L&T Plug-in EV charge point management system

Study on Plug-in EV charging effects on LV grid

Digital Energy Solutions
Power Transmission & Distribution

Impact of Plug-in Electric Vehicles on LV Grid

ELECTRIC VEHICLE RETAIL SALES IN INDIA FOR FIRST 5 MONTHS OF CY2023					
Sub-segments	**January '23**	**February '23**	**March '23**	**April '23**	**May '23**
Two-wheelers	64,663	66,053	86,252	66,725	1,04,829
Three-wheelers	34,315	36,011	45,236	38,012	44,609
Passenger vehicles	3,433	4,752	8,805	5,982	7,443
Buses	97	98	87	84	274
Light goods vehicles	66	114	83	142	160
Heavy goods vehicles	0	0	183	46	0
Others	1	81	23	8	23
Total	**1,02,575**	**1,07,109**	**1,40,669**	**1,10,999**	**1,57,338**
Data: Vahan					

EV SALES IN INDIA HIT RECORD 157,000 UNITS IN MAY 2023			
Sub-segments	**May '23**	**May '22**	**YoY Growth**
Two-wheelers	1,04,829	42,415	147.15%
Three-wheelers	44,609	24,099	85.10%
Passenger vehicles	7,443	2,961	151.36%
Buses	274	165	66%
Light goods vehicles	160	44	263%
Heavy goods vehicles	0	217	
Others	23		
Total	**1,57,338**	**69,901**	**125%**
Data: Vahan			

Characteristics of Plug-in Electric Vehicles loads

The characteristics of plug-in electric vehicles (EV) load are

1. Non-linearity of load
2. Electronic circuitry
3. Single phase load

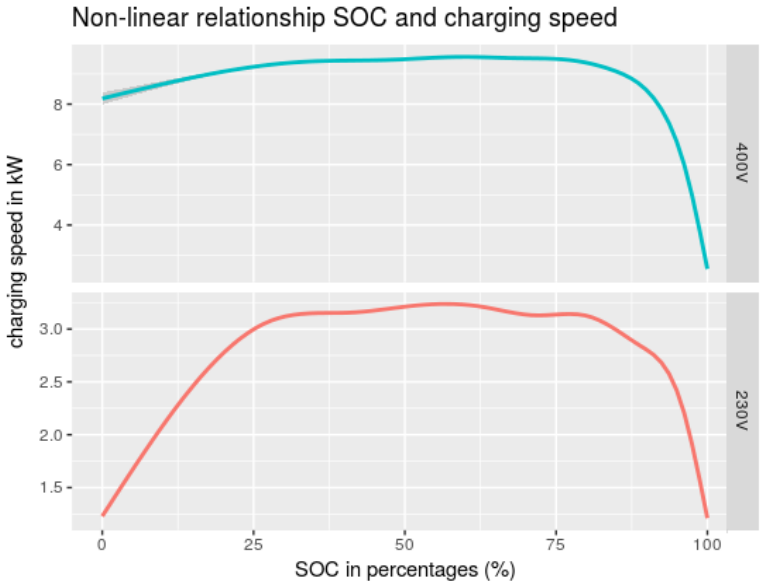

Figure no. 1: Non-linear EV charging

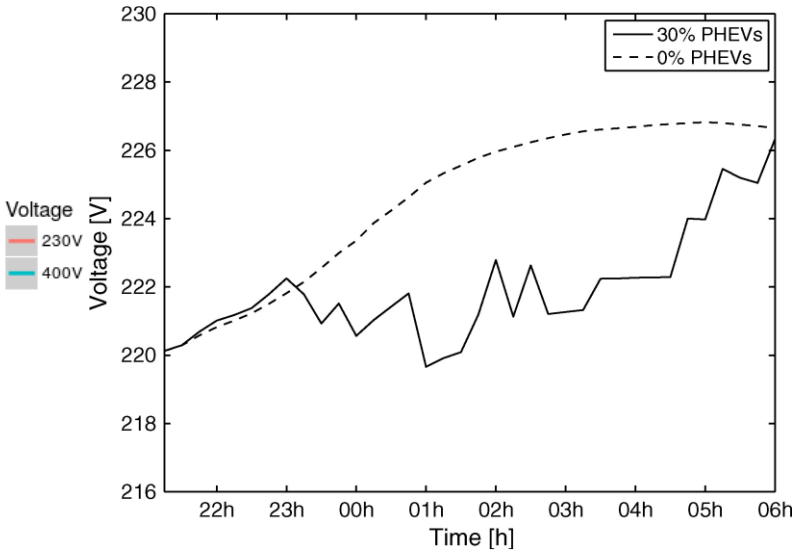

Figure no. 2: Voltage profile

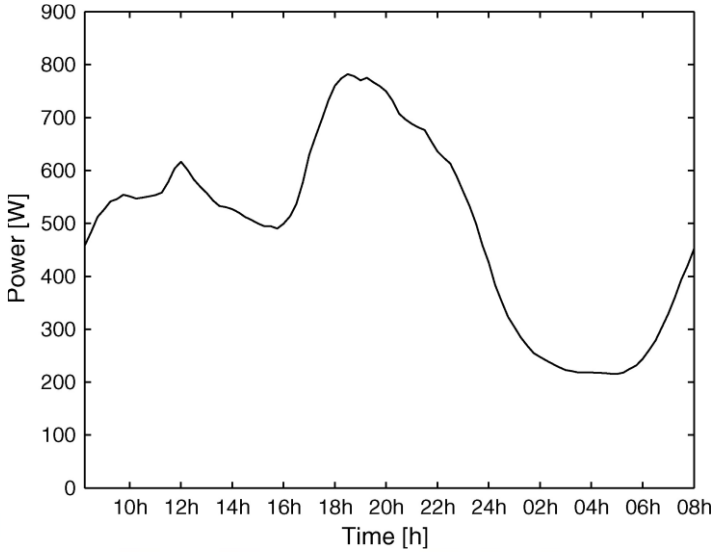

Figure no. 3: Daily power profile

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The fast-charging stations of electric vehicles (EV) results in increased

1. Peak load demand
2. Reduced reserve margins
3. Voltage instability
4. Reliability problems
5. Harmonic distortions
6. Stress on the existing distribution network such as transformers and cables
7. Degradation of performance parameters and penalties

Voltage profile

- Voltage imbalance
- Voltage instability
- Reduction in voltages
- Voltage sag and swell

Harmonic injection

- Increased insulation temp voltage
- Lower power factor
- Decrease insulation life
- Decrease efficiency
- Increase heat losses

Loading of electrical assets

- Uncertainties in charging
- Unequal charging rates
- Long feeders are more effected
- Increase in -ve sequence current
- Heating of the electrical assets

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- Monte Carlo modelling approach used for analysis of impact of uncertainties in EV charging rates & connection sites
- Single phase PV, battery storage and EV charging all add to these points
- Low negative sequence impedance causes 6–10 times the voltage unbalance in a power circuit
- Excess phase currents can damage cable insulation and trip overload protection circuits, shortening the life of the cable, increased losses, additional heating effects, and vulnerability of the system to failures
- Household single-phase chargers starts at 1.6 kW and rises to tens of kW for fast charging

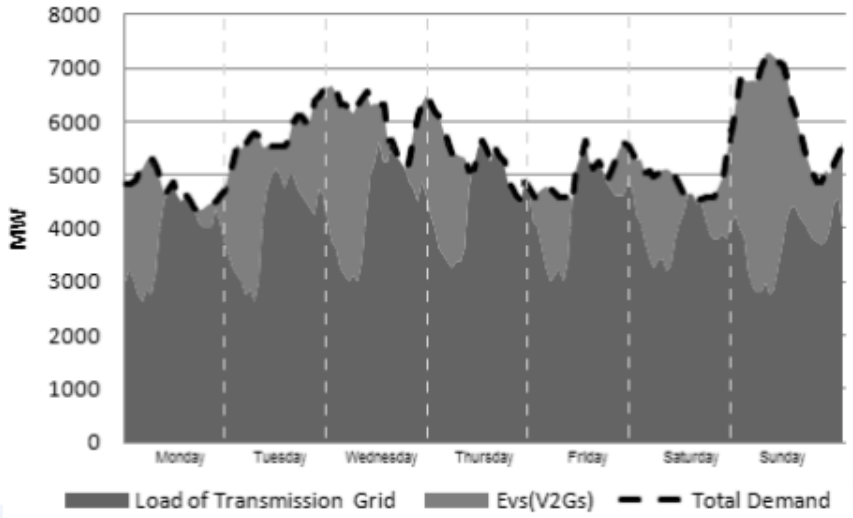

Figure no. 1: Load of EV charging

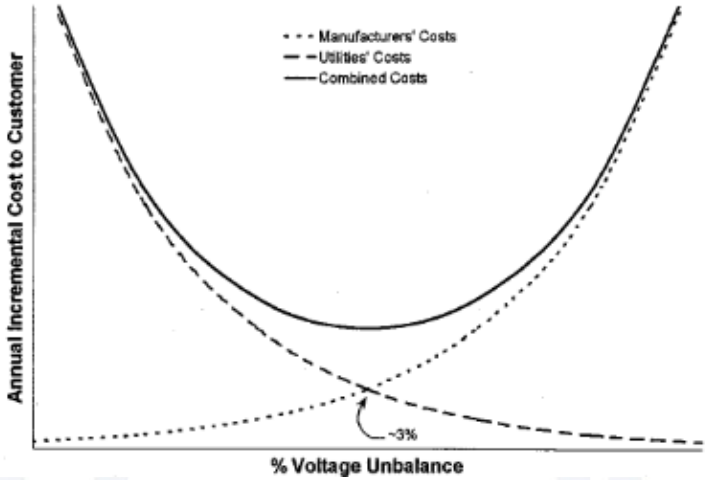

Figure no. 2: Voltage unbalance

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1. **Utility factor =** $\frac{\sum_{i=1}^{N} D_{ei}}{\sum_{i=1}^{N} D_i}$

Percentage of daily vehicle kilometers that are less than or equal to the stated distance.

2. **Electric range utility factor =** $\frac{\sum_{i=1}^{N} D_{ei}}{N * k}$

The ratio of actual miles driven on electricity to the total miles travelled on electricity.

3. **State of charge =** $\begin{cases} 100 * \left(\frac{k-d}{k}\right) & d \leq k \\ 0, & d > k \end{cases}$

The amount of charge left in the vehicle when it arrives is known as the state of charge.

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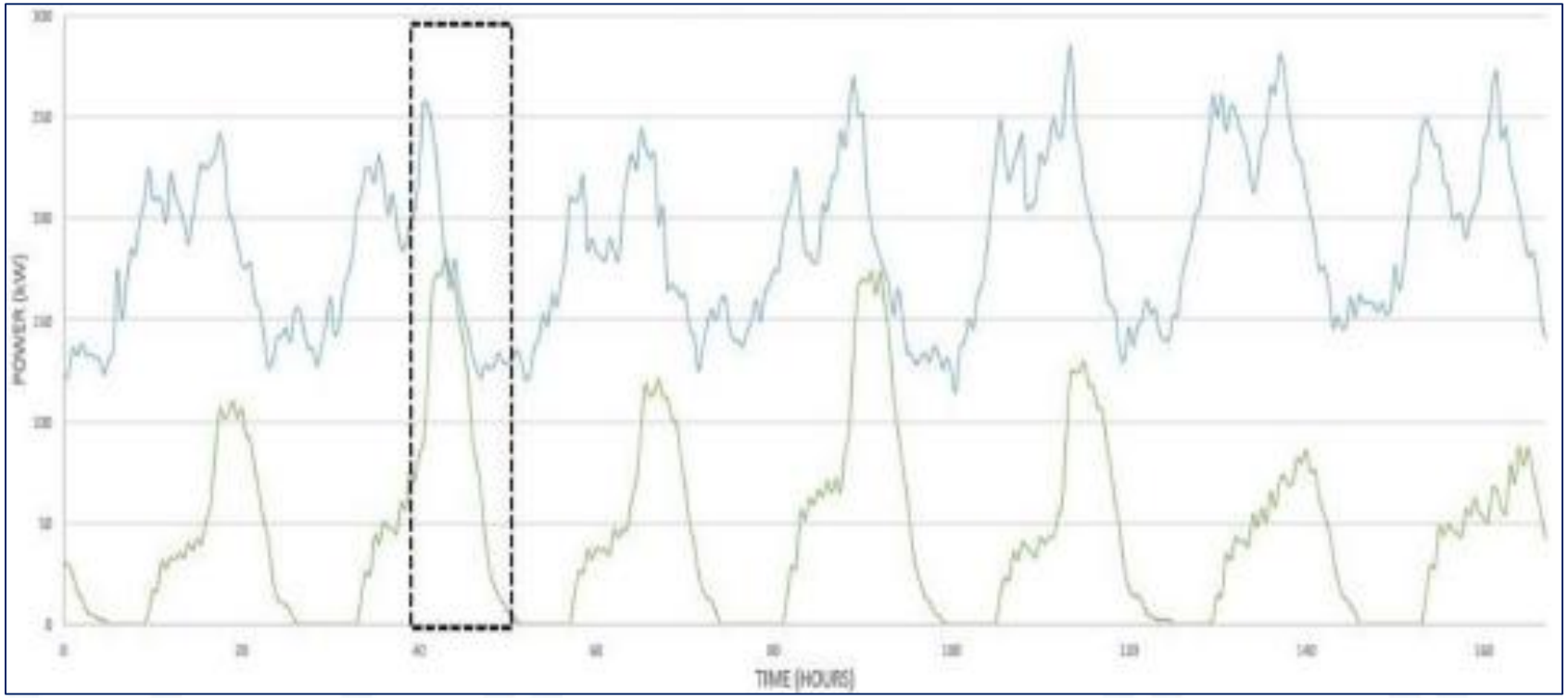
Uncontrolled charging nature of EVs



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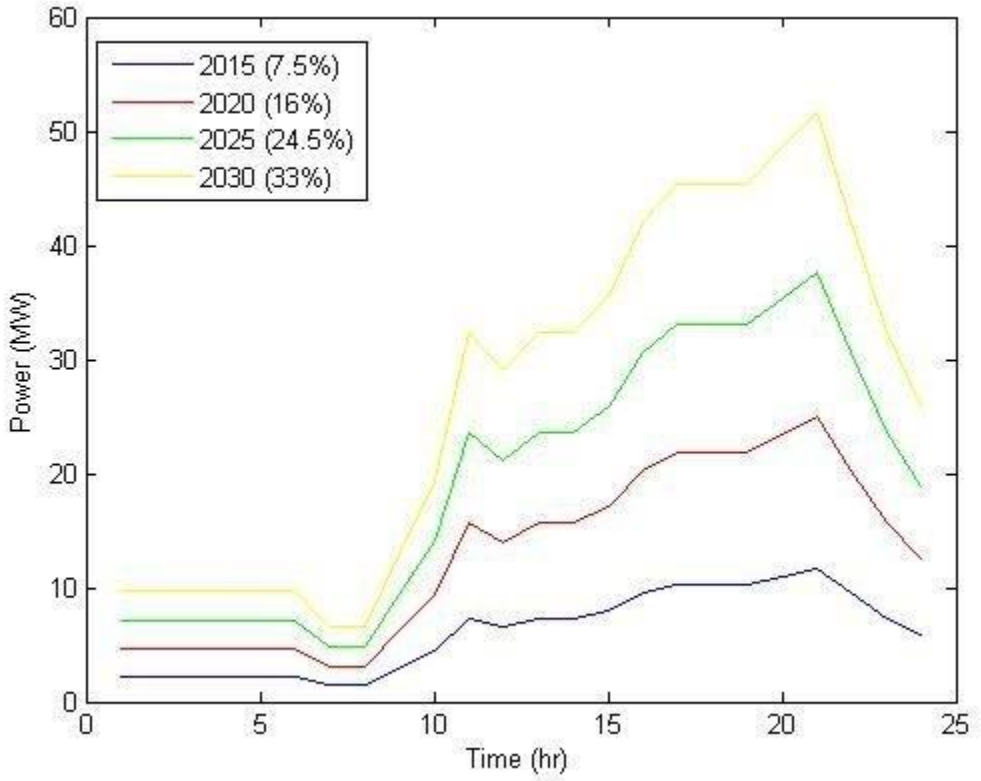

Figure no. 1: Daily load curve of EV charging at charging station

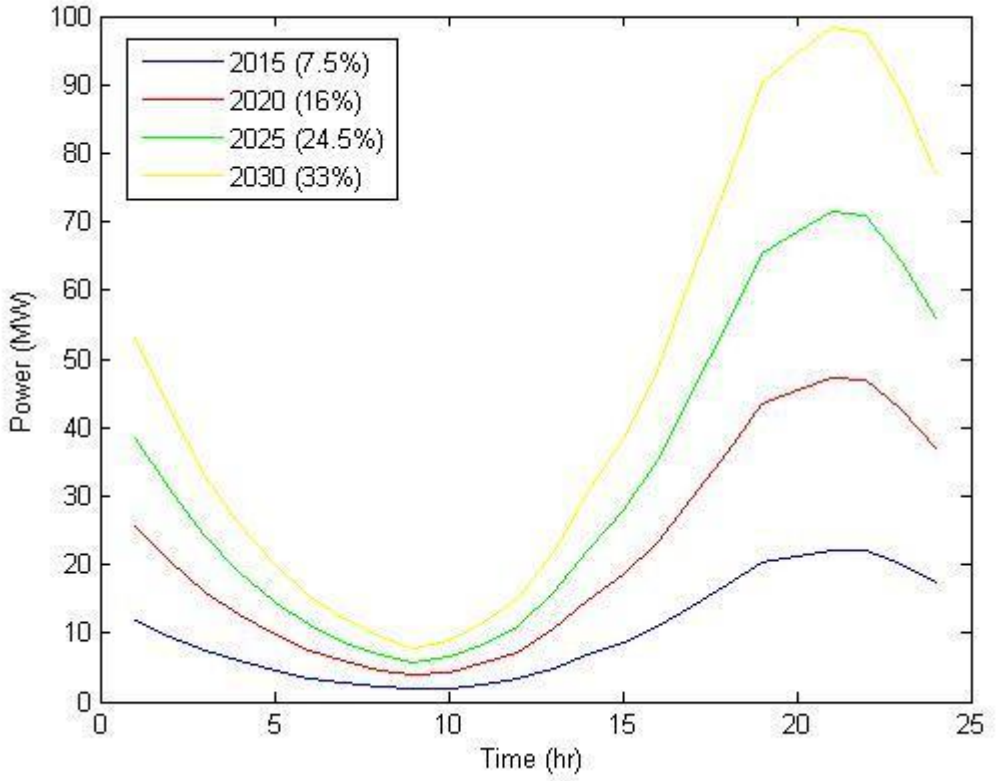

Figure no. 2: Daily load curve of EV charging at home

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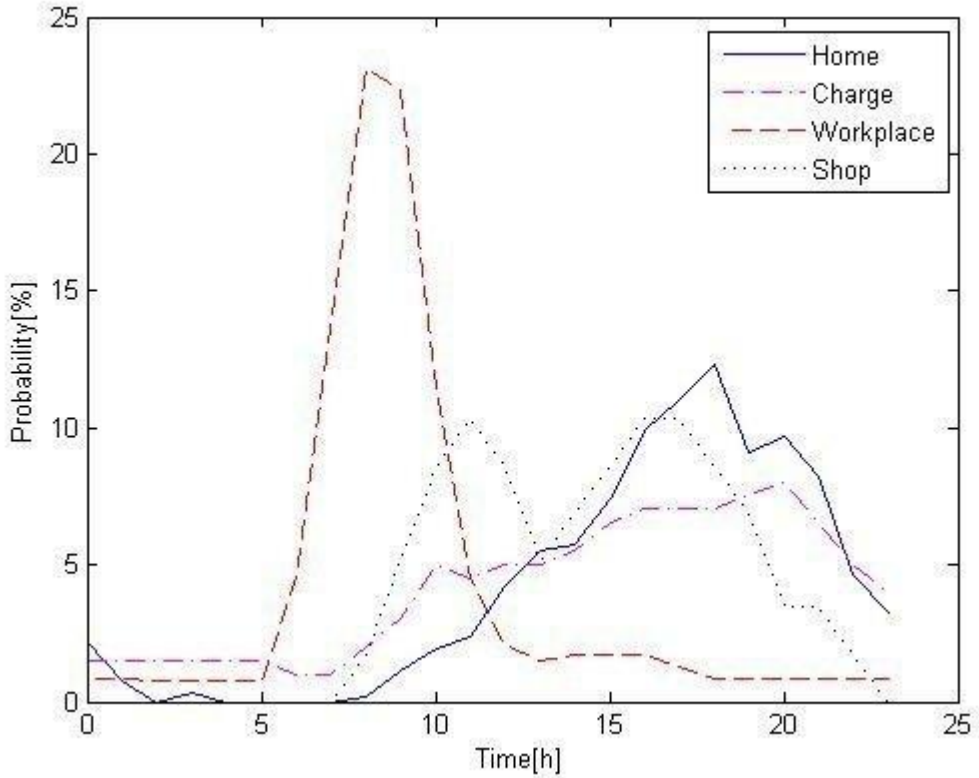

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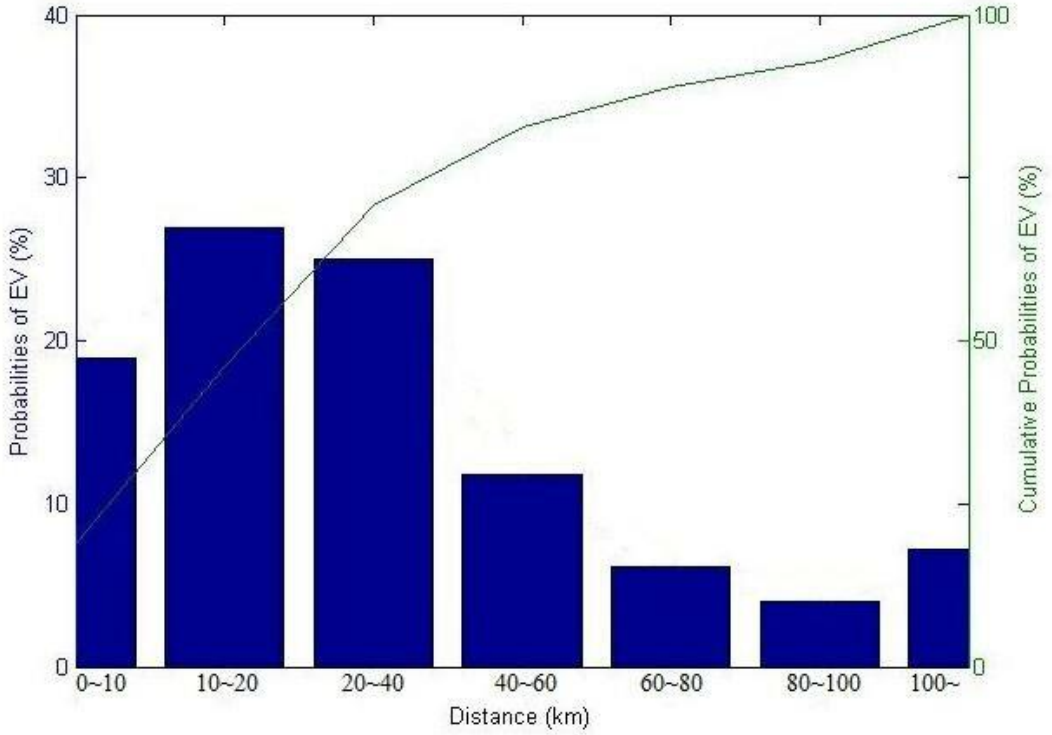

Figure no. 2: Probabilities of EV driving kilometers

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Mitigation strategies of ill effects of plug-in electric vehicles (PEV) charging

1. Phase reconfiguration
2. Time of use tariff
3. Use of energy storage devices, feeder capacitors and S-Statcom
4. Grid tied power filters.
5. Modulation techniques e. g. SPWM, SVPWM, DPWM, SHE, interleaving.
6. Power filter design L-, LCL-filter, etc. are typically used to reduce switching frequency noise
7. Solid state transformers

Thank you!