Impact of technological innovation on the energy utilities

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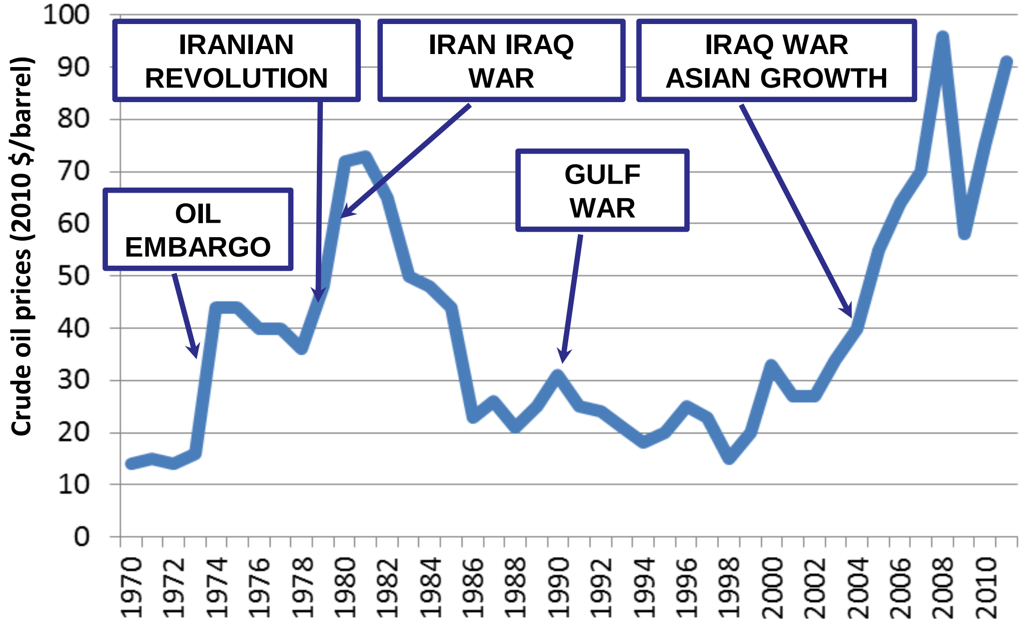
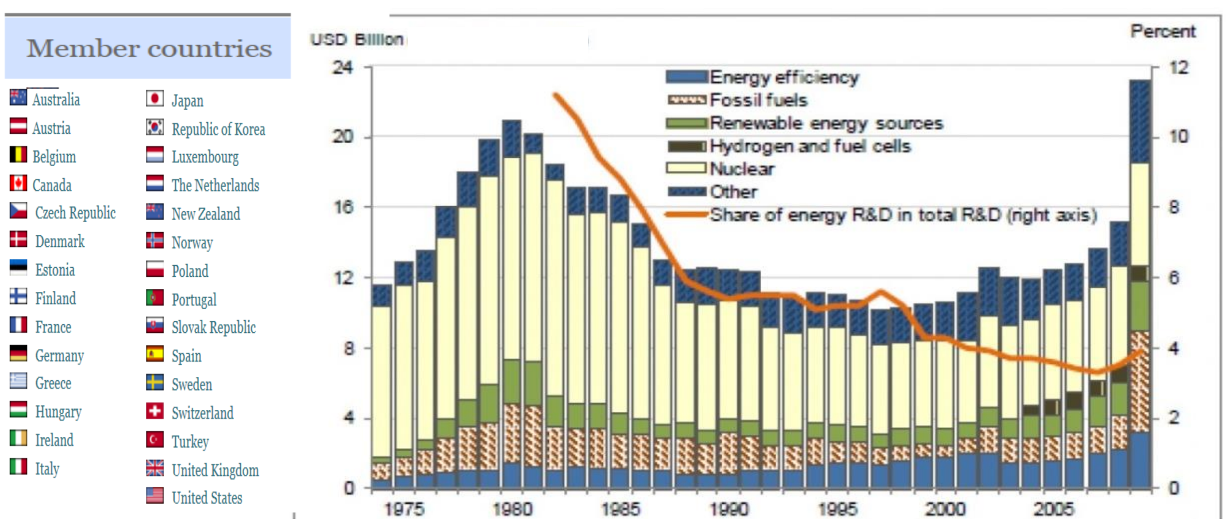
Energy R&D expenditures in IEA Countries vs oil price

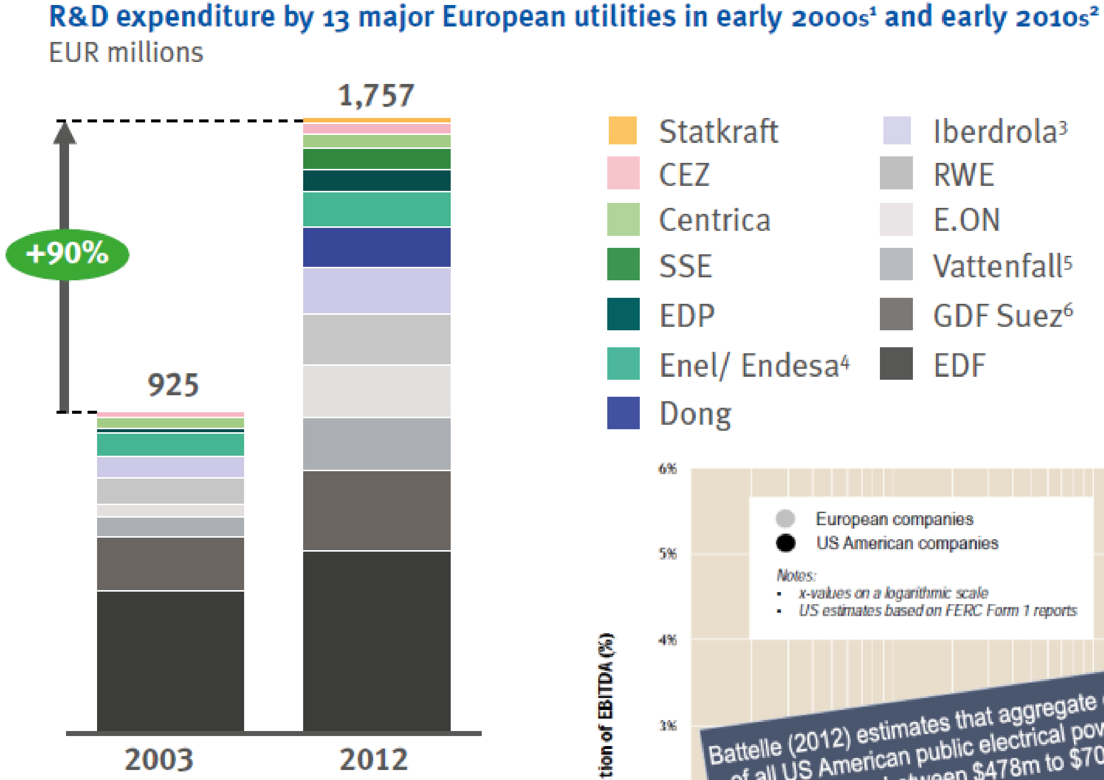


Government RD&D expenditures in energy in IEA member countries: 1974-2009



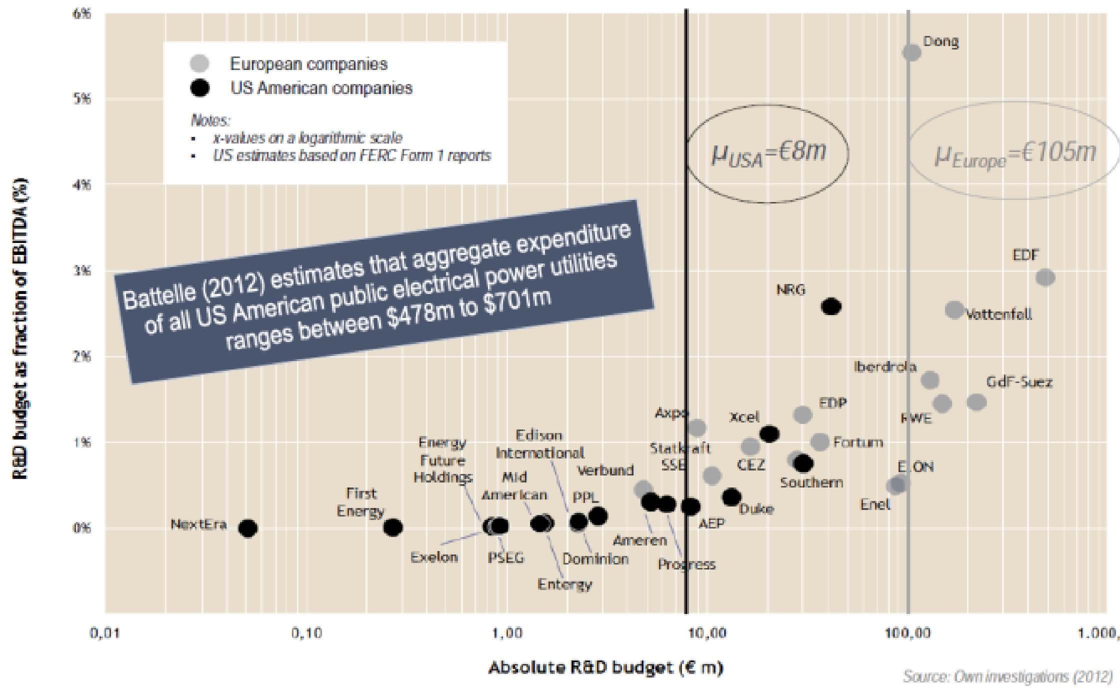
Spending on energy R&D closely tracked the oil price (period 1970 – 2010)

R&D expenditure of European utilities: doubled in last decade



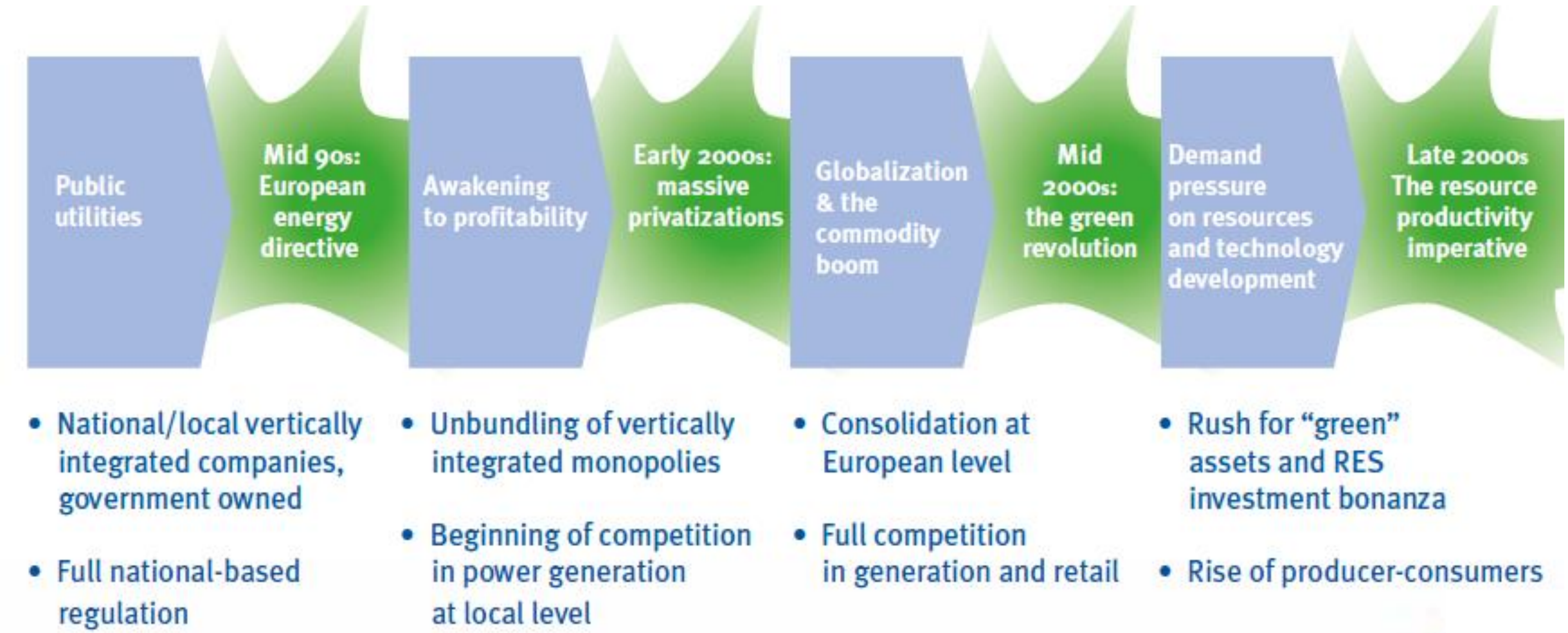
Sources: Capital IQ, company annual reports; EURELECTRIC Innovation Action Plan Taskforce analysis

Technological innovation becomes for utilities a competitive advantage.



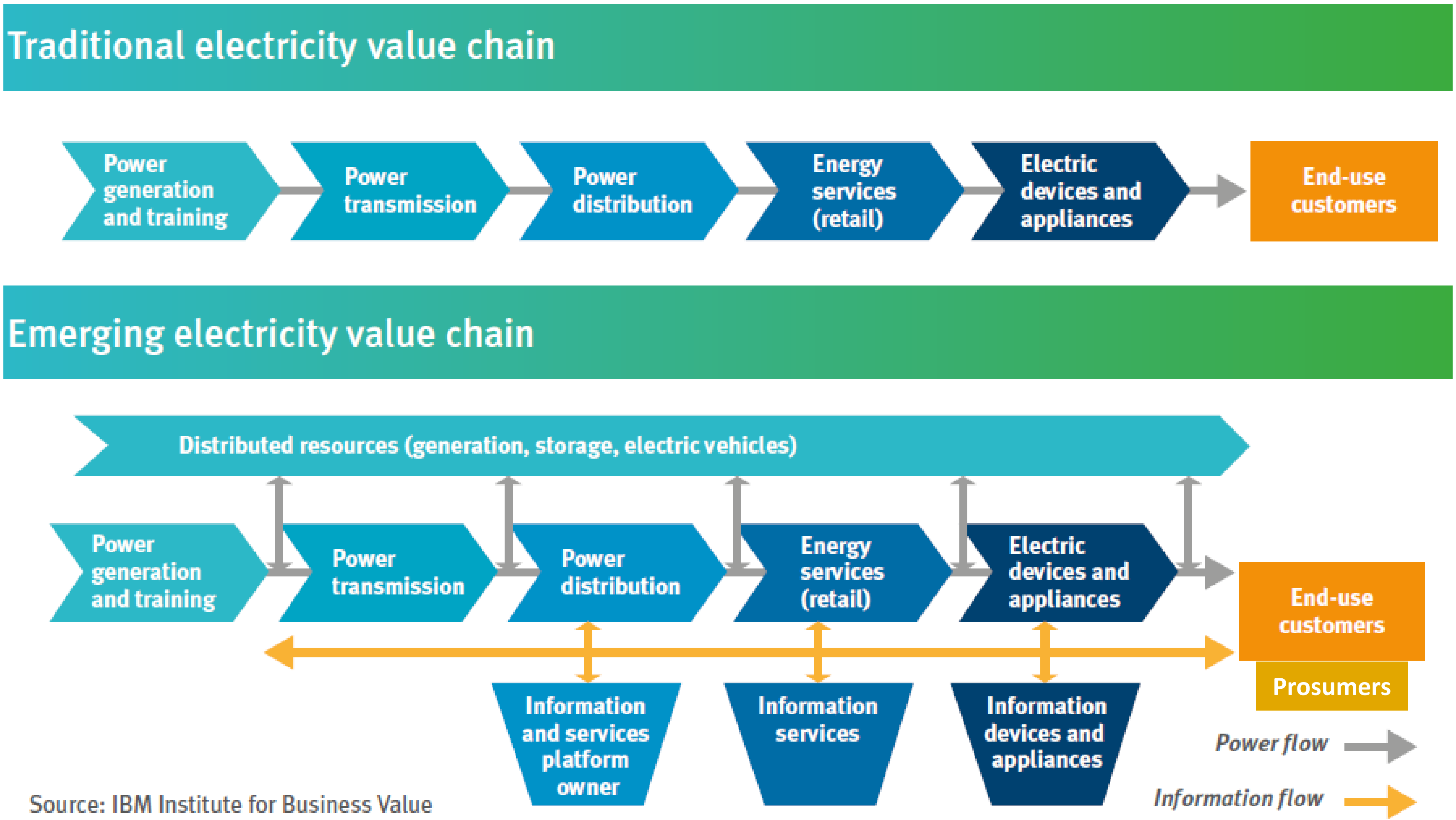
Transformation of the power sector in the last decades

energy R&D expenditures of major utilities are increasing in the recent years to implement innovation perceived as a competitive advantage in a fast changing energy market.



source: Eurelectric:powerhouses of innovation

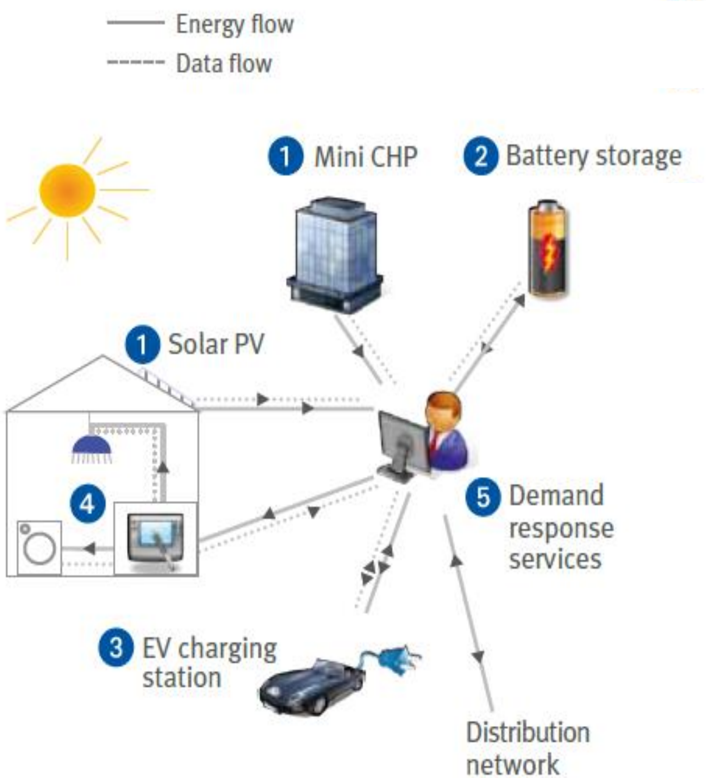
Electrical Power System is changing: from «*one-way*» to «*smart two-way*»



Source: IBM Institute for Business Value

New challenges for utilities

- Profound changes are taking place in the energy sector :
  - ✓ *growth and competitive costs of RES;*
  - ✓ *distributed generation for grid market and*
  - ✓ *self-consumption.*
  - ✓ *additional uses of electricity (electrical mobility,*
  - ✓ *heat pumps, …);*
  - ✓ *storage systems;*
  - ✓ *implementation of ICT (smart grids, smart cities,*
  - ✓ *smart buildings);*
  - ✓ *new business models and services;*
  - ✓ *new players and prosumers.*



source: Eurelectric:powerhouses of innovation

- Risk of a significant impact on the utilities in the future.
- Utilities cannot remain merely providers of commodities; technological innovation becomes a competitive advantage.

Learning from the past: companies who snubbed innovation

Two examples of companies failed or shrunk as a consequence of their moving at slow pace to respond to innovation and/or disruptive technologies.

The telephone industry
Change from fully regulated monopoly to deregulation, new technologies, new infrastructure systems and new services available.
Opportunity for new entrants in the last decades to the detriment of previous dominant companies that lost most of their "copper wire " based customers.

Film and related supplies market (photography)
Kodak: dominant, blue chip company succumbed to new entrants: the company "only watched" the photo business transformed by digital technology and finally filed for bankruptcy in 2012.

*Analogies with the power market

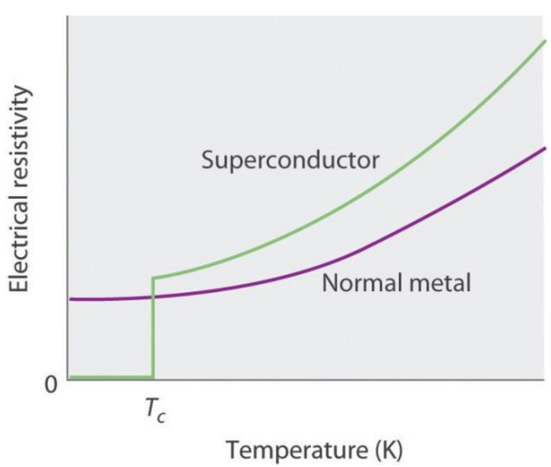
Case Studies

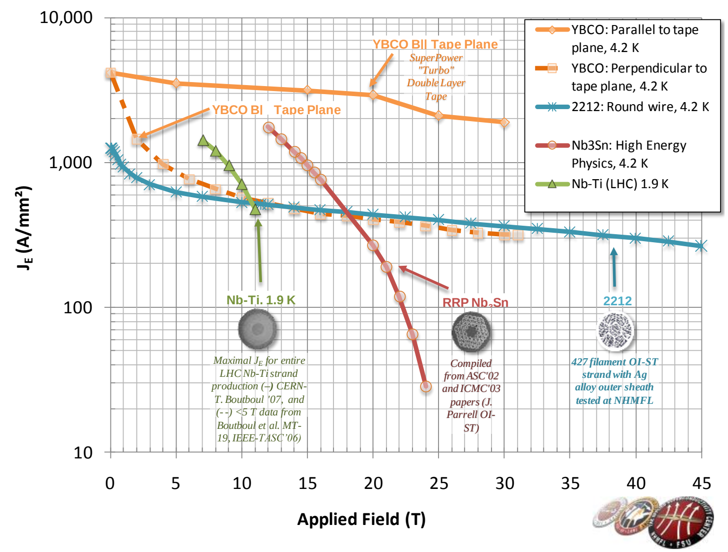
Two representative case studies to illustrate how innovation may influence (or not) the scenarios of the power sector:

- High Temperature Superconductivity
- Photovoltaics

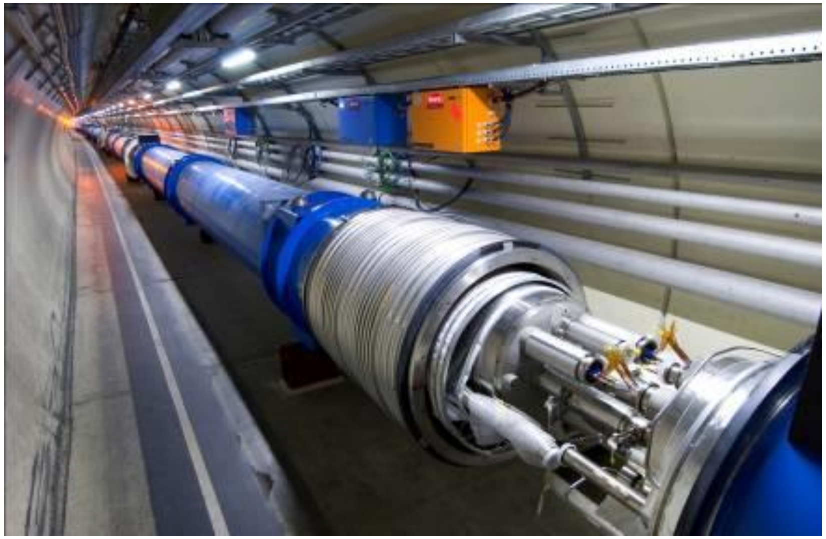
First Case Study: Superconductivity

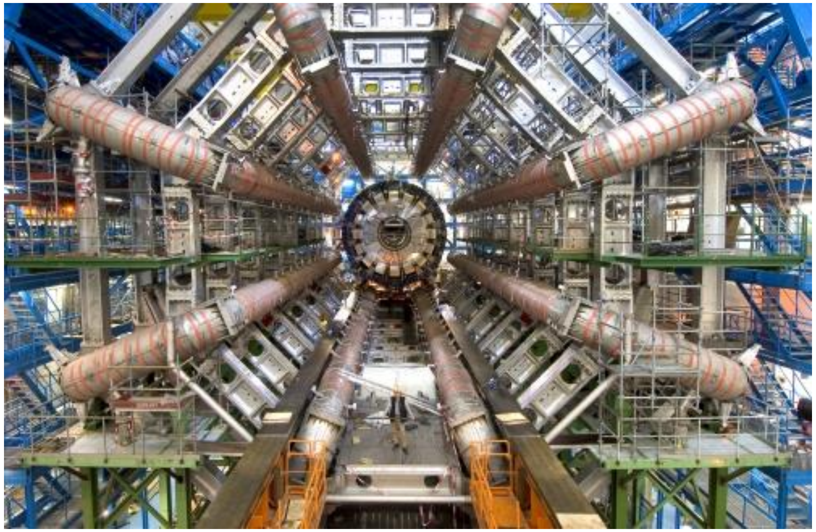
- Superconductivity discovered in 1911 by Dutch physicist Heike Kamerlingh Onnes.
- No-losses and high transport current density: use of superconducting materials as a substitute of copper in power equipments may drastically improve their efficiency and performances as well as reduce their sizes.
- Obstacles: working at very cold temperatures, reliability and costs.
- After more than 100 years, 5 Nobel Price for Physics, new discoveries and improvements, Superconductivity still remain an unloved application for the power sector.





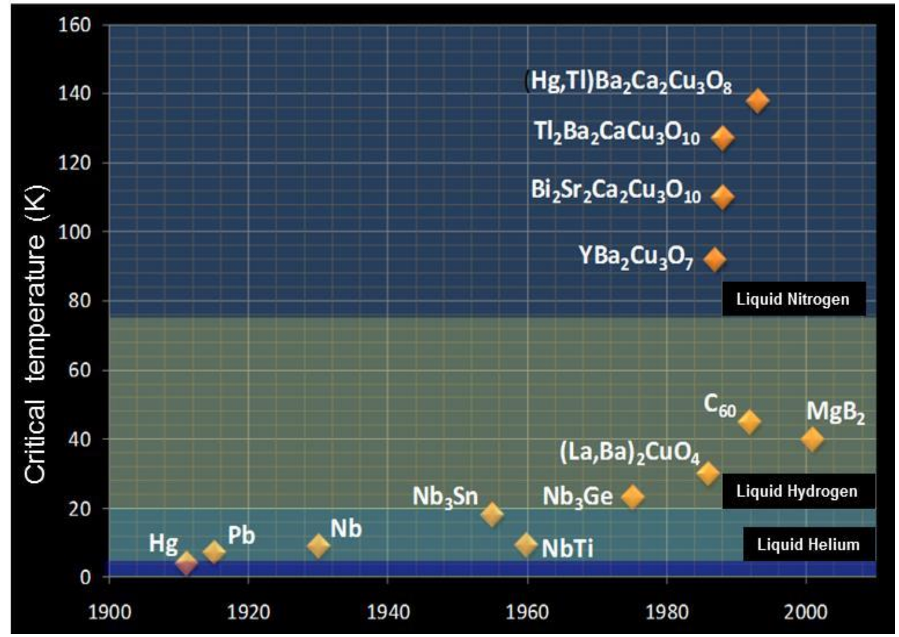
Successfull applications of SC: LHC at CERN and MRI in hospitals

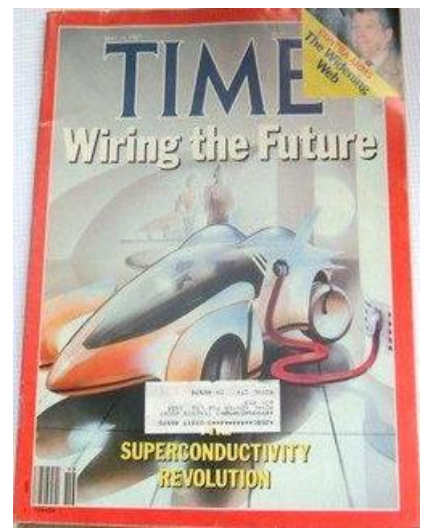




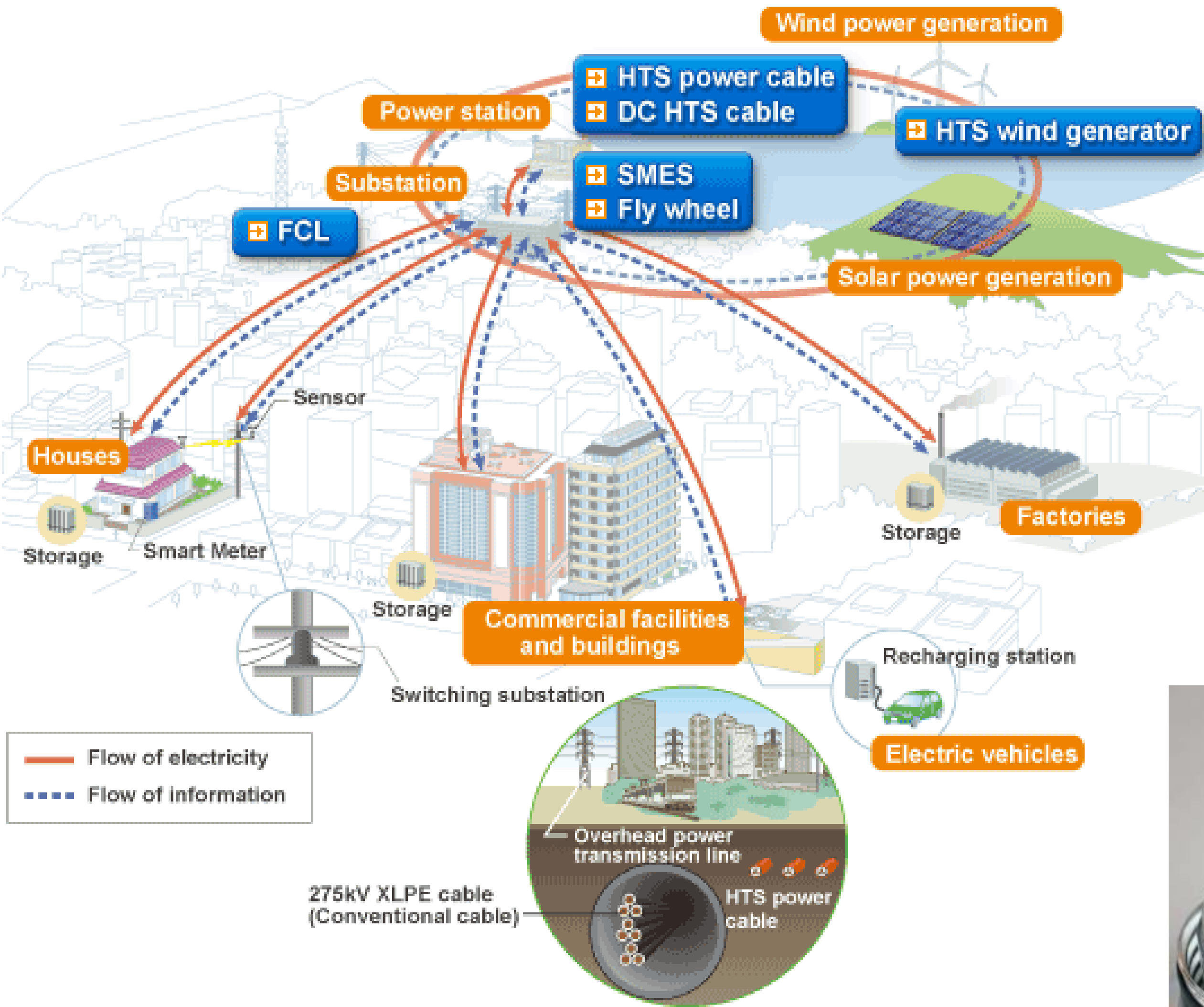
High Tc superconductors in the power system

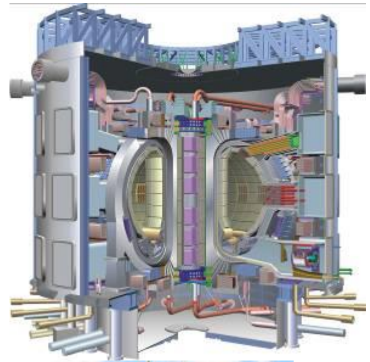
- ✓ Great Interest of Utilities for applications of superconductivity after the discovery in 1986 of High Temperature Superconductors (HTS). HTS's require less expensive cryogenic systems, liquid nitrogen replaces liquid helium, and have the potential to transform the electric power technologies and systems.
- ✓ Several HTS power devices (power cables, fault current limiters, SMES, transformers, generators, etc..) built in the last 20 years to evaluate their performances and prospects of commercialization.
- ✓ HTS's envisaged as a breakthrough and disruptive technology but the prospects for SC power devices still remain a long standing promise.



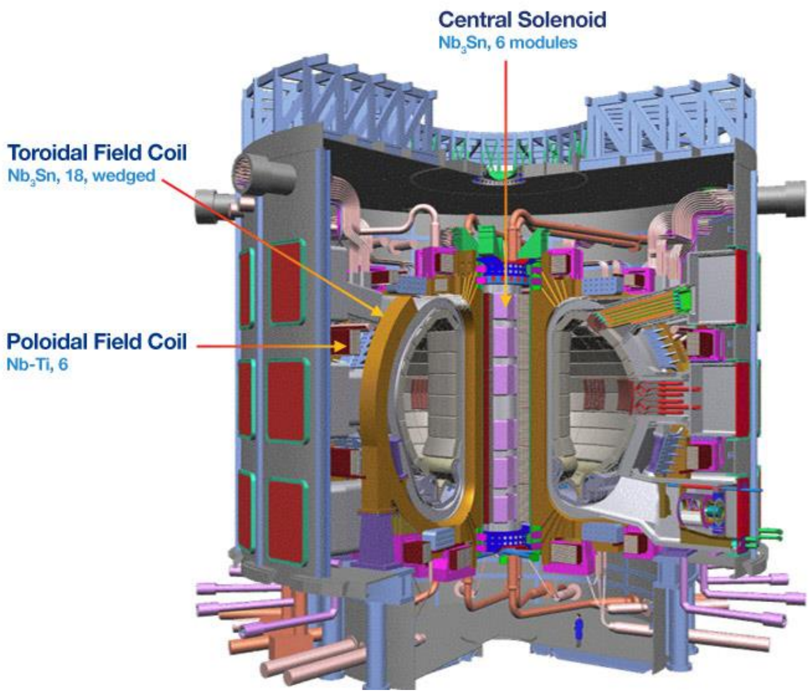


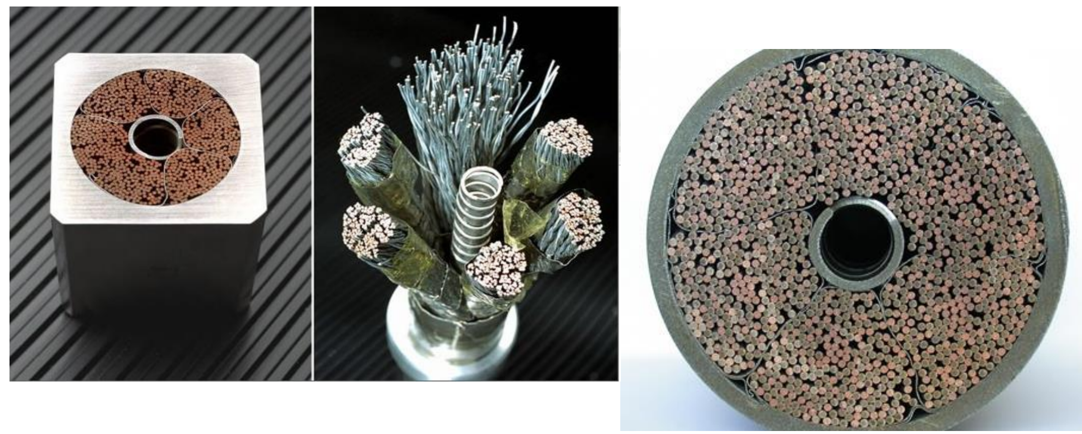
Superconducting Power Devices in a smart grid





ITER: the world's largest experimental fusion facility





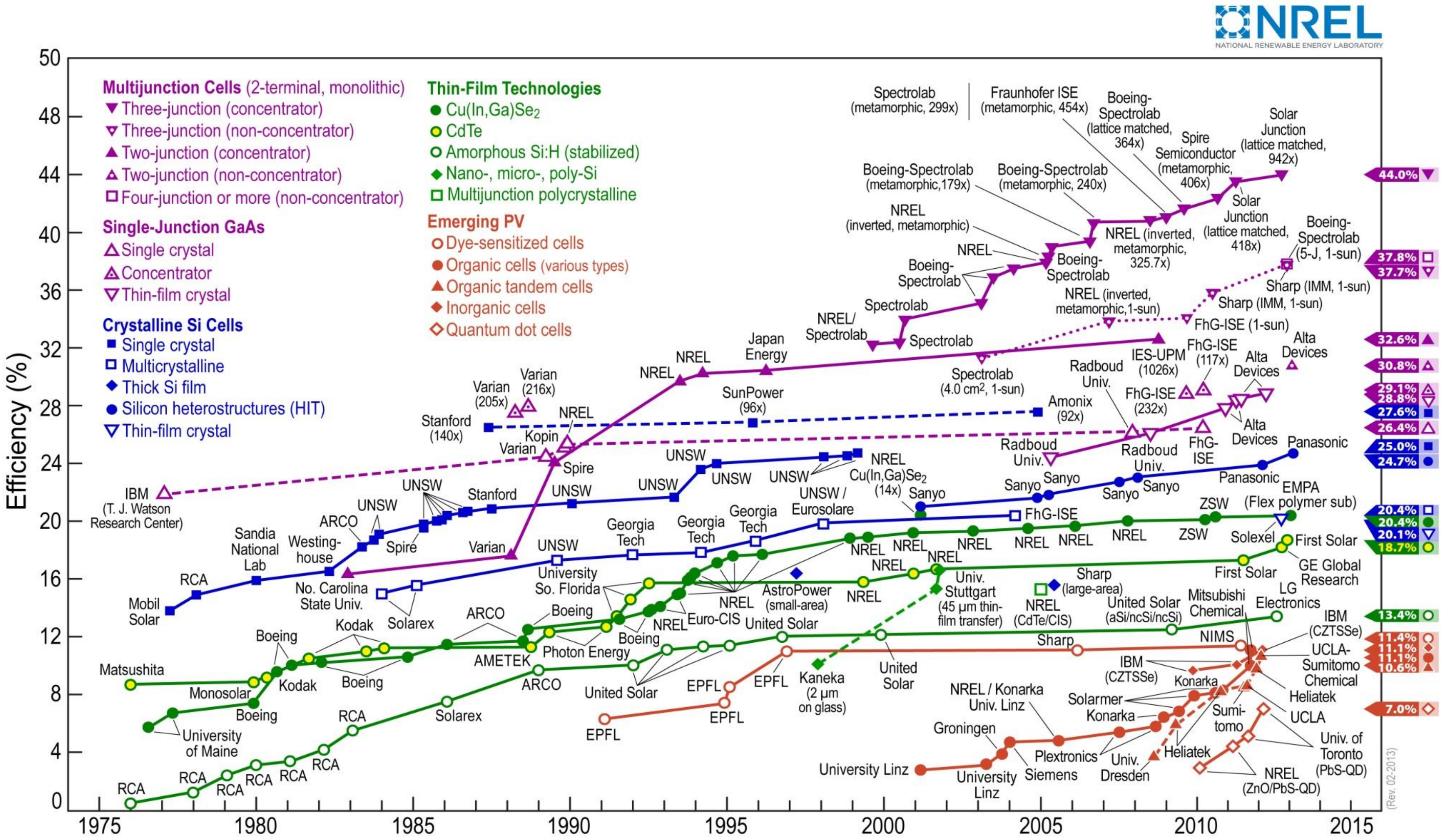
- Goal of ITER: produce a net gain of energy (Q>10, 500 MW vs 50 MW of input power) and set the stage for the demonstration fusion power plant to come (2 GW DEMO reactor, first commercial reactors by 2050).
- Estimated cost of the 10-year construction phase at Cadarache: 13 billion euros, shared by the seven ITER Members (representing 35 countries).
- 80,000 km of Nb3Sn superconducting strands will be necessary for toroidal field magnets.

Second Case Study: Photovoltaics

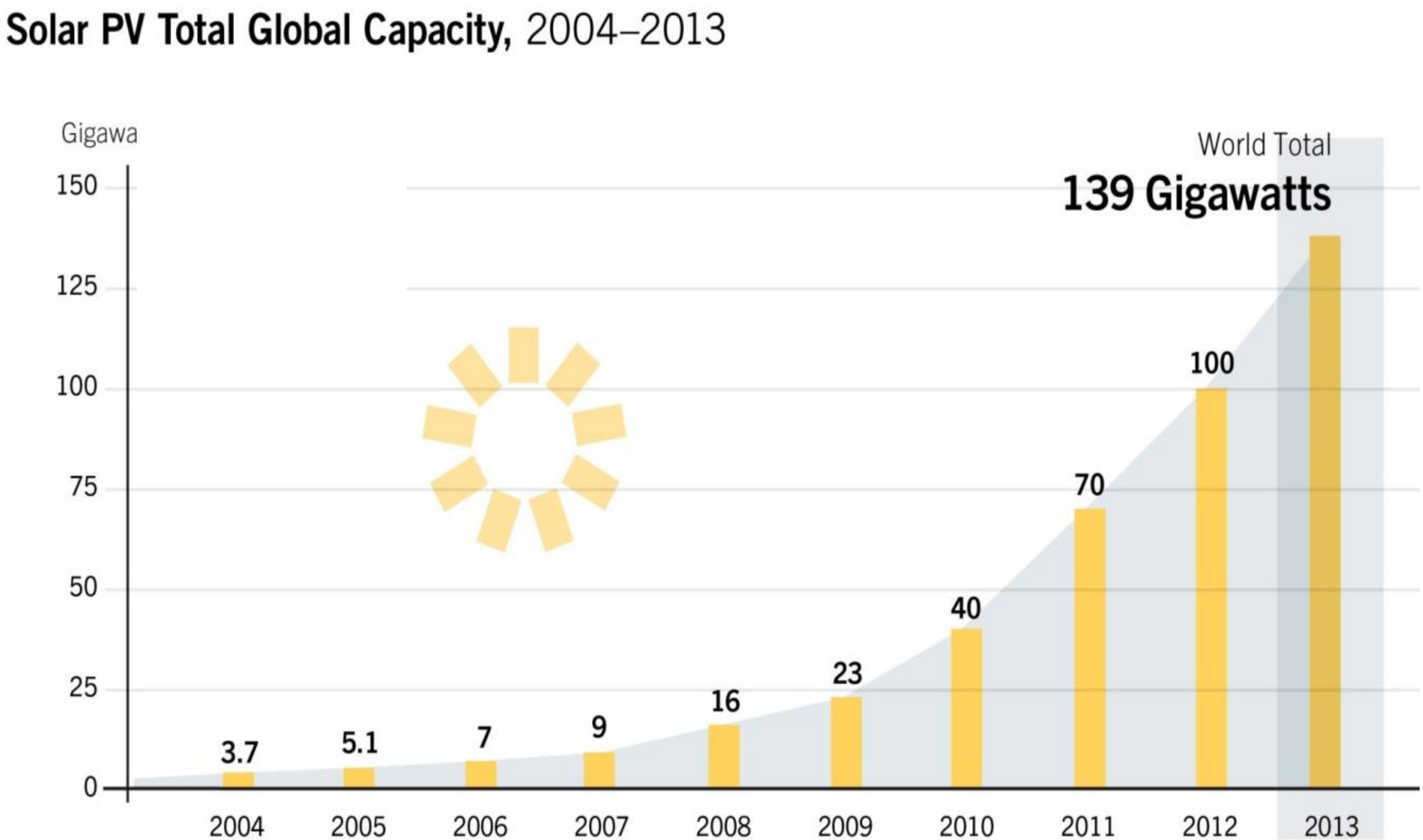
PV History

1839
Edmund Becquerel, a French experimental physicist, discovered the photovoltaic effect.
1923
Albert Einstein receives the Nobel Prize for his theories explaining the photoelectric effect.
1954
Bell Labs announces the invention of the first practical silicon solar cell with 6 % efficiency.
1982
Worldwide PV production exceeds 9 MW.
2014
Worldwide PV installations exceeds 150 GW in Q1'14, 200 GW expected by end of the year.

Evolution of PV efficiencies

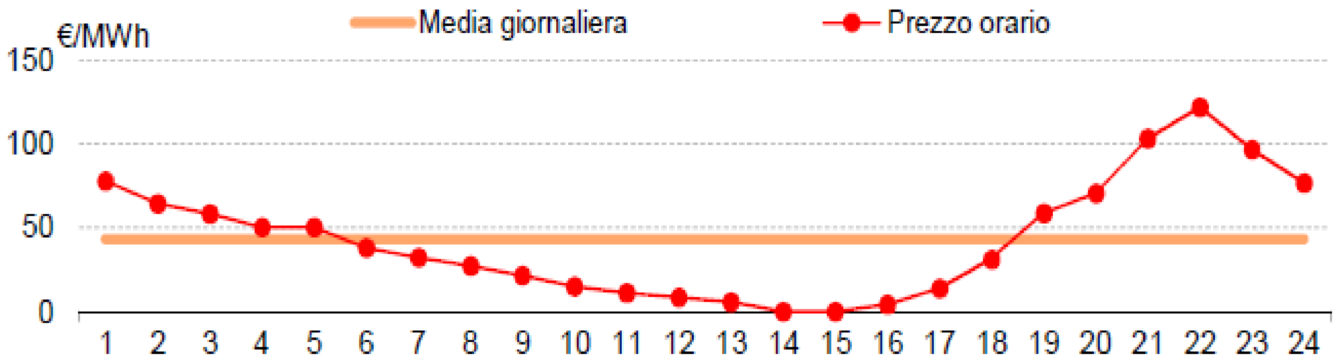


Growth of PV global capacity and cells price reduction

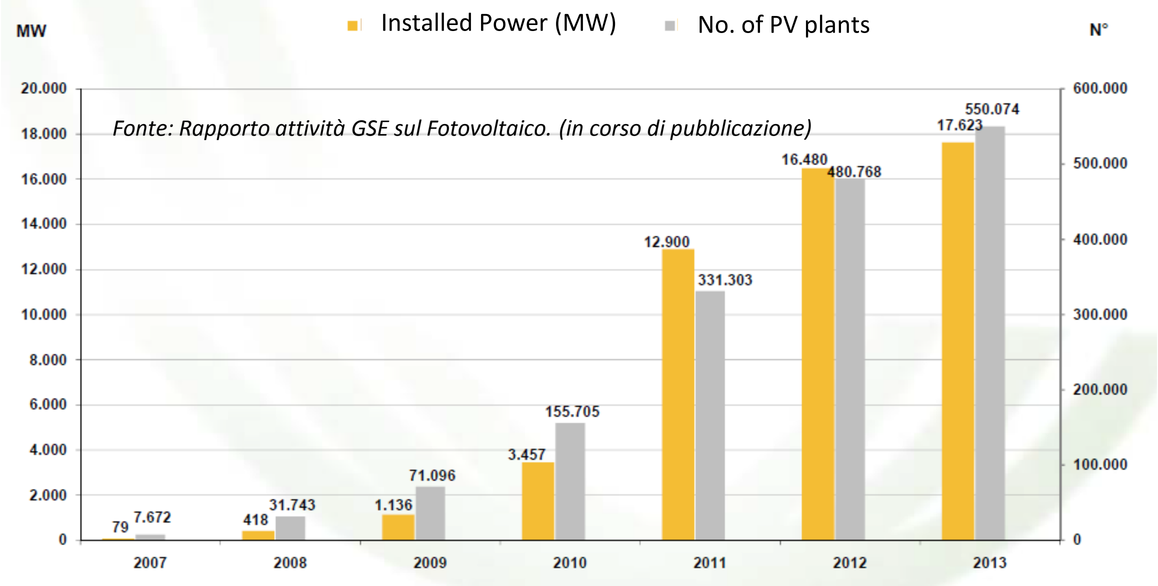


Renewable Energy Policy Network: RENEWABLES 2014 GLOBAL STATUS REPORT

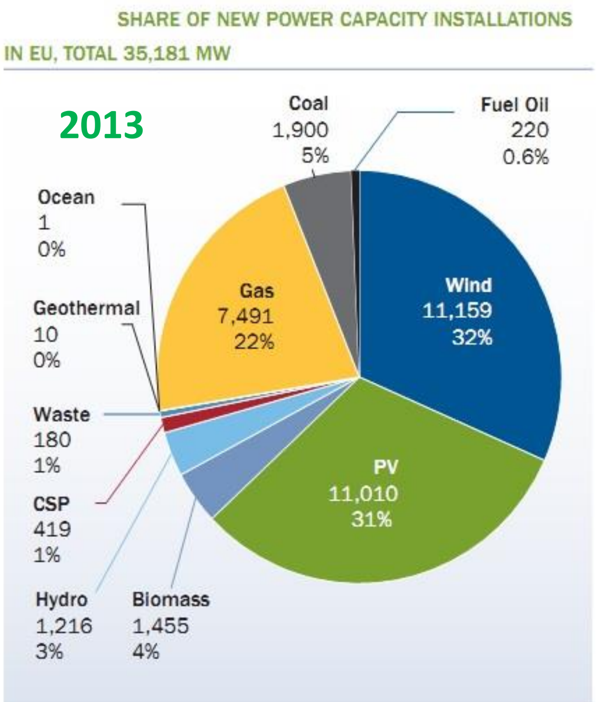
RES impact on the energy market (Italy)

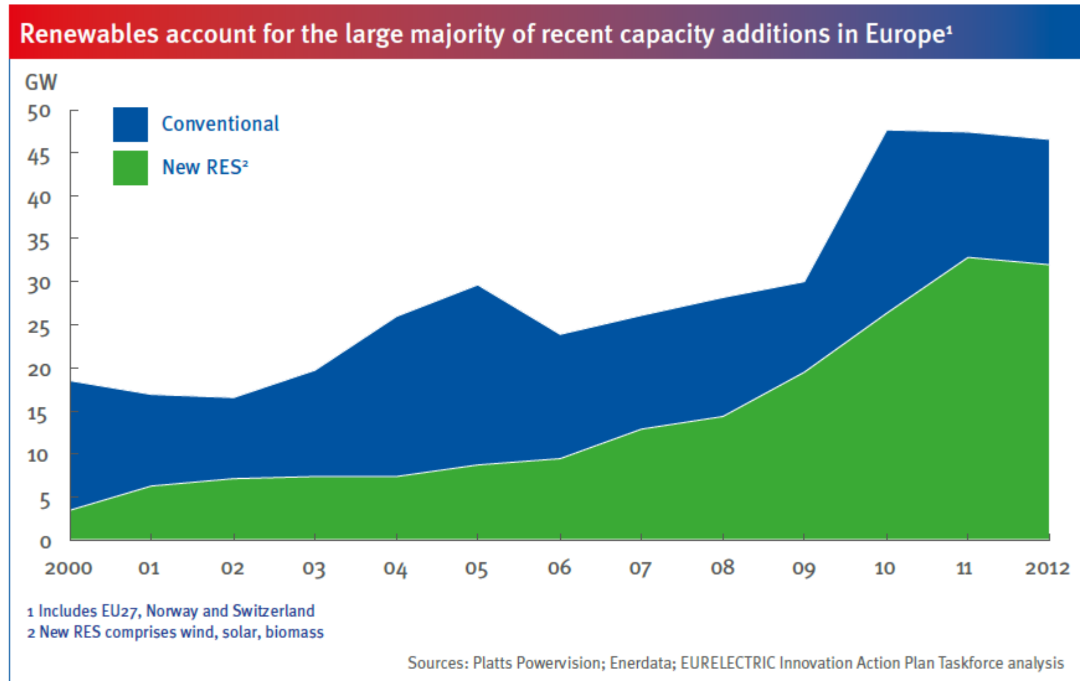


Italy, June 16, 2013 (Sunday)
Electricity Purchase Price = 0 €/MWh @ 14:00–15:00



The growth of RES (Europe) and especially PV (subisdized)





New installed power generating capacity per year in Europe

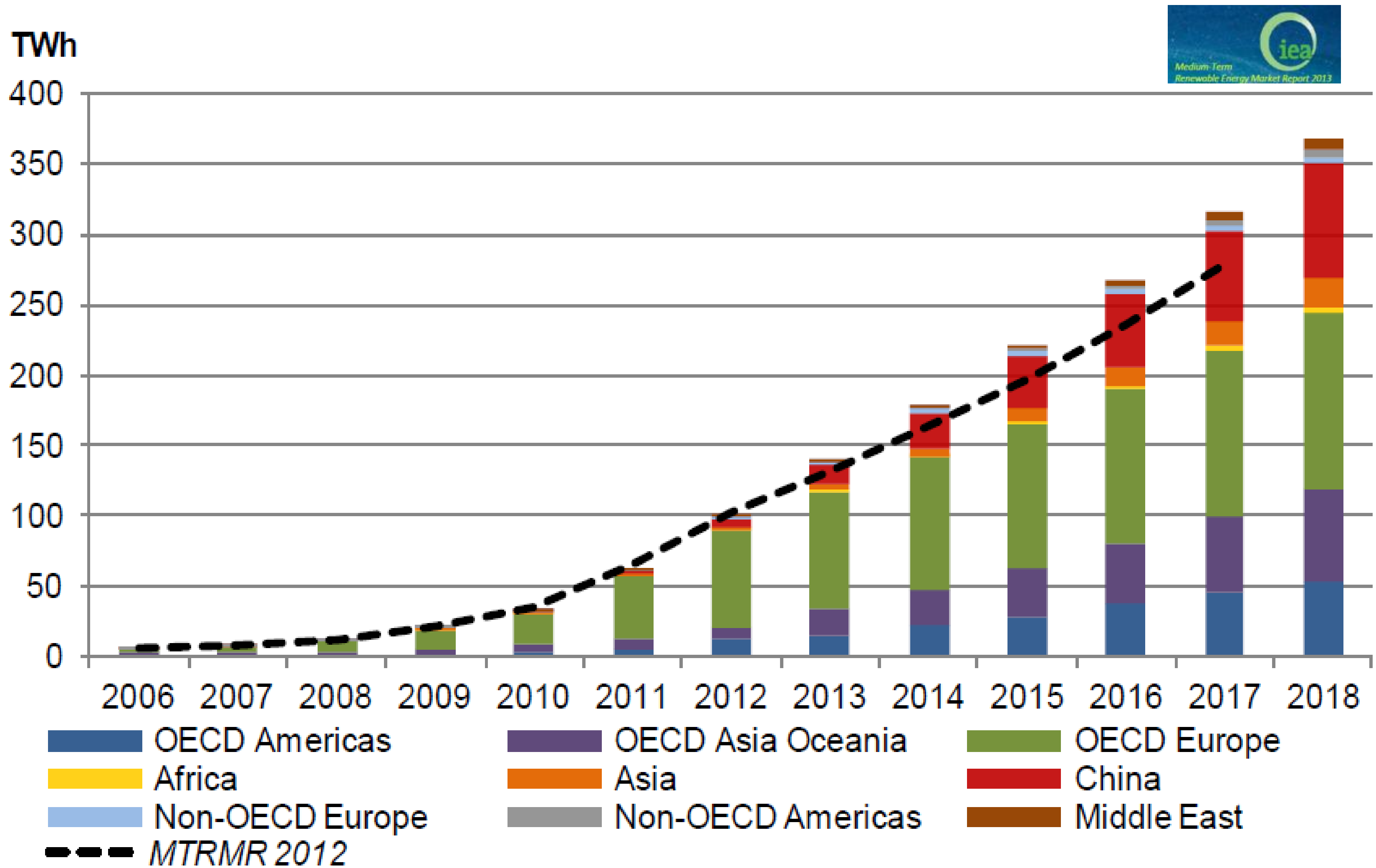
2000: 16 GW with a RES share of 22.4% (3.6 GW).

2013: 35 GW with a RES share of 72 (25 GW).

PV was negligible in 2000 !

High shares cost-effectively integration of RES calls for a system-wide transformation

Worldwide forecasting for PV energy



Competitive Levelized Energy Cost (LEC) of PV

Germany LEC for different generation technologies (2013)	
Technology	**LCE range (EUR/MWh)**
brown coal	38-53
hard coal	63–80
CCGT plants	75-98
onshore wind	45-107
offshore wind	119–194
PV plants	**78-142 …. now competitive without incentives**
biogas	135–250

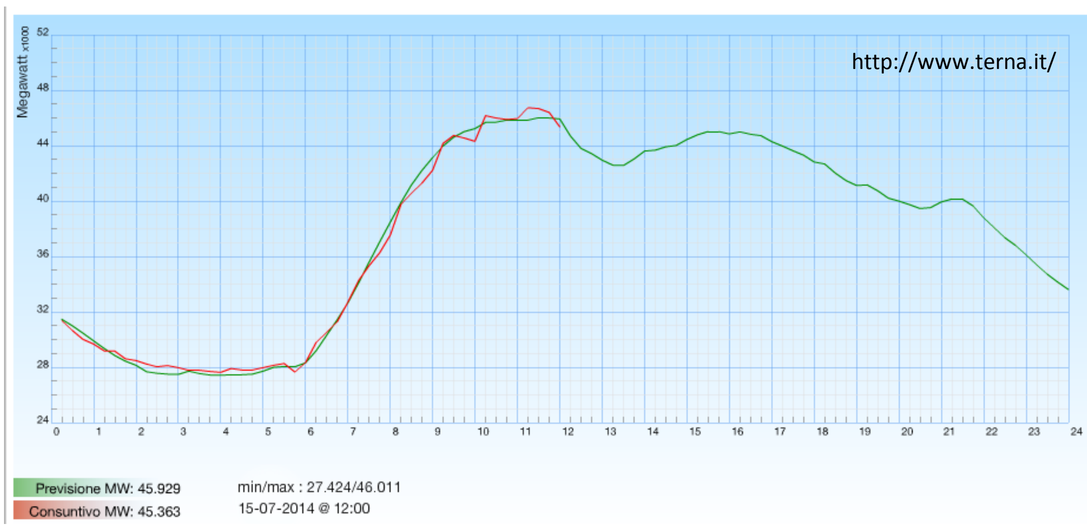
LEC includes all the costs over its lifetime: investment, O&M, cost of fuel, cost of capital, ...

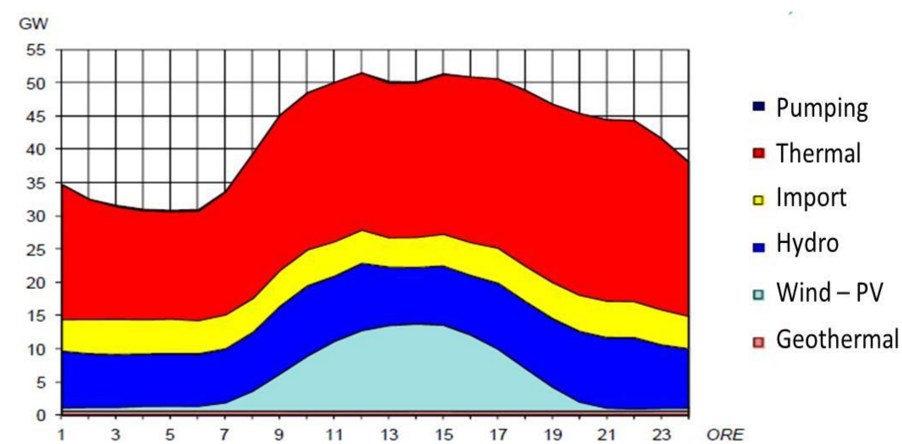
It= Investment expenses in the year t
Mt= Operations and maintenance expenses in the year t
Ft= Fuel expenses in the year t
Et= Electricity generation in the year t
r= discount rate
T = Life of the system

$$\mathrm{LEC} = \frac{\sum_{t=1}^{n} \frac{I_t + M_t + F_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}}$$

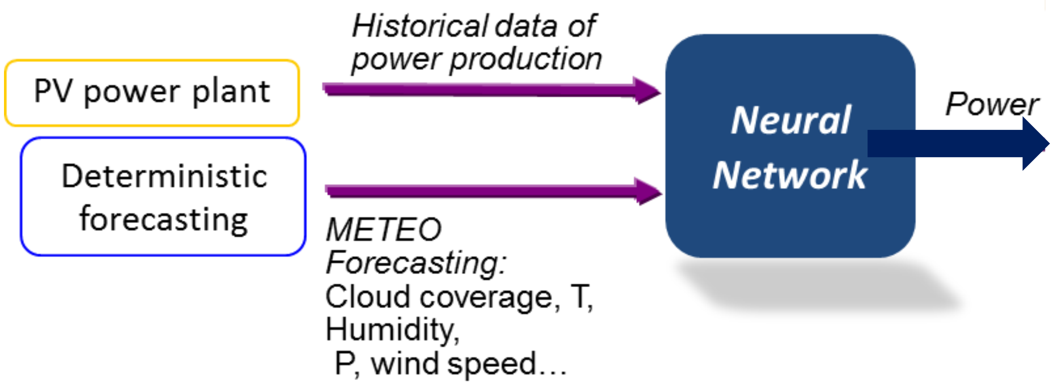
PV (intermittent) integration in electrical network

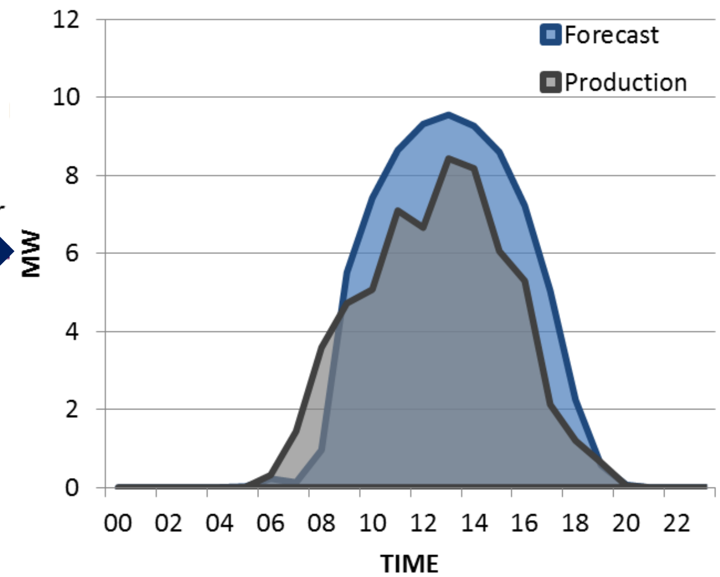
- Electricity has to be produced at the moment we ask for.
- Real Time Network management by grid operator allows the equilibrium between production and consumption of electrical energy.
- Electricity production is assured by large programmable plants able to control their output (like CCGT) …. and by not programmable systems (like PV and Wind).





Solving PV intermittence: forecasting of PV energy production

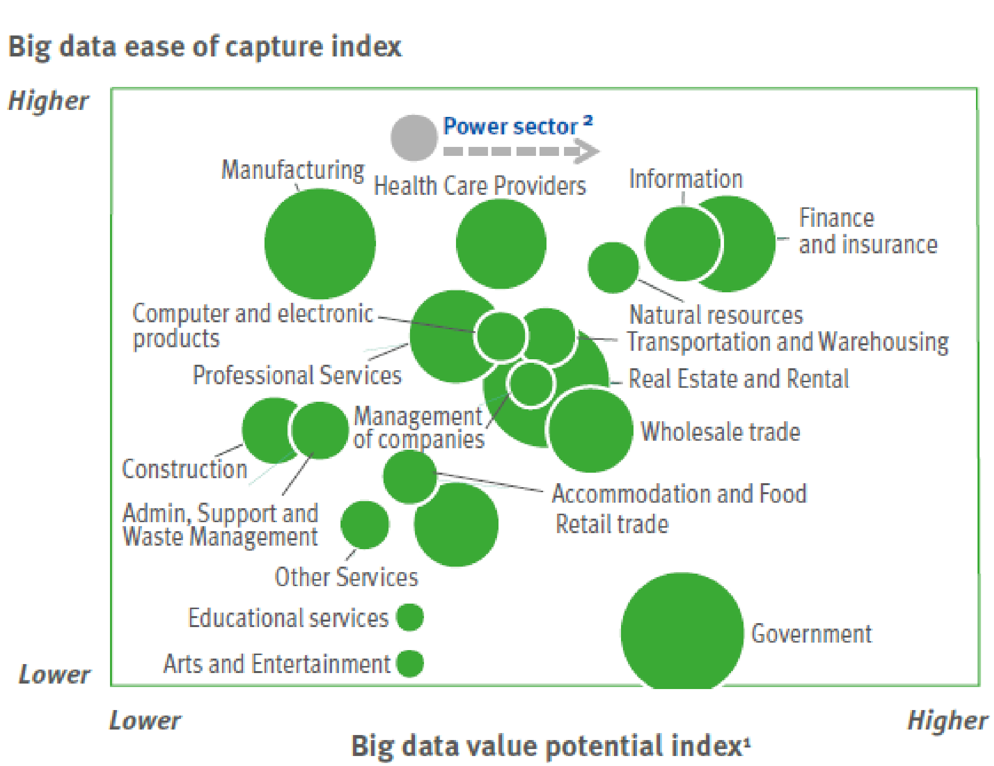




2 days ahead hourly power profile.

Big Data

Big data is easier to capture in the power sector than in many other industries, and its potential value is rising



Bubble sizes denote relative sizes of GDP[3]

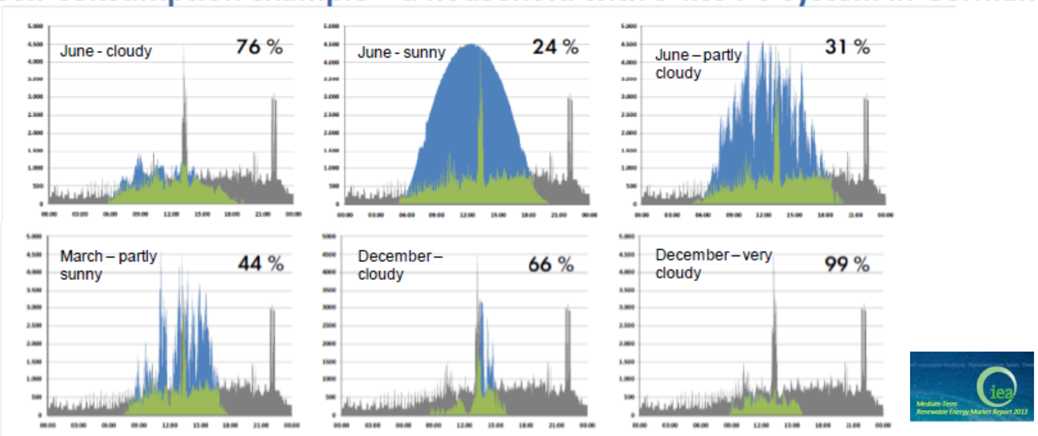
- Power sector players are well positioned to capture large amount of data
- Sources of value from big data for power sector players
  - Tailored/new products & services
  - Enhanced customer targeting
  - Enabling of demand side management
  - Optimized operations

1 Potential to create value. Some portion of the value created can be captured as profits
2 Electricity and gas utilities
3 based on US GDP data

Source: McKinsey Global Institute

PV self-consumption

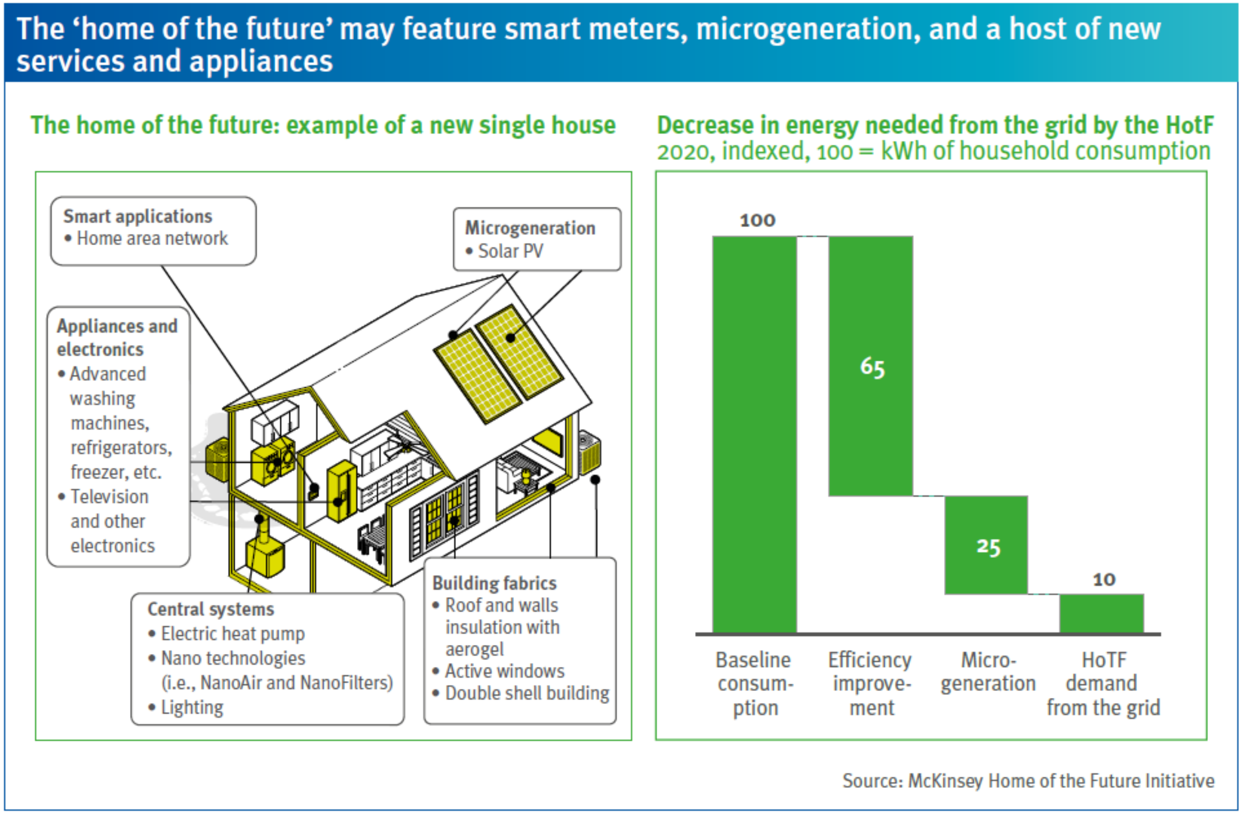
Daily self-consumption example – a household with 5-kW PV system in Germany



In grey, electricity drawn from the grid. In blue, electricity injected into the grid. In green self-consumption. Numbers indicate the percentage of self-consumed electricity. Horizontal axes: hours. Vertical axes: watts.

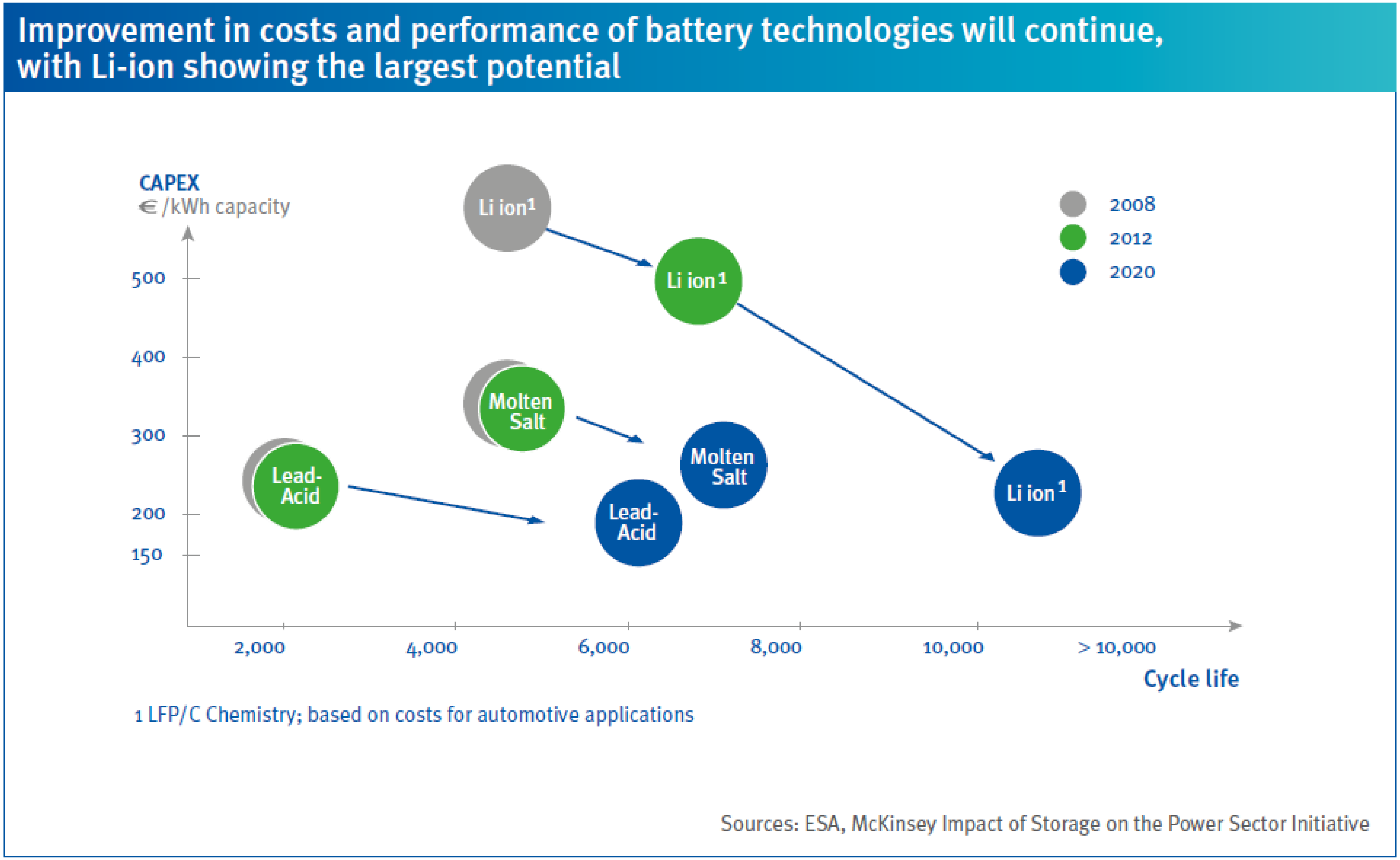
- LEC of PV residential plant: 0.12-0.16 €/kWh vs retail electricity price: 0.2–0.3 €/kWh.
- High PV Self-consumption in terziary and industrial buildings.
- Low match between load curve and PV generation profiles in residential.
- To increase self-consumption (and redditivity):
  storage systems (individual/decentralised), load management and smart appliances.

Quasi-zero energy homes (EU requirement by 2020)

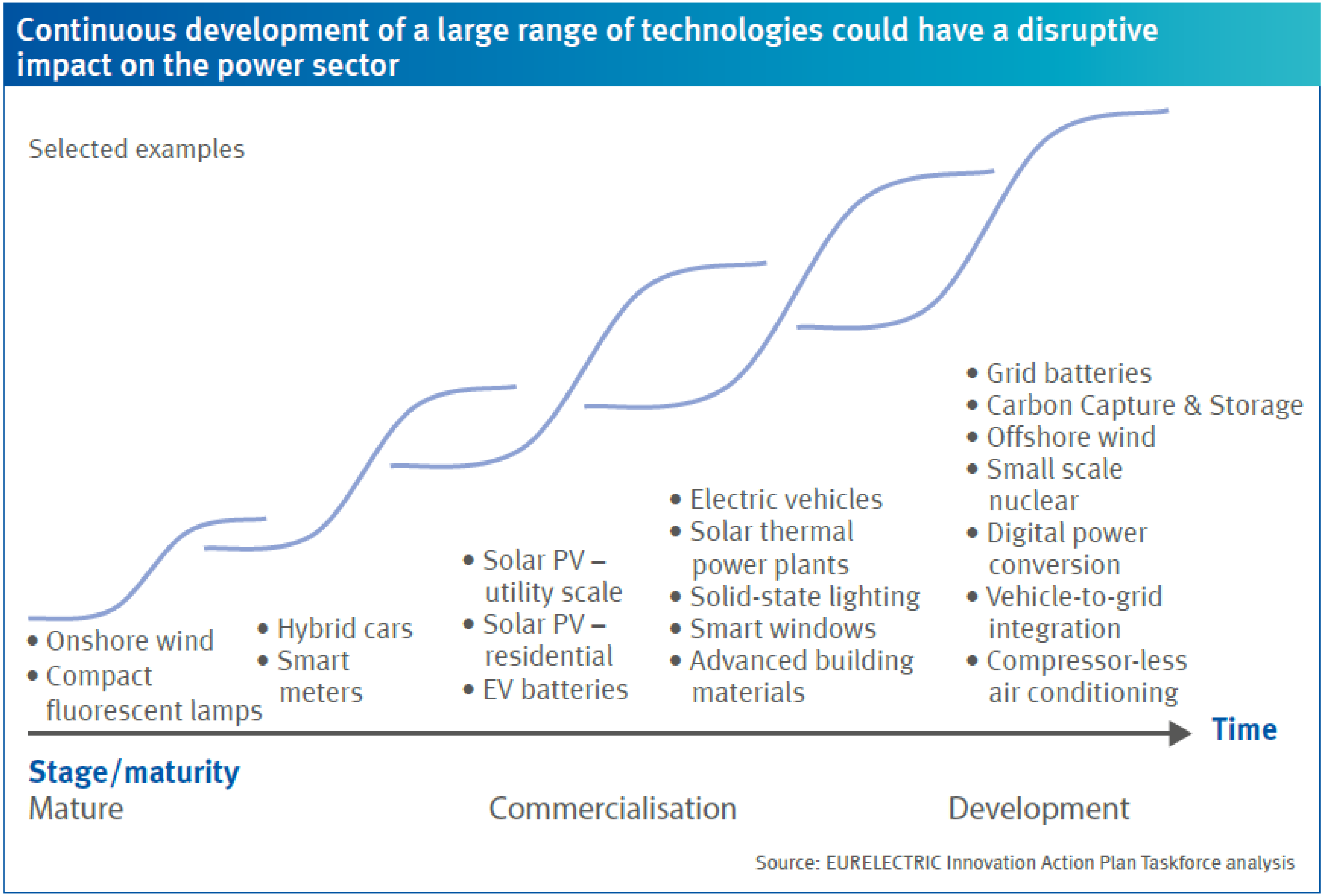


Directive 2010/31/EU, Article 9: *"Member States shall ensure that by 31 December 2020 all new buildings are nearly zero-energy buildings; and after 31 December 2018, new buildings occupied and owned by public authorities are nearly zero-energy buildings". Member States shall furthermore "draw up national plans for increasing the number of nearly zero-energy buildings" and "following the leading example of the public sector, develop policies and take measures such as the setting of targets in order to stimulate the transformation of buildings that are refurbished into nearly zero-energy buildings".*

Storage may change the way to use PV



Impact of new technologies in the power sector



New players in the Energy Arena

- The customer base of energy companies becomes an entry gate for other players: telecom operators, IT companies, energy service companies, innovative start-ups, ……, Google.
- Google funds:
  - energy R&D more than US utilities all together.
  - clean energy projects : > 1 billion $ in solar and wind plants.
  - software and hw development to manage "smart grid".
  - start-up acquisition: in January 2014 spent 3.2 billion $ to buy Nest Labs to strengthen its position in the "Internet of things" market.

  The founder of Nest Lab, earlier in the "iPhone team" of Apple, developed a smart thermostat *learning your schedule and the temperatures you like saving energy when you're away* …. a way to enter into the homes of potential new customers.

Role of Open Innovation

- New skills are required and utilities cannot face alone all the present-day profound challenges.
- Internal R&D may fruitful take advantage expanding the platform of collaborations with universities, research institutions, technological suppliers, companies …. even competitors.
- Open Innovation is a valid tool to increase the efficiency and effectiveness of the innovation process (*open innovation is a concept, created by Henry Chesbrough in 2003 as one of the solutions to expand and accelerate technological knowledge*).