Is Nuclear still an Option?

SCCER School – Shaping the Energy Transition

Engelberg, 19 October 2017

Dr. Philippe Renault, swissnuclear

swissnuclear

Who is swissnuclear?

swissnuclear

is an association of the four plant operators (KKL AG, KKG AG; Axpo Power AG, BKW AG).

is committed to supporting the nuclear power plants in ensuring their safe and sustainable operation as well as the safe and sustainable disposal of the resulting radioactive waste.

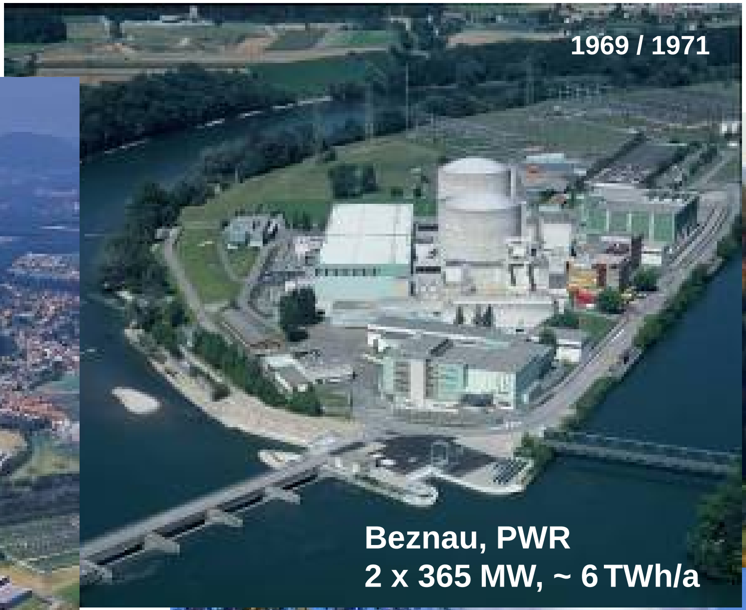
coordinates overarching activities such as:

- research and education
- maintaining know-how and exchange of experience
- communication and public affairs
- representation in international bodies
- improvement of boundary conditions

We are a team of 11 people, our office is in Olten.
www.swissnuclear.ch; www.kernenergie.ch

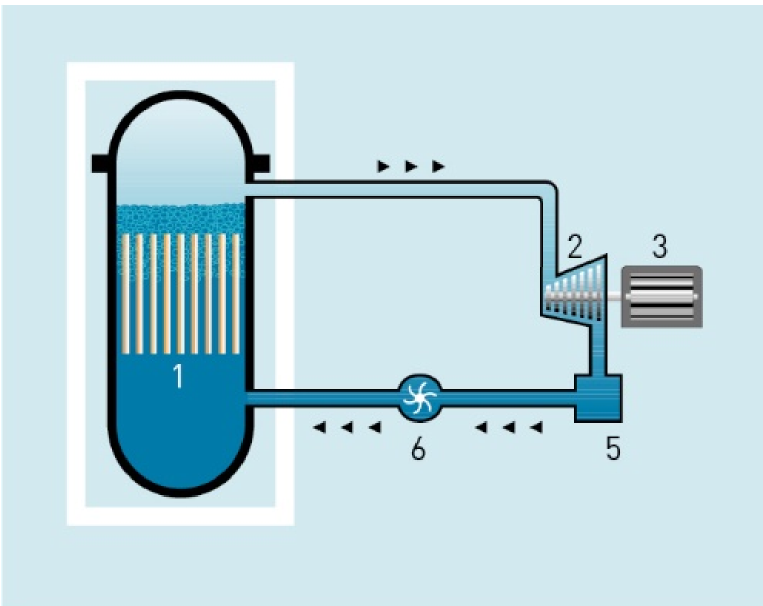
swissnuclear

Nuclear Power Plants in Switzerland

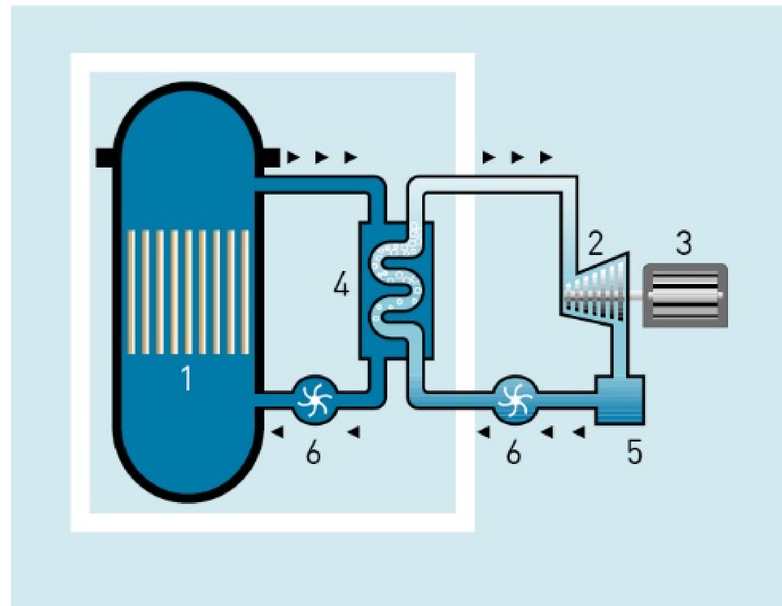


Most common reactor types worldwide in operation in Switzerland: PWR and BWR

Boiling Water Reactor (BWR



Pressurized Water Reactor (PWR)



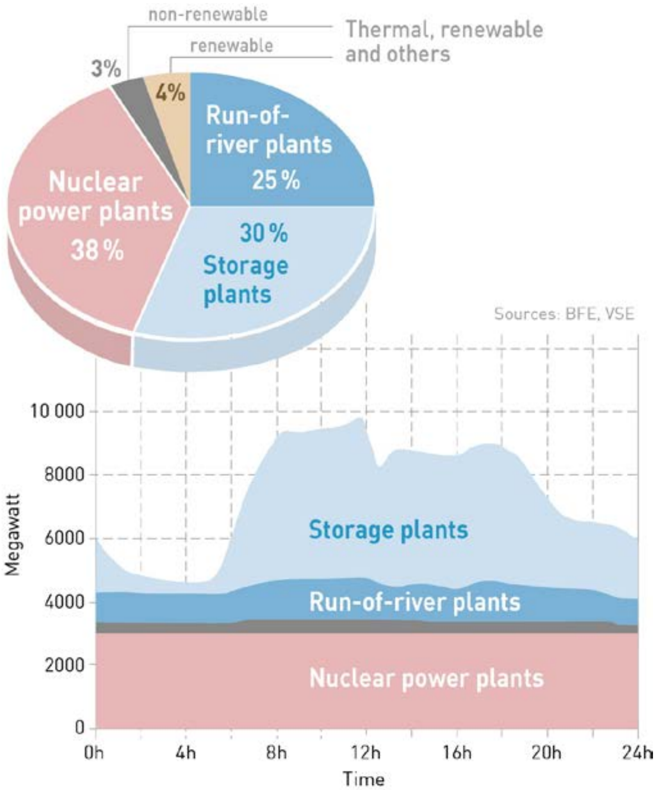
1 Reactor pressure vessel
2 Steam turbine
3 Generator
4 Steam generator (PWR only)
5 Condenser
6 Pump

In a **BWR**, the reactor core heats water, which turns to steam and drives a steam turbine.

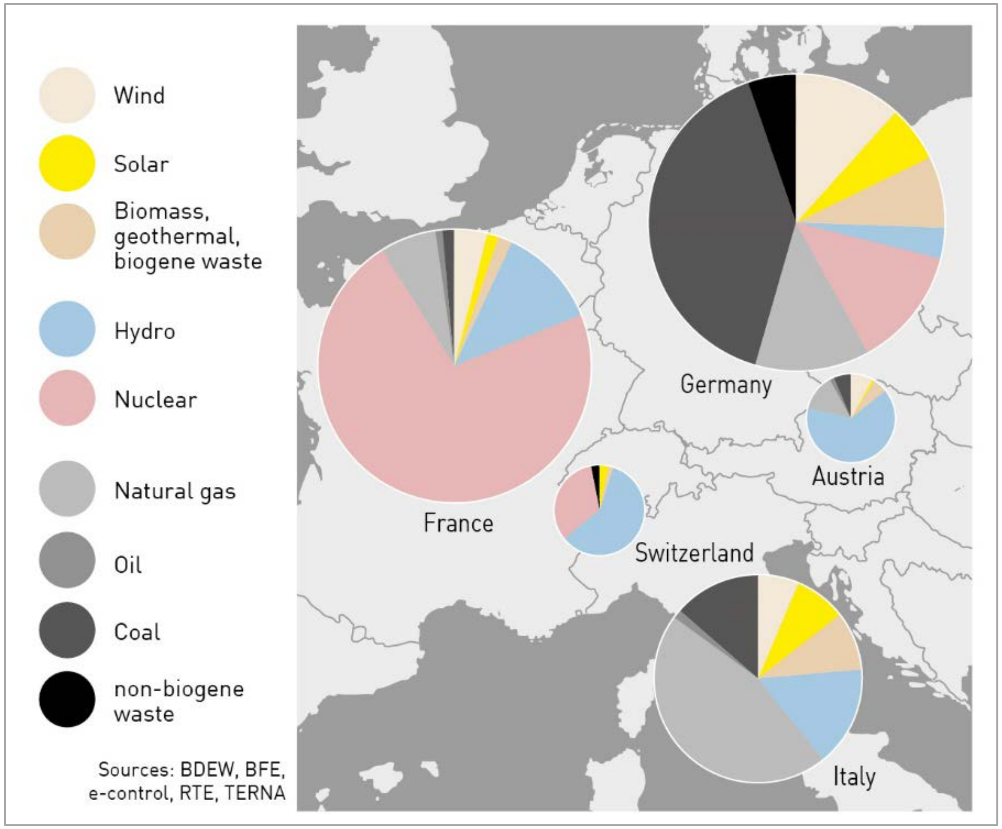
In a **PWR**, the reactor core heats water, which under high pressure does not boil. This hot water then exchanges heat with a lower pressure water system, which turns to steam and drives the turbine.

Power production in Switzerland and neighbouring countries

swissnuclear

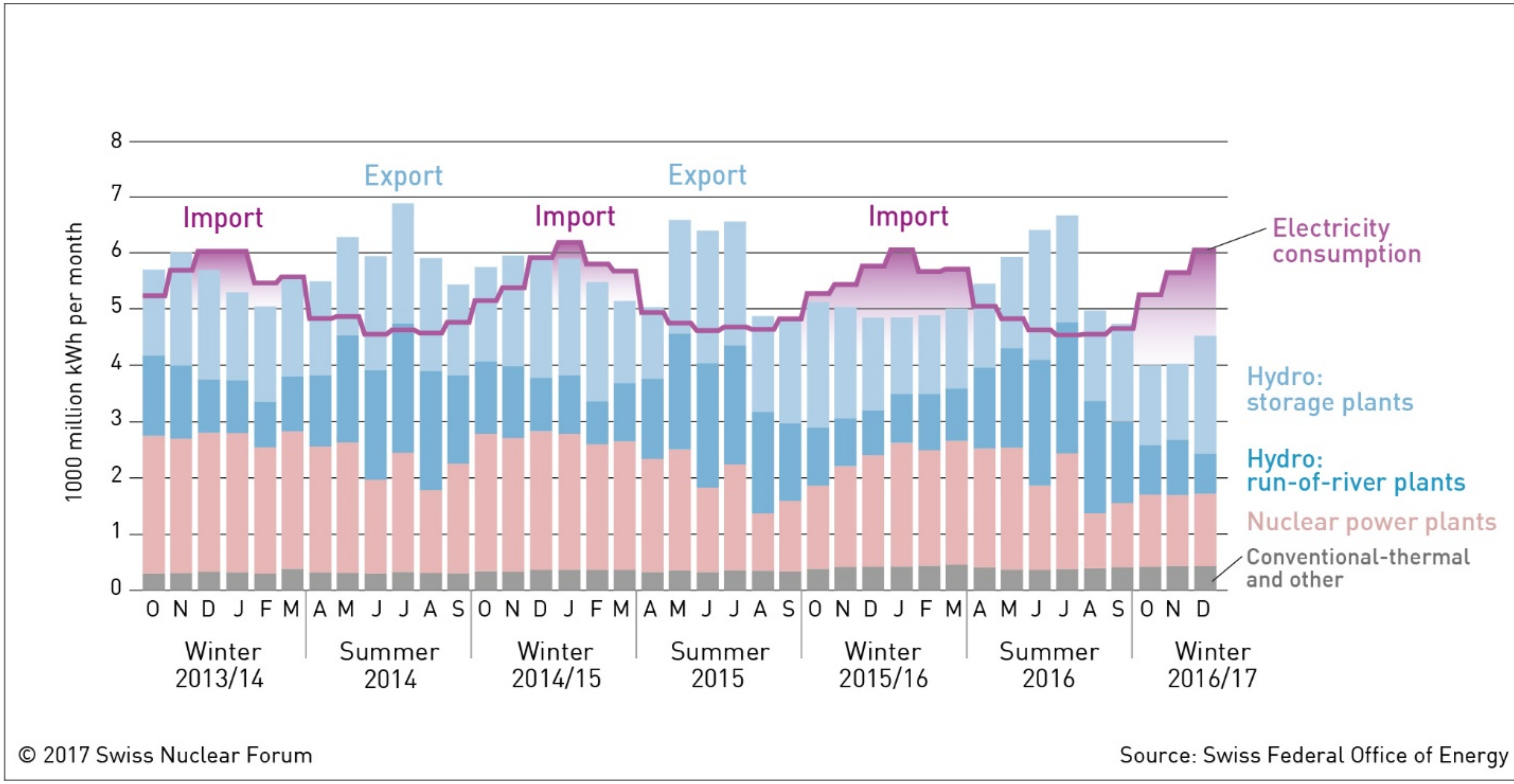


Electricity production in the course of a day



➡ Switzerland's production mix of nuclear and hydro power is reliable and in line with demand

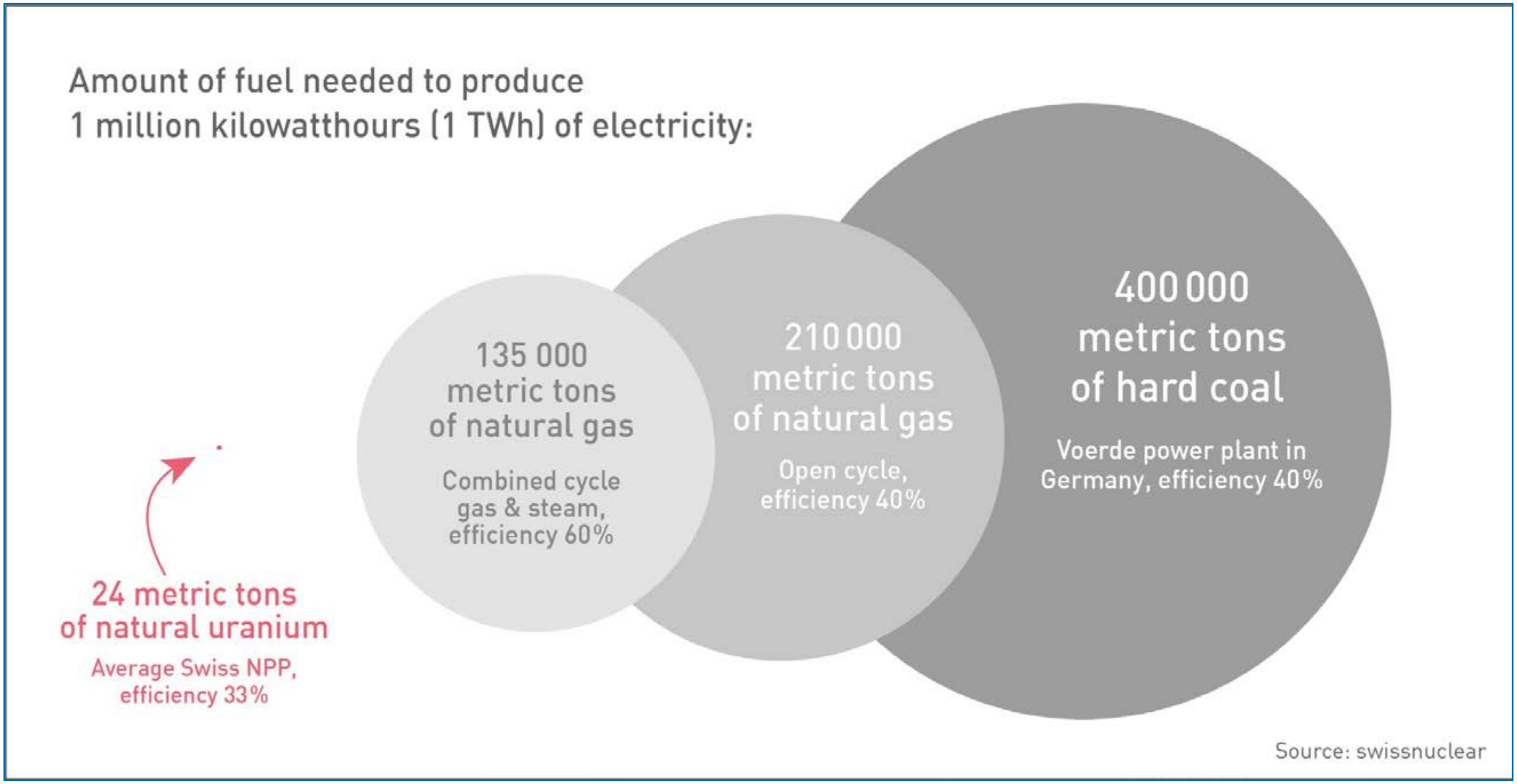
Electricity production and demand in Switzerland, 2013-2016



➡ During winter, nuclear provides up to 50% of Switzerland's domestic production, while the country still has to import electricity!

swissnuclear

Security of supply

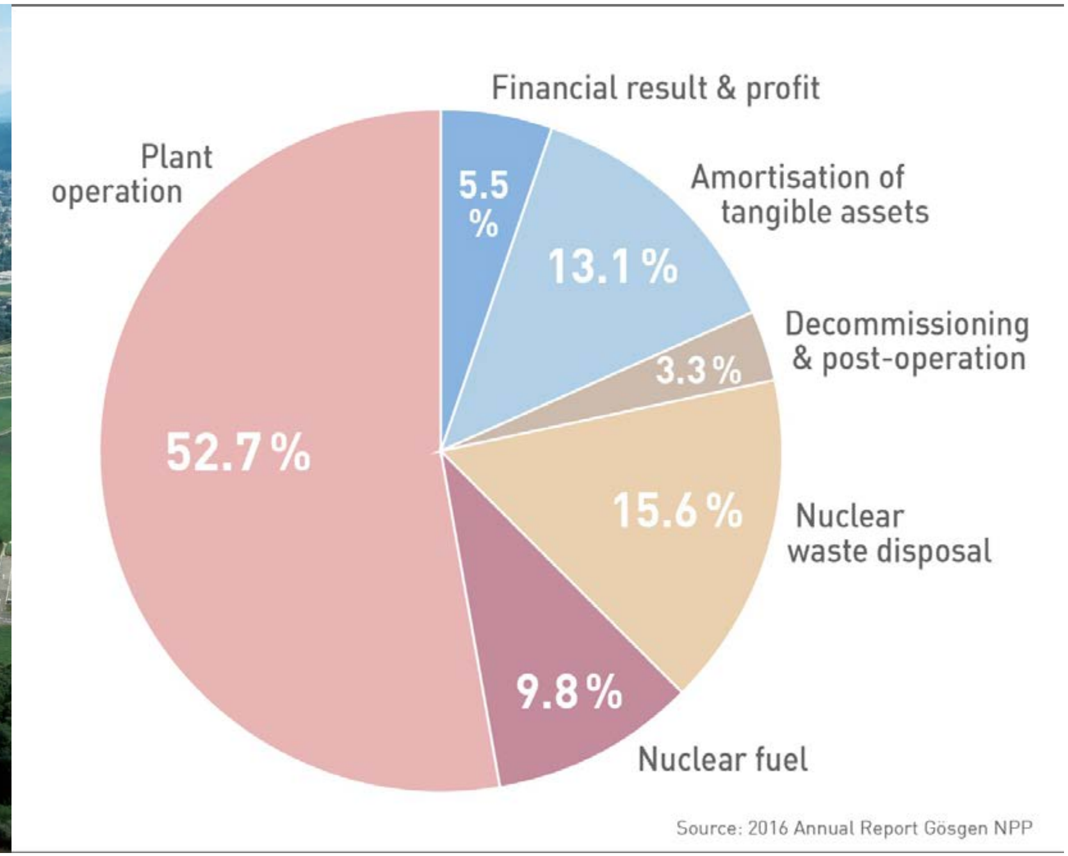


➡ Due to the enormous energy density of uranium,
a car trunk full of fuel covers the need of a NPP for a year

swissnuclear

Annual cost structure of Gösgen NPP in 2016

Normalized annual costs to balance variations in the funds for decommissioning and waste disposal



	2014	2015	2016
➡ Cost of production per kWh:	4.81 Cts	4.31 Cts	4.63 Cts

Economics of nuclear energy in Switzerland

Average production costs today
Cts / kWh

NPP	4,5
Run-of-river plants	5,2
Storage plants	5,9
Small hydro plants	15,0
Wind	18,7
Solar (PV)	37,0

Market price 2016
Cts / kWh

4,0

Market price outlook 2019 (as of 13.07.2017)
Cts kWh

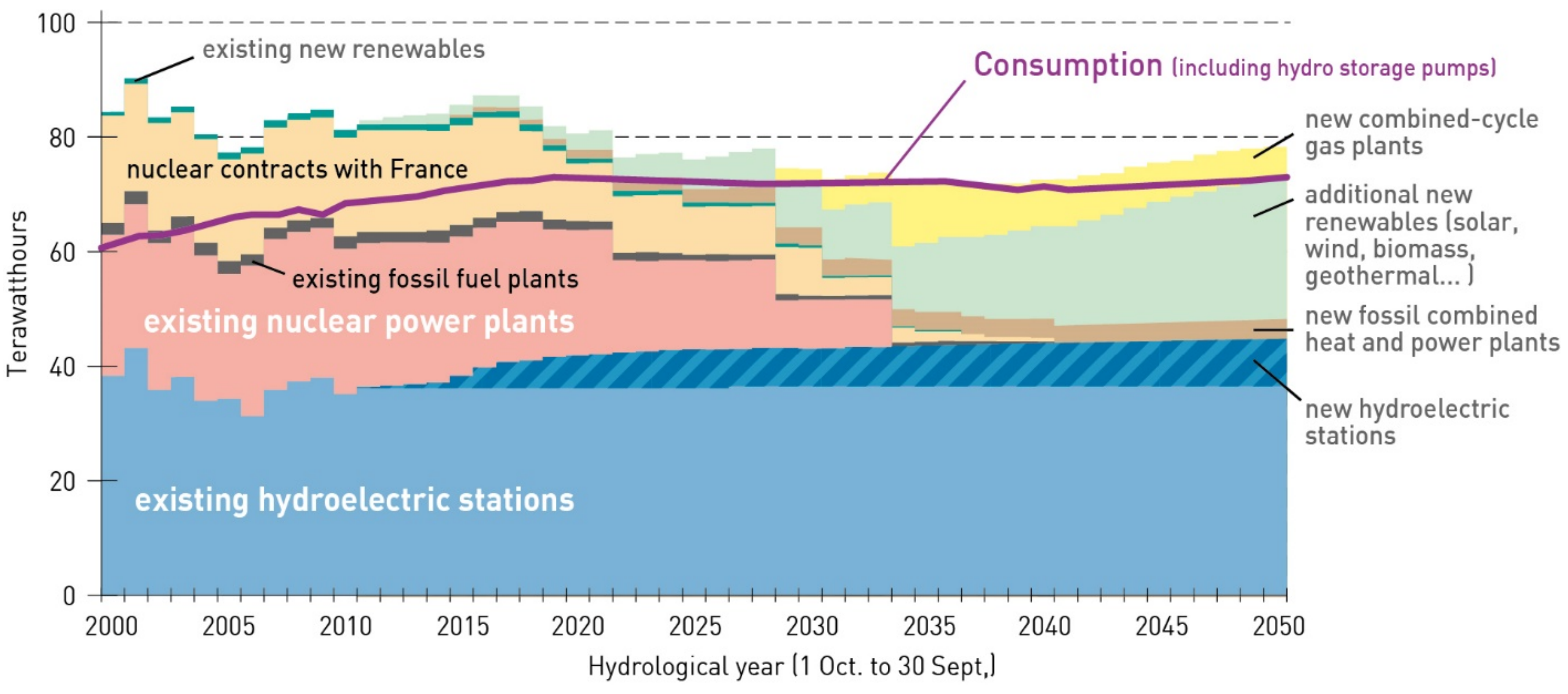
3,8

➡ NPPs are the most economic power source in Switzerland. Still their production costs are higher than the market price.

Sources: Stiftung Kostendeckende Einspeisevergütung, Annual Report 2015; Sonderdruck Wasserzins 2017

swissnuclear

Energy strategy 2050: government scenario based on the package of actions already decided upon



Source: Federal Office for Energy, public consultation September 2012

➡ During the transition period, and still after 2050, the foreseeable production gap is said to be closed by gas-powered plants or not assured imports

Energy strategy 2050: considered expansion of Swiss production facilities

swissnuclear

To replace the existing NPPs, the Swiss government considers the expansion of low carbon power production up to 2050 that corresponds to the following additions:

10'000'000 solar panels of 10 m² each

+

more than 1000 wind turbines of 2 Megawatts each

+

175 geothermal power plants

(as planned and abolished in Basel)

+

more than 1'000'000 tons of wood annually

(for biomass power plants)

+

25 hydroelectric power stations like Beznau

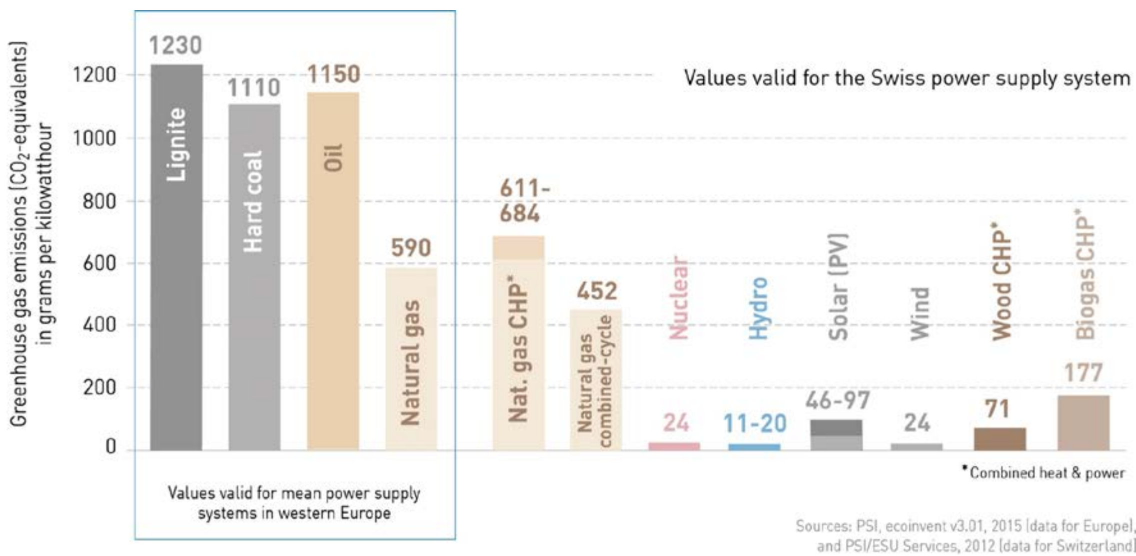
+

2-3 hydroelectric storage plants like in the Grimsel area

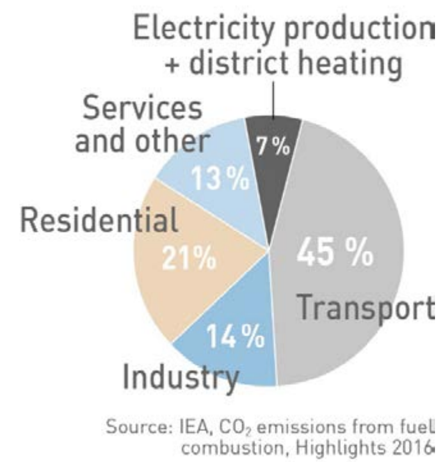
Climate policy and energy-related greenhouse gas emissions in Switzerland

swissnuclear

Greenhouse gas emissions (life cycle)



Origin of energy-related CO2-emissions in Switzerland by sector

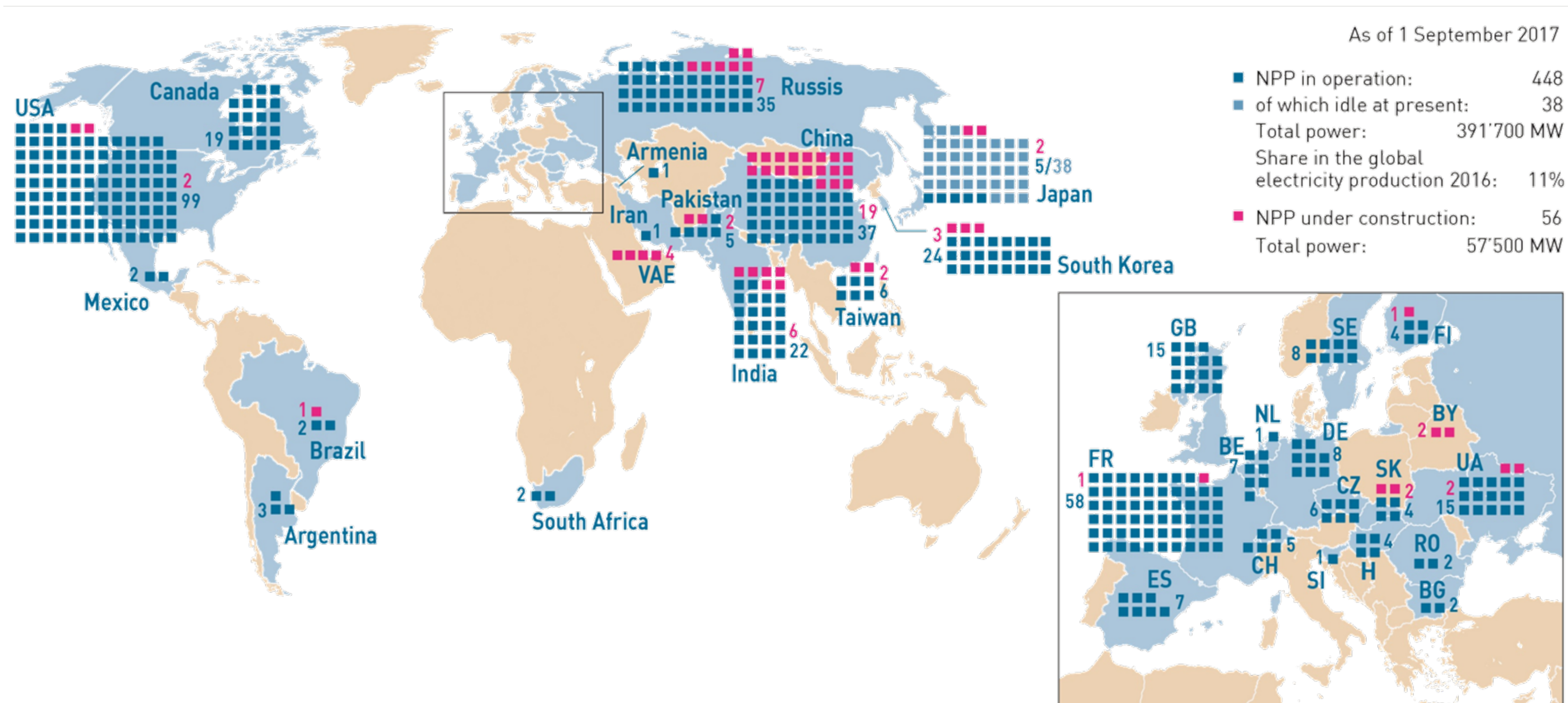


Official Swiss climate policy objectives:

- Kyoto protocol: reduction of greenhouse gases to **15.8%** below 1990-level until 2020
- Federal law on CO2: reduction of CO2-emissions to **20%** below 1990-level until 2020
- Paris agreement: reduction of greenhouse gases to **50%** below 1990-level until 2030

swissnuclear

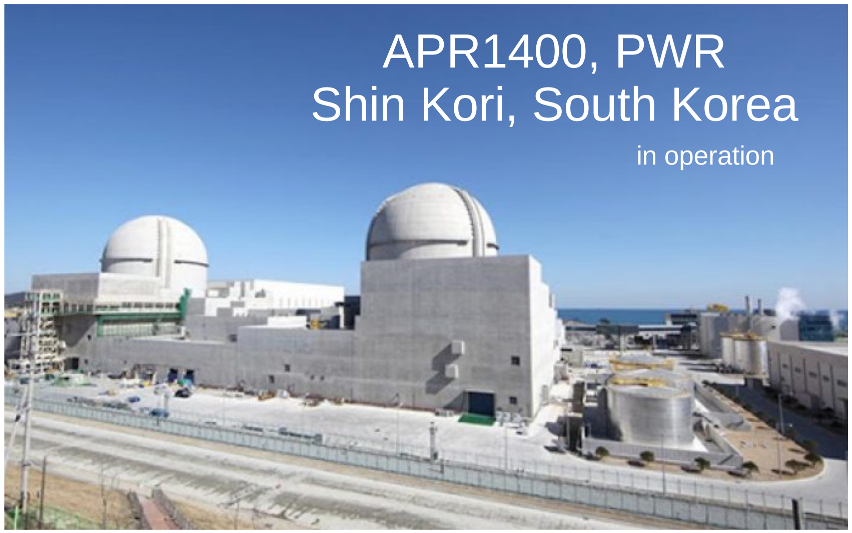
Nuclear power plants worldwide



Source: Swiss Nuclear Forum, 2017

➡ Currently there are 56 NPPs under construction in 15 countries. In addition, planning for about 150 NPPs is well advanced in 20 countries.

Advanced nuclear reactor systems in operation and under construction



Coming soon: the High-Temperature Gas-cooled Reactor – Pebble Bed Module

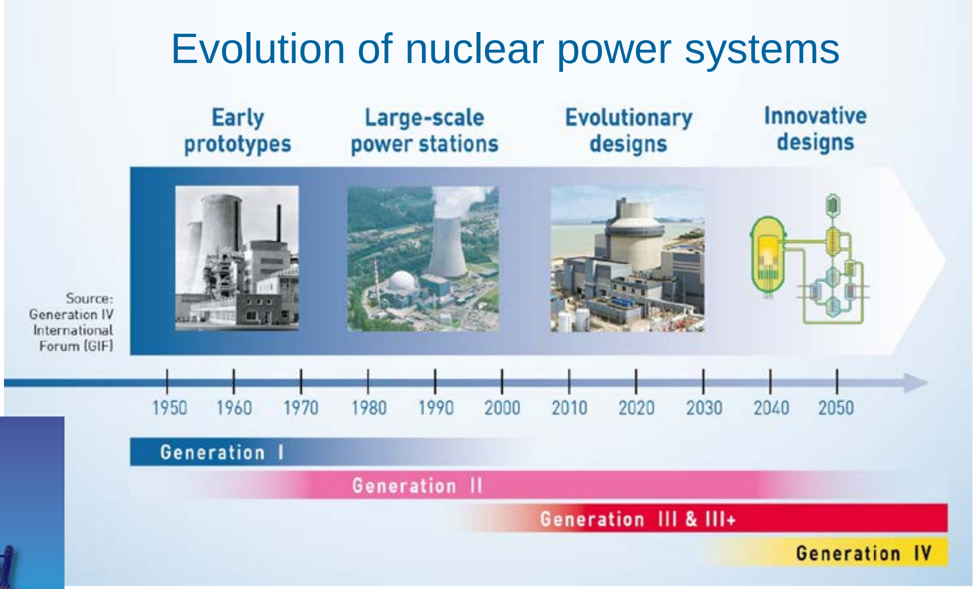
Main characteristics:

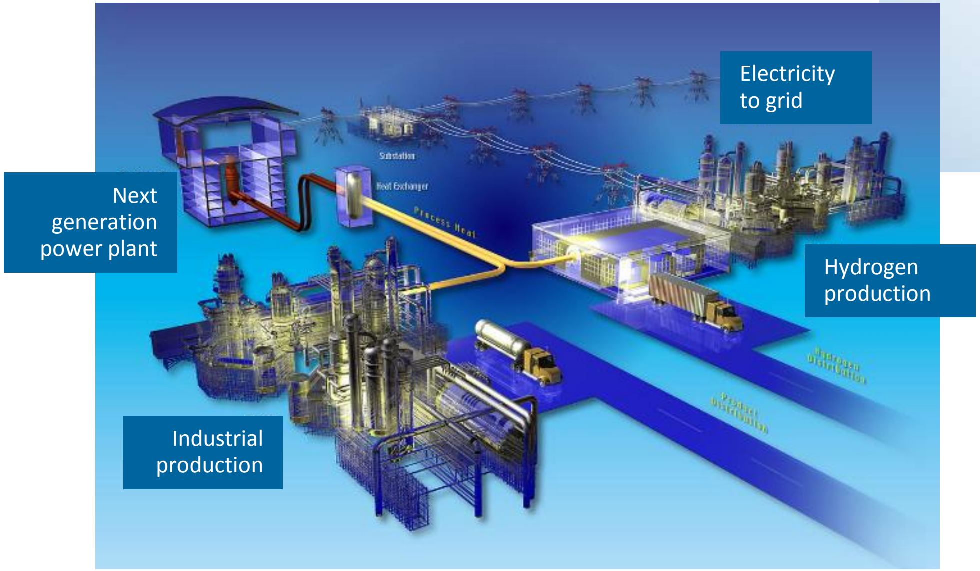
- Inherently safe: melting of core impossible, even if all cooling systems fail
- Fuel pebbles stay undamaged even at highest possible temperatures in the reactor
- Small & modular: step-by-step investments possible with lower project risks
- Economics: to be demonstrated – depends strongly on series production

Next generation: sustained use of fuel, less nuclear waste and resistant to proliferation

Developed within the frame work of the "Generation IV International Forum":

- Sodium-cooled Fast Reactor
- Lead-cooled Fast Reactor
- Gas-cooled Fast Reactor
- Molten Salt Reactor
- Supercritical Water-cooled Reactor
- Very High Temperature Reactor

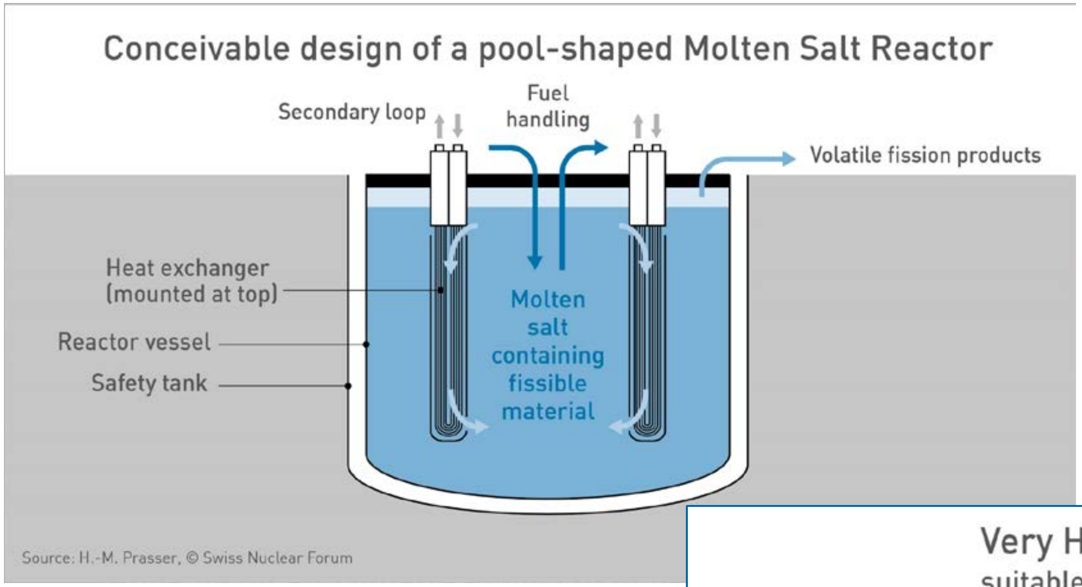




High technological potential, but:

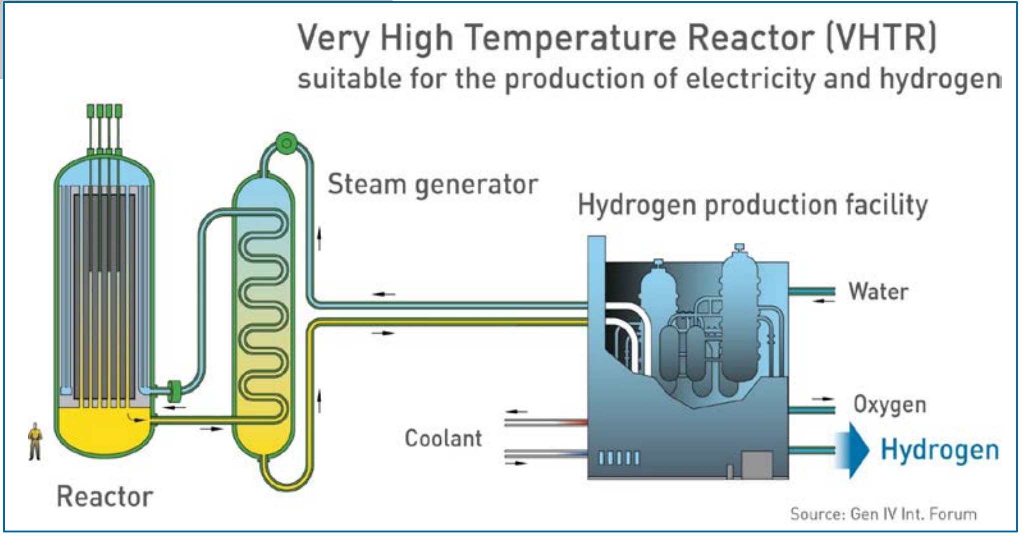
- Too much risk for private industry
- Advanced reactor deployment depends on government support
- Chinese HTR-PM is an example of this support

Examples of generation IV reactors



Advantages:

- No high pressures
- Leak proof – no openings for pipes in the reactor vessel
- Excellent heat exchange

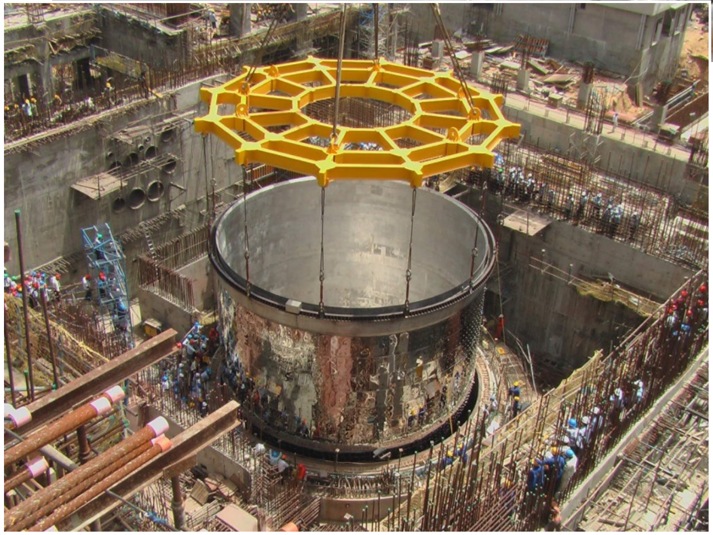


Advantages:

- Very high efficiency
- Multipurpose use: electricity, industrial heat, district heating, hydrogen production (traffic), desalination...

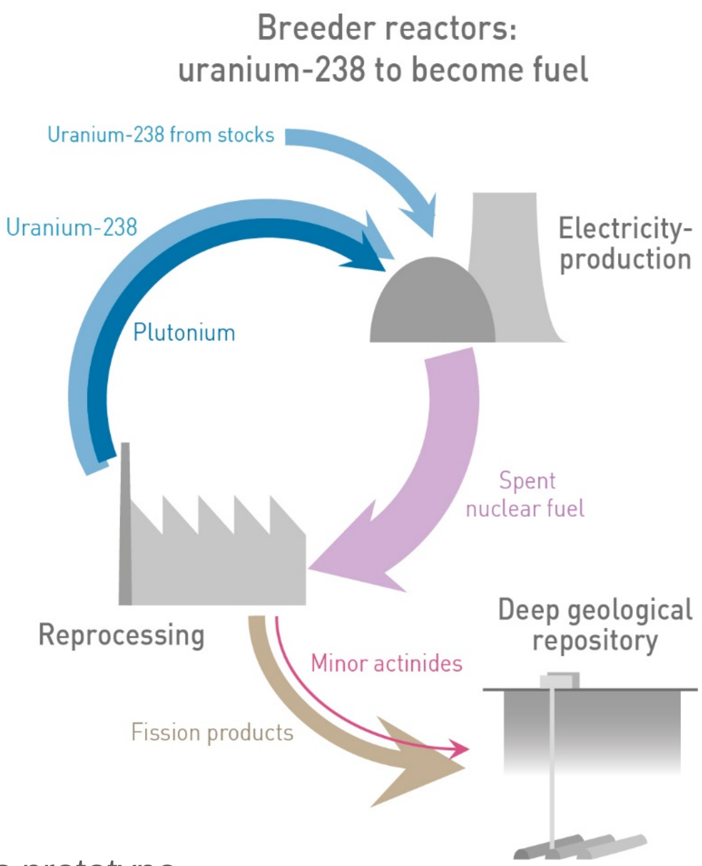
swissnuclear

Closing the nuclear fuel cycle
Replacing uranium by thorium



Loaded with uranium, to be replaced later by thorium: assembly of India’s prototype fast breeder reactor vessel in Kalpakkam (500 MW)

Start of operation planned by end of 2017



swissnuclear

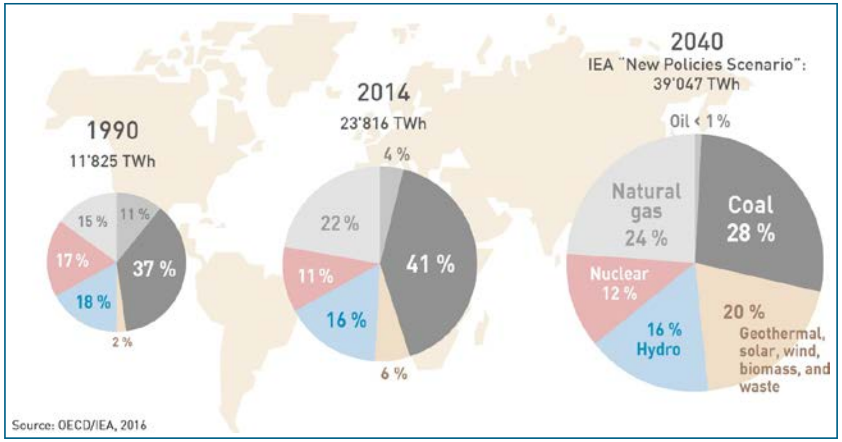
Unclear future

Economics of nuclear
under pressure:

- Low electricity market prices
- Market distortions by subsidies
- Production costs versus system costs (24/365 grid stability)
- “Missing-money”-problem
- New electricity market designs examined
- Economics of generation IV reactors still to be demonstrated

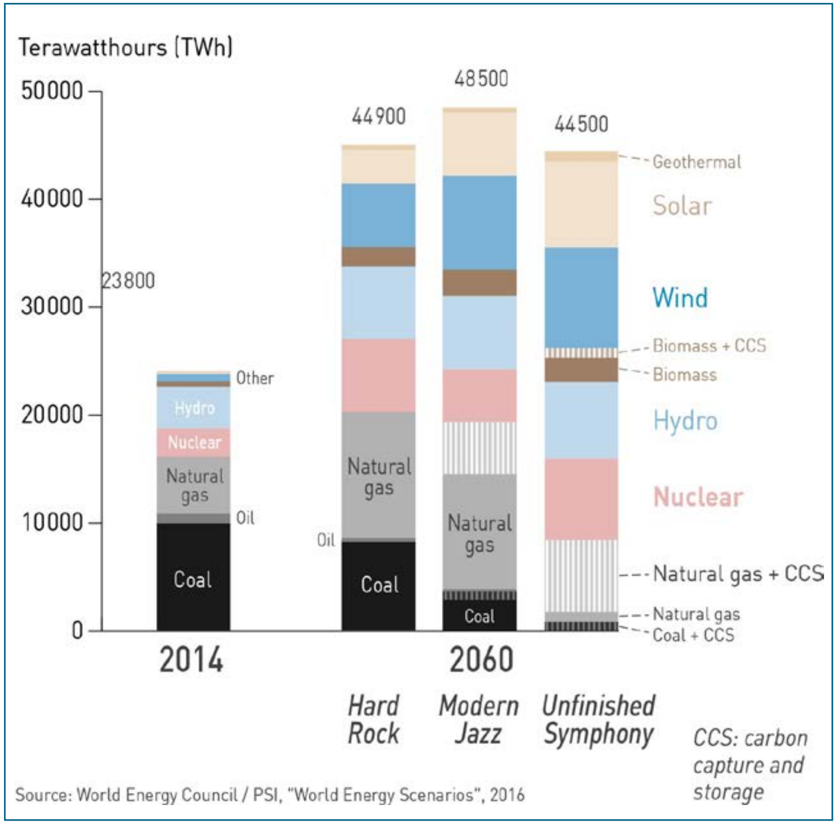
➡ Development of “green” nuclear technologies depend on strong and lasting support by government - will China and Russia soon be in the lead?

Outlook on the electricity demand worldwide



"New Policies Scenario" (reference scenario) by the International Energy Agency (IEA) of OECD:

➡ Demand will grow by more than 60% until 2040, fossil fuels will still dominate, nuclear will almost double

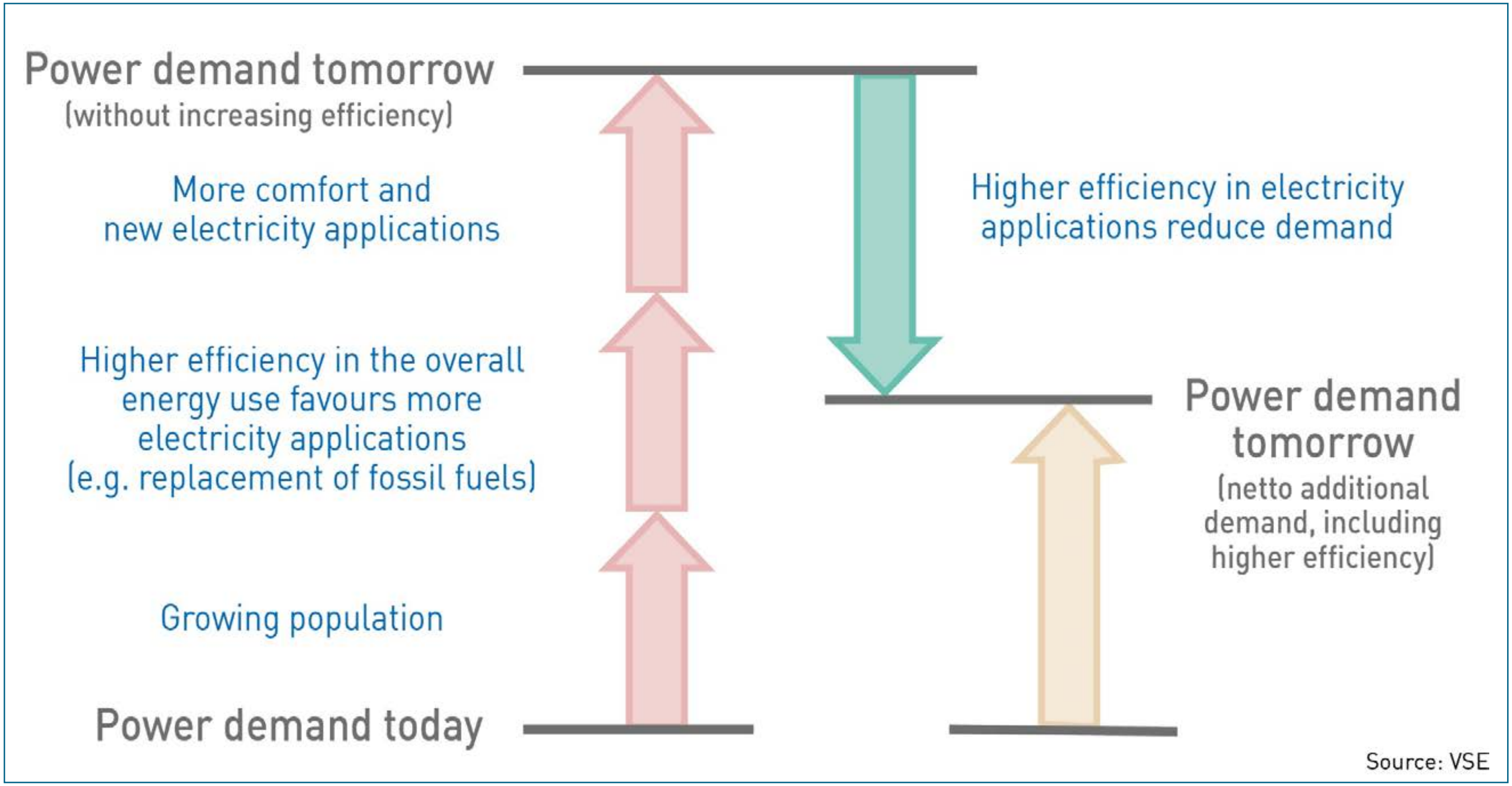


Scenarios by the World Energy Council (WEC):

➡ Nuclear will grow (up to threefold) until 2060 - the "greener" the production mix, the higher the share of nuclear

swissnuclear

Energy efficiency and power consumption



➡ Electricity is key to the energy supply of tomorrow

swissnuclear

Federal Office for Civil Protection: the 10 biggest risks in Switzerland

1. **Persistent power shortage in winter**
2. **Pandemic**
3. **Heat wave**
4. **Earthquake**
5. **Regional power failure**
6. **Storm**
7. **IT-failure**
8. **Wave of refugees**
9. **Crash of a flying object**
10. **Animal disease**

→ "We estimate the direct costs of a blackout to be at least in the order of **2000 to 4000 million Swiss francs daily**."

Federal councillor Guy Parmelin
Swiss Power Congress, 12 January 2017, Berne

Source: BABS, «Katastrophen und Notlagen Schweiz – Technischer Risikobericht 2015»

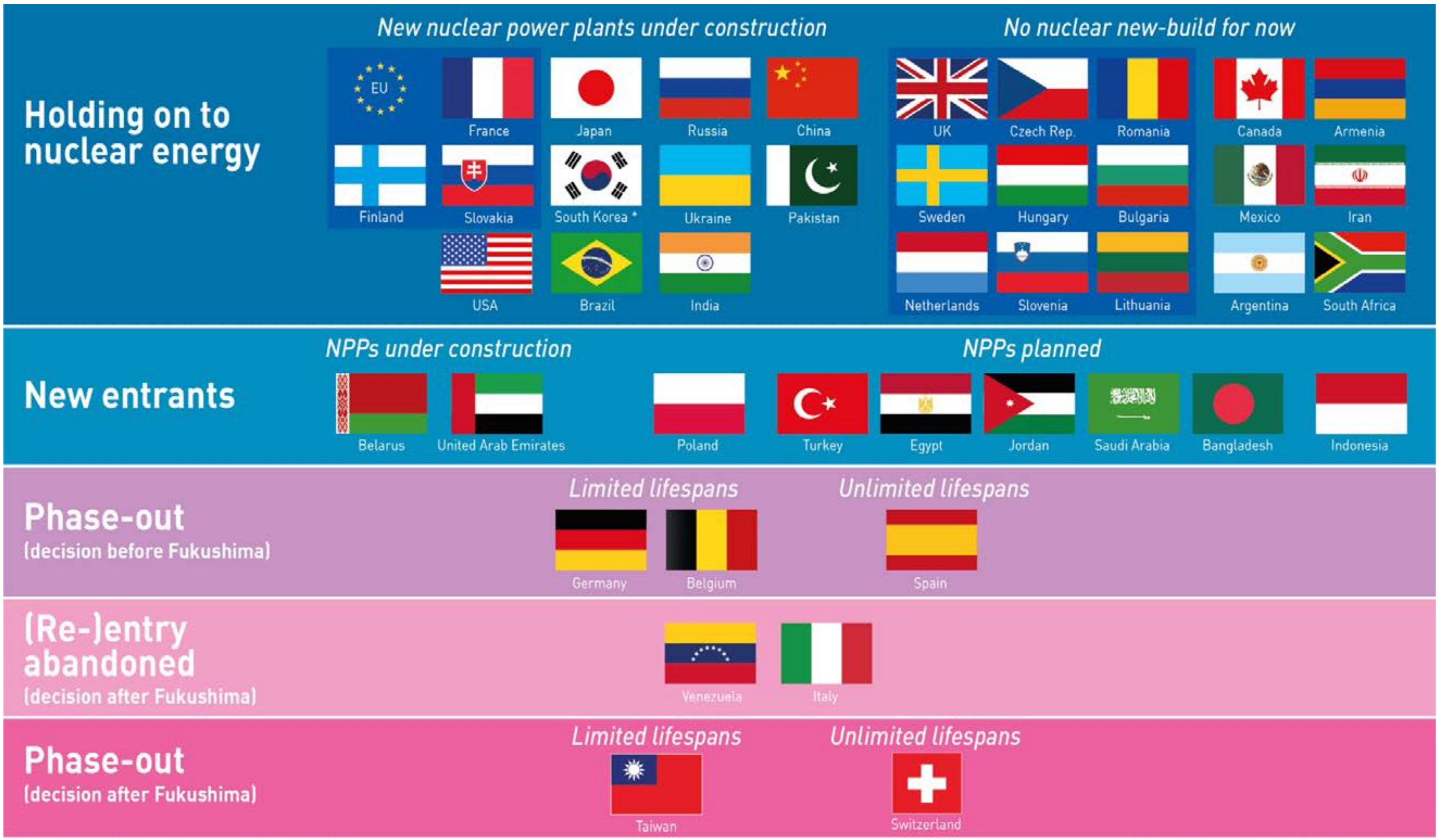
Swiss nuclear power plants: well protected against extreme external hazards

- Swiss NPPs: Safety has always been a process (very high safety culture)
- Excellent protection against terror attacks, flooding, earthquakes etc.
- Extremely low risk of a severe accident with relevant release of radioactivity (1:10^{-6})
- No technology without risks: objective factual comparisons based on scientific evidence and fair information is necessary – so are trade-offs!
- Residual risk has been acceptable in view of major benefits: preservation of resources, environment, climate, security of supply, costs etc.

swissnuclear

Nuclear energy is a promising option, but not in Switzerland

Nuclear energy policies after Fukushima



Source: Swiss Nuclear Forum, as of August 2017

* Currently re-evaluating long-term strategy

swissnuclear

Conclusions

Global level:

R&D, construction and operation of NPPs ongoing. Nuclear energy remains an important asset in fighting growing energy needs, air pollution and supporting climate policies.

Switzerland:

Nuclear option blocked for decades. Losses to be faced:

- industrial high-tech know-how (incl. academic education)
- security of supply, notably in winter
- economic stability and attractiveness
- climate policy actions hampered massively

➡ Nuclear energy is essential to implement the “Energy Strategy 2050”. Current NPPs must operate as long as technically possible and safety is guaranteed.

➡ Politically motivated deterioration of regulatory and economic frame conditions must be avoided.

➡ A fair market model is needed accounting for the importance of the current Swiss NPPs for the security of supply and climate policy.