

Is nuclear power sustainable?



The results of a mapping exercise of current research



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The study – a literature survey

What is the view of research on

- Whether nuclear power is part of a sustainable energy system?
 - To what extent nuclear power contributes to climate mitigation?
- and
- what are the prospects for the future of nuclear power according to some well-known scenario studies



SUSTAINABILITY ASPECTS ON NUCLEAR POWER

REPORT 2019:607

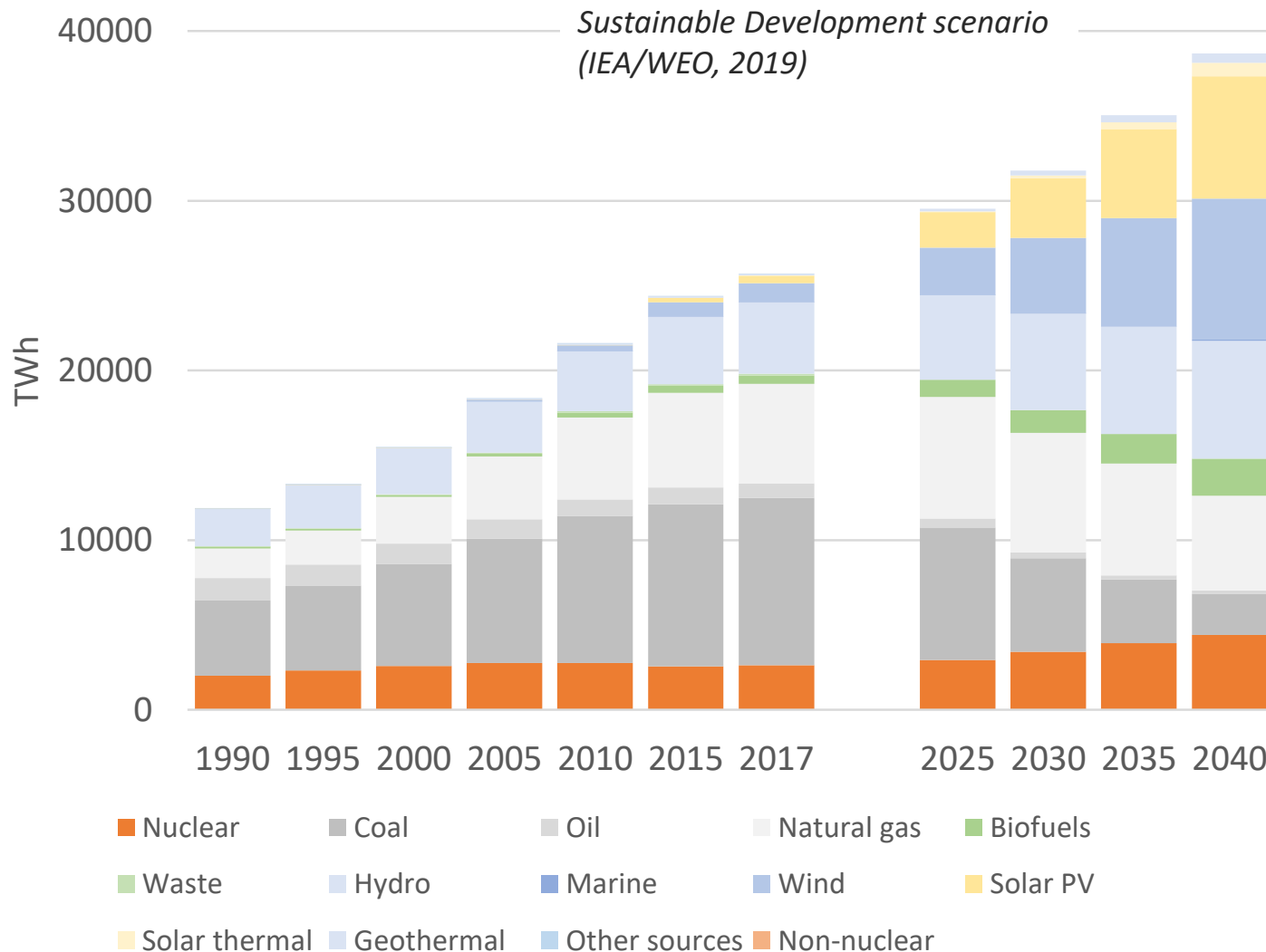


This is how we chose our literature

- General search (academic databases and Google) including search terms such as:
 - Nuclear power/energy, sustainability, sustainable development, climate change
- A focus on academic papers published in scientific journals
- Our main criterias for selecting articles to include were that they contained the search terms either in the title, abstract, and/or table of content
- Mainly articles published *after* 2010, with a few exceptions
- After reading the selected articles/papers, additional papers cited in the selected papers were in some cases added to the list.
- Some 50 different scientific papers have been included in the assessment (some of them excluded due to lack of relevance and quality)
- Besides scientific articles/papers, reports from official bodies such as IEA, IPCC, NEA and IAEA, position papers from environmental NGOs as well as reports from the nuclear industry (WNA) have been included in the literature review → scenario studies and further arguments related to our main question.

How much nuclear power is generated today and what is a possible development?

World electricity generation (IEA)



What does the IEA/WEO 2019 say about nuclear power?



- Nuclear power can play an important role in clean energy transitions
- However, huge hurdles to invest in new nuclear projects
- New technologies could offer new opportunities
- Achieving the clean energy transition with less nuclear is possible but is likely to cost more
- The contribution from nuclear power has decreased in the long-term clean energy scenarios by the IEA over time while the contribution from renewables has increased

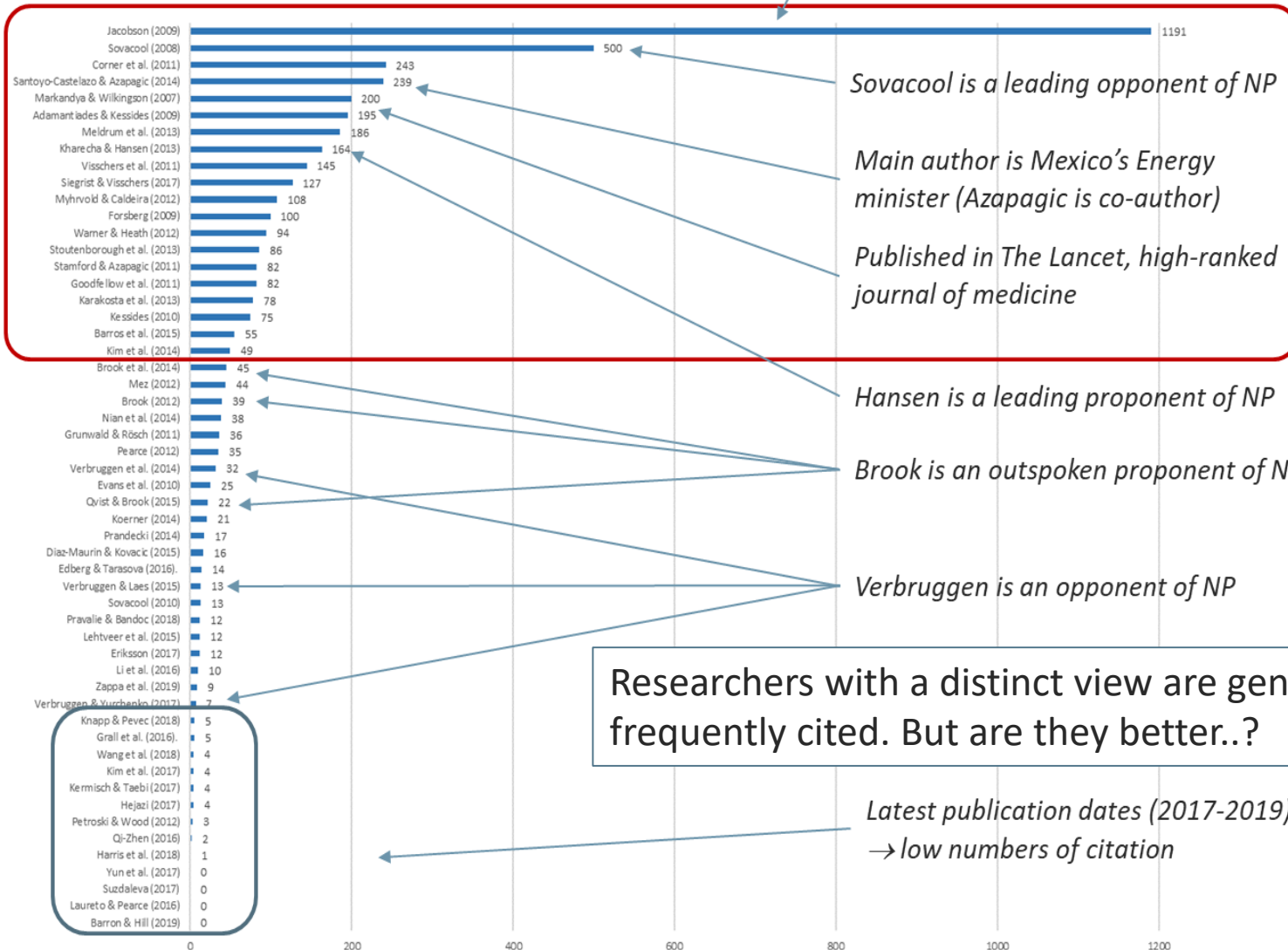
What does the much renowned IPCC special report on the 1.5°C target say about nuclear? (IPCC, 2018)



Nuclear power increases its share in most 1.5°C pathways with no or limited overshoot by 2050, but in some pathways both the absolute capacity and share of power from nuclear generators decrease (Table 2.15). There are large differences in nuclear power between models and across pathways (Kim et al., 2014; Rogelj et al., 2018). One of the reasons for this variation is that the future deployment of nuclear can be constrained by societal preferences assumed in narratives underlying the pathways (O'Neill et al., 2017; van Vuuren et al., 2017b). Some 1.5°C pathways with no or limited overshoot no longer see a role for nuclear fission by the end of the century, while others project about 95 EJ yr⁻¹ of nuclear power in 2100 (Figure 2.15).

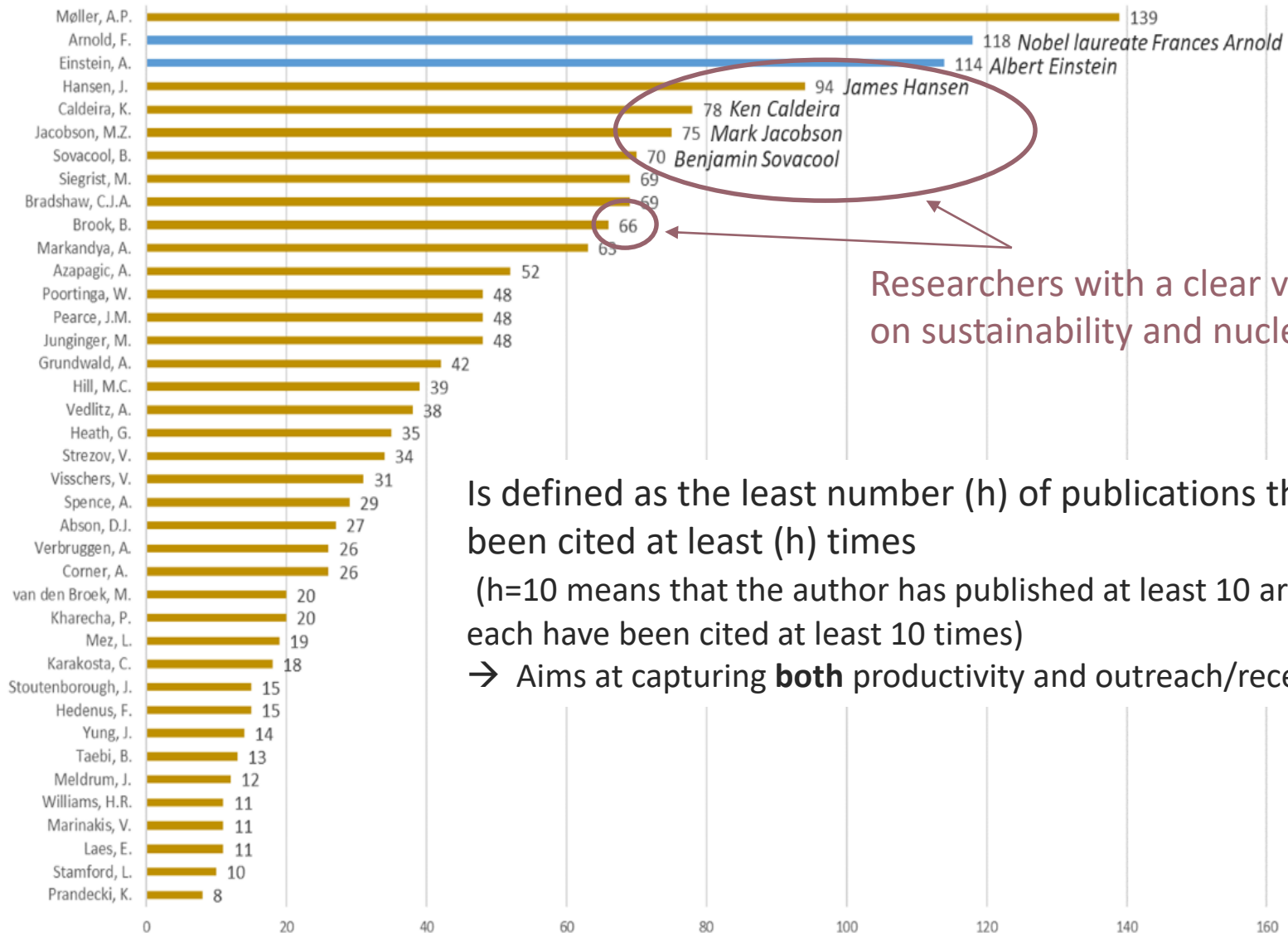
What is good research? Number of citations?

Number of citations



What is good research? The H-index

h-index



Researchers with a clear viewpoint on sustainability and nuclear power

Is defined as the least number (h) of publications that have been cited at least (h) times

($h=10$ means that the author has published at least 10 articles that each have been cited at least 10 times)

→ Aims at capturing **both** productivity and outreach/reception

Definitions of *sustainability*

Brundtland, Our Common Future (1987):

This is the most commonly quoted definition:

*Sustainable development is development that **meets the needs** of the present without compromising the needs of future generations to meet their own needs.*

→ Circular economy

Environmental sustainability

- examples on pros and cons mentioned in research



- (Very) low emissions of GHGs and other pollutants
- Small amounts of waste produced (compared to FF)
- Land-use efficient when allocated on generated electricity
- Practically infinite resource base when considering all uranium available (eg. i sea water) and breeding technologies

- Radioactive waste that needs to be stored for a long time (intergenerational problem → social dimension)
- Mining (destruction of land and pollution)
- Uranium resources are finite (low-grade ore implies increased abundance but also increased exploitation costs)
- Water use one of the highest compared to all other electricity/power plants/generation
- Cooling water (incl. intake) causes harm to marine organisms
- Far-reaching environmental (and social) impacts of accidents

Economic sustainability and nuclear power

– examples on pros and cons mentioned in research



- Low generation costs in existing plants
- Lifetime extension – a cost-efficient climate-mitigation measure
- We need to keep open for all available options
- Safe, secure and dispatchable technology – long experience in different regions with respect to operating in load following mode
- Technological development will potentially improve things even further
- Significantly lower costs in Asia → re-learn in the Western World!

- (Very) high investment costs in the Western World
- Technological development has yet to prove itself
- Other competing low-carbon options are more cost-efficient
 - we have limited amount of capital and time → go for the safe options
- Insurance amount does not cover full monetary responsibility in case of an accident (insurance amount+utility assets<<estimated costs of accident → society needs to cover the gap)
- NPPs are not designed for an electricity system with increased variability

Economic sustainability and nuclear power



S&P Global ratings, Nov 2019

<https://www.spglobal.com/marketintelligence/en/>

We see little economic rationale for new nuclear builds in the U.S. or Western Europe, owing to massive cost escalations and renewables cost-competitiveness, which should lead to a material decline in nuclear generation by 2040. China and Russia by contrast, continue to build new nuclear capacities, supported by energy policies and significantly lower construction costs.

“One obstacle is that the cost of new nuclear plants has escalated.....

This may limit the role of NP in a low-carbon portfolio and raise the costs of deep decarbonization. The good news is that the cost of new nuclear plants can be reduced.”

(Authors of the MIT interdisciplinary study: “The future of nuclear energy in a carbon-constrained world”, 2018)

Social sustainability and nuclear power

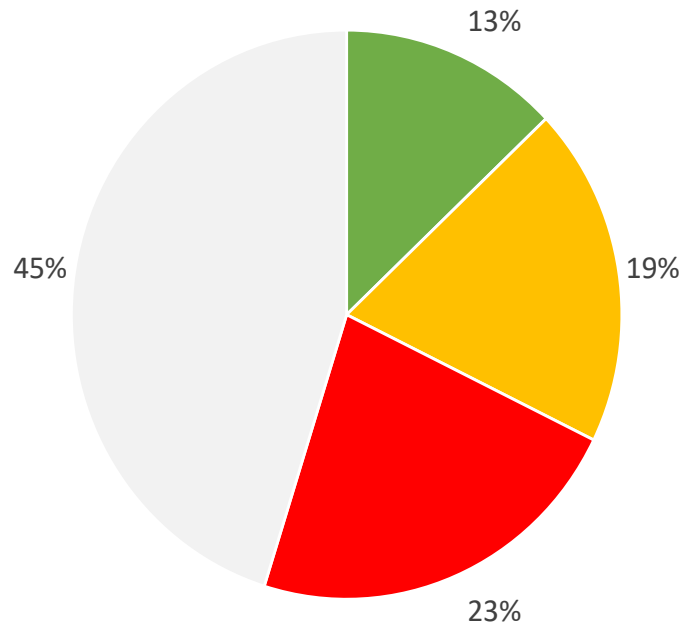
– examples on pros and cons mentioned in research

- Supply of secure (“energy independancy”), stable and abundant electricity spurring economic growth
- Human casualties from accidents (very) limited when related to generated electricity (comparable with renewables and far lower than FF)
- Risk (and consequences) of accidents (no consensus on health effects from accidents)
- Health aspects (radiation) – wide range of estimates of impacts
- Public opinion/perception
- Risk of proliferation
- Mining (working conditions)
- Intergenerational issues (radiation/waste) etc
- The link between civil use of nuclear energy and military use

Large discrepancy between objective risk (which may be calculated) and perceived risk (which is subjective but, nevertheless, relevant)!

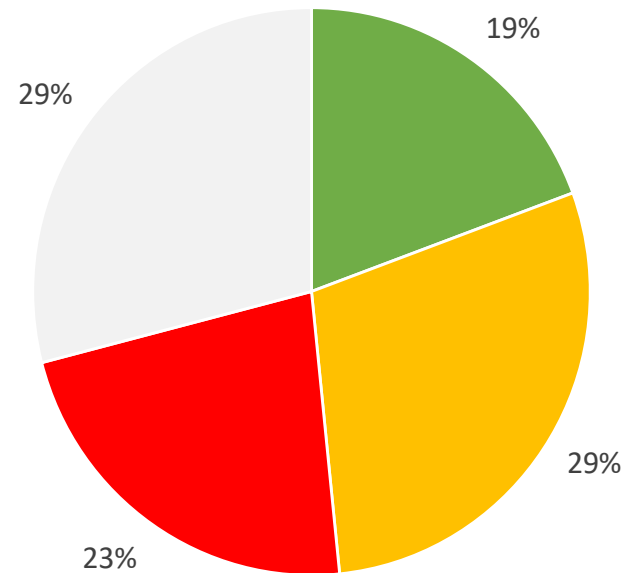
So, what does research say?

Is NP part of a sustainable energy system?



■ Yes ■ Maybe ■ No ■ Not specified

Is NP part of a climate-mitigation solution?



■ Yes ■ Maybe ■ No ■ Not specified

Final assessment of some 30 papers after a total of approximately 50 papers

Final conclusions

- No clear consensus among researchers whether nuclear power is, or may become, part of a sustainable energy system
- No easy answers to difficult questions! Nuclear power and sustainability is a difficult and complex subject (as well as there are other difficult subjects)
- A minority of researchers express clear answers or viewpoints (on "both sides") while the majority takes on a more cautious perspective – acknowledge both benefits and challenges
- Public acceptance is considered as a key issue, especially trust in the nuclear industry and regulation authorities
- In general, nuclear power is viewed as a *potentially effective* climate-mitigation measure -> whether it actually becomes an *efficient* solution depends on overcoming key challenges
- Key challenges often mentioned are: costs and economic risks (Western World), waste management, risk of proliferation, accidents and terrorist attacks
- Some authors reflect upon the question whether any energy source is sustainable today. Nevertheless, "sustainability" gains in importance both as a phrase and in action

