"We Should Definitely also Look Into New Deployment Models Such as Shipyard-manufactured Floating Power Plants and 'Gigafactories' "

Interview with the Founder and Managing Director of Terrapraxis, Kirsty Gogan and Rauli Partanen of Think Atom

Kirsty Gogan
Kirsty Gogan is co-founder and Managing Director of TerraPraxis and LucidCatalyst. She is a global leader in the field of nuclear innovation and is a member of the UK Government's Nuclear Innovation Research and Advisory Board (NIRAB).

Rauli Partanen
Rauli Partanen is an award-winning science writer and communicator whose books have been published in 8 languages. Today he leads a non-profit think tank called Think Atom that studies and popularises how we can use new nuclear to decarbonise our energy systems.

The major challenge for nuclear new build particularly in developed economies with liberalized electricity markets is financing. What financial instruments and other ways do exist to overcome this hurdle?

The challenges go a lot deeper than just financing mechanisms for nuclear, such as political and regulatory risk and poor market design, but innovative financing can surely help. Cost of finance plays an enormous role in big long-term projects like nuclear plants.

It would be a big positive sign to get nuclear included in the taxonomy, which seems quite likely at the moment, even if it is happening with some strange conditions. That would increase the availability of financing and decrease rates significantly.

In the UK, for example, we have come up with a regulated asset base model for lowering the cost of financing. The Finns have a model called Mankala, essentially a creation of a non-profit co-operative which is owned by utilities and heavy industry and sells electricity to them at cost, which has resulted in very low costs on financing. Long term power-purchasing agreements and zero-emissions credits for nuclear are also good ways to decrease the market risk and with it, the cost of financing.

Part of the cost and financing issue is the concept of LCOE and market designs that focus on plant-based cost but disregard systemic effects. How could electricity markets be reformed to reflect positive external effects of NPPs in the areas of disposability and ancillary services on the one hand and external costs generated by volatile renewable sources such as system integration, decreased load factors and the problem of concurrency on the other hand.

As per how to reform the electricity markets, we should first decide what outcome we want, something along the lines of "a reliable, low carbon and low-cost energy system with minimal externalities" and go from there. For example, a large share of variable renewable energy creates externalities in regard to system reliability and energy availability, while fossil fuels cause air pollution and accelerate climate change. These externalities should be internalized into their costs according to the polluter pays-principle.

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In several recent projects in Europe and the US the increase of construction cost was a big problem. What are the major levers to improve the cost and time performance of the industry in your judgement?

There are a couple major levers we can pull, all of which sound quite obvious. First, we should not stop nuclear construction when we get it going. If we stop building for a decade or two, we lose all the experience, lessons learned, validated supply chains and subcontractors and so forth. Re-building them is both expensive and time consuming. Second, the power plant design should be nearly finished when the construction project starts. Starting construction with an unfinished design is a recipe for costly changes, dismantling and rebuilding and a lot of time-consuming interaction with the regulator.

Third, we should follow best practices in project management, tendering and contracting between parties. This can have a surprisingly big effect on the outcome.

Fourth, building multiple reactors with the same design at the same site in parallel, with 1-2 years between starts, is a proven way to reduce costs. We should incentivize and facilitate maximum learning and cost saving between builds.

From the regulatory side, requirements need to be stabilized and locked in at a relatively early stage, as dismantling and rebuilding is very expensive. And finally, we should definitely also look into new deployment models such as shipyard-manufactured floating power plants and “Gigafactories” that make standardized advanced nuclear reactors for a local, large scale hydrogen plant, on site.

The concrete challenge in the decarbonization of the electricity sector in many countries is to reduce and ultimately to end the use of coal. Can nuclear play a role right on the ground, i.e. in coal regions and sites?

The social justice aspect of decarbonization is a very important aspect that is often overlooked. Coal regions often act as important energy hubs, have a lot of valuable grid infrastructure, and a lot of the local wealth and jobs are generated by these. Many of the coal plants are also quite young with decades of cheap operations left in them. More than half of the coal plants in the world are younger than 14 years. To be successful, we need to offer these people and regions an alternative. Our initiative at TerraPraxis, called “Repowering Coal”[1], is working towards this goal. By replacing coal-fired boilers at existing coal plants with carbon-free small modular reactors (SMRs), also known as advanced heat sources, these power plants can generate carbon-free electricity, rather than carbon-intensive electricity. This would quickly transform coal-fired power plants from polluting liabilities facing an uncertain future, into jewels of the new clean energy system transition and important part of the massive and pressing infrastructure buildout needed to address climate change. Repowering coal fleets therefore offers a fast, large-scale, low-risk, and equitable contribution to decarbonizing the world’s power generation. Converting 5,000 – 7,000 coal plant units globally between 2030 and 2050 (250 – 350 per year) will require a redesigned delivery model to meet this rate of deployment. To be successful, the deployment model has to de-risk the construction process: the riskiest part of a project. To successfully de-risk, we must provide coal plant owners and investors with high-certainty schedules and budgets. To this end, purpose-built automated tools can achieve rapid, repeatable, and confident project assessments. By establishing planning confidence, modern automated tools can facilitate initiation and completion of repowering projects.

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How do you judge the viability of different decarbonization paths with nuclear, which promises the best effective result: nuclearization on a national program scale with large reactors, site by site replacements with conventional technology SMRs or the implementation of advanced heat sources as power plants and for industrial applications?

I think those are not exclusive, as we have different needs. Large scale national nuclear programmes are, so far, the only proven way to rapidly and deeply decarbonize an electricity system with relatively low cost. This doesn’t mean there are no other ways to do it and we encourage the build of all sorts of clean energy sources. But, we should certainly not overlook the evidence. Then again, those programmes were implemented in a very different, regulated market between the 1970s and 1990s. Smaller light water reactors can be built faster and need less up-front investment, and can fit in local grids and company balance sheets more easily. They use familiar technology and existing, licensed fuels and materials. It might be possible to site them with greater flexibility, even on floating barges, which can lower costs further.

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Advanced heat sources have the potential to lower costs further and enter new markets such as industrial process steam at high temperatures, more efficient hydrogen production and so forth. Eventually, they can close the fuel cycle and radically decrease the amount of high-level radioactive waste we need to manage. So, the different nuclear technologies are quite complementary, as they are solutions to different problems.

1 https://www.terrapraxis.org/projects/repowering-coal

Apart from new applications of advanced heat sources there is the more classical cogeneration of heat at lower temperatures. Do you see potential here at existing plants or in SMR deployment at new sites?

Yes. Cogeneration of low-temperature heat increases the total efficiency and value production of a power plant significantly, from around 35 % to over 80% in good cases – but only if we have use for that heat. There are two major markets for this. First, especially in northern and eastern Europe, there are a lot of district heating networks, where towns and cities are heated (and sometimes cooled) by central power plants, piping hot water into the households and businesses in the area. Europe uses over 400 TWh of district heat annually and there is a lot of talk of expanding the networks in order to replace fossil fuel heating like gas boilers. China has a lot of district heating networks as well, and very ambitious plans to build nuclear reactors to heat those.

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The other major use-case for heat at around 90°C is desalination of seawater, for which there is already an enormous market which is set to go with population growth and climate change. Imagine having a floating barge parked near-coast for example in Africa, providing clean energy and desalinated water at large scale and low cost to the local communities, helping them develop.

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One major playing field for advanced nuclear could be a hydrogen economy including synthetic fuel production for sectors as diverse as aviation and home heating. What can be achieved here in terms of cost and deployment?

One of the things we have to bear in mind are the scales involved. For a long time, hydrogen production was seen as a solution to wind and solar variability, both to use the excess electricity when it is windy and sunny, and then to burn the hydrogen back into electricity when wind and sun production goes down. This is a solution to the variable production of renewables, but it is not a solution for our massive need for clean fuels.

We will need clean hydrogen at a completely different scale, potentially in the billions of tons annually – and this means we will need more clean electricity to make the hydrogen than we currently use for everything else, globally. We also need the hydrogen to be extremely low cost so we can replace fossil fuels with it. We have recently concluded two studies on this (Missing Link to a Livable Climate[2]; Decarbonising Hydrogen in a net zero economy[3]), and our conclusions are that by rethinking our nuclear deployment models and focusing laser-like on cost reduction, we can bring the costs of nuclear-made hydrogen low enough to compete with fossil fuels, even without significant carbon-fees.

Two of the deployment models we looked at were shipyard-manufacturing of floating nuclear power plants at massive scale and a Gigafactory, where we build a reactor-factory next to a site that will host dozens of those reactors and make clean hydrogen at massive scale. Both models show great promise.

The US Department of Energy launched the Energy Earthshots initiative last year with the first shot being the Hydrogen Shot to bring down the cost of clean hydrogen from 5 Dollar per Kilogram to 1 Dollar within 10 years. Does nuclear, advanced or conventional, play a role in this initiative?

If nuclear power is allowed to play a role, it surely will. The benefit of 24/7 energy supply to feed the electrolysers is very significant when it comes to reducing the cost of the hydrogen. The second benefit that nuclear can bring is to enable the use of high-temperature electrolysis, which can produce up to 50 % more hydrogen from the same amount of electricity, compared to low temperature electrolysers. In our studies we show that there are few other ways to lower the hydrogen cost close to $1 per kg before mid-century, other than with nuclear energy. And we really can't wait 30 years to get started. By 2050, we need to already be at massive scale and very low-cost hydrogen.

2 https://www.terrapraxis.org/projects/clean-synthetic-fuels
3 https://www.lucidcatalyst.com/hydrogen-modelling-2

Author:

Nicolas Wendler
Head of Press and Politics
KernD (Kerntechnik Deutschland e. V.)

nicolas.wendler@kernd.de

Nicolas Wendler has been Head of Press and Politics at KernD since August 2013 (Nuclear Technology Germany e. V. / German Atomic Forum e. V.) and started his career in March 2010 as Policy officer. Previously he was an international consultant for the international relations of the Young Union (Junge Union) of Germany among other topics of energy, climate and economic policy for the organization. Since January 2022 he is also the editor in chief at atw. Wendler studied in Munich and Bordeaux political science and economics and (North) American cultural history.