



CEEDATA energy analysis

Kvanefjeld / Kuannersuit uranium mining

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Kvanefjeld/Kuannersuit uranium mining





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Importance of Kvanefjeld/Kuannersuit

Resource of rare earth elements (REEs)
and uranium

- very large REE resources
- REEs indispensable: electronics, LEDs
- REEs geopolitically important
- REEs dependence on China

How important is the uranium resource?



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Key issue in this talk:

The ores contain uranium, thorium and other radioactive elements.

How to cope with the radioactive contents?

Environmental issues of REE recovery not discussed here



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Outline of this talk

- size of the uranium resources
- outline of uranium recovery process
- radioactive constituents of mining wastes
- health effects of radioactive materials
- is safe uranium mining possible
- importance of uranium, global perspective

Focus on radioactive materials



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Size of the uranium resources

Greenland Minerals & Energy Ltd (GMEL):

More than 220 000 metric tonnes

Average ore grade of 232 ppm uranium

(= 232 grams U per tonne ore)

Also 500 000 tonnes U mentioned



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Size of the uranium resources

IAEA and OECD/NEA Red Book 2011:

(International Atomic Energy Agency and OECD Nuclear Energy Agency)

Recoverable 134 000 metric tonnes

Average ore grade of 218 ppm uranium

Assumed recovery factor 65%

Highest cost category: 260 USD/kg U



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Size of the uranium resources

Disparities in figures from GMEL and IAEA/NEA

- ore grades and cut-off grades
- size of uranium resources



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Size of the uranium resources

GMEL: resources *in situ*

IAEA/NEA: recoverable resources



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Size of the uranium resources

No recovery factor mentioned by GMEL

Assume 40%:

Recoverable resources (GMEL):

$$0.40 \times 220\,000 = 88\,000 \text{ tonnes U}$$

=> annual production 1500 tonnes/year
(60 years mine life)



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Uranium recovery from ore

- mining
- sorting (cut-off grade)
- milling
- beneficiation
- leaching
- extraction of U
- extraction of other metals (REEs, Zn, etc)



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Mining waste

Mining + milling = series of separation steps

Each step generates waste —> mill tailings

Separation processes never go to completion



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Uranium recovery factor

= fraction of recovered U from U *in situ*

Recovery factor lower as:

- uranium grade of ore lower
- more chemical species in ore
- chemical composition ore more refractory



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Coal equivalence

At 200 ppm U (200 g U/tonne ore)
amount of U ore mined and processed =
amount of coal to be mined
to produce same amount of electricity

Kvanefjeld deposit ore grade 218 ppm



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Thorium resources

GMEL: thorium not mentioned

IAEA/NEA Red Book 2011:

86 000 – 93 000 tonnes Th

at cost <80 USD/kg Th

could be 400 000 tonnes Th

Risø 1966: steenstrupine Th grade 10x U grade



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Radioactive elements in ore

- emit radiation: alpha, beta, gamma
- decay to other radioactive elements

⇒ Ore contains U + Th + decay products
e.g. radium, polonium, radioactive lead



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Exposure to radioactivity

Big difference exposure to radioactive sources
outside body or inside body

U + Th + decay products highly dangerous
inside body

Inhalation of dust, ingestion via food and water



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Health effects of radioactivity
(exposure to 'low' doses)

Cancers (usually lethal)

Non-cancer chronic diseases,
lethal and non-lethal

Premature senescence

Stillbirths

Genetic malformations

Inheritable diseases



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Health effects of radioactivity

IAEA and WHO (World Health Organization) do not recognise health effects attributable to exposure of low doses



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Health effects of radioactivity

- biological behavior radionuclides inside body
- chronic exposure to radioactive substances: dust, food and water

Poorly understood and poorly investigated



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Bioaccumulation

A number of radionuclides in seawater accumulate in seaweed, crustaceans, shellfish and other organisms

Entering the foodchain

Poorly understood and poorly investigated



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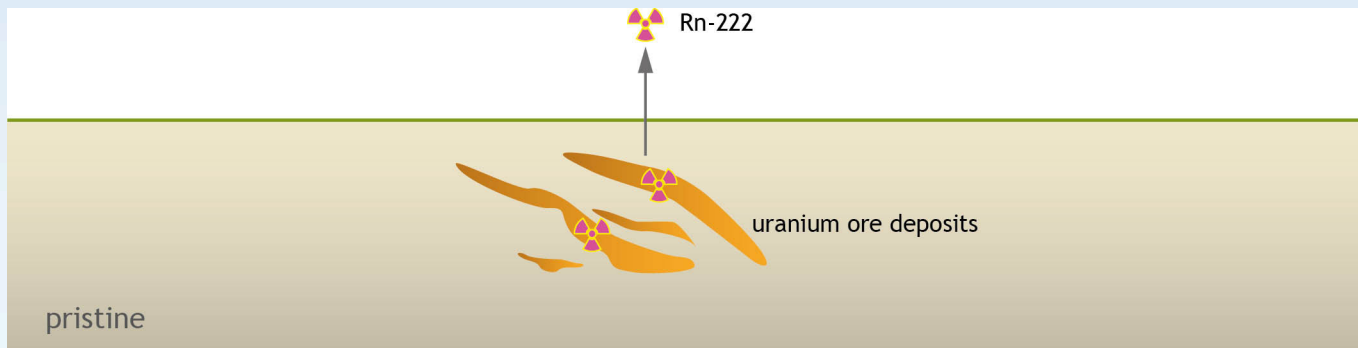
Is safe mining possible?

- radioactive elements from ore
- non-radioactive toxic elements from ore
- added chemicals in mining + milling



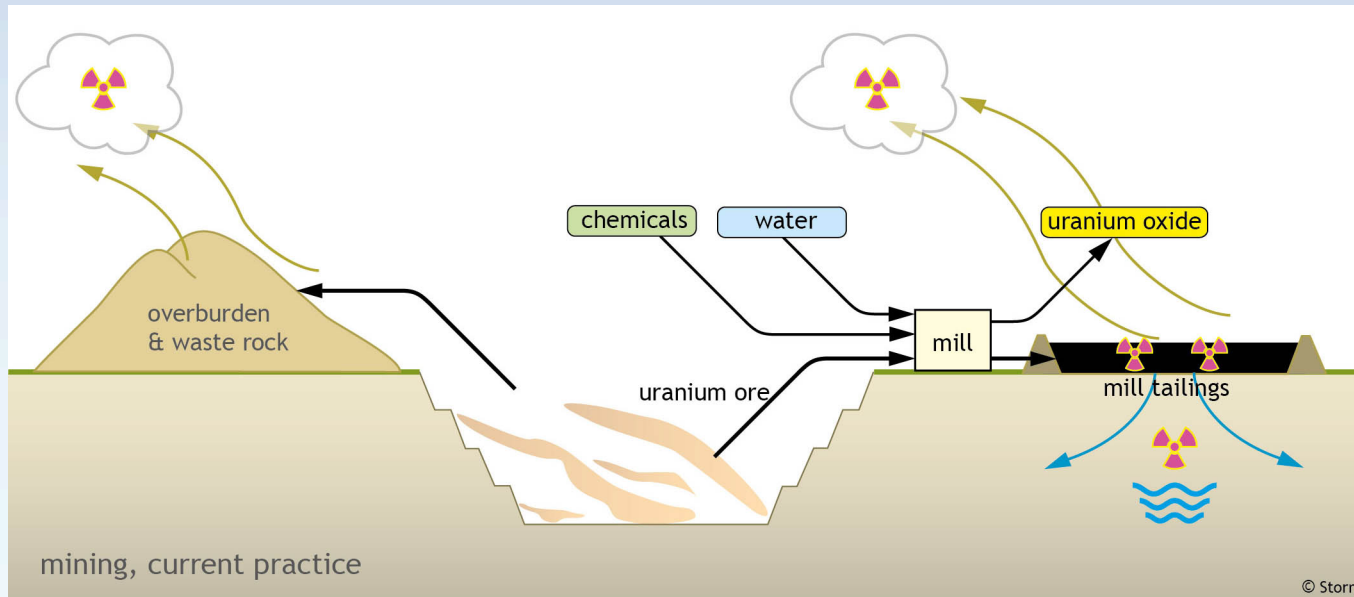
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Pristine situation before mining



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Operation of the mine



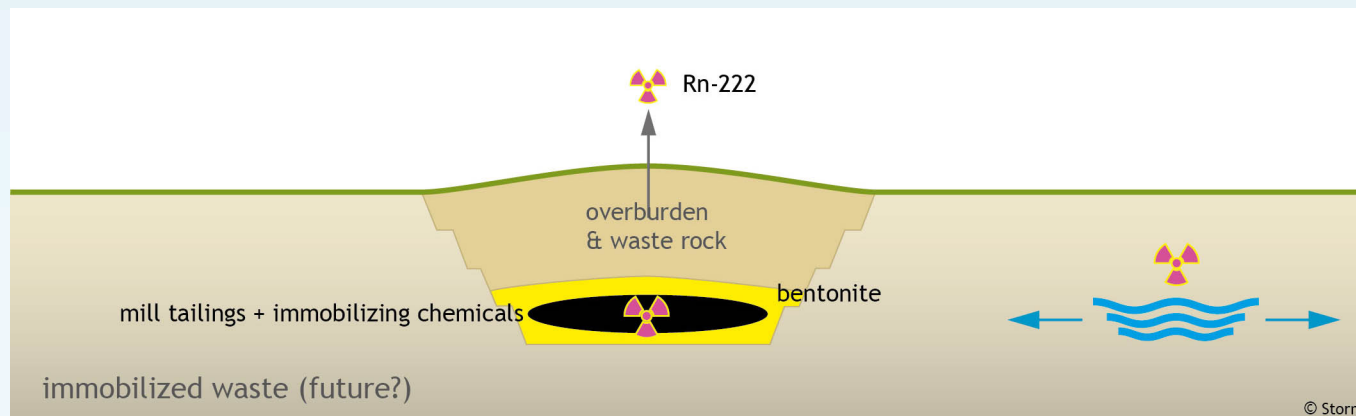


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Rehabilitation of the mine

Key activities:

- Immobilization of radioactive materials
- Permanent isolation from biosphere





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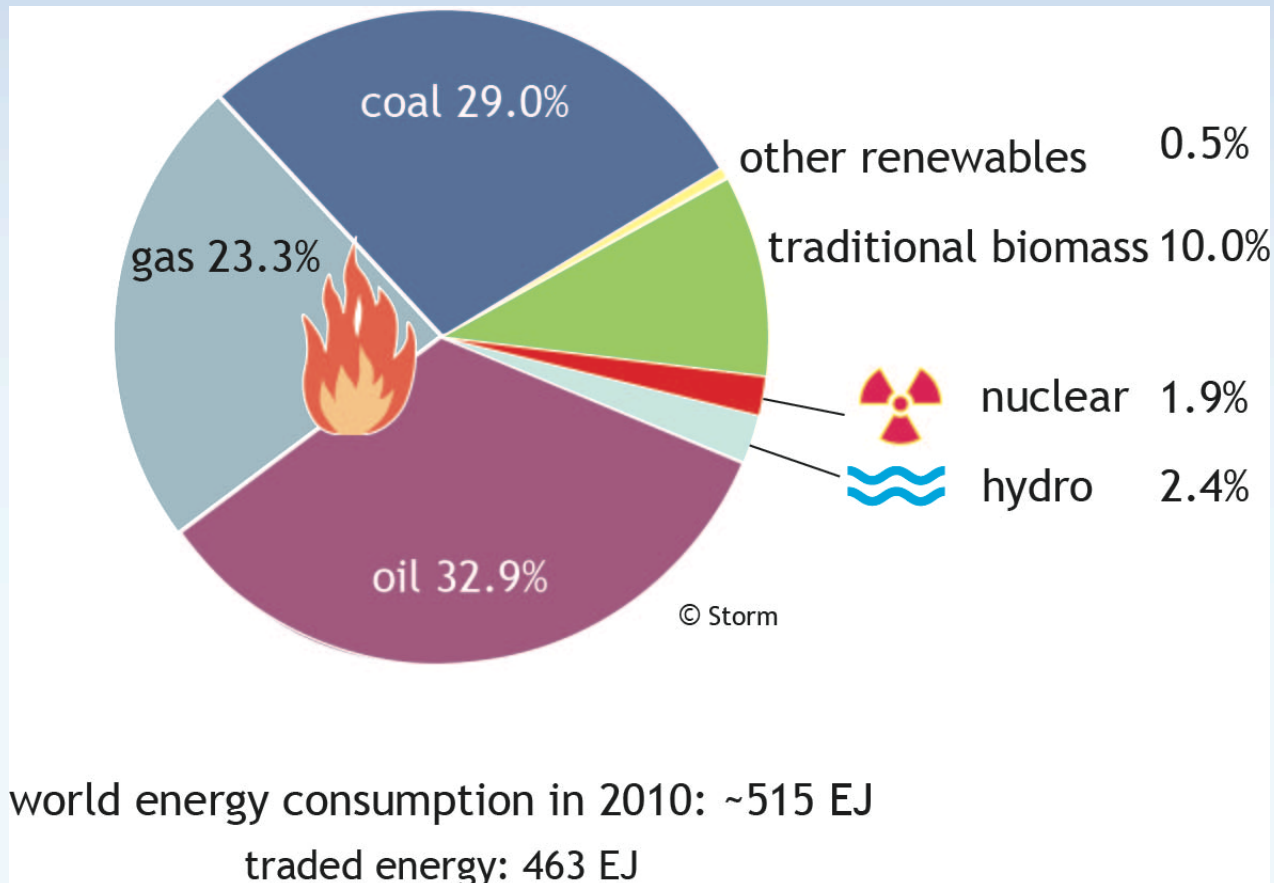
Importance of uranium, global perspective

- nuclear share world energy
- energy costs energy : EROEI
- energy cliff
- CO2 trap



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Nuclear contribution world energy in 2010





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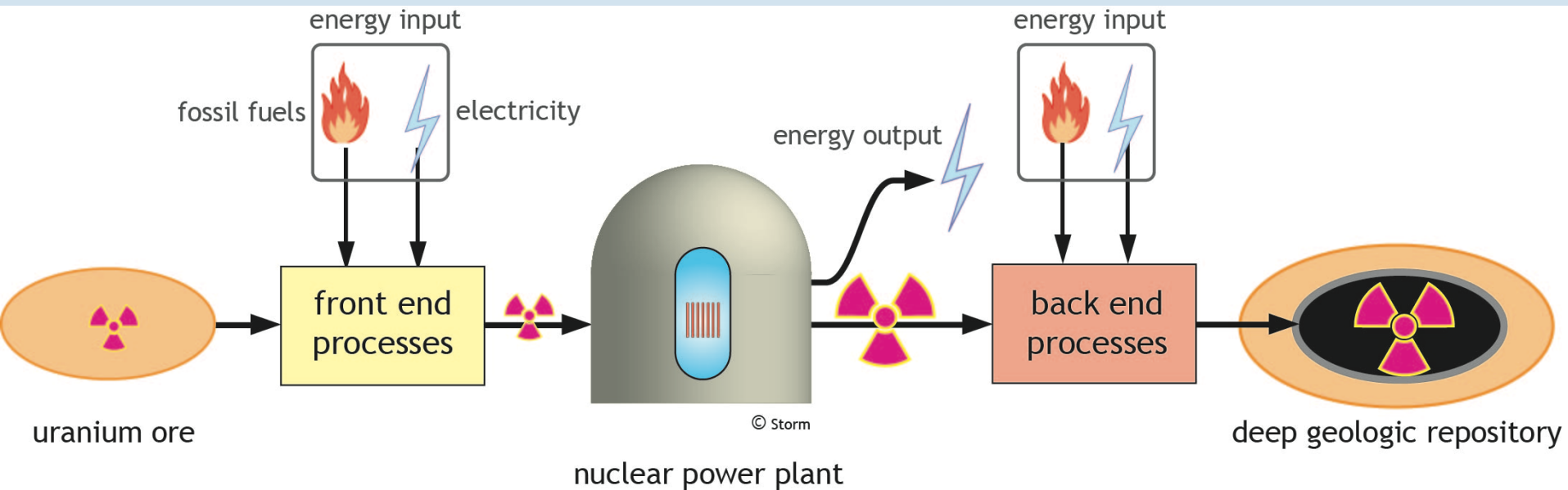
Uranium mining costs energy

Energy consumption per kg recovered U higher as:

- uranium grade of ore lower
- more chemical species in ore
- chemical composition ore more refractory

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Nuclear process chain



cooking the meal

enjoying the meal

washing the dishes + clearing the mess



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EROEI

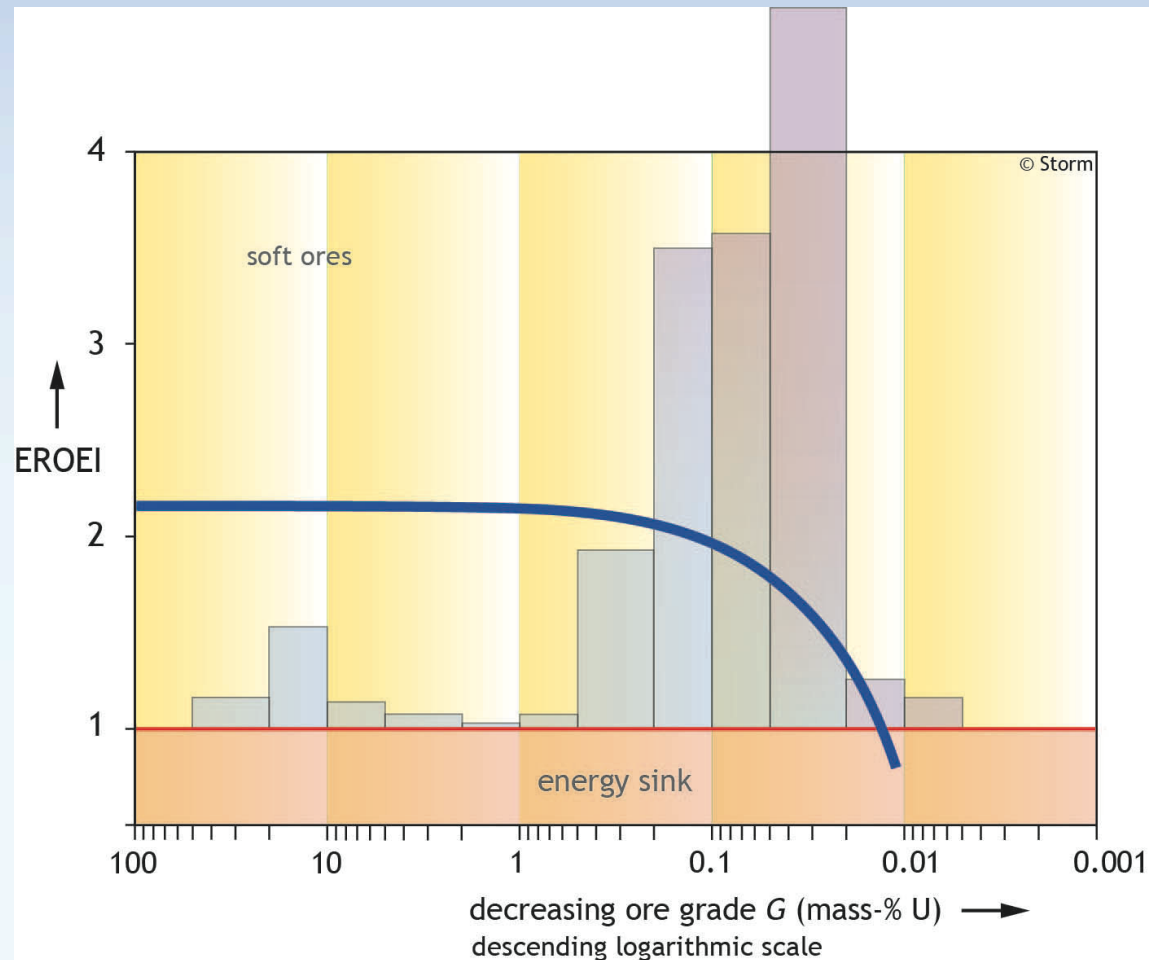
Energy return on energy investment

$$\text{EROEI} = \text{net energy output} / \text{sum energy inputs}$$



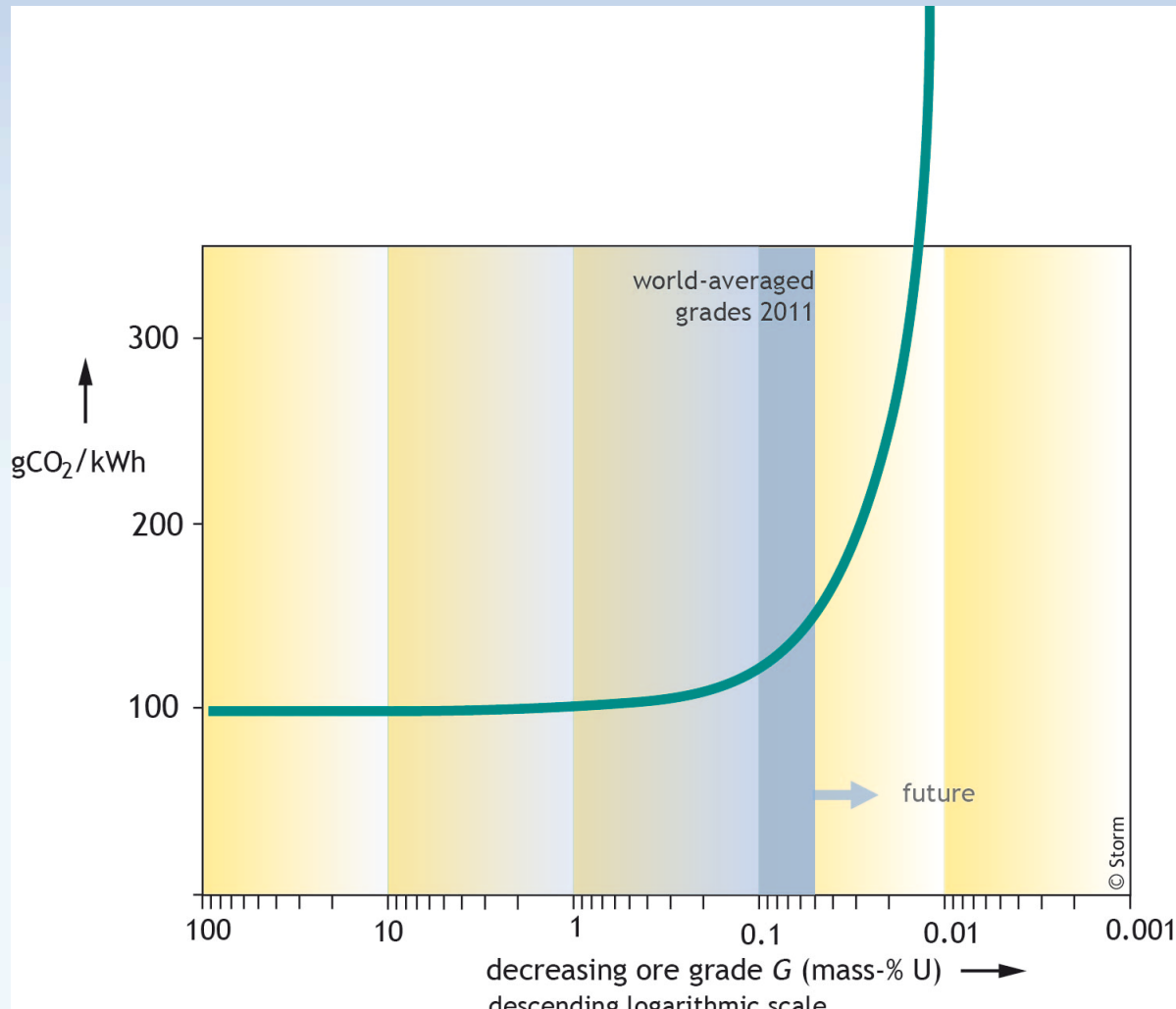
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Energy cliff



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The CO₂ trap: nuclear CO₂ emission vs ore grade





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We do not need nuclear power

- not for climate control
- not for energy security
- not for geopolitical stability

Uranium mining very polluting

Health hazards poorly understood and
poorly investigated

