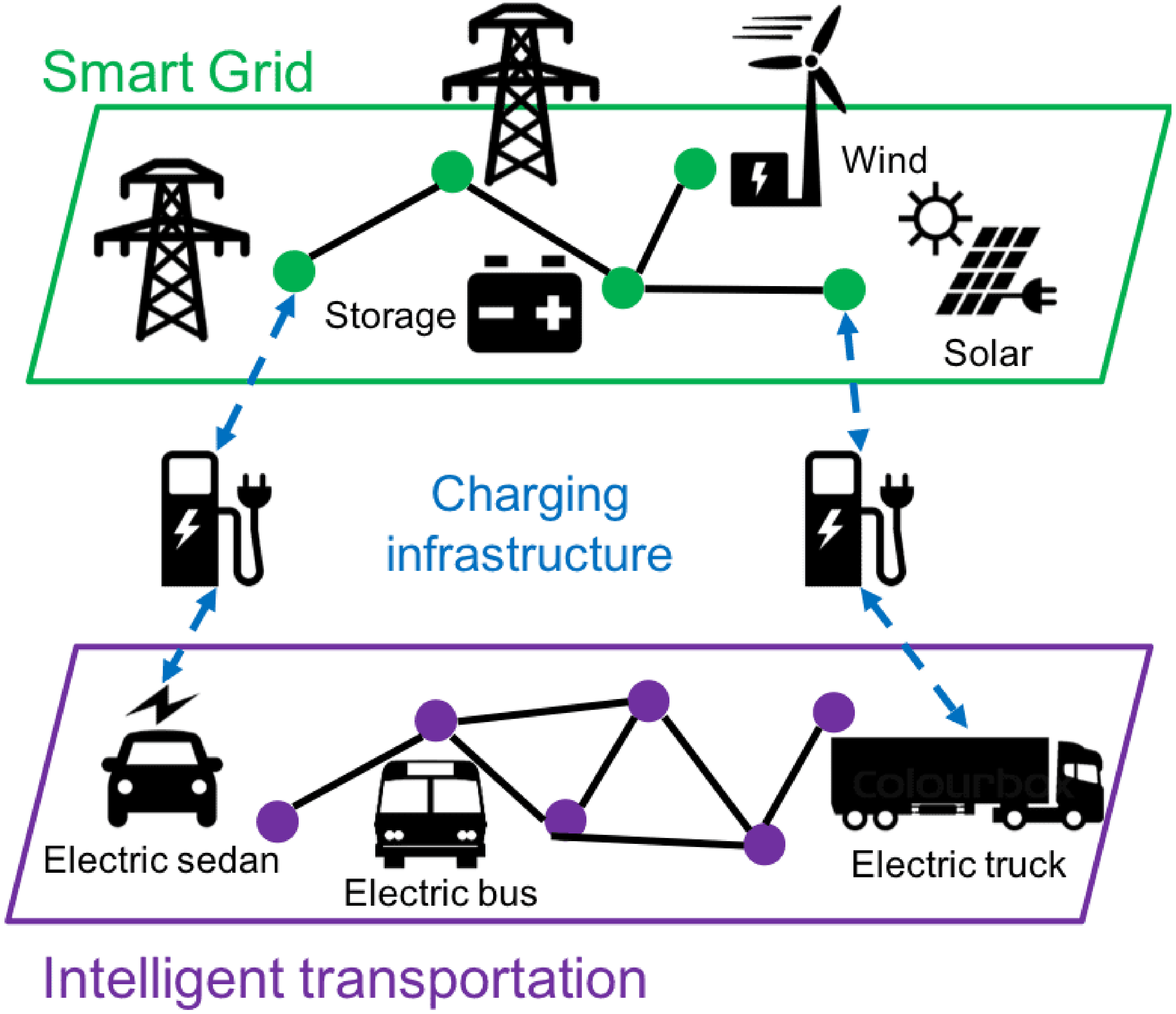
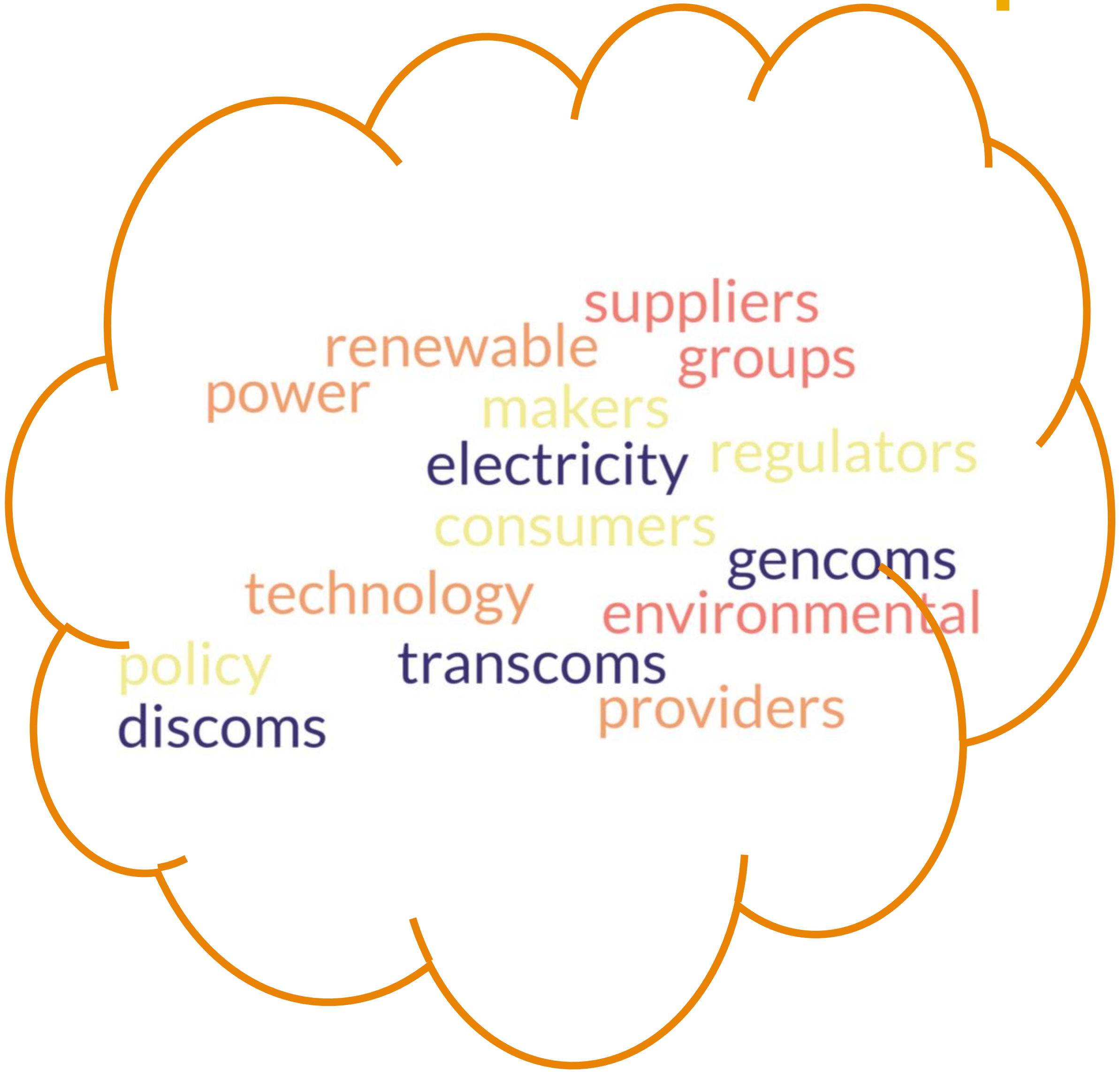
WRI INDIA
—ROSS CENTER

NAVIGATING THROUGH BLURRING BOUNDARIES BETWEEN POWER AND AUTOMOBILE SECTOR



Past Power and Transportation Sectors



Electrical Power Sector Stakeholders

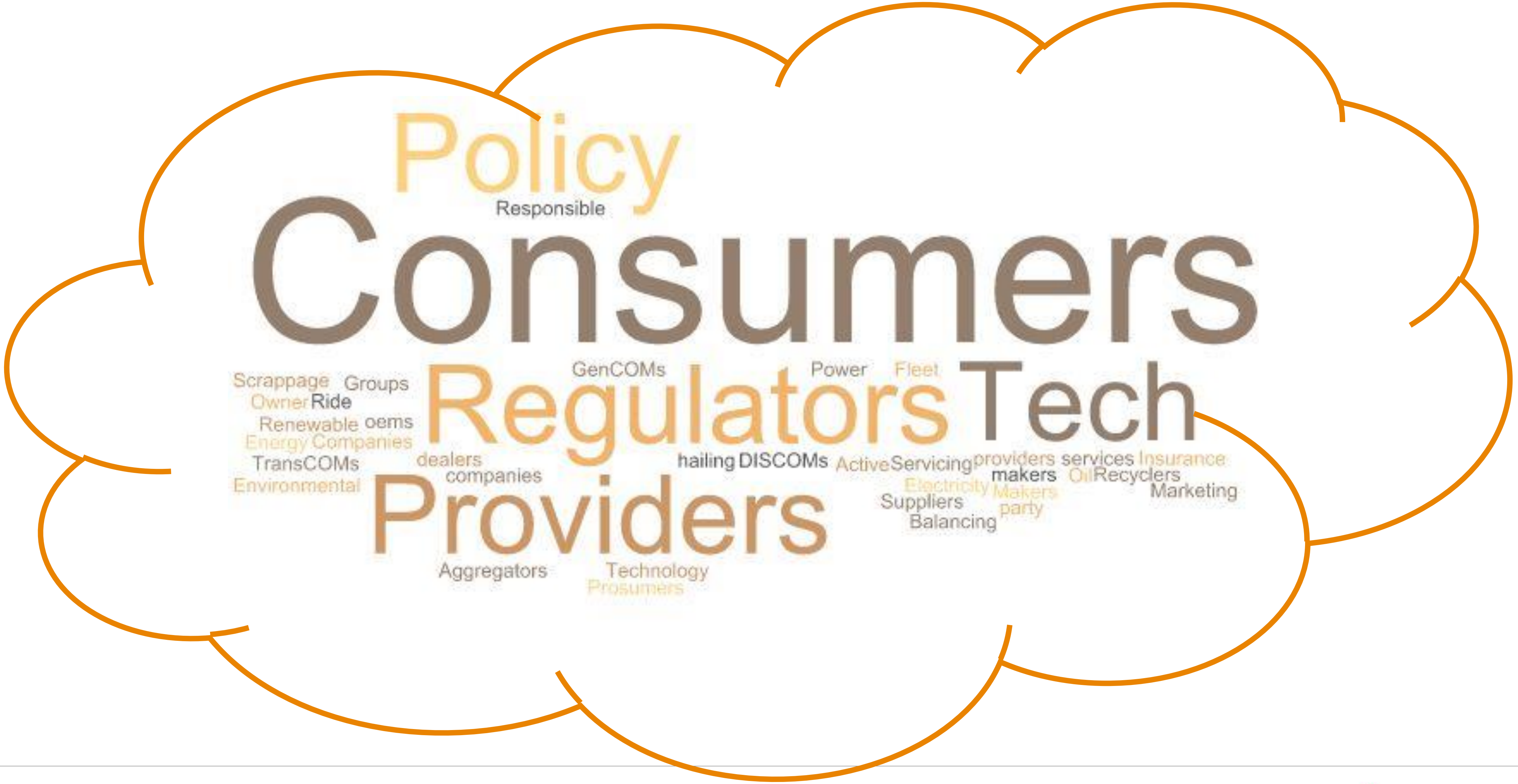
Transportation Sector Stakeholders

Source :Author’s Compilation

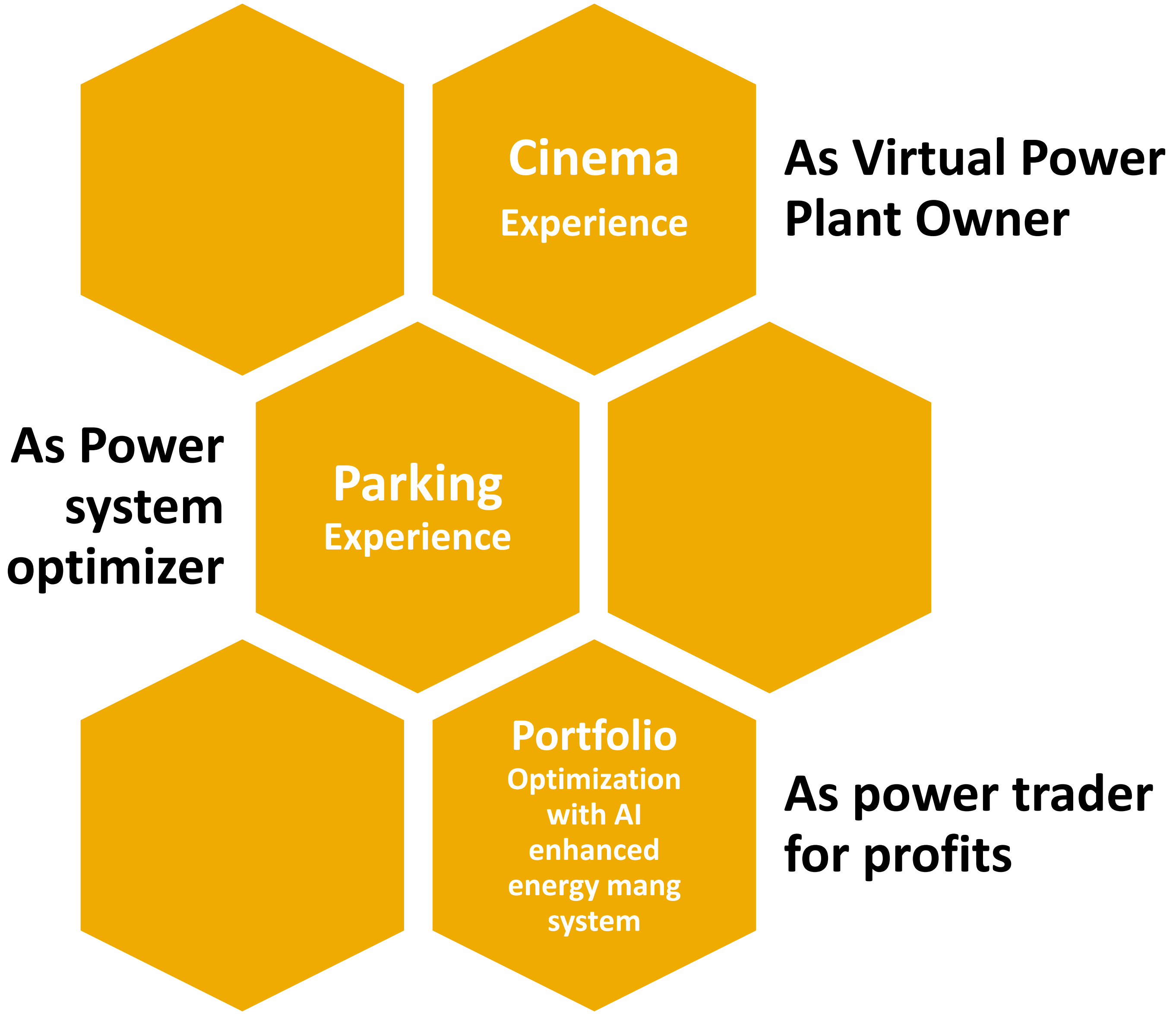
WRI INDIA

Power and Transportation Nexus

Automotives as Energy players

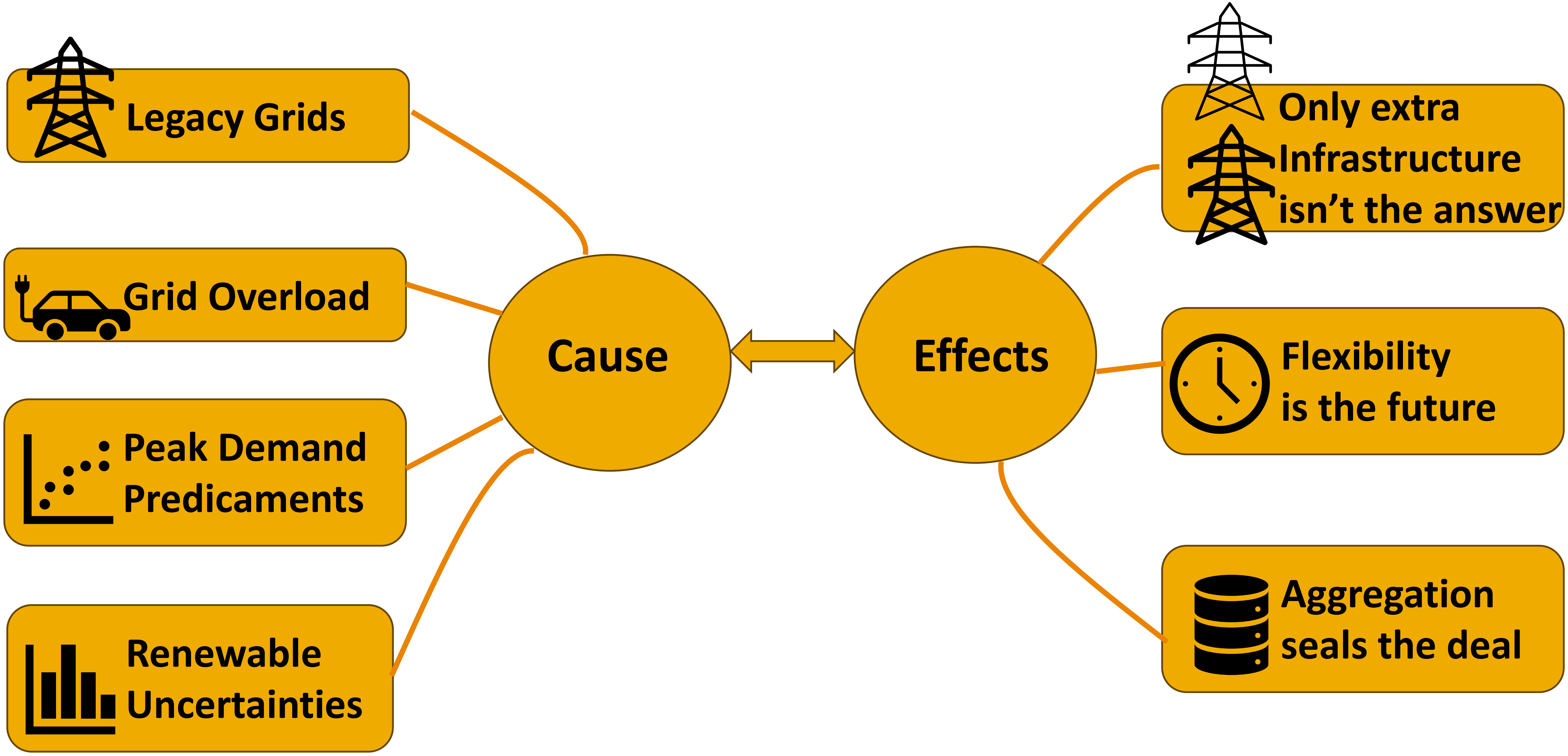


Imagine…



Cinema
Experience
As Virtual Power Plant Owner
As Power system optimizer
Parking
Experience
Portfolio
Optimization with AI enhanced energy mang system
As power trader for profits

Lets come to down to earth…



EV CHARGING IN INDIA

As EV sales grow in India, the EV charging demand is expected to grow exponentially in the coming decade

Types of EV charging:

- Public charging
- Semi-public charging
- Private charging

Public and semi-public EV charging in India is being incentivized through the FAME schemes and the various State EV Policies

Source: Fortune India (2022)

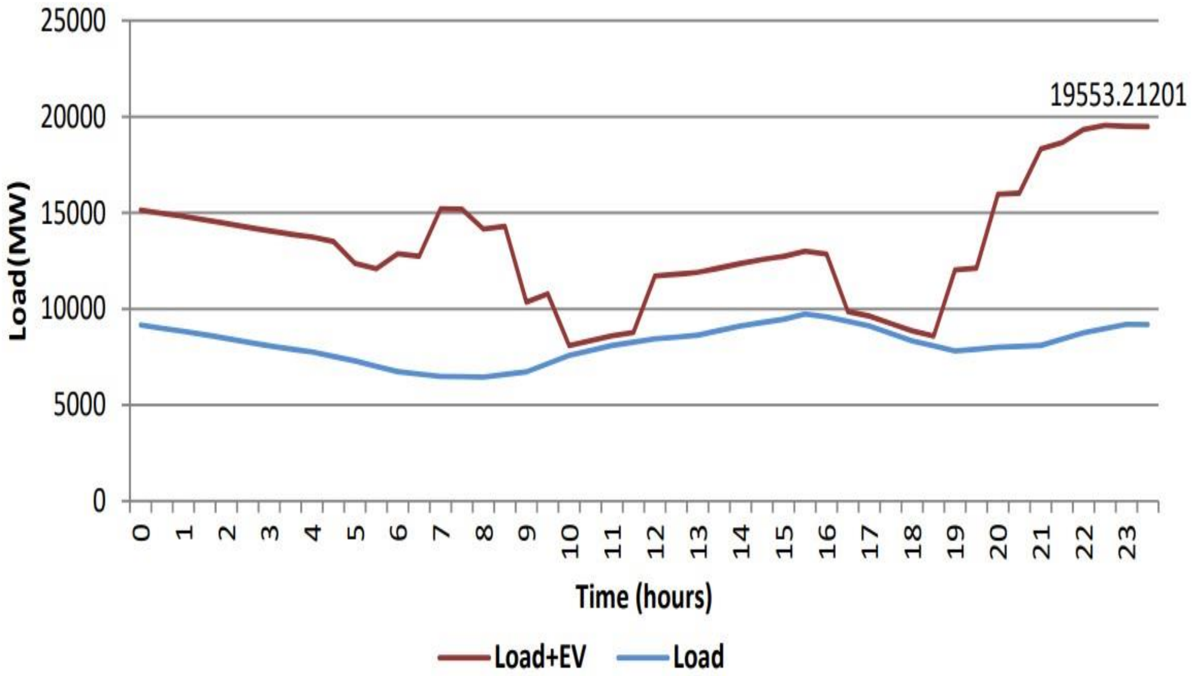
EV CHARGING – ADDITIONAL LOAD ON THE GRID

- The aggregate electricity demand for EV charging by 2030 is not expected to be significant compared to India's annual consumption
- EV charging is however expected to increase the instantaneous peak load on the distribution network

Impacts of unmanaged EV charging:

- Voltage instability
- Harmonic distortion
- Power losses
- Degradation of reliability indices

Estimated Daily Electricity Load Curve in Delhi (2030)



Source: Indian Institute of Technology Kanpur (2019)
Note: WRI India has not validated the results of this study

Source: Indian Institute of Technology Kanpur (2019)

MANAGING EV CHARGING LOAD

Passive management

Influencing EV users' charging behavior using specially designed electricity tariffs or incentives to encourage charging at a certain level and/ or a certain time

Unidirectional active management

Throttling the rate of energy delivery for EV charging dynamically based on different factors to manage grid-level load. Referred to as V1G.

Bidirectional active management

Enabling bidirectional movement of energy between the electrical grid and the EV battery for managing grid-level load and supply shortages. Referred to as V2G.

Grid Integration of EV Charging

PASSIVE MANAGEMENT

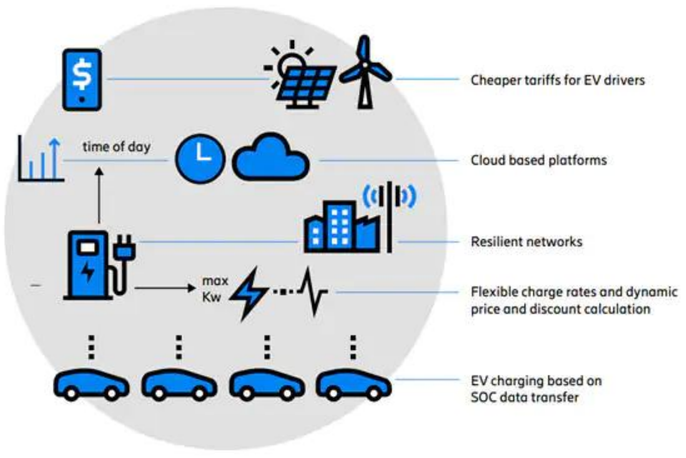
EV charging demand can be passively managed by using the following measures:

- **Time-of-Use (ToU) charges**
  - Differential electricity tariff for different times of the day can be used to incentivize people to charge EVs during off-peak hours
- **Demand charges**
  - Levying demand charges on high power charging would help in ensuring judicious use of fast charging, thus minimizing instantaneous peak loads
- **Rebates for off-peak charging**
  - In the absence of dynamic tariff systems, rebates can be provided to EV owners, CPOs and businesses for charging at off-peak hours

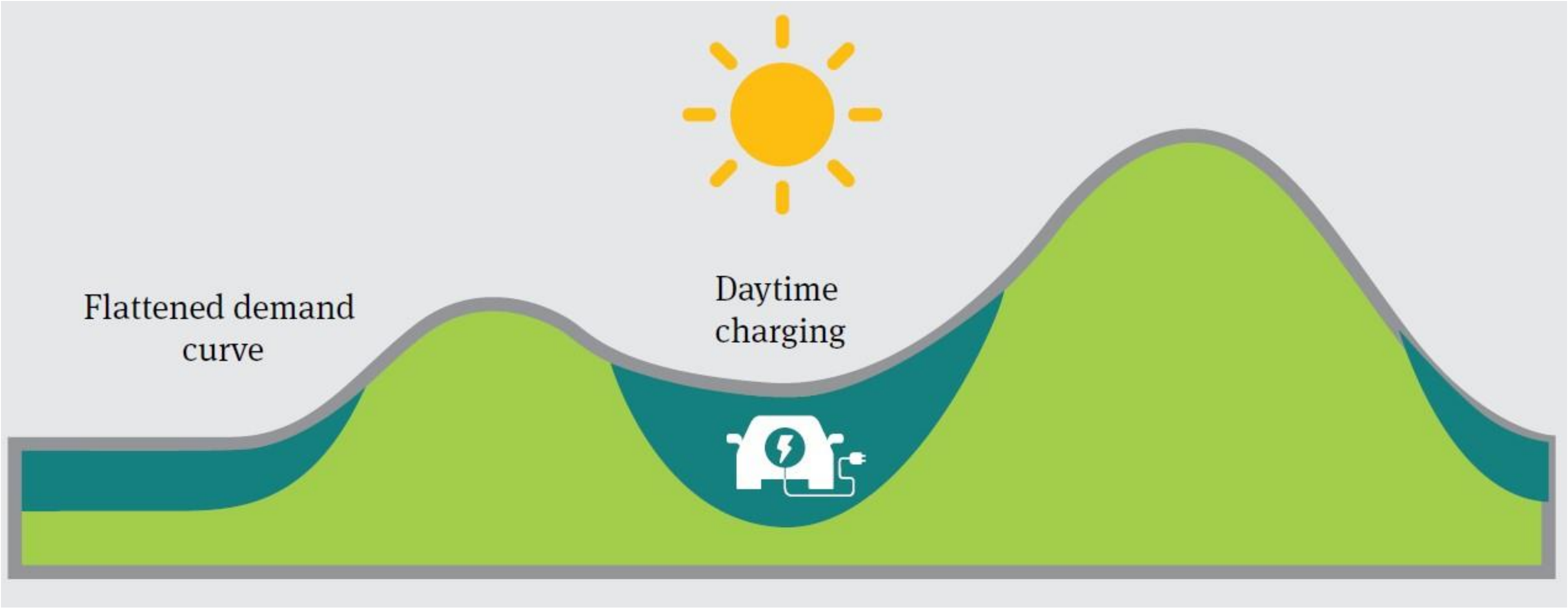
UNIDIRECTIONAL ACTIVE MANAGEMENT

Smart Charging

- The speed at which an EV can charge can be throttled using smart charging technology
- Smart chargers are programmed to control the rate of energy delivery while charging based on the existing battery level, historical & real-time load on the grid, and RE availability
- An effective tool to flatten the demand curve and reduce instantaneous peaks



Smart Charging



Demand Curve Management using Smart Charging

Source: Alliance for Energy Efficient Economy (AEEE) (2020)

BIDIRECTIONAL ACTIVE MANAGEMENT

- Technology that allows for bidirectional energy flow, enabling energy stored in EV batteries to be pushed back to the electricity grid
- Achieved using a smart charger which can be programmed to deliver energy to the EV battery during off-peak load hours
- Distribution networks have the ability to tap energy from EV batteries to meet energy demands during peak load hours

APPLICATIONS

Peak shaving

Smart charging can help DISCOMS in efficiently managing peak loads by off-setting charging demand to off-peak hours

Arbitrage opportunities

V2G can be leveraged to store and trade energy depending on market and pricing conditions

Frequency regulation

EV batteries can be used to manage the grid frequency by managing any supply-demand mismatch in the distribution network

RE storage

EV batteries, along with bidirectional charging, can also provide ready storage of energy generated by local RE sources.

BENEFITS OF V2G

EV Owners/CPOs

- Reduction in electricity bills through use of ToU rates and/or avoiding high demand charges
- Provision of back-up power in case there is a supply disruption or issue with power quality
- Increased solar self-consumption to address localized overgeneration from solar energy

Distribution System

- Deferral of distribution capacity upgrades
- Better integration of renewables and reduction in backflow on distribution system in high solar penetration areas
- Voltage support and reliability in services

Transmission System

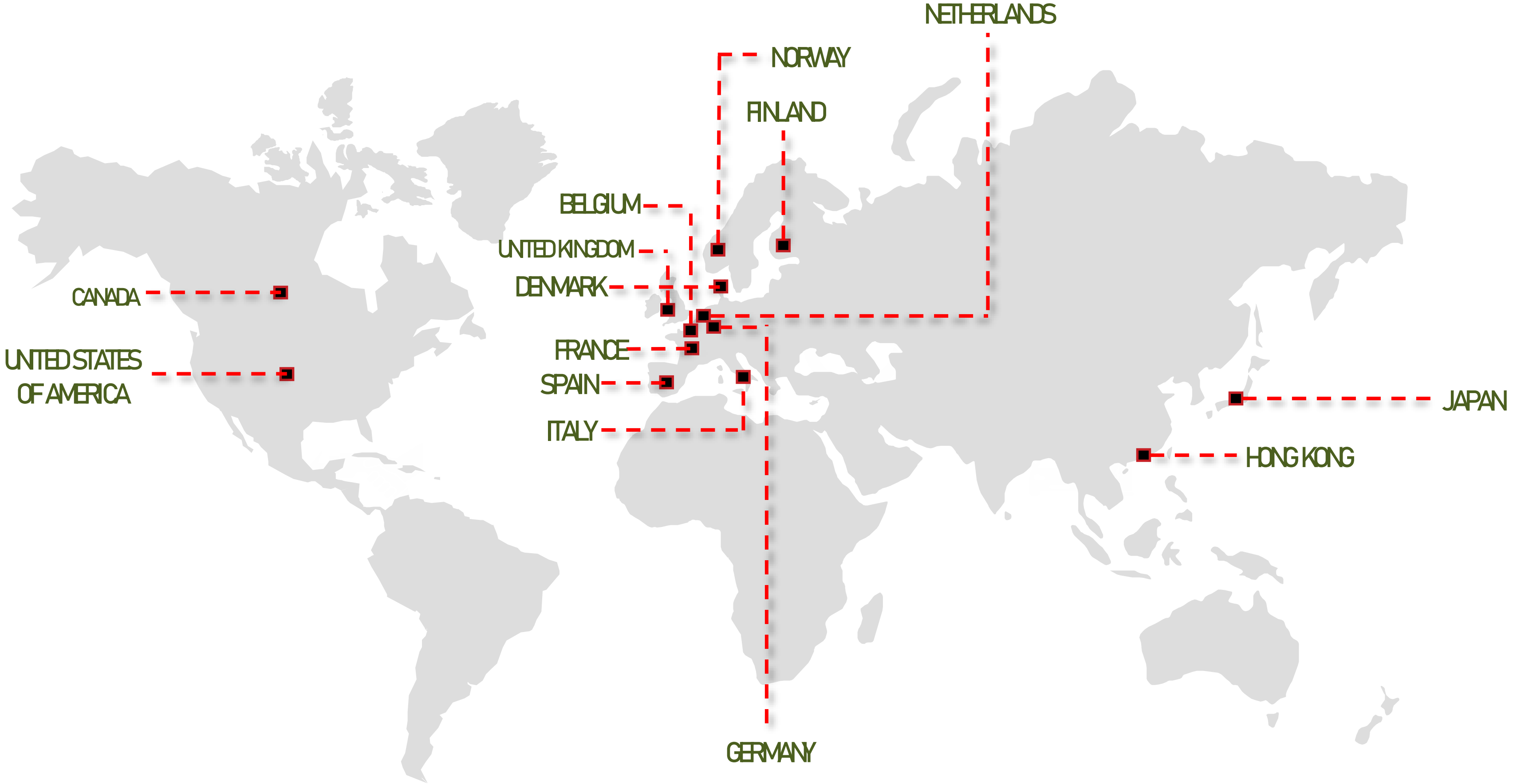
- Deferral of transmission capacity expansion
- Better integration of renewables
- Voltage support and primary frequency response
- Operational efficiency and black-start services

Societal & Environmental

- Reduction of power system/transport sector's carbon footprint
- Reduction of air pollutants
- Creation of economic opportunities
- Generation of employment and upskilling opportunities

GLOBAL V2G PILOTS

- While V2G is yet to garner wide-spread adoption, there have been multiple pilot implementations of V2G technology to explore its feasibility, operational viability, stakeholder preparedness, avenues for R&D and potential impacts on the grid



Source: Compiled by WRI India nased on

CASE STUDY-1

Parker Project (2016 to 2018)

Denmark

- Aimed to test ability of electric vehicles to provide grid services using real world fleets
- Identified and addressed barriers to commercialization by analyzing grid applications, readiness, scalability, and replicability of V2G technology
- Ten Nissan e-NV-2001 EVs performed 100 hours of V2G per vehicle, returning 130,000 KWh to the grid in two years, which is equivalent to the consumption of 21 households per year
- 130,000 kg of CO_2 emissions were saved
- Each car generated €1,860 per year by participating in energy markets, selling unused electricity back to the grid

Source: Parker Project website

CASE STUDY-2

INVENT (2017 to 2020)

United States of America

- Large scale trial on UCSD campus, with multiple vehicle types and chargers, supporting move towards commercial deployment in California
- Demonstrated the real-world benefits of advanced vehicle grid integration (VGI) applications for EVs
- Identified the following challenges:
  - Availability of cars
  - EVSE reliability
  - Adapting system to local requirements
  - Market Access Paths
  - Battery Degradation

CASE STUDY-3

M-tech Labo (2010 to 2013)

Japan

- An early smart grid demonstration system that utilizes rechargeable batteries in EVs for electric-demand levelling of Mitsubishi factory facilities
- Successfully demonstrated load shifting by charging at night when demand is low, storing power produced from renewable sources in rechargeable batteries, then supplying power back to the grid when factory facilities and offices face peak demand

Findings:

- 30-50kWh/day discharged for the peak hours (1-4pm) from the EVs
- Shaved peaks by 12.7% on average
- No noticeable impact on battery degradation
- Reduction of electricity fluctuation at the administration building of MMC's Nagoya Plant

Source: Everoze & EVConsult (2018), Mitsubishi Corporation website

Battery Degradation :
Biggest Concan for EV Ecosystem

- Two Major perspectives used to measure battery degradation
  - the calendar ageing
  - the cycle ageing mechanisms.

CHALLENGES IN INDIA

- Insufficient number of EVs on the road
- Lack of required infrastructure
- Lack of regulatory framework
- All Chargers not equipped for V2G
- Grid Safety concerns regarding reverse power flow
- Energy losses due to V2G
- Lack of demonstration projects in Indian Context

WAY FORWARD

- Incentivizing EV owners to participate in V2G
- Adopting robust communication standards for charging
- Decentralizing the power sector
- Encouraging OEMs and DISCOMs to embrace bidirectional charging and implementing demonstration projects
- Encouraging EV charging aggregation
- Prioritizing investments in infrastructure and R&D

THANK YOU.