

# Barriers to the Electrification of the Automobile



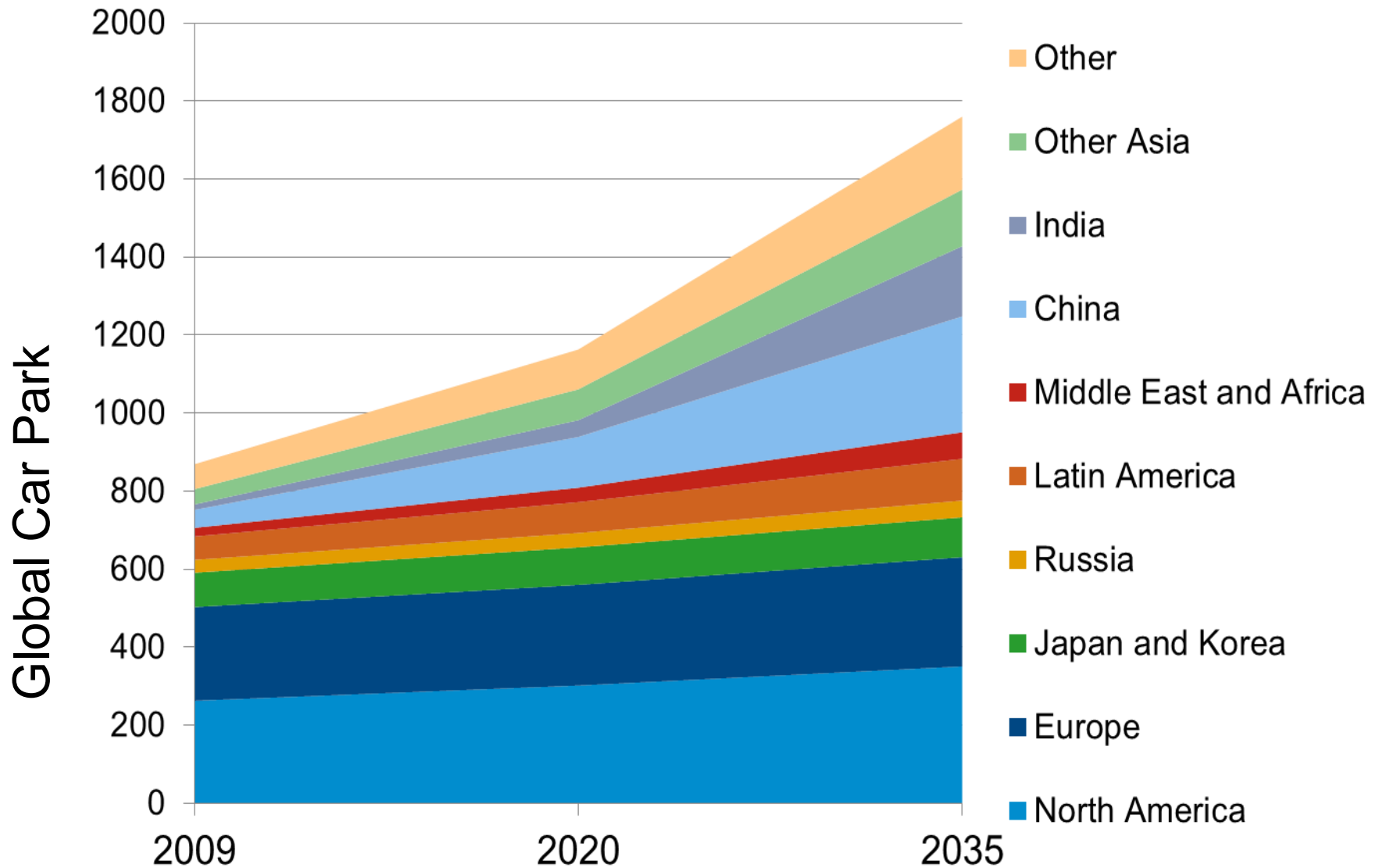
September 15<sup>th</sup>, 2014



Peter Savagian, General Director  
Electrification Engineering

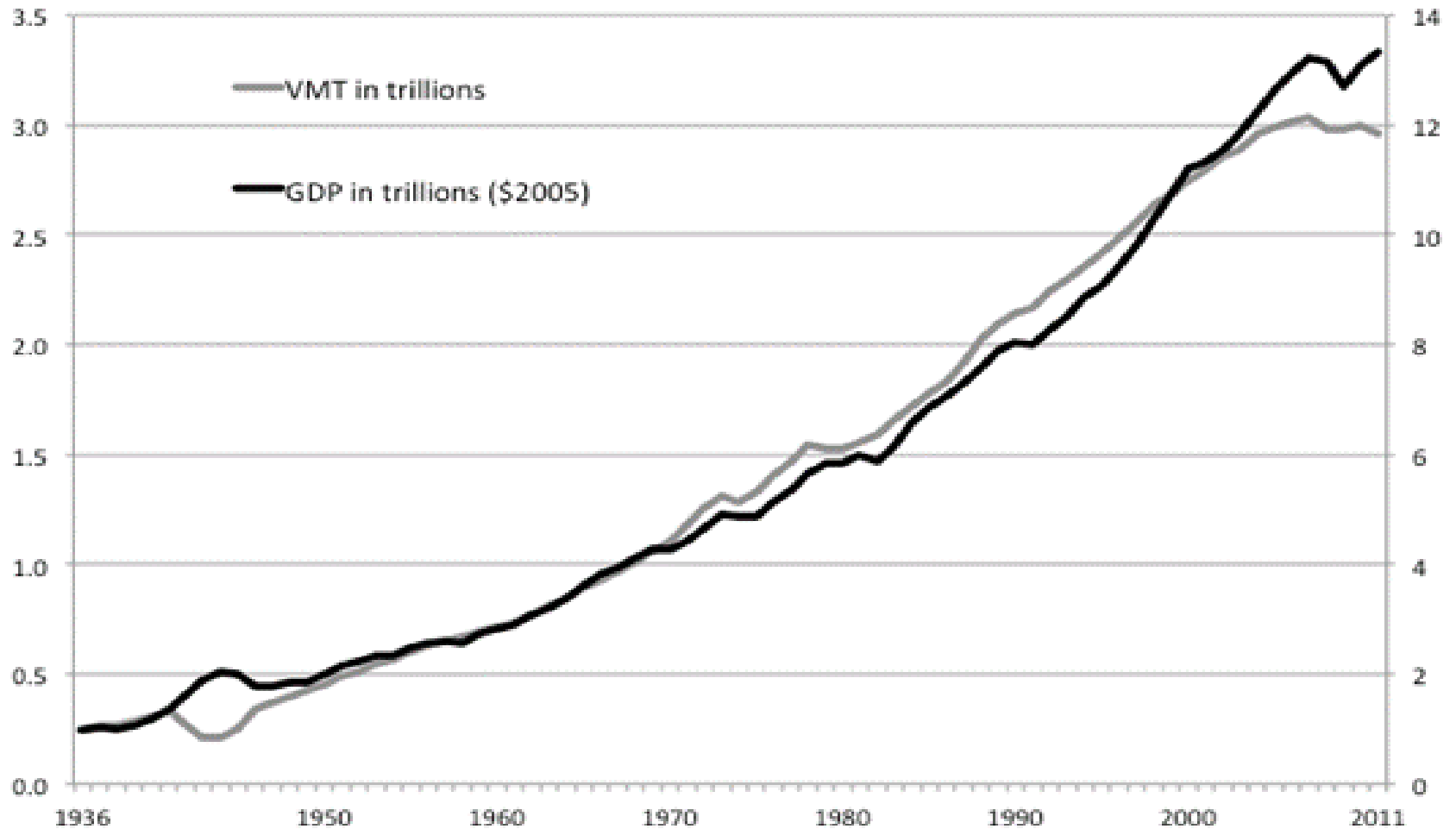


# Automobiles are a growth business



Source :  
World Oil Outlook, 2012, OPEC and IEF

# Automotive use correlates to economic growth

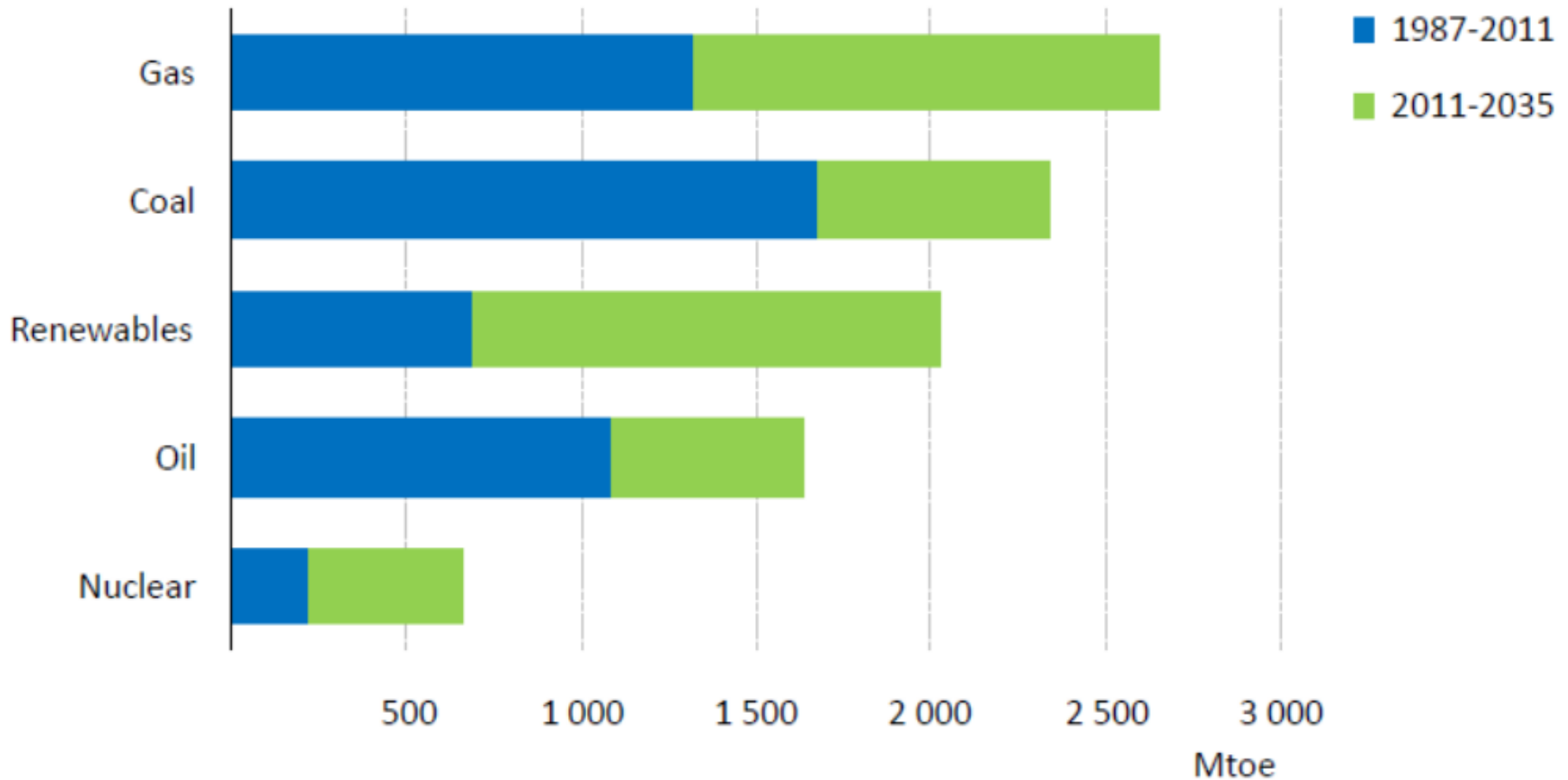


Source: Rand Corporation  
2012 DOTFHA Report

96% of transportation energy comes from petroleum

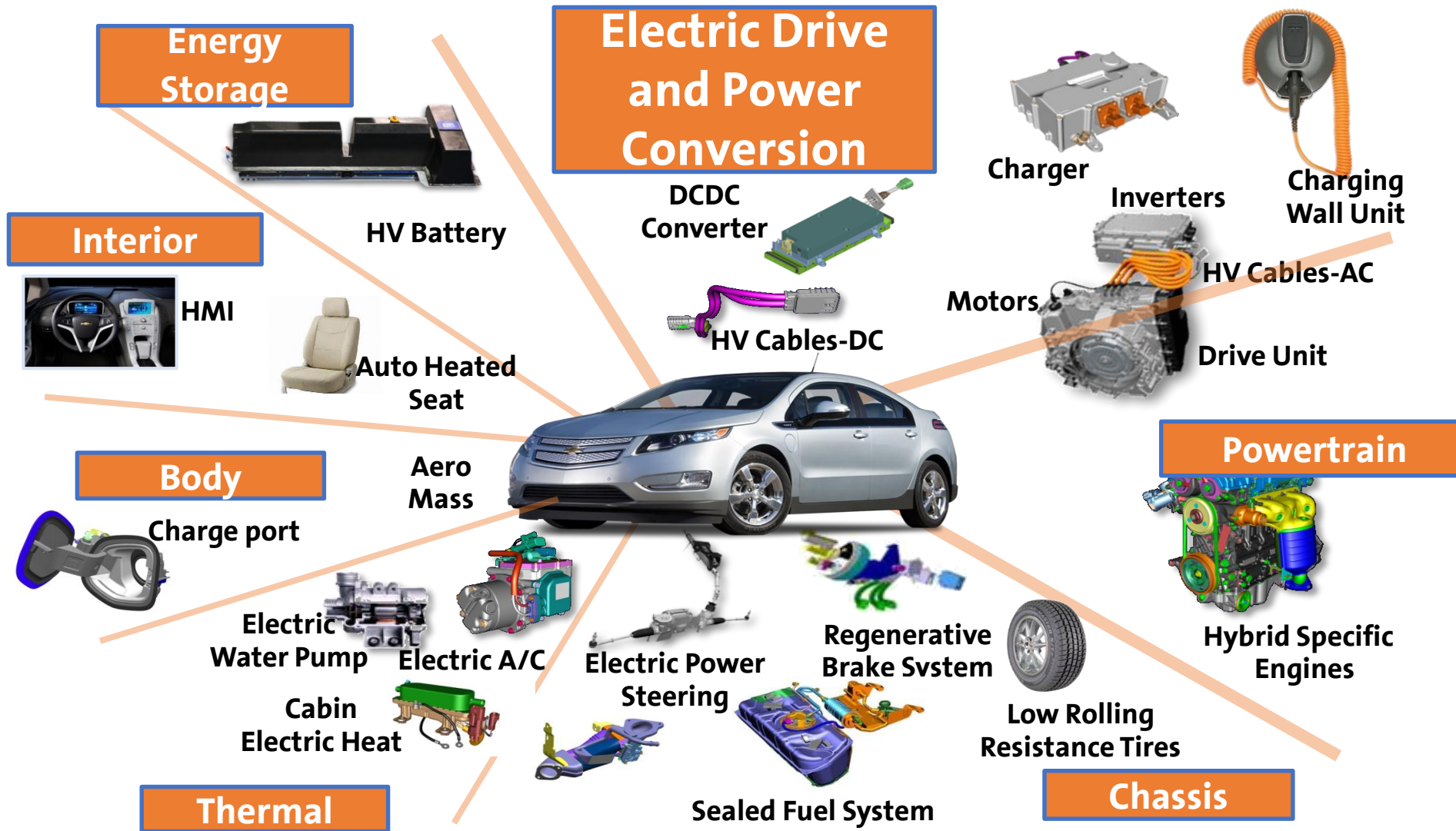


# Future energy growth is counting on renewables and natural gas for much of the increased growth

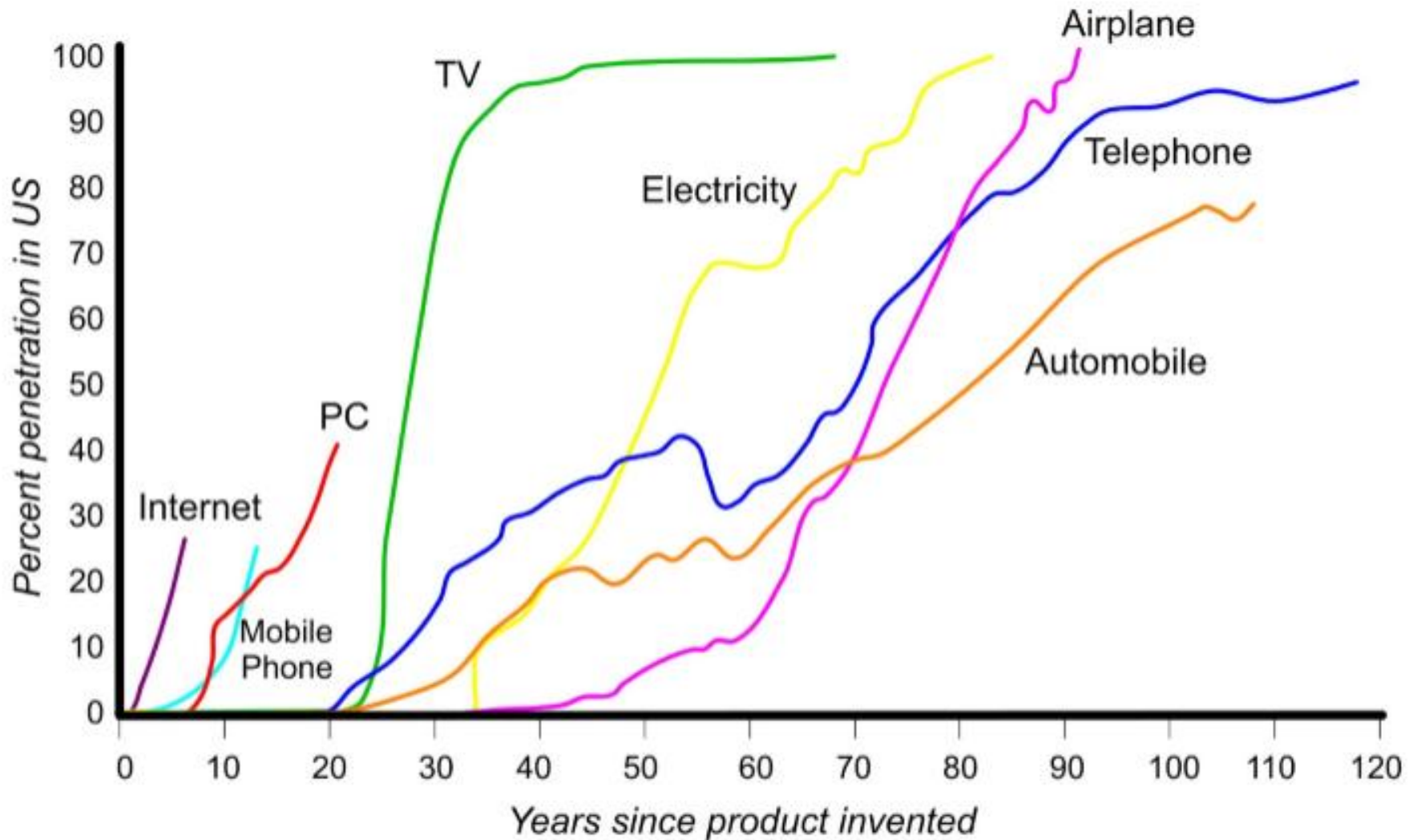


Source: 2013 EIA World Energy Outlook

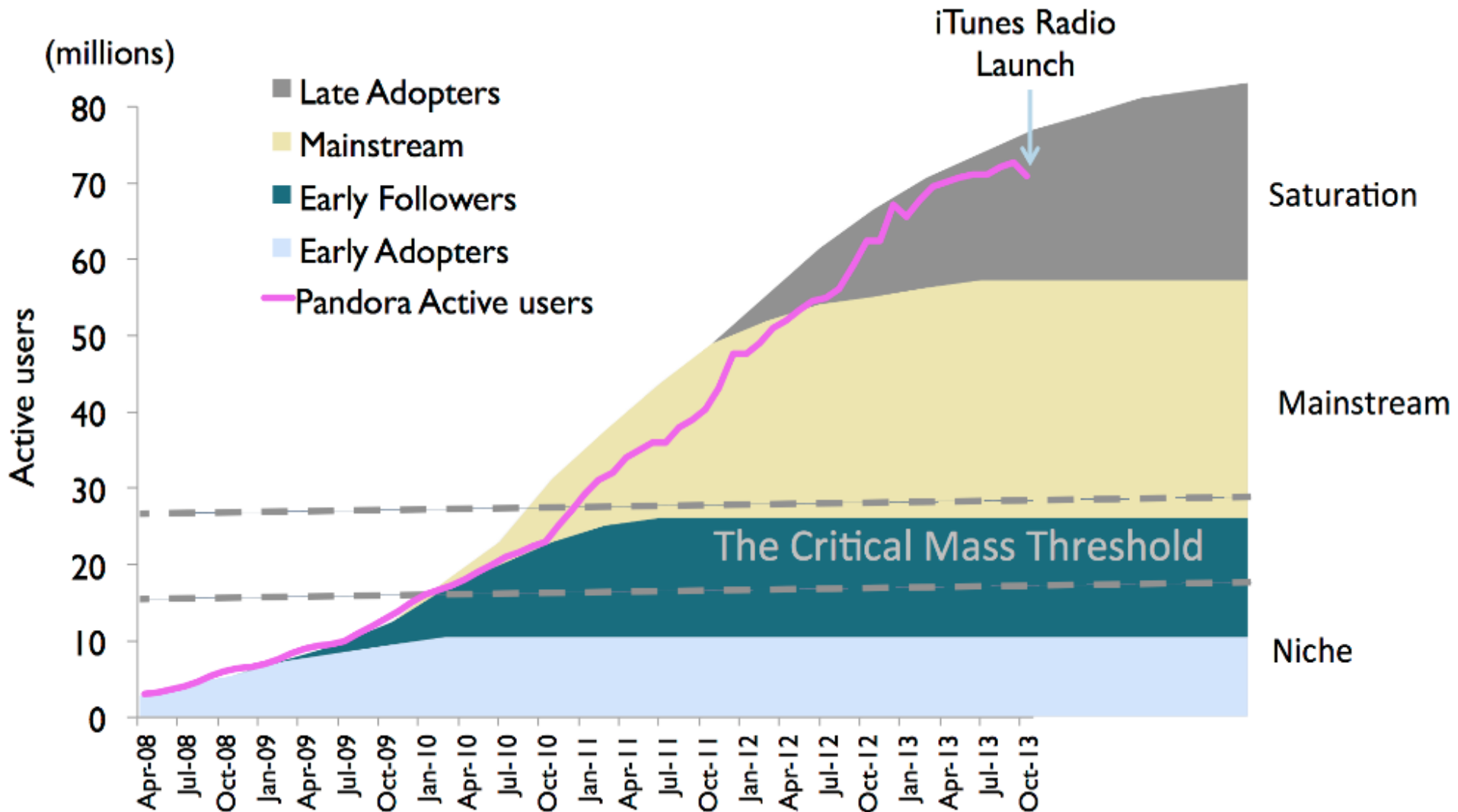
# Automotive electrification will grow the electric drive and power conversion Industry



# What limits the adoption of a new technology?



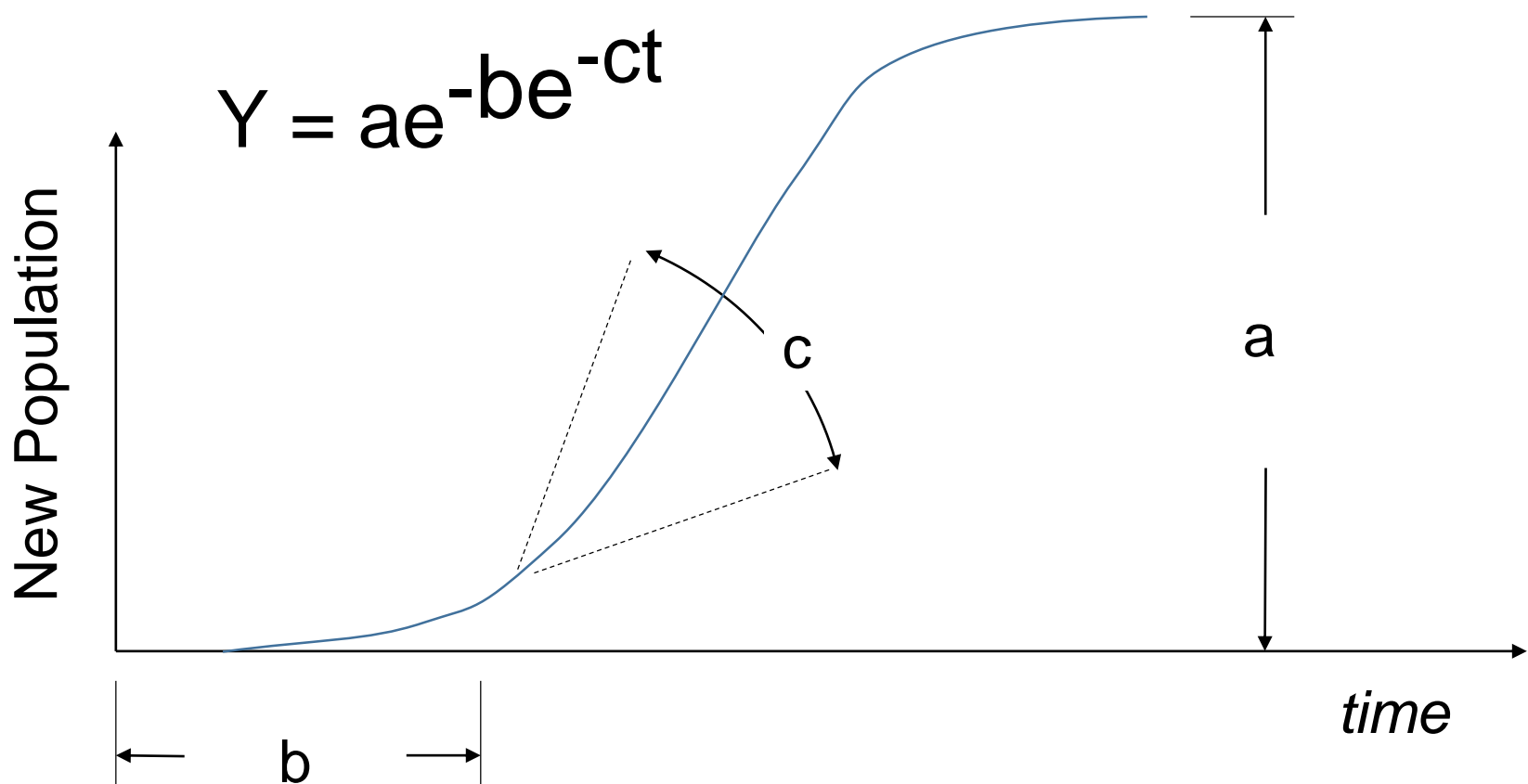
# Technology adoption – Pandora music service



Source: Company reported numbers

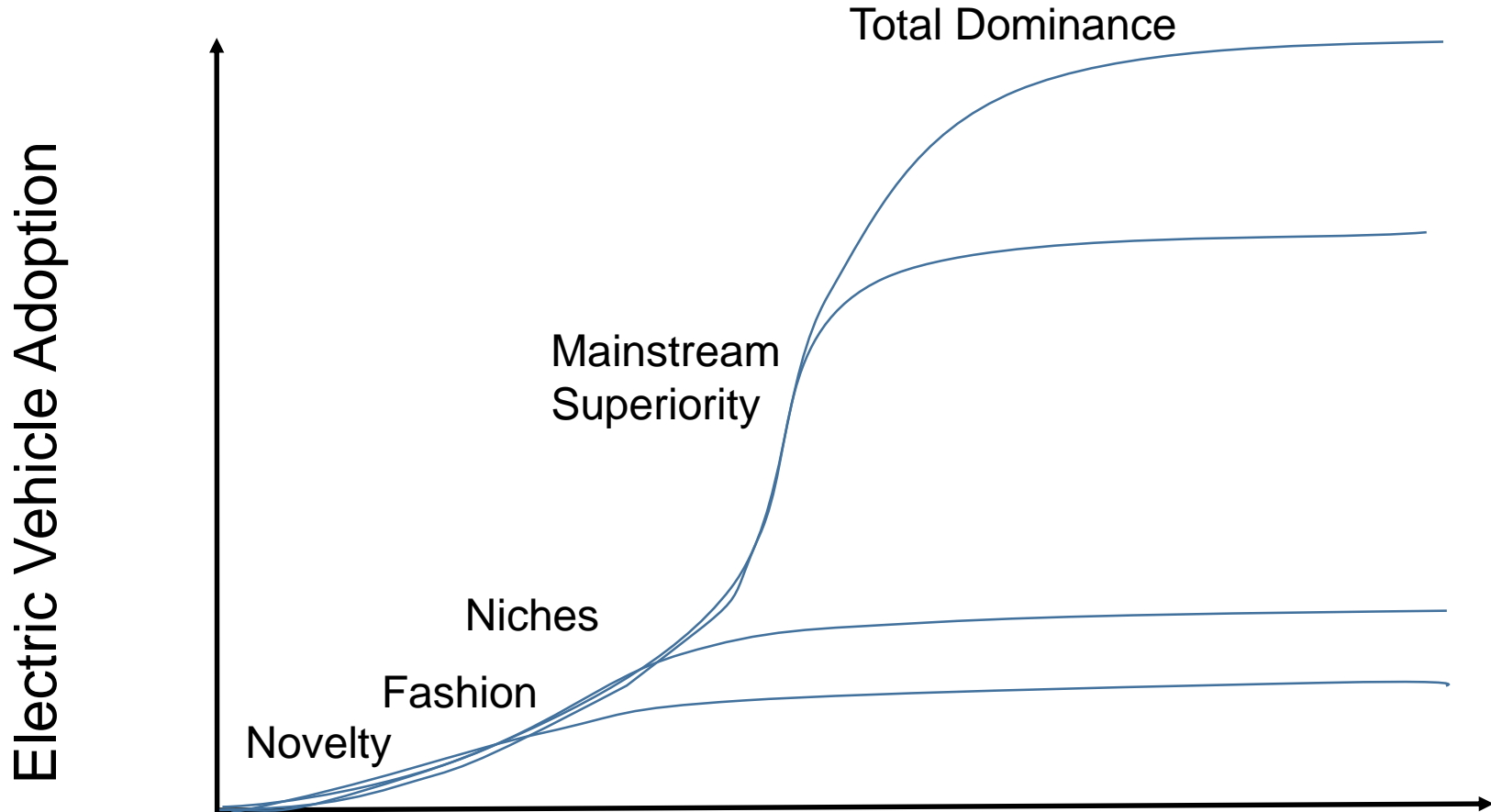


# The Gompertz model of the sigmoid “S” curve



- $a$ : ultimate market size. eg, suitability for applications
- $b$ : time from invention to inflection. eg, economic proposition
- $c$ : growth rate. eg, marketing, turnover, gen'l economics

# What does the electric vehicle S-Curve look like?



# Barriers that limit factor “a”: EV total market size

- Battery Power Density
  - Driving range
  - Vehicle size
  - Vehicle utility
  - Accessory power consumption
- Charging / Infrastructure
  - At-home charging model
  - Charge-where-you-are model
    - Workplace charging
    - Public charging
      - Fast charging
- Complementary transportation
  - Car sharing

# Basic economic consideration is cost of ownership



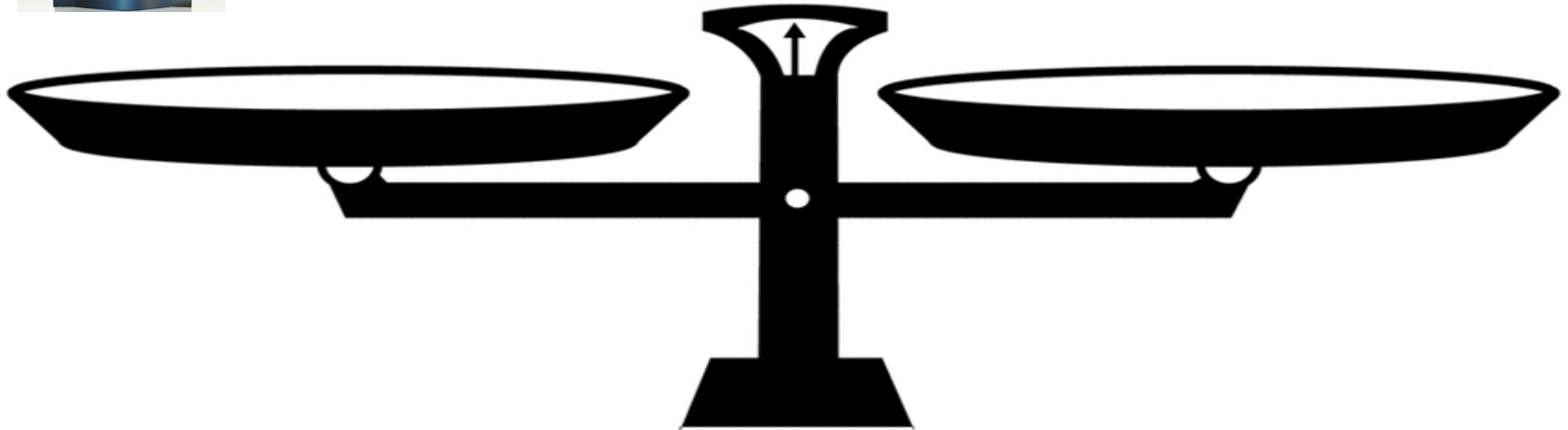
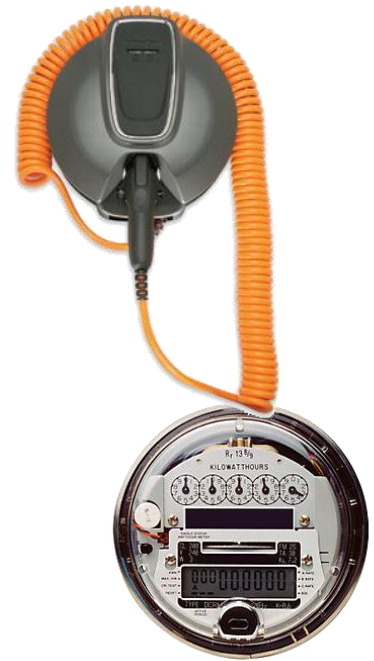
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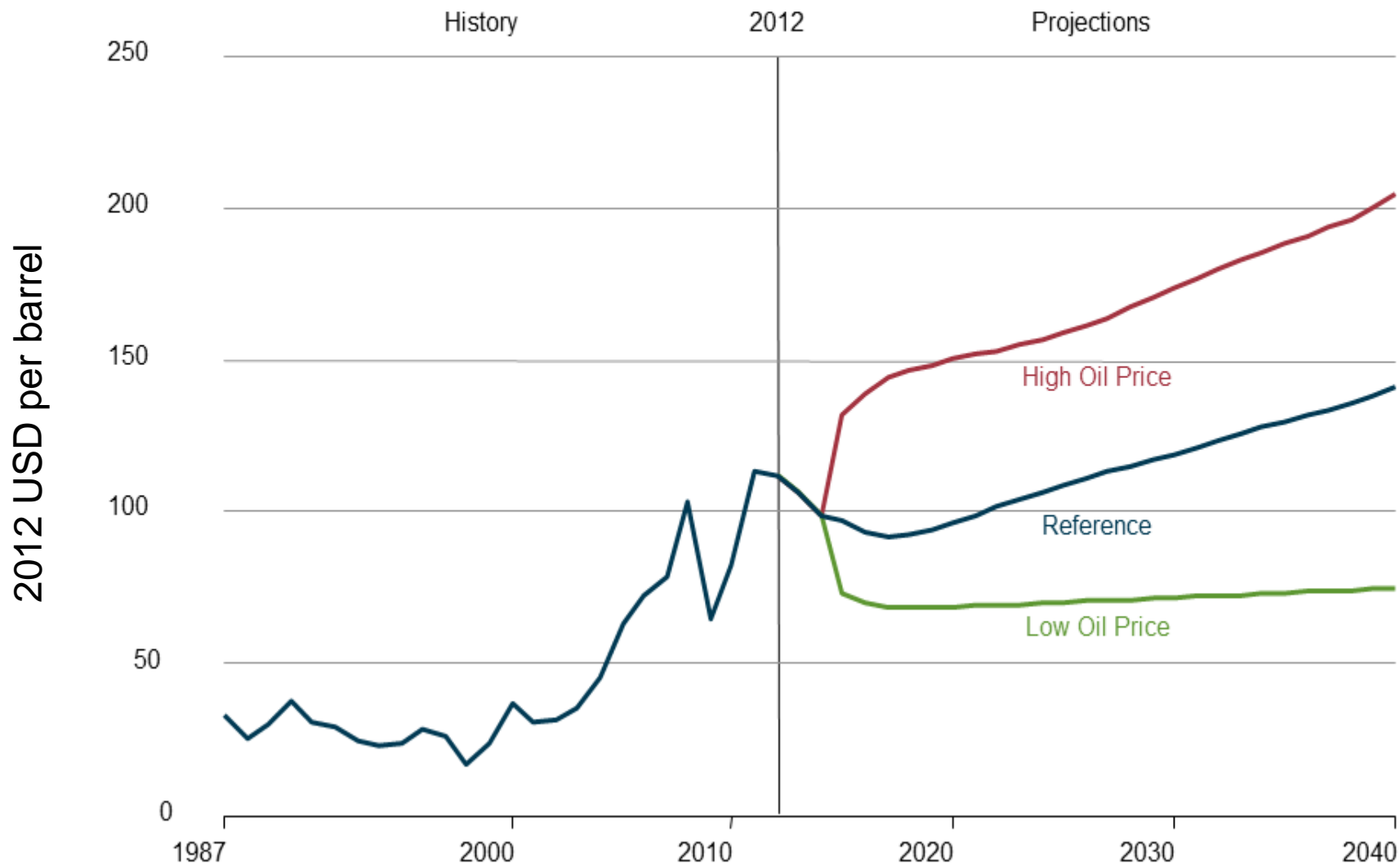
UNLEADED	3.58 <sup>9</sup>
UNLEADED PLUS	3.70 <sup>9</sup>
DIESEL	3.95 <sup>9</sup>



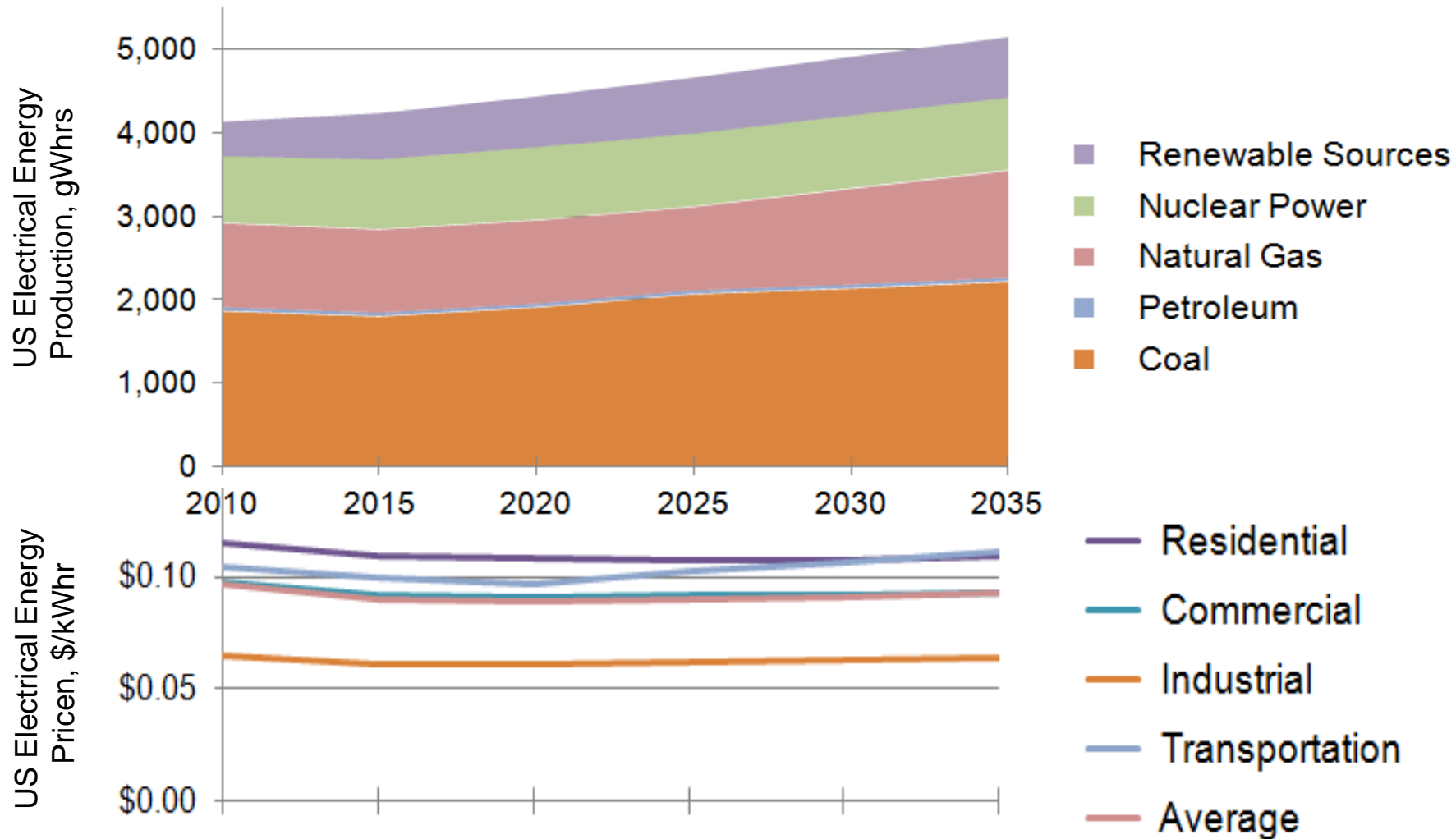
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# Petroleum prices - short-term stability but long-term trend is likely rising



# Diverse Sources will Maintain Low and Stable Electricity Prices



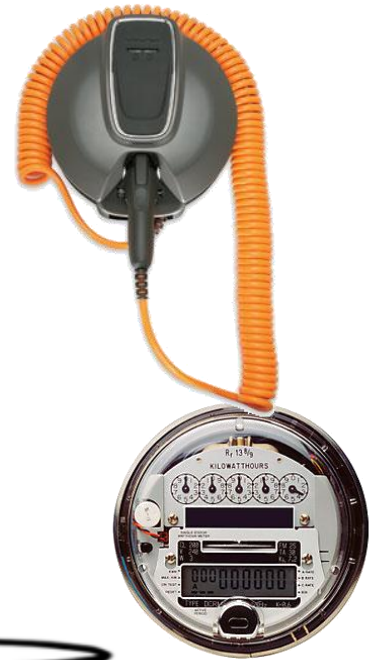
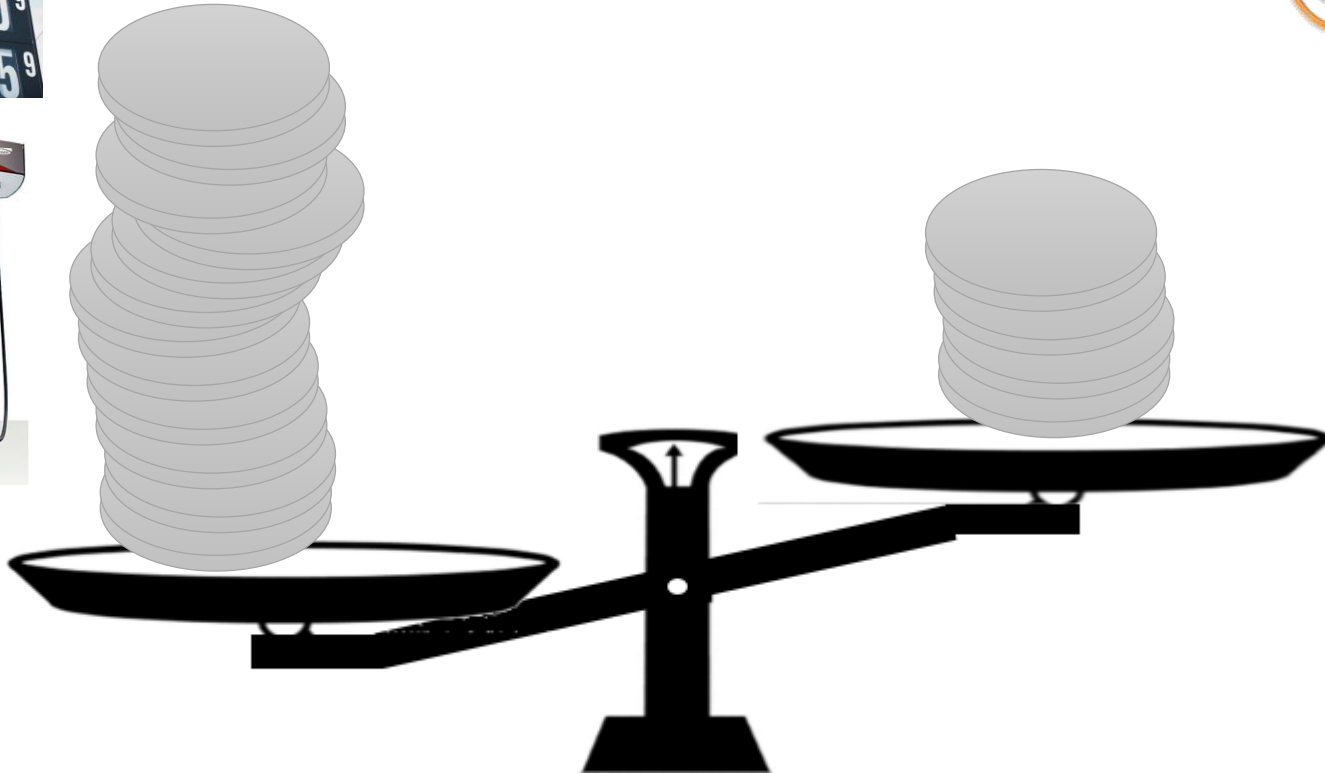
Source:  
 Annual Energy Review 2010, DOE/EIA-0384(2010) (Washington, DC, October 2011) and supporting databases.

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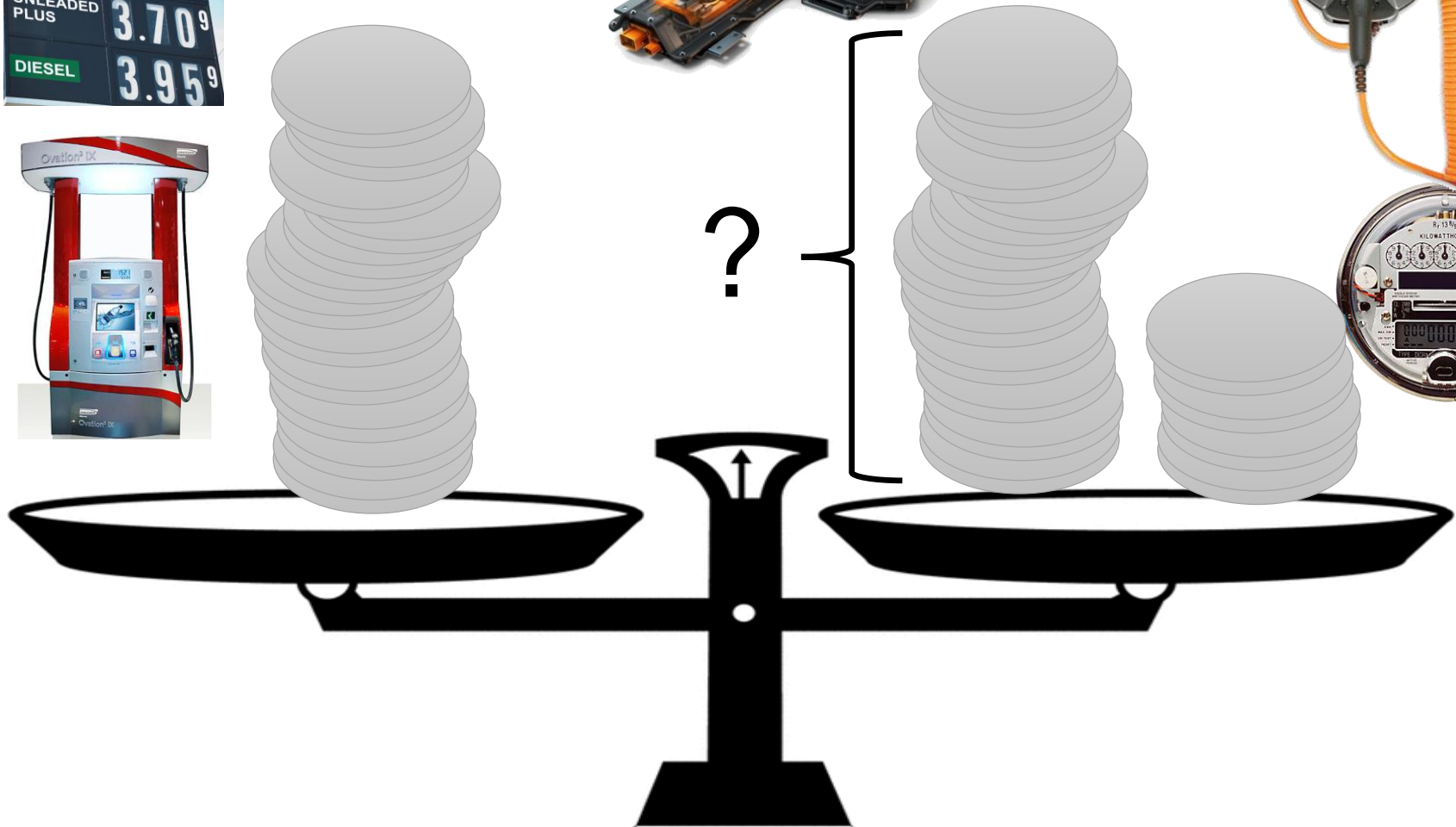
A digital gas price sign with three rows of text and prices.

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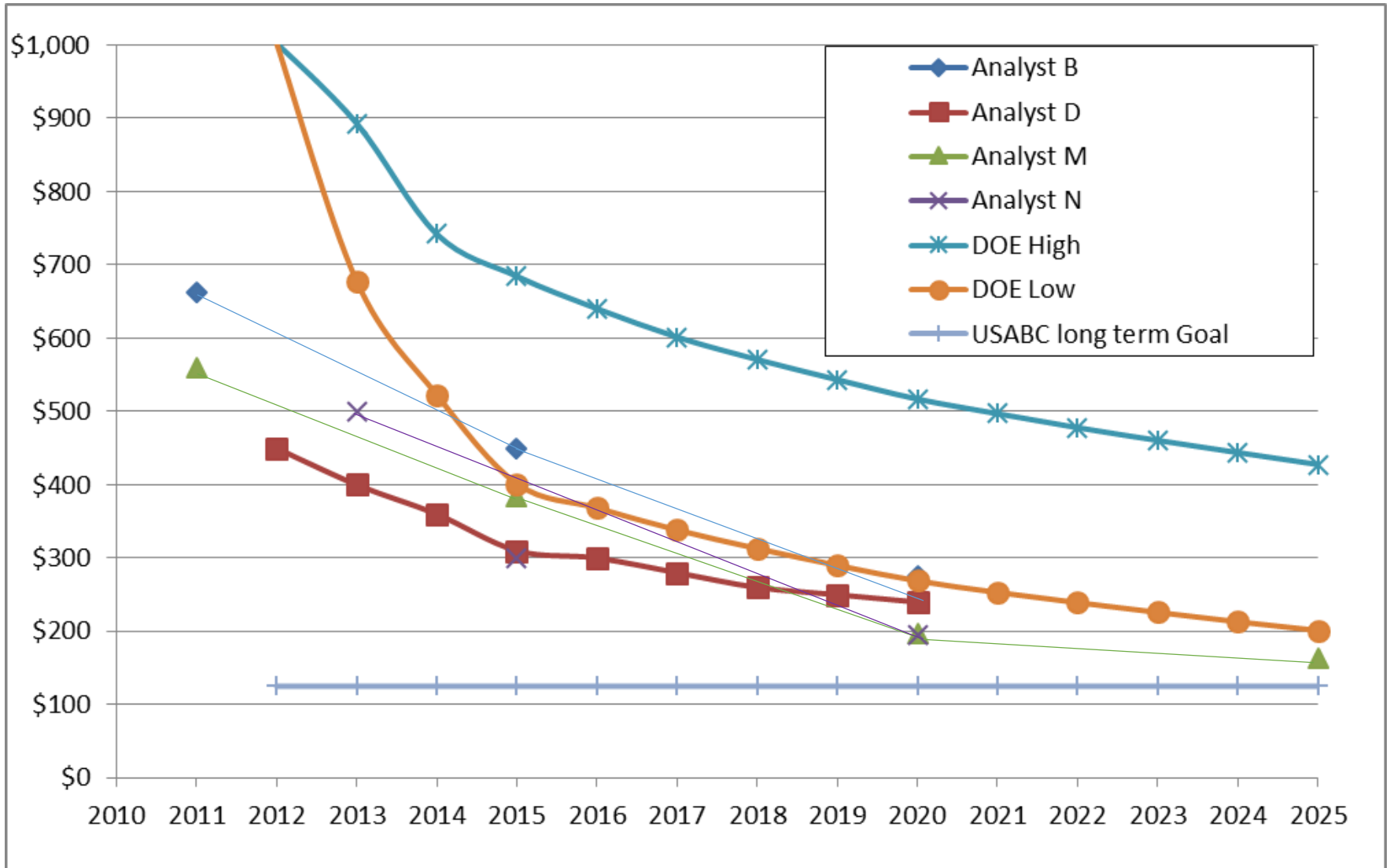




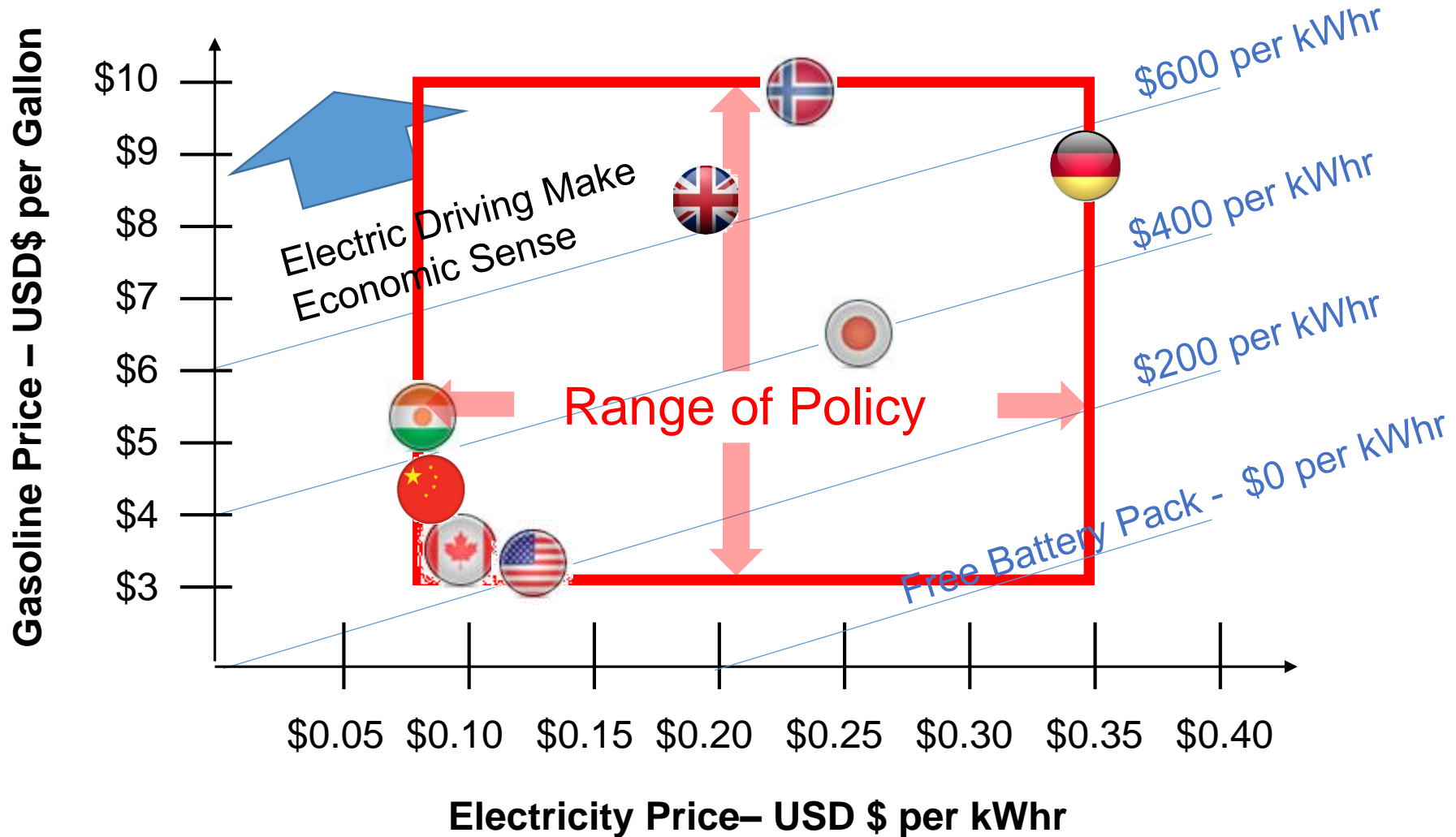
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# Predictions on the cost of EV energy storage



# Breakeven Total Energy Cost – Battery Pack and Electricity Prices



# Summary

- Adoption of EVs beyond niche applications requires the cost of ownership of an EV to be better than a similar utility gasoline powered vehicle.
- The economics of driving on electricity hinges on future developments in the durability and cost of energy batteries.
- Oil and electricity policies are material to the economics of electric driving. Some countries already have policies in place that make electric driving more economic.
- Most analysts agree that \$200 per kWhr will be realized within the next decade.
- \$125/kWhr is a good long term enabling target for most mainstream vehicle applications and will not depend on policies.



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# Thank You!



Q and A



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