CEEDATA energy analysis

Kvanefjeld/Kuannersuit uranium mining

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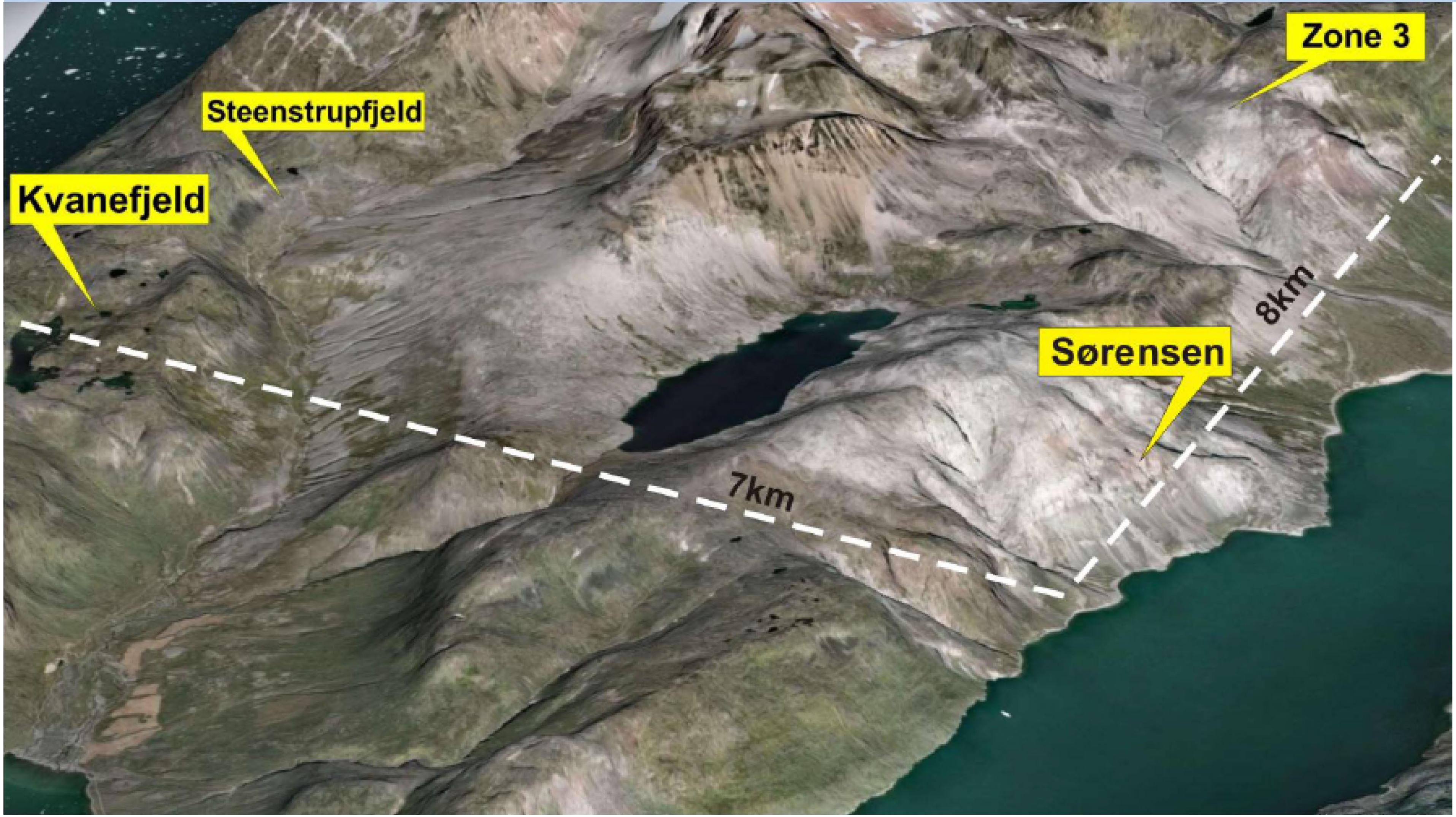

Importance of Kvanefjeld/Kuannersuit

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

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

Size of the uranium resources

Disparities in figures from GMEL and IAEA/NEA

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

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 x 220 000 = 88 000 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

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

Radioactive elements in ore

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

$\Rightarrow$ 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

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

Health effects of radioactivity

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

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

Is safe mining possible?

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

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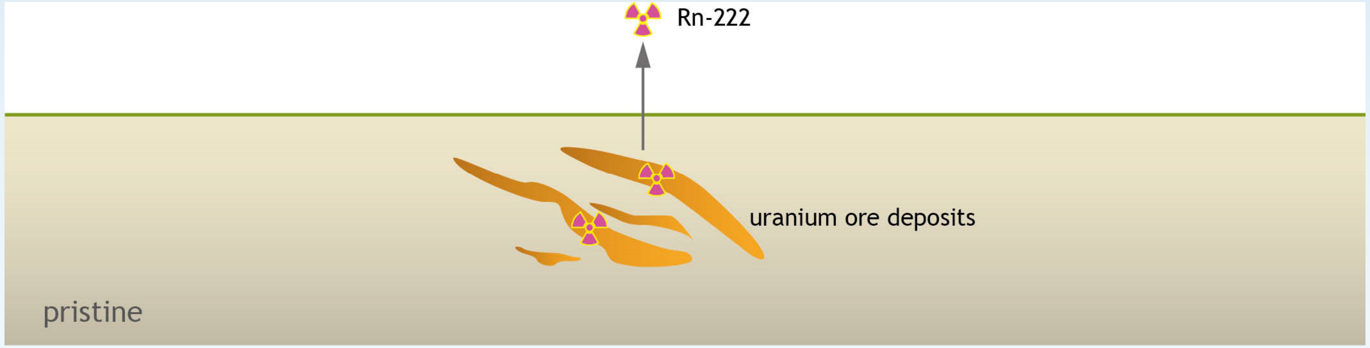
Pristine situation before mining



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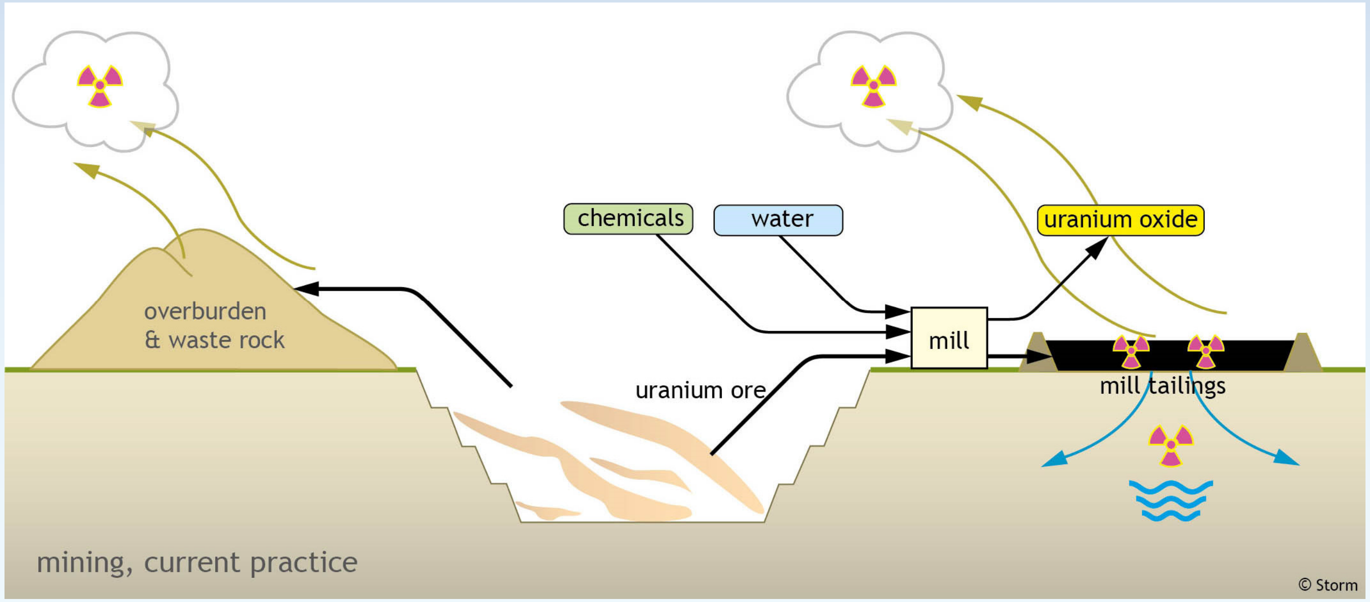
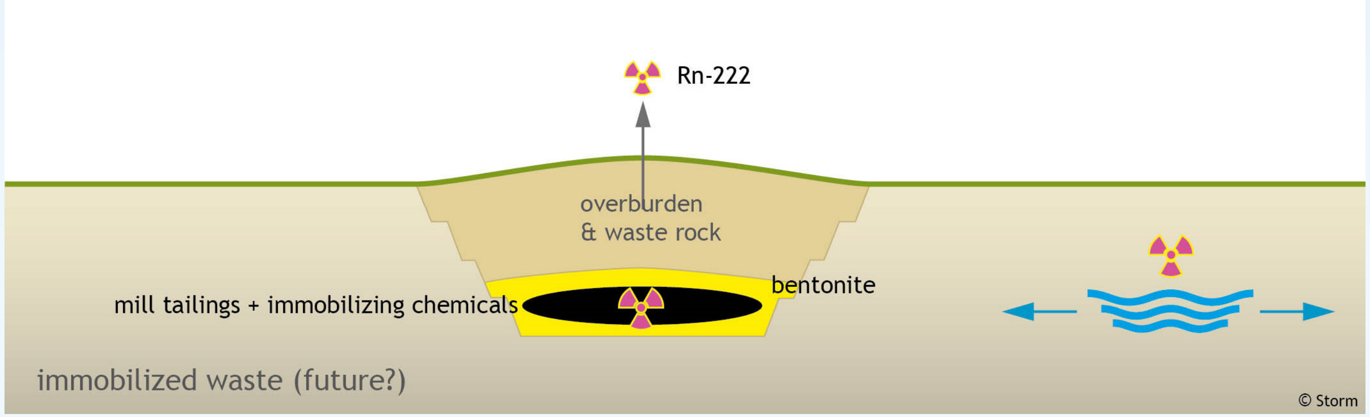
Operation of the mine



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
- CO_2 trap

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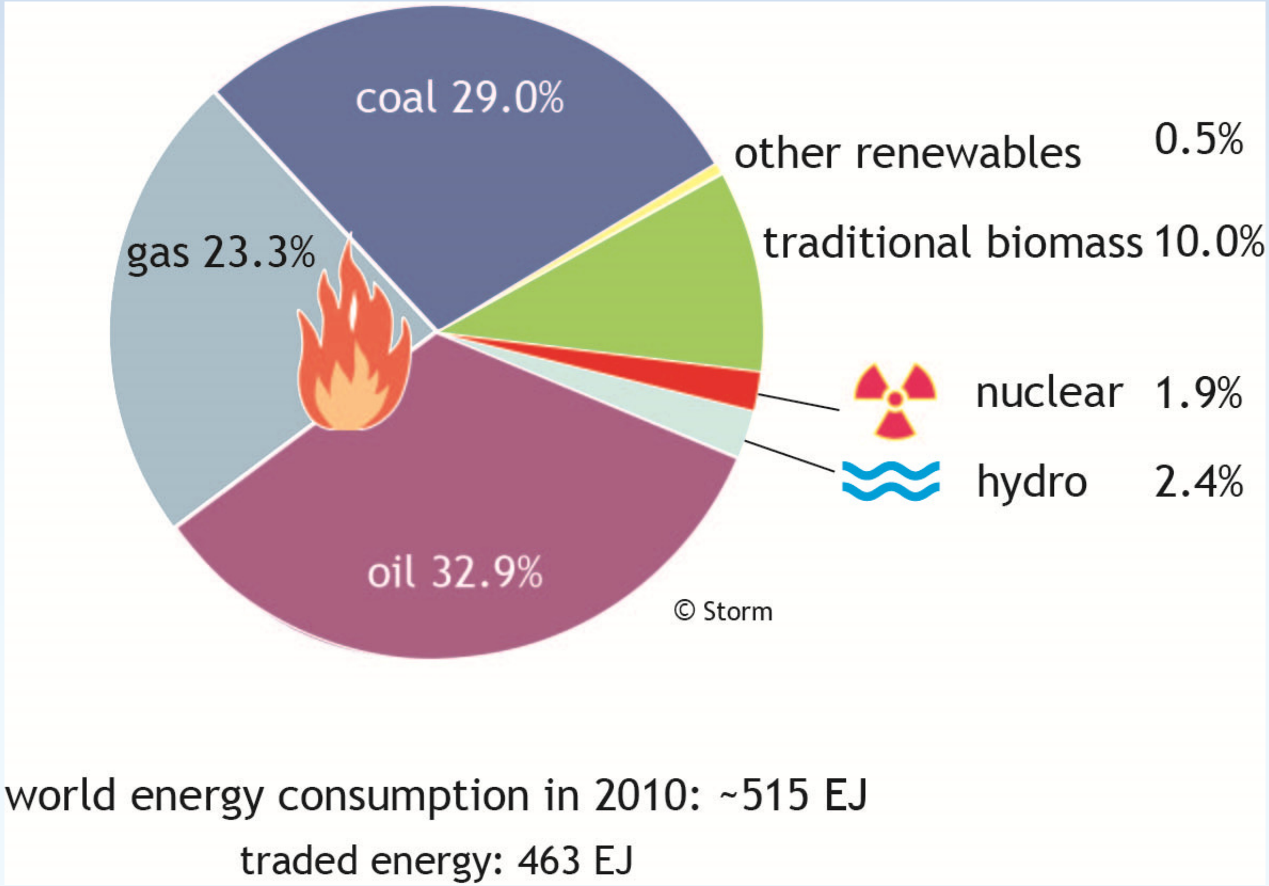
Nuclear contribution world energy in 2010



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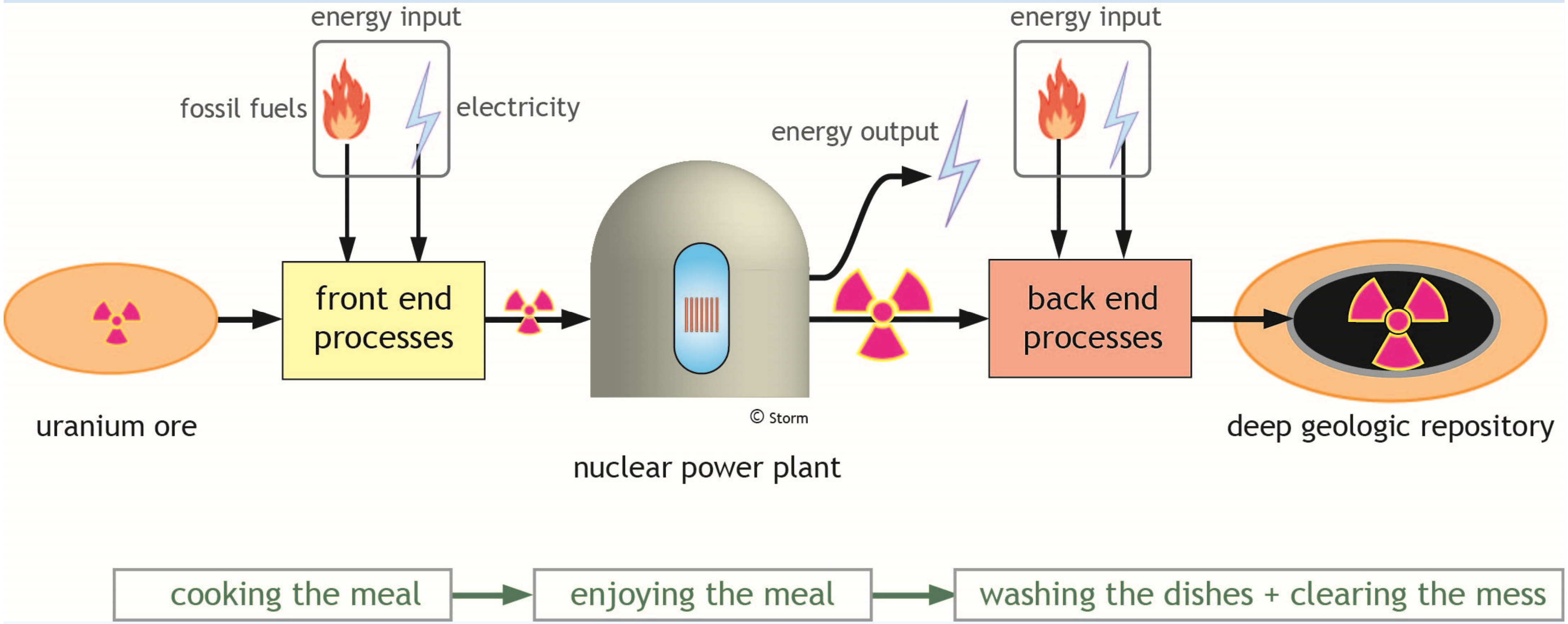
Uranium mining costs energy

Energy consumption per kg recovered U higher as:

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

Nuclear process chain



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EROEI

Energy return on energy investment

EROEI = net energy output/sum energy inputs

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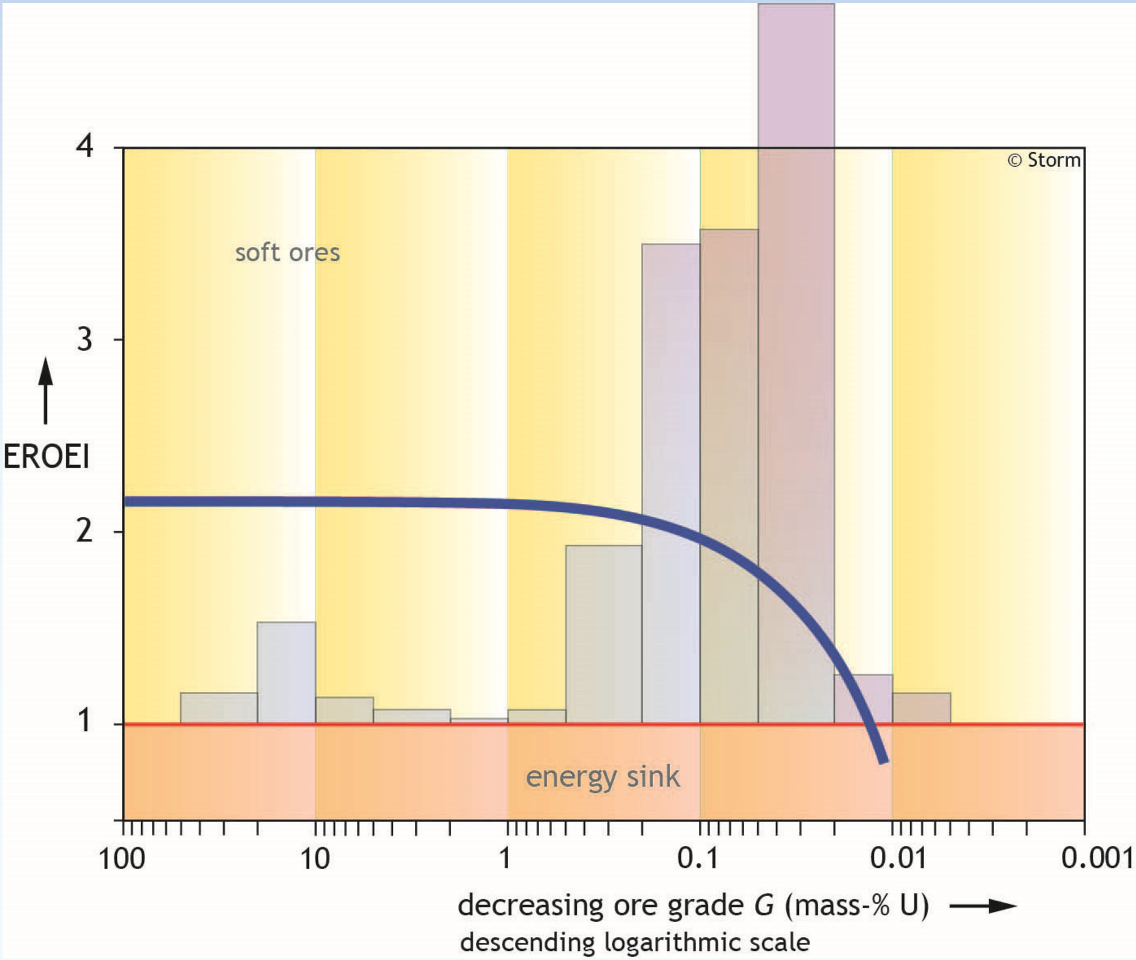
Energy cliff



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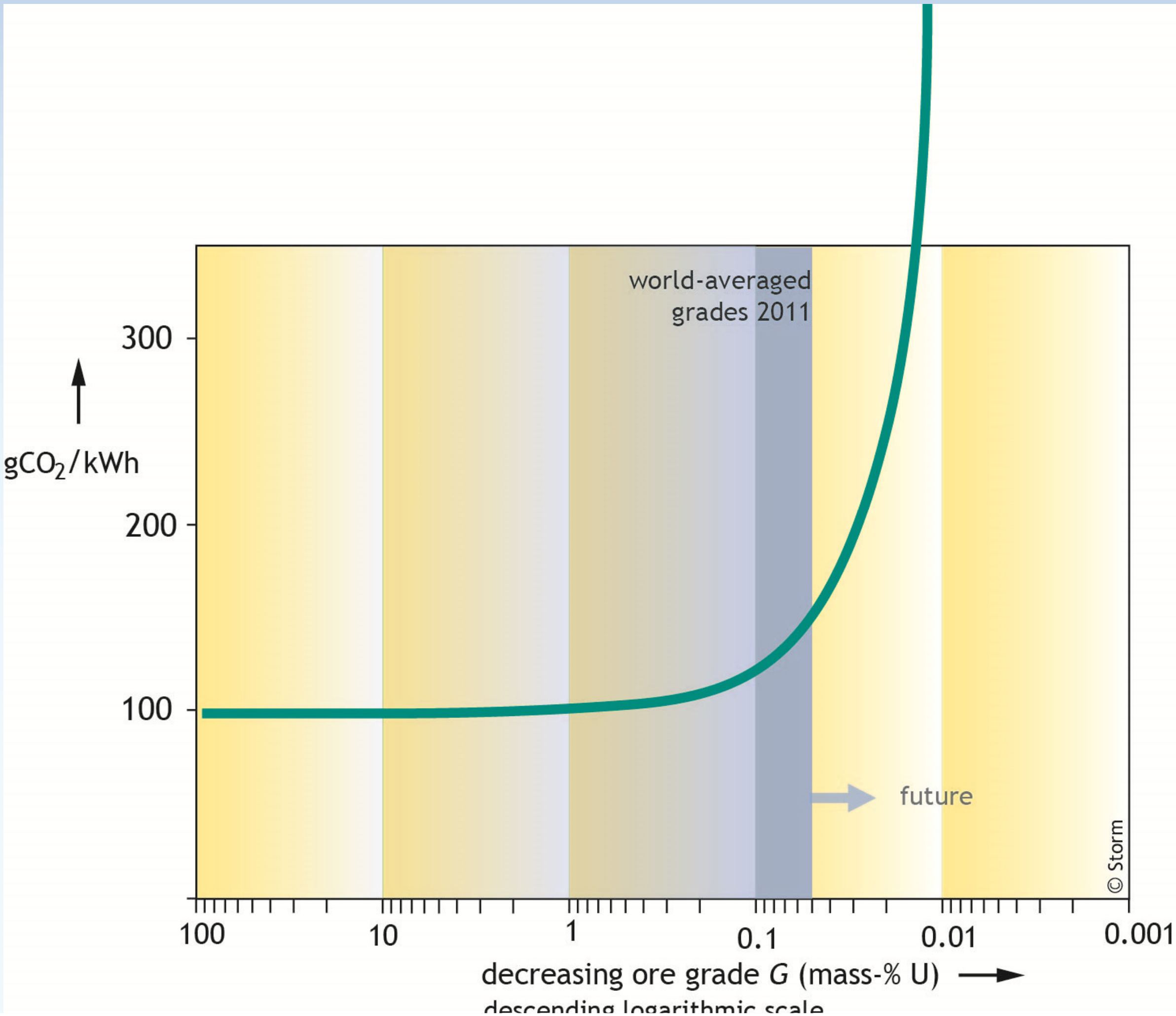
The CO_2 trap: nuclear CO_2 emission vs ore grade



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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