The energy cliff

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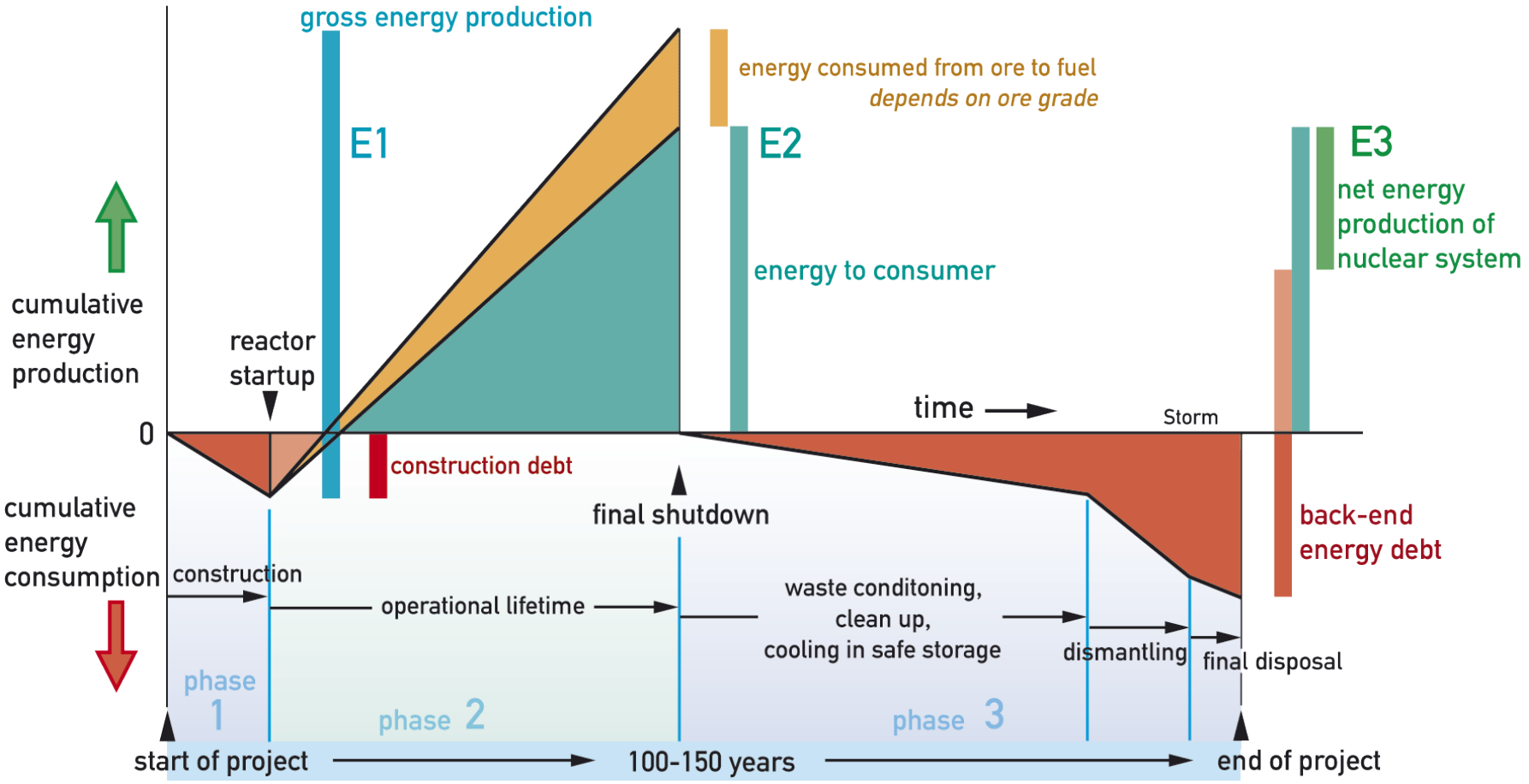
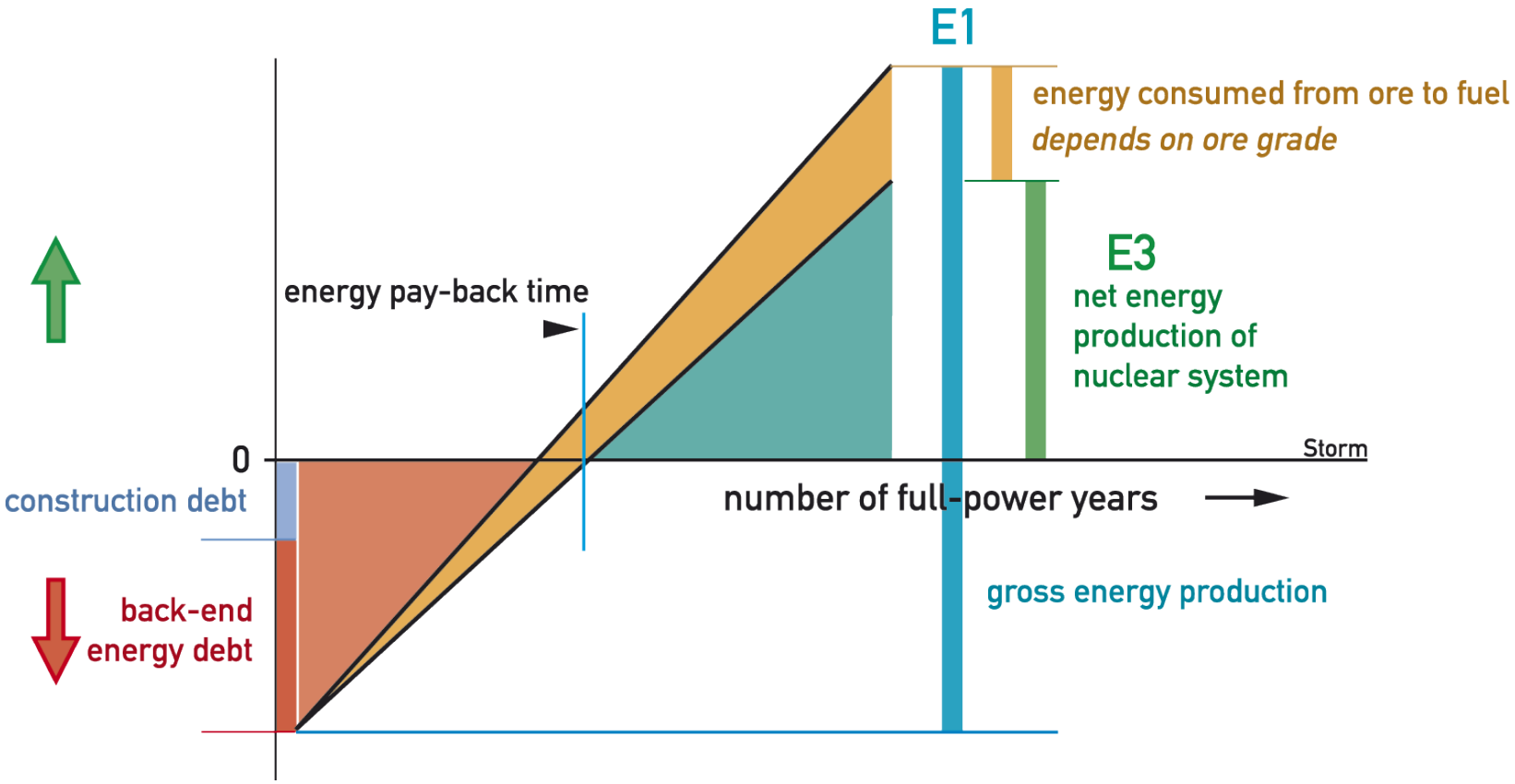
Energy debt


gross energy production
E1
energy consumed from ore to fuel
depends on ore grade
E2
energy to consumer
E3
net energy production of nuclear system
cumulative energy production
0
reactor startup
time
Storm
construction debt
final shutdown
back-end energy debt
cumulative energy consumption
construction
operational lifetime
waste conditoning, clean up, cooling in safe storage
dismantling
final disposal
phase 1
phase 2
phase 3
start of project
100-150 years
end of project

Energy debt 'capitalized'



Energy from uranium

Net energy extractable from a uranium-bearing deposit depends on its *quality*.

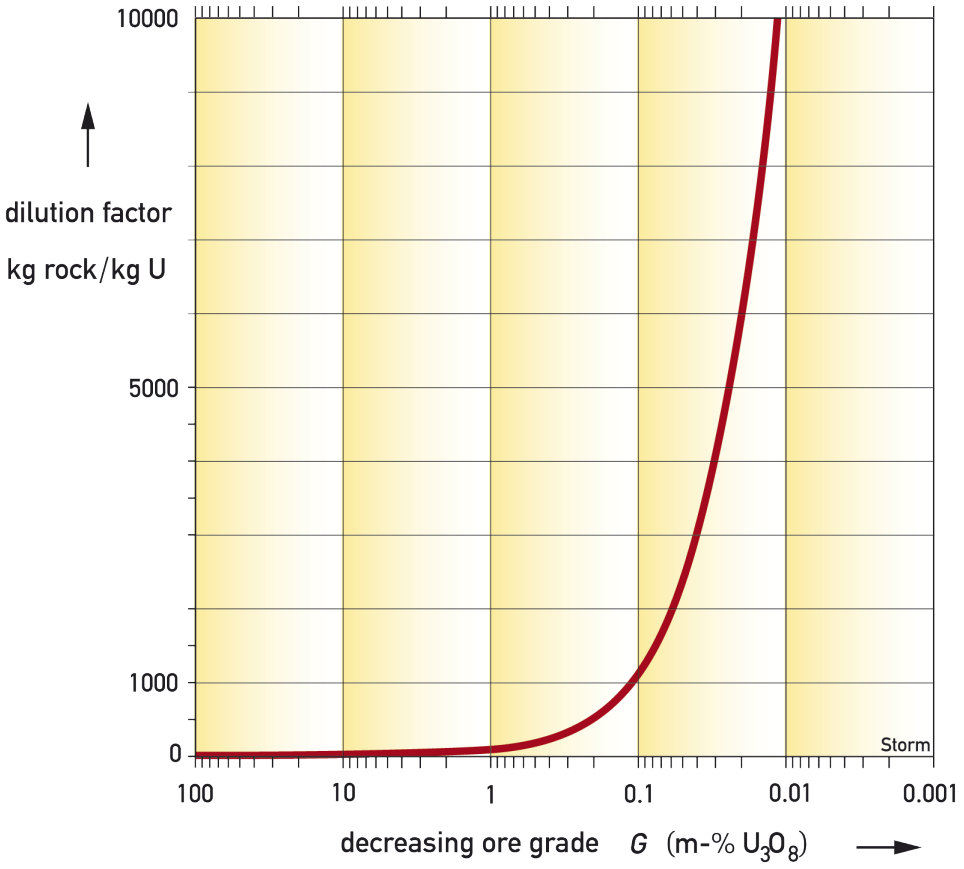
Main parameters:

- ore grade
- type of rock
- size of deposit
- depth of deposit
- location

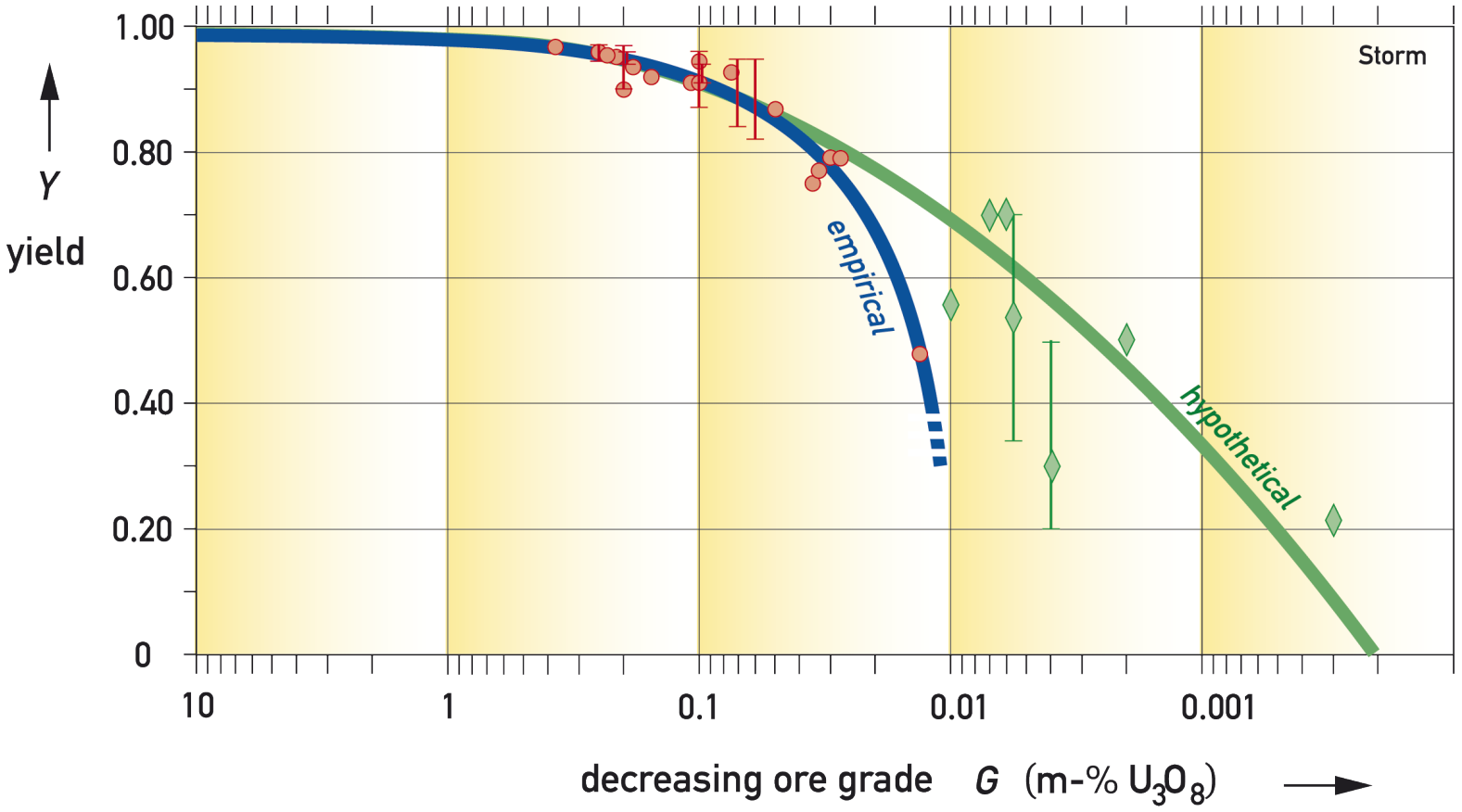
Energy from uranium

Uranium resources ≠ energy resources

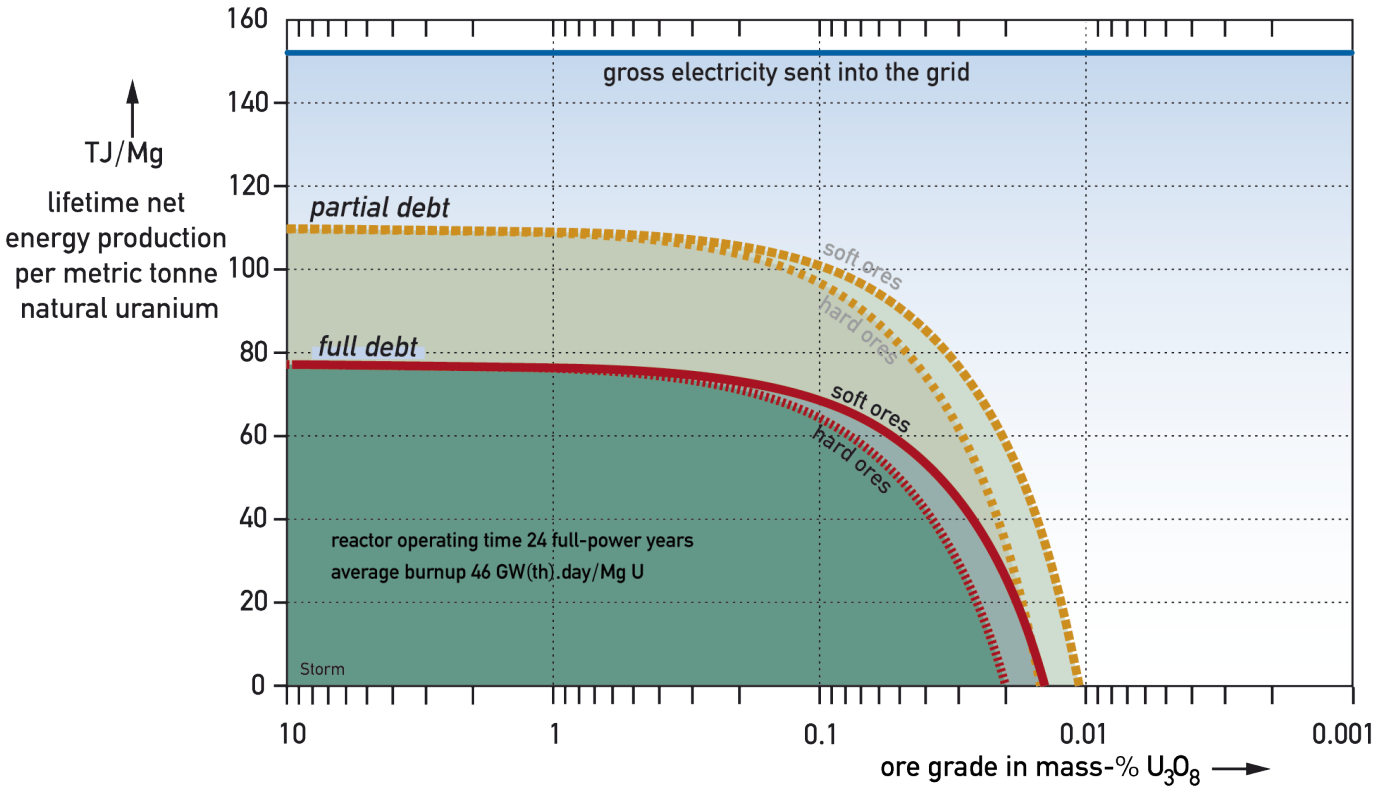
Dilution factor = kg(rock)/kg(U)



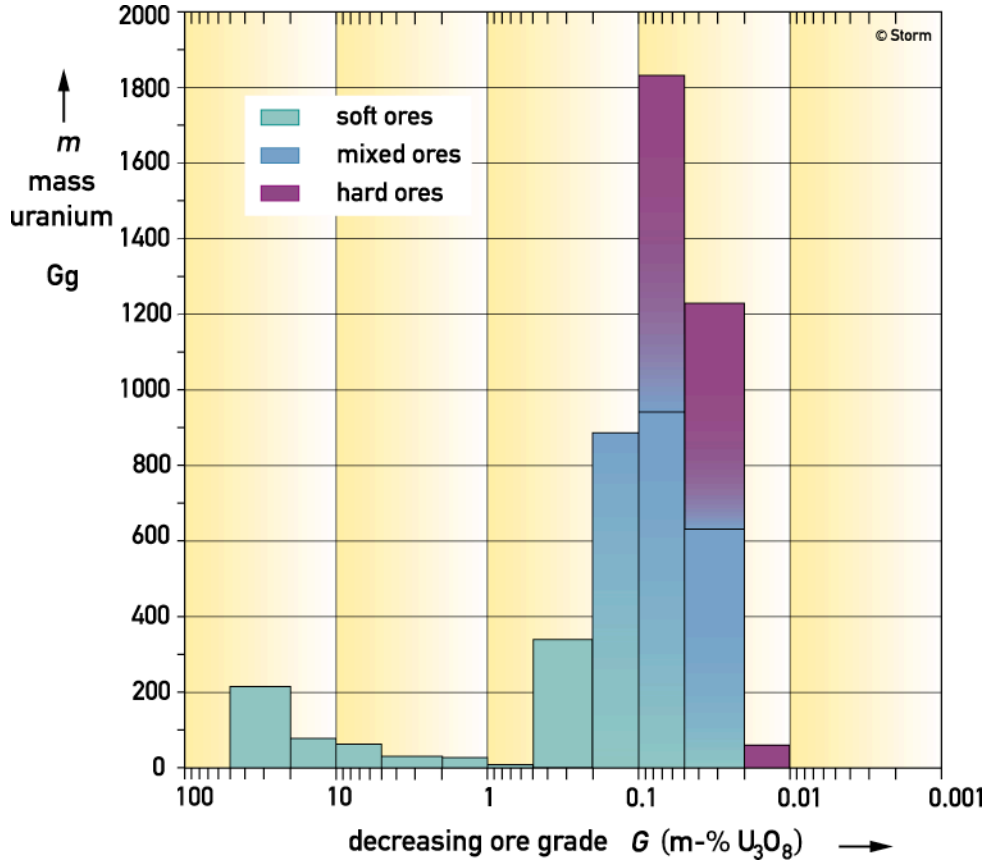
Extraction yield $Y = mU_{ex}/mU_{rock}$



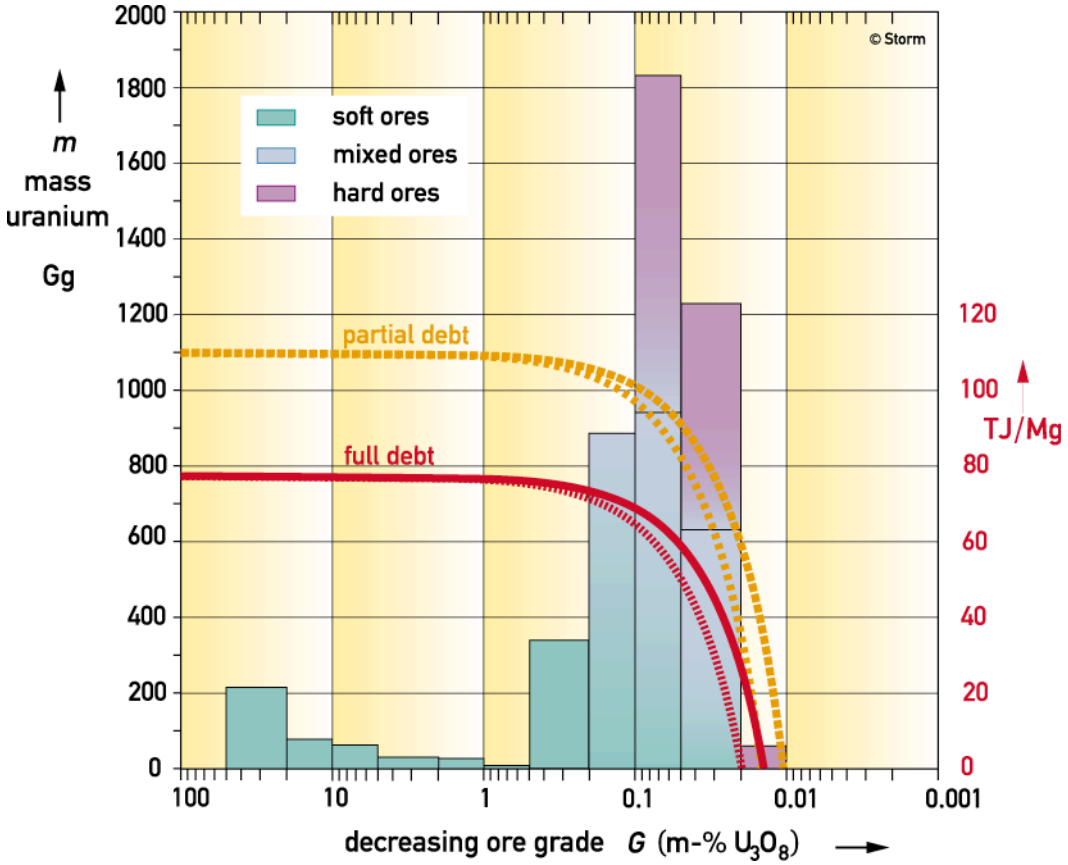
Energy cliff



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.

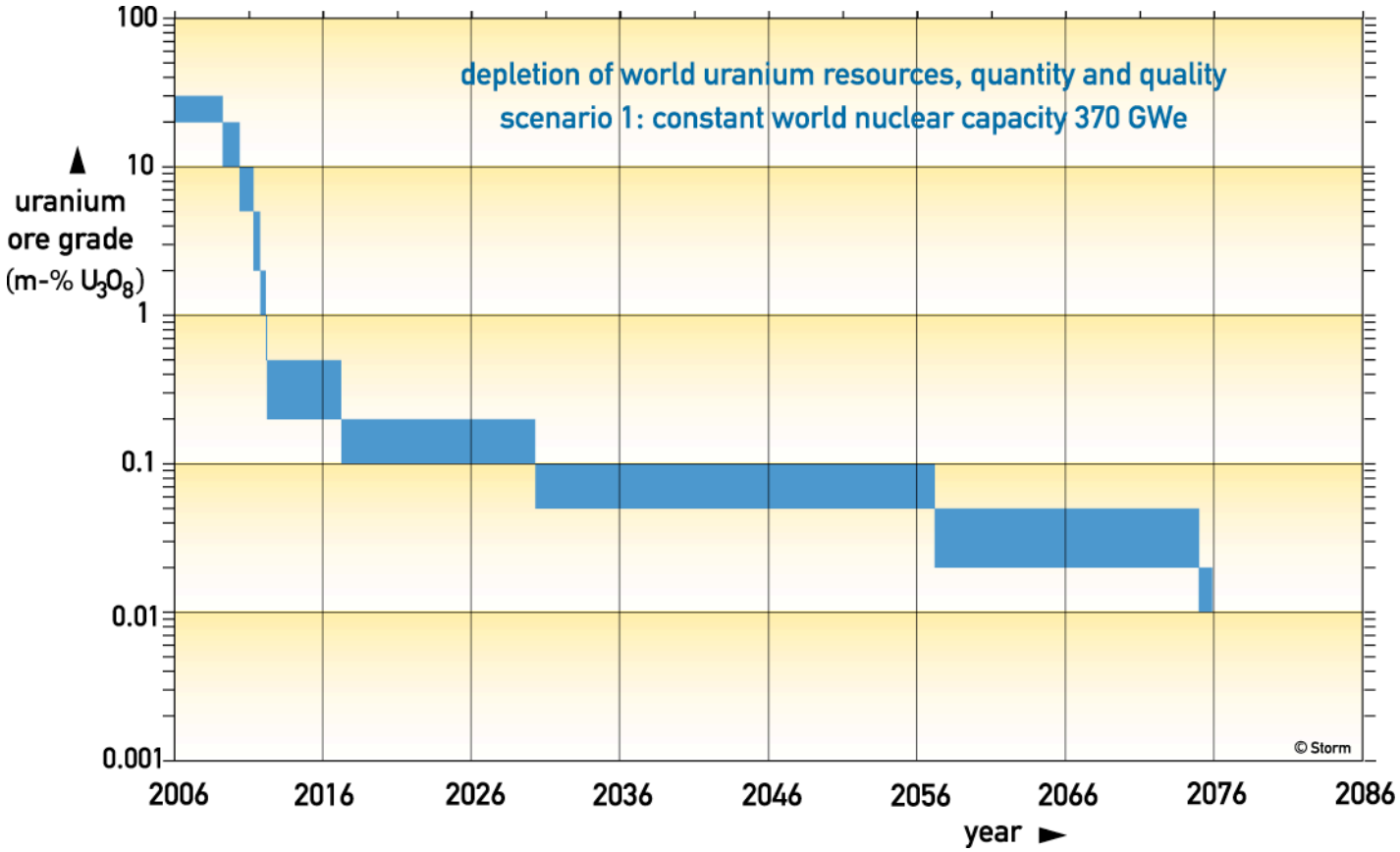
nuclear energy in the future

Scenario 2

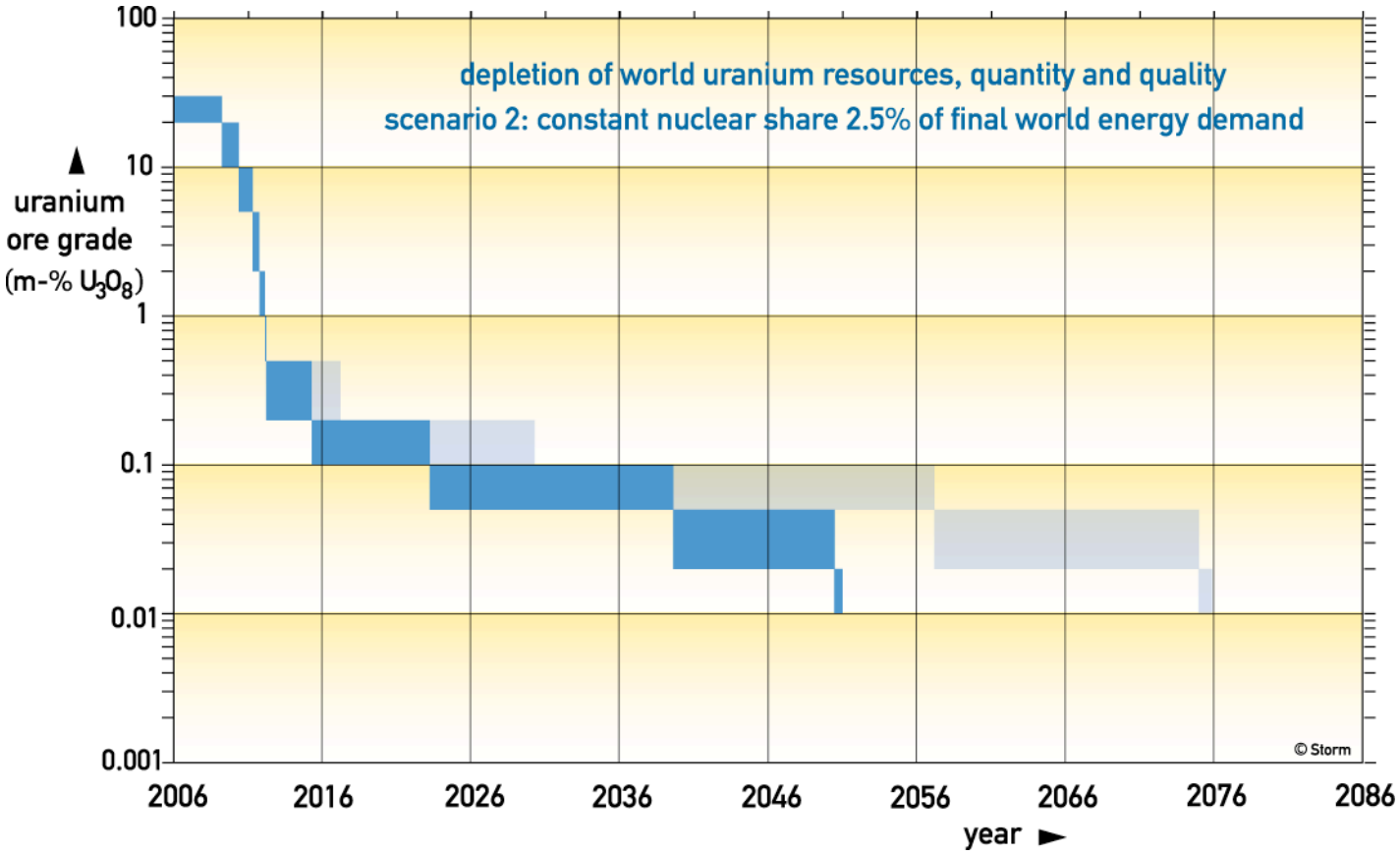
World nuclear share remains constant at current level, 2.5% of world energy supply.

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

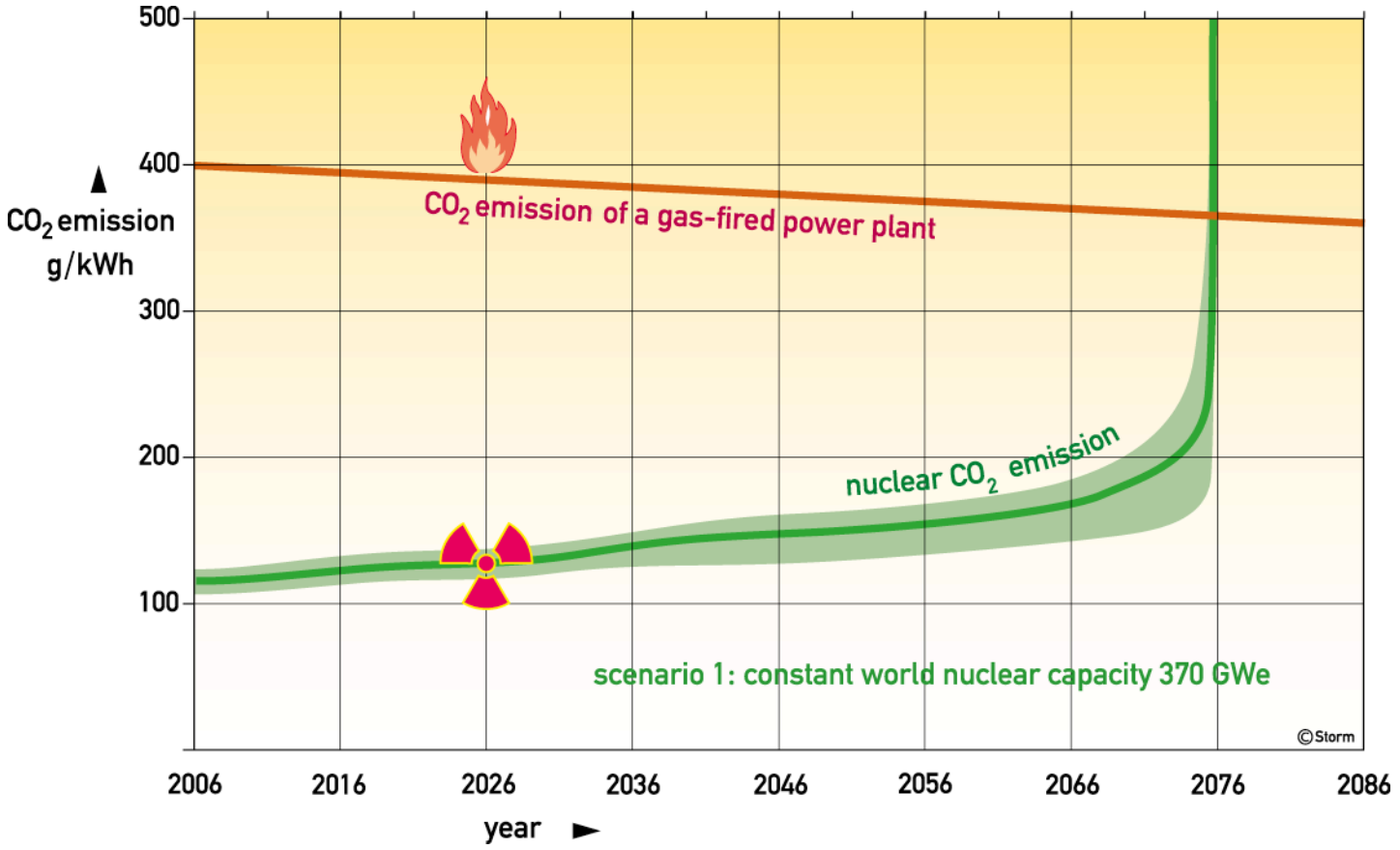
Depletion of uranium resources in scenario 1, quantity and quality



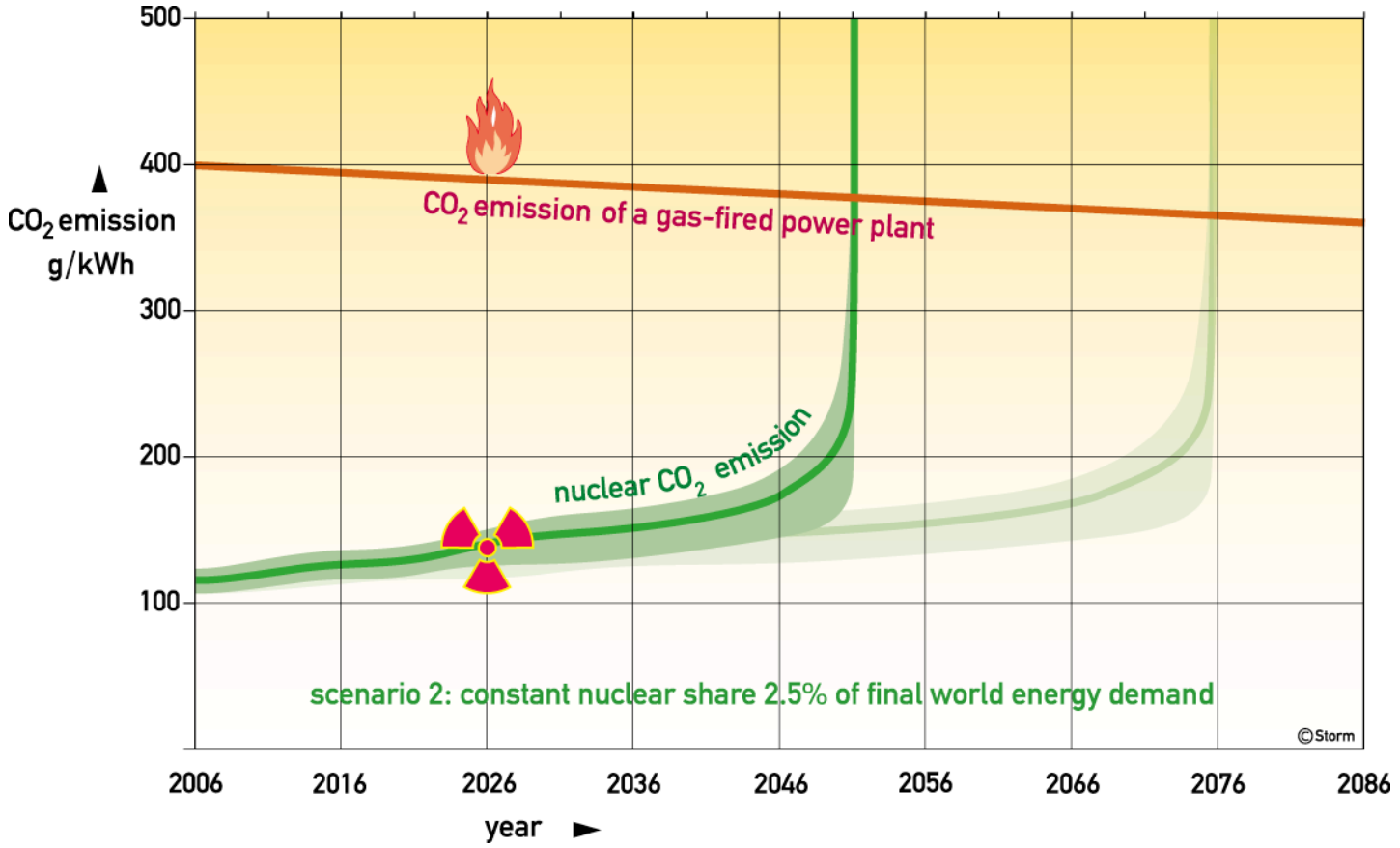
Depletion of uranium resources in scenario 2, quantity and quality



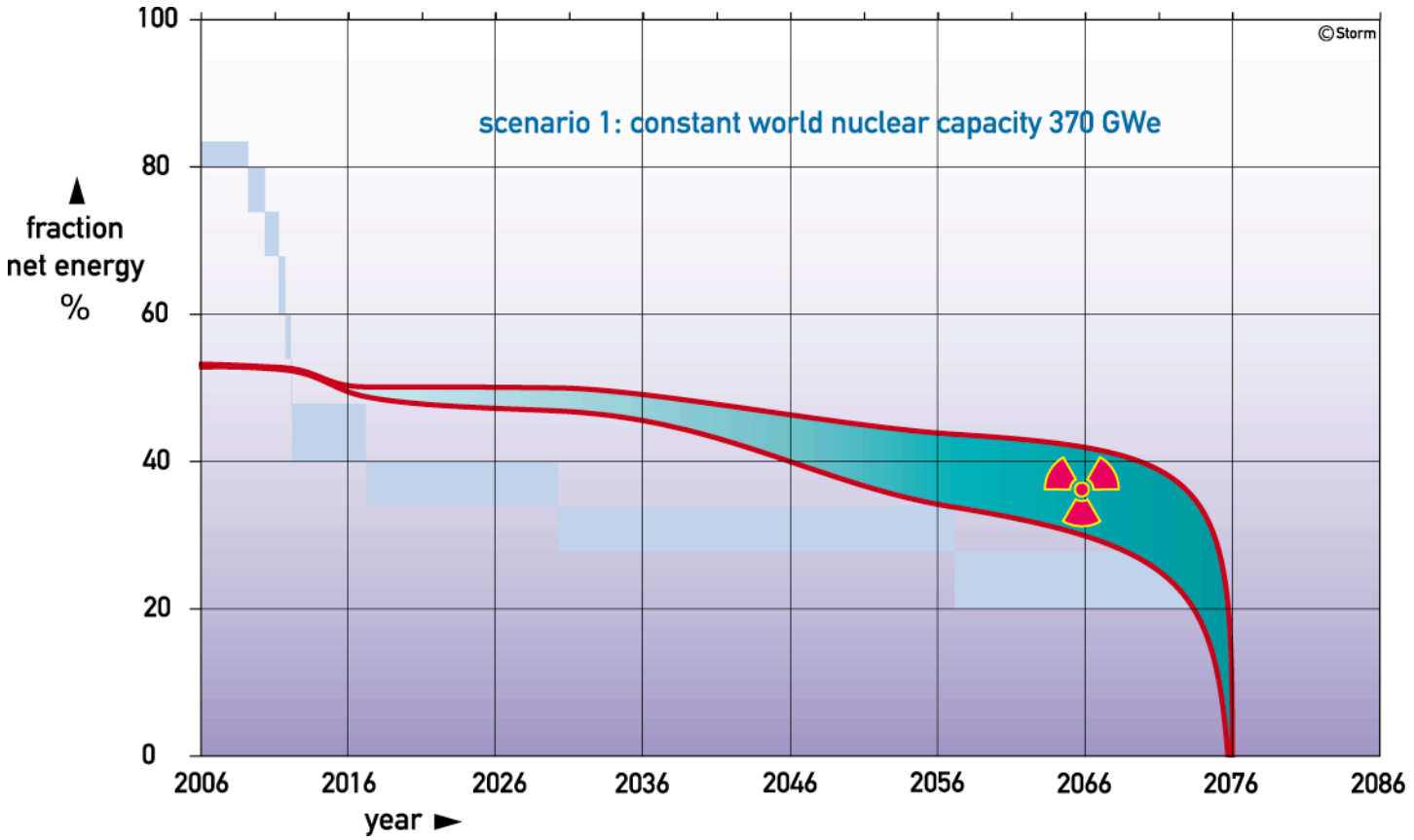
Rise of specific CO_2 emission by nuclear power with time, scenario 1



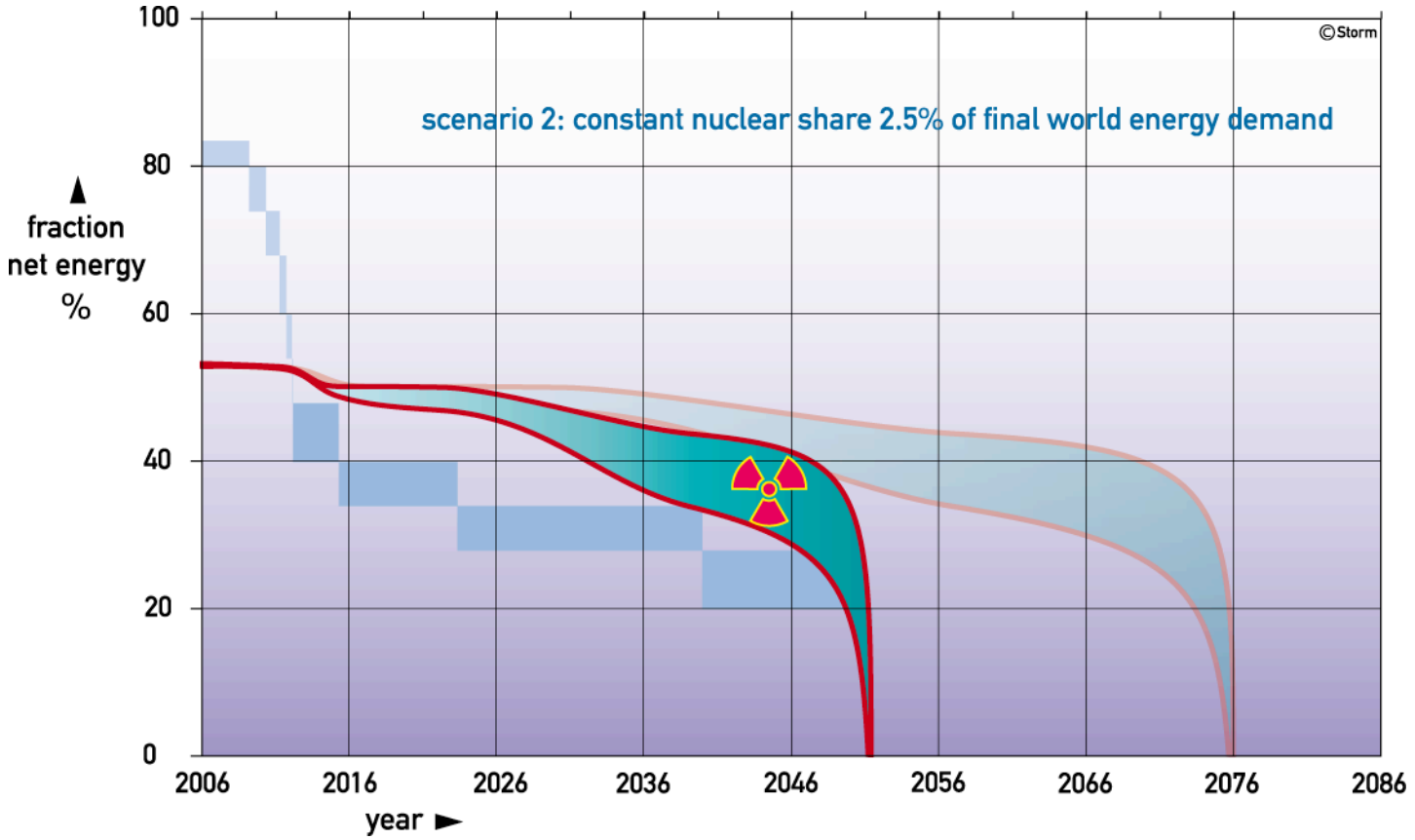
Rise of specific CO_2 emission by nuclear power with time, scenario 2



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 extremely slim.
- New finds: the larger the deposit, the lower its quality.
- Lower quality means more energy consumed per kg extracted uranium.

Outlook

- New finds of uranium deposits will be closer to the energy cliff.
- Time of depletion of net nuclear energy from uranium ores may not change significantly in the future, nor by new finds, nor by advanced technology.

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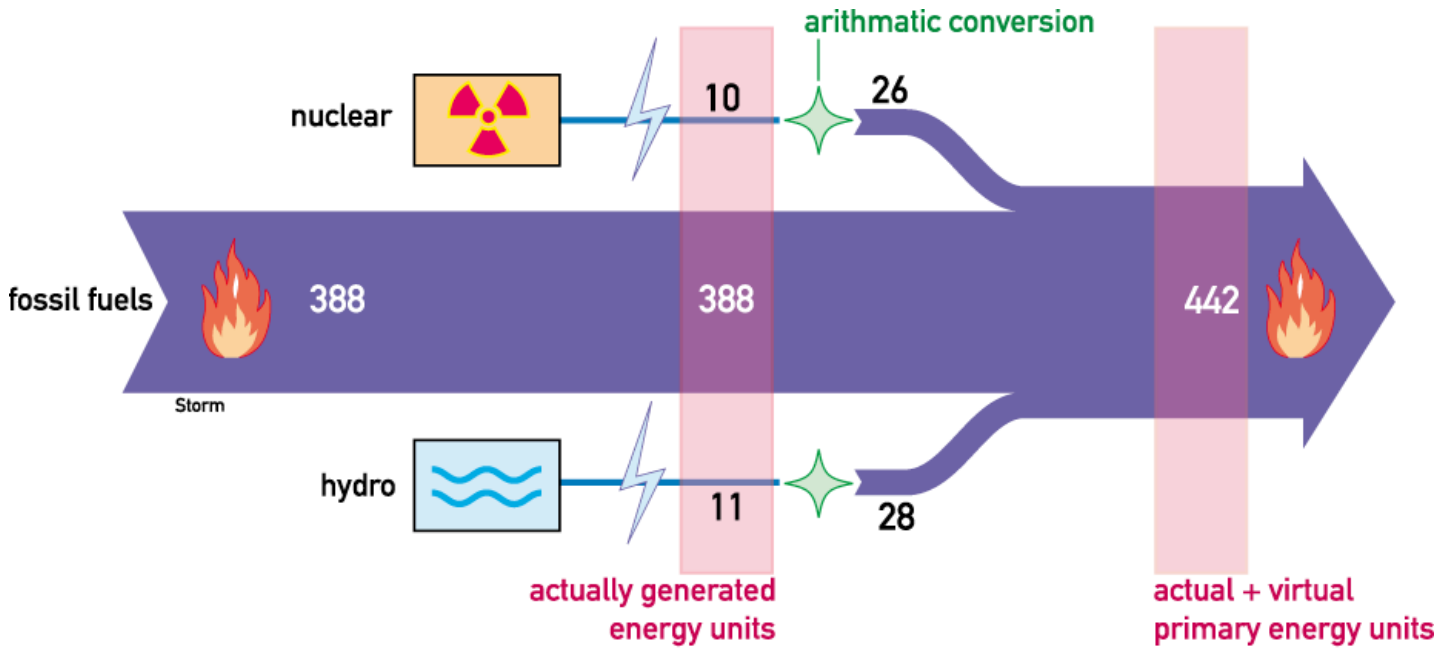
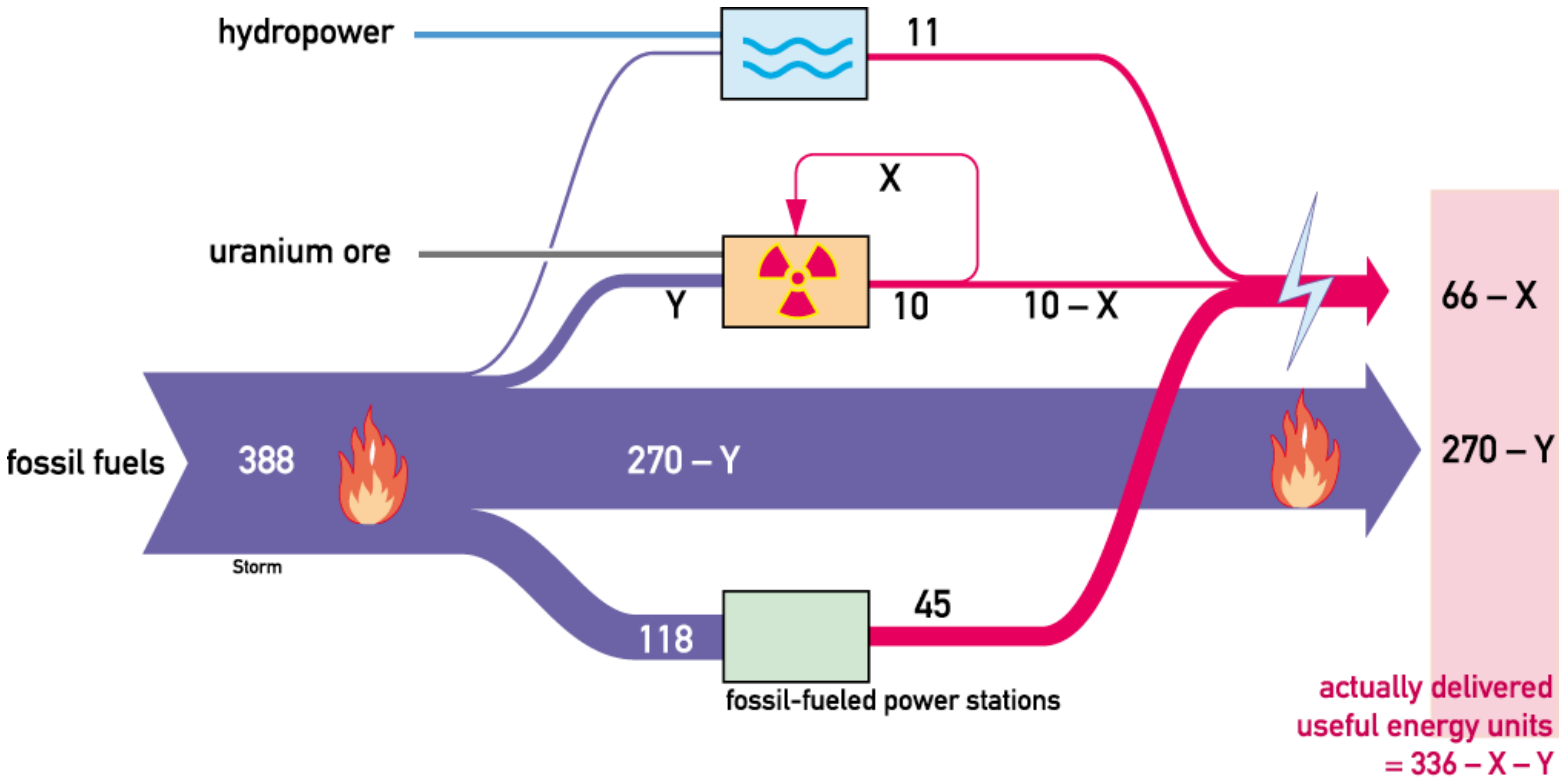
World energy consumption statistical view



World energy consumption 2005, statistical view

World energy, physical flows
actually produced energy units



World energy consumption 2005, physical view

Nuclear share of world electricity