Organized by:
Energy Regulators Regional Association

ERRA
ENERGY REGULATORS
REGIONAL ASSOCIATION

1st ERRA Educational Workshop

INNOVATION AND REGULATION

September 6-7, 2018 // Budapest, Hungary

Overview of new technologies possibly affecting energy regulation; Regulatory roles and economic incentives for innovation

Dr. Okan YARDIMCI

Education

1999-04 (B.Sc)	Petroleum and Natural Gas Eng.	(METU)
2005-08 (MBA)	Business Management	(Atılım U.)
2008 (Executive P.)	Public Utilities	(Michigan State U.)
2013-15 (LL.M.)	Law	(Penn State U.)
2010-16 (Ph.D.)	Finance	(Hacettepe U.)

Work Experience

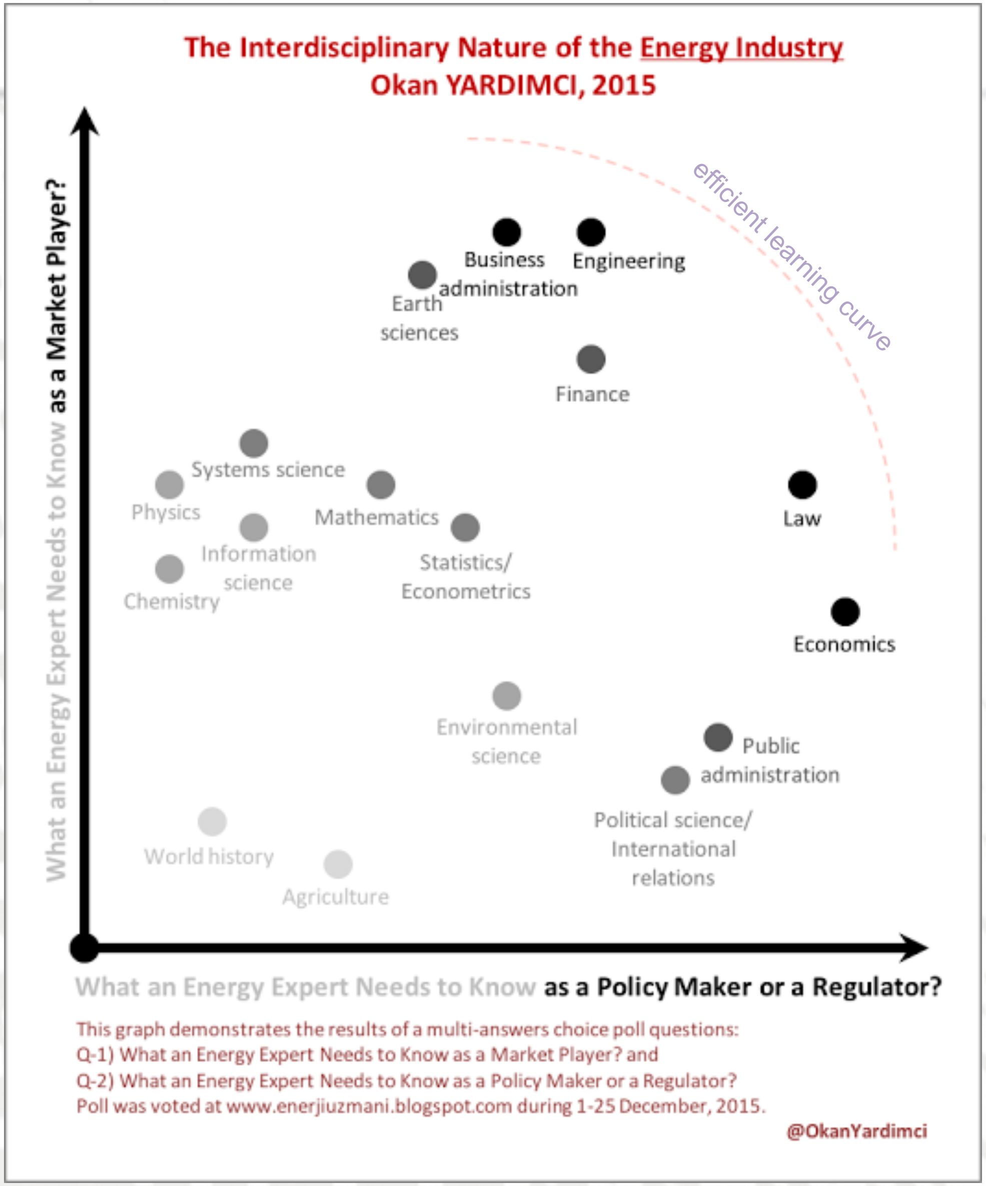
2002	Intern, TPAO (NOC of Turkey)
2003	Intern, Perenco (a French originated IOC)
2004-2006	Reservoir Engineer, Perenco
2006-Cont.	Energy Expert, Energy Market Regulatory Authority, Turkey

Other

Lecturer (energy, economics, regulation, finance, law): @METU, Bilkent, Hacettepe Universities (Turkey), SWUFE (China)

Mediator: @Energy Community, Austria

Interests: economics of regulation, tariffs, contracts, international business transactions, global energy markets, energy geopolitics, shale gas, oil and natural gas prices, econometrics, finance, energy law, international law, economy of law, arbitration, negotiation



Primary Goals of this Session:

To understand/learn/discuss/think about…

- Promising technologies in the energy sector,
- Their effects on regulation,
- Regulatory roles in the era of technology,
- Economics of innovation,
- Using a magic tool: incentivisation

Promising Energy Technologies in 2000
(IEA, 2000a)

Energy-Efficiency Technologies (Buildings)

- Heating and Cooling Technologies: efficient heating, ventilation and air-conditioning (HVAC) equipment, ie: heat pumps, water heating and refrigeration equipment
- Efficient lighting: electronic ballasts and compact fluorescent lamps (CFLs), high efficiency sodium discharge lamps, sulphur lamps
- Building energy management and control systems: automatically regulates the operation of HVAC, lighting and other systems in buildings
- District heating and cooling (DH&C) systems
- Technologies that reduce leaking electricity losses: devices continue to use electricity while in stand-by mode or turned off.

Energy-Efficiency Technologies (Industry)

- Process integration
- High-efficiency motors, drives and motor-driven systems
- High-efficiency separation processes
- Advance end-use electro-technologies

Promising Energy Technologies in 2000
(IEA, 2000a)

(Cont.)

Energy-Efficiency Technologies (Transport)
- Efficient convenient vehicles
- Electric and hybrid vehicles
- Fuel-cell-powered vehicles
- Biofuels

Clean Power Generation
- Natural-gas fired technology: natural gas combined-cycle (NGCC)
- More efficient coal technologies
- Renewable-energy technologies (biomass, wind, solar)
- Nuclear plant optimisation and life extension
- Fuel cells for stationary generation

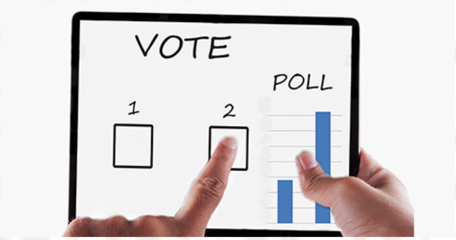
Crosscutting Technologies
- Combined Heat and Power (CHP)
- Advanced gas turbines
- Sensors and controls
- Power electronics

ERRA Workshop Program (in 2018)

Regulatory roles / economic aspects
Network planning / utilisation of the network
Smart grid and smart metering
Demand side response / flexibility
Self-generation
Energy storage (technical and legal aspects)
E-mobility / EV charging
Digitalisation
Blockchain

How familiar are you with the new technologies in the energy sector?

Please visit the page: http://etc.ch/FdeP for online voting!!!



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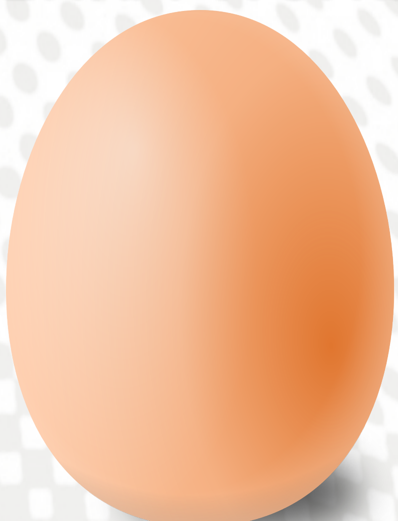
In order to

- achieve commitments within the Paris Protocol (or probably a new one after the failure of Paris Protocol),
- maximise social welfare,
- …

ERRA Workshop Program (in 2036)



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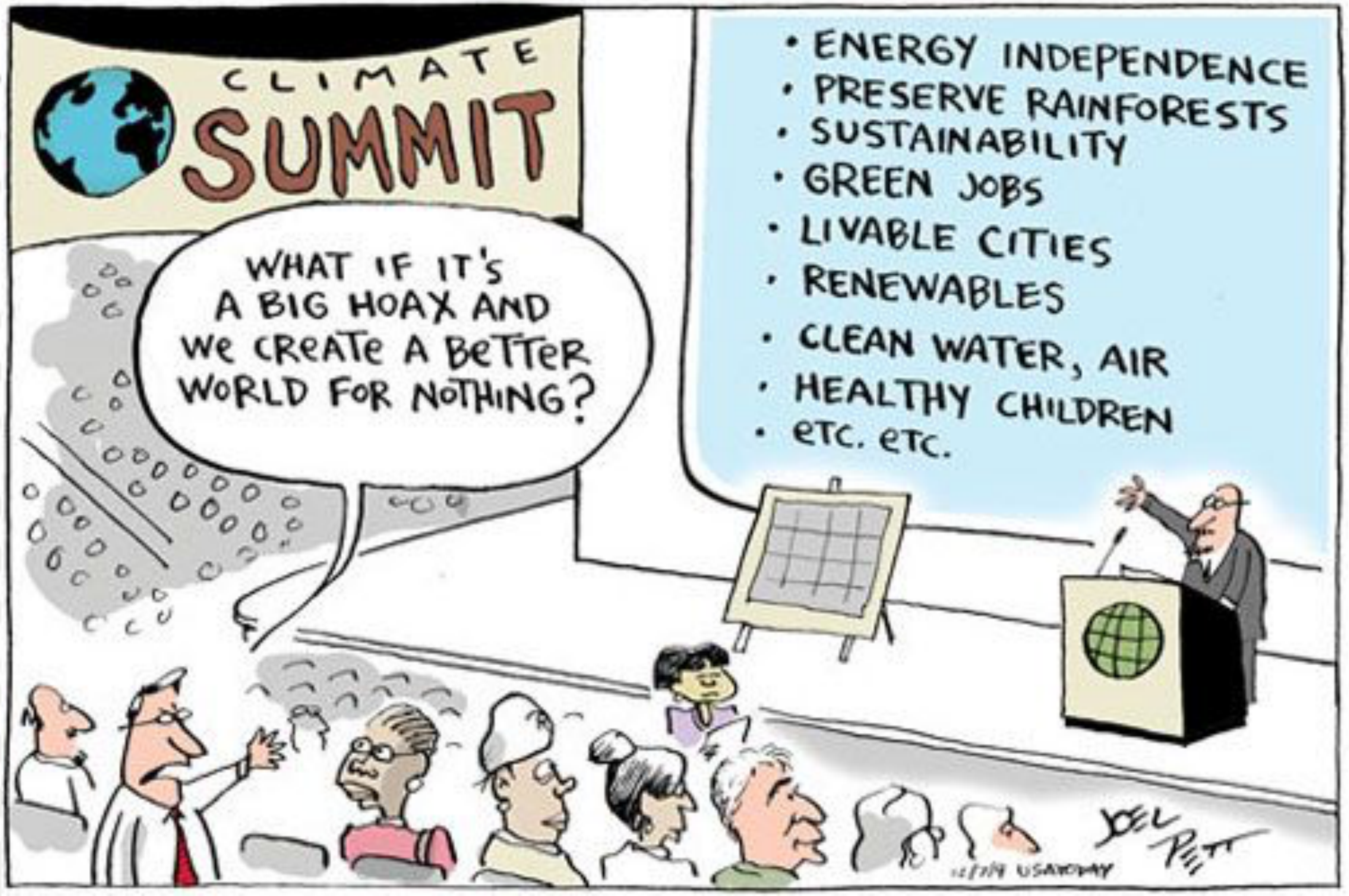

CLIMATE SUMMIT
WHAT IF IT'S A BIG HOAX AND WE CREATE A BETTER WORLD FOR NOTHING?
• ENERGY INDEPENDENCE
• PRESERVE RAINFORESTS
• SUSTAINABILITY
• GREEN JOBS
• LIVABLE CITIES
• RENEWABLES
• CLEAN WATER, AIR
• HEALTHY CHILDREN
• etc. etc.
JOEL PETT

Donald J. Trump
@realDonaldTrump

It's snowing & freezing in NYC. What the hell ever happened to global warming?

RETWEETS 653 LIKES 317

12:25 AM - 22 Mar 2013

Donald J. Trump
@realDonaldTrump
Following

Snowing in Texas and Louisiana, record setting freezing temperatures throughout the country and beyond. Global warming is an expensive hoax!

RETWEETS 428 LIKES 358

1:27 AM - 29 Jan 2014

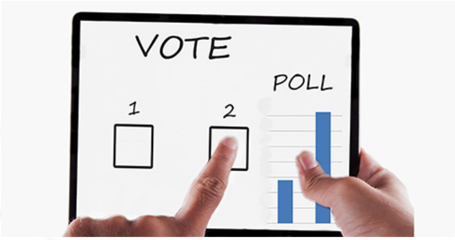
Donald J. Trump
@realDonaldTrump
Following

Give me clean, beautiful and healthy air - not the same old climate change (global warming) bullshit! I am tired of hearing this nonsense.

RETWEETS 336 LIKES 366

1:44 AM - 29 Jan 2014

Spending on Climate Change & Economic Impact of Climate Change



Environmental Aspects of Innovation and Regulation

The United Nations Framework Convention on Climate Change (UNFCCC) is the main international agreement on climate action. It was one of three conventions adopted at the Rio Earth Summit in 1992. To date, it has been ratified by **195 countries**. It started as a **way for countries to work together to limit global temperature increases and climate change**, and to cope with their impacts.

The Council handles two issues related to the UNFCCC:

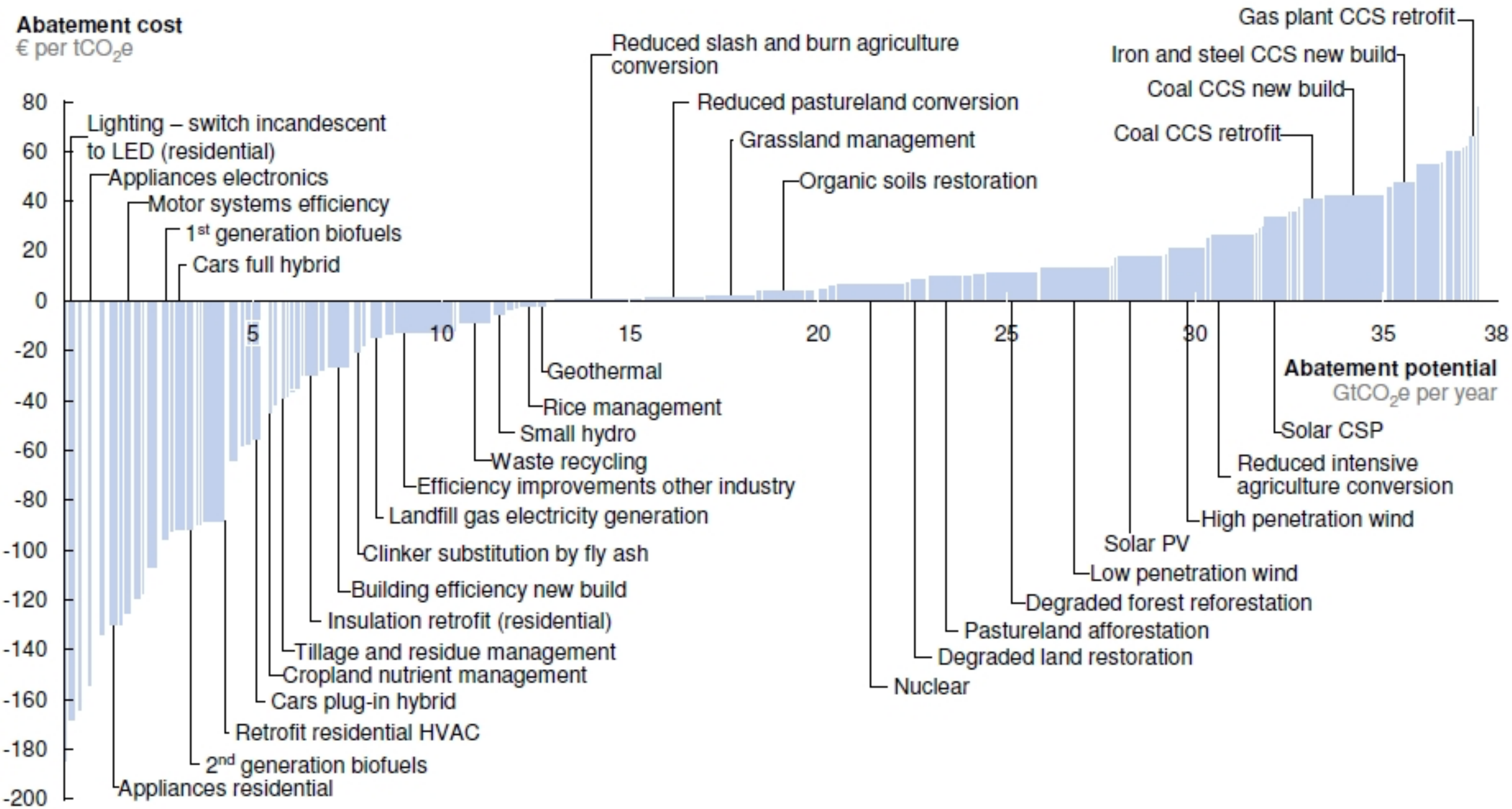
1- ratification of the **Doha amendment to the Kyoto Protocol**, which concerns commitments under the second period, running from 2013-2020

2- **Paris Agreement** - new global climate change agreement covering all UNFCCC countries, its ratification, implementation and enter into force in 2020.

The agreement presents a balanced outcome with an action plan to limit global warming 'well below' 2°C.

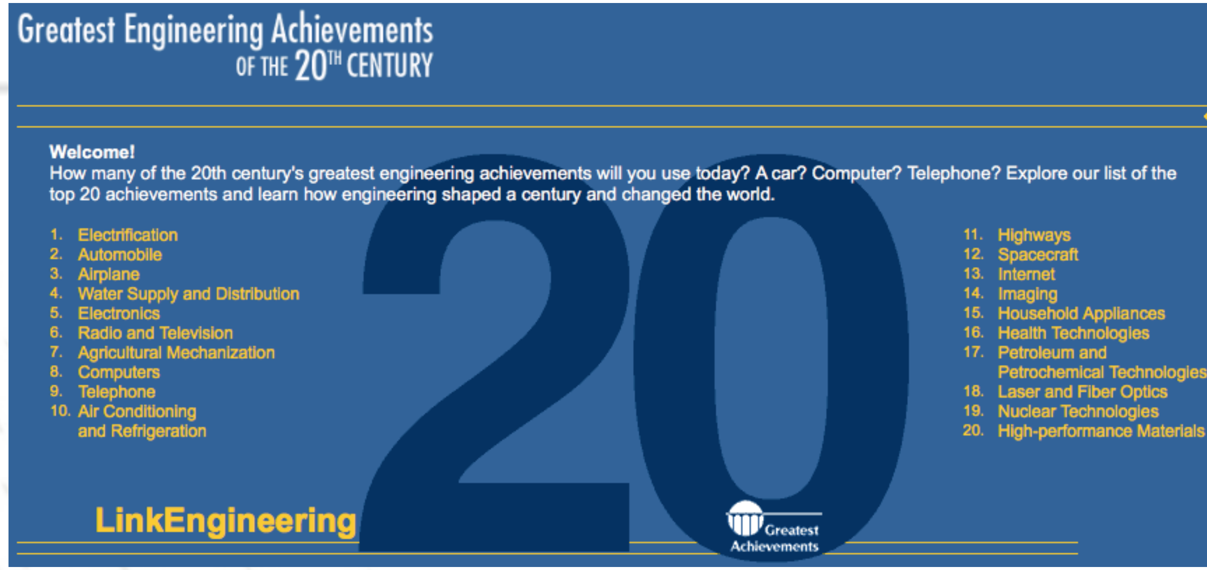
[Paris Agreement - Status of Ratification]

V2.1 Global GHG abatement cost curve beyond BAU – 2030



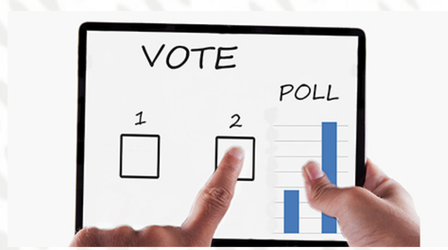
Network

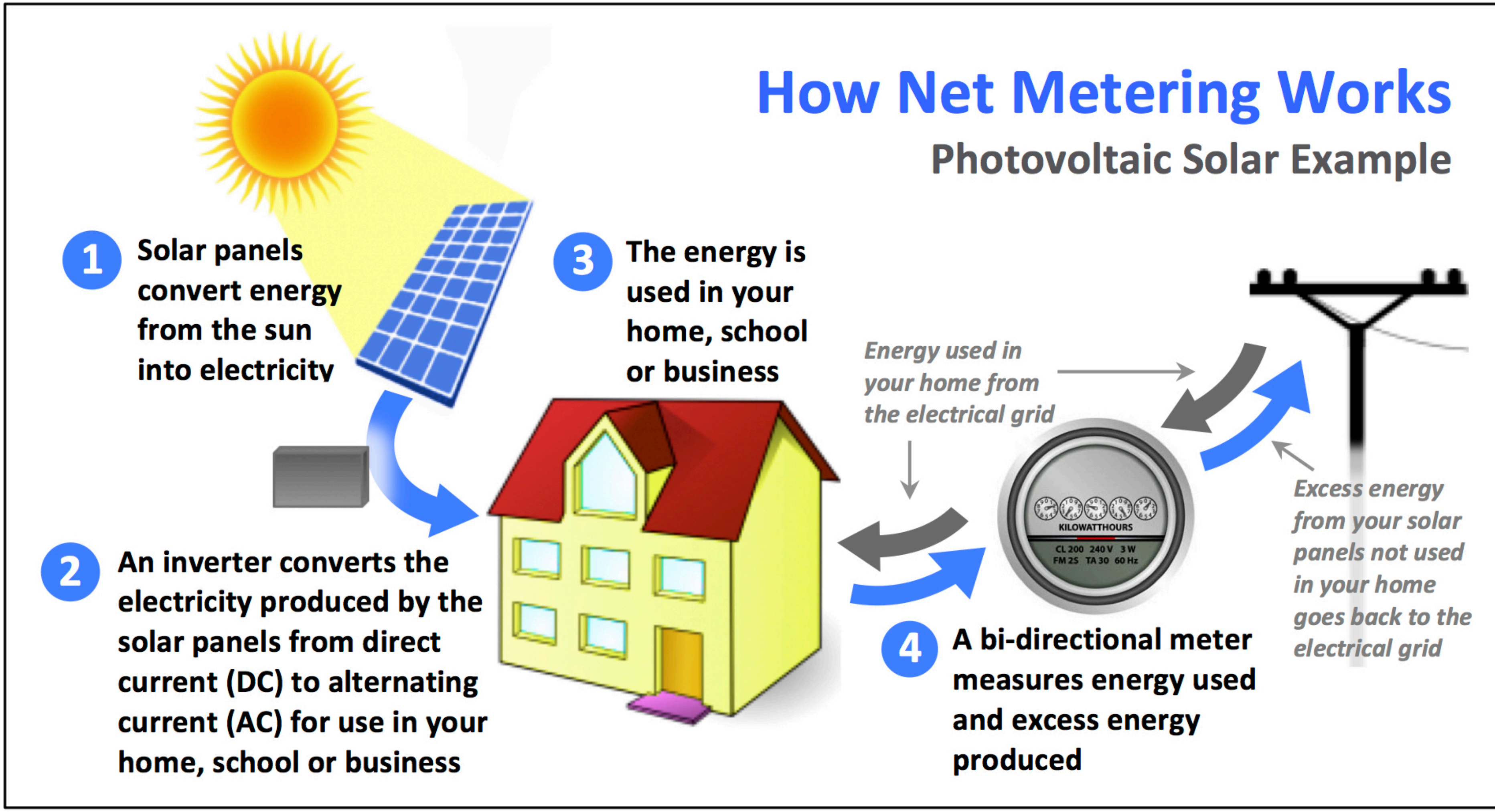
Power generations should be located where they're used allowing for independence from the grid. This protects power supply during natural disaster and blackouts.



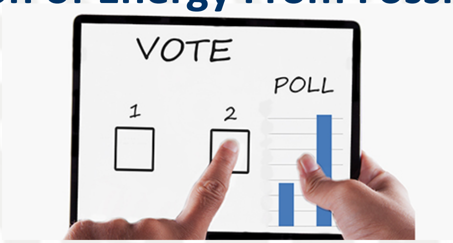
www.greatachievements.org

Electric Grid Efficiency



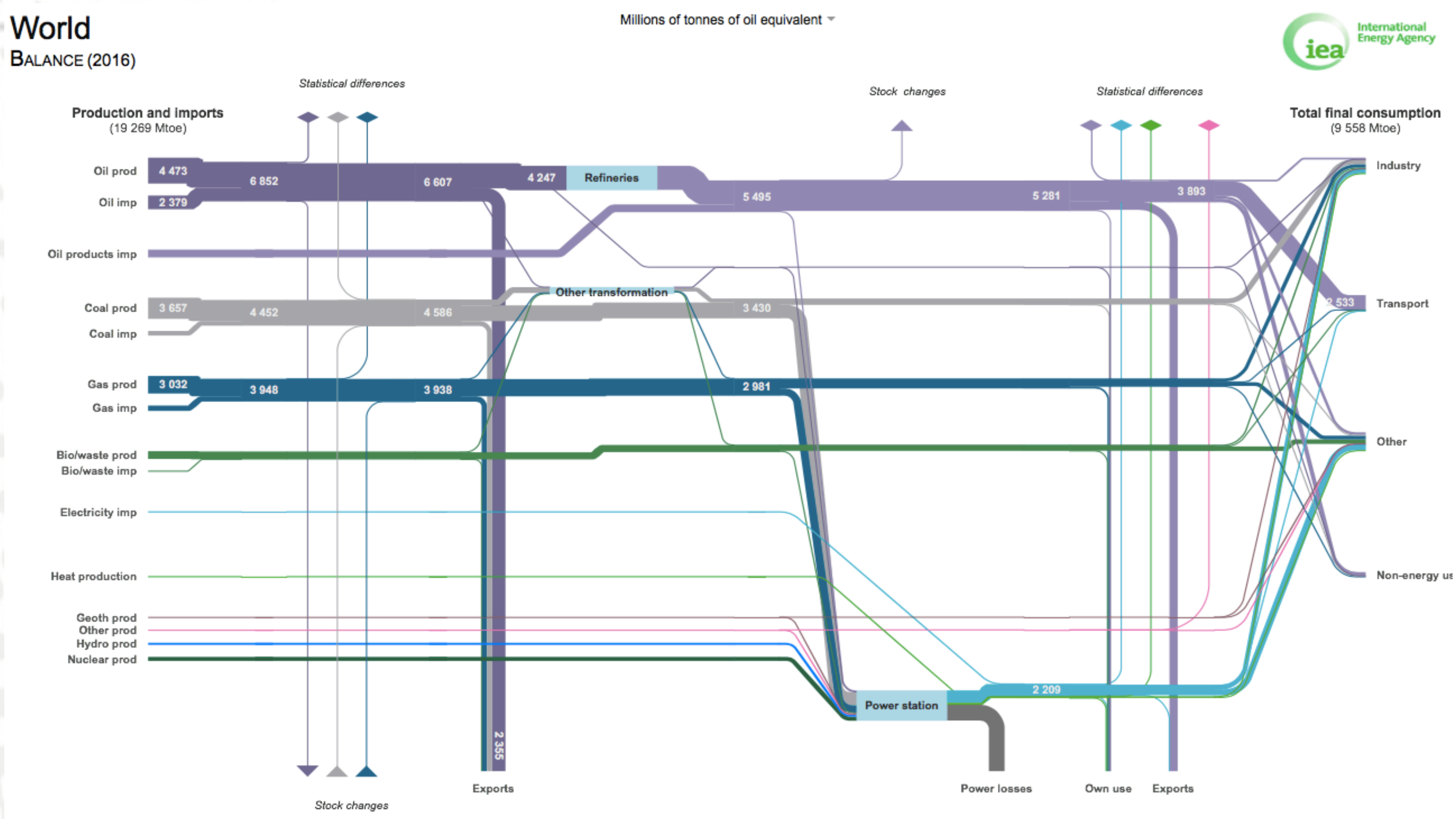


Fraction of Energy From Fossil Fuels



Share of renewables are increasing rapidly. But still small share in the total consumption. The intermittency of the solar and wind energy matters.

Sankey Diagram



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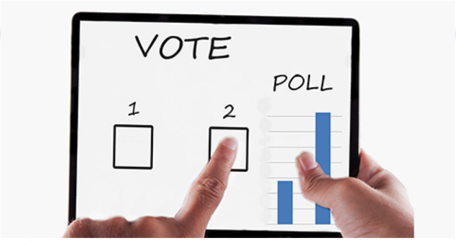
Coal Power Efficiency

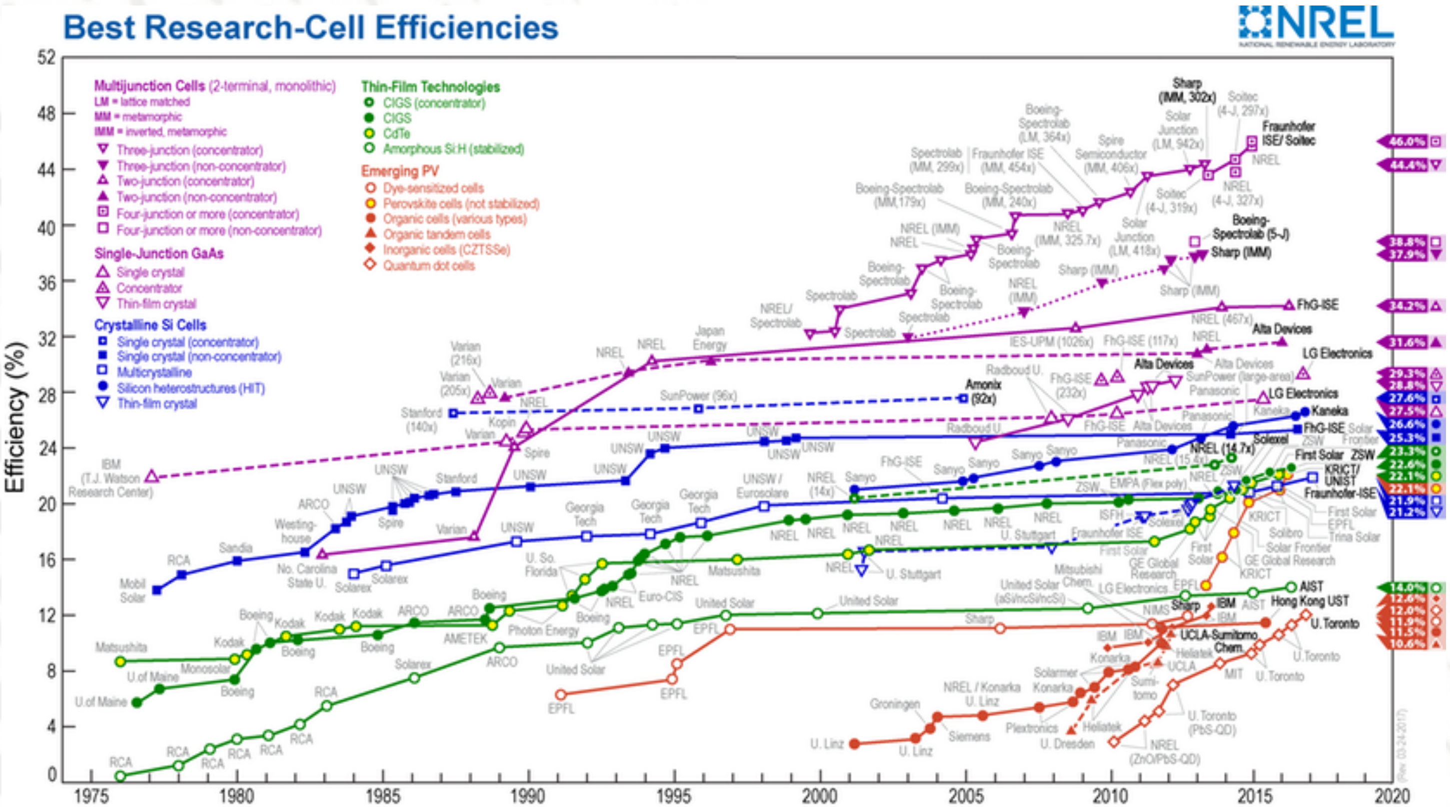


Cogeneration

With conventional power generation exhaust heat is lost to the atmosphere and this thermal energy is wasted. With combined heat and power (cogeneration) both electricity and heat are created from the same source and utilizes the energy from this exhaust heat.

Solar Cell Efficiency

Commercial PV modules have efficiencies of about 20% but there are much more efficient solar cells out there. Concentrating solar power has the advantage that when you produce very high-grade heat, it's relatively easy to store energy, and that allows you to solve some of the storage problem and generate power day and night. It also allows you to make industrial chemicals that you couldn't make directly from solar PV.



A chart of solar cell efficiency by technology highlights the gradual climb of diverse options, some of which may contribute to decreasing costs and terawatt scale expansion.

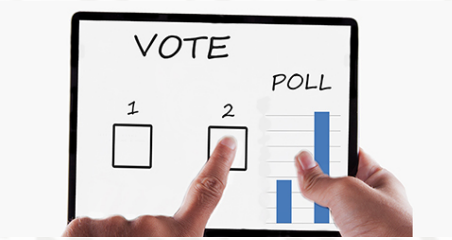
Rooftop vs Utility Solar

Some solar energy is shown flowing into the residential sector, representing rooftop PV, and some into electricity generation, representing utility-scale solar installations. How do these flows compare in magnitude?

Hint: Utility-scale solar is significantly cheaper than rooftop.

(David Keith, 2018)

Rooftop vs Utility Solar



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Smart Grid and Smart Metering

The system is already complicated and smart. The question is how we can add modern digital tools to make it a little bit smarter.

Smart meters: allow demand in homes or small businesses to respond to the real time minute-by-minute system price.

Real time monitoring of power quality abnormalities, network failures: less need for technicians. High power solid state electronics switches that would allow more fine–grained control of transmission and distribution infrastructure.

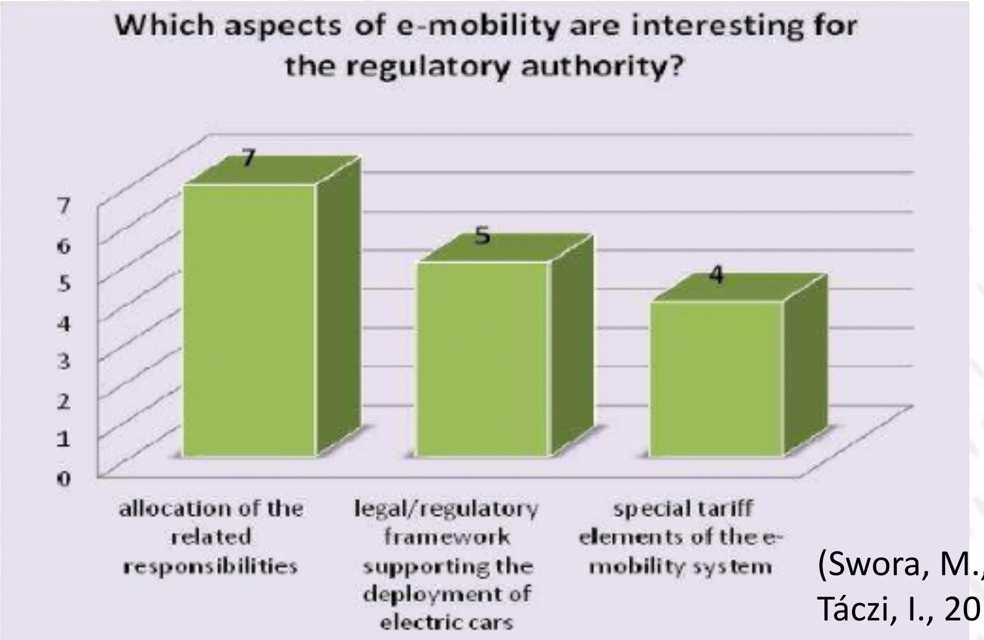
These applications increases efficiency while reducing the amount of so-called spinning reserve*.

(David Keith, 2018)

Spinning Reserve** *is the on-line* ***reserve *capacity that is synchronized to the grid system and ready to meet electric demand within 10 minutes of a dispatch instruction by the System Operator.* ***Spinning Reserve*** *is needed to maintain system frequency stability during emergency operating conditions and unforeseen load swings.*

Electric and Hybrid Vehicles

Electric vehicles use electric motors and batteries instead of internal combustion engines and fuel. Hybrid vehicles also use electric motors but rely on small internal combustion engines to provide electrical power. Therefore, the hybrid vehicle is still powered by gasoline or diesel fuel (or some alternative, such as natural gas, methanol or ethanol), but due to the system efficiencies of such an arrangement, relatively high fuel efficiency is achieved. The battery is recharged by the engine, so no external recharging is required.

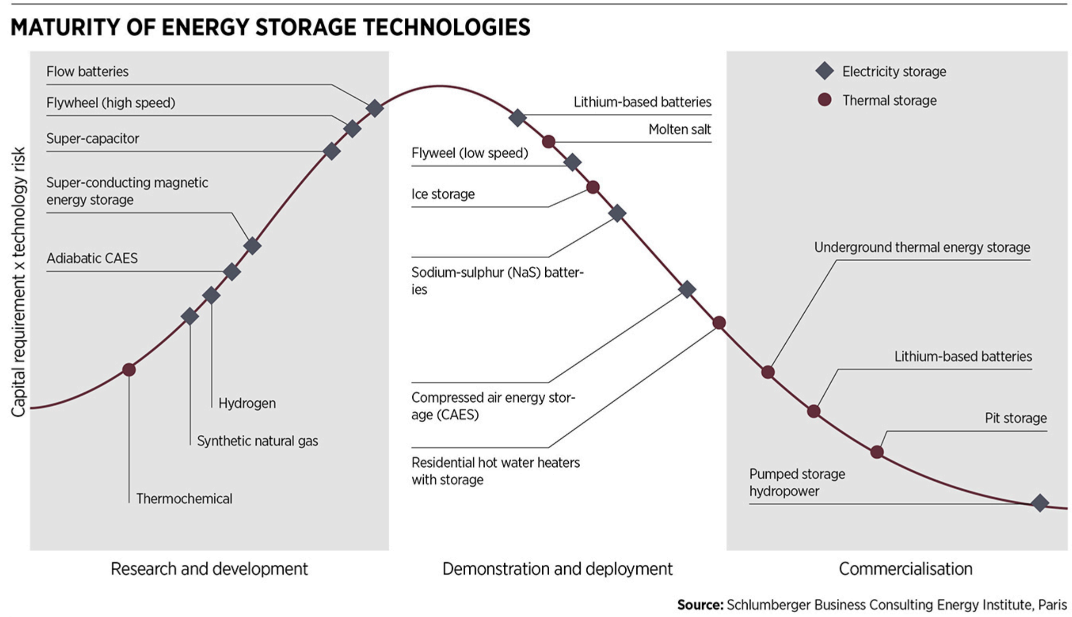


(Swora, M., Szörényi, G., Benysek, G., degli Esposti, C., Táczi, I., 2016)

Energy Storage

The greatest value for electricity systems is that they can enable better use of intermittent renewable-energy sources, such as solar energy and wind.
The major challenge for all storage technologies is cost reduction. Key R&D needs include developing new electrocatalysts, new electrode materials and new structural materials for electrochemical systems; magnetic bearings, better fail-safe designs and lightweight containment, and composite rotors with higher spesific-energy for flywheels; better corrosion-resistant materials for batteries with higher power density; commercial high-temperature superconductors (operating at liquid nitrogen temperatures) for superconducting magnetic energy systems; higher energy-density ultracapacitors for light-duty vehicles; and improved power conditioning systems. **(David Keith, 2018)**

Hydrogen
Hydrogen is a carbon-free energy carrier that has potential uses in many applications.



Energy Storage (Regulatory Treats)

- The current regulation in Germany and the UK enables participation of storage technologies in frequency reserve markets via combined offerings (“pooling”) with other providers.
- The use of storage technologies for Transmission & Distribution deferral is currently possible in Italy and the UK.
- The UK enables small generating facilities, including energy storage, to obtain exemption from the obligation to hold a generation license on a case-by-case basis, which enables TSOs and DSOs to deploy smaller-scale energy storage for T&D deferral.
- National legislation in Italy also allows TSOs and DSOs to build and operate storage if it is proven to be the most efficient way to address T&D problem.

(Swora, M., Szörényi, G., Benysek, G., degli Esposti, C., Táczi, I., 2016)

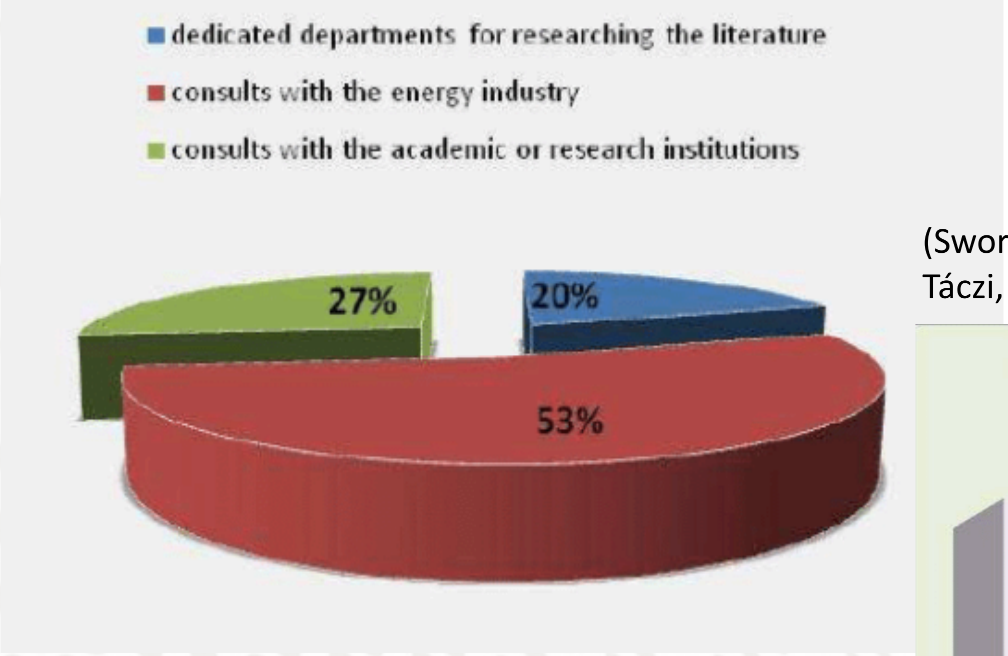
- Turkey is seeking a method to incentivise storage investments.

DISCUSSION

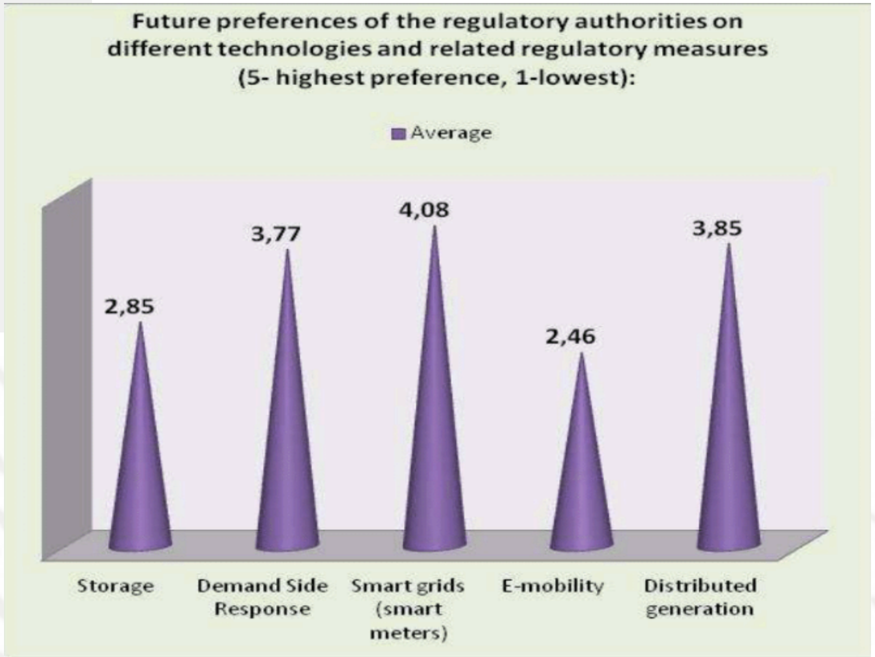
BLOCKCHAIN TECHNOLOGY

Regulatory Knowledge

How does your regulatory authority follow the energy industry trends regarding innovative technologies and operation methods?



(Swora, M., Szörényi, G., Benysek, G., degli Esposti, C., Táczi, I., 2016)



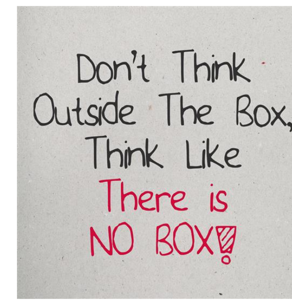
Innovation (Some Basics)

"The entrepreneur disturbs the equilibrium by coming up with innovations and implementing them." **(Scholtens, 2018)**

The Closed World Principle

"When solving a problem or creating a new solution, one should strive to use only those resources that exist in the product or system itself or in its immediate vicinity."

Example: The Flat Tire



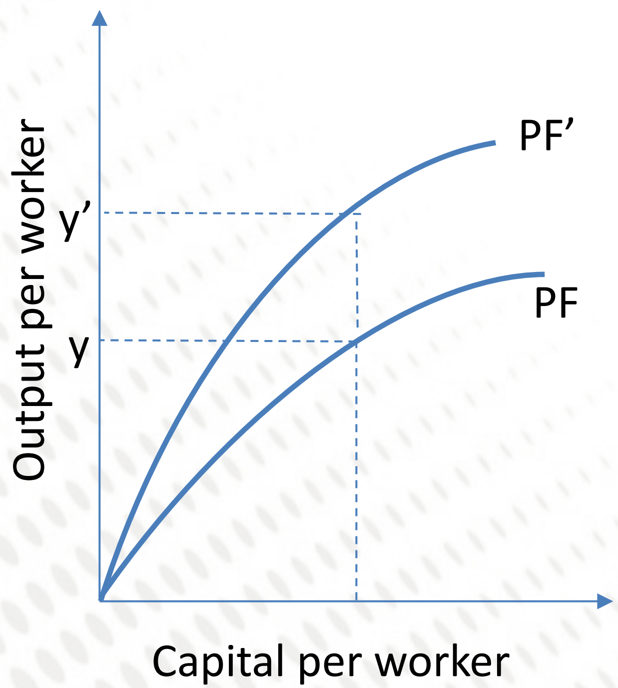
There are two types of inventions:
- cost-reducing processes and
- new products

Stages of a Technological Change (Viscusi-Harrington, 2005):

Basic Research → Applied Research (directed toward a particular product or process) → Invention → Development (commercial application of the invention, or innovation) → Diffusion of the product or process throughout the industry, or economy

Importance of Technological Change

According to Robert M. Solow, 80 percent of the increase in gross output per worker-hour from 1909 to 1949 in the US could be attributed to technological change.



Market Barriers (IEA, 2000a)

The most important market barrier for many technologies is that they ………………………………………

- Individuals and businesses do not always have full information about technologies or the ability to survey and calculate the cost of all opportunities.
- Transaction costs exit, such as that of gathering information or training workers in new maintenance techniques.
- Real and perceived risks associated with new technologies can make potential users wary of investing.
- There can be difficulties in obtaining financing
- Infrastructure investments may be needed that are beyond the capacity of any one market actor.
- Technology may be efficient but now well adopted to users' non-energy needs and tastes.
- There may be environmental barriers to using some technologies even though they may be attractive in terms of their overall environmental impact – for example, the noise and visual effects of wind generators.
- Regulations unrelated to energy may require time-consuming prosedures, evaluations and certification that can delay deployment.
- Slow rates of capital stock turnover and expension constrain the rate at which new technologies can enter the market.
- Signals about market interest in new technology may not reach developers and marketers.

Overcoming Technology Cost Barriers:
In some cases R&D will be undertaken by the private sector alone; in others it is of sufficient cost, duration or public interest that governments provide direct or indirect support or government-industry partnership is needed.

Overcoming Infrastructure Barriers:
Mass transit infrastructure, as an example: new gas pipelines, refuelling stations.
Governments can invest directly in new infrastructure or provide incentives (such as tax incentives, subsidies and expedited regulatory review) for the private sector to do so. To be effective, incentives must signal a long-term commitment to new ways of delivering energy services, to provide needed investor confidence.
Governments can also integrate energy-efficiency considerations into broader policies affecting the end-use sectors, with view to influencing new or replacement capital stock investments.

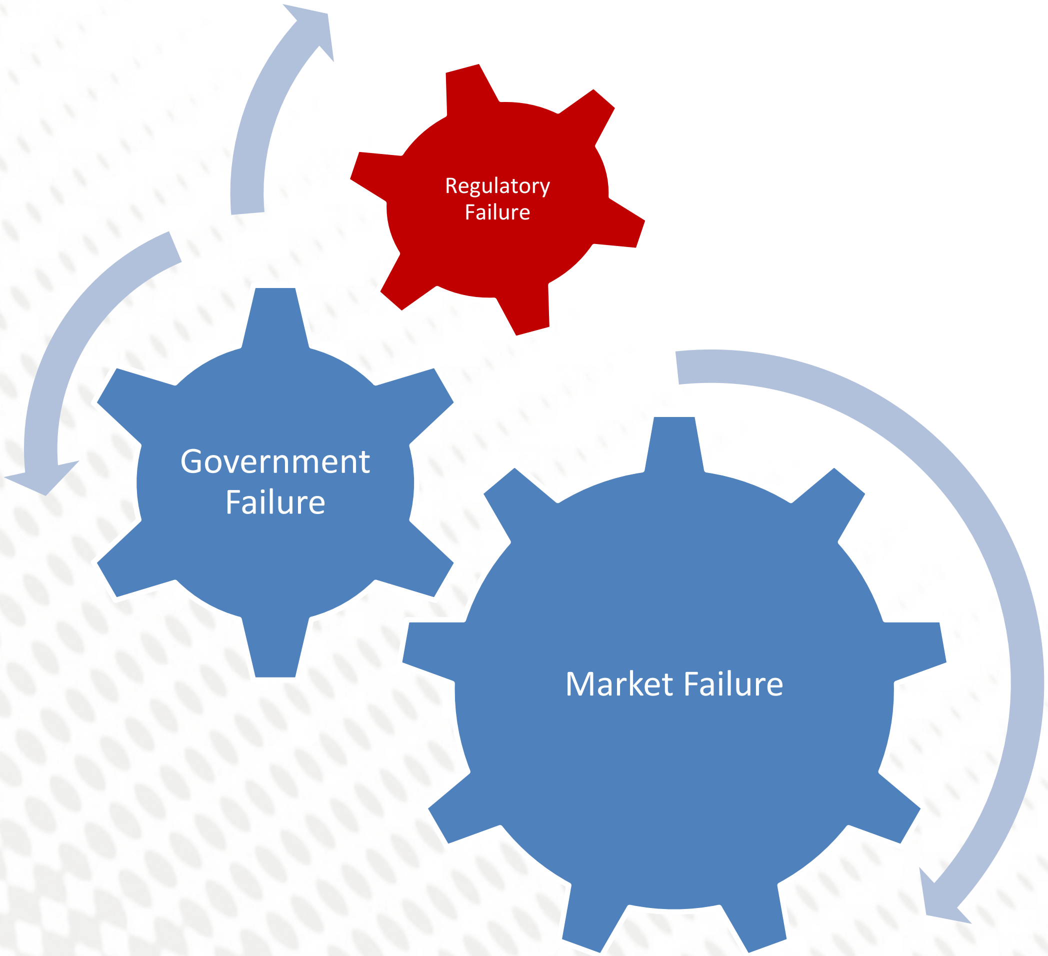
Overcoming Capital Stock Turnover Barriers:
Missed opportunities to put efficient and cleaner stock into place when old stock is refurbished or replaced.

Overcoming Barriers Related to Market Organisations:
Subsidized energy prices makes energy cost smaller fraction of total household and business expenses for most individuals and companies.

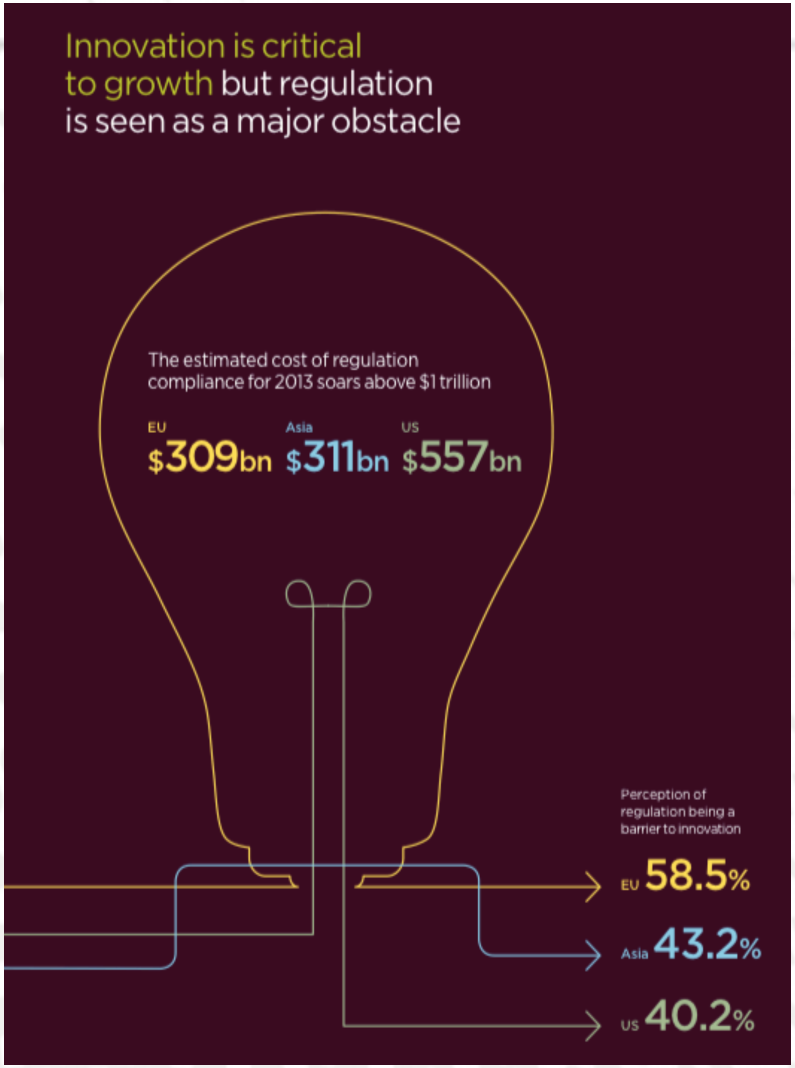
Overcoming Other Barriers in the End-Use Sectors:
Governments and the public sector have an important role to play in transforming barriers into opportunities. At a minimum, governments can make sure that policies for energy efficiency are consistent and stable over time, so as to send reliable, long-term signals to businesses and consumers and to allow them to plan accordingly.
Develop new mechanisms to support innovative efforts. As an example the procurement power of the public sector, because of its size and ability to set an example, can be a strong force for promoting good performance, motivating technology development and increasing demand. Increased demand will contribute to lowering costs through the process of technology learning.

(IEA, 2000a)

Market– Government - Agency

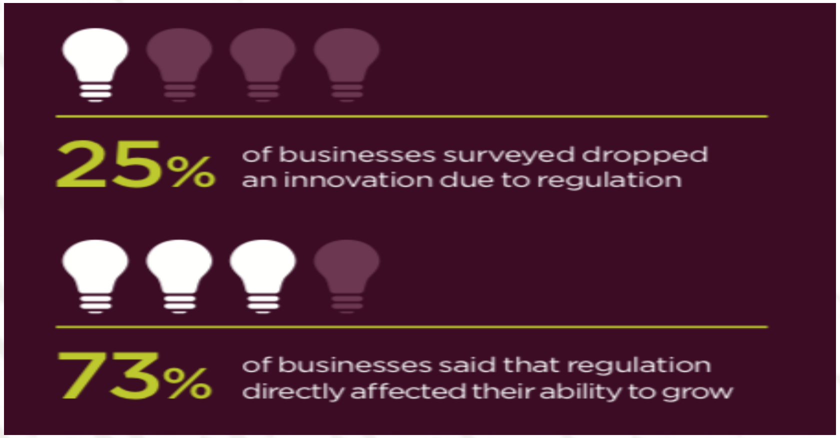


Regulation: A Barrier or a Guider



CEOs and executives of 250 companies worldwide believe that innovations are being put at risk;

- 97% of respondents agreed innovation is a key driver for growth
- Yet nearly a quarter of boards are insufficiently informed of regulations and legislation affecting their business
- 25% of respondents say they have dropped an innovation in the last five years as a result of regulation



(BLP, 2013)

“while no regulatory system is perfect, economies with well-designed regulations can perform far better than those with inadequate regulation”

(Stiglitz, 2009, p.11)

Factors Affecting Innovation

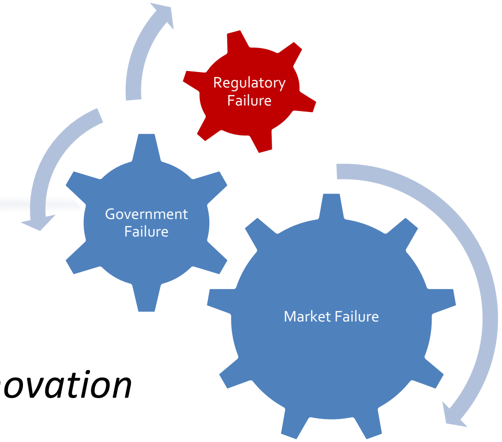
(BLP, 2013)

Innovation ecosystem is created by different institutional actors (universities, business, seed funds, venture capitals, government agencies (incl. funding ones) and policymakers). Regulators may play also important role in this institutional setup, considering their specific place hold somewhere between core government and market forces.
(Swora, M., Szörényi, G., Benysek, G., degli Esposti, C., Táczi, I., 2016)

Potential impacts of regulations on the speed of business

Positive impacts	Negative impacts
+ Protects intellectual property	- Administrative burden
+ Establishes standards	- Direct costs (time & money)
+ Reassures customers	- Slows down innovation
+ Forestalls litigation	- Creates uncertainty
	- Puts off (foreign) investment
	- Can hurt competition
	- Affects the ability to raise capital

Regulators’ Roles



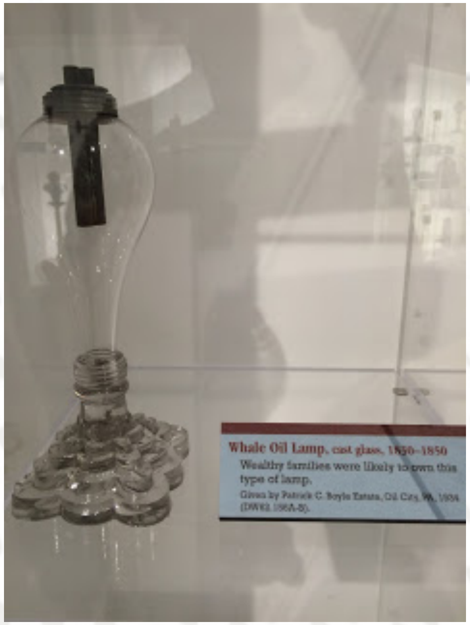
Energy regulators may use following measures to carry on pro-innovative policy:

- Initializing public consultations and debates;
- Gathering and sharing information amongst various stakeholders of energy innovation ecosystem;
- Building internal capacity in terms of professional staff and/or units dealing with energy innovations;
- Promotion of various types of innovations in the energy sector (incl. starting and participation in public debates);
- Using various forms of cooperation with other actors of innovative ecosystem and promotion of such a cooperation between regulated entities and other stakeholders;
- Financial incentives like extra rewards in tariffs or incentive schemes for innovators or specific funds (e.g. British Low Carbon Network Fund);
- Creation of friendly environment and adopting non-financial measures enabling the deployment of energy innovations.

Deployment of any measure mentioned above, should be preceded by gaining internal excellence in technical and economic aspects of energy innovations and accompanied by extended dialogue with other actors of innovation ecosystem (utilities, universities, NGOs, professional organizations, government agencies etc.).

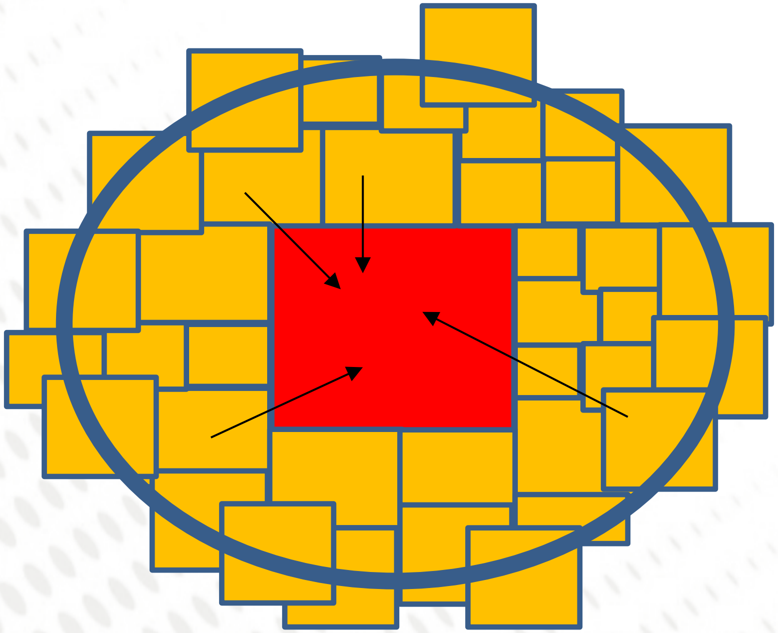
(Swora, M., Szörényi, G., Benysek, G., degli Esposti, C., Táczi, I., 2016)

DISCUSSION: MONOPOL POWER OR COMPETITION?
(WHICH ONE IS BETTER FOR PROMOTING TECHNICAL PROGRESS?)




GO TO JAIL
MARVIN GARDENS
WATER WORKS
VENTNOR AVENUE
ATLANTIC AVENUE
READING RAILROAD
B. & O. RAILROAD
INDIANA AVENUE
CHANCE
KENTUCKY AVENUE
FREE PARKING
ST. CHARLES PLACE
STATES AVE.
RENT $10.
With 1 House $ 50.
With 2 Houses 150.
With 3 Houses 450.
With 4 Houses 625.
With HOTEL $750.
Mortgage Value $70.
Houses cost $100. each
Hotels, $100. plus 4 houses
ST. JAMES PLACE
RENT $14.
MON
POLY
SHERMAN ANTI-TRUST ACT

Monopsony



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Competition and Regulation Consepts in Modern Economic Systems

State owned companies – Private companies

Classical Economics

Invisible hand, laissez faire...

Keynesian Economics

Government interventions, over-regulations...

Neoliberalism

Unbundling, privatization, liberalisation in the EU,

Deregulation in the USA...

?

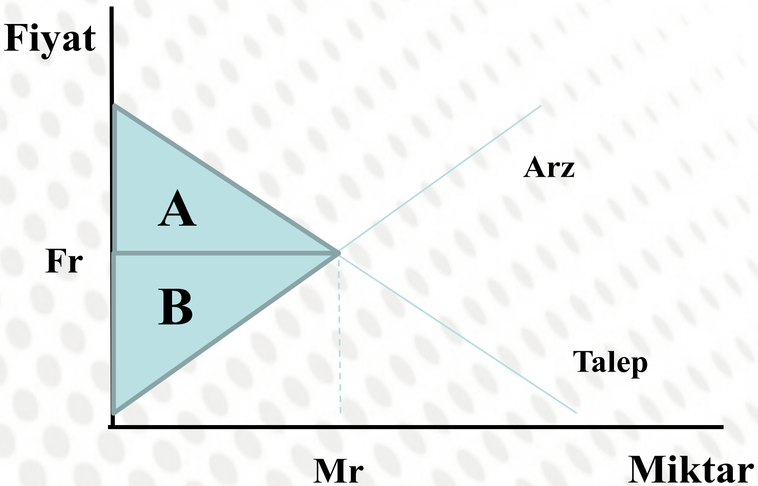
What About a Special Approach for the Energy Industry?

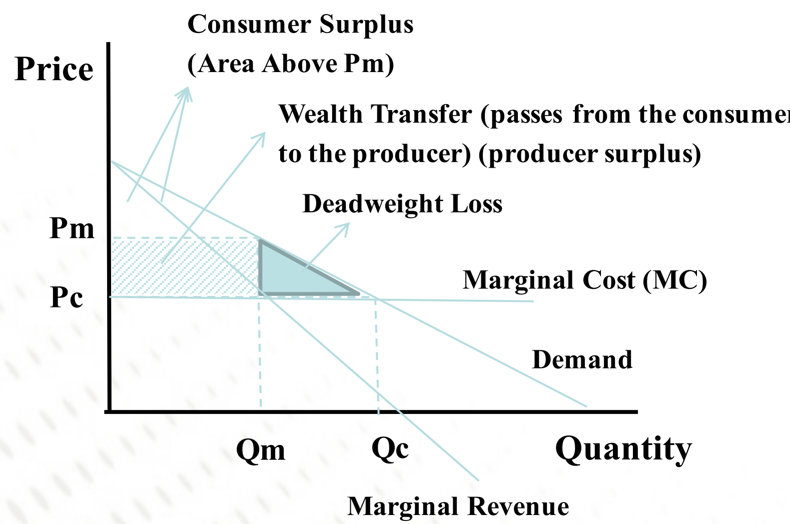
John Tirole (market power and regulation, sectoral differences)

Stiglitz (American style socialism)

- Socialism and Marxism
- Other Schools of Economic Thought

Competition vs Monopol





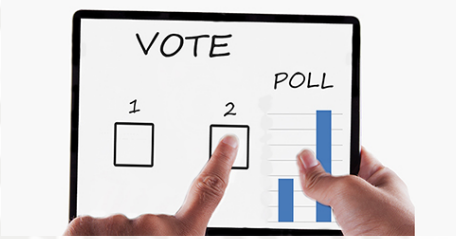
Social Surplus

DISCUSSIONS: MONOPOL POWER OR COMPETITION?
(WHICH ONE IS BETTER FOR PROMOTING TECHNICAL PROGRESS?)

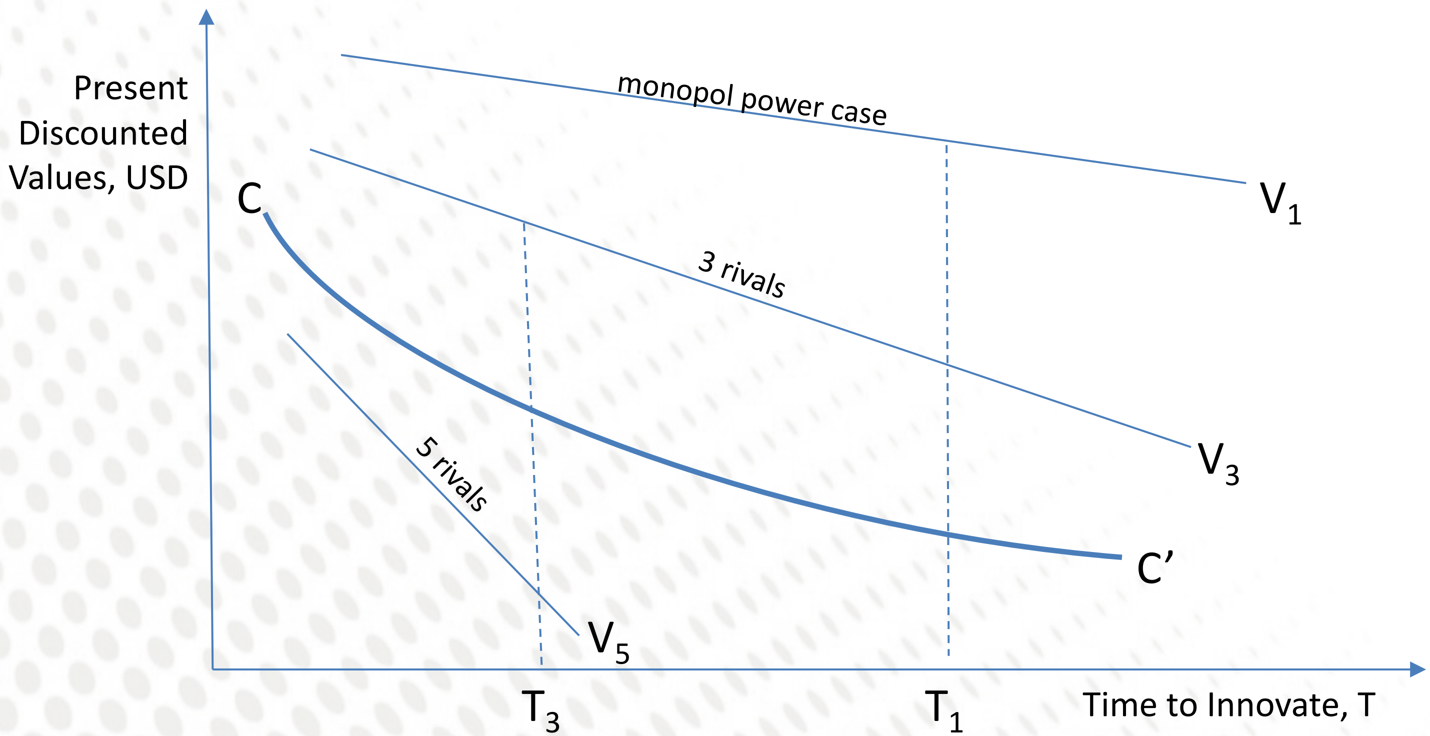
"Some quite persuasive economists have argued that some monopoly power is necessary to provide incentives for firm to undertake research and development programs. The rationale for existing patent policy rests to some extent on this argument.
Others, however, have taken the opposite position, namely, that it is competitive pressures that produce the higher rates of progressiveness." **(Viscusi-Harrington, 2005)**

"Schumpeter (1883-1950), sought to prove that innovation-originated market power could provide better results than the invisible hand. Technological innovation creates temporary monopolies, allowing abnormal profits. These profits may be competed away by rivals and imitators. Temporary monopolies provide the incentive necessary for firms to develop new product and processes. However, they also bear the risk of the advent of powerful lobbies that protect vested interests and hamper innovation and change and results in institutional rigidit. Schumpeter argues that the state should promote technologies and industries. But only while they are young and vulnerable. If protection becomes permanent, vested interests become too powerful and block progress." **(Scholtens, 2018)**

Monopol Power or Competition?



Best Time to Innovate
According to a Model Introduced by Viscusi-Harrington, 2005 (A Model of R&D Rivalry)



V represents the net revenues which is equal to revenues from sales of product minus the production and marketing costs incurred.

It is assumed that firms choose the time to innovation, T in order to maximize the present discounted value of their profits.

C-C' line:

There is a cost-time trade-off. Clearly, it costs more to shorten the time of innovation. There are several reasons:

- First, costly errors can be made when development steps are taken concurrently instead of waiting for the information early experiments supply.
- Parallel experimental approaches may be necessary to hedge against uncertainty.
- There are diminishing returns in the application of additional scientific and engineering manpower to a given technical project.

DISCUSSION: MONOPOL POWER OR COMPETITION?
(WHICH ONE IS BETTER FOR PROMOTING TECHNICAL PROGRESS?)

According to Viscusi-Harrington (2005);
"neither pole of perfect competition nor pure monopoly seems to be ideal. <u>No simple relationship between the number of rivals and the rates of innovation exits</u> – a larger number of rivals does not always produce better results for society."

According to Scherer and Ross (1990);
" - <u>more rivals tend to stimulate more rapid innovation</u> in order to be first with a new product and benefit from the disproportionate rewards of being first
- <u>more rivals split the potential benefits into more parts</u>, making each firm's share less."

"What is needed for rapid technical progress is a <u>subtle blend of competition and monopoly,</u> with more emphasis in general on the former than the latter, and with the <u>role of monopolistic elements diminishing when rich technological opportunities exit.</u>"

Choosing the optimal market structure to optimize the trade-off between static allocative efficiency and progressiveness is a difficult task!!!

Regulators should focus MORE on;

- **Shortening the duration of innovation** while regulating the natural monopol market/activity/segment.

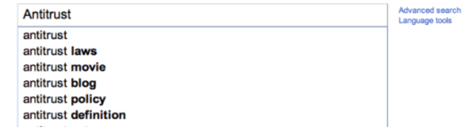
- **Companies' return (incentive)** while regulating the competitive market/activity/segment.

DISCUSSION

PUBLIC vs PRIVATE

DISCUSSION

Antitrust and Innovation (Google case)

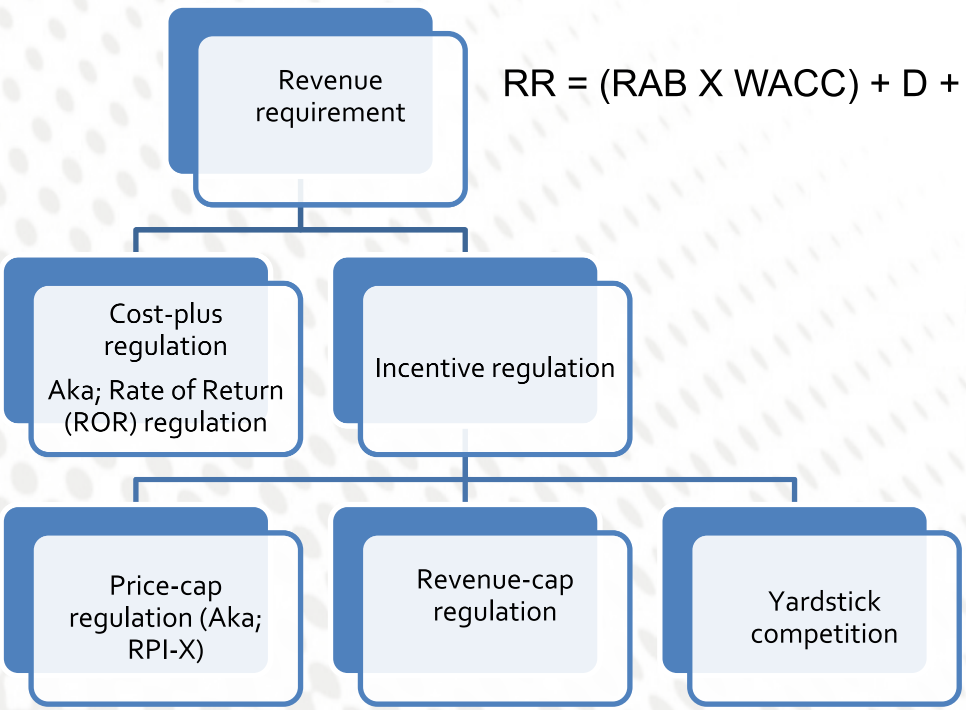


Commissioner Margrethe **Vestager,** in charge of competition policy, said: "*Google has come up with many innovative products and services that have made a difference to our lives. That's a good thing. But Google's strategy for its comparison shopping service wasn't just about attracting customers by making its product better than those of its rivals.*

Instead, Google abused its market dominance as a search engine by promoting its own comparison shopping service in its search results, and demoting those of competitors.
What Google has done is illegal under EU antitrust rules. It denied other companies the chance to compete on the merits and to innovate. And most importantly, it denied European consumers a genuine choice of services and the full benefits of innovation."

Best Tool for the Regulated Activities: Tariff Setting

Tariff = Revenue Requirement / Consumption



$$RR = (RAB \times WACC) + D + OPEX$$

$$P_1 = P_0\,(1 + \text{inflation} - X)$$

*Alternatives of RAB Calculations

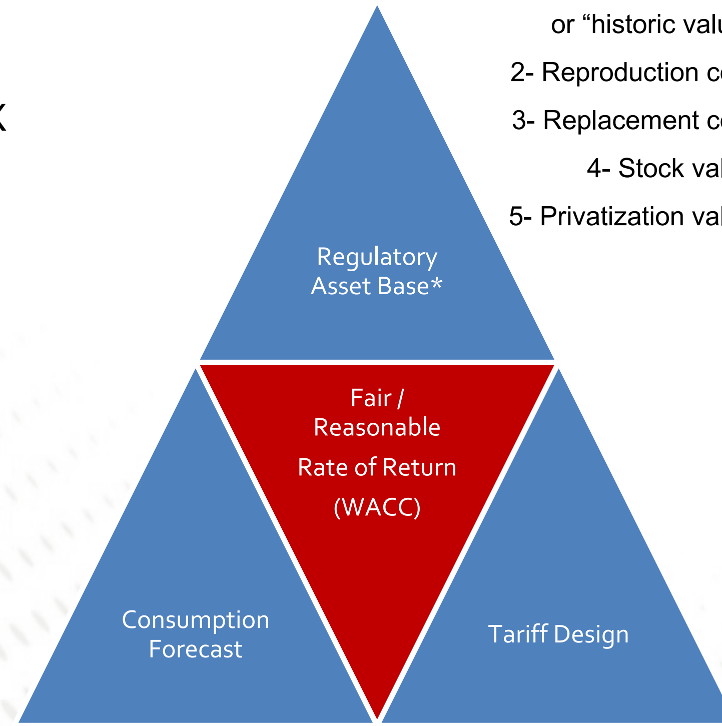
1- Original cost valuation", "historic cost" or "historic value"

2- Reproduction cost

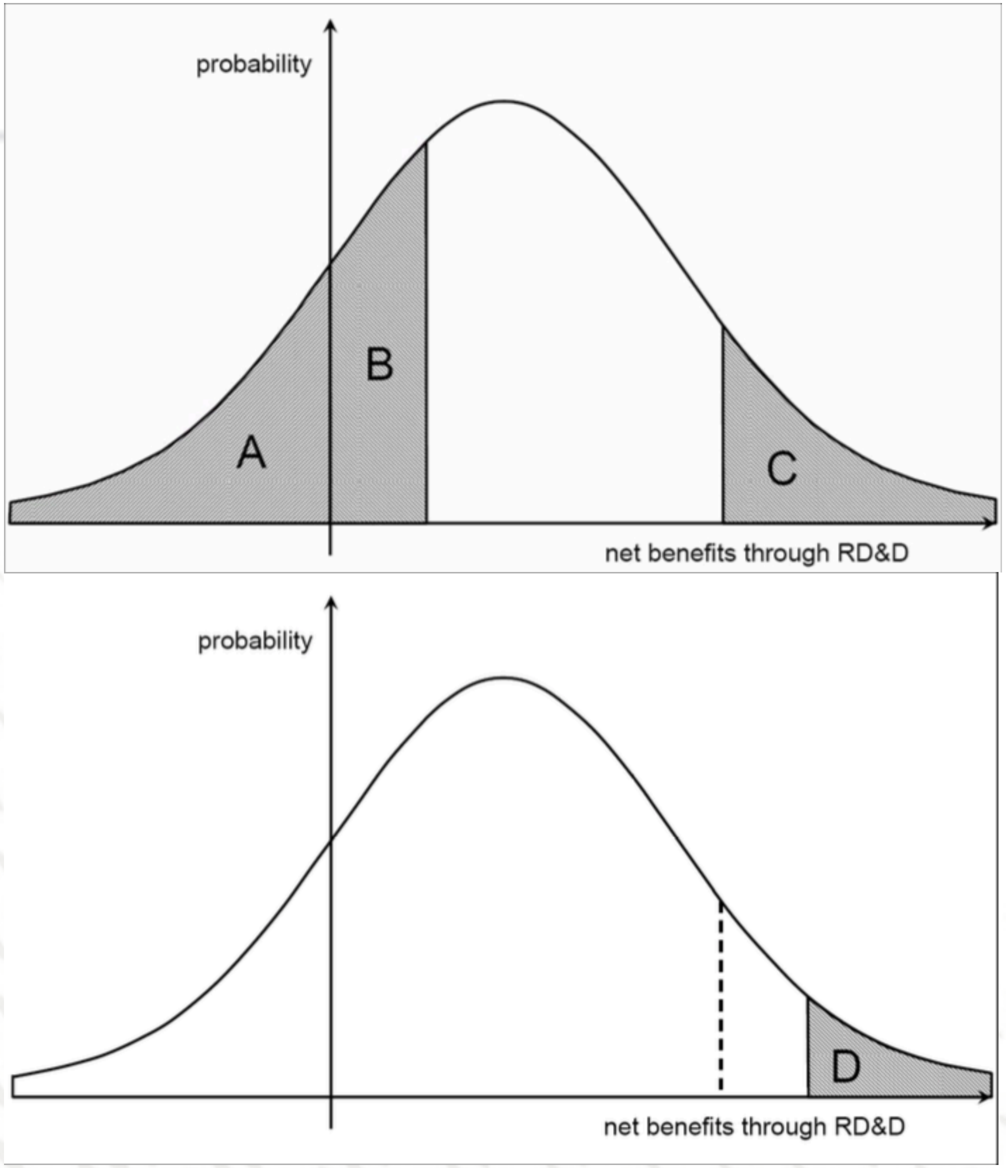
3- Replacement cost

4- Stock value

5- Privatization value



Truncation effects under
- cost-based regulation &
- price-based regulation



(Bauknecht, 2011)

Incentivizing Utilities

Different approaches to incentivizing utilities

- Input-based mechanisms – which target the costs of RD&D (Research, Development & Deployment) and explicitly include them in the regulatory scheme. Such a mechanisms may be well implemented in price-based regulatory environment and may take following forms:
= pass through RD&D to consumers,
= capitalization of such costs (i.e. such costs are treated as operational)

- Output-based mechanisms – under these approach companies may only benefit from successful innovations. Examples of output based mechanisms are:
= Additional allowances rising the cap imposed by regulator,
= Extending the regulatory period
= Regulatory holidays*

(Bauknecht, 2011; summary is derived from Swora, M., Szörényi, G., Benysek, G., degli Esposti, C., Táczi, I., 2016)

*Excluding regulated entities from some part of regulatory requirements for some time-period.

ENERGY REGULATORS REGIONAL ASSOCIATION

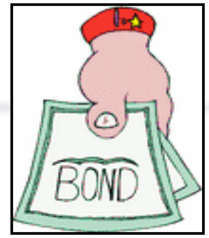
Where?

OPEX

+

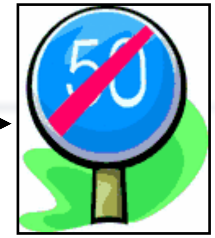
Depreciation

+



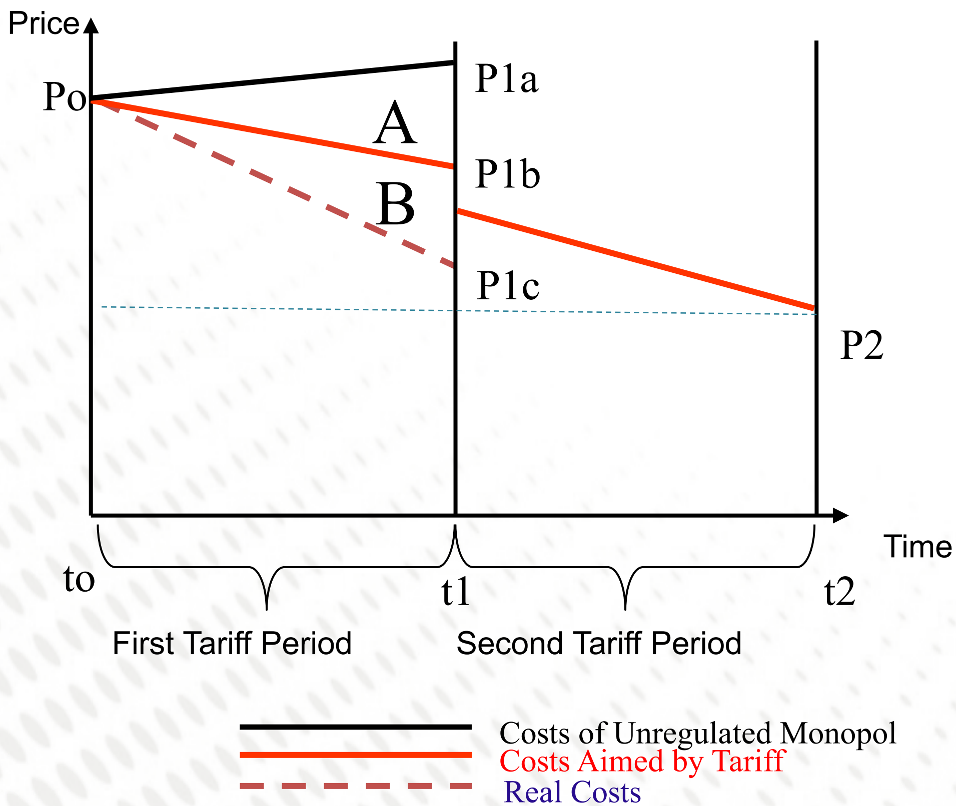
Return

→

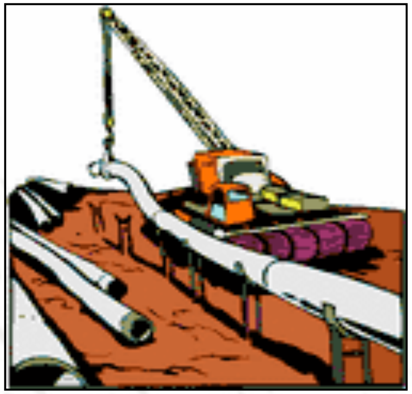


Revenue Requirement (RR)

Price Cap Regulation (Allocation Between Consumers and Producer)



Risk vs Return



"investment decision means;
to give up something - opportunity cost!!!"

risk / return relationship

Risicare vs Gain

You have 10 million Euro, and 12 alternatives… Which one is your choice?

1) put it under your pillow
   10 million Euro remains same…
2) lend your money to the government
   interest rate: 10%
3) lend your money to the bank
   interest rate: 12%
4) buy 10 houses
   rent fee: 3000 Euro/month/house
5) own a distribution company (gas or electricity)
   license fee: 5 million Euro, WACC: 12% (reel and before tax), price cap method
6) operate a pump station
   initial investment: 8 million Euro, margin of the last year: from +4% to +10%
7) invest in stock exchange
   last year's gain: 15%, the year before it was -10%
8) operate a wholesale company (electricity or natural gas)
   license fee: 0.5 million Euro, margin of the last year: from -5% to +25%
9) construct a hotel
   if it goes well IRR is 35%, if not it is 5%
10) drill a production well (oil or gas)
   drilling cost: 3 million Euro, success ratio:1/2, expected production if succeed: 20 bbls/day
11) drill an exploration well (oil or gas)
   license fee: 1 million Euro, drilling cost: 4 million Euro, success ratio:1/6, e.p.: 100 bbls/day
12) gamble or invest on Bitcoin ☺
   one shot - 50% bankruptcy, 50% 20 million Euro

Increasing risk

Increasing gain?

1

ENERGY REGULATORS REGIONAL ASSOCIATION

Efficiency

- Productive Efficiency
- Allocative Efficiency
- Dynamic Efficiency

(Sullivan et all, 2014)

Pareto Efficiency:*"no one can be made better off without making another worse off"*

(Stiglitz)

*"Energy efficient innovations induce an increase in energy consumption that partly offsets the energy savings, there is a so-called **rebound effect.**"*

(Scholtens, 2018)

Jevons Paradox (aka Jevons Effect)

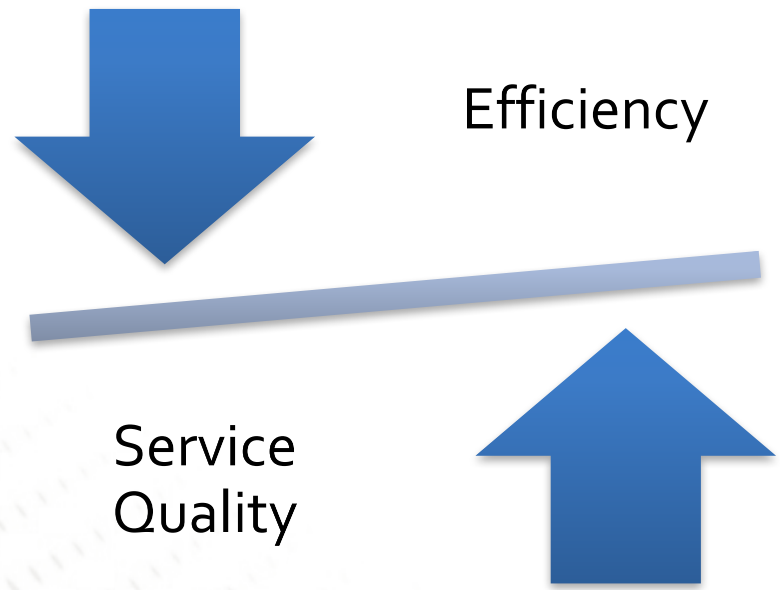
"Named after William Jevons, who observed in the 19th century that an incrrease in the efficiency of using coal to produce energy tended to increase consumption, rather than reduce it. Why? Because, Jevons argued, the cheaper price of coal–produced energy encouraged people to find innovative new ways to consume energy."

(McDonald, 2011)

What About Service Quality?

Alternative-1:
Your electricity bill will be 100 USD/month
in a good service quality

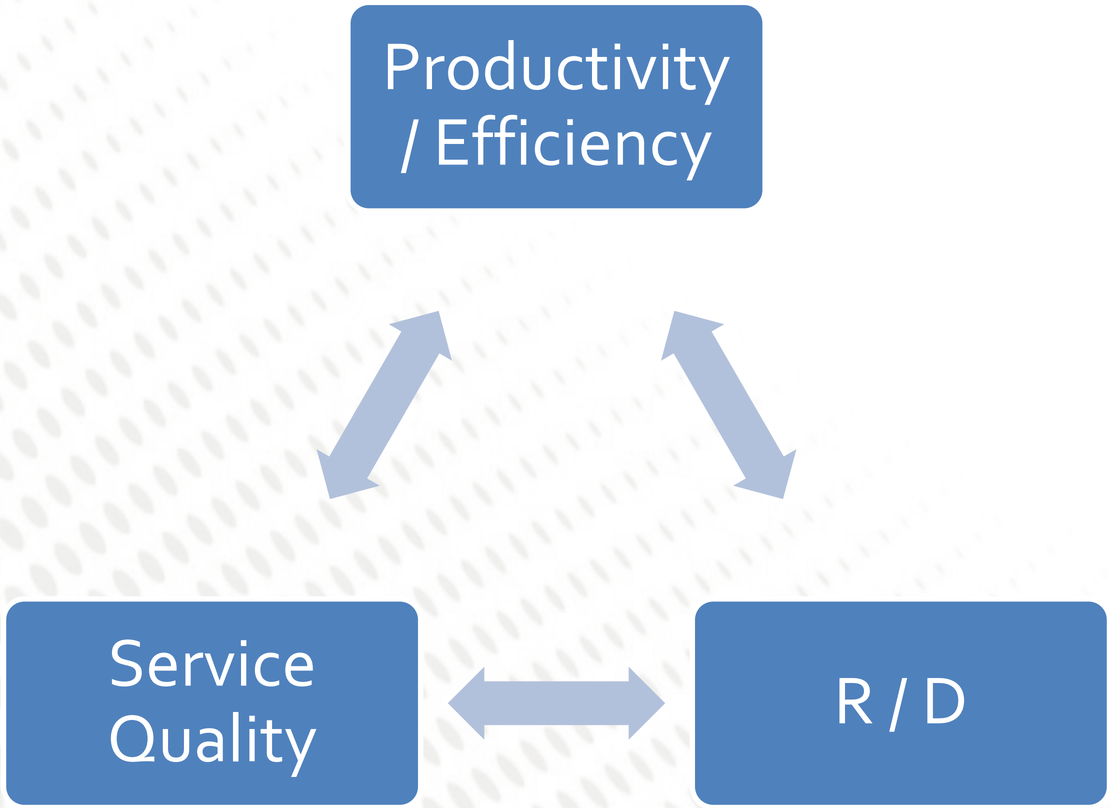
Alternative-2:
Your electricity bill will be 50 USD/month
5 hours/week power cut,
2 hours waiting in the line in order to pay the bill



Efficient Turkish natural gas distribution companies reduce—whereas inefficient ones increase—the service quality. These results reveal that a reward/penalty scheme is vital for an effective regulation.

(Yardımcı, O., Karan, M.B., 2015)

Improving the social welfare



R&D Expenditures (Turkish Natural Gas Distribution Segment)

R&D Expenditures (Total of Tendered Companies)

Yıllar	Staff Training + R&D Expenditures (TL)	(Staff Training + R&D Expenditures) / OPEX
2009	1.166.834	0,92%
2010	1.722.085	1,14%
2011	2.049.575	1,08%
2012	1.294.085	0,43%
2013	1.553.303	0,40%
2014	1.689.724	0,38%

R&D Expenditures (Total of Existing Companies)

Yıllar	Staff Training + R&D Expenditures (TL)	(Staff Training + R&D Expenditures) / OPEX
2009	1.074.948	0,36%
2010	1.160.141	0,36%
2011	1.323.059	0,36%
2012	1.206.324	0,28%
2013	1.728.822	0,34%
2014	1.902.365	0,35%

R&D Expenditures (Whole Sector)

Yıllar	Staff Training + R&D Expenditures (TL)	(Staff Training + R&D Expenditures) / OPEX
2009	2.241.782	0,53%
2010	2.882.226	0,61%
2011	3.372.634	0,61%
2012	2.500.408	0,34%
2013	3.282.125	0,37%
2014	3.592.089	0,37%

(Yardımcı, O., Karan, M.B., 2018)

Some aspects of long-term R&D are public good*.
(IEA, 2000a)

*Public Good: Individuals or businesses have access to a good without having to pay for it. Because suppliers of a public good cannot collect a price from all who consume it (free-riders problem), they tend to produce too little of it despite its value to society.

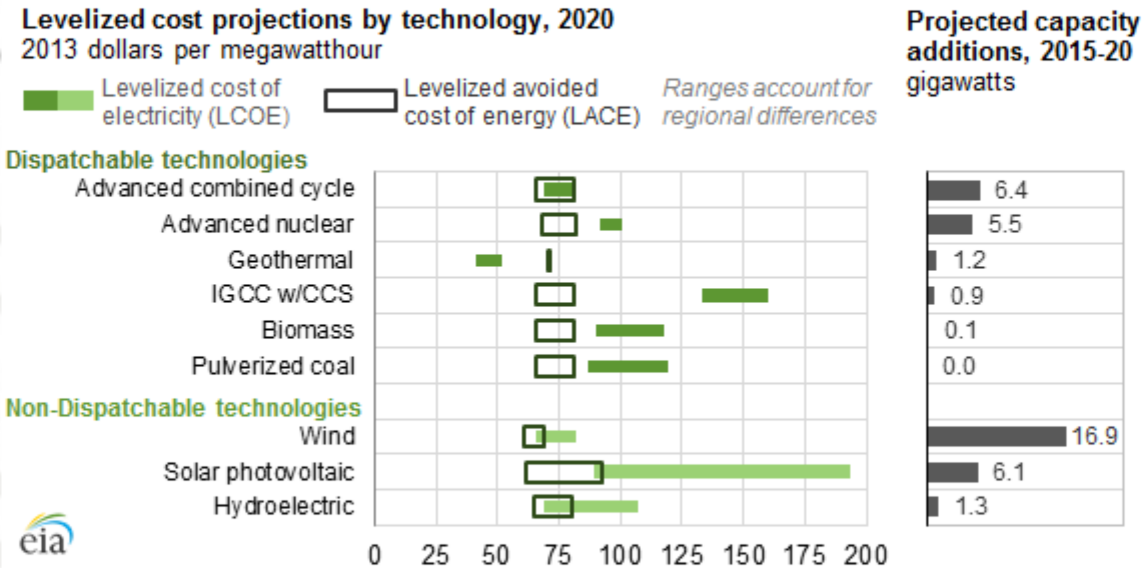
Best Practices

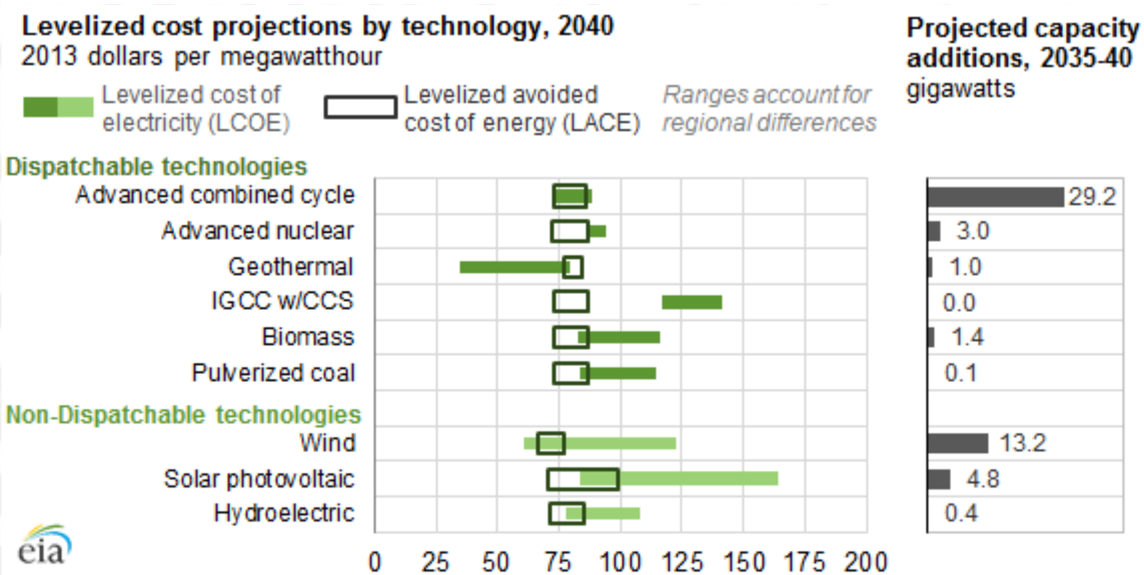
INCENTIVE BASED REGULATION IN GREAT BRITAIN – THE RIIO MODEL
https://www.ofgem.gov.uk/network-regulation-riio-model/current-network-price-controls-riio-1/network-innovation

DISCUSSION

SUPPORTING RENEWABLE ENERGY SOURCES (FEED-IN-TARIFF SYSTEM)

The levelized cost of electricity (LCOE)





The levelized cost of electricity (LCOE), also known as Levelized Energy Cost (LEC), is the net present value of the unit-cost of electricity over the lifetime of a generating asset. It is often taken as a proxy for the average price that the generating asset must receive in a market to break even over its lifetime.

Note: Costs reflect utility-scale systems and include federal tax incentives for renewables as applicable in 2020 under current law. IGCC is integrated gasification combined cycle; CCS is carbon capture and sequestration. Capacity additions reflect electric power sector additions only, and include planned capacity already under construction as well as projected model builds.

(EIA, 2015)

LCOE (cont.)

The levelized cost of electricity (LCOE) is given by:

$$\mathrm{LCOE} = \frac{\text{sum of costs over lifetime}}{\text{sum of electrical energy produced over lifetime}} = \frac{\sum_{t=1}^{n} \frac{I_t + M_t + F_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}}$$

I_t	:	investment expenditures in the year t
M_t	:	operations and maintenance expenditures in the year t
F_t	:	fuel expenditures in the year t
E_t	:	electrical energy generated in the year t
r	:	discount rate
n	:	expected lifetime of system or power station

Levelized Cost of Energy Calculator
(U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy):
https://www.nrel.gov/analysis/tech-lcoe.html

Experience Curve

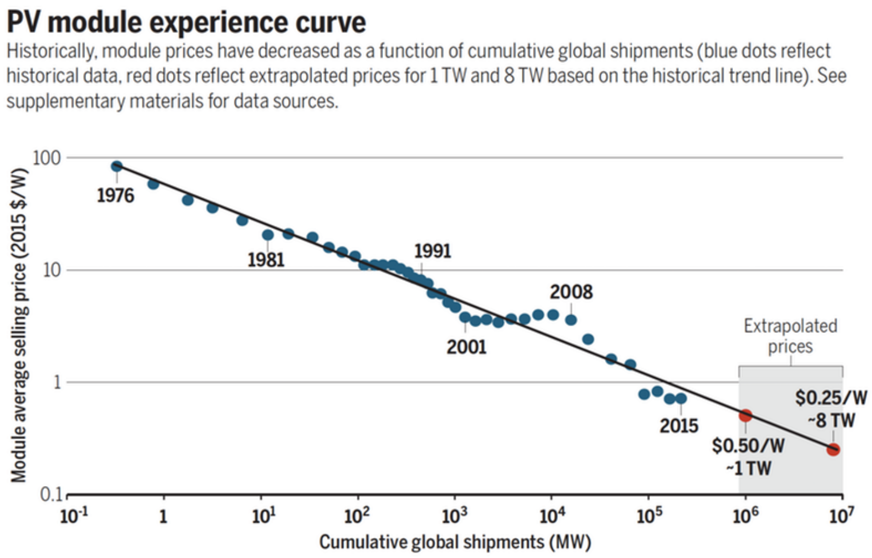
Price is the most important measure of performance for new technologies.
Energy policy-maker can exploit the **experience-curve** phenomenon to set targets and to design measures to make new technologies commercial.

Governments support these technologies;
- Through funding of R&D
- Through price subsidies
- Other forms of deployment policy

Crucial question: how much support a technology needs to become competitive and how much of this support has to come from government budgets. Experience curves make it possible to answer such questions because they provide a simple, quantitative relationship between price and the cumulative production or use of a technology.

(IEA, 2000b)

Experience Curve (cont.)



Trend line is commonly referred as the experience curve.

Price at year t = P_o x X^{-E}

P_o = the price at one unit of cumulative production or sales or shipment

X = cumulative production or sales or shipment in year t

E = the (positive) experience parameter, which characterizes the inclination of the curve. Large values of E indicate a steep curve with a high learning rate.

Progress Ratio (PR) = $(P_o \times (2X)^{-E}) / (P_o \times X^{-E})$
$= 2^{-E}$

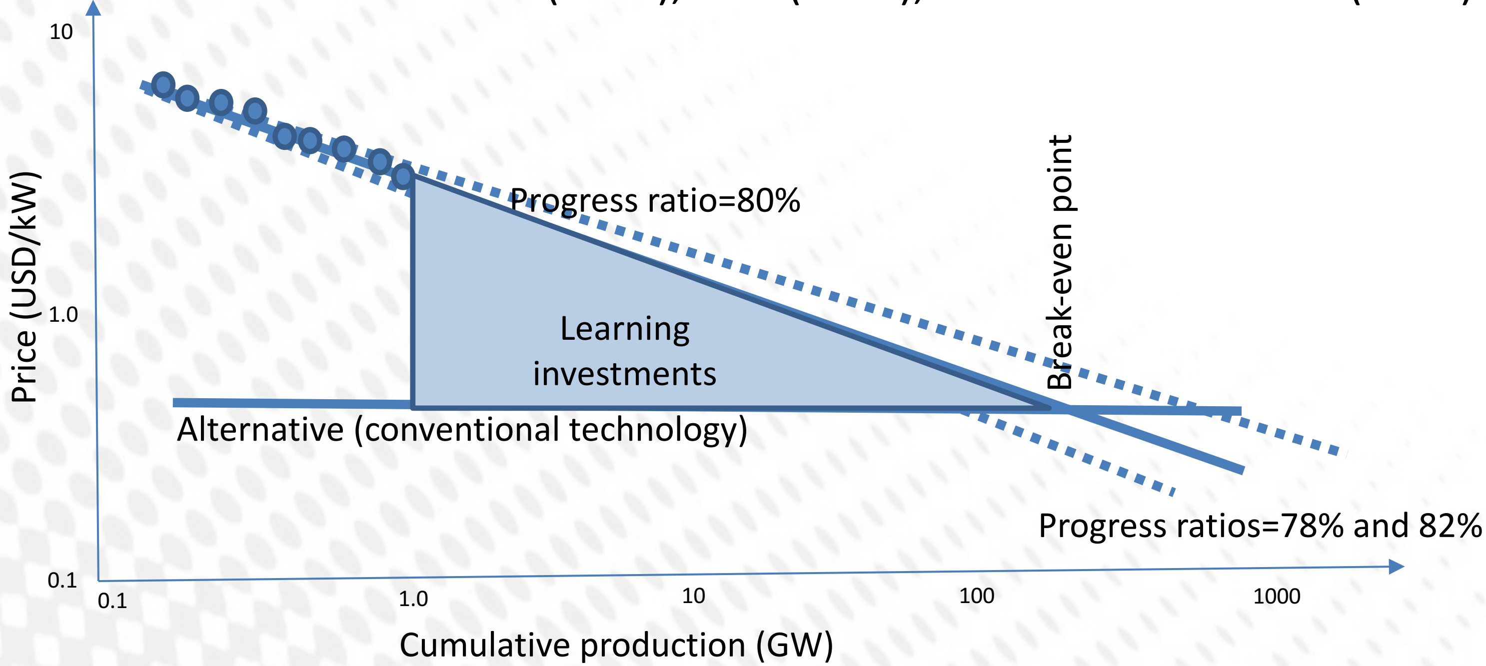
As an example: E=0.25; PR=$2^{-0.25}$ = 0.84
or 84%

Future Prospects

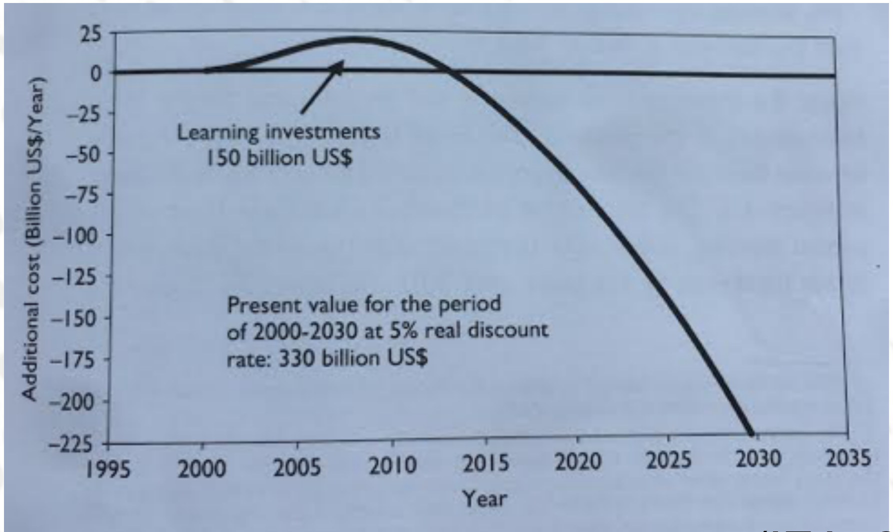
I have seen the future and it is very much like the present, only longer.

Kehlog Albran

The engineers and managers in the aeroplane industry were the first to define a quantitative expression for the observation that experience improves performance. Wright (1936) discussed the functional relationship between cost and quantity in his study named as factors affecting the cost of airplanes. Other studies: Arrow (1962), BCG (1968), Abell and Hammond (1979)



How should we provide learning investments:
- Through market mechanisms,
- Government expenditures for research, development and demonstration (RD&D),
- Subsidies / Incentives (feed in tariff), taxes (carbon taxes)



Additional cost for photovoltaics in the breakaway path from 2000 to 2030.

(IEA, 2000b)

Market conditions is working but what about externalities:

- Climate change
- We need local flexibility
- We should manage the risk of technology failure

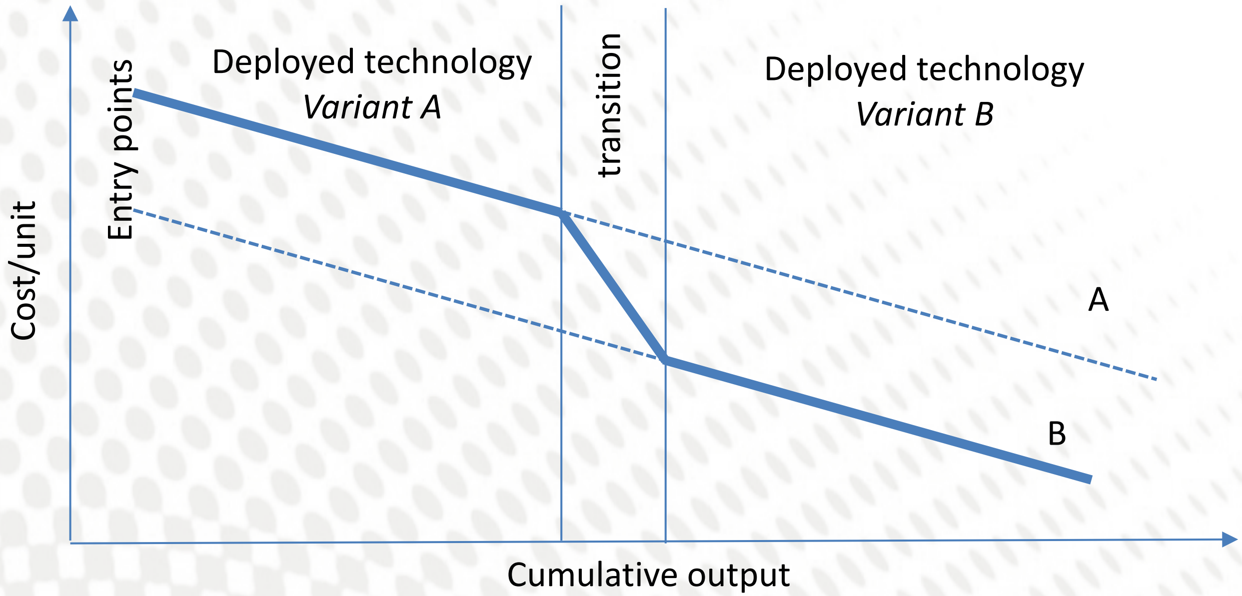
Technology portfolios

Inside the Learning System: Technology Structural Change

A radical change in the content of the development process, eg. a shift in the technology paradigm leading to a new variant of the technology or a major change in the way the technology is produced.

There may be some discontinuities in the experience curve.

Technology Structural Change



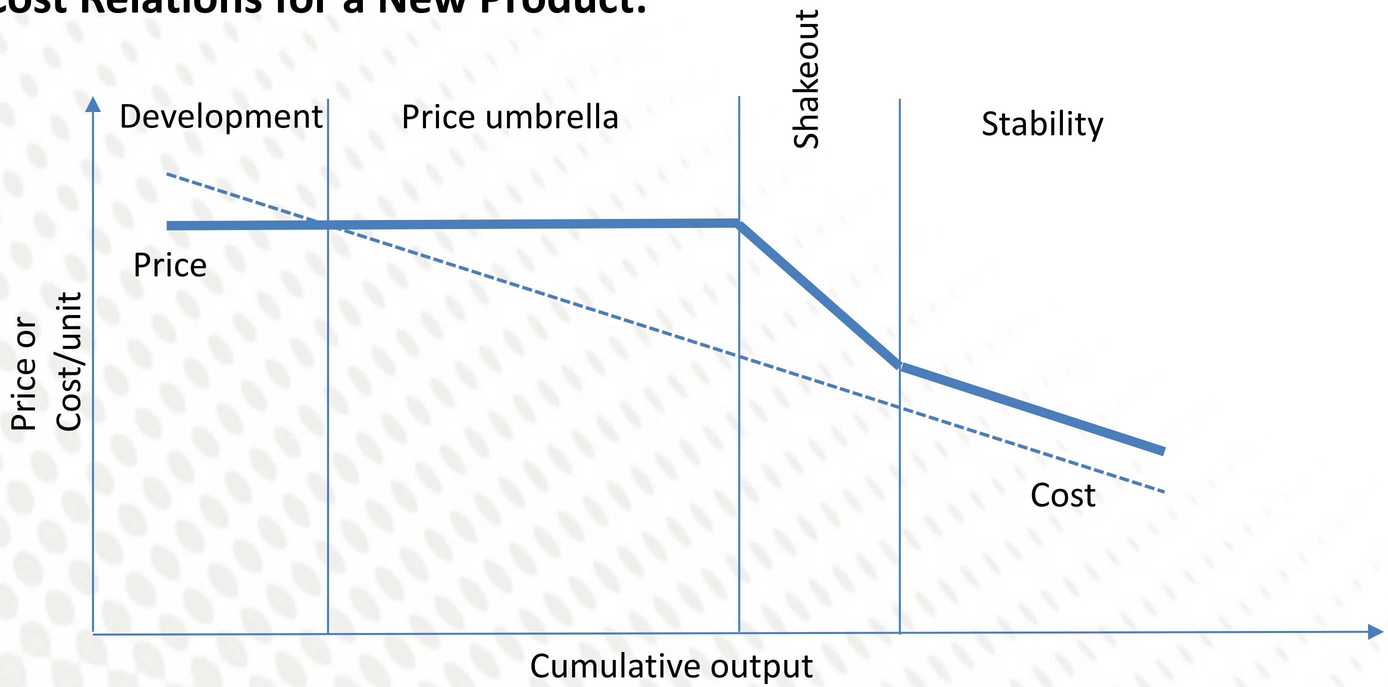
Investors realise the advantages of variant B. The two variants are assumed to be similar, so that during the transition period variant B can accumulate the experience learned from deploying variant A

(IEA, 2000b)

Oustside the Learning System: Market Structural Change

BCG (1968) has analysed the relationship between price and cost experience curves, and the following discussion draws on their conclusion.

Price-Cost Relations for a New Product:



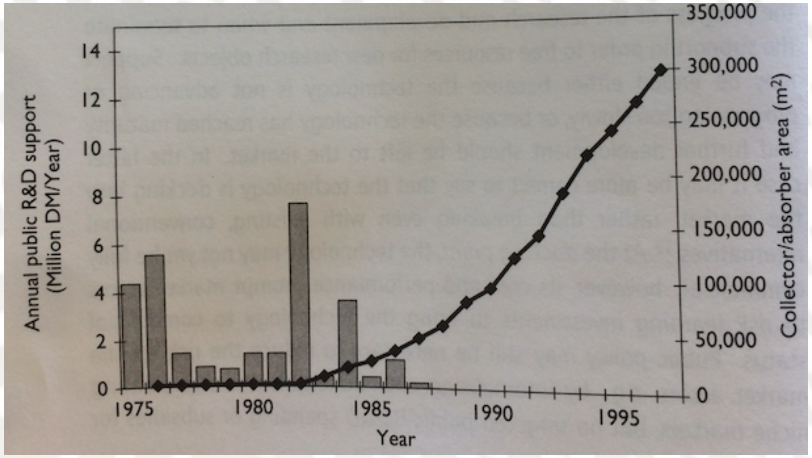
(IEA, 2000b)

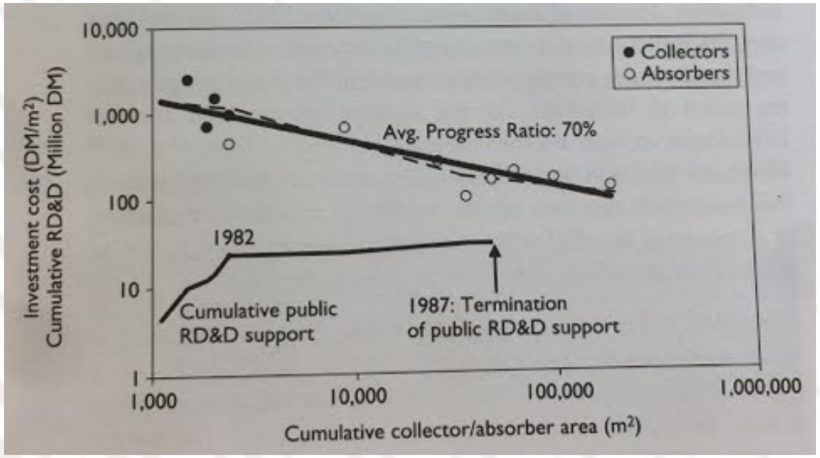
Incentivisation Stages

- Supporting RD&Ds for a technology
- Monitoring the progress of the research
- Terminating the support in order to free resources for new research objects and leading to a market condition

Support may be ended either because the technology is not advancing or progressing too slowly or because the technology has reached maturity and further development should be left to the market.
In the last alternative, the technology may not yet be fully commercial; however, its cost and performance prompt market actors to risk learning investments to bring the technology to commercial status.

Case Study: Solar Heating-Monitoring and Terminating an RD&D Program
Solar Heating Swimming Pools: Germany, 1975-1997





(IEA, 2000b)

Uncertainities

- Uncertainty about deployment and global learning: will the technology be deployed in the energy system? Will deployment also lead to efficient global learning?

- Uncertainty about ability to learn: What's the progress ratio for a new technology? Will the learning rate remain constant for technologies, which already have proven their ability to learn on the market but not yet reached break even?
  - Technological surprises
  - Physical limits to improvements for a part of system

(IEA, 2000b)

DISCUSSION

SUPPORTING LOCAL/DOMESTIC PRODUCTION (BONUS PAYMENT AND ANTI-DAMPING TAX APPLICATIONS)

Cooperation

Learning requires continuous action. Cooperation is necessary for effective solutions. Technology learning needs to be global. On the other hand, local autonomy is needed in order to ensure efficient use of local resources, meet local demands and spread the risk of technology failures.

Patent
A patent is an exclusive right to one's invention. In the US, the right lasts for twenty years. Basically, either products or processes can be patented; an idea itself cannot be patented unless it is applied.

Information is a commodity with peculiar attributes, particularly embrassing for the achievement of optimal allocation. In the first place, any information obtained, say a new method of production, should, from the welfare point of view, be available free of charge (apart from the cost of transmitting information). This insures optimal utilization of the information but of course provides no incentive for investment in research… In a free enterprise economy, inventive activity is supported by using the invention to create property rights; precisely to the extend that it is successful, there is an underutilization of the information.

(Arrow, 1962)

Patent is an important tool for the prize of the inventions. On the other hand, long patent life (by giving the inventor a monopoly of long duration) favors appropriability at the expense of use. That is, optimal use is not achieved during the patent life because of pricing above marginal cost. On the other hand, a short patent life favors use at the expense of approriability-with the result being levels of investment that are too low. Hence a second-best patent life lies somewhere in between.

(Viscusi-Harrington, 2005)

(See chapter 24 @ Viscusi-Harrington, 2005 for more details of innovation and patent)

Data, Privacy and Emerging Technologies

Importance of data

Privacy?

Traditional database (central authority): access is restricted by authority

Distributed Ledger Technology

A distributed ledger is a database that is spread across several nodes or computing devices.

(individual computers)

To Sum Up

The regulators should discover the possibilities adjusting the existing price-regulation systems and other type of incentives to support resolving different challenges, like;

- consulting with researchers, academic institutions, energy industry experts and customer representatives on the available new technologies, innovative methods, behaviour-changes and the related regulatory challenges,
- building internal capacity of regulatory staff in the area of new and innovative technologies,
- supporting smart grid development (without accusing too much burden on end-users),
- supporting smart meter deployment; empowering consumers and addressing data privacy and cybersecurity concerns,
- preparing special support (and network tariff) system for the different storage technologies allowing these technologies to compete on the ancillary service markets assisting system operators and customers to keep the balance,
- developing (or just implementing) such regulatory incentives of the network operators, which give them impetus to support the end-user in energy efficiency measures (e.g. decoupled rates) and in different demand side response activities,
- adjusting the regulation to the special requirements of e-mobility deployment,
- setting requirements and providing incentives for DSOs smoothly connecting the distributed generators,
- creating such pricing regimes, which support the "prosumers" managing the surplus of their self generated power,
- continuously measuring the expectation and satisfaction of customers and adjusting the relevant regulation accordingly. (Swora, M., Szörényi, G., Benysek, G., degli Esposti, C., Táczi, I., 2016)

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THANK YOU
FOR YOUR ATTENTION!

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