

Electric Vehicle Integration into the Smart Grid:

Development of an In-Vehicle Communication Board

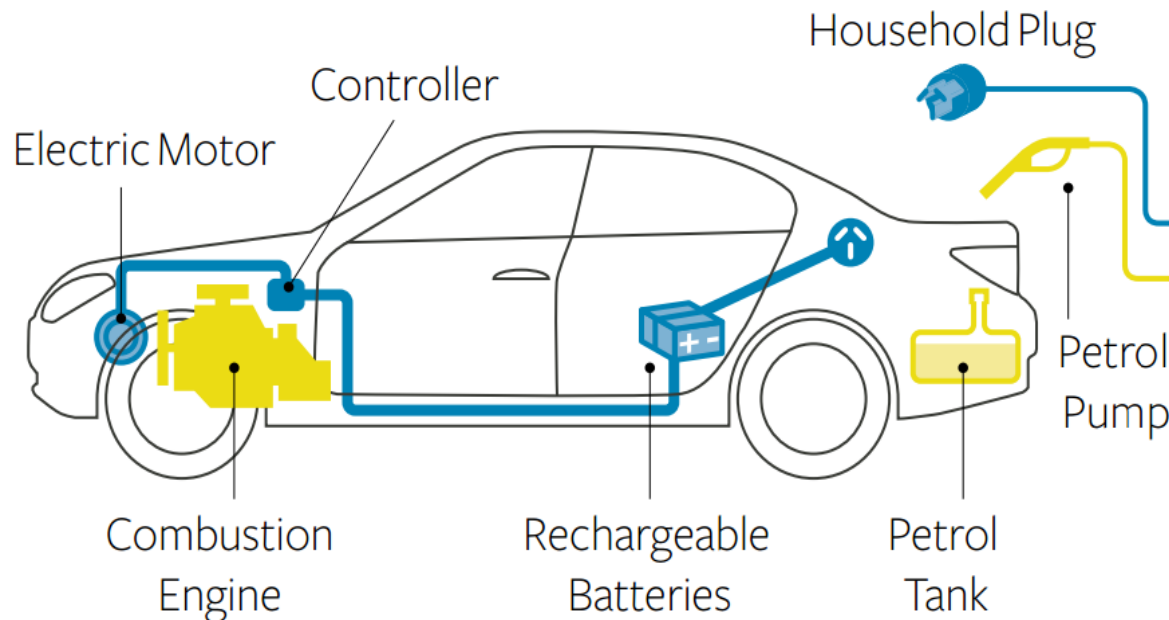
James Cook University
College of Science, Technology & Engineering

Kirk Martel

Supervisor: A/Prof Ahmad Zahedi

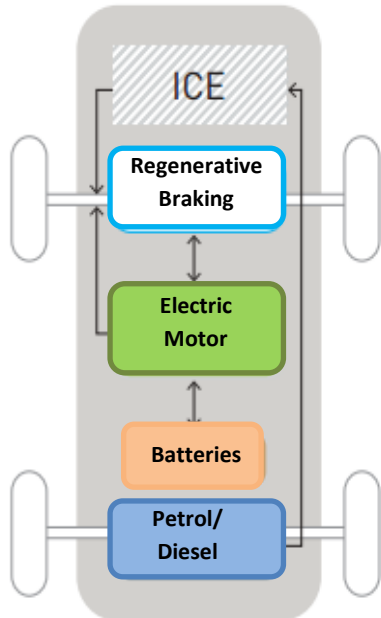
What is an Electric Vehicle?

An electric vehicle (EV) is any vehicle that uses electricity as a source for driving.

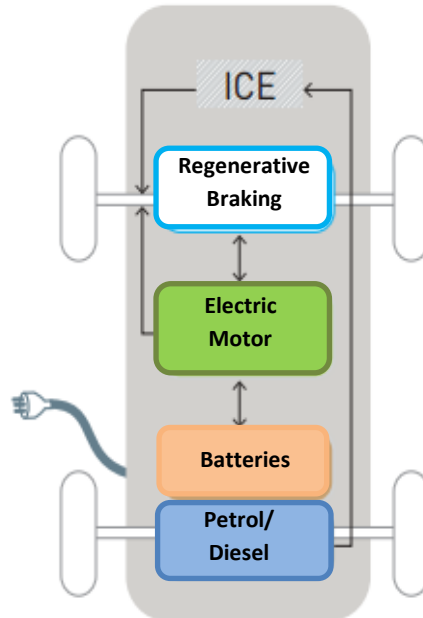


What is an Electric Vehicle?

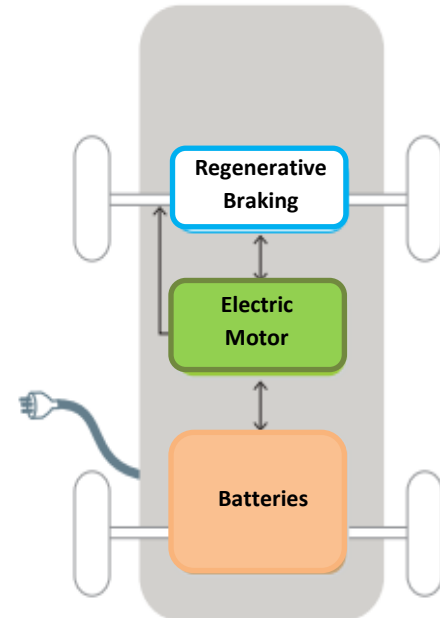
HEV
Hybrid Electric Vehicle



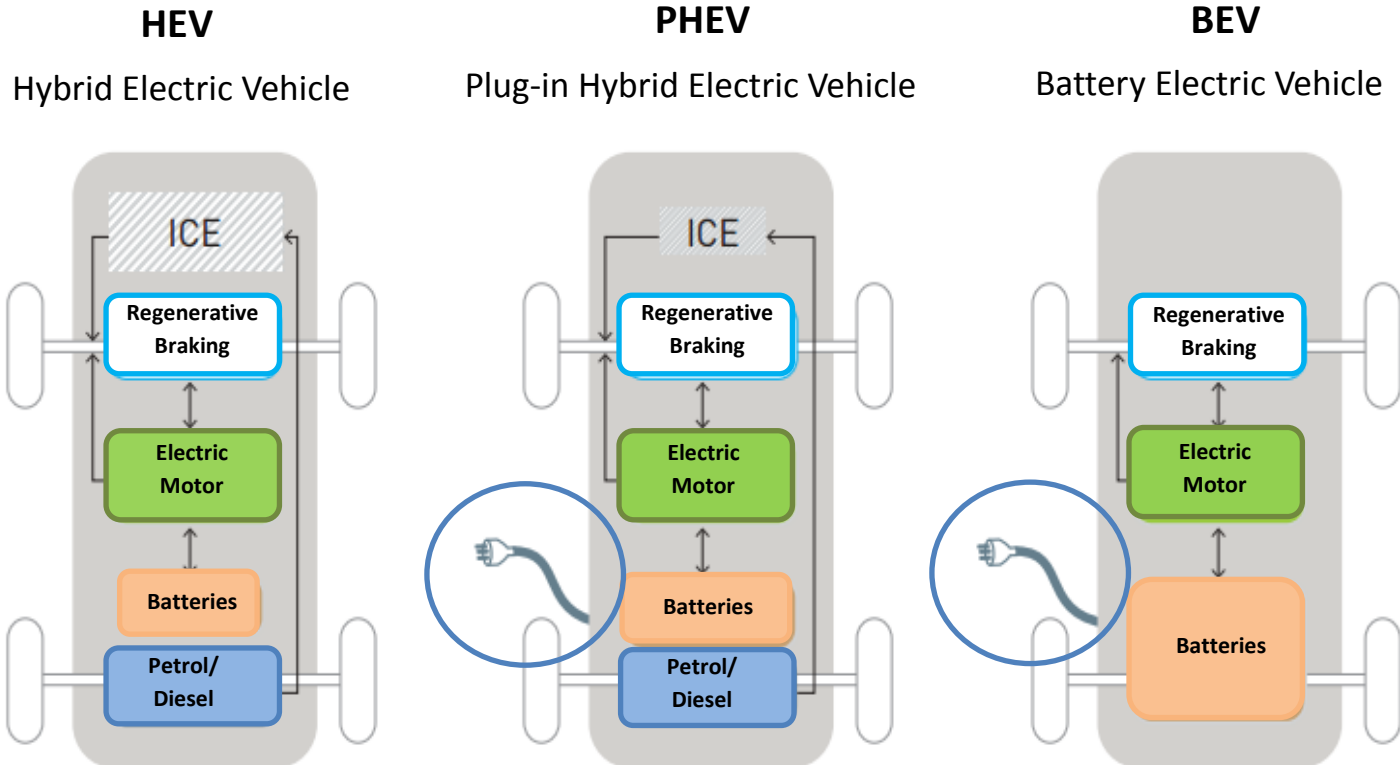
PHEV
Plug-in Hybrid Electric Vehicle



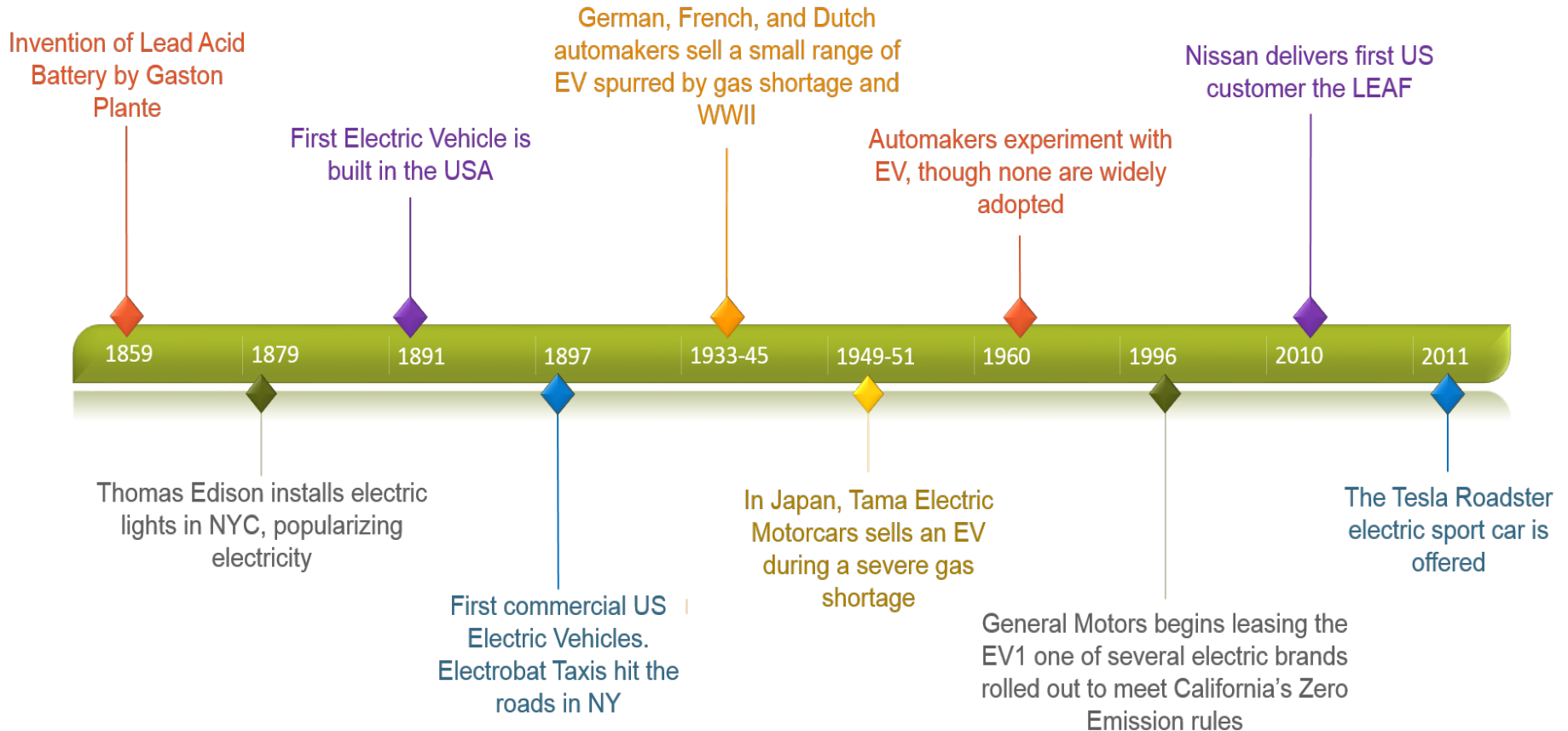
BEV
Battery Electric Vehicle



What is an Electric Vehicle?



History of Electric Vehicles



Why Electric Vehicles?

- In recent years, the uptake of EVs has been encouraged on a global scale.
- EVs offer a number of benefits, including:
 - Reduction of greenhouse gas emissions in the transport industry
 - The elimination of reliance on scarce resources, such as oil and gasoline

Why Electric Vehicles?

- In recent years, the uptake of EVs has been encouraged on a global scale.
- EVs offer a number of benefits, including:
 - Reduction of greenhouse gas emissions in the transport industry
 - The elimination of reliance on scarce resources, such as oil and gasoline
- A number of uptake hindrances have included:
 - Limited power delivery
 - Limited range
 - High upfront costs

Electric Vehicle Technologies

- Recent advancements in both EV and battery technologies have addressed these previously inherent limitations.
- The advent of Lithium ion (Li-ion) battery technology has contributed to the recent spark in the electric vehicle market.
- These batteries offer:
 - Higher energy density
 - Higher power
 - A longer cycle life

Electric Vehicle Technologies: Models



Tesla Model S (480 km)



BMW i3 (190 km)



Mitsubishi i-MiEV (150 km)



Nissan LEAF (135 km)

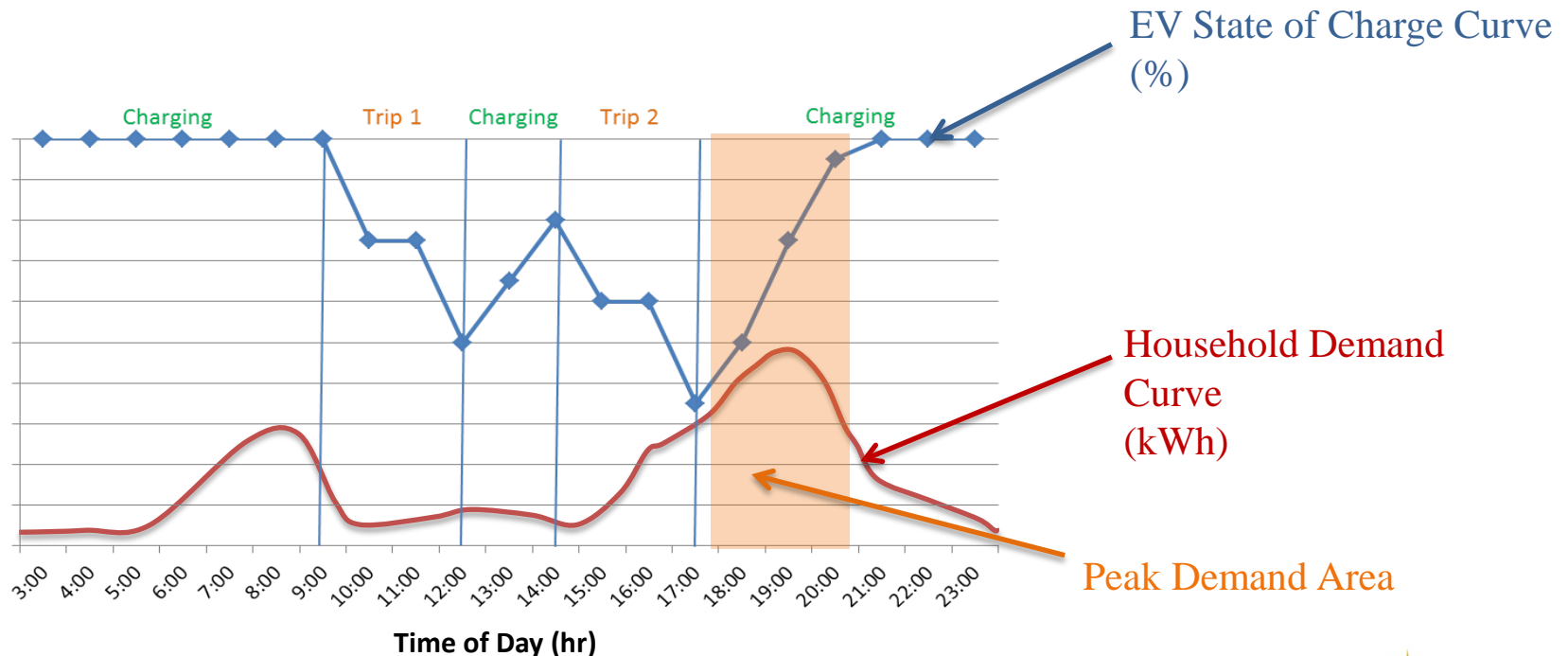
Electric Vehicle Technologies: Models

Model	EV Type	Battery	Range (up to)
Tesla Model S	BEV	Li-ion	480 km
BMW i3	BEV	Li-ion	190 km
Mitsubishi i-MiEV	BEV	Li-ion	150 km
Nissan LEAF	BEV	Li-ion	135 km
Chevrolet Spark	BEV	Li-ion	130 km
Kia Soul EV	BEV	Li-ion	160 km

- Most BEV models can come with a petrol engine range extender to overcome range anxiety (effectively making them a PHEV).

Future Impacts

- The impact that EVs will have on electricity networks depends on how the owners will charge their vehicles.
- Uncontrolled charging:



Smart Charging

- Smart charging involves charging electric vehicles when the electricity demand is low.
- Furthermore, if operated properly, EVs can be used to provide support to the network during times of peak demand; a concept called Vehicle-to-Grid (V2G) support.
- The integration of EVs could present a great opportunity for improving both the efficiency and reliability of networks on a large scale, provided that smart charging practices are adopted.

Smart Charging

- How do we encourage the adoption of smart charging practices?
 - By communicating with electricity consumers the negative impact of uncontrolled charging
 - By establishing smart charging incentives
 - By informing consumers of the equivalent benefits that can be reaped from these incentives
- All of this can be done with future technologies of the Smart Grid.

The Smart Grid

The Smart Grid is considered *smart* because it:

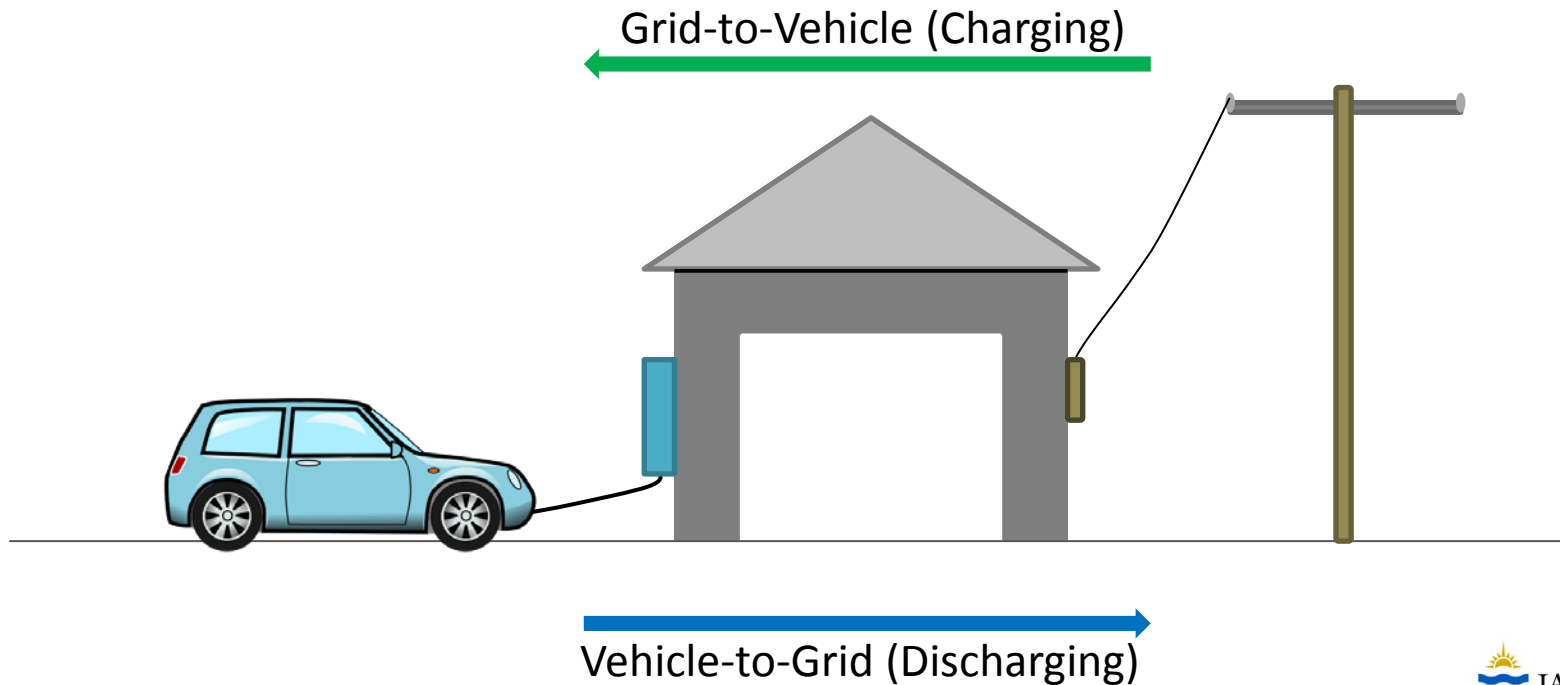
- Supports renewable technologies
- Empowers consumers through communication

This is through:

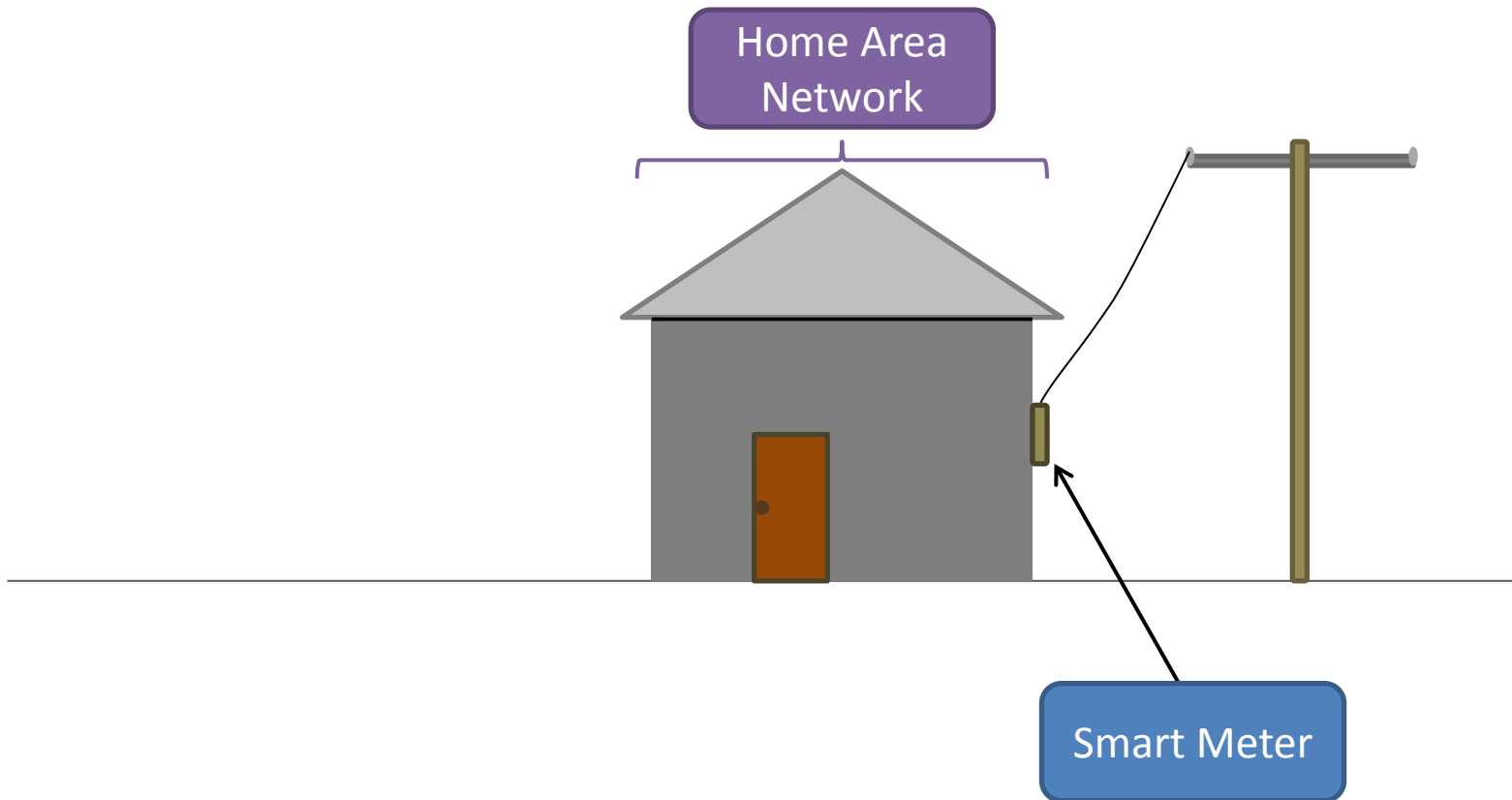
- Bi-directional power flow
- Bi-directional communication in near real-time via smart meters
- Remote control of loads

EV Integration Strategies

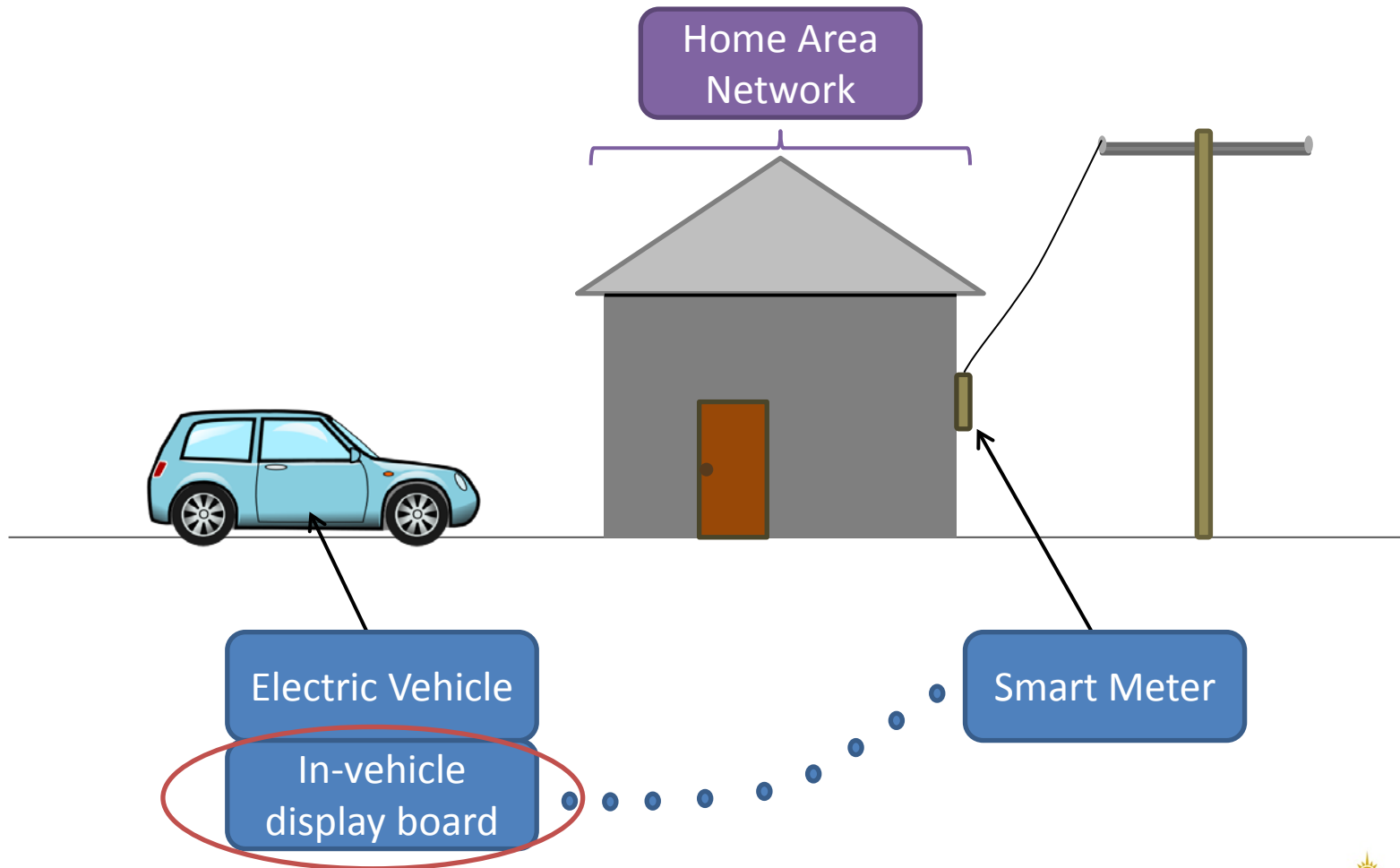
- Flexible Pricing
- Time of Use (TOU) Tariffs
- Vehicle-to-Grid Incentives



In-Vehicle Communication Board



In-Vehicle Communication Board



Display Features

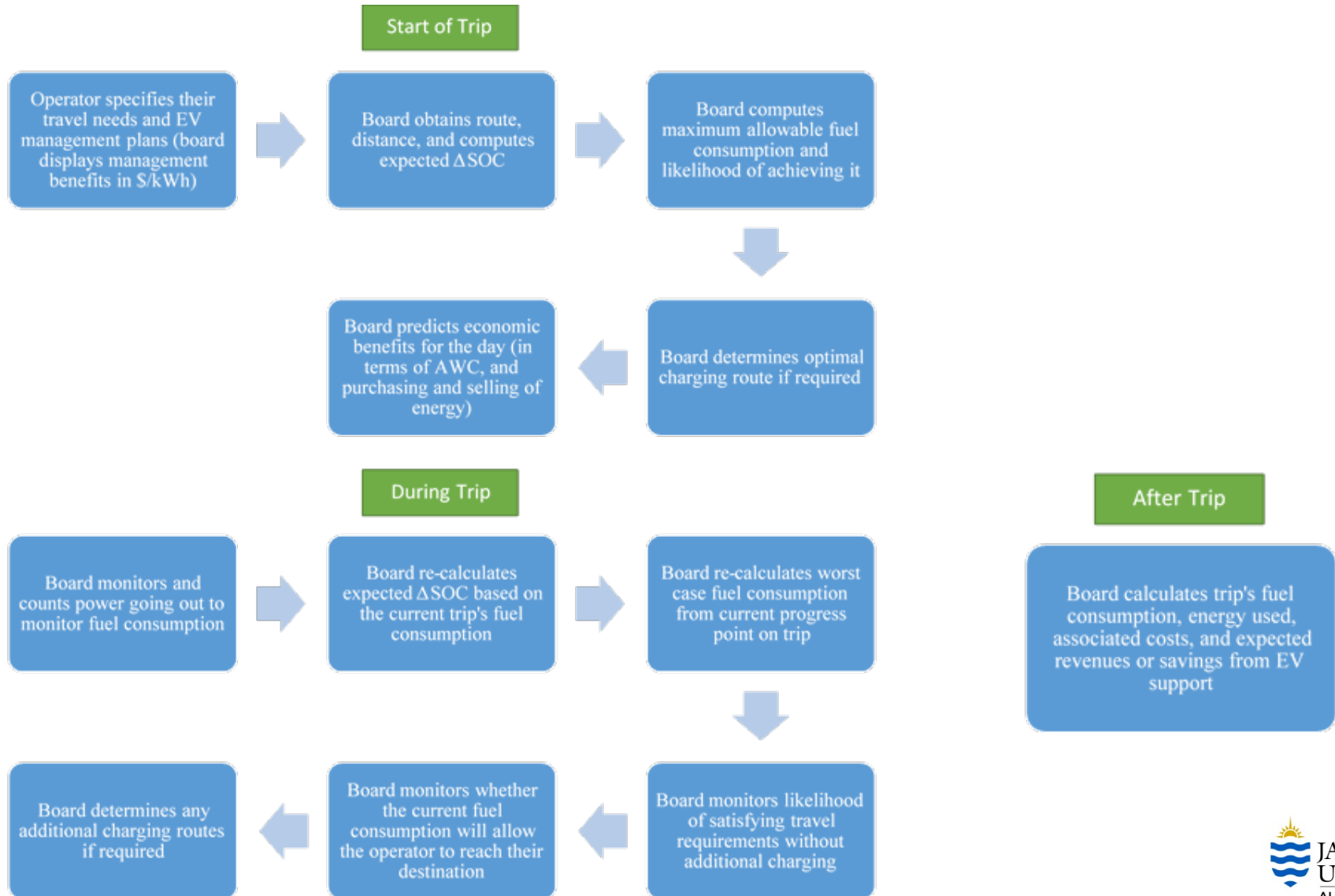
- Battery characteristics:
 - State of Charge
 - State of Health
 - Remaining Useful Life
- Electricity network information:
 - Prices
 - System load conditions
 - Equivalent emissions intensity of the network's electricity

Display Features

- Charging/Discharging schedule optimization:
 - Schedule times
 - Schedule costs
- Equivalent battery wear costs
- Economic benefits due to smart charging practices

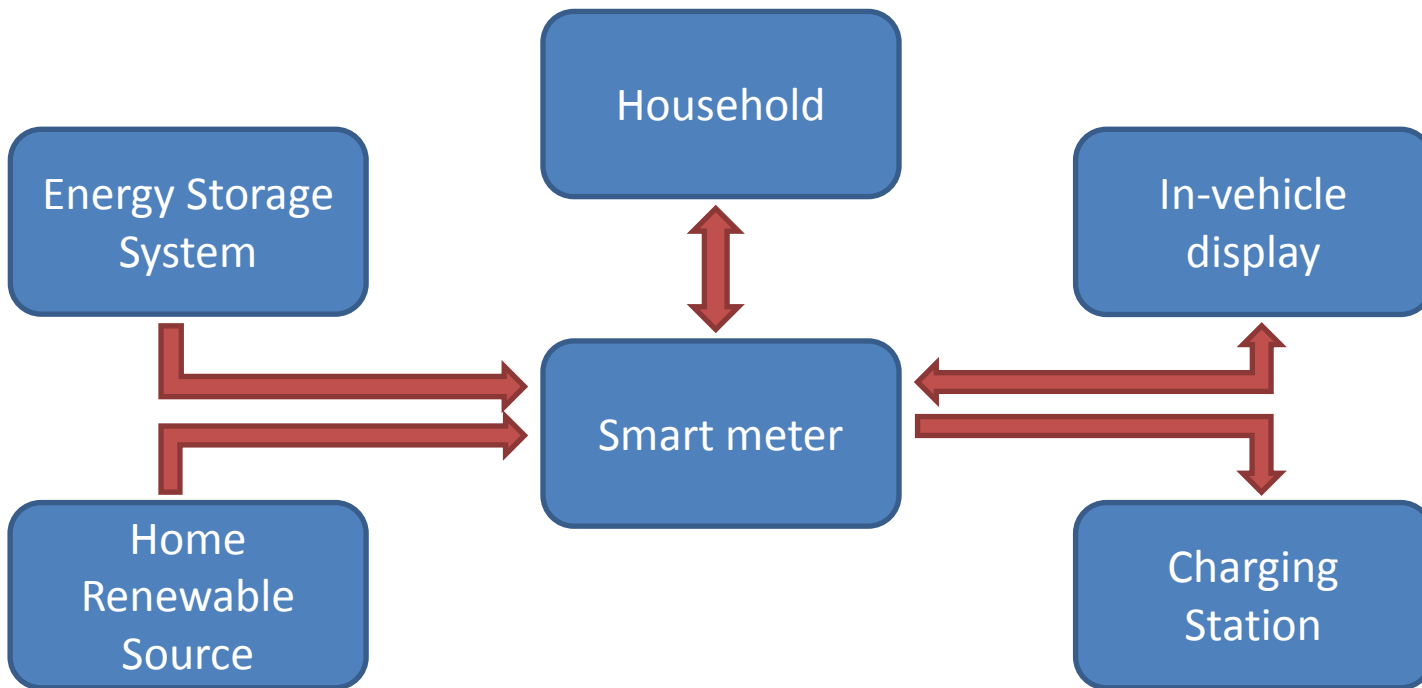
Display Features

- Travel Information:



Display Features

- Smart Home Information:



Conclusion

- A renewed interest in the EV industry has been sparked due to:
 - Emerging technologies in this industry
 - Issues such as climate change and the reliance on scarce energy resources
- A large-scale deployment of EVs could adversely affect our electricity networks.
- Appropriate preparation for this deployment, as well as the deployment of Smart Grid technologies, could create a positive impact for the future integration of EVs.

Conclusion

- A smooth integration of EVs requires their respective operators to adopt smart charging practices.
- This can be done using the proposed communication board, where:
- The purpose of this device is to encourage smart charging and V2G services whilst providing the consumer with relevant information to ensure they will be rewarded.

Thank you all for listening.

Myself:

Kirk Martel (Undergraduate)

James Cook University
Bachelor of Electrical and Electronic
Engineering

P: 0408 158 941

E: kirk.martel@my.jcu.edu.au

Thesis Supervisor:

A/Prof Ahmad Zahedi (PhD)

James Cook University
College of Science, Technology and
Engineering

P: 07 4781 6907

E: Ahmad.Zahedi@jcu.edu.au