Leapfrogging to Electric and Smart Vehicles: Key Challenges and Opportunities

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Introduction to Lawrence Berkeley National Laboratory

BERKELEY LAB
Lawrence Berkeley National Laboratory

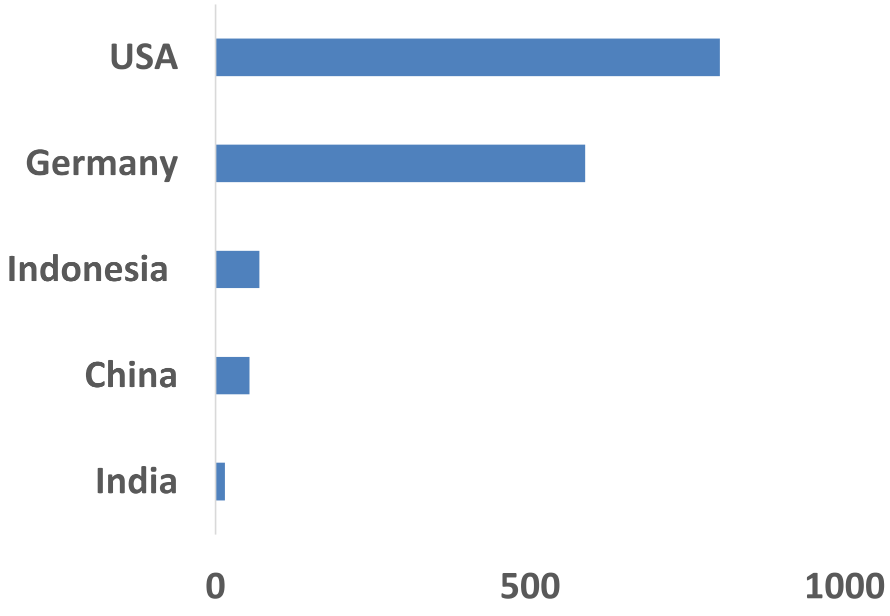
Managed by the University of California for
the United States Department of Energy

BERKELEY LAB
Lawrence Berkeley National Laboratory

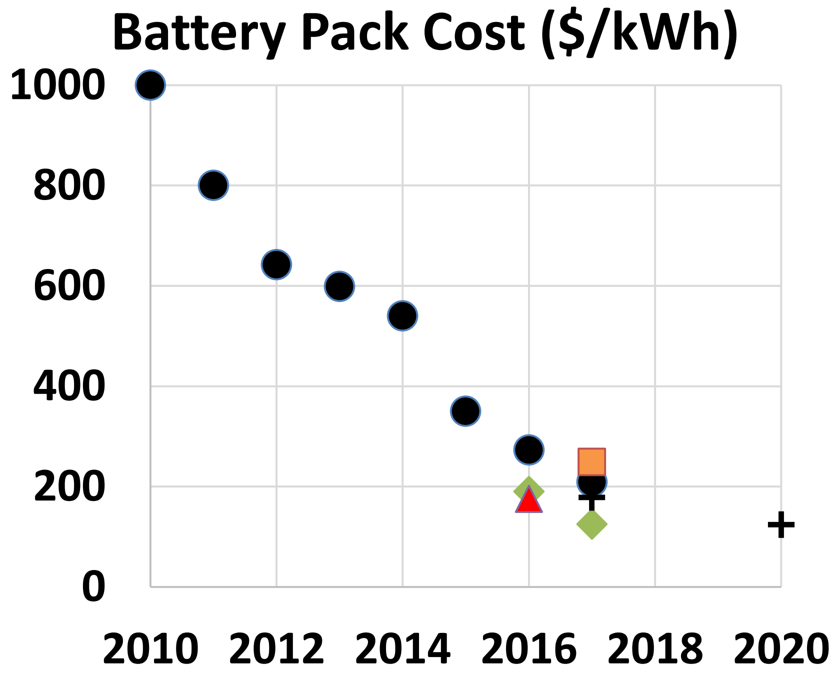
13 — Nobel Prizes
13 — National Medal of Science recipients
4,200 — Employees
200 — Site acreage

- **Dedicated to solving the most pressing scientific problems facing humankind**
  - Basic science for a secure energy future
  - Science of living systems to improve the environment and energy supply
  - Understanding and control of matter and energy in the universe
  - Translation to applied energy programs
- **Build and safely operate world-class scientific facilities**
- **Train the next generation of scientists and engineers**

Emerging Economies Have a Unique Leapfrogging Opportunity



Cars per 1000 people



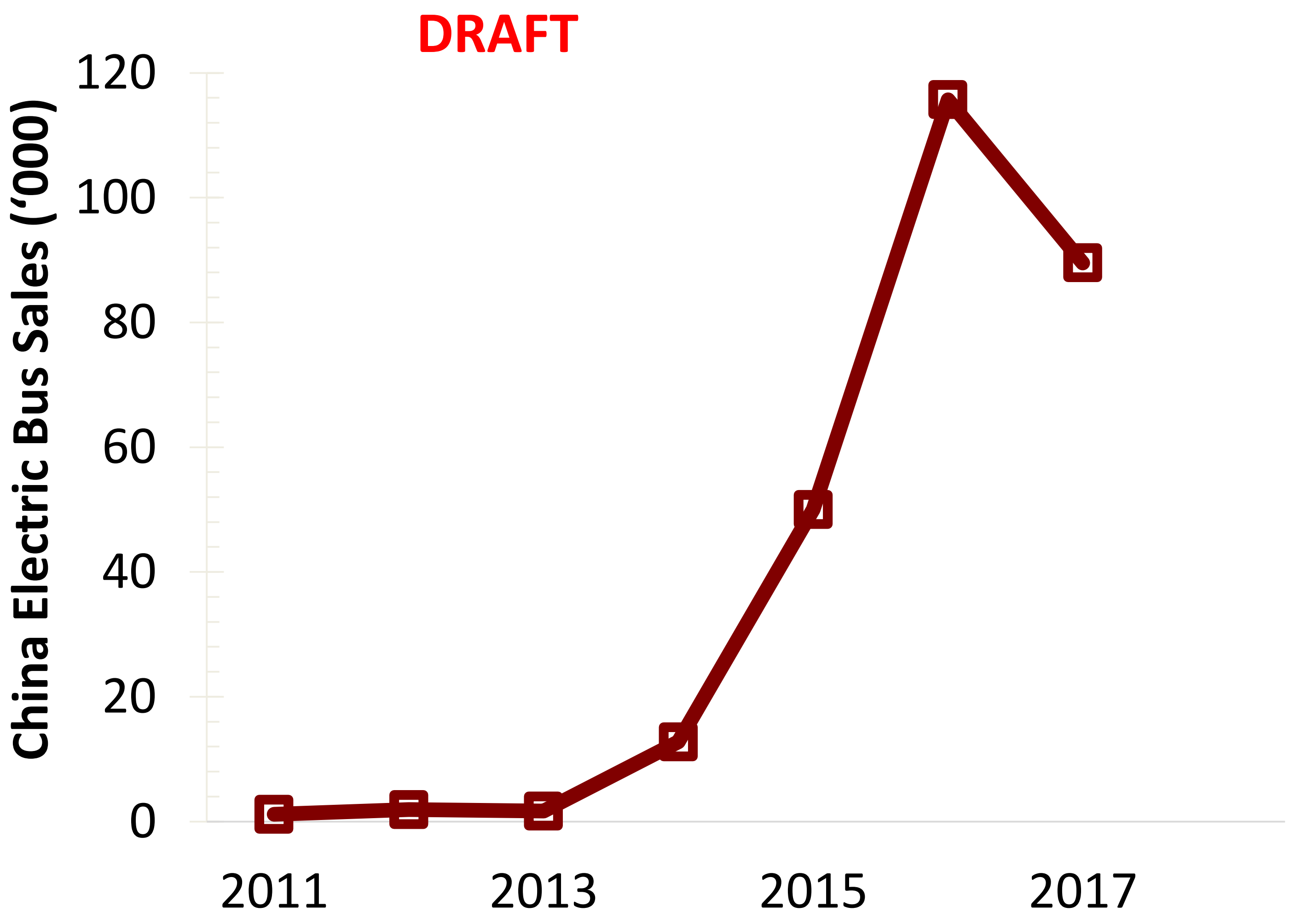
Data Sources: BNEF (2017), Kammen et al (2017), Tesla(2017), Bolt (2017)

80% of the vehicles that will exist by 2030-2035 are yet to be purchased

Li-ion battery prices have dropped by over 90% in the last 10 years

EVs have much higher benefits under congested driving conditions

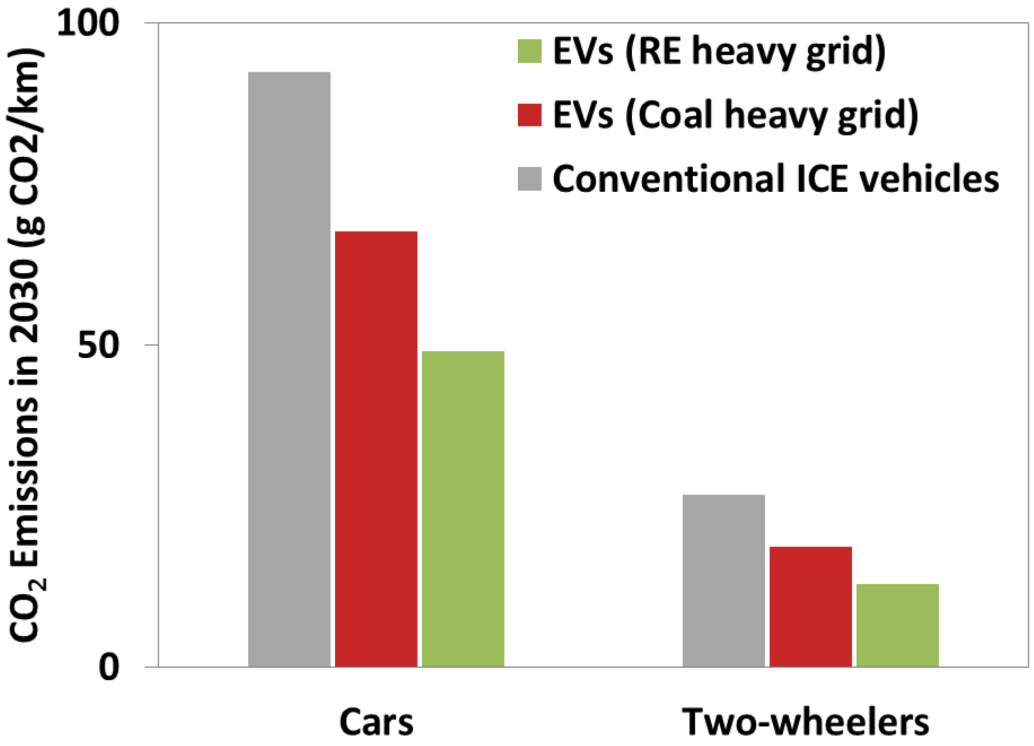
In China, electric bus manufacturing has already scaled with bus market almost transformed



Data Sources: Bloomberg (2018), IBER (2018), F&S (2018) and Other industry reports

- Total EV sales in China are ~600-700,000/yr
- Subsidies (up to ~50%), sales targets, air quality regulations accelerated the EV bus adoption
- Recently, subsidies are down to ~5-10% of the upfront bus cost; vehicles with range <150km don't get any subsidy
- Electric bus costs have also fallen and only marginally higher than diesel buses

EVs reduce carbon emissions – even in a coal heavy grid

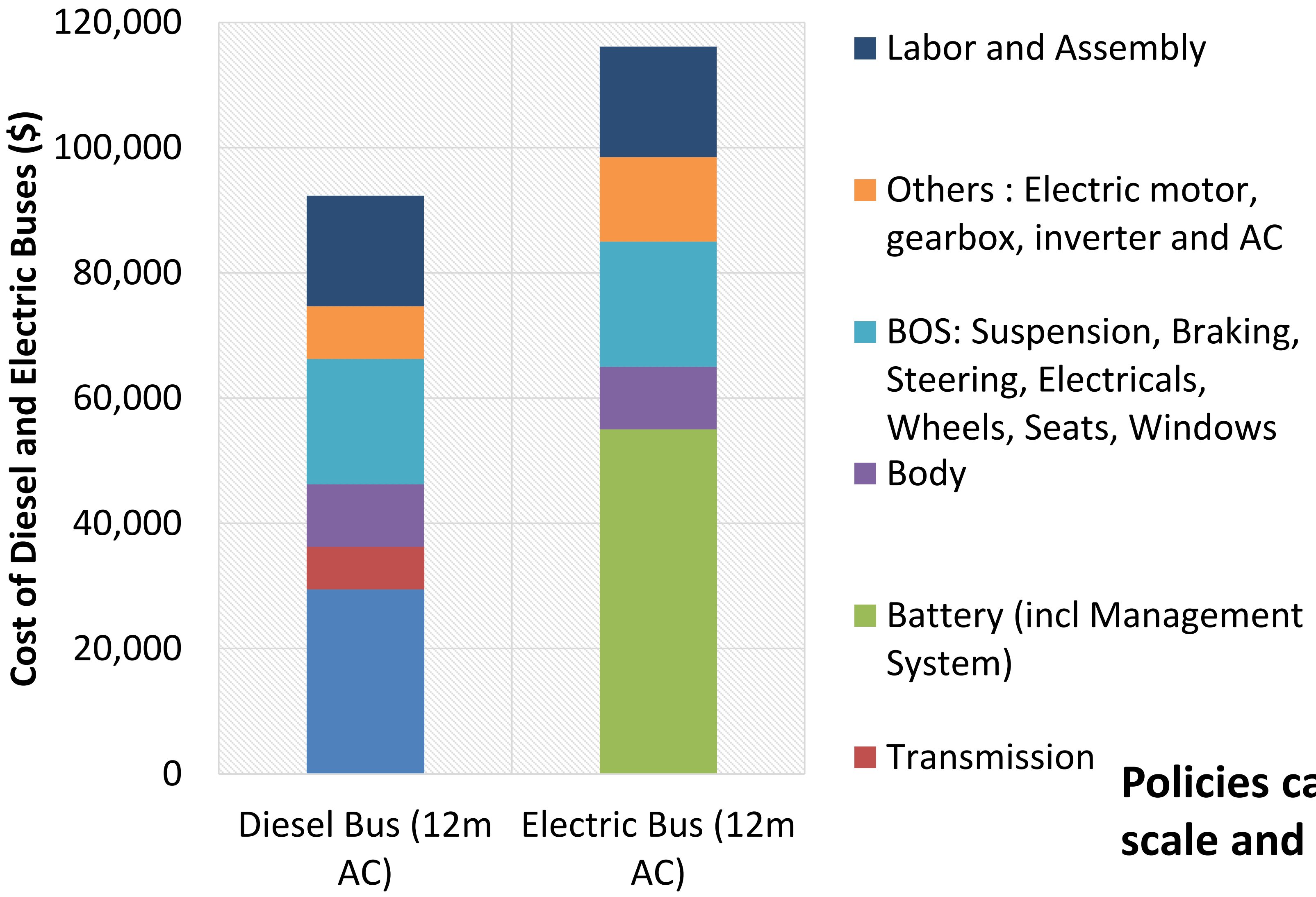


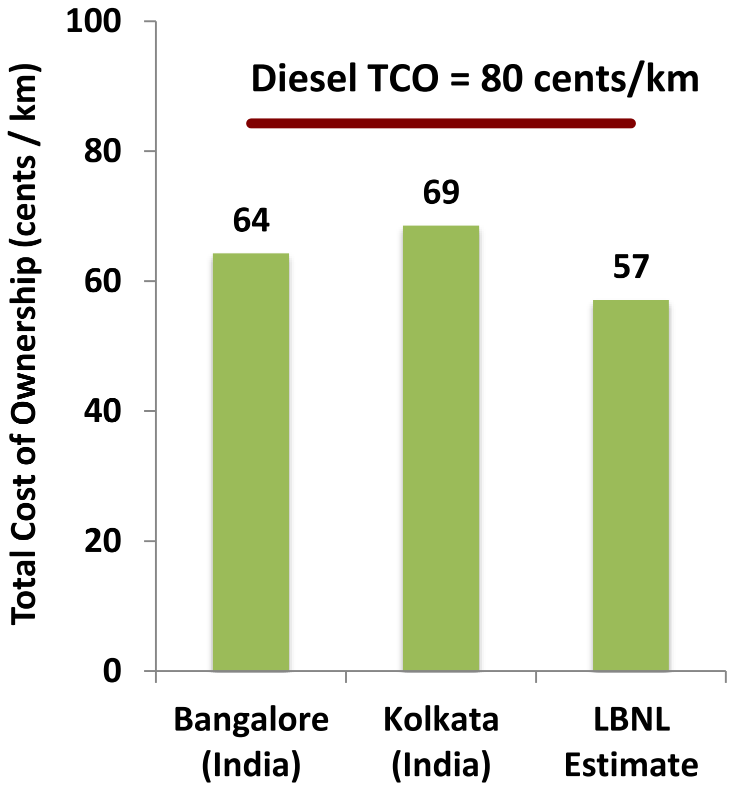
Results from India analysis

Local environmental benefits are not even counted here

- Since EVs are inherently more efficient than gasoline/diesel vehicles, greenhouse gas emissions reduce even in case of the current coal heavy grid
- Much deeper decarbonization of transportation is possible with more ambitious clean power targets

Although Electric Bus Capital Cost is Marginally Higher than a Diesel Bus, its Total Cost of Ownership (cost per km) is much lower





Policies can play a major role in achieving scale and ensuring sustained cost reduction

Policy has a big role to play for ensuring manufacturing scale and sustained cost reduction

- Accounting of the externalities (local air pollution and greenhouse gas emissions) is crucial

- Creating a demand for electric vehicles
  - California's Zero Emissions Vehicle (ZEV) policy

- Incentives and bulk procurement programs
  - Fleet level electrification e.g. government vehicles or buses etc.

- Complementary programs
  - E.g. demand response, smart charging etc.

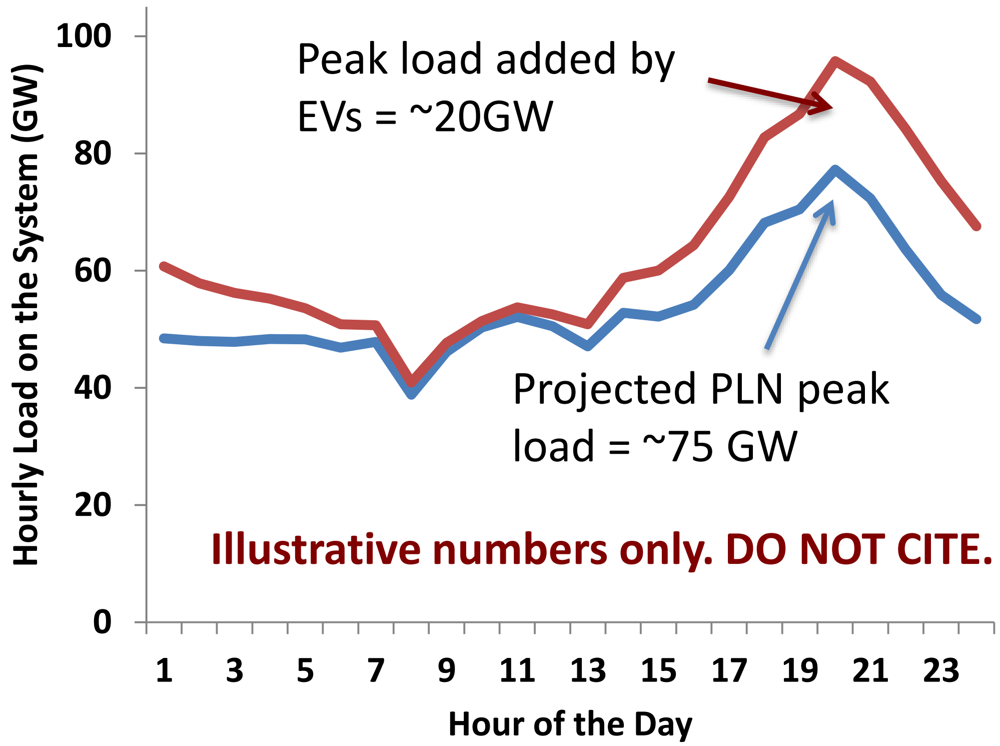
In Indonesia, EVs can add significant peak load onto the system

- *Let's do a simple math for 2030:*
- Assume Indonesia has 150 cars per 1000 people by 2030 (i.e. ~50 million cars in total)
- Assume the entire fleet is converted to electric
- Typical electric car efficiency = 0.15 kWh/km
- Distance traveled = 40 km/day (~12,000 km/yr)
- Total electricity use by EVs in 2030 = ~80 TWh/yr
- Projected PLN sales by 2030 = ~450 TWh/yr
- >20% increase in PLN's sales and revenue !

Illustrative numbers only. DO NOT CITE.

- Fast charging infrastructure may change the grid dynamics locally and also in cities with smaller electricity loads

Projected Indonesia Load Curve in 2030



Fast charging infrastructure is crucial for aggressive EV adoption

- Slow charging may lead inefficient use of the EV assets

- Several fast charging standards / protocols exist
    - CHAdeMO (Japan) – up to 70kW (CAN)
    - CCS (Europe and US) – up to 90 kW (PLC)
    - Tesla Supercharger (US) – 120 kW
    - GB/T (China) - ~70-300 kW standard, ~900 kW (proposed along with CHAdeMO) (CAN)

- In China, fast chargers (~300kW) have been deployed in several cities
    - @ 300 kW, battery can be charged within ~1 hour
    - No significant impact on battery life or performance despite high ambient temperatures (40-42 deg C)

- LTO batteries may perform better with fast charging than NMC or LFP

- Legal and regulatory barriers in setting up third party chargers need to be addressed

Key Takeaways

- Emerging economies such as Indonesia have a unique opportunity to leapfrog to a cleaner and smarter mobility future
- Policies can help EV manufacturing reach scale and lower costs
- EVs will likely increase the PLN revenue and can offer several services to the grid and help cost-effective integration of renewable energy
- Creation of the fast charging infrastructure is crucial – need to address certain technical, siting, and regulatory challenges

Thank you

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Example Simulation

Charging Events

Residential

Level 1

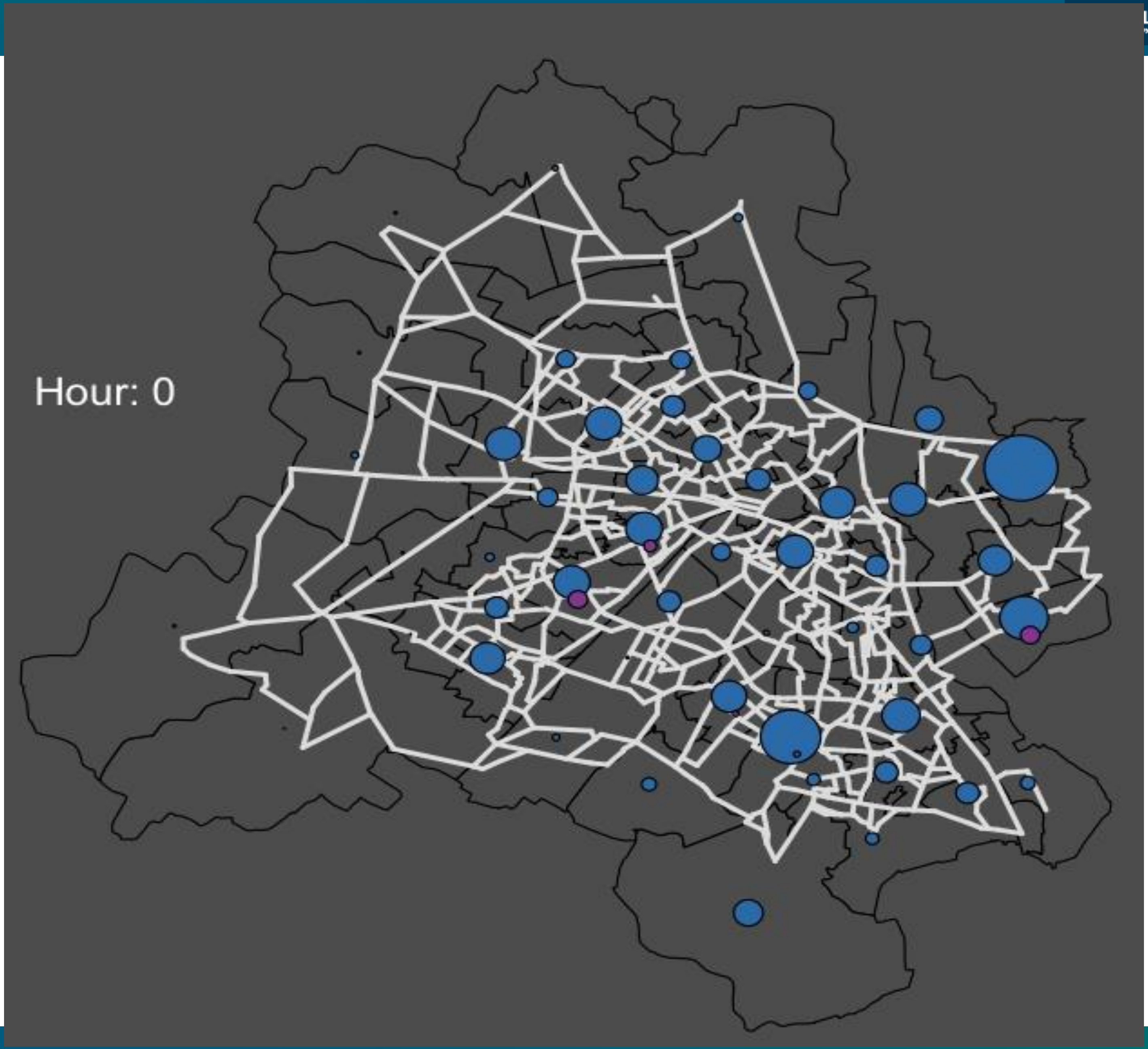
Level 2

Level 3

Driver Inconvenience

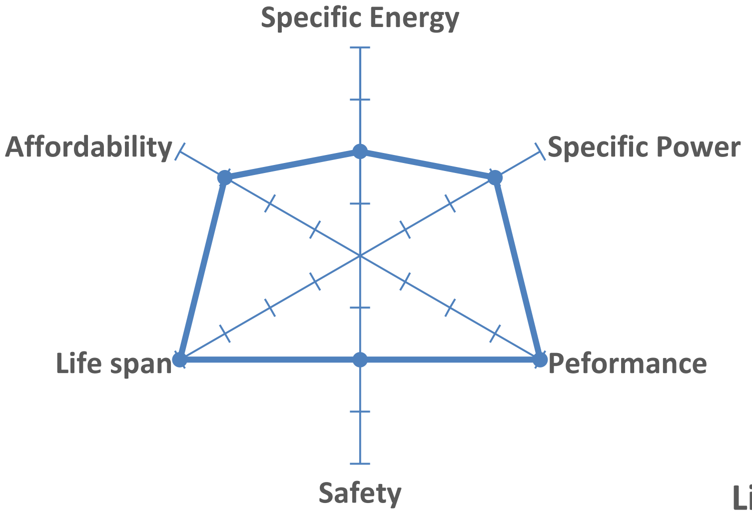
Delayed

Stranded

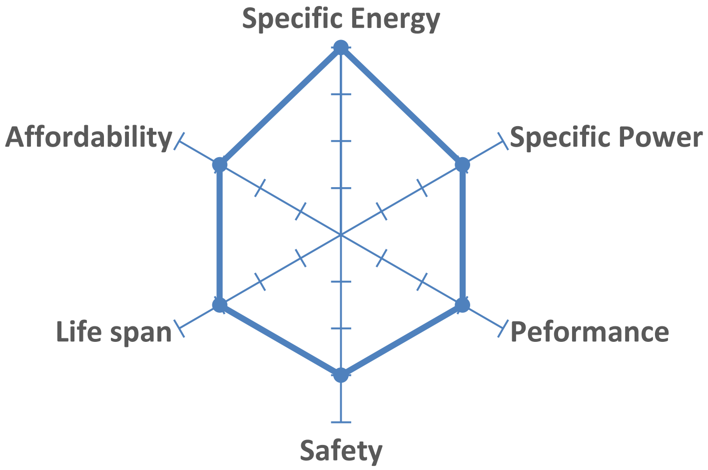


Most EV manufacturers want to move from using LFP to NMC due to higher specific energy and stability

Lithium iron phosphate (LFP)



Lithium nickel manganese cobalt oxide (NMC)



Lithium Titanate (LTO)