Future low-carbon energy systems and uranium resources

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Division of Nuclear Technology Development and Economics

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The NEA serves as a framework to address global challenges

The Role of the NEA is to:

- Foster international co-operation to develop the scientific, technological and legal bases required for a safe, environmentally friendly and economical use of nuclear energy.
- Develop authoritative assessments on key issues as input to government decisions on nuclear technology policy.

33 NEA countries operate more than 80% of the world's installed nuclear capacity

Why are we here today?

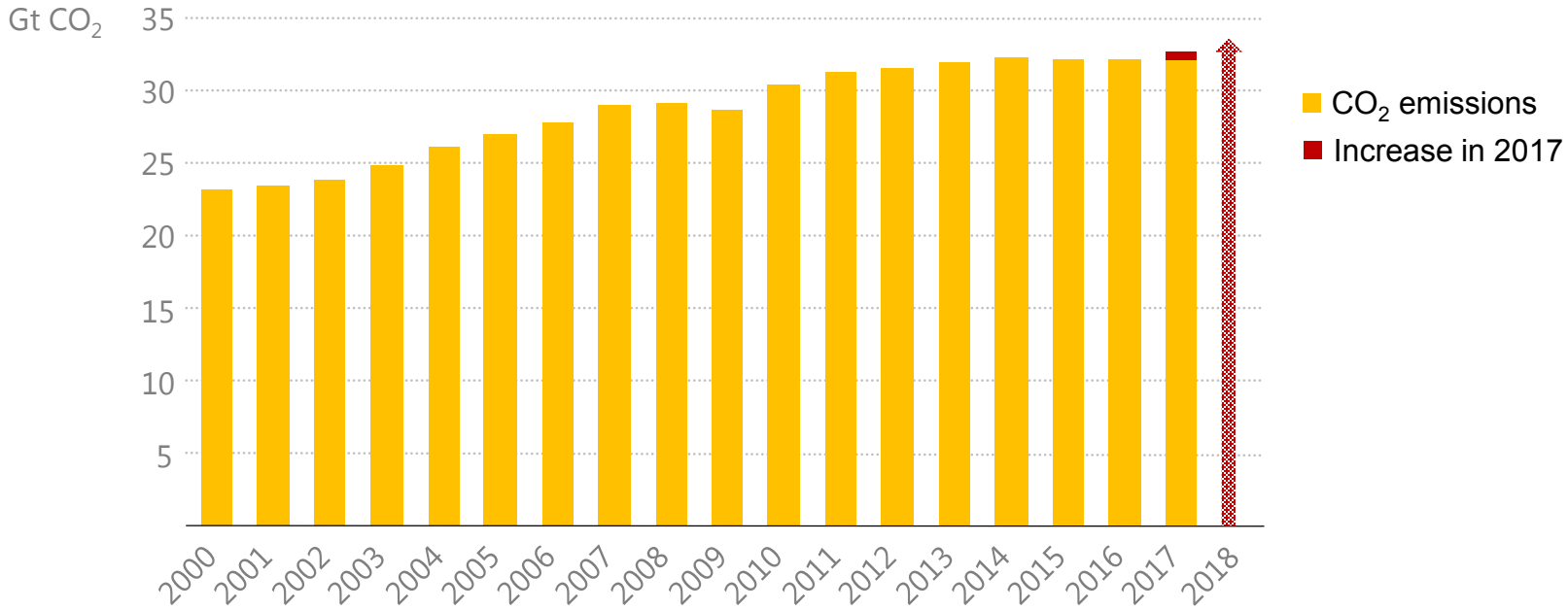
ANSWER: *the economics and environmental benefits of nuclear energy are overwhelmingly convincing*

- cost of 1 kg of enriched fuel is < $2,000
- this yields about 360,000 kWh of electricity
- equivalent to 160 tons of steaming coal

- Nuclear power avoids each year between 1.2 and 2.4 Gt of CO_2 emissions

(assuming this power would otherwise be produced by gas or coal)

Global energy-related CO_2 emissions are increasing

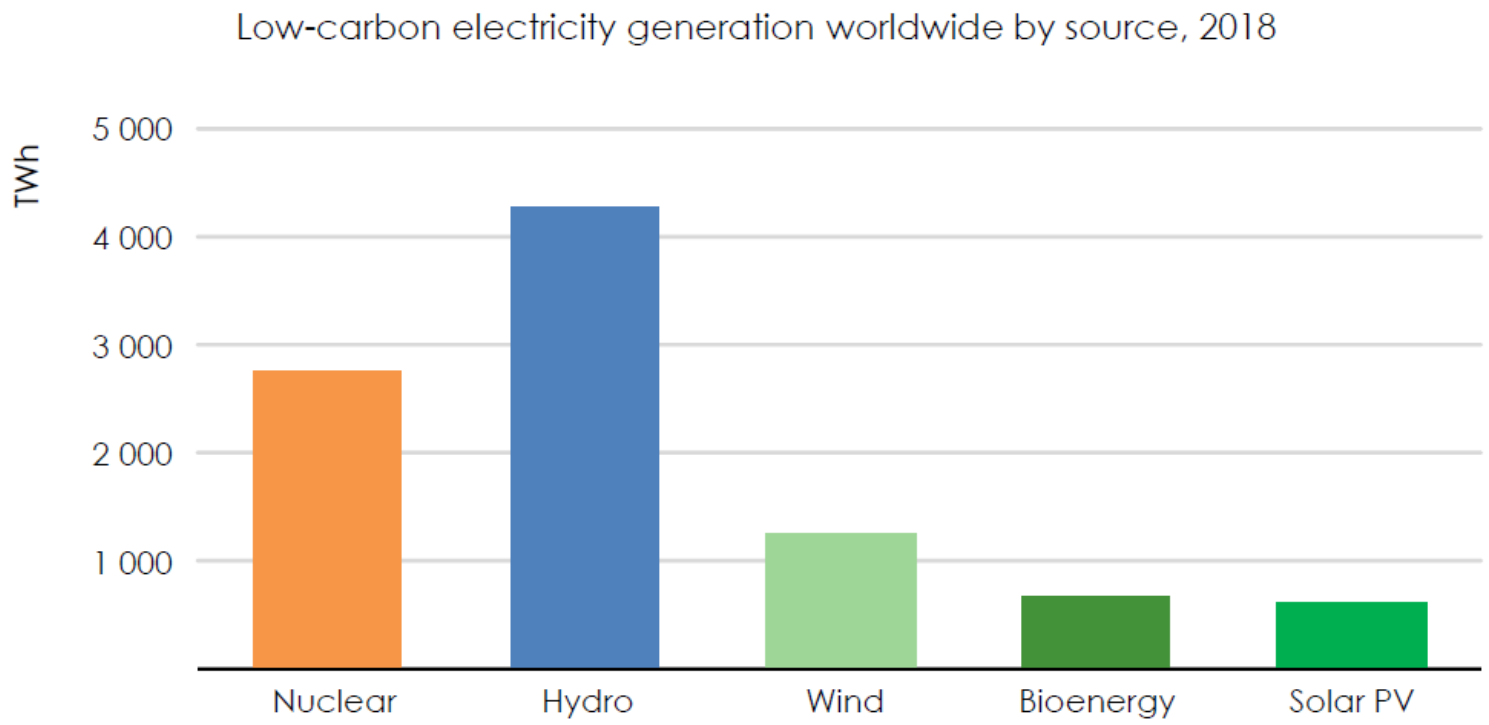


Source: OECD-IEA, 2018

- Global energy-related carbon dioxide emissions are increasing despite record adoption of renewable power. The world is not moving towards the Paris goals but rather away from them…

Why do we need nuclear?

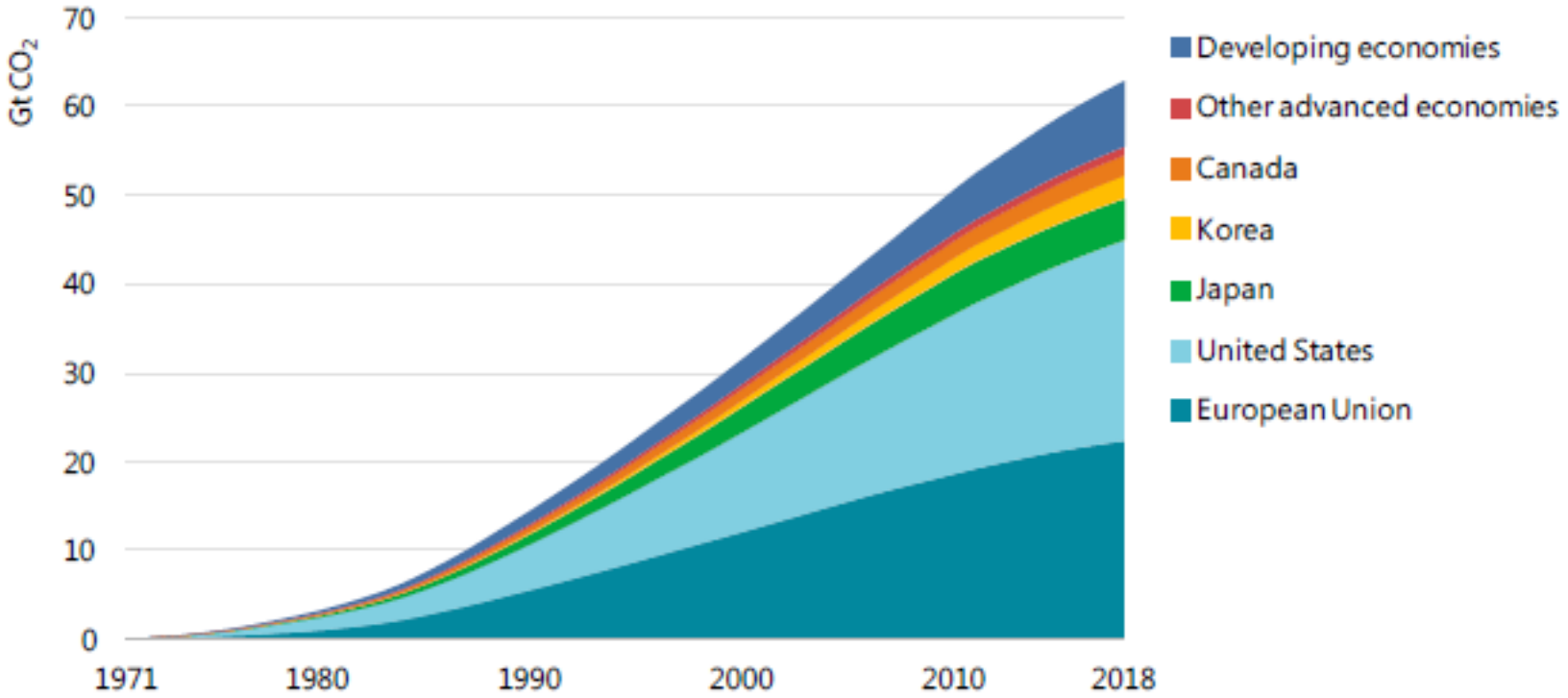
More clean energy technologies are required to address climate change, achieve universal energy access and reduce the impact of air pollution.



Source: OECD/IEA, 2019

Why the climate needs nuclear energy?

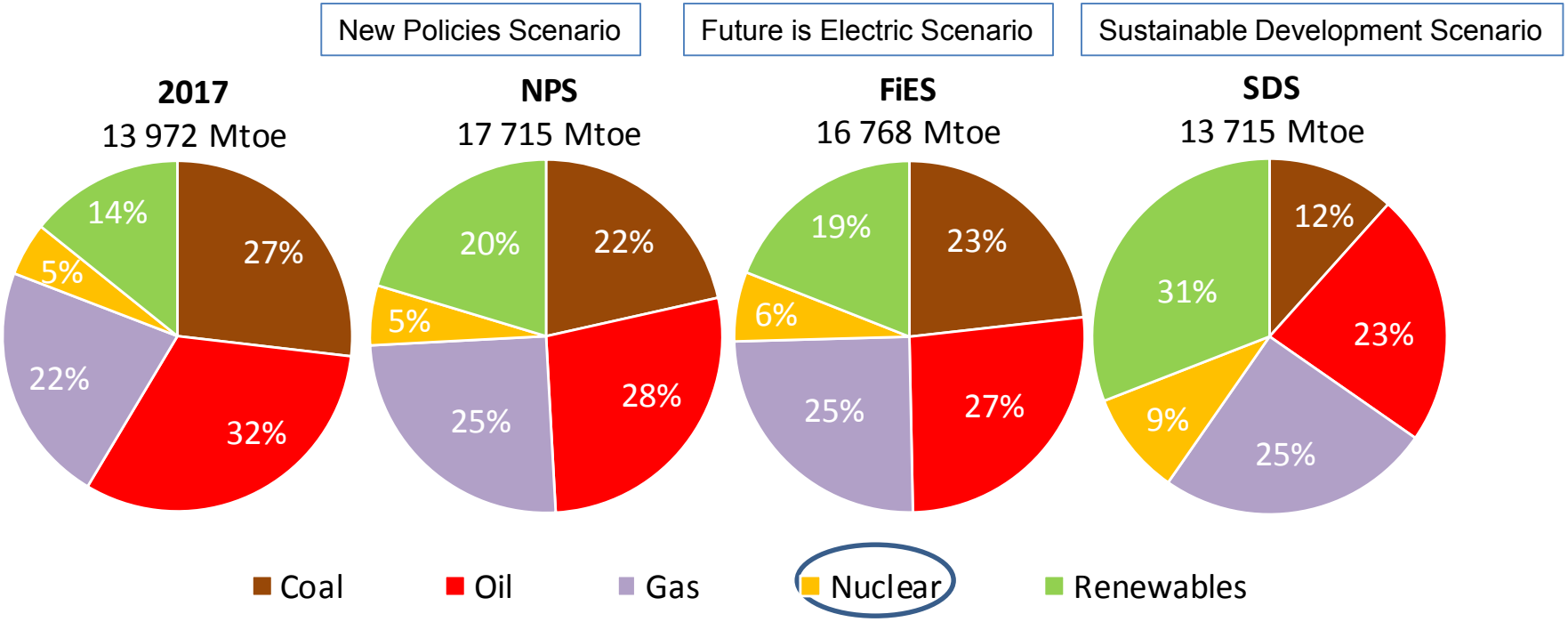
Without nuclear power, global CO2 emissions from electricity generation would have been 20% higher…



Source: OECD/IEA, 2019

Cumulative CO2 emissions avoided by nuclear power worldwide, 1971-2018

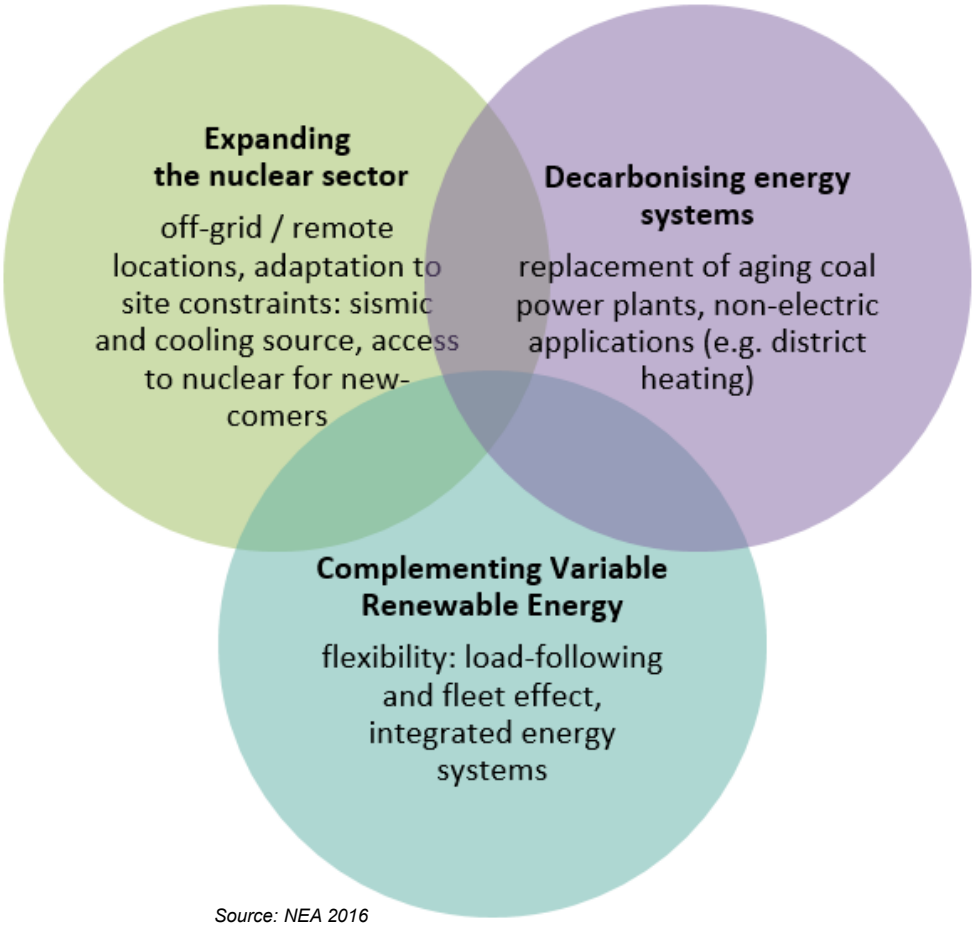
Shares of fuels in world primary energy demand: a view to 2040



Source: OECD-IEA, WEO 2018

- **Achieving global sustainable energy goals will mean using all available fuels and technologies, including large-scale NPPs and small modular reactors (SMRs).**

The market opportunities for SMRs

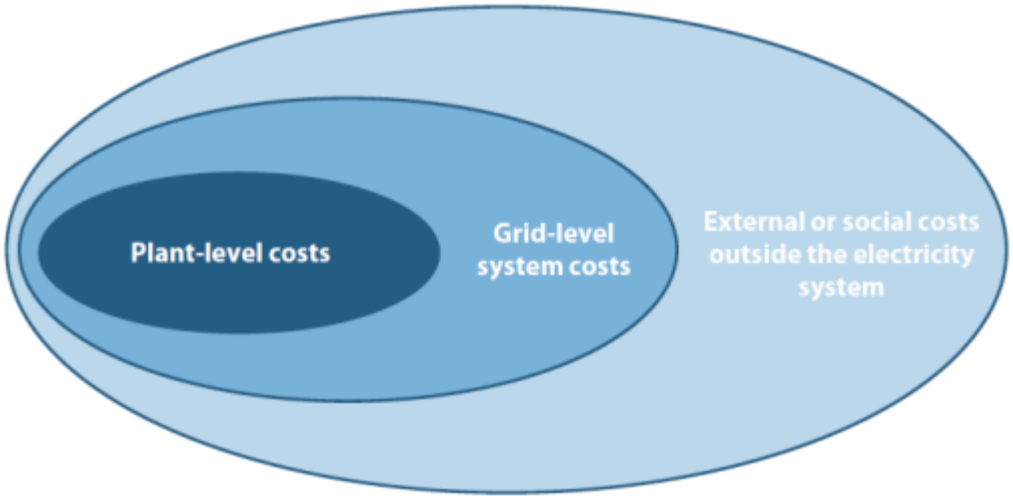


Source: NEA 2016

- **Due to its distinctive features, the SMR technology may open new markets. An opportunity to revisit business models, regulatory interactions and public acceptance approaches…**

Costs of electricity production: the whole story

The price of electricity in today's markets does not accurately reflect the cost of electricity on society and the environment.



- Additional costs include the social cost of emissions, climate change risks, air pollution, accidents, land-use and the depletion of natural resources.

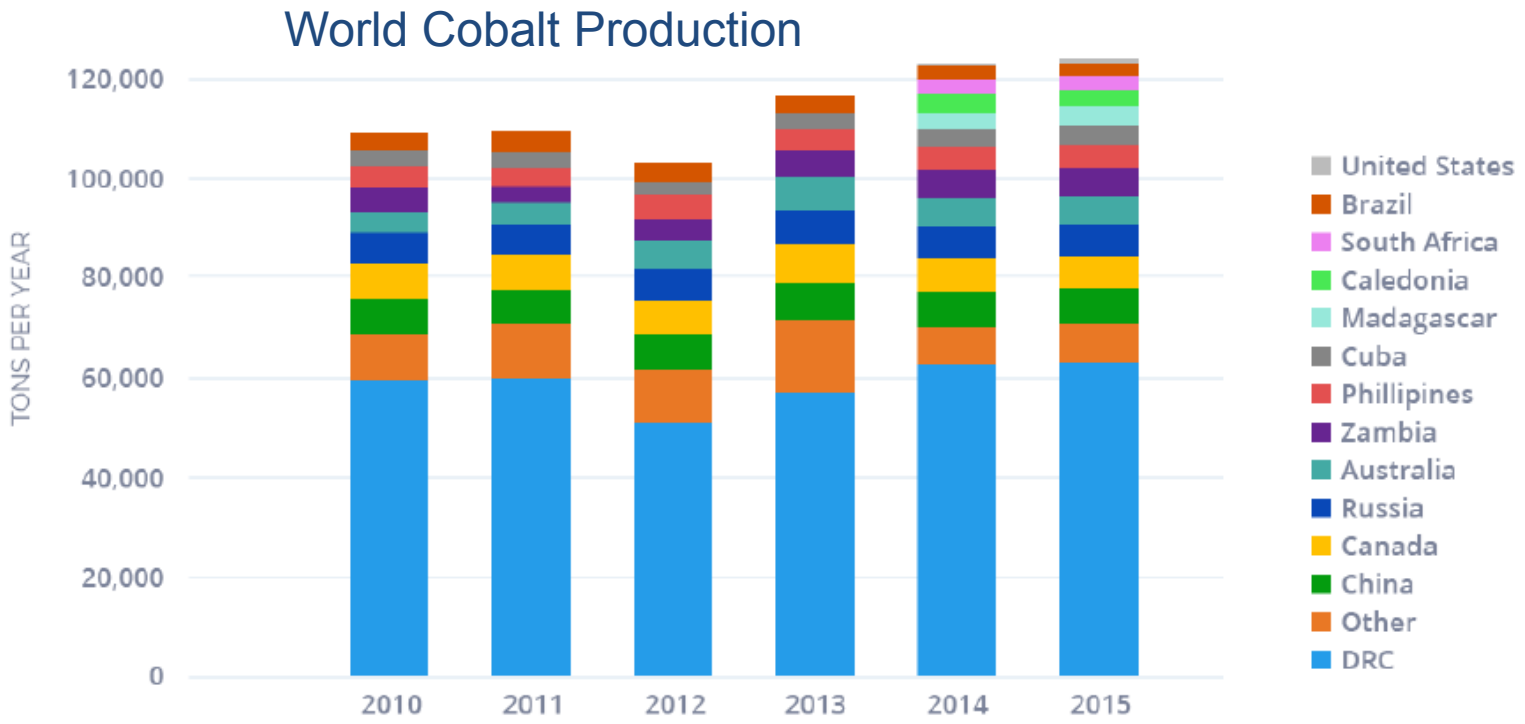
Source: OECD-NEA, 2018

Mineral demand in a low carbon future: focus on renewables

- A recent study of World Bank indicates that the renewables technologies are significantly MORE material intensive than current traditional fossil-fuel-based energy supply systems.
- Electric storage batteries - the most significant example - where the rise in relevant metals (aluminium, cobalt, iron, lead, lithium, manganese, and nickel) grow in demand from a relatively modest level to more than 1 000% under 2DS.

Source: World Bank Group, Extractives Global Programmatic Support, 2017

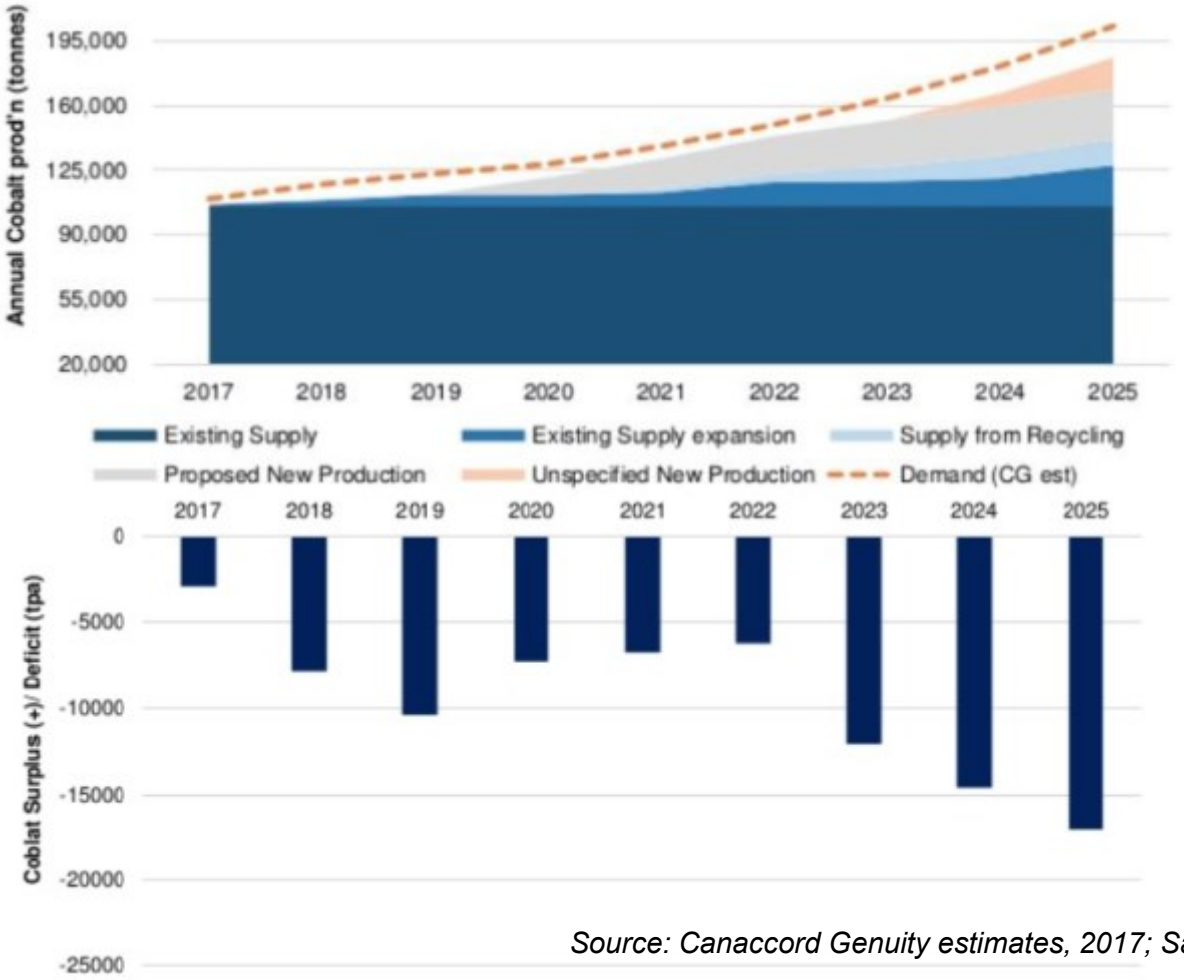
Critical minerals for renewables: Cobalt case study (1)



Source: LiCo Energy Metals, Inc, 2017; Saleem H. Ali, 2018

- 60% of world's supply is coming from Democratic Republic of Congo (political conflict, corruption)
- Almost entirely (90%) produced as byproduct of other ore mining operations (such as Cu, Ni, Pt)
- China has 60% of the refining capacity for cobalt

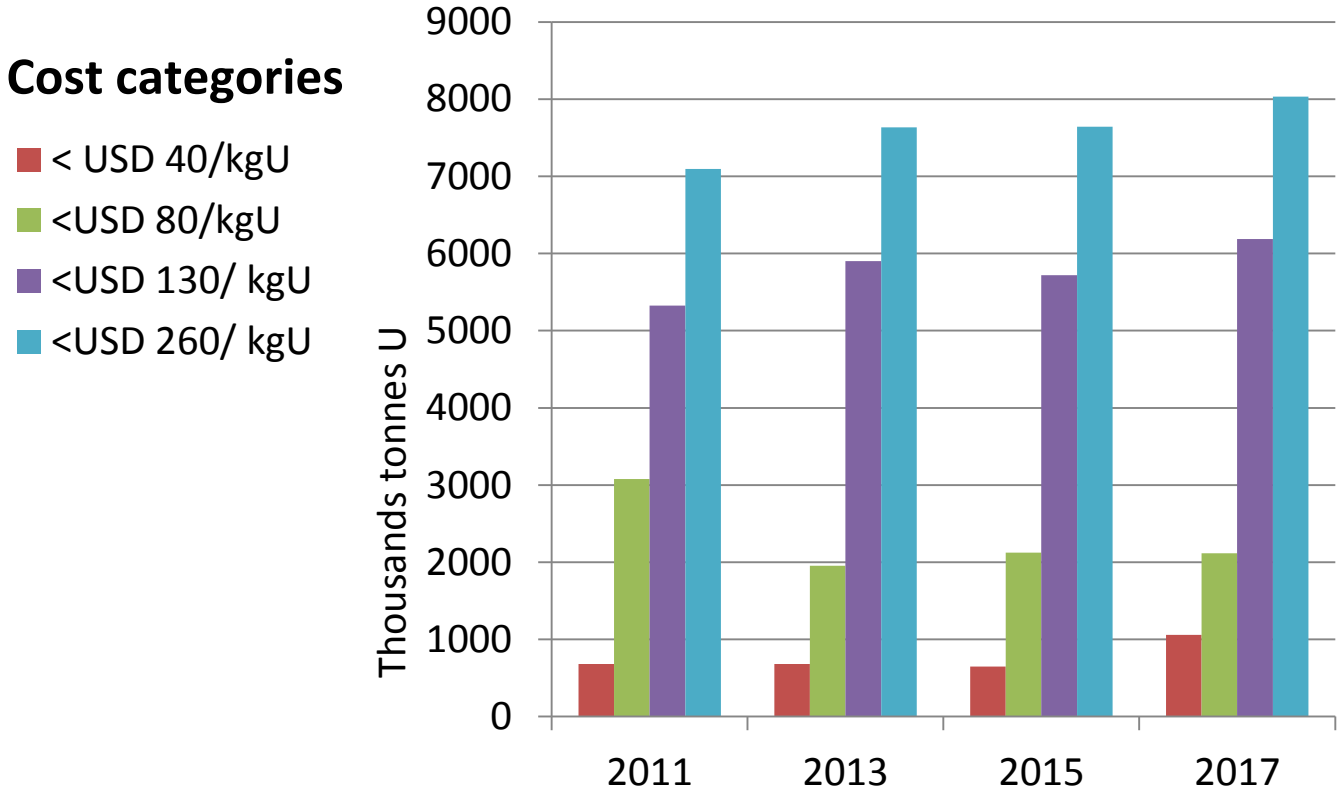
Critical minerals for renewables: Cobalt case study (2)



- Predictions in future cobalt supply, demand and deficit
- Important unbalance between supply and demand for cobalt, based on the high needs of the battery sector.

Source: Canaccord Genuity estimates, 2017; Saleem H. Ali et al, 2018

What resources are available to meet the world's demand for nuclear energy?



Source: OECD-NEA/IAEA, Uranium 2018: Resources, Production, Demand (« Red Book »)

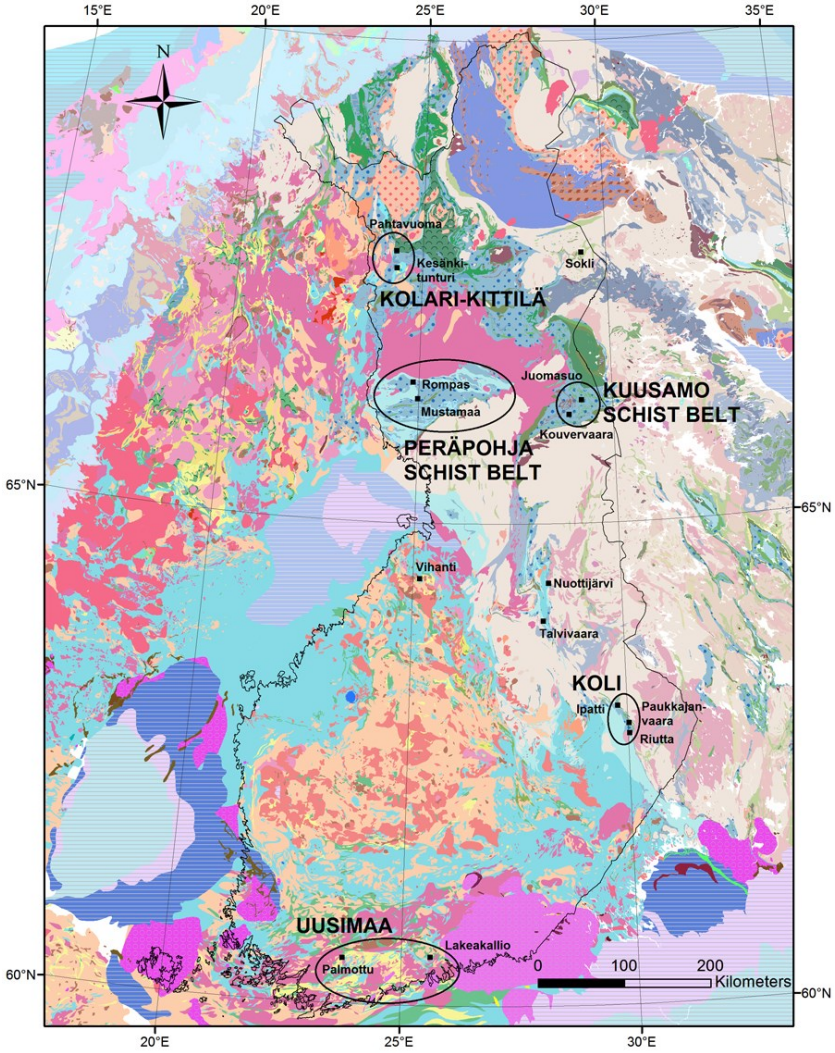
- Global identified conventional uranium resources increased but especially in the highest cost categories.
- Resources have been added at a greater rate than they have been consumed.

World distribution of uranium resources

Source: OECD-NEA/IAEA « Red Book » 2018

- Widespread distribution of uranium resources

Uranium potential in Finland

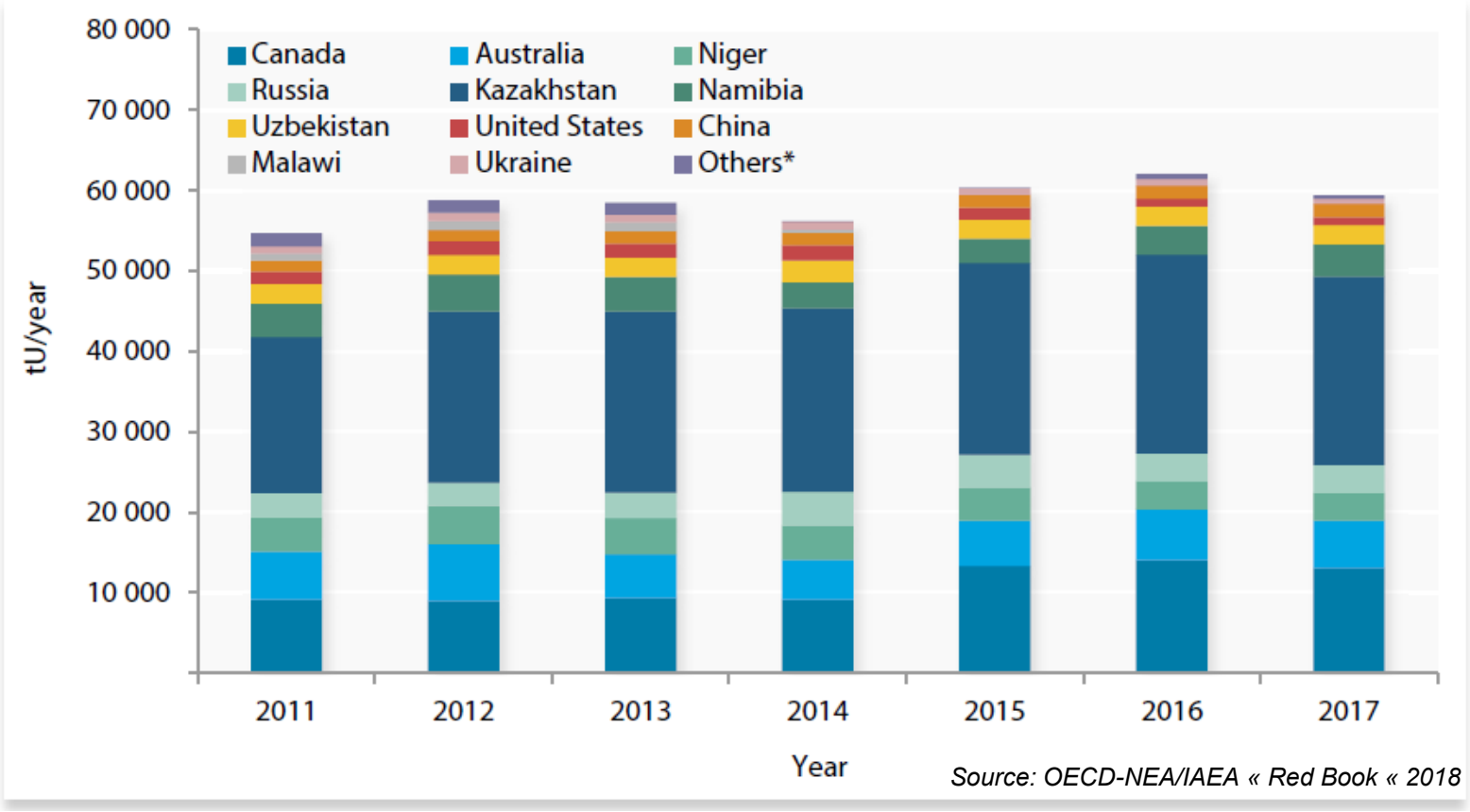


Source: Geological Survey of Finland

Terrafame Ni Mine – By-product Uranium Recovery

- Black schist-hosted polymetallic (Ni-Zn-Cu-Co) Talvivaara deposit
- Terrafame Ltd applied for a licence to recover uranium as a by-product in 2017

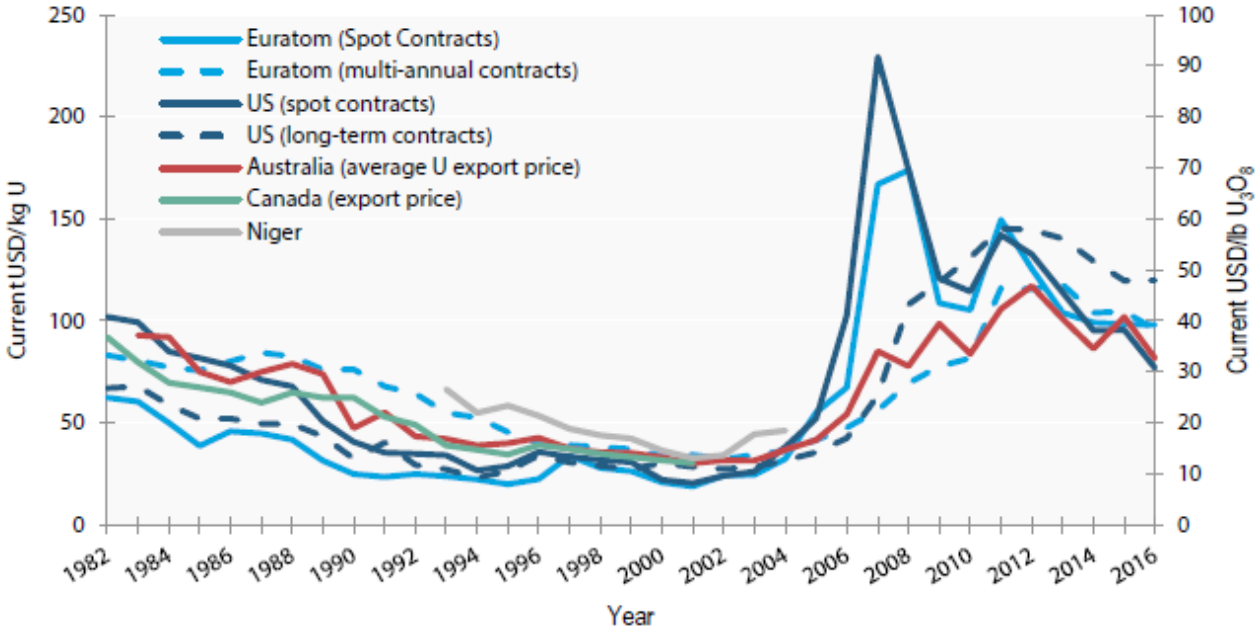
Recent world uranium production



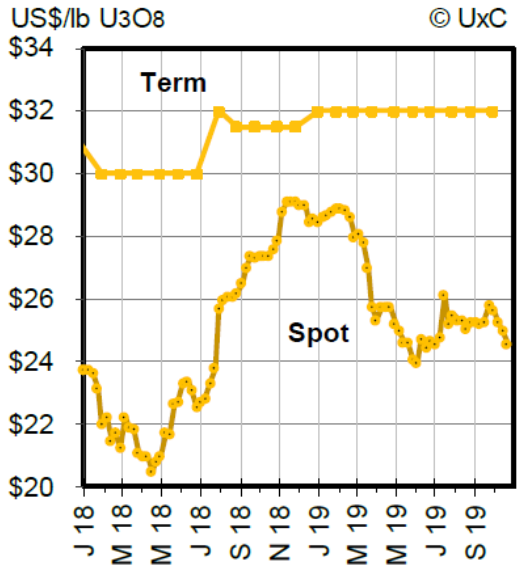
Source: OECD-NEA/IAEA « Red Book « 2018

- Production has started to decline in 2017 as major producers, including Canada and Kazakhstan, limit total production in response to the sustained low price of uranium.

Uranium market outlook



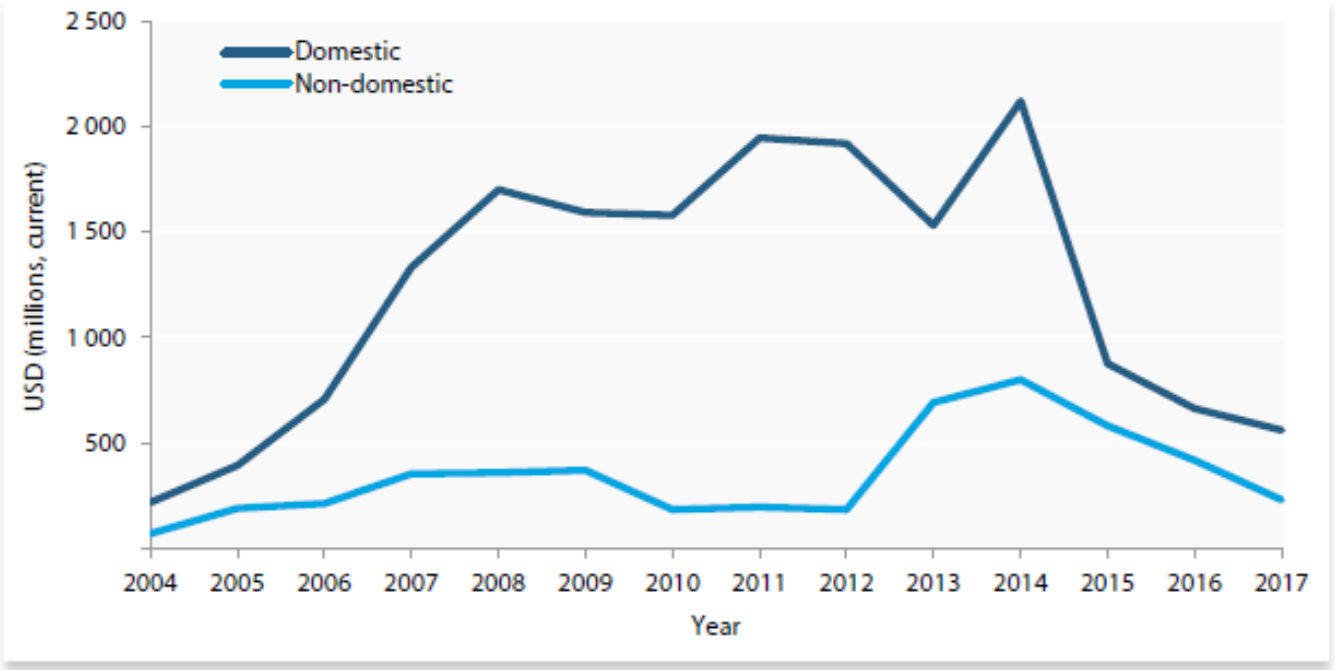
Source: Australia, Canada, Euratom (ESA), Niger and US EIA.



Source: UxC Weekly

- 2011-2017 - Spot and long term contracts prices were generally on a downward trend
- 2017-2018 - Uranium prices have recovered due to the renewed interest from financial investors coupled with production cutbacks by producers.

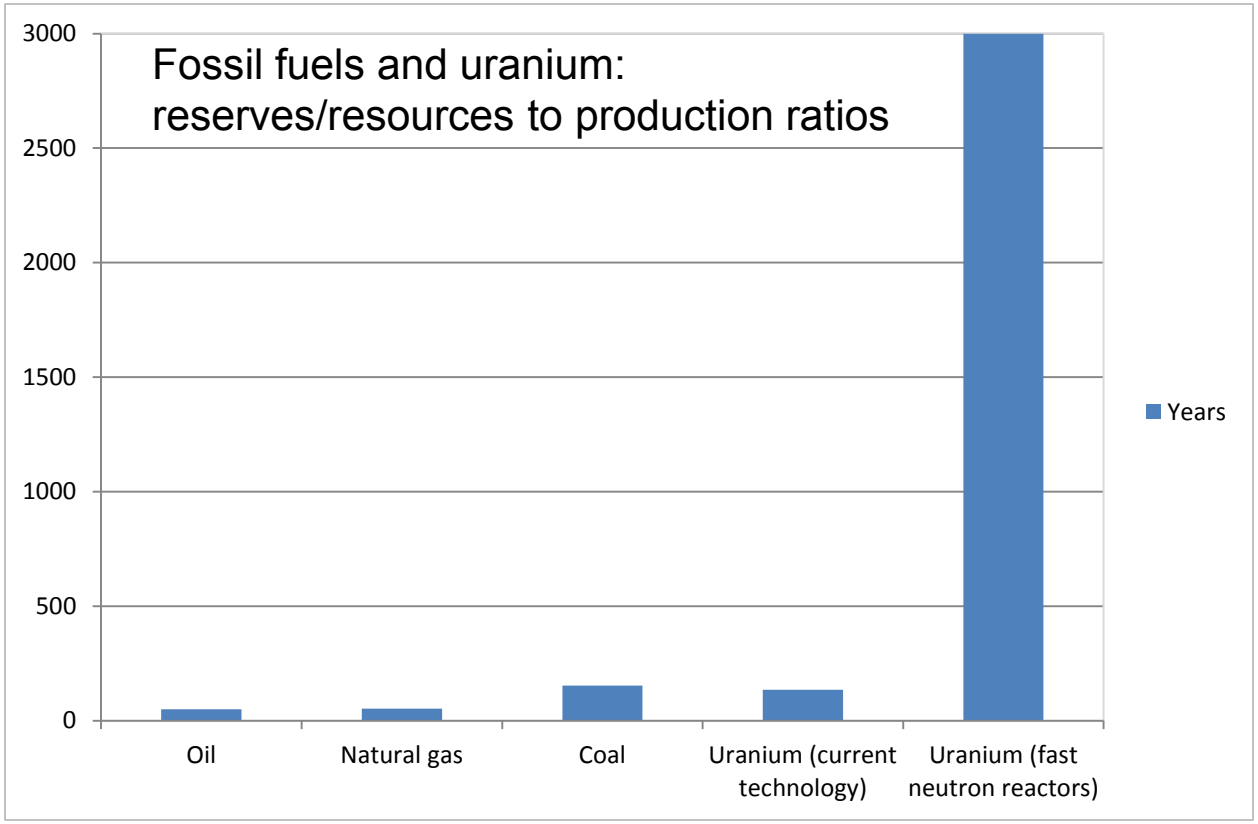
Trends in global uranium exploration and development expenditures



Source: OECD-NEA/IAEA « Red Book « 2018

- After a peak in 2014 attributed to the development of Cigar Lake mine (Canada) and Husab (Namibia), global expenditures significantly decreased.
- Investment is required to ensure that new resources can be brought into production.

The long term perspective



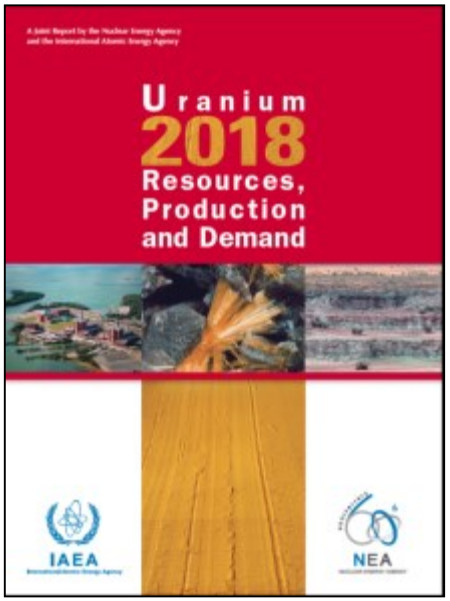
- Identified uranium resources are sufficient for 130 years of production.
  Unconventional resources and new reactors technologies can increase significantly the availability of uranium;
- Global oil and natural gas reserves are sufficient to meet ~50 years of current production.
- What about materials for renewable energy systems?

Major opportunities but also some concerns…

Source: BP Statistical Review of World Energy, 2017; OECD-NEA / IAEA « Red Book », 2018

Summary

- **Nuclear is an indispensable part of future low-carbon energy systems**
- **SMRs can play a key role**
- **Global energy landscape requires more conversations about resources**



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