The Economics of Nuclear Energy

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The levelized costs of electricity from renewables have decreased by up to 90% in the past decade. During the same period, the cost of nuclear power has increased by more than a third. This led to a domination of renewables in new investments worldwide. Even when factoring in integration costs of renewables and new nuclear technologies, building new nuclear power remains multiple times more expensive than new solar or wind projects. Given the financial, project, and technological risks, the role of nuclear in the energy transition should be questioned.

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References:
Weibezahn, J., Steigerwald, B. (2022). The Economics of Nuclear Energy. The Green Bond, September 2022, 16-18. Stockholm, Sweden: Skandinaviska Enskilda Banken AB. https://sebgroup.com/siteassets/cision/documents/2022/20220915-sebs-green-bond-report-accelerated-transition-held-up-before-2023-take-off-en-gb-0-3155392.pdf

The Economics of Nuclear Power

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Today, steep declines in generation costs of renewable energy systems, particularly solar photovoltaics (PV) and wind energy, combined with a recent spur in storage and flexible technologies driven by batteries and increasingly renewable hydrogen, drive a paradigm shift in energy systems: renewable energy now dominates investments in electricity generation systems installed around the world[6].

In the last year, 13% of generated electricity came from renewable energy sources with a conjugated growth rate of 10.7% between 1974 and 2021 in contrast to a share of 10% for nuclear-generated electricity from 413 nuclear reactors operated by 33 countries with an average age of 30.9 years and a worldwide conjugates growth rate of 1.5% between 1974 and 2021[7].

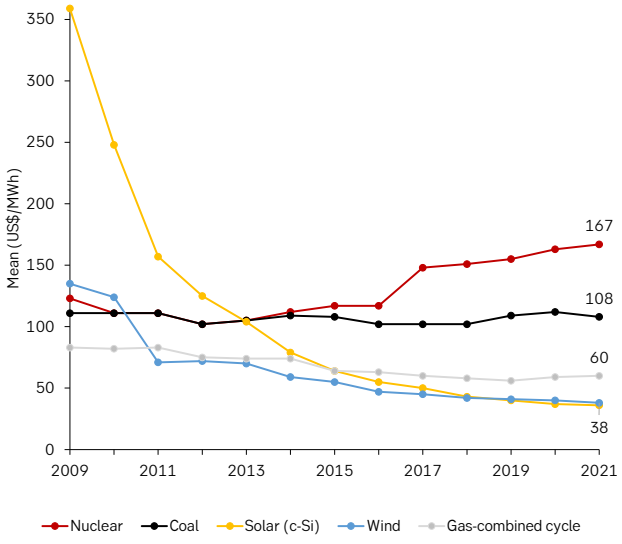
On the other hand, direct public energy research, development, and demonstration (RD&D) spending during this year is estimated at about 2021 USD 4.8bn for nuclear-generating technologies, which equals a share of 21% and a conjugated growth rate of -1% between 1974 and 2021, while renewable energy generating technologies received about 2021 USD 3.2bn, which equals a share of 14% and a conjugated growth rate of about 6% between 1974 and 2021[8].

Some countries, international organizations, private businesses, and scientists accord nuclear energy a role in the pursuit of climate neutrality and in ending the era of fossil fuels. The IPCC, too, includes nuclear energy in its scenarios. Yet, the experience with commercial nuclear energy generation acquired over the past seven decades points to significant technical, economic, and social risks[9].

Economic efficiency

The described estimation of current public research expenditures in electricity generating technologies provides a first implication of greater efficiencies in renewables since less direct spending and the right policies delivered a greater worldwide share in renewably generated decentralized electricity.

Figure 29 Levelized cost of electricity for selected technologies



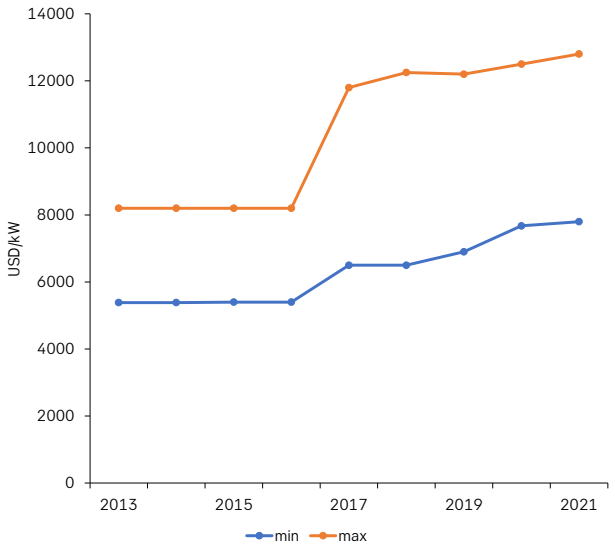
Source: Lazard[10]

[6] Ram et al. (2022) https://doi.org/10.1016/j.energy.2022.123419
[7] BP (2022) https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html
[8] IEA (2022) https://www.iea.org/reports/energy-technology-rdd-budgets-overview/public-energy-rdd-in-iea-countries
[9] Wealer et al. (2021) https://www.diw.de/documents/publikationen/73/diw_01.c.812103.de/dwr-21-07-1.pdf
[10] Lazard (2021) https://www.lazard.com/media/451881/lazards-levelized-cost-of-energy-version-150-vf.pdf

From an investor's perspective, the cost of electricity generation for different technologies provides a more interesting insight to evaluate a project. A commonly used comparable metric is the so-called levelized cost of electricity (LCOE). Here, CAPEX and OPEX over the economic life of a power plant are broken down over the expected energy produced, yielding a comparable number between technologies with different cost structures.

Figure 29 shows that renewable technologies like wind and photovoltaics are by far the cheapest source of electricity with around 38 USD per MWh in 2021. For PV this means a cost decrease by around 90% over the last 12 years and around 70% for wind. During the same time, the cost of nuclear increased by 35% to 167 USD per MWh. This is largely due to the increased investment costs (Figure 30).

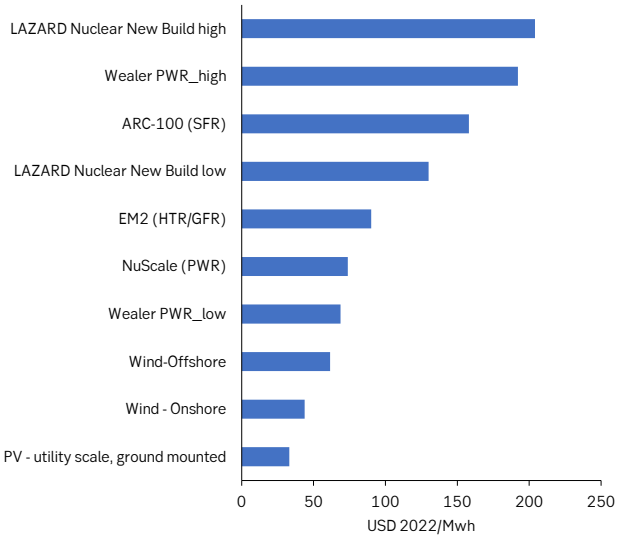
Figure 30 Average capital costs for new-build nuclear power



Source: Lazard[11]

Figure 31 shows more detailed calculations based on a Monte Carlo investment simulation and expands the picture to assumptions on Small Modular Reactor (SMR), where – based on available data – the cost development does not look any better but overall, could potentially achieve safety advantages compared to power plants with a larger power output, as they have a lower radioactive inventory per reactor and aim for a higher safety level especially through simplifications and an increased use of passive systems. Yet, the first projects also went over budget and even the highly advertised NuScale project is still not realized with costs increasing[12].

Figure 31 Levelized cost of electricity in 2022



Source: Authors' own calculations

From an energy system perspective, it is often argued that a purely renewables-based system is not viable due to the intermittency of solar irradiation and wind such that nuclear would be a natural complement[13].

Yet, studies focusing on 100% renewable energy systems conclude that the cost of system integration of renewables via flexibility options will only about double the LCOE[14]. This is still not in the realm of nuclear power. Also, conventional nuclear power plants are mostly operated as baseload power plants with a low degree of capacity regulation (+/- 5%) making them not flexible enough to complement renewables.

Current nuclear power projects in the Global North have shown tremendous cost and time overruns, for example, Vogtle Station (two AP1000 reactors) rose from 2018 USD 16,400mn to 2021 USD 28,500mn or V.C. Summers (units 2 and 3) started in 2013 and were abandoned in the year 2017 due to the bankruptcy of the US company Westinghouse.

The MIT found that the recent experience of nuclear construction projects in the United States and Europe has demonstrated repeated failures of construction management practices in terms of their ability to deliver products on time and within budget[15].

[11] Lazard (2021) https://www.lazard.com/media/451881/lazards-levelized-cost-of-energy-version-150-vf.pdf
[12] https://ieefa.org/wp-content/uploads/2022/02/NuScales-Small-Modular-Reactor_February-2022.pdf).
[13] OECD and Nuclear Energy Agency(2019) Nuclear Energy Agency (NEA) - The Costs of Decarbonisation: System Costs with High Shares of Nuclear and Renewables (oecd-nea.org)
[14] Bogdanov et al (2019) https://doi.org/10.1038/s41467-019-08855-1
[15] MIT (2018) http://energy.mit.edu/wp-content/uploads/2018/09/The-Future-of-Nuclear-Energy-in-a-Carbon-Constrained-World.pdf

Four categories determine whether there will be delays and cost overruns:

- Design and supply chain maturity
- Effectiveness of project management
- Nuclear safety regulation stability and predictability
- Policy framework (in terms of political leadership and multi-unit projects).

In addition to that, there are still largely unknown cost components for the dismantling of nuclear power plants as well as the safe storage of spent fuel and other nuclear waste. Nuclear safety is another political issue: should society take on more nuclear energy with the risk of accidents, terrorism, and proliferation when other less risky renewable technologies are available at lower costs?

Role of nuclear power in the transition

In conclusion, it can be said that nuclear power – neither in its current form and envisioned advanced or modular technologies – is not viable from an economic point of view. In the light of budget and construction time overruns given the short time remaining for a sustainable energy transition to tackle climate change, all efforts should now be concentrated on building a flexible and renewables-based system with high European integration. The inclusion of nuclear power as transitional activities in the EU Green Taxonomy certainly makes these investments more attractive. Yet, given the financial, project, and technological risks it should be doubted that investors will start to crowd in at a large scale.