

# ***Energy Disruptions 'Hidden' In Three Big Questions***

**What happens when ...**

- **World adds 1 billion cars & batteries don't beat barrels ?**
- **Digital infrastructures consume more electricity than Japan ?**
- **Digital revolution hits shale & US oil & gas output doubles ?**

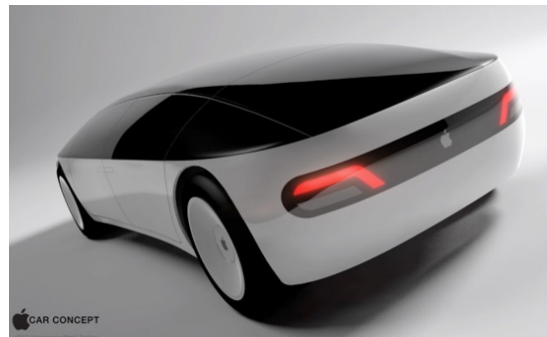
# 1. Cars – Big Kahuna For Oil Demand

## The future of personal transport

à **Fuel** because of Tesla

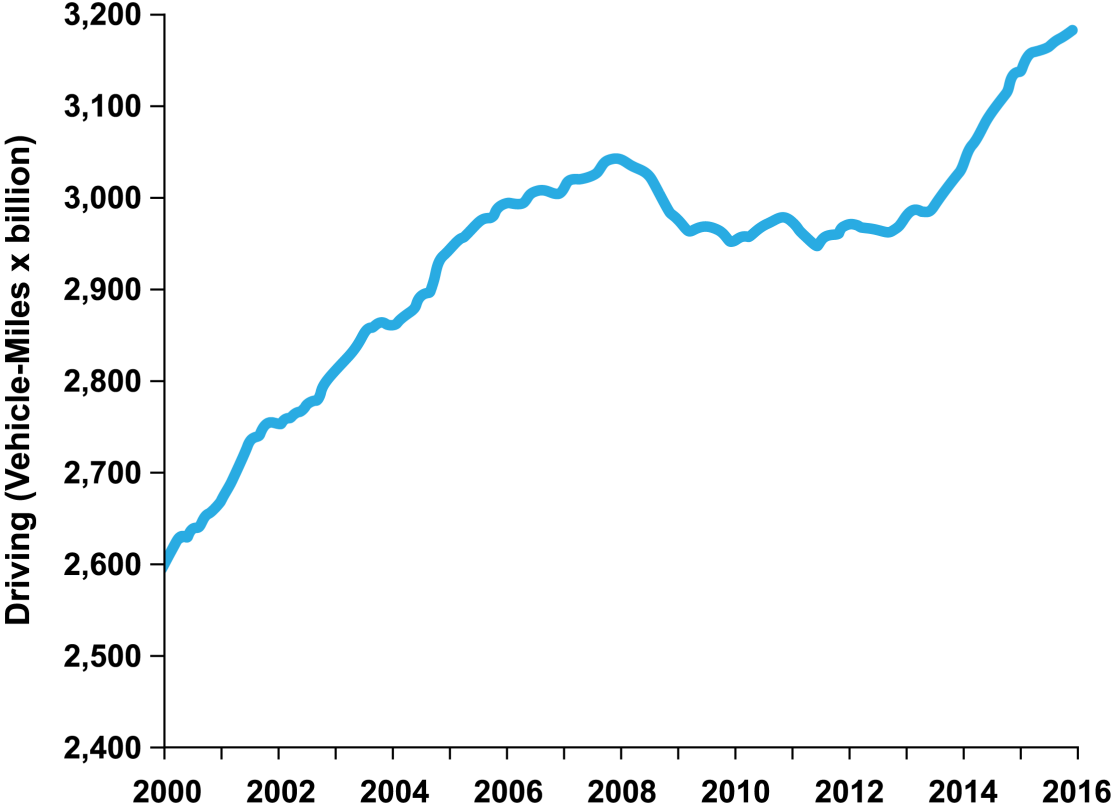
à **Ownership** because of Uber

à **Driving** because of Google



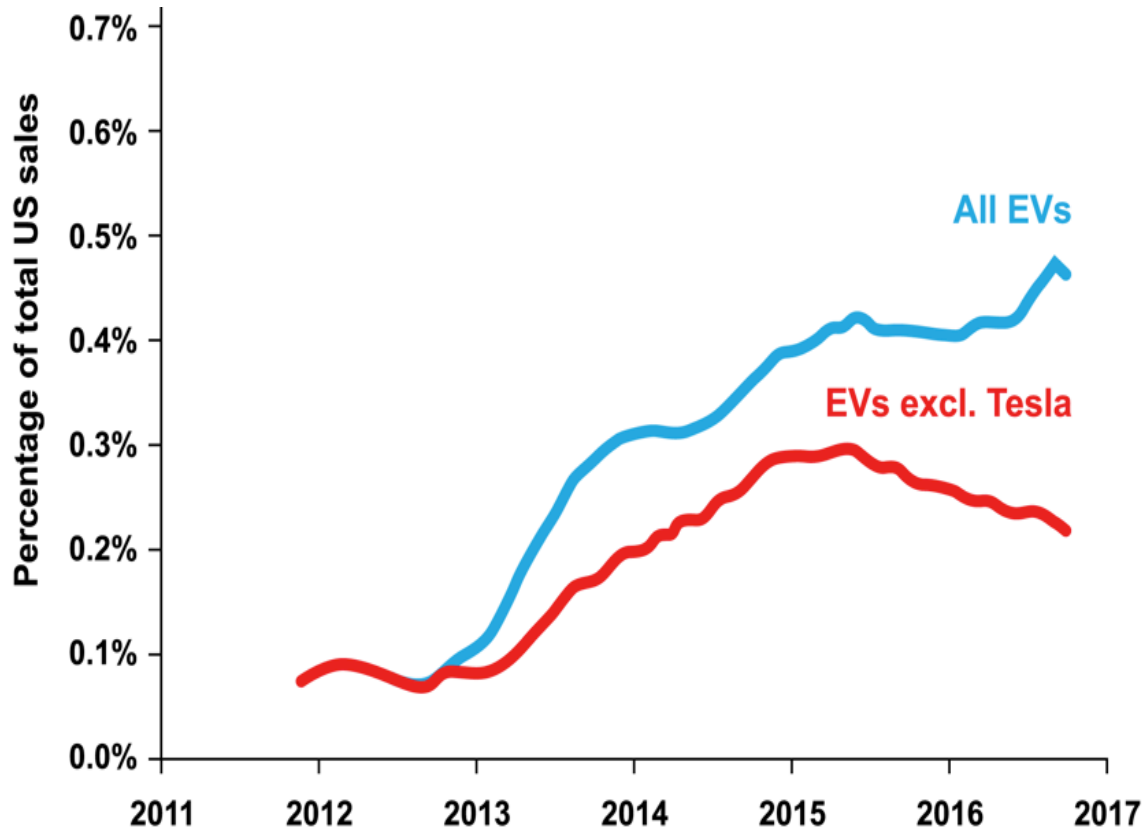
# *But First... Has U.S. Reached Peak Driving?*

Annual U.S. Vehicle-Miles



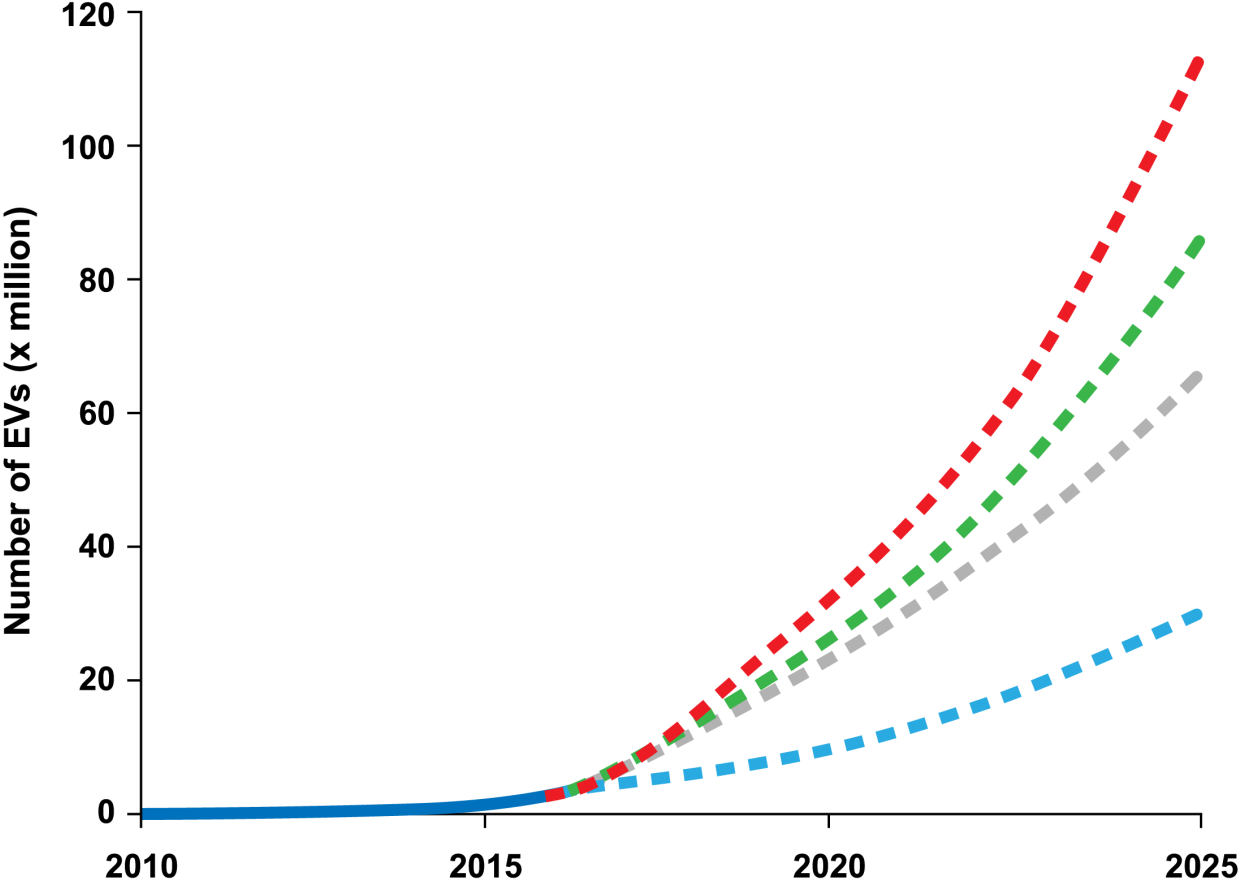
# *EV Sales Realities Thus Far In America*

## EV Share Of All U.S. Car Sales



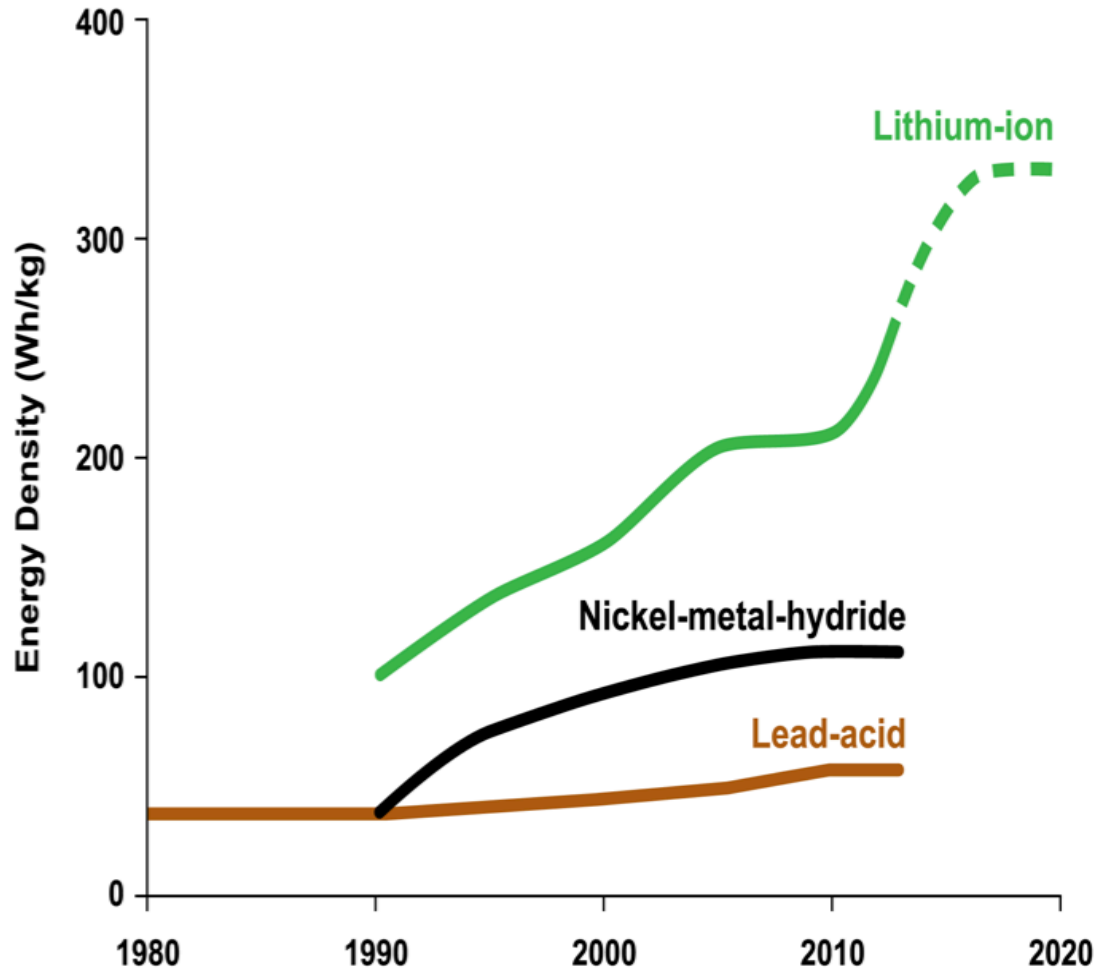
# Tesla Effect: What If EV Optimists Are Right?

## IEA Global EV Outlook



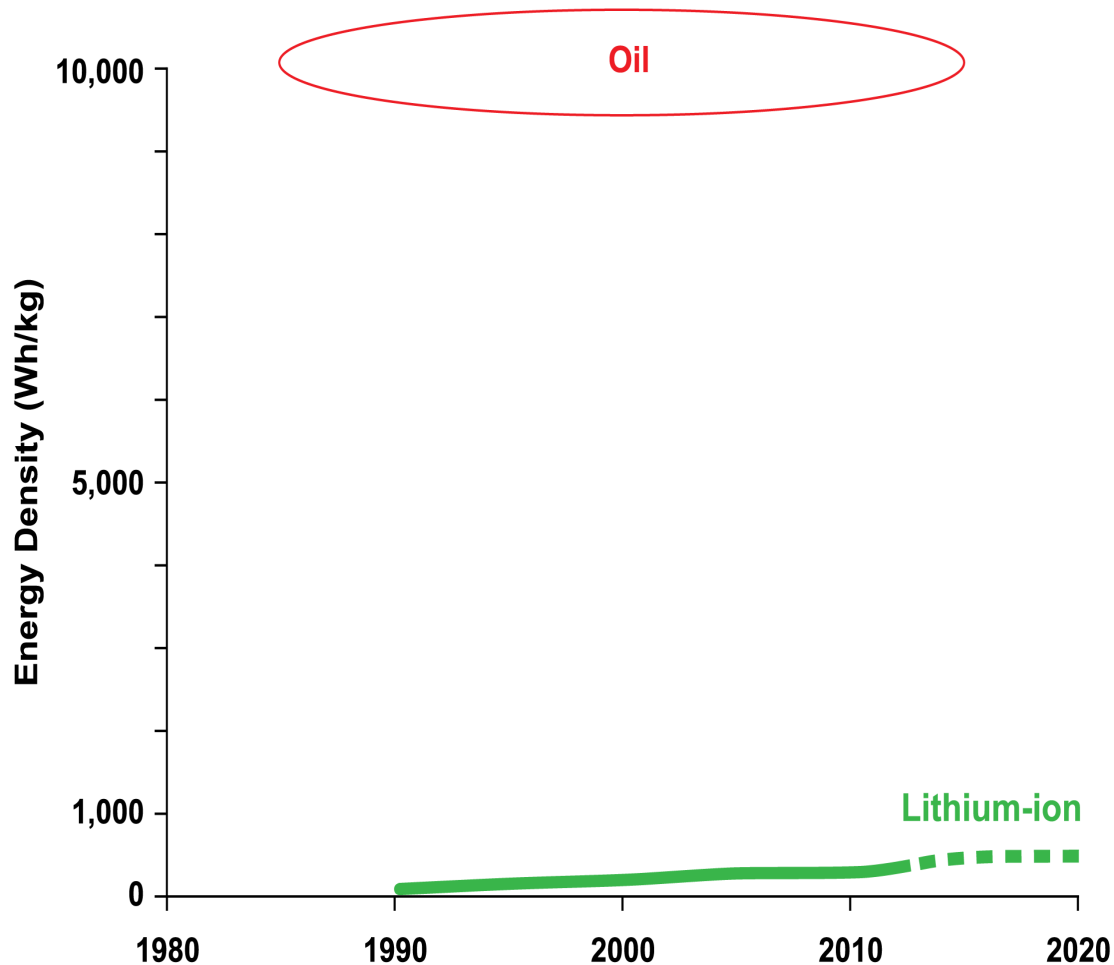
# *The Big Bet On Better Batteries*

## Energy Density Of Fuel



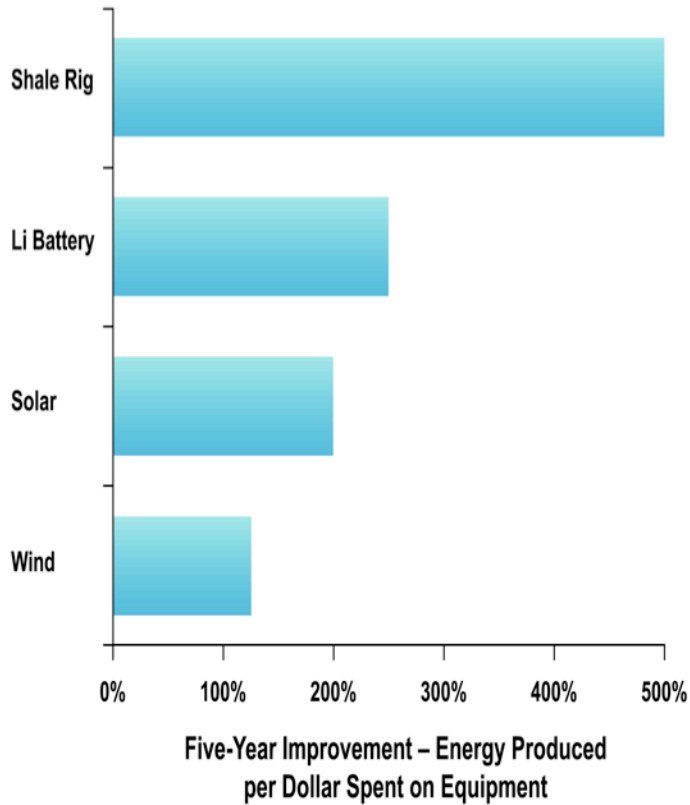
# *But... Batteries Will Never Get Good Enough*

## Energy Density Of Fuel

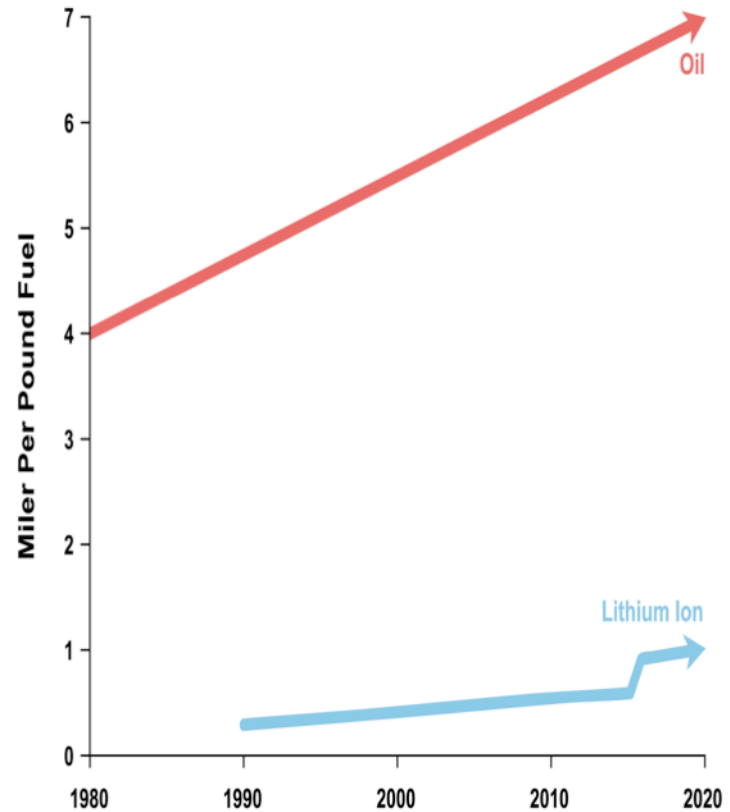


# Better Transportation Tech ... Batteries vs Barrels

## Tech Improves Everything



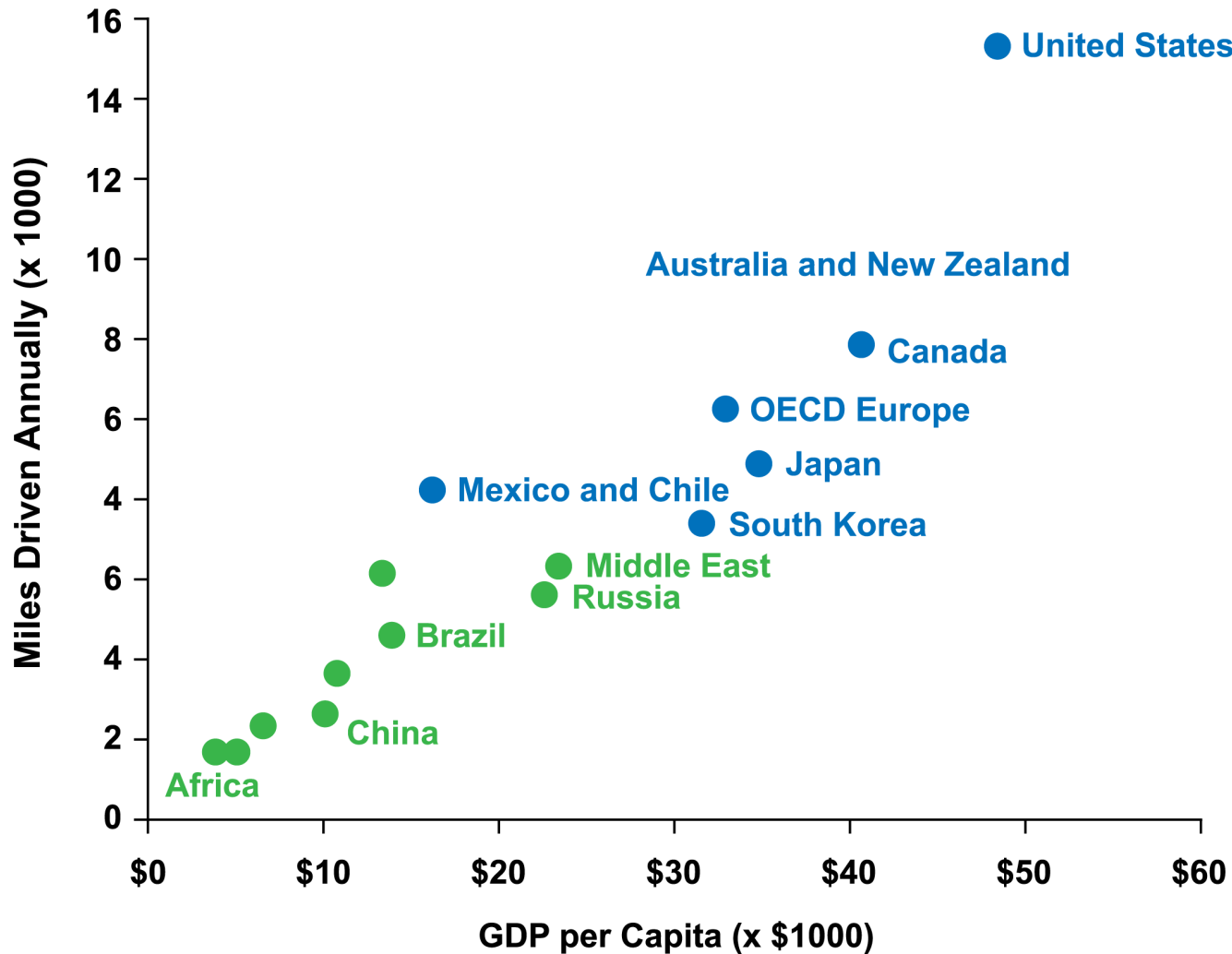
## Range Per Pound Of Fuel





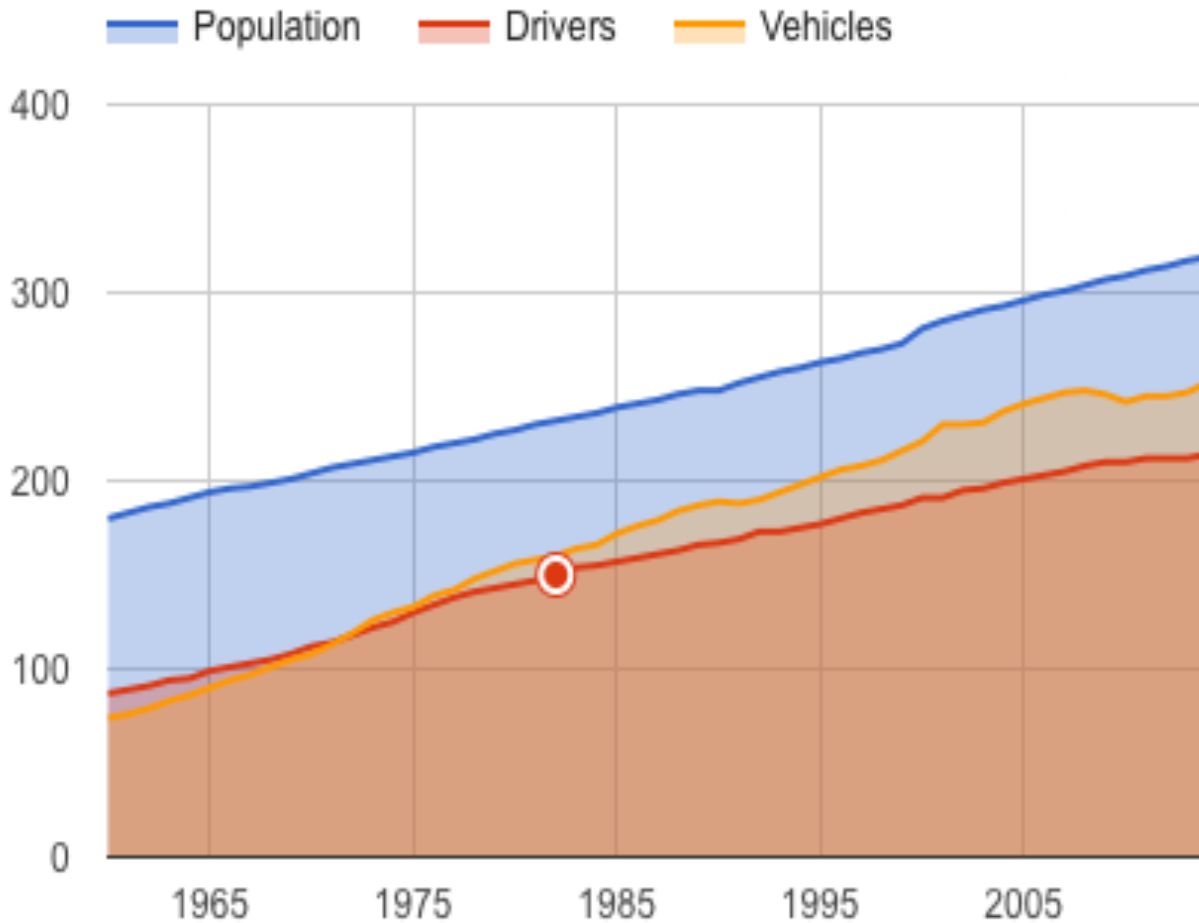
# Uber Effect [?] Driving More Affordable

## Wealth Increases Driving



# *Another Uber Effect* [?] *More Fun Cars*

**U.S. Population, Vehicles & Drivers**  
( x 1 million)



# Google Effect: Eternal Dream Of Self-Driving

*The car of the future will have no such thing as a “driver’s seat.” Driving will be done from a small control board.”*

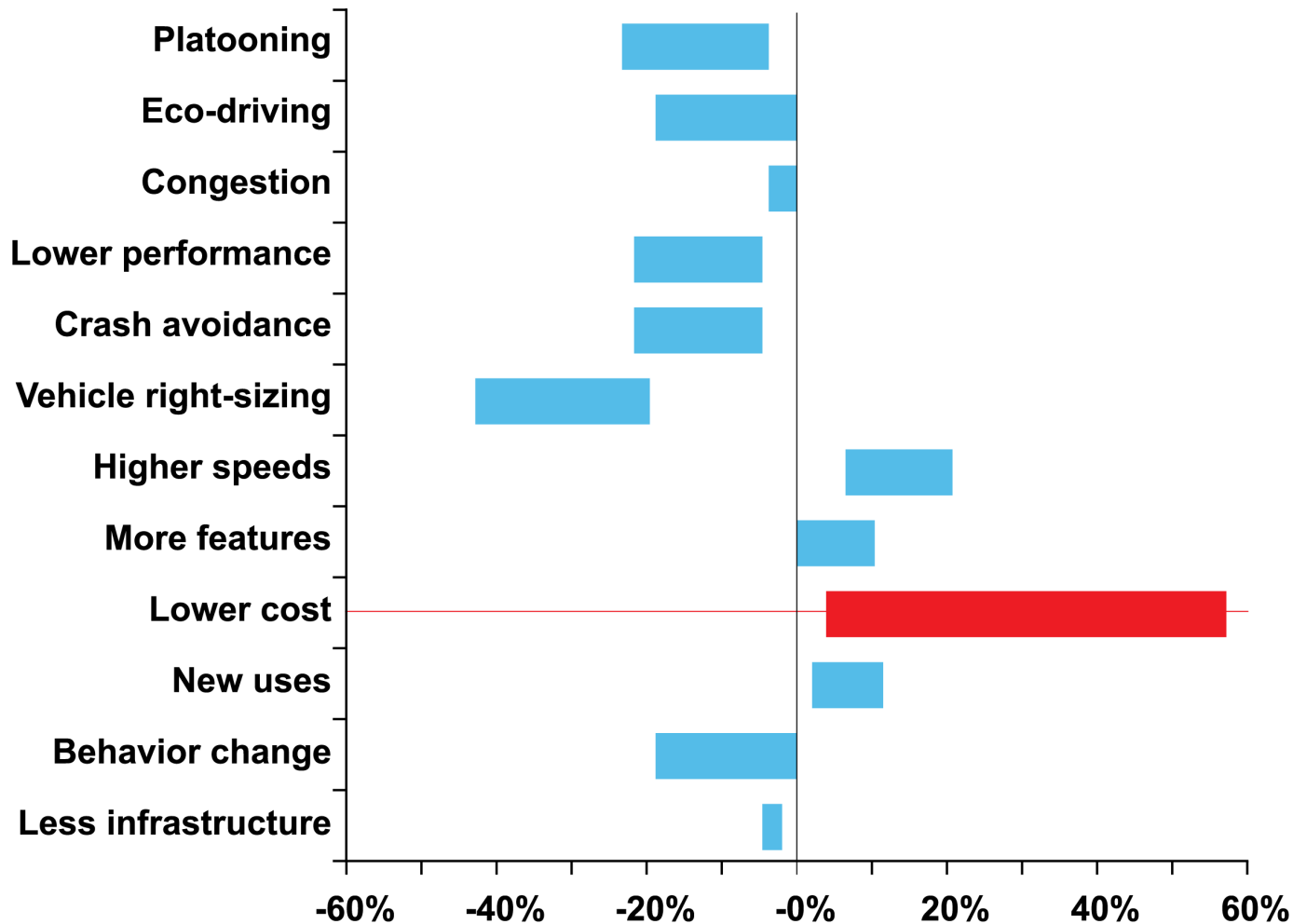
**January 5, 1918, Scientific American**

*“You ... push the button marked ‘Electronic Drive.’...Fantastic? Not at all. The first long step ... was successfully illustrated by RCA.”*

**October 10, 1957, Engineering News**



# *Energy Impacts of Sharing & Robocars*



# ***Demand Wild Card: Amazon Drones & Uber Air***

**2020 Lilium**



**2017 Airbus Self-Flying Taxi**

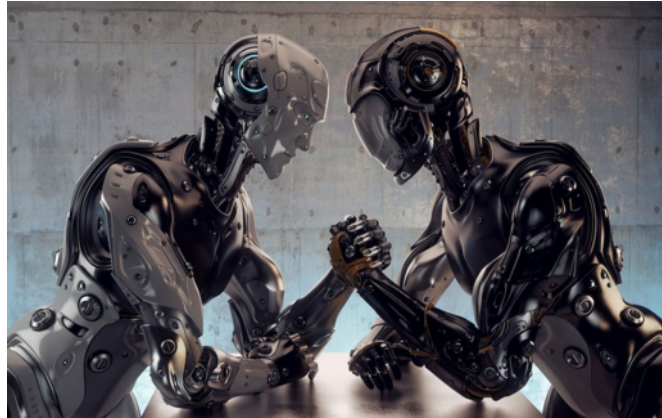


**1944 Artist's Conception**



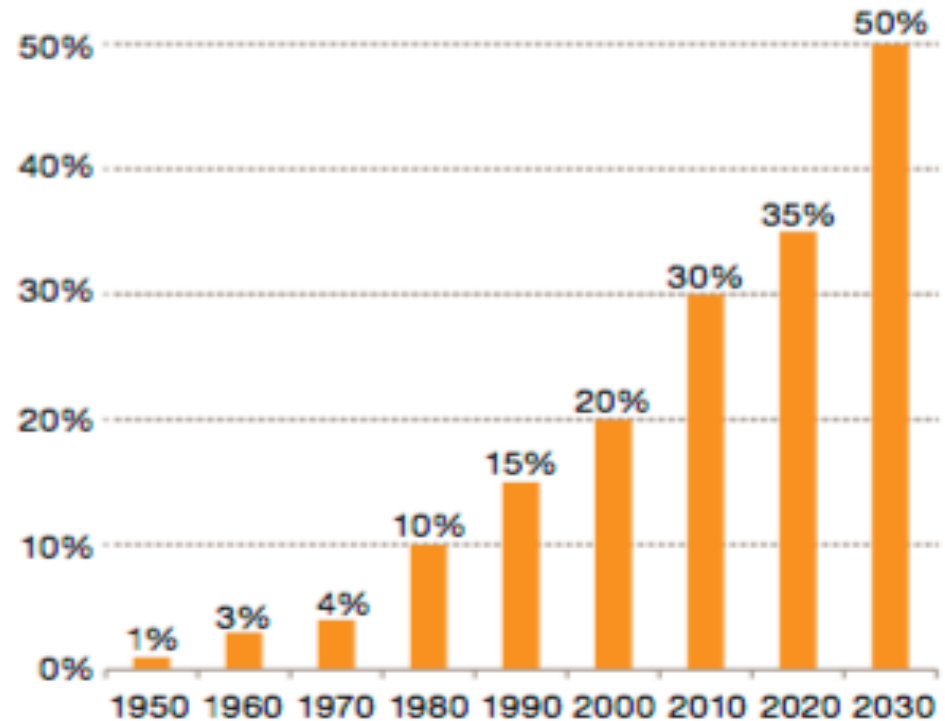
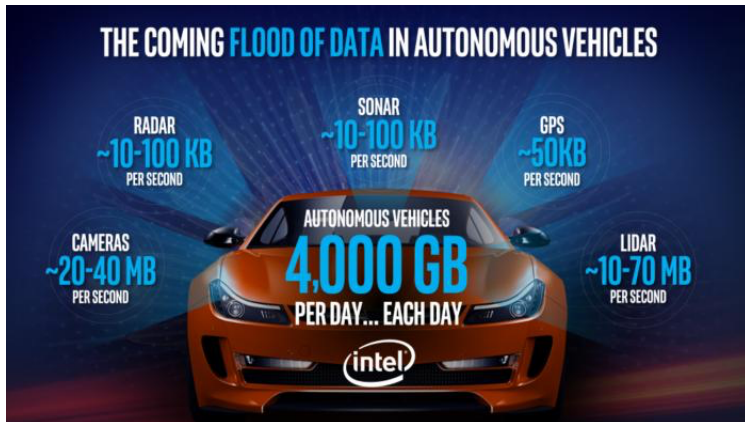
# *Eventual Google + Uber Effect [?] End Of Mass Transit*

**Robots vs. Subways & Buses**



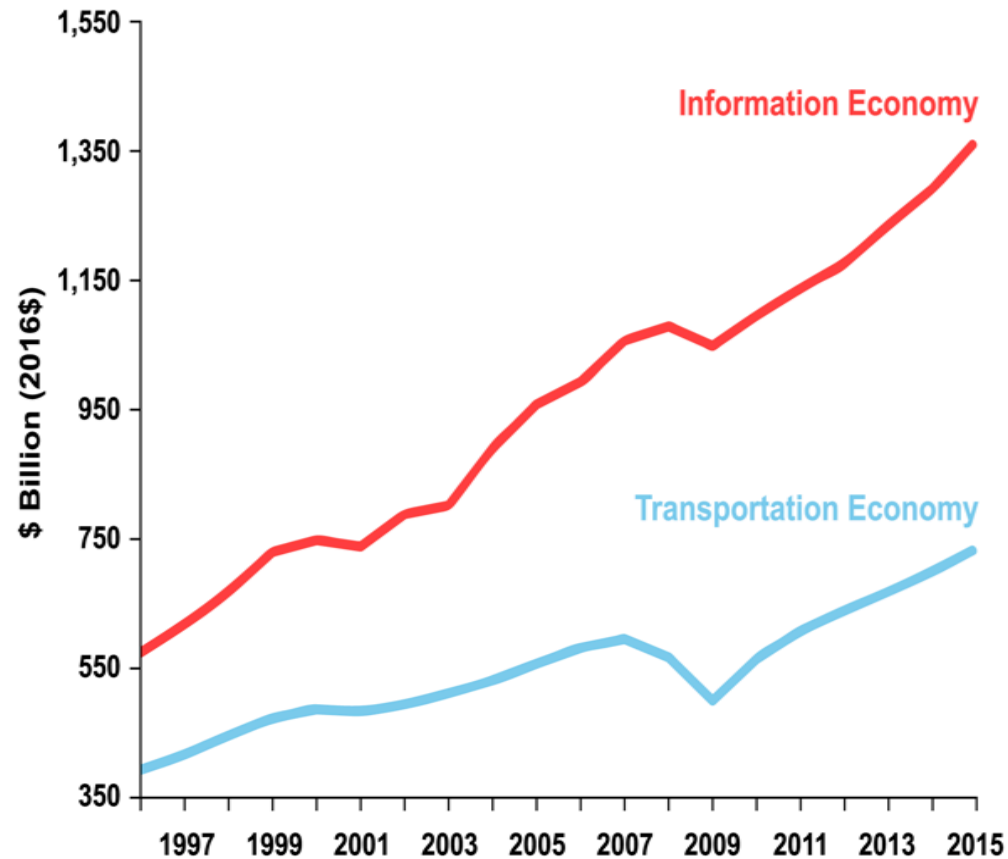
# Real Google Effect ... Demand For Silicon & Data

## Electronics Share Of Cost To Build A Car



## 2. Energy Demand From The Digital Infrastructure

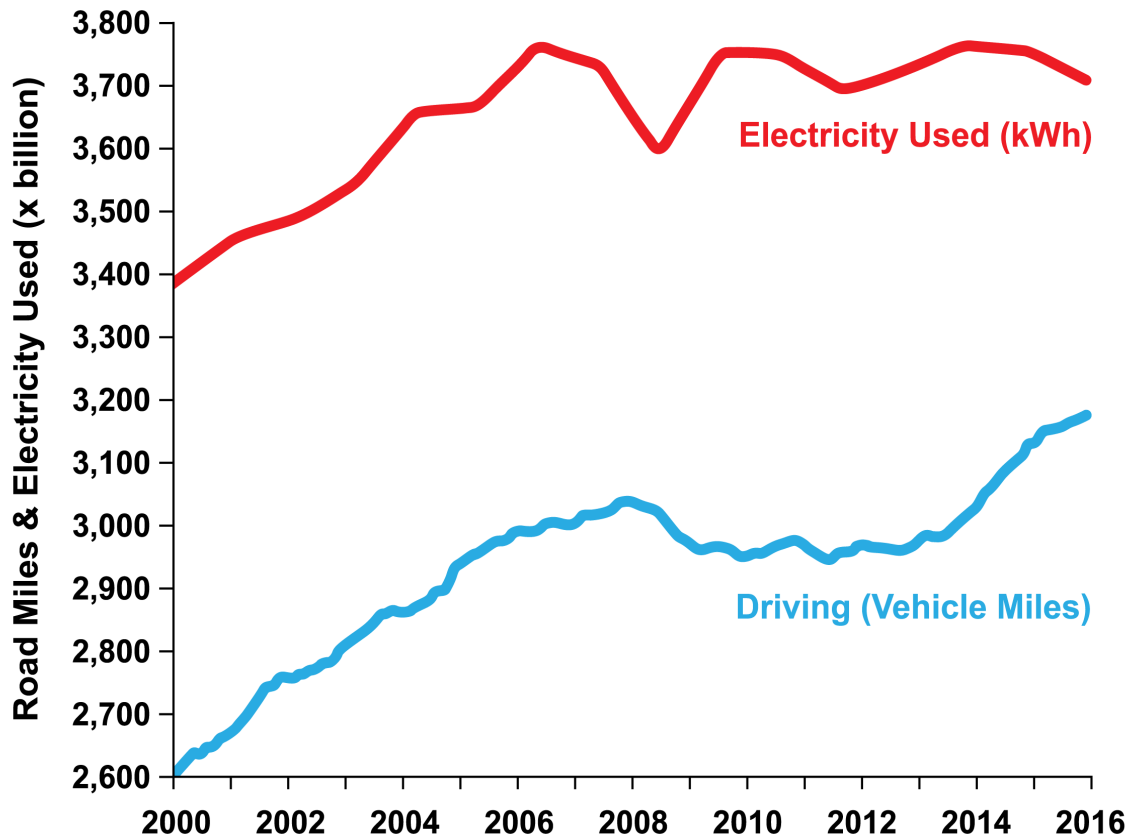
Share Of U.S. GDP





# Are We At Peak Electricity Demand?

Confusing A Recession 'Effect' With A "New Normal"



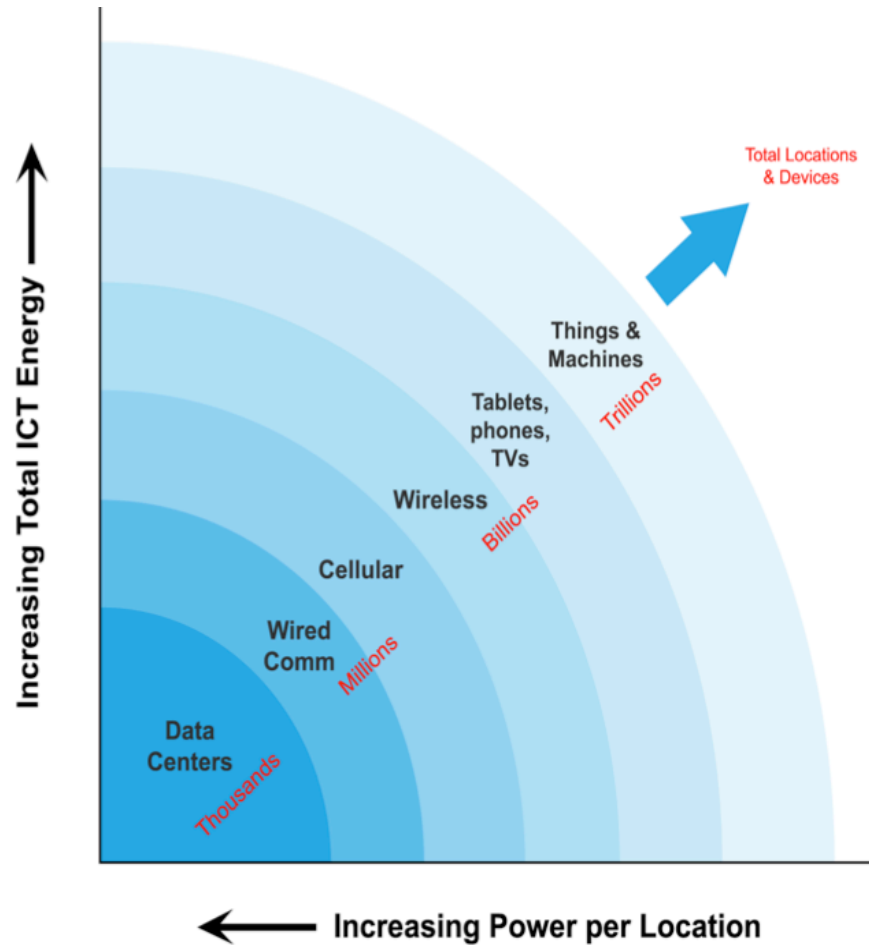
# Power Taxonomy Of Global ICT Infrastructure

## Cyber Infrastructure

- Data centers
- Networks
- Devices

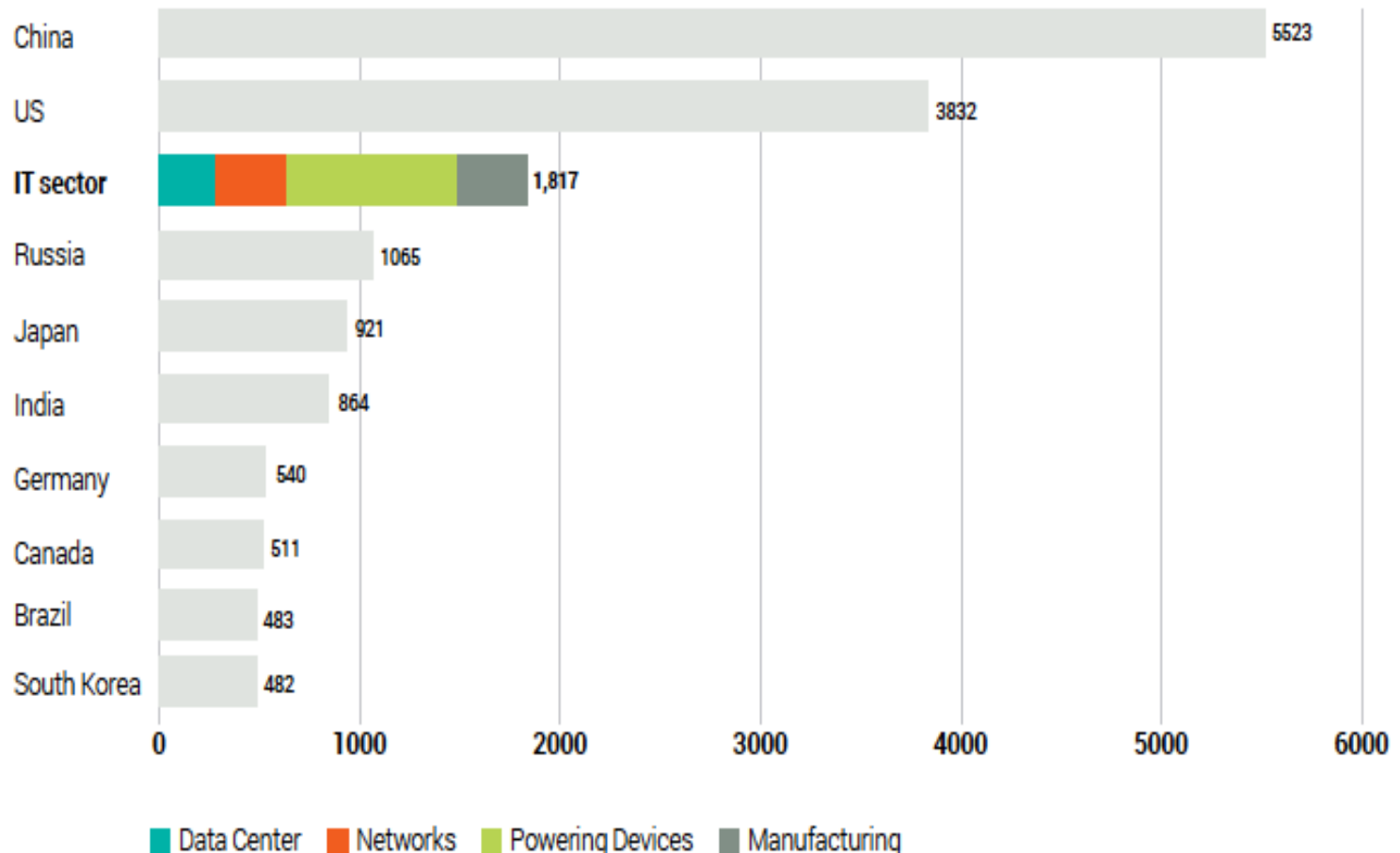
## Cyberphysical Infrastructure

- Cars
- Virtual Reality
- Drones
- 3D printing
- Robots .... More ...



# Electricity Demand: Countries vs The Cloud

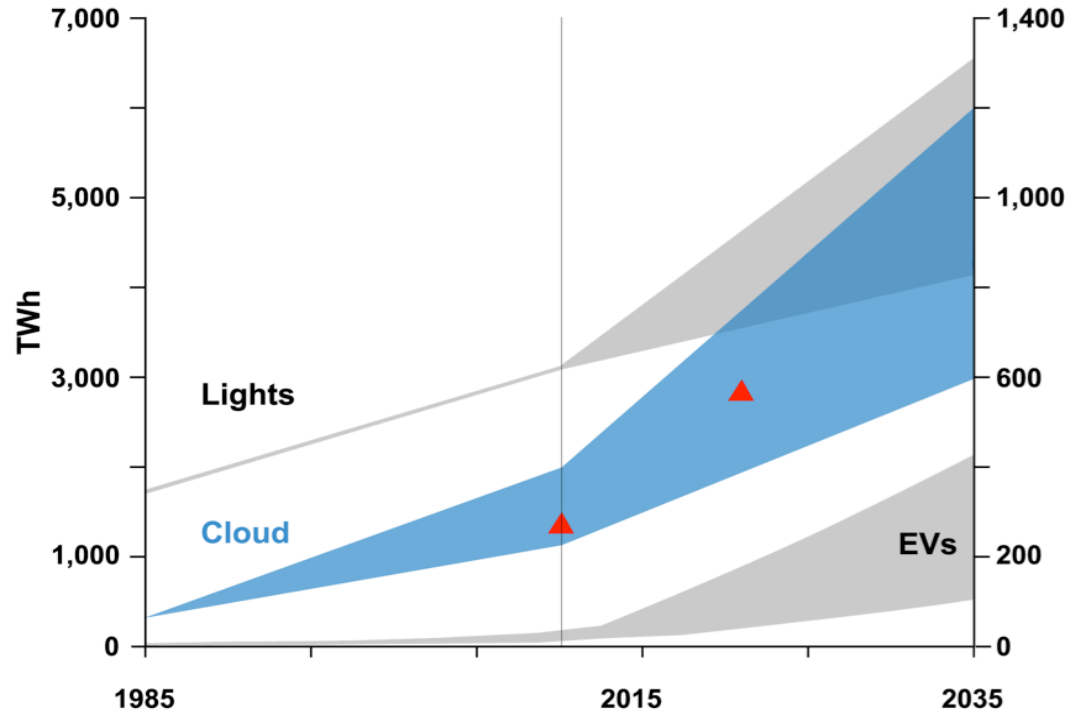
Greenpeace “Clicking Green”  
billion kWh/yr





# Ascendancy Of New Electricity Demands

## Electricity Use: Cloud, Cars, Lights

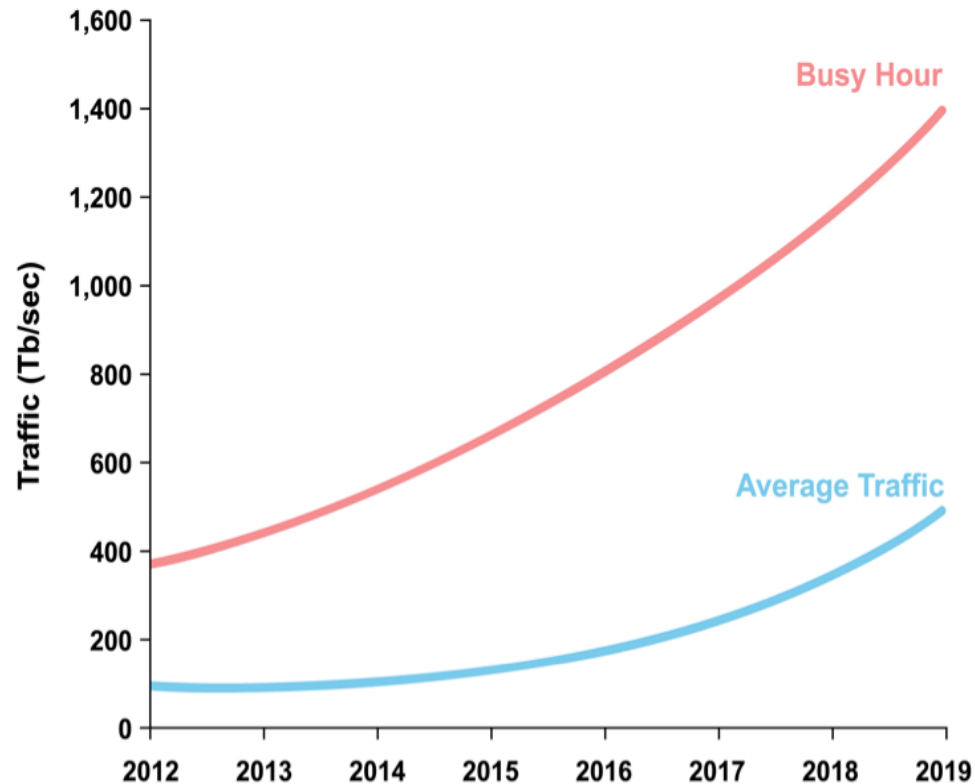


“[A]s dependent as we are on communication technology, we’re even more dependent on electricity.”

**Vinton Cerf**, **Google** VP and Chief Internet Evangelist. 2016

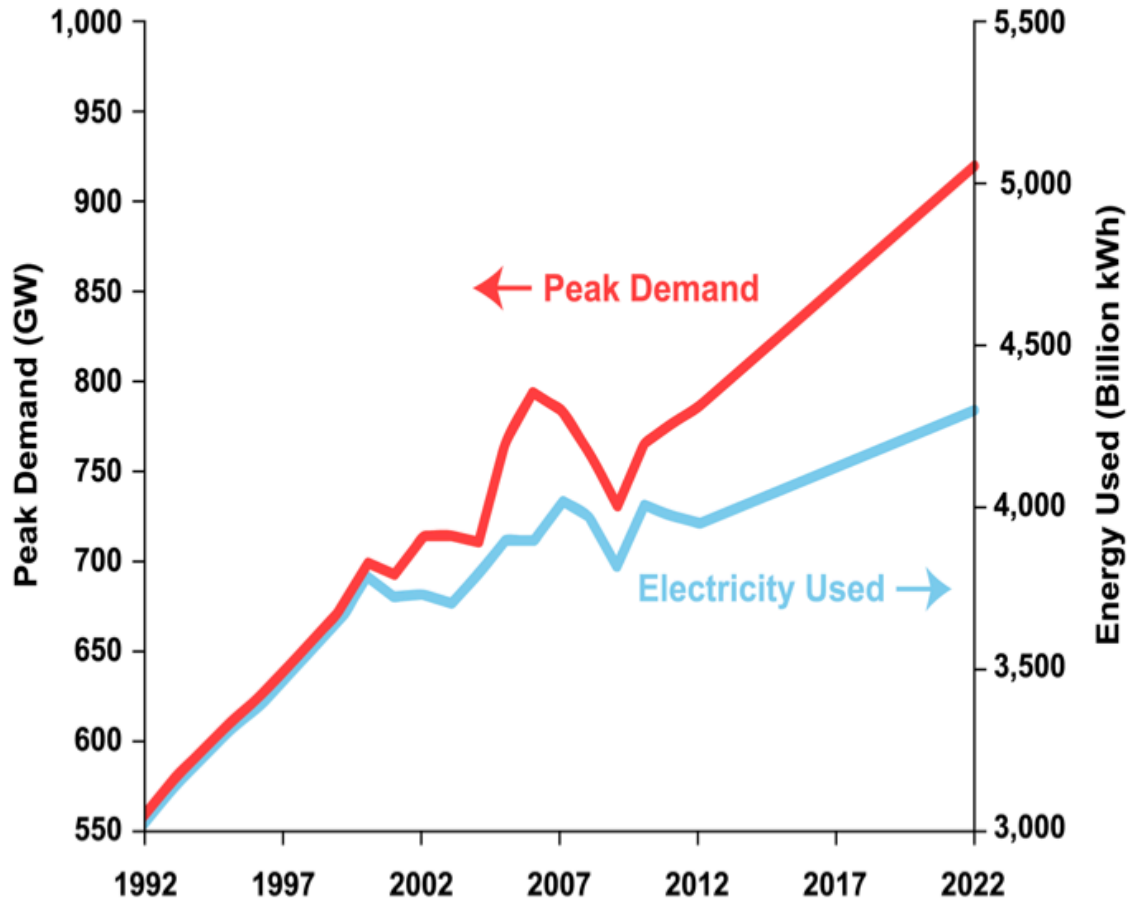
# Peak Demand : Familiar Territory For Electric Utilities

## Average vs Peak Digital Traffic



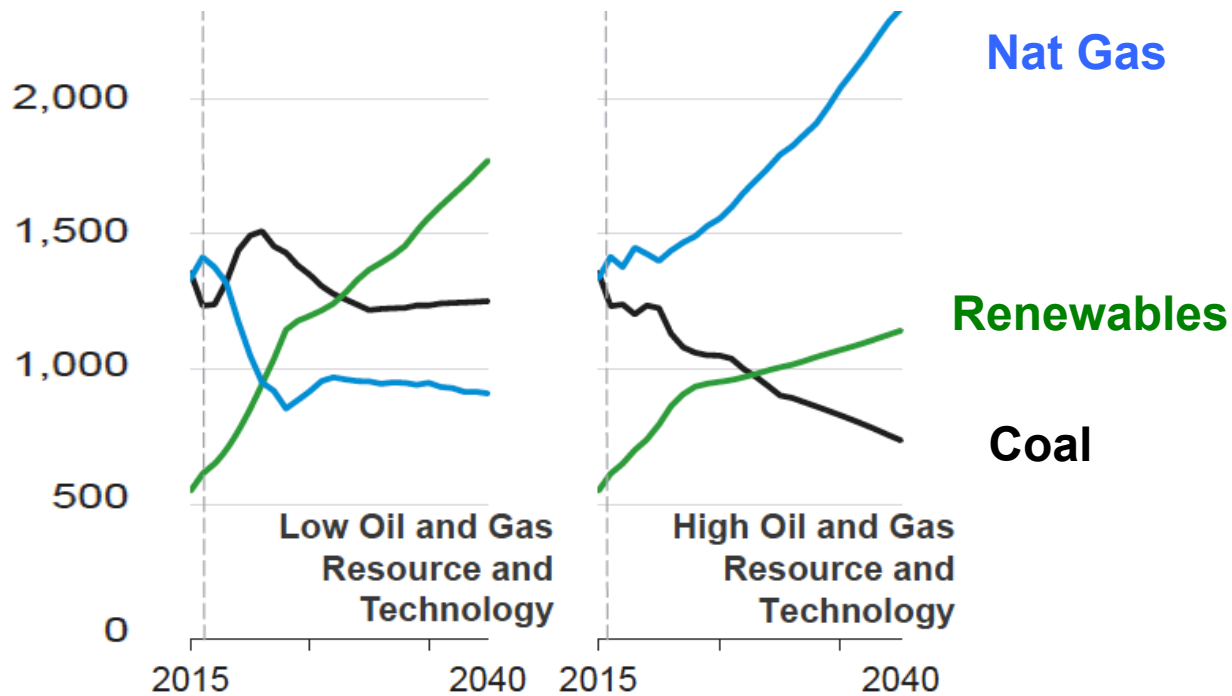
# Wither Electricity Demand?

## Peak vs Average Demand



# Fueling Future Electric Demand: Shale Wild Card

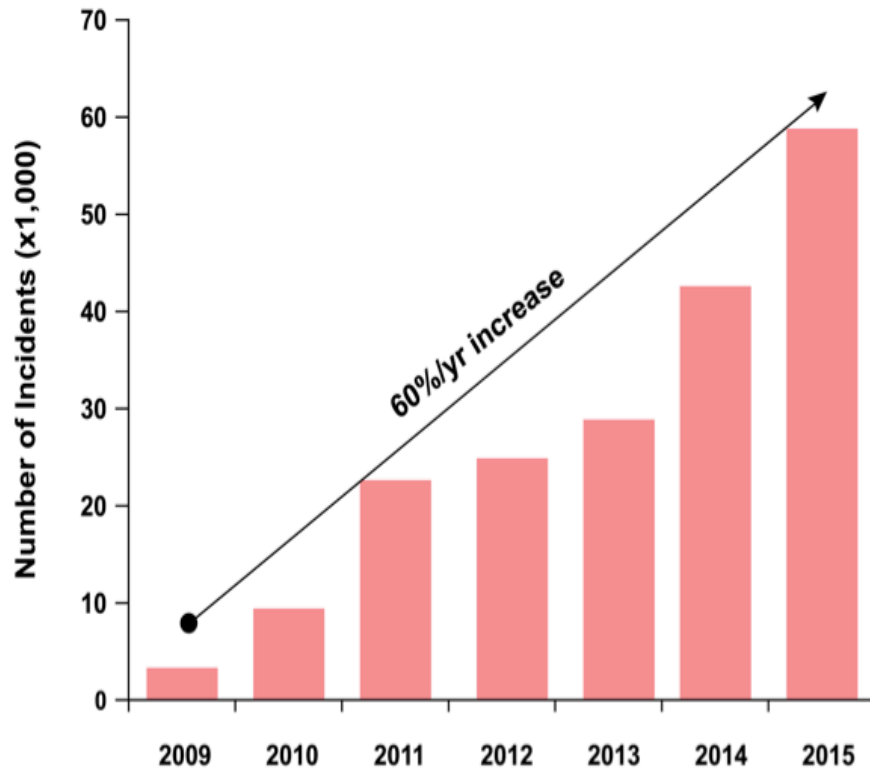
EIA Forecast Electric Generation  
(billion kWh)





# Cyber Security -- New Grid Challenge

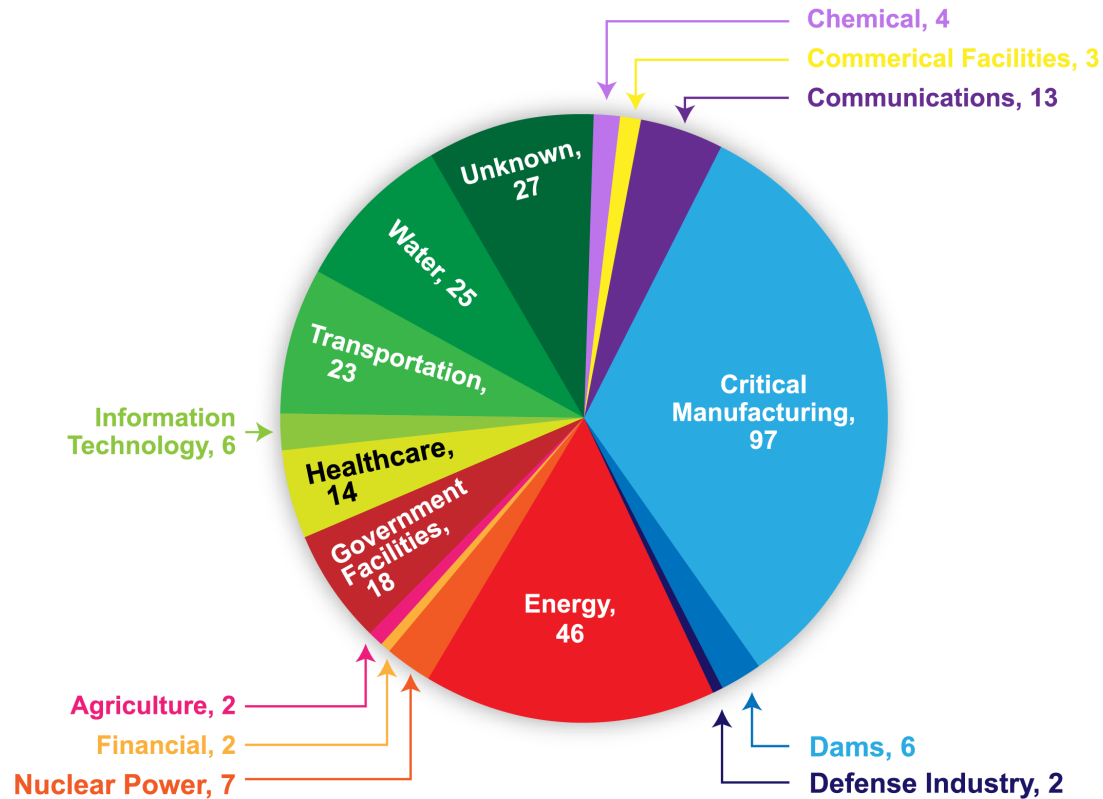
## Annual Cyber Attack “Incidents”



## Map Of China-Centric DDS Attacks



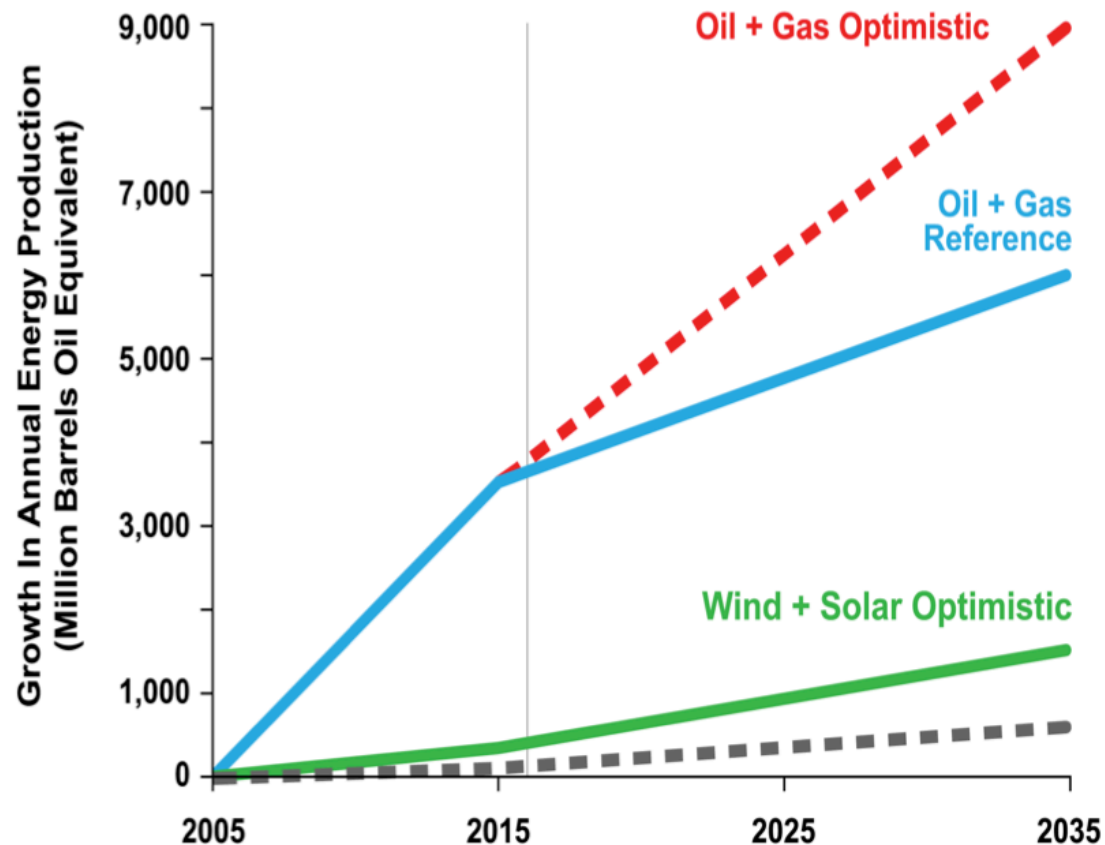
# Targets Of Cyberphysical Attacks



Data from NCCIC 2015

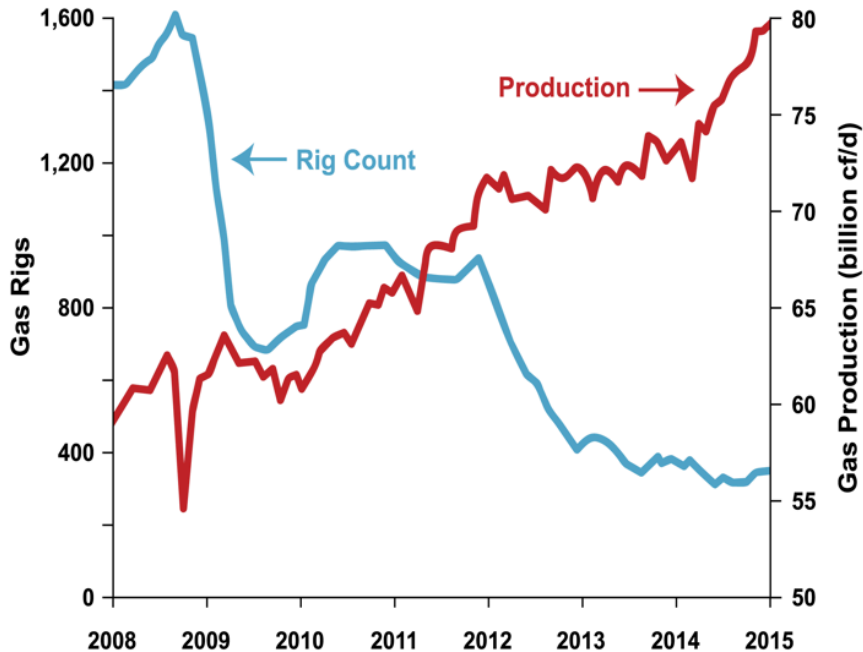
# 3. From “Peak Oil” (And Gas) To ‘Hidden’ Revolution

## History & Forecast Growth In U.S. Energy Production

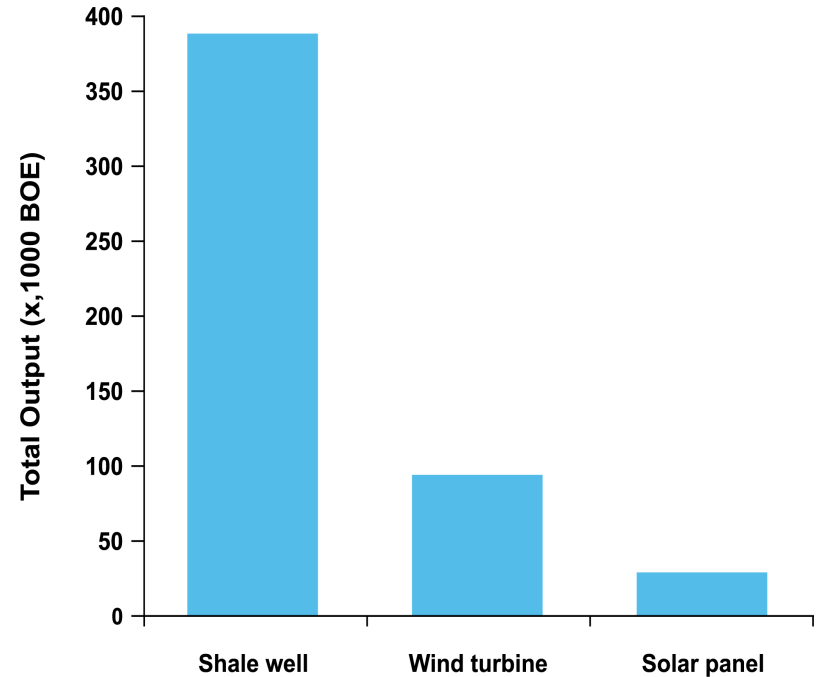


# Shale + Tech [?] 'Infinite' Cheap Gas

## Gas Rig Count vs Total Production

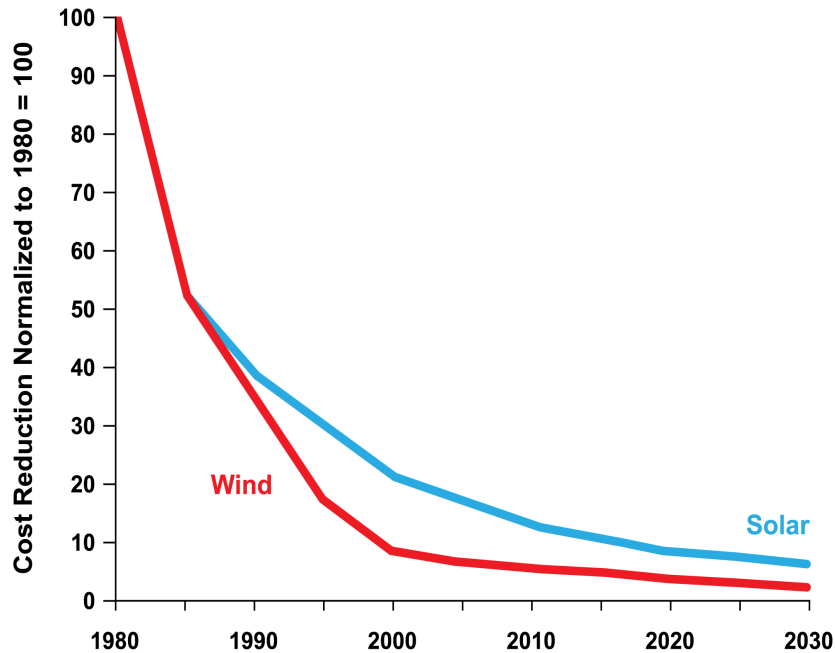


## 30-Year Output Per \$1 Million CapEx

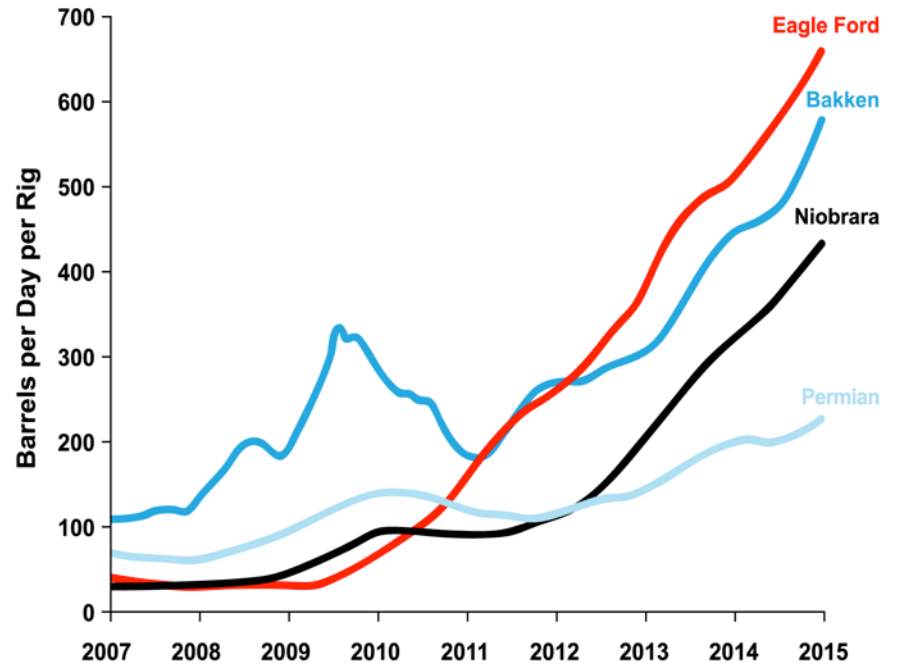


# Shale Tech Advancing > Green Tech

## Solar & Wind Cost per kW

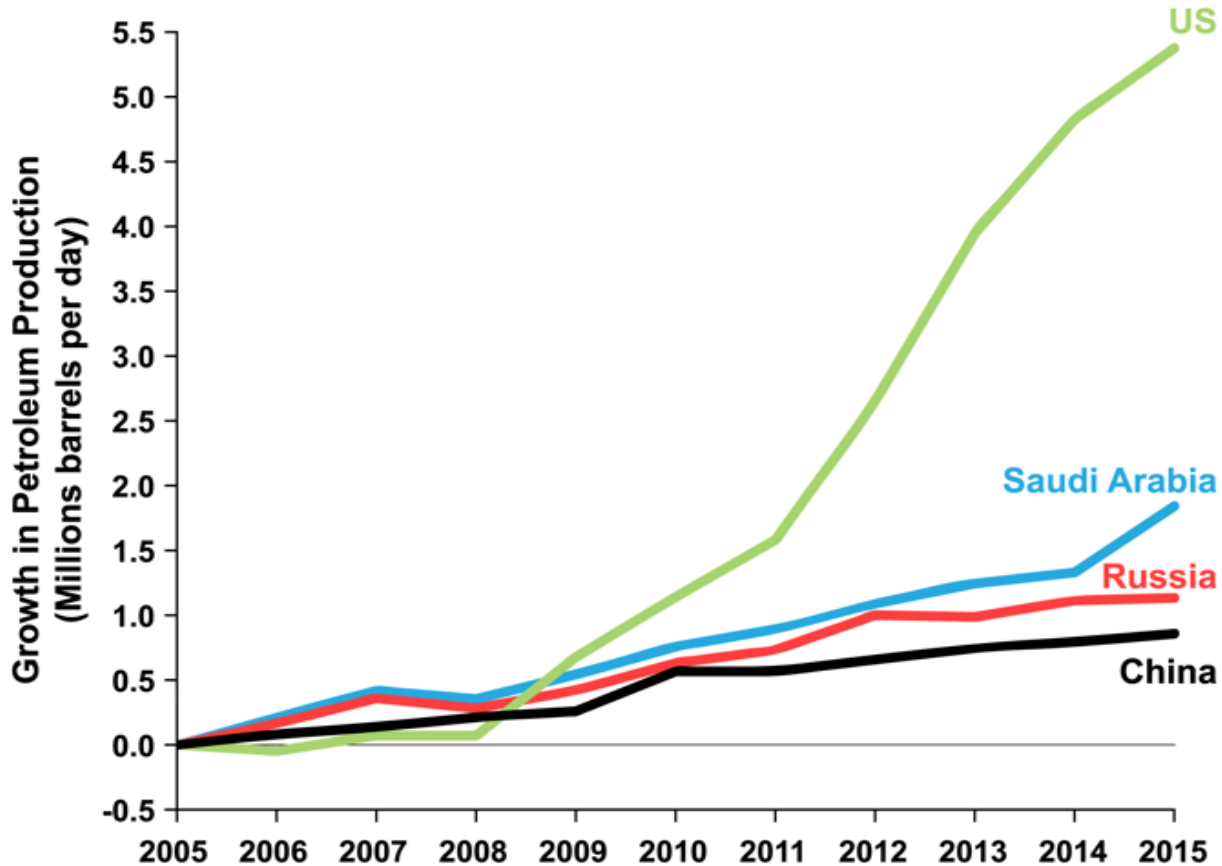


## Shale Rigs Output Per Rig Soars



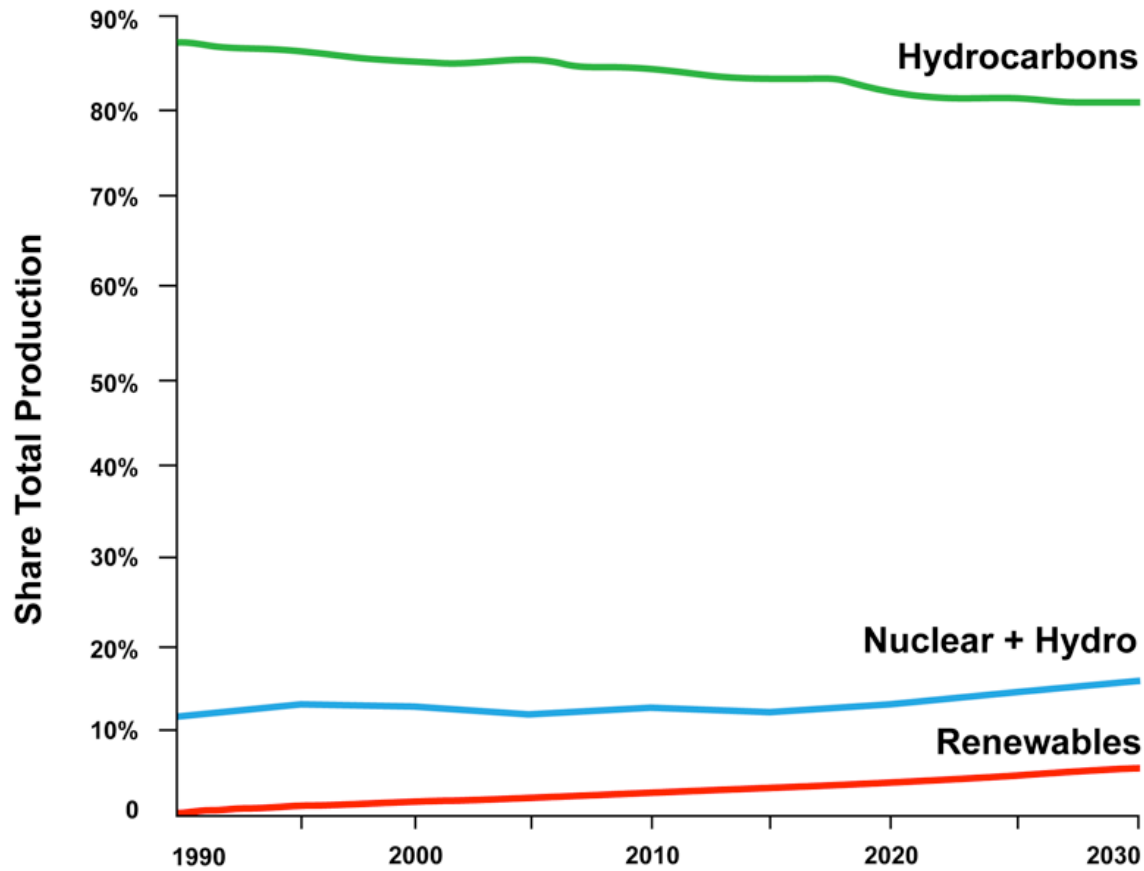
# *Game-Changer: From Dependency To Dominance*

## Growth in Oil Output Of Four Big Producers



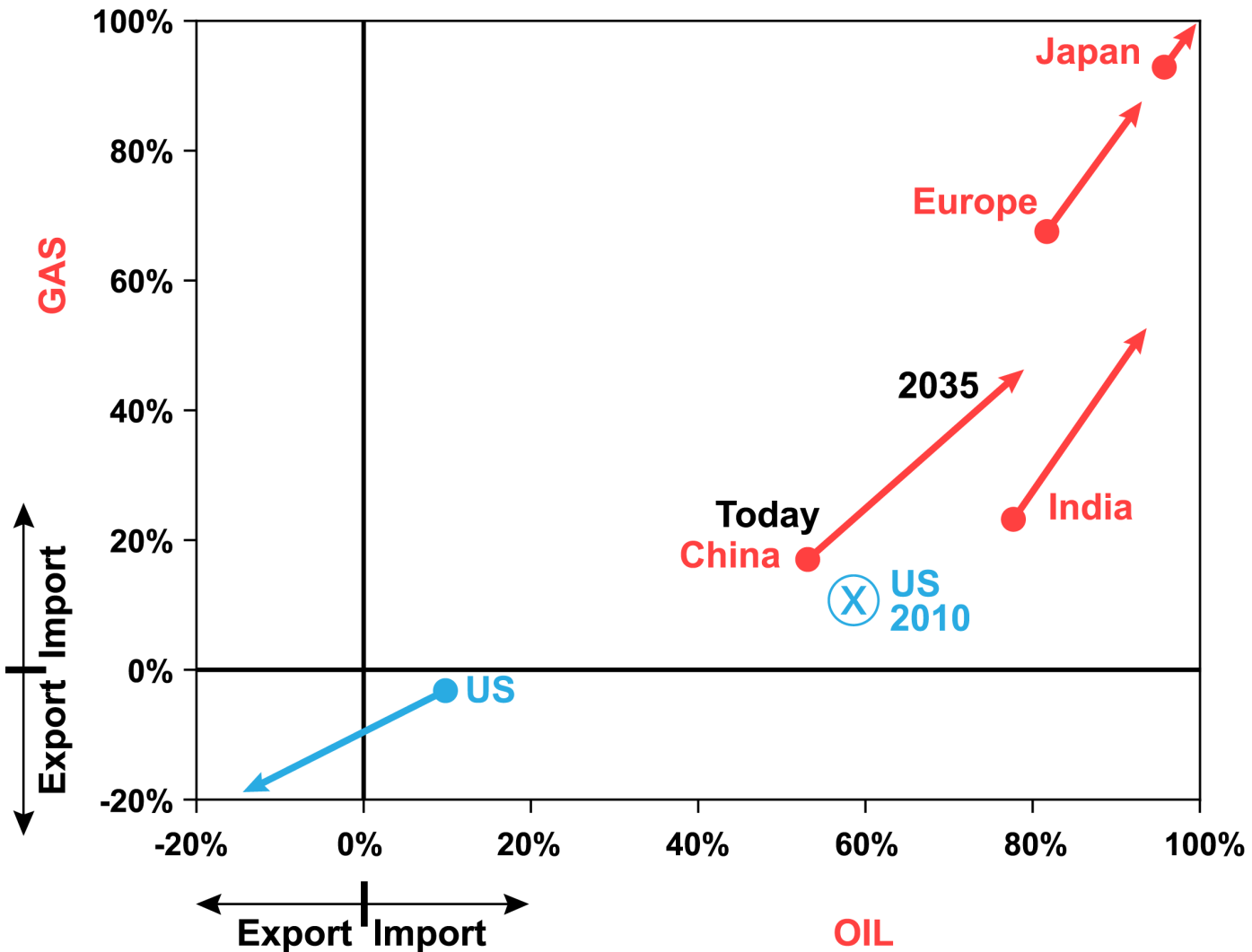
# *The Global Context*

## *History & Future Of World Energy Demand*



# Why Shale Matters

## Global Energy Dependencies





# Public & Political Realities

## Poll #1

Believe solar + wind **20%** now & **35%** in 5 yrs  Actual **< 2%** now & in 20 yrs **< 10%**

## Poll #2

Share Adults Saying Give Priority To 'Green' vs Hydrocarbons

