CONSUMER ACCEPTANCE OF ADVANCED ELECTRIC VEHICLES

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THE CONTENT OF THIS PRESENTATION REPRESENTS THE CONSIDERED OPINION OF THE SPEAKER AND NOT THAT OF ANY SPECIFIC ELECTRIC UTILITY

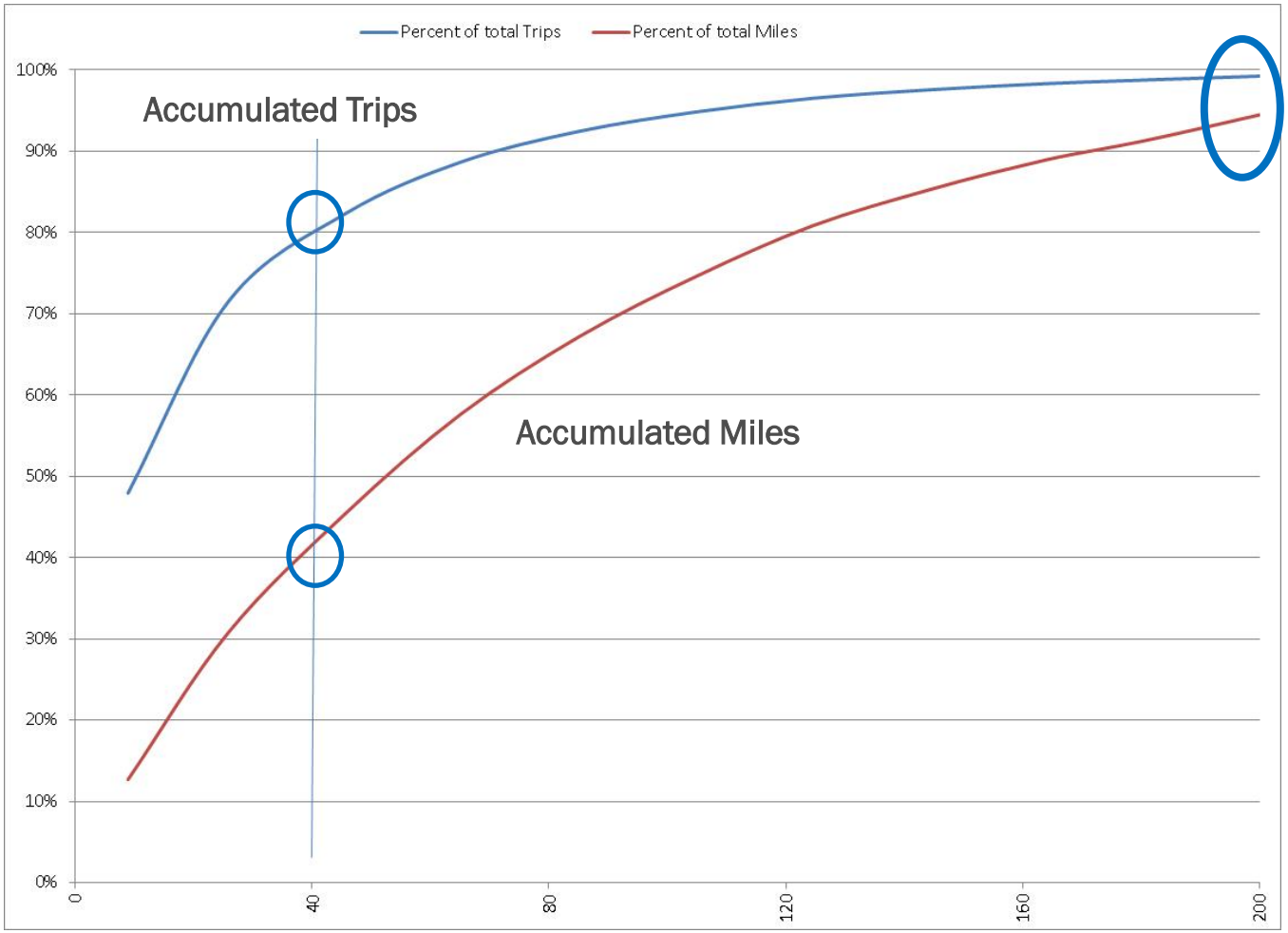
4 KEY MESSAGES FOR EVS

1. Increased Range: By 2030 EVs must achieve ~200 mile range (200 sticker, 160 nominal) to replace a consumer vehicle, more range = less infrastructure
2. Lower Cost: Battery cost determines EV cost as well as vehicle efficiency (wh/mi)
3. Cheap Fuel: The cost of electricity can be ~$1.50/GAL (12.7 kWh @ $0.12/kWh) @ ~36 mpg conventional
4. Electric infrastructure : (low and slow) is already pervasive, "fast" chargers don't increase range, don't make batteries less expensive, don't make batteries last longer, don't make EVs more efficient, don't make electricity cheaper, don't alleviate range anxiety…

200 MILE RANGE IS THE FIRST HURDLE

- 40 kWh Capacity: Battery technology (specific power, specific energy, weight, volume) has improved dramatically but are still costly so manufacturers use less kWh and in some cases a "spare" engine
- 200 wh/mi Efficiency: EVs must get more efficient, current EVs lack optimal efficiency, most >300 wh/mile (~36 mpg chassis); fuel economy standards will drive us to 200 wh/mi
- Question: Would a consumer buy a gasoline vehicle that only has a 3 gallon fuel tank and 100 mile range? Answer: Probably not, too many trips to the petrol station

WHY 200 MILE RANGE?



80% of "day trips" are less than 40 miles, but these trips comprise less than 50% of the annual miles (i.e. half a car)

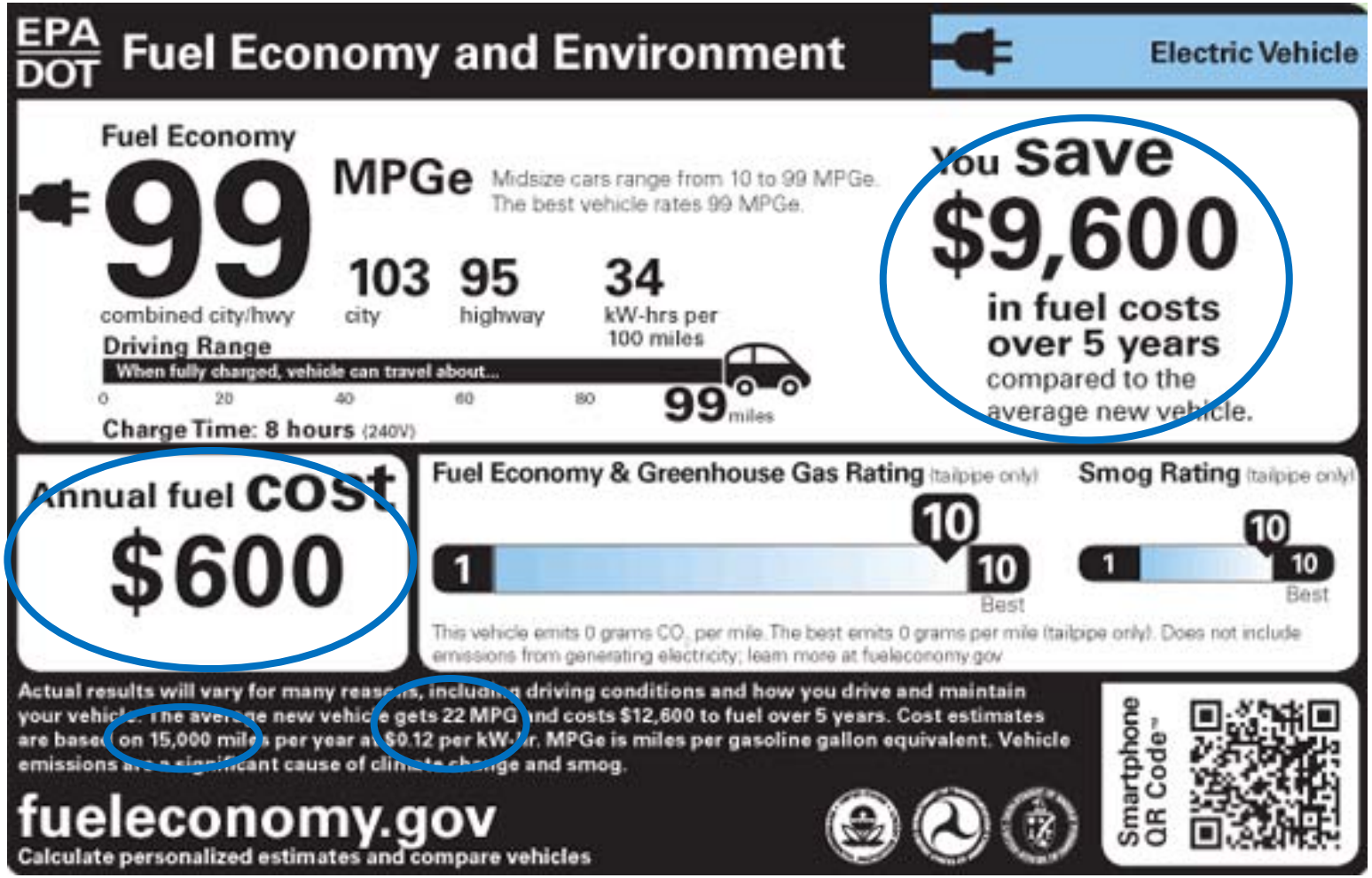
95th percentile day trip 200 miles (i.e. a whole car)

- National Household Travel Survey, http://nhts.ornl.gov/
- Trips over 250 miles eliminated, multiple trips per day combined

BATTERY COST IS THE FIRST AND SECOND HURDLE

- 2012, 24 kWh = $24,000 incremental cost:
  Expensive with limited range because of
  >$1,000/kWh battery cost (LiB)
- 2020, 40 kWh = $12,000 incremental cost:
  EVs still too expensive but with adequate range and
  battery life at $300/kWh battery cost (LiP)
- 2030, 40 kWh = $4,000 incremental cost:
  Target $100/kWh battery cost (presumably LiAir),
  adequate range, cost and battery life
- Question: What incremental cost does not require
  incentives? Answer: Less than $4,000

EV FUEL SAVINGS APPLES AND ORANGES?

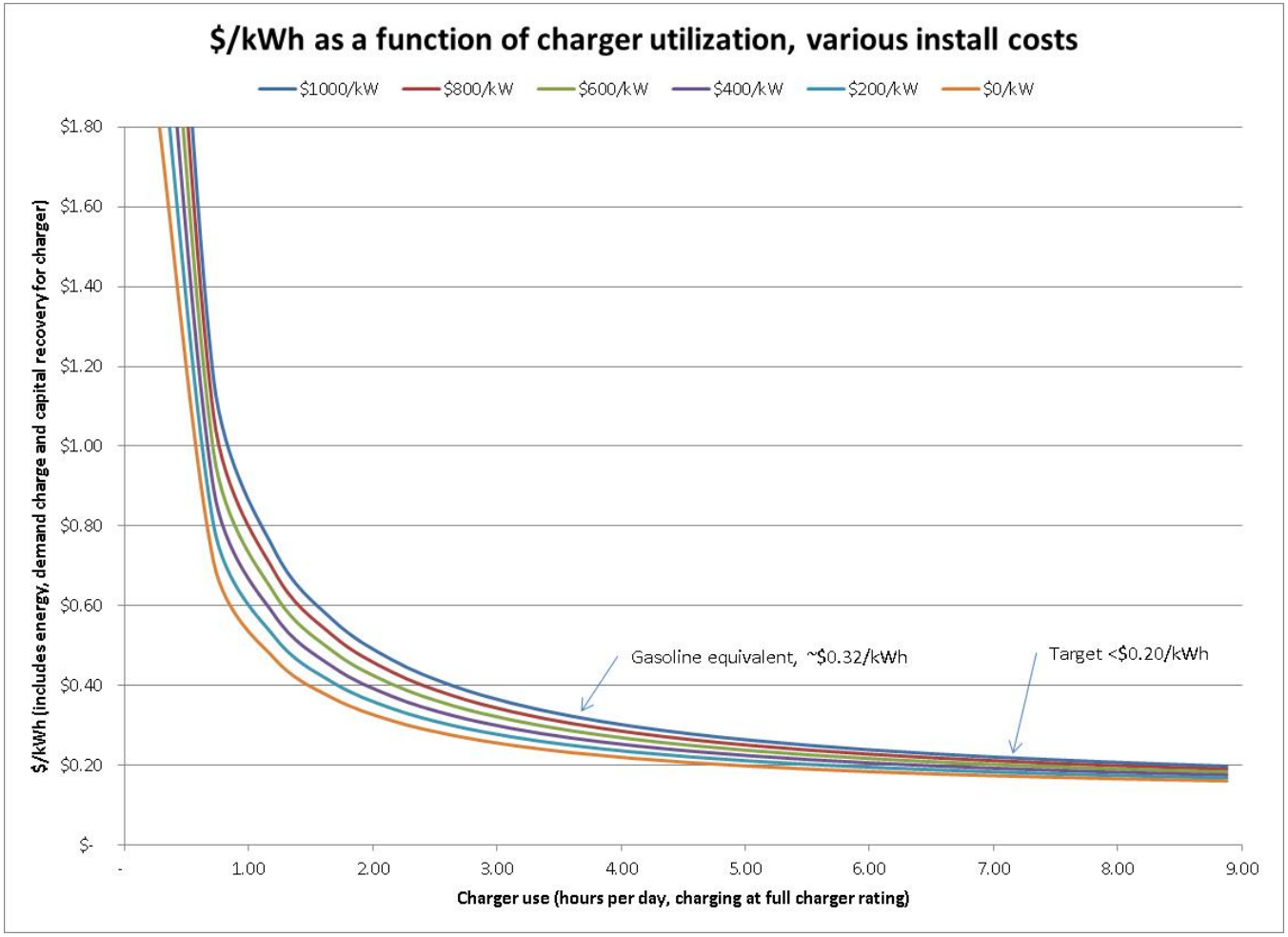


*DOT road taxes not included

CHEAP ELECTRICITY IS THE THIRD HURDLE

- **Prioritize inexpensive home and work charging while parked**
  - Inexpensive means: 12 gauge conductor, 20 amp circuits, >6 hour charging duration
- **Inexpensive at Home (<4 kw, 40 kWh in 10 hours, ~14 hrs/day)**
  - Inexpensive Charging at Night, even a 40 kWh pack
  - Vehicle preconditioning for consumers w/o garage
- **Inexpensive at Work (<2 kW, 12 kWh in 6 hours, ~8 hrs/day)**
  - Parking Garage Level 1 Charging (~$1.50/day, Free?) Low and Slow during the day
- **Expensive Public Fast Charging (>20 kW=1 mi/min, ~2 hrs/day)**
  - Some of this time spent driving
  - Active management to avoid "occupy-fast-charger"

WHAT CHARGING RATE = ~$1.50/GAL ELECTRICITY?



*Energy @ $0.11265, Demand Charge @ $13.07/kW, Various $/kW Capex

For electricity $ < gasoline $, need >6 hour per day utilization

*DOT road taxes not included

CLOSING SUMMARY

- **Question:** If consumers dislike gasoline stations, why copy?
- **Answer:** Utilities **don't believe** fast chargers are the answer
- **Progressive** Utilities, Low Flat Tariffs (some free at work)
  - Low public charger utilization results in high $/GALe, the 98% socializing the 2% is not sustainable
- **Wires** Utilities, earnings on assets, not kWh
  - EV consumer installs, keeping the lights on, will tie in but don't want stranded assets (chargers) unless free
- **Generation** Utilities, earnings on kWh & kW capacity, revenue depends on time of use
  - Fast chargers will only be used during the day, high $