



**We have two modes:  
"Complacency and Panic"**

James Schlesinger



## Credits

- Dr. Anup Bandivadekar MIT “Evaluating the Impact of Advanced Vehicle and Fuel technologies in U.S. Light-duty Vehicle Fleet “
- Michael Kinter-Meyer, Kevin Schneider and Robert Pratt from Pacific Northwest National Lab. Impacts Assessment of Plug-in Hybrid Vehicles on Electric Utilities and regional U.S. Power Grid.



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## Background

- About 230 million passenger and light trucks on the roads today.
- Vehicles per 1000 people
  - In the US about 800
  - Compared to Western Europe/Canada- 600
  - Or China – 20
- MPG ~ in low 20s



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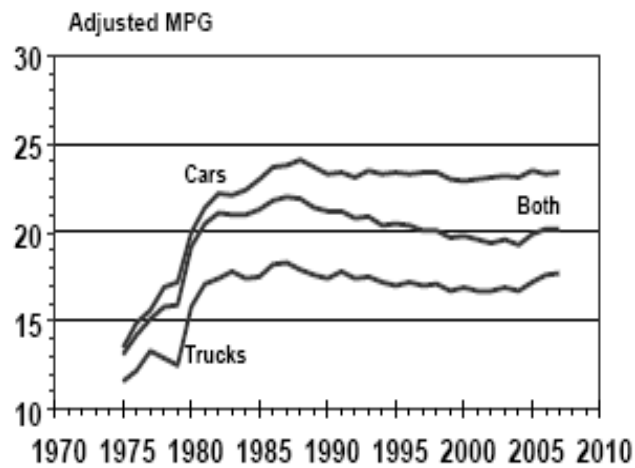
## Changes in Transportation

	1970	2005
Number of Vehicles (millions)	110	235
Miles traveled (Trillion)	1.1	2.9
Miles per vehicle	10,303	12,482

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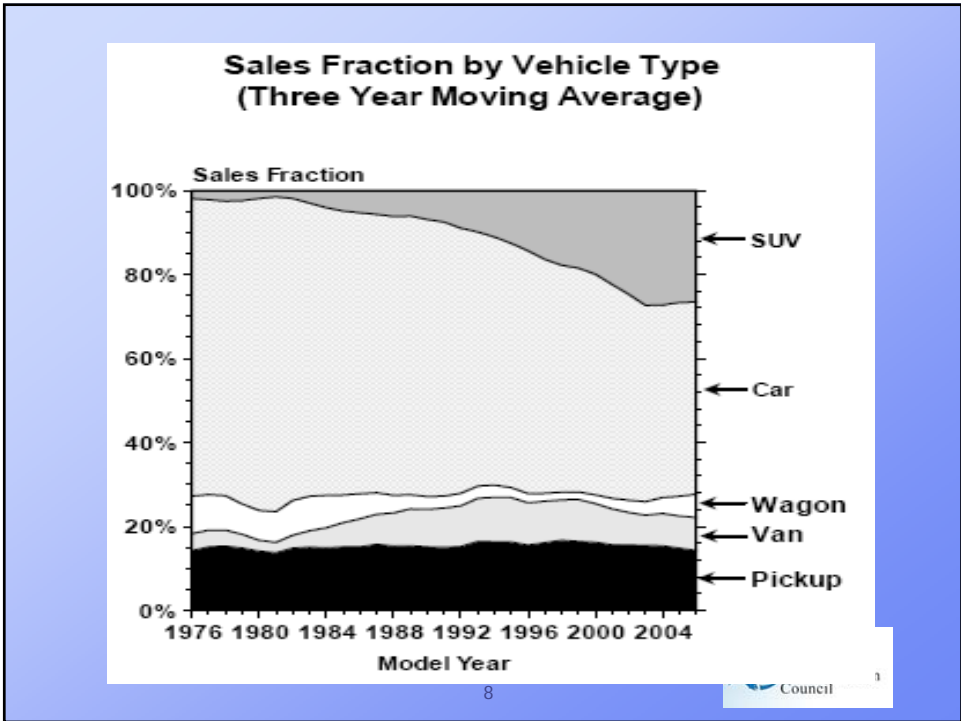
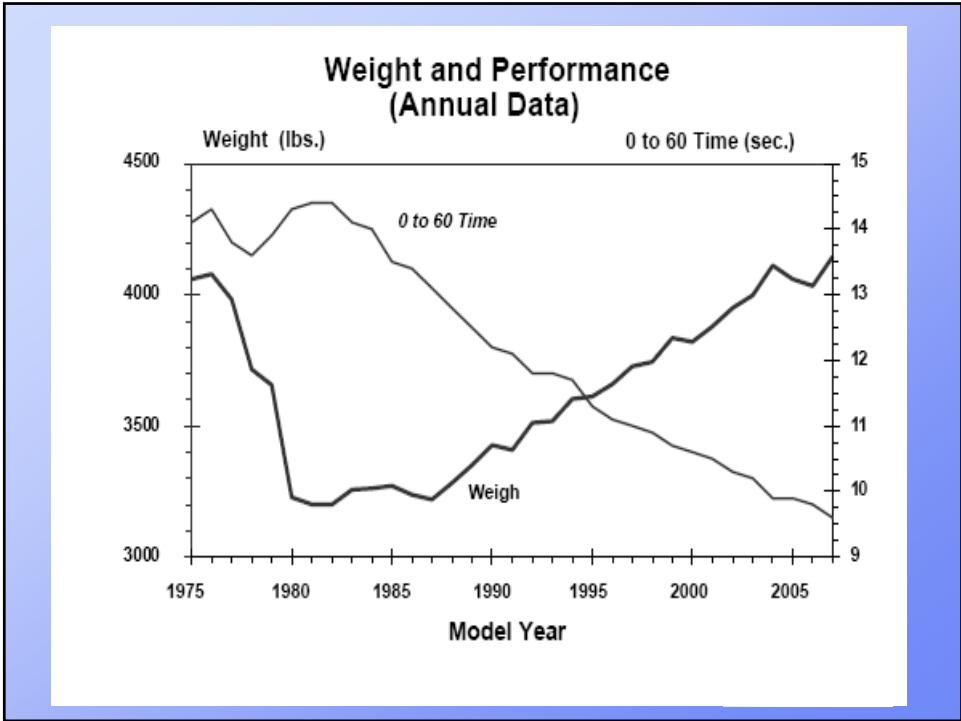


Adjusted Fuel Economy by Model Year  
(Annual Data)



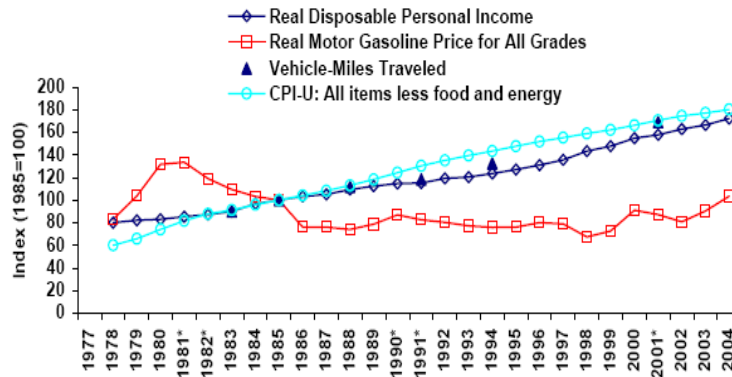
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# Trends in Cost of Transport

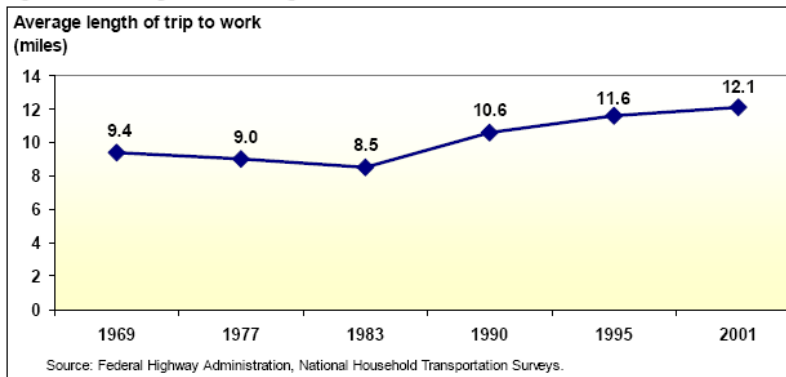
Figure 10. Annual Indices of Real Disposable Income, Vehicle-Miles Traveled, Consumer Price Index (CPI-U), and Real Average Retail Gasoline Price, 1978-2004, 1985=100



Sources: Energy Information Administration, Annual Energy Review 2004; Bureau of Economic Analysis.  
Note \* = recession year.



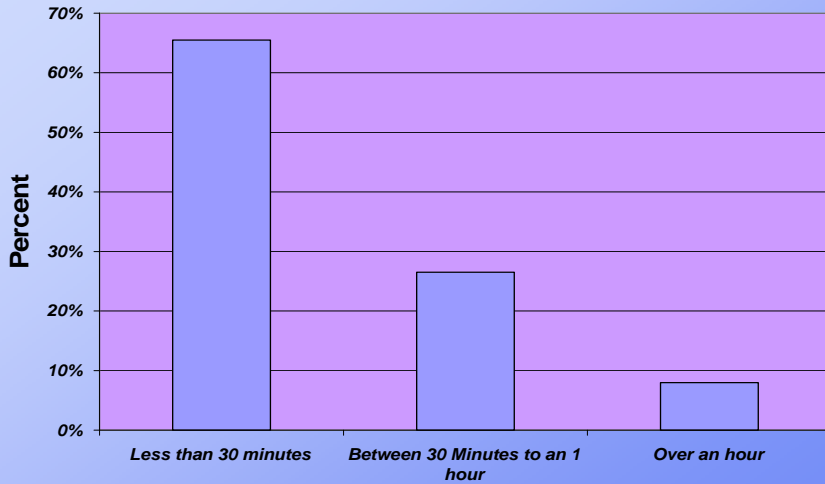
Figure 5. Average Commuting distances, 1969-2001



Source: Federal Highway Administration, National Household Transportation Surveys.



## Travel Time to Work



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## Description of different options

### ➤ Current options

- Gasoline system
- Turbo Diesel
- hybrid



Audi Turbo Diesel



GM Volt

### ➤ Future options

- Gasoline
- Turbo Diesel
- Hybrid
- plug-in hybrid
- Battery electric
- Fuel Cell



Hyundai's Fuel Cell



Tesla's Battery electric car



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## Barriers to new alternative fueled vehicles

### ➤ Demand

- High first cost for vehicle
- Fuel storage/limited range
- Reliability and durability
- Lack of refueling infrastructure
- Market entry barriers (high entry cost)
- High discount factors and risk aversion

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## Barriers to new alternative fueled vehicles

### ➤ Supply side constraints

- Lead times for new product line
- High Capital investment requirements
- Limitations of critical supply components
- Global market response / increase in price of components/ backlog

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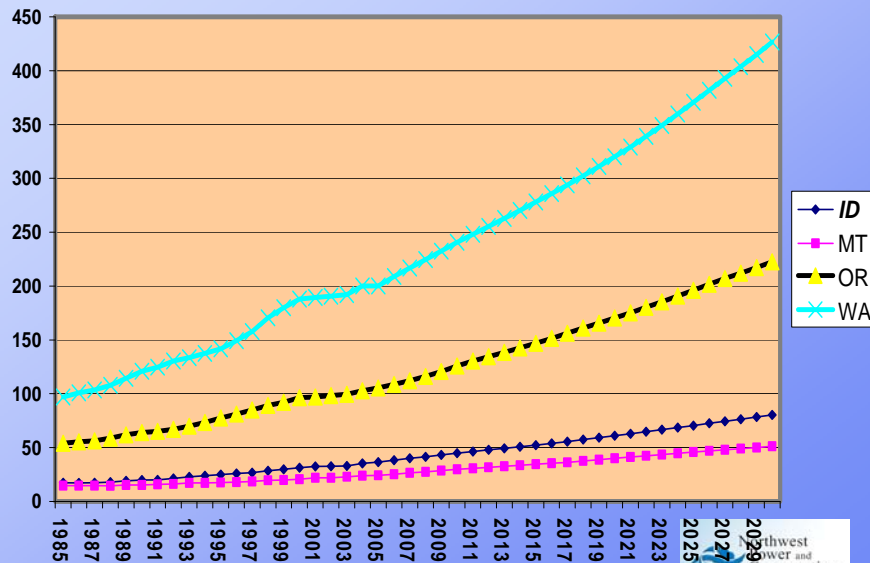
## Simple model

- Forecast of passenger and light trucks –Global Insight
- Market share fraction ~ 3% to start 26% in 10 years
- Miles traveled per day ~33 held constant
- Energy requirement ~ 0.26-0.46 watts/mile (0.3 midsize)
- Energy efficiency improvement -5% per year
- Battery size 10 KWh
- Battery type Lithium-Ion
- T&D and conversion efficiency losses ~20%
- Recharge at 110 v 15 amp in 8 hours
- Recharge at 220 v 30 amp in under 2 hours
- Assumed 95% recharge off peak, 5% during peak hours
- Current average MPG for gasoline vehicles 20.2
- CO2 emissions for gasoline ~ 1 lb/mile



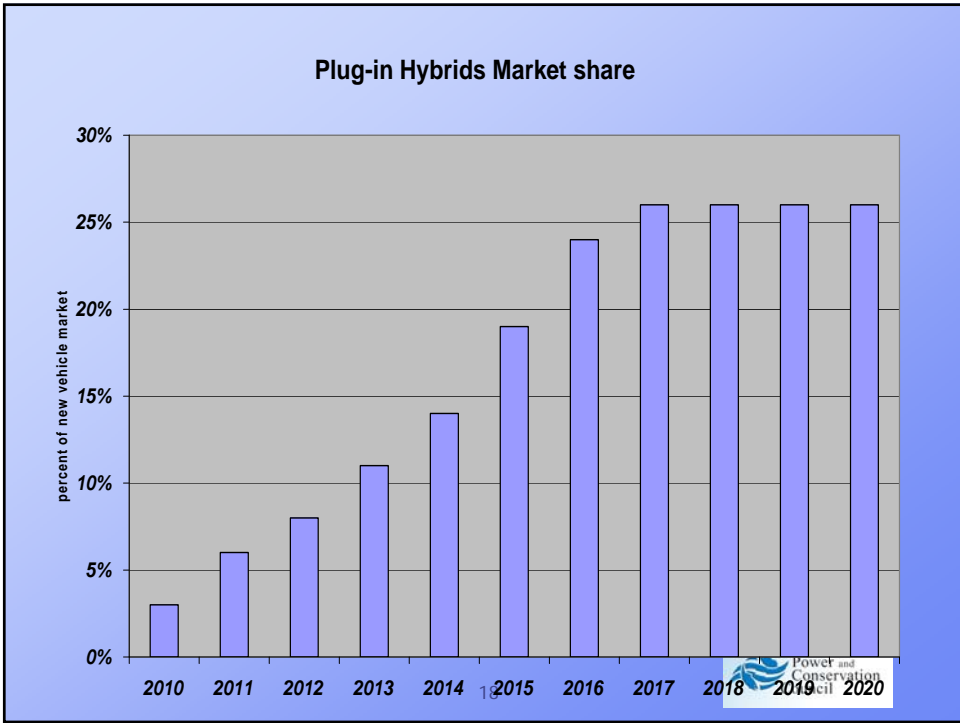
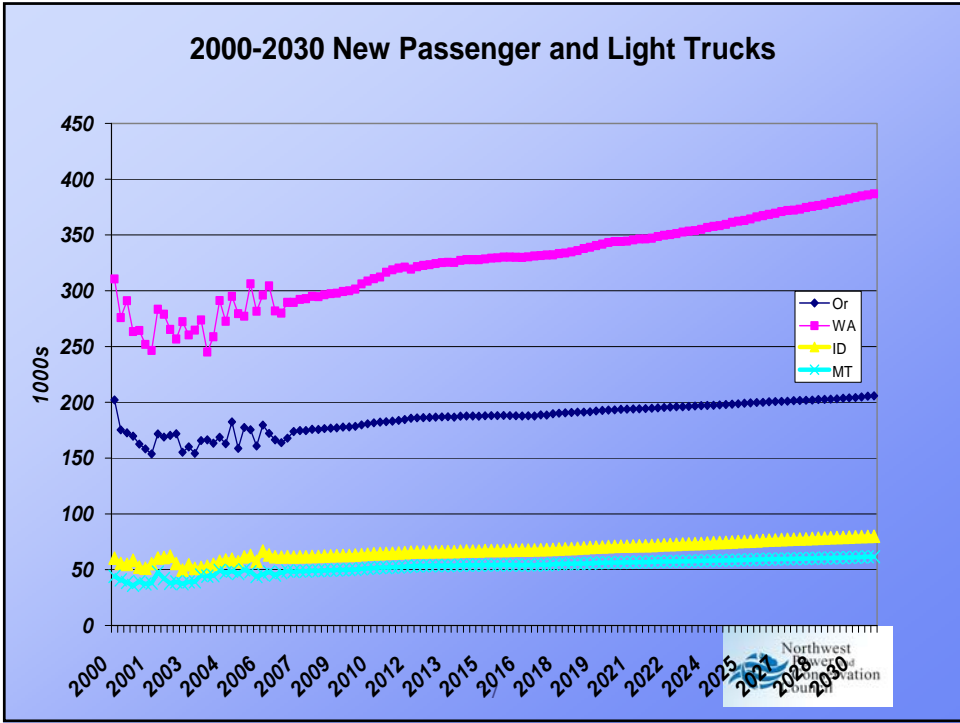
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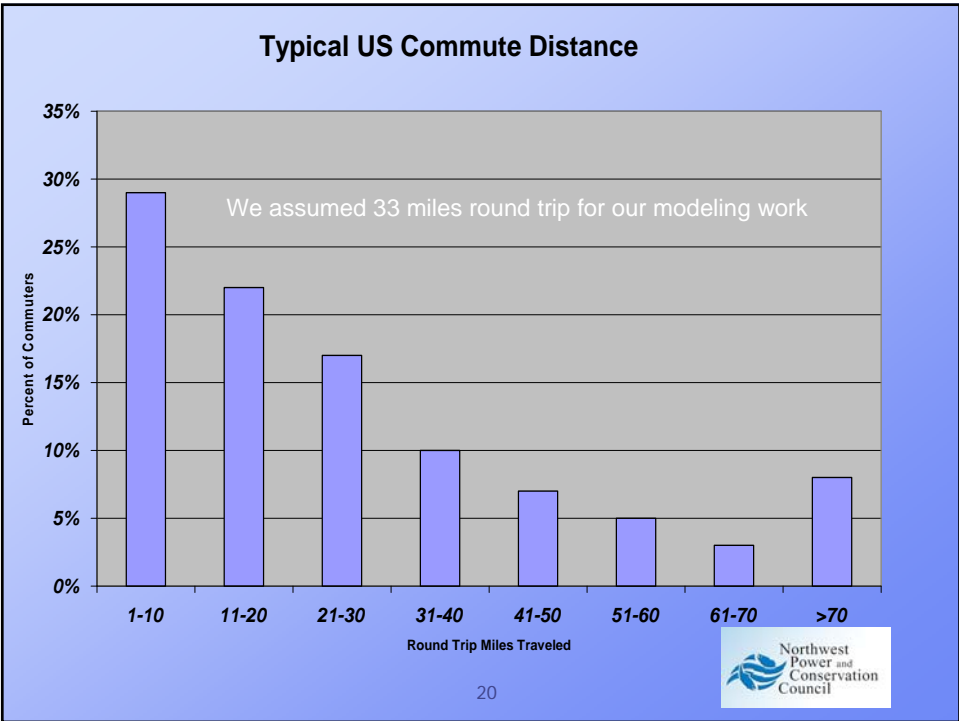
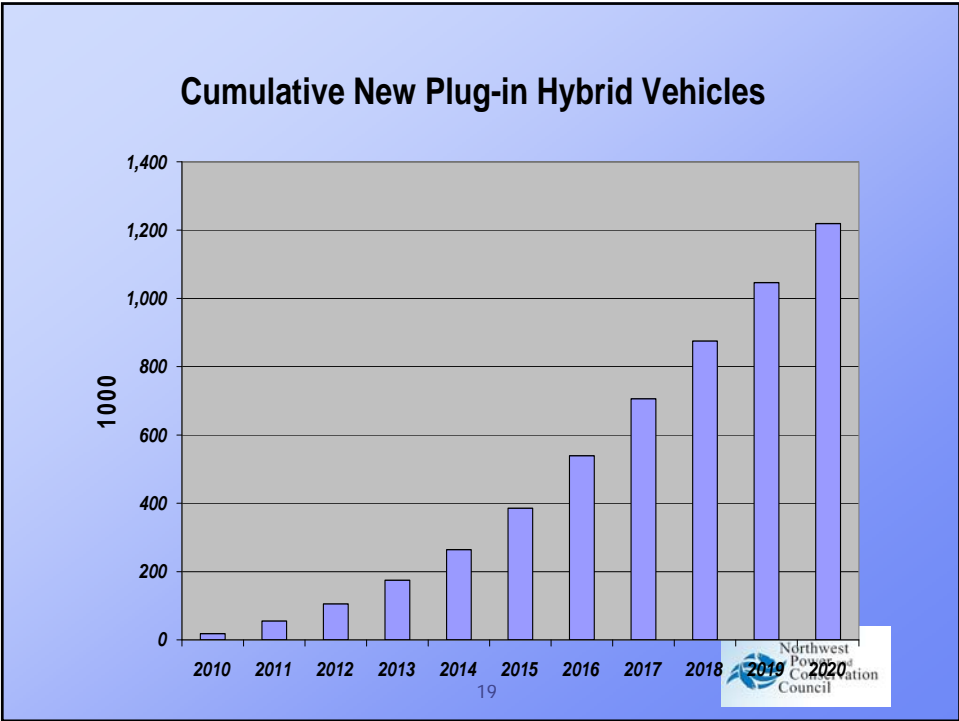
### Personal Income (Billions \$2000)



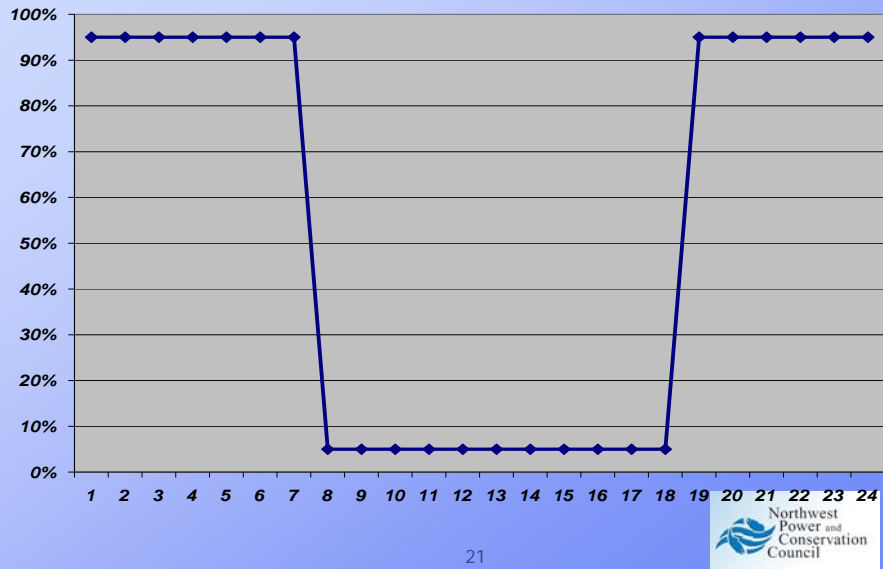
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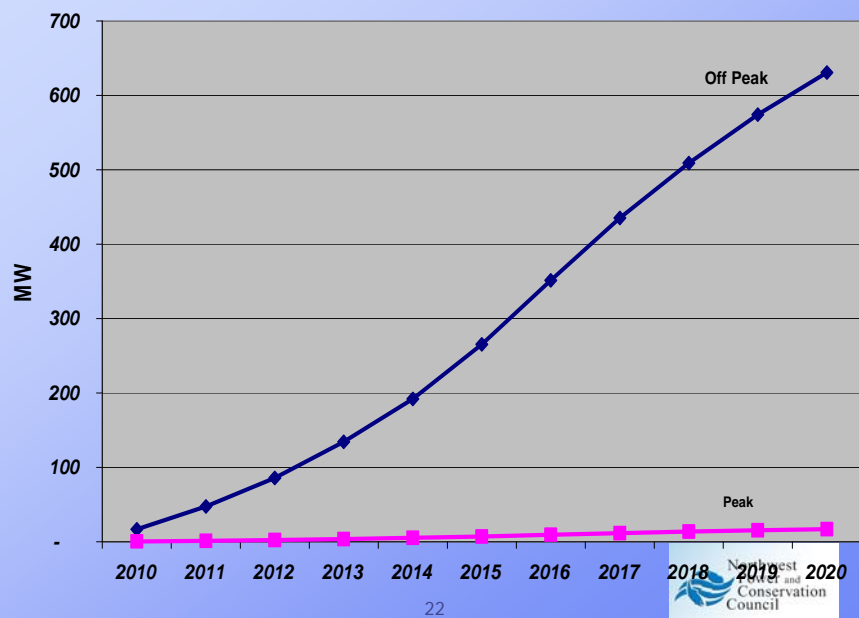
## Assumed Daily Recharge Schedule



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## Impact of Plug-in Hybrids on system Load



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## Modeling Storage Opportunities

- Assumed that 25 MW of storage can be placed in the Plug-in vehicles.
- Charge period
- Discharge Period
- Assumed efficiency

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## Implications of Hybrids

- 2020 MID C prices (annual mean)
  - Base case - \$71.42 /MWh
  - With Plug-ins - \$ 72.07/MWh
  - With Plug-in and V2G- \$65.27/MWh
  - Discharge period price \$70.30
  - Recharge period price \$54.60
- Power Plant CO2 Emissions (WECC wide)
  - Base case - 475 million tons
  - With Plug-ins - 476 million tons
  - With Plug-in and V2G- 444 million tons
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## Preliminary results from Aurora

- Increased Load
- CO2 reduction
- Increase in off peak prices

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## Incorporating Plug-in Hybrids

- Plug-in hybrid characteristics will be incorporated into Energy2020 model
- Penetration rates can be exogenously set or endogenously determined.
- V2G will be incorporated into Aurora model.

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