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Reactions to Studies of PHEV-Electric Generation Interaction

DOE PHEV Grid Impacts Technical Review
March 14, 2007

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Two Closing Quotes from:

Considering Plug-in Hybrids to Allow Electric Generation Infrastructure to Augment International Petroleum Reserves

Plug-in Hybrid Workshop
April 3, 2005, Monaco
At EVS-21
21st Worldwide Battery, Hybrid and Fuel Cell Electric Vehicle Symposium and Exposition
April 2-6, Monaco

"A program designed to encourage plug-in hybrids should be planned to first exhaust excess generating capacity.

Over the lifetime of P-HEVs, excess electric capacity availability would not be a constant. Relative prices of gasoline and electric operation should vary over the life of the vehicle (and seasonally)."

(Of course I should also have said "vary by hour of the day".)

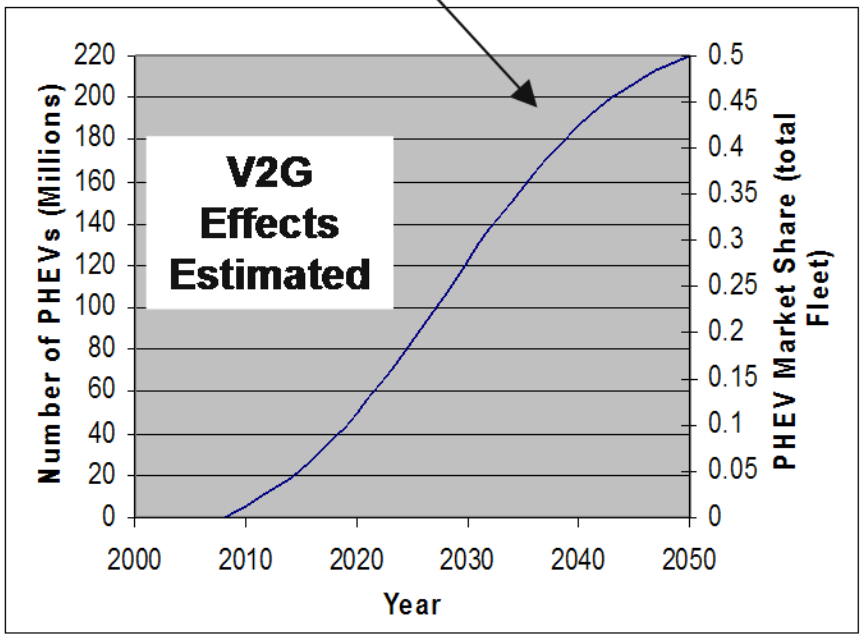
Questions:
(1) Existing studies assume 1 charge per day. In crisis circumstances, or simply in the event of significant increases in oil prices – could multi-day charging be possible?

(2) If particulate matter or carbon dioxide were taxed, how could the mix of generators be adjusted?

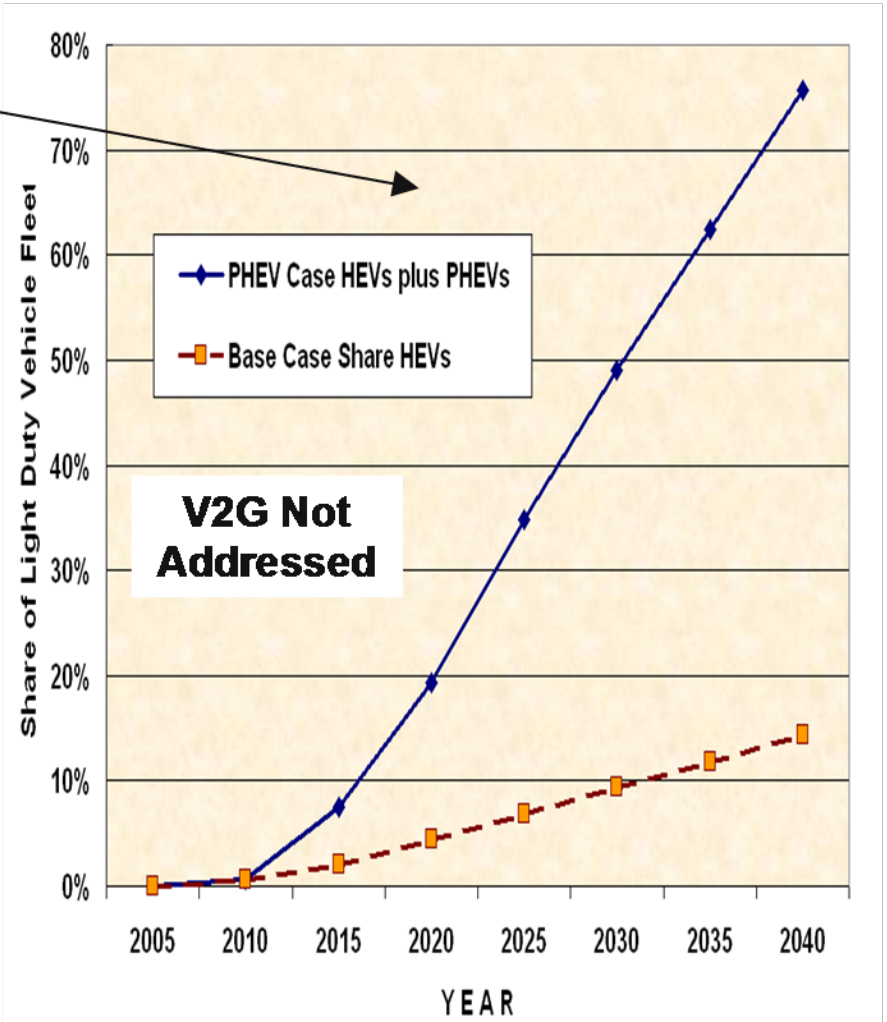
How Were the Market Penetration Estimates Developed?

AMIGA Scenario by Argonne

WinDS Scenario by NREL



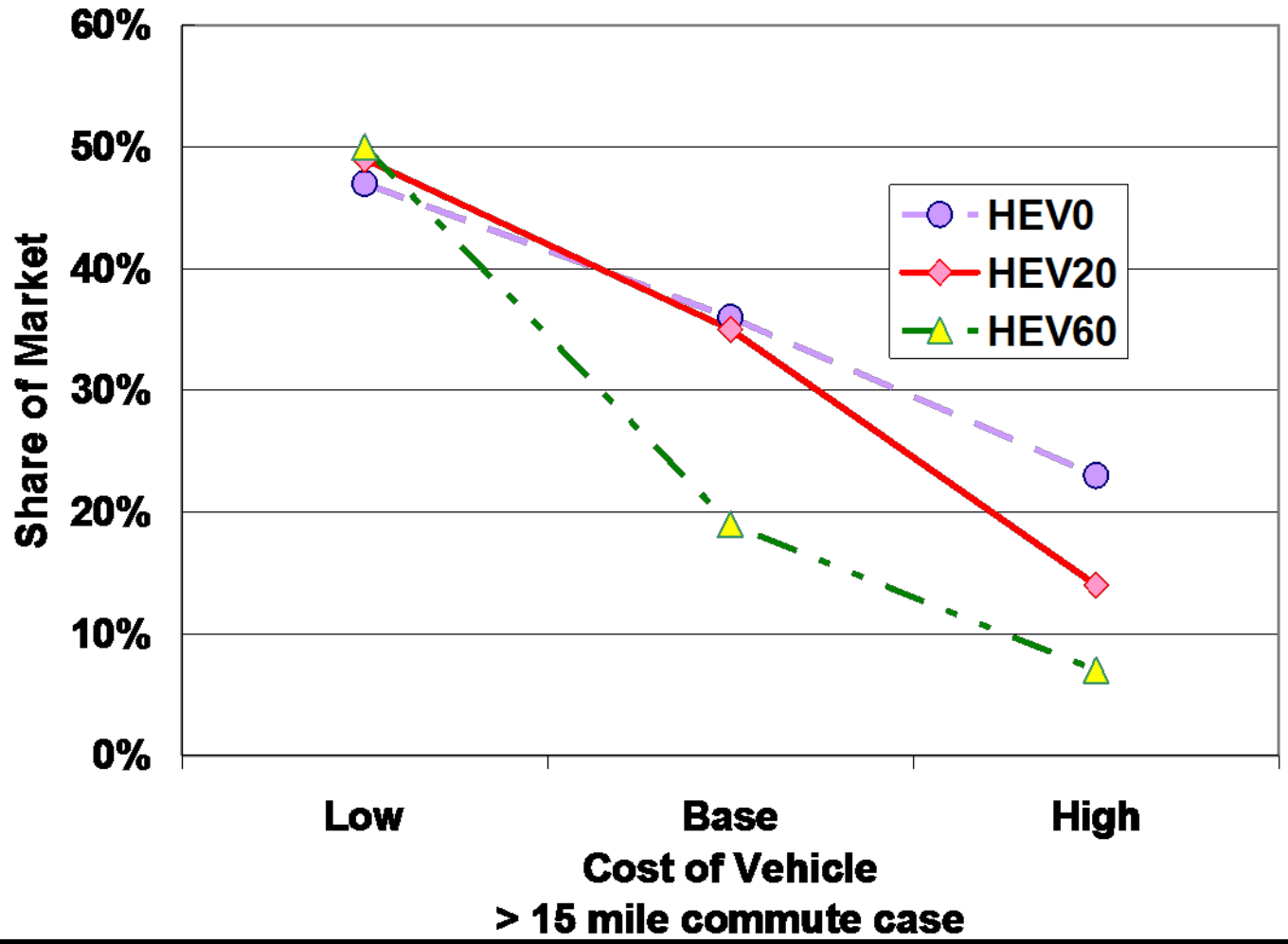
Courtesy of W. Short, NREL



Courtesy of D. Hanson, Argonne

The EPRI 2001 Study Estimated Theoretical Market Share Attainable for PHEVs in the Long Run, Based on Interviews of Residents of Four Major Urban Areas.

PHEV60 Share Was Less than for PHEV20s



Source: Comparing the Benefits and Impacts of Plug-in Hybrid Electric Vehicle Options R. Graham. July 2001. EPRI 1000349

NREL - Massive Success Requires a Few % Increase in Total Generation, Leads to Significant Use of Wind Power

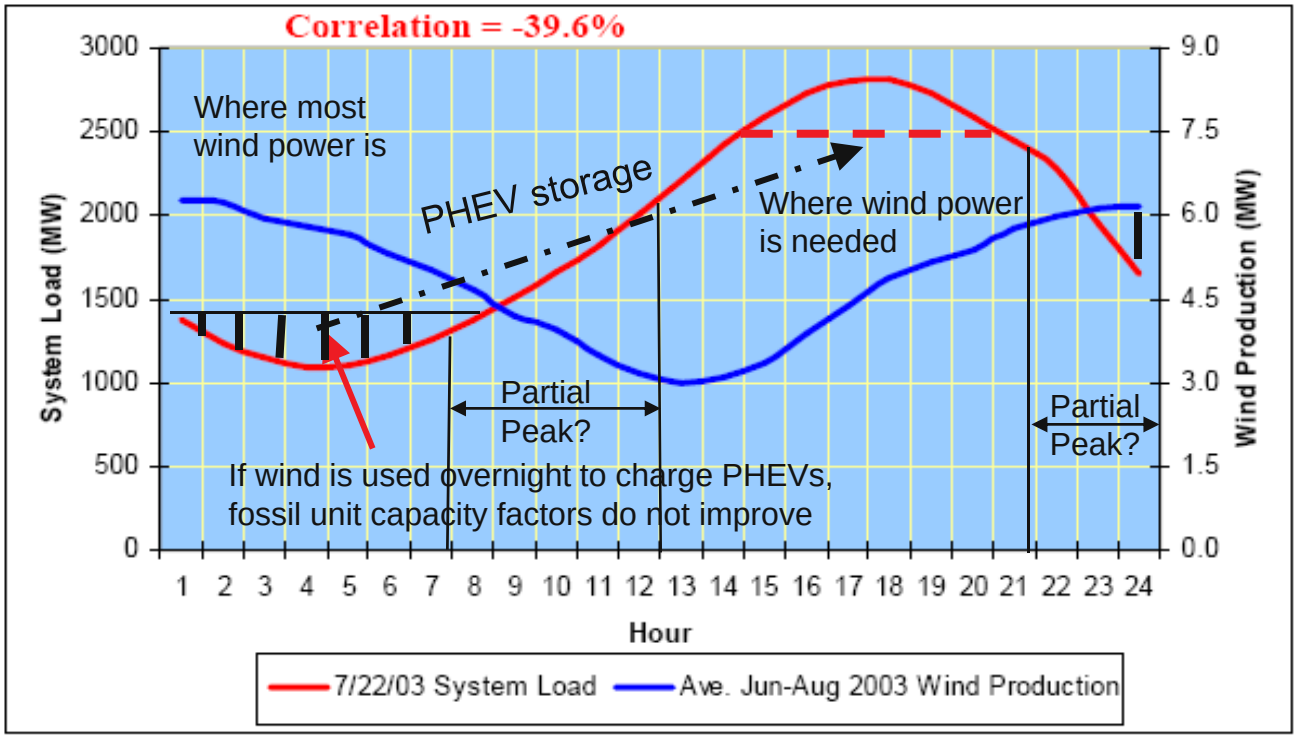
Summary of 2050 WinDS/PHEV Results – PHEV Cases Compared to Base Case

2050 Projected Values	Base Case (no PHEVs)	PHEV-20 Case	PHEV-60 Case
Gasoline use (Billions of Gallons)	368	255 (31% decrease)	212 (43% decrease)
Wind Generation (TWh/year)	757	853 (13% increase)	1554 (105% increase)
Total Load (TWh/year)	9392	9808 (4.4% increase due to PHEV load)	10082 (7.3% increase due to PHEV load)
Increase of Wind Electricity vs. Base Case	-	0.6%	7.5%
Total Installed Generation Capacity (GW)	2161	2092	1972
Generation from Coal (TWh/year)	8272	8597 (3.9% increase)	8169 (1% decrease)
Electric and Light Duty Transport Sector CO2 (Million Tons CO2/year)	10956	9910 (9.5% decrease)	9346 (14.7% decrease)

Courtesy of W. Short, NREL

Sacramento Summer Wind Does Peak in Night Time Hours, When Cars are Parked at Home in Garages. Questions – Is ozone worst on calmest days? Are these also hottest days? Does air conditioning peak when wind is calm?

Comparing HOURLY System Load on a Hot Summer Day
with Wind Production at Solano



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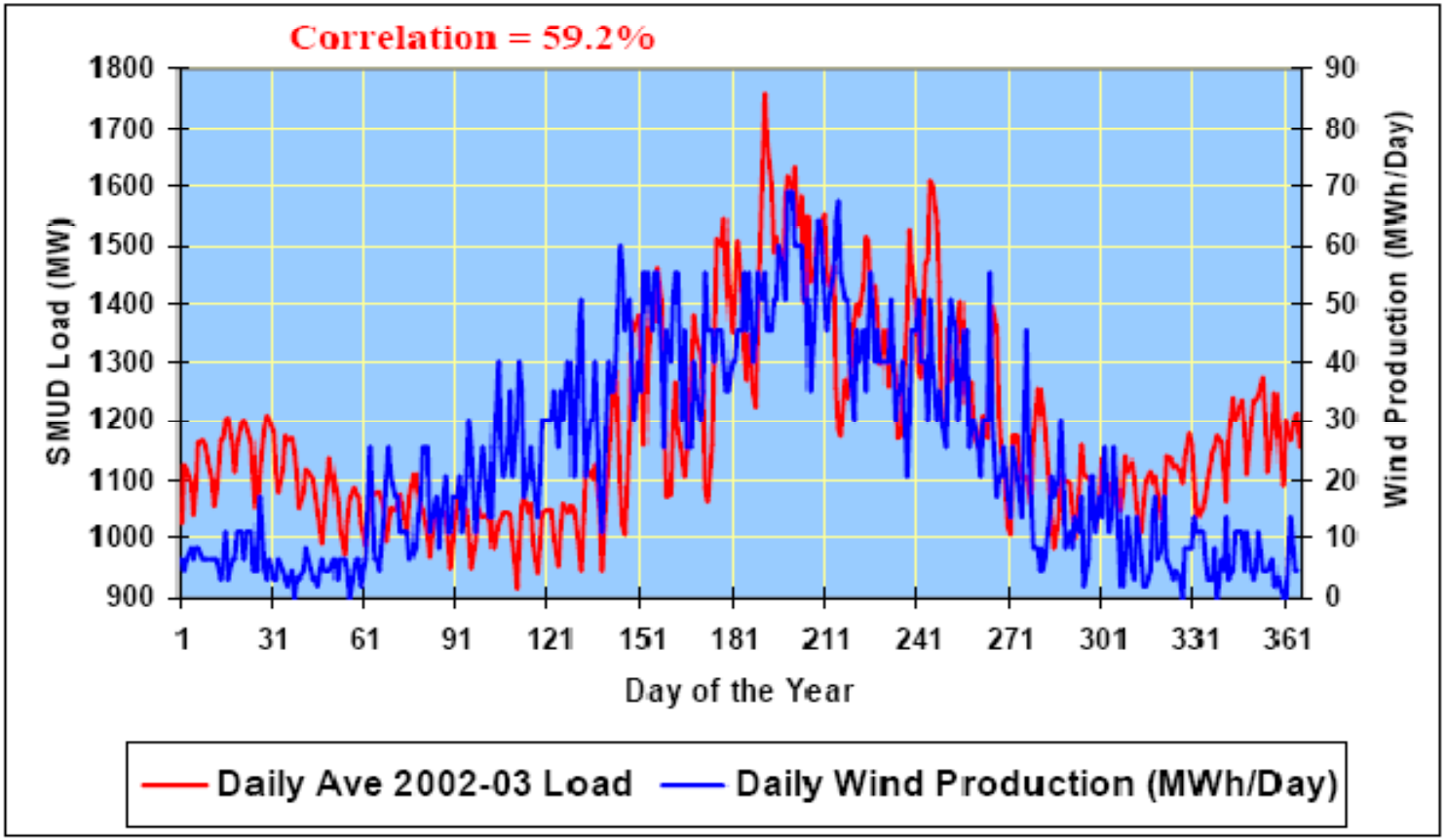
Source: Modeling V2G for a Utility With a High Wind Generation Portfolio – W. Kempton and C. Murley, CARB ZEV Symposium, 9/26/06

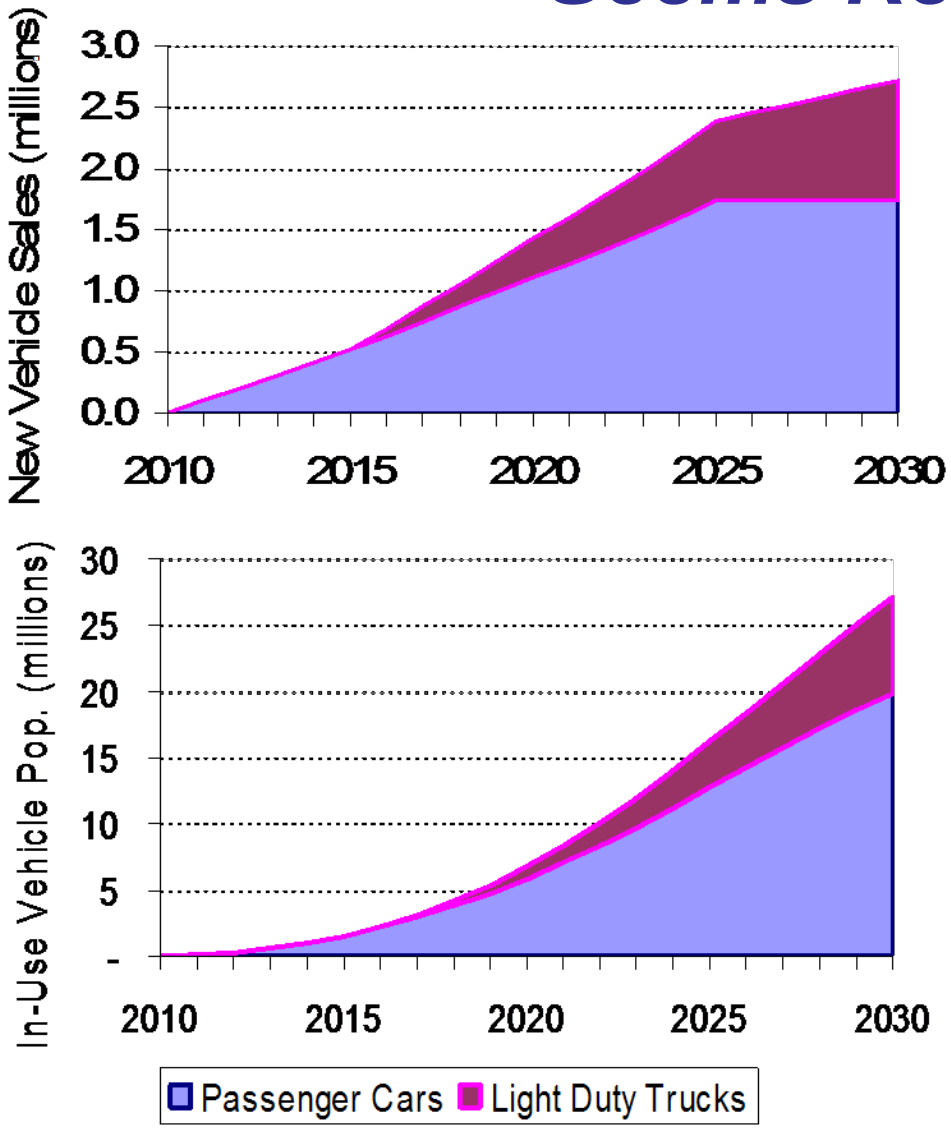
In Sacramento, Wind is a Clean Summer Fuel. But Could It Reduce Ozone Forming Generation – & What About Winter? (In PA the Wind Dies in the Summer, Not the Winter)

Comparing DAILY System Load with Wind Production at Solano



Source: Modeling V2G for a Utility With a High Wind Generation Portfolio – W. Kempton and C. Murley, CARB ZEV Symposium, 9/26/06

EPA's National PHEV Rollout Scenario Seems Reasonable



- Passenger vehicle fleet: PHEVs start penetrating in 2011 and grow to 15% of passenger vehicle sales by 2030

In 2030:

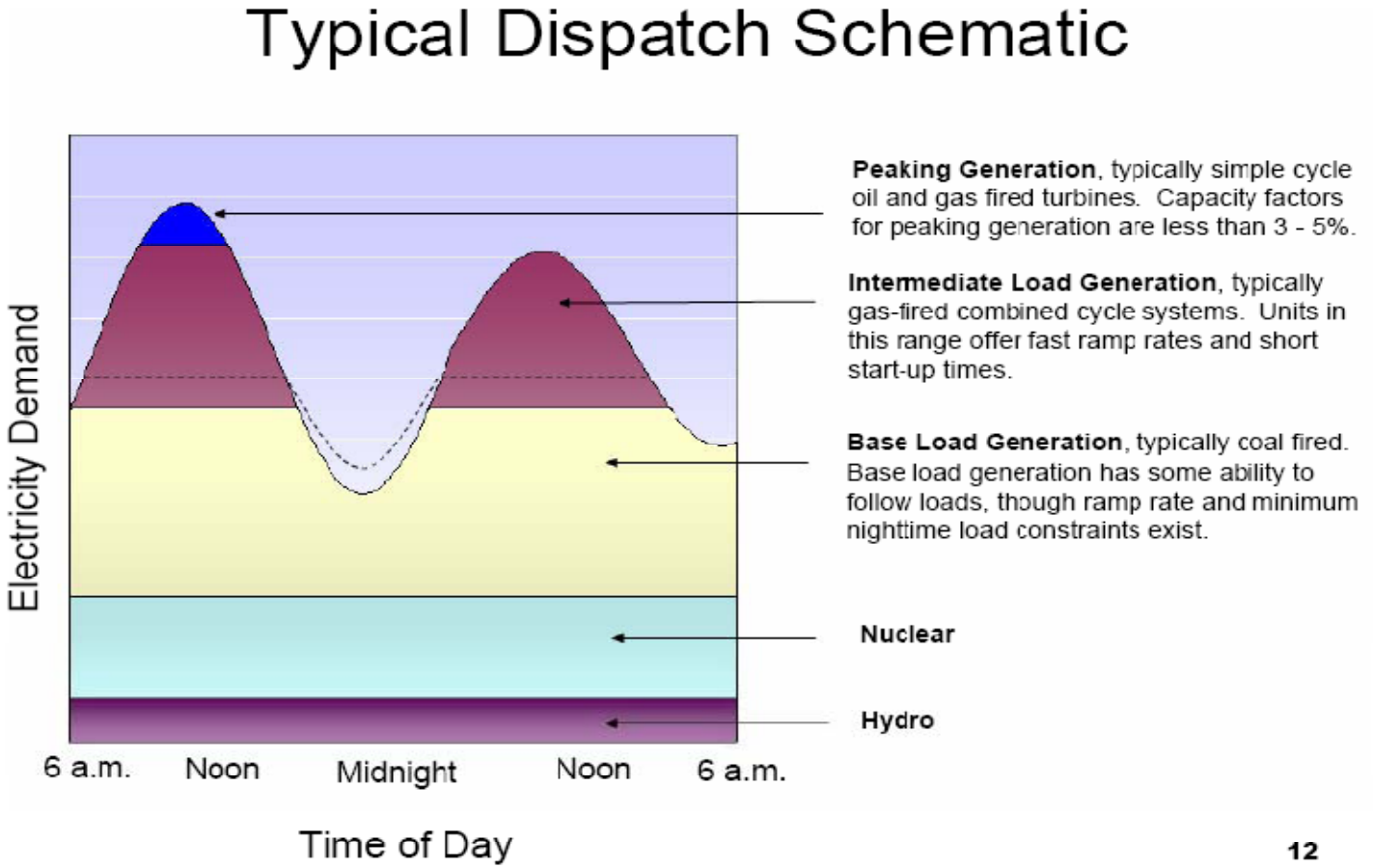
- Annual sales reach 2.7 million PHEVs
- 27 million PHEVs on the road (9% of the nearly 300 million vehicles)

By comparison:

- Conventional hybrids represented 1.2% of all U.S. sales in 2005 (~ 5% by 2010)

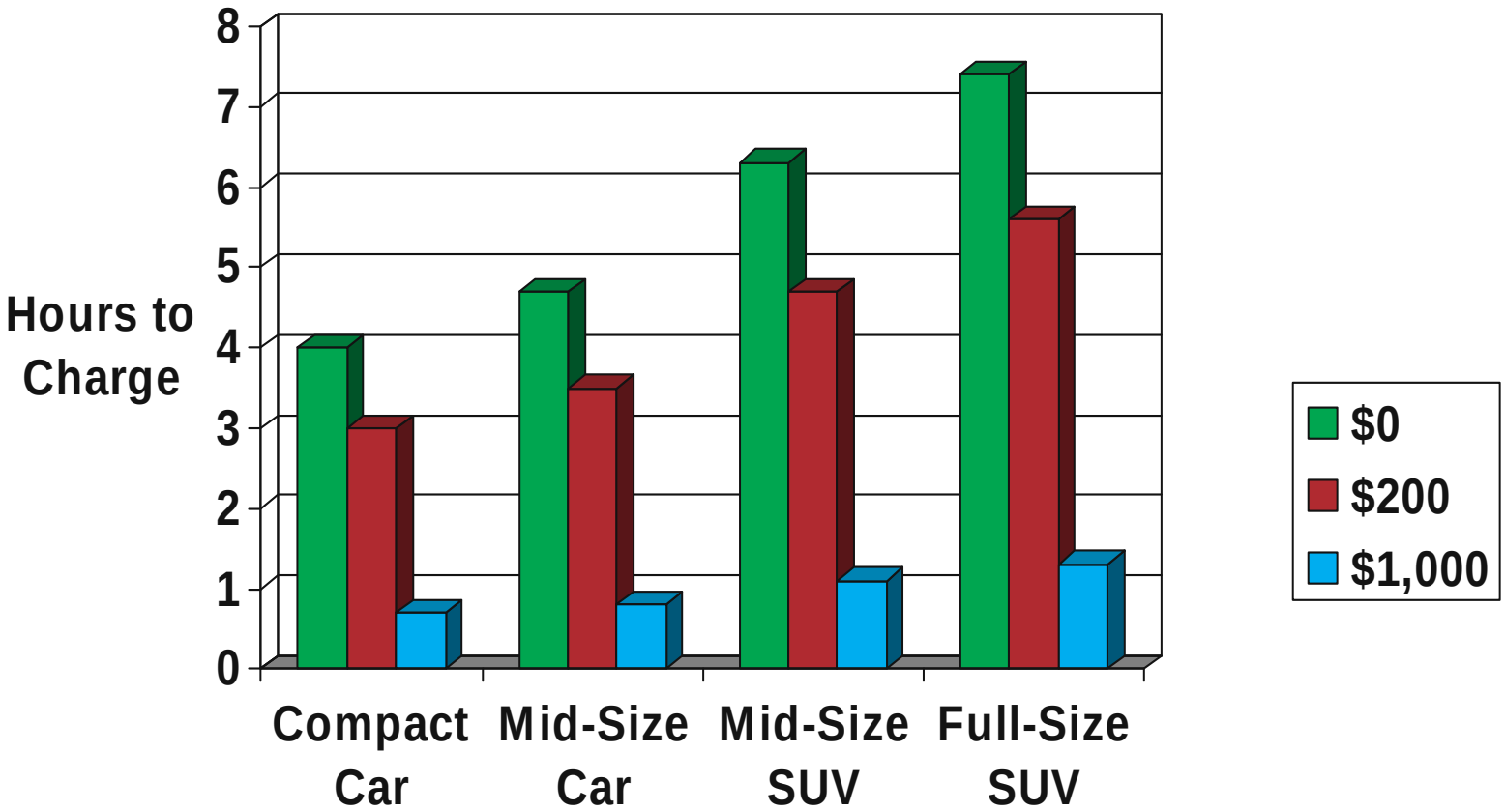
Source: Plug-in Hybrids: A Scenario Analysis Shelby and Mui. 86th Annual Meeting of TRB, Jan. 22. 2007

For Early PHEVs, EPA Provides a Typical(?) Diurnal Load Profile, Where Coal and Natural Gas Generators are the Options



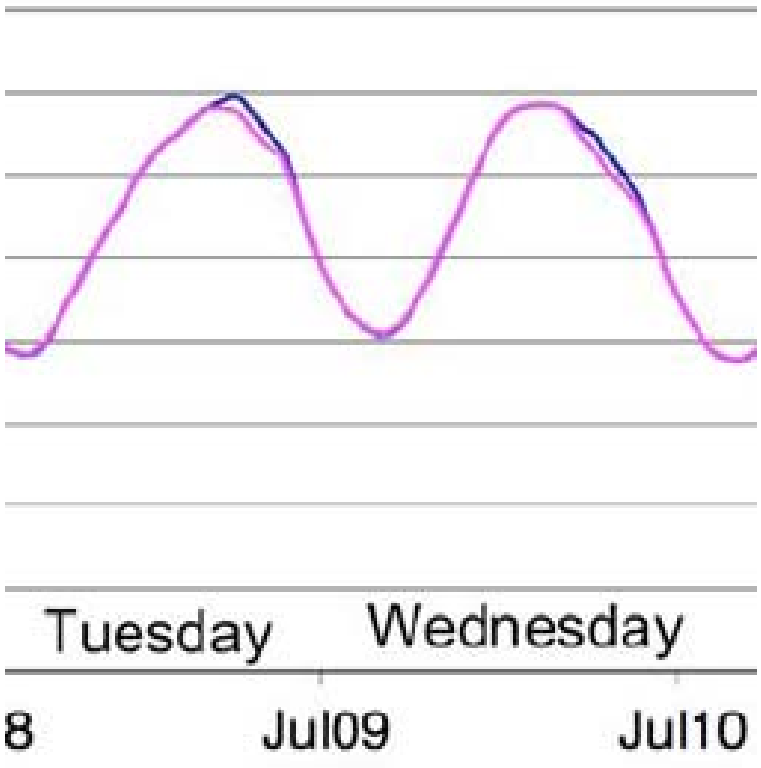
Source: Plug-in Hybrids: A Scenario Analysis Shelby and Mui. 86th Annual Meeting of TRB, Jan. 22. 2007

Even With No Infrastructure Investment, EPRI 2001 P-HEVs w 20 Miles Electric Equivalent Charge Overnight

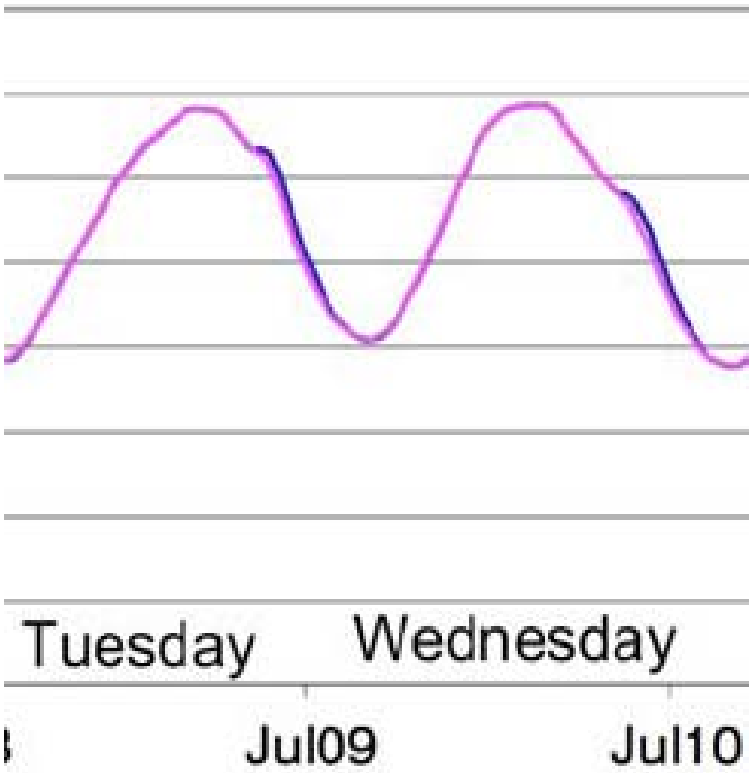


EPRI Estimate of Infrastructure Cost vs. Hours to Charge

For "Early" PHEVs, Hadley Shows the Timing of Charging is Flexible, And Can Result in Use of Different Generators



Hadley, p. 11 Option



Hadley, p. 12 Option

Source: Impact of Plug-in Hybrid Electric Vehicles on the Electric Grid. S. Hadley 10/06 ORNL-TM/2006/554

Hadley Estimates a Mix of Combined Cycle Natural Gas and Coal, Depending on Charging Time and Rate

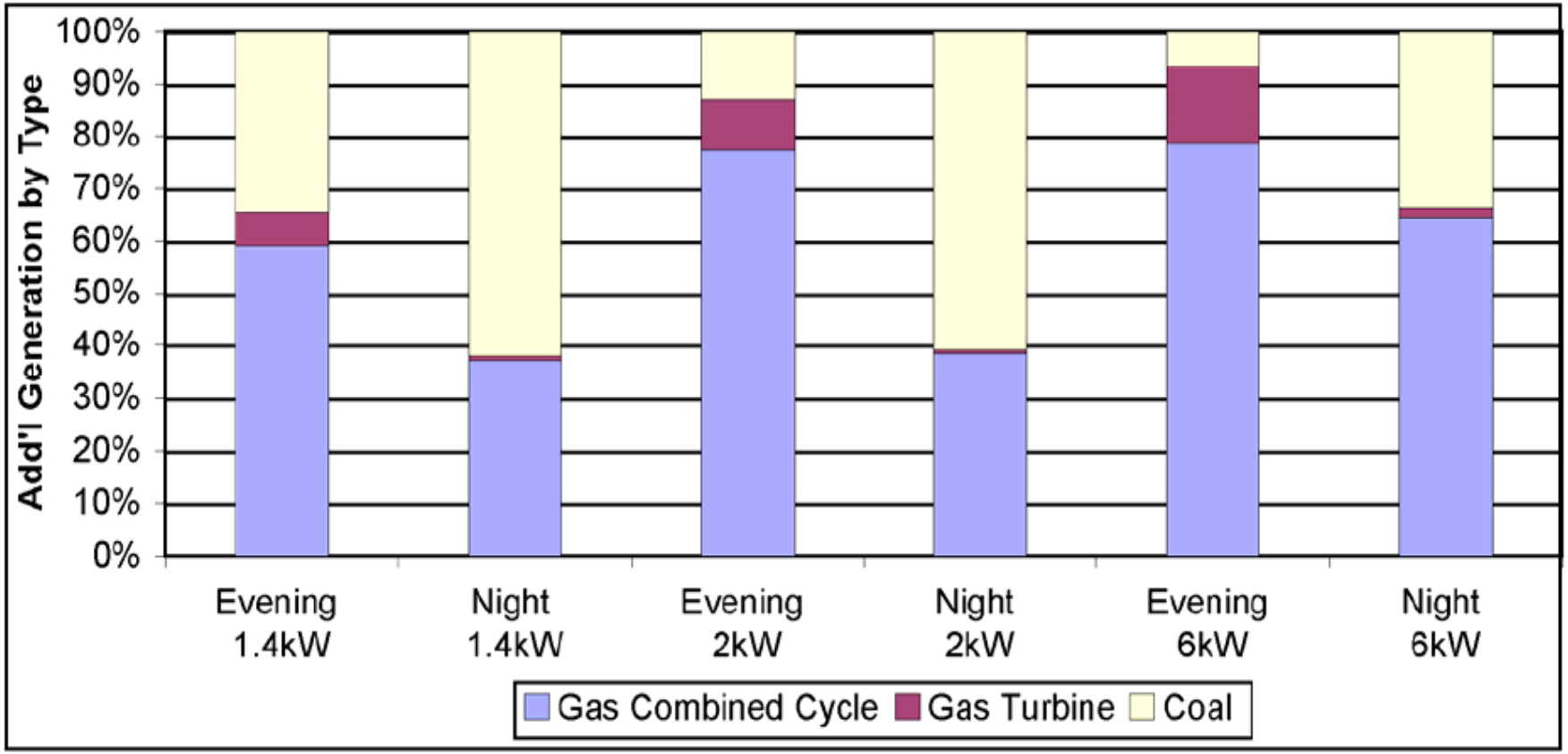
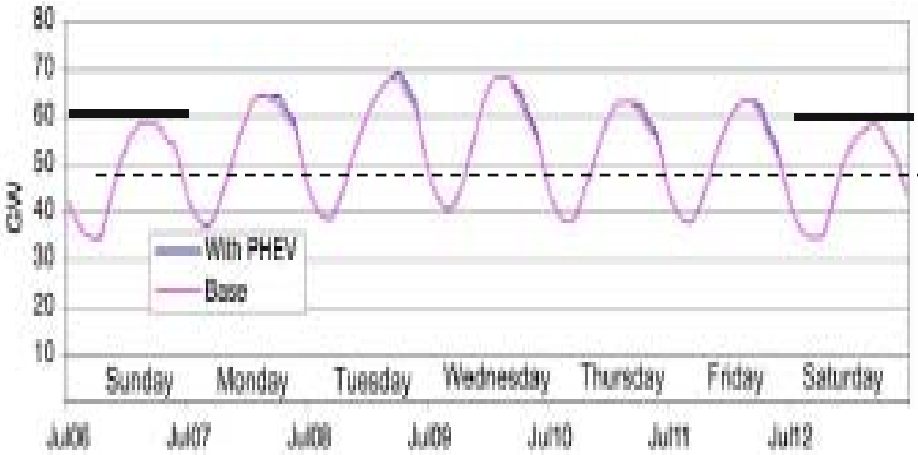


Figure 12. Generation shares by plant type for PHEV charging level and timing

Source: Impact of Plug-in Hybrid Electric Vehicles on the Electric Grid. S. Hadley 10/06 ORNL-TM/2006/554

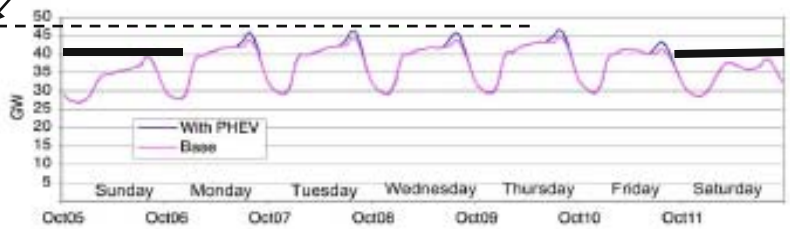
Should we be Careful About Assuming that a Summer Profile is Typical?

In Addition to the Lower Utility Load in Spring and Fall, Is There a Consistent Drop in Load on Weekends?

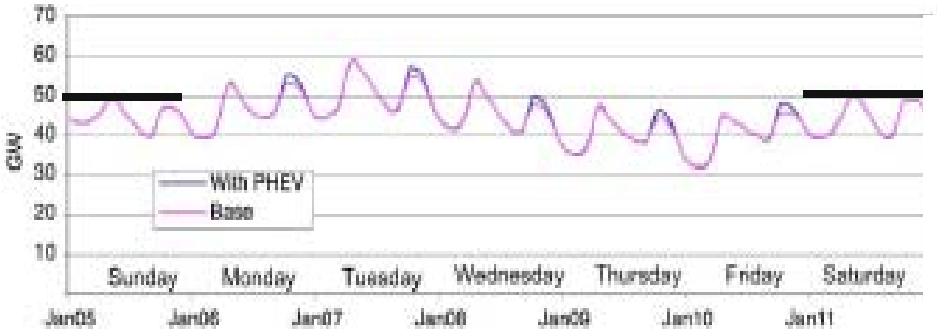


July

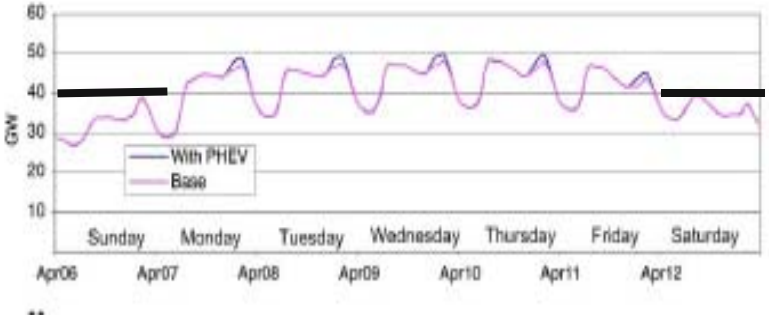
Hypothetical combustion turbine line – will coal units be the only ones on in Oct? (Ramp rates?) Can PHEVs charge multiple times per day in Oct.?



October



January



April

Source: Impact of Plug-in Hybrid Electric Vehicles on the Electric Grid. S. Hadley 10/06 ORNL-TM/2006/554

PG&E Apparently Also Has Lower Loads on Weekends, Since it Grants More Extended "Off Peak" Rates Then. Question - Could PHEVs Generally Charge Twice on Weekends?

Example: PG&E's TOU Summer time periods

	12am		7am		2pm		9pm	12am
Monday	Off peak		Partial Peak		Peak			Partial Peak
Tuesday								
Wednesday								
Thursday								
Friday								
Saturday						Partial Peak		Off Peak
Sunday								

Pacific Gas and Electric Company®

Source: Thesen, 9/26,06 CARB ZEV Workshop

"Excess" Generating Capacity is Seasonally Available, as Well as Diurnally and Weekly.

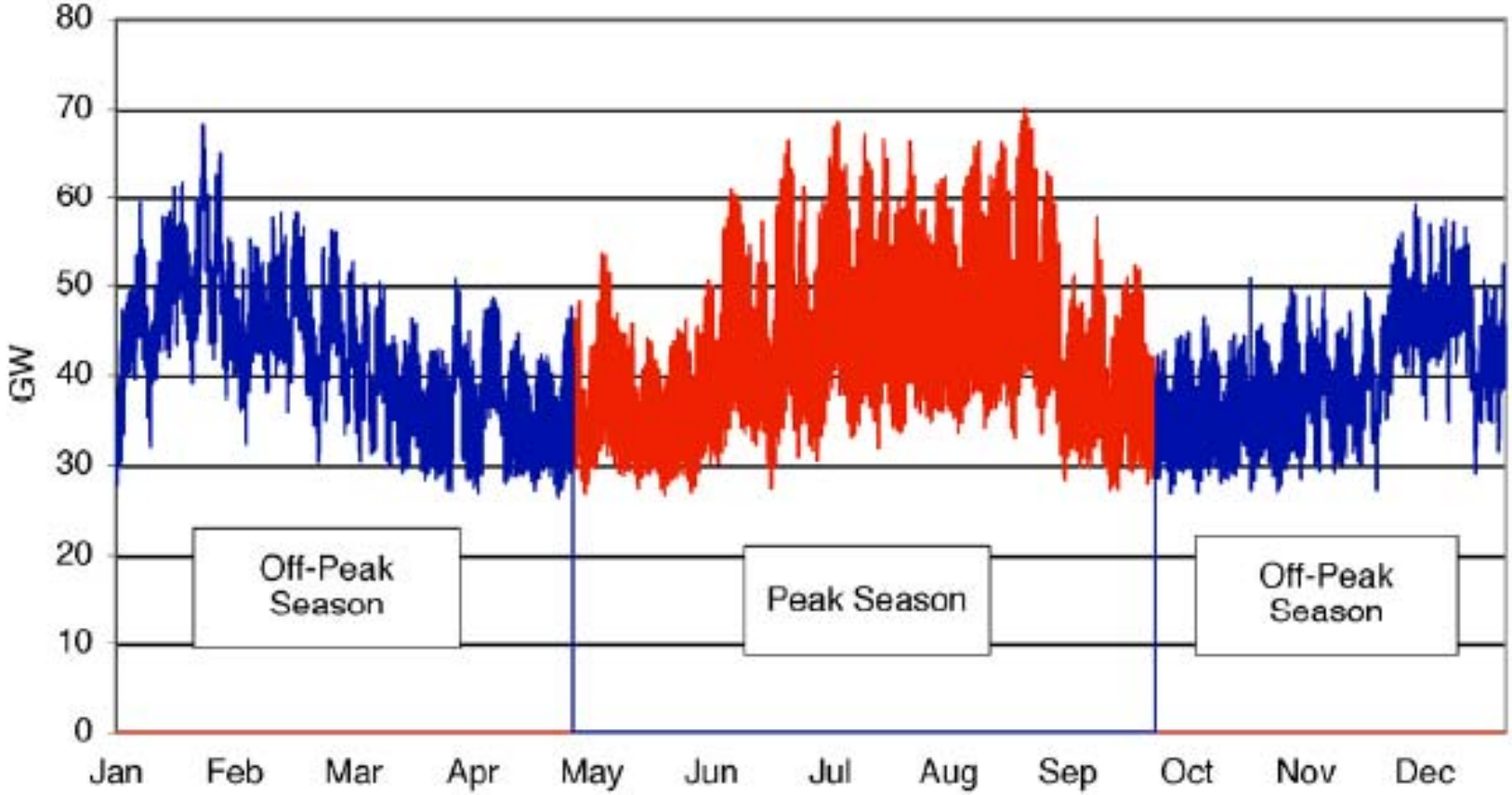


Figure 7. Projection of hourly loads for the VST region in 2018

Source: Impact of Plug-in Hybrid Electric Vehicles on the Electric Grid. S. Hadley 10/06 ORNL-TM/2006/554