Modeling the deployment of plug-in hybrid and electric vehicles and their effects on the Australian National Electricity Market.

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Plug in Hybrid Electric Vehicles:

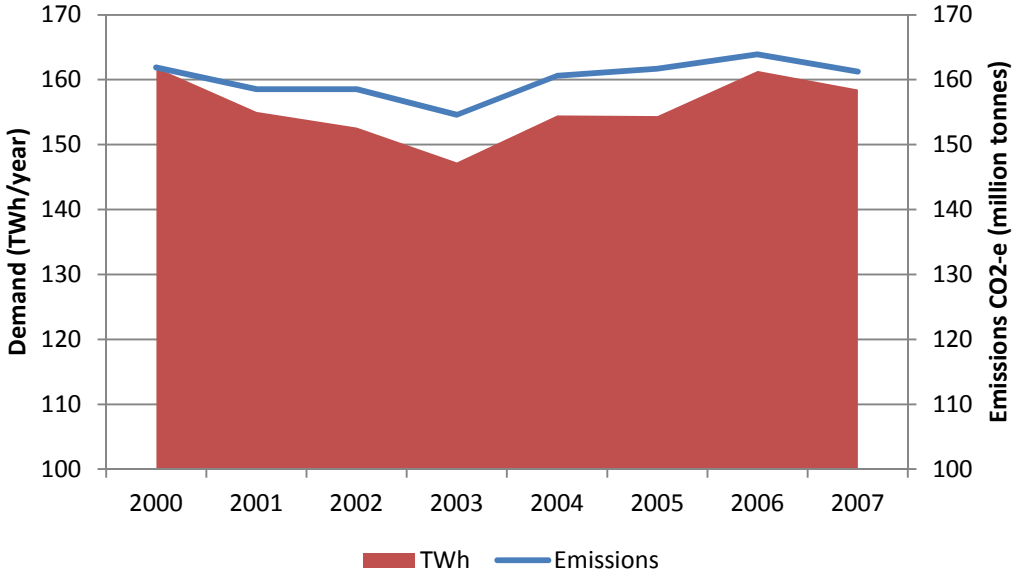
- Enhance Australia's emissions abatement target.
- Could have an impact on demand during evening peak.
- Growth maybe be slow for consumer uptake.
- Effect on grid security has yet to be examined in Australia.
- We examine Light and Medium commercial vehicles and their affects on the National Electricity Market.
- These types of PHEV's have been used by large companies to reduce their carbon footprint such as the US post Office.

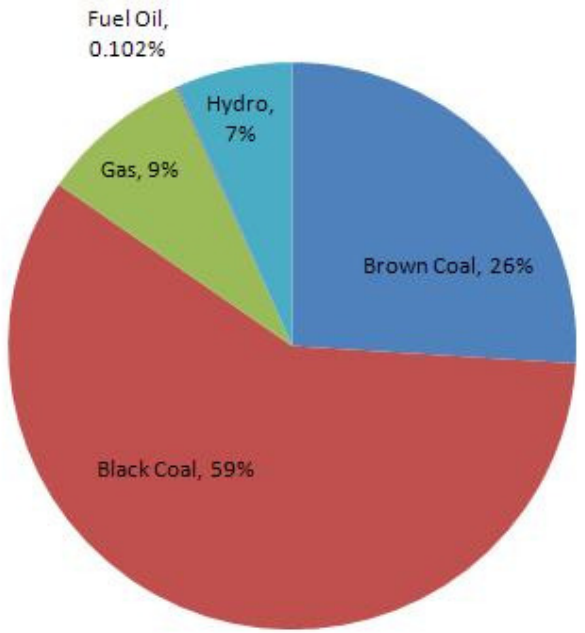
Mercedes-Benz Sprinter, used by the US Postal Service

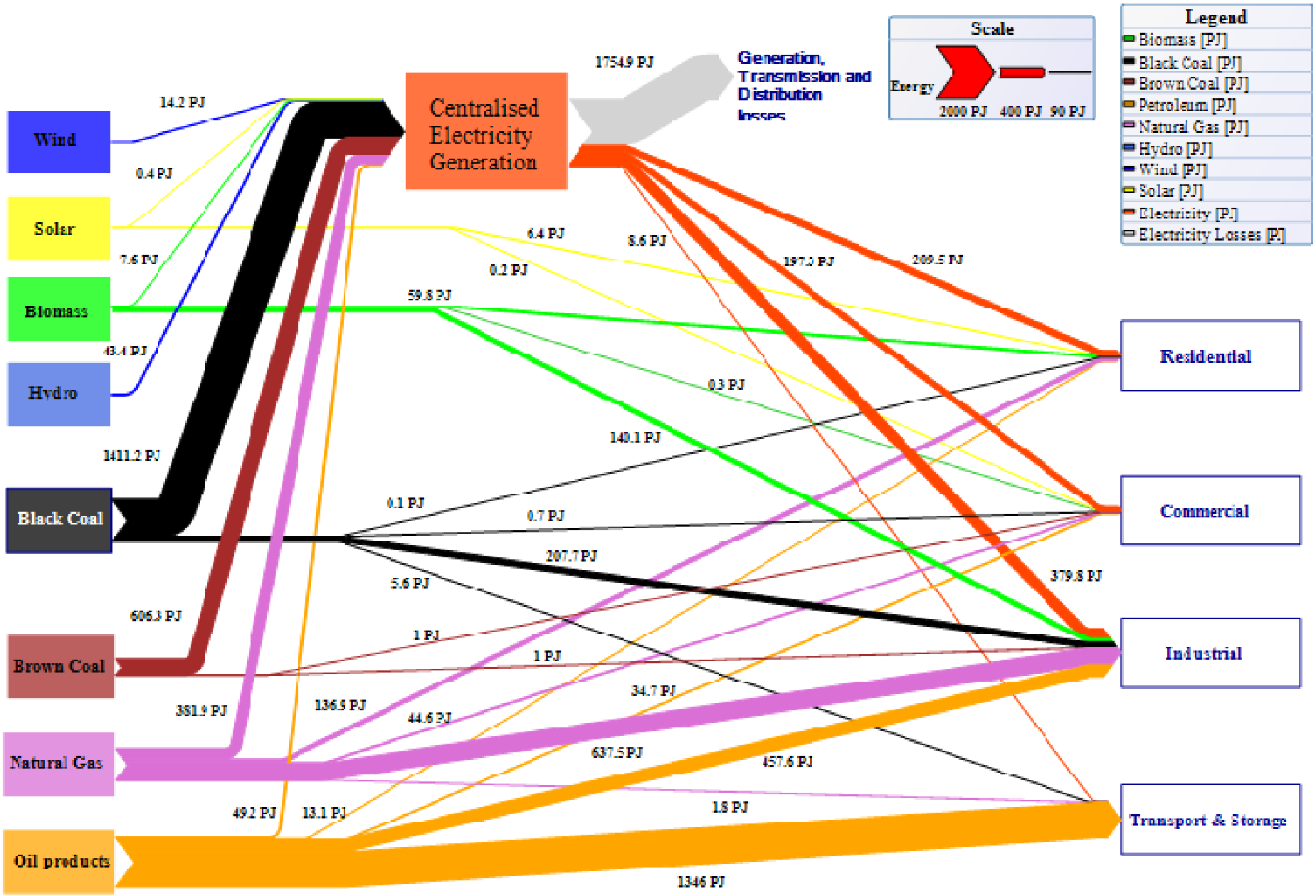
Renault Kangoo, small delivery van

Electricity in Australia:

- The average Emissions Intensity Factor (EIF) for electricity generation is 1.01t-CO_2/MWh
- Emissions trading scheme is still one of the key energy and environmental policies currently in flux.
- Black and Brown coal fired power stations compose 85% of generation.







Australian Energy Supply, Energy Flows 2007/2008

Sources: L.D. Wagner (2010), ABARE, ABS, AEMO, AER, ESAA

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Modeling Assumptions:

- CSIRO ESM model used to provide customer growth data.
- Energy usage and new plant entry timing forecasts from the AEMO, SOO 2009.
- No National Emissions Trading Scheme
- Renewable Energy Target met by 2020 (45 TWh/year)

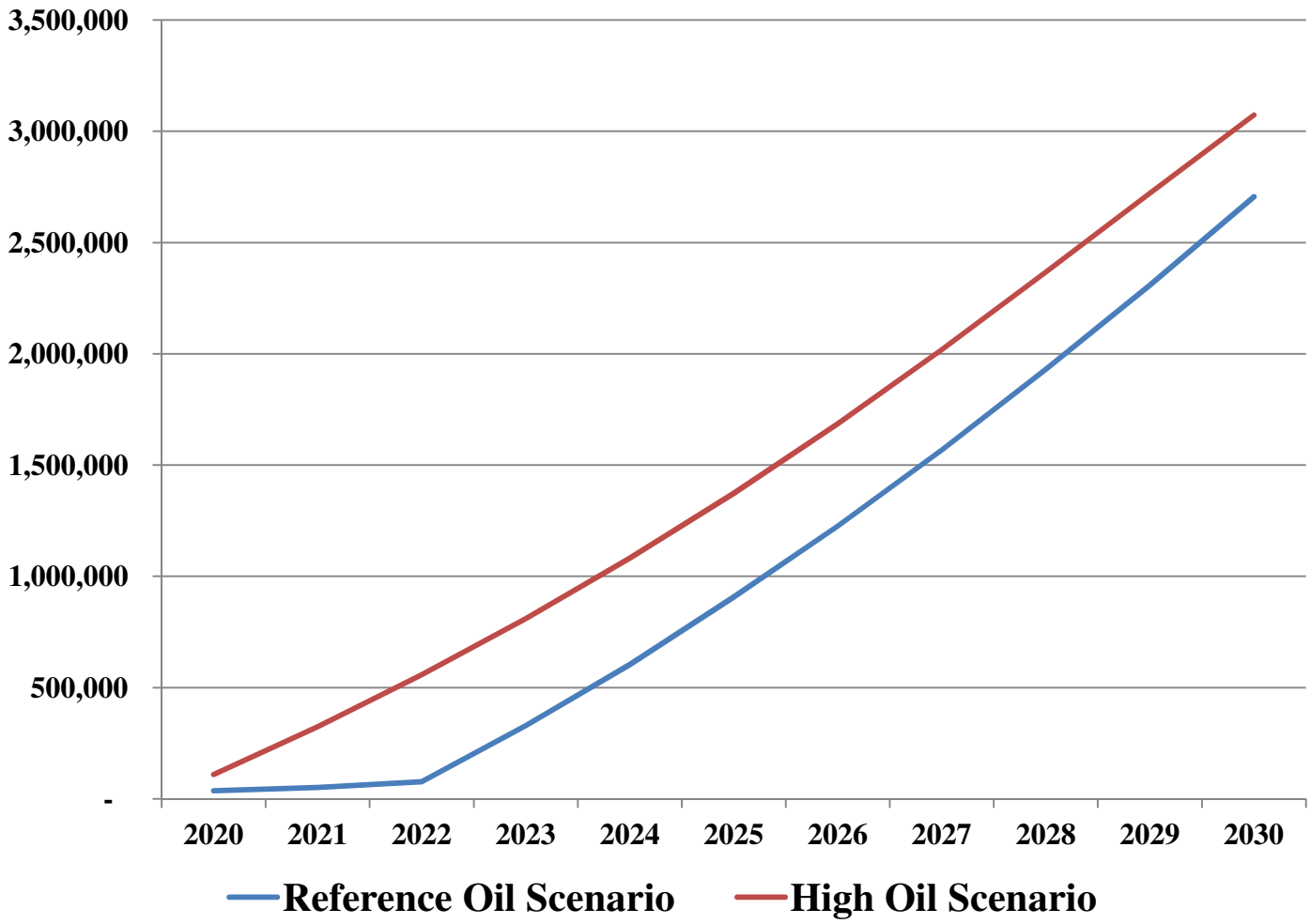
Energy Sector Model (ESM)

- Forecasted consumer demand for PH and EV based on cost of technology types and fuel prices.
- Linear model to maximize social welfare
- Constraints include fuel supply limitations and vehicle stock

Plexos Simulates:

- Optimal Power Flow (OPF) using a DC approximation.
- Optimal dispatch of generators across the NEM.
- Optimal bid stack formulation for each station for Short Run and Long Run Marginal Cost (SRMC and LRMC) recovery.
- Transmission and Interconnector flows.

Vehicle Uptake Scenarios



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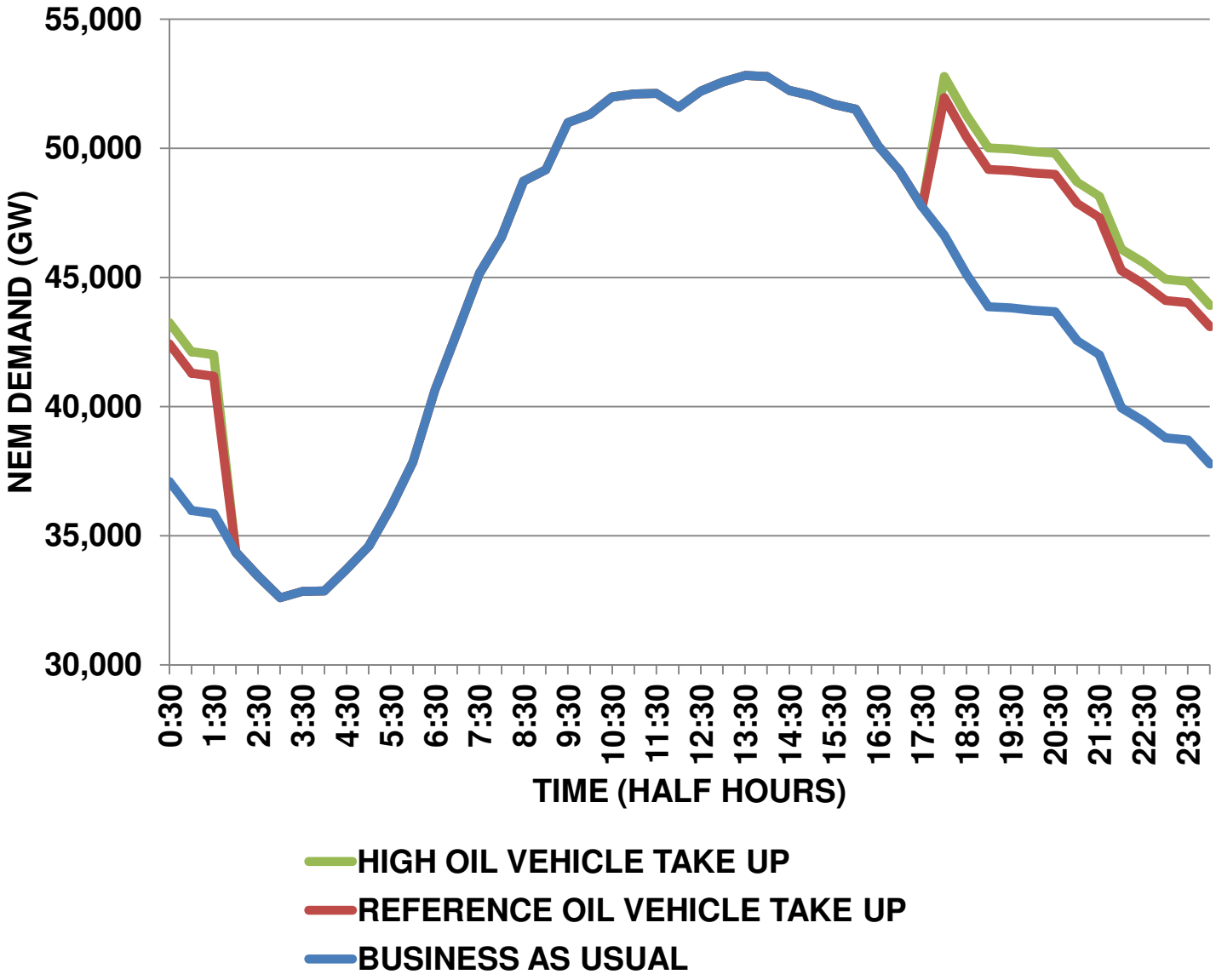
Scenario 1: Uncontrolled Charging



Scenario 1: Uncontrolled Charging

Uncontrolled charging of PHEV's assumes:

- Drivers will connect their vehicles to a power source from 6pm
- Charging rates are assumed to be approx. 2kW/h.
- Charging will require around 6 and 8 hours for light and medium vehicles respectively.

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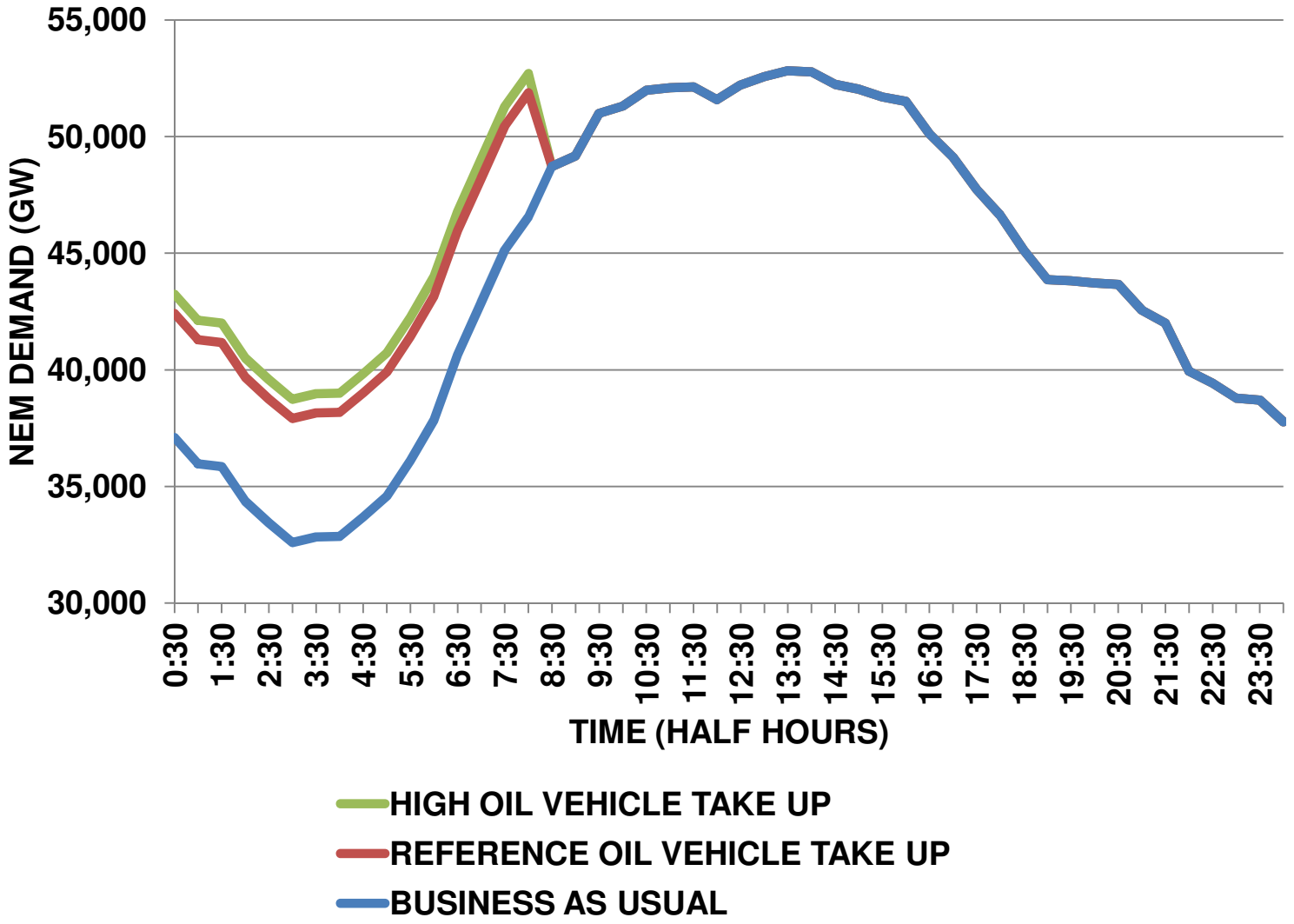
Scenario 2: Controlled Charging

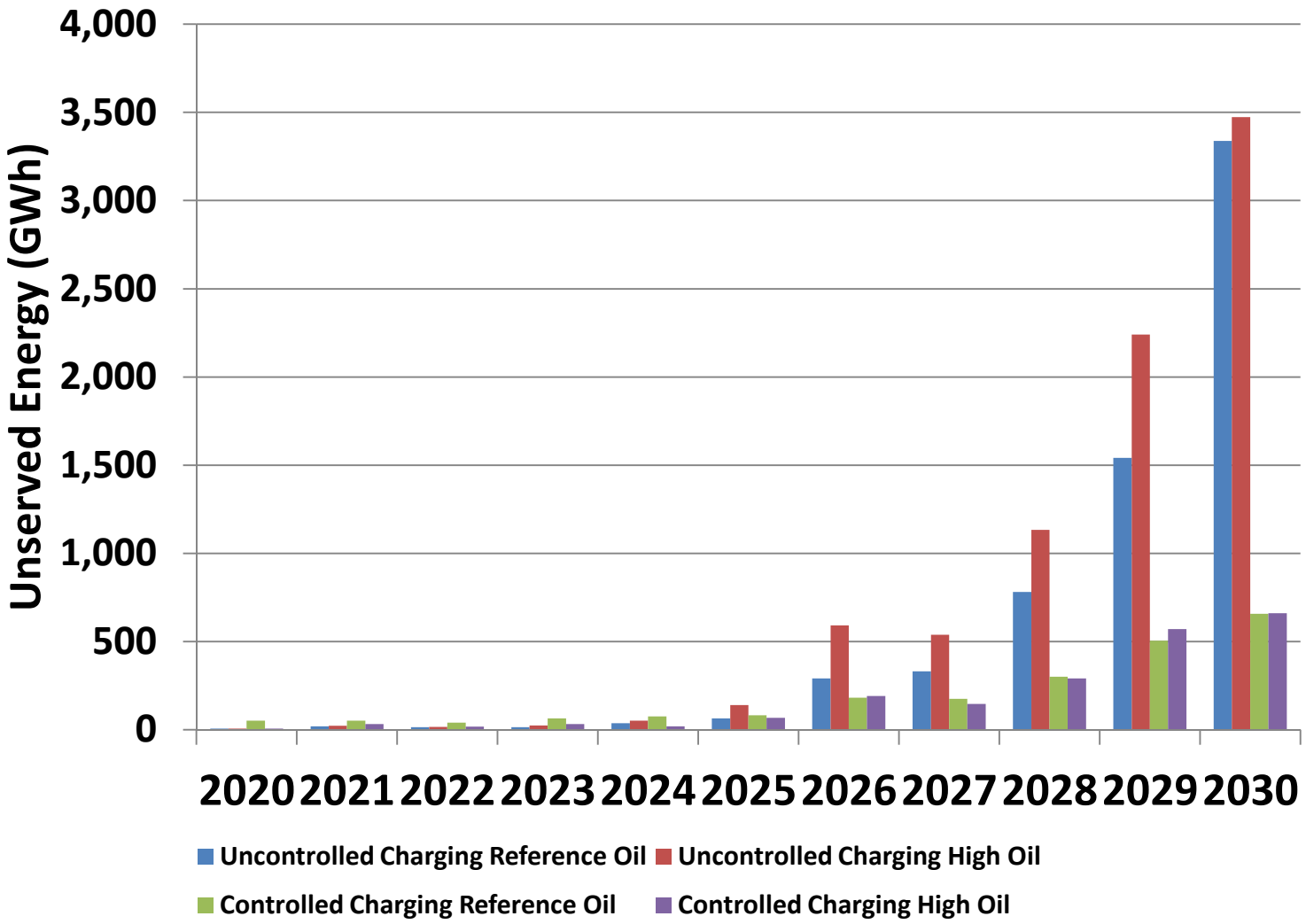


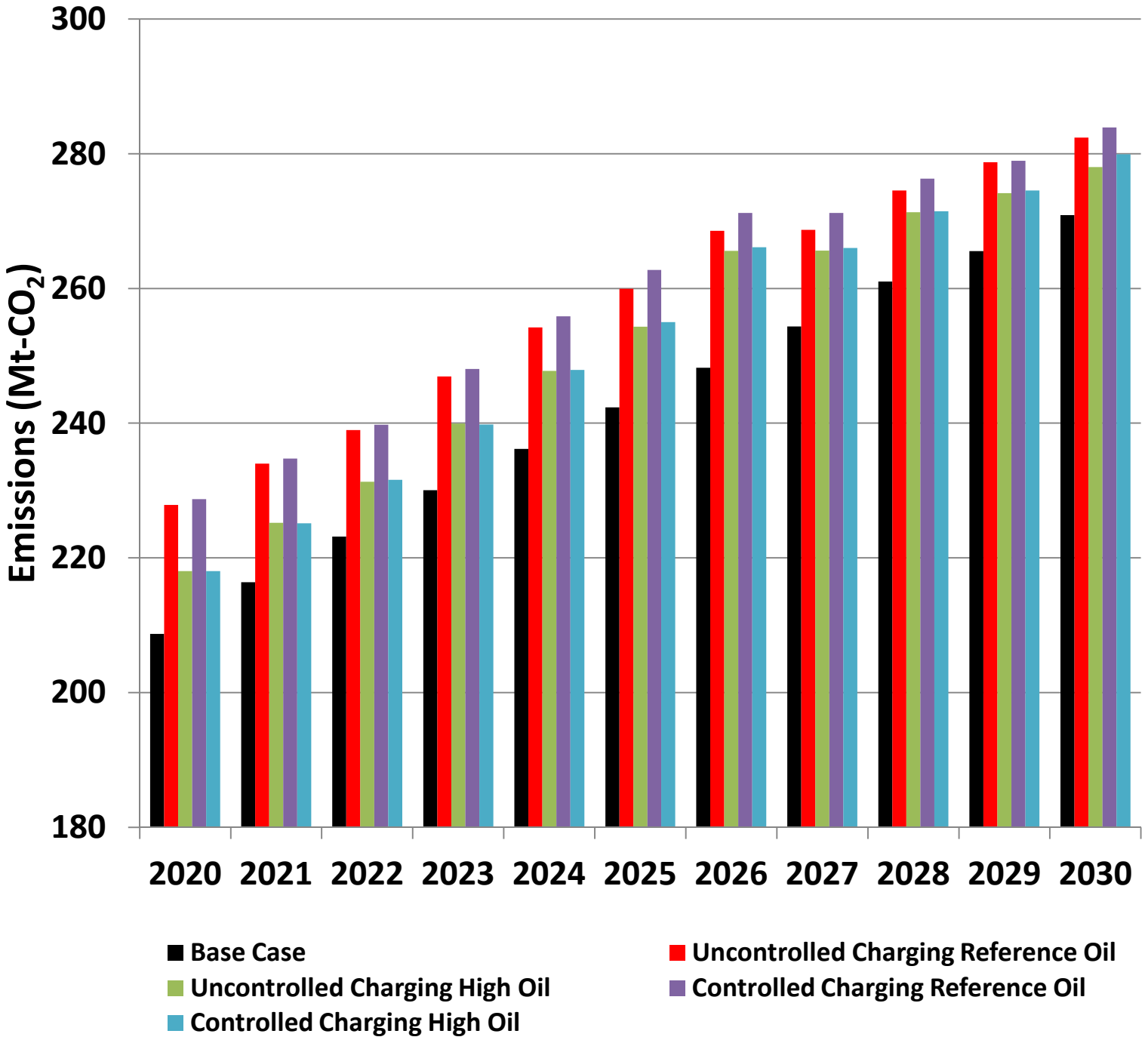
Scenario 2: Off Peak Charging

Controlled charging of PHEV's assumes:

- Charging station/ vehicle control to prevent charging from starting till 10pm.
- The typical off-peak load shape is still distorted.
- NSLP's from all region load centres indicate charging in winter may have an adverse affect on network stability.
- Use of ripple control to time off-peak charging to force restrictions on time of use.

Results:


Unserved Energy (GWh)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
Uncontrolled Charging Reference Oil
Uncontrolled Charging High Oil
Controlled Charging Reference Oil
Controlled Charging High Oil


300
280
260
240
220
200
180
Emissions (Mt-CO2)
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
Base Case
Uncontrolled Charging Reference Oil
Uncontrolled Charging High Oil
Controlled Charging Reference Oil
Controlled Charging High Oil

Conclusions:

- Scenario presents some concerning results with respect to USE compared to our base forecast.
- Modeling suggests Uncontrolled charging during peak time could result in a higher incidence of USE /load shedding.
    - Price and demand duration are significantly less volatile during peak time during summer.
- Demand during winter also presents concerns for charging PHEV with respect to the slower decay rate from evening peak.
- More work needs to be done on charge station control for both domestic and 3-phase charging.