

# Electricity Markets

Fundamental Questions, History,  
Economy and Contemporary Discussions

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# Some words

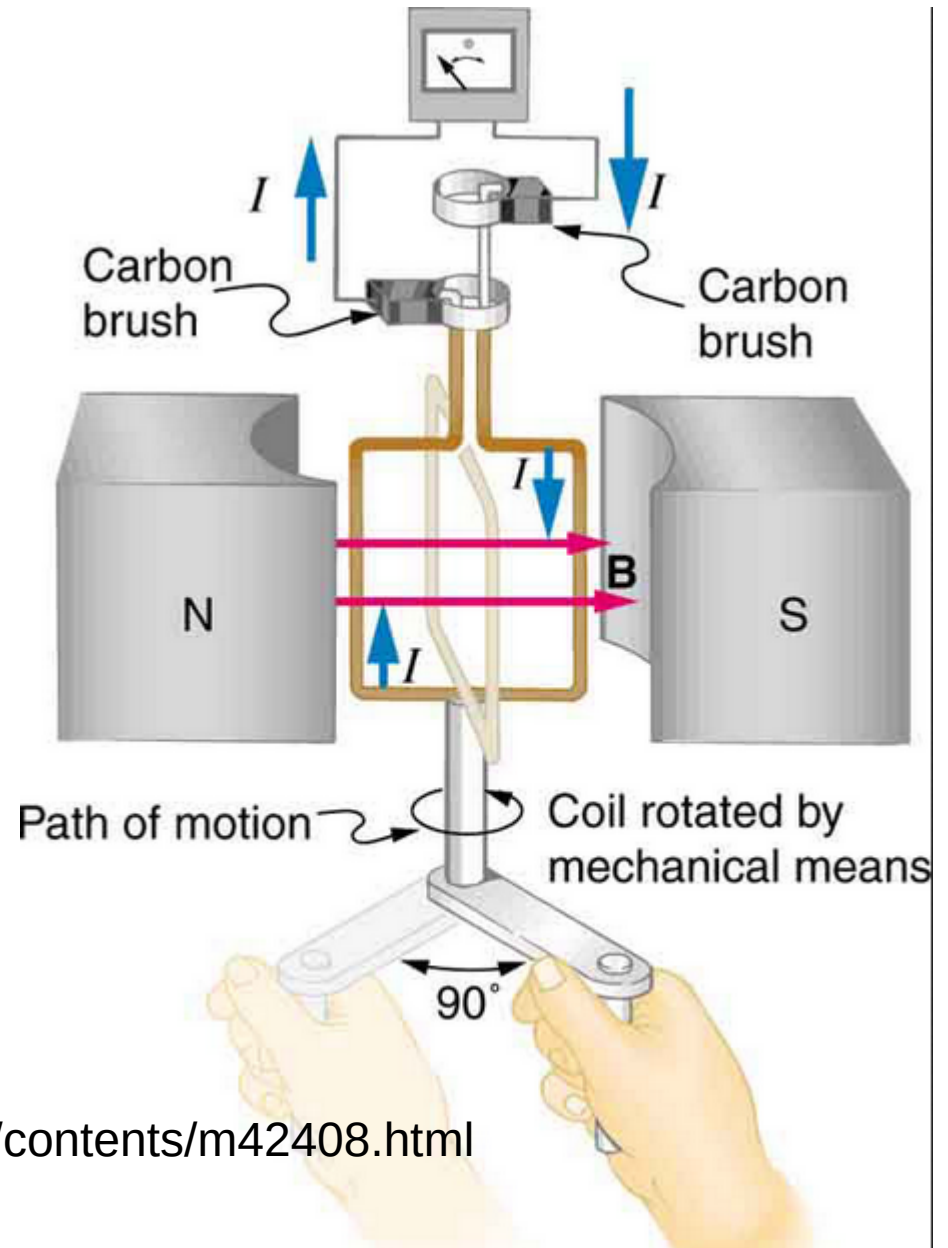
- History does not repeat itself, but it rhymes  
( Mark Twain )
- Markets can be made but not happen  
overnight
- Regulation changes when technology changes

# Index

- Simple concepts (Electrical Engineering)
- First part of book : **“From Edison to Enron”**
- Primer on economics of electricity markets: Ch1 of **“Spot pricing of Electricity”**
- Working Paper: **Mapping the course of the EU "Power Target Model" on its own terms**, Jean Michel Glachant
- Report: **Railroads, Utilities and Free Parking What the evolution of Transport Monopolies tells us about the Power Network of the Future**, A. J. Goulding
- Discussion on **"Clean Energy for All Europeans"**, EU package, 30th Nov 2016

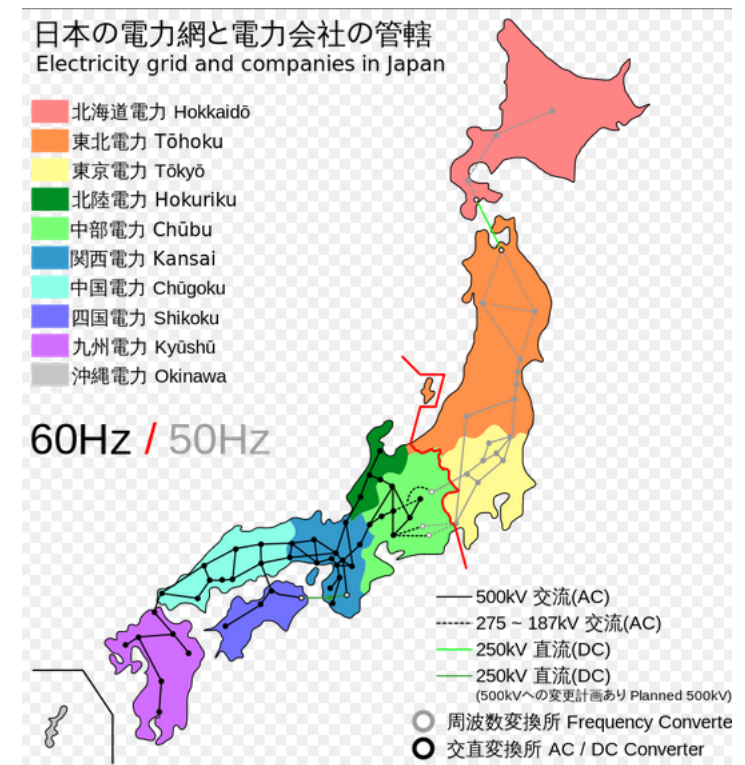
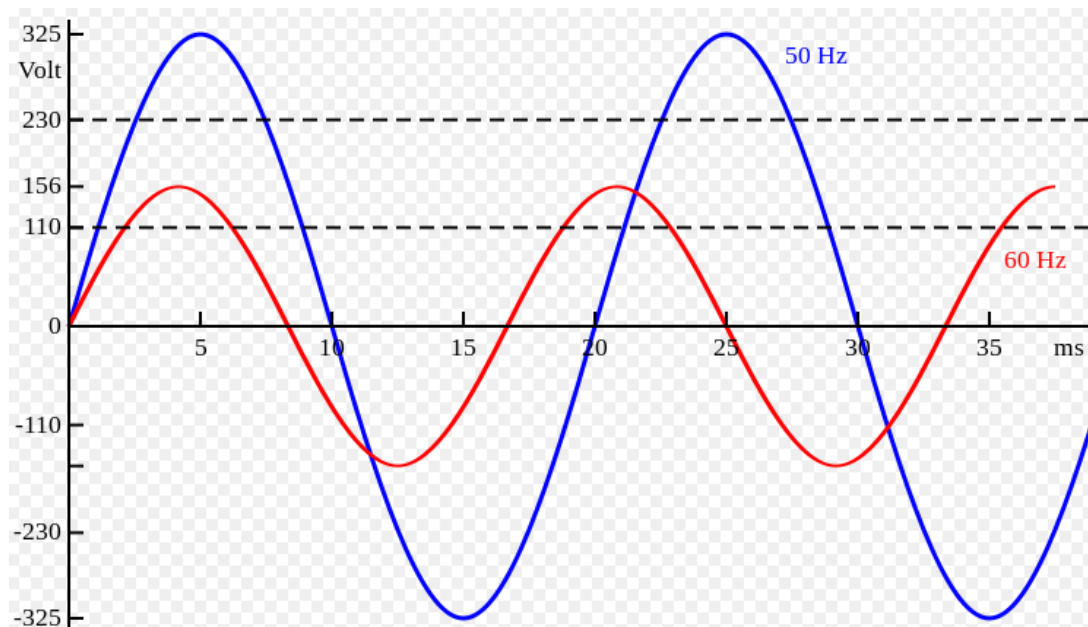
# Simple concepts

- Watt
- Kilowatt (1000=kilo)
- Megawatt (million=mega)
- Gigawatt(billion)
- Kwh or Mwh or Gwh  
(maintaining power at x  
for an hour)



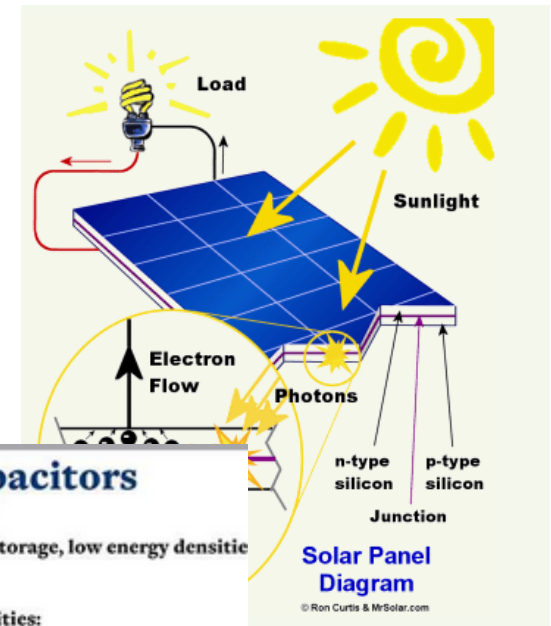
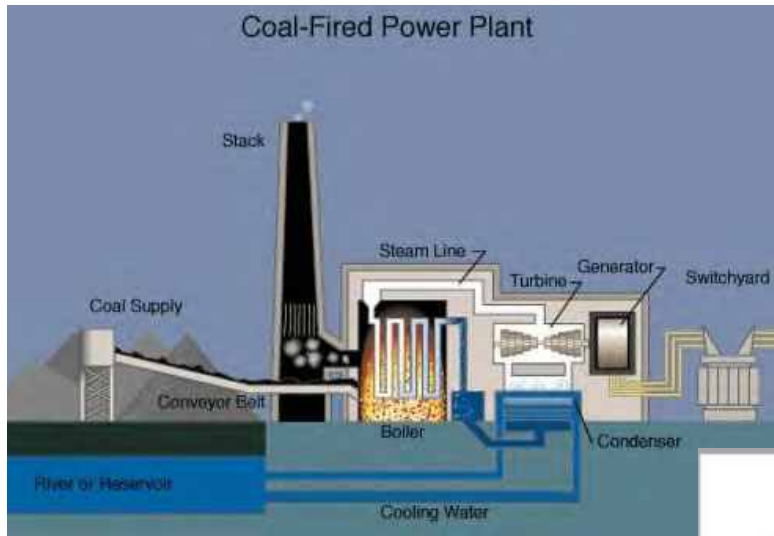
# Electricity concepts

- Frequency (for europe 50 hz, us 60 hz, japan:) )
- AC/DC



# How electricity is generated

- Rotating bodies / Chemical reactions / Physical



## Batteries vs. Supercapacitors

Chemical Storage, high energy densities:  
100's Wh/kg

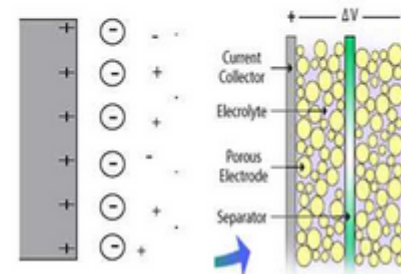
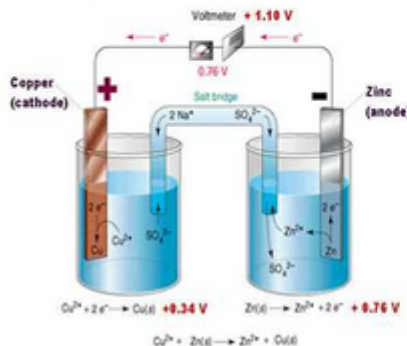
Surface Charge Storage, low energy densities:  
1-10 Wh/kg

Reactant diffusion, low power densities:  
10 W/kg

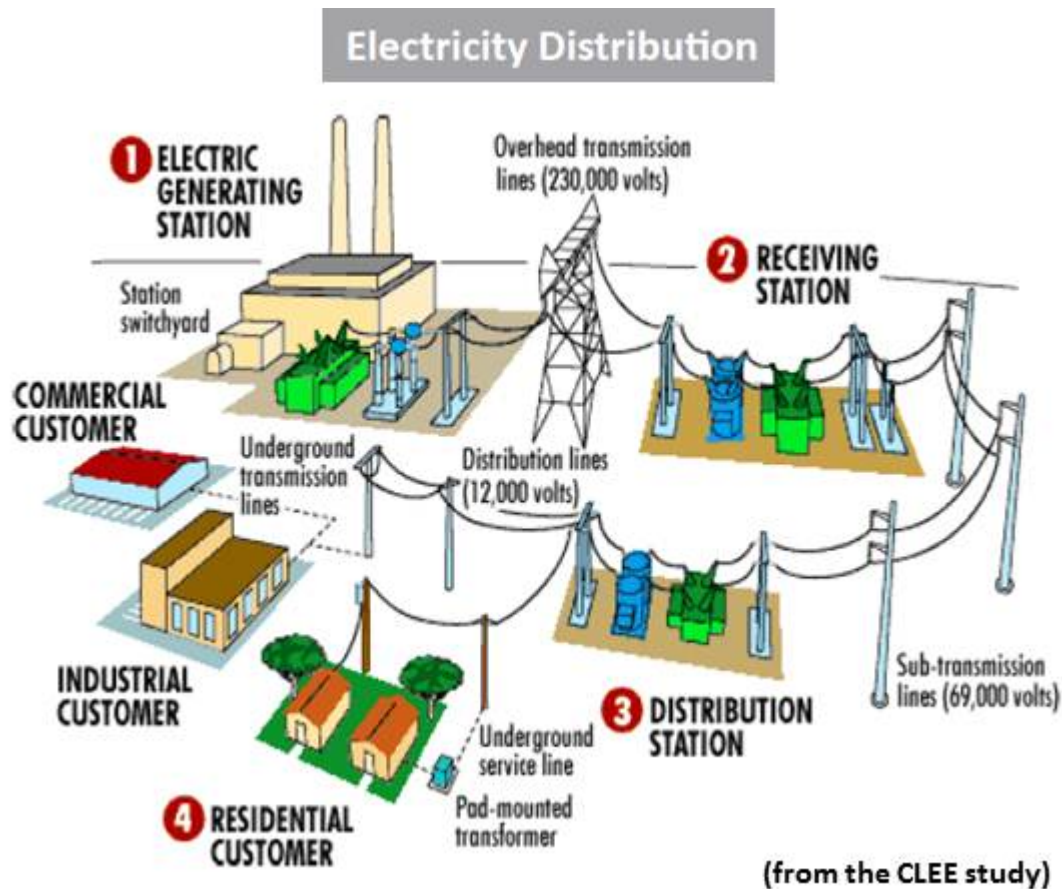
High power densities:  
1 kW/kg

Low cycle life due to degradation

High cycle life (10<sup>5</sup> cycles)



# How electric system works



- Why transmission?
  - Losses are lower at high voltage
- Why three phases?
  - To carry optimum power
- Why distribution?
  - Customer needs

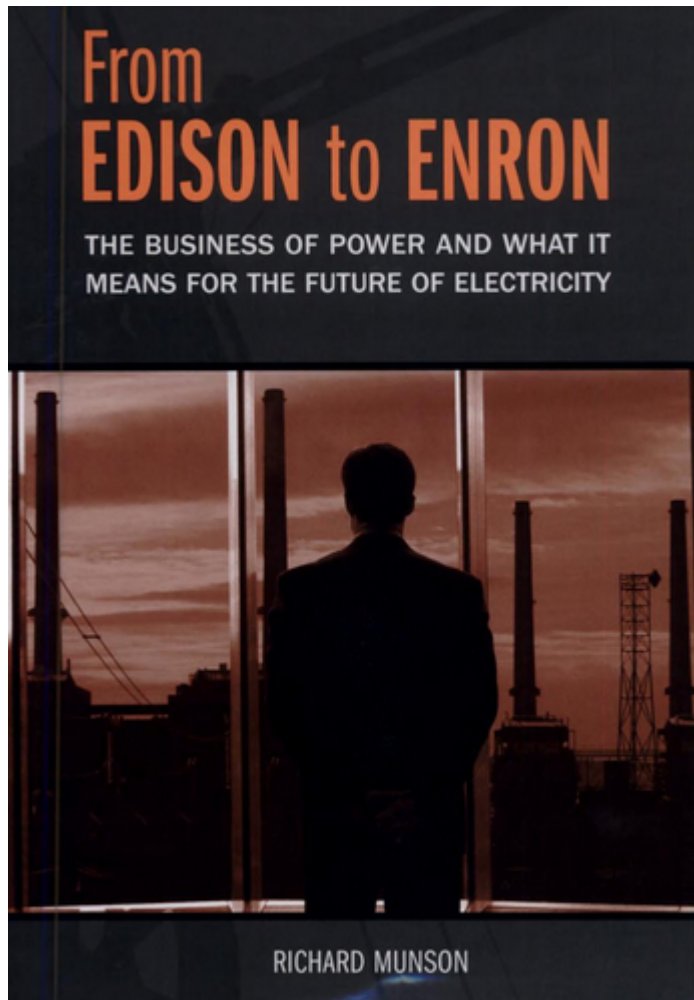
# Advanced issues

- Electricity industry and cabs
  - You have four seats but generally carry one (redundancy)
  - At the cab station, cabs waiting idle (ancillary services)





# Political History of Electric Power



- 2005, Richard Munson

- |    |   |     |
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[https://books.google.com.tr/books?id=MNCea\\_BbzQcC](https://books.google.com.tr/books?id=MNCea_BbzQcC)

# What happened when MIT tried to self-produce its own electricity consumption?

- 1985, MIT considered generating its own electricity
- Cambridge Electric Company (Celco)
- Finally settled on 20 MW, CHP (heat+power)
- Will cut uni's annual bills by 5.4 million \$, meeting 94% of energy needs
- MIT offered to pay 1 million \$ for supplemental power needs

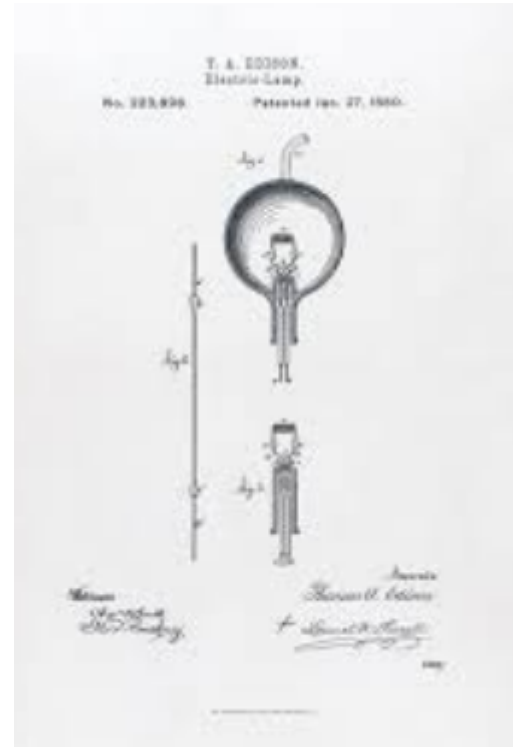


# Celco not happy

- Demanded “customer transition charge”: 3500\$/day = 1.3 million \$ as a compensation
- Massachusetts Department of Public Utility agreed with CelCo
- University appealed in Federal Court
- Sept 1997, Mass Supreme Judicial Court overturned
- Utility lobbied env regulators. NOx standard
- MIT responded with complex life cycle assessment

# How it all started

- Edison – Menlo Park - Light
- Oct 21, 1879 for 40 hours
- For several week silence
  - To design generator
- New York Herald
- Gas company securities plummeted



# Early steps

- Dec 1880, created EEI
- Pearl Street, 4 Sept 1882
- 1890, 30 firms manufactured lambs
- JP Morgan's own experience
- “sun's only rival”
- “My electric light inventions have brought me no profits only 40 years of litigation”



- Twenty electric light, telephone, telegraph companies separate wires on poles
- Edison was a team: Samuel Insull (personal sec), Frank Sprague (Mathematician), Tesla
- Tesla working in Edison telephone company in Yugoslavia “His ideas are splendid, but they are utterly impractical”
- Tesla -> Westinghouse

# War of Currents

- Edison DC, Westinghouse AC
- AC -> effective transformer and motor
- DC -> generation should be close by
- By 1888 Edison & Westinghouse
- Edison : “AC is dangerous”, electromorty, “Westinghoused”
- Westinghouse “125 central stations of leading direct current company... numerous fires
- 700 V AC killed horse

# Edison General Electric

- 1890 , Edison General Electric
- Financiers, consolidation
- JP Morgan
- General Electric



# Niagara

- 1725- first saw mil
- 1891, 17 firms
- 1893, Tesla designed turbines
- 22 miles to Buffalo
- Voltage stepped up from 2000 V from 10000 V.
- Nov 16, 1896



THIS PICTURE WAS TAKEN  
WHEN NIAGARA FALLS WAS COMPLETELY FROZEN IN THE YEAR 1911.  
A VERY RARE PHOTO.

I've read of this but never saw the photo before. Makes you wonder just HOW COLD and HOW LONG it was that cold!!



# Monopolists

- Different systems
  - DC: 100, 110, 220, 600
  - AC freq: 40,60,66, 125, 133
- Enter Samuel Insull “realized AC enables larger generators”
- Envisioned creating giant monopolies
- Rejected GE’s 36000\$ and for \$12000 managing Chicago Edison Company

# Samuel Insull

- 1892 – Arrived at CEC
- Shutdown isolated street lighting demand and obtained night time demand
- Acquired coal mines, railroads
- 189 apartments 68.5 kW
- At any time max demand 20 kW
- Central power 20 KW will be enough



- 1912 , selling off-peak for half cent/kWh
- Charge according to consumption
- Selling lighting to marketing electricity
- Dual rate structure
- 1912 encompassed 400 communities, served 4 million customers

# New Age - Regulation

- 1907, Wisconsin, “first power company regulation”
- Insull : “deal with only one state agency rather than hundreds of city councils”
- Chief proponent of Regulation and Monopoly
- “There is one great advantage that must follow regulation, and that advantage is protection”
- MIT launch first program for electrical engineers 1890

# Scandal

- Insull, 1925, supported Frank Smith (head of Illinois Commerce Commission) against McKinley
- Federal Trade Commission (FTC) criticized utilities for “buying” elections, 30 million \$ annually
- New York Governor, Franklin Roosevelt : Insull network “kind of private empire within the nation”
- Sept 1931 – England abandoned gold standard

# SEC

- Accused “stock watering and capital inflation, manipulation of subsidies and improper accounting principles”
- Escaped
- 1934 – arrived at New York harbour

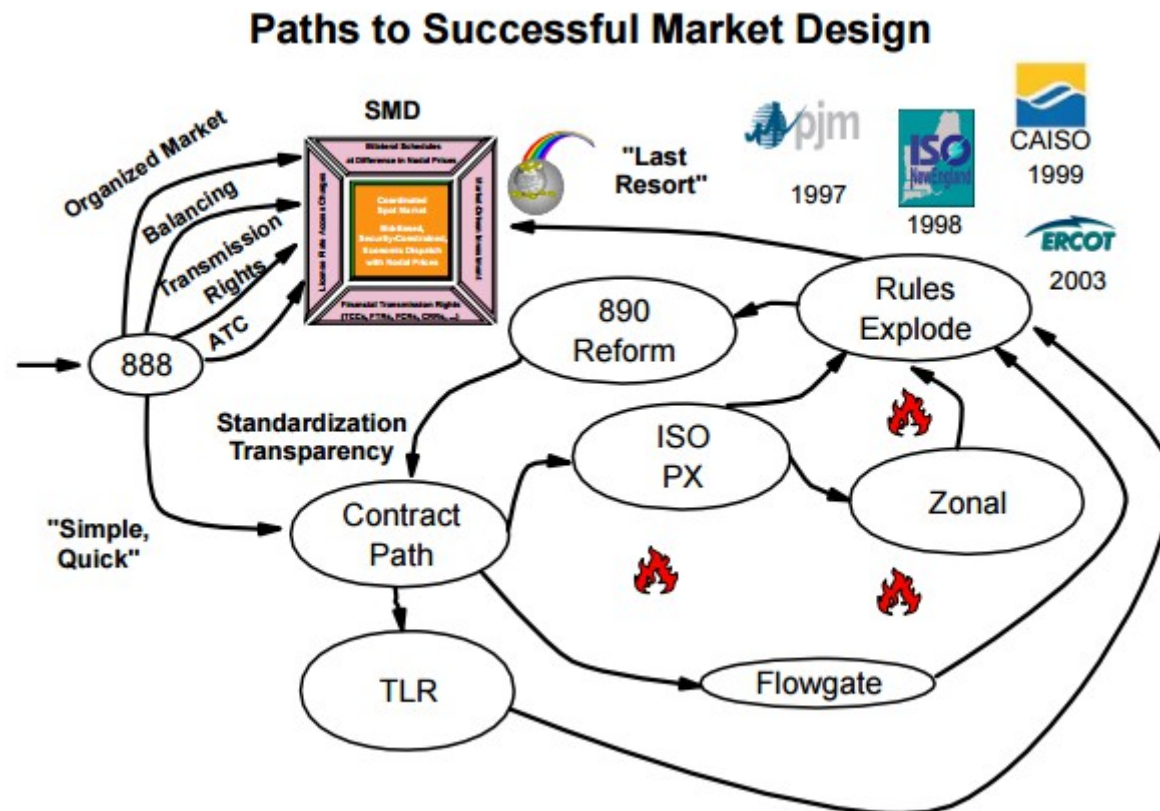
# George Norris

- Norris & FDR
- FDR launched “waffle iron campaign”
- Govt owned utilites would provide lower rates

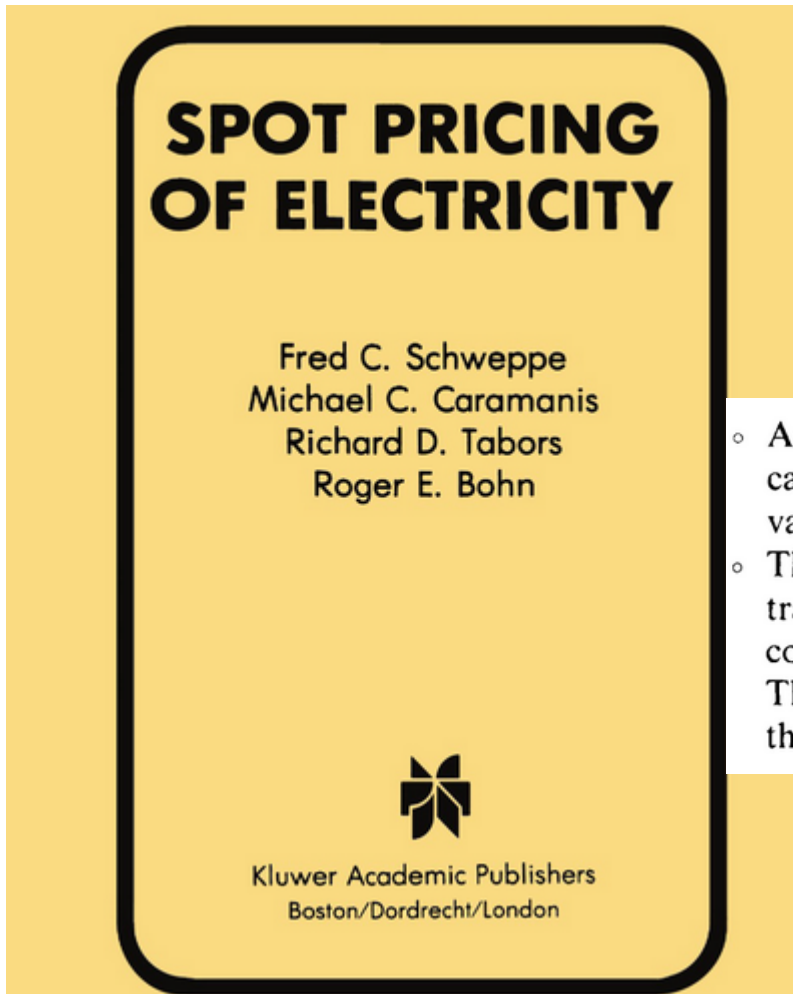


# Rest of the story is in the book

- 1935 Public Utility holdings (Insull factor)
- 1978 Purpa (Co-gen)



# Spot Pricing of Electricity



- A primer on electricity market economics
- 1988 (Schweppe et al)

- An hourly spot price (in dollars per kilowatt hour) reflects the operating and capital costs of generating, transmitting and distributing electric energy. It varies each hour and from place to place.
- The spot price based energy marketplace involves a variety of utility-customer transactions (ranging from hourly varying prices to long-term, multiple-year contracts), all of which are based in a consistent manner on hourly spot prices. These transactions may include customers selling to, as well as buying from, the utility.

# Why

- Spot price based energy market place
- Benefits
  - Improvements in operating efficiency
  - Reductions in needed capital investment
  - Customer preferences

# Six basic criteria

- Economic efficiency: Motivate customers to adjust their own electric energy usage patterns to match utility marginal costs
- Equity: Reduce customer cross-subsidies (i.e. a customer's charges are based on the utility's costs to serve that customer)
- Freedom of choice: Provide customers with options on the cost and reliability of supply and how they choose to use electric energy
- Customer acceptance and understanding: Customers should be able to understand the nature of the transactions and be convinced that they are fair
- Utility control, operation and planning: Consider the engineering requirements for  
controlling, operating and planning an electric power system
- Customer control, operation, and planning: The customers' reaction to transactions should not have to be unwieldy or unnecessarily complex

# Energy Marketplace Transactions

The five essential ingredients for a successful marketplace are

1. A supply side with varying supply costs that increase with demand
2. A demand side with varying demand levels which can adapt to price changes
3. A market mechanism for buying and selling
4. No monopsonistic behavior on the demand side  
(monopsony is difficult on the demand side because the number of customers ranges from thousands to millions)
5. No monopolistic behavior on the supply side

# Steps to Energy marketplace

## **SECTION 1.2. THREE STEPS TO AN ENERGY MARKETPLACE**

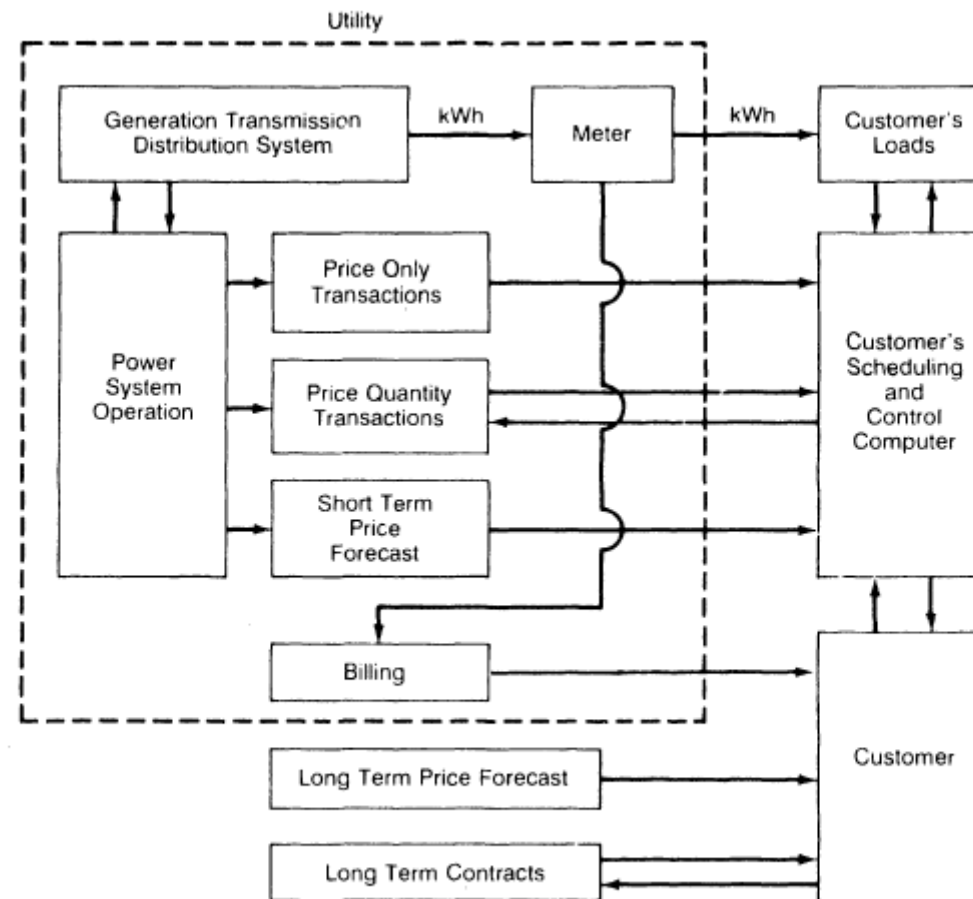
A spot price based energy marketplace that meets the four criteria of Section 1.1 can be achieved in three steps:

- Step I: Define hourly spot prices and evaluate their behavior.
- Step II: Specify an appropriate set of utility–customer transactions based on the hourly spot price and associated transactions costs.
- Step III: Implement the energy marketplace considering the needs and capabilities of both the utility and the customers.

The hourly spot price is determined by the supply/demand conditions that exist at that hour. In particular it depends on that hour's:

- Demand (in total and by location)
- Generation availability and costs (including purchases from other utilities)
- Transmission/distribution network availability and losses

# Functions and Information Flow



**Figure 1.4.1.** Functions and information flow in an energy marketplace.

# EU's Target Model



RSCAS 2016/23  
Robert Schuman Centre for Advanced Studies  
Florence School of Regulation

Mapping the course of the EU "Power Target Model" ...  
on its own terms

Jean-Michel Glachant

Written by Jean-Michel  
Glachant

Twitter:  
<https://twitter.com/JMGlachant>



# Highlights

## **Highlights**

The European Union has a “continent scale” power target model; while the USA and Canada have no such model.

But, it took decades (since the first “internal market” directive in 1996) to produce it, and it largely relies on the former concept of EU- wide “cross-border CCGT competition”.

The corresponding market pricing is zonal and mainly Day-Ahead; the power system operation is also zonal, both intra-day or “real-time”. Will this Target Model resist the integration of massive renewables?

Would the EU easily produce a new Target Model to integrate massive renewables? Or, would it prefer to keep the existing one and upgrade it with a few “add-ons”?

I do not yet foresee if the EU will succeed in undertaking all of the challenging but necessary “target model” upgrades to enter soon a 2030 forward- looking strategy.

# EU started without a “Target Model”

- No Target Model, no Market Design for (1996-2009)
- Target model-> in the 3rd package
  1. “Merit Order” as a reference pricing mechanism for day-ahead (Day ahead energy pricing)
  2. Simplified cross-border zoning (Market coupling)
  3. Zones/Cross border process for real time or close to real time (intraday&balancing) – (Closing the gaps with reserves and balancing energy)

# 1st Energy Package

- 1986- European dream of “single act”
- 1990 – UK Electricity pool
- 1992- target for implementation
- 1996 – 1st Energy Package
  - Big consumer to shop around
  - TSO – transmission system operators
  - Third party access (negotiated or regulated?) - no obligation to regulated
    - Germany - national negotiated TPA

# 2nd package

- 2002 - - needed for a “truly single market”
- “shopping rights”->“eligibility” for all
- “Regulatory bodies”
- “regulated TPA”
- DG Comp ->
- 2007: 20-20-20 (German Presidency)

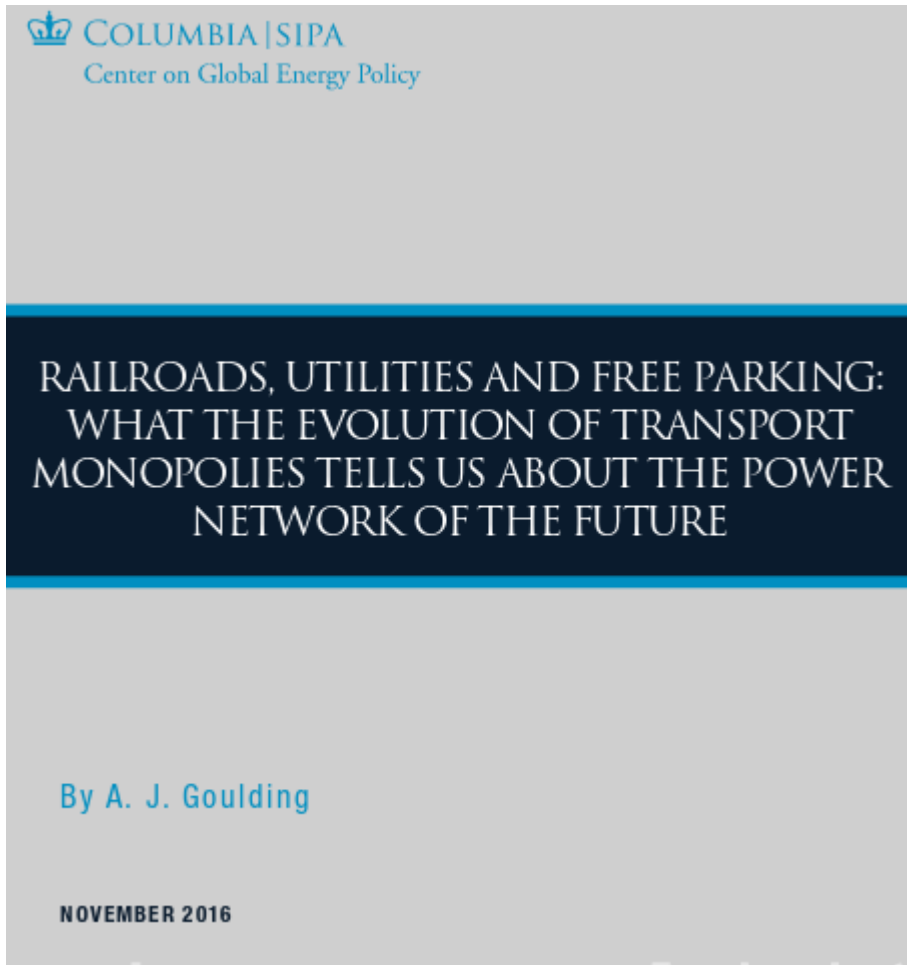
# 3rd Energy Package

- 2009 – An institutional framework
- ACER – a federal energy regulator
- ENTSO-E – European body of TSOs
- 2008 – big RES push by 20-20-20
  - Q1) Fully “integrating RES into power market”
  - Q2) Will market-drive investment then deliver generation adequacy?

# Way forward?

- Target model+ or Target Model 1.1
- RES push is shaking power market
- Capacity Markets – add-on?
- DSO mirroring TSO operations?
- Or Target Model 2.0

# Reading for Discussion



- How the history of Railroads can be the future of power networks?
- A. J. Goulding
- Interesting perspectives

[http://energypolicy.columbia.edu/sites/default/files/energy/Railroads\\_Utilities\\_and\\_Free\\_Parking\\_What\\_Evolution\\_of\\_Transport\\_Monopolies\\_tells\\_us\\_about\\_Power\\_network\\_of\\_future.pdf](http://energypolicy.columbia.edu/sites/default/files/energy/Railroads_Utilities_and_Free_Parking_What_Evolution_of_Transport_Monopolies_tells_us_about_Power_network_of_future.pdf)

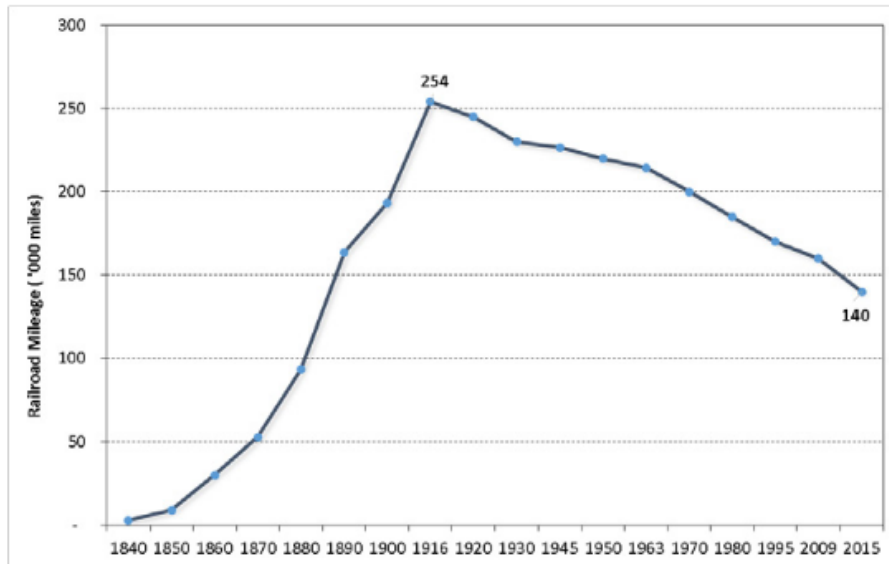
# Paper Argues

- Electric utilities will eventually cease to be natural monopolies and will need to be given vastly greater latitude in how rates are set, while the role of regulators will increasingly shift to matters of safety and access.
- Utilities will need to rethink business and investment planning under the assumption that the sector will eventually become competitive.
- As power customers are offered more choices, they will need to reassess the ways in which they use power and the attributes they value in service.
- Utilities will be less able to rely on steady cash flow from existing customers to finance ongoing operations and will need to adjust dividends accordingly.
- Utilities should reassess their capabilities and focus on what they do best: moving large volumes of electricity over great distances.



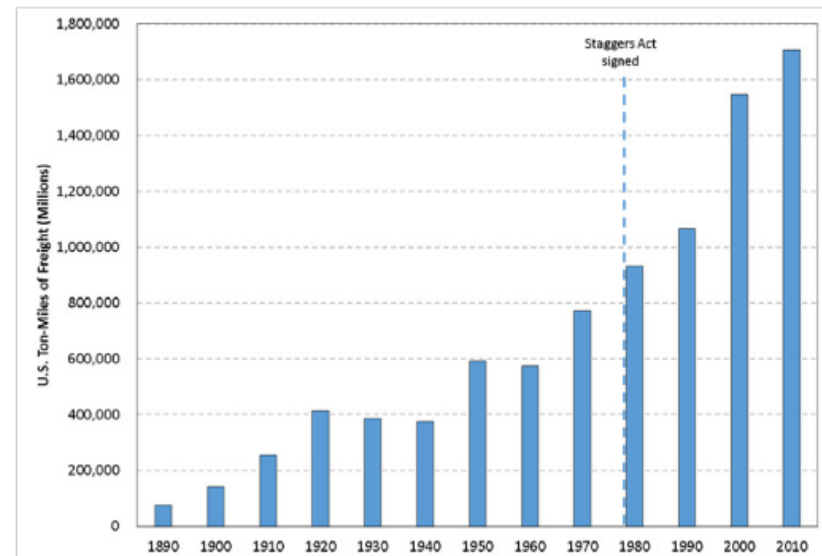
# Changes in rail road network mileage

Figure 1: Changes in railroad network mileage, 1840–2015



Source: Association of American Railroads (AAR), American-Rails.com.

Figure 2: Ton-miles of freight carried by rail, 1890–2010



Note: The Staggers Act of 1980 was the culmination of nearly a decade of deliberation on deregulating railroads.

In 1913, railroads accounted for 21% of NYSE,

By 2015, dropped to 1.23%

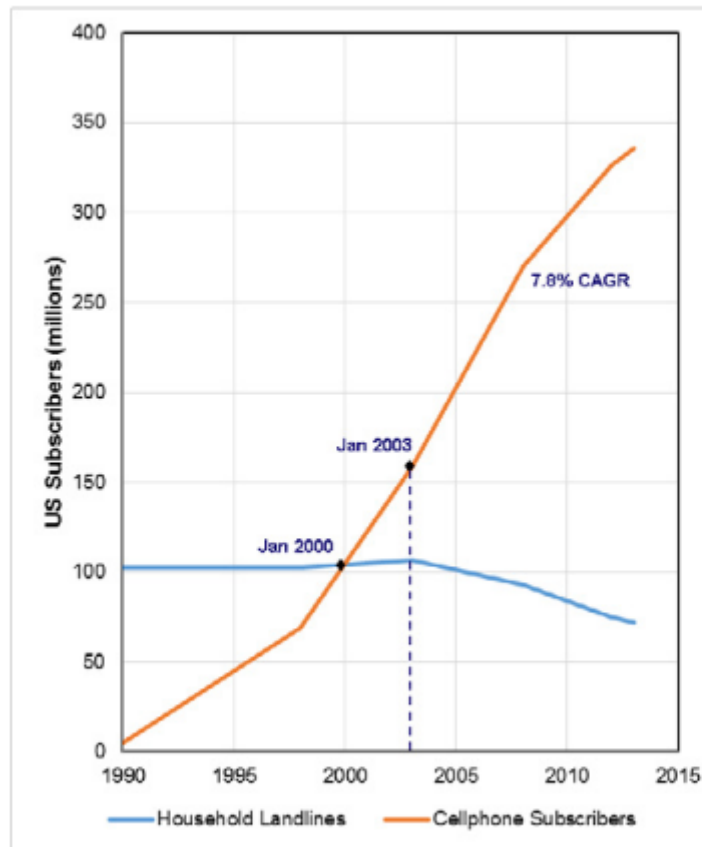
First cars, then planes.... Land grants shifted to road networks & airports -postal contracts

The Staggers Act of 1980 – freed railroads from economic regulation

But productivity increased RTM(revenue ton mile) +110% 1979-2009

# Cell phone or Land lines

Figure 4: Cell phone subscribers versus house landlines (1990–2013)

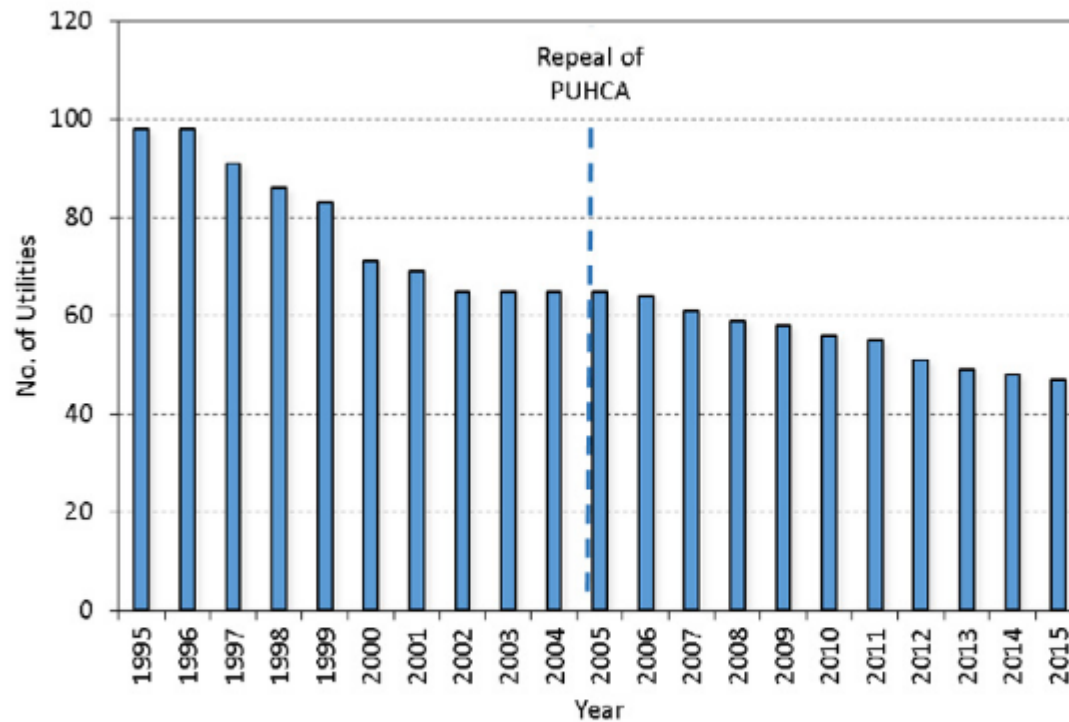


- Customers value freedom, flexibility, , convenience (mobility and speed)

Source: London Economics International LLC using data from CTIA—The Wireless Association. 2003 when landline subscriptions began to fall.

# Decline in utility holding companies

Figure 5: Decline in utility holding companies since 1995



PUHCA refers to the Public Utility Holding Company Act of 1935, which was repealed in 2005 after having been rolled back in 1992. Among other things, the act limited the activities of holding companies of investor-owned utilities in unregulated industries.

Source: Edison Electric Institute, EEI Financial Review (2015).

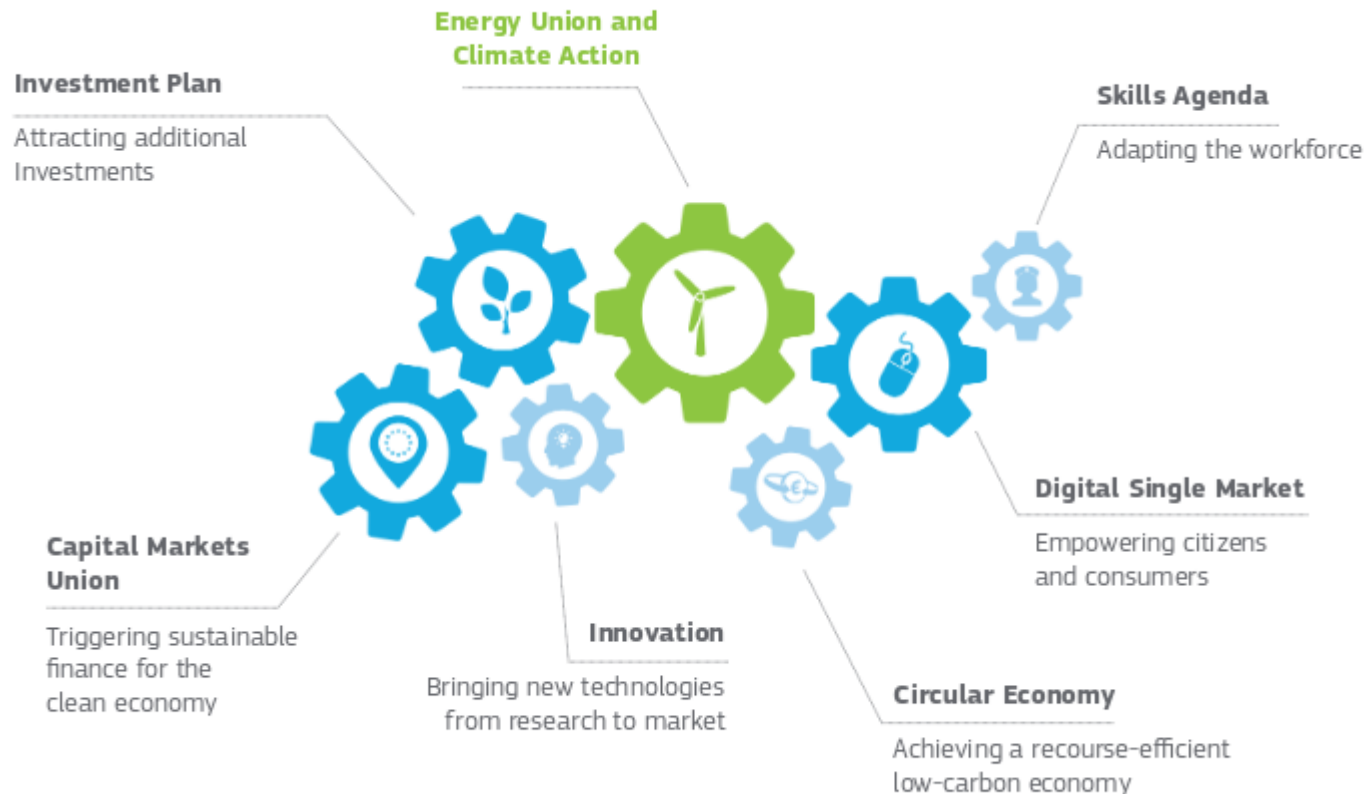
# Challenges

- Rail monopolies disappeared long before regulators recognized that trucks were a viable alternative... Think Uber now
- Selling electricity or providing means for customers to generate it themselves
- Stranded costs are inevitable
- Rate setting fails to properly price optionality
- Change: if the cost of doing so can be avoided by shifting to another form of service delivery.
- Number of utility holding companies declined 50% between 1995-2015

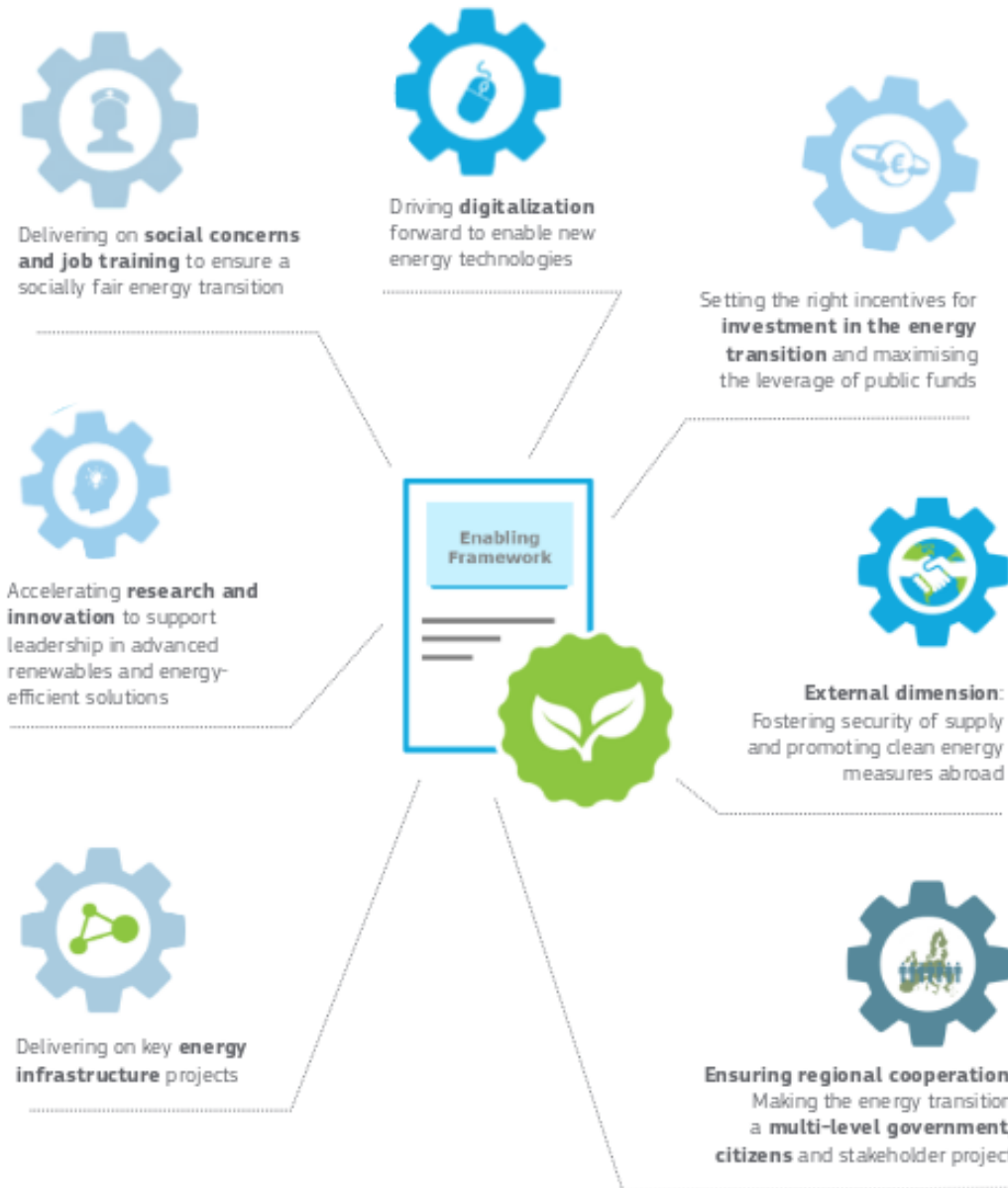
# Implications for regulators, customers and share holders

- Electric utilities will eventually cease to be natural monopolies
- Utility management needs to adapt to a world of falling prices
- The world is becoming more complicated for power customers
- Dividends will disappear (quite grim!)
- Railroads didn't die, electric utilities won't either

# 30th Nov 2016 - “Clean Energy for all Europeans”



# How to get there?



# Efficiency and Renewables

## ENERGY EFFICIENCY SECTOR GENERATES JOBS AND MONEY

By **2030**, improve energy efficiency across the EU by



+ EUR 70 billion



+ 400,000 JOBS

## ECODESIGN HELPS TO MAKE PRODUCTS ENERGY EFFICIENT



### Benefits for Consumers

Ecodesign policy means potential savings of **EUR 490** on household energy bills each year



## THE RENEWABLE ENERGY DIRECTIVE



EUR 138 billion in 2013



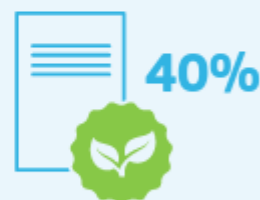
1.2 million employees

**The Renewable Energy Directive** will focus on getting to the 27% target by creating the right conditions for renewables to thrive. It's a sector that already employs 1.2 million people and accounted for EUR 138 billion in 2013.

## CLEAN ENERGY IS THE GROWTH OF TOMORROW



EU's renewable energy sector created in **2014** an annual turnover of around **EUR 143.6 billion**.



EU companies have a share of **40% of all patents** for renewable technologies.



**2.4 million** Europeans are employed in sectors providing energy efficiency products and services. More than **1 million** people work in the renewable energy sector, with potentially **3 million more jobs by 2020**.



A **30% energy efficiency target** improves energy security by reducing oil and gas imports by **12% (EUR 70 billion saved) in 2030**.



Energy Labelling



Ecodesign



Nearly **half of the energy savings target** set by the EU for 2020



A **quarter of the emissions reduction targets** set by the EU for 2020

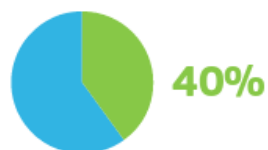


# Financial Support and Investment

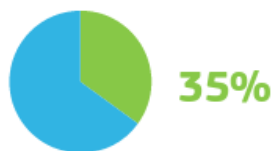
## FINANCIAL SUPPORT AND INVESTMENTS



20% of the EU budget should go to climate-related expenditure



At least 40% of the infrastructure projects under European Fund for Strategic Investments (EFSI) will contribute to climate action, in line with the commitments under the Paris climate



Climate-related expenditure will exceed 35% of the overall Horizon 2020 budget



European External Investment Plan will support energy projects in Africa and in the Neighbourhood

## WHAT CAN WE EXPECT IN TERMS OF RESULTS?

The package presents a dual opportunity to speed up decarbonisation and to speed up growth and job creation.



**Investment:**  
extra EUR 177 billion per year of investment from 2021 to meet 2030 climate & energy targets  
Crucial role for EFSI



**Economic growth\*:**  
1% increase in GDP  
EUR 190 billion into the economy  
900,000 new jobs  
\*Upper end of estimates



**Decarbonisation:**  
Carbon intensity of the economy 57% lower in 2030 than in 2015  
72% share of non-fossil fuels in electricity generation in 2030

# My Impression

- Lots of gold plating
- Renewable development in market mechanism
- Efficiency two ways:
  - New products (niche or technologically advanced)
  - Increase turn over
- Labeling :
  - A soft way for “protectionism”
- Any essence? Maybe

Thank you