

Webinar September 24, 2024 Astana, Kazakhstan

Essential Questions about Atomic Power

Emeritus prof. Aviel Verbruggen
University of Antwerp, Belgium
www.avielverbruggen.be

Biographical note focused on electricity and atomic power:

- **1979: PhD on Combined Heat & Power up to 2016 ASME (American Society Mechanical Engineers) journal article solving the CHP enigma**
- **1981-1988: Electricity generation systems & Belgian Atomic power expansion plans (4x1300MWe) – not built by critique on failing Decision-making methodology & process + on flawed cost estimates**
- **1998-2014: IPCC (Intergovernmental Panel on Climate Change) WorkingGroup 3, author, reviewer, Belgian Government delegate**
- **2008-2024: Academic publications on Atomic power economics, sustainability assessments, climate policy, conflict with renewable electricity in baseload coverage and electric network development, stealthy activities by IAEA (International Atomic Energy Agency), Nuclear Fora fake news, ...**

Overview

Prior essential question: how escaping climate collapse?

Essential questions about atomic power:

- 1. Is atomic power good economics?**
- 2. Are its environmental impacts acceptable?**
- 3. Does atomic power fit with PV and wind power?**
- 4. Are disruptive innovations in atomic technology likely?**
- 5. Can a now decided atomic plant deliver power before the year 2035?**

Conclusion: view on a sustainable future

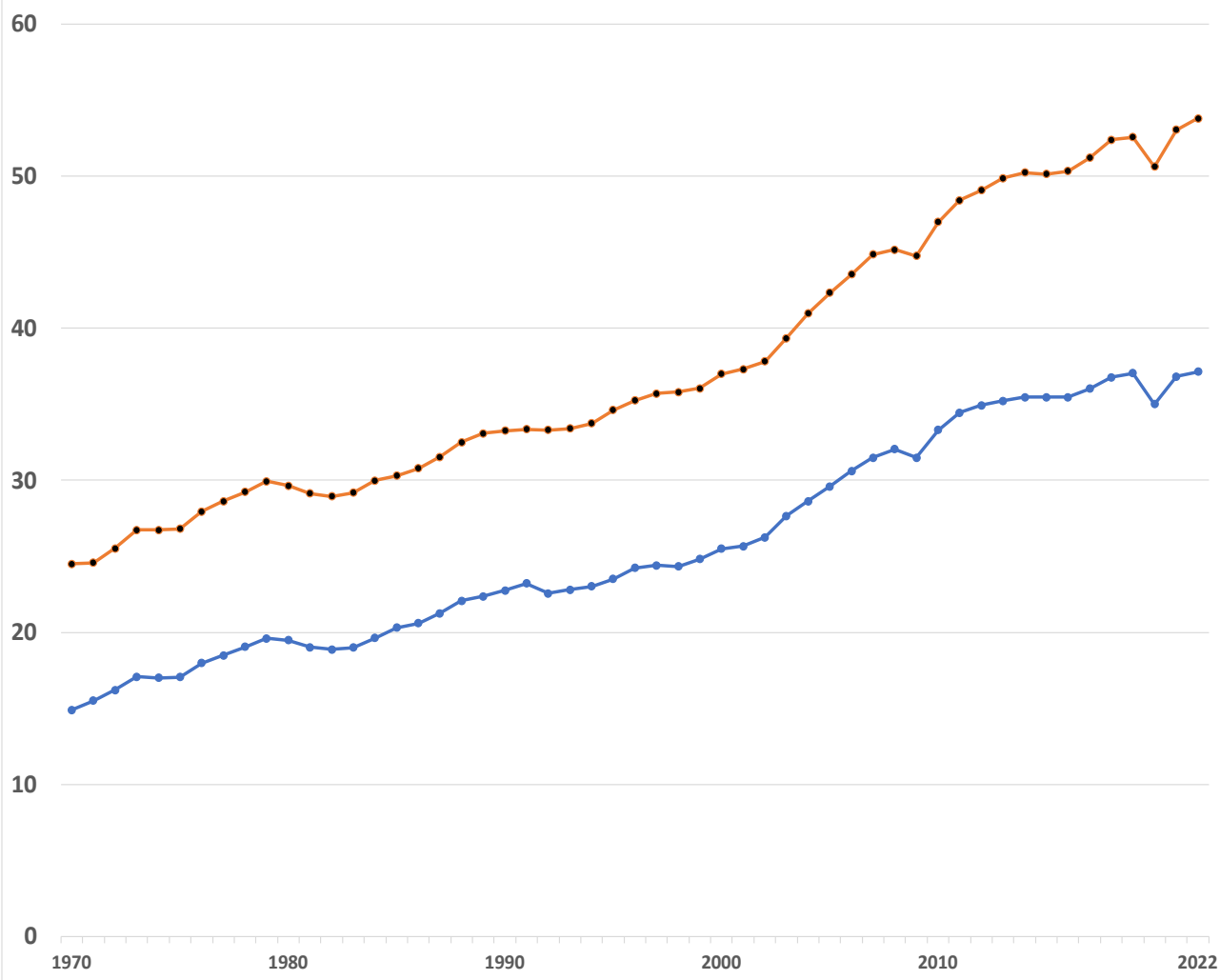
Emissions of CO2 and CO2-eq. Greenhouse Gases

cause

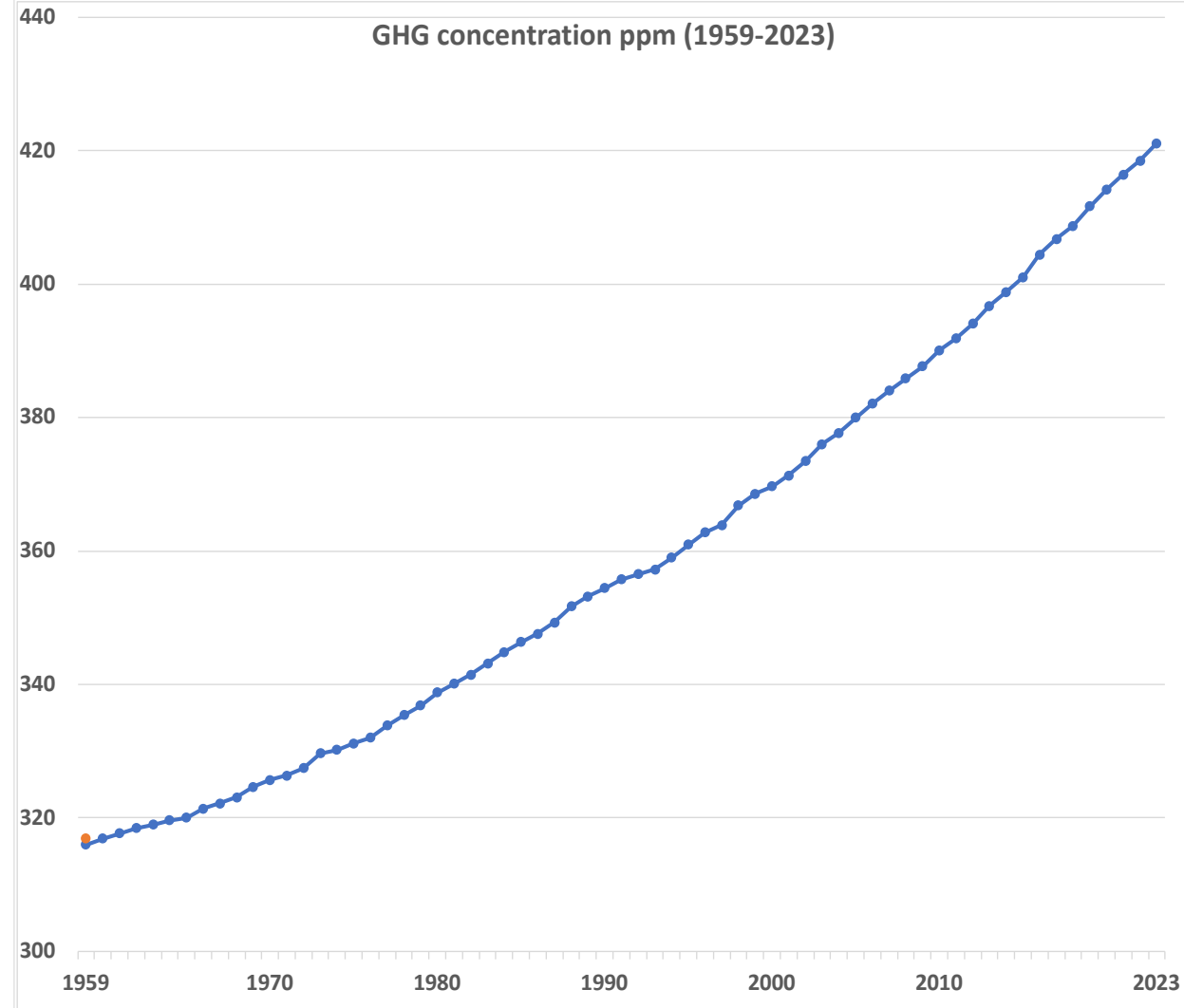
steadily increasing GHG concentration in the atmosphere.

Mounting emissions & concentration reflect failing climate policies, and invisible impact of *atomic power surge* in the 1970-80s

CO2 (lower curve) & CO2-eq (upper curve) Gigatons emissions in the years 1970-2022



GHG concentration ppm (1959-2023)



**Can mankind escape climate collapse without
very urgently (before 2030) transform
the inherited prevailing energy systems?**

Fossil & Atomic Thermal Power Generation

Fossil thermal power generation causes half of the energy-related CO₂ emissions = **every year +18 Gton CO₂**

**If not sea-bounded,
cooling water of big thermal plants affects rivers, lakes.**

Atomic power plants do not create CO₂
However,
the atomic power surge in the 1970-80s did not reduce CO₂ emissions

Can atomic power be helpful for dissolving the climate crisis?
Clear answers on 5 essential questions needed

Question 1. Is atomic power good economics?

Actual construction experiences in the West:

United States of America:

- The 1960-70s **BUILD NUCLEAR NOW** campaign saw 197 reactors ordered. However, less than half were commissioned for producing electricity
- After 1978, only 2 projects with 2 reactors each were initiated
- **VC Summer** South Carolina, stopped in 2017 after more than **US\$10.4bn spent**
- **Vogtle** Georgia budgetted US\$14bn in 2009 for 2x1117MWe plants by 2016. The spending went up to almost **US\$35bn** with plants starting in 2023 and 2024.

Europe:

1600MWe EPR reactors constructed by state company Electricité de France (EDF)-Areva

- Finland, Olikulioto: budget of €3bn in 2005 for operation in 2010. Spending went up beyond **€11bn** and grid connected in 2023 (**Finland €5.5bn; France +€5.5bn**)
- France, Flamanville: budget of €bn3.3 in 2007 for operation in 2012. Spending went up to **€19.1bn** and reactor tests started in 2024.
- UK, 2x1630MWe reactors Hinkley Point C: budget of £18bn in 2016; went up to £25-26bn in May 2020. In February 2023 revised to **£32.7bn** at 2015 prices (in present prices ca. **£46bn**) for delivery in 2029-2031.

No private electric power company in the USA and Europe is willing to invest in new atomic power plants.

They invest in large-scale wind & photovoltaic panel fields, storage, load control, ...

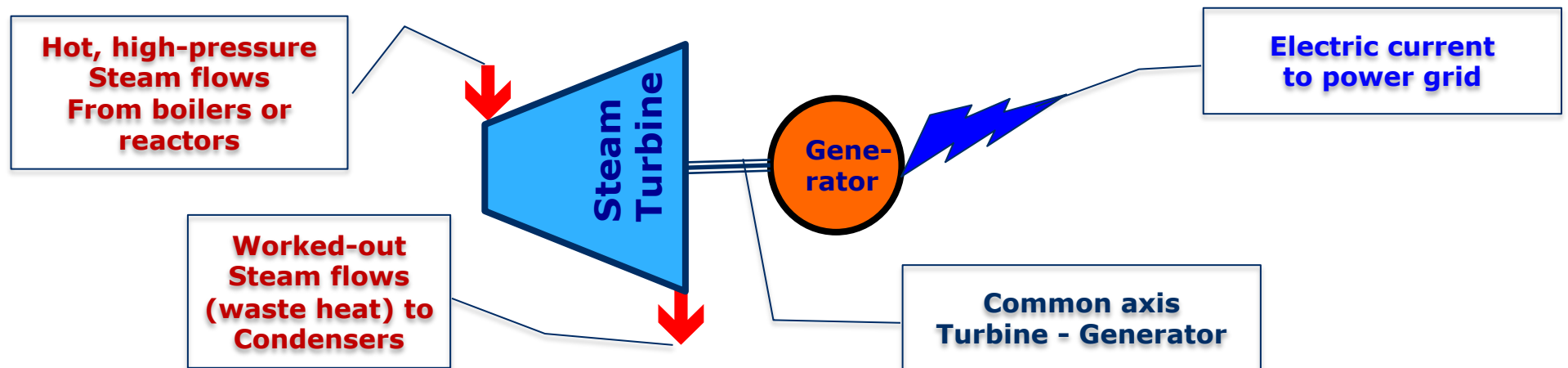
Thermal power generation (atomic, fossil, biofuels, geothermal)

CORE of steam power generation plant

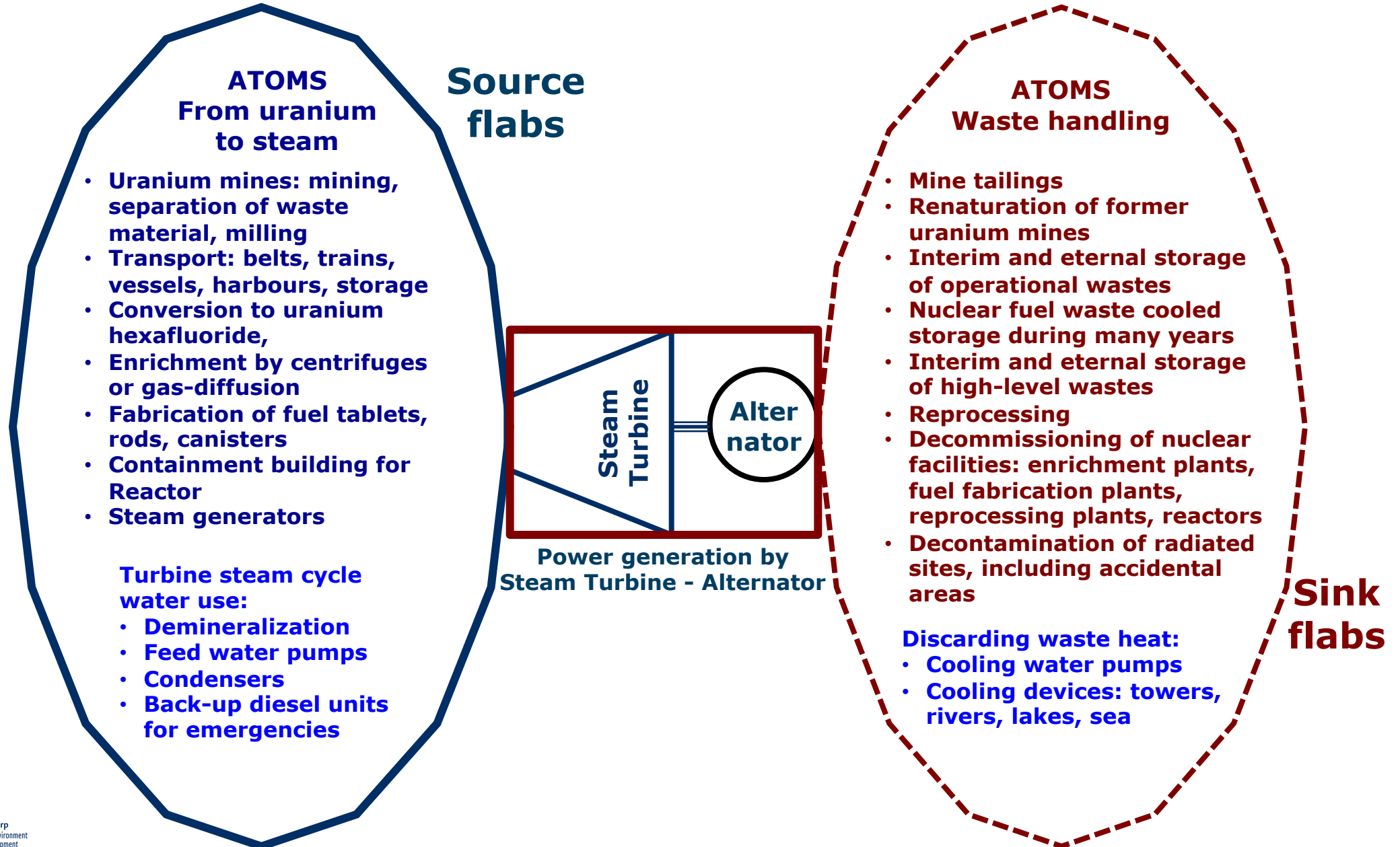
SteamTurbine: kinetic energy in high-pressure steamflows

Causes turbine-axis to rotate

Generator converts rotation in electricity



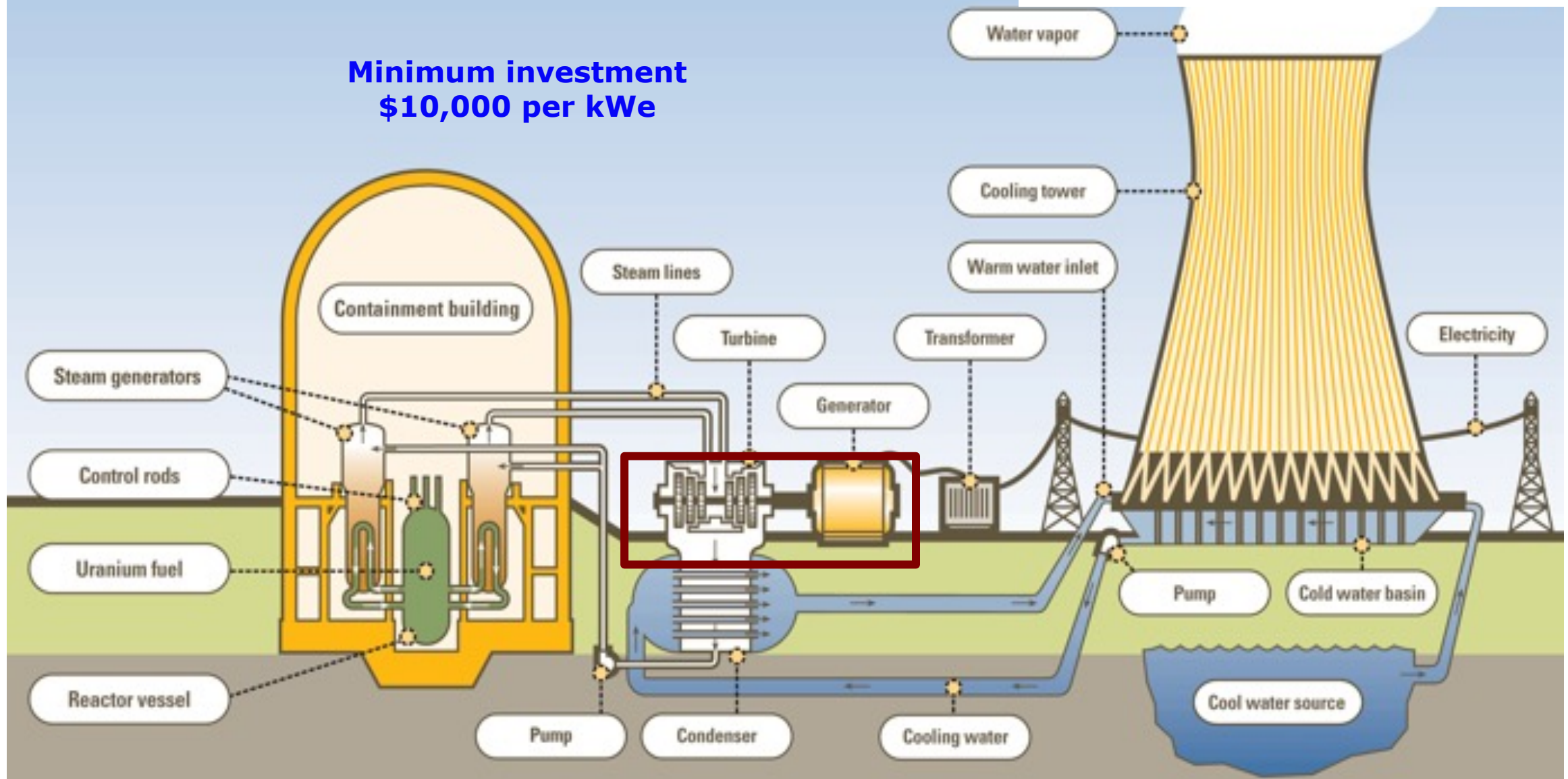
Atomic power needs fuel-cycle and cooling source & sink activities



Economics & efficiency of behaving atomic power plant, the minor part of the source & sink flabs

Generation efficiency of 33% implies
1 kWh electric → 2 kWh waste heat

Minimum investment
\$10,000 per kWe



Examples of FLABS: Offshore oil&gas platform, refinery, coal power plant, Fukushima Daichi nuclear plant destroyed



Fukushima Daiichi destroyed in March 2011

Cleaning the accident area and the cooling water stocks may cost bn\$500 to bn\$750

RISKS related to atomic power are REAL costs.
So high, that no re-insuring company in the world is willing to sell insurance coverage.

Japan's atomic program costs more than the value of all generated atomic power

Question 1. Is atomic power *good* economics?

Atomic power plants are *bad* economics

- many economic-financial disasters
- requesting subsidies for building & operations
 - subsidies via
 - direct grants from the treasury,
 - extortion of captive customers,
 - price guaranties for their kWh output (e.g., UK, Belgium)

Excuses for draining subsidies from the state budgets and customers

- after WW2: **access to atomic weapons**
- since oil price crisis in 1973: **substitute for fossil fuels**
- since 1992 Rio Summit UNFCCC: **solution for climate change**

Question 2. Are atomic power environmental impacts acceptable?

Major environmental impacts:

- **Radioactive releases** during accidents
polluting air, water and soils
with loss of human habitats
- **Cooling water** from rivers, lakes
evaporation,
fish starvation,
biocides
- **Radioactive waste**, low-level to high-level
from reactor operation & dismantling
 - * reprocessing supports the plutonium economy with breeders
 - * no valid technological solutions for the waste exist or are foreseen
- **Storage** in pools, hangars, and deep underground → **intergenerational injustice**
present generation's 50 year bulk power discards eternal waste to coming generations

Question 3. Does atomic power fit with PV and wind power?

Solar PV and wind power generation is totally different from atomic power

- ❖ **Natural currents without source and sink flabs**
- ❖ **No need of cooling water**
- ❖ **No major risks = cheap to buy insurance**
- ❖ **Limited environmental impacts**

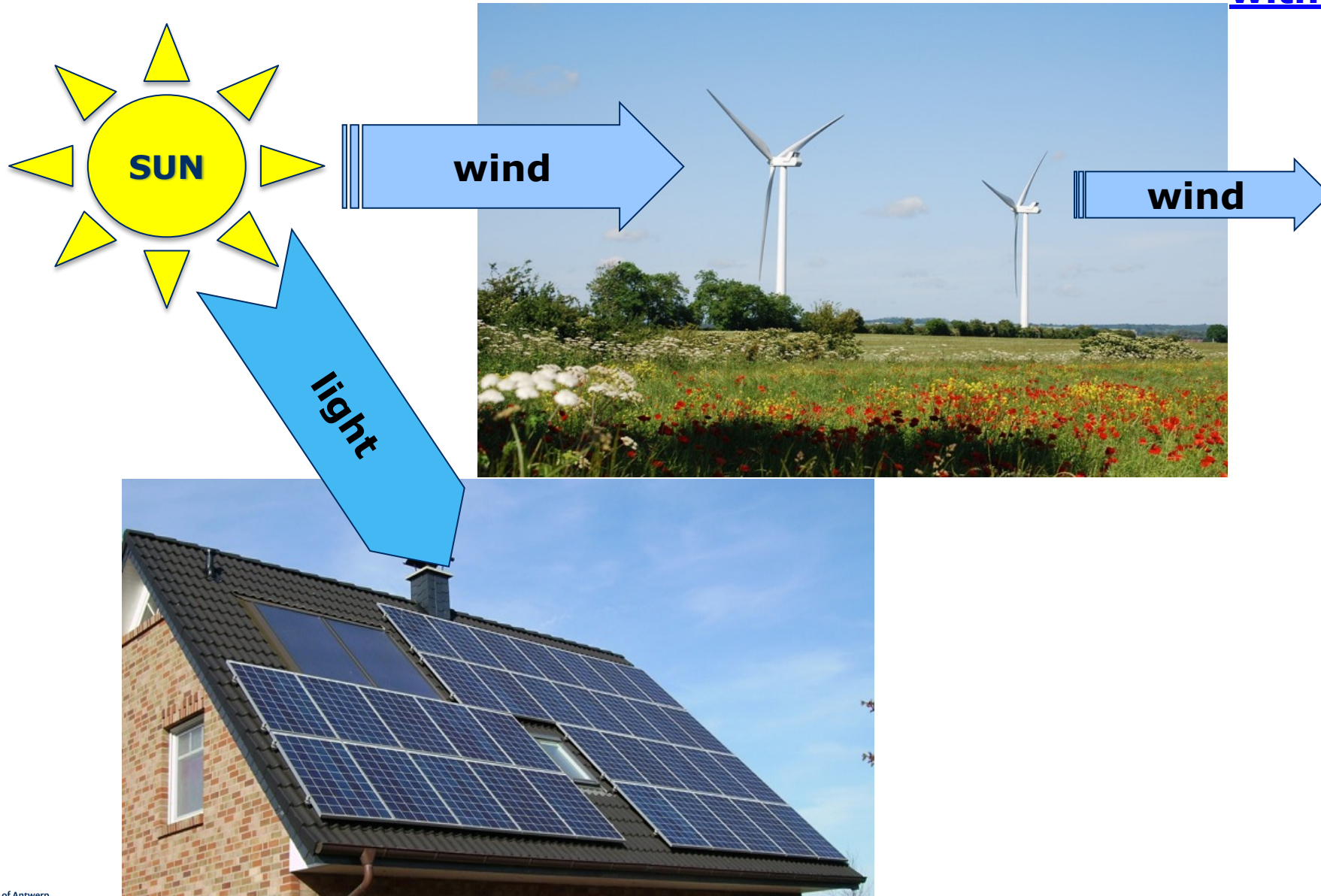
- ❖ **Technological development continues**
- ❖ **Expenses per kWh generated are lowest and for PV decreasing**

Small scale Photovoltaics & Medium scale wind turbines on land

- ❖ **Applicable everywhere**
- ❖ **Affordable for poor communities (Climate Change is a global issue!)**
- ❖ **Desirable for stimulating community life**

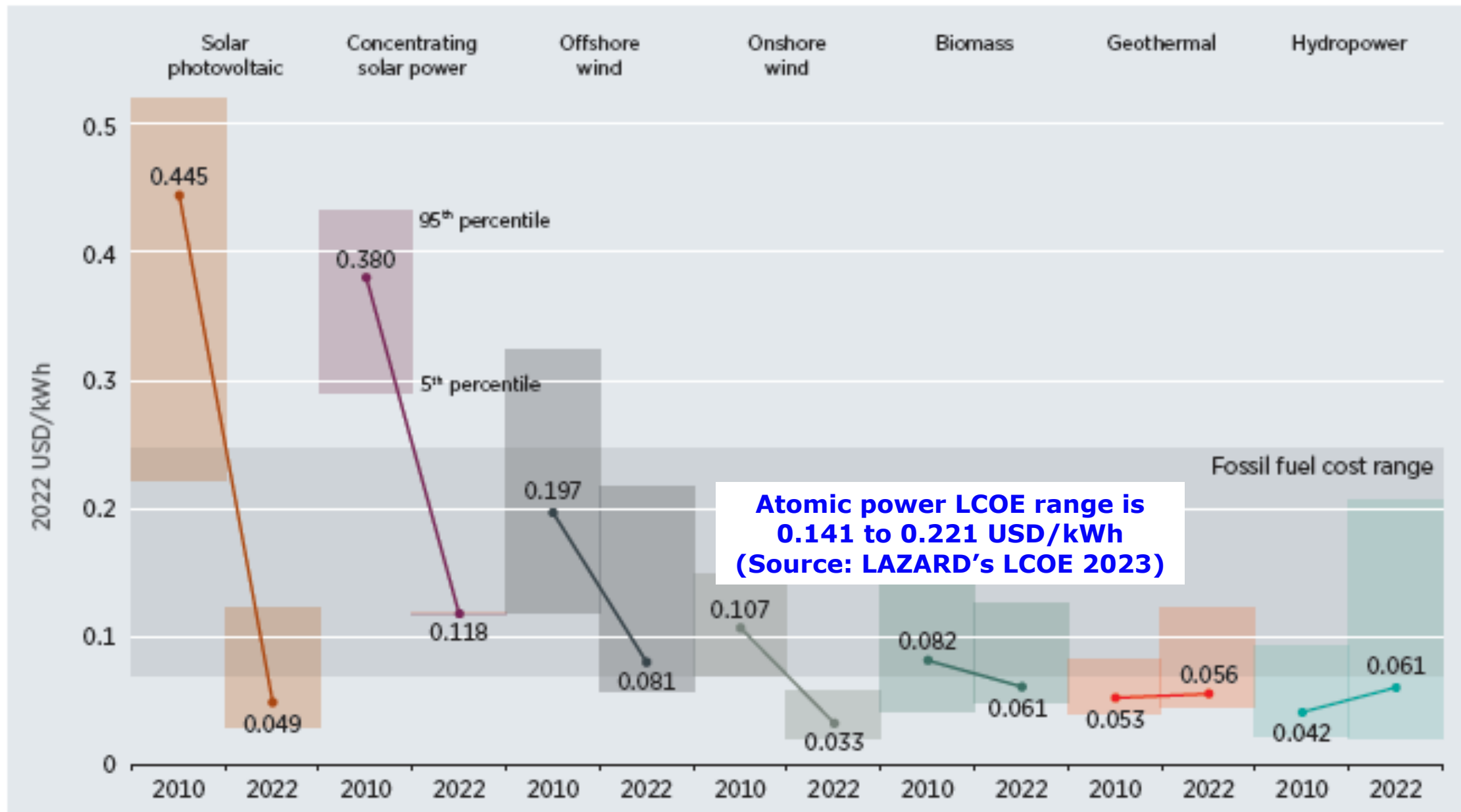
In the same integrated electricity system, it is observed and obvious that atomic power conflicts with PV and wind power

Harvesting ambient currents for power without source and sink flabs, without major risks



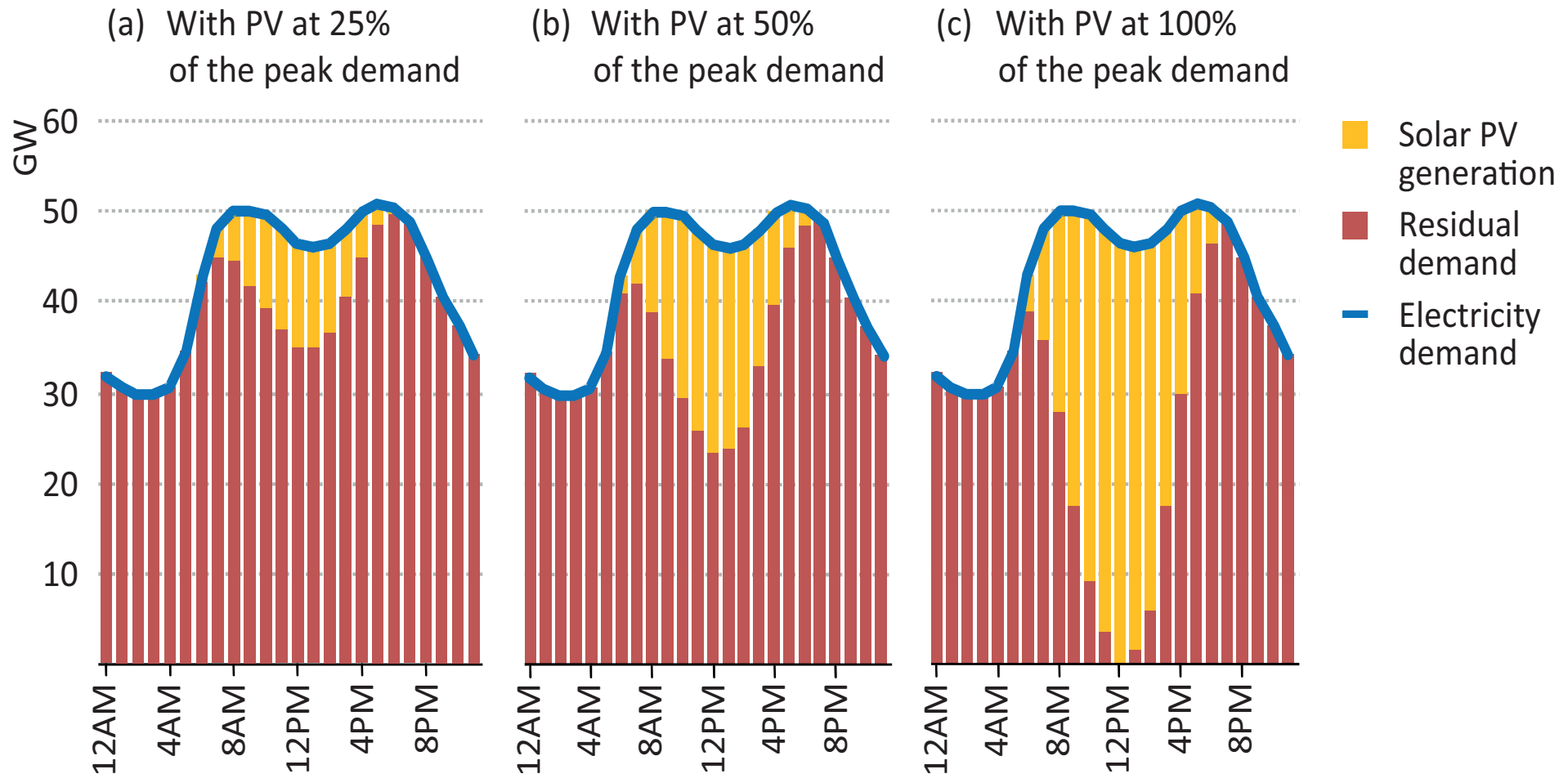
LCOE (Levelized Cost Of Energy) of Renewable Electricity vs. Atomic & Fossil (source: IRENA)

Figure S.4 Global LCOE from newly commissioned utility-scale renewable power technologies, 2021 and 2010



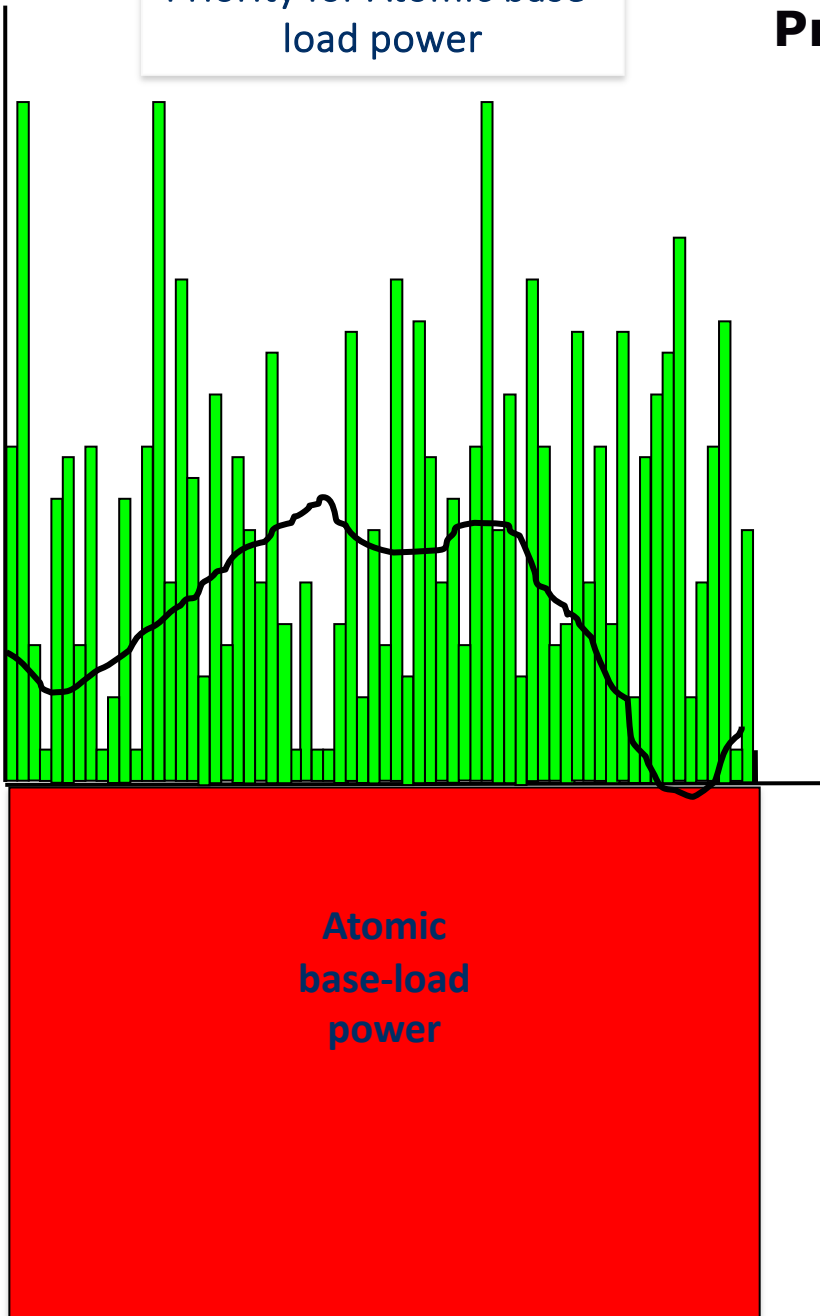
Covering the base-load of an integrated electricity system.
See: IEA Outlook 2013, for PV without storage & redundancy

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

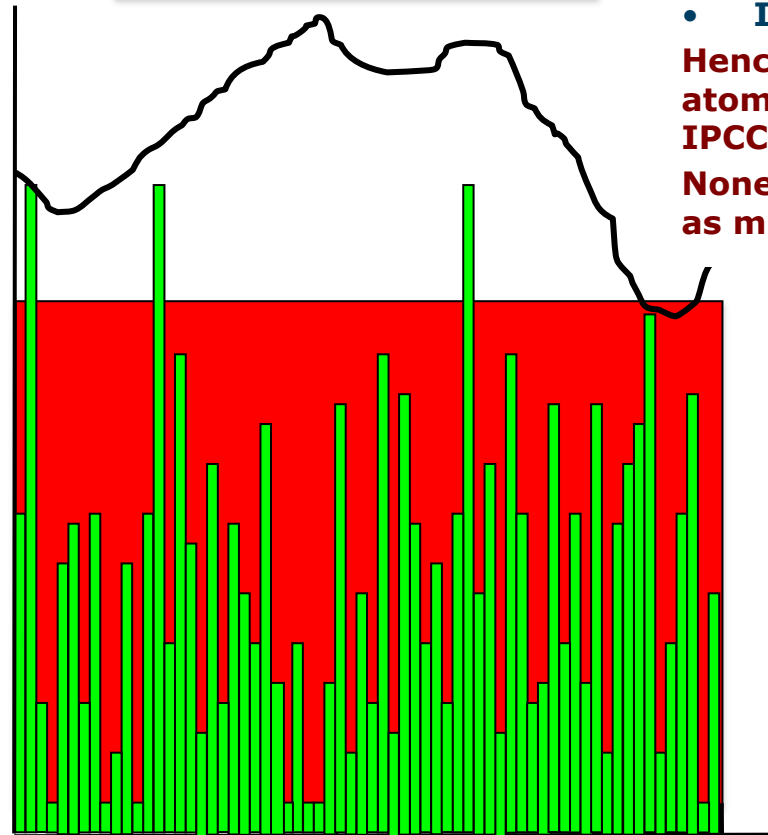


Atomic power and renewable electricity currents conflict: Priority for the one ruins the business case of the other

Priority for Atomic base-load power



Priority for renewable power currents



Integrated Assessment Models (IAM) used by IPCC are too coarse to 'see' the conflicts

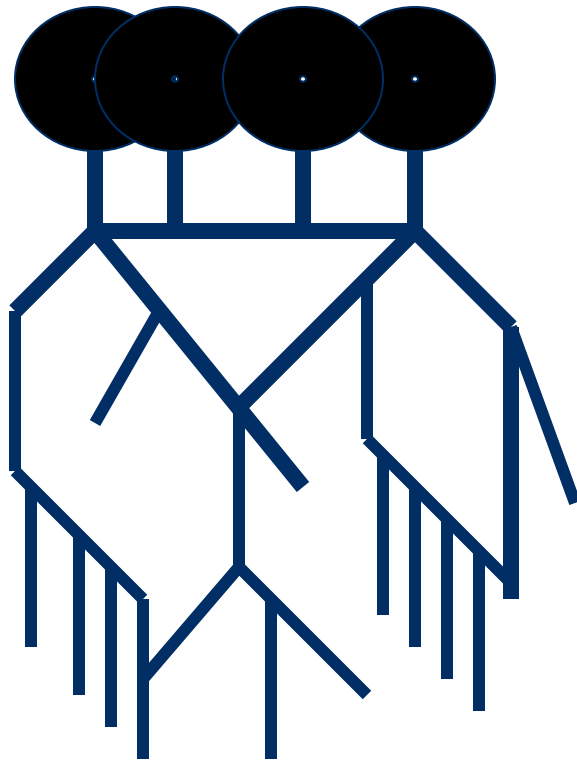
- Electricity is a transient phenomenon
- Renewable electricity and atomic power are both inflexible, but differently
- Both claim the first place in instantaneous merit-order rankings
- Electricity generation modeling needs hourly or quarter-hourly chronology
- IAMs juxtapose yearly volumes

Hence: the incompatibility renewable currents / atomic power is concealed by the IAM models and IPCC WorkingGroup3 statements.

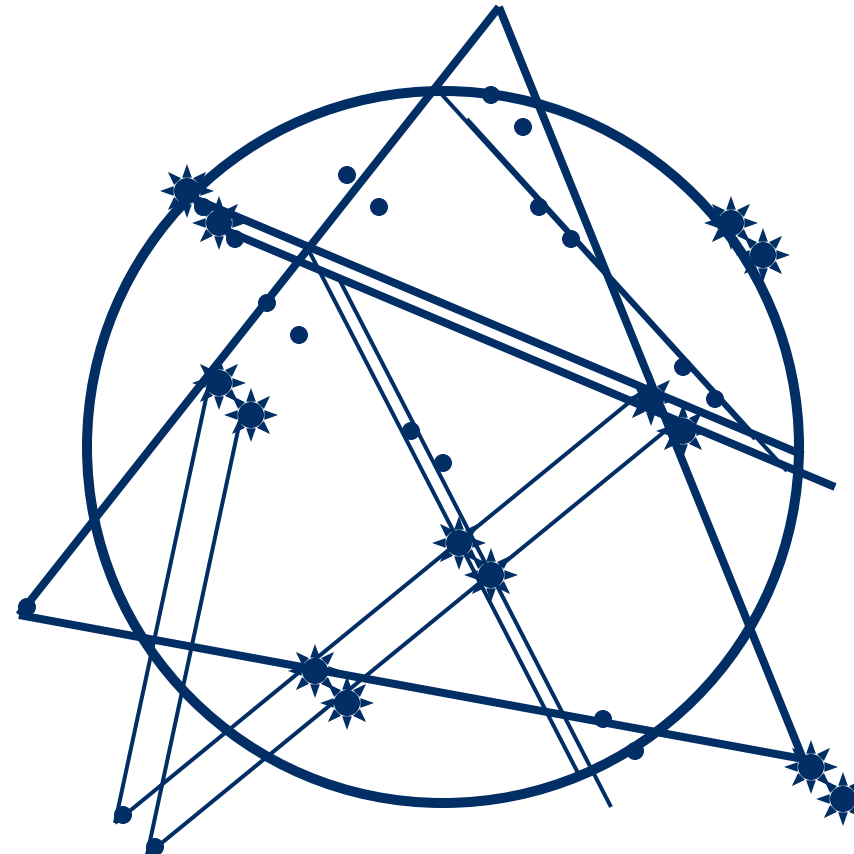
Nonetheless, the flawed discourse of 'RE, NP, CCS' as mitigation solutions is spread

Millions of Independent Generators of Own Power (IGOP)-prosumers request different grid developments

**Pyramidal
(incumbent grids)
for atomic power**



**Multilateral
(smart grids) for
community power**



Question 4. Are disruptive innovations in atomic technology likely?

Atom's GEN4: Fast-neutron breeders, High temperature GEN5: fusion

Breeders source of infinite atomic power?

Despite spending **US\$100bn** in RD&D, all breeder reactors in Western countries have been closed by incidents, accidents, cost overruns, e.g.,

- USA 1966: **partial meltdown** in Fermi-1 plant
- Belgium-Germany-Netherlands: 1985 Kalkar breeder 327MWe abandoned after **€4.1bn** spent
- France 1973-2004 Phénix 233MWe research breeder & 1986-1996 Superphénix 1200MWe commercial breeder of **US\$10bn**, generated 7.5TWh over 11 years (capacity factor 7%)
- Also Canada, Japan, UK stopped their breeder experiments

High-temperature

- Developed by Germany (1983-1989): 300MWe plant operated in 1985, with immediate fuel problems and cladding in May 4, 1986, a few days after the Chernobyl disaster.
- South-Africa experimented during 1993-2010 a pebble bed SMR - mothballed
- China started in 2022 the 200MWe Shidaowan plant on high-temperature steam from 2 reactors

Fusion?

- ITER demo-project holds 10 million parts to assemble
- Now expected spending is **€34bn** by 2035
- No single kWh will be produced; the 500MWe transfo-station is for feeding ITER
- The Livermore Lab. Dec.2022 fusion experiment served **military ends**

Quantum physics used in two directions

Mega-Giga: $E = mc^2$

- **1941-45: Atomic bombs: Manhattan project to bombing Hiroshima & Nagasaki**
- **After WW2: bomb proliferation USSR, UK, France, China, Israel, India, Pakistan, N.-Korea**
- **Since 1950, deployment of atomic reactors of diverse technologies in many countries, absorbing all energy RD&D budgets until mid-1970s**
- **Incredible support by governments, industry, academics, media, citizenry, until end 1960s**
- **Not quantum physics, but similar hype is now constructed for hydrogen!**

Micro-Nano

- **Micro-processors, semi-conductors, computers, ICT, new materials, 3D-printing, LED, ...**
- ***www.name.com* and smartphones: impossibilities have become reality**
- **Power electronics**
- **Batteries**
- **Photovoltaics PV: converting light directly in electricity, growing in efficiency and stability, decreasing costs by nanosciences, unbeatable by any other technology.**

Photovoltaics history

- **Developed for space ships, however obstructed in civil applications**
- **In 1973, no PV in Nixon's energy R&D plan; in 1981 Reagan aborted PV budding; 2011-2014 EU prefers subsidies for atomic power and slash grassroots PV expansion**
- **In 2008 China started its path to 80% of global PV market and 34% of installations in 2023. Now a production capacity of 1000GW per year**
- **PV is fast spreading globally; +199GW in 2022, +346GW in 2023, to a total of 1,600GW.**
- **The goal of tripling by 2030 will likely be surpassed**

Question 5. Can a now decided atomic plant deliver power before the year 2035?

**Given the 21st century experiences
in atomic power plant projects
in Western countries,
a construction time shorter than a decade is very unlikely**

Eastern countries (South-Korea, China) did realize projects on time.

**For a project in a nearby eastern country, look at IRAN:
Sea-side Bushehr, site of 1 existing reactor
+ work on 2x1050MWe VVER under construction,
started in 2016, planned to operate by 2025-26.
Information on progress and costs is incomplete.**

**In September 2016, I taught a course on CHP in Tehran
for leading staff of Iran's regional electricity authorities;
Several staff members criticized the performance and costs of the Bushehr atomic plant**

Conclusion: Technological reversals in electricity generation WILL occur

18th – begin 21st century ⇔

3rd millennium

Thermal flows, costly & risky ⇔

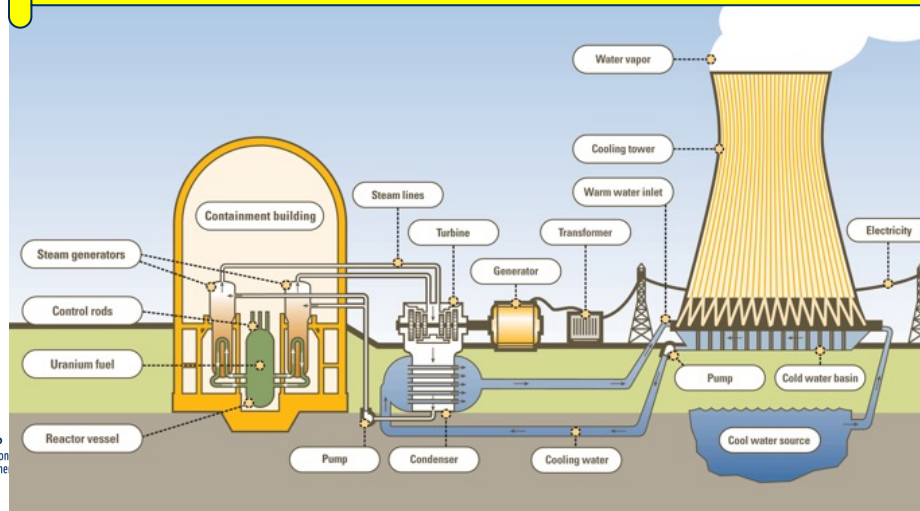
Harvesting light, wind, water



From cumbersome techniques
on concentrated energy sources



To direct harvesting
of diffuse, variable flows

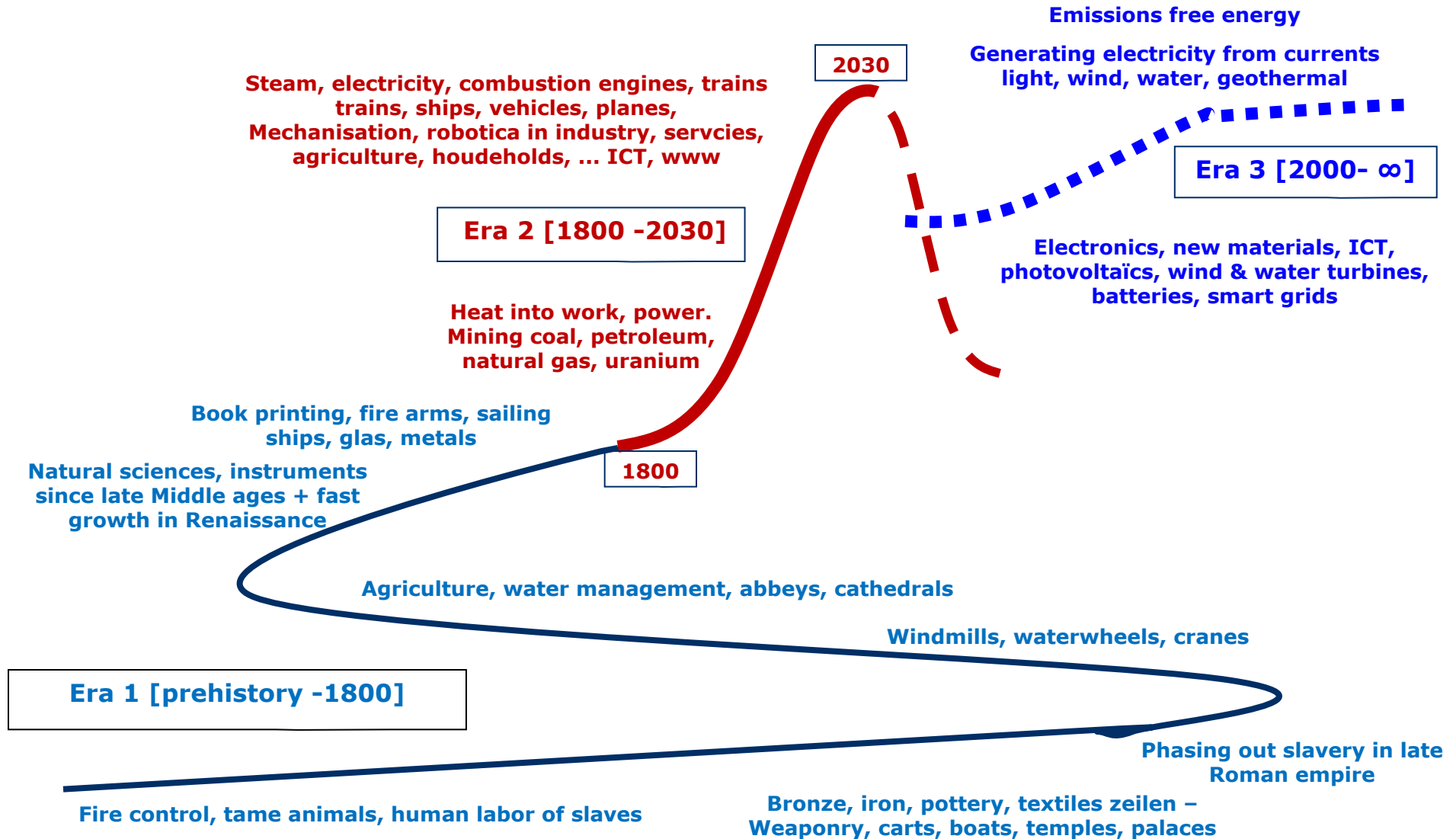


Vision of three main eras of energy use and related civilization

Era 1 [prehistory-1800]

Era 2 [1800-2030]

Era 3 [2000-∞]



Salient points to remember (home reading)

- Atomic technology was developed to make atomic weapons. Atomic weapons remain the main goal of atomic technology.
- The neo-modernists' *Build nuclear Now* dates back to the 1970s. The great financial efforts of those days have been bogged down in financial nightmares and catastrophic accidents.
- The promising atomic technologies have been all demonstrated, and failed. There is no real element to assume things will be any different in the 2020-30s.
- IAEA is the spider in the web of atomic energy propaganda. The mantra *renewable energy, nuclear power, carbon capture & storage* as equivalent mitigation options is flawed. IAEA infiltrated Working Group3 of the IPCC, and managed to suppress a scientific review of the literature on atomic power. This derogates from the essential mission of IPCC. The traditional media are blind to this big *atom climate-gate*.
- In 2007 Saatchi & Saatchi conceived new atomic power propaganda for the Nuclear Forum, traditional media and neo-modernists, *Merchants of Doubt* like documented cases on tobacco, global warming.
- Atomic power requires heavy source and sink flabs related to its fuel cycle and to the cooling water needs
- Atomic power is several times more expensive than electricity from sunlight and wind in commercial terms, and even more when social costs are considered.
- Private power companies refuse spending on atomic power, and try to pass on the eternal burdens of high-level radioactive waste to the public community.

Post scriptum: information sources (home reading)

Be careful when reading the propaganda of IAEA, NEA, EURATOM, IEA, ... publications, and the sources they do influence

Go to the free access independent scientific publications on atomic power issues: Bulletin of the Atomic Scientists (<https://thebulletin.org>), founded in 1948 out of Princeton University (Albert Einstein): crucial scientific reports on for example fusion, etc.

World Nuclear Industry Status Report (<https://www.worldnuclearreport.org>) gives a yearly status of the global industry, more correct than the IAEA does.

IRENA.org gives info about renewable energy

My website – English section under Publications holds a stack ATOM with my English-language publications and PDF's of lectures. When you want a pptx version of a lecture for further use, send a mail to aviel.verbruggen@uantwerpen.be