IPRO 311

Integration of Plug-in Hybrid Electric Vehicles and Renewable Energy Systems

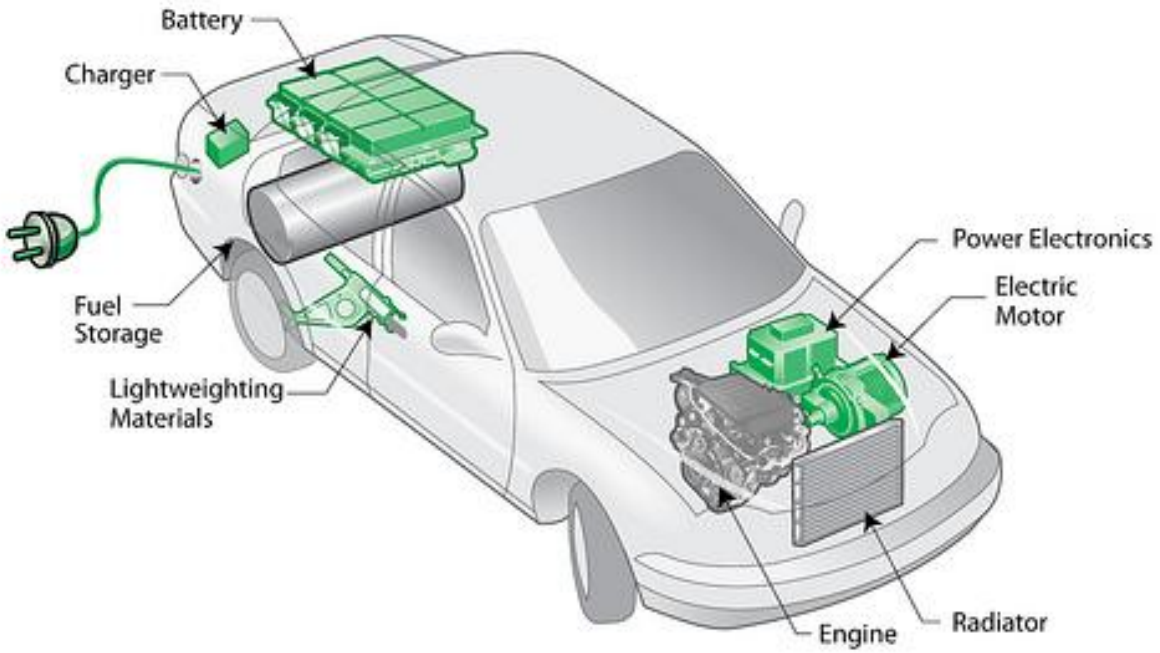
Fall 2010

PURPOSE & OBJECTIVES

- Investigate the economic effects of the integration of wind power generation systems and PHEVs
- Determine the feasibility of using PHEVs as an electrochemical energy storage system to mitigate the natural inconsistencies of wind generated power using simulation tools
- Evaluate the impacts of PHEVs on operational costs
- The results will benefit the automotive industry, wind power generation industry, utilities and will benefit the environment in general

WHAT IS A PHEV?

- Combines advantages of HEVs and EVs
  - Onboard drive batteries can be charged by ICE or any 120-volt outlet for an equivalent cost of under $1/gallon.

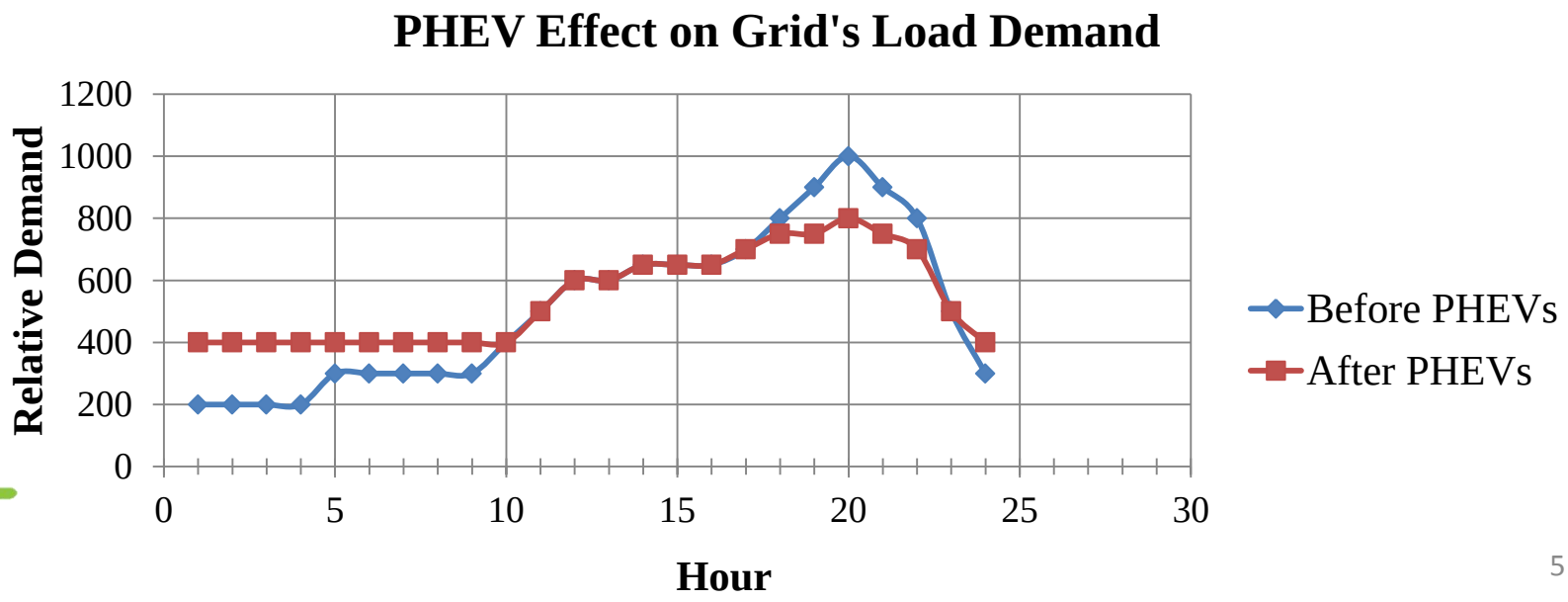


CHEVROLET VOLT

- Battery Capacity: 16 kWh
- SOC Variation: .3 to .85
- Energy Range: 4.8 kWh to 13.6 kWh
- Available Energy: 8.8 kWh
- Charge Times: 3-4 hours (240V), 8 hours (120V) at 15A

VEHICLE-TO-GRID

- Potential for Vehicle to Grid (V2G) charging
  - This can offset grid demand peaks, therefore reduce operational costs of the grid
  - Affects PHEV battery capacity and battery life



WHAT IS OBJECTIVE FUNCTION

- The objective function quantifies in mathematical terms the different variables and parameters as well as constraints that are needed to solve the optimization problem
- Objective function minimizes the operating cost

Inputs

1. The load demand for charging PHEV
2. The usual load demand
3. Power system constraints
4. The extra power that is eligible for V2G

ADDING PHEV TO POWER SYSTEM

Factors

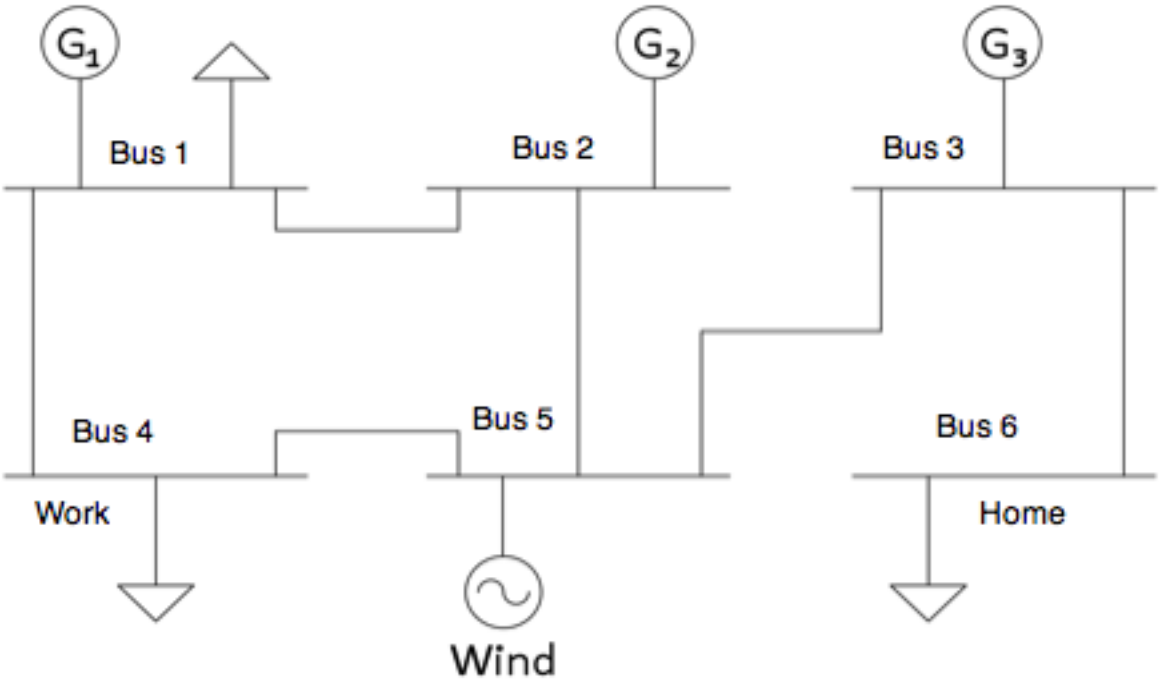
- Driving patterns and habits
- Charging rate
- Time to charge/V2G and vehicular availability
- Fleet size
- Travel times
- SOC variations

ADDITIONAL POWER DEMAND FROM PHEV

- Calculate amount of power needed to charge PHEVs
- Calculate amount of power reintroduced during V2G
- Create curve of power/hour

SYSTEM SPECIFICATION

- Cars travel from bus 6 (home) to bus 4 (work) in the morning and back home in the evening
- The locations and times for charging and V2G are variable
- Each scenario has an associated load demand that the PHEVs make



SYSTEM SPECIFICATION

Unit	a ($/MW^2)	b ($/MW)	c ($/h)	P_{min} (MW)	P_{max} (MW)
G1	0.099	6.589	211.4	100	320
G2	0.203	7.629	217.4	10	160
G3	0.494	10.07	102.8	10	100
Wind	0	0	0	37.7	75.6

SCENARIO DESCRIPTION

- No wind: No PHEVs
- Only wind: No PHEVs
- Scenario 1: No V2G and night charging
- Scenario 2: V2G during afternoon and night charging
- Scenario 3: V2G during evening and night charging
- Scenario 4: Charging during afternoon and night and V2G during evening

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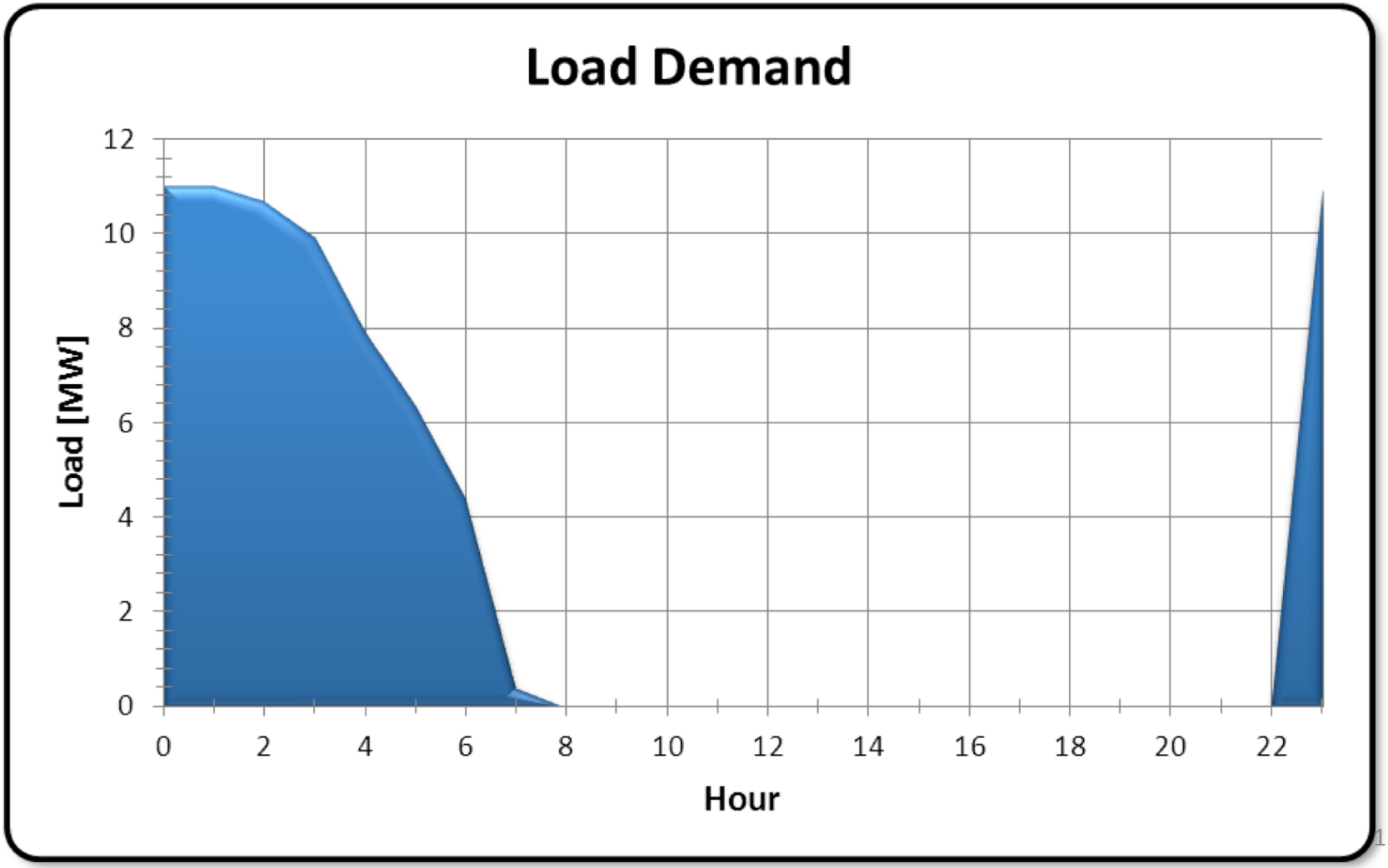
SCENARIO 1 PHEV LOAD DEMAND



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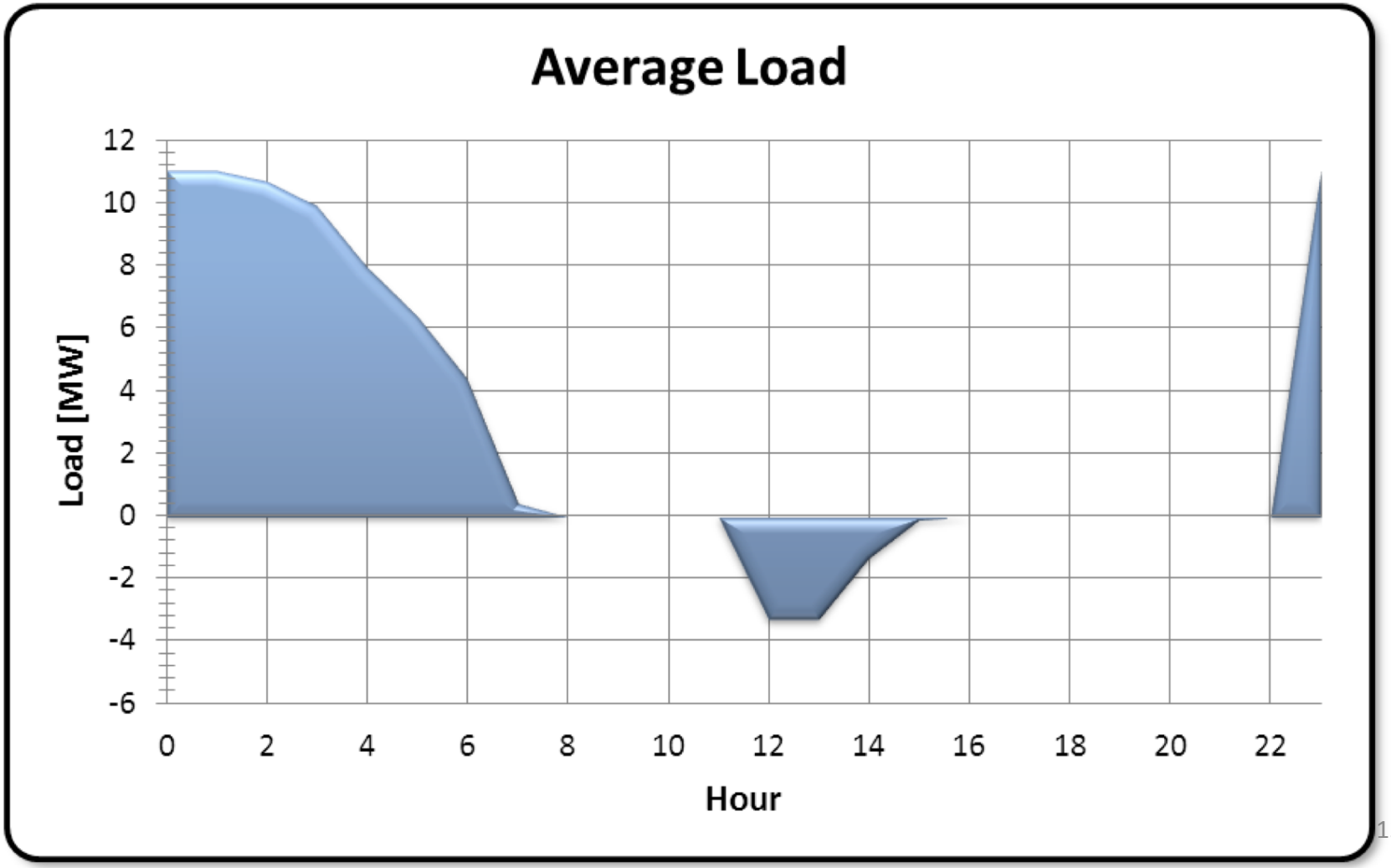
SCENARIO 2 PHEV LOAD DEMAND



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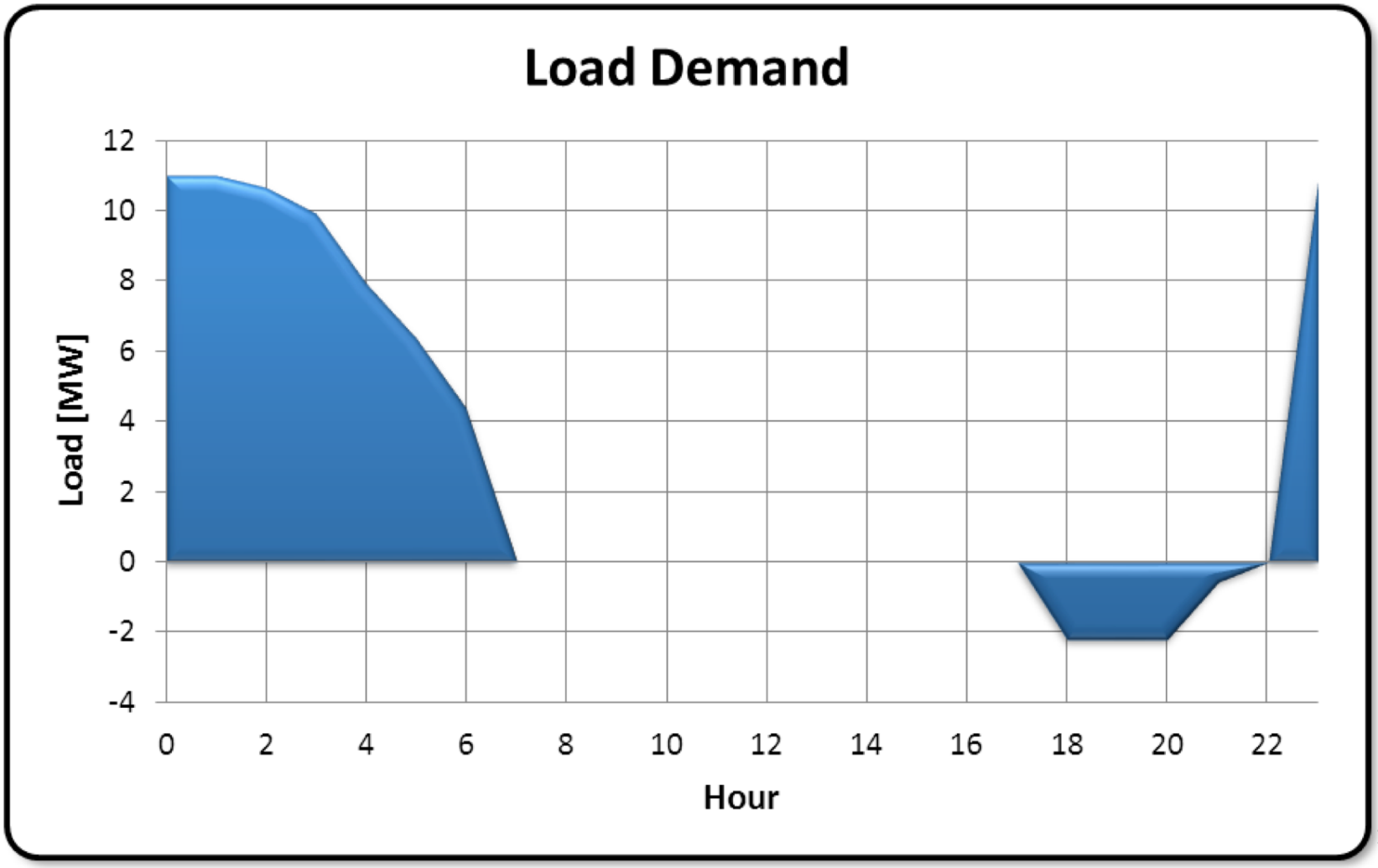
SCENARIO 3 PHEV LOAD DEMAND



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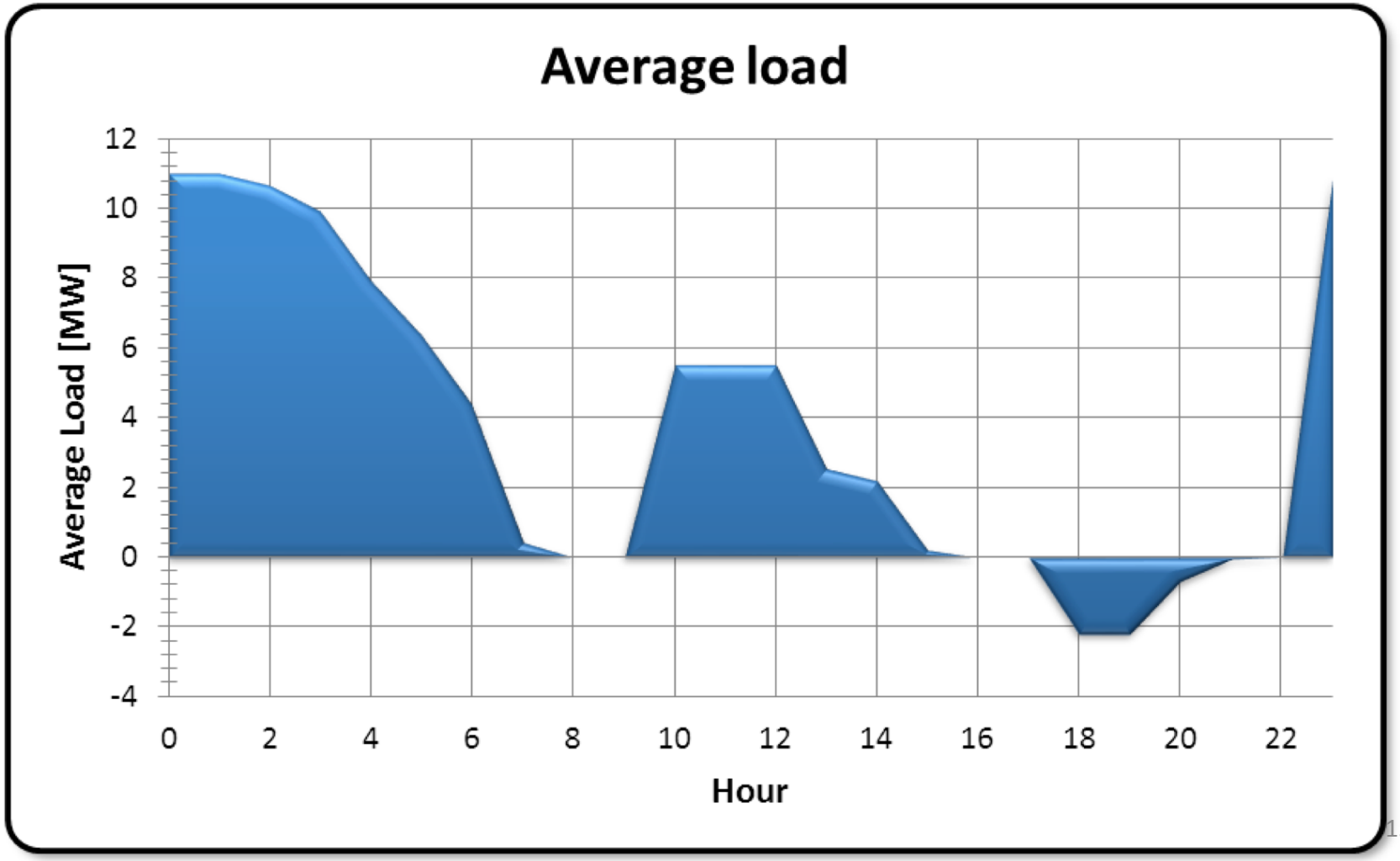
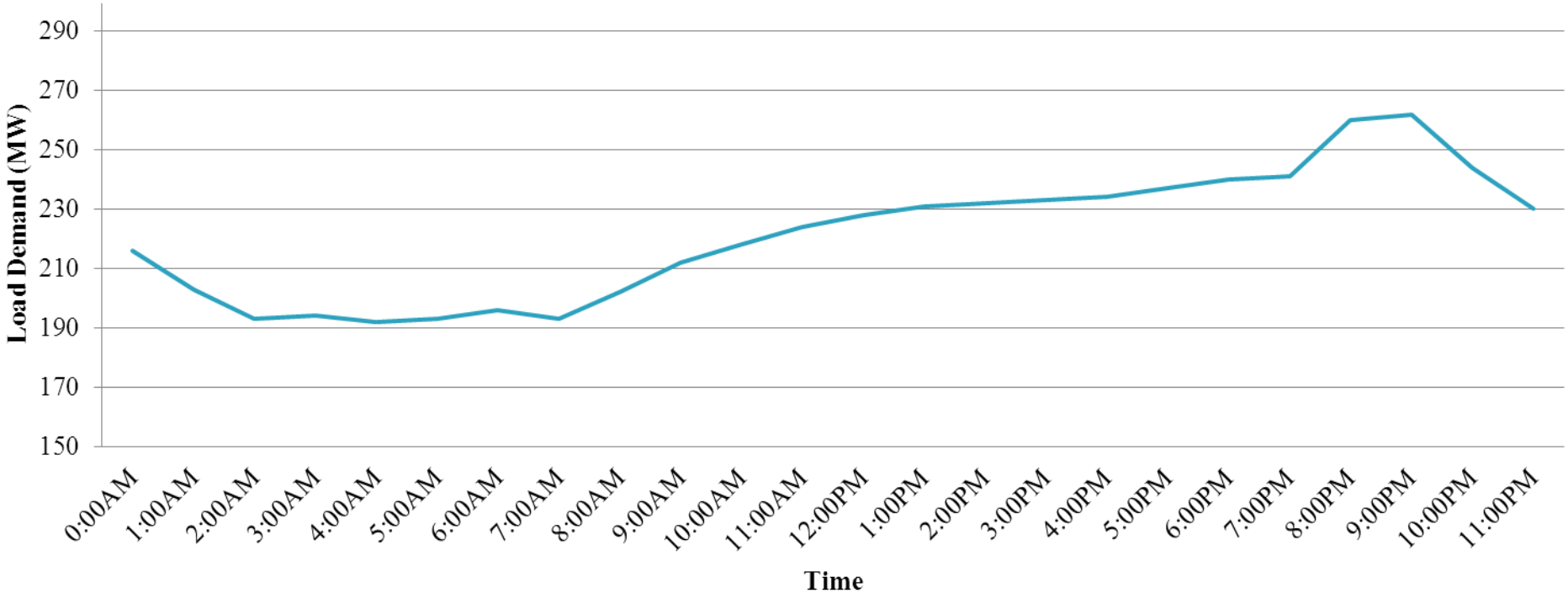
SCENARIO 4 PHEV LOAD DEMAND



DAILY LOAD PROFILE WITHOUT PHEVS



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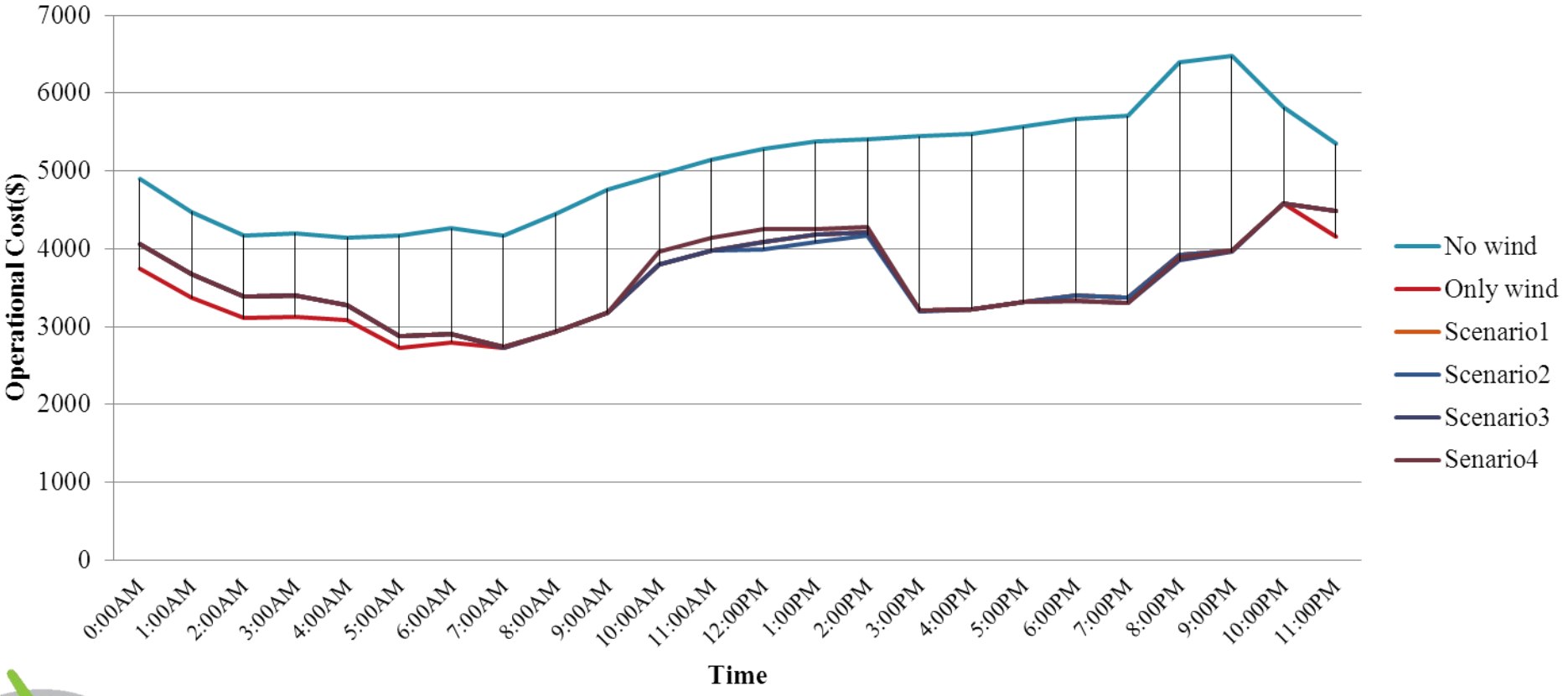
OPTIMAL OPERATIONAL COST



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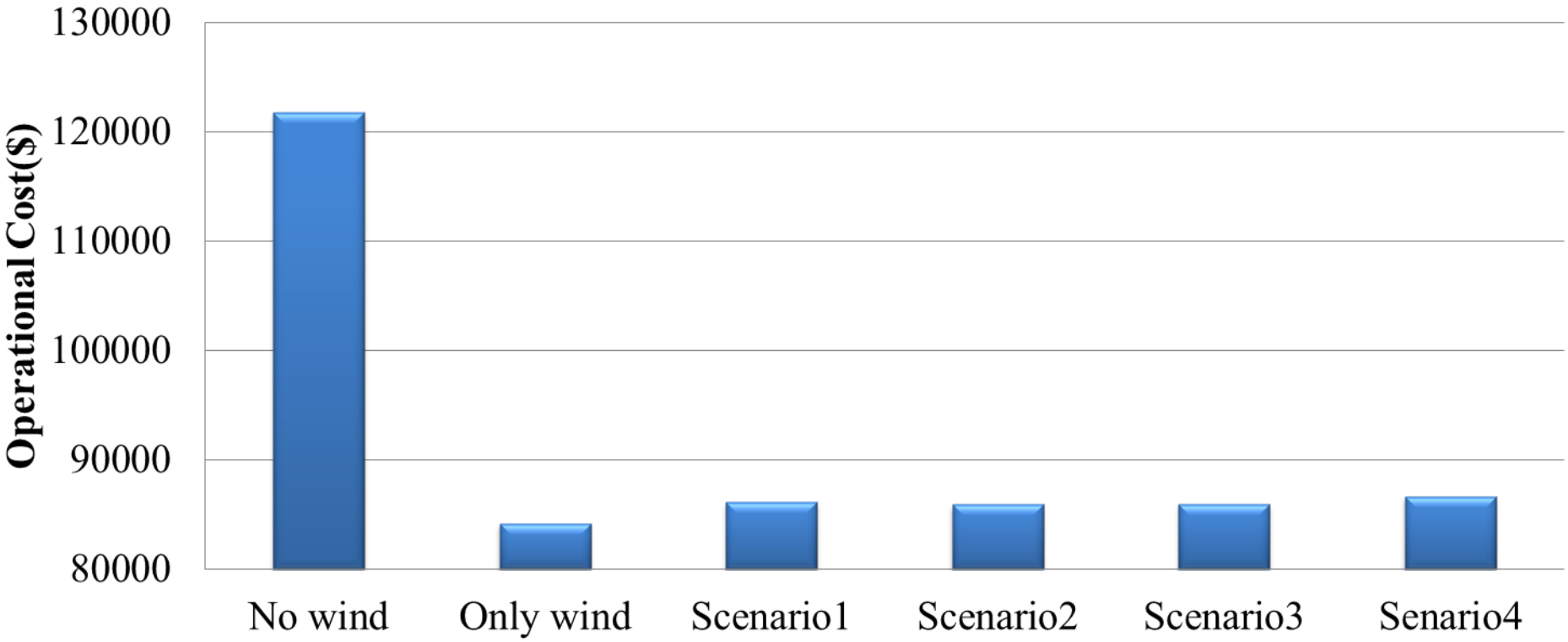
DAILY OPERATIONAL COST



ANALYSIS

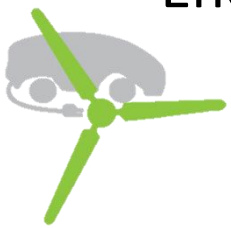
- The peak time has not been changed by adding PHEV
  - 1st peak time: 10:00 pm to 1:00 am
  - 2nd peak time: 10:00 am to 3:00 pm
- V2G decreased 0.28% of total operational cost (Scenario2)
- V2G decreased the operational cost for the 2nd peak time by 1.02% (Scenario2)
- Night-time charging(Scenario2 & Scenario3) is better than night time and day-time charging(Scenario4)
- Mid-afternoon V2G (Scenario2) is more effective to the system than late-afternoon V2G (Scenario3)
- Charging when actual system demand is minimal is one of the best times to charge. The price/kWh is also the least at night.

CONCLUSION

1. Wind: 0% emissions, operational cost down
2. PHEV: Peak sharing, 0% emission in all electric mode
3. Wind + PHEV: 0% emissions from PHEV charging

Benefits:

- Energy industry
- Reduces global warming
- Cheaper $/kWh
- Cheaper $/gallon of gasoline
- Energy independence
- Energy security



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QUESTIONS?