The Paradigm Shift in Energy Policies – Challenges for International Relations

Panel: Geopolitics of Renewable Energy

TUM, Hochschule für Politik an der TU München

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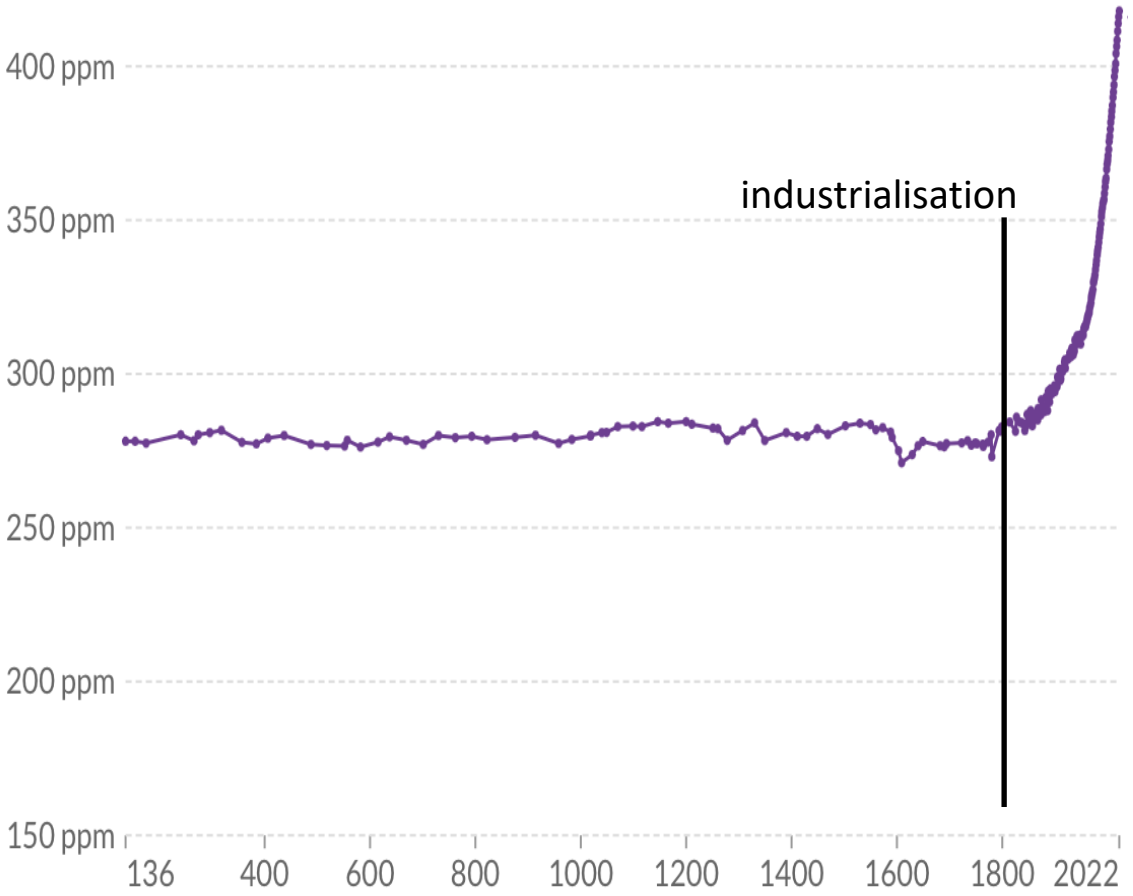
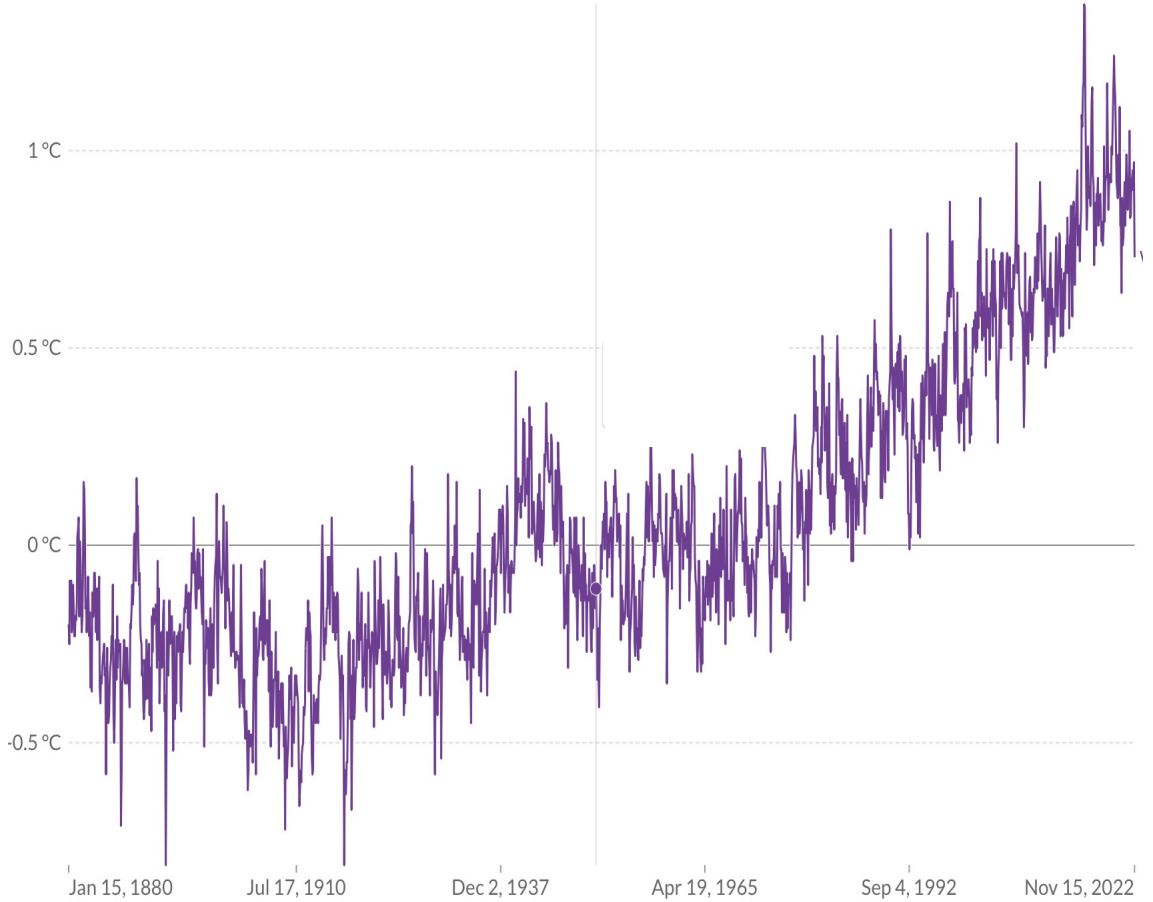
Hochschule für Politik München
an der Technischen Universität München

In coordination with the
GeoReSim Erasmus+ Project

We have a problem

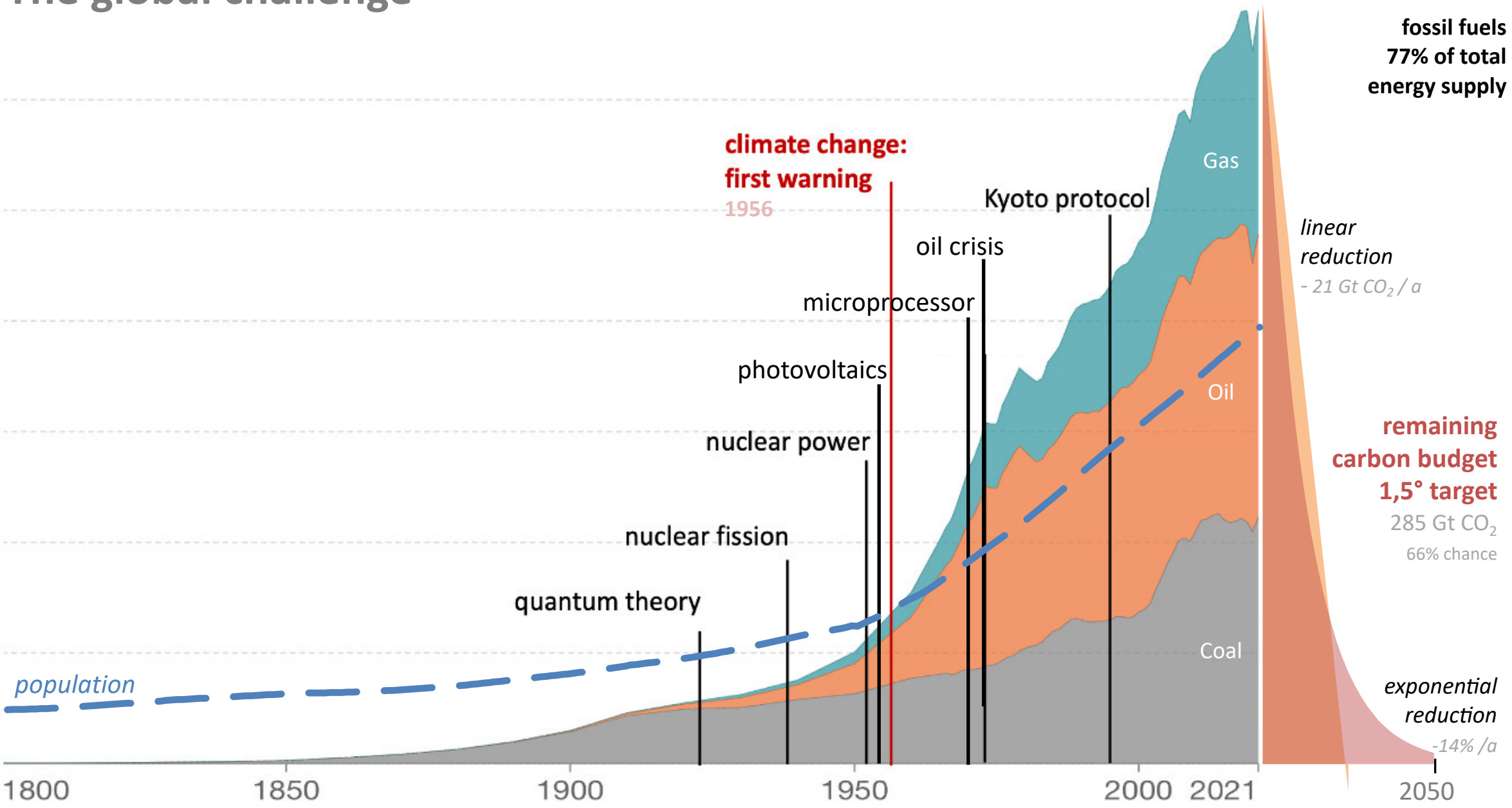
rising atmospheric CO_2 concentrations → *rising global temperatures*





Ruggero Schleicher-Tappeser
sustainable strategies

The global challenge



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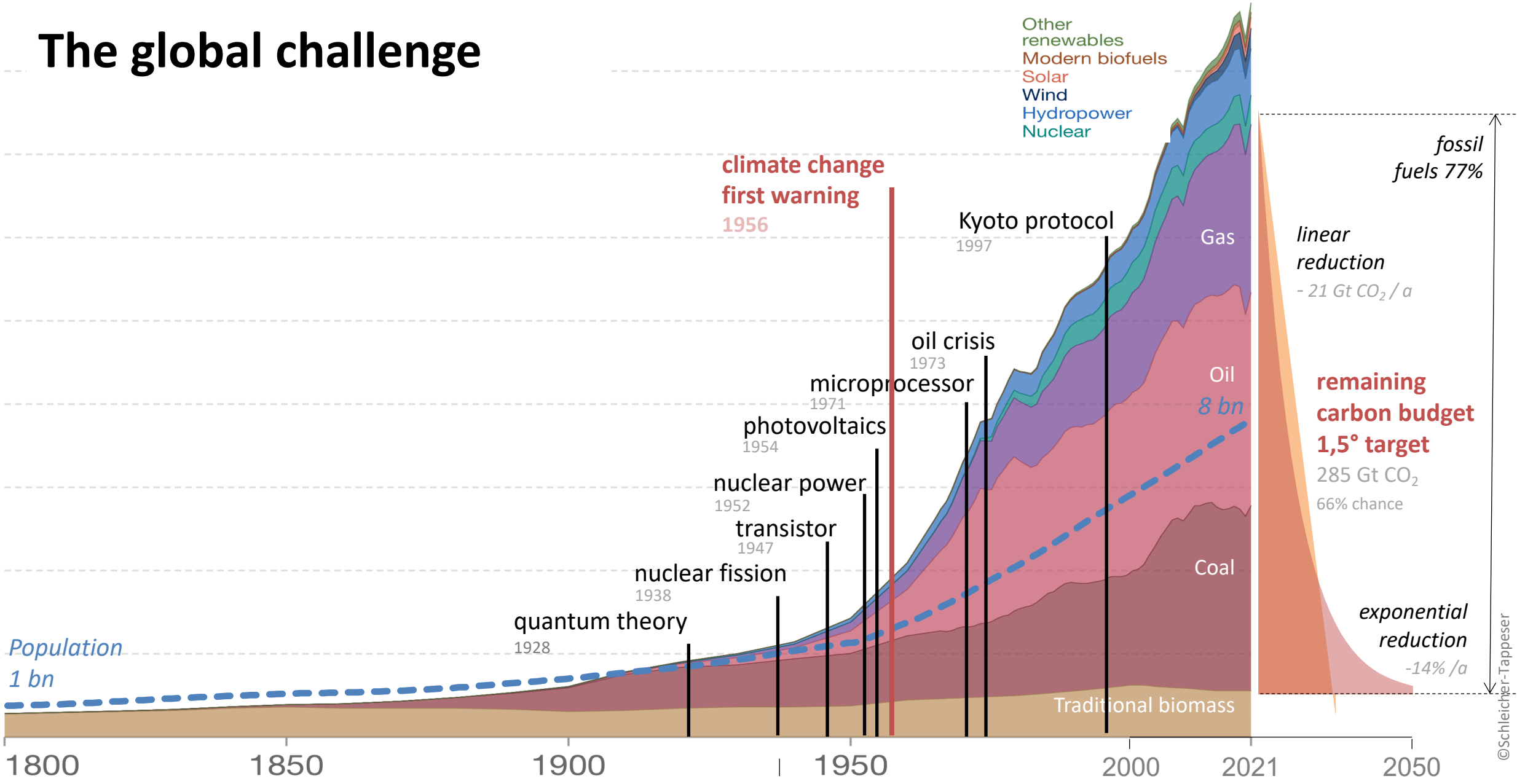
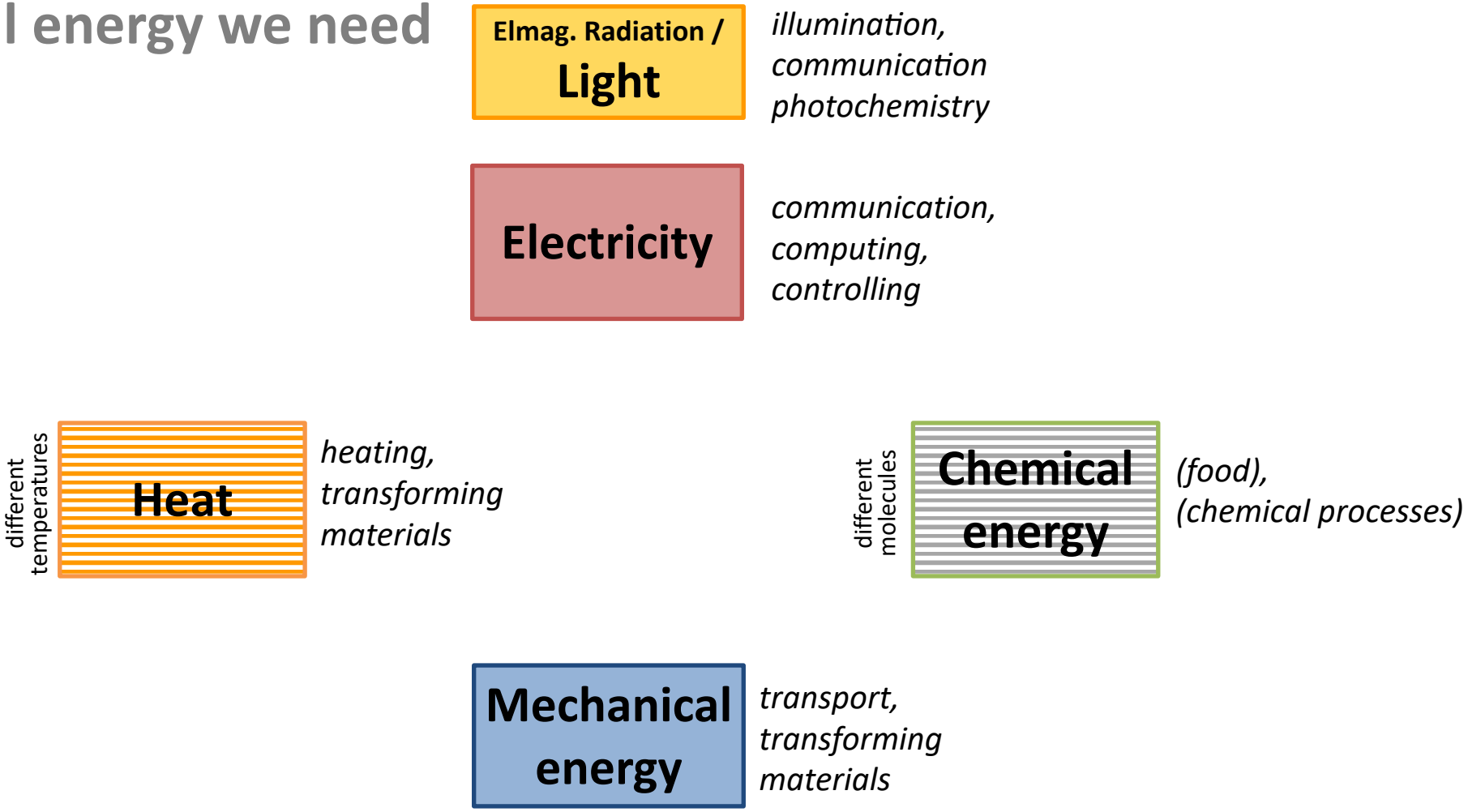
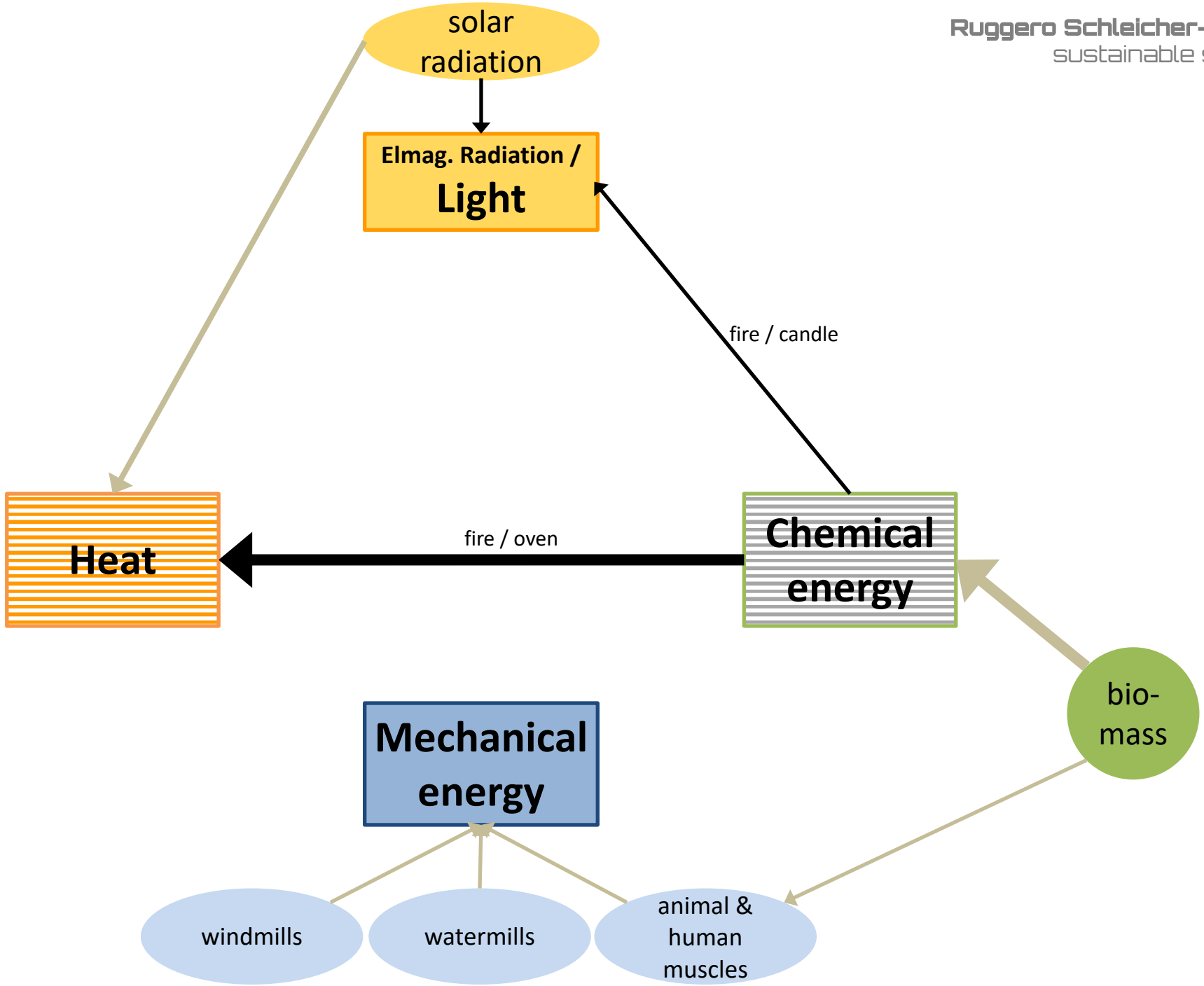


Useful energy we need



1700 - 1800



1800 - 1900
Start of industrialisation

Coal

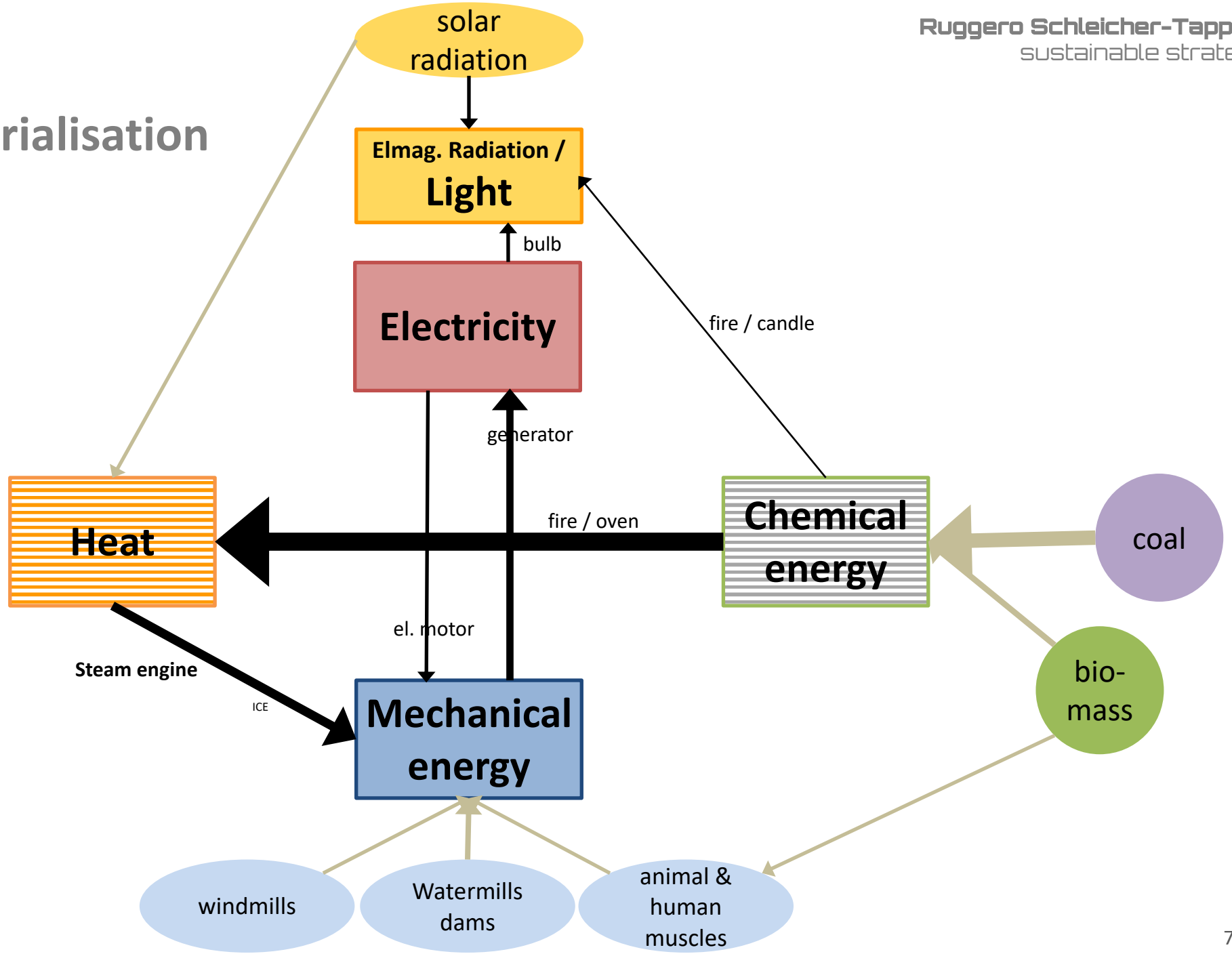
- high energy density
- only in some locations
- transportable

→ Steam engine

- mechanisation
- railways, ships
- geographical expansion

→ Electricity

- telegraph, telephone
- flexible & small mechanical energy
- Illumination
- scientific challenge



1900-1938:
Upheaval in Physics: discovery of new laws at the atomic level

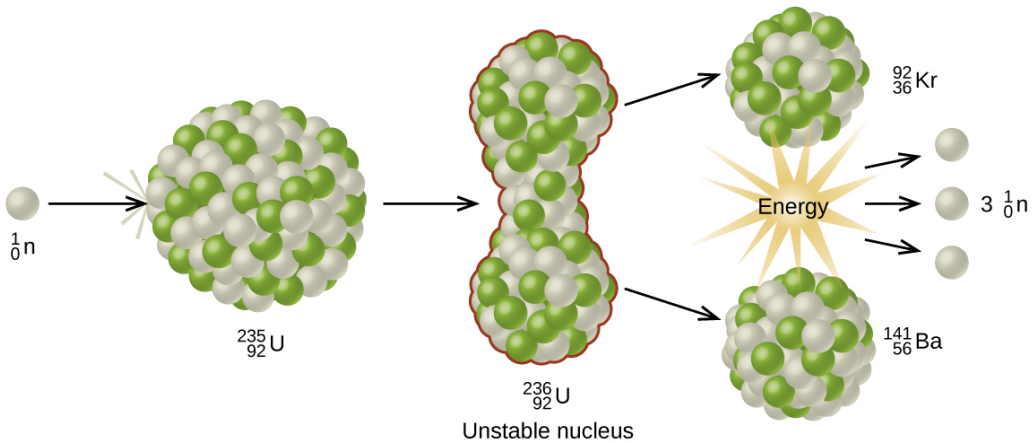
1900 Max **Planck** postulates that electromagnetic radiation is portioned into discrete "quanta"

1904 Albert **Einstein** postulates the equivalence of mass and energy in his Special Relativity Theory

1911 **Rutherford**'s atom model: a small positively charged heavy nucleus is orbited by negatively charged electrons

1926-28 **Heisenberg**, **Schrödinger** and **Dirac** develop a mathematical formulation of quantum theory

1938 Otto **Hahn** and Lise **Meitner** discover & explain nuclear fission



Prospect of unprecedented powerful weapon →

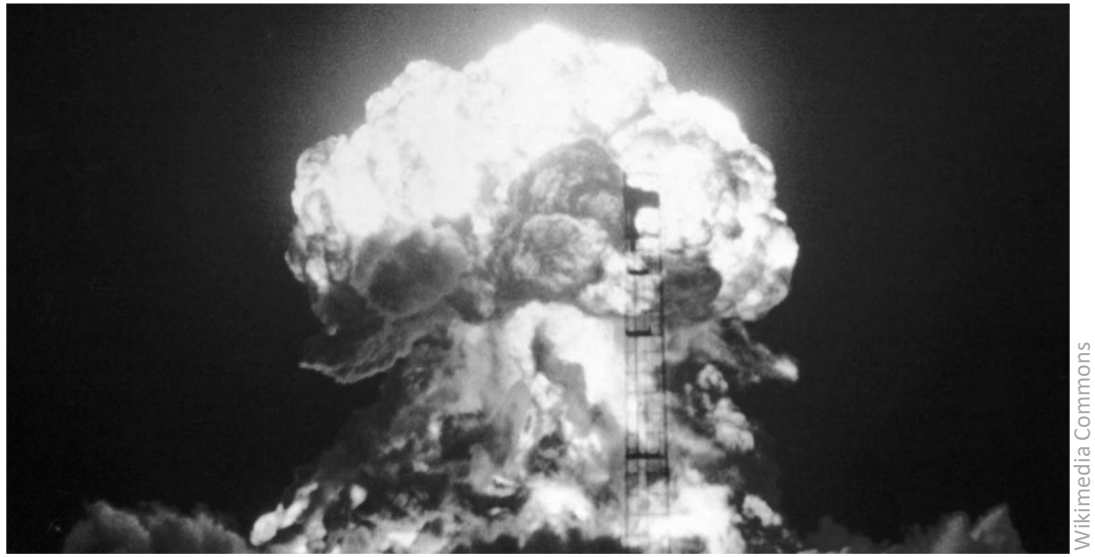
International scientific cooperation collapses

Meanwhile:

Key role of fossil fuels in World Wars

- WW I: fight for coal resources in Europe
- WW II: fight for coal and oil resources in Europe, MENA, Caucasus, Indochina, Indonesia
- US oil industry: key to the rise of US power

First applications of nanosciences: Nuclear bomb and Nuclear power



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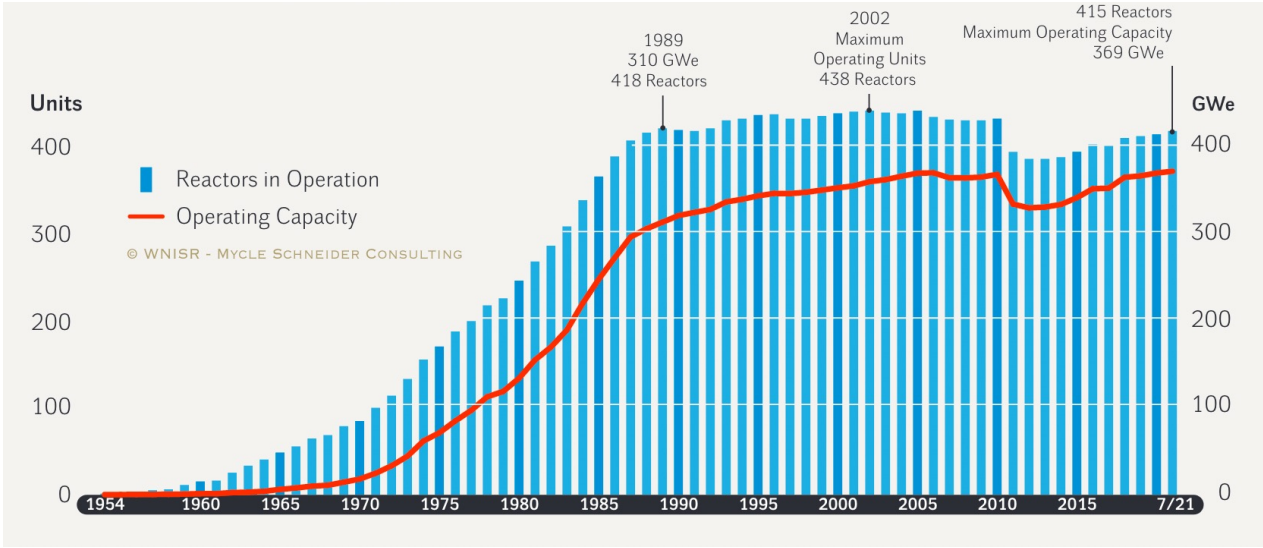


1945 **Nuclear bombs on Hiroshima and Nagasaki**

1952 **First electricity production with a nuclear reactor EBR-1 (USA)**

1979 **Three Miles Island reactor accident: end of the nuclear power euphoria**

Two key problems of nuclear power:

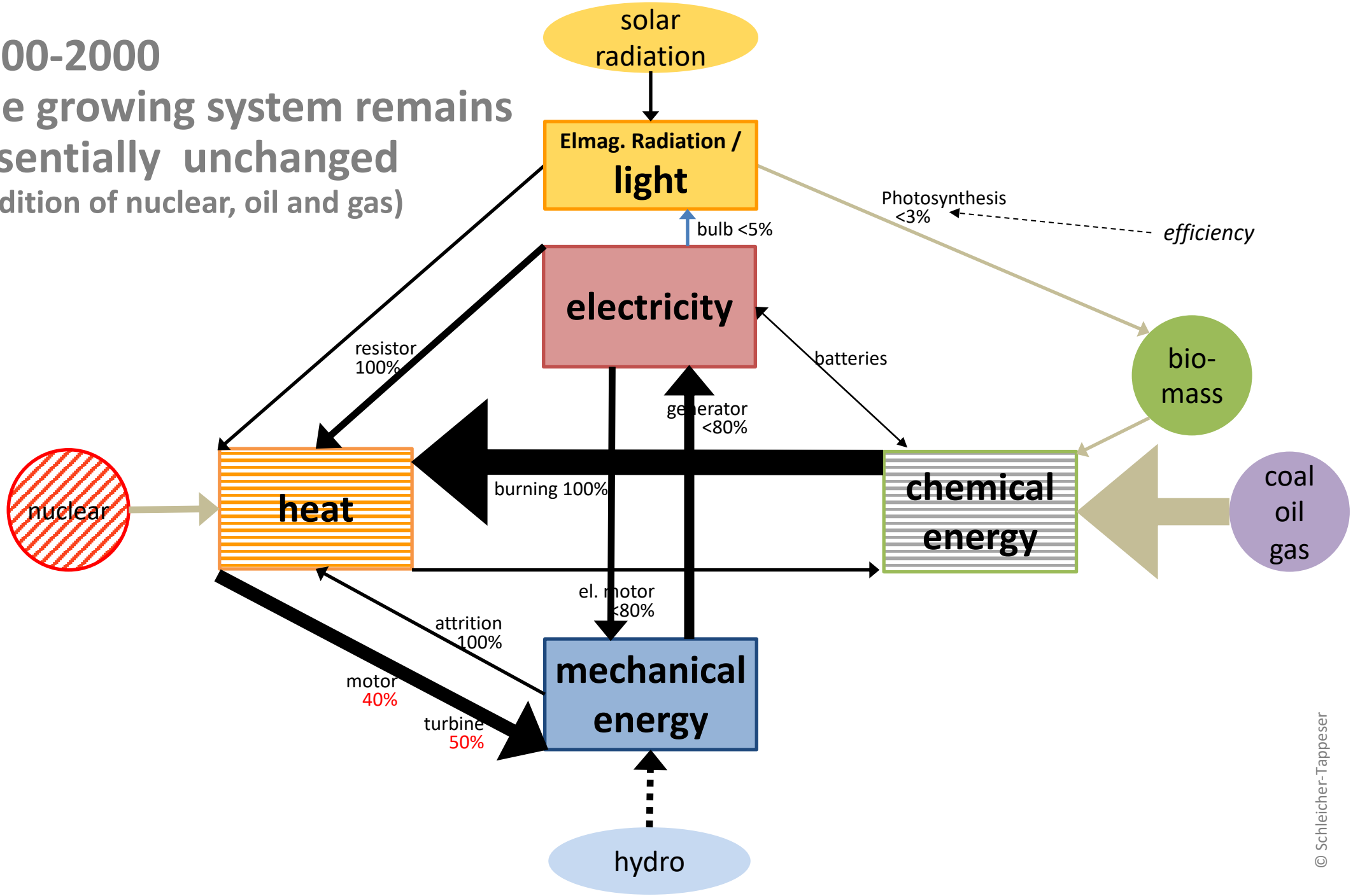
- permanent shielding of intensive radioactive radiation
- containing a potentially explosive chain reaction

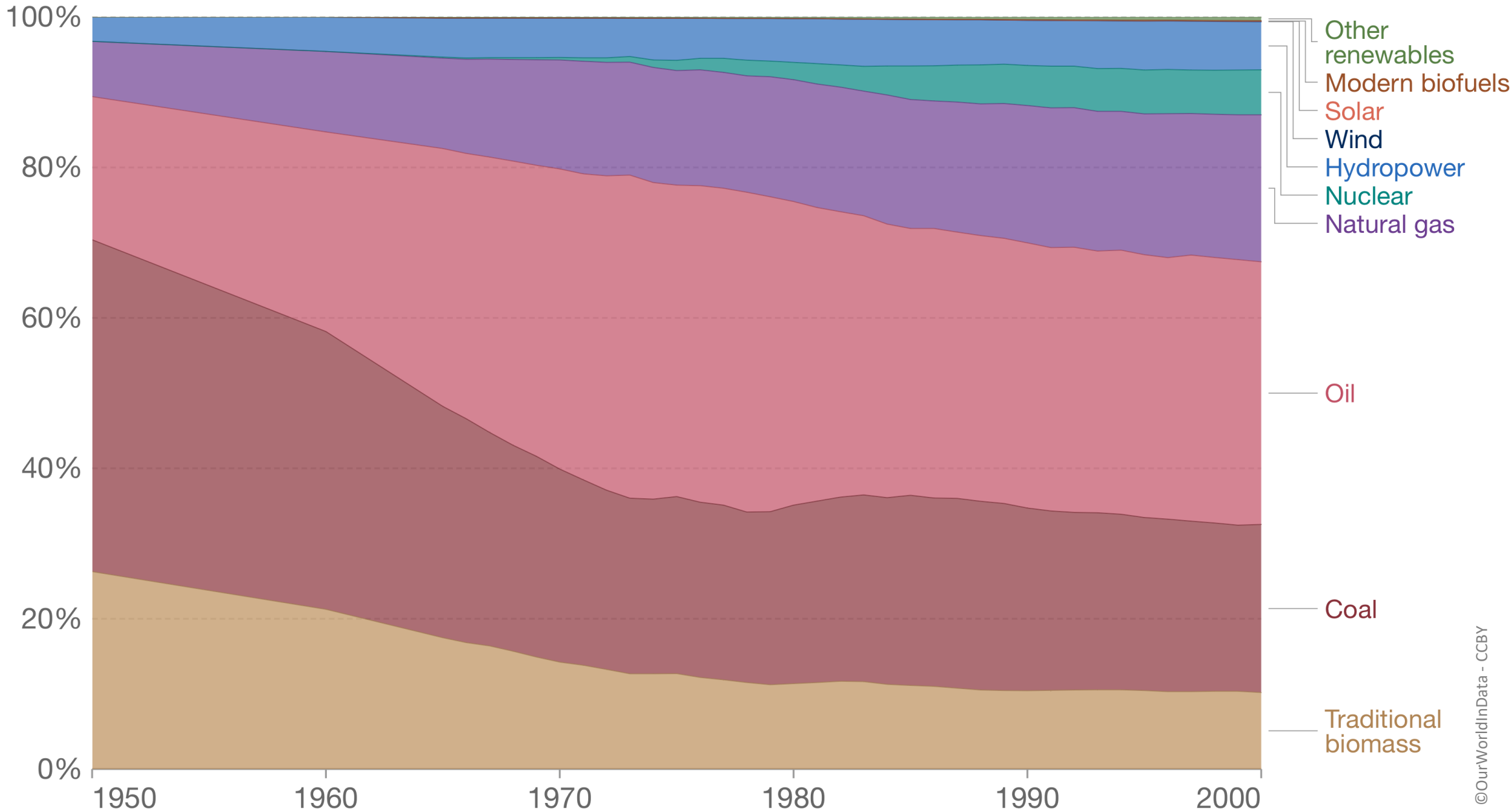
Efforts for increasing safety led to inexorably rising costs

Without civil nuclear power, no military nuclear power,
without military nuclear power, no civil nuclear power

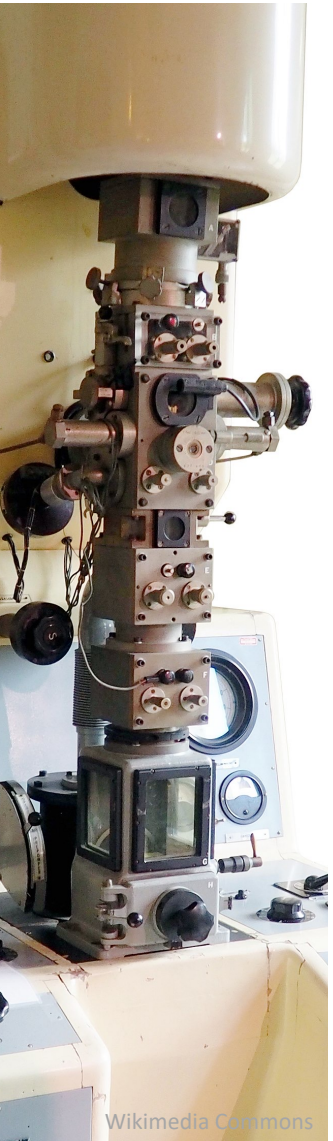
President Macron in his programmatic speech on the future of nuclear power on 8 December 2020

1900-2000
The growing system remains essentially unchanged
(addition of nuclear, oil and gas)





After 1950: Nanosciences bring new technologies RESEARCH and INFORMATION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New measurement methods and instruments → discovery of nanoworlds

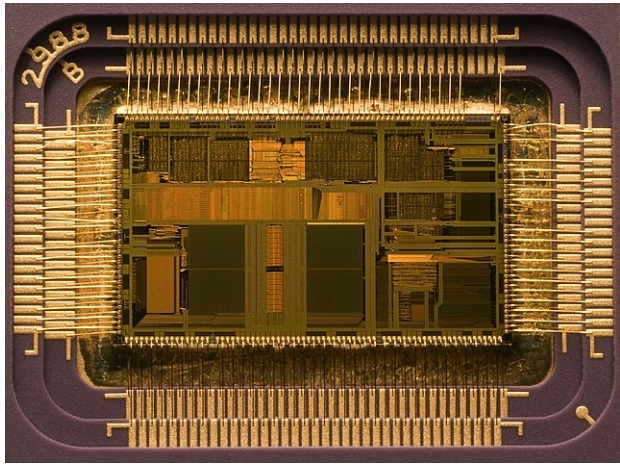
- Mass & other spectrometers
- Electron & X-ray microscopes
- Magnetic resonance imaging
- Sensors for chemicals
- Image sensors
- Positron Emission Tomography
- …

Transistor → Microelectronics → Digitalisation

1971: Microprocessor with 8,000 Transistors

2021: Microprocessor with 80,000,000,000 Transistors

Boost for all other technologies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DNA structure → Microbiology → Gene technology

1953: Discovery basic DNA structure

2021: mRNA vaccine beats Covid


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Information processing increasingly decoupled from matter and energy

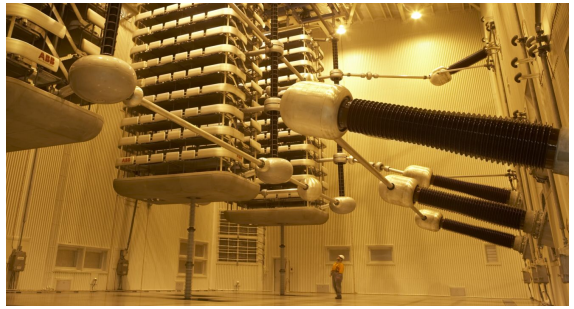
- **miniaturisation** saves energy, material and costs → boost in performance
- **increase in speed** saves energy, material and costs → boost in performance

Nanosciences bring
KEY NEW ENERGY TECHNOLOGIES

Photovoltaics

Power generation

- Direct generation of electricity from sunlight
- >20 times more efficient than photosynthesis
- Lowest electricity costs
- Decentralised generation
- Fluctuation with solar radiation



Power Electronics

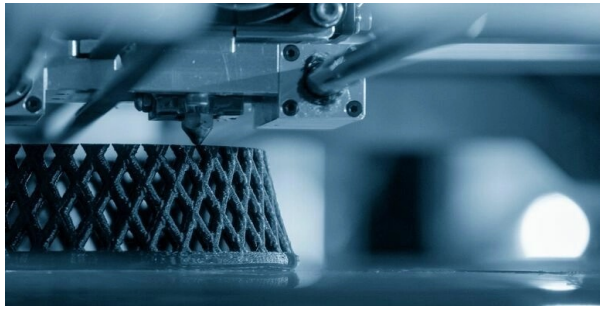
Power transformation, transport and control

- Electricity converters
- Wind power to grid
- Digital control of electricity systems
- Efficient grids, HVDC, superconductors
- Digital frequency control → efficient e-motors

Batteries

Power storage

- High-density electro-chemical battery cells
- Flow batteries for longer-term-storage
- Strong density improve-ments and cost reduction
- Fuel cells
- Improved electrolysers



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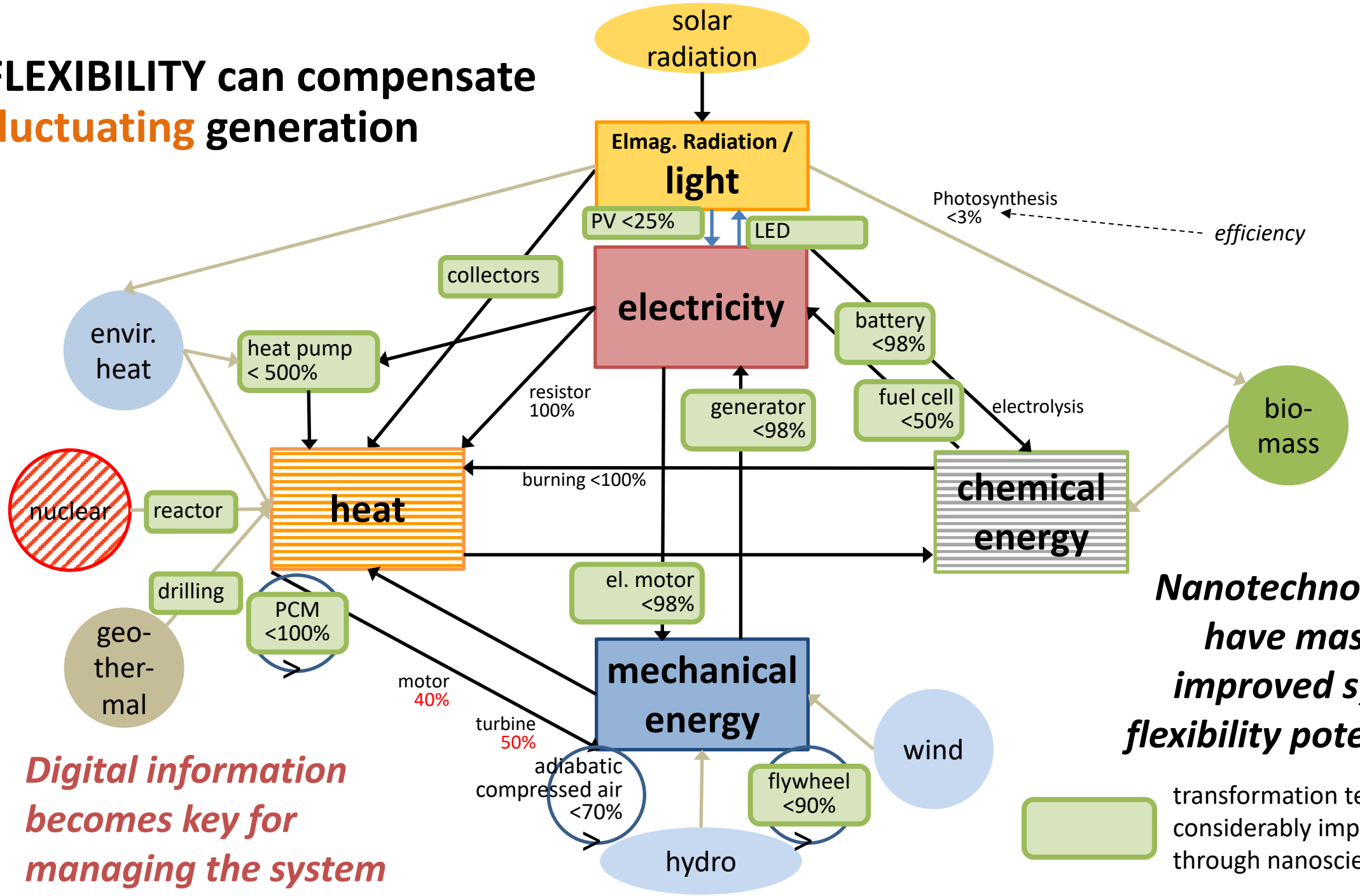
Additive Manufacturing

Material processing

- Up to 75% material savings
- High life-cycle energy savings
- Efficient decentralised small series production

Very rapid performance boost and cost reduction well above macroscopic process learning curves: miniaturisation and speed/efficiency increase due to improved processes at nanoscale

FLEXIBILITY can compensate fluctuating generation



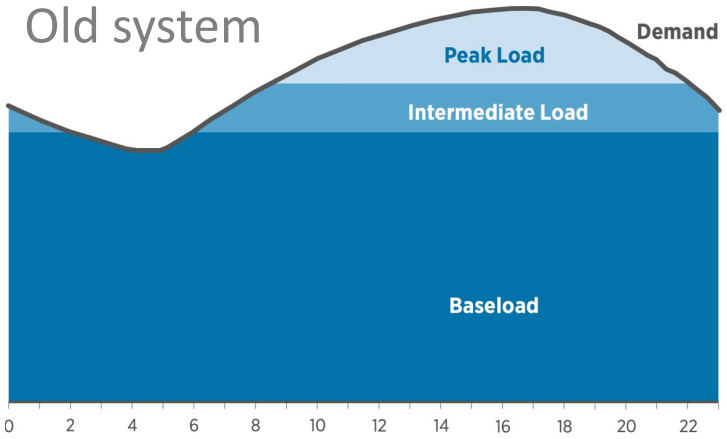
Digital information becomes key for managing the system

Nanotechnologies have massively improved system flexibility potentials

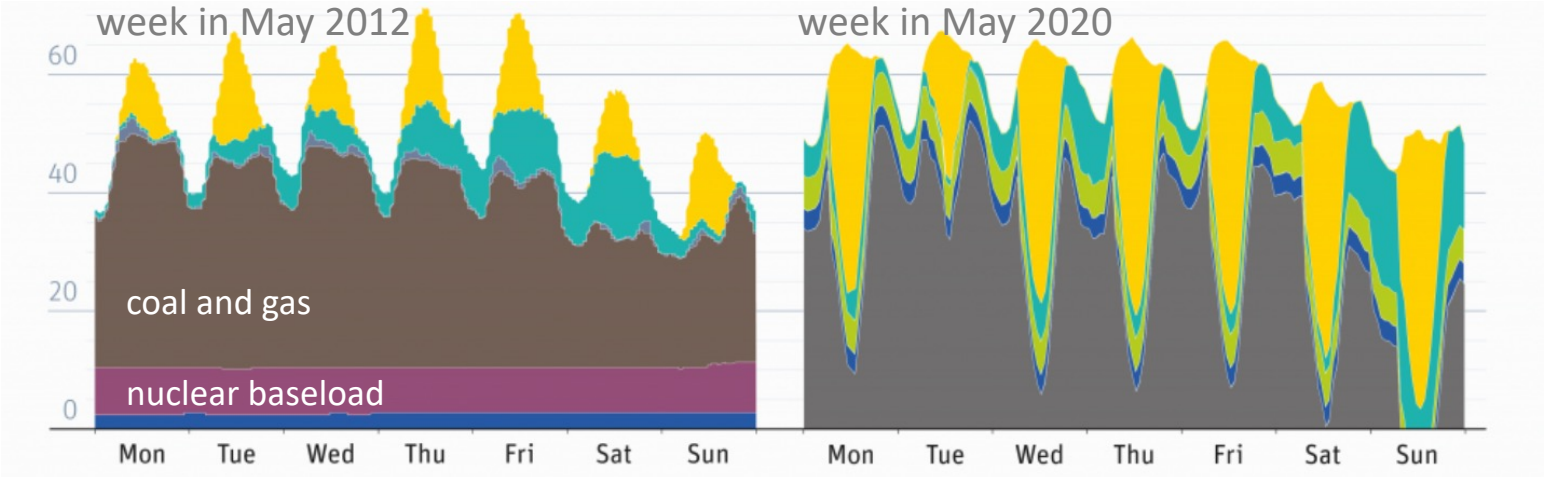
transformation technology considerably improved through nanosciences

System Transformation
New Paradigm

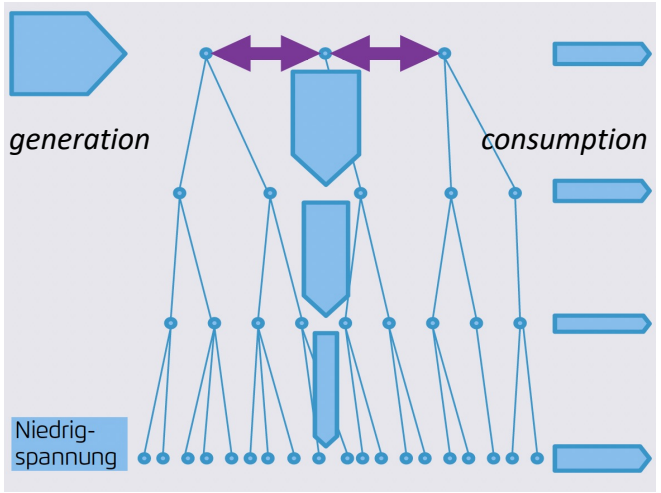
Old system



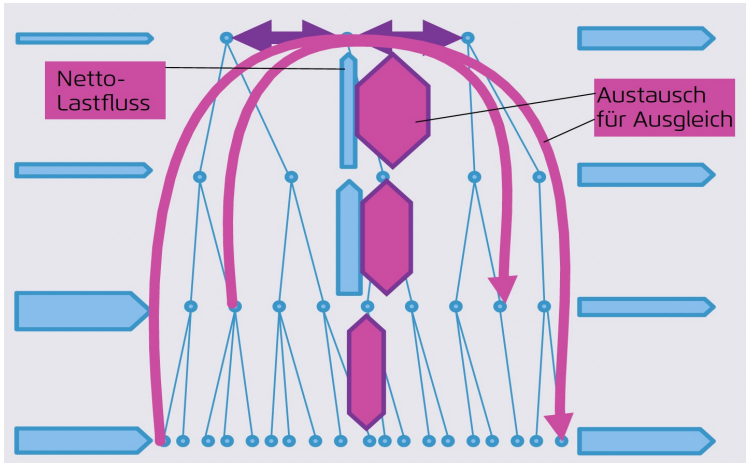
German electricity generation: no use for baseload



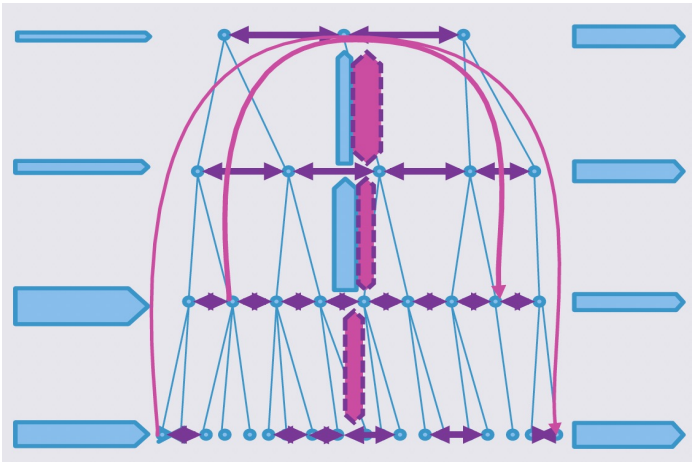
old system
central generation



old system + bidirectional flows
decentral generation



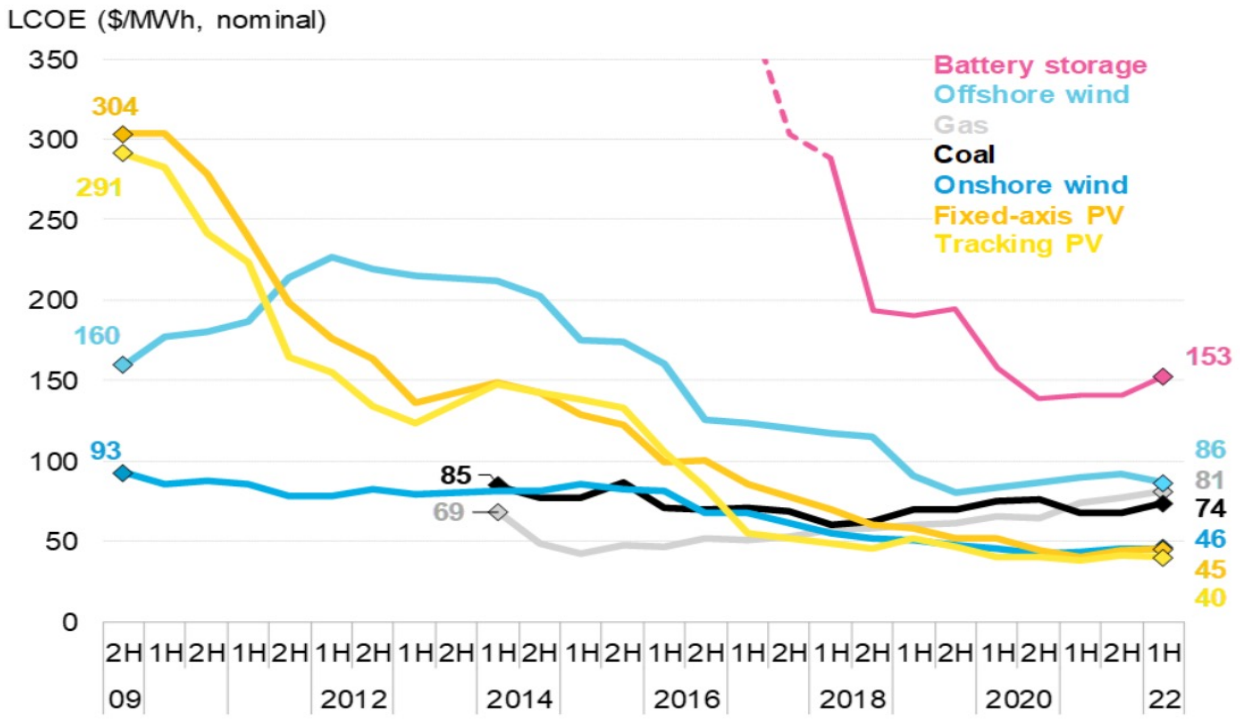
new flexible system
decentral generation



Unbeatable Photovoltaics

1. **Extremely reliable.** No moving parts, no fuel, very low risks. Last for 30 to 40 years
2. **Mass production.** Classical economies of scale. New factories: 50 million modules per year
3. **Rapid innovation at nano-scale.** 2010-21: module efficiency 14%→ 22%
4. **Extremely scalable, up and down.** Energy transformation occurs at nano-level
5. **Rapid deployment.** Factories 2a, plants ½ a → 10 x shorter innovation cycles
6. **Strong potential for further cost reduction.** Perovskite cells , material reduction with BIPV

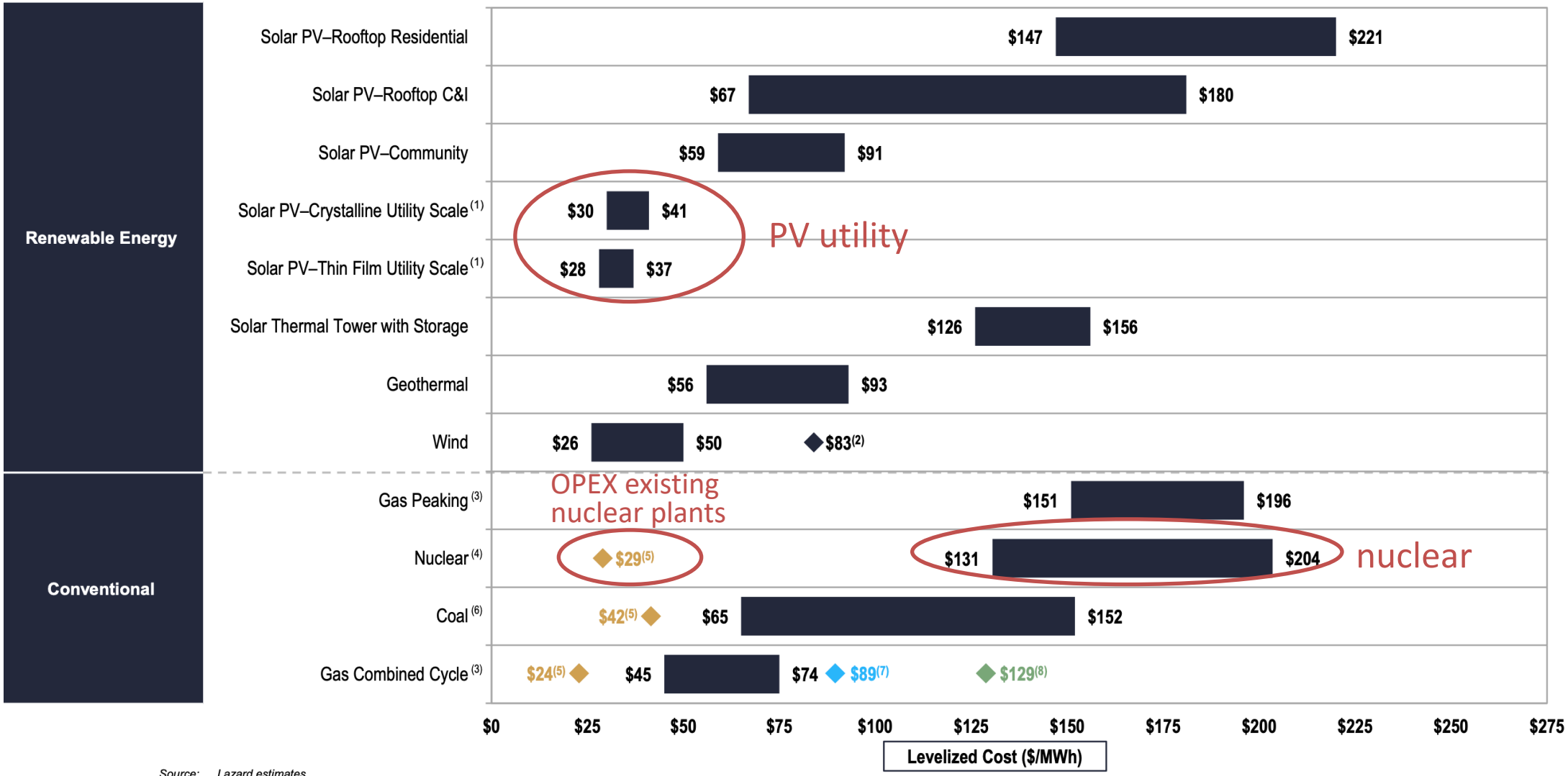
- No other energy source has matched efficiency gains, cost reductions and growth rates of PV
- **About half of module cost reductions (2010-2021: -88%) is due to nanotechnical innovation**



LAZARD

Levelized Cost of Energy Comparison—Unsubsidized Analysis

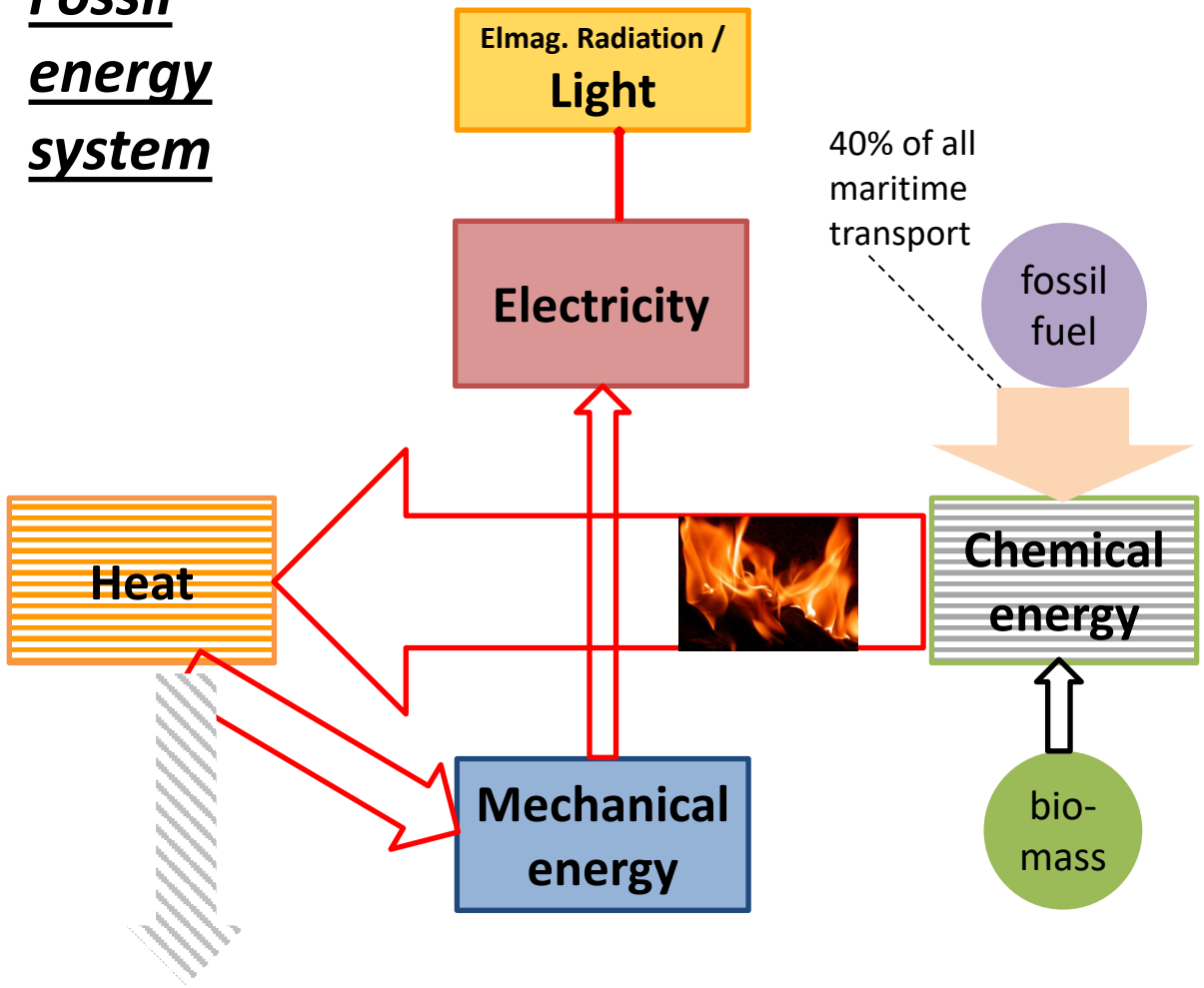
Selected renewable energy generation technologies are cost-competitive with conventional generation technologies under certain circumstances



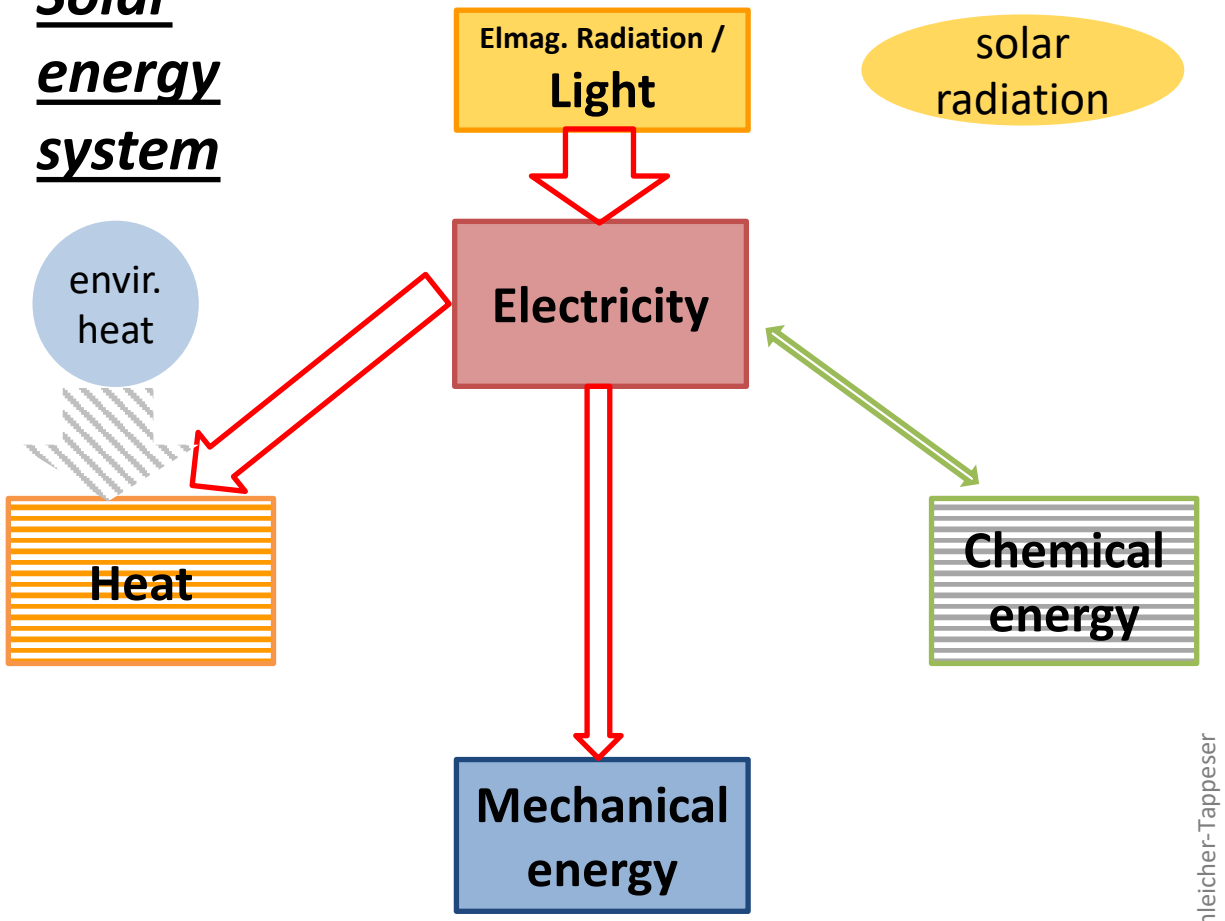
Source: Lazard estimates

A fundamental paradigm shift
Abandoning fire as basis of our civilisation
Huge gains in energy and material efficiency

Fossil energy system



Solar energy system



Drastically reduced energy & material throughput

PV and system change meet strong resistance since 50 years Intertwined national politics and IR

EXAMPLES

1973: Nixon's national energy research plan

1981: Reagan and U-turn of oil industry kill fledgling PV industry

2000: Introducing feed-in-tariffs

2009: Foundation process of IRENA

2011: European governments slash PV surge, 100'000 jobs lost in D

2014: No chance for PV industry in Europe – xGWp

2022: The hydrogen hype

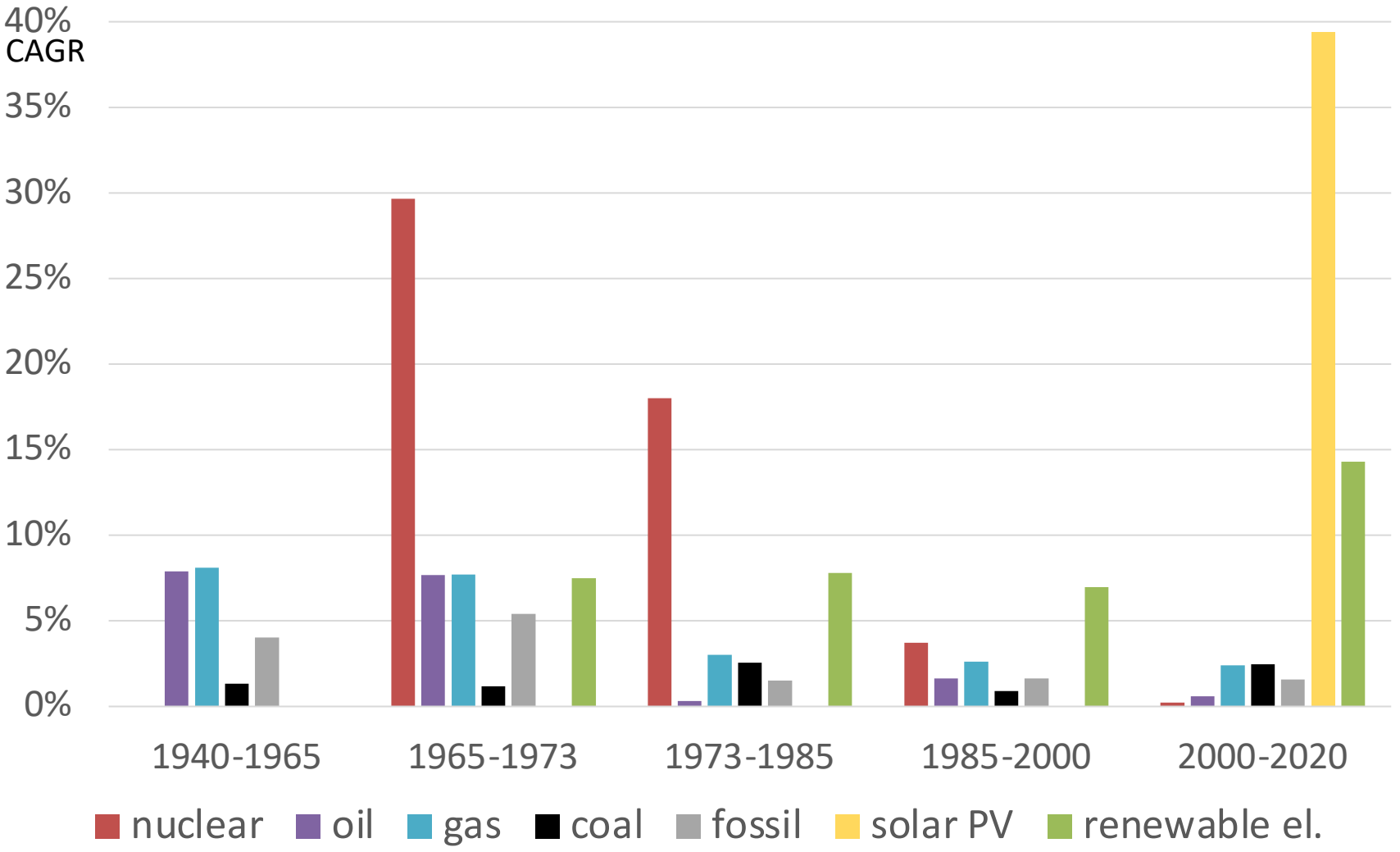
Politics is powerful
It can maintain structures beyond economic rationality over decades

- **Worldwide fossil fuel subsidies amounting to 6,8% of GDP (year 2000)**
- **Nuclear power in France**
- **Biomethanol additions to gasoline in Europe and the US**

Vehicle Distance From 1 Hectare of Solar Energy of Ethanol from Sugar or Maize:

Source: IEEFA: India's ethanol roadmap off course

Despite all: Growth patterns have shifted



- After oil crisis 1973, oil growth drops sharply from over 7% to 0,9%
- Nuclear growth drops with delay after 1979 TMI nuclear accident
- Solar grows sharply after 2000
- After growth drop in 1990, coal restarts to grow faster around 2000

Data: bp energy statistics, Our World in Data

Challenges for international relations – Accelerating the paradigm shift

- Understanding the new paradigm requires minimum **technological insight**
- Usually paradigms change with generations. We need a **technological tsunami** – more rapid and demanding than the one in information technology
- Implementing and improving **existing best technologies will do the job**. Waiting for miraculous innovations is harmful
- **IR tasks**: Cross-cultural learning, developing skills, technology transfer

Challenges for international relations – Overcoming the resistance of incumbents

- **Institutional and financial structures of old industrialised countries** have grown with the old technologies and resist change
- **Incumbent industries in old industrialised countries** were used to benefit from a long-grown privileged global oligopoly. They have adapted to slow growth and resist change. If unavoidable, they try to get subsidies.
- **Newcomers to the international economy –** emerging economies, tech industries – build fast-growing competition with new technologies.
- **Continued resistance and inaction** by incumbent industries in old industrialised countries have led to problematic dependence from newcomers (batteries, PV…)
- **IR tasks**: Encourage long-term thinking. Acknowledge the role of newcomers. Reduce incumbent privileges and subsidies. Adapt market designs to low marginal costs and decentralised networks. Support technologies that allow for decentralisation & transparency. Encourage diversification & reduce dependencies.

Challenges for international relations – Managing comparative advantage shifts

- **Energy system change will shift established patterns** of comparative advantages: More widely distributed cheap primary electricity. Lower marginal, higher fixed costs – especially for heat. More expensive long-haul transport, lower transport volume.
- This puts **pressure on energy-intensive industries, equipment providers and international logistics** to adapt spatial patterns and volumes.
- **Adapting spatial patterns may have important consequences** for labour, skills, education. As energy-intensive industries have formed clusters, this **may hit whole regions.** In times of labour shortage, development of new skills is key.
- **Resisting adaptation with subsidies or protectionism** is tempting but comes at a high long-term cost : Slower change, lower economic efficiency, financial losses.
- **IR tasks**: Establish multilateral adaptation schemes. Facilitate experience exchange and migration. Enhance economic cooperation, especially within continents.

Thank you

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