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ESTABLISHING THE POTENTIAL GRID BENEFITS AND DETRACTIONS OF THE DEPLOYMENT OF VEHICLE TO GRID ELECTRIC VEHICLES

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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

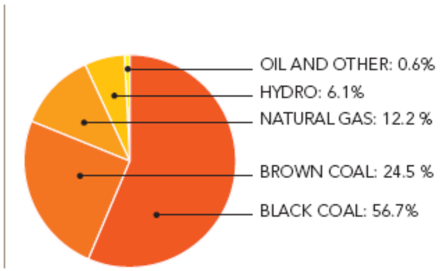
The ~41 GW supply-side covers all of eastern Australia:

- Queensland 10,400MW
- New South Wales 12,300MW
- Snowy Mountains 3,700MW
- Victoria 8,600MW
- South Australia 3,500MW
- Tasmania 2,500MW

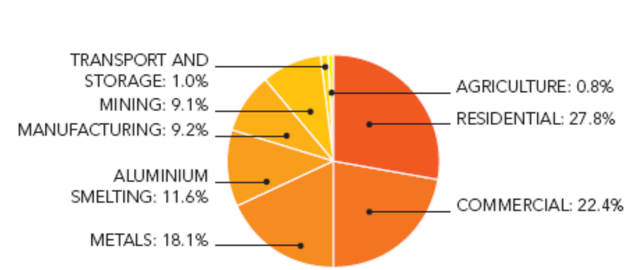
The demand-side:

- Aggregate demand (simultaneous) 32,000MW
- Aggregate energy 205,000GWh
- CO2 emissions at approx 200Mt, about ~35% of the national total

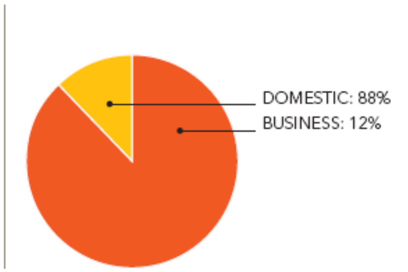
GENERATION BY FUEL TYPE



ELECTRICITY CONSUMPTION BY SECTOR



NUMBER OF CUSTOMERS BY SECTOR



Source: An Introduction to Australia's National Electricity Market, July 2009
Australian Energy Market Operator (AEMO)

Modeling Assumptions:

- CSIRO ESM model used to provide customer growth data.
- Energy usage and new plant entry timing forecasts from the AEMO, SOO 2011.
- Large Renewable Energy Target met by 2020 (~40 TWh/year)
- No carbon price is implemented in this modelling
- EIA Oil price scenarios (Reference and High)
- Australia currently has ~15 million register cars and trucks (2010 ABS)

Energy Sector Model (ESM) (Developed by CSIRO)

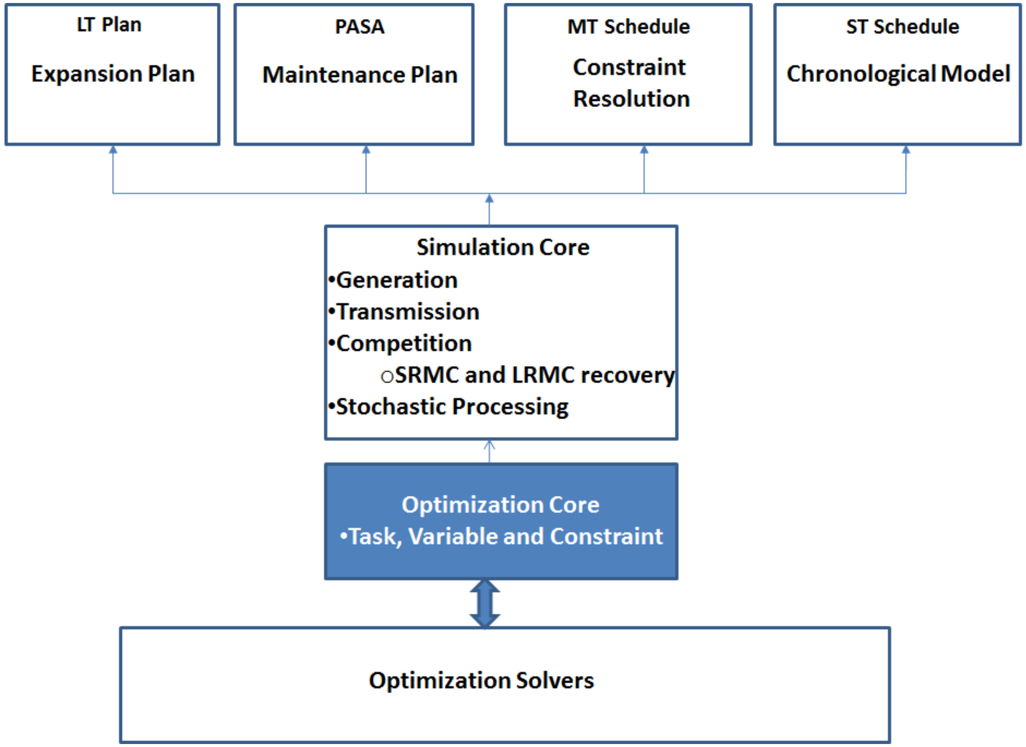
- A Markal type top down modelling framework of Australia's energy system which forecasts:
- Generation investment (Both Central and Distributed technology types)
- Demand forecasts
- Fuel usage
- Transportation sector
- Forecasted consumer demand for PH and EV based on cost of technology types and fuel prices.
- Linear model to maximize social welfare
- Constraints include fuel supply limitations and vehicle stock

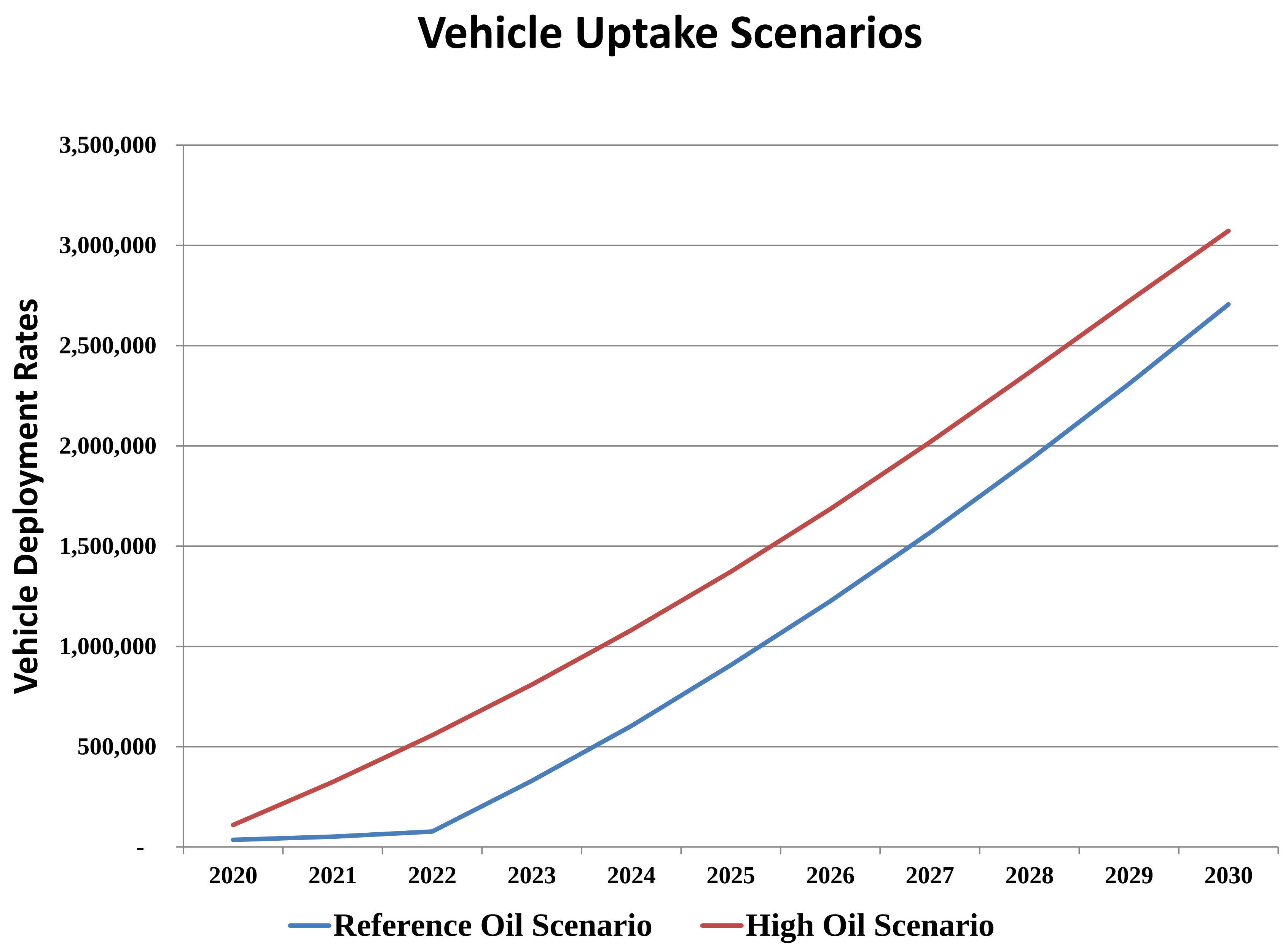
Plexos Simulates:

- 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.





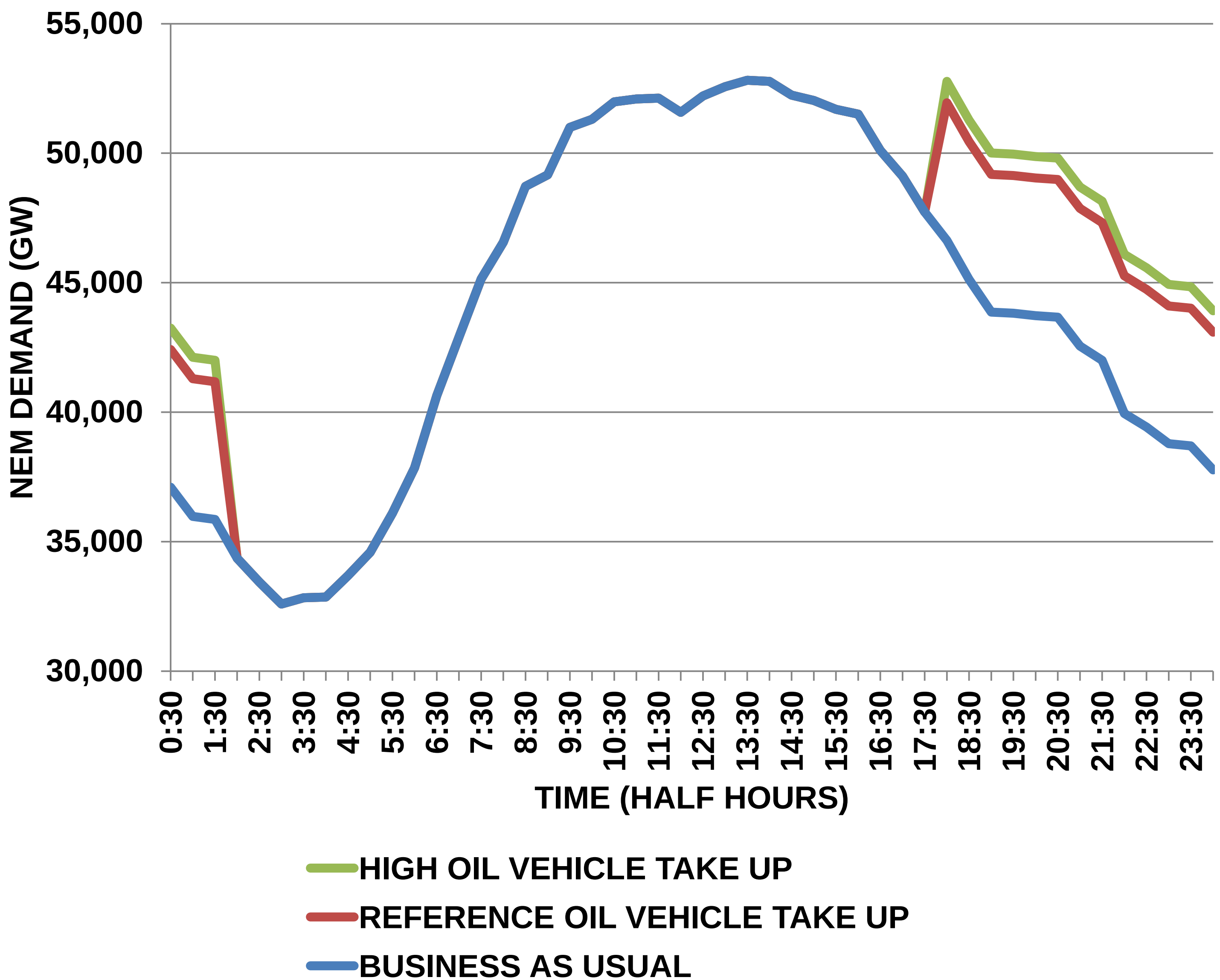
Vehicle Uptake Scenarios
Vehicle Deployment Rates
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
-
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
Reference Oil Scenario
High Oil Scenario

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.
- No vehicle-to-grid control

Scenario 1: Uncontrolled Charging



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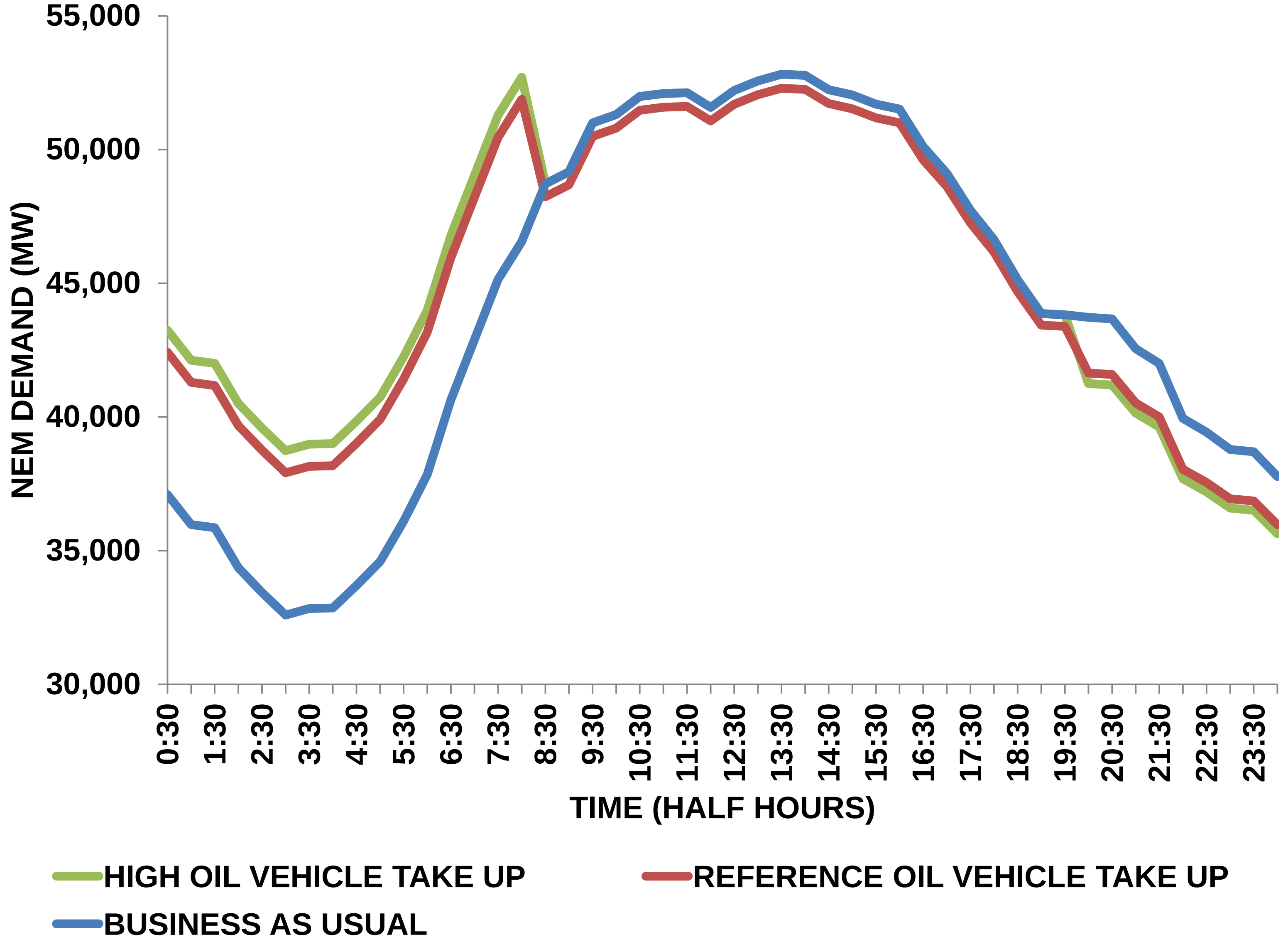
Scenario 2: Off Peak Charging and V2G Discharge

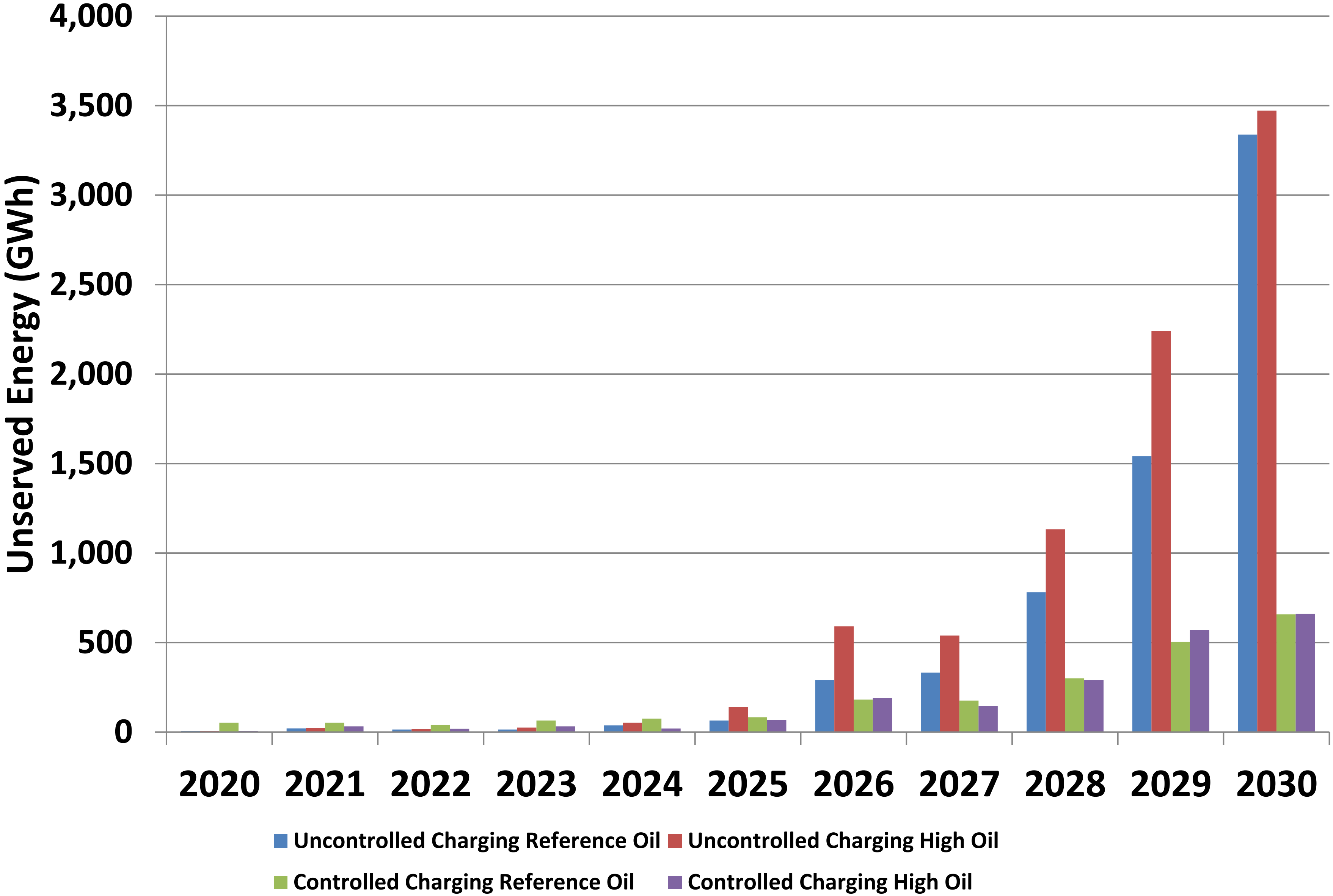
Controlled charging of PHEV’s assumes:

- 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.
- Vehicle-to-grid infrastructure enabled

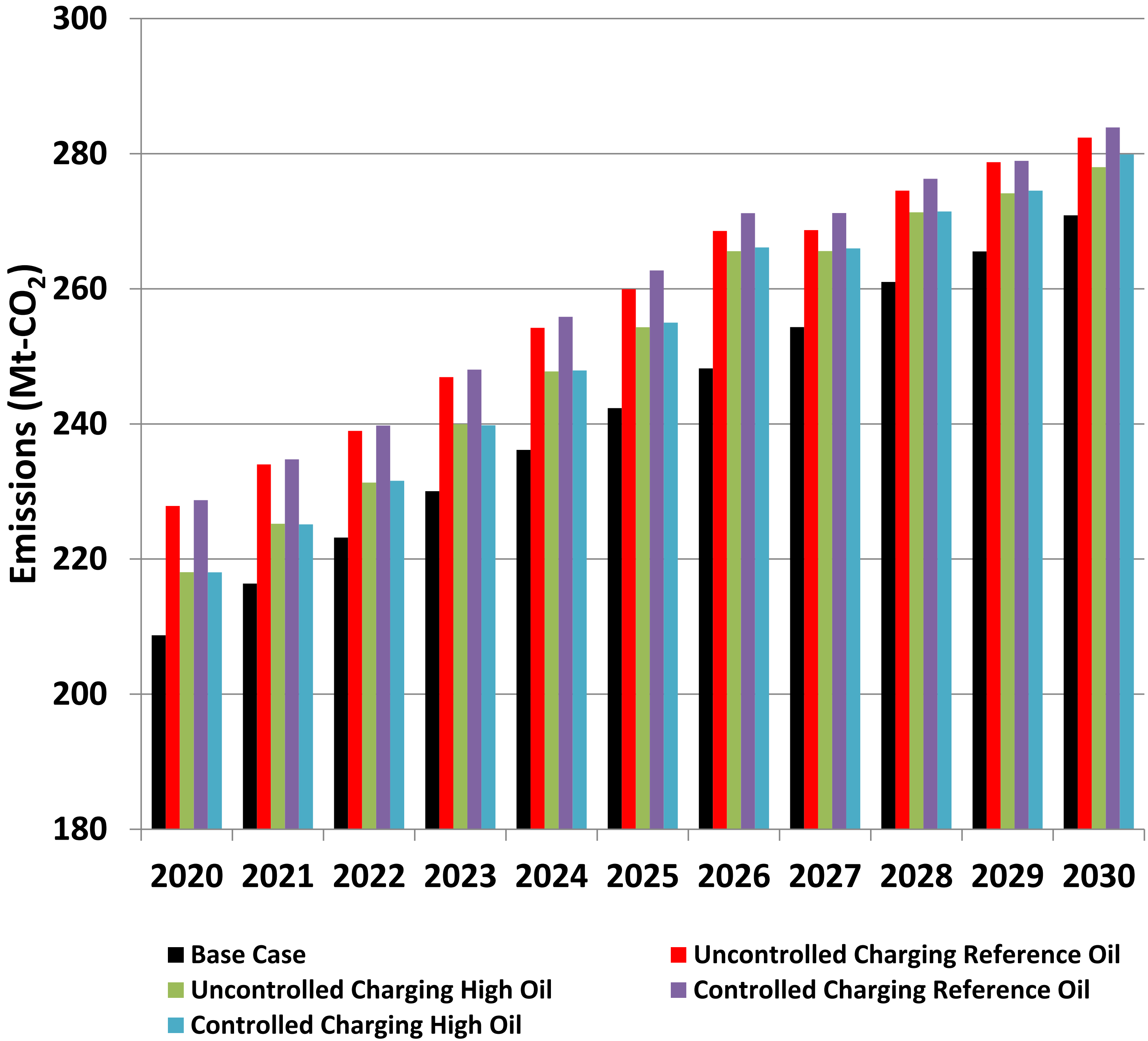
Scenario 2: Controlled Charging



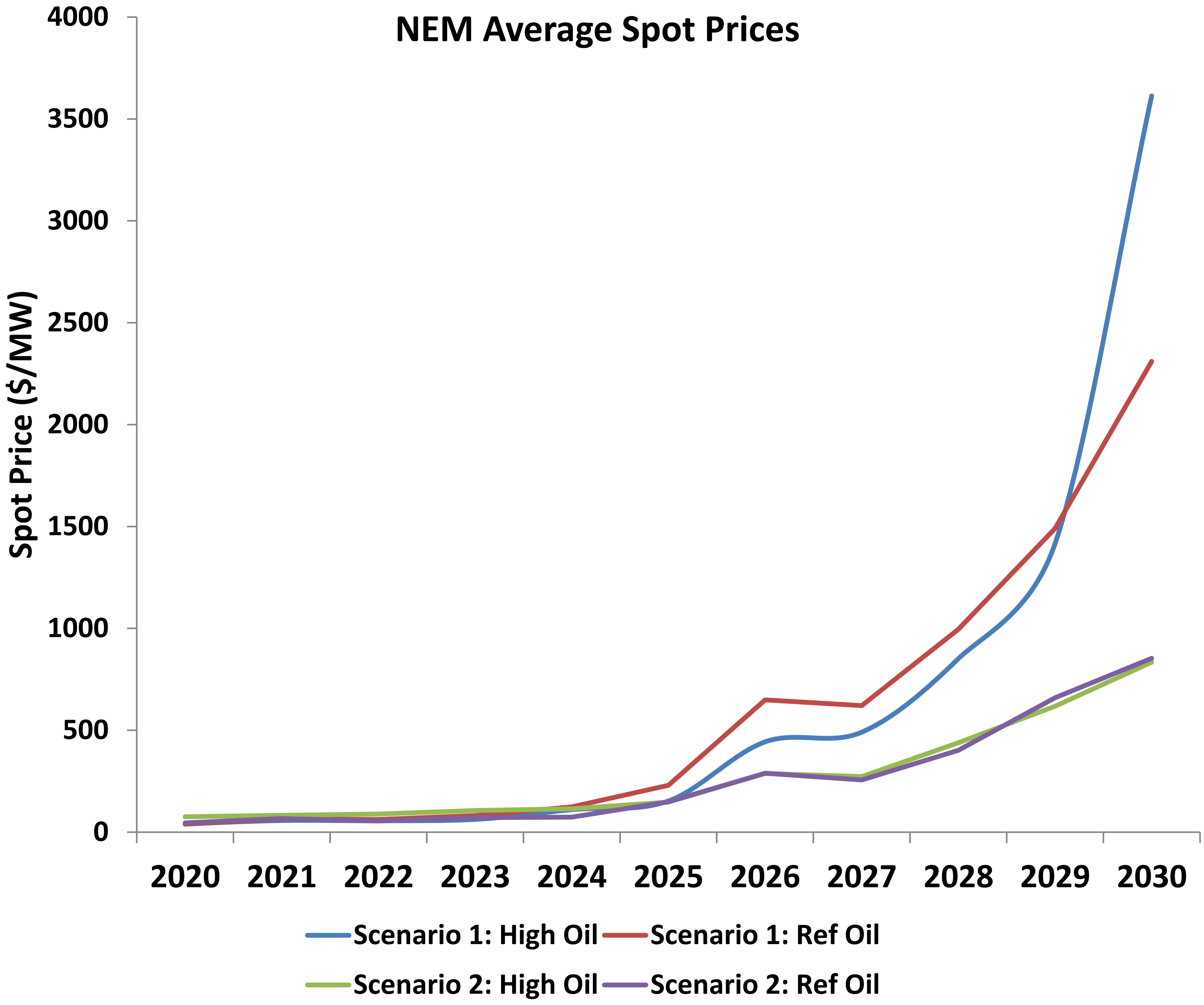
Results:



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



NEM Average Spot Prices
Spot Price ($/MW)
4000
3500
3000
2500
2000
1500
1000
500
0
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
Scenario 1: High Oil
Scenario 1: Ref Oil
Scenario 2: High Oil
Scenario 2: Ref 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.