TECHINCAL DUE DILIGENCE

A. Project Background

1. The Asian Development Bank (ADB) will provide a loan[1] to Energy Efficiency Services Limited (EESL), to be guaranteed by the Government of India. The proposed project, ***Scaling Up Demand-Side Energy Efficiency Sector Project*** will support scaling up investments in a growing energy efficiency market in India. EESL is a joint venture of NTPC Limited, Power Finance Corporation, Rural Electrification Corporation and Power Grid Corporation of India Limited, and was set up under Ministry of Power (India) to facilitate implementation of energy efficiency projects. ADB's loan will support expansion of EESL's business lines to include: (i) on-grid solar energy at existing distribution substations to reduce losses in agricultural feeders; (ii) smart meters and other intelligent energy management system elements; and (iii) electric vehicle and charging systems. This report provides an assessment of these three initiatives of the Government of India and EESL and some technical features of the proposed subprojects based on the detailed project reports and other documents available to be supported under the Project.

B. Distributed Solar PV at Distribution Sub-Stations

1. Introduction

2. For the implementation of the distributed solar PV at distribution substations, EESL entered into a Memorandum of Understanding (MOU) initially with Maharashtra State Electricity Development Company Ltd (MSEDCL) for establishing Solar Photo Voltaic (PV) Power Generating Systems projects within the proximity of their sub-stations ranging from 1-2 megawatt (MW) (or higher in rare cases). The power generated from these projects will be sold to MSEDCL at agreed prices for a period of 25 years. Project feasibility studies have been conducted by Price Waterhouse Coopers (PWC) which covered technical, commercial and financial analysis. A review of the feasibility study reports were undertaken and the key findings are summarized in this section.

2. Technical Assessment

3. The feasibility studies were conducted on the two of the multiple projects in Maharashtra: 1 MW solar photovoltaic (PV) in Nandgaon and 2 MW solar PV in Badnera. The locations identified considered energy generation through fixed tilt angle and double-axis tracking options and concluded that in order to reduce operation and maintenance activities and auxiliary energy consumption, the fixed axis (without tracking and any seasonal adjustment) was preferred. Although, energy generation is somewhat higher in the tracking design approach, the fixed axis and fixed tilt angle design under the circumstances is acceptable. The optimum tilt angle has been determined PVsyst computer software.

4. **Site Assessment**: The local climate data used in the study are generic. The climate data should be more specific to the site, and historical data could be obtained from the associated organizations rather than relying on standard values or passing this responsibility to the engineering purpose vehicle (EPC) contractor. It is suggested that the following meteorological, land characteristics and infrastructure information is also provided:

[1] ADB received formal request from the Department of Economic Affairs, Ministry of Finance on 24 May 2018 for this project.

a. Wind Speed: historical data on maximum and average windspeed and how often the typhoon or tornado attacking the selected location in the past. This information is very important for the design of mounting structures.

b. Rainfall Data: historical data on maximum and average rainfall in the selected location. This is important for the design of the site drainage systems.

c. Flood Data: If the selected location experienced flooding in the past, its data such as flood level and frequency shall be shown. This is very important to design the height of the mounting structure. This could also lead to the needs of having dikes around the site or even pumping stations.

d. Land Characteristics: Site topography

e. Infrastructure: Relevant schematic diagrams, single line diagram, grid layout should be included; Water availability - details of nearest water pipe, reservoir, water quality of each source; Access to site/ Proximity to road/ Power quality: more specific data relating to the selected location. Site accessibility and road have implications on costs of logistics during the construction phase.

5. **Plant Composition**: Multi-crystalline thin solar PV modules with nominal maximum power of 320Wp and overall dimensions of 1960 mm x 990 mm has been proposed. The analysis is based on Model WSM-320 PV Module manufactured by Waaree Energies Pvt. Ltd., which is one of the largest solar panel manufacturers in India. However, project developers are free to choose the manufacturer based on their own techno-commercial considerations. The Inverter model considered in the analysis is Sunny Central 1000MV-11 manufactured by SMA, which is the world's largest producer of solar inverters.

a. The **1 MW** Solar PV Plant consists of 3,914 modules (19 in series and 206 in parallel) with one Inverter.

b. The **2 MW** Solar PV Plant consists of 7,820 modules (20 in series and 391 in parallel) with two Inverters.

6. **Energy Yield Assessment:** In determining the energy yield estimation detailed hour by hour analysis has been conducted using PV system software. This included the assessment of the intensity of solar radiation over fixed axis inclined surface towards the south; and the optimization of the tilt and orientation along with inter row spacing. The key inputs to the assessment included solar and meteorology data, orientation and tilt angle of solar PV modules, major components (PV modules and Inverter), technical losses in solar photo voltaic system, capacity utilization factor (CUF), annual degradation, uncertainty analysis and probability of exceedance (PoE). The electricity generation and the CUF for two different DC/AC ratios are summarized in the Tables below. P50-P90 represent different yield levels, for which the probability that the production of a particular year is over this value is 50%.

Table 8.1: Yield Assessment – 1 MW PV Plant (Nandgaon) – DC/AC Ratio 1.25

#	Variability	Annual Generation (MWh)	CUF (%)
1	P50	1,874	21.41
2	P75	1,804	20.60
3	P90	1,740	19.87
4	P95	1,703	19.44

Table 8.2: Yield Assessment – 1 MW PV Plant (Nandgaon) – DC/AC Ratio 1.00

#	Variability	Annual Generation (MWh)	CUF (%)
1	P50	1,517	17.10
2	P75	1,456	16.64
3	P90	1,392	15.91
4	P95	1,354	15.48

Table 8.3: Yield Assessment – 2 MW PV Plant (Badnera) – DC/AC Ratio 1.25

#	Variability	Annual Generation (MWh)	CUF (%)
1	P50	3,759	21.45
2	P75	3,617	20.64
3	P90	3,489	19.91
4	P95	3,413	19.48

Table 8.4: Yield Assessment – 2 MW PV Plant (Badnera)– DC/AC Ratio 1.00

#	Variability	Annual Generation (MWh)	CUF (%)
1	P50	2,996	17.10
2	P75	2,916	16.64
3	P90	2,788	15.91
4	P95	2,712	15.48

7. **Capital Cost Estimation:** The estimation of project costs has been sourced from recent EPC bids and equipment suppliers. It is noted that the estimated project cost for the 2 MW project has been extrapolated from the 1 MW project. It is recommended that the itemized project costs of the 2 MW project be reviewed as some non-material cost items may not be in proportion with the size of the project.

8. **Financial Analysis:** The analysis has been based on an annual PV tariff escalation of 5% and Operation & Maintenance (O&M) cost escalation of 4%. This means the rate of the revenue increase assumed is faster than the rate of the operating cost increase. The O&M expenses for technologies approved by MNRE recommends an escalation rate of 5.72% per annum. It is recommended that uniform rates are used in the analysis. Sensitivity analysis on PV tariff rates could consider two additional scenarios, namely, no increase and increase of less than 5% (say 3%); and also include the impact of CUF.

3. Estimated Energy Savings and Emission Mitigation

9. The annual electricity generation is considered in determining the greenhouse gas (GHG) emission reduction based on an emission factor of 0.82 tCO_2/MWh/year for India[2].

Table 9.1: Emission Mitigation – 1 MW PV Plant

#	Variability	Annual Generation (MWh)	Emission Reduction (tCO_2/year)
DC/AC Ratio 1.25			
1	P50	1,874	1,537
2	P75	1,804	1,479

[2] Central Electricity Authority of India, Government of India (June, 2018), CO_2 Baseline Database for the Indian Power Sector.

#	Variability	Annual Generation (MWh)	Emission Reduction (tCO_2/year)
3	P90	1,740	1,427
4	P95	1,703	1,396
DC/AC Ratio 1.00			
1	P50	1,517	1,244
2	P75	1,456	1,194
3	P90	1,392	1,141
4	P95	1,354	1,110

Table 9.2: Emission Mitigation – 2 MW PV Plant

#	Variability	Annual Generation (MWh)	Emission Reduction (tCO_2/year)
DC/AC Ratio 1.25			
1	P50	3,759	3,082
2	P75	3,617	2,966
3	P90	3,489	2,861
4	P95	3,413	2,799
DC/AC Ratio 1.00			
1	P50	2,996	2,457
2	P75	2,916	2,391
3	P90	2,788	2,286
4	P95	2,712	2,224

4. Conclusions

C. The projects adopt proven Solar PV technology with most appropriate balance of systems required for optimized performance suitable for the proposed sites. The annual generation figures have been determined based on realistic assumptions. There is scope for further refining the feasibility study reports using site specific data.**Smart Meters and other Intelligent Energy Management elements ("Smart Grid")**

1. Introduction

11. Smart Meter National Programme (SMNP) was launched as a part of National Mission on Enhanced Energy Efficiency. EESL, through this effort, aims to help utilities reduce billing inefficiencies by replacing 250 million conventional meters with Smart Meters under SMNP. Smart Meter roll-out is an 8-year program, proposed under the Build-Own-Operate-Transfer (BOOT) model on a cost-plus approach. This means all Capex/ Opex shall be undertaken by EESL and the States/ Utilities are not required to invest upfront for up to 8 years. EESL on its investment shall earn a nominal IRR through a mutually agreed automated payback structure during the concession period along with payment security mechanism from State Governments/ DISCOMs. The meters will be procured in bulk by EESL and will be leased out to DISCOMs at rentals that are equal to or less than the enhanced revenues that will be generated from increased billing efficiency and avoided meter reading costs.

12. Under the ADB proposed loan, EESL targets to procure and install 5 million Smart Meters in the selected States by 2024. The implementation plan devised by EESL is as follows

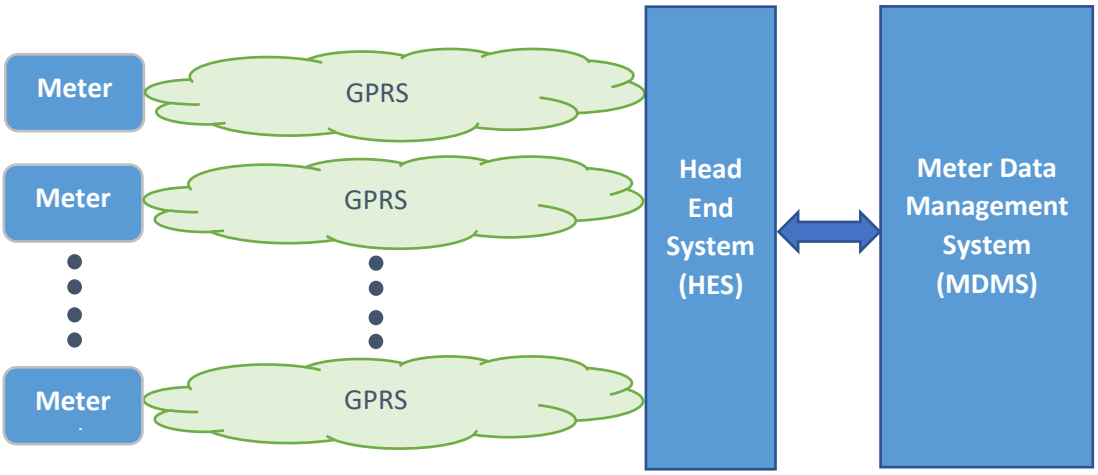
- EESL initiated MOUs with distribution companies (Q3 2018 onwards);
- EESL prepared detailed project reports, and conducted pilot tests to demonstrate technology and savings (Q3 2018 onwards);
- EESL is in the process of finalizing contractual agreements with DISCOMs and ensuring a secure payment mechanism (Q3 2018 onwards);
- EESL plans to procure equipment and implement the subproject (Q3 2019 onwards);
- EESL will undertake monitoring and verification activities (Q3 2019 onwards).

2. Technology Adopted

13. EESL has identified Advanced Metering Infrastructure (AMI) - a collective term for an integrated infrastructure of Smart Meters, two way-communication networks, Control Centre equipment; and the applications that enable near real-time gathering and transfer of energy usage information. It includes:

1. Smart Meters with general packet radio service (GPRS) Module Communication networks (Cellular) Services;
2. Head End System (HES), Meter Data Management System (MDMS) and other related software;
3. Cloud Hosting Services for HES and MDMS;
4. Integration of MDMS with Legacy system of Utilities for Billing and data Analytics.

14. Smart meters installed at consumers premises would communicate with the Head End System (HES) using GPRS communications module. The communications module is of pluggable-type and capable of servicing GPRS technology. Meter Data Management System (MDMS) collects data from the HES and validates and processes it; and integrate with other IT applications such as Billing, Customer Care, and Outage Management System etc. There is on-going work to integrate AMI with online payment systems and digital wallets, such as Paytm, Payzone, E-mitra, so that consumers can re-charge through the internet using web portals or apps. The IT infrastructure will manage remote meter operations such as scheduled & on demand reading, connection/disconnection, and firmware upgrade etc. The high-level solution architecture of Smart Metering is depicted in figure below.[3]



[3] Business Proposal For "Advanced Metering Infrastructure (Smart Metering Solutions)" Implementation across Identified towns in UPPCL.

15. There are several domestic and international companies having active presence in the field of smart metering and smart grids in India (refer to Table 1). Some IT companies such as Infosys, Accenture and Kalkitech, specialize in AMI services consultancy and technology. EESL will be undertaking the bulk procurement of AMI systems through international competitive bidding. Implementation has already commenced in Varanasi.[4]

Table 1: List of Smart Meter and Smart Grid Companies in India.

Company	Head Office	India office	Service offered
Capgemini	French Multinational	Gurugram, Haryana	IT company providing global service line that will provide full spectrum of smart metering, smart grid, smart home solutions, and smart analytics to utilities across the globe.
HCL Info systems	India	Multiple locations	IT company in India providing hardware, software, and system integration services. HCL has partnered with Echelon (Smart Grid product development company) for providing services.
General Electric	USA	Multiple locations	GE is one of the major players in Smart Grid domain. Through its eco-imagination GE is focusing its research efforts towards clean energy including Smart Grid. In India, GE has collaborated with NDPL for improving energy and transmission efficiency.
Powergrid	India	Multiple locations	One of the largest transmission utilities in the world with 72,000 circuit km transmission lines in India; and also has presence in telecommunication sector with more than 19,000 km telecommunication network. The company is now focusing on Smart Grids and likely to be one of the major players in India.
Telvent	Spain	Multiple Locations	IT and industrial automation company specializing in SCADA, GIS and related IT systems for pipeline, energy utility, traffic, agriculture and environmental monitoring industries.
ABB	Switzerland	Multiple locations	Leading power and automation technology company in the world. Has strong Smart Grid focus and has been actively collaborating with utilities from US, UK, Europe, China, and India.
CISCO	USA	New Delhi, Gurugram	Largest supplier of communications products in the world. It has strong presence in India. Through its Smart Grid ecosystem it plans to develop smart grid technologies and standards.
IBM	USA	Multiple locations	IBM is one of the top 10 Smart Grid companies leading the charge for advancement of this technology.
Echelon	USA	Noida	Echelon's NES System – the backbone for the smart grid – is used by utilities to replace existing stand-alone

[4] https://www.thehindubusinessline.com/news/eesl-to-instal-smart-meters-across-75000-delhi-households/article23527240.ece

Company	Head Office	India office	Service offered
			electricity meters with a network infrastructure that is open, inexpensive, reliable, and proven.
Infosys	Bengaluru, India	Multiple locations	Indian multinational corporation that provides business consulting, information technology and outsourcing services. Infosys, along with C-STEP co-developed report "Technology: Enabling Transformation of Power Distribution" for Ministry of Power, India and is associated with India's Smart Grid Development Program.
Accenture	Ireland	Multiple locations	The company offers products and consulting and technology services in AMI, Intelligent Network Data Management, Home Area Network, Distributed Energy Integration, Demand Response, and network application and architecture for technologies like plug-in Electric Vehicles.
eMeter	USA	Noida, India	Meter Data Management System (MDMS) provider company that has been serving the utility industry since 1999. It is expanding in emerging markets like India, Taiwan, and China.
Ecolibrium	Ahmedabad, India	Ahmedabad, India	India's first Smart Grid startup company focusing on Demand - Response segment. Incubated by Center for Innovation, Incubation, and Entrepreneurship (CIIE) at Indian Institute of Management, Ahmadabad (IIMA).
Siemens	Germany	Multiple Locations	Provides integrated energy solutions to the entire energy value chain starting from generation and transmission to distribution. Siemens has partnered with emerging startups e-Meter, BPL Global, and Viridity for its Smart Grid offerings and is engaged in various Smart Grid pilots across the world.
Tridium	USA	Multiple Locations	Global leader in open platforms, application software frameworks, automation infrastructure technology, energy management and device-to-enterprise integration solutions.
Schneider Electric	France	Multiple Locations	Leading organization in power generation, transmission and distribution. Acquired the distribution branch of AREVA T&D, another French transmission and distribution Company, along with ALSTOM, has given Schneider a good hold in the global distribution market and enhanced its Smart Grid Vision. It provides solutions for power and energy management.
Mahindra Satyam	Hyderabad, India	Hyderabad, India	Indian IT services company; recently launched Smart Grid Customer Demo Center in collaboration with Schneider Electric to simulate various smart grid technologies.
Landys+Gyr	Switzerland	Noida	Leading provider for total metering solutions in the world with operating presences in more than 30 countries. Recently Toshiba acquired Landys+Gyr for

Company	Head Office	India office	Service offered
			$2.3 billion making it one of the largest acquisition in Smart Grid domain.
POSOCO	India	Gurugram	Power Management wing of Power Grid Corporation of India Ltd. The company is also implementing various projects on Synchrophasors/WAMS in India. Synchrophasors/WAMS is the most essential part of Smart Grid in EHV grid. One pilot project is already operational at National Load Dispatch Center, New Delhi.
Kalkitech	USA	Multiple locations	Smart Grid Communication and Optimization Solutions for Generation, Transmission and Distribution. We provide AMR AMI Metering, Distribution Automation.
Cyan	London, UK	Gurugram	Cyan Is a smart energy solution provider and has been present in the Indian market; and has been successful in getting orders worth $1m along with a number of pilots with specific utilities around the country including the PGCIL pilot project in Puducherry. Recent project was a pilot for a North-Indian utility with one of its meter manufacturing partners.

3. Estimated Energy Savings and Emission Mitigation

16. As per the tender issued for UPPCL by EESL, the billing efficiency is expected to increase from 75% to 88% and the collection efficiency is expected to increase to 92-95%. Based on UP experience, the aggregate technical and commercial (AT&C) losses significantly decreased to 19%. Table 2 summarizes energy saving and revenue generation calculations by EESL.

Table 2. Summary of Energy Saving and Revenue Generation

Cash inflows (with Smart Metering)	**Unit**	**Value**	**YEARS**														
			1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Billing efficiency	%	75	79%	83%	87%	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%
Collection efficiency	%	92	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%
AT&C losses	%	31	28%	24%	20%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%	19%
Revenue to Discom with Smart Metering solution																	
Energy Input	MU	2251 0.60	2284 8.26	2319 0.99	2388 6.72	2460 3.32	2534 1.42	2610 1.66	2688 4.71	2769 1.25	2852 1.99	2937 7.65	3025 8.98	3116 6.75	3210 1.75	3306 4.80	3405 6.75
Energy billed	MU	1692 3.52	1805 0.13	1924 8.52	2078 1.44	2165 0.92	2230 0.45	2296 9.46	2365 8.54	2436 8.30	2509 9.35	2585 2.33	2662 7.90	2742 6.74	2824 9.54	2909 7.03	2996 9.94
Billed amount	INRCr.	1129 8.14	1205 0.26	1285 0.30	1387 3.68	1445 4.15	1488 7.77	1533 4.40	1579 4.44	1626 8.27	1675 6.32	1725 9.01	1777 6.78	1831 0.08	1885 9.38	1942 5.16	2000 7.92
Revenue collected	IN	**1034**	**1103**	**1176**	**1270**	**1323**	**1362**	**1403**	**1445**	**1489**	**1533**	**1579**	**1627**	**1676**	**1726**	**1778**	**1831**

Cash inflows (with Smart Metering)	Unit	Value	YEARS														
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	RCr.	3.02	1.56	3.97	0.84	2.23	9.20	8.07	9.22	2.99	9.78	9.98	3.98	2.20	5.06	3.01	6.50
Cash inflows	INRCr.		11031.56	11763.97	12700.84	13232.23	13629.20	14038.07	14459.22	14892.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00

16. In terms of GHG emission reduction, a study conducted in Brazil (a country with similar geographical conditions to major parts of India) by Electric Energy Research Center (Brazil), concluded that the load reductions obtained through better demand –side management lead to a lower system loading and peak load shifting for low-voltage residential consumers, improving power system efficiency, hence production of power at source. Some of these DSM activities included voluntary reduction by consumers and manually recorded Units billed[5], varying time rates and demand response and non-technical losses (such as theft). Furthermore, according to government of India studies conducted on AT&C losses in various states, it is seen that nearly 30-35% T&D losses are due to manually billed Units which in turn significantly affect actual GHG emissions attributed to end-use electricity consumption. With the installations of smart meters a more accurate reflection on electricity usage and corresponding GHG emissions can be recorded.

4. Conclusions

17. The project is considered to be well designed and with a project duration of 8 years prior to transfer to DISCOMs. While the SMNP focusses mostly on combating billing inefficiency and AT&C losses through better data management, however, it also needs to consider grid efficiency and net metering aspects in long run to integrate the efforts and plans with Solar Rooftop Programme in India as well as the National Smart Grid Mission of Government of India. Additionally, the project could look into capacity building of DISCOMs for operation and management of the system after 8 years/project duration. Data and device security can be further looked at. As the project is still new in India, site specific challenges may help in further defining the project.

D. E-Mobility with Electric Vehicles and Charging Stations

1. Introduction

18. The Minister of State for Power and New and Renewable Energy, GoI launched the National Electric Mobility Program on 7th March 2018. Under this program, EESL aims to set the momentum for Indian origin equipment manufacturers (vehicles), charging infrastructure providers, fleet aggregators/operators and service providers etc. With the loan from ADB, towards achieving this aim, EESL intends to procure 2,000 Electric Vehicle (EV) chargers and 10,000 more E-vehicles to kick start the eco-system of E-Vehicles by aggregating demand across Public Sector. Initially, it will procure and deploy EVs in government offices and PSUs across the country.

[5] http://www.forumofregulators.gov.in/completed.aspx

2. Policy Initiatives in the context of EVs and Program Scope

19. ***National Electric Mobility Mission Plan – 2020:*** The plan envisages the following:

- A total investment of $ 4 – 4.5 billion which includes investments in R&D and electric vehicle infrastructure by the private sector. Proposed Investment by the government is $ 2.7 – 3 billion.
- The cumulative sale of electric vehicles is expected to reach 15-16 Million by 2020. It is expected to save 9500 Million Liters of crude oil equivalent to INR 62000 Cr. savings.
- Government investment will include roll out of demand incentives. Joint government-industry investment will include investment in R&D, power infrastructure and fuel procurement for power generation.
- 6-7 million units of new vehicle sales of the full range of electric vehicles, along with resultant liquid fuel savings of 2.2 – 2.5 million tons can be achieved.
- Savings from the decrease in liquid fossil fuel consumption as a result of shift to electric mobility alone will far exceed the support provided thereby making this a highly economically viable proposition.

20. **Faster Adoption and Manufacturing of Electric Vehicles in India *(FAME – India):*** As part of the National Electric Mobility Mission, Department of Heavy Industries (DHI) formulated a scheme namely FAME – India. The overall scheme was proposed to be implemented over a period of 6 years, till 2020, wherein it is intended to support the hybrid/electric vehicles market development and its manufacturing eco-system to achieve self-sustenance at the end of the stipulated period. The Phase-1 of the scheme was planned to be implemented over a 2-year period i.e. FY 2015-2016 and FY 2016-2017 commencing from April 1st, 2015. Now, Phase-1 has been extended till March 2018 or till the time when Phase-2 will be announced. The scheme is planned to focus on 4 areas, namely, technology development, demand creation, pilot projects and charging infrastructure. Table 1 provides a summary of the allocated budget under Phase-1.

21. In 2019, Government of India has also announced a significant reduction in Good and Services Tax (GST) on EVs (including charging stations) from 12% to 5% to further foster rapid growth and adoption in India. Furthermore, for consumers purchasing EVs, there will be additional INR 150,000 reduction on individual income tax.[6]

Table 3: Component-wise budget under FAME Phase-1

#	Component of the scheme	2015-2016 [INR cr.]	2016-2017 [INR cr.]
1	Technology platform	70	120
2	Demand incentives	155	340
3	Charging infrastructure	10	20
4	Pilot projects	20	50
5	IEC/Operations	05	05
Total		**260**	**535**
Grand Total (INR Cr)		**795**	

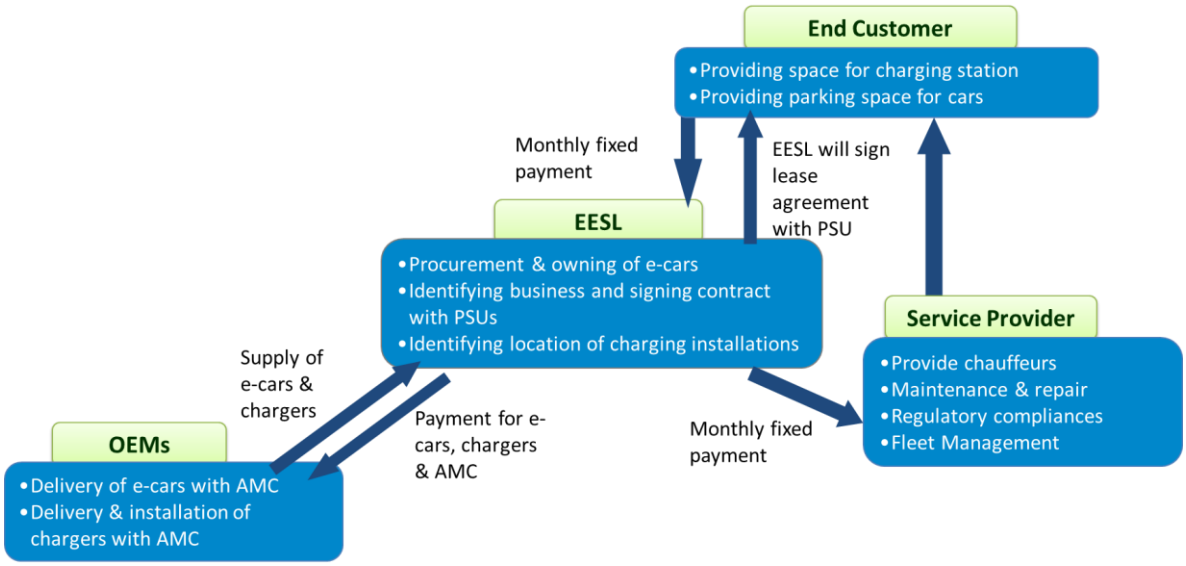
[6] https://www.indiabudget.gov.in/doc/Budget_Speech.pdf [para 112]

21. EESL is currently working with various state governments for implementation of the program and intend to procure about 10,000 EVs under the project and has signed MoU and agreements for more than 11,500 vehicles. These include:

- ***Andhra Pradesh:*** EESL has signed a MoU with Government of Andhra Pradesh (through New & Renewable Energy Development Corporation of Andhra Pradesh Ltd) for 10,000 e-cars on February 24, 2018.
- ***Maharashtra:*** EESL has signed a MoU with Government of Maharashtra (through PWD) for 1,000 e-cars on May 31, 2018
- ***Madhya Pradesh:*** EESL has entered an agreement with MPUVNL to supply 7 e-cars on outright sale basis.
- ***Delhi NCR:*** EESL is in negotiations with various clients in Delhi NCR for supply of more than 500 vehicles.
- ***Other States:*** Negotiations are ongoing with various states regarding signing of MoUs/Agreements including Gujarat (8000 e-cars), Jharkhand and Uttarakhand.

3. Technology Adopted

22. There is no clear policy on EV technology in India at the moment. However, several agencies and the key Ministries are trying to introduce different technologies and then develop a technology roadmap. EESL has issued tenders for a significant number of EVs and this would push the market. The business models could be adopted for the launch of EVs in India are discussed below.



23. ***Business Model 1: Wet Lease*** **-** The key stakeholders of this business model are EESL, Service Provider, End customer and E-Car and electric vehicle supply equipment (EVSE) Original Equipment Manufacturer (OEM). EESL will provide the investment for procurement of E-cars and EVSE. The OEM manufacturing the E-car will deliver the vehicles to EESL with a comprehensive extended on-site warranty and annual maintenance cost (AMC). The EVSE will also have an AMC with the OEM for 5 years. EESL will aggregate demand for E-car leasing and engage a service provider for end-to-end fleet management services to the end customer. EESL will sign a wet-lease agreement with the end customer for a period of 6 years. The end customer will provide parking space for the E-cars, area for setting up charging infrastructure and pay electricity charges required for charging electric

vehicle. EESL will then install the EVSE at client's location. The end customer will pay EESL a fixed monthly amount (assuming a contractual mileage of 80km per day per e-car). If the vehicle is used for more than 80km, the end customer will pay EESL a variable charge which would be a per km rate over and above the fixed amount. EESL would pay 90% of the total cost (for E-car and AMC) upfront. The remaining amount would be paid on a yearly basis for 5 years. Similarly, for EVSE, EESL will pay the OEM 75% of the total cost (Cost of EVSE+AMC) as upfront cost and the remaining would be paid on a yearly basis for 5 years. During operation, EESL will be the interface (single-point contact) for the end customer. Currently, the cost incurred by end customers for vehicle leasing is INR 50,000 per month. EESL aims to provide a similar service at INR 40,000 per month with a yearly escalation of 10%. Table 2 provides a summary of the financial model for wet lease.

Table 4: Financial Model for Wet Lease

Monthly Payments	**Year**	**1**	**2**	**3**	**4**	**5**	**6**
Payment for Debt per month	INR Thousand	15.2	15.2	15.2	15.2	15.2	15.2
Payment for Equity per Month	INR Thousand	5.1	5.1	5.1	5.1	5.1	5.1
Payment for Service provider/Driver	INR Thousand	21.8	22.8	23.9	25.0	24.8	26.0
AMC Payment to OEM	INR Thousand	2.0	2.0	2.0	2.0	2.0	0.0
Maintenance Cost after Letter of Award (LoA) period	INR Thousand	0.0	0.0	0.0	0.0	0.0	1.5
Project Establishment and Administrative charges	INR Thousand	2.0	2.0	2.0	2.0	2.0	2.0
Insurance Charges	INR Thousand	1.0	0.9	0.9	0.8	0.8	0.7
Charger Cost	INR Thousand	0.7	0.7	0.7	0.7	0.7	0.7
Total cost per month to EESL	**INR Thousand**	**47.87**	**48.74**	**49.77**	**50.85**	**50.53**	**51.25**
Rate Charged to end customer	INR Thousand	40.0	44.0	48.4	53.2	58.6	64.4
Profit/Loss	INR Thousand	-7.8	-4.7	-1.4	2.4	8.0	13.2
Overall Profit/Loss per month	INR Thousand	3.2					

24. ***Business Model 2: Dry Lease with chargers and basic services -*** The key stakeholders of this business model are EESL, end customer and E-Car and EVSE OEM. EESL will provide the investment for procurement of e-cars and EVSE. The OEM manufacturing the E-car will deliver the vehicles to EES and provide comprehensive extended on-site warranty and AMC. The EVSE will also have an AMC with the OEM for 5 years. EESL will aggregate demand for E-car leasing and sign a dry-lease agreement with the end customer for a period of 6 years. The end customer will provide parking space for the e-cars, area for setting up charging infrastructure and pay electricity charges required for charging electric vehicle. EESL will then install the EVSE at client's location. The end customer will pay EESL a fixed monthly amount. EESL's payment terms with the E-Car and EVSE OEM will be the same as wet lease for all business models. During operation, EESL will be the interface

(single-point contact) for the end customer. EESL will charge the end customer INR 22,500 per month with a yearly escalation of 10%. Table 3 provides a summary of the dry lease model (with chargers and basic services).

Table 5: Financial Model for Dry Lease with chargers and basic services

Monthly Payments	**Year**	**1**	**2**	**3**	**4**	**5**	**6**
Payment for Debt per month	INR Thousand	15.2	15.2	15.2	15.2	15.2	15.2
Payment for Equity per Month	INR Thousand	5.1	5.1	5.1	5.1	5.1	5.1
AMC Payment to OEM	INR Thousand	2.0	2.0	2.0	2.0	2.0	0.0
Maintenance Cost after LoA period	INR Thousand	0.0	0.0	0.0	0.0	0.0	1.5
Project Establishment and Administrative charges	INR Thousand	2.0	2.0	2.0	2.0	2.0	2.0
Insurance Charges	INR Thousand	1.0	0.9	0.9	0.8	0.8	0.7
Charger Cost	INR Thousand	0.7	0.7	0.7	0.7	0.7	0.7
Total cost per month to EESL	**INR Thousand**	**28.07**	**28.06**	**28.05**	**28.04**	**26.58**	**26.10**
Rate Charged to end customer	INR Thousand	22.5	24.8	27.2	29.9	32.9	36.2
Profit/Loss	INR Thousand	-5.6	-3.3	-0.8	1.9	6.4	10.1
Overall Profit/Loss per month	INR Thousand	3.4					

25. ***Business Model 3: Dry Lease with only E-Car -*** The key stakeholders of this business model are EESL, end customer and E-Car OEM. EESL will provide the investment for procurement of e-cars only. The OEM manufacturing the E-car will deliver the vehicles to EESL and provide comprehensive extended on-site warranty and AMC. EESL will aggregate demand for E-car leasing and sign a dry-lease agreement with the end customer for a period of 6 years. The end customer will provide parking space for the e-cars. EVSE and charging infrastructure is the end customer's responsibility in this model. The end customer will pay EESL a fixed monthly amount. EESL's payment terms with the E-Car OEM will be the same as wet lease for all business models. During operation, EESL will be the interface (single-point contact) for the end customer. EESL will charge the end customer INR 20,000 for the duration of the contract. Table 4 provides a summary of this business model.

Table 6: Financial Model for Dry Lease with only e-car

Monthly Payments	**Year**	**1**	**2**	**3**	**4**	**5**	**6**
Payment for Debt per month	INR Thousand	11.8	11.8	11.8	11.8	11.8	11.8
Payment for Equity per Month	INR Thousand	3.9	3.9	3.9	3.9	3.9	3.9
AMC Payment to OEM	INR Thousand	2.0	2.0	2.0	2.0	2.0	0.0

Monthly Payments	Year	1	2	3	4	5	6
Maintenance Cost after LoA period	INR Thousand	0.0	0.0	0.0	0.0	0.0	1.5
Project Establishment and Administrative charges	INR Thousand	1.1	1.1	1.1	1.1	1.1	1.1
Insurance Charges	INR Thousand	1.0	0.9	0.9	0.8	0.8	0.7
Charger Cost	INR Thousand	0.0	0.0	0.0	0.0	0.0	0.0
Total cost per month to EESL	**INR Thousand**	**20.02**	**19.98**	**19.95**	**19.92**	**19.90**	**19.36**
Rate Charged to PSU	INR Thousand	20.0	20.0	20.0	20.0	20.0	20.0
Profit/Loss	INR Thousand	0.0	0.0	0.0	0.1	0.1	0.6
Overall Profit/Loss per month	INR Thousand	0.6					

26. ***Outright Sale -*** The key stakeholders of this business model are EESL, end customer and E-Car OEM. EESL will carry out competitive bidding for the E-cars and procure the E-cars on behalf of end customers at the competitively determined price. The end customers will indicate the quantity of E-cars to be procured by EESL for which they will provide investment. The ownership of the E-cars will be transferred to the end customers. The OEM manufacturing the E-car will deliver the vehicles to EESL, after which the end customer will take possession of the E-cars following payment to EESL (competitively determined vehicle cost plus EESL's administrative charges). The OEM will provide comprehensive extended on-site warranty and AMC for 5 years. All the responsibilities including financial (AMC charges to OEM), regulatory (insurance etc.) and others related to the E-cars would lie with the end customer. Table 5 provides a summary of the cost for this model

Table 7: Calculations for outright purchase

Price Breakup for EV - Base Variant					
S. N.	**Particulars**	**GST Rate**	**Unit Price**	**GST Amount**	**Total**
a	Base Price	12%	10,16,333	1,21,960	11,38,293
b	AMC	18%	25,000	4,500	29,500
c	INLAND TRANSPORT	12%	10,453	1,254	11,707
a + b + c	Total		10,51,786	1,27,714	11,79,500
d	EESL PMC Charges @ 5%	18%	52,589	9,466	62,055
a + b + c + d	**Grand Total (INR)**				**12,41,556**

4. Estimated Energy Savings and Emission Mitigation

27. With 20,000 electric cars, India is expected to save over 5 crore liters (50 million liters) of fuel every year leading to a reduction of over 0.56 million tons of annual CO_2 emission. The per kilometer cost for an electric car is just INR 0.85 versus INR 6.5 for normal petrol/diesel vehicles. Following are the benefits of implementation of this project:

- Minimized environmental impact due to development and deployment of electric vehicles in place of fossil fuel powered vehicles;
- Reduced city-level greenhouse gas emissions;
- Reduced dependence of the state on imported energy sources;
- Improved competence of the EV industry;
- Enhanced employment generation in the state;
- Increased awareness among masses on advantages of electric vehicles;
- Improvement of the system stability, reliability and transparency.

28. ***CO_2 Emission Analysis:*** Table 6 below provides a comparison of net CO2 emissions between Diesel and Petrol Vehicles based on 15 km per litre and average emission as 2,680 gCO_2 per litre[7] for diesel and 2,310 gCO_2 per litre[8] for petrol.

Table 8. Comparison of Net Emissions from Diesel and Petrol Vehicles

	Unit	Diesel Variant	Petrol Variant
Average Emissions	gCO_2/litre	2,680	2,310
Average Mileage	km/litre	15	15
Net Emissions	gCO_2/km	178.7	154

The analysis for an Electric Vehicle considered, a 4-W passenger car (sedan) with a charge efficiency of 0.115 kWh/km and average emissions to generate 1 KW electricity from the grid. Table 7 provides details of the net emissions.

Table 9. Net Emissions from Electric Vehicles

	Unit	Value
Average Emissions	gCO_2/liter	820
Charge Required	kWh/km	0.115
Average Mileage	km/kWh	8.696
Net Emissions	gCO_2/km	94.3

5. Conclusions

29. This program will provide an impetus for Indian vehicle manufacturers, charging infrastructure companies, fleet operators, service providers, and the industry to gain efficiencies of scale. This in turn drive down costs, create local manufacturing facilities, grow technical competencies for the long-term growth of the EV industry in India. Subsequently, it will enable the Indian EV manufacturers to emerge as a major global player.

[7] Retrieved from https://people.exeter.ac.uk/TWDavies/energy_conversion/Calculation%20of%20CO2%20emissions%20from%20fuels.htm.

[8] Retrieved from https://people.exeter.ac.uk/TWDavies/energy_conversion/Calculation%20of%20CO2%20emissions%20from%20fuels.htm.