«Several SMR designs are making real progress towards market launch»

Small modular reactors (SMRs) are being widely talked about and are also the focus of this interview with Diane Cameron, Head of the Nuclear Technology Development and Economics Division at the OECD Nuclear Energy Agency (NEA).

In the Interview, Diane Cameron discusses the unique advantages of SMRs and identifies opportunities and challenges on their way to market. She also reveals to us the NEA's motivations for creating «NEA Small Modular Reactor Dashboard» and says for whom it's particularly useful. She also impressively shows us the role women can play as multipliers of trust in the nuclear industry. With increasing knowledge, she herself went from being a critical person to a committed supporter of nuclear energy.

Switzerland wants to phase out nuclear energy and Germany has already shut down its nuclear power plants. But: Don't we need all types of energy production together – renewables and nuclear energy – to achieve net zero and ensure security of supply?

Each nation's pathway to net zero emissions is going to look different and is going to be informed by their energy endowments and by the choices and preferences of the population in that country.

In general, we don't see any credible pathways to net zero on a global scale that do not include a significant build-out of new nuclear power plants and also long-term operation of existing nuclear power assets. And we see that the time left for decarbonisation is getting shorter and shorter, especially as the reality of climate change becomes more acute.

Now, coupled with the energy security crisis, we are seeing quite a few nations – including across Europe and abroad – return to serious consideration and plans for nuclear power. This includes consideration for refurbishment and long-term operation of existing nuclear power plants, but also for construction of new nuclear plants

This does not mean that every nation is going to choose nuclear energy, but the technology does have a role to play on the global scale. Finally, let me say something about the question of how it works with renewables: It's not a question of nuclear energy versus renewables. The world needs maximum deployment of all non-carbon-emitting technologies to improve our chances of reaching net zero, including both nuclear energy and renewables.

Is it true that nuclear energy can help integrate even more renewables because it has a stabilizing effect on the power grid?

Yes, that's one of the benefits of nuclear power, like hydro power. It provides base-load power and grid stability, and it's dispatchable. It can enable greater deployment of variable renewables into the mix.

What was your motivation for creating the SMR dashboard and who benefits from it?
Our motivation was to provide an independent and factual report that tracks real progress by SMR innovators. Because there is a lot of excitement around SMRs, it's sometimes hard to see what's really happening by just reading the headlines. The Dashboard is a tool for public sector policymakers, the private sector and academia as well as journalists to see what's happening. We wanted to create a useful tool in a simple layout that's easy for policymakers and non-specialists alike.

Another aspect is that progress on SMRs is moving fast now. Therefore, we also wanted to capture evidence that a lot is happening and that there's real progress. Site owners are selecting SMRs, regulators are reviewing SMRs, financiers are making investments, the supply chain is gearing up, the public is being engaged and the fuel supply chain is getting ready. These are all necessary steps on the path to SMR deployment. And capturing these milestones shows which SMRs are moving forward in the real world.

Someone can have really nice ideas for an SMR and have a great design on paper, but if the other steps for siting, licensing, financing, supply chain, etc. are not taken, it remains just an idea. In the real world, nothing is happening for that design yet. Our SMR dashboard shows that for several designs, progress is being made in the real economy, in the real world.

Part of the excitement is due to the fact that SMRs have the potential to solve some of the energy challenges that are otherwise very difficult to solve. Like large reactors, SMRs can generate electricity for the grid. But SMRs can also provide solutions in places that don't require or can't support a large nuclear power reactor. Some SMRs could be suitable for a smaller electricity grid or even off-grid. Of course, they can also provide heat, for example for the heavy industries and mining sites. As SMRs become commercially available, they could create a whole new set of possible options and solutions for some of these hard-to-abate sectors.

What criteria did you use to select the dashboard's 21 SMRs? Was it a difficult decision and what are your plans with the dashboard?
There are many interesting designs for SMRs under development around the world – more than 80 – but some of these designs are only ideas at this stage. Others are moving forward

on the path to actual deployment. To identify which SMRs should be included in the first volume of the NEA SMR Dashboard, we started by looking at the websites of nuclear safety regulators in our member countries to see which SMR companies are engaged with regulators. This was the first filter that we used to identify some SMR designs that are actively moving forward.

One other criterion was that there had to be enough information about a certain SMR from public, verifiable sources. Everything in the dashboard is based on public, verifiable sources. If an SMR didn't have enough information in the public domain, we could not include it. The last criterion was that the company had to be willing to be included. This is how we arrived at the first 21 SMRs.

The second volume will include another 20 or more SMRs and we will publish it this summer. It will also show a lot of progress, though some of the designs may still be in earlier stages on the road to commercialisation. Some may not yet have a site or have not yet started securing financing. By the end of the calendar year, our goal is to have reviewed all the SMRs around the world.

For example, the AP300 SMR from Westinghouse is a bit late and was only recently introduced to the public …

Yes, very recently, but I wouldn't say it is «late». Some of the SMRs that are in the earlier stages will accelerate, and they will pick up steam. There really is a race to see which designs will be first to market, but many potential customers have not taken their final decisions yet. It's an exciting time.

We have already talked about some of the benefits that SMRs can provide. Are there any other benefits and what are SMRs particularly good for?

It's important to understand that the global market can and probably will support multiple SMR designs. We don't think that 80 SMRs will reach commercialisation. But there will be room for different types of SMRs in different sizes, with different outlet temperatures and different technical features for various applications. We're not just talking about generating electricity on-grid, but also reaching off-grid or edge-of-grid and providing different outlet temperatures for industrial and district heat applications, potentially.

There are also countries that are looking at potentially using SMRs for the propulsion of marine merchant ships. I think you'll see a few different technologies across these different applications. At the end of the day, you could have several SMR designs deployed globally and successfully commercialised. So, it’s not about one winning SMR design for the whole world, but maybe a small number of designs for different applications.

One really exciting thing about advanced SMRs is the approach that many are taking to ensure safety. Some people call it passive safety, walk away safety or inherent safety. The idea is to take the lessons learned from the past 60+ years of operating experience and to use the laws of physics to maximum advantage. In this way, they can simplify the design and move from what we call active safety – which requires a lot of engineering and active human interventions to maintain safety – to passive safety, which uses the laws of physics to ensure safety. It will be important for SMR innovators to prove that their designs achieve these goals, which could really open up the opportunities for SMR deployment.

I have also heard that for certain SMRs, the size of the Emergency Planning Zone can be reduced. Is it true?
This is an important area of discussion. We see some nuclear safety regulators taking a closer look at how best to determine the Emergency Planning Zone to see whether it can be reduced in some cases, in a manner that is risk informed. And yes, in some cases, they are determining that the size of the Emergency Planning Zone for some SMRs can be reduced.

Some SMRs, such as the Chinese HTR-PM, are already in operation and the ACP100 is under construction. When do you expect further SMRs entering the market?
One of the first grid-scale SMRs to reach commercial operation in an OECD country may be the BWRX-300 at Ontario Power Generation’s Darlington site just outside Toronto in Canada. They have already started preparatory work and they are making real progress towards possible commercial operation by 2029. A couple others in the United States could be on a similar timeline.

Those would be the larger grid scale units. I think we will also see some microreactors that are intended for off-grid-applications, especially for remote mining sites, which could be demonstrated quite soon. We know that there is a huge potential market for the micro units from mining companies and other industrial end users from outside the nuclear sector. Many prospective customers for the micro units are essentially saying «We need to see SMRs demonstrated and working first. We may not want the first-of-a-kind at our site because we’re not a nuclear company ourselves but show us that it works first and then we’ll be ready to proceed.» So, I think if these microreactors are successfully demonstrated, the demand to deploy significant numbers of them at industrial sites could grow very quickly and be quite substantial.

As they are much smaller units – sometimes as small as five megawatts – they could potentially be demonstrated and built faster. We expect microreactors to be demonstrated by the mid-to-late 2020's and ready for commercial deployment in significant numbers in the following few years. We may then see another wave of reactors classified as Generation IV technologies, with additional interesting potential benefits. However, they are at earlier stages of research and demonstration. Some still require research, new materials or new types of fuels. They'll be very exciting when they happen, but that might be closer to the mid-2030s or later.

What happens after 2050?
Not only does the world have to get to net zero, but we also have to stay at net zero. If we don't achieve net zero in time, we will even have to go to negative emissions. It's very important to have a pipeline of innovation of technologies that will be ready in five years, ten years, and beyond to offer more and more options. We should also have in mind that nuclear fusion is in the pipeline. I can't estimate the timetable for nuclear fusion, but I'm hopeful that it's coming. Whether that happens before we get to net zero by 2050 or afterwards and helps us to stay at net zero and to keep growing the economy around the world, fusion could make an important contribution.

What conditions must be met for power generation from SMRs to be financially attractive and for SMRs to gain market acceptance?
The first basic requirement is a commitment to decarbonization. Whether you have a policy or legislated requirement or just a voluntary commitment to decarbonize, it really forces a seriousness in the conversation. If you are no longer willing to use coal as a matter of principle, then it no longer matters whether coal is the lowest cost option. So, the first driver of the economics of SMRs is the policy framework that necessitates decarbonization.

Where hydroelectricity is widely available at low cost, nuclear energy may never be competitive. Where there's no hydropower, you may look to variable renewables. But you have to back up the variable renewables either with batteries, storage or nuclear energy. In that context, nuclear energy can become an important part of the mix.

There are several ways that economics of SMRs can be improved. It remains to be proven whether this will be successful, but it is a very exciting promise. Possibilities to bring down the costs of SMRs are: factory-production (at least for big components and in some cases of even the entire SMR), modular construction, simplified designs, but also economies of series production. The first unit of anything is always the most expensive. And then you learn by doing. With the knowledge gained with the second unit, the cost of the third unit goes down and so on.

At some point you get into a very efficient manufacturing and construction rhythm, but you only achieve that if you have consecutive projects. If you build something but don't build anything more for 20 years, you lose the knowledge and learnings and your costs go up again. We are going to see that in some countries that have not built nuclear recently on time, on budget. There's a lot of relearning that has to happen. Many of those countries did build nuclear on time and on budget in the past, but it was always during a time of consecutive projects. For example, France built and connected to the grid 52 new nuclear reactors between 1975 and 1990. It was wonderful from an economic point of view that they were able to do it fast. We can relearn and we can drive costs down again. But it's really taking a programmatic approach that's going to drive down the costs.

Moreover, there's digital innovation and advanced manufacturing and all of the wonderful learnings that have happened in other industries in terms of project management and procurement strategies. We have to bring all those learnings in and repeat, repeat, repeat.

Are there any major challenges that could hinder the commercialization of SMRs?
There certainly are some challenges that need to be overcome. One of the challenges is the pipeline of talent and human resources. Many of the most experienced people in the sector are retiring. We need to train young people and we need to have a good pipeline of talent. China and Russia are both training a lot of engineers and are taking steps to ensure that they will have a talent pipeline available for their sectors. Europe and North America should take steps to increase their talent pipelines to make sure that the younger generation is getting trained.

The supply chain is another factor. We know that we can build up the supply chain again, but it will take some time in countries that used to have a supply chain and then allowed it to atrophy through lack of investment over many years. We know what needs to be done. We simply have to start building and then the supply chain will become more efficient. There's also an issue in terms of fuel availability regarding High-Assay Low-Enriched Uranium (HALEU). Many of the projects that need HALEU had previously planned to use HALEU from Russian sources. They are now looking for alternative sources. Capacities and reliability in the fuel supply chain will need to be built. Not all SMRs plan to use HALEU, so that won't impact all of them.

The world has refocused on this issue of energy security and is seeing energy supply chains as strategic assets. We are seeing some very serious conversations about how to diversify fuel supply chains and ensure secure supplies of fuel.

Regulatory readiness is also part of our dashboard. We see that regulators are getting ready for deployment in their own countries. But we see that a lot of SMR technology proponents are hoping for more harmonization or more collaboration across regulators in different countries, so that a technology that was licensed in one country can also be deployed in other countries without starting over from scratch in the regulatory process in each country. There are conversations happening here at the Nuclear Energy Agency, and there's an initiative at the International Atomic Energy Agency that aims to increase collaboration and information sharing amongst regulators. This is a difficult challenge that will affect costs and timelines. We can improve efficiency and reduce costs if regulators can collaborate. Those are the main issues that we spend a lot of time working hard on.

You are talking about the Nuclear Harmonization and Standardization Initiative (NHSI) from IAEA?

Yes, that is one part: the IAEA is convening a multilateral, global conversation among regulators under NHSI. We also see bilateral conversations, trilateral conversations and – in the EU – regional conversations. It's going to be a mix: Some things can be dealt with multilaterally, but others will be dealt with bilaterally or regionally. That will be very helpful for a number of technologies that need to be deployed in multiple countries.

When it comes to the acceptance of nuclear energy, we see differences in the opinion of women and men here in Switzerland. Our goal is to get women interested in our topic and to attract more women to the nuclear industry. What are your thoughts and how could that be done?

That's a wonderful question! There's a basic concept about building trust. To build trust with any stakeholder group requires engagement with that group, and I think that the nuclear sector has not always been very good at engagement in the past. In the meantime, there are examples where the nuclear sector is learning and doing better. The most common mistake in the past – and it's still made today sometimes – is to think of this as a communications or marketing problem. As if I just had to explain how it works and then the person I'm explaining it to would agree with me, as long as they could understand it the way I do.

It's not actually about a one-way flow of information, it's about a conversation. Different groups have different ways of thinking about the world, different priorities and different ways of absorbing information. If we really want to understand why women have different views than men on this topic, we need to talk to women and listen to them.

It's not just about pushing information and data. It's about engagement and having a conversation. We know that people who have more direct experience with the nuclear sector have a higher level of trust in the nuclear sector. As nuclear technology is very high tech, it can be intimidating. The more you know, the more familiar you are with the nuclear sector, whether it's through a job you have in the nuclear sector or through tours to nuclear power plants. The more familiarity, the less intimidating it is. We need to bring it down to a human level. We need to invite people, communities, and schools on tours, starting at very young ages in elementary schools but also in universities. We need to be present at high school community engagement days.

We can also do a better job of recruiting women into science and technology, into engineering and into the nuclear sector. Data collected by the NEA show that women are less likely to enter the nuclear sector and face barriers that keep them from advancing to leadership positions. Having more women in the nuclear sector will have huge effects on public confidence because women will not only become more comfortable themselves, but they'll be talking to their families. Nuclear energy will become something that can be talked about in the home with a level of comfort.

I talked about the fact that the nuclear sector needs human resources, we need to train more people, and we need a pipeline of talents. We can expand that pipeline of talent by recruiting women, which I expect will also have a positive impact on public confidence. This is very important and these priorities go hand in hand.

I'm very pleased to share some recent news about progress on this topic: the OECD's 38 member countries agreed in June to NEA recommendations that focus on attracting, retaining and advancing more women in the sector.

How did you get into the nuclear industry?

I'm an engineer by trade. My undergraduate and graduate studies were in engineering, but I came to the nuclear sector from the climate change perspective. I had been working on climate change mitigation from a variety of different perspectives in the private sector and in the public sector for many years. And finally, the evidence base led me to nuclear energy.

The pathways to net zero are faster, more achievable and less expensive with nuclear energy and maybe impossible without it.

I didn’t accept that at first, because I really wanted to see a path to net zero based exclusively on variable renewables. I wasn’t very familiar with nuclear energy 30 years ago when I was first starting out as an engineer, but the more I learned, the clearer it became that the world needs nuclear energy. So I undertook to learn more about it and when I did, I started to understand the role nuclear energy could play. I became very passionate about it.

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((Fotoquelle)) NEA
((Fotolegende)) Diane Cameron is Head of the Nuclear Technology Development and Economics Division at the OECD Nuclear Energy Agency (NEA).

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About Diane Cameron’s career
Diane Cameron is Head of the Nuclear Technology Development and Economics Division at the OECD Nuclear Energy Agency (NEA). In her role at the NEA, she leads an expert team of economists and scientists that supports energy policy and nuclear energy policy development among NEA Member Countries by advancing evidence-based, authoritative assessments and analyses in the areas of nuclear economics, financing, and cost reduction, as well as nuclear technology, innovation, and the fuel cycle.

From 2014 to 2021, Diane was Director of the Nuclear Energy Division with the Government of Canada. As Director, she headed up the division responsible for leading and co-ordinating Canadian public policy on nuclear energy, and served as Chair of Canada’s Small Modular Reactor (SMR) Roadmap and Action Plan. She joined the Government of Canada in 2007 to work on energy, environment, and economic policy – including international relations and negotiations. Prior to her tenure with the Government of Canada, she worked in management consulting and engineering in the private sector specializing in global value chains and international logistics.

A Canadian national, Diane holds a Master’s Degree in Technology Policy from Massachusetts Institute of Technology (MIT) where she was named Alfred Keil Fellow for

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