Nuclear power and global warming

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Global warming

Anthropogenic contribution by emission of greenhouse gasses.

- carbon dioxide CO_2

  mainly by burning fossil fuels
- CFCs, chlorofluorocarbons

  mainly by industrial processes
- other, e.g. methane CH_4

  various sources

Emissions of greenhouse gases (GHGs) by nuclear

- carbon dioxide CO_2

  by all industrial processes in the nuclear process chain, except the nuclear reactor itself (this study)

- CFCs and other greenhouse gases

  never investigated and/or published, but highly probable

Mitigation of CO_2 emissions by nuclear, now and in the future

Global problem.

Three parameters.

Per reactor:

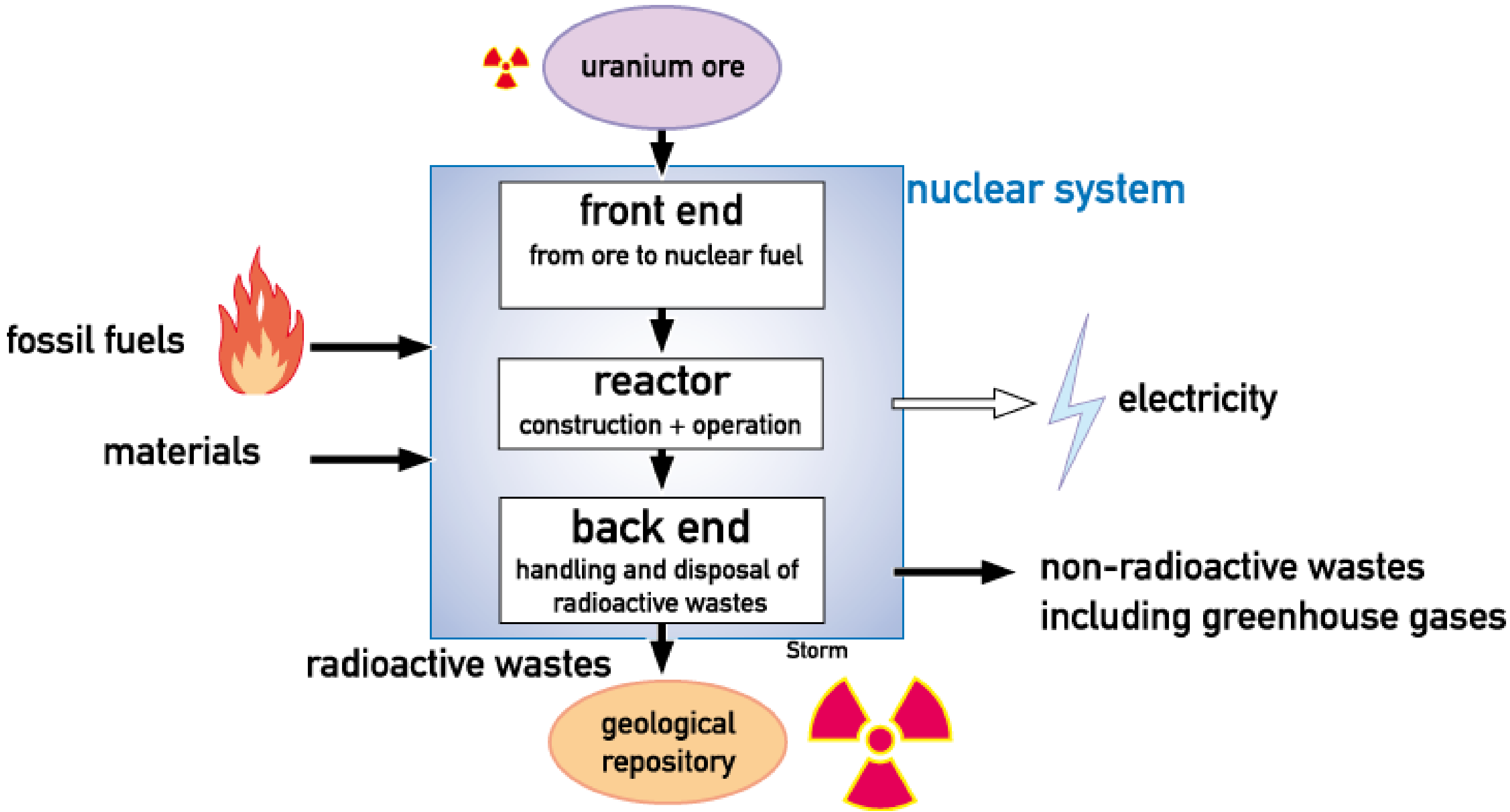
1 Specific CO_2 emission, per kWh

Nuclear share of world energy supply:

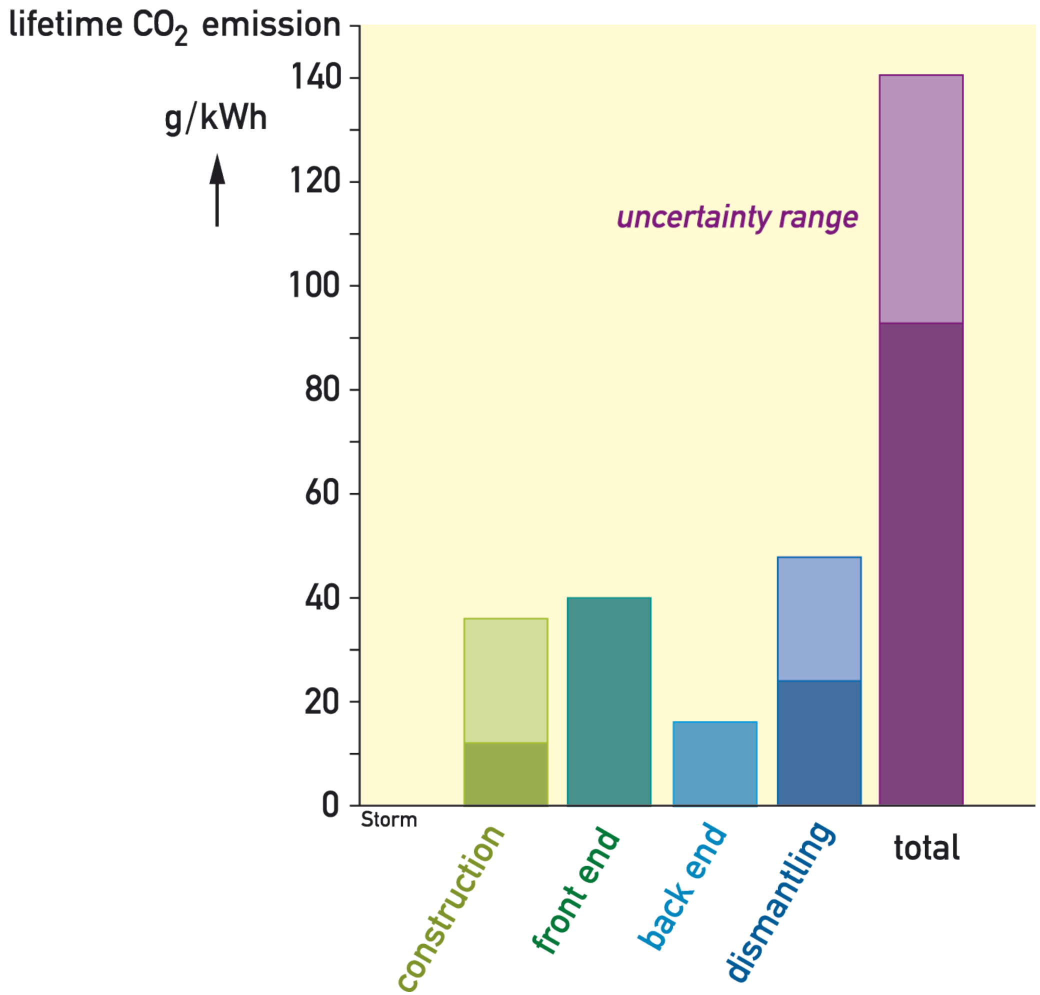
2 How large can it be?

- How long will it last?

Basic nuclear process chain



Current CO_2 emissions by nuclear



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Uranium as an energy source

Uranium is found as a mineral in earth's crust.

Uranium resources are subject to the same physical and chemical laws as any other mineral resource.

Energy from uranium

Net energy extractable from a uranium-bearing deposit in the earth's crust is limited by basic thermodynamic laws.

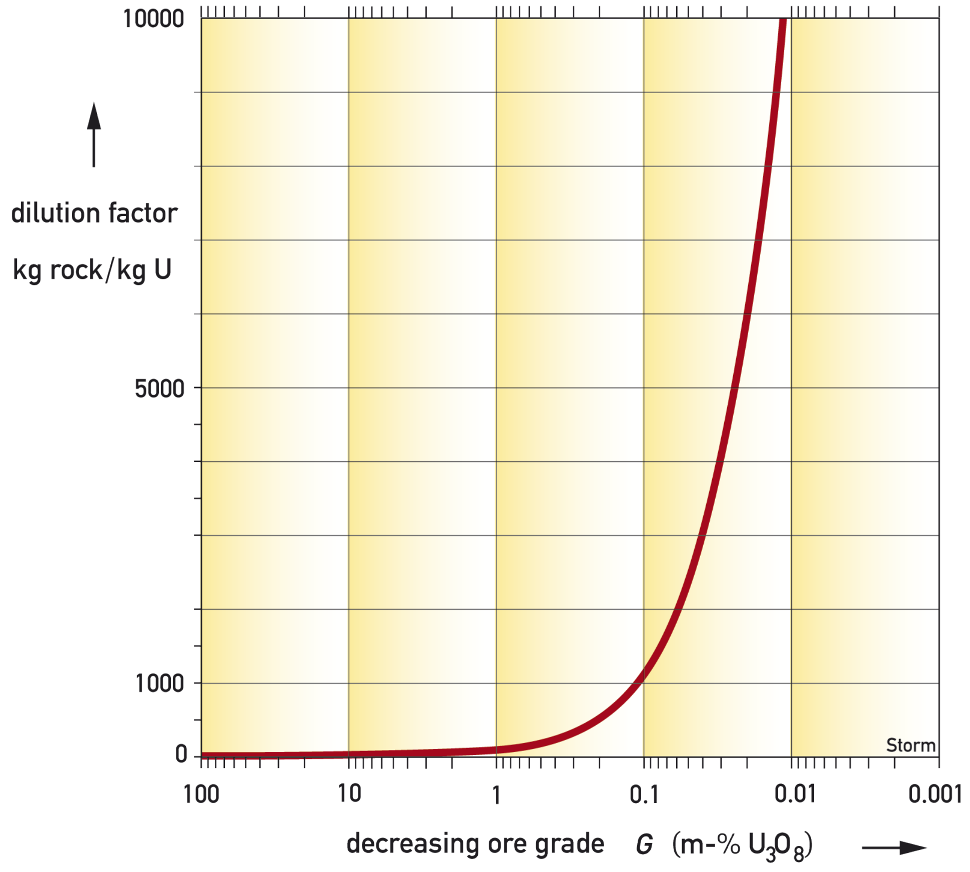
Not only the *quantity* of an U-resource counts, but also its *quality* from an energetic point of view.

Energy from uranium

Main parameters of the thermodynamic (energetic) *quality* of an U-resource:

- ore grade
- type of rock
- geochemical characteristics of U
- size of deposit
- depth of deposit
- location

Dilution factor = kg(rock)/kg(U)



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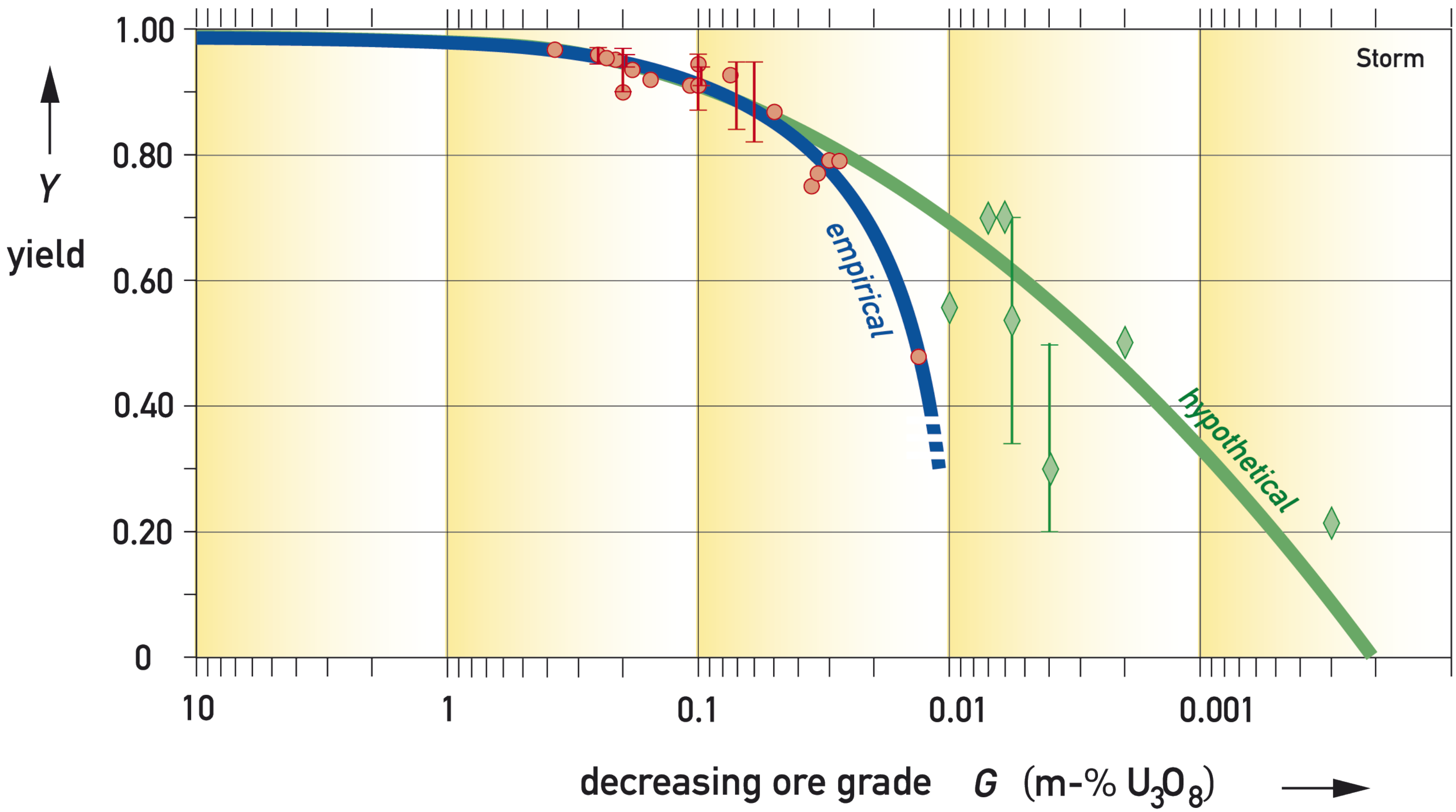
Extraction yield $Y = mU_{ex}/mU_{rock}$



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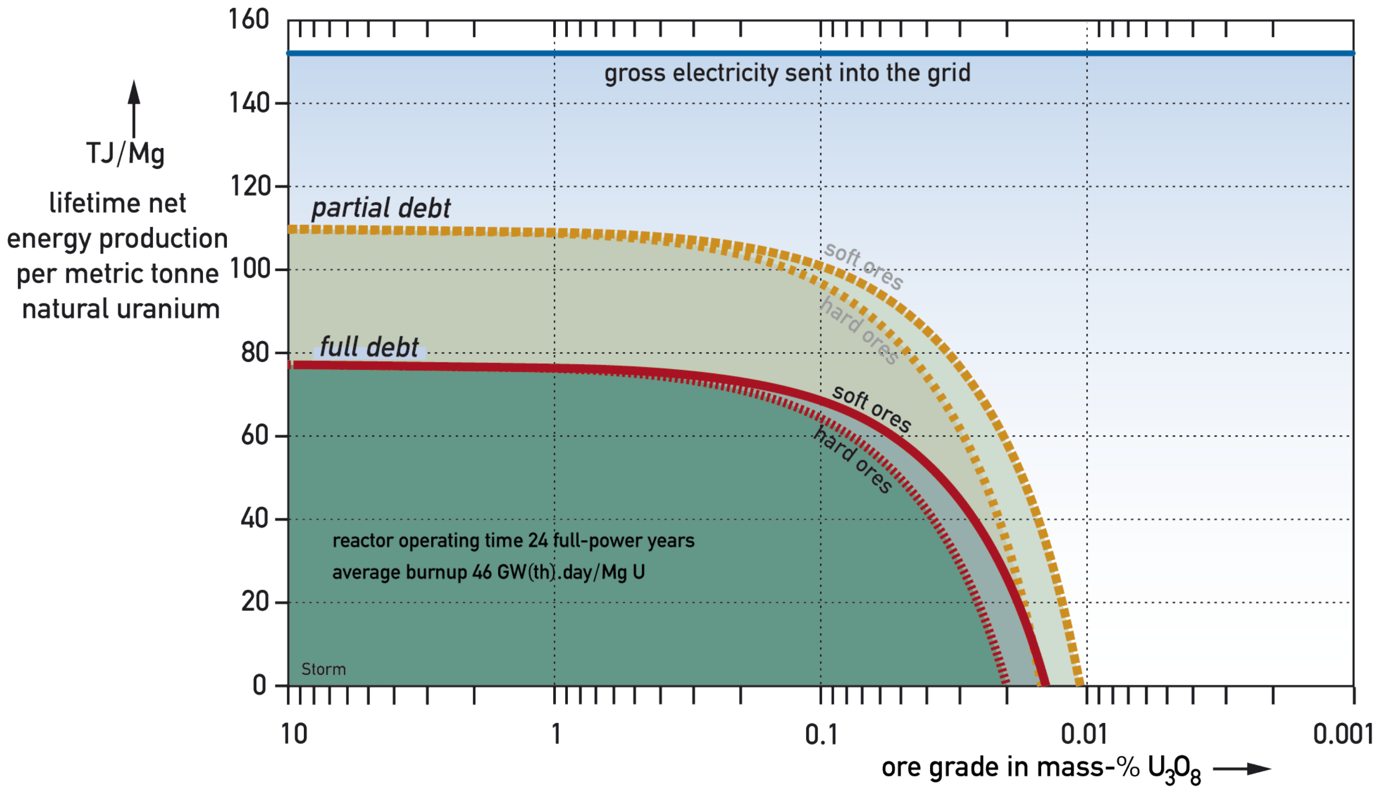
Energy cliff



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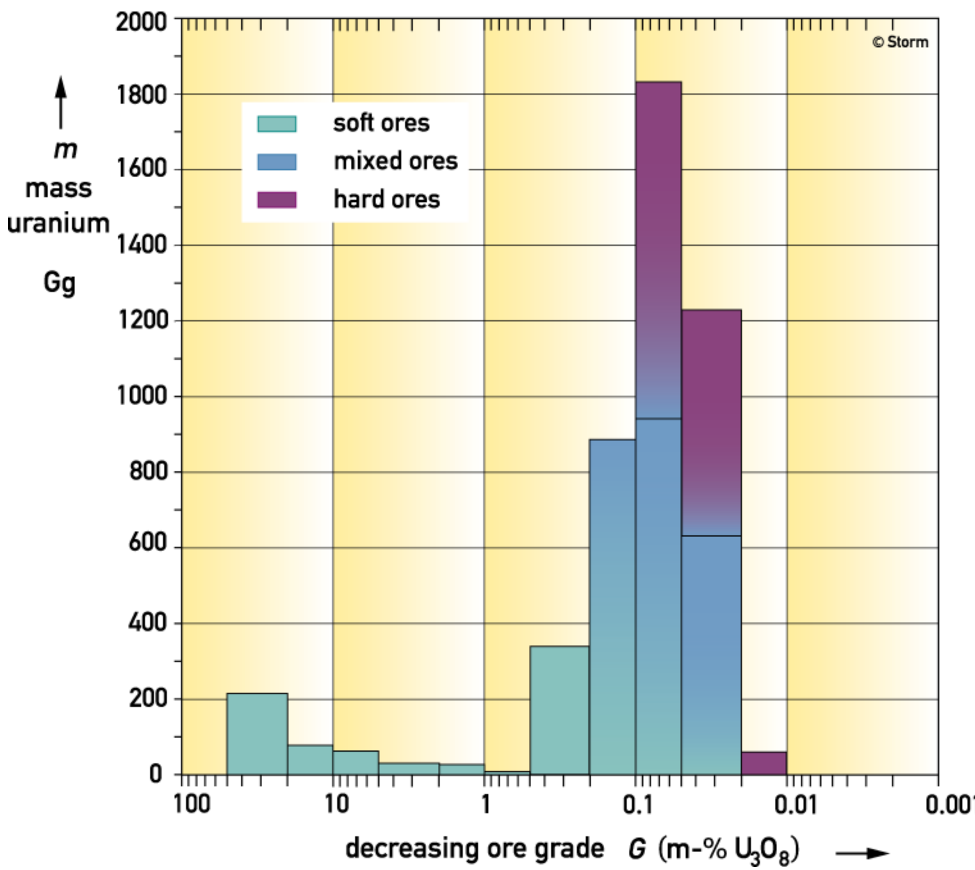
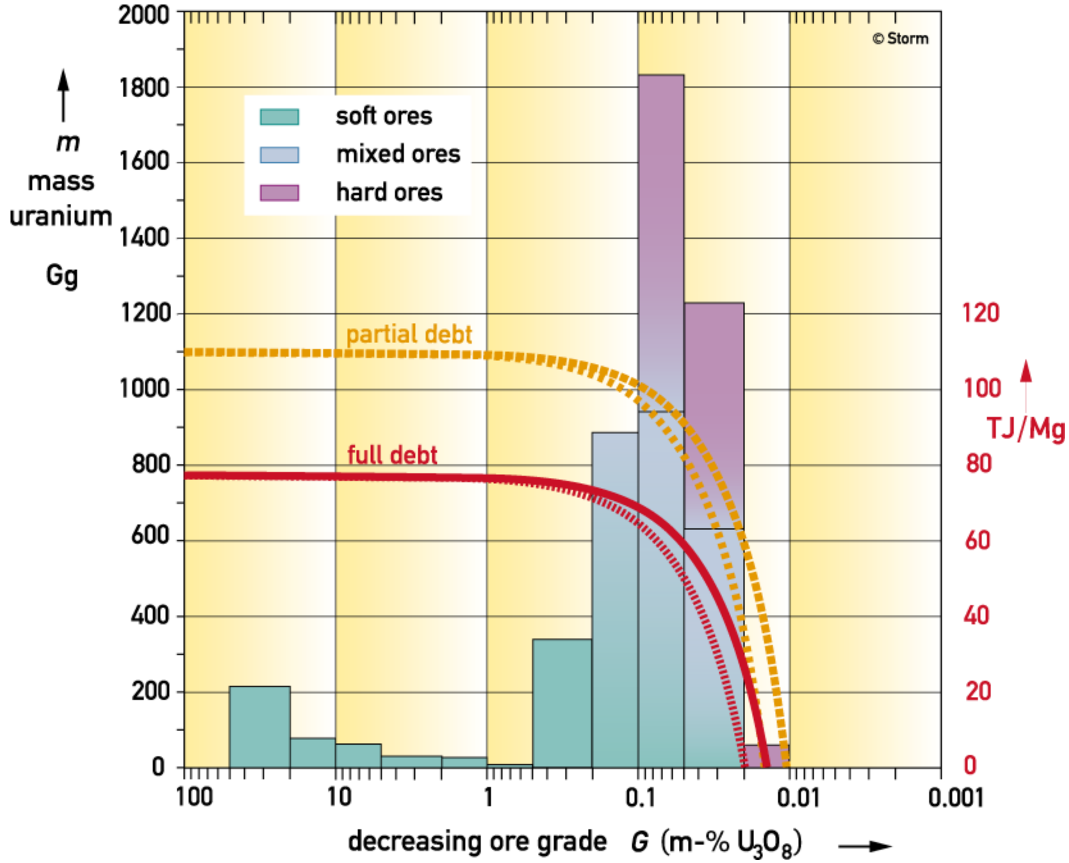
Energy from uranium

Uranium resources ≠ energy resources

Uranium resources and ore grade
(Red Book 2006, WNA)



U resources and the energy cliff



nuclear energy in the future

Scenario 1

World nuclear capacity remains constant at current level, 370 GW(e).

Share declines to < 1% of world energy supply by 2050, for rising world energy demand.

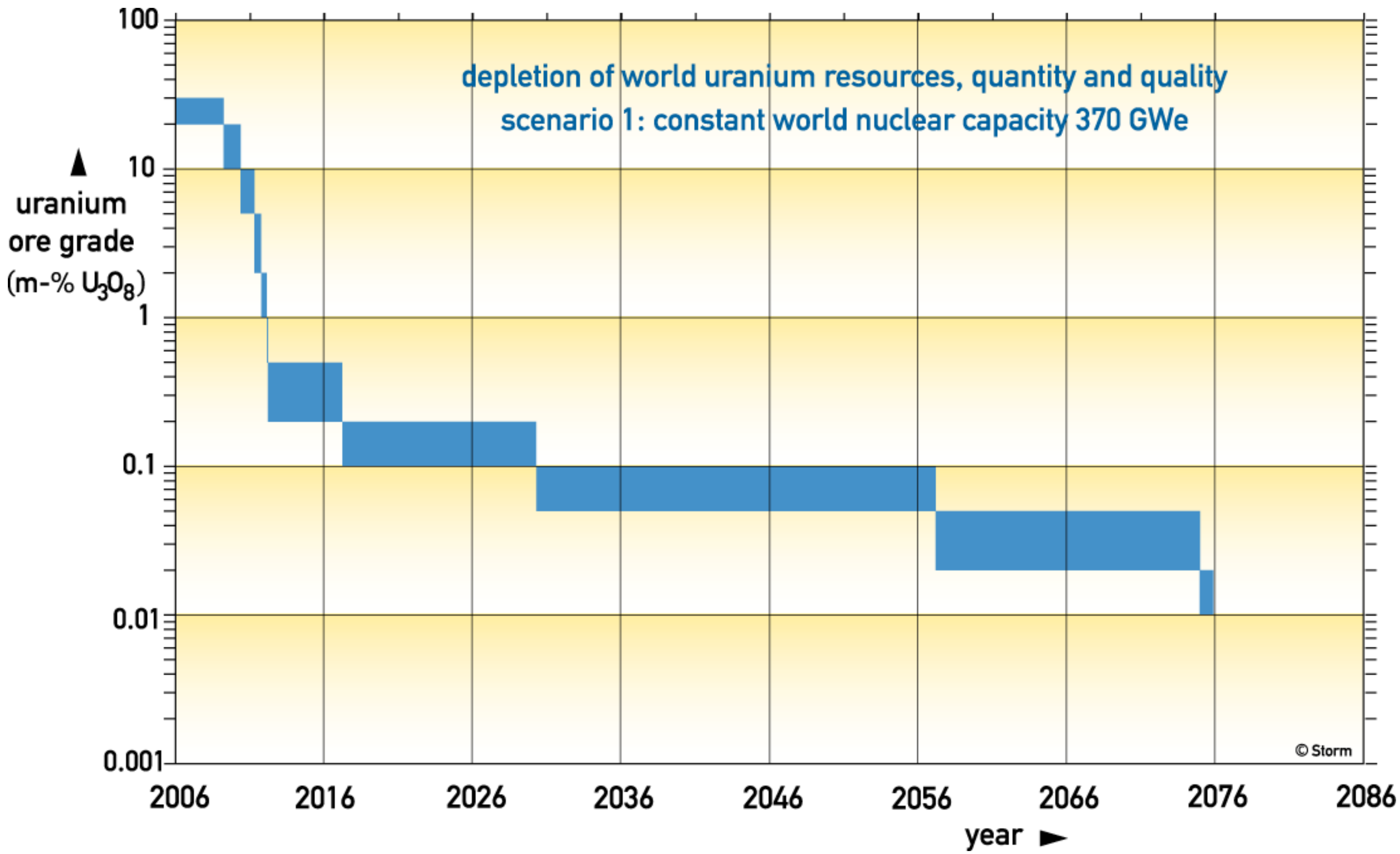
nuclear energy in the future

Scenario 2

World nuclear share remains constant at current level, 2.5% of world energy supply.

World nuclear capacity increases by 2-3% a year (7.5-10 GW/a), to keep pace with rising world energy demand.

Depletion of uranium resources in scenario 1, quantity and quality



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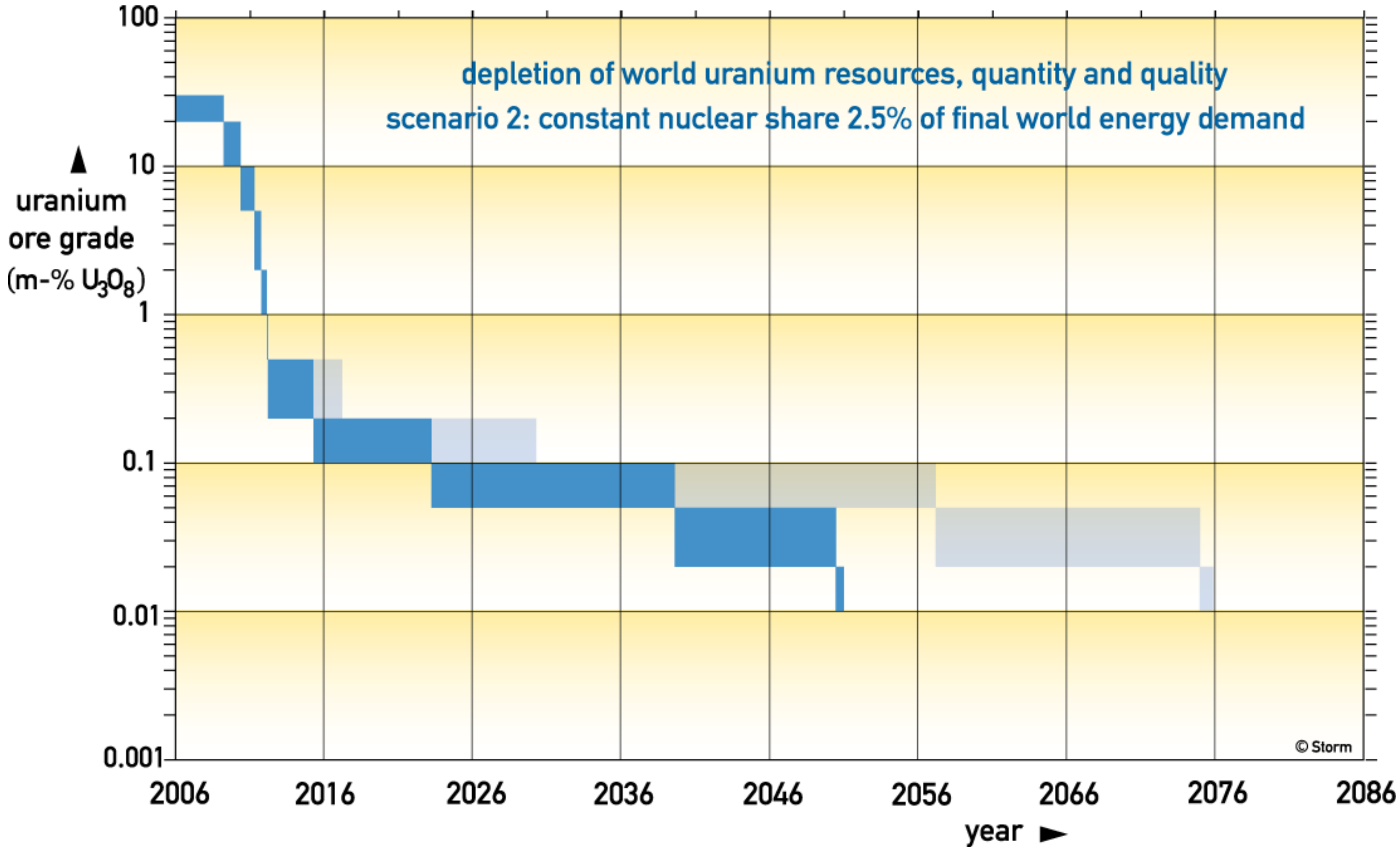
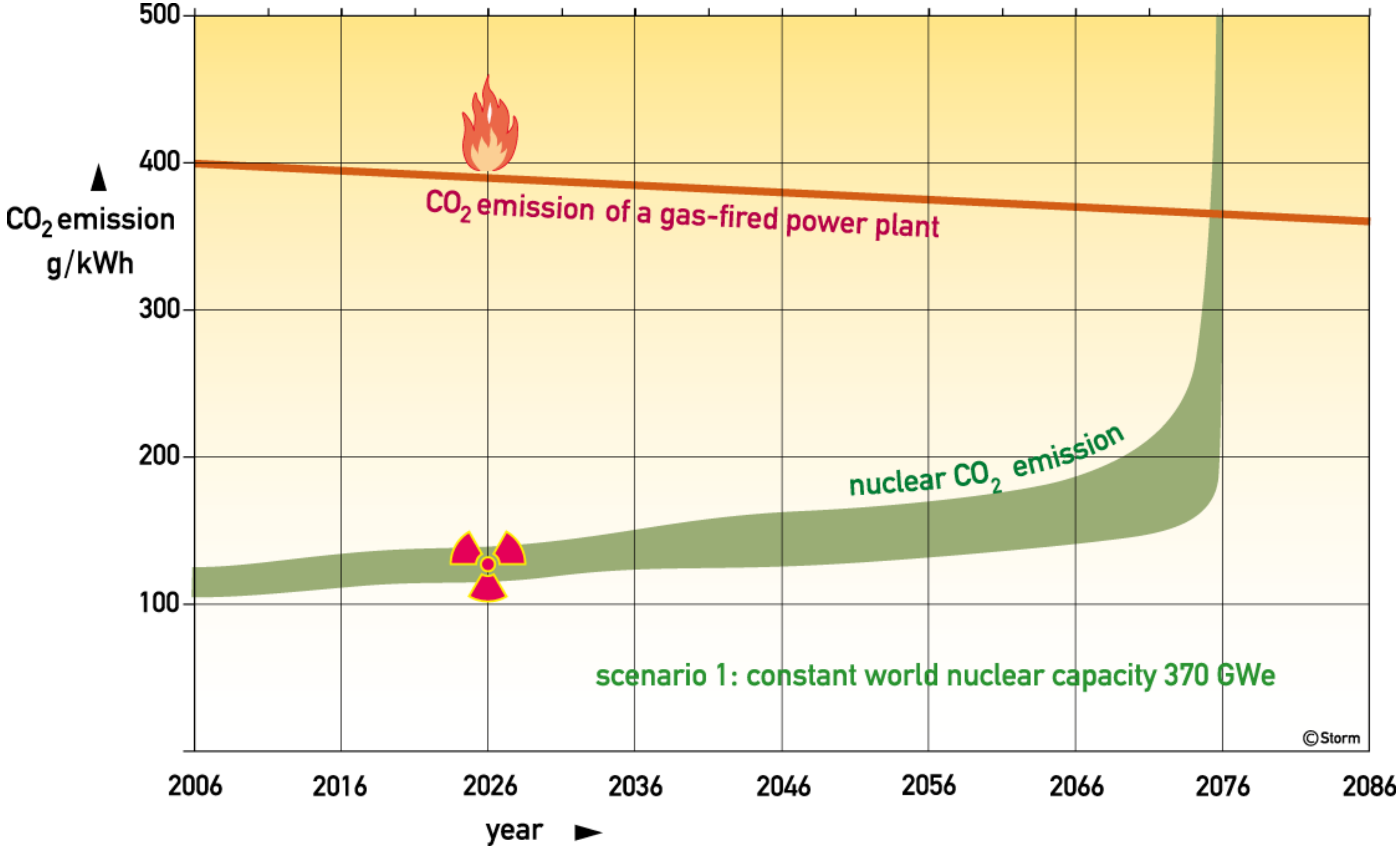
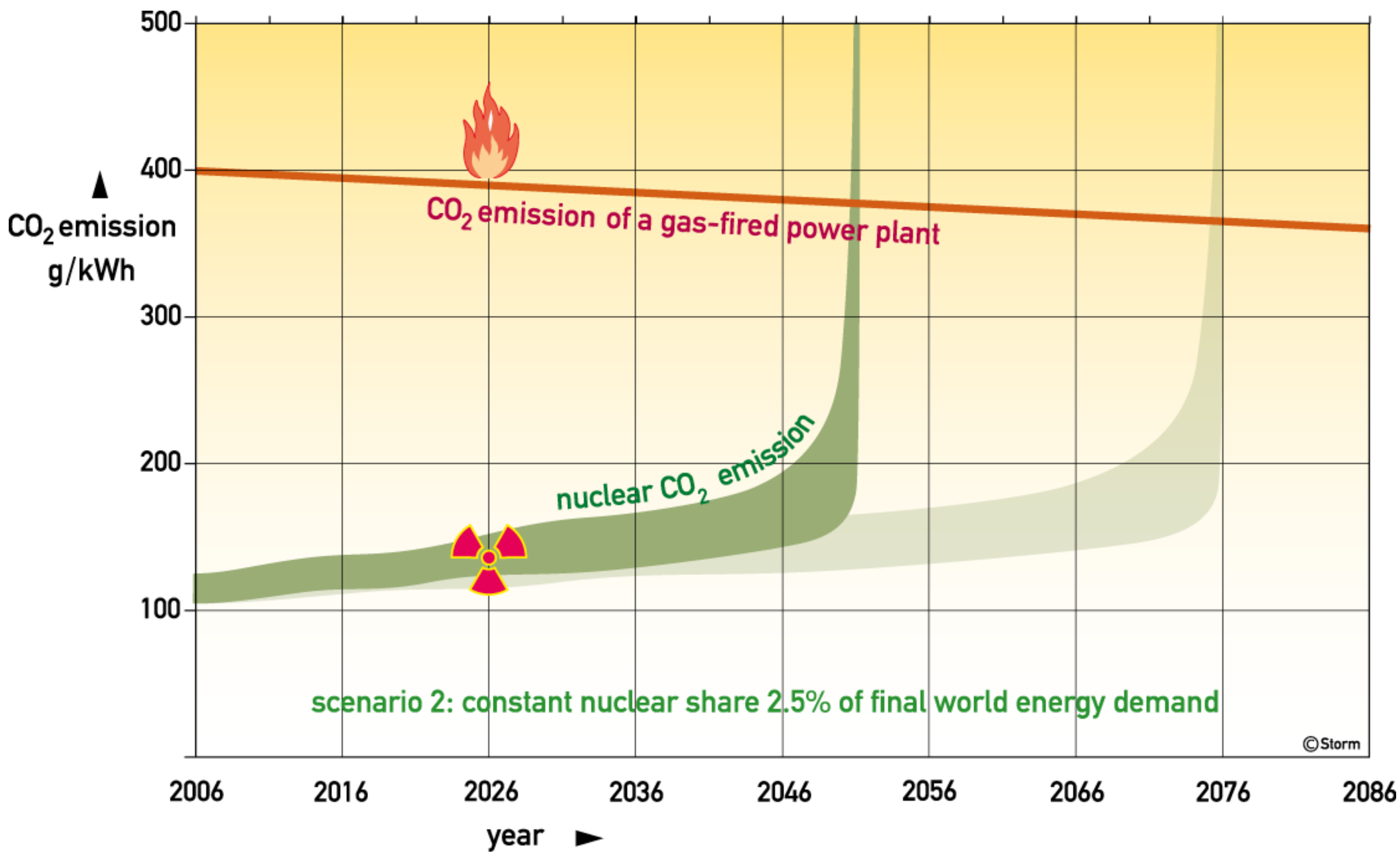
Depletion of uranium resources in scenario 2, quantity and quality



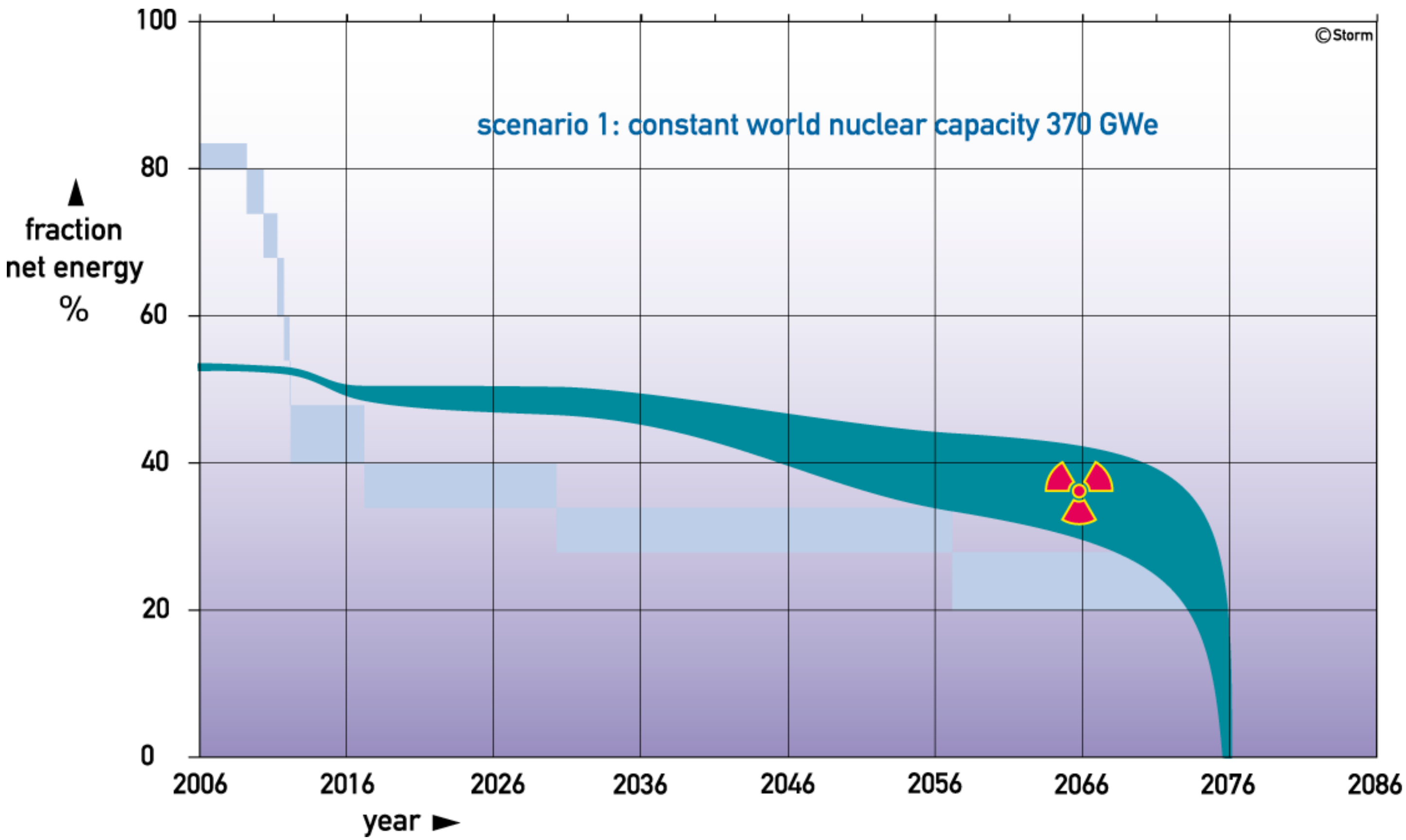
Rise of specific CO_2 emission by nuclear power with time, scenario 1



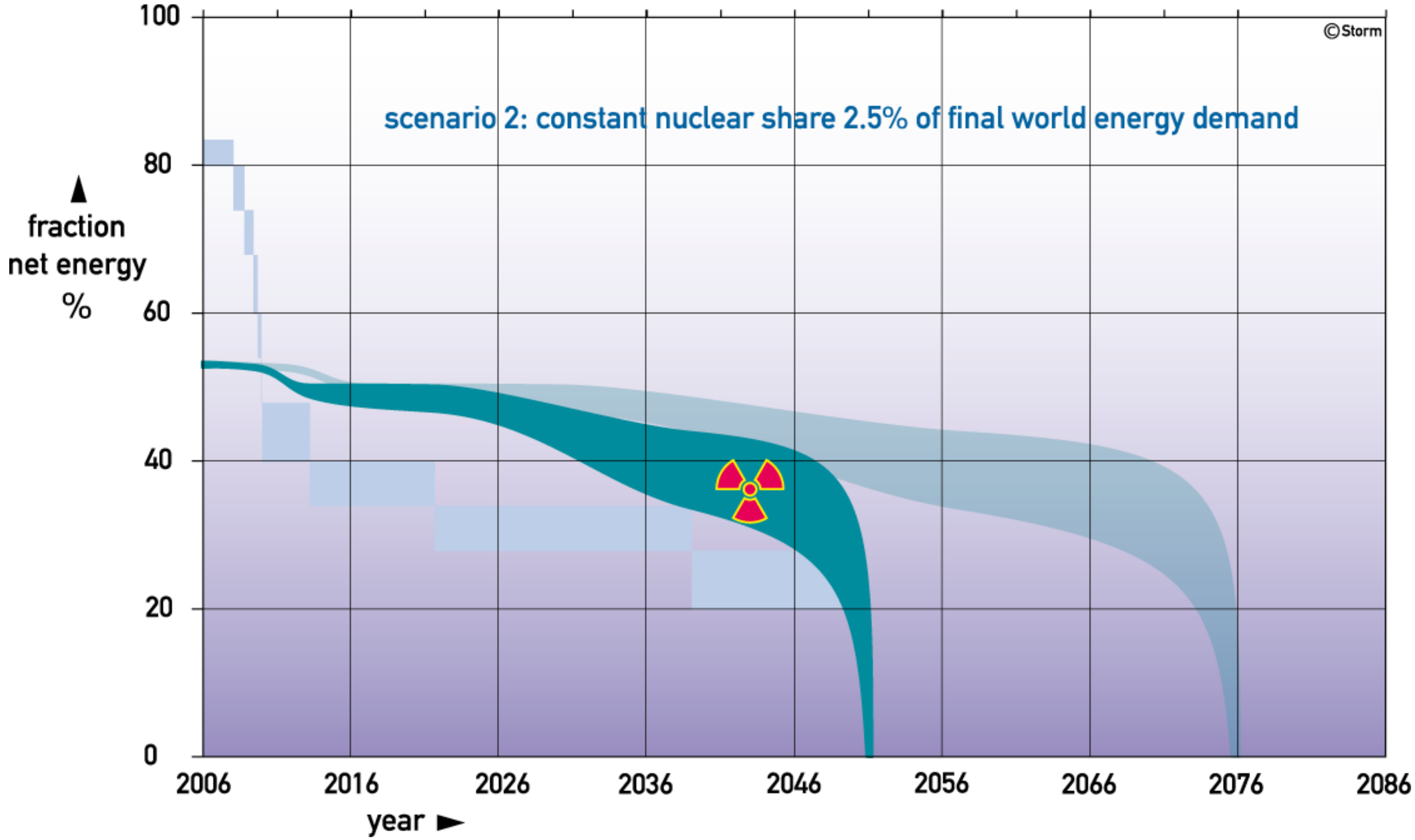
Rise of specific CO_2 emission by nuclear power with time, scenario 2



The energy cliff in time, scenario 1.
Net energy from nuclear power.



The energy cliff in time, scenario 2.
Net energy from nuclear power.



Outlook

- Highest-quality uranium deposits already known and in production.
- Chances of finding new large high-quality deposits unknown, but seem very slim.

Outlook

- New finds: large deposits have low energetic quality.

- Lower energetic quality means more energy consumed per kg extracted uranium.

Outlook

- New finds of uranium deposits will be closer to the energy cliff, due to lower energetic quality.
- Note the difference between *high-grade* and *high-quality* ores.

Conclusion

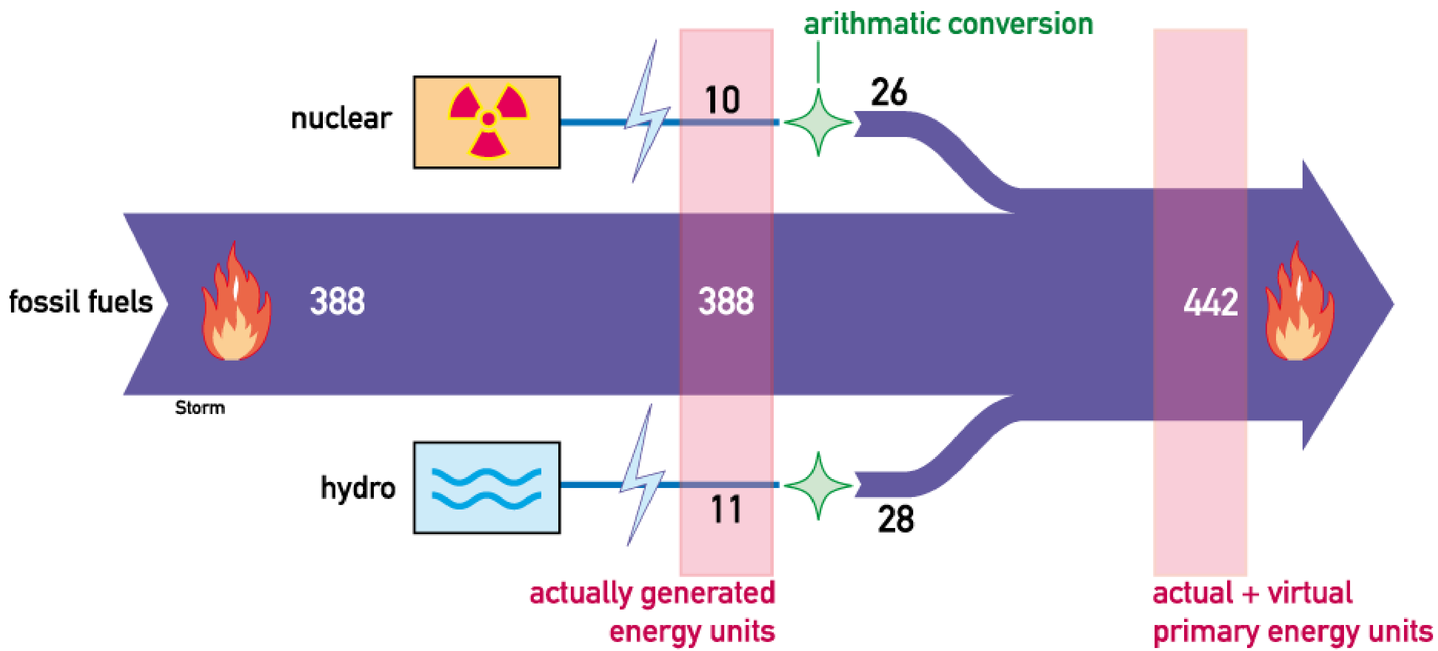
Potential amount of net nuclear energy from uranium ores may not change significantly in the future,

nor by new finds,

nor by advanced technology.

sun, sand and wind

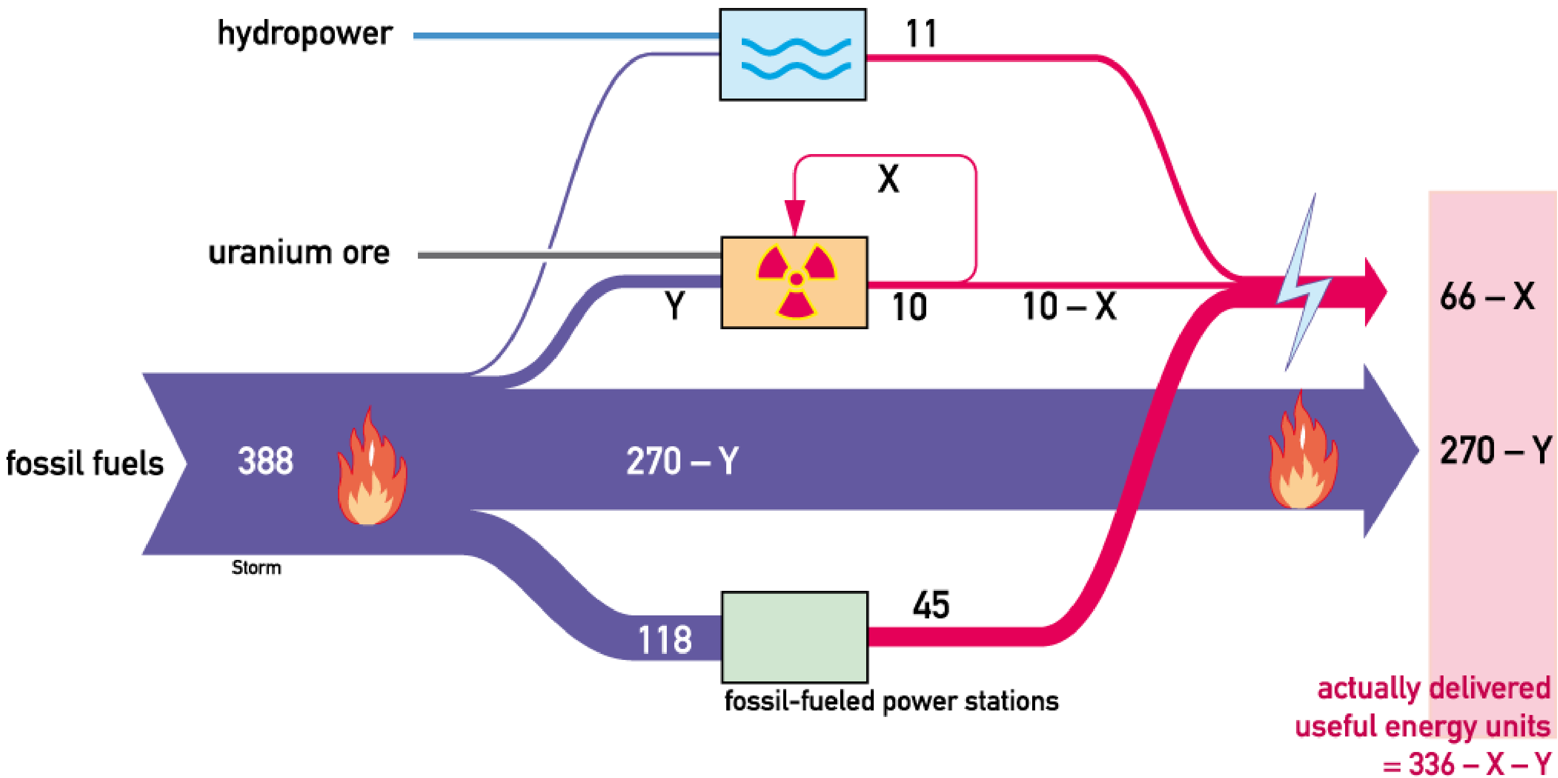
World energy consumption
statistical view (traded energy only), ref: BP



World energy consumption 2005, statistical view

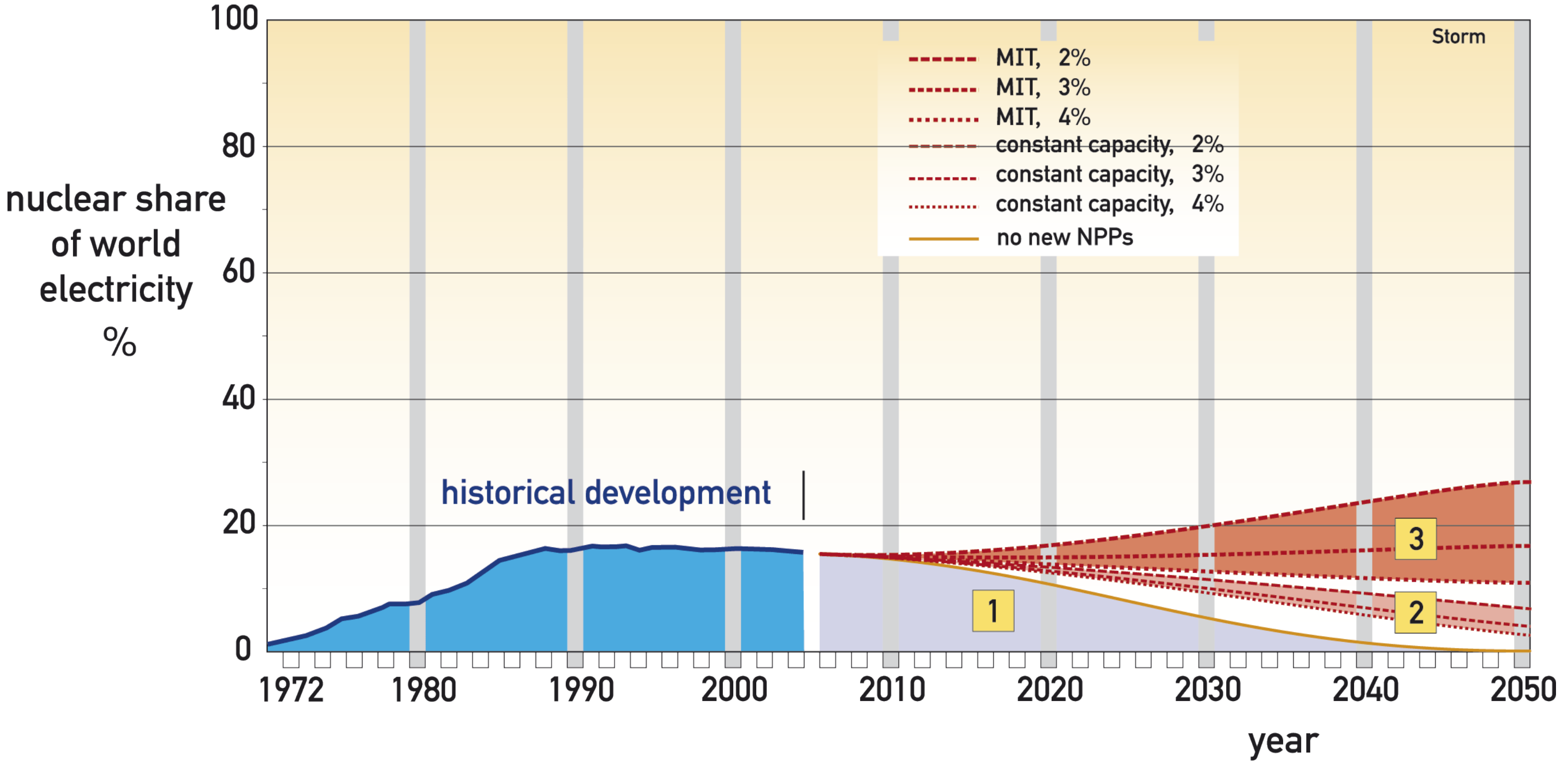
World energy, physical flows

actually produced energy units (traded energy only)



World energy consumption 2005, physical view

Nuclear share of world electricity



CO_2 emission from construction

	reference NPP Stormsmith		Sizewell B ExternE-UK
	low	high	
total CO_2, Tg	2.5	7.5	3.74
spec CO_2, g/kWh	12	35	14