure in terms of meter room, laying of cables, supply	***Target Maturity Level - 2***

	wise exploitation of 300 GW RE potential. The augmented power capacity can support the additional EV charging load • DABS to assess the availability of spare capacity in distribution transformers in areas having potential for charging station implementation at bus depots and terminus, three wheeler parking spaces, etc. in major cities • DABS to assess the power availability and peak demand to figure out the EV demand the load network can sustain with the given supply including power import	meters etc. in bus depots and terminus, three wheeler parking spaces, etc. in major cities by DABS for installation of charging stations • DABS should seek low cost loans and donations for the upgradation expense	• Improvement in power quality through deployment of technologies like harmonic filters, static compensators etc. • Upgradation expense can be shared by OEMs or third party service providers of charging stations • Planning on electrical infrastructure for the proposed electrification of railway corridors
EV Technology	***Target Maturity Level - 1*** • As the electric buses and three wheelers for the pilot projects will most likely be imported from China and India, GB/T, CHAdeMO or CCS2 should be adopted	***Target Maturity Level - 1*** • Retrofitting of existing three wheelers which are operating for a long time (already aid up their capital for existing three wheelers) into electric three wheelers	***Target Maturity Level - 2*** • Government along with international research labs, technology institutes, private companies should work on optimization of lithium extraction process. Afghanistan getting the status of Extractive Industries Transparency Initiative (EITI) will facilitate the above mentioned activity
Value Chain Integration	***Target Maturity Level – 1*** • Big business houses like Watan Group, Pamir Airways, East Horizon Airlines, and donor agency offices like ADB, World Bank, USAID etc. can use EV two wheelers and four wheelers for their own use and can set up EVSE in their areas of business operations • Hotels, hospitals and companies to pool their CSR funds for financing of electric buses, four wheelers and charging stations on pilot basis	***Target Maturity Level - 2*** • Government building and offices to install charging stations in their premises for EV usage • Battery swapping model can be used for three wheelers with the help of a Battery Leasing Agency which will charge the batteries on a large scale and facilitate the three wheelers by providing a charged battery against a specified fee. The Battery Leasing Agency may be formed by the battery or EVSE supplier	***Target Maturity Level - 2*** • Pilot project charging stations should be established at prominent bus routes and areas having high three wheeler concentration • Projects to be allocated to renewable energy companies must include a clause of implementing one or two public charging stations outside their plant's premises which can operated

		• Initially DABS along with Ministry of Transport to invest in setting up charging infrastructure for electric buses in bus depots for overnight charging and in bus terminus for fast charging during the day with the cost being treated under regulated capex route	
Customer	***Target Maturity Level - 1*** • Create awareness regarding electric vehicle pilot programs and encourage the population to use electric buses and three wheelers stating various benefits	***Target Maturity Level - 1*** • Government vision on electric vehicles is communicated to customers • All the incentives and benefits for adopting or cruising an electric vehicle to be communicated properly to customers	***Target Maturity Level - 2*** • Time of use pricing and its benefits to the customers must be displayed to make them aware of their benefits
Social & Environmental	***Target Maturity Level - 1*** • Organizing EV awareness programs, conduct workshops and seminars to make people aware of the benefits of EV adoption in terms of improved air quality, health benefits	***Target Maturity Level - 2*** • EV deployment mainly the buses and commercial taxi fleets can also provide opportunity to the existing workforce by providing them adequate training on O&M skills	***Target Maturity Level - 2*** • The deployment goals by the government will also help to bring electricity in the remote areas which can help in improving the living standard of the people in those areas

7. Bangladesh: EV Scenario

7.1 Country Profile

7.1.1 Demography and Economy

Bangladesh is low-lying, mainly riverine country located in South Asia with a population of about 160 million, growing at an annual rate of about 1.3% over the last five years. As of 2016, with an area of about 147 thousand sq. km., the population density of Bangladesh is 1,083 people per sq. km[22]. More than two thirds of the population live in the rural areas with urbanization growing steadily[23] over the last decade.

GDP of Bangladesh grew by 7.1% to USD 221.4 billion in 2016 with its per capita value of USD 1359. GDP contribution (%) from electricity sector is 0.16% and Transport sector is around 0.67%. Inflation dropped from 6.4% in 2015 to 5.2% in January which was supported by domestic output growth, accommodative monetary policy and controlled global commodity prices. A brief country profile has been represented in the below table.

Parameters	2016
General Parameters	
Population, million	**159.9**
Population growth rate, % (2011-16)	**1.3**
Total Surface area, '000 sq. km	**147.6**
Population density, persons per sq.km of total surface area	**1083.1**
Macro-economic parameters	
GDP, USD billion	**221.4**
GDP per capita, USD	**1359**
Current Account Balance, % of GDP	**1.7**
Debt, % of GDP	**35.8**
Inflation, %	**5.2%**

Table 20 Demography and Economy Parameters in Bangladesh

Bangladesh is one of the world's leading exporters of textiles, garments, fish, seafood and jute. The majority of employment is in agriculture, comprising nearly 40% of the workforce and contributing around 14.23% of the country's GDP. The country has diversified its economy through a growing industrial sector, which contributes 33.66% of GDP. Currently, service sector has been the major contribution to GDP with share around 52.11[24]%. The major imports commodities of Bangladesh are petroleum products, food stuffs, cement, machinery and equipment etc.

[22] 2016 Statistical Year Book Bangladesh, Bangladesh Bureau of Statistics, May 2017
[23] Statistical Pocket Book, Bangladesh 2016, Bangladesh Bureau of Statistics, March 2017
[24] Economy of Bangladesh, Wikipedia 2018

7.1.2 Energy and Climate

The Government of Bangladesh (GoB) recognizes that the pace of power development has to be accelerated in order to achieve overall economic development targets of the country and avoid looming power shortages. To meet the increasing demand for power, the GoB has undertaken massive steps towards increasing the power supply in the short span of time by encouraging private sector power production as well as import of power from neighboring countries. The Government of Bangladesh has set a target to bring the whole country under electricity coverage by 2021.

The below table shows the Bangladesh power sector at a glance (in 2017):

Power Sector Overview	
Power Plants	**111.0**
Expired Plants	**3.0**
Grid Capacity (MW)	**15,821 (Including Captive)**
Highest Generation (MW)	**9,507 (18 Oct 2017)**
Power Import (MW)	**660**
Total Consumers (million)	**26.7**
Transmission Line (Ckt Km)	**10,436**
Distribution Line (Km)	**412,000**
Grid sub-station capacity (MVA)	**30,993**
Access to Electricity (%)	**80**
Per Capita Generation (kWh)	**433 (Inc. captive) (30 June 2017)**
System Loss (%)	**12.2**

Table 21 Bangladesh Power Sector Overview

Source: http:// www.powerdivision.gov.bd (19 September 2017)

According to 'Power System Master Plan, 2010 (PSMP)'[25], Bangladesh targets power generation up to 40,000 MW in 2030.

Year	Target (MW)
2016	**~16,000**
2021	**24,000**
2030	**40,000**

Table 22 Bangladesh Power Generation Target by 2030

Present Structure of Power Sector[26] in Bangladesh includes Apex Institution like Power Division, Ministry of Power and Energy & Mineral Resources (MPEMR). Bangladesh Energy Regulatory

[25] https://www.unescap.org/sites/default/files/Mohammad%20Hossain%20-%20Bangladesh%20Presentation.pdf

[26] https://www.usea.org/sites/default/files/event-file/493/overviewofbpdb.pdf

Commission (BERC) is the regulatory body of Bangladesh. Power generation bodies includes Bangladesh Power Development Board (BPDB), Ashuganj Power Station Company Ltd. (APSCL), Electricity Generation Company of Bangladesh (EGCB), North West Power Generation Company Ltd. (NWPGCL), Independent Power Producers (IPPs) while Power Grid Company of Bangladesh Ltd (PGCB) looks for Transmission. Bangladesh Power Development Board (BPDB), Dhaka Power Distribution Company (DPDC), Dhaka Electric Supply Company Ltd (DESCO), West Zone Power Distribution Company (WZPDC), North-West Zone Power Distribution Co. (NWZPDC), Rural Electrification Board (REB) through Rural Co-operatives are the Distribution utilities in Bangladesh.

Bangladesh GHG emission (2012) from various sectors are shown in below figure. It is seen that agriculture is the main contributor with 39%, followed by energy sector contributing 33%, Land-use change and forestry (LUCF) contributing 31% and waste contributing 18%. The energy sector is the second highest emitter, with energy sub-sectors as follows: electricity and heat production (46%), other fuel combustion (21%), manufacturing and construction (20%), and transportation (14%)[27].

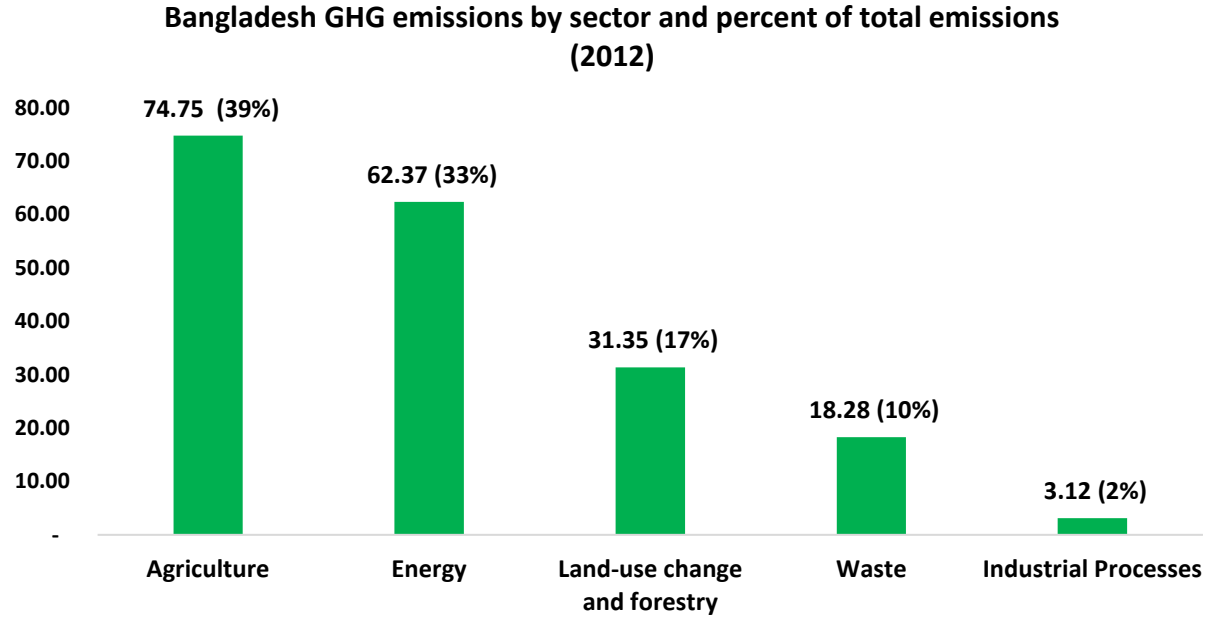


Figure 33 Bangladesh GHG emissions by sector and percent of total emissions (2012)
Sources: WRI CAIT 2.0, 2015; FAOSTAT, 2015
Note: Percentages do not add up to 100% due to rounding

Bangladesh's in its Intended Nationally Determined Contribution (INDC)[28], communicated its intent of an unconditional contribution to reduce GHG emissions by 5% from business as usual levels by 2030 (12 MtCO2e) from power, transportation, and industry. It pledges to increase its contribution to 15% reduction (36 MtCO2e), subject to international support, and pledges further mitigation actions in other sectors, also subject to additional international resources.

[27] World Resources Institute Climate Analysis Indicators Tool (WRI CAIT) 2.0, 2015.
[28] Ministry of Environment and Forests (MOEF), Government of the People's Republic of Bangladesh. Intended Nationally Determined Contributions. September 2015: http://www4.unfccc.int/submissions/INDC/Published%20Documents/Bangladesh/1/INDC_2015_of_Bangladesh.pdf

7.1.3 Automobiles and Transport Sector

7.1.3.1 Fossil Fuel Dependence

Petroleum sector is considered the most sensitive sector of economy. Macroeconomic indicators are highly sensitive to the price of petroleum products. The three oil distribution companies namely Padma Oil Company Limited, Jamuna Oil Company Limited, and Meghna Petroleum Limited procure, store, and market petroleum products all over the country from their main installations. The price and margin of the petroleum products is fixed by the Government on the basis of quantity sold. Fuel is used intensively in every sector including irrigation of agriculture sector, transportation sector and power production. The use of petroleum products in the country is varied. Petrol and diesel are the major fuels for transportation. Diesel is also widely used by farmers for irrigation, while kerosene is mostly used for lighting, especially by rural households without electricity. As a result, an increase in petroleum price directly influence the inflation and GDP of the economy. Transportation, power and agriculture sectors are the main fuel-demand driver of Bangladesh. According to BPC, the demand of petroleum products in our country stood at 5.26 million MT[29] in year 2015-16. The consumption of petroleum products in Bangladesh decreased by 1.23% in 2015-16 compared to the previous year. High Speed Diesel (HSD) and Furnace Oil (FOSH) drive 82.2% of total petroleum demand. A whole import dependency of fuel requires huge foreign exchanges that have a major impact on country's macro economy.

The major portion of imported petroleum is crude oil. Crude oil is refined through Eastern Refinery Ltd. (ERL), another subsidiary of BPC and distributed through its oil marketing companies namely Meghna Petroleum Ltd. (MPL), Padma Oil Company Ltd. (POCL) and Jamuna Oil Company Ltd. (JOCL). Currently, total industry storage capacity is 1,189,172 MT. ERL has the highest storage capacity (42.5% of total) as crude oil is refined through it followed by three distribution companies POCL (20.6%), MPL (18.1%) and JOCL (15.5%).

The Government of Bangladesh (GoB) was particularly keen on the energy and local air quality benefits. Since early 2000, they built and pursued the policy to encourage a fuel switch to CNG for motor vehicles, especially in the large cities. They have been successful in attaining its intended environmental and energy objectives through converting a major share of Dhaka's vehicles fleet to run on CNG and in reducing air pollution in the two largest cities, however, during the policy making, potential (adverse) impact i.e. dire traffic congestion was not considered. They increase the price difference between petroleum and CNG with CNG being made available at a low cost. The low prices increased vehicle travel and aggravated the already dire traffic congestion in Dhaka and Chittagong. Later on, GoB increased the price of CNG to combat the perceived additional traffic congestion (and potential future scarcity of natural gas.

[29] Comparative Analysis of Fuel-Oil Distribution Companies of Bangladesh by EBLSL,2017

7.1.3.2 Industry Overview and Major Players

Bangladesh has been producing auto-rickshaws since the 1980s and the local production of the motorcycle has begun in early 2000. Bangladesh is also manufacturing locally designed three-wheeler motor vehicle, Mishuk, utilizing an engine from Honda**.** Over the last two decades, as the use of vehicles has increased significantly with the increasing population, improved infrastructure along with the increased mobility of people from one place to another for jobs and improved living standard, the demand for automobiles has been also increasing in Bangladesh.[30]

In 4W segment, the sale of Toyota cars[31], imported from Japan, are constantly increasing in Bangladesh. In the case of 2W or motorbikes, the Indian brand Bajaj is most popular in Bangladesh. Recently Bangladeshi Brand Walton is also coming in focus (with annual production of 200,000 units) for motorcycles (Board of Investment Bangladesh, 2017). The market of Bangladesh is alluring to investors at home and abroad and has the potentiality of making a significant profit. There are foreign companies who are showing interest in investing in the automobile industry in Bangladesh. Many big companies like Tata Motors have come forward with investment initiatives. Tata Motors, in partnership with Bangladesh-based Nitol Motors, launched its Prima range of Heavy Commercial Vehicles (HCVs) in Bangladesh.

There were total 3,419,884 registered vehicles in Bangladesh up to 2017. Below chart shows distribution for different vehicle segments.

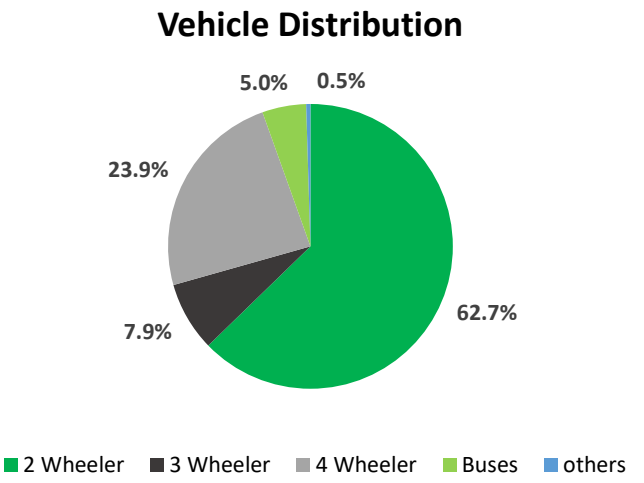


Figure 34 Vehicle Distribution in Bangladesh
Source: Bangladesh Road Transport Authority

In Bangladesh, around 80 percent of the cars are imported from Japan. According to the regulation of Bangladesh government, import of used cars, jeeps, microbus, minibus including other old vehicles & tractors are allowed. In Bangladesh, imported vehicle should not be more than four years old. It should be JAAI (Japan Auto Appraisal Institute) certified.

[30] Vol. - I Emerging Bangladesh Credit Rating, 2017
[31] Bangladesh Automobile Industry, ECRL Report, 2017

Products	Brand Name
Heavy Bus	Hino, Isuzu, Volvo, Scania, Hyundai, Tata, Mercedes Benz, Man etc.
Mini Bus	Hino, Mitsubishi, Isuzu, Toyota, Sawraj Mazda, Tata, Eicher etc.
Microbus	Nissan, Mitsubishi, Toyota etc.
Heavy Truck	Hino, Tata, Bed Ford, Isuzu, Ashok Leyland
Mini Truck	Hino, Tata, Mitsubishi, Isuzu, Toyota, Eicher, Sawraj, Mazda etc.
Motor Car	Toyota, Mercedes-Benz, Nissan, Mitsubishi, Ford, Daewoo, Proton Saga, Proton Wira, Hyundai, BMW, Maruti Suzuki etc.
Four Wheels	Toyota, Tata, Mitsubishi, Nissan etc.
Auto Tempo	Bajaj, Krishan
Scooter	Bajaj, Krishan
Motor-cycle	Honda, Xingfu, Jialing, Zongshen, Yamaha, Suzuki, Hero, TVS Victor, Bajaj, Vespa etc.
Light & Heavy Commercial Vehicles	Nissan, Daewoo, Hyundai, Volvo, Ashok Leyland, Tata, Hino, Mitsubishi etc.
Farm & Agricultural Vehicles	Hyundai, Daewoo, Dongfang, Dong- chang etc.

Table 23 Major Automobile Companies by Vehicle Category in Bangladesh
Source: Bangladesh Automobile Industry, ECRL Report, 2017

7.1.3.3 Transport Sector

Transport sector contributes up to 15% of CO2 emissions from energy-related sectors. The majority of this (around 70%) comes from trucks and buses, along with around 20% from cars. Roads are the backbone of Bangladesh's transportation sector, carrying over 80% of national passenger traffic, mostly via privately operated diesel buses. Below table shows a brief view of Transport sector in Bangladesh.

Roadways	
Road Network (million km)	21,322
Total passenger traffic handled through road (%)	80%
National Highways (km)	3,813
Regional Highways (km)	4,217
Railways	
Total route length (km)	2,877
Goods carried (million tonnes)	2.5
No. of Passengers travelling per annum (million)	67

Airways	
No. of airports	**12**
No of International Airport	**3**
Air passenger traffic per annum (million)	**23**
Cargo traffic handled through domestic and international route (million tonnes)	**42,221**
Waterways	
Cargo traffic handled at port (million tonne)	**22.71**

Table 24 Bangladesh Transport Sector at a glance

Bangladesh is a riverine country with ferry boats being the major means of communication in the rural area. Engine boats used for transporting people from one side of a river bank to the other use diesel as the fuel. Solar power boat is proposed to avoid environmental damage.[32]

7.1.4 Proposition for EVs in Bangladesh

In 2016, around 78[33] percent have the access to electricity whereas the decade ago this percent was less than 50, thereby underlining the impressive progress made by the Government of Bangladesh in providing power to all its citizens, which it aims to do by 2021.

The performance of Bangladesh's energy sector compares favorably with that of its larger South Asian neighbors, at least when it comes to collection efficiency (above 90 percent) and distribution and transmission losses (together around 14 percent).

However, considerable challenges remain. Power cuts and the low reliability of the power supply are the major problem of the grid extension. Power outages are still common here, leading to losses of about (2-3) % of the country's gross domestic product, or GDP. Energy supply is limited due to inefficient technology, poor operational practices, and inadequate maintenance. There is also the shortage of natural gas, which fuels about 70 % of Bangladesh's power needs.

This shortage of natural gas means many energy generators have turned to inefficient, diesel and fuel oil. This led to increase in the cost of power in Bangladesh and led to government subsides of $500 million to $600 million each year to keep prices at current levels. The planned liquefied natural gas imports will drive up the price of gas domestically.

Also, transmission capacity in Bangladesh is not growing fast enough to keep up with power generation. This has resulted in supply bottlenecks in important commercial corridors (such as Chittagong and Comilla). And periodic outages, like the November 2014 country-wide blackout, perpetuate concerns about the security and stability of the country's power grid.

[32]https://www.researchgate.net/publication/315771594_Solar_Powered_Ferry_Boat_for_the_Rural_Area_of_Bangladesh
[33]Bangladesh reliable and quality energy supply-World Bank 2016
http://www.worldbank.org/en/results/2016/10/07/bangladesh-ensuring-a-reliable-and-quality-energy-supply

Considering the above power sector situation and its dependency on natural gas for efficient working, it is important to look at consumption of natural gas in other sectors. The below figure shows the sector wise natural gas consumption:

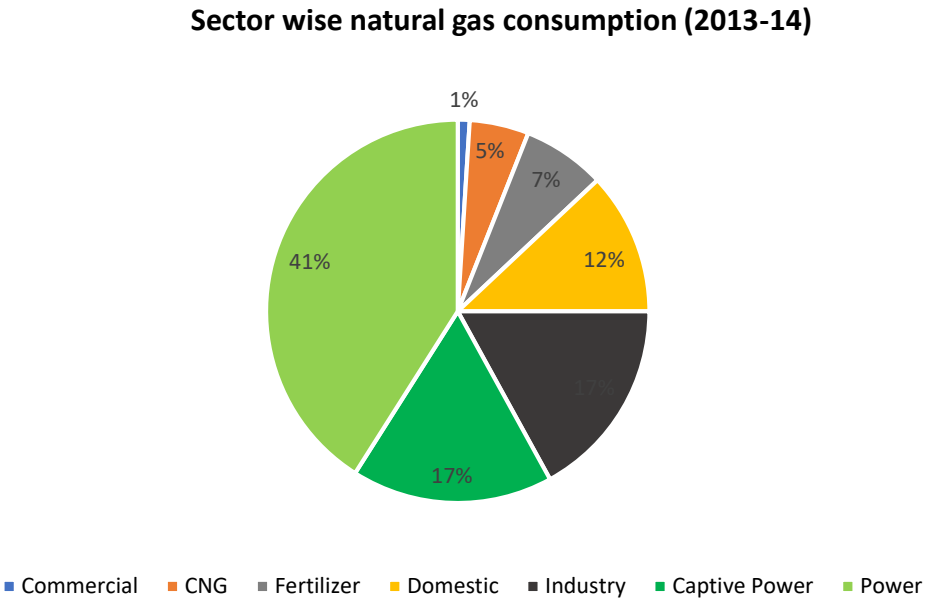


Figure 35 Sector-wise Natural Gas Consumption (2013-14) in Bangladesh
Source: Petrobangla Annual Report 2013-14

To reduce pressure on high gas dependency, diversification of fuel is necessary (through revision of the Coal for domestic coal development). We must also find ways for saving its consumption or alternative to it. One prospects for this can be conversion of ICE vehicles to Electric vehicles (EV). The below analysis considers that in 2014, by converting around 10% of the existing car stock to EVs, natural gas saved can be around 8.26%. Hence, on an overall basis, by converting the ICE vehicles to EVs, the natural gas can be saved. This gas can then be further used in the power sector to increase its efficiency and thereby reducing the power problems in Bangladesh.

Equivalent Conversions	
1000 cubic feet of natural gas	293.07 kWh of electricity[34]
1000 cubic feet of natural gas	0.17 barrels of oil[35]

	Units	
No of cars in Bangladesh till 2014	no.	267,175.00 [36]
Average distance travelled by car per day	Km	25.00
Total distance travelled in a year	Km	9,125.00
Overall distance travelled in 1 year	Km	2,437,971,875.00
Average Mileage of car	km/liter	18.20
Total barrels of oil required	no.	1,217,768.17
Total 1000 cubic feet of natural gas required	no.	7,163,342.17

Now, if 10% of the car stocks is converted to EVs, then natural gas required is,

No. of EVs	no.	26,717.50
Non- electric cars	no.	240,457.50
Distance travelled by EV in 1 year	Km	243,797,187.50
Average battery size of car	kWh	15.00
Average vehicle efficiency of cars	(km/full charge)	100.00
Total electricity required for charging	kWh	36,569,578.13
Equivalent 1000 cubic feet of natural gas required for EV charging (conversion equivalent)	no.	124,810.85[37]
Equivalent 1000 cubic feet of natural gas required for non-electric	no.	6,447,007.96
Total 1000 cubic feet of natural gas required	no.	6,571,818.80
Total cubic feet of natural gas saved	no.	591.52
	%	8.26%

Table 25 Propositions for EVs in Bangladesh

[34] http://www.kylesconverter.com/energy,-work,-and-heat/cubic-feet-of-natural-gas-to-kilowatt--hours
[35] http://www.kylesconverter.com/energy,-work,-and-heat/cubic-feet-of-natural-gas-to-barrels-of-oil-equivalent
[36] MV_statistics-bangladesh-march-18.pdf
[37] Kyles converter, Cubic feet of natural gas to equivalent kWh)

7.2 Existing EVs Landscape

7.2.1 EV Related Policies

Bangladesh does not have much traction for electric vehicles. The country did see a surge in demand for low cost electric tuk-tuks (local name for auto-rickshaws), however, the government had to curb their usage, primarily due to widespread electricity theft caused by owners/operators of these tuk-tuks.

While there is no policy to promote or incentivize purchase of electric vehicles or buses, the government does have a Bangladesh Climate Change Strategy and Action Plan (BCCSAP)[38]. Specific actions proposed under this plan includes the following:

- Promotion of low-cost public transport modes such as rapid transit;
- Reduction of fossil fuels by improving the efficiency of energy usage;
- Review of political, institutional and fiscal planning; and
- Substitution of biofuels, fossil fuels as appropriate

7.2.2 EVs Fleet Size, Models and Players

Bangladesh currently has battery-run three-wheelers (BRTW) which are popularly known as Easy-Bikes and Tom-Toms. This mode of transport is one of the most widely used means of transportation for the mass people in both urban and rural areas. It is estimated that more than 0.5 million battery-run electric three-wheelers are operating across the country, consuming a significant amount of electricity per day. These vehicles are also increasingly replacing fuel-operated three-wheelers in the rural areas[39] and its generating important benefits like reduction in air pollution, less dependency on fuel etc. With a proper regulatory framework, these have the potential of creating huge economic, social and environmental benefits in Bangladesh.

There are various models of BRTW; some are called Borak (easy-bike) and others auto-rickshaw. Borak can accommodate six passengers whereas the auto-rickshaw has the capacity to accommodate two passengers. The speed of BRTW is maximum 30-35 km per hour and is normally driven by one driver, who works 8-10 hours a day. Garage charge and charging cost of EV per day are 100-200 BDT ($1.2 – $2.4)[40] per day.

BRTW usually requires 5 batteries and take 7-10 hours to charge the batteries. It is generally seen that these are majorly charged from domestic electricity lines and some from commercial electricity lines as well. They don't have any designated charging stations and there is also no planned or announcement for creating the necessary infrastructure for charging stations. As these vehicles can replace the fuel operated CNGs and also help to some extent in the minimization of air pollution in the country along with economic, environmental and social benefits. It is important that Government of Bangladesh should focus on creating the framework and build roadmap for Electric vehicle and its charging stations.

While analyzing the current policies, it is seen that these vehicles need to fall under the category of motor vehicles for regulation by the BRTA. But due to some procedural and mechanical shortcomings, the Bangladesh Road Transport Authority (BRTA) is unable to register easy-bikes as motor vehicles and

[38] BCCSAP report, 2009
[39] Battery run three-wheeler policy support in Bangladesh
https://thefinancialexpress.com.bd/views/views/battery-run-three-wheelers-need-policy-support-1530633388
[40] Considering 1 BDT= 0.012 USD ($)

provide licenses, route permits and fitness certificates. There is a controversy regarding whether these easy-bikes are motor vehicles or not. As a stop-gap arrangement, these three-wheelers are now plying on roads with parking numbers given by city corporations, municipalities and union councils[41]. However, the current arrangement is neither sustainable nor desirable for effective regulation of the transport sector.

In Bangladesh, private electric cars are still yet to be popular, but these battery-run three-wheeler auto-rickshaws which are used as public transport are rapidly gaining popularity. These vehicles have the potential to play a vital role in the employment creation, mass and green transportation and development of new industry. It has the capacity to play a vital role in the mass and green transportation, employment creation and development of new industry.

7.2.3 Tariffs for EV

The Power Development Board (PDB) has asked the Bangladesh Energy Regulatory Commission (BERC) to form a new tariff category for drivers and owners of battery-operated vehicles. It made the proposal at a BERC to bring the 'green' vehicles including auto-rickshaws under existing regulation. This proposal was backed by the BERC technical evaluation committee, and later sets a distinct price figure for battery-operated vehicles of Tk7.25 against consumption of per unit electricity. The service charge was proposed at Tk25 for a one-phase line and Tk40 for a three-phase line[42].

It was also mentioned by PDB that more than 500,000 electricity-powered easy-bikes or battery-operated auto-rickshaws are operating across the country consuming more than 450MW of electricity per day. Easy-bikes or auto-rickshaws have a set of five batteries with a capacity of 60V, which consume 8-11 kW[43] of electricity daily and take 4-5 hours to be fully charged. Most of these easy-bikes or auto-rickshaws are currently charging batteries from household connections and therefore are consuming the electricity at minimum price, but if we can set a tariff, they will come into a regulation.

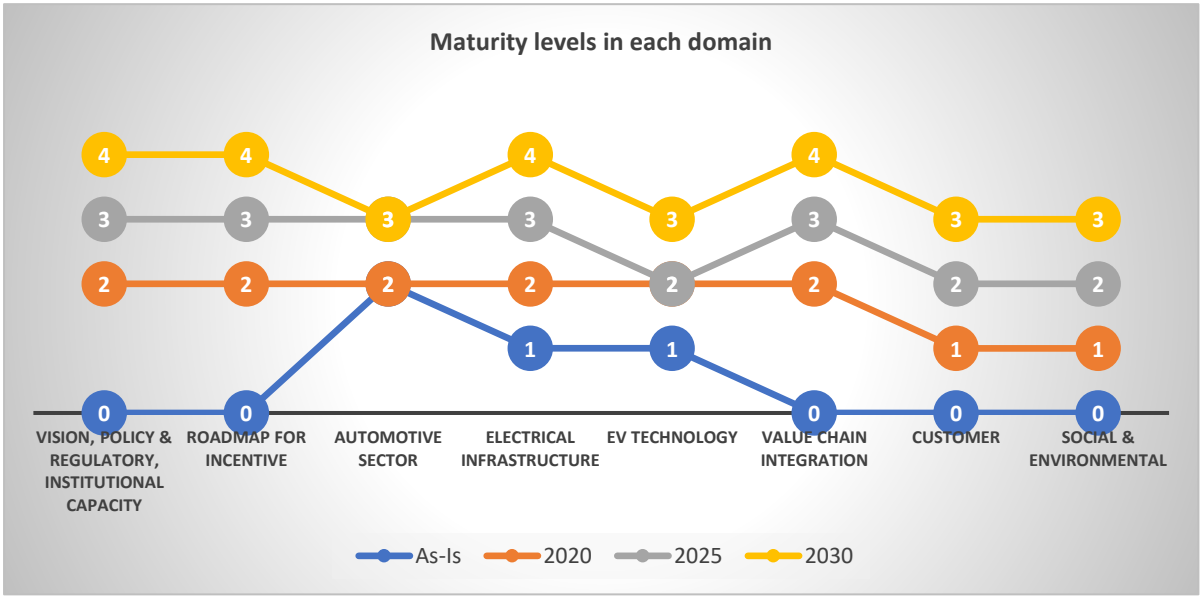
[41] Battery run three-wheeler policy support in Bangladesh

[42] PDB for bringing battery-run vehicles under tariff https://www.dhakatribune.com/bangladesh/power-energy/2017/09/27/pdb-bringing-battery-run-vehicles-tariff-regulations/

[43] Study on Power Consumption and Social Aspects of Battery Operated Auto-rickshaw, 2014

7.3 EVMM Assessment & Recommendations for Bangladesh

Based on the As-Is scenario (previous chapters), we have assessed[44] the existing conditions in each of the eight domains and identified the levels (as explained in Executive Summary) that they ought to attain in future years i.e. 2020, 2025 and 2030. We have also provided summary recommendations to ensure a sustainable EV adoption from one level to the next. A graphical representation showing the As-Is maturity level and the maturity level they need to attain in future is depicted below[45]



[44] A detailed assessment requires stakeholder interviews

[45] "0" means default level which indicates that the basic minimum initiatives have been undertaken in this domain

Domain	By 2020	By 2025	By 2030
Vision, Policy & Regulatory, Institutional Capacity	***Target Maturity Level – 1*** • Government to come up with a nation- wide EV mission along with a set of policies, to send clear signal to both OEMs & consumers to invest in and adopt EV respectively • Government (Ministry of Road, Transport & Bridges) to identify and dictate EV adoption target and should also provide city target with respect to public transportation including buses • Government along with Bangladesh Road Transport Authority and Municipalities should come out with guideline to regulate the operation of battery operated three wheelers • Government should ease norms on import of components and EV parts for local manufacturing and assembling companies and come out with guidelines on the same • Government should encourage adoption of electric two wheelers by providing subsidies on CAPEX through various schemes like 20% subsidy for first 5000 purchases and 10% on next 10,000 etc. • A nodal agency must be setup to oversee the EV implementation process. The responsible institutions may include: BPDB or other concerned distribution companies (DISCOMs) for charging infrastructure and upgradation of electrical network, DISCOMs and municipal authorities or local	***Target Maturity Level - 3*** • Bangladesh Inland Water Transport Authority and Bangladesh Road Transport Authority to define guidelines with respect to licensing, driving norms, routes of operation to streamline the EV adoption process • Government should provide targets to Road Transport Authority to transform the entire fleet of public buses and three wheelers into electric vehicle specifically in Dhaka and Chittagong and installation of charging stations in bus depots and terminus • Dedicated space in parking lots, in malls residential buildings for charging station installation to be made mandatory through building codes • Tariff policy by recognising EV as a separate group of consumers to be developed and aspects of Time of Use pricing to be introduced to smoothen the load curve • Bangladesh Inland Water Transport Authority to identify and dictate EV adoption target for ferries and inland water ferries operated by Bangladesh Army and Navy for cargoes and other general purposes can be converted into electric ferries as a pilot project and setting up of charging stations in those areas • Similarly, short distance ferries like from Chandpur to Shariatpur or ferries from inland ports like Mawa, Chittagong etc. can be converted to electric ferries on pilot basis	***Target Maturity Level - 4*** • Government to make mandatory conversion of private taxi fleets into electric vehicle throughout the country • Government to make mandatory conversion of water transport into electric fleet • Government to provide guidelines for setting up of charging stations by third party and providing charging as a service without any kind of licensing at least for one year • Grid Code and Distribution Code guidelines must be updated for Vehicle to Grid (V2G) integration • Guidelines for mandatory battery buy back by OEMs on completion of battery life or in case of any faulty battery

	governments for charging station implementation, Ministry of Power, Energy & Natural Resources, Ministry of Transport, Roads and Bridges, Ministry of Civil Aviation and Tourism, Ministry of Housing & Public Works for policy, planning and strategy development for EV deployment • Organizational restructuring with the creation of an EV cell within Ministry of Transport, Roads & Bridges and BPDB to facilitate future deployment strategy, policy, O&M guidelines, consumer awareness etc. • As most of the cars are imported used cars, government should increase the number of years of usage before importing e.g. should allow import of up to three year old high capacity cars in case of electric vehicle till the EV adoption sets its pace	• In cities like Dhaka and Chittagong, fleet operators of private taxis should be encouraged to shift to electric vehicle through incentives like subsidised parking charges, reduced tariff for charging, reduced toll etc. • Creation of a PPP cell and Investment Facilitation Center with members from Ministry of Finance, Ministry of Transport & Bridges, Ministry of Power, Energy & Natural Resources, Bangladesh Investment Development Authority, Bangladesh Inland Water Transport Authority to evaluate project proposal on EV, battery and EVSE manufacturing and act as a single window for FDI, PPP and JV projects	
Roadmap for Incentive	***Target Maturity Level – 2*** • Exemption of import and custom duty on EV components and subsidised import duty on the imported electric vehicle • Reduced property tax for electric three wheeler manufacturers and electric vehicle assembly companies • Subsidized registration charges for one year for electric three and four wheelers • Reduced tariff for passengers using electric buses • Reduced electricity tariff for charging for all categories of electric vehicle	***Target Maturity Level - 3*** • Tax free or reduced tax for profit repatriation for foreign companies • Reduced tariff for passenger using electric water transport • Reduced road tax for electric four wheeler commercial fleet • Duty free import of plant and machinery for setting up of assembly unit on one time basis • Reduced property tax for hotels using electric vehicle for their guests and for personal purpose	***Target Maturity Level - 4*** • Reduced property tax for residential complexes in few initial years which will be installing charging stations to facilitate personal vehicles • Promote battery recycling industry through tax free income in initial years or reduced interest on loans for JVs with minimum 25% stake of local companies

	• Free parking and reduced tolls for electric vehicles		
Automotive Sector	***Target Maturity Level - 2*** • Electric rickshaws with internationally approved design to be developed in the local market or can be assembled with parts being imported from India or China • Electric buses and electric cars to be deployed on pilot basis need to be imported from countries like India and China with services for these vehicles provided by the manufacturing companies for few initial years • Battery and charging stations to be imported from countries like India or China for the pilot projects • Promote local manufacturing of electric two wheelers through PPP or with joint ventures with Indian or Japanese companies	***Target Maturity Level - 3*** • Servicing on electric ferries can be provided by the manufacturing companies for few initial years • Servicing facility for charging stations to be provided by OEMs • Manufacturing of EV to be developed through foreign collaborations or 100% FDI and EV parts by local manufacturers • Creation of special manufacturing zone for EV, charging station and battery manufacturing with government providing land on lease and other basic necessity like water and logistic support at reasonable cost	***Target Maturity Level - 3*** • Local manufacturing units to joint venture with foreign companies for EV manufacturing including ferries with and service centres to be developed locally with skilled workforce • 100% FDI in Lithium ion battery manufacturing • Local capacity development on O&M of charging stations through training and skill development • Battery recycling industry to be developed with foreign collaborations or the battery manufacturing companies already present • Municipal authorities can come up with green bonds to finance EVs
Electrical Infrastructure	***Target Maturity Level - 2*** • Distribution utilities to assess the availability of spare capacity in distribution transformers in areas having potential for charging station implementation like bus depots and terminus, existing malls, residential buildings etc. in major cities • Distribution utilities to assess the power availability and peak demand and also the seasonal variability in these parameters to figure out the EV demand the load network can sustain with the given supply including power import	***Target Maturity Level - 3*** • Upgradation of electrical infrastructure in terms of meter room, laying of cables, supply meters etc. in bus depots and terminus, ferry ghats etc. by concerned distribution utilities for installation of charging stations • Upgradation expense should be included in the annual capex of concerned distribution utility and to be factored in tariff as the spreading of upgradation expense over entire population will have negligible impact on tariff	***Target Maturity Level - 4*** • Upgradation of electrical infrastructure in in various areas like parking lots, malls, city centres, railway stations for installation of public charging stations • Upgradation expense can be shared by OEMs or third party service providers of charging stations • Grid asset modernization for facilitating two way communication for implementing vehicle to grid solution • With EV adoption at a large volume, tariff for charging should consider the

	• Distribution utilities to consider power supply from renewable sources in island and remote areas or areas having high renewable potential for installation of charging station for electric three wheelers	• Improvement in power quality through deployment of technologies like harmonic filters, static compensators etc.	opportunity cost of gas which is freed up from transport sector and can be used in power sector, which is cheaper compared to imported coal
EV Technology	***Target Maturity Level - 2*** • Batteries used in electric three wheelers to be upgraded to lithium ion batteries • Technology for electric two wheelers to be upgraded in terms of design, battery capacity etc.	***Target Maturity Level - 2*** • With majority of vehicles being imported from Japan and India, Bangladesh may consider adopting EV standards of India and Japan to ensure interoperability. This include IS:17017 standard, which India has recently published for both AC and DC charging and allows both CHAdeMO and CCS charging standards	***Target Maturity Level - 3*** • EV testing and certification centre to be developed in Bangladesh • R&D on EV design and battery technology to be initiated in collaboration with technology institutes, research labs, industries etc. • Local EV manufacturers to contribute in enhancement of the charging standards and communication protocols being used e.g. CCS, CHAdeMO, OCPP etc.
Value Chain Integration	***Target Maturity Level – 2*** • Government building and offices to install charging stations in their premises for EV usage • Battery swapping model can be used for three wheelers with the help of a Battery Leasing Agency which will charge the batteries on a large scale and facilitate the three wheelers by providing a charged battery against a specified fee. The Battery Leasing Agency may be formed by the battery or EVSE supplier • Bangladesh has major utilities like BPDB, REB etc. controlling generation, transmission and distribution. These Utilities can invest in setting up public	***Target Maturity Level - 3*** • PPP model with private parking owners or service providers or OEMs taking technology risk and invest in operation of the charging infrastructure whereas utilities providing the CAPEX and taking the payment risk and government providing the land on lease and taking the policy risk, force majeure risk may be explored • Bundle EVSE as mandatory in new buildings through Building Codes for all categories of buildings exceeding certain built area. In this case the impact of EVSE infrastructure cost is negligible in per square meter cost • Municipal authorities, Bangladesh Inland Water Transport Authority along with	***Target Maturity Level - 4*** • Dedicated fleet operators like for e-Buses and e-4Ws can invest by themselves or bring third party to invest in charging stations • With transition of private cars into electric fleets will provide opportunity for the retailer or third party service providers to provide door to door servicing on charging of electric vehicle with a premium charged on the regular tariff.

	charging and dedicated fleet infrastructure. The utilities can also provide end-end charging services or can lease/out-source operations. The main advantage of this model is that the utility need not worry about low volume of business in the initial years as the assets are created under regulated capex route • Gas companies like Petrobangla can invest in electric vehicle charging infrastructure as the transport sector's shift from gas to electricity will provide them enough gas to supply to power industries or fertilizer industries and will be an win-win situation on both sides • For electric buses, charging stations can be installed in bus depots for overnight charging and in bus terminus for fast charging during the day • Big business houses to pool their CSR funds for financing of electric buses on pilot basis	distribution companies in major cities and tourist places like Dhaka, Chittagong, Syhlet, Rajshahi, Jessore, Cox Bazar etc. can prioritize the installation of charging stations in parking lots, urban centres, railway stations, ferry ghats etc. and upgradation of electrical infrastructure to promote and support the EV deployment • Similarly big business houses like S Alam Group, Basundhara Group, BEXIMCO Group etc. and defence units like Bangladesh army and navy can install public charging stations outside their premises and ferry ghats and can convert their general movement vehicles and boats into electric vehicles and ferries • Private bus companies to set up charging stations in their premises and can allow public during certain hours against a specified rate (flat rate)	
Customer	***Target Maturity Level - 1*** • Government vision and target for electric vehicle is communicated to customers • All the incentives and benefits for adopting or cruising an electric vehicle to be communicated properly to customers • Carry out research on the customer pattern of vehicle usage and identify probable charging pattern to figure out the load curve for a particular day by the EV cell	***Target Maturity Level - 2*** • Time of use pricing and its benefits to the customers must be displayed to make them aware of their benefits • Subsidised electric two wheelers and cars for first few thousand customers on first come first serve basis	***Target Maturity Level - 3*** • Customers are engaged in prosumer programs through V2G integration on pilot basis • Advance booking of parking slots through e-booking based on time and amount of charge required by the individual in major cities like Dhaka

Social & Environmental	***Target Maturity Level - 1*** • Organizing EV awareness programs, conduct workshops and seminars to make people aware of the benefits of EV adoption in terms of improved air quality, health benefits (In few cities of Bangladesh like Dhaka, Khulna Air Quality Index is above 400 which is extremely unhealthy)	***Target Maturity Level - 2*** • EV deployment mainly the buses and commercial taxi fleets can also provide opportunity to the existing workforce by providing them adequate training on O&M skills	***Target Maturity Level - 3*** • EV manufacturing will help in job creation and people of rural areas can opt for a sustainable living in all aspects • The deployment goals by the government will also help to bring electricity in the remote areas which can help in improving the living standard of the people in those areas • Usage of electric boats and launches will negate the chances of oil spills from boats and facilitate in reducing water pollution

8. Bhutan: EV Scenario

Bhutan is a growing economy, backed largely by hydropower development, tourism, and services. Bhutan's national strategy places great emphasis on ecologically balanced sustainable development. The nation currently faces a serious macroeconomic management issue of ever-increasing account deficit fueled mostly by large imports. In Bhutan, as in many developing countries, sustainable transport development is intertwined with broader development issues such as the trade deficit and macroeconomic management, energy security, and green growth. In keeping with this view, improving the availability and quality of urban and rural transport services by implementing an Electric Vehicle (EV) program has been recognized as a crucial action plan by the Bhutan Government. The Royal Government of Bhutan (RGoB) has announced its Electric Vehicle (EV) initiative that will be developed in line with the country's commitment to resolve environmental issues and decrease dependency on imported fossil fuel with the main urban centers of Bhutan (Thimphu and Phuentsholing) in focus. Along with the EV initiative, RGoB has also brought in various other policies and regulations to drive the EV revolution in the country.

8.1 Country Profile[46]

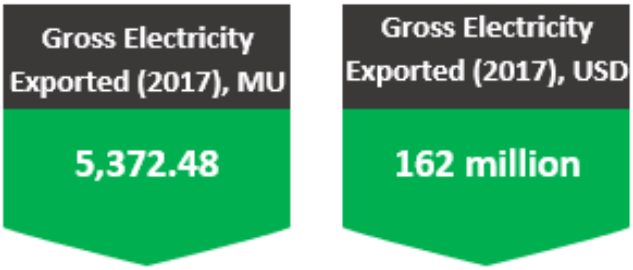
GDP per capita, USD 2677.1	Fuel Imports, % of GDP 1.3%
Installed Electricity Capacity, GW 1.62 (Hydro is 99%)	Electricity Access, 2016 Urban: 100% Rural: 100%
CO_2 Emissions, tons per capita 1.3	INDC Commitment Remain carbon neutral (GHG emissions < 6.3 million tons of CO_2)

Bhutan is one of the quickest-growing economies in South Asia. Economic growth has averaged 7.5% a year over the past 3 decades, with Bhutan recording a GDP of 2.074 billion USD in 2017. The energy sector has been a prime force in bosltering the Bhutanese economy; the nation has high energy access and excellent generation capacity (mostly hydro) that has made it evolve into a significant exporter of hydroelectricity. However, fuel imports have displayed a rising trend in recent years for fulfilling energy requirements, particularly for transport. Bhutan, aware of its vulnerability to the adverse impacts of climate change, committed to remain carbon neutral under the Paris Agreement. In its INDC, Bhutan has designed an action plan including the establishment of a low-carbon transport system, diversification of its renewable energy sources and other steps, that will lead to opportunities for private sector investment.

[46] Undata; Statistical Yearbook of Bhutan 2017; Annual Environmental Accounts 2017, Bhutan; World Development Indicators

8.2 Electricity Generation and Distribution Network Profile

Generation[47]: With a total installed capacity of 1,623 MW (2016) of five major hydro power plants, Bhutan meets its electricity demand majorly by hydro-electricity resource. Bhutan is currently a net power surplus economy. With low domestic demand, Bhutan exports electricity in the summer months to India. However, in the lean winter seasons, Bhutan imports electricity from India. The power generated throughout the year depends on the run-of-the river which fluctuates seasonally. The monthly generation of electricity is at its peak during the summer and least in winter. As per the RGoB's National Transmission Grid Master Plan (NTGMP), it is predicted that, "total hydro capacity of 11,814 MW and 26,534 MW by 2020 and 2030 respectively would be installed, primarily for export". According to an analysis, 80 BU and 116 BU can be potentially exported by Bhutan in 2030 and 2050 respectively.



Distribution[48]**:** Bhutan Power Corporation (BPC) served the following number of consumers:

Low Voltage Consumers	Low Voltage Bulk Consumers	Medium Voltage Consumers	High Voltage Consumers
184277	778	59	16

Table 26 Bhutan Electricity Consumer Segregation

In 2017, domestic electricity consumption was 2,185.75 Million units (MU). The peak coincidental load recorded was 362.09 MW on November 14, 2017. Although the trend of electrical energy demand throughout the day remains similar for both winter and summer, the Peak Demand is significantly higher during the winters at all hours. In particular, the peak demand in the Winter ranges to about 1.5 to 1.8 times that of the Summer electricity demand. The domestic T&D loss (excluding wheeling) in 2017 was 6.54%. According to an analysis, Bhutan will have an annual electricity demand of 6,258 MU in 2050. The overall transformer capacity in Bhutan is 5,48,505 MVA; the length of overhead lines and underground lines is 13682.86 km and 474.21 km respectively. A Distribution Management System (DMS) Project is underway to improve the overall electrical power reliability, quality and operational efficiency of the distribution network in Thimphu region.

BPC Tariff Structure: Wheeling charges are almost 0.0027 USD/kWh. The medium voltage (6.6/11/33 kV) energy charges and demand charges for the July 2018 to June 2019 period are 0.03 USD/kWh and 4.143 USD/kVA/ month respectively, while that of high voltage (66 kV and above) are 0.022 USD/kWh and 3.62 USD/kVA/ month respectively. The low voltage tariffs are in the table on the right.

Block	kWh/month	Energy Charges (USD/kWh)
I (Rural)	0 – 100	0
II (Others)	0 – 100	0.0177
II (All)	101 – 300	0.037
III (All)	Above 300	0.049
Low Bulk Voltage		0.056

Table 27 Bhutan Electricity Tariff Structure

[47] USAID, IRADe, SARI: Impact of Cross-Border Electricity Trade on Bhutan (Country Series)
[48] BPC Annual Report 2017; Bhutan Energy Data Directory 2015

8.3 Transport Sector Profile[49]

Road Safety and Transport Authority is the chief governing body for the Transport sector in Bhutan. The Transport, Storage and Communication sector of Bhutan recorded an 11.20 percent growth in 2016, a year-on-year growth of 2.40 percentage points.

Transport sector contribution to GDP	**7.67 %**
Gross Value Added by the Transport, Storage and Communication sector	**USD 2,005.84 million**

Transport Energy Consumption for 2014 (TOE)	
Road Transport	**Aviation**
11,8202	**3,016**

Table 28 Bhutan Transport Energy Consumption for 2014 (TOE)

Bhutan consumed a total of 6,50,220 TOE in 2014, out of which the transport sector amounted for 18.64%. Road transport was a major contributor to the energy consumption, approximately 1,18,202 TOE.[50]

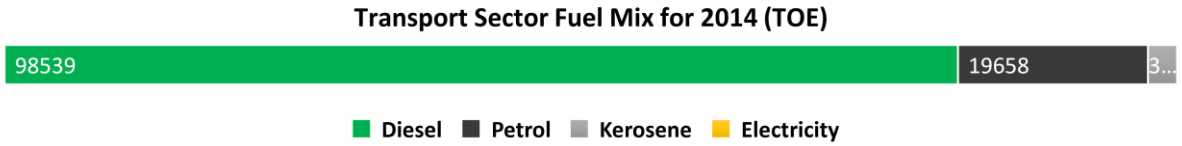


Figure 36 Bhutan Transport Sector Fuel Mix for 2014 (TOE)

Fuel Imports for Transport Sector

- Fuel imports for the transport sector ranked **2nd in the top ten commodities imported** by Bhutan in 2017. The transport fuel imports accounted for approximately Nu 2 trillion or USD 27 million, which is **1.3% of the GDP**.
- Due to the increasing individual dependency on private vehicles and other forms of motorized transport, the total petroleum import bill rose from Nu. 369 million in 1998 to Nu 8,432 million in 2014. The most significant contribution to the import bill can be attributed to the **usage of diesel** in the country. The import bill for diesel itself constituted 70% of the total import of petroleum. The total import bill for diesel increased from Nu. 214 million in 1998 to Nu 5,911 million in 2014. **Consequently, the total import bill is creating a burden on the government exchequer nullifying a large amount of revenue earned by export of electricity to India.**

Diesel and Petrol accounted for 97% of the fuel utilized for transport. Electricity share, at 0.004% is expected to increase with the adoption of electric vehicles by the Bhutanese market.

GHG Emissions: The transport sector emitted 0.118 million tCO_2e from fuel combustion activities, accounting for about 45 percent of all energy-related emissions or 7.5 percent of national GHG emissions for the year 2000. According to the *Urban and Rural Settlements in Bhutan: a Low Emission Development Strategy 2017* Report, carbon emissions from road transport in a BAU scenario are expected to reach 348 kt CO_2e by the year 2040.

[49] National Account Statistics 2017, Bhutan

[50] Bhutan Energy Data Directory 2015

No. of Registered Vehicles by type in Bhutan (2017)	
Heavy Vehicles	9,832
Medium Vehicles	1,657
Light Vehicles	57,010
2 Wheelers	9,866
Power Tillers	2,132
Taxis	4,283
TR	446
Earth Moving Equipment	2,844
Electric Vehicles	93

Table 29 Number of Registered Vehicles by type in Bhutan (2017)

The total number of registered vehicles in Bhutan for 2017 is 88,227. According to the Bhutan Transport 2040 Integrated Strategic Vision, considering a high growth rate, the number of vehicles is expected to shoot up to 6.7 million by 2040.

Thimphu, the capital of Bhutan has the greatest share of vehicles in the country (52%), followed by Phuntsholing (35%).

Light cars are the most popular vehicle (64.6%), after which come 2 wheelers (11.2%), heavy cars (9.6%) and taxis (5%).

8.4 EV Landscape in Bhutan

8.4.1 Review of Government Plans and Policies supporting EV implementation

Timeline	Plan/Policy/Strategy/Regulation	Description (reference to EVs)
2012	National Strategy & Action Plan for Low Carbon Development	This strategy defined an emissions baseline until 2040 and discussed mitigation options for all sectors of the Bhutanese economy. It recommended a medium term (2-5 years) pilot test of electric vehicles – both cars and buses.
2013	Alternative Renewable Energy Policy	This Alternative Renewable Energy Policy promoted the RE interventions of 'fossil fuel substitution' through green energy sources like bio-fuels, electric and hybrid vehicles. The targets set were: "Fossil fuel energy in transport sector (1000 kilo litres of oil equivalent) to be replaced by 111 GWh of electricity; 20% of state owned and 10% of private vehicle fleet to be encouraged to run on clean green fuels by 2025."
2013	Bhutan Transport 2040: Integrated Strategic Vision	It combines all existing transport-related plans, policies, initiatives, and actions in Bhutan to form a long-term, integrated and comprehensive transport strategy for the next three decades. The overall vision is "to provide the entire population with a safe, reliable, affordable, convenient, cost-effective and environment-friendly transport system in support of strategies for socio-economic development".

2014	**Bhutan Green Transport & Electric Vehicle Initiative (EVI)**	Policy to promote electric vehicles as part of RGoB's efforts to curb the dependency on fossil fuels and simultaneously address environmental issues by imposing heavy tariffs on conventional vehicles, which are the major consumers of petroleum. Shift from use of fossil fuel to clean hydro-power generated electricity is encouraged through implementation of tax exemption on electric vehicles.
2016	**Economic Development Policy (EDP)**	Section 6.2.11.b: Manufacturing of electric vehicles and transport identified as an area of greatest potential to yield wealth, employment and sustainable growth within the framework of GNH, which will be promoted by the Royal Government. Section 7.13.11 Suitable policy interventions will be used by the Royal Government to encourage hybrid and electric vehicles.
2016	**National Energy Efficiency & Conservation Policy (Draft)**	Section 9: Energy performance of the Transport sector can be improved through systematic adoption of sustainable transportation modalities including use of EVs, use of public transportation, promotion of non-motorized transportation, efficient urban planning, etc. Accordingly, the roles are assigned to the Ministry of Information and Communication, Nodal Agency and Ministry of Finance to promote EVs and improve transport.
2016	**Low Emission Development Strategy for the Transport Sector**	The strategy proposes a timeline for implementation of Low Emission Development Strategy (LEDS) for EVs/Hybrids that includes charging infrastructure installation, government EV fleet deployment, introduction of regulatory framework/incentives for EVs in tourism sector, deployment of electric buses and exploration of PPP opportunities for full-scale EV rollout and expansion for tourism sector in Bhutan.
2017	**Vehicle Emissions Roadmap**	The roadmap proposed restriction of diesel passenger cars and light duty vehicles, and fostering low carbon vehicles: Diesel vehicles will be restricted to large trucks, buses and

		mobile machinery. Registration of passenger cars, taxis and light vehicles up to 3.5t using diesel fuel shall be disallowed in Bhutan. For these vehicle types, gasoline vehicles or EVs with similar characteristics are readily available. Existing registered diesel vehicles will be permitted to continue operations.
2017	**Urban and Rural Settlements in Bhutan: A Low Emission Development Strategy**	This strategy proposed the following pilot activities and incentives to be implemented: • Electric vehicle fleet for institutional cars and taxis. There are about 4,283 taxis in Bhutan, which could be replaced by electric vehicles over time. • Install required infrastructure, e.g. charging stations. • Introduction of energy efficiency/fuel standards for conventional diesel/petrol-fuelled cars and trucks, e.g. maximum fuel consumption or CO_2 emissions per kilometre. • If a replacement rate of 2% per year is assumed until 2030, approximately 24,000 electric cars can replace conventional cars. As a result, ca. 3,500 tCO_2 (Indian GEF) or 26,600 tCO_2 (Bhutan GEF) can be mitigated until 2030. • Electrification of public mass transit, specifically buses.
2017	**Bhutan's Sustainable Low Emission Urban Transport Systems Project**	Bhutan is building the charging infrastructure before the project implementation to fast-track the process. 23 electric car charging stations will open within and at the peripheries in Thimphu and nearby dzongkhags. Of the 23 electric stations, 12 will be located in various areas of Thimphu while others will be in Phuentsholing, Punakha, Paro, and Wangdue. As part of the project, 300 EVs will hit the roads of Thimphu. This initiative is part of the 3-year project under the Information and Communications Ministry and Global Environment Facility (GEF). GEF will also support vehicle buyers with a 20% subsidy.

		Individual buying electric vehicle for a taxi will receive a 50% loan as part of the project.[51]
2017	**Strategy for Low Carbon Commercial Vehicles in Bhutan**	Emission reductions equal to 13% of current CO_2 transport emissions or 5% of projected 2030 BAU transport emissions for Bhutan are deemed possible by implementing this strategy: deployment of electric & hybrid buses and taxis.

Table 30 Review of Government Plans and Policies supporting EV implementation in Bhutan

[51] News Article: Bhutan to set up 23 electric car charging stations; weblink: https://www.devdiscourse.com/Article/agency-wire/8994-bhutan-to-set-up-23-electric-car-charging-stations

8.4.2 Status of EV implementation in Bhutan

Promoting the uptake of electric vehicles in Bhutan is a priority initiative of the government, with the aim of reducing air pollution and fossil fuel dependency. As mentioned already, the feasibility study carried out in 2015 by the World Bank, ADB and UNDP, provides recommendations on the next steps for full implementation of this initiative. The Prime Minister of Bhutan has made a public commitment to provide free electricity at electric vehicle charging stations. Tax incentives are already in place to support the purchase of electric and hybrid vehicles in Bhutan. The government has also partnered with a number of leading vehicle manufacturers to scale up the introduction of electric vehicles in Bhutan. The government is actively seeking bilateral and development bank support for a range of actions to further encourage uptake of electric vehicles, including funding for subsidies and charging station infrastructure, and capacity building and regulatory efforts. Further, policy measures are being considered to promote greater use through small-scale assembly of electric cars, battery swapping and maintenance within Bhutan. A low-carbon commercial vehicle strategy with the help of financial instruments for the mass low carbon vehicle deployment is being realized in Bhutan. Bhutan aims to avail international climate funds to support the country in implementing a low-carbon vehicle policy.

Present Status of Electric Vehicles in Bhutan[52]			
Region	**Government Vehicles**	**Private Vehicles**	**Diplomatic Vehicles**
Thimphu	**19**	**56**	**1**
Phuntsholing	**7**	**6**	**0**
Bhutan (Total)	**26**	**66**	**1**

Table 31 Present Status of Electric Vehicles in Bhutan

8.5 Key Benefits of EV deployment in Bhutan

Electric vehicles emit no tailpipe pollutants, thus reducing GHG emission rate and facilitating Bhutan in doing justice to its INDC committment and maintaining its carbon neutral status.

Electric vehicles can be powered using hydropower, a clean source of energy which is both abundant and cheap in Bhutan, thus reducing dependence on fossil fuels. The fuels can hence be put to alternative use in the Industry, Agriculture and Service Sectors.

Shifting the transport sector away from reliance on fossil fuels towards use of domestically produced hydroelectricity would help to control Bhutan's growing trade deficit by decreasing expensive fuel imports.

Provision of clean, affordable and comfortable transport facility for the Bhutan population.

[52] Statistical Yearbook of Bhutan 2017

8.6 Key Challenges for EV uptake in Bhutan

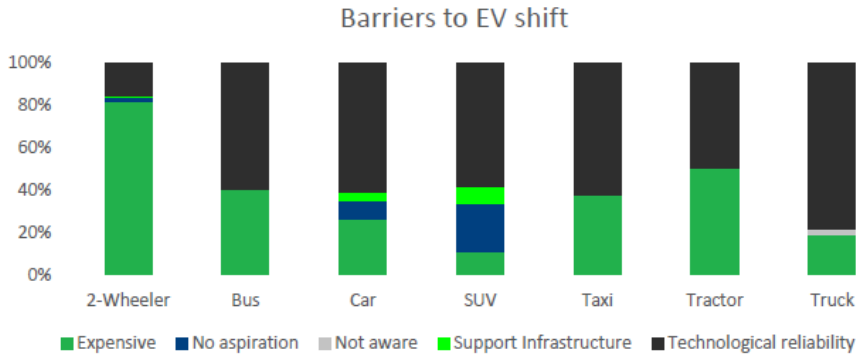


Figure 37 Barriers to EV Shift in Bhutan

The lack of technical expertise to support EV operation and maintenance, and the high initial costs of purchase are the most likely barriers to the implementation of this intervention. According to an audit exercise, commuters were asked the challenges they faced in the past related to EVs and perceived barrier to use an electric vehicle. These responses are presented in the figure.[53]

The high investment cost of EVs and EVSE is a major cause of detriment for EV adoption

Lack of regulatory clarity owing to multiple regulations and plans

Lack of proper business models for charging infrastructure and manufacturing facilities is a matter of great risk to the market players

Lack of technical expertise for EVSE setup as well as O&M activities

Lack of public awareness regarding EVs

[53] Energy Efficiency in Transport Sector 2015, Department of Renewable Energy, Ministry of Economic Affairs, RGoB

8.7 ISGF Proposition for EVs in Bhutan

The taxis are the largest consumer of petrol amongst the different types of vehicles plying in the country. Although taxis are the sole largest consumer of petrol (2.25 kl) annually, the largest consumers of diesel are the trucks (4.9 kl) and buses (4.3 kl) followed by the taxis (3.9 kl) (EY analysis, 2015). For 2014, a 6.34% CAGR increase in the consumption of Petrol and an increase of 9.51% CAGR for diesel was observed, demonstrating a high, dependence on diesel. With the increasing energy usage, GHG emissions have shown an exponential growth rate as have fuel imports (mentioned earlier).

In a feasibility study conducted by the World Bank, ADB and UNDP in 2015, the calculation for the amount of GHG emissions and fuel imports that could be avoided between 2015-2027 if the Electric Vehicle Initiative (EVI 2014) were implemented immediately was derived. The study considered three scenarios based on level of uptake of electric vehicles in Bhutan for three target market segments:

1. Target Group 1: Government Fleet (Estimated number in 2015: 2524 & Projected in 2020: 3000)
2. Target Group 2: Private Cars (Estimated number in 2015: 36736 & Projected in 2020: 49379)
3. Target Group 3: Taxi Fleet (Estimated number in 2015: 5271 & Projected in 2020: 6500)

Scenario 1: Low Uptake	Scenario 2: High Uptake	Scenario 3: Super High Uptake
•For the low uptake scenario, EV replacement rates of 1 percent and 2 percent were assumed for the three target groups. The replacement rate of EVs for the government and private fleets is about 1 percent, which is just under international replacement rate in places like the Netherlands and Norway. The EV replacement rate for taxis under this scenario is assumed to be 2 percent because this is the main target group for EV deployment in Bhutan.	•For this scenario, an EV replacement rate for government and private vehicles of 3 percent is assumed, which is higher than the replacement rate in countries with leading EV markets. For taxis, an even higher rate of 10 percent is used, meaning that 1 in 10 new taxis is replaced by an EV each year.	•The third scenario is calculated to match the RGoB ambition to introduce about 1,000 EVs per year. The EV replacement rate for taxis is estimated at 100 percent, which means that every new taxi is assumed to be an EV, while the EV replacement rate for the private and government fleets is assumed to be 5 percent

Summary of Impacts for the three scenarios:

	Scenario 1—low uptake	Scenario 2— high uptake	Scenario 3—super high uptake
Aggregated impact			
Aggregated benefits (million US$)	13	43	321
Accumulated avoided fuel imports (2015–2027) (million US$)	13	41	309
Accumulated avoided GHG emissions (2015–2027) (tCO_2e)	17,276	55,774	4,16,897
Magnitude of impact			
Annual avoided fuel imports in 2027 (% of total fuel imports in 2012)	1.57	5.1	38
Net impact on imports during 2015–2027 (Max. annual import reduction as % of annual imports)	0.07	0.24	1.81
Annual GHG savings (as % of annual transport emission in 2000)	1.39	4.5	33.6
Annual fiscal impact to government during 2015–2020 (as % of annual taxes revenue)	0.30–0.45	0.99–1.51	3.60–5.47

Table 32 Summary of Impacts for the three scenarios for EVI Strategy in Bhutan

8.7.1 ISGF Proposition for Electric 2 Wheelers (2W) in Bhutan:

While the EVI strategy has considered government cars, private cars and taxi fleets for electrification, it has not considered 2 wheelers, which represent a significant portion (11.2%) of the registered vehicles in Bhutan. Electric 2Ws have shown the brightest prospect for adoption worldwide, with an estimated global stock of 250 million. Electric 2Ws, have the added advantage of being residentially-charged, unlike cars or buses, which require proper public/private (here on referred to as 'p/p') charging infrastructure. Hence, the 2Ws segment represents substantial potential for the Bhutanese market.

ISGF has prepared an analysis for immediate electrification of 2Ws considering the three scenarios:

1. Scenario 1: 10% of the 2Ws replaced with electric 2Ws
2. Scenario 2: 50% of the 2Ws replaced with electric 2Ws
3. Scenario 3: 100% of the 2Ws replaced with electric 2Ws

Premises:

The 2Ws in Bhutan are assumed to have 100-125 CC gasoline engines, with a fuel efficiency of 35 km/litre and an average annual distance travelled per 2W as 5000 km (as per the Energy Efficiency in Transport Sector 2015 Report, RGoB). The GHG emission factor is considered to be 0.029 $kgCO_2$/km (as per India GHG Program).

The 2Ws are assumed to be replaced with electric 2Ws of comparable specifications; the electric 2Ws are considered to have a 1.152 kWh battery, with a range of 70km/Charge (as per Hero Electric Optima Plus Electric Bike specifications). The tariff rate for residential charging is taken as 0.02 USD/kWh while that of p/p charging is taken as 0.05 USD/kWh (as per Bhutan Power Corporation Tariff Rates). The price of petrol in

Analysis results:

Scenarios	Annual GHG reductions (tCO_2e)	Annual fuel imports reduction (million USD)
Scenario 1: 10% replacement	**143**	**0.13**
Scenario 2: 50% replacement	**715.2**	**0.66**
Scenario 3: 100% replacement	**1,430.4**	**1.32**

Table 33 ISGF Proposition for Electric 2 Wheelers (2W) in Bhutan: GHG and Fuel Import Annual Reductions

Complete electrification of the 2 Wheelers population will result in 1.32 million USD reduction in the fuel imported, which amounts to nearly 5% of total fuel imports. While the reduction in GHG emissions are low in comparison to that observed for other vehicle categories, the monetary benefit to the consumer is notable as shown below:

Annual savings per consumer using residential charging, % of current fuel expense	Annual savings per consumer using p/p charging, % of current fuel expense
98.8%	**96.9%**

Table 34 ISGF Proposition for Electric 2 Wheelers (2W) in Bhutan: Annual Savings for Consumer

From the consumer point of view, shifting to electric 2W translates into a more economically attractive experience (OPEX) given that per consumer, the energy requirement for electric 2W is only 82.3

electricity units with a yearly expense of USD 1.65 for residential charging & USD 4.11 for public charging as opposed to 143 litres of fuel with a yearly expense of USD 134.42 for normal 2W.

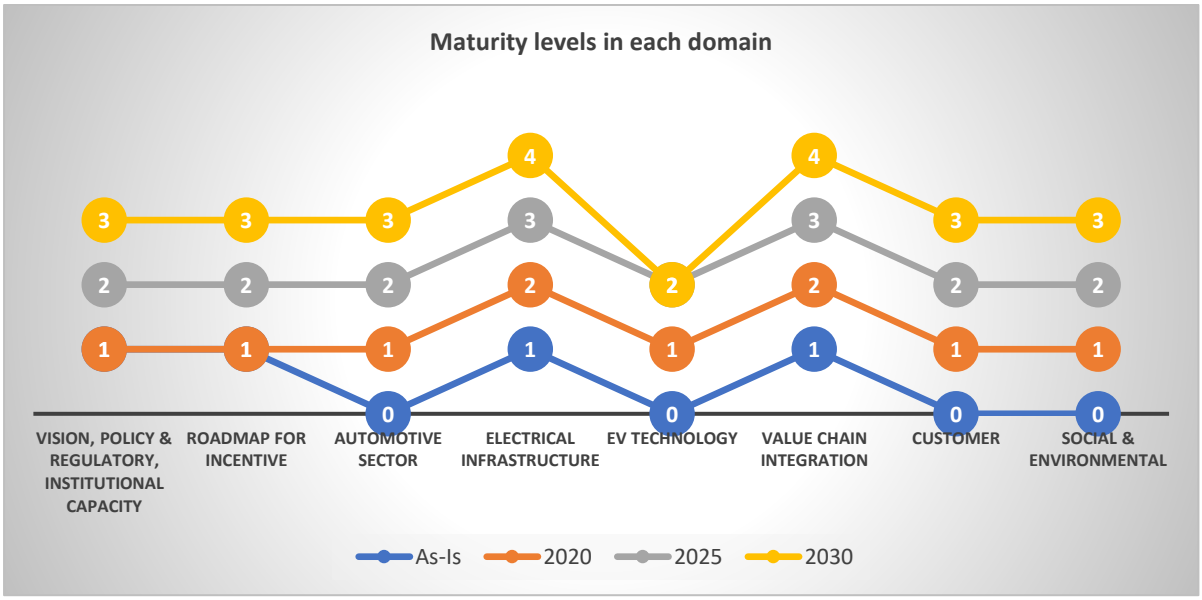
Considering that the Electric Vehicle Initiative (EVI) strategy is implemented, the energy saved can be used alternatively to satisfy the energy requirements for the Industry and Buildings sectors. The direct impact of this would result in a surge in GDP growth coupled with abatement in the nation's trade deficit due to reduction in the fuel imports.

In addition to the energy savings and real time monetary benefits, there would be GHG emission reductions which will help Bhutan to adhere to its INDC commitment of remaining a carbon neutral nation by ensuring that Bhutan's GHG emissions do not exceed the sink capacity of their forests, i.e. the GHG emissions are maintained below 6.3 million tons equivalent of CO_2.
While electrification of 2Ws does not have a considerable impact on the GHG emissions and fuel imports reduction, the concept holds merit from the consumer perspective owing to the large savings in terms of fuel expenditure.

Electric three wheelers like the Y4 model by Japanese firm Terra Motors having good operation range of 100 km/charge with a battery capacity of 4.8 kWh, can also be introduced to the Bhutan markets to provide last mile connectivity and shared e-mobility.

8.8 EVMM Assessment & Recommendations for Bhutan

Based on the As-Is scenario (previous chapters), we have assessed[54] the existing conditions in each of the eight domains and identified the levels (as explained in Executive Summary) that they ought to attain in future years i.e. 2020, 2025 and 2030. We have also provided summary recommendations to ensure a sustainable EV adoption from one level to the next. A graphical representation showing the As-Is maturity level and the maturity level they need to attain in future is depicted below.[55]



[54] A detailed assessment requires stakeholder interviews

[55] "0" means default level which indicates that the basic minimum initiatives have been undertaken in this domain

Domain	By 2020	By 2025	By 2030
Vision, Policy & Regulatory, Institutional Capacity	***Target Maturity Level – 1*** • Government to come up with a nation- wide EV mission along with a set of policies and defined targets, to send signal to both foreign OEMs, local entrepreneurs & consumers to invest and adopt EV respectively • The Government, including Department of Road, Ministry of Works and Human Settlement (DoR), Ministry of Information and Communication (MoIC) and Road Safety and Transport Authority (RSTA) to identify and dictate EV adoption target and should also provide city target with respect to public transportation including buses and taxi fleets • Bhutan Postal Corporation Limited (runs operation of city buses in Thimphu and long-distance bus between Thimphu and Phuentsholing) should be considered as implementing agency for public buses electrification. Phase-wise electrification of public buses in Thimphu and Phuentsholing should begin with initial target of 50%. • Government should mandate setting up of charging infrastructure at government offices and embassies and that government vehicles and diplomatic vehicles should be fully electrified	***Target Maturity Level - 2*** • Government should mandate full electrification of public buses in Thimphu and Phuentsholing and pilot projects can be considered for other urban/suburban areas. Private buses to be given target of 30-50% electrification • Tariff policy by recognising EV as a separate group of consumers to be developed and aspects of dynamic pricing to be introduced to smoothen the load curve • Government should encourage adoption of electric two wheelers and four wheelers by providing subsidies on CAPEX through various schemes • In Thimphu, fleet operators of private taxis should be encouraged to shift to electric vehicle through incentives like subsidised parking charges, reduced tariff for charging, reduced toll etc. Electric two wheeler taxi fleet should be initiated • Guidelines for mandatory battery buy back by OEMs on completion of battery life or in case of any faulty battery	***Target Maturity Level - 3*** • Government should mandate full electrification of public and private buses • Government to make mandatory conversion of commercial taxi fleets into electric vehicle throughout the country • Government to provide guidelines for setting up of charging stations by third party and providing charging as a service without any kind of licensing at least for one year • Dedicated space in parking lots, in malls residential buildings for charging station installation to be made mandatory through building codes in select urban and tourist destinations • Public and private transport operators at tourist places mandated to convert fleet to electric vehicle. Local tourism department of municipalities to supervise operations, with Tourism Council of Bhutan as apex body • Grid Code and Distribution Code guidelines must be updated for Vehicle to Grid (V2G) integration

	• Government should ease norms on import of components and EV parts for local assembling companies and come out with guidelines on the same • Ministry of Finance should be brought in to collaborate with foreign development banks and institutions for financing EV initiative in Bhutan • Organizational restructuring with the creation of an EV cell with member from Bhutan Electricity Authority, BPC, Tourism Council of Bhutan and RSTA with overseeing authority of Ministry of Information & Communication to facilitate future deployment strategy, policy, O&M guidelines, consumer awareness etc		
Roadmap for Incentive	***Target Maturity Level – 1*** • Exemption of import and custom duty on EV and EV components • Reduced property tax for electric vehicle assembly companies • Reduced tariff for passengers using electric buses • Free parking and reduced tolls for electric vehicles • Subsidized registration charges for one year for electric two and four wheelers	***Target Maturity Level - 2*** • Reduced electricity tariff for charging for EV charging • Reduced road tax for electric four wheeler commercial fleet • Tourist places designated as "Only Eco-Sensitive Zones" and creation of EV Only zones in and around certain city centres • Reduced property tax for residential complexes in few initial years which will be installing charging stations to facilitate personal vehicles	***Target Maturity Level - 3*** • Attractive FDI policy with single window clearance, registration, tax breaks, repatriation facility etc. may be given to attract foreign investment in the EV • Bulk insurance at concessional rate for commercial fleets.
Automotive Sector	***Target Maturity Level - 1*** • Bhutan should encourage EV assembly units mainly two and four wheelers (Thunder Motors has already started building the	***Target Maturity Level - 2*** • Servicing facilities of electric vehicles and charging stations to be provided by OEMs and subsequent local capacity development on	***Target Maturity Level - 3*** • Testing and certifying facility to be established in conjunction assembling units for EVs

	assembly plant for EV cars) with internationally approved design within the country which can be achieved by promoting collaborations between local entrepreneurs and foreign manufacturers. The vehicle parts to be imported from India or China • Electric buses, electric cars and electric two wheelers to be imported from countries like India and China • Battery and charging stations to be imported from countries like India and China	O&M of EV and charging stations through training and skill development programs	• Promote local manufacturing of electric two wheelers through PPP or with joint ventures with foreign companies like in India, Japan etc.
Electrical Infrastructure	***Target Maturity Level - 2*** • BPC to assess the availability of spare capacity in distribution transformers in areas having potential for charging station implementation like bus depots and terminus, shopping centres, residential buildings etc. in major cities • BPC to assess the power availability including import and peak demand and also the seasonal variability in these parameters to figure out the EV demand the load network can sustain with the given supply	***Target Maturity Level - 3*** • Upgradation of electrical infrastructure in terms of meter room, laying of cables, supply meters etc. in bus depots and terminus, etc. by BPC for installation of charging stations • Upgradation expense should be included in the annual capex of BPC and to be factored in tariff as the spreading of upgradation expense over entire population will have negligible impact on tariff. BPC can also seek grants from foreign aid or the Royal Government of Bhutan for grid assets modernization and expansion to support EV rollouts • Improvement in power quality through deployment of technologies like harmonic filters, static compensators etc. • Development of safety guidelines, standard operating procedure for grid management, charging and operations, etc.	***Target Maturity Level - 4*** • Upgradation of electrical infrastructure in in various areas like parking lots, shopping centres, city centres for installation of public charging stations • Upgradation expense can be shared by car dealers or third party service providers of charging stations • Grid asset modernization for facilitating two way communication for implementing vehicle to grid solution

EV Technology	***Target Maturity Level - 1*** • For the older EV models, upgradation should be done in the battery segment with latest Li-ion batteries. As Bhutan has comparatively colder temperature, the EVs will not be affected by heating issues to EV battery.	***Target Maturity Level - 2*** • With presence of more of Indian vehicles in Bhutan, it may consider adopting EV standards of India to ensure interoperability. This include IS:17017 standard, which India has recently published for both AC and DC charging a combination of CHAdeMO and CCS2	***Target Maturity Level - 2*** • R&D on EV design to be initiated in collaboration with technology institutes, research labs, industries etc.
Value Chain Integration	***Target Maturity Level – 2*** • Government building and offices to install charging stations in their premises for EV usage and all government vehicles to be converted to EV • BPC is looking after electricity distribution and can invest in setting up public charging and dedicated fleet infrastructure. It can also provide end-end charging services or can lease/out-source operations. The main advantage of this model is that the utility need not worry about low volume of business in the initial years as the assets are created under regulated capex route • For electric buses, charging stations can be installed in bus depots or bus stations for overnight charging and in city bus parking for fast charging • Tourism Council of Bhutan can plan for developing charging stations in various tourist places to facilitate the tourist cars, a major chunk of taxi fleet, and tourist buses. They may appoint private companies, energy companies and contractors as EV	***Target Maturity Level - 3*** • PPP model with private parking owners or service providers or OEMs taking technology risk and invest in operation of the charging infrastructure whereas utilities providing the CAPEX and taking the payment risk and government providing the land on lease and taking the policy risk, force majeure risk may be explored • Municipal authorities, Tourism agencies along with BPC in major cities and tourist places like Thimphu, Phuentsholing, Tashichho Dzong, Norzin Lam Street, etc. can prioritize the installation of charging stations in parking lots, urban centres, markets, tourist spots etc. and upgradation of electrical infrastructure to promote and support the EV deployment • Big business houses like Tashi Group, holding companies of Druk Holding & Investments (DHI) and donor agency offices like ADB, World Bank, USAID etc. can use EV two wheelers and four wheelers for their own use and can set up EVSE in their areas of business operations like factories, hotels etc.	***Target Maturity Level - 4*** • Bundle EVSE as mandatory in new buildings through Building Codes for all categories of buildings exceeding certain built area. In this case the impact of EVSE infrastructure cost in the per square meter cost; this should be initially implemented in Thimphu and then spread to other urban areas • Dedicated fleet operators like for e-Buses and e-4Ws can invest by themselves or bring third party to invest in charging stations and price it rightly in their pricing to the end-customers • With transition of private cars into electric fleets will provide opportunity for the retailer or third party service providers to provide door to door servicing on charging of electric vehicle with a premium charged on the regular tariff. This should be initiated in Thimpu and Phuentsholing

	Service Providers (EVSP) for charging operations and payment settlements who ensures certain level of interoperability amongst different EVSE network owners	• Bhutan Post in his central and regional head offices can install public charging stations and also can use EVs for their day to day activities e.g. electric mail vans • Mandatory for the JV hydropower project companies to develop public charging stations in government land in major cities as a part of the royalty or government need to define a part of the royalty they get to contribute in implementation of public charging stations • Various car renting companies and taxi fleets can also convert EVs and can also set up EVSE at their location that anyone can use for a fee	
Customer	***Target Maturity Level – 1*** • Government vision on electric vehicle is communicated to customers • Carry out research on the customer pattern of vehicle usage and identify probable charging pattern to figure out the load curve by the EV cell	***Target Maturity Level - 2*** • Time of use pricing or special EV tariff and its benefits to the customers must be displayed to make them aware of their benefits • All the incentives and benefits for adopting or cruising an electric vehicle to be communicated properly to customers	***Target Maturity Level - 3*** • Customers are engaged in prosumer programs through V2G integration on pilot basis • Advanced services for customers like door to door service for car charging where the retailer or service provider picks up the car for charging and drop it to the customer after the required amount of charging has been done in urban areas
Social & Environmental	***Target Maturity Level - 1*** • Organizing EV awareness programs, conduct workshops and seminars to make people aware of the benefits of EV adoption in terms of maintaining air quality and corresponding health benefits (Bhutan is a carbon neutral country so necessity for Bhutan to maintain this status can be conveyed to the public)	***Target Maturity Level - 2*** • EV deployment mainly buses, four wheelers and two wheelers can also provide opportunity to the existing workforce by providing them adequate training on O&M skills	***Target Maturity Level - 3*** • Third party service providing of charging stations will lead to job creation and people • The deployment goals by the government will also help to improve quality of electricity supply in remote areas either through grid extension or through microgrid which can help in improving the living standard of the people in those areas

9. India: EV Scenario

9.1 Country Profile

9.1.1 Demography and Economy

India lies on the Indian Plate, the northern portion of the Indo-Australian plate situated north of the equator. It is the second most populous country of the world, with nearly a fifth of the world's population. It has a population of about 1.29 billion, growing at a rate of about 1.26% over the last five years. With an area of about 3.3 million sq. km., the population density of India is 395 people per sq. km.

India's GDP grew at 7.9% in FY 2015-16, fastest in the last five years, supported by domestic consumption, favourable monsoons and robust investments in various sectors. The long-term growth prospective of the Indian economy is positive due to its young population, corresponding low dependency ratio, healthy savings and investment rates, and increasing integration into the global economy.[56] The central government has met its commitments towards fiscal consolidation and kept the fiscal deficit within its targets of 3.5% of the GDP A brief profile of the country is represented below:

Parameters	2016
General Parameters	
Population, billion	**1.29**
Population growth rate, % (2011-16)	**1.3**
Total Surface area, '000 sq. km	**3287.3**
Population density, persons per sq. km of total surface area	**395.2**
Macro-economic parameters	
GDP, USD billion	**2448.4**
GDP per capita, USD	**1847.0**
Current Account Balance, % of GDP	**-1.0**
Debt, % of GDP	**69.2**
Inflation, %	**5.2**

Table 35 Demography and Economy Parameters in India

In 2016, the GDP contribution by sector is Services (53.66%), Industry (29.02%) and agriculture (17.32%). India has one of the fastest growing service sectors in the world with an annual growth rate above 9% since 2001, contributing 57% of GDP in 2012–13. It has become a major exporter of IT services, Business Process Outsourcing (BPO) services, and software services with $154 billion revenue in FY 2017. This is the fastest-growing part of the economy. The IT industry continues to be

[56] Coatings. http://www.coatingsjournal.com/single-editorial.php?id=13

the largest private-sector employer in India. The agricultural sector is the largest employer in India's[57] economy but contributes to a declining share of its GDP (17% in 2013–14).

9.1.2 Energy and Climate

The power sector in India is mainly governed by the Ministry of Power. The Central government controls the Central Electricity Authority (CEA), the main regulatory body, and the central generating companies, which are National Thermal Power Corporation (NTPC), National Hydro-Power Corporation (NHPC) and Nuclear Power Corporation (NPC) which then sell their entire output to state-run utilities. The states control the State Electricity Boards (SEBs), which generate power and account for most of the distribution in the country.

The sources of power generation in India range from conventional sources such as coal, lignite, natural gas, oil, hydro and nuclear power to viable non-conventional sources such as wind, solar, and agricultural and domestic waste making it the most diversified in the world. 70% of India's power demand is currently met through coal and other fossil fuels. Electricity demand in the country has increased rapidly and is further expected to rise in the years to come. Massive addition to the installed generating capacity is required[58] in order to meet the increasing demand for electricity in the country.

India has the fifth largest power generation capacity in the world and its ranks third globally in terms of electricity production. In May 2018, the overall power measure index ranks India 4th in the Asia Pacific region out of 25 nations. Electricity production in India reached 1,201.5 Billion Units (BU) during FY18. The below table shows the installed capacity with respect to fuel type:

Fuel	MW	% of Total
Total Thermal	**2,21,803**	**64.3%**
Coal	**1,96,098**	**56.9%**
Gas	**24,867**	**7.2%**
Oil	**838**	**0.2%**
Hydro (Renewable)	**45,457**	**13.2%**
Nuclear	**6,780**	**2.0%**
RES* (MNRE)	**70,649**	**20.5%**
Total	**344,689**	**100%**

Table 36 Installed Electricity Capacity for India in 2018

Installed capacity in respect of RES (MNRE) as on 30.06.2018. Source: Power sector, MoP; RES (Renewable Energy Sources) include Small Hydro Project, Biomass Gasifier, Biomass Power, Urban & Industrial Waste Power, Solar and Wind Energy.

The Government of India is looking to expand use of renewable energy (RE) as a major source of power in India. It has set a target to achieve 175 GW installed capacity of renewable energy by FY22. The total installed RE capacity is 69.02 GW with wind energy accounting for 49.33 percent thereby being the largest source of renewable energy in India. The government is planning to double wind power generation capacity to 60 GW by 2022. It has also raised the solar power generation capacity addition

[57] Economy of India - Wikipedia. https://en.wikipedia.org/wiki/Economy_of_India

[58] Business Opportunities in Energy Sector. Business Ideas in .... https://www.youtube.com/watch?v=vJwrUMVAWU

target by five times to 100 GW by 2022 along with preparing a 'rent a roof' policy for supporting its target of generating 40 gigawatts (GW) of power through solar rooftop projects by 2022. By March 2019, government of India has set the vision of ensuring 24x7 affordable and quality power for all. As of August 2018, around 88.6% (194.2 million households out of 219.2 million households) were electrified and the remaining 11.4% (25.0 million households) are expected to be electrified by end March 2019, under the Pradhan Mantri Sahaj Bijli Har Ghar Yojana- "Saubhagya" scheme.[59]

In 2014, the country emitted 3,079.81 million tonnes of CO2e of GHG emissions (excluding Land Use Change and Forestry); highest among the SAARC Member States. The country also has high GHG emissions per GDP (PPP) of 441.63 tonnes of CO2e/million USD and 2.38 tonnes CO2e per capita GHG emissions. The transportation sector accounted for 8% of total GHG emissions.

Internationally, the government of India has voluntarily agreed to reduce the emissions intensity of its gross domestic product (GDP) by 20–25 percent from 2005 levels by 2020. Based on its existing policy package and macroeconomic trends, the Indian and international studies suggest that India is likely to meet or even exceed this pledge. However, significant obscurity surrounds the effective implementation of these policies and changes in the GDP composition. Domestically for tackling the climate change, the government launched the National Action Plan on Climate Change (NAPCC) which includes eight mission.

9.1.3 Automobiles and Transport sector

9.1.3.1 Industry Overview and Major Players

Indian automobile industry contributes 7.1% to GDP. With sales increasing 9.5 per cent year-on-year to 4.02 million units (excluding two wheelers) in 2017, it became the 4th largest in the world. The 2W segment dominates the market in terms of volume due to a growing middle class and a young population. Additionally, the companies' interest is growing in exploring the rural markets, which further aided the growth of the sector.

The below table shows the category wise sales for each segment in 2017-18[60]:

Category	Numbers	Percent wise distribution
Passenger Vehicles	**32,87,965**	**13.17%**
Commercial Vehicles	**8,56,453**	**3.43%**
Three Wheelers	**6,35,698**	**2.55%**
Two Wheelers	**2,01,92,672**	**80.86%**
Total	**2,49,72,788**	

Table 37 Automobile Category-wise Sales for India in 2017-2018

Total automobile production in India for FY17 was 25.31 million units with 2W being the major segment contributing 79% and passenger vehicles contributing 15% of the total production. The

[59] India Power Sector, Available at: https://www.ibef.org/industry/power-sector-india.aspx
[60] SIAM India Statistics

Compound Annual Growth Rate (CAGR) for the FY06-17 has been 9% with the fastest growing segment being the passenger vehicles followed by 2W, growing by 10% and 9%[61] respectively.

India is also a prominent auto exporter with the expectation of strong growth in the near future. Automobile export is expected to grow at a CAGR of 3.05 per cent during 2016-2026. Additionally, by 2020 the government and major automobile players in Indian market are expecting to make India a leader in 2W and 4W in the world.

The government of India aims to develop India as a global manufacturing as well as a research and development (R&D) hub. It has set up National Automotive Testing and R&D Infrastructure Project (NATRiP) centres as well as a National Automotive Board to act as facilitator between the government and the industry. Under (NATRIP), five testing and research centres have been established in the country since 2015.

The below table shows the major players for each of the vehicle category:

Vehicle Category	Major players
Motorcycle (2W)	**Honda, Bajaj Auto, TVS Motors, Hero Motocorp, etc.**
Three wheelers (3W)	**Bajaj Auto, Piaggio, Mahindra and Mahindra etc.**
Cars (4W)	**Maruti Suzuki, Hyundai, Toyota, Honda etc.**
Bus and Heavy Trucks	**Tata Motors, Ashok Leyland, Eicher Motors etc.**

Table 38 Major Automobile Companies by Vehicle Category in India

9.1.3.2 Transport Sector

India has the second largest road network globally, with 5.47 million km of roads as of FY 2016-17. 85.9% of the total passenger traffic and 64.5% of all goods in India are moved through roads. Apart from roadways, railways and airways play an important role in mass transit in India.

Indian Railway has 13,313 passenger trains running daily carrying 8.10 billion passengers per annum. Further, it is estimated to have carried 1.1 billion tonnes of freight in FY 2016. The rail network is spread across 7,216 stations with a total of 66,687 route km.

The airways mode of transportation is been pivoted on 133 airports in India, which includes 24 international airports. Air passenger traffic, both domestic and international has grown to 134.98 million passenger per annum, witnessing a CAGR of 10.1% during the last decade. Approximately 26.28 lakh MT of freight traffic is also handled in the domestic and international routes. The below table shows the overall transport sector at a glance:

[61]two-wheeler-industry-analysis-research-report, Available at: https://www.fintapp.com/blog/two-wheeler-industry-analysis-research-report

Roadways[62]	
Road Network (million km)	5.47
Total passenger traffic handled through road (%)	85.9
Total goods moved through road (%)	64.5
National Highways (km)	103,933 (2%)
State Highways (km)	161,487 (3%)
District and Rural roads (km)	5,207, 044 (95%)
Railways[63]	
No. of passenger trains running daily	13,313
No. of Passengers travelling per annum (billion)	8.10
Freight carried (billion tonnes)	1.1
No. of stations	7,216
Total route length (km)	66,687
Airways[64]	
No. of airports	133
No of International Airport	24
Air passenger traffic per annum (million)	134.98
Freight traffic handled through domestic and international route (million MT)	2.63
Waterways[65]	
Major Ports	12
Non-major ports	200
Cargo traffic handled at port (MMT)	1758.3

Table 39 Indian Transport Sector at a glance

9.1.3.3 Fossil Fuel Dependence

In 2016, India's oil consumption was 212.7 million tons, making it rank 3rd after USA and China. In 2015, India imported 195.1 million tons crude oil and 23.3 million tons refined petroleum products and exported 55 million tons refined petroleum products. It has built surplus world class refining capacity using imported crude oil for exporting refined petroleum products. After accounting exports and imports of refined petroleum products, the net import of crude oil is lesser by one fourth.

62 Roads Sector Overview - June 2017, Indian Brand Equity Foundation

63 Indian Railways Statistical Publications 2015-16, Ministry of Railways

64 Handbook on Civil Aviation Statistics, 2015-16

65 Ports Sector Overview - June 2017, Indian Brand Equity Foundation

India's net oil and gas import bill after adjusting for exports of petroleum products amounts to be around 2.5%[66] of GDP. This bill is higher than India's overall current account deficit (CAD) and hence plays a big role in determining the dynamics related to the balance of payments.

9.1.4 Propositions for EVs in India

The past modes of transport and infrastructure will not suffice in coming years to cater the requirement of large India's population, hence the mobility in India is required to be changed dramatically to fulfil the demand. Recognising this aspect, the Government of India, is working towards developing a mobility option which is 'Shared, Connected and Electric'. It also believes that there is an increased need to reduce dependence on imported fossil fuel by preparing for a green future for Indian mobility. In India, the automobile industry is one of the key sectors contributing and driving the economic growth. However, this sector has also been contributors to GHG emissions in the country.

Also, as oil import account for 80% of India's current oil needs due to which India have high import bill. These high import bill will lead to high current account deficit due to which there will be heavy economic burden to the country and hence, management of fuel economy/energy efficiency becomes very important aspect. The government is already giving a big push to e-vehicles because of its commitments at global forums to control carbon emissions and India's high dependence on imports to fuel its economic growth.

In study conducted by NITI Aayog shows that India would need nearly 1.6 billion metric tonnes of oil equivalent of petrol and diesel to fuel its passenger mobility sector from 2017-2030. At a conservative crude oil price estimate of $52/bbl, this oil import demand would cost nearly $670 billion or Rs 4.4 million crore over the period 2017-2030. Assuming India continues to import 80 per cent of its oil, this could represent a total import bill of roughly $550 billion or Rs 3.6 million crore.

In contrast, meeting India's EV ambitions through 100 per cent domestic manufacturing of batteries would require at least 3,500 GWh of batteries at a wholesale cost of $300 billion (Rs 2 million crore) from 2017–2030 less than half the cost of the avoided oil imports.[67] Battery manufacturers could seize 25-40 per cent of the market's value by assembling battery packs in India and importing only battery cells. In this case, India's total value of imports for EVs would be between $180–$225 billion or Rs 1.2-1.5 million crore. India may still be consuming nearly Rs 1.7 million crore worth of petrol and diesel, this would still represent an import saving opportunity of Rs 0.4 million crore for India.[68]

66 https://www.livemint.com/Industry/ro8NqXjBC4gk1i2OAQdGYN/Why-oil-can-spoil-Indias-budget-math.html

67 India Energy Storage Mission - NITI Aayog, 2017

68 https://economictimes.indiatimes.com/markets/stocks/news/oil-price-rise-gives-evs-a-big-boost/articleshow/64117882.cms

9.1.4.1 Key Benefits of EV deployment in India

Electric vehicle will reduce the GHG emission, thereby allowing India to align with their INDC goals.

Electric Vehicle has potential of reduced Total Cost of Ownership (TCO) as compared to ICE vehicles.

Shifting the transport sector away from reliance on fossil fuels towards use of electricity powered vehicles will help in reducing India oil import bill

Provision of clean, affordable and comfortable transport facility for the India population.

9.1.4.2 Key Challenges of EV deployment in India

The high investment cost of EVs and charging equipment is a major cause of detriment for EV adoption

Lack of standardisation in specifications will lead to wide cost difference for the same model and it may act as baarier to adoption

Lack of clarity in subsidy mechanism and in availing the subsidy without any road map at city level.

Obscure policies and lack of future roadmap for consolidating the demand can act as a major challenge for EV adoption

9.2 Existing EV Landscapes

9.2.1 EV Related Policies

The government has been taking several initiatives to promote faster adoption of EVs. In 2011, Government of India had unveiled the National Electric Mobility Mission Plan (NEMMP) 2020 to accelerate the growth of electric vehicles by focusing primarily on fast-tracking the manufacturing. Further, the Department of Heavy Industries (DHI) had launched FAME (Faster Adaptation and Manufacturing of (Hybrid & Electric Vehicles) in April 2015 to promote electric and hybrid vehicles in India by providing incentives to develop technology platforms and charging infrastructure along with subsidies on the demand side[69].

In May 2017, the National Institution for Transforming India (also known as NITI Aayog) had come up with probable ideas to make India's passenger mobility shared, electric, and connected, envisaging curtailment of its energy demand by 64% and reduction of carbon emissions by 37%[70]. DHI has also released a draft 'Standardization of protocol for Charging Infrastructure' (Bharat EV Charger Specifications) in order to facilitate common specifications and standards for all categories of vehicles ensuring seamlessly growth in adoption across the country[71].

Ministry of Urban Development has also introduced a new scheme under consideration, the Green Urban Transport Scheme (GUTS) for enabling a shift towards electric vehicles for public transport and use of non- fossil fuel for powering vehicles[72]. The Scheme is expected to focus on growth of urban transport in a manner that allows for substantial and measurable reduction in pollution while providing a permanent and sustainable framework for funding Urban Transport Mobility Projects. The Scheme will target state capitals and cities with population of 5 lakhs and above. Expenditure of about USD 3.7 billion over the next five years has been estimated from the central government.

In 2018, there has been the announcement about the FAME II offering incentives for mass adoption of electric vehicles with an outlay of Rs 5,500 crore. It is planned that subsidy will be given to all categories of electric vehicles but hybrid vehicles won't be entitled to sops anymore[73]. Its key focus will be on Buses and setting charging infrastructure for all categories of EV. However, this policy is still in draft stage and an official announcement is yet to be made.

States are also coming up with their own policies to attract investments. The governments of Maharashtra, Karnataka, Telangana, Andhra Pradesh, Gujarat and Delhi have already come out with policies for promoting e-mobility. In September 2017, Karnataka became the first state to roll out the Electric Vehicle and Energy Storage Policy 2017. Besides providing incentives and concessions to EV and battery manufacturing players and charging equipment firms, the state will amend the building bylaws for providing mandatory charging infrastructure in all high-rise buildings. It will also create a special purpose vehicle involving several state agencies to create charging infrastructure.

[69] Hybrid and Electric Vehicles in India, The International Council on Clean Transportation, December 2016

[70] India Leaps Ahead: Transformative Mobility Solutions for All, Niti Aayog, May 2017

[71] Standardization of protocol for charging infrastructure - Committee Report on Standardization of Public EV Chargers, Ministry of Heavy Industries and Public Enterprises, 15 May 2017

[72] Ministry of Urban Development, Government of India Press Release on 8 November, 2016

[73] FAME II scheme, 2018 Available at: https://energy.economictimes.indiatimes.com/news/power/rs-5500-cr-fame-ii-scheme-finalised-all-evs-to-get-subsidy-support/65523529

With all this policy development from central and state government promoting EVs happening, it is seen that India has developed a good ecosystem around EVs. Various players in chargers, batteries, fleets, vehicle manufacturers have started making announcement for investment in this space. Thus, making India being the most advanced in this space among the SAARC countries.

9.2.2 EV Fleet Size Models and Players

The current situation of Electric car market in India is at a very nascent state with very few players already having their vehicles running on road. Around 4,800[74] cars were on road till 2017 and these deployments were focused majorly in Delhi and Bangalore cities. Mahindra Electric started their journey in to the EV space in 2001 by launching Mahindra Reva, India's first electric car. Their current version of on road is Mahindra E20 models. Tata motors also have recently entered the EV market in passenger vehicles and electric buses. It has launched the electric buses in the state of Himachal Pradesh. It has plans to deliver 25 hybrid buses to MMRDA in Mumbai. They launched their EV Passenger cars business by winning a major tender of 10,000 cars launched by EESL. They have launched a car – Tigor EV and have recently delivered their first set of cars to EESL[75].

Electric two wheeler market (e-2W) in India is also at a very nascent stage There are around 0.1 million e-2W running on the road. Major e-2W players who have their model running on road are Hero electric, Ather, Okinawa autotech and Lohiya auto. While the players like Bajaj and TVS have announced to launch their model in the coming year.

It is estimated that there are around 0.5 million of e-rickshaws on road, mostly with lead acid batteries. However, registered e-rickshaws form only 16% (80k). The geographical spread for the e-rickshaws is dominant in the NCR, Uttar Pradesh, West Bengal, Bihar and Maharashtra region.

9.2.3 Charging Station and Standards

The Government of India has recently notified the Protocol for Adaption of standards for Bharat Chargers (AC-001 & DC-001). The process of adapting these standards included the following steps:

- Under the FAME Policy in 2015, the Department of Heavy Industries (DHI) had authorized the Automotive Research Association of India (ARAI) to come up with Draft Standards for EV Chargers in India
- ARAI had published these standards in 2016 and the DHI invited Industry response to the same
- DHI along with NITI Aayog has proposed standards for EV Chargers in India

The EV charging business in India is in early stages with only Mahindra being the major car manufacturer. The below table shows the no. of EV chargers installed. These include only public EV charging stations. Home chargers are excluded in these estimations. Mahindra has 80 locations across 10 cities with nearly 86% located in Delhi, Kolkata, Bangalore and Pune.

[74] Global EV Outlook 2017, International Energy Agency (IEA)
[75] India EV Story. Emerging Opportunities - PDF. https://docplayer.net/80380553-India-ev-story-emerging-opportunities.html

	Installed base of August 2017
EV Charging stations	**130**
Total EV chargers installed	**270**
No. of AC Slow chargers	**246**
No. of DC Fast chargers	**24**

Table 40 EV Charging Status for India in 2017
Source: India EV Story, 2017

9.2.4 EV Pilots

Ola launched its electric vehicle pilot project in Nagpur in 2017 with an investment of $8 million. They Launched 200+ cars that are charged by the company as of now. Electric vehicles used in the pilot are from Mahindra electric (E20 plus model). They had also announced to build 50 charging stations at 4 strategic locations in Nagpur with support from the ACME group. The Ola cars are charged by the company under the subsidy. The Ola is Planning to launch the same in 2 Tier-I and 3 Tier-III cities in coming years and its plan to invest $2 billion in EVs in all cities of India and run one million electricity powered vehicles on its platform by 2020.

There was also a recent quick pilot planned on EV charging infrastructure rollout in the Gurgaon-IGI-South Delhi-Noida corridor by NITI Aayog. The plan for the corridor includes 55 locations with 135 charging stations of which 46 are DC quick charging stations and 89 are slower AC charging stations[76]. The actual deployment will rely on co-operation with state governments, selected government authorities, Ministry of Power, grid companies as well as some private enterprises (e.g. DIAL at IGI, DLF Mall).

There are other pilots also running in metro cities like Mumbai, Delhi, Kolkata, Bangalore and Hyderabad. It is also seen that discoms are taking lead in setting up public charging stations in metro cities.

9.2.5 Tariffs for EV

Some states in India have announced the special tariff for charging electric vehicle. It is also believed that other states are also likely to follow the trend and announce their policy soon. In Maharashtra, Maharashtra Electricity Regulatory Commission (MERC) has created a new category for Electric Vehicle (EV) Charging Stations at HT and LT Voltage levels, with effective variable charge of Rs.6 per unit and demand charges of Rs.70 per kVA per month. Additionally, they will also be eligible for Power Factor (PF) incentives/penalties, besides Time-of-Day (ToD) tariffs[77].

[76] EV infra report, http://niti.gov.in/writereaddata/files/document_publication/Report-EV-Infra.pdf
[77] Retail Electricity Tariff of Maharashtra State Electricity Distribution Co. Ltd, 2018

In its 2017-18 tariff order, the Delhi Electricity Regulatory Commission (DERC) introduces the following special tariff for EV charging:

Category	Tariff charge
LT	**Fixed Rs. 5.5/kWh**
HT	**Fixed Rs. 5.0/kWh**

Table 41 Delhi Electricity Tariff for EV Charging

The Karnataka Electricity Regulatory Commission (KERC) in its 2018 tariff order[78] introduces the following tariff charges for EV charging:

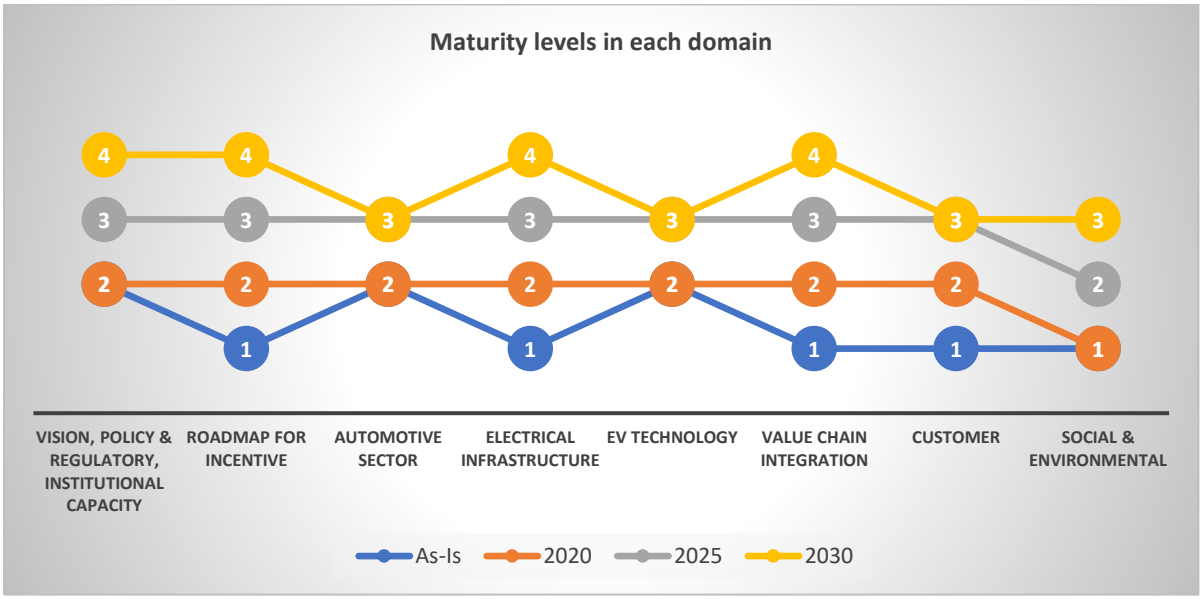
Details		Approved tariff
Under LT Supply	**Fixed charges per KW**	**Rs. 50/KW/month**
Under HT supply	**DC per KVA**	**Rs. 180/KW/month**
	Energy charges per KWH for both LT & HT	**Rs. 4.85/unit**

Table 42 Karnataka Special Tariff for EV Charging

[78] KERC tariff order 2018

9.3 EVMM Assessment & Recommendations for India

Based on the As-Is scenario (previous chapters), we have assessed[79] the existing conditions in each of the eight domains and identified the levels (as explained in Executive Summary) that they ought to attain in future years i.e. 2020, 2025 and 2030. We have also provided summary recommendations to ensure a sustainable EV adoption from one level to the next. A graphical representation showing the As-Is maturity level and the maturity level they need to attain in future is depicted below.[80]



[79] A detailed assessment requires stakeholder interviews

[80] "0" means default level which indicates that the basic minimum initiatives have been undertaken in this domain

Domain	By 2020	By 2025	By 2030
Vision, Policy & Regulatory, Institutional Capacity	***Target Maturity Level – 2*** • The Government (NITI Aayog, Ministry of Power (MoP), Ministry of New and Renewable Energy (MNRE), Ministry of Road Transport and Highways (MORTH), Ministry of Urban Development and the Ministry of Heavy Industries and Public Enterprises) should focus on creating charging infrastructure and national electric vehicle policy framework to provide an impetus to the entire e-mobility ecosystem including vehicle manufacturers, charging infrastructure companies, fleet operators, service providers, consumers, etc. • State governments should be encouraged to release EV policies that are also aligned with the national EV policy. States such as Himachal Pradesh, Uttarakhand, North-Eastern States, etc. with large tourism potential should promote their respective road transport corporations, tourism development corporations and municipalities to collaborate to establish state EV policy with dual motive of tourism and e-mobility • Organizational restructuring with the creation of an EV cell within the ministries mentioned earlier to facilitate future deployment strategy, charging station implementation, O&M guidelines, consumer awareness etc.	***Target Maturity Level - 3*** • Government should target full electrification of three wheelers and at least 25-40% electrification of intra-city buses in metro cities and tier-1 and tier-2 cities along with the compulsory installation of charging stations in depots, terminus and highways. Fleet operators of private taxis should be encouraged to shift to electric vehicle in these cities through incentives like subsidised parking charges, reduced tariff for charging, reduced toll etc. • Public transport electrification to be placed as high priority in the agenda of Smart City Mission. • Government should encourage banks to provide low interest rate loans for electric two wheelers and passenger cars • Grid Code and Distribution Code guidelines must be updated for Vehicle to Grid (V2G) integration • Creation of a PPP cell and Investment Facilitation Center with members from concerned (previously mentioned) ministries to evaluate project proposal on EV, battery and EVSE manufacturing and act as a single window for FDI, PPP and JV projects • Dedicated space in parking lots, in malls, commercial buildings and residential buildings for charging station installation to be made	***Target Maturity Level - 4*** • Government to make mandatory full electrification of public bus fleets in metro cities and tier-1 and tier-2 cities and that of private taxi fleets throughout the country • Government to provide guidelines of battery recycling • Private companies should be mandated to fully electrify the company cars • Government should establish India as an EV manufacturing hub and export of EV technology must be explored

	• The National E-Mobility Programme that uses the demand aggregation model, should be expanded to include electric buses and three wheelers. Other government agencies, specifically Public Sector Units (PSUs) should also be brought on board for implementation • Charging infrastructure and EV fleet should be mandated for transport services used by all government offices across India	mandatory through revisions to building codes	
Roadmap for Incentive	***Target Maturity Level – 2*** • GST rate for EV should be rationalized to minimize slab on all input EV components and same slab also on the EV sales • Allow electric bus, electric three wheeler manufacturers and electric vehicle assembly companies to be setup in Special Economic Zones (SEZs) or Special Manufacturing Zones • Provide tax exemption or subsidy for charging station equipment • Reduced fare for commuters using electric buses • Introducing separate EV tariff for charging in all states • Accelerated depreciation allowed for assets or machineries imported by manufacturing or assembling units • R&D grant for battery technology development	***Target Maturity Level – 3*** • Reduced tax on profit repatriation for foreign companies entering into JV or 100% FDI • Subsidized registration charges for one-two years for electric three wheelers • Fleet operators of electrified private taxis to be given incentives like subsidised parking charges, reduced tariff for charging, reduced toll etc. • Road and toll tax exemption for electric buses • Subsidized parking charges for electric cars • Government should encourage banks to provide low interest rate loans for electric two wheelers and passenger cars • Reduced property tax for residential complexes in few initial years which will be installing charging stations to facilitate personal vehicles. Accelerated depreciation allowed for charging stations setup in parking lots, malls, commercial buildings, etc.	***Target Maturity Level – 4*** • Road and toll tax exemption for commercial electric taxi fleets. Bulk insurance at concessional rate for these fleets. • Promote battery recycling industry through tax free income in initial years or reduced interest on loans for JVs with minimum 30% stake of local companies

Automotive Sector	***Target Maturity Level – 2*** • Local manufacturing of EVSE, electric two and three wheelers, EV batteries, electric buses, etc. through joint ventures with foreign companies like in Europe, China, Japan etc. • In house development of motors and power electronic equipment used for EVSE and EV	***Target Maturity Level - 3*** • Servicing facility for charging stations can be provided by OEMs and local capacity development on O&M of charging stations through training and skill development • 100% local manufacturing units to be set up for electric two wheelers, three wheelers, cars and buses and service centres to be developed locally with skilled workforce	***Target Maturity Level - 4*** • Battery manufacturing through 100% FDI and JV with local companies Battery recycling industry to be established with foreign collaborations • Manufacturing of high end luxury cars and buses with higher battery capacity • Manufacturing of low cost two and four wheelers with improved battery technology for long distance travel
Electrical Infrastructure	***Target Maturity Level - 2*** • Distribution utilities to assess the supply and availability of spare capacity in distribution transformers in areas having potential for charging station implementation like bus depots and terminus, existing malls, residential buildings etc. in major cities • Distribution utilities to consider power supply from renewable sources in areas having high renewable potential for installation of charging station for electric three wheelers • Upgradation of electrical infrastructure in terms of meter room, laying of cables, supply meters etc. in bus depots and terminus, parking lots, malls etc. by distribution utilities for installation of charging stations	***Target Maturity Level - 3*** • Improvement in power quality through deployment of technologies like harmonic filters, static compensators etc. • Implementation of charging stations by supermarkets, big retailers with electrical network upgradation at own cost. • Upgradation expense can be shared by OEMs or third party service providers of charging stations	***Target Maturity Level - 4*** • Grid asset modernization for facilitating two way communication for implementing vehicle to grid solution • Facilitate EV owners to participate in demand response programs
EV Technology	***Target Maturity Level - 2***	***Target Maturity Level – 3*** • The Bureau of Indian Standards (BIS), Department of Science and Technology (DST),	***Target Maturity Level - 3***

	• Retrofitting for earlier EV models; converting lead acid battery run three wheelers to run on lithium ion battery • Develop custom charging connector and communication protocol for India • A combination of OCPP and smart charging protocols like OpenADR 2.0 or IEEE 2030.5 can create robust smart EV ready grid network and systems. These standards to be used by new Charge Point Operators (CPOs) or Network Service Providers (NSPs) to setup their network of charging stations and providing value added services around EV charging to the end-customers, the Charge Station Operators and Utilities	various think-tanks, distribution utilities, technocrats and EV associations to contribute in enhancement of the charging standards and communication protocols being used • In house development of motor technology, power electronics equipment like switch mode power supply for charging stations along with international technology institutes etc. • New approaches and technologies should be promoted for long-term R&D in all aspects of EV technologies. These include new battery-chemistries (with higher specific energy and energy densities), battery materials and chemicals, distributed motors, batteries withstanding higher temperatures, motors without permanent magnets, heavy trucks, and two-way power transfer between grid and EV chargers	• R&D on battery and battery recycling to be initiated in collaboration with international research labs, technology institutes, etc.
Value Chain Integration	***Target Maturity Level – 2*** • Central, state government and PSU buildings and offices should install charging stations in their premises for EV usage • Distribution utilities along with Ministry of Road Transport and Highways to invest in setting up charging infrastructure for electric buses in bus depots for overnight charging and in bus terminus for fast charging during the day with the cost being treated under regulated capex route and private bus companies to set up charging stations in their premises and can allow	***Target Maturity Level - 3*** • Battery swapping model can be used for three wheelers with the help of a Battery Leasing Agency which will charge the batteries on a large scale and facilitate the three wheelers by providing a charged battery against a specified fee. The Battery Leasing Agency may be formed by the battery or EVSE supplier • Bundle EVSE as mandatory in new buildings through Building Codes for all categories of buildings exceeding certain built area. In this case the impact of EVSE infrastructure cost is negligible in per square meter cost. Charging	***Target Maturity Level - 4*** • Bundle EVSE with highway development cost and install charging stations in the highways • Dedicated fleet operators like for e-Buses and e-4Ws can invest by themselves or bring third party to invest in charging stations • With transition of private cars into electric fleets will provide opportunity for the retailer or third party service providers to provide door to door servicing on charging

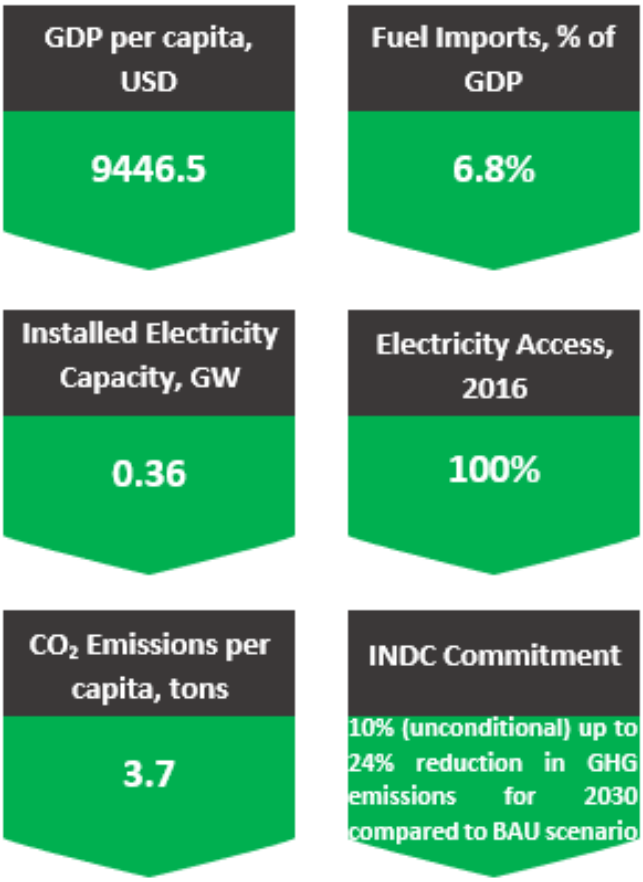
	public during certain hours against a specified rate (flat rate) • Private parking owners or service providers can implement public charging stations along with distribution utilities or service providers along with distribution utilities and the mall owners or hospitals can install public charging stations in government land • Travel & Tourism companies to install public charging station near tourist spot and resorts respectively • Mandatory for two and four wheeler rental agencies at tourist places to install charging stations and use electric vehicle • Oil majors like IOCL, BPCL and HPCL and retail gas distribution companies should be mandated to setup public charging infrastructure in areas of EV concentration	coupled with parking business can emerge as good model for value added service • Projects to be allocated to renewable energy companies must include a clause of implementing one or two public charging stations outside their plant's premises • State Transport Authorities to install charging stations on ferry ghats for boats facilitating inland transportation • Creation of EV only zones in and around urban centres or city centres in major cities to promote EV • PPP model with private parking owners or service providers or OEMs taking technology risk and invest in operation of the charging infrastructure whereas utilities providing the CAPEX and taking the payment risk and government providing the land on lease and taking the policy risk, force majeure risk may be explored • Pilot projects to convert water transport fleet including the fishing boats into electric fleet along with installation of charging stations in coastal region	of electric vehicle in major cities with a premium charged on the regular tariff
Customer	***Target Maturity Level – 2*** • Government vision target for electric vehicle is communicated to customers • Carry out research on the customer pattern of vehicle usage mainly two wheelers and four wheelers identify probable charging pattern to figure out the load curve for a particular day	***Target Maturity Level – 3*** • All the incentives and benefits for adopting or cruising an electric vehicle to be communicated properly to customers • Advance booking of parking slots through e-booking based on time and amount of charge required by the individual	***Target Maturity Level - 4*** • Customers are engaged in prosumer programs through V2G integration on pilot basis • Customers are informed about the benefits of participating in demand response program

	• Time of use pricing and its benefits to the customers must be displayed to make them aware of their benefits		• Advanced services for customers like door to door service for car charging where the retailer or service provider picks up the car for charging and drop it to the customer after the required amount of charging has been done
Social & Environmental	***Target Maturity Level - 1*** • Organizing EV awareness programs, conduct workshops and seminars to make people aware of the benefits of EV adoption in terms of improved air quality, health benefits. • Tourism will flourish by projecting areas as carbon neutral with EV being the only transport mechanism in those areas	***Target Maturity Level - 2*** • EV deployment mainly the buses, and commercial taxi fleets can also provide opportunity to the existing workforce by providing them adequate training on O&M skills • Electric two wheelers and three wheelers manufacturing and assembling plants will help in job creation	***Target Maturity Level - 3*** • The deployment goals by the government will also help to bring electricity in the remote areas which can help in improving the living standard of the people in those areas • Usage of electric boats and launches will negate the chances of oil spills from boats and facilitate in reducing water pollution

10. Maldives: EV Scenario

Maldives is a growing economy, based primarily on tourism and construction. Maldives currently faces the multiple issues of high fiscal deficit, public debt and adverse impacts of climate change.
The transport sector and the tourism sector are major contributors to the GHG emissions in the country. In keeping with this view, the government of Maldives has identified low carbon development as the route to take towards addressing this issue. Electric Vehicles, though mentioned in some of the recent strategies developed by Maldives, has not yet been given the requisite push through policy intervention and implementation; Maldives will have to place emphasis on electric vehicles to achieve the goals of low carbon development for the nation.

10.1 Country Profile[81]



Real GDP in Maldives grew by 7.1 percent in 2017, supported by positive performance of the tourism sector, as well as the construction, transport and communication, and fisheries sectors. Almost 5 percentage points were contributed by these sectors to growth. The current account deficit narrowed approximately to 18.8 percent of GDP in 2017, however the gap remains considerably wide majorly due to rising fossil fuel imports. Maldives uses imported fuel mainly for electricity generation and for consumption in the transport sector. This has led to high energy access but has aslo exponentially increased the GHG emission rate in the country. Maldives being a region that is extremely vulnerable to ill effects of climate change, has declared in its INDC to reduce its GHG emissions from 10% to 24% uptil 2030. Adoption of electric vehicles would facilitate the commitments made by the country in its intent to follow a low carbon approach.

[81] Undata; CIA Factbook; Maldives Custom Service; Island Electricity Data Book 2017; Maldives Monetary Authority AR 2017

10.2 Electricity Generation and Distribution Network Profile

Generation: The Maldives Energy Authority regulates the electricity sector of Maldives. The Maldives has an installed generating capacity of 363 MW. The inhabited islands, resorts and industrial islands have 214 MW, 123 MW and 20 MW generating capacities respectively, mostly driven by diesel generators; Maldives also has renewable energy generation of 6 MW.[82] Maldives has a renewable energy potential of solar, wind, ocean tidal, etc. of greater than 200 MW.[83]

Distribution: The scattered nature of the islands necessitates each island to have its individual power generation and distribution system. The plants are mainly controlled by 3 utility companies: State Electric Company Ltd. (STELCO), FENAKA Corporation Ltd., and Male Water and Sewerage Company Pvt. Ltd. (MWSC). Remaining powerhouses are managed by island councils and a private company. Maldives consumed 628.1 GWh of electricity in 2016. The Male region consumed the largest share of electricity: 59.8%.[84] The electricity demand for the year 2015 in Male was about 260 GWh. The electricity demand for Male is forecasted to reach 562 GWh by 2037.[85] Electricity demand in Maldives is expected to double, from 2014 levels, by 2020, led by an increase in usage by tourist resorts.[86] The average distribution losses for different parts of Maldives were 7-13% in 2012.[87]

STELCO Tariff Structure:

Units Band (30 Days)	Greater Male Region Tariff (USD/kWh)			Other Island Powerhouses Tariff (USD/kWh)	
	Domestic	Commercial	Government	Domestic	Commercial and Government
0 – 100	0.097	0.21	0.21	0.097	0.29
101 – 200	0.11	0.22	0.22	0.11	0.37
201 – 300	0.14	0.24	0.22	0.14	0.42
301 – 400	0.16	0.26	0.24	0.16	0.49
401 – 500	0.19	0.28	0.24	0.26	0.49
501 – 600	0.23	0.37	0.26	0.29	0.49
More than 600	0.27	0.43	0.28	0.36	0.49

Table 43 STELCO Electricity Tariff Structure

EV Potential: Maldives has dispersed renewable energy potential; the Male region, which is the most urbane of the Maldives archipelago can exploit this potential for EV charging; the EVs can in turn be utilized as distributed energy storage devices that can be used for vehicle-to-grid (V2G) application, meeting consumer needs and reducing the dependence on diesel generator sets as well as diesel ad petrol vehicles.

[82] Maldives Energy Sector & SREP IP
[83] Renewable Energy Roadmap: The Republic of Maldives
[84] Island Electricity Data Book 2017
[85] Sustainable Energy Systems in Male
[86] ADB: Interim Country Partnership Strategy: Maldives, 2014–2015
[87] Maldives Energy Supply and Demand Survey 2010-2012

10.3 Transport Sector Profile[88]

Maldives Transport Authority is the central governing body for the transport sector in Maldives. Transport sector of Maldives recorded a 2.67 percent growth in 2016, down from a 4 percent growth in 2015.

Transport sector contribution to GDP in 2016	7.23 %

Transport Energy Consumption in 2012 (TOE)		
Land Transport	**Sea Transport**	**Air Transport**
22594.4	**51307.1**	**25919.5**

Table 44 Transport Energy Consumption for Maldives in 2012

The Transport sector of Maldives consumed a total of 99,821 TOE in 2012, out of which, Sea transport was the major contributor to the energy consumption, approximately 51%.[89]
Diesel and Petrol accounted for 74.8% of the fuel utilized for transport. Air Transport energy consumption was fulfilled majorly through Jet A1 fuel – 23,552.1 TOE.

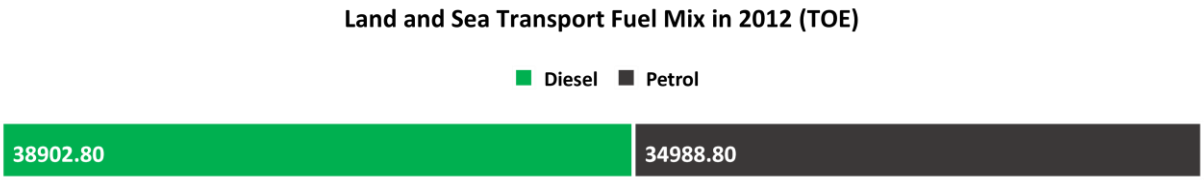


Figure 38 Land and Sea Transport Fuel Mix for Maldives in 2012

Fuel Imports

- Maldives meets maximum of its energy requirements through the import of fossil fuels. In 2017, Maldives imported petroleum products worth USD 314.3 million, which was about 13.3% of total imports; expenditure on import of petroleum products increased markedly by US$67.0 million during the period 2016-17.
- Overreliance on these imports makes Maldives largely vulnerable to world fuel hikes, affecting the balance of payments of the country. The dispersed nature of the islands and given their small size makes storage of significant amounts of fuel diifficult; hence, the existing fuel storage capacity of the nation is modest, approximately 28 MT, that lasts for only 10 days. As a result, fuel has to be imported 2 or 3 times a month, thus increasing the expenditure on fuel imports due to fuel transportation.

GHG Emissions: By end of year 2012, 1,229,615.5 tCO_2 was emitted. Among the main contributors, tourism sector contributed the largest; the transport sector, which is an allied sector to the tourism sector, contributed 3,04,186tCO_2e GHG emissions in 2012, approximately 25% of the overall GHG emissions in the Maldives. ADB has estimated that the emissions from the transportation sector of the Maldives will reach 9,00,000 tCO2e by 2020, which will inflate by an additional 1 million tCO2e to 1.9 million tCO_2e by 2030; this is a 624.6% increment compared to the GHG emissions in 2012.

[88] Maldives Monetary Authority AR 2017
[89] Low Carbon Strategy for the Transport Sector, Republic of Maldives

Number of registered vehicles and vessels in Maldives by type in 2016	
Yacht Dhoni	220
Launches	3,081
Boats	582
Motor Cars	5,754
Motor Cycles	74,354

Table 45 Number of registered vehicles and vessels in Maldives by type in 2016

The total number of registered vehicles and vessels in Maldives for 2016 was 83,991. The majority of the vehicles registered in the Maldives are operated in Male.

The total registered vehicles in Male increased more than 295% from 22,303 in 2007 to 65,932 in 2014, of which 83% were motorcycles. Furthermore, the total number of vessels registered also increased to 3883.

Motor Cycles are the most popular in the vehicle segment (93%) while Launches ranked highest in the vessels segment (79%).

10.4 EV Landscape in Maldives

10.4.1 Review of Government Plans and Policies supporting EV implementation

Timeline	Plan/Policy/Strategy/Regulation	Description (reference to EVs)
2014	Maldives Low Carbon Development Strategy	As part of its GHG mitigation options, the strategy advocated the promotion of hybrid vehicles and electric vehicles, including electrical bicycles, and RE based charging stations in Maldives.
2014	Low Carbon Strategy for the Transport Sector	This strategy emphasises on: • Introduction of Smaller and Smarter Vehicles Technologies such as light-duty hybrids • Promotion of Hybrid Vehicles • Promoting Electro-mobility (BEVs and FCVs) specifically in Male. • Development of Hybrid Vessels • Promote the Use of Low Carbon Alternative Fuels • Investment in Low Carbon Fuel Research
2015	Renewable Energy Roadmap: The Republic of Maldives	This Roadmap recommends the use of renewable energy for electric vehicle charging.

Table 46 Review of Government Plans and Policies supporting EV implementation in Maldives

10.4.2 Status of EV implementation in Maldives

Despite a number of assessments and strategies designed by the government of Maldives on the subject of low carbon development, no deliberate headway has been made in the formulation of a plan or policy for electric vehicle implementation in the island nation. Most of the strategies have focussed on transport demand management, improvement in transport infrastructure, promoting biofuels, implementing efficient motor vehicles and encouraging better traffic behaviour, there has been little mention of electric or hybrid vehicles. In consequence, there has been negligible adoption

of electric vehicles; in 2014, there were a reported 31 battery cars in the Male region of Maldives.[90] It is estimated that the number of battery cars has increased in the region given that ILAA Maldives Pvt Ltd, a company in Maldives, manufactures electric vehicles indigenously. The models that it produces are:

1. Model 1: SHUTTLE™ 2: Electric Precision Drive System Cargo Carrier
2. Model 2: SHUTTLE™ 4: Electric Powered Personnel Carrier
3. Model 3: SHUTTLE™ 6: Electric Powered Personnel Carrier

10.5 Key Benefits of EV deployment in Maldives

Maldives suffers from large proportions of air pollution caused by its tourism and transport sectors. Electric vehicles would drastically reduce the GHG emissions from these two interlinked sectors.

According to the Renewable Energy Roadmap developed by IRENA for Maldives, there is greater than 200 MW renewable energy potential in the country; this energy can be utilized for electric vehicle charging, thus replacing fossil fuel consumption

Shifting the transport sector away from reliance on fossil fuels towards use of renewable energy produced electricity would help to control Maldive's growing trade deficit by decreasing expensive fuel imports.

Provision of clean, affordable and comfortable transport facility for the Maldives population.

[90] Low Carbon Strategy for the Transport Sector, Republic of Maldives

10.6 Key Challenges for EV uptake in Maldives

The high investment cost of EVs and EVSE equipment is a major cause of detriment for EV adoption

Lack of concrete regulations or policy for electric vehicles in Maldives; this creates risk for electric vehicle manufacturers and dealers

Lack of technical expertise for EVSE setup as well as O&M activities

Lack of public awareness regarding EVs

10.7 Proposition for EVs

Energy consumption in the industry sector of Maldives amounted to 7004 TOE (4.12%) in 2013. Energy consumption by the households stood at to 34000 TOE (20%) while that of agriculture sector was 8007 TOE (4.71%). The transport sector was the largest consumer of energy 110007 TOE (64.71%). With the development of the Maldives economy, the energy usage has multiplied; and with most of the energy requirements being satisfied through fossil fuels, the GHG emissions have shown a corresponding rise as have fuel imports. It is of paramount importance that this issue must be addressed to ensure the low carbon development and economic growth that Maldives has committed to and also so that Maldives INDC is adhered to. According to the Climate Change Legislation in Maldives, "In 2011, the government exempted import duty on electric cars and motorcycles, while retaining a 200% tariff on petrol and diesel-powered vehicles. The number of vehicle licences in Malé has been drastically reduced, with electric vehicles highly vehicles gaining momentum in the city. As part of the same decision in 2011, the government also reduced the import duty from 25% to zero percent on solar and wind-powered ships and equipment, including sails."[91]

[91] Climate Change Legislation in Maldives, An Excerpt from the 2015 Global Climate Legislation Study, London School of Economics

10.7.1 ISGF Proposition for Electric 2 Wheelers (2W) in Maldives:

Two wheelers represent a 93% of the registered vehicles in Maldives. Electric 2Ws have shown the brightest prospect for adoption worldwide, with an estimated global stock of 250 million. Electric 2Ws, have the added advantage of being residentially-charged, unlike e-cars, which require proper public/private (here on referred to as 'p/p') charging infrastructure. Hence, the 2Ws segment represents substantial potential for Maldives.

ISGF has prepared an analysis for 2Ws electrification considering the three scenarios:

1. Scenario 1: 10% of the 2Ws replaced with electric 2Ws
2. Scenario 2: 50% of the 2Ws replaced with electric 2Ws
3. Scenario 3: 100% of the 2Ws replaced with electric 2Ws

Premises:

The 2Ws in Maldives are assumed to have 100-125 CC gasoline engines, with a fuel efficiency of 35 km/litre and an average annual distance travelled per 2W as 5000 km. The GHG emission factor is considered to be 0.029 $kgCO_2$/km (as per India GHG Program).

The 2Ws are assumed to be replaced with electric 2Ws of comparable specifications; the electric 2Ws are considered to have a 1.152 kWh battery, with a range of 70km/Charge (as per Hero Electric Optima Plus Electric Bike specifications). The tariff rate for residential charging is taken as 0.16 USD/kWh while that of p/p charging is taken as 0.21 USD/kWh (as per State Electric Company Limited, Maldives Tariff Rates). The price of petrol in Maldives is taken as 0.71 USD/litre.

Analysis results:

Scenarios	Annual GHG reductions (tCO_2e)	Annual fuel imports reduction (million USD)
Scenario 1: 10% replacement	**1078.1**	**0.76**
Scenario 2: 50% replacement	**5390.7**	**3.78**
Scenario 3: 100% replacement	**10781.33**	**7.57**

Table 47 ISGF Proposition for Electric 2 Wheelers (2W) in Maldives: GHG and Fuel Import Annual Reductions

Complete electrification of the 2 Wheelers population will result in 7.57 million USD reduction in the fuel imported, which amounts to nearly 2.4% of total fuel imports. While the reduction in GHG emissions are low in comparison to that observed for other vehicle categories, the monetary benefit to the consumer is notable as shown below:

Annual savings per consumer using residential charging, % of current fuel expense	Annual savings per consumer using p/p charging, % of current fuel expense
87.03%	**83%**

Table 48 ISGF Proposition for Electric 2 Wheelers (2W) in Maldives: Annual Savings for Consumer

From the consumer point of view, shifting to electric 2W translates into a more pocket-friendly experience (OPEX) given that per consumer, the energy requirement for electric 2W is only 82.3 electricity units with a yearly expense of USD 13.17 for residential charging & USD 17.28 for p/p charging as opposed to 143 litres of fuel with a yearly expense of USD 101.53 for normal 2W.

With the implementation of this strategy, the energy saved can be used alternatively to satisfy the energy requirements for the Industry sector and for Residential segment. The direct impact of this would result in a surge in GDP growth coupled with abatement in the nation's trade deficit due to reduction in the fuel imports.

In addition to the energy savings and real time monetary benefits, there would be GHG emission reductions which will help Maldives to adhere to its INDC commitment of reducing its GHG emissions by 10%-24% till 2030, for BAU scenario.

While electrification of 2Ws does not have a considerable impact on the GHG emissions and fuel imports reduction, the concept holds merit from the consumer perspective owing to the large savings in terms of fuel expenditure.

10.7.2 ISGF Proposition for Electric ferries in Maldives:

Sea transport contributed to 51% of the total energy consumption in 2012; given the growth in the tourism sector, the sea transport energy consumption is expected to have increased exponentially for passenger transport. Electric ferries can be introduced to replace the yacht dhonis, which would lead to extensive fuel savings and reduction in GHG emissions.

Premises:

The yacht dhonis in Maldives are assumed to have fuel consumption of 39 litre/hour and 625 annual hours of operation as per the 'Low Carbon Strategy for the Transport Sector'. The electric ferry used for replacing the yacht dhoni is assumed to have 300 kWh battery as per the 'Implementation Plan for Electrification of Public Transportation in Kolkata'. The price of petrol in Maldives is taken as 0.73 USD/litre.

Analysis Results:

The total savings in diesel for various scenarios is as follows:

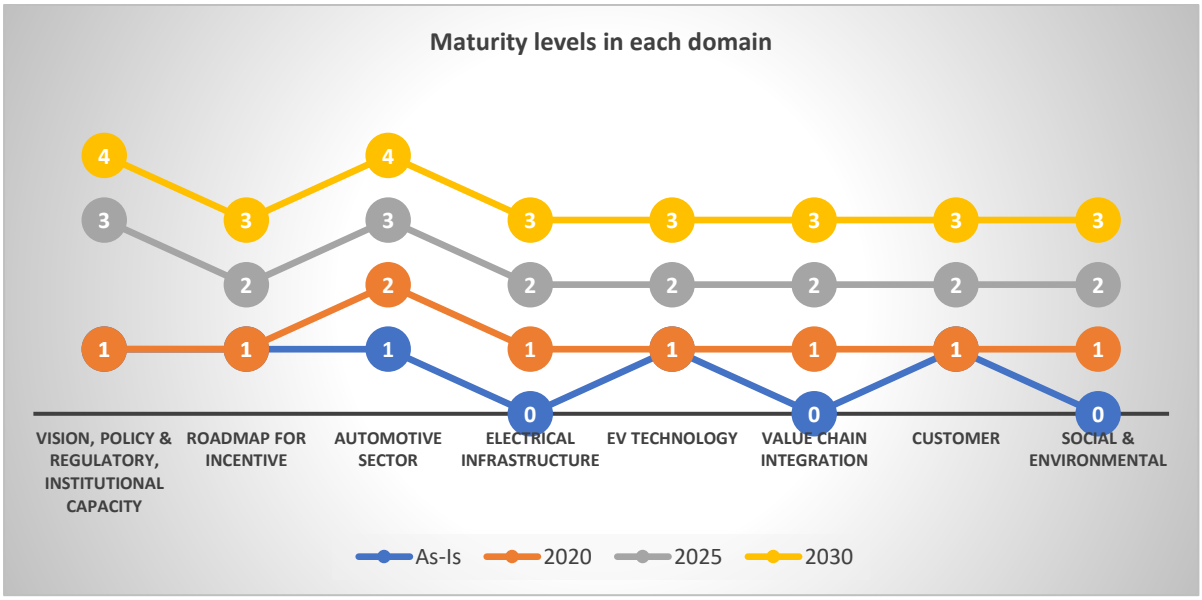
Scenarios	Annual fuel imports reduction (litres)	Annual fuel imports reduction (million USD)
Scenario 1: 10% replacement	**536250**	**0.39**
Scenario 2: 50% replacement	**2681250**	**1.96**
Scenario 3: 100% replacement	**5362500**	**3.91**

Table 49 ISGF Proposition for Electric ferries in Maldives: Fuel Import Annual Reductions

Ferries serve multiple passengers and hence will reduce the per capita consumption of diesel as well as the per capita GHG emissions; shared mobility for sea transport is thus promoted. The concept of electric sea transport should also be studied for application to smaller vessels such as speed boats as well as the large safari vessels.

10.8 EVMM Assessment & Recommendations for Maldives

Based on the As-Is scenario (previous chapters), we have assessed[92] the existing conditions in each of the eight domains and identified the levels (as explained in Executive Summary) that they ought to attain in future years i.e. 2020, 2025 and 2030. We have also provided summary recommendations to ensure a sustainable EV adoption from one level to the next. A graphical representation showing the As-Is maturity level and the maturity level they need to attain in future is depicted below.[93]



[92] A detailed assessment requires stakeholder interviews

[93] "0" means default level which indicates that the basic minimum initiatives have been undertaken in this domain

Domain	By 2020	By 2025	By 2030
Vision, Policy & Regulatory, Institutional Capacity	***Target Maturity Level – 1*** • Ministry of Environment and Energy, Ministry of Economic Development and Maldives Transport Authority should work together and come up with a nation-wide mission on electric vehicle and a EV specific policy with a defined target and deadline, to send clear signal to both OEMs & consumers to invest in and adopt EV respectively • Government should target two wheelers to electric fleet in Male and other major areas. as it is contributing to major share for public transport and can start it with a pilot project in one of these cities • Government to discuss with banks to provide low cost loans for electric two wheelers in the initial years or can provide subsidy on CAPEX for few initial two wheelers like 20% subsidy on first 50,000 to accelerate the adoption of two-wheelers • Organizational restructuring with the creation of an EV cell within Maldives Transport Authority and distribution utilities with Ministry of Environment and Energy, Ministry of Economic Development as overseeing authority to facilitate future deployment strategy, charging station implementation, O&M guidelines, consumer awareness etc. Distribution utilities should also be roped in for suggestions on grid upgradation requirement	***Target Maturity Level - 3*** • Government to make mandatory the use of electric two and four wheelers for vehicle rental companies, resorts and hotels • Tariff policy by recognising EV as a separate group of consumers to be developed and aspects of Time of Use pricing to be introduced to smoothen the load curve • Dedicated space in parking lots, in malls residential buildings for charging station installation to be made mandatory through building codes in Male • Creation of a PPP and Investment Facilitation Center with members from Ministry of Environment and Energy, Ministry of Economic Development, Maldives Transport Authority to evaluate projects on investment in EV manufacturing and assembling and act as a single window for FDI, PPP and JV projects	***Target Maturity Level - 4*** • Government to make mandatory conversion of yacht, boats, fishing boats, four wheelers and launches used for public transportation into electric fleet • Government to streamline the third party charging process by providing guidelines • Government should ease norms on import of components and EV parts for local manufacturing and assembling companies and come out with guidelines on the same • Grid Code and Distribution Code guidelines must be updated for Vehicle to Grid (V2G) integration • Guidelines for mandatory battery buy back by OEMs on completion of battery life or in case of any faulty battery

Roadmap for Incentive	***Target Maturity Level – 1*** • Exemption of import and custom duty on EV components • Subsidized registration charges for one year for electric two and four wheelers • Reduced electricity tariff for charging for all categories of electric vehicle and electric boats • Subsidized parking charges for electric vehicle and electric boats • Reduced property tax for hotels & resorts using electric vehicle or electric boats for their guests and for personal purpose	***Target Maturity Level - 2*** • Reduced road tax for electric vehicles • Reduced property tax on electric vehicle assembling units • Reduced tariff for passengers using electric vehicles for public transportation • Tax free or reduced tax for profit repatriation for foreign companies • Reduced property tax for residential complexes in few initial years which will be installing charging stations to facilitate personal vehicles • Reduced anchorage fee and taxes for electric yacht • Government to provide subsidy or low interest loan from banks for small fishermen for purchasing electric boats	***Target Maturity Level - 3*** • Duty free import of plant and machinery for setting up of manufacturing or assembly unit on one time basis • Reduced property tax for EV manufacturers and assembly units
Automotive Sector	***Target Maturity Level - 1*** • EV Testing and Certification Centre to test and validate electric vehicles being manufactured and assembled • Battery and charging stations to be imported from countries like China for the pilot projects	***Target Maturity Level - 2*** • Assembling units for electric cars, two wheelers and boats mainly to be set up on JV model with foreign companies • Promote local manufacturing of electric vehicles like manufacturing of EV by ILAA Maldives Pvt. Ltd by providing land, water and import logistic facility for manufacturing at a reasonable cost	***Target Maturity Level - 3*** • Promote local manufacturing of electric two wheelers or yacht and boats through PPP or joint ventures with foreign companies and service centres to be developed locally with skilled workforce • Servicing facility for charging stations can be provided by OEMs and local capacity development on O&M of charging stations through training and skill development
Electrical Infrastructure	***Target Maturity Level - 1*** • Distribution utilities to assess the supply and availability of spare capacity in distribution transformers in areas having potential for	***Target Maturity Level - 2*** • Upgradation of electrical infrastructure in terms of meter room, laying of cables, supply meters etc. in docks, parking lots, malls etc. by	***Target Maturity Level - 3*** • Implementation of charging stations by supermarkets, big retailers with electrical network upgradation at own cost

	charging station implementation like docks, parking lots, existing malls, residential buildings etc. in Male • Distribution utilities to consider power supply from renewable sources in remote areas or areas having high renewable potential for installation of charging station for electric vehicle • Distribution utilities should also assess the possibility of incorporating charging stations in the existing mini and micro grids	electricity distribution utilities for installation of charging stations • Improvement in power quality through deployment of technologies like harmonic filters, static compensators etc. • With EV adoption at a large volume, tariff for charging should consider the opportunity cost of oil which is freed up from transport sector and can be used in power sector for electricity generation	• Upgradation expense can be shared by OEMs or third party service providers of charging stations • Planned mini or micro grids to consider EV charging station as a component • Grid asset modernization for facilitating two way communication for implementing vehicle to grid solution
EV Technology	***Target Maturity Level - 1*** • Technology for electric two wheelers to be upgraded in terms of design, battery capacity etc. • Maldives being mostly flooded with Japanese and European cars, combination of CHAdeMO and CCS charging standards can be used • Maldives can also follow the Indian standard which has recently been published for both AC and DC charging and allows both CHAdeMO and CCS charging standards	***Target Maturity Level – 2*** • EV two & four wheeler testing and certification centre to be developed in Maldives • In house development of motor technology, power electronics equipment like switch mode power supply for charging stations along with international technology institutes etc. • R&D on EV design to be initiated in collaboration with international research labs, technology institutes, etc. and can also have contribution from companies like ILAA Maldives Pvt. Ltd. who are already in the process of manufacturing electric vehicles	***Target Maturity Level - 3*** • Maldives Energy Authority along with technocrats and EV associations etc. to decide on the interoperability of charging and contribute in enhancement of the charging standards and communication protocols being used e.g. CCS, CHAdeMO, OCPP etc.
Value Chain Integration	***Target Maturity Level – 1*** • Government building and offices to install charging stations in their premises for EV usage	***Target Maturity Level - 2*** • Distribution utilities and along with the transport authority with support from central government to invest in setting up charging infrastructure for electric vehicles in parking lots, malls, residential buildings, docks etc.	***Target Maturity Level - 3*** • Private parking owners or service providers can implement public charging stations along with distribution utilities or service providers along with distribution utilities

	• Two wheeler manufacturers and assembly units can also set up charging stations in Male to accelerate EV two wheeler adoption • Resorts and hotels can use electric vehicle and electric boats for tourist transportation as well as for internal purposes and can install charging station in their premises	with the cost being treated under regulated capex route • Vehicle renting and boat renting companies can rent electric vehicle and electric boats for tourist transportation and can also install charging stations in their premises and docks for charging their fleets • Bundle EVSE as mandatory in new buildings through Building Codes for all categories of buildings exceeding certain built area. In this case the impact of EVSE infrastructure cost is negligible in per square meter cost • Renewable energy companies setting up project or companies setting up micro grid or mini grid should install charging stations outside their premises which can be used by public for a reduced tariff for first three years and then can be charged normal tariff	and the mall owners or hospitals can install public charging stations • Dedicated taxi fleet operators can invest by themselves or bring third party to invest in charging stations • Fishing companies to use electric trawlers and boats and can install charging stations for their own use or collectively two or three fishing companies can install charging stations for their own use and can provide it to public when not in use or during holidays when not in use against a specified fee.
Customer	***Target Maturity Level - 1*** • Government vision target for electric vehicle is communicated to customers • All the incentives and benefits for adopting or cruising an electric vehicle to be communicated properly to customers • Carry out research on the customer pattern of vehicle usage mainly two wheelers and identify probable charging pattern to figure out the load curve for a particular day by the EV cell	***Target Maturity Level – 2*** • Time of use pricing and its benefits to the customers must be displayed to make them aware of their benefits	***Target Maturity Level - 3*** • Customers are engaged in prosumer programs through V2G integration on pilot basis • Advance booking of parking slots through e-booking in Male based on time and amount of charge required by the individual
Social & Environmental	***Target Maturity Level - 1*** • Organizing EV awareness programs, conduct workshops and seminars to make people	***Target Maturity Level - 2*** • EV deployment mainly the two wheelers, and commercial taxi fleets can also provide	***Target Maturity Level - 3*** • The deployment goals by the government will also help to bring electricity in the

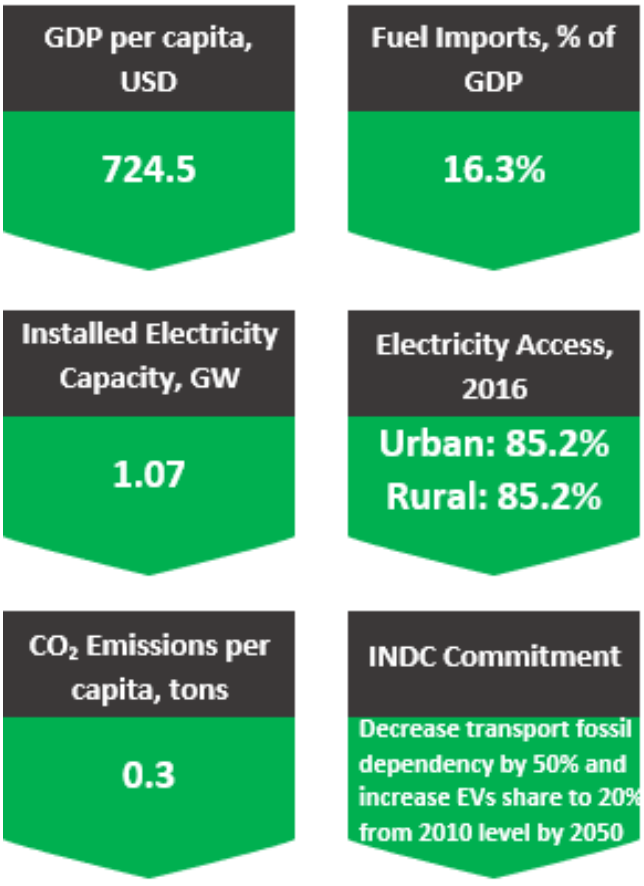
	aware of the benefits of EV adoption in terms of improved air quality, health benefits	opportunity to the existing workforce by providing them adequate training on O&M skills • Tourism will flourish by projecting areas as carbon neutral with EV being the only transport mechanism in those areas • Fishing and touring in electric boats and yacht will negate the chances of oil spills from boats and facilitate in reducing water pollution	remote areas which can help in improving the living standard of the people in those areas • Electric two wheelers, cars and boats manufacturing and assembling plants will help in job creation and people of rural areas can opt for a sustainable living in all aspects

11. Nepal: EV Scenario

Nepal is a growing economy, with the main growth drivers being the service and industry sectors. Nepal, ranks amongst the least contributors to GHG emissions in the world. However, its development agenda is restricted due to Nepal being one of the most vulnerable countries to the adverse effects of climate change.

In consequence, the government has initiated a number of steps to tackle climate change, of which Electric Vehicle deployment is an important agenda. Nepal launched the Environment-friendly Vehicle and Transport Policy (2014) that targets, inter alia, to decrease transport sector emissions, increase EV share by 20% till 2020, encourage retrofitting for conversion of regular vehicles to EVs, and offer subsidies to promote EVs and non-motorized vehicles. Along with this policy, the government has also brought in various other policies and regulations to drive the EV revolution in the country.

11.1 Country Profile[94]



Nepal grew by 6.3 percent in 2017-2018, despite less favorable monsoons and the easing of rapid growth that ensued following the trade blockade in 2016-17. Nepal recorded a GDP of 20.66 billion USD in 2017. The energy sector remains the backbone of the Nepalese economy for driving the industry and service sectors; the nation has achieved high energy access and reduced load shedding. Fuel imports, however, have soared over the past decade; the transport sector has emerged as a highly-energy intensive sector, in this regard. Through its INDC commitment, Nepal has focussed on achieving sustainable development of its economy; as part of its climate change commitment, Nepal is focussing on forest conservation, renewable energy development, EV promotion and other low carbon strategies; this signals the potential for new market investments in Nepal.

[94] Undata; NEA Annual Report 2018; Nepal Statistical Yearbook 2017; Nepal Economic Survey 2016-2017; World Development Indicators

11.2 Electricity Generation and Distribution Network Profile

Generation: Nepal has an installed generation capacity of 1.07 GW of which 1.02 GW is hydropower. Nepal domestically generated about 4082.69 GWhs of electricity in 2017; over 2175.04 GWhs were imported from India. Nepal has an exploitable hydro potential of 43 GW. Various hydroelectric projects have been planned that have a cumulative capacity of 2.92 GW. It is expected that with this generating capacity augmentation, power deficit in Nepal will most likely be eliminated for the wet season (summer) however deficit will still persist in the dry season (winter).[95]

Distribution: Distribution and Consumer Services Directorate (DCSD) is responsible for overall management of electricity distribution network and services of the Nepal Electricity Authority (NEA). It served 32,57,814 consumers in 2017. The total annual demand for Nepal in 2017-2018 was 7,489.62 GWh and the peak load stood at 1,444.1 MW. The system loss was 22.9% in 2016-17. According to forecast by NEA, the annual electricity demand and peak load are expected to reach 82,620.73 GWh and 18,137.67 MW respectively by 2039-2040. The DSCD has undertaken 'Distribution System Augmentation and Expansion Project' as well as grid modernization plans such as Gas Insulated Substation (GIS), renewable energy projects and advanced metering infrastructure (AMI) deployment.

NEA Electricity Tariff Structure[96]:

Voltage Level	Service Charges (USD/month)	Energy Charges (USD/kWh)
Domestic Single Phase	**0.26 to 2.37**	**0.026 to 0.11**
Domestic Three Phase (230/400 V)	**9.5 to 15.54**	**0.11 to 0.12**
Domestic Three Phase (33/11 kV)	**9.5**	**0.095 to 0.11**
Voltage Level	**Demand Charges (USD per KVA/month)**	**Energy Charges (USD/kWh)**
Low Voltage Commercial	**2.81**	**0.097**
Medium Voltage Commercial (11 kV)	**2.72**	**0.096**
High Voltage Commercial (33 kV)	**2.72**	**0.093**

Table 50 Nepal Electricity Tariff Structure

The special electricity tariffs for transport are as follows:

Transport mode	Demand Charge (USD per KVA/month)	Energy Charge (USD/kWh)
Medium Voltage (11 kV and 33 kV)		
Trolley Bus	**1.99**	**0.048**
Other Transportation	**2.20**	**0.074**

Table 51 Special Electricity Tariff for Transport in Nepal

Nepal also has Time of Day (TOD) Tariffs defined for two different half-yearly periods. The transport energy charge is 0.06 to 0.083 USD/kWh in peak hours; for summer period, the off-peak hour energy charge is 0.032 to 0.036 USD/kWh.

EV Potential: Nepal's hydropotential can be tapped for EV charging requirements in the summer season. Nepal already has special EV tariffs and TOD tariff in place that can encourage EV uptake.

[95] Power Sector Overview, Nepal

[96] Nepal Electricity Authority Annual Report 2018

11.3 Transport Sector Profile[97]

Department of Transport Management is the chief governing body for the Transport sector in Nepal. Transport, Storage and Communication sector of Nepal recorded a 6.5 percent growth in 2016-17, a year-on-year growth of 4.48 percentage points.

Transport, Storage and Communication sector contribution to GDP for 2016-2017	8.11 %
Gross Value Added by the Transport, Storage and Communication sector for 2016-2017	USD 781.5 million

Sectoral Energy Consumption in 2015 (MTOE)				
Residential	Industrial	Agriculture	Commercial	Transport
9.04	0.904	0.113	0.452	0.791

Table 52 Sectoral Energy Consumption in Nepal in 2015

Nepal recorded a total energy consumption of 11.5 MTOE in 2014-2015, out of which the Transport sector accounted for 7%.

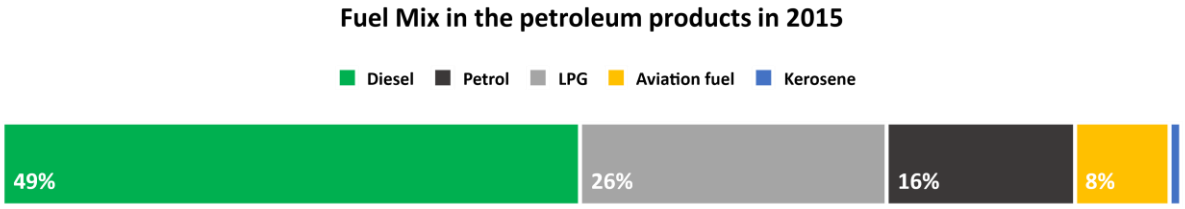


Figure 39 Fuel Mix in Nepal in 2015

Diesel and Petrol accounted for 75% of the petrofuel utilized in the country (nearly 1.8 million kilolitres). While part of the diesel is used for DG sets, the rest is utilized for diesel vehicles that are the dominant vehicle category in Nepal.

Fuel and Vehicle Imports

- Nepal has no known large-scale fossil fuel reserves. Aside from some minor coal production, all of the oil and coal used in the country is imported. Fuel imports accounted for approximately **1.17 billion USD**, which is **16.3% of the GDP of Nepal**.
- India is the supplier of over **80%** of the vehicles in Nepal, for which Nepal spent nearly **72 million USD in imports** till the first two and a half months of the FY2018.

GHG Emissions: According to IEA (2013), Nepal's per capita CO_2 emissions from fuel consumption in 2011 was only 133 kg against the world average of 4,504 kg per capita. However, growth rate of emissions is among the highest in the world. From 1990 to 2011, CO_2 emission from fuel consumption increased by 395 % in Nepal while the average figure for Asia and the world was just 172.5 % and 49.3 % respectively. In 2011, the share of transport sector in the total CO_2 emission of the world remained as 24 % while that in Nepal is 45 %. Relatively higher share of transport emissions in Nepal indicates importance of reducing transport emission to address the issue of GHG emissions.

[97] National Sustainable Transport Strategy (NSTS) for Nepal (2015~2040); Nepal Oil Corporation (2015); Nepal Statistical Yearbook 2017

11.4 EV Landscape in Nepal

11.4.1 Review of Government Plans and Policies supporting EV implementation

Timeline	Plan/Policy/Strategy/Regulation	Description (reference to EVs)
2001	National Transport Policy	The following are specific provisions for electric mobility included in the policy: • Expanding the use of electric vehicles, using electricity from renewable energy sources. • Operating electric bus, tram and other public transport vehicles, especially in cities. • Planning for an electric rail service, utilizing hydropower.
2014	Environment Friendly Transport Policy	The following are specific provisions and targets for electric mobility included in the policy: • Increasing the share of what the policy terms "environment friendly vehicles" to a minimum of 20% of the total vehicle fleet by 2020. • Encouraging manufacturing of environment friendly vehicles, which include electric vehicles. • Encouraging private sector to invest in construction and management of electric vehicle parking stations and service centres. • Facilitating land for the construction of ten charging stations in Kathmandu, under a pilot initiative. • Installing charging stations in retail outlets such as shopping malls, hotels and large parking areas. • Improving the possibility of local assembly by improving access to required vehicle parts, including batteries.
2015	National Sustainable Transport Strategy [Draft]	The following are specific provisions for electric mobility included in the policy: • Promoting electric vehicles across all systems. • Undertaking feasibility studies for alternative, electric transport initiatives. • Encouraging the development of a high-priority, national electric rail system. • Developing required institutional structures and support for electric mobility. • Introducing electric bus public transportation in urban areas

		• Providing electric vehicle options in priority tourist destinations. • Aligning and integrating the development of hydropower with the development of electric mobility (vehicles). • Introducing electric rickshaws in small and medium-sized cities.
2016	**Fourteenth Three-Year Plan 2016/2017- 2018/2019**	The plan includes the following provisions related to electric mobility: • Support for the creation of an environmentally-friendly transport sector. • Encouragement of vehicles powered by alternative and renewable energy sources. • Recognition of the need to strengthen electric rail and sustainable mass transport services. • Recognition of the need to undertake feasibility studies for the establishment of a metro or monorail service in the capital.
2017	**National Urban Development Strategy**	The plan includes the following provisions related to sustainable transport: • Promoting the development of sustainable urban public transport services in all urban areas with over 100,000 residents. • Calling for balanced road network development. • Promoting integrated land-use and transport planning, through institutional and capacity development. • Preparing comprehensive transport management standards and plans.
2013	**National Energy Strategy**	The strategy includes the following selected provisions related to sustainable transport: • Emphasizing the role of electric vehicles in accomplishing the strategy's goals. • Undertaking research and analysis into the viability of establishing electric ail and ropeways. • Prioritizing the development of electric rail systems. • Facilitating and increasing the import of hybrid and electric vehicles.

		• Ensuring continuous supply of power to electric vehicle charging stations.
2011	**Climate Change Policy**	The plan includes the following provisions related to sustainable transport: • Highlighting the importance of promoting clean energy such as hydropower, renewable and alternative energy sources. • Encouraging the use of green technology and increasing energy efficiency. • Promoting transport industries that use electricity.
2016	**Budget Speech 2016/2017**	For electric vehicles for public transport: • A custom (import) duty of 1% is in place (compared to a custom duty of 5% for fossil fuel vehicles with more than 40 seats for public transport mentioned in the Budget Speech for FY 2015/16). • Exemption of value added tax (compared to a VAT of 13 % levied on fossil fuel vehicles for public transport). For electric vehicles for private transport: • A custom (import) duty of 10% is in place (compared to a custom duty of 80% for fossil fuel vehicles for private usage). • Exemption of value added tax (compared to a VAT of 13 % leveed on fossil fuel vehicles for private usage). For battery recycling equipment: • A custom duty of 1 % is in place on machinery and equipment used for the recycling of batteries. For electric rickshaw parts: • Exemption of value added tax (compared to a VAT of 13 % levied on fossil fuel vehicle parts).
2017	**Bank Monetary Policy**	The policy includes the following provision related to electric mobility: • The maximum loan-to-value ratio for personal electric vehicles loan has been increased to 80 percent.

2017	**National Ambient Air Quality Standards**	While the standards do not specifically address vehicular emissions per se, they do in effect support the validity of electric vehicles, which enjoy zero tailpipe emissions.

Table 53 Review of Government Plans and Policies supporting EV implementation in Nepal

11.4.2 Status of EV implementation in Nepal

Starting in 1975, electric trolley buses operated from Tripureshwor to Suryabinayak, till their official retirement in 2009. Since 1996, "safa tempos" or battery-operated white tempos, have played an integral role in Kathmandu's public transportation system; 1,200 Safa Tempos approximately ply the roads of Kathmandu. Thus, history shows that Nepal has been progressive in its outlook toward vehicle electrification; As described earlier, the Nepalese government has brought in various policies, schemes and incentives to support the purchase of electric and hybrid vehicles in Nepal. The government has also promoted various electric vehicle manufacturers to scale up the introduction of electric vehicles in Nepal.

Status of Electric Vehicles in Nepal[98]		
Electric Cars	**Electric Scooters**	**Safa Tempos**
300	**2000**	**1200**

Table 54 Status of Electric Vehicles in Nepal

Available Electric Vehicles in Nepal:

- **Mahindra Reva e2o sportz and e2o plus**
- **KIA's Soul EV**
- **BYD E6 Car**
- **Chinese and Indian brand Electric 2 Wheelers**
- **BYD-Goldstone to launch eBuzz K6 bus**

[98] Website: https://thehimalayantimes.com/business/nepal-electricity-authority-promote-electric-vehicles/
Website: http://www.onwardnepal.com/nepal/electric-vehicles-nepal/

11.5 Key Benefits of EV deployment in Nepal

Increased electric mobility will reduce fossil fuel consumption in the country. Even moderate increases in share of electric vehicles and electric mobility systems deliver lasting benefits, in addition to meeting NDC

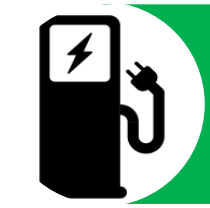
Increased electric mobility will significantly support strategic goals for hydropower

Significant improvements in urban air quality can be achieved through increased electric mobility

11.6 Key Challenges for EV uptake in Nepal

Insufficient financing, limited technical and human resources, and limited data availability restrict investment and business activity for electric mobility and undermines decision-making

Gaps in the policy and governance system for electric vehicles undermine operational action and progress on the ground



Insufficient infrastructure and underdeveloped electric vehicle markets discourage consumers and inhibit private sector investment and entrepreneurship

11.7 Proposition for EVs

Number of Registered Vehicles by type in Nepal until 2016-2017	
Bus	46,346
Minibus	23,622
Truck/Tanker/Dozer/Crane	78,257
Jeep/Car/Van	2,13,320
Pickup	45,631
Microbus	5,724
Tempo	29,463
Motorcycle	21,89,099
Tractor	1,30,566
E-rickshaws	14,141
Other vehicles	7,259

Table 55 Number of Registered Vehicles by type in Nepal until 2016-2017

Road transport is the predominant mode of transport in Nepal, accounting for 90% of the movement of passengers and goods. 2 wheelers are the most popular vehicle segment, occupying 79% of total registered vehicles motor share, followed by jeep-car-can segment (7.7%). The Electric Vehicle Association of Nepal (EVAN) states that the approximate number of EVs in Nepal is about 21,000 however a recent estimate reveals that there are around 300 electric cars and 2,000 electric scooters in use in Nepal. Additionally, there are a few hundred electric three-wheelers running mostly in the Terai and also a few hundred safa tempos or tuk-tuks (three wheeler type) operating in Kathmandu.[99]

[99] Website: https://thehimalayantimes.com/opinion/electrifying-transport-near-far/
Website: http://mnsvmag.com/news/2017-10-27/electric-vehicles-kathmandu-loadshedding

The consumption distribution by car and fuel type in Nepal for 2011-12 was as follows[100]:

Transport Type	Fuel (Thousand GJ)					
	Diesel	Petrol	ATF	LPG	Electricity	Total
Bus	4,272.73	-	-	-	-	4,272.73
Mini & Micro Bus	1,988.17	-	-	-	-	1,988.17
Car, Jeep, Van, Pickup	2,305.38	4,373.63	-	-	-	6,679.01
Truck, Tanker, Lorry	6,671.03	-	-	-	-	6,671.03
3 Wheeler	222.69	-	-	219.79	-	442.47
Tractor, Others	463	-	-	-	-	463
2 Wheeler	-	2,143.48	-	-	-	2,143.48
Rails	97.73	-	-	-	-	97.73
Cable Car	-	-	-	-	23.36	23.36
Domestic flight	-	-	973.27	-	-	973.27
International flight	-	-	2,998.49	-	-	2,998.49
Total	16,020.72	6,517.11	3,971.76	219.79	23.36	26,752.73

Table 56 Consumption distribution by car and fuel type in Nepal for 2011-12

Energy consumption in the industrial sector amounted to 29.7 million GJ in 2011-12, almost 7.89% of the total consumption. Coal, fuelwood, diesel and electricity were the most significant contributors to energy consumption for the industry sector close to 98.7%. The residential sector had the largest sectoral share in energy consumption that amounted to 302.4 million GJ in 2011-12, almost 80.36% of the total consumption. The major contributors were fuelwood, agriresidue, LPG, grid electricity and biogas. Transport sector accounted for 7.12% of the total energy consumption in 2011-12. Diesel and petrol were the most consumed fuels in the transport sector, nearly 60% and 24.4% respectively of the total transport fuel consumption. In 2011-12, the truck-tanker-lorry segment made almost a quarter of all transport fuel consumption, while that for the bus segment was approximately 23.5%; the energy consumption for 2 wheelers was approximately 8%, however, given the large increase in 2 wheeler numbers in the past decade, the energy consumption share is expected to have surged drastically. Urban areas in Nepal rely on road and non-motorized modes for mobility. There is no provision of public transport services for the smaller size municipalities beyond the Kathmandu Valley. This has resulted in a rapid growth of personally owned motorized vehicles in the country. Proportional to the vehicle growth and the increasing energy usage, GHG emissions have shown an exponential growth rate as have vehicle and fuel imports (as mentioned earlier). It is imperative that this issue must be addressed to ensure the sustainable growth that Nepal has committed to. Electrification of transport sector would help to achieve this goal, while also allow for the fuel, otherwise required for transport sector, to be diverted for utilization in the other sectors.

[100] Energy Data Sheet, Nepal, Water and Energy Commission Secretariat (WECS), June 2014

11.7.1 ISGF Proposition for Electric 2 Wheelers (2W) in Nepal:

There were more than 2189099 motorcycles registered in Nepal, until 2016-2017. Till 2017, there existed an estimated 2 wheeler global stock of 250 million, the largest in any electric vehicle segment. Electric 2 wheelers, have the advantage of being residentially-charged, unlike cars or buses, which require proper public/private (here on referred to as 'p/p') charging infrastructure; given the nature of the Nepalese market, the 2 wheelers segment represents substantial potential for electrification.

ISGF has prepared an analysis for 2Ws electrification considering the three scenarios:

1. Scenario 1: 10% of the 2Ws replaced with electric 2Ws
2. Scenario 2: 50% of the 2Ws replaced with electric 2Ws
3. Scenario 3: 100% of the 2Ws replaced with electric 2Ws

Premises:

The 2Ws in Nepal are assumed to have 100-125 CC gasoline engines, with a fuel efficiency of 42.5 km/litre and an average annual distance travelled per 2W as 9000 km. The GHG emission factor is considered to be 0.029 $kgCO_2$/km (as per India GHG Program).

The 2Ws are assumed to be replaced with electric 2Ws of comparable specifications; the electric 2Ws are considered to have a 1.152 kWh battery, with a range of 70km/Charge (as per Hero Electric Optima Plus Electric Bike specifications). The tariff rate for residential charging is taken as 0.11 USD/kWh. The price of petrol in Nepal is taken as the rate for October 2018, which is 0.95 USD/litre. Considering 2000 electric 2Ws already on road in Nepal, the fossil-fuel run 2Ws number is taken as 2187099.

Analysis Results:

Scenarios	Annual GHG reductions ($mtCO_2e$)	Annual fuel imports reduction (million USD)
Scenario 1: 10% replacement	**0.057**	**44**
Scenario 2: 50% replacement	**0.285**	**220**
Scenario 3: 100% replacement	**0.57**	**440**

Table 57 ISGF Proposition for Electric 2 Wheelers (2W) in Nepal: GHG and Fuel Import Annual Reductions

Complete electrification of the 2 Wheelers population will result in 440 million USD reduction in the fuel imported, which amounts to nearly 37.6% of total fuel imports. While the reduction in GHG emissions significant at 0.57 $mtCO_2e$; the monetary benefit to the consumer is notable as shown below:

Annual savings per consumer using residential charging, % of current fuel expense
91.9%

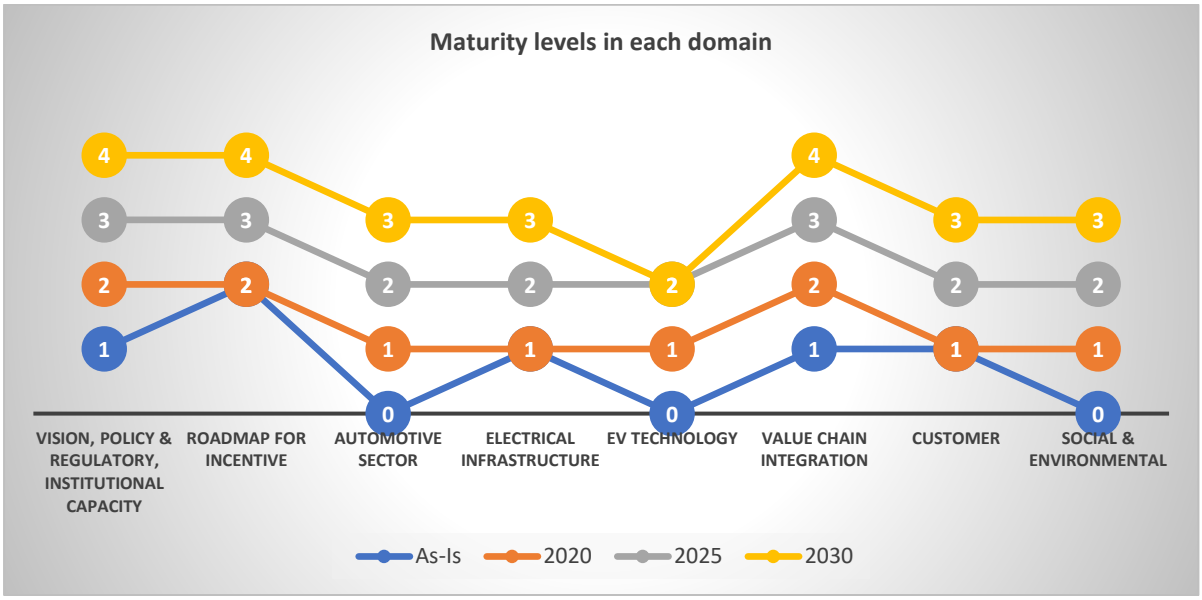
Table 58 ISGF Proposition for Electric 2 Wheelers (2W) in Nepal: Annual Savings for Consumer

From the consumer point of view, shifting to electric 2W translates into a more economically attractive experience (OPEX) given that per consumer, the energy requirement for electric 2W is only 148.11 electricity units with a yearly expense of USD 16.29 for residential charging as opposed to 211.8 litres of fuel with a yearly expense of USD 201.2 for a normal 2W.

The energy saved can be used alternatively to satisfy the energy requirements for the Industry and Residential sectors. The direct impact of this would result in a surge in GDP growth coupled with abatement in the nation's trade deficit due to reduction in the fuel imports. In addition to the energy savings and real time monetary benefits, there would be GHG emission reductions.

11.8 EVMM Assessment & Recommendations for Nepal

Based on the As-Is scenario (previous chapters), we have assessed[101] the existing conditions in each of the eight domains and identified the levels (as explained in Executive Summary) that they ought to attain in future years i.e. 2020, 2025 and 2030. We have also provided summary recommendations to ensure a sustainable EV adoption from one level to the next. A graphical representation showing the As-Is maturity level and the maturity level they need to attain in future is depicted below.[102]



[101] A detailed assessment requires stakeholder interviews

[102] "0" means default level which indicates that the basic minimum initiatives have been undertaken in this domain

Domain	By 2020	By 2025	By 2030
Vision, Policy & Regulatory, Institutional Capacity	***Target Maturity Level – 2*** • Government to come up with a nation- wide mission on electric vehicle and specific EV policy with a defined target and deadline, to send clear signal to both OEMs & consumers to invest in and adopt EV respectively • Government (Ministry of Physical Infrastructure & Transport) to identify and dictate EV adoption target to cities with respect to public transportation including buses and three wheelers • Government to convert all three wheelers into electric vehicle and notify guidelines on licensing, routes of operations along with implementation of pilot project on electric buses in major cities like Kathmandu, Pokhran, Biratnagar etc. • Government to discuss with banks to provide low cost loans for electric vehicles in the initial years to accelerate the adoption of two-wheelers • Organizational restructuring with the creation of an EV cell within Ministry of Physical Infrastructure & Transport, Nepal Engineering Company and NEA to facilitate future deployment strategy, policy, charging station implementation, O&M guidelines, consumer awareness etc.	***Target Maturity Level - 3*** • Government should provide targets to Department of transport Management to transform the entire fleet of public buses and installation of charging stations in depots and terminus in all the cities with maximum usage of public buses • Dedicated space in parking lots, in malls residential buildings for charging station installation to be made mandatory through building codes • Tariff policy by recognising EV as a separate group of consumers to be developed and aspects of Time of Use pricing to be introduced to smoothen the load curve • In cities like Kathmandu, Pokhran fleet operators of private taxis should be encouraged to shift to electric vehicle through incentives like subsidised parking charges, reduced tariff for charging, reduced toll etc.	***Target Maturity Level - 4*** • Government to make mandatory conversion of private taxi fleets into electric vehicle throughout the country • Government to provide guidelines for setting up of charging stations by third party and providing charging as a service without any kind of licensing at least for one year • Grid Code and Distribution Code guidelines must be updated for Vehicle to Grid (V2G) integration • Guidelines for mandatory battery buy back by OEMs on completion of battery life or in case of any faulty battery

Roadmap for Incentive	***Target Maturity Level – 2*** • Exemption of import and custom duty on EV components and subsidised import duty on the imported electric vehicle • Reduced property tax for electric three wheeler manufacturers and electric vehicle assembly companies • Reduced tariff for passengers using electric buses • Subsidized registration charges for one year for electric three and two wheelers • Reduced electricity tariff for charging for all categories of electric vehicle • Subsidized parking charges for electric vehicle	***Target Maturity Level - 3*** • Reduced road tax for electric four wheeler commercial fleet • Reduced property tax for residential complexes in few initial years which will be installing charging stations to facilitate personal vehicles • EV assembling companies or companies manufacturing EV parts to be provided with land, water and other requirement at a subsidised cost • Reduced property tax for resorts & hotels using electric vehicle for their guests and for personal purpose in major cities	***Target Maturity Level - 4*** • Promote battery recycling industry through tax free income in initial years or reduced interest on loans for JVs with minimum 25% stake of local companies
Automotive Sector	***Target Maturity Level - 1*** • Electric three wheelers with internationally approved design to be assembled with parts being imported from India or China • Battery and charging stations to be imported from countries like India and China for the pilot projects • Promote local manufacturing of electric two or through PPP or with joint ventures with foreign companies like in India, Japan etc.	***Target Maturity Level - 2*** • Servicing facility for charging stations to be provided by OEMs • 100% local manufacturing units to be promoted for electric two and three wheelers and service centres to be developed locally with skilled workforce • Feasibility study for monorail in the capital	***Target Maturity Level - 3*** • Local capacity development on O&M of charging stations through training and skill development • Charger manufacturing units to be set up with 100% FDI or through JVs with local companies
Electrical Infrastructure	***Target Maturity Level - 1*** • Distribution utilities to assess the availability of spare capacity in distribution transformers in areas having potential for charging station implementation like bus	***Target Maturity Level - 2*** • Upgradation of electrical infrastructure in terms of meter room, laying of cables, supply meters etc. in bus depots and terminus, parking lots, malls etc. by NEA for installation of charging stations	***Target Maturity Level - 4*** • Implementation of charging stations by supermarkets, big retailers with electrical network upgradation at own cost

	depots and terminus, existing malls, residential buildings etc. in major cities • Distribution utilities to assess the power availability and peak demand in both summer and winter season to figure out the EV demand the load network can sustain with the given supply including power import	• Upgradation expense should be included in the annual capex of concerned distribution utility and to be factored in tariff as the spreading of upgradation expense over entire population will have negligible impact on tariff • Improvement in power quality through deployment of technologies like harmonic filters, static compensators etc.	• Grid asset modernization for facilitating two way communication for implementing vehicle to grid solution • Electrical infrastructure upgradation for monorail implementation in Kathmandu
EV Technology	***Target Maturity Level - 1*** • Batteries used in electric three wheelers to be upgraded to lithium ion batteries • Technology for electric two wheelers to be upgraded in terms of design, battery capacity etc. • With majority of vehicles being imported from India, Japan, South Korea, Nepal may consider adopting EV standards of India and Japan to ensure interoperability. This include IS:17017 standard, which India has recently published for both AC and DC charging and allows both CHAdeMO and CCS charging standards	***Target Maturity Level – 2*** • Nepal Engineering Company to contribute in enhancement of the charging standards and communication protocols being used e.g. CCS, CHAdeMO, OCPP etc. • EV two wheeler testing and certification centre to be developed in Nepal	***Target Maturity Level - 2*** • R&D on battery recycling to be initiated in collaboration with Nepal engineering Company, technology institutes, etc.
Value Chain Integration	***Target Maturity Level – 2*** • Government building and offices to install charging stations in their premises for EV usage • Battery swapping model can be used for three wheelers with the help of a Battery Leasing Agency which will charge the batteries on a large scale and facilitate the three wheelers by providing a charged	***Target Maturity Level - 3*** • Private parking owners or service providers can implement public charging stations along with NEA or service providers along with NEA and the mall owners or hospitals can install public charging stations • Bundle EVSE as mandatory in new buildings through Building Codes for all categories of buildings exceeding certain built area. In this	***Target Maturity Level - 4*** • Dedicated fleet operators like for e-Buses and e-4Ws can invest by themselves or bring third party to invest in charging stations • With transition of private cars into electric fleets will provide opportunity for the retailer or third party service providers to provide door to door servicing on charging

	battery against a specified fee. The Battery Leasing Agency may be formed by the battery or EVSE supplier • Initially NEA along with Department of Transport Management to invest in setting up charging infrastructure for electric buses in bus depots for overnight charging and in bus terminus for fast charging during the day with the cost being treated under regulated capex route • Mandatory for the JV hydropower project companies to develop public charging stations in government land in major cities as a part of the royalty or government need to define a part of the royalty they get to contribute in implementation of public charging stations • Big business houses and hydropower companies to pool their CSR funds for financing of electric buses on pilot basis	case the impact of EVSE infrastructure cost is negligible in per square meter cost • Projects to be allocated to renewable energy companies must include a clause of implementing one or two public charging stations outside their plant's premises • Travel & Tourism companies, resort owners to install public charging station near tourist spot and resorts respectively • Private bus companies to set up charging stations in their premises and can allow public during certain hours against a specified rate (flat rate)	of electric vehicle in Kathmandu and other major cities with a premium charged on the regular tariff.
Customer	***Target Maturity Level - 1*** • Government vision and target for electric vehicle is communicated to customers • All the incentives and benefits for adopting or cruising an electric vehicle to be communicated properly to customers • EV cell of the distribution utilities to carry out research on the customer pattern of vehicle usage mainly two wheelers and identify probable charging pattern to figure out the load curve for a particular day in both summer and winter season	***Target Maturity Level - 2*** • Time of use pricing and its benefits to the customers must be displayed to make them aware of their benefits	***Target Maturity Level - 4*** • Customers are engaged in prosumer programs through V2G integration on pilot basis • Advanced services for customers like door to door service for car charging in Kathmandu where the retailer or service provider picks up the car for charging and drop it to the customer after the required amount of charging has been done • Advance booking of parking slots through e-booking based on time and amount of

			charge required by the individual in Kathmandu
Social & Environmental	***Target Maturity Level - 1*** • Organizing EV awareness programs, conduct workshops and seminars to make people aware of the benefits of EV adoption in terms of improved air quality, health benefits • Tourism will flourish by projecting areas as carbon neutral with EV being the only transport mechanism in those areas	***Target Maturity Level - 2*** • EV deployment mainly the buses and commercial taxi fleets can also provide opportunity to the existing workforce by providing them adequate training on O&M skills • Electric two wheelers and three wheelers manufacturing and assembling plants will help in job creation and people of rural areas can opt for a sustainable living in all aspects	***Target Maturity Level - 3*** • The deployment goals by the government will also help to bring electricity in the remote areas which can help in improving the living standard of the people in those areas

12. Pakistan: EV Scenario

12.1 Country Profile

12.1.1 Demography and Economy

Pakistan is located in the north-western part of the South Asian subcontinent has a population of about 195.4 million, growing at a rate of about 2% and has an urban population of 39%. With an area of about 796,000sq. km., the population density of Pakistan is 245 people per sq. km.

Growth prospects for the country continue to improve as the GDP grew at 4.7% in FY 2016 to USD 284 billion. Agricultural and industrial outputs have started improving which has been supported by construction of the China Pakistan Economic Corridor (CPEC) projects. Inflation indicators are estimated to be contained in upcoming years however, trade deficit is expected to be strained by modest growth in exports and increase in imports to support the growing economic activities. Pakistan's fiscal position continues to improve as the budget deficit has fallen from 6.4% in 2013 to 4.3% in 2016. Below table shows the brief profile of the country.

Parameters	2016
General Parameters	
Population, million	**195.4**
Population growth rate, % (2011-16)	**2**
Total Surface area, '000 sq. km	**796**
Population density, persons per sq. km of total surface area	**345**
Macro-economic parameters	
GDP, USD billion	**284**
GDP per capita, USD	**1473**
Current Account Balance, % of GDP	**-1.1**
Debt, % of GDP	**67.4**
Inflation, %	**2.9**

Table 59 Demography and Economy Parameters in Pakistan

In 2017, the GDP contribution by sector is Services (53.09%), Industry (17.94%) and agriculture (22.88%)[103]. The main economic sectors of the country are tourism, agriculture, construction, IT and others. Main export goods are rice, mangoes surgical instruments, cotton fibre, wheat, sea food, cement, marble, etc. accounting to value of $24 billion. Main imports goods are food, machinery, transport, agriculture chemicals etc. accounting to value of $48.1 billion.[104]

[103] Economy of Pakistan - Wikipedia. https://en.wikipedia.org/wiki/Economy_of_Pakistan
[104] Pakistan profile Available at: https://atlas.media.mit.edu/en/profile/country/pak/

12.1.2 Energy and Climate

Pakistan has been an energy importer and is highly dependent on fossil fuels with oil and gas being the dominating energy sources with a share of 64% followed by hydropower which has a share of 30% and other renewable energies only play a minor role. Nuclear power accounts for around 5% of the total installed capacity in Pakistan.[105]

Table 60: Installed Electricity Capacity for Pakistan in 2017

Fuel	MW	% of Total
Total Thermal	**16,463**	**62%**
Coal	**810**	**3.09%**
Gas	**8,868**	**33.87%**
Oil	**6,785**	**25.91%**
Hydro (Renewable)	**7,116**	**27.17%**
Nuclear	**1,142**	**4.36%**
RES* (MNRE)	**1,465**	**5.6%**
Total	**26,186**	

The power sector in Pakistan is facing serious energy deficit as there is big gap between demand and supply resulting in load shedding of electricity. Pakistan's national electrification rate was 73% in 2016 with urban electrification rate 90% and rural electrification rate of 61%[106]. Below table shows Electricity consumer and Electricity distribution profile of Pakistan[107]:

Electricity Consumer Profile	Number	% of Total
Number of electricity consumer	**27,997,799**	
Domestic	**23,938,118**	**85.50%**
Commercial	**3,258,943**	**11.64%**
Industrial	**3,35,973**	**1.20%**
Other	**4,64,763**	**1.66%**
Electricity Distribution		
Electricity Distribution substations	**977**	
Medium voltage distribution lines (km)	**370,208**	
Low voltage distribution lines (km)	**251,760**	

Table 61 Electricity Consumer and Electricity Distribution Profile of Pakistan

[105] Electricity sector overview Available at: https://en.wikipedia.org/wiki/Electricity_sector_in_Pakistan
[106] Pakistan Energy Situation Available at: https://energypedia.info/wiki/Pakistan_Energy_Situation
[107] MoP RE Performance 2017 and Program 2018 report

In 2012, Pakistan emitted 342 million metric tons (MtCO2e), with energy sector being the major contributor with contributing 46 percent to overall emissions, followed by agriculture (41%), land-use change and forestry (6%), industrial processes (5%) and waste (2%). Energy sector has the highest percentage share of GHG emissions, of which 26% is attributed to electricity consumption[108], 25% to manufacturing, 23% to transportation and the remaining 25% to other energy subsectors. Greenhouse gas emissions increased by 87 percent from 1990 - 2012, primarily due to the energy and agriculture sector emissions.[109]

Pakistan in its Intended Nationally Determined Contribution (INDC)[110], aims to reduce up to 20% of its projected GHG emissions subject to availability of international grants. The country's 'National Climate Change Policy' developed in 2012 states that the Government will develop an Action Plan for implementing climate change mitigation measures in the energy, agriculture and forestry sectors. This will also include promoting renewable and hydroelectric power, prioritizing natural gas imports over oil and coal, introducing energy conservation measures, developing public transit and implementing vehicle emission standards, promoting better agriculture and livestock management practices, setting afforestation and reforestation targets, and curbing illegal deforestation However, actions are contingent upon affordability, provision of international climate finance, transfer of technology and capacity building.

12.1.3 Automobiles and Transport sector

12.1.3.1 Industry Overview and Major Players

Pakistan automotive industry contributes around 4% to the country's GDP and employs the workforce of over 1.8 million people. There are around 3200 automotive manufacturing plants in the country, with an investment of Rs. 92 billion (US$870 million) producing 1.8 million motorcycles and 0.2 million vehicles annually. It is one of the fastest growing industries of the country and its contribute nearly Rs 50 billion (US$470 million) to the national exchequer. The sector, as a whole, provides employment to 3.5 million people and plays a pivotal role in promoting the growth of the vendor industry.

In March 2016, Pakistan passed the "Auto Policy 2016-21", offering benefits to new automakers to establish manufacturing plants in the country in terms of tax incentives[111]. It is believed that rising per capita income with changing demographic distribution along with an anticipated influx of 30 to 40 million young people in the economically active workforce in the next decade will provide a stimulus to the industry to expand and grow.[112] It is observed that the imports of vehicles fell in last few years majorly due to increased custom duties. It is essential that a stable and consistent regime which creates balance between imports & local manufacturing is established to provide an enabling, conductive to development and growth for this industry.

In 2015 the total number of registered vehicles were 17.32 million, with number of registered motor cycle (2 wheeler) 12.17 million, motor cycle (3 wheels) 0.51 million, motor cars, jeeps and station

[108]Greenhouse Gas Emissions in Pakistan - Climatelinks
[109]GHG emissions factsheet Pakistan, 2016
[110] Pakistan INDC, 2016
[111] AUTOMOTIVE DEVELOPMENT POLICY (2016-2021), Available at http://boi.gov.pk/AutoPolicy.aspx?sid=5
[112] Automotive Industry in Pakistan, - Wikipedia Available: https://en.wikipedia.org/wiki/Automotive_industry_in_Pakistan

wagon 2.53 million, motor cabs/ taxis 0.16 million, buses 0.23 million, trucks 0.25 million, others 1.44 million.[113]

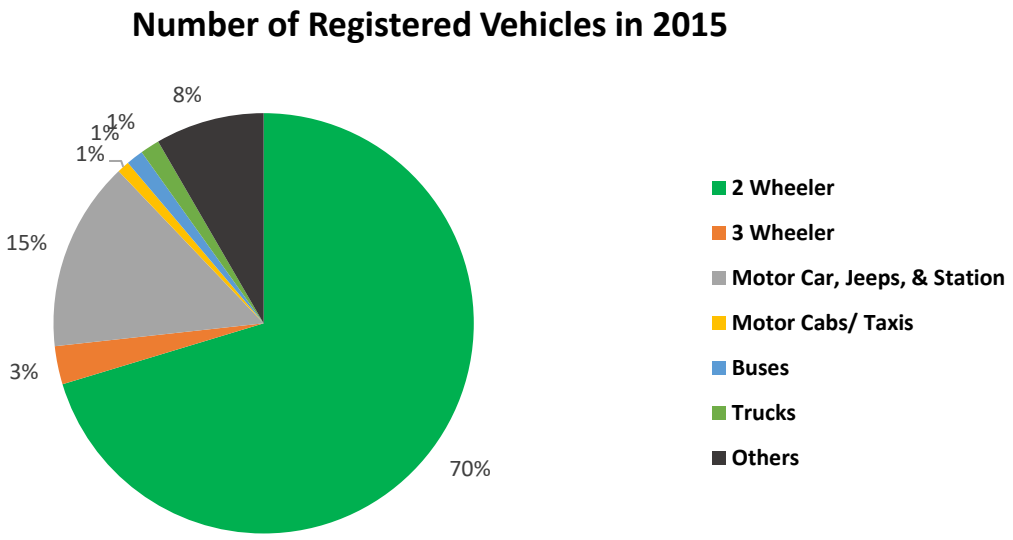


Figure 40 Number of Registered Vehicles for Pakistan in 2015

During the period 2000-15, motorization has increased tremendously in Pakistan. The figures show that privately-owned transport vehicles have increased more in comparison to the public transport vehicles, while road infrastructure has increased by just 5%. This slight increase in road infrastructure creates a question of sufficiency of accommodation of threefold increase in total vehicles. If government continues its policy of incentivizing private automobile users and shows a lack of interest in laying a strong foundation for a mass transit system, the urban transport problem will remain unsolved.

The below table shows the major players for each of the vehicle category:

Vehicle Category	Major players
Motorcycle (2W)	**Honda, Yamaha, Suzuki**
Three wheelers (3W)	**Qingqi, Sazgaar, Road Prince[114] etc.**
Cars (4W)	**Suzuki, Honda, Toyota etc.**
Bus and Heavy Trucks	**Hino, Master, Isuzu[115]**

Table 62 Major Automobile Companies by Vehicle Category in Pakistan

12.1.3.2 Transport Sector

Transportation sector becomes critical for the economy of Pakistan contributing ~10 per cent of the GDP and over 17 per cent of the Gross Capital Formation. The total road network is about 264,401

[113] Gallup-Pakistan-Big-Data-Analysis-Series-Edition-2-on-Transportation-Infrastructure-in-Pakistan-2000-to-20151.pdf, 2016
[114] Three-wheeler players, Available at: http://www.pama.org.pk/images/stories/pdf/five-years.xls
[115] Statistics/flash sales/sales figure Pakistan, 2017

km, including national highways, motorways, expressway and strategic routes. The country also has two Bus Rapid Transit BRT corridors in Lahore and another in Islamabad-Rawalpindi. They are 27 and 23 km. in length respectively. The Lahore BRT is busier and, in 2015, carried about 180,000 passengers per day. The Islamabad-Rawalpindi carried about 125,000 passengers per day.

Pakistan railways has a 7,791 km route length as of FY 2015-16, which has been constant over a decade. 52.19 million passengers travelled in FY 2015-16, showcasing a drop of 1.4% over the previous year. The total freight handled in FY 2015-16 grew more than three time in two years to 5 million tonnes, majorly driven by transportation of public goods. Civil Aviation also plays a crucial role carrying 19.64 million passengers in FY 2015-16, 65% of which were for international travel. Further, 338,467 tonnes of cargo were being handled across 31 airports. The below table shows the transport sector at glance:

Roadways	
Road Network (million km)	**2.6**
Railways	
No. of Passengers travelling per annum (million)	**52.19**
Freight carried (million tonnes)	**5**
Total route length (km)	**7,791**
Airways	
No. of airports	**31**
Air passenger traffic per annum (million)	**19.64**
Cargo handled (tonnes)[116]	**338,467**

Table 63 Pakistan Transport Sector at a glance

12.1.3.3 Fossil Fuel Dependence

In 2014, fossil fuel energy consumption (% of total) in Pakistan was reported at 59.7 %, according to World Bank collection of development indicators.[117] Pakistan's Oil Consumption was reported at 588.62 Barrel/Day in Dec 2017. This records an increase from the previous number of 566.02 Barrel/Day for Dec 2016.[118] Pakistan is an energy-hungry country with consistently rising import bill every year. The oil import bill stands at $9.89 billion, up by 32.61 percent in July-May 2016-17 compared to $7.462 billion in the same period of the last financial year majorly. This rise in import bill is majorly due to government importing Liquefied Natural Gas (LNG) worth $1.150 billion. The LNG import during last eleven month of the 2017 surged by 134 percent compared to the import of $491.25 million in the same period of 2015-16. The total oil bill includes crude oil and other petroleum products

[116] Major Traffic Flows by Airports During the Year, Pakistan Civil Aviation Authority, September 22, 2016
[117] https://tradingeconomics.com/pakistan/fossil-fuel-energy-consumption-percent-of-total-wb-data.html
[118] Pakistan Oil consumption data, Available at: https://www.ceicdata.com/en/indicator/pakistan/oil-consumption

imports, which increased by 11.76 per cent (to $2.331bn from $2.087) and 31.21 per cent (to $6.207bn from $4.730bn), respectively.[119] About 57%[120] of the petroleum is consumed by the transport sector.

12.1.4 Propositions for EVs in Pakistan

Fossil fuels primarily drive the transport and electricity generation sectors. The increased dependence on fossil fuels has led to an increase in Pakistan's GHG emissions. Although Pakistan's per capita emissions of greenhouse gases is one of the lowest in the world but it still it ranks amongst the top ten countries most affected by climate change during the last twenty years.[121] As the fossil fuel prices are rising, the cost of importing oil is creating a dent on Pakistan's foreign exchange reserves. This rise in prices of oil along with the rising demand for uninterrupted power, is creating additional pressure on the electricity grid of Pakistan which is already fragile.

For a developing country like Pakistan, the electric vehicles can be useful. These vehicles could help save Pakistan from spending a large chunk of money to import petroleum products along with saving precious amount of foreign reserves. Also, it would help Pakistan in reducing a terrible amount of gases, which will contribute positively towards the environment protection of which Pakistan is a victim. With, Pakistan being a signatory of the Kyoto Protocol, it is an imperative to use such vehicles which help in reducing the emission of poisonous gases[122].

The below analysis shows that by converting 10% of the car stocks to EV, barrels of oil saved is around 8%. Hence, by converting to EVs, the oil requirement will be reduced overall which will in turn reduce the import of petroleum fuels there by allowing Pakistan to reduce its oil import bill.

Equivalent Conversions	
1000 cubic feet of natural gas	**293.07 kWh of electricity[123]**
1000 cubic feet of natural gas	**0.17 barrels of oil[124]**

Parameters	Units	Value
Distance travelled per day	**Km**	**25.00**
Car stock	**no.**	**2,695,500.00**
Total distance travelled per year	**Km**	**67,387,500.00**
Mileage of car	**km/litre**	**18.00**
Total barrels of oil required	**no.**	**34,034.09**

[119]https://profit.pakistantoday.com.pk/2017/06/28/countrys-oil-imports-bill-up-32-61-in-11-months/

[120] Petroleum consumption in Pakistan, Available at: https://dunyanews.tv/en/Business/429389-Petroleum-consumption-Pakistan-increase-business

[121] https://propakistani.pk/2017/07/25/pakistans-carbon-emissions-grow-4-times-15-years/

122 Pakistan needs full electric vehicles - Daily Times. Available at: https://dailytimes.com.pk/140459/pakistan-needs-full-electric-vehicles

123 http://www.kylesconverter.com/energy,-work,-and-heat/cubic-feet-of-natural-gas-to-kilowatt--hours

124http://www.kylesconverter.com/energy,-work,-and-heat/cubic-feet-of-natural-gas-to-barrels-of-oil-equivalent

Now, if 10% of the car stock is converted to EVs,

	Units	
No. of EVs	**no.**	**269550**
No. of ICE vehicles	**no.**	**2425950**
Distance travelled by EVs	**Km**	**6738750**
Efficiency of EVs	**km/full charge**	**100**
Battery size of EVs	**kWh**	**15**
Total electricity required for charging	**kWh**	**1010812.5**
Total barrels of oil required for generating equivalent kWh	**no.**	**594.59**
Total barrels of oil required for ICE vehicles	**no.**	**30630.68**
Total barrels of oil required	**no.**	**31225.27**
Barrels of oil saved	**no.**	**2080.81**
		8%

Table 64 Propositions for EVs in Pakistan

12.1.4.1 Key Benefits of EV deployment in Pakistan

Electric vehicle will reduce the GHG emission, thereby allowing Pakistan to align with their INDC goals.

Electric Vehicle has potential of reduced Total Cost of Ownership (TCO) as compared to ICE vehicles.

Shifting the transport sector away from reliance on fossil fuels towards use of electricity powered vehicles will help in reducing Pakistan oil import bill

Provision of clean, affordable and comfortable transport facility for the Pakistani population.

12.1.4.2 Key Challenges of EV deployment

The high investment cost of EVs and EVSE equipment is a major cause of detriment for EV adoption

Shortfall of electricity and lack of infrastructure are major reason for not taking steps towards boosting Electric Vehicle scope in the country.

Charging time required and the driving range offered are considered to be the negative factors that discourage the local consumer from buying EVs.

12.2 Existing EV Landscapes

12.2.1 EV Related Policies

Pakistan currently has no supply and demand of electric vehicles and the government has no policies aimed at creating an ecosystem for electric vehicles. However, the Pakistan Transport Plan Study (PTPS), a comprehensive transportation master plan for Pakistan for the period from 2005 to 2025, suggests the initiatives required to counter the environmental adverse effects of transport.

The government of Pakistan in April 2018 announced some measures to encourage the use of clean vehicles in the country along with cost cutting. This came at a time when several new players were gearing up to enter the auto industry of Pakistan by reaping benefits of the auto policy announced in 2016. In budget of fiscal year 2018-19, importance is given to promote environment-friendly electric vehicles and to enable fiscal environment, related infrastructure is necessitated. In this regard, it is proposed that customs duty on charging stations for electric vehicles which stands at 16% should be withdrawn. It is also proposed that customs duty on the import of electric cars to be reduced from 50% to 25%. This is in addition to exemption from 15% regulatory duty. 10% is proposed for the import of CKD (completely knocked down) kits for the assembly of electric cars.[125] These measures are the additional incentives along with incentives already announced in the Auto Development Policy for 2016-21.

12.2.2 EV Fleet Size Models and Players

The government plans to reduce the cost of oil import to some extent through promoting the imports of hybrid vehicles considering they are light on fuel. The government passed SRO-499(I)/2013 to promote the import of hybrid electric vehicles. This tax subsidy led to the increased imports of hybrid vehicles. This has developed a significant market for hybrid vehicles with Honda's Vezel, Toyota's Prius and Aqua, and other such models having a significant presence on the Pakistani roads. In the fiscal year 2015-16, 6,400 hybrid vehicles have been imported to Pakistan. Around 4500 of those 6400

[125] https://tribune.com.pk/story/1697321/2-customs-duty-import-electric-cars-cut-25/

hybrid vehicles fall in the 1300 to 1500 cc category while others fall in 1501 cc and above category.[126] Though exact number of hybrid vehicles running on road is not available.

Rahmat Group in Pakistan, is anticipating a huge demand in market and hence, planning to bring electric cars to Pakistan. The Group has signed as much as 14 technical collaboration agreements and Memorandum of Understanding (MoU) with different Chinese companies[127]. This agreement includes building complex which will begin with manufacturing electric/battery powered buses. The company will then enter the two-wheeler electric market as well once it progresses and also plans to develop lithium batteries for buses, cars and two-wheelers.

JAC Motors, a Chinese state-owned automobile company, is planning to bring electric cars in Pakistan as they believe that country's economy is now flourishing and more improvement is expected with better infrastructure. The company also plans to build an automobile manufacturing plant for EV in Pakistan to expand its production line. The company is looking to take advantage of the huge price cut in electric cars which also seems an inexpensive alternative for the people of Pakistan. It also plans to introduce the first ever electric cars in the country.[128]

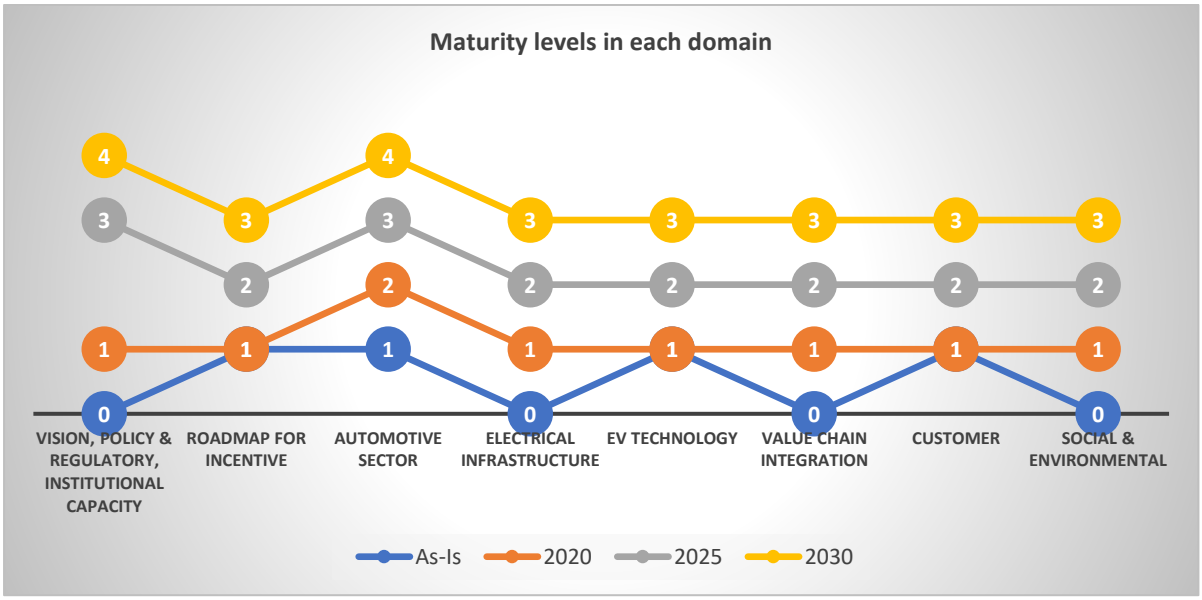
12.2.3 Charging Station and Standards

In November 2016, Pakistan inaugurated very first BMW ChargeNow electric charging station for hybrid cars. In one year, Dewan motors installed 7 BMW ChargeNow stations in the country across different cities. Although it is still obscure that what system this dock would adhere to, we can anticipate that it could be a CCS system as BMW supports it. [129] ChargeNow DC Fast charging is offered by BMW in cooperation with EV go. Globally, BMW is also reportedly working on developing wireless inductive charging system. Mentionable work is still not done in the EV space and its charging infrastructure. To promote environment friendly hybrid vehicles, the government has proposed withdrawal of 16 percent customs duty on electric vehicles also a reduction in customs duty on import of electric vehicles from 50 percent to 25 percent, and 15 percent regulatory duty exemption.[130] Though EV charging specific tariff order is not found.

[126] https://www.pakwheels.com/blog/government-gave-rs4-7bn-of-rebate-for-imported-hybrid-vehicles-in-pakistan/
[127] https://propakistani.pk/2018/06/11/rahmat-group-is-launching-electric-cars-in-pakistan-this-year/
[128] https://www.techjuice.pk/china-plans-to-introduce-electric-cars-in-pakistan/
[129] https://www.techjuice.pk/the-first-electric-car-charging-station-of-pakistan-inaugurated/
[130] https://customnews.pk/2018/04/27/duty-on-hybrid-cars-reduced/

12.3 EVMM Assessment & Recommendations for Pakistan

Based on the As-Is scenario (previous chapters), we have assessed[131] the existing conditions in each of the eight domains and identified the levels (as explained in Executive Summary) that they ought to attain in future years i.e. 2020, 2025 and 2030. We have also provided summary recommendations to ensure a sustainable EV adoption from one level to the next. A graphical representation showing the As-Is maturity level and the maturity level they need to attain in future is depicted below.[132]



[131] A detailed assessment requires stakeholder interviews

[132] "0" means default level which indicates that the basic minimum initiatives have been undertaken in this domain

Domain	By 2020	By 2025	By 2030
Vision, Policy & Regulatory, Institutional Capacity	***Target Maturity Level – 1*** • Ministry of Communication and ministry of Industry & Production should work together and come up with a nation-wide mission on electric vehicle and a EV specific policy with a defined target and deadline, to send clear signal to both OEMs & consumers to invest in and adopt EV respectively • Government should target buses for public transport to be changed to electric fleet in major cities like Karachi, Lahore and Islamabad etc. as it is contributing to major share for public transport and can start it with a pilot project in one of these cities • Government to discuss with banks to provide low cost loans for electric two wheelers in the initial years or can provide subsidy on CAPEX for few initial two wheelers like 20% subsidy on first 50,000 to accelerate the adoption of two-wheelers • Organizational restructuring with the creation of an EV cell within Pakistan Automotive Institute and distribution utilities with Ministry of Communication, Ministry of Energy (Power Division) and Engineering Development Board (Auto industry Development Committee) as overseeing authority to facilitate future deployment strategy, charging station implementation, O&M guidelines, consumer awareness etc. Distribution utilities should	***Target Maturity Level - 3*** • Government should provide targets to respective provincial transport departments to transform the entire fleet of public buses for intra city transfers in to electric fleet and installation of charging stations in depots and terminus • Conversion of entire fleet of three wheelers in to electric fleet and the conversion of jeeps and motor cars used for public transport in major cities • Government should make mandatory the installation of charging stations in bus depots and terminus, highways and should request utilities to evaluate the same to promote the usage of electric buses for both intracity and intercity travel • Tariff policy by recognising EV as a separate group of consumers to be developed and aspects of Time of Use pricing to be introduced to smoothen the load curve • Dedicated space in parking lots, in malls residential buildings for charging station installation to be made mandatory through building codes • Creation of a PPP cell and Investment Facilitation Center with members from Ministry of Industry and Production, Engineering Development Board, Board of Investment to evaluate projects on investment in EV manufacturing and	***Target Maturity Level - 4*** • Government to make mandatory conversion of motor cars and jeeps for public transportation into electric vehicle throughout the country • Government to streamline the third party charging process by providing guidelines • In major cities like Karachi, Lahore fleet operators of private taxis should be encouraged to shift to electric vehicle through incentives like subsidised parking charges, reduced tariff for charging, reduced toll etc. • Government should ease norms on import of components and EV parts for local manufacturing and assembling companies and come out with guidelines on the same • Grid Code and Distribution Code guidelines must be updated for Vehicle to Grid (V2G) integration • Guidelines for mandatory battery buy back by OEMs on completion of battery life or in case of any faulty battery

	also be roped in for suggestions on grid upgradation requirement	assembling and act as a single window for FDI, PPP and JV projects	
Roadmap for Incentive	***Target Maturity Level – 1*** • Exemption of import and custom duty on EV components and subsidised import duty on the imported electric vehicle • Subsidized registration charges for one year for electric three and two wheelers • Reduced tariff for passengers using electric buses • Reduced electricity tariff for charging for all categories of electric vehicle • Subsidized parking charges for electric vehicle	***Target Maturity Level - 2*** • Reduced road tax for electric vehicles • Reduced property tax on electric vehicle assembling units • Reduced tariff for passengers using electric vehicles for public transportation • Reduced property tax for residential complexes in few initial years which will be installing charging stations to facilitate personal vehicles • Reduced property tax for hotels using electric vehicle for their guests and for personal purpose in major cities • Duty free import of plant and machinery for setting up of manufacturing or assembly unit on one time basis • Special manufacturing economic zone to set up for manufacturing and assembling of EV with land on lease and water facility provided by the government	***Target Maturity Level - 3*** • Reduced property tax for EV and battery manufacturers and promote battery recycling industry through tax free income in initial years or reduced interest on loans for JVs with minimum 30% stake of local companies
Automotive Sector	***Target Maturity Level - 2*** • Automotive Testing and Training Center to approve the three wheelers and two wheelers being manufactured and assembled • Battery and charging stations to be imported from countries like China for the pilot projects	***Target Maturity Level - 3*** • Local manufacturing units to be set up for electric two and three wheelers and service centres to be developed locally with skilled workforce • Manufacturing and assembling units for electric cars and buses mainly to be set up with JV with foreign companies	***Target Maturity Level - 4*** • Battery manufacturing units to be set up with JVs with foreign companies • Servicing facility for charging stations can be provided by OEMs and local capacity development on O&M of charging stations through training and skill development • Battery recycling industry to be developed with foreign collaborations

Electrical Infrastructure	***Target Maturity Level - 1*** • Distribution utilities to assess the supply and availability of spare capacity in distribution transformers in areas having potential for charging station implementation like bus depots and terminus, existing malls, residential buildings etc. in major cities • Distribution utilities to assess the power availability and peak demand in both summer and winter season to figure out the EV demand the load network can sustain with the given supply including power import and should also take in to account the upcoming power projects for future assessment • Distribution utilities to consider power supply from renewable sources in remote areas or areas having high renewable potential for installation of charging station for electric vehicles	***Target Maturity Level - 2*** • Upgradation of electrical infrastructure in terms of meter room, laying of cables, supply meters etc. in bus depots and terminus, parking lots, malls etc. by electricity distribution utilities for installation of charging stations • Improvement in power quality through deployment of technologies like harmonic filters, static compensators etc. • With EV adoption at a large volume, tariff for charging should consider the opportunity cost of oil & gas which is freed up from transport sector and can be used in power sector and various other sectors	***Target Maturity Level - 3*** • Implementation of charging stations by supermarkets, big retailers with electrical network upgradation at own cost • Upgradation expense can be shared by OEMs or third party service providers of charging stations • Grid asset modernization for facilitating two way communication for implementing vehicle to grid solution
EV Technology	***Target Maturity Level - 1*** • Currently Pakistan has BMW Chargenow charging stations which follows CCS standards and as most of the vehicles are Japanese and Chinese, Pakistan can use CHAdeMO and GB/T charging standards for electric vehicle charging • Pakistan can also follow the Indian standard which has recently been published for both AC and DC charging and allows both CHAdeMO and CCS charging standards	***Target Maturity Level – 2*** • Automotive testing and training centre to validate and certify the quality of electric vehicles manufactured • In house development of motor technology, power electronics equipment like switch mode power supply for charging stations along with international technology institutes etc. • In house development of EV technology for two wheelers for development of low cost two	***Target Maturity Level - 3*** • Pakistan Automotive Institute along with technocrats and EV associations etc. to decide on the interoperability of charging and contribute in enhancement of the charging standards and communication protocols being used e.g. CCS, CHAdeMO, OCPP etc. • R&D on battery and battery recycling to be initiated in collaboration with international research labs, technology institutes, etc.

		wheelers as these constitute the major chink of transportation	
Value Chain Integration	***Target Maturity Level – 1*** • Government building and offices to install charging stations in their premises for EV usage • Distribution utilities and along with the provincial transport authority with support from central government to invest in setting up charging infrastructure for electric buses in bus depots for overnight charging and in bus terminus for fast charging during the day with the cost being treated under regulated capex route • Two wheeler manufacturers can also set up charging stations in major cities like Islamabad, Karachi. Lahore etc. to accelerate EV two wheeler adoption • Big business houses to pool their CSR funds for financing of electric buses on pilot basis	***Target Maturity Level - 2*** • Infrastructure projects under CPEC can act as an important launchpad for accelerating EV deployment by installing charging stations across highways being developed and deploying EVs in the project areas with funding from both the governments • Battery swapping model can be used for three wheelers with the help of a Battery Leasing Agency which will charge the batteries on a large scale and facilitate the three wheelers by providing a charged battery against a specified fee. The Battery Leasing Agency may be formed by the battery or EVSE supplier • Private bus companies to set up charging stations in their premises and can allow public during certain hours against a specified rate (flat rate) • Bundle EVSE as mandatory in new buildings through Building Codes for all categories of buildings exceeding certain built area. In this case the impact of EVSE infrastructure cost is negligible in per square meter cost • Projects to be allocated to renewable energy companies must include a clause of implementing one or two public charging stations outside their plant's premises	***Target Maturity Level - 3*** • Private parking owners or service providers can implement public charging stations along with distribution utilities or service providers along with distribution utilities and the mall owners or hospitals can install public charging stations • Bundle EVSE with highway development cost and install charging stations in the highways. • Dedicated fleet operators like for e-Buses and e-4Ws can invest by themselves or bring third party to invest in charging stations

Customer	***Target Maturity Level - 1*** • Government vision target for electric vehicle is communicated to customers • All the incentives and benefits for adopting or cruising an electric vehicle to be communicated properly to customers	***Target Maturity Level – 2*** • Carry out research on the customer pattern of vehicle usage mainly two wheelers and identify probable charging pattern to figure out the load curve for a particular day by the EV cell • Time of use pricing and its benefits to the customers must be displayed to make them aware of their benefits	***Target Maturity Level - 3*** • Customers are engaged in prosumer programs through V2G integration on pilot basis • Advance booking of parking slots through e-booking based on time and amount of charge required by the individual in major cities like Karachi, Islamabad etc.
Social & Environmental	***Target Maturity Level - 1*** • Organizing EV awareness programs, conduct workshops and seminars to make people aware of the benefits of EV adoption in terms of improved air quality, health benefits.	***Target Maturity Level - 2*** • EV deployment mainly the buses, and commercial taxi fleets can also provide opportunity to the existing workforce by providing them adequate training on O&M skills	***Target Maturity Level - 3*** • The deployment goals by the government will also help to bring electricity in the remote areas which can help in improving the living standard of the people in those areas • Electric two wheelers and three wheelers manufacturing and assembling plants will help in job creation and people of rural areas can opt for a sustainable living in all aspects

13. Sri Lanka: EV Scenario

13.1 Country Profile

13.1.1 Demography and Economy

Sri Lanka is a tropical island lying close to the southern tip of India and near the Equator, situated in the south-eastern part of Asia with population of about 21.2 million, growing at a rate of about 0.96% and has an urban population of 18.4%. With an area of about 65,610 sq. km., the population density of Sri Lanka is 323.17 people per sq. km.

The Average GDP growth rate for Sri Lanka in 2013-2016 is 4.63%. It has slowed down reflecting the impact of floods and drought cycles faced by the country, despite being supported by policy measures towards fiscal consolidation and monetary tightening, along with the backdrop of the IMF Program. In November 2016, the first review of the funding (about USD 1.5 billion) was completed, allowing the disbursement of the second tranche. Fiscal deficit is estimated to fall to 5% in 2017 from 6.1% in 2016, due to implementation of revenue measures through changes in the VAT act increasing collections, in addition to the controlled expenditure and low oil prices[133].

Parameters	2016
General Parameters	
Population, million	**21.2**
Population growth rate, % (2011-16)	**1.0**
Total Surface area, '000 sq. km	**65.6**
Population density, persons per sq.km of total surface area	**323.2**
Macro-economic parameters	
GDP, USD billion	**80.6**
GDP per capita, USD	**3824.0**
Current Account Balance, % of GDP	**-3.0**
Debt, % of GDP	**79.1**
Inflation, %	**4**

Table 65 Demography and Economy Parameters in Sri Lanka

In 2017, the GDP contribution by sector is Services (61.7%), Industry (30.5%) and agriculture (7.8%)[134]. The main economic sectors of the country are tourism, tea export, apparel, textile, rice production and other agricultural products with total export value accounting to around $11.4 billion[135]. Main export goods are petroleum, machinery and transportation equipment, textile fabrics, building materials, mineral products, foodstuffs etc. accounting to value of $21.14 billion. The transport sector contribution to GDP has been around 10% and generated about 4% of the employment.[136]

[133] ERMT Study Report
[134] Economy of Sri Lanka, Available at: https://en.wikipedia.org/wiki/Economy_of_Sri_Lanka
[135] http://www.ft.lk/top-story/Sri-Lanka-achieves-record-exports-in-2017/26-647750
[136] World Bank Analysis, 2015

13.1.2 Energy and Climate

The energy sector falls under the purview of Ministry of Power & Energy. There are number of institutions under the ministry which manages the different energy sub-sectors. Ceylon Electricity Board (CEB) and several independent power producers generate electricity in Sri Lanka. CEB operates the transmission system and grid substations. Electricity distribution is done by both CEB and Lanka Electricity Company (LECO). Sri Lanka Sustainable Energy Authority (SLSEA) administers the new renewable energy (small hydro, wind, solar, biomass, etc.) sector development and energy management. Public Utilities Commission of Sri Lanka (PUCSL) is the electricity sector regulator.

In 2015, 52[137] percent of Sri Lanka's electricity was generated through fossil fuels. Indigenous fossil fuel resources are scare, so the fossil fuel used for electricity is imported which forms a significant part of Sri Lanka's import expenditure. Also, Sri Lanka's energy demand is catered by several energy sources which consists of both imported fossil fuels and indigenous non-fossil fuels. Most of the country's energy needs are met through biomass, an indigenous fuel source, and imported fossil fuels, such as petroleum and coal. The remainder is made up of other indigenous sources which, include large hydro and renewables such as solar, small hydro and wind.[138]

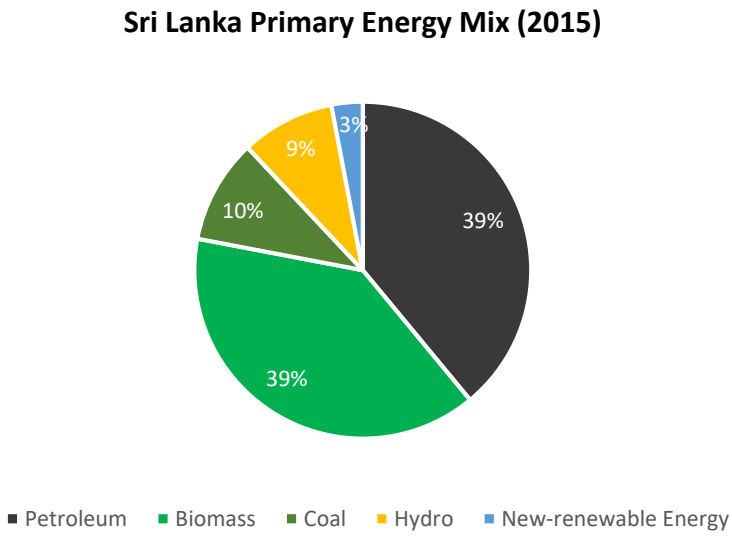


Figure 41 Sri Lanka Primary Energy Mix (2015)

Sri Lanka's national electrification ratio has grown from 99.3% in 2016 to 99.7% in October 2017 and has already reached 100% electricity accessibility with 24 hours uninterrupted electricity supply which is a commendable feat by south Asian standards. The demand for electricity in Sri Lanka is growing at a rate of about 6% per year.

Sri Lanka has set the target of 100% Renewable Energy generation of 34.3 GW (including 1.5GW of large hydropower generation) by 2050. Also, as part of its Energy Sector Development Plan for a

[137] 100% Electricity Generation Through Renewable Energy by 2050, ADB and UNDP, 2017
[138] SLSEA, "Sri Lanka Energy Balance", 2014. Available from: http://www.info.energy.gov.lk/

Knowledge-based Economy (2015-2025)[139]. It aims to become energy self-sufficient by 2030 which it intends to do so using indigenous natural gas and large hydro along with renewable sources of energy.

The below table shows the electricity consumer profile and electricity distribution scenario:

Electricity Consumer Profile	Number	% of Total
Number of electricity consumer	**6,647,074**	
Domestic	**2,260,005**	**34%**
Industrial	**1,927,651**	**29%**
General Purpose	**1,395,885**	**21%**
Religious organization, Hotels, Government Institutions, Street Lighting etc.	**1,063,531**	**16%**
Electricity Distribution		
Low Voltage Electricity Distribution substations	**28,479**	
Medium voltage distribution lines (km)	**32,863**	
Low voltage distribution lines (km)	**139,213**	

Table 66 Electricity Consumer and Electricity Distribution Profile of Sri Lanka

Sri Lanka's GHG profile in 2011 was dominated by the energy sector (40%), followed by the waste (28%), land use change and forestry (LUCF) (15%) and agriculture (14%) sectors and Industrial processes (IP) contributed (3%). Energy sector which contributed 40% to overall emissions, consist of transportation (39%), electricity and heat (28%), other fuel combustion (27%), and manufacturing and construction (5%).[140]

According to the Second National Communication (SNC) to the UNFCCC[141], the transport sector emitted 48% of all carbon dioxide from fossil fuel combustion and has the highest contribution to GHG emissions. Cars, motorcycles, and three-wheelers runs on gasoline while trucks operate on diesel fuel and consume 50% of the total diesel fuel in the country. In recent years, it is seen that two and three-wheeled vehicles has risen four to six-fold compared to other vehicles. Over half of the vehicle fleet consists of two- and three-wheeled vehicles and the total fleet is expected to grow with economic development[142].

[139] Ministry of Power and Energy," Sri Lanka Energy Sector Development Plan for a Knowledge-Based Economy 2015-2025", Colombo, n.d. Available from: http ://powermin.gov.lk/sinhala/wp-content/uploads/2015/03/ENERGY_EMPOWERED_NATION_2015_2025.pdf.

140 Greenhouse Gas Emissions in Sri Lanka - Climatelinks. Available at: https://www.climatelinks.org/sites/default/files/asset/document/Sri%20Lanka%20Fact%20Sheet%20-%20rev%2010%2012%2016_Final_0.pdf

141 Sri Lanka. Sri Lanka's Second National Communication (SNC) to the UNFCCC, 2012.

142 Ministry of Power & Energy, Sri Lanka Energy Sector Development Plan for a Knowledge-based Economy 2015-2025, 2012.

Sri Lanka in its Intended Nationally Determined Contribution (INDC)[143], communicated or aims to reduce GHG emissions unconditionally by 7% by 2030 compared to a business-as-usual scenario (with 2010 as a base year), achieving 4% from energy and 3% from other sectors. It commits to a more ambitious, conditional reduction of 23% that would increase reductions from energy to 16%, and 7% from other sectors. The unconditional energy target will be met through the implementation of non-conventional renewable energy sources projects including mini and micro hydro, wind and solar farms. The conditional target would require future support for the non-conventional renewables. Reductions from other sectors would consist of activities in the transport, waste, industrial, and forestry sectors[144], with detailed plans yet to be completed.

13.1.3 Automobile and Transport

13.1.3.1 Industry Overview and Major Players

The cost of vehicles in the local market of Sri Lanka is heavily dependent on the importation taxes as it does not have the local vehicle manufacturing industry. The present tax system in the country has become very convoluted, and with frequent changes in coverage and rates, it leads to further complexity. The irrationality in formulating subsidies is also an issue in Sri Lanka. While aimed at protecting consumers (or supplier), subsidies usually aggravate fiscal imbalances, and influence consumers (or suppliers) choices leading to wide-ranging economic consequences. The Impacts of such issues are well recognized in the transport sector, particularly with subsidies imposed on fuels, vehicles, public transport fare / tariff, etc.[145].

There has been announcement from Indian vehicle maker Mahindra & Mahindra to build an assembly plant in Sri Lanka[146]. As this is also in line with the long-term policy of Sri Lankan government in developing local manufacturing but the major challenge in doing this has been the motor vehicle tax structure which keeps on changing and carmakers are demanding a long-term policy to plan their operations more smoothly.

In 2017, total vehicles stock on road was 7.2 million with motor cycle having the majority vehicle share.

Vehicle Category	Share (%)
Motor Cycle	**56**
Motor Tricycle	**16**
Motor Cars	**10**
Buses	**1**
Others	**17**

Table 67 Model Share Distribution of Vehicles in Sri Lanka

143 Sri Lanka's Intended Nationally Determined Contributions (INDC) to the UNFCCC, October 2015.

144 Greenhouse Gas Emissions in Sri Lanka - Climatelinks

145 Fuel Economy of LDV in Sri Lanka, 2015

146 https://automotivelogistics.media/news/mahindra-mahindra-looks-assembly-sri-lanka

The total number of hybrid cars registered was over 56% of the total number of cars in 2014 due to benefit of tax concessions which was provided to the hybrid cars a few years back. As there is a reversal of these concessions in the recent tax revisions, the sales of hybrid cars had gone down.

The below table shows the major players for each of the following vehicle category.

Vehicle Category	Major players
Motorcycle (2W)	**Honda, Bajaj, TVS, Hero, Royal Enfield etc.**[147]
Three wheelers (3W)	**Bajaj, TVS etc.**
Cars (4W)	**Suzuki, Toyota, Nissan etc.**
Bus and Heavy Trucks	**Tata, Lanka Ashok Leyland etc.**

Table 68: Major Automobile Companies by Vehicle Category in Sri Lanka

13.1.3.2 Fossil Fuel Dependence

Sri Lanka depends on import for the fossil fuel as it does not have it own fossil fuel resources, but recent explorations indicate presence of gas reserves (most probable). More detailed investigations are required to identify technical and economic potentials. The country has long been an importer of refined products for domestic consumption. During the year 2014, the crude oil and refined petroleum products imports were 1,824 and 3,385 thousand metric tons, with annual expenditure of about 1.44 and 3.00 billion US$, respectively. Transport sector consumes about 70% of the petroleum where the main fuel is diesel and the total expenditure for petroleum imports was about 6%[148] of GDP.

13.1.3.3 Transport Sector

Sri Lanka has the highest road density of any country in South Asia, with some 173.9 km of roads per 100 sq. km of land as of 2016, according to the World Bank. The railway network handles only a small fraction of country's transport needs and it is extremely slow by modern standards. The below table shows the transport sector at a glance:

Roadways	
Road Network (km)	**31,262**
Railways	
No. of Passengers travelling per annum (million)	**136**
Goods carried (million tonnes)	**2**
No. of stations	**336**
Total route length (km)	**1,562**
Airways	
No. of airports	**17**
No of International Airport	**3**

[147] Popular Motorcycles in Sri Lanka, 2018 Available at: https://www.srilankamotorcycle.com/Popular-Motorcycles.php
[148] Fuel Economy of LDV in Sri Lanka, 2015

Air passenger traffic per annum (million)	**4.5**
Cargo transported by air industry (million tonnes)	**0.1**
Waterways	
Ports[149]	**7**
Cargo traffic handled at port (million tonnes)[150]	**51.8**

Table 69 Sri Lanka Transport Sector Overview

13.1.4 Propositions for EVs

Sri Lanka has to increase its dependence on costly imported fossil fuels (49 percent of the total energy mix) with the increasing demand of electricity. Fossil fuel drives the transport and electricity generation sectors. This increased dependence on fossil fuels has also led to an increase in Sri Lanka's GHG emissions, which while amongst the lowest in the world (ranked 194th out of a total 251 countries) as well as in South Asia (0.8 mtCO2e/capita in 2015) has been growing steadily over the past decade (from 0.5 mtCO2e/capita in 2000).

As the petroleum fuels are totally imported, there is a heavy economic burden to the country and management of fuel economy/energy efficiency becomes very important aspect in the energy sector. The below analysis shows that by converting 10% of the car stocks to EV, barrels of oil saved is around 8%. Hence, by converting to EVs the oil requirement will be reduced overall which will also reduce the import of petroleum fuels.

Equivalent Conversions	
1000 cubic feet of natural gas	**293.07 kWh of electricity**[151]
1000 cubic feet of natural gas	**0.17 barrels of oil**[152]

	Units	
Distance travelled per day	**Km**	**25.00**
Car stock	**no.**	**756,856.00**
Total distance travelled per year	**Km**	**18,921,400.00**
Mileage of car	**km/liter**	**18.00**
Total barrels of oil required	**no.**	**9,556.26**

[149] https://en.wikipedia.org/wiki/List_of_ports_in_Sri_Lanka
[150] Economic and Social Statistics of Sri Lanka – 2017, Central Bank of Sri Lanka
[151] http://www.kylesconverter.com/energy,-work,-and-heat/cubic-feet-of-natural-gas-to-kilowatt--hours
[152] http://www.kylesconverter.com/energy,-work,-and-heat/cubic-feet-of-natural-gas-to-barrels-of-oil-equivalent

Now, if 10% of the car stock is converted to EVs,

	Units	
No. of EVs	**no.**	**75686**
No. of ICE vehicles	**no.**	**681170**
Distance travelled by EVs	**Km**	**1892140**
Efficiency of EVs	**km/full charge**	**100**
Battery size of EVs	**kWh**	**15**
Total electricity required for charging	**kWh**	**283821**
Total barrels of oil required for generating equivalent kWh (conversion table)	**no.**	**166.95**
Total barrels of oil required for ICE vehicles	**no.**	**8600.63**
Total barrels of oil required	**no.**	**8767.59**
Barrels of oil saved	**no.**	**788.67**
		8%

Table 70 Proposition for EVs in Sri Lanka

13.1.4.1 Key Benefits of EV deployment

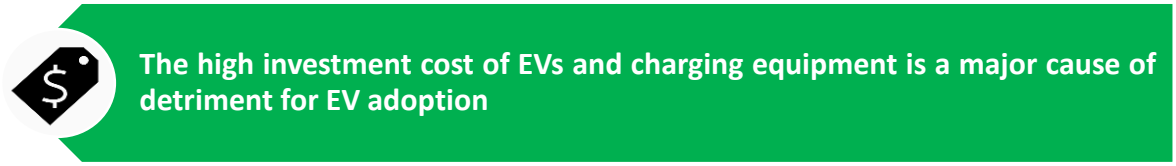
Electric vehicle will reduce the GHG emission, thereby allowing Sri Lanka to align with their INDC goals.

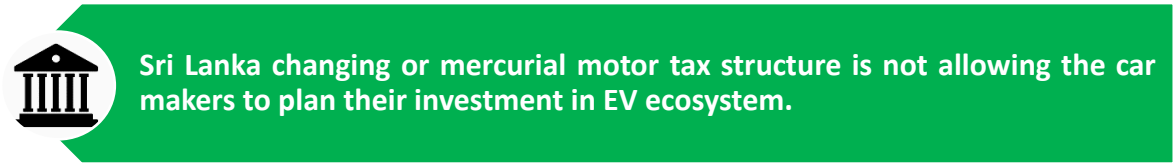
Electric Vehicle has potential of reduced Total Cost of Ownership (TCO) as compared to ICE vehicles.

Shifting the transport sector away from reliance on fossil fuels towards use of electricity powered vehicles will help in reducing Sri Lanka oil import bill

Provision of clean, affordable and comfortable transport facility for the Sri Lanka population.

13.1.4.2 Key Challenges of EV deployment





13.2 Existing EV Landscape

13.2.1 EV Related Policies

In 2013, the government drastically reduced import duty on electric and hybrid vehicles. This was widely hailed as a step in the right direction because hybrid vehicles use less fuel and are more environment friendly. This has led to the importation of many hybrid cars, and presently over 50,000 vehicles are in use. In 2014 alone, 19,557 hybrid cars and 90 electric cars have been imported, which represents 60% of the total number of cars registered. However, in the recent tax revisions, the tax concessions for hybrid vehicles have been partially removed, in claiming to create level playing field for hybrid and normal cars, thus resulting less preference from the consumers. This action of the government goes against the global trend of promoting echo-environment for hybrid vehicles by way of tax incentives, which is a policy of the government too. In fact, both government policy documents being formulated, the National Action Plan for Haritha (Green) Lanka Program and Enhancing the Quality of Fossil Fuels for Managing Air Quality in Sri Lanka, the promotion of electric and hybrid vehicles are recommended.

13.2.2 EV Fleet Size, Models and Players

Sri Lanka currently has 4,200 EVs running on the roads with Nissan Leaf having 90% share, and also around 900 electric motorcycles in the country. Current users are faced with problems of battery replacement as in Sri Lanka 90 per cent of the EVs are Nissan Leaf and the local agents are not undertaking the battery replacements.

Recently, one of the Japanese high-tech firm[153] has announced plan to set up electric vehicle manufacturing facility in Sri Lanka. It will be the country's first ever eco-green EV three-wheeler and motor-bike production facility. The firm will also be setting up international standard EV charging systems known as 'micro-grid' stations across the country as part of their hi-tech transfer.

[153] Japanese firm to set up EV manufacturing facility, 2018

13.2.3 Charging Stations and Standards

Public Utilities Commission of Sri Lanka (PUCSL) found out that, 39 Direct Current (DC) fast chargers are functioning (while 50 were installed at the beginning of the year), and most of them are not dedicated Electric Vehicle Charging Station (EVCS) (they are annexed to some other business activity). In addition, there are many slow chargers and plug socket providers that facilitate EV charging. The total Electric Vehicle (EV) population is around 5,000 and the regular public charger users may be only a small fraction of it[154].As mentioned above that majority of EVs in Sri Lanka are Nissan leaf, therefore option of CHAdeMO for DC fast charging and J1772 for AC slow charging are assumed to be used. In March 2018, PUCSL rolled out a tender for preparation of Technical Guidelines and Minimum Standards for Electric Vehicle Charging Stations.

13.2.4 EV Pilots

The pilot project named National Appropriate Mitigation Action (NAMA) on Sustainable Transport in Sri Lanka through Electric Bus Rapid Transit Systems to promote greenhouse gas emission reductions and at the same time sustainable development. The Sri Lanka NAMA has an overarching target for promotion and adoption of clean, sustainable and efficient means of public transportation within the Colombo Metropolitan Area, resulting in a modal shift from private to public mode of transportation. The NAMA[155] is intended to help Sri Lanka achieve the following objectives for the transport sector as identified in the National Transport Policy:

- encourage the use of public transport and high occupancy vehicles resulting in a modal shift from private to public modes of transportation
- encourage the promotion and adoption of new cleaner technologies such as electric or hybrid vehicles and reduce the environmental (GHG emissions and pollution), economic (expenditure on fossil fuels) and social (health benefits) impacts of a conventionally fueled transport sector.

The Sri Lanka transport NAMA consists of a single intervention that involves the introduction and operation of 100 electric buses in the Galle BRT in place of what would have otherwise been 100 articulated, GHG emitting, diesel fueled conventional buses. The funding for the pilot will be obtained from International climate financing agencies, private sector financing and government of Sri Lanka in different phases.

For the Sri Lanka transport NAMA, viable autonomous electric battery powered bus options are proposed. The drive system for a battery-electric bus consists of an electric motor, a battery pack to provide energy storage, and a control system that governs the vehicle's operation. The battery pack is either recharged daily or "swapped out" when the batteries are depleted[156].

[154] Regulation of EV Charging Station pdf, 2017

[155] NAMA Study Sri Lanka

156 Paper presentation: hybrid electric bus. http://azhar-paperpresentation.blogspot.com/2010/04/hybrid-electric-bus.html?m=1

Motor			
Max. Rated Power: 150 kW (EBUSCO Buses)360 kW (BYD Buses)			
Battery Pack			
Lithium Ion (LiB) Batteries	Lithium Ferrous Phosphate (LiFePO4)	Energy Density: 110 -150 Wh/kg	Preferred battery of choice in electric vehicles due to their high energy/power densities and stable chemistry, which prevents them from overheating at high temperatures.
	Lithium Manganese Oxide (LiMnO2)	Energy Density: 280 Wh/kg	
Nickel Metal Hydride (NiMH)		Energy Density: 140 Wh/kg	Used in early hybrid/electric cars.
Lead Acid Batteries		Energy Density: 30 -50 Wh/kg	

Table 71 Components of Battery Powered Electric Buses in Sri Lanka

13.2.5 Tariffs for EV

The existing private Electric Vehicle Charging System (EVCS) charge different Tariffs; flat per kWh or hourly charges and some have prepaid card systems. The comments from consumers, called for common prepaid system and lower tariffs. Apart from recovering cost of service for the EVCS, few other outcomes are also desired through tariff; a) Demand Side Management, whereby most charging happen during off peak times and b) Existing system capacity is optimally used to avoid over investment in distribution capacity at the EVCS end.

The below table shows the Time of Use (ToU) tariff which is currently available to apply 3-phase, 30 A or above power supply from both LECO & CEB. According to ToU tariff, there are three separate time blocks as shown below[157]:

Time of use	Energy charge (LKR/kWh) (considering 1 LKR = 0.0057 USD)	Fixed charge (per charging point connection) (LKR/month)
Off Peak (22:30-05:30 hrs.)	13.00 (USD 0.07)	540.00 (USD 3.1)
Day (05:30-18:30 hrs.)	25.00 (USD 0.14)	
Peak (18:30-22:30 hrs.)	54.00 (USD 0.31)	

Table 72 Time of Use Tariff Structure in Sri Lanka

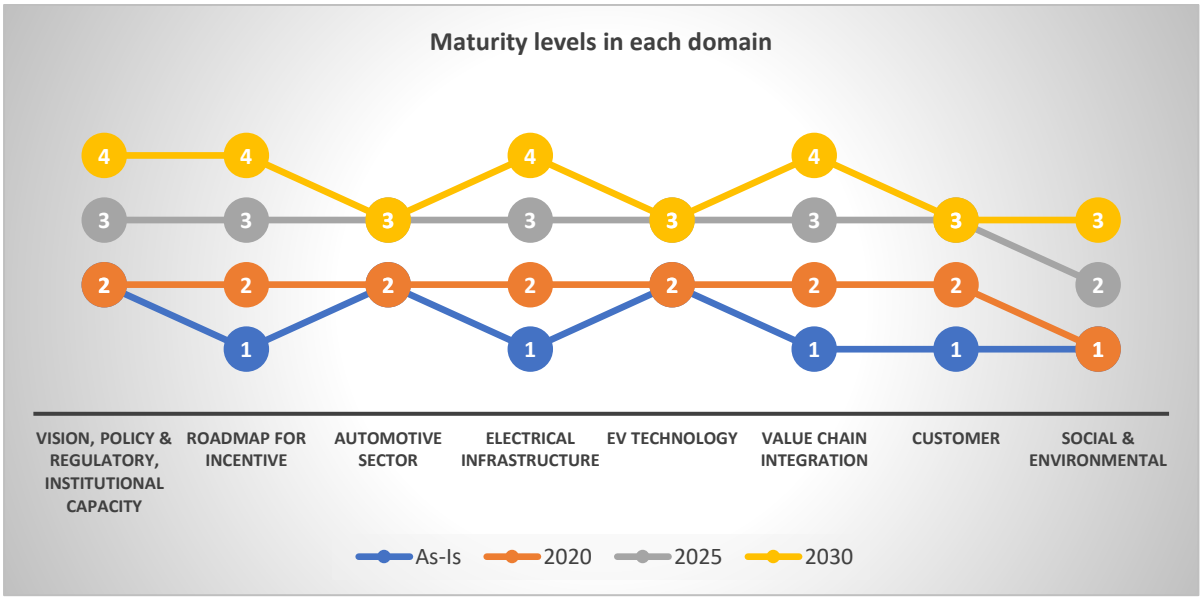
[157] EV club Sri Lanka Available at: https://www.evclub.lk/faq/

The Time of use tariff would benefit the domestic users and aims to reduce power usage during the peak time and promote power usage during the off-peak time. This is an optional tariff for single phase consumers for which the connection can be changed only upon their request to the utility.

PUCSL approved that the extension of ToU tariff to the single-phase domestic users will plan to encourage energy efficiency and will be benefited by the EV users in Sri Lanka by allowing them to charge their vehicles at a lower cost. The option of ToU tariffs given to the large volume of customers can help shift peak load demand to off-peak, thereby implement the demand side management initiatives as well.

13.3 EVMM Assessment & Recommendations for Sri Lanka

Based on the As-Is scenario (previous chapters), we have assessed[158] the existing conditions in each of the eight domains and identified the levels (as explained in Executive Summary) that they ought to attain in future years i.e. 2020, 2025 and 2030. We have also provided summary recommendations to ensure a sustainable EV adoption from one level to the next. A graphical representation showing the As-Is maturity level and the maturity level they need to attain in future is depicted below.[159]



[158] A detailed assessment requires stakeholder interviews

[159] "0" means default level which indicates that the basic minimum initiatives have been undertaken in this domain

Domain	By 2020	By 2025	By 2030
Vision, Policy & Regulatory, Institutional Capacity	***Target Maturity Level – 2*** • Already having targets on EVSE, Government (Ministry of Transport) should come up with a nation-wide mission on electric vehicle and a EV specific policy with a defined target and deadline, to send clear signal to both OEMs & consumers to invest in and adopt EV respectively • Government should target three wheelers to be changed to electric fleet in major cities like Colombo, Kandy etc as it is contributing to major share for public transport • Government to discuss with banks to provide low cost loans for electric two wheelers in the initial years to accelerate the adoption of two-wheelers • Organizational restructuring with the creation of an EV cell within Sri Lanka Transport Board and PUSCL to facilitate future deployment strategy, charging station implementation, O&M guidelines, consumer awareness etc. • Government along with Sri Lanka Transport Board to set target and facilitate introduction of electric buses majorly intra city buses in major cities	***Target Maturity Level - 3*** • Government should provide targets to Sri Lanka Transport Board to transform the entire fleet of public buses in to electric fleet and installation of charging stations in depots, terminus and highways • Conversion of entire fleet of three wheelers in to electric fleet and electrification of water transport (inland water transport) in Colombo • Government to streamline the third party charging process by providing guidelines • In major cities like Colombo, Kandy, fleet operators of private taxis should be encouraged to shift to electric vehicle through incentives like subsidised parking charges, reduced tariff for charging, reduced toll etc. • Dedicated space in parking lots, in malls residential buildings for charging station installation to be made mandatory through building codes • Mandatory for resort owners and two and four wheeler rental agencies tourist places to install charging stations • Creation of a PPP cell and Investment Facilitation Center with members from Ministry of Investment Promotion, Ministry of Transport, Ministry of Power & Energy, Sri Lanka Transport Board to evaluate project proposal on EV, battery and EVSE manufacturing and act as a single window for FDI, PPP and JV projects	***Target Maturity Level - 4*** • Government to make mandatory conversion of private taxi fleets into electric vehicle throughout the country • Grid Code and Distribution Code guidelines must be updated for Vehicle to Grid (V2G) integration • Target to convert entire water transport fleet including the fishing boats into electric fleet along with installation of charging stations • Guidelines for mandatory battery buy back by OEMs on completion of battery life or in case of any faulty battery

Roadmap for Incentive	***Target Maturity Level – 2*** • Exemption of import and custom duty on EV components and subsidised import duty on the imported electric vehicle • Reduced property tax for electric three wheeler manufacturers and electric vehicle assembly companies • Subsidized registration charges for one year for electric three and two wheelers • Subsidized parking charges for electric vehicles • Reduced property tax for hotels & resorts using electric vehicle for their guests and for personal purpose	***Target Maturity Level - 3*** • Tax free or reduced tax for profit repatriation for foreign companies • Reduced road tax for electric four wheeler commercial fleet • Land on lease, water and logistic facility at reasonable cost for manufacturing or assembling units on EV and electric boats • Duty free import of plant and machinery for setting up of assembly unit on one time basis	***Target Maturity Level - 4*** • Reduced property tax for residential complexes in few initial years which will be installing charging stations to facilitate personal vehicles • Promote battery recycling industry through tax free income in initial years or reduced interest on loans for JVs with minimum 30% stake of local companies
Automotive Sector	***Target Maturity Level - 2*** • Electric three wheelers with internationally approved design to be assembled with parts being imported from India or China or • Battery and charging stations to be imported from countries like India and China for the pilot projects • Promote local manufacturing of electric two and three wheelers through PPP or with joint ventures with foreign companies like in India, Japan etc.	***Target Maturity Level - 3*** • Servicing facility for charging stations can be provided by OEMs and local capacity development on O&M of charging stations through training and skill development • 100% local manufacturing units to be set up for electric two and three wheelers and service centres to be developed locally with skilled workforce • Assembling units for EVs and electric ferries and boats to be set up with JV with foreign companies	***Target Maturity Level - 3*** • Charger manufacturing units to be set up with JVs with foreign companies • Battery recycling industry to be developed with foreign collaborations
Electrical Infrastructure	***Target Maturity Level - 2*** • Distribution utilities to assess the supply and availability of spare capacity in distribution transformers in areas having potential for charging station implementation like bus	***Target Maturity Level - 3*** • Upgradation of electrical infrastructure in terms of meter room, laying of cables, supply meters etc. in bus depots and terminus,	***Target Maturity Level - 4*** • Grid asset modernization for facilitating two way communication for implementing vehicle to grid solution

	depots and terminus, existing malls, residential buildings etc. in major cities • Distribution utilities to consider power supply from renewable sources in island and remote areas or areas having high renewable potential for installation of charging station for electric vehicles	parking lots, malls etc. by CEB & LECO for installation of charging stations • Improvement in power quality through deployment of technologies like harmonic filters, static compensators etc. • Implementation of charging stations by supermarkets, big retailers with electrical network upgradation at own cost. • Upgradation expense can be shared by OEMs or third party service providers of charging stations	
EV Technology	***Target Maturity Level - 2*** • Technology for electric two wheelers to be upgraded in terms of design, battery capacity etc. • As Sri Lanka is currently using CHAdeMO & CCS it may use Indian standard which has recently been published for both AC and DC charging and allows both CHAdeMO and CCS charging standards	***Target Maturity Level – 3*** • PUCSL, technocrats and EV associations to contribute in enhancement of the charging standards and communication protocols being used e.g. CCS, CHAdeMO, OCPP etc. • EV two & three wheeler testing and certification centre to be developed in Sri Lanka • In house development of motor technology, power electronics equipment like switch mode power supply for charging stations along with international technology institutes etc.	***Target Maturity Level - 3*** • R&D on EV design & battery recycling to be initiated in collaboration with international research labs, technology institutes, etc.
Value Chain Integration	***Target Maturity Level – 2*** • Government building and offices to install charging stations in their premises for EV usage • CEB along with Sri Lanka Transport Management Board to invest in setting up charging infrastructure for electric buses in	***Target Maturity Level - 3*** • Battery swapping model can be used for three wheelers with the help of a Battery Leasing Agency which will charge the batteries on a large scale and facilitate the three wheelers by providing a charged battery against a specified	***Target Maturity Level - 4*** • Bundle EVSE with highway development cost and install charging stations in the highways • Dedicated fleet operators like for e-Buses and e-4Ws can invest by themselves or

	bus depots for overnight charging and in bus terminus for fast charging during the day with the cost being treated under regulated capex route and private bus companies to set up charging stations in their premises and can allow public during certain hours against a specified rate (flat rate) • Private parking owners or service providers can implement public charging stations along with CEB, LECO or service providers along with CEB, LECO and the mall owners or hospitals can install public charging stations • Travel & Tourism companies, resort owners to install public charging station near tourist spot and resorts respectively	fee. The Battery Leasing Agency may be formed by the battery or EVSE supplier • Bundle EVSE as mandatory in new buildings through Building Codes for all categories of buildings exceeding certain built area. In this case the impact of EVSE infrastructure cost is negligible in per square meter cost • Projects to be allocated to renewable energy companies must include a clause of implementing one or two public charging stations outside their plant's premises • Transport Board along with distribution utility can set up charging stations for inland water transportation in Colombo	bring third party to invest in charging stations • With transition of private cars into electric fleets will provide opportunity for the retailer or third party service providers to provide door to door servicing on charging of electric vehicle in Colombo and other major cities with a premium charged on the regular tariff
Customer	***Target Maturity Level - 2*** • Government vision target for electric vehicle is communicated to customers • All the incentives and benefits for adopting or cruising an electric vehicle to be communicated properly to customers • Carry out research on the customer pattern of vehicle usage mainly two wheelers and identify probable charging pattern to figure out the load curve for a particular day • Time of use pricing and its benefits to the customers must be displayed to make them aware of their benefits	***Target Maturity Level – 3*** • Advance booking of parking slots through e-booking based on time and amount of charge required by the individual	***Target Maturity Level - 4*** • Customers are engaged in prosumer programs through V2G integration on pilot basis • Advanced services for customers like door to door service for car charging where the retailer or service provider picks up the car for charging and drop it to the customer after the required amount of charging has been done
Social & Environmental	***Target Maturity Level - 1*** • Organizing EV awareness programs, conduct workshops and seminars to make people aware of the benefits of EV adoption in	***Target Maturity Level - 2*** • EV deployment mainly the buses, and commercial taxi fleets can also provide opportunity to the existing workforce by	***Target Maturity Level - 3*** • The deployment goals by the government will also help to bring electricity in the remote areas which can help in improving

	terms of improved air quality, health benefits.	providing them adequate training on O&M skills • Electric two wheelers and three wheelers manufacturing and assembling plants will help in job creation and people of rural areas can opt for a sustainable living in all aspects • Tourism will flourish by projecting areas as carbon neutral with EV being the only transport mechanism in those areas	the living standard of the people in those areas • Usage of electric boats for inland transport and fishing will negate the chances of oil spills from boats and facilitate in reducing water pollution

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