Electric Vehicle Infrastructure

A Utility perspective

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Technical Review Subcommittee

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Electric Vehicle Market Drivers

- **At what level of electric vehicle penetration is there an electric utility business case for encouraging and incentivizing EVs?**
  - Regulated entities, does not matter … as long as there is a return on investment

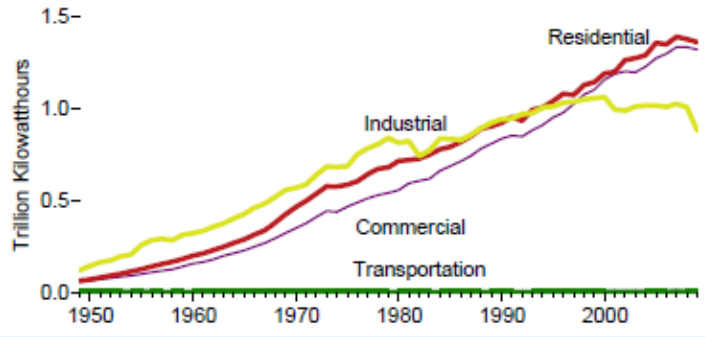
- **Which is more important?**
  - Availability of affordable electric cars (and batteries) **(majority)**
  - Availability of public charging portals
  - Both are equally important **(minority)**

- **How many charging stations are necessary for each electric vehicle (and how large)?**

  (For comparison there are currently about 2,000 gasoline vehicles per motor gasoline station or about 300 vehicles per day per station)
  - One charging station at home **(majority)**
  - One at work
  - One public "station" serving perhaps 20 electric vehicles (minority)

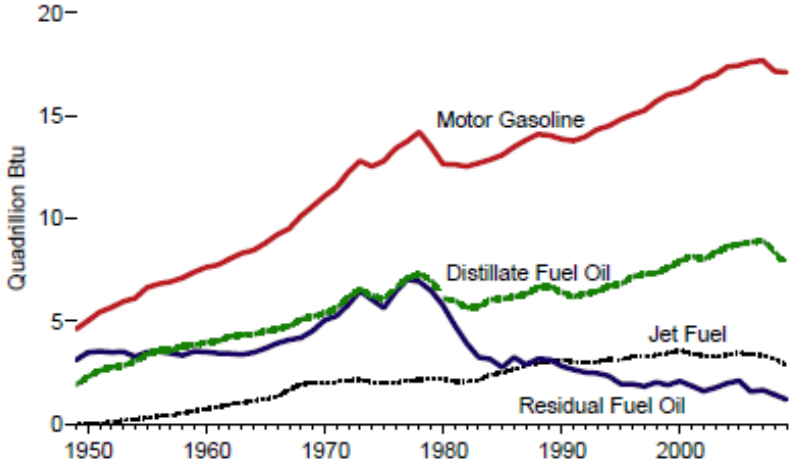
Energy Consumption Comparison

Figure 48. Electricity Retail Sales by Sector



Enormous growth occurred in the amount of electricity retail sales to the three major sectors—residential, commercial, and industrial. Industrial sector sales showed the greatest volatility. Sales to residences exceeded sales to industrial sites beginning in the early 1990s, and sales to commercial sites surpassed industrial sales beginning in the late 1990s.

By Selected Product, 1949-2009



- **Residential**: ~1.4 million GWh direct electrical consumption
- **Motor Gasoline**: ~1.6 million GWh electric equivalent consumption
- Ten (10) percent light duty electric vehicle penetration would increase Residential electrical consumption by perhaps 12% and increase total electrical consumption by ~4%
- Its not a matter of consumption, but rather a matter of "demand" management

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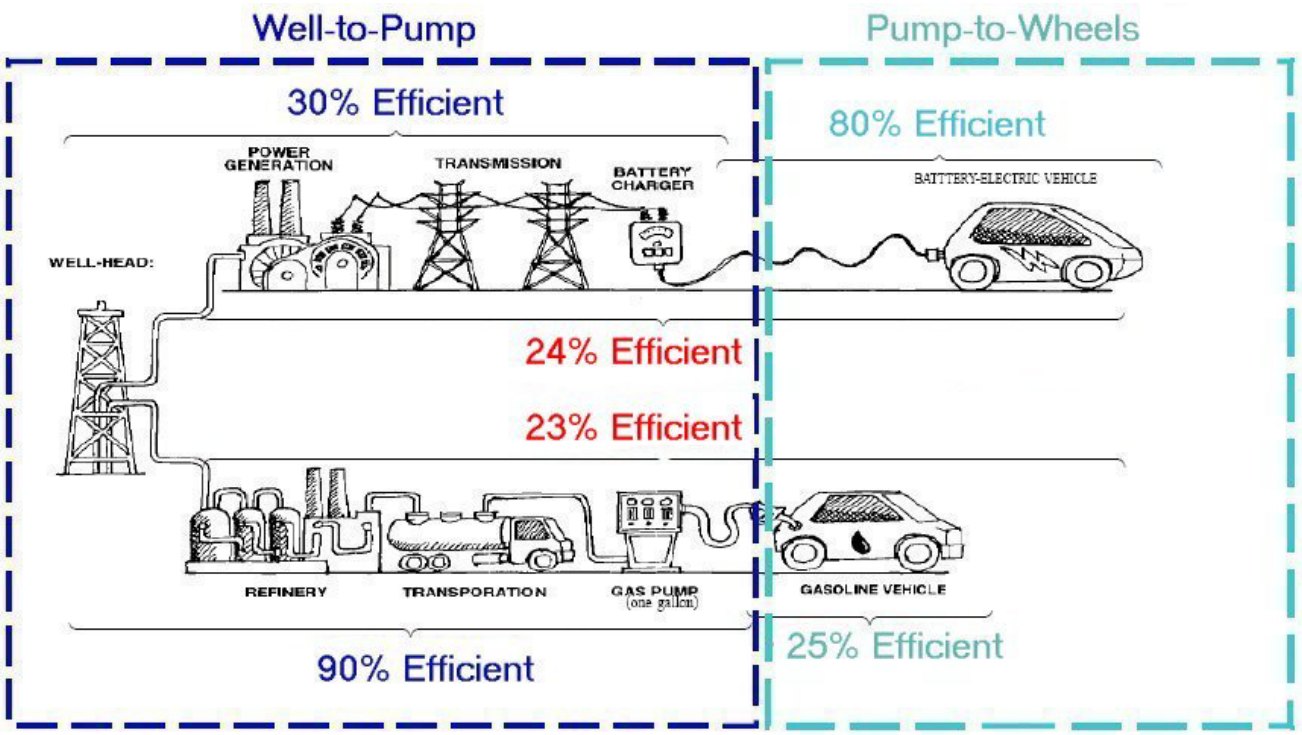
Source: US EIA, Annual Energy Review 2009

Comparison of Conversion Efficiencies



- **Electric Generation**: Combined Cycle Natural Gas (and IGCC), renewables all increase efficiency
- **Gasoline Vehicles**: Hybrid-electric, direct injection, Atkinson cycle all increase efficiency

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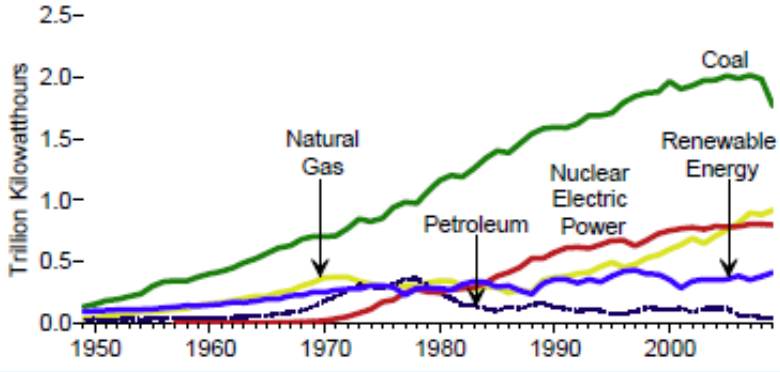
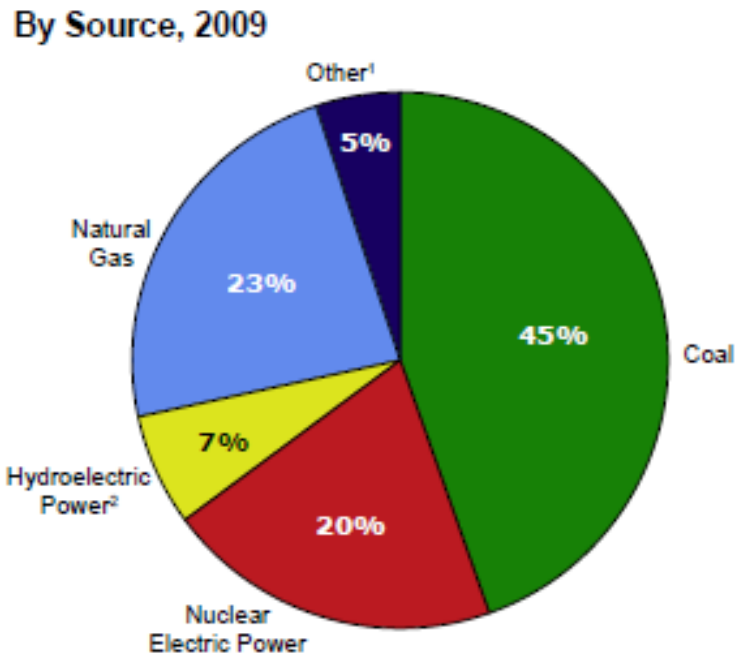
Source: image from www.nesea.org, % labels by MJB&A

Current US Electric Generation Mix

Figure 44. Total Electricity Net Generation by Source

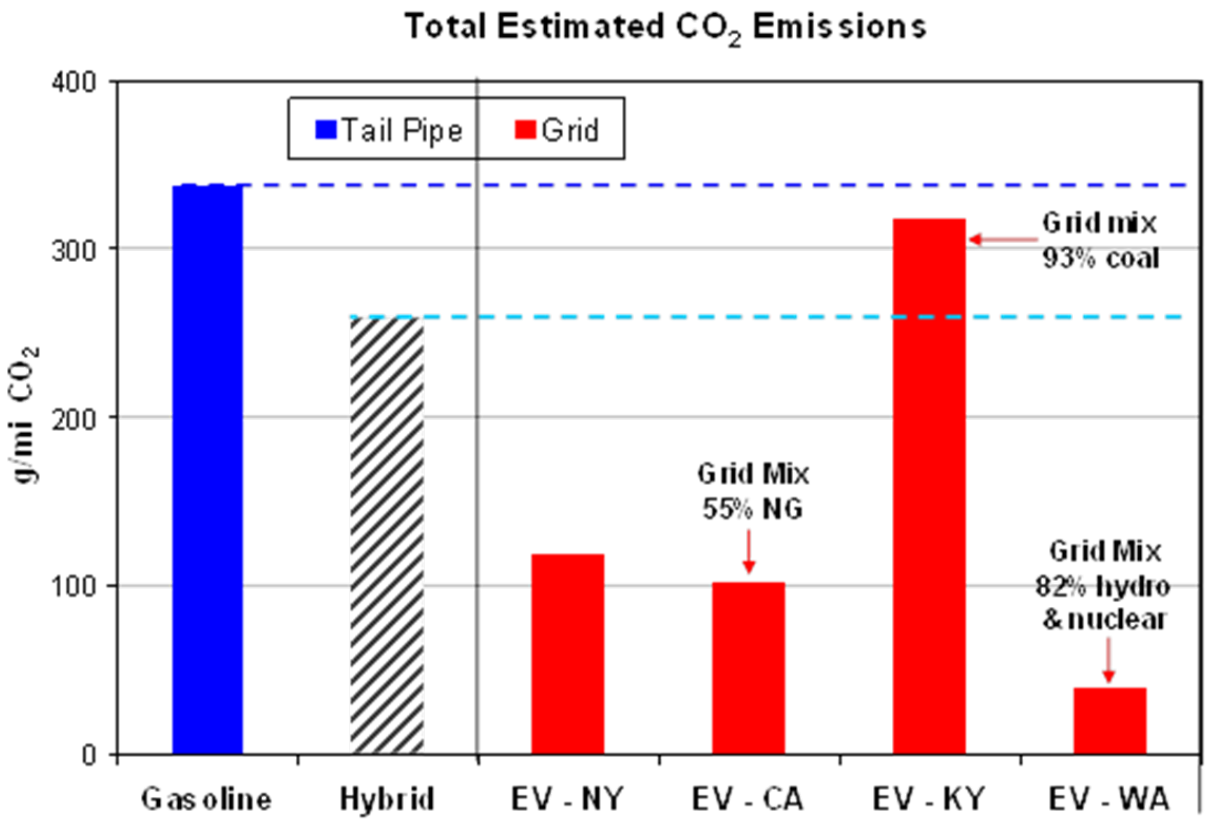


Most electricity net generation came from coal. In 2009, fossil fuels (coal, petroleum, and natural gas) accounted for 69 percent of all net generation, while nuclear electric power contributed 20 percent, and renewable energy resources 10 percent. In 2009, 66 percent of the net generation from renewable energy resources was derived from conventional hydroelectric power.



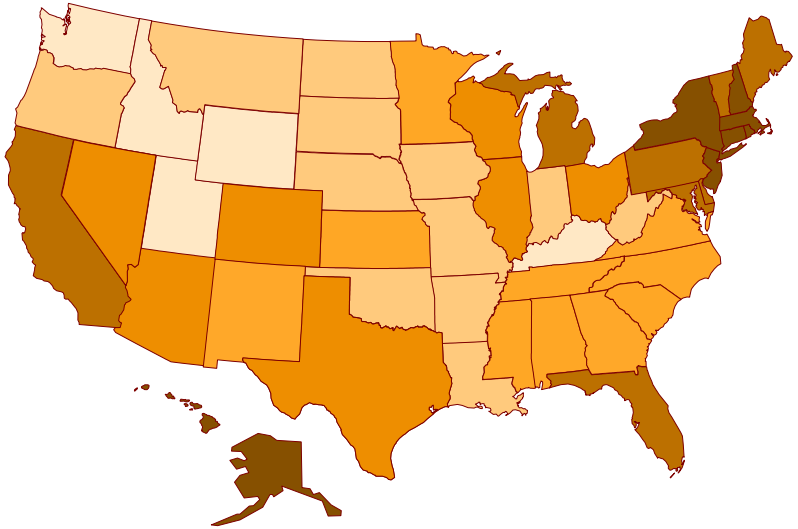
Source: US EIA, Annual Energy Review 2009

Effect of Grid Mix on Vehicle emissions



Source: MJB&A, all vehicles mid-size sedan equivalent

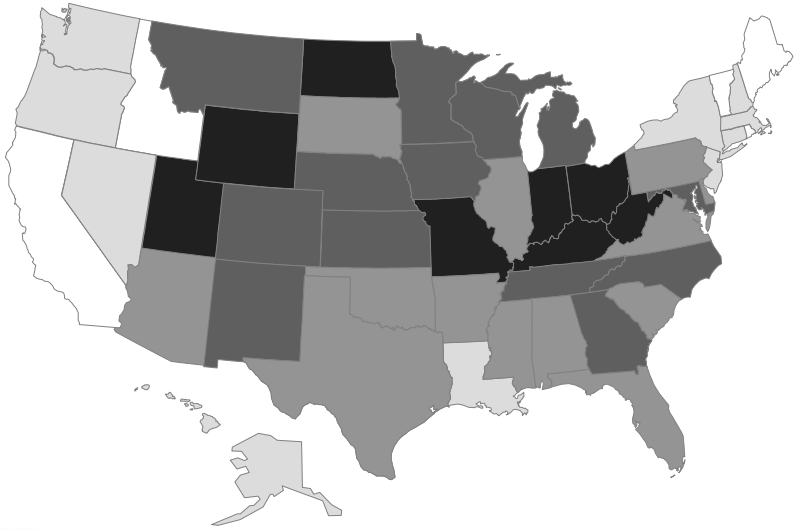
Average Electric Rates and Coal Generation



Average Electricity Rates
(2010 all sectors, cents/kWh)

6 7 8 9 10 14 25

cents/kWh



Coal Generation
(2010 percent)

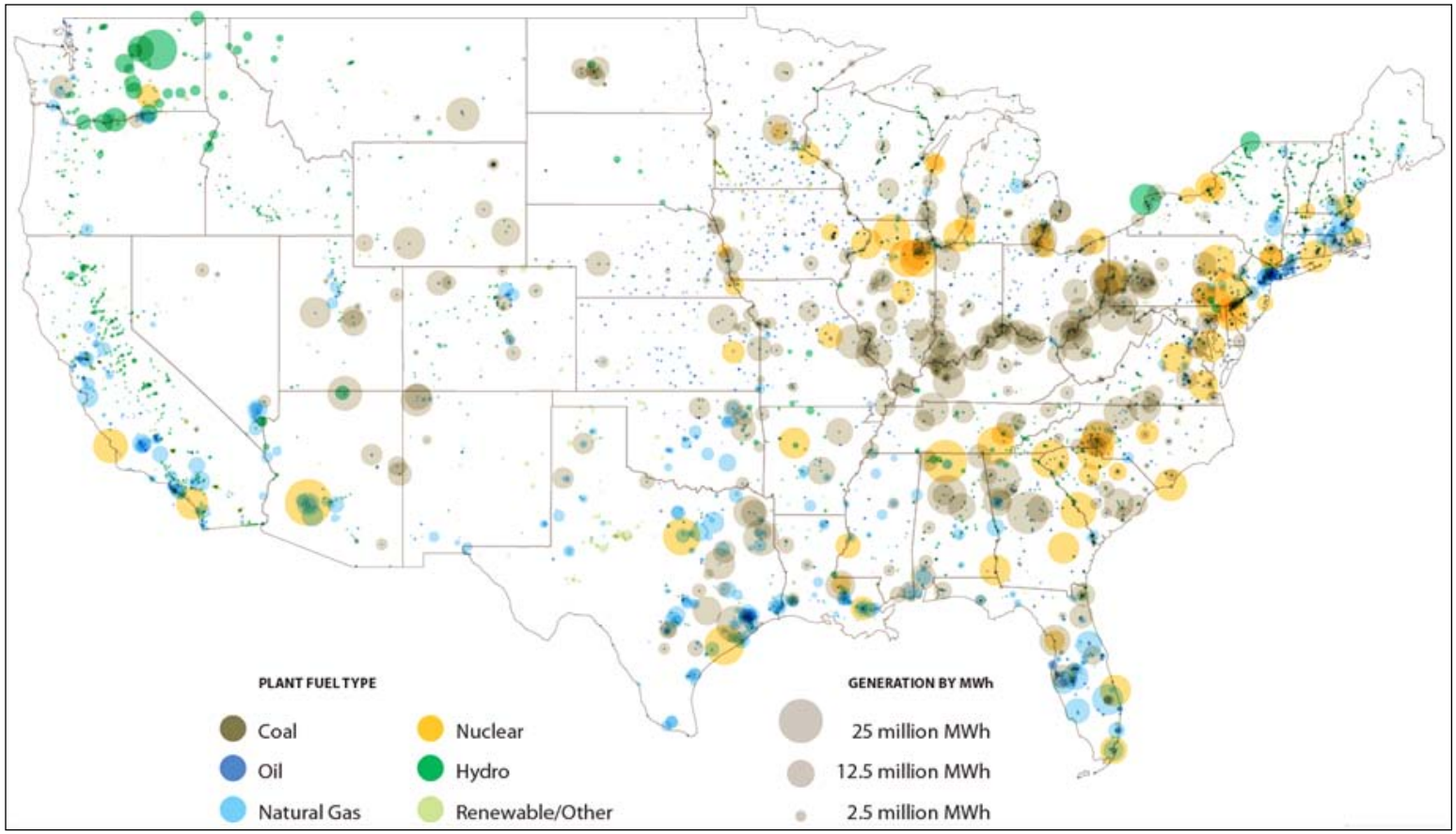
0 5 25 50 75 100

% of total in-state generation from coal

Source: U.S. EIA, Electric Power Monthly, 2011

US Electricity Generating Facilities

Location and Relative Generation of U.S. Power Plants by Fuel Type



Source: www.ceres.org Benchmarking Air Emissions June 2010

Vehicle Locations

- **Will a majority of EV charging happen at night?**
  - **Yes, and electric rate tariffs will incentivize this behavior**

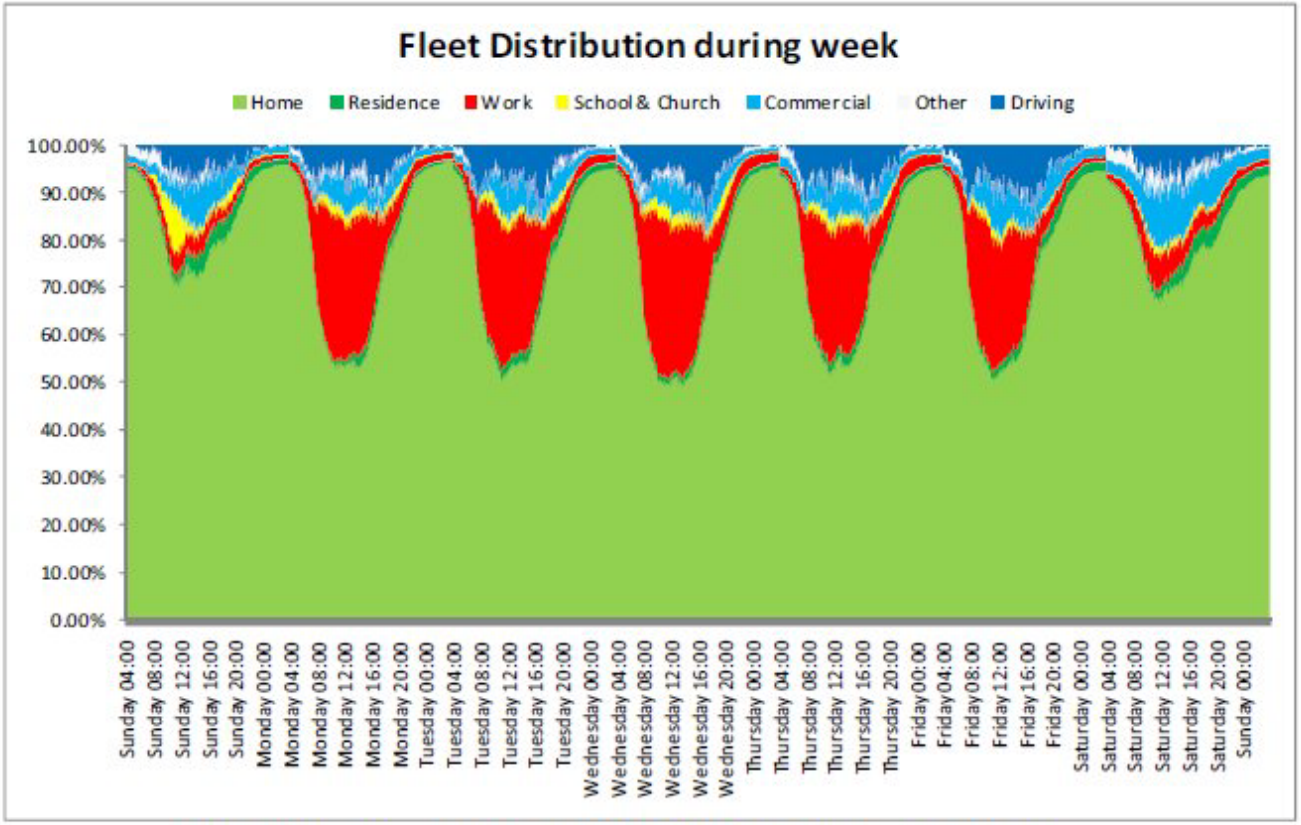


Figure 5 - Expected Vehicle Location

Source: SAE_2009-01-1311

Electric Tariffs are designed to cover costs

- **Electric tariffs can vary significantly by region, time of use and demand level. Residential customers will likely continue to be exempt from "demand" charges, but this could change with fast charging**

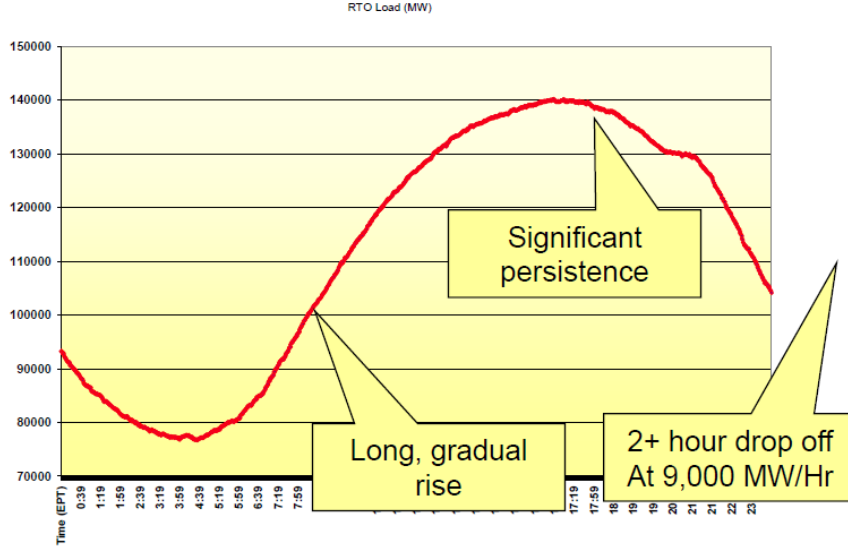
  - Level 1 – 12 to 20 hours to charge No demand tariff, free infrastructure
    - "time of use" optional in some locales
    - Expect **$0.15**/kWh (typical national average)

  - Level 2 – 4 to 8 hours to charge
    - "time of use" meter optional
    - "demand" meter may be required for high kW
    - Expect **$0.15**/kWh with a straight residential tariff
    - Expect to pay **$0.12** (night) to as much as **$0.25**/kWh (day)

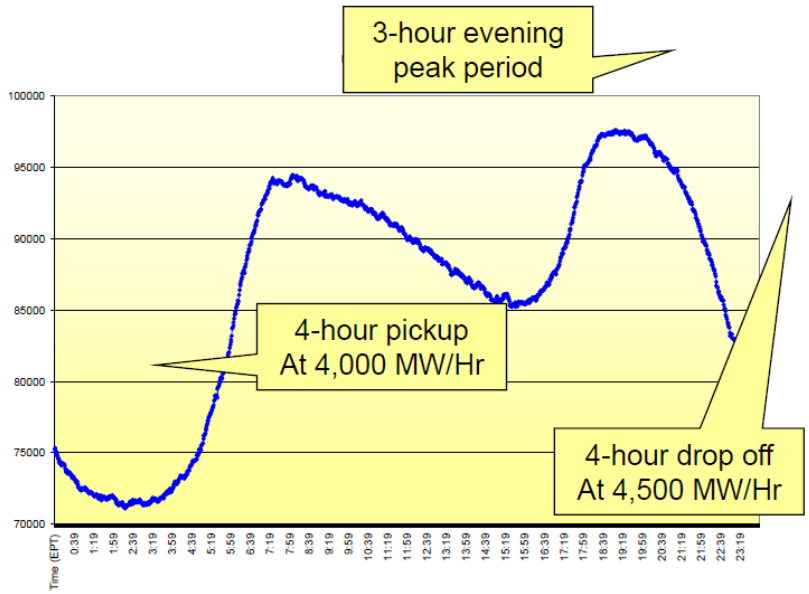
  - Level 3 – <15 minutes to charge
    - Time of day demand tariff, variable pricing also possible
    - Smart meter may be required (or alternate communication)
    - Load leveling strategy potentially required
    - Expect to pay **$0.15** to **$0.25**/kWh (night) but **$0.45**/kWh and higher (day)
    - Low equipment load factors could substantially increase kWh costs

Power Generation Load Profile (examples)

Summer



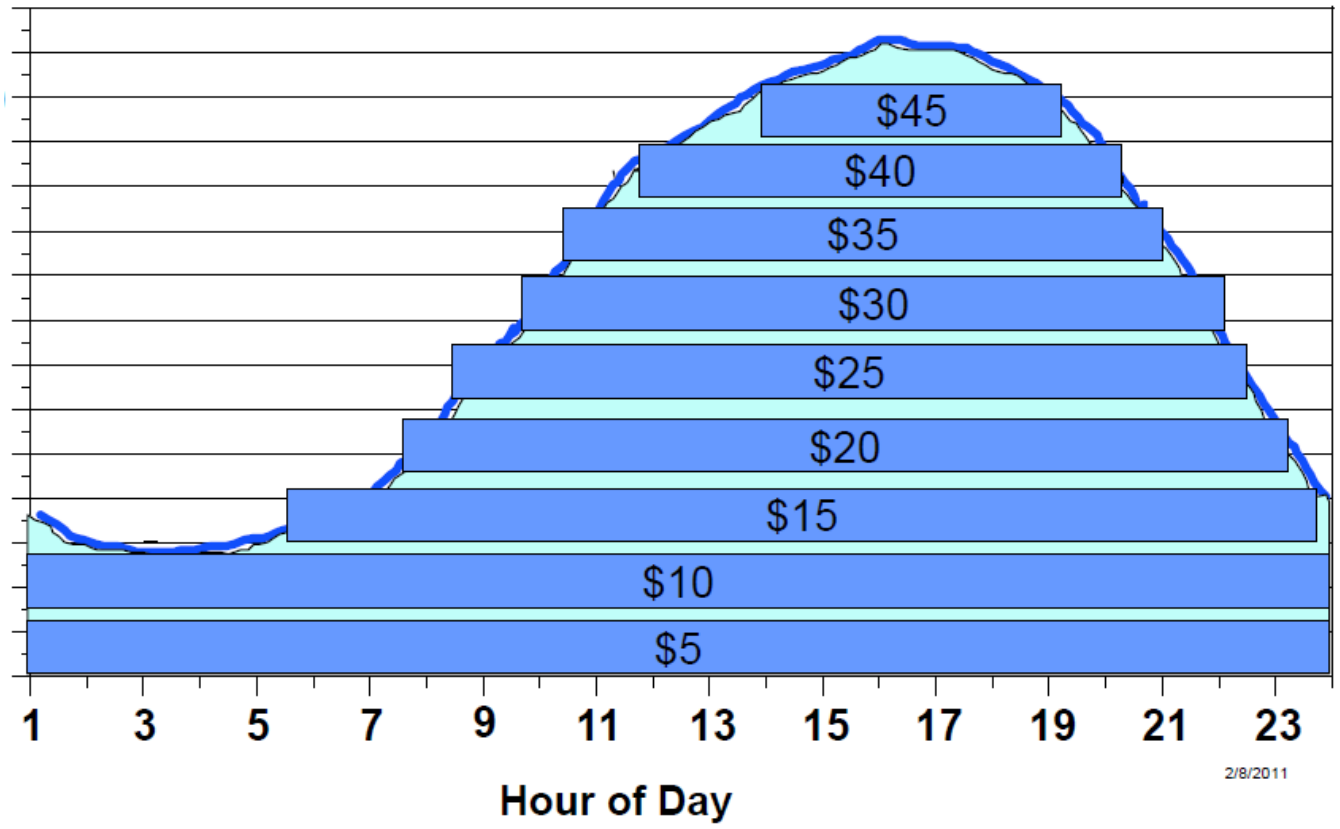
Winter



- **Late day peaks are becoming more common, with low loads shifting toward an 11pm to 7am period**
- **Summer more critical than Winter**
- **Note, Y axis scales are different in these two charts**

Source: PJM Generation Basics 101 2/8/11

Power Generation Economic Dispatch (example)



- **Unlike gasoline (which can be stored), electricity must be generated as it is consumed and is more expensive when generated by peaking units**

Source: PJM Generation Basics 101 2/8/11

Infrastructure Upgrades

- **At what charging level is there a need for distribution infrastructure reinforcement?**
  - Level 1 - No issues
  - Level 2 - Below 3.3 kW no issues
  - Level 2 – Above 3.3 kW potential issues
    - Service panel upgrade (customer cost) or local transformer upgrades (utility cost), may necessitate “demand” meter
  - Level 3 – Upgrades likely
    - Network upgrades, 480 volt service, customer charger, customer transformer
    - High capital and high operating costs make a reasonable ROI unlikely

Summary Thoughts

- **Will consumers buy electric cars?**
  - Yes, if they are less expensive to own and operate than conventional cars. Modest residential charging at night is the key to keeping the cost effectiveness gap between electricity and motor gasoline providing a positive ROI for the consumer
- **Is charging infrastructure the problem?**
  - No, increased consumption revenues will likely offset the costs of local distribution upgrades up to a point
  - "Public" charging infrastructure above 6.6 kW may alleviate range anxiety but it may also end up being an underutilized stranded asset
- **Do electric cars really get X MPG?**
  - Should be reported in Wh/mile or Mi/kWh
  - The "gallon" equivalent value that ultimately matters will be the one that DOT uses to assess road taxes for electric vehicles

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