



# Lecture on Energy Transitions for the Climate

## Energy: from Culprit to Saver of the Climate

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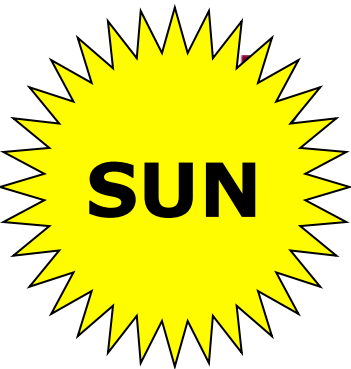


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- ❖ **What makes the world go round?**
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- ❖ **Energy transitions = core of climate policies**
- ❖ **Affordable, possible but Radical, Rational, Reverse**
- ❖ **A little of political economy**



# What makes the world go round



**SUN**

**Discourses, myths  
Paradigms**

**People  
Families  
Communities  
Cities, States  
Supernational  
Organisations**

.....

**Institutions  
(habits, norms,  
rules, institutes)**

\$\$\$\$\$  
\$\$\$  
\$

**Money**

**Infrastructures  
(housing, transport,  
production, commerce,  
education, recreation)**

**ENERGY ⌘ Technology**



## 20<sup>th</sup> century bequest: problems & solutions

### **Populations, wealth growth unrestricted, uneven, thoughtless**

- From 2.5 billion [1950] to 7.5 billion [2017] humans
- Unequal wealth across countries + within countries
- Environment & Nature depletion, pollution, destruction, ...

### **1987 Sustainable Development (SD): Our Common Future**

- WCED: Environment & Development address together

### **1992 Rio de Janeiro world summit**

- World leaders accept global SD as future paradigm
- UNFCCC: avoid dangerous climate change, all countries' common but differentiated responsibility (repeated in Paris, 2015)

### **Fossil fuels: CO<sub>2</sub> + other environmental pressures**

- Continuous growth of petroleum, natural gas, coal use
- Geopolitical conflicts, wars, in resources endowed regions

### **1953 'Atoms for Peace': atomic electric power**

- Promised energy Eden ⇔ today <2% final energy use
- Risks (accidents, atomic weapons), eternal waste, mounting costs

### **Science & Technology**

- Exponential increase and diversity of technologies
- Surfboard for globalization (www), new media (fake news), renewable energy & efficient use of energy, ...



# Civilization ⌘ Energy uses



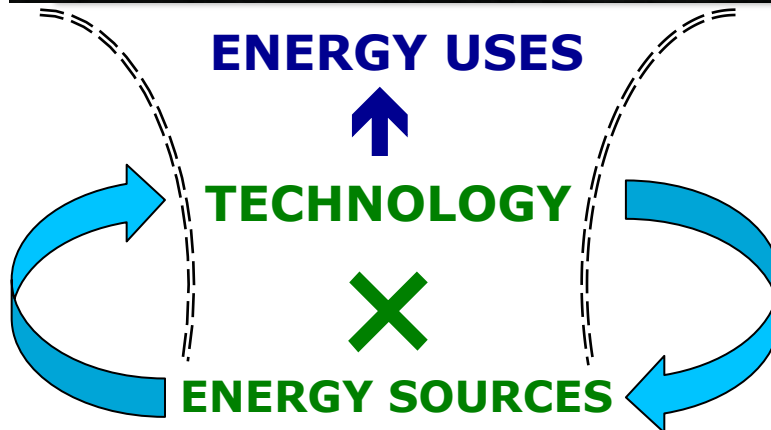
## Civilization

### Inertia (lock-in)

- Paradigm of economic growth
- Discourses (myths; fake news)
- Institutions (norms, institutes)
- Interests, small to giant

Reversal feasible

⌘ policies, social constructs, vocal youth4climate, ...



## Substraat

### Inertia (lock-in)

- Infrastructures
- Habits (!mobility)
- Influential interests (oil&gas, electricity, atomic sector)

Reversal feasible

⌘ new knowledge, technology

From: Weak Technology requiring Dense Sources  
To: Strong Technology harvesting Diffuse Sources



**1. People**

≈  
**7.6 billion (2018)**

**2. Wealth**

≈ triljon \$US  
**75.64 (2016)**  
**87.50\* (2018)**

**3. Fossil fuels**

≈ 11.5 billion toe (2017)  
coal, petroleum, natural gas

**Gaseous litter**

≈ 36 billion tons CO<sub>2</sub> (2016)  
+ SO<sub>2</sub>, NO, NO<sub>2</sub>, PICs, PACs  
+ Particulate Matter  
(PM<sub>2,5</sub>; PM<sub>10</sub>), etc.

**4. Nuclear fuel**  
**< 2% of final energy use**

**Eternal waste problems**  
**Accidents-Catastrophes**  
**Proliferation weapons**



## Present

Obscene  
Rich  
Wealth  
↑  
American  
Dream  
↓  
Poverty  
Behoeftig  
Kansloos

**Fossil  
fuels**  
&  
Atomic power

Transition 2

Transition 1

RE  
Renewable  
Energy

Energy  
efficiency

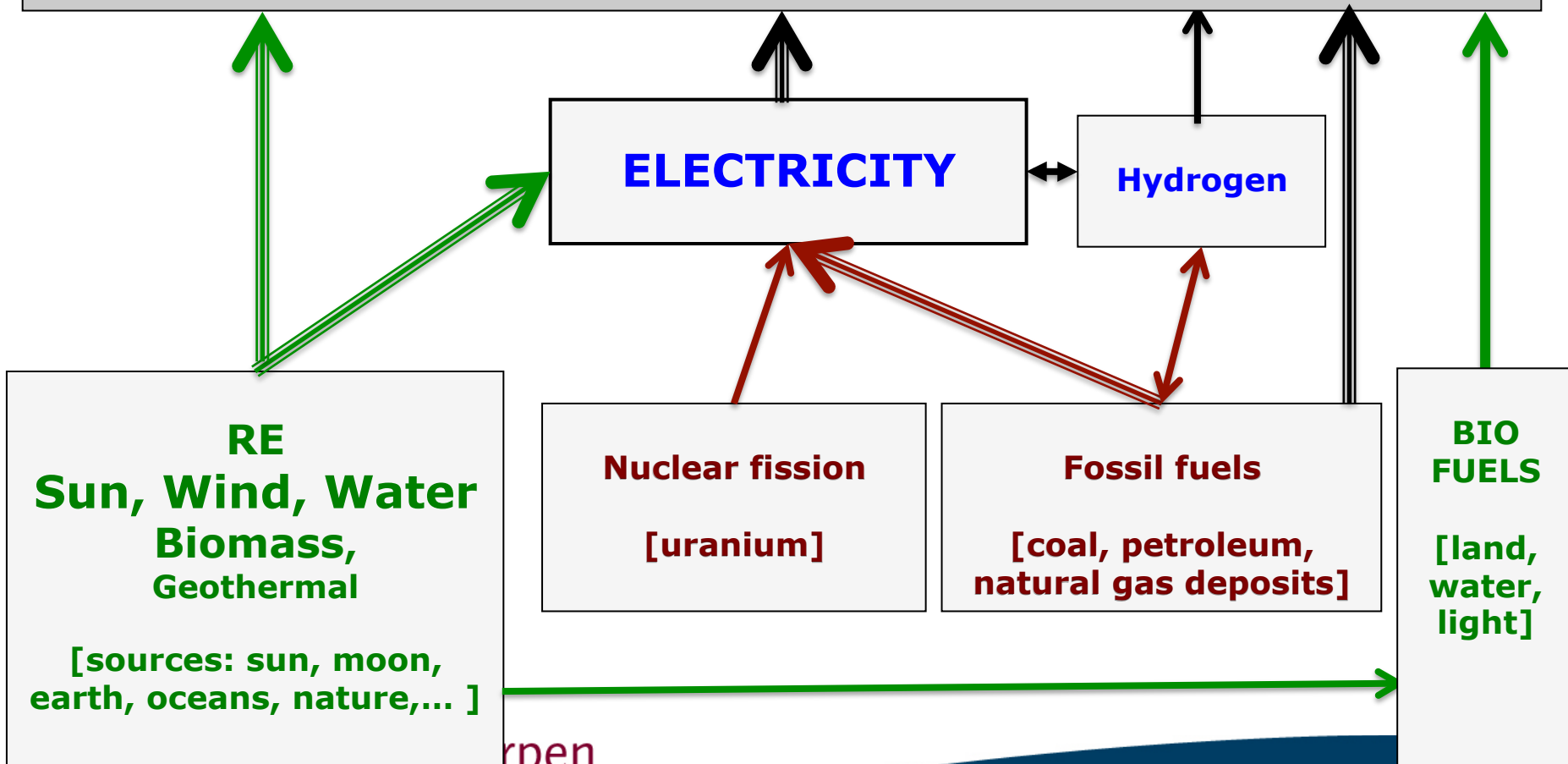
## Future

Global Sustainable Development



# Comprehensive view Energy Demand & Supply

Activities in  
Households + Services + Agriculture + Industry + Trade + Transport  
need  
Energy Services  
Light + Process heat + HVAC + Drive power (stationary, mobile)





## Energy system transitions – reversals

Of all times, spontaneous, wanted

- Progress by domesticating fire, animals; inventing tools
- **Linked with technology** from levers, wheels, sails, ... to electronics, ICT, new materials, biotechnology, ...
- **Revolutionizes civilizations, human societies**
  - 18<sup>th</sup> – 20<sup>th</sup> century: steam, electricity, internal combustion engine**
  - 21<sup>st</sup> century: renewable power directly harvested in the environment**

**NOW: forced transitions by climate change, environment & nature degradation, rising risks**

### ToDo list:

- (1) **Electricity (+ hydrogen) as major energy vector**
- (2) **Exclusively renewable energy**
  - + rational improving of energy efficiency**
- (3) **Keep fossil fuels underground**
- (4) **Phasing out atomic power**



# (1) Electricity as major energy vector


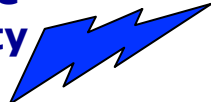
## Electric energy is a flow

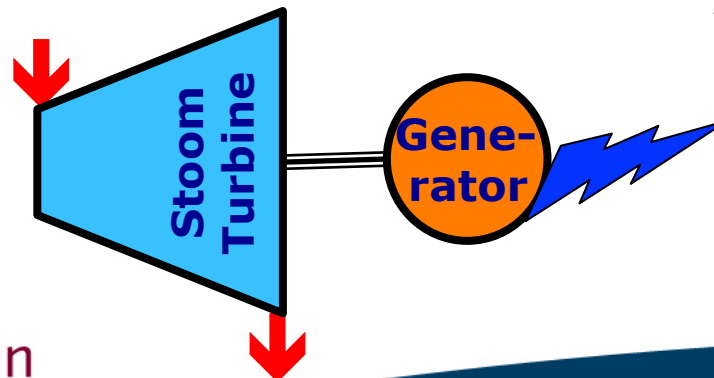
- Not available in nature for human use (as lightning is)
- Supply by conversion of other energy flows
- Non-storable

## Steam era (18<sup>th</sup> – 20<sup>th</sup> century)

- Geothermal steam at some locations (e.g., Iceland), low pressure, polluted, ...
- Steam from fossil (bio) fuels, & atom fission

## CORE of steam power generation plant:

SteamTurbine: kinetic energy in high-pressure steamflows  
Causes turbine-axis  to rotate  
Generator converts rotation in electricity 





# Steam for electricity generation

## Source flabs

## Sink flabs

### ISSUES

The long & costly ways for obtaining high-pressure steam flows spinning the turbine

Essential resources:

1. **Fuel**
2. **Water**

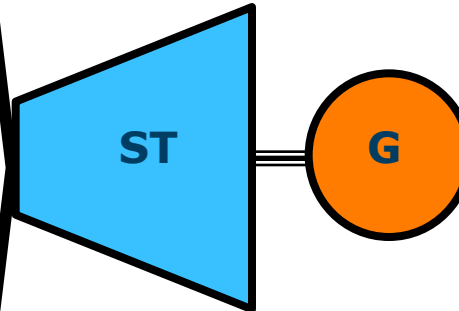
Major fuel stages:

- Exploration of sources
- Development of mines, wells
- Exploitation
- Transport & storage
- Fuel cleaning, conversion, upgrading, preparing

Major water stages:

- Tap clean sources
- Demineralize flows
- Pressurize
- Re-use condensate

CORE Steam Power Plant  
Turbine --- Generator



The long & costly proper disposal of residual outputs

Major residuals:

1. Flue gases
2. Solid waste
3. Radiation
4. Cooling water

Flue gas problems:

- Dust, particulate matter
- Carbon dioxides
- Sulphur & nitrogen oxides
- Incomplete combustion

Waste issues:

- Coal ash, dust, ...
- Nuclear wastes of various degrees

Cooling water:

- Large flows
- Evaporation

# Steam for electricity generation

## Source flabs

## INSTALLATIONS

## Sink flabs

### From fuel to steam

#### Coal

- Mines: delving machinery
- Washing, sorting, storing
- Transport: belts, trains, vessels, harbours
- Crushing, milling, powdering
- Combustors, ventilators
- Feed water pumps
- Boilers, economizers, ..
- Steam pipes, nozzles

#### Natural Gas

- Wells: winning, cleaning
- Compressing, liquefying, storing
- Transport: pipelines, LNG ships
- Air capture & compression
- Gas turbines + steam turbine
- Heat recovery steam generator

#### Nuclear

- Uranium mines
- Yellow cake, enrichment
- Fuel tablets, canisters
- Containment, Reactors
- Feed water pumps
- Steam generators

CORE Steam Power Plant  
Turbine --- Generator

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### Waste handling & Installations

#### Coal

- Flue gas cleaning
- Dust precipitators, filters
- Sulphur scrubbers
- Carbon Capture & Storage
- Stacks
- Ash, dust, gypsum management

#### Natural gas

- Flue gas cleaning
- Catalytic NOx reduction
- Carbon Capture & Storage

#### Nuclear

- Nuclear facilities decommissioning
- Nuclear fuel waste cooled storage, reprocessing, eternal storage
- Decontaminating radiated sites, including accidental areas

#### Discarding waste heat:

- condensers, pumps,
- cooling towers,
- rivers, lakes, sea



# Illustration of source flab installations at coal fired power plants



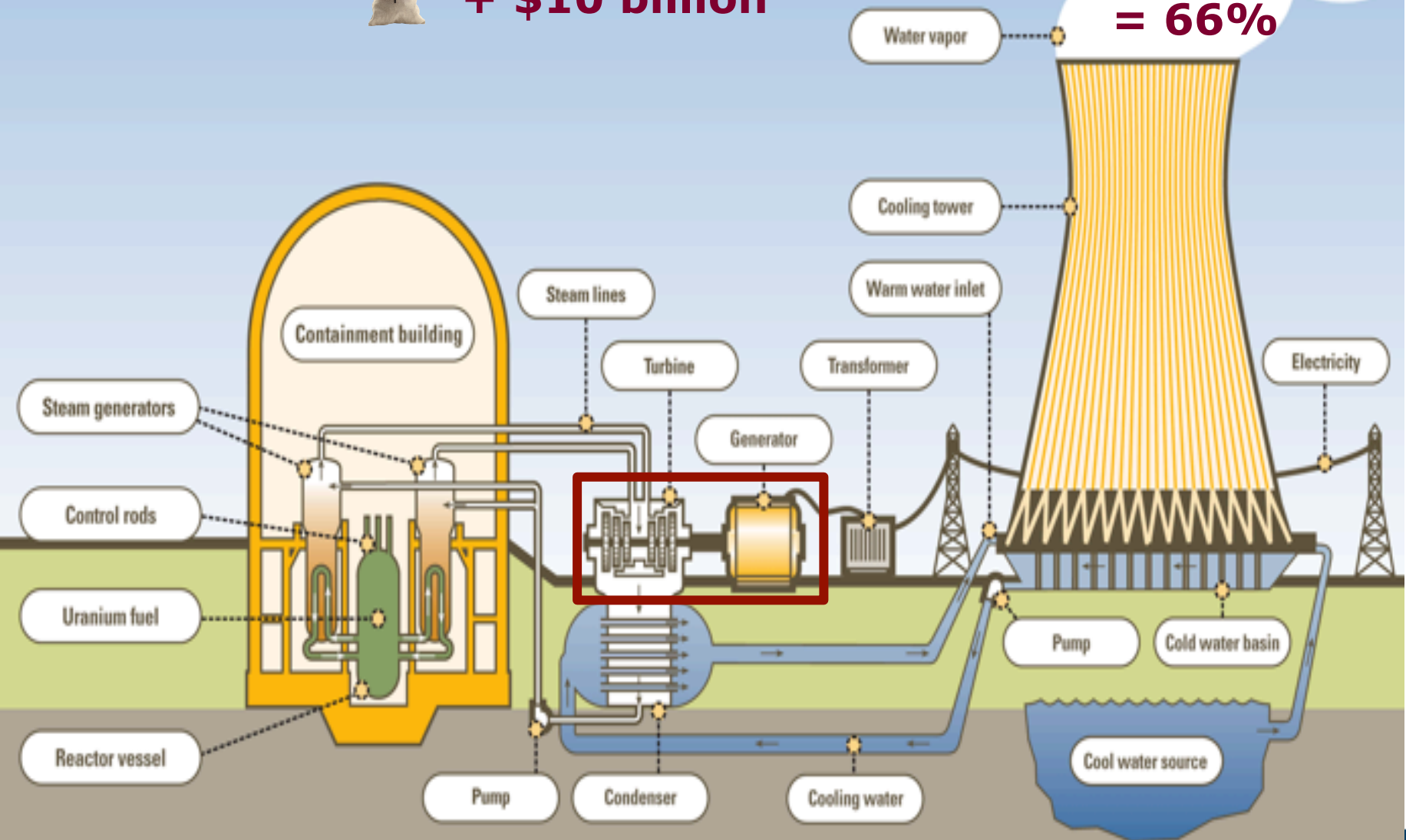


# Nuclear plant as 'should' (Walt Disney picture)



**Construction  
+ \$10 billion**

**Waste heat  
= 66%**





# Illustration sink flab atomic power Fukushima Daiichi destroyed (photo)

**Clean area and cooling water stocks  
+ \$500 billion?**







# Energy-industrial revolutions

18<sup>th</sup> – 19<sup>th</sup> century ⇔ 3<sup>rd</sup> millennium

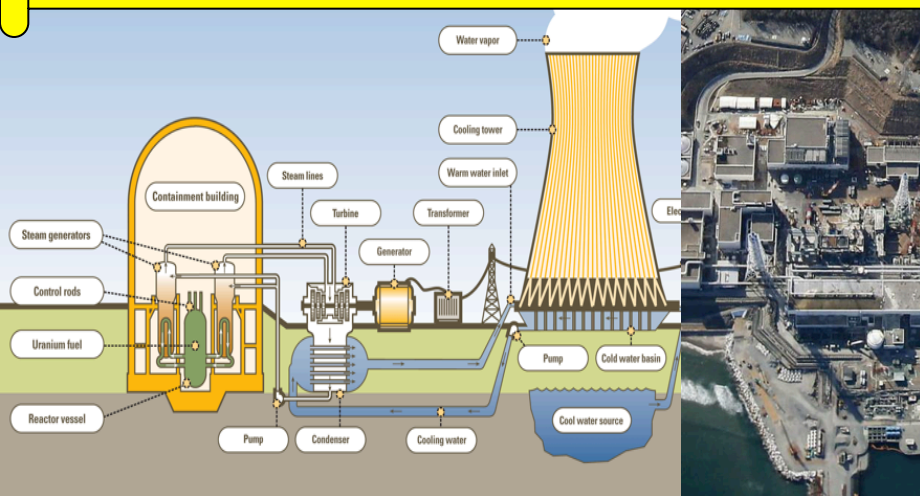
**Heat to Power** ⇔ **Harvest Ambient Power**



**From cumbersome technology  
requiring dense sources**

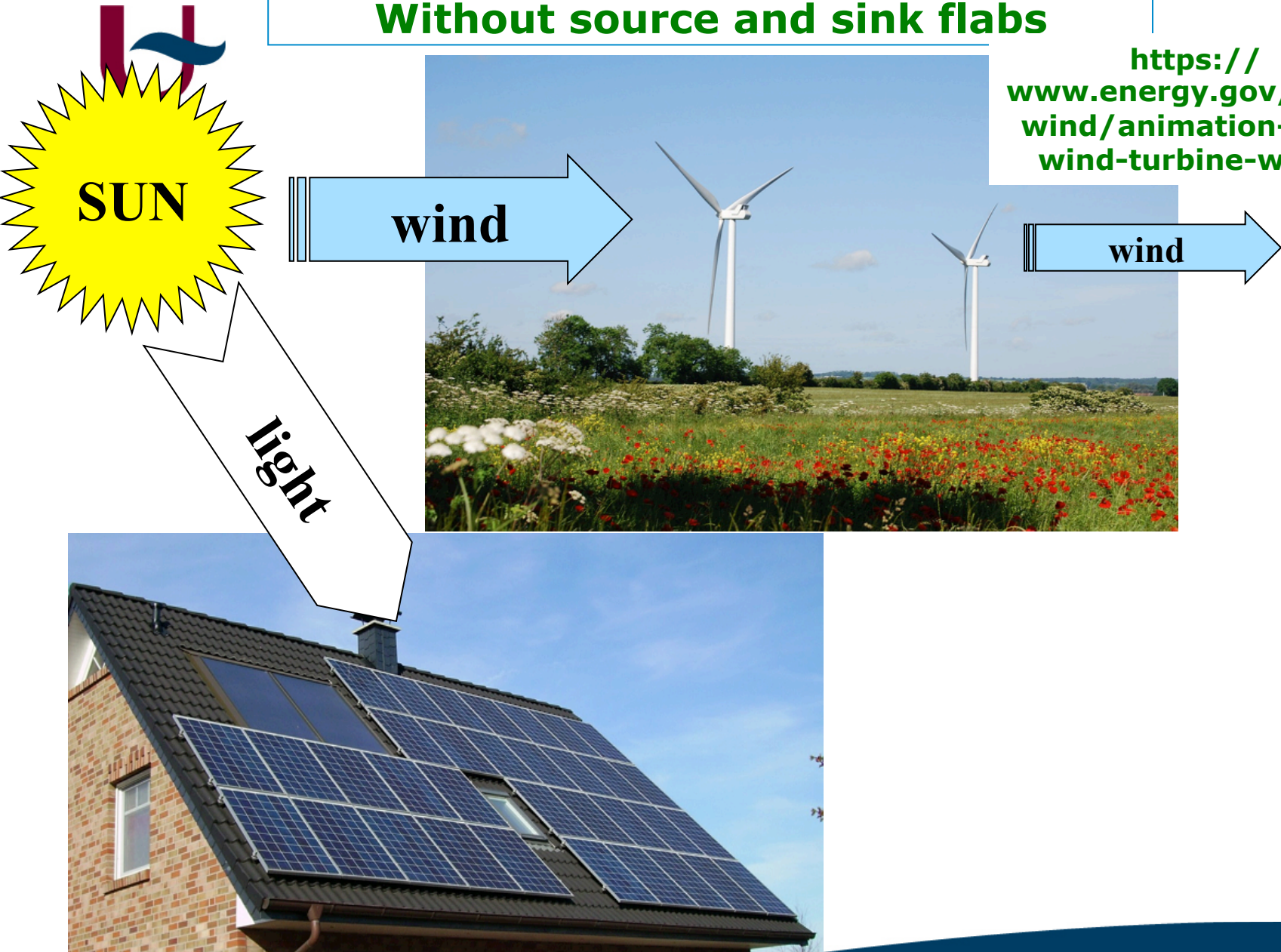


**To direct harvesting of  
diffuse, variable flows**



# Harvesting Ambient Power Without source and sink flaps

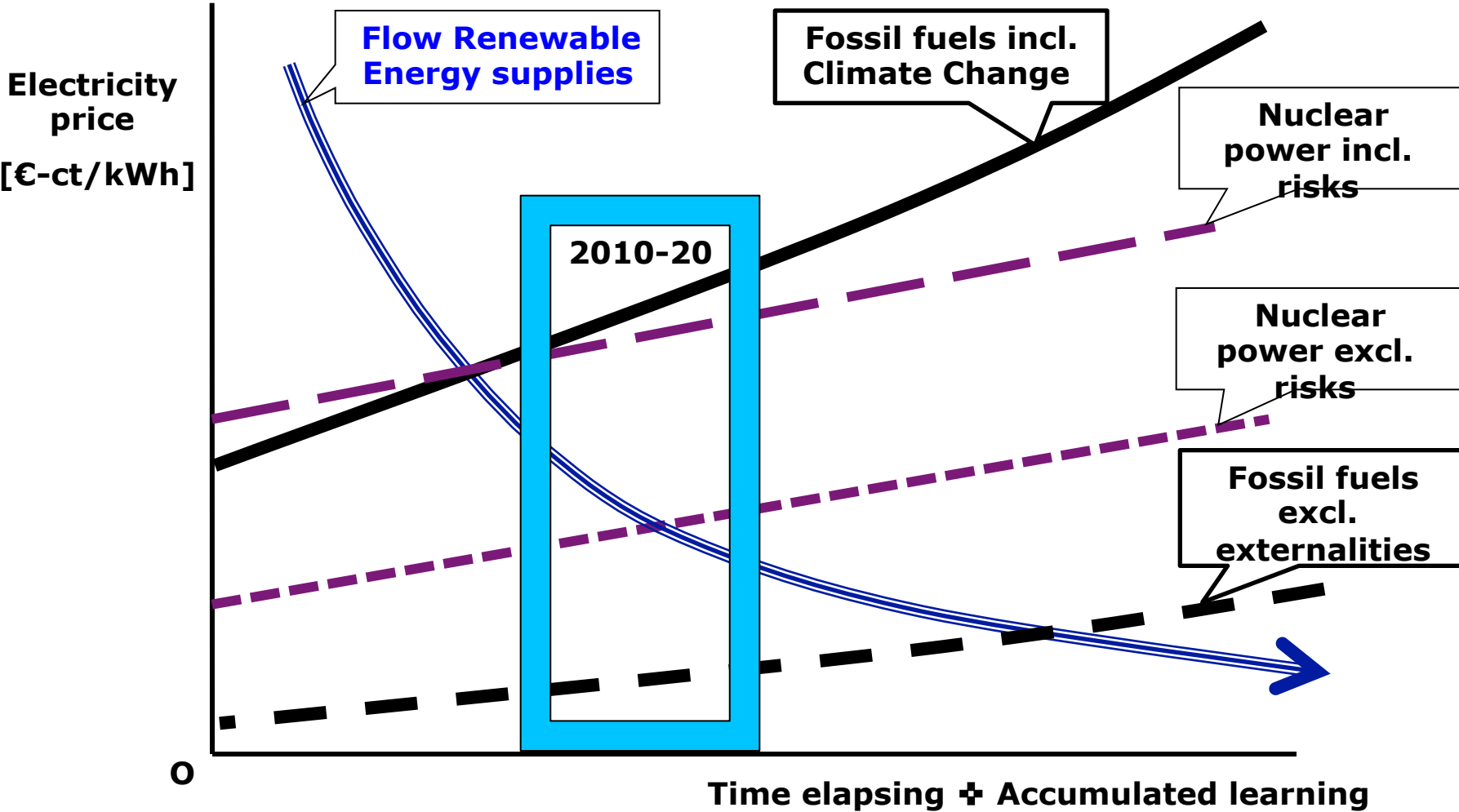
[https://  
www.energy.gov/eere/  
wind/animation-how-  
wind-turbine-works](https://www.energy.gov/eere/wind/animation-how-wind-turbine-works)







Denmark, Germany, ... created a decisive, irrevocable reality by RE-technology specific support





## (2) All on Renewable Energy (RE): Technical & Economic feasibility?

RENEWABLE ENERGY SOURCES  
AND  
CLIMATE CHANGE MITIGATION

Renewable  
Power  
Generation  
Costs in 2017



INNOVATION LANDSCAPE FOR A  
RENEWABLE-POWERED FUTURE:  
SOLUTIONS TO INTEGRATE  
VARIABLE RENEWABLES

**IRENA (2018): RE cheaper  
than fossil energy {exclusive  
of fossil external costs!}**

**IRENA (2019):  
Several RE innovations  
are upcoming**

**IPCC (2011): RE can supply  
all energy services**

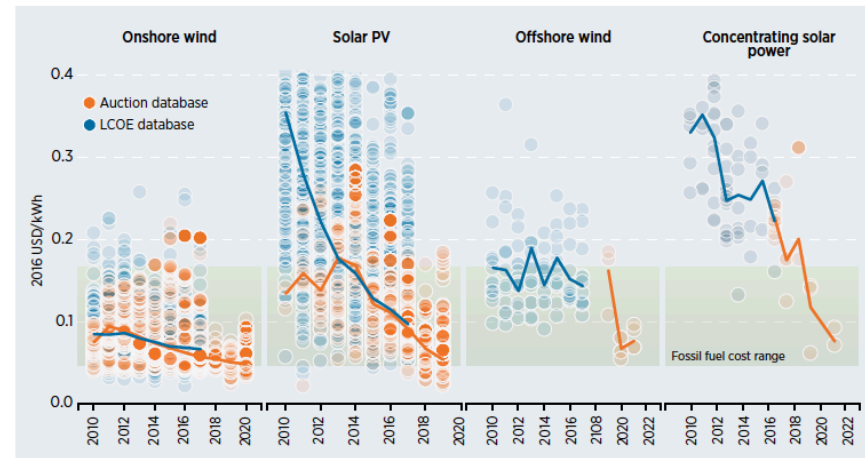
SPECIAL REPORT OF THE  
INTERGOVERNMENTAL PANEL  
ON CLIMATE CHANGE



**RE motto:**

**Drops aggregate to flows**

**Figure ES.2** The levelised cost of electricity for projects and global weighted average values for CSP, solar PV, onshore and offshore wind, 2010-2022

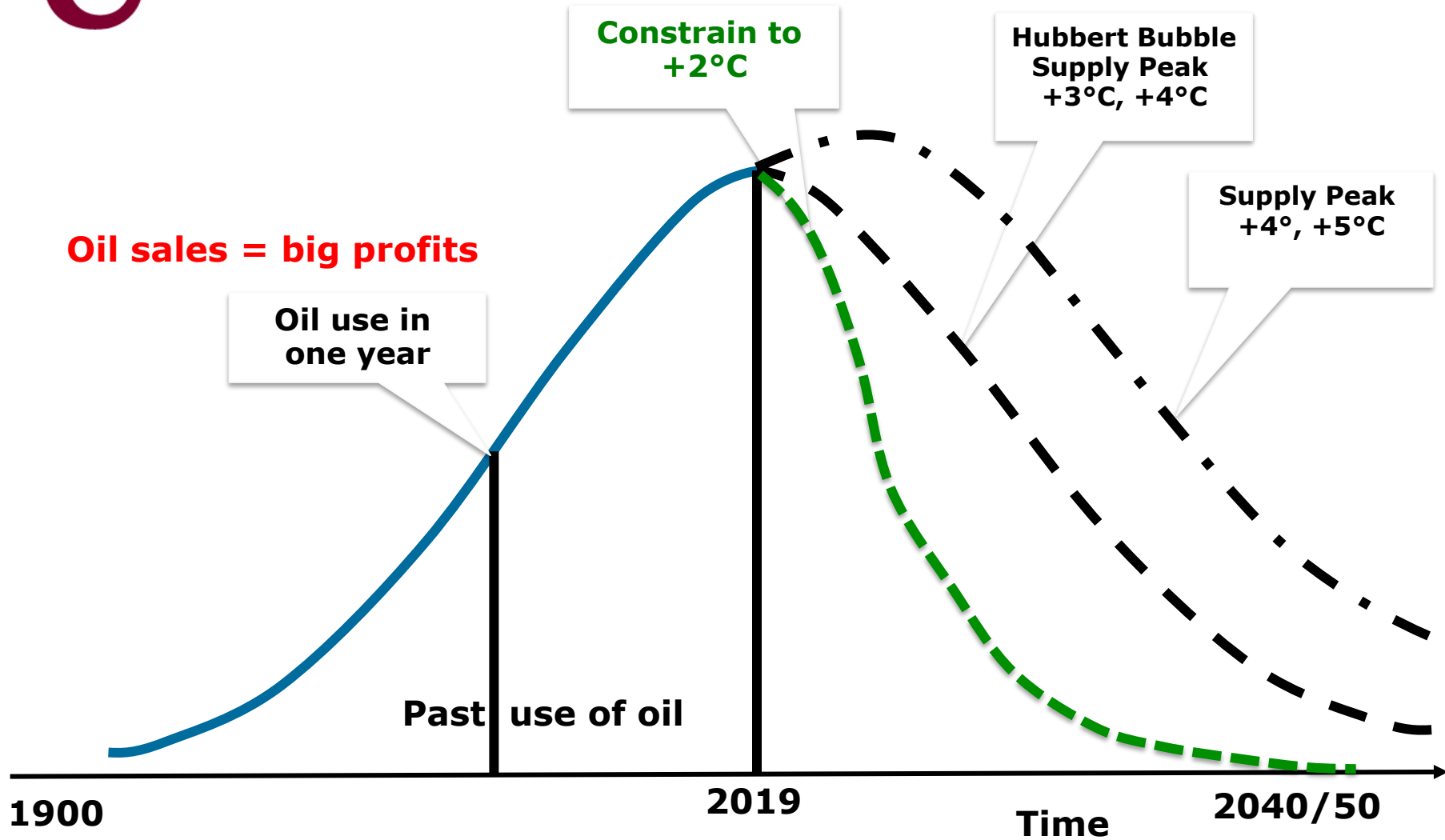


Source: IRENA Renewable Cost Database and Auctions Database.

Note: Each circle represents an individual project or an auction result where there was a single clearing price at auction. The centre of the circle is the value for the cost of each project on the Y axis. The thick lines are the global weighted average LCOE, or auction values, by year. For the LCOE data, the real WACC is 7.5% for OECD countries and China, and 10% for the rest of the world. The band represents the fossil fuel-fired power generation cost range.



### (3) Constrained oil use ⇔ Depletion oil sources ⌘ gloabl warming +2°C, +3°C, +4°C, +5°C, ...





**Constraining oil use = geopolitical conflicts**

**Embargoes – Invasions – Civil wars**



**USA Oil giants & Gulf states pursue monopoly in oil sales**



## (4) Atomic power: a death horse

### Atomic power: World War-II fetish

- Trailblazer of energy obesity since 1950s
- **1950-2000: ALL** means for development & experimenting
- 'Outcomes/Inputs' is negative
  - Huge costs and risks, already in present GEN-III+ reactors
  - Technological failure of GEN-IV breeder, high temperature, small modular reactors, plutonium and thorium fuel cycles

### Persistent problems:

- Fake '*Atomrisks are negligible; people, behave rational: accept the risks*' ⇔ **global re-insurance companies refuse the risks**
- Giant power stations (1700 MW), many units on one site, series building; if not, too expensive (International Energy Agency)
- Atomic waste is a burden for all future generations
- Illusion: GEN-V fusion (ITER demo-project)

**Opposite to Sustainable Development**

**Atomic not compatible with wind, solar, water flow power**

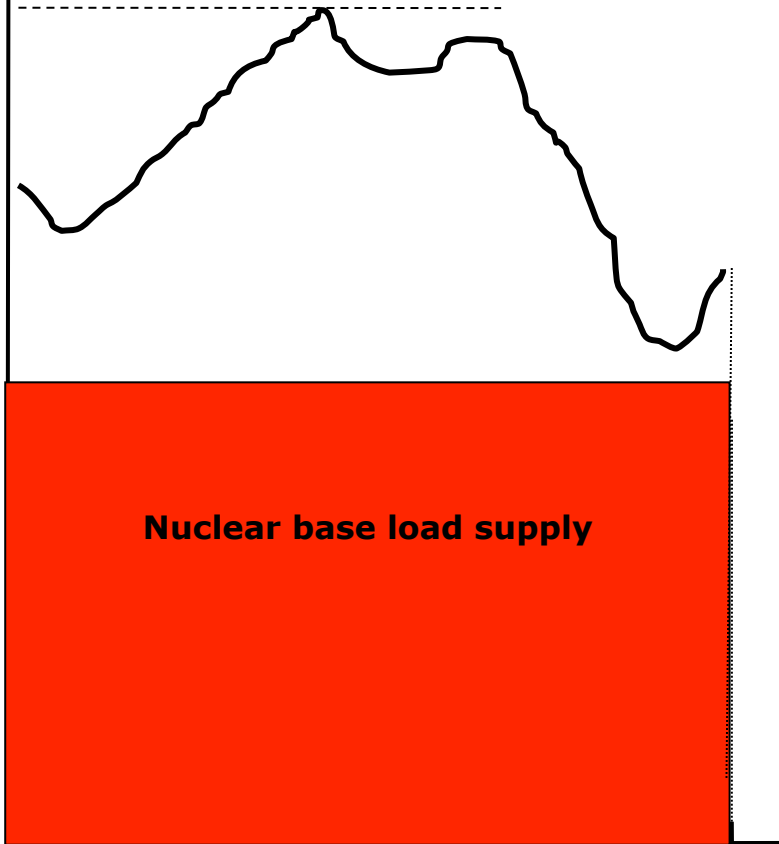


# Atom $\Leftrightarrow$ Renewable Elektricity

## Andere vraag & 'brandstofmix'

MW

Expansive Consumption



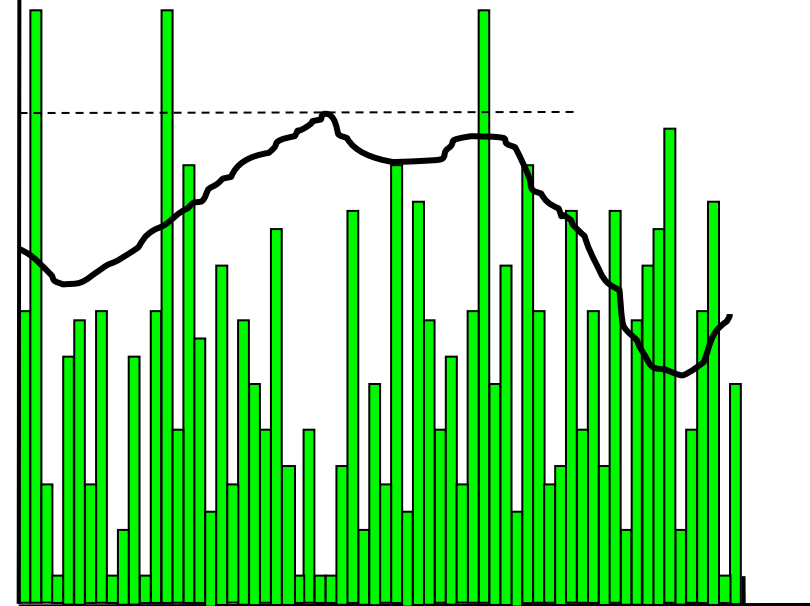
Nuclear base load supply

hours

MW

Efficient Use of Electricity

Renewable flow supplies

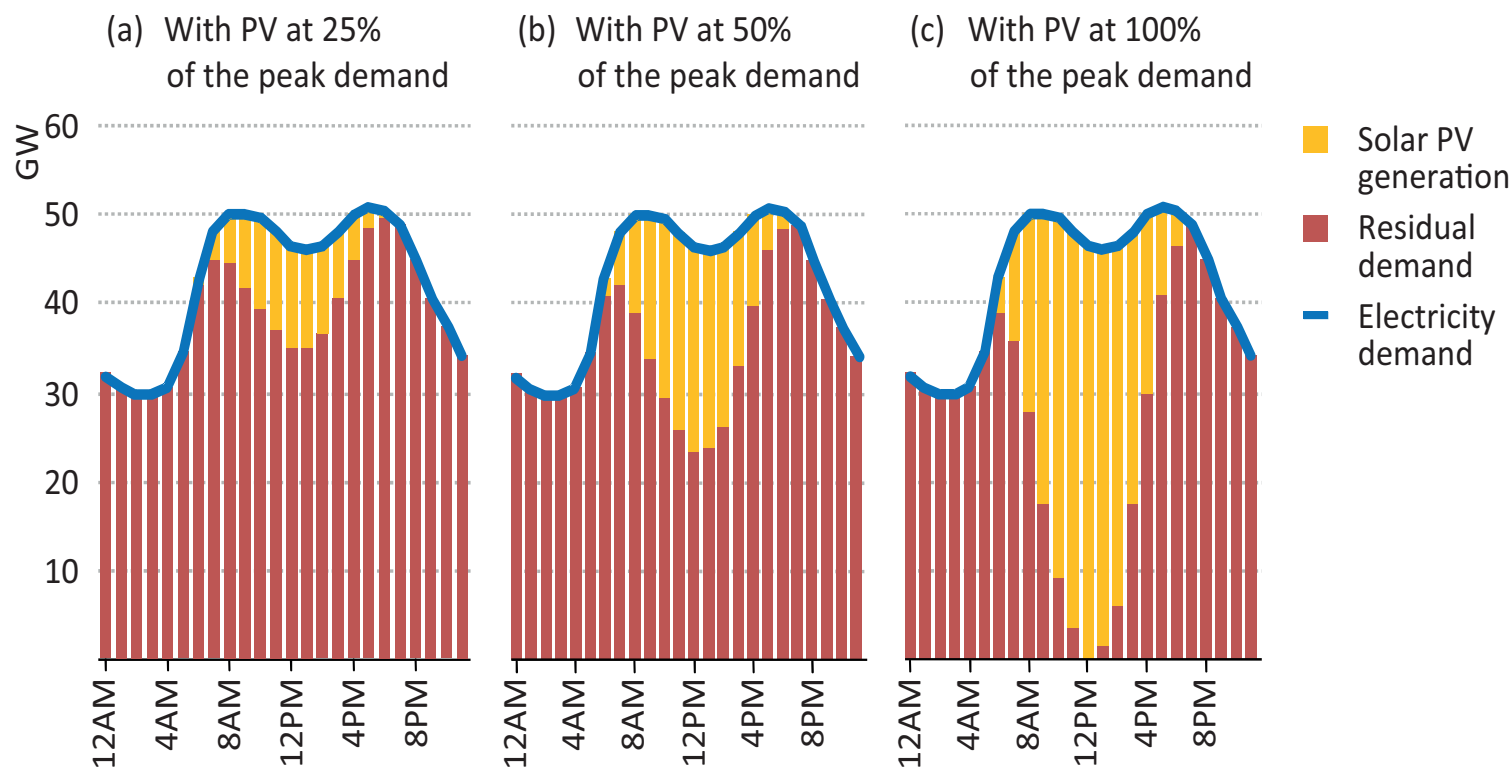


hours



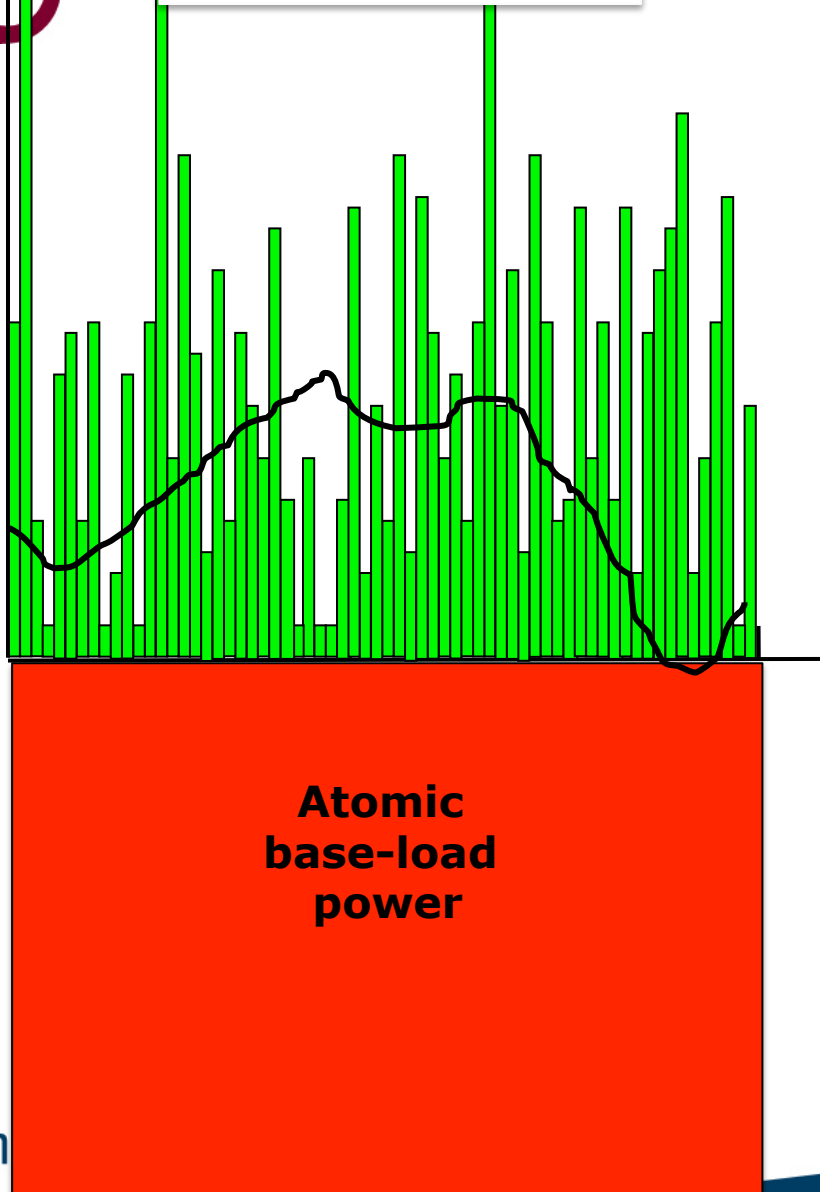
## Solar PV @25%, 50%, 100% of peak load demand creates production canyon [source: IEA Outlook 2013]

**Figure 6.8** ▶ Indicative hourly electricity demand and residual electricity demand with expanding deployment of solar PV



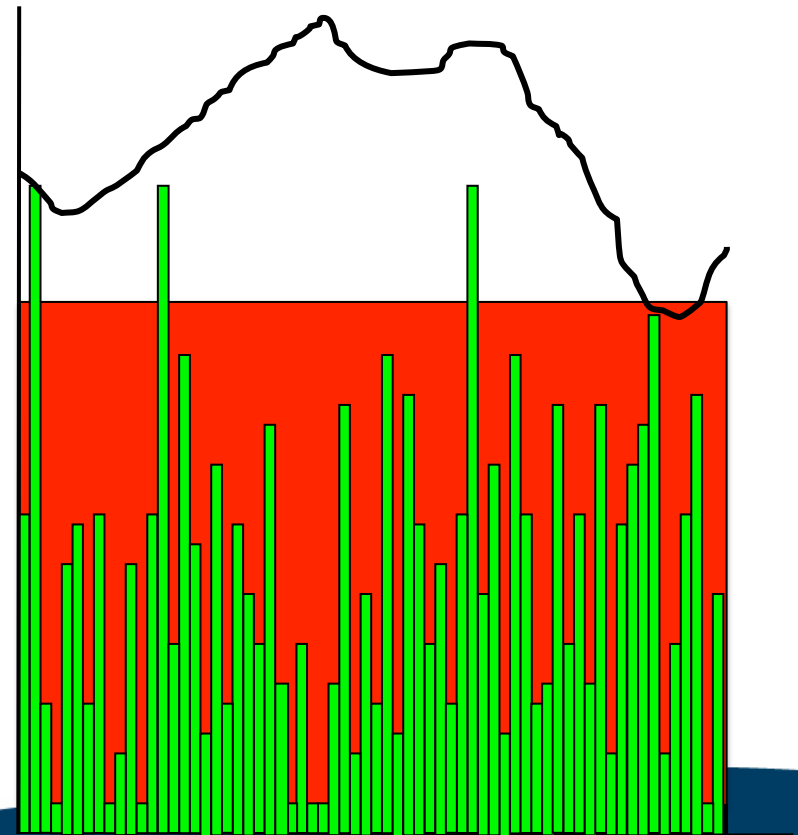


**Priority for Atomic  
base-load power**



**Priority for one ruins the  
business case of the other**

**Priority for Flow  
renewable power**

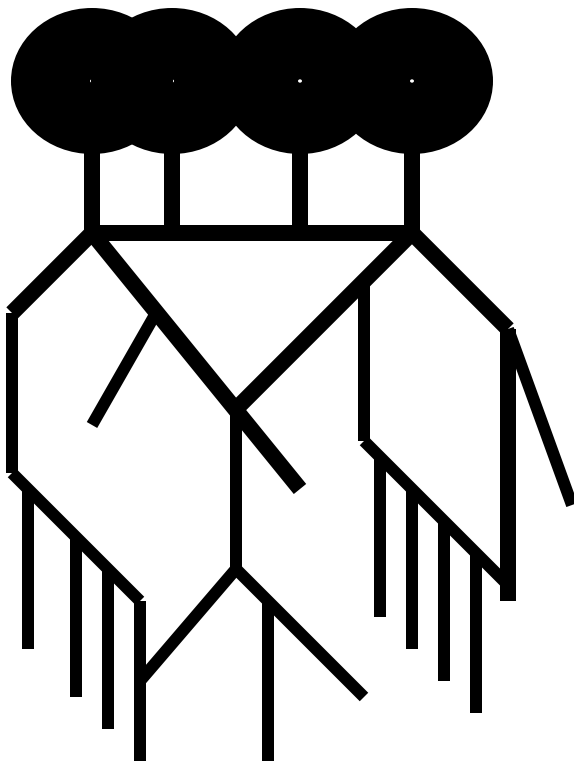




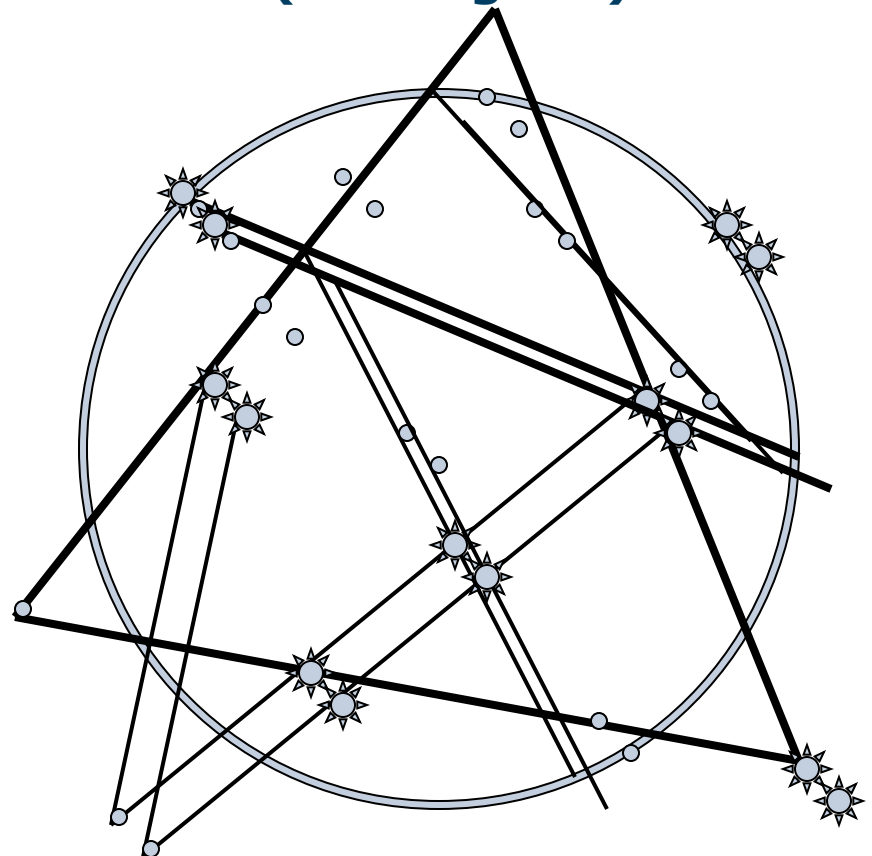
# Atomic $\Leftrightarrow$ Renewable Electricity

## Different electricity grids dominate

**Atomic power**  
**Pyramidal**  
**(old grids)**



**Renewable power**  
**Multilateral**  
**(smart grids)**







## Energy transitions = core of climate policy

### Energy use

- Motor of human societies
- Main culprit of the Gigaton CO<sub>2</sub> emissions
  - Radical transition from steam era to 100% RE harvesting:  
**necessary + possible + desirable**

Energy transitions are going on - **UNABLE TO STOP**

Crucial are **PACE + CONTROL**

#### Delaying

Conservative interests like:

- Energy industry (fossil fuels, atomic power, steam electricity)
  - Energy intensive industry (chemical, cement, transport, aviation, shipping)
- want

Neoliberal capital accumulation  
& **LARGE** scale RE by  
multinational corporations

#### Accelerating

Youth4Climate

Scientists4Climate

RE & future oriented industry

Millions of people in the North

Billions of people in the South

Want

Global Sustainable Development  
& **SMALL** scale RE by local firms,  
cooperatives, households

All people live on the same planet.  
Sustainable Development is the best for everyone  
Large scale RE must complement, not suppress  
Small scale RE



## RE transition affordable?

### CO<sub>2</sub> emissions (% of total)

- Energy sector as such = 25% à 40%
- Flabs fossil/nuclear steam power = 15% à 20%
- **I.e.: RE reduces CO<sub>2</sub> emissions with 40% à 60%**
- **HOWEVER: vanish many old economic activities**

### Renewable electricity

- Wind & PV technologies continue to improve
- Their costs continue to decrease
- Investment in electric load management, multilateral grids, energy storage (batteries, hydrogen), digital control

### WHO owns and controls the energy future?

- Energy giants: large scale, central control
- **Public utilities, cooperatives, local firms, households, ... : energy by human standards, needs**
- **Crucial role: public authorities, regulators, juridical justice, ...**



## Rational • Radical • Reverse Think + Talk + Act

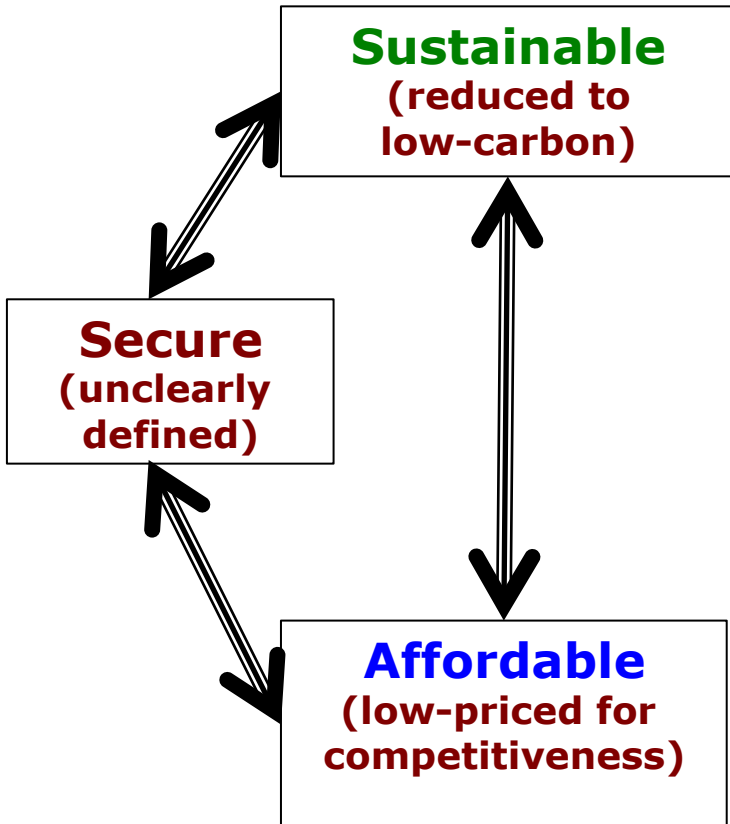
- **Radical**  
= recapture Sustainable Development in full significance (1987)  
+ approved by the community of world leaders in Rio (1992)  
⇔ deforced, abused for concealing Business-as-Usual
- **Rational**  
= transform the energy world (pulling) ⌘ human societies (following)  
+ efficiency & renewable energy suffice ⇔ atomic power, CCS  
!! 'new climate man' is a dangerous fallacy
- **Reverse, the opposite of the present businesses**  
+ **Think:** Reality of endangered ecosystems: biodiversity, climate, ...  
⇔ *Realism of incumbent interests*  
!! *'We cannot solve our problems with the same thinking we used when we created the them' (Einstein)*  
  
+ **Talk:** Gaseous littering is illegal ⇔ *'Present generations bring offers when they reduce some CO<sub>2</sub> emissions'*  
  
+ **Act:** the commons, public goods >>> private money interests
  - paradigm Sustainable Development: beacon & testframe of actions
  - facts and science ⇔ fake, lies, deception
  - critical inquiry of technology, institutions, politicians, media, ...  
... originators, protectors of the present state-of-the-world



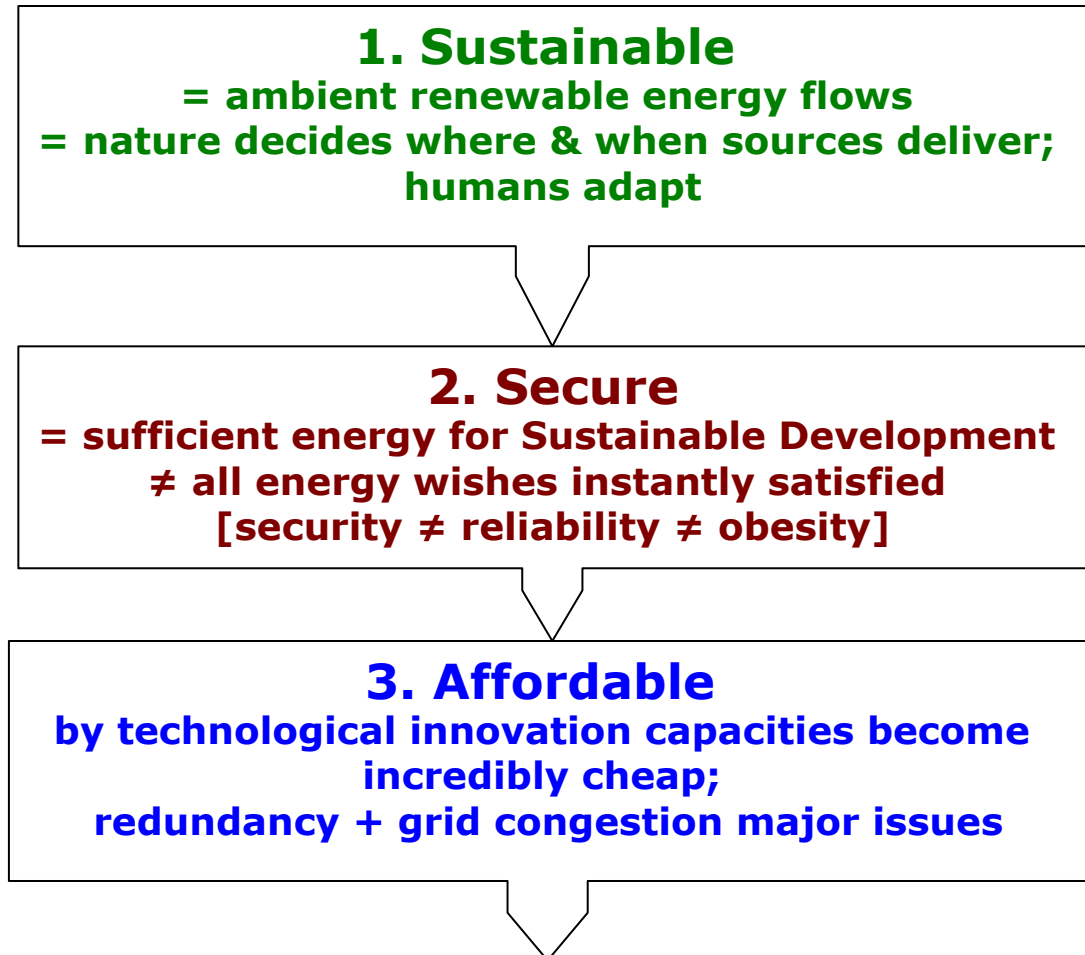
# Flawed discourse on EU energy policy goals

## Trilemma ↔ Cascade Logic

### Trilemma



### Actual Cascade





## **Nipping distributed RE growth by large energy companies ☞ EU Commission**

- **Magritte Group (March 19, 2014) recommends:**
  - **Preference for 'mature renewables in the regular market'**
  - **Priority to the utilization of existing competitive power capacity rather than subsidizing new constructions**
  - **Restore the ETS as climate and energy policy flagship**
- **EU (April 9, 2014) New Energy State Aid Guidelines**
  - **Refrain the German Energiewende**
  - **Payments for UK coal power capacity**
  - **Subsidize planned atomic plant at UK Hinkley Point (£92,5/MWh during 35 years)**
  - **Since then, EU lost pace and leadership in Renewable Energy deployment**
- **Nuclear discourse molds fake reality**
  - **No real sustainability assessment of atomic power**
  - **Hides incompatibility of nuclear with wind & solar power**



## Control the “Energy Policy” discourse

### In the EU, vested energy interests

- are centralized power houses
- principal in the Brussels and national lobbyism webs
- active in universities and on scientific fora

### Control EU and Member State regulation

Stock-stakeholders participate (**victoriously**) in comitology  
EU officials are **limited** in capability, capacity, action radius  
Member States maintain significant energy authority

### Control the hearts and minds

**Dominant discourse** by supreme advocacy  
**Changed editors** of *Energy Policy* **reject** disclosing analysis  
IPCC accepts nuclear power as valid mitigation option, by  
**skipping the assessment of critical publications**



## Reversal feasible?

**People (like us) are naturally**

- **A little naive (hot air, fake news, is ubiquitous since always)**
- **Quiet minded ⇔ Alert**
- **A little lazy ⇔ Action prone**
- **BUT: Irresistible in resistance when the tide turns**
- **NECESSARY: Cooperate, overcome social dilemmas**

### **Critical analysis ...**

- **Present public policies are weak ⌘ CO<sub>2</sub> emissions ↗**
- **Excessive influence of economic-financial interests**
- **Humans are humans: 'new (climate)man' is a fallacy**
- **Change Paradigms, institutions, politics, communities, ...**

**... is not cynic, but hopeful**

- **Liberating energy transition: RE develops exponentially**
- **Emancipation of the South billions means Sustainable Development**
- **Absolute reversal, like the switch *Eagle* → *Cross (Rome, 313)***