Readings about Small Modular [Nuclear] Reactors – SMRs.

An Essential Component of a Comprehensive Energy Program.

CT.org believes nuclear energy is one of the sustainable sources of energy that will provide safe, cheap electrical power complementing wind and solar sources, as the readings discuss.

A Concept.

The idea of a comprehensive, long-range energy program relies on considering all possibilities, relying on best available information and understanding the best application for each source of energy, i.e., using each energy source for its best application.

- A comprehensive plan includes a breadth and depth of analysis applied to every available source of energy. Energy sources, infrastructure, supply chains, technologies and adverse impacts all require examination and evaluation.
- A long-range plan extends the current understanding of resources decades into the future. There are many "knowns" that can be extrapolated decades into the future; and there are many "unknowables" that need to be gamed with scenario planning methods.

The prize is a sustainable future with ample resources to provide a reasonable standard of living to the world's population. The attributes of a sustainable future require study and geopolitical policy commitments to the mission. The governance system necessary to produce an equitable process for managing and distributing resources is, as they say, a "work in progress". However, the preparation of a Comprehensive, Long-range Energy Program is within grasp if we remember the Olde Adage – "Don't make the problem so big that it can't be solved."

Readings from 2019-2021:

- From…**Rolls Royce,** *The SMR programme.*
- From…**Office of Nuclear Energy, U.S. Department of Energy,** *Advanced Small Modular Reactors (SMRs).*
- From…**Scientific American,** *First U.S. Small Nuclear Reactor Design Is Approved.*
- From…**Wikipedia,** *Small modular reactors.*
- From…**The World Nuclear Association,** *Safety of Nuclear Power Reactors.*
- From… **Our World in Data,** *What are the safest and cleanest sources of energy?*
- From…**Medium**, *Towards a different future: Small Modular Reactors.*
- From…**Yale's Climate Connections,** *What role for small modular nuclear reactors in combating climate change?*
- From…**Management of Spent Fuel from Nuclear Power Reactors,** *France's Efficiency in the Nuclear Fuel Cycle: What Can 'Oui' Learn?*
- From…**International Atomic Energy Agency [IAEA],** Small Modular Reactors: A Challenge for Spent Fuel Management.

From…Rolls Royce.

The SMR programme.

The SMR programme is one of the ways that Rolls-Royce is meeting the need to ensure the UK continues to develop innovative ways to tackle the global threat of climate change.
With the Rolls-Royce SMR technology, we have developed a clean energy solution which can deliver cost competitive and scalable net zero power for multiple applications from grid and industrial electricity production to hydrogen and synthetic fuel manufacturing.

Proven technology

Rolls-Royce SMR is using proven nuclear technology, coupled with a unique factory-made module manufacturing and on-site assembly system, to harness decades of British engineering, design and manufacturing knowhow.
It brings together the best of UK industry to ensure a decarbonisation solution that will be available to the UK grid in the early 2030s. The potential for this to be a leading global export for the UK is unprecedented.

Factory built

Nine-tenths of an individual Rolls-Royce SMR power plant will be built or assembled in factory conditions and around 80% could be delivered by a UK supply chain – a unique offering in energy infrastructure in the UK. Much of the venture's investment is expected to be focused in the North of the UK, where there is significant existing nuclear expertise.

A clean energy solution

A single Rolls-Royce SMR power station will occupy the footprint of two football pitches and power approximately one million homes. It can support both on-grid electricity and a range of off-grid clean energy solutions, enabling the decarbonisation of industrial processes and the production of clean fuels, such as sustainable aviation fuels (SAF) and green hydrogen, to support the energy transition in the wider heat and transportation sectors.

As a major shareholder in Rolls-Royce SMR, we will continue to support its path to successful deployment. Find out more at www.rolls-royce-smr.com.

LINK: https://www.rolls-royce.com/innovation/small-modular-reactors.aspx#section-about-smrs

From…Office of Nuclear Energy
U.S. Department of Energy.

Advanced Small Modular Reactors (SMRs)

SMRs are a key part of the Department's goal to develop safe, clean, and affordable nuclear power options. The advanced SMRs currently under development in the United States represent a variety of sizes, technology options, capabilities, and deployment scenarios. These advanced reactors, envisioned to vary in size from tens of megawatts up to hundreds of megawatts, can be used for power generation, process heat, desalination, or other industrial uses. SMR designs may employ light water as a coolant or other non-light water coolants such as a gas, liquid metal, or molten salt.

Advanced SMRs offer many advantages, such as relatively small physical footprints, reduced capital investment, ability to be sited in locations not possible for larger nuclear plants, and provisions for incremental power additions. SMRs also offer distinct safeguards, security and nonproliferation advantages.

NuScale Power Reactor Building

NuScale Power Reactors.

These advanced reactors, envisioned to vary in size from tens of megawatts up to hundreds of megawatts, can be used for power generation, process heat, desalination, or other industrial uses.

The Department has long recognized the transformational value that advanced SMRs can provide to the nation's economic, energy security, and environmental outlook. Accordingly, the Department has provided substantial support to the development of light water-cooled SMRs, which are under licensing review by the Nuclear Regulatory Commission (NRC) and will likely be deployed in the late 2020s to early 2030s. The Department is also interested in the development of SMRs that use nontraditional coolants such as liquid metals, salts, and gases for the potential safety, operational, and economic benefits they offer.

Advanced SMR R&D Program.

Building on the successes of the SMR Licensing Technical Support (LTS) program, the Advanced SMR R&D program was initiated in FY2019 and supports research, development, and deployment activities to accelerate the availability of U.S.-based SMR technologies into domestic and international markets. Significant technology development and licensing risks remain in bringing advanced SMR designs to market and government support is required to achieve domestic deployment of SMRs by the late 2020s or early 2030s. Through this program, the Department has partnered with NuScale Power and Utah Associated Municipal Power Systems (UAMPS) to demonstrate a first-of-a-kind reactor technology at the Idaho National Laboratory this decade. Through these efforts, the Department will provide broad benefits to other domestic reactor developers by resolving many technical and licensing issues that are generic to SMR technologies, while promoting U.S. energy independence, energy dominance, and electricity grid resilience, and assuring that there is a future supply of clean, reliable baseload power.

U.S. Industry Opportunities for Advanced Nuclear Technology Development

The Department issued a multi-year cost-shared funding opportunity (*U.S. Industry Opportunities for Advanced Nuclear Technology Development*, DE-FOA-0001817) in 2018 to support innovative, domestic nuclear industry-driven concepts that have high potential to improve the overall economic outlook for nuclear power in the United States. This funding opportunity will enable the development of existing, new, and next-generation reactor designs, including SMR technologies.

The scope of the funding opportunity is very broad and solicits activities involved in finalizing the most mature SMR designs; developing manufacturing capabilities and techniques to improve cost and efficiency of nuclear builds; developing plant structures, systems, components, and control systems; addressing regulatory issues; and other technical needs identified by industry. The funding opportunity will provide awards sized and tailored to address a range of technical and regulatory issues impeding the progress of advanced reactor development. Read more on the FOA here. Also, see the awards that have been selected to date.

LINK: https://www.energy.gov/ne/advanced-small-modular-reactors-smrs

From…**SCIENTIFIC AMERICAN.**

First U.S. Small Nuclear Reactor Design Is Approved

Concerns about costs and safety remain, however

- By Dave Levitan on September 9, 2020

The U.S. Nuclear Regulatory Commission (NRC) has approved the design of a new kind of reactor, known as a small modular reactor (SMR). The design, from the Portland, Ore.–based company NuScale Power, is intended to speed construction, lower cost and improve safety over traditional nuclear reactors, which are typically many times larger. Supporters of SMRs have long touted them as a way to help revive the country's nuclear industry and widen the spread of low-carbon electricity. But some experts have expressed concerns over the potential expense and remaining safety issues that the industry would have to address before any such reactors are actually built.

"This is a significant milestone not only for NuScale, but also for the entire U.S. nuclear sector," said NuScale chairman and CEO John Hopkins in a press release.
The NRC's design approval and related final safety evaluation report (FSER) do not mean that the firm can begin constructing reactors. But utility companies can now apply to the NRC to build and operate NuScale's design. With almost no new nuclear construction completed in the U.S. over the past three decades, SMRs could help reinvigorate a flagging industry.

NuScale's SMR, developed with the help of almost $300 million from the U.S. Department of Energy, has a generating capacity of 50 megawatts—substantially smaller than standard nuclear reactors, which can range to well more than 1,000 megawatts (MW). A utility could combine up to 12 SMRs at a single site, producing 600 MW of electricity—enough to power a midsize city. The NRC says it expects an application for a 60-MW version of NuScale's SMR in 2022.

The nuclear industry says SMRs could be built much faster and cheaper than conventional reactors—like products that are rolled off a production line and shipped to various locations rather than custom-built at each site. A customer could also order and combine various numbers of units, making a wide range of capacity possible. According to the International Atomic Energy Agency, dozens of SMR designs are under consideration around the world, and several are in "advanced stages of construction" in Argentina, China and Russia.

Some industry proponents argue that SMRs are the best option for bringing large amounts of emissions-free technology online in the short term to help battle climate change.

Opponents have cited the unresolved issue of disposing nuclear waste, as well as the significant price tag and time involved in building any nuclear plant, compared with renewable energy sources.

NuScale believes it can avoid the dramatic cost overruns and years-long delays that have plagued construction of traditional nuclear power plants in recent decades. Diane Hughes, the company's vice president of marketing and communications, says that the company expects to sell anywhere from 674 to 1,682 reactors between 2023 and 2042. The high end of that range would represent more than 80 gigawatts of capacity, which approaches the 98 gigawatts of existing nuclear capacity in the U.S. That power is supplied by just under 100 large reactors; the existing plants provide approximately 20 percent of the country's electricity. NuScale has signed memorandums of understanding with companies and utilities in the U.S., Canada, Jordan, Romania, Ukraine and other countries. The agreements simply mean the parties will jointly explore potential deals.

NuScale's first scheduled project is with Utah Associated Municipal Power Systems (UAMPS), a state-based organization that supplies wholesale electricity to small, community-owned utilities in surrounding states. NuScale plans to deliver its first reactor to the UAMPS project at the Idaho National Laboratory by 2027; it is scheduled to be operational by 2029. Another 11 reactors will round out the 720-MW project by 2030. A portion of the generated power will be sold to the U.S. Department of Energy, with the rest purchased by UAMPS member utilities. Agreements for some of the power are in place, although a few municipalities have already walked away because of price concerns. Others have until September 30 to exit the project.

Experts have expressed skepticism about both the safety of the NuScale SMR and its potential costs. In an online press event on September 2, M. V. Ramana, a professor and nuclear expert at the University of British Columbia, discussed a report he prepared at the request of Oregon Physicians for Social Responsibility that highlighted significant issues associated with the UAMPS project.

"I am sorry to say that what lies ahead is risky and expensive," Ramana said. Just in the past five years, he noted, cost estimates from various sources for the UAMPS project have risen from approximately $3 billion to more than $6 billion. NuScale's initial goal of having operational reactors by 2016 has been extended by more than a decade, reflecting the sluggish U.S. nuclear industry in general. Costs to consumers could far exceed those associated with other emissions-free power sources such as solar and wind, Ramana added.

And despite the NRC's design approval of the new SMR, some safety features still require adjustment. "I don't think future NuScale applicants will benefit from a design certification that has safety gaps in it," says Edwin Lyman, director of nuclear power safety at the Union of Concerned Scientists. He points out that the NRC has issued its final safety report in spite of questions raised both by an expert at the agency and an external advisory board.

In a July 2020 report, NRC nuclear engineer Shanlai Lu discussed a complicated issue known as boron dilution, which could possibly cause “fuel failure and prompt criticality condition”—meaning that even if a reactor is shut down, fission reactions could restart and begin a dangerous power increase. And in another report, the NRC’s Advisory Committee on Reactor Safeguards also noted that “several potentially risk-significant items” are not yet completed, though it did still recommend that the NRC issue the FSER. The agency’s response to the latter report stated that those items will be further assessed when site-specific licensing applications—the step needed to actually begin building and operating a reactor—are submitted.

“NuScale and the U.S. Nuclear Regulatory Commission staff examined boron dilution in great detail and reached similar conclusions that the NuScale small modular reactor design is safe and meets all requirements, as is affirmed by the NRC’s recent issuance of the FSER,” NuScale’s Hughes says.
Lyman says that in general, the NRC’s design certification process should reduce uncertainty for utilities aiming to build nuclear plants because they can reference a completed safety review. But he thinks the NuScale approval undermines that advantage. Whether the gaps in safety will result in further delays to NuScale’s time line remains to be seen. The NRC will undertake another review when the company’s 60-MW design is submitted.

ABOUT THE AUTHOR(S)

Recent Articles by Dave Levitan

- Will the Earth 'Remember' the Coronavirus Pandemic?
- Ozone Pollution Grows, but It Can Be Fixed
- Radical Proposal Would Prop Up Coal Power Industry

LINK: https://www.scientificamerican.com/

From...Wikipedia.
Small modular [nuclear] reactors.

Small modular reactors (**SMR**s) are nuclear fission reactors that are smaller than conventional nuclear reactors and typically have an electrical power output of less than 300 MW_e or a thermal power output of less than 1000 MW_{th}.

They are designed to be manufactured at a plant and transported to a site to be installed. Modular reactors will reduce on-site construction and increase containment efficiency and are claimed to enhance safety. The greater safety should come via the use of passive safety features that operate without human intervention, a concept already implemented in some conventional nuclear reactor types. SMRs also reduce staffing versus conventional nuclear reactors.[1][2] SMRs are claimed to cross financial and safety barriers that inhibit the construction of conventional reactors.[2][3]

The term SMR refers to the size, capacity and modular construction only, not to the reactor type and the nuclear process which is applied. Designs range from scaled down versions of existing designs to generation IV designs. Both thermal-neutron reactors and fast-neutron reactors have been proposed, along with molten salt and gas cooled reactor models.[4]

While there are dozens of modular reactor designs and yet unfinished demonstration projects, the floating nuclear power plant Akademik Lomonosov, operating in Pevek in Russia's Far East, was as of the end of 2019 the first and only completed working prototype in the world connected to the grid. The plant has two reactors, each with a capacity of 35 MW_e. The concept was based on the design of nuclear icebreakers.[5] The construction of the world's first commercial land-based SMR started in July 2021 with the Chinese power plant Linglong One. The operation of this prototype is due to start by the end of 2026.[6]
One hindrance to commercial use may be licensing, since current regulatory regimes are adapted to conventional designs. SMRs differ in terms of staffing, security and deployment time.[7] Licensing time, cost and risks are critical success factors. US government studies that evaluated SMR-associated risks have slowed licensing.[8][9][10] One concern with SMRs is preventing nuclear proliferation.[11][12]

LINK: https://en.m.wikipedia.org/wiki/Small_modular_reactor

From... WORLD NUCLEAR ASSOCIATION

Safety of Nuclear Power Reactors.

(*Updated March 2021*)

- **From the outset, there has been a strong awareness of the potential hazard of both nuclear criticality and release of radioactive materials from generating electricity with nuclear power.**
- **As in other industries, the design and operation of nuclear power plants aims to minimise the likelihood of accidents, and avoid major human consequences when they occur.**
- **There have been two major reactor accidents in the history of civil nuclear power – Chernobyl and Fukushima Daiichi. Chernobyl involved an intense fire without provision for containment, and Fukushima Daiichi severely tested the containment, allowing some release of radioactivity.**
- **These are the only major accidents to have occurred in over 18,500 cumulative reactor-years of commercial nuclear power operation in 36 countries.**
- **The evidence over six decades shows that nuclear power is a safe means of generating electricity. The risk of accidents in nuclear power plants is low and declining. The consequences of an accident or terrorist attack are minimal compared with other commonly accepted risks. Radiological effects on people of any radioactive releases can be avoided.**

LINK: https://world-nuclear.org/information-library/safety-and-security/safety-of-plants/safety-of-nuclear-power-reactors.aspx

From... Our World in Data.

What are the safest and cleanest sources of energy?

Based on safety and carbon emissions, fossil fuels are the dirtiest and most dangerous, while nuclear and modern renewable energy sources are vastly safer and cleaner.

by Hannah Ritchie

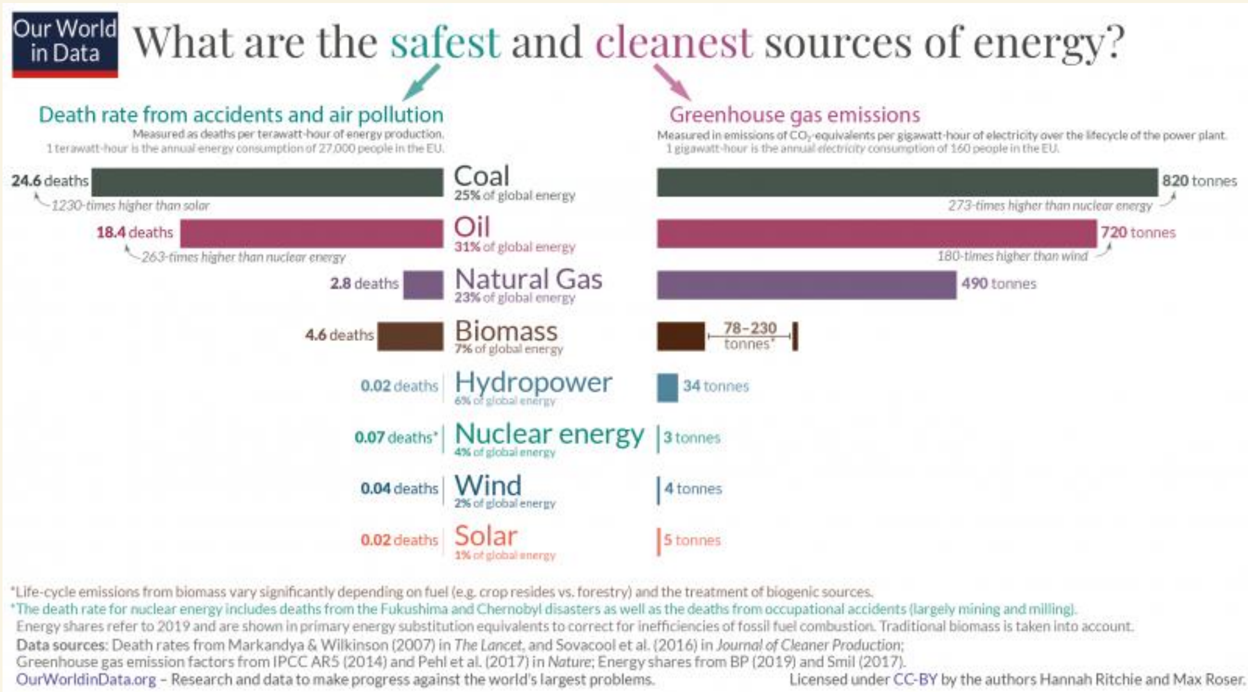
February 10, 2020

LINK: https://ourworldindata.org/safest-sources-of-energy

Summary

All energy sources have negative effects. But they differ enormously in size: as we will see, in all three aspects, fossil fuels are the dirtiest and most dangerous, while nuclear and modern renewable energy sources are vastly safer and cleaner.

From the perspective of both human health and climate change, it matters less whether we transition to nuclear power *or* renewable energy, and more that we stop relying on fossil fuels.



Two centuries ago we discovered how to use the energy from fossil fuels to make our work more productive. It was the innovation that started the Industrial Revolution. Since then, the increasing availability of cheap energy has been integral to the progress we've seen over the past few centuries. It has allowed work to become more productive, and people in industrialized countries are much richer than their ancestors, work much less, and enjoy much better living conditions than ever before. Energy access is therefore one of the fundamental driving forces of development. The United Nations rightly says that "energy is central to nearly every major challenge and opportunity the world faces today."

LINK: https://ourworldindata.org/safest-sources-of-energy

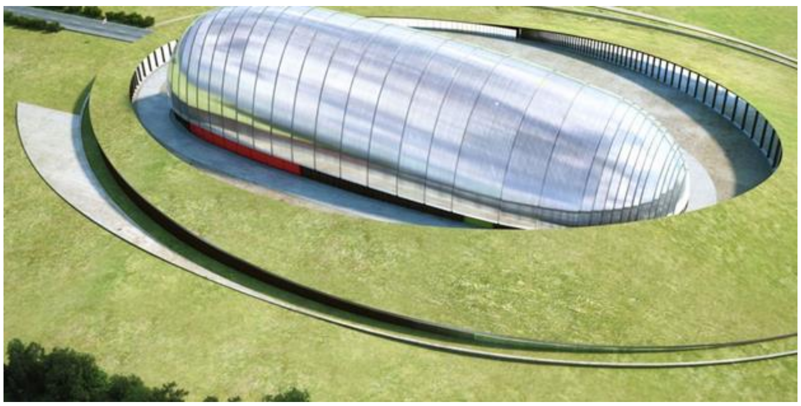
From…Medium

Towards a different future: Small Modular Reactors.

Yazgi Akin

LINK: https://medium.com/@yazgiakin/towards-a-different-future-small-modular-reactors-b652c46b4b62

Mar 30, 2020·4 min read



An impression of the Rolls Royce's compact nuclear power station.

Most of the countries try to meet the growing population's energy demand with a better use of energy sources, but some strategic changes in the energy mix and the new energy sources' applications should be remained on the agenda. As a carbon free energy source, nuclear power has a significant share of worldwide electricity generation. In terms of meeting energy demand; financial advantages in the long-term; quantity and quality of the human capital during the infrastructure phases; and positive contributions to the climate change and energy security, nuclear power is evaluated as a necessity in the energy mix of the countries.

Today, there are about 450 nuclear power reactors in operation while the construction of 53 reactors is continuing. However, nuclear power industry has decided to change its conventional methods with the help of advanced Small Modular Reactors (SMRs). The SMRs are recognized as one of the key parts of the countries which have some goals to develop safer, cleaner, and more affordable nuclear power industry. The SMRs have a variety in terms of size, technology, and deployment, and they offer several advantages to the countries and investors. Being "small" and "modular" brings some significant benefits such as less commissioning time.

When we do a basic comparison between the SMRs and large conventional reactor designs, it is clearly seen that the SMRs are modular to be constructed in a factory in more easier and faster ways. Moreover, they are designed to be ready for transportation from the factory to the nuclear power plant (NPP) site by boat, truck or railway. This offers a big opportunity to the manufacturers, transporter companies and construction site staffs. The SMRs have several design characteristics and this feature gives the advantage to easily diversify them. Today, there are around 50 SMR designs in more than 10 countries either for energy supply or for providing various industrial demands. These miniature reactors' capacity can be in a range between a couple megawatts and hundreds of megawatts in contrast to the larger conventional ones that generate more than 700 MW(e). However, the SMRs mostly produce less than 300 MW(e). This is the main reason why they are called as "small".

From the safety perspective, by using advanced fuels and developed material utilization, the risk of nuclear accident will be minimized; so the reactors will be less affected when an accident occurs with a possible radioactive contamination.

Beyond these, economics and financing of the SMRs emerge as another underlying reason for why we should consider them. Technically speaking, the NPPs' construction and operation cost is based on how many similar units are likely to be built. The fundamental reason is that when a similar unit is delivered several times, the "economy of multiples" is happened. Moreover, economy of multiples is directly related with the mass production which is the case for the SMRs. The plant size, the number of units to be built, the site location, vessel cost, turbine cost and working hours determine the cost. However, by putting the SMRs into operation, many companies will achieve economies of scale in regard to the production and maintenance at a lower cost per megawatt. In brief, an advanced SMR design will result in less components and overnight costs, and its modularity will actualize the standardization of components and design while it is setting up a significant substructure for the economies of mass production. Just 3 days before, the International Atomic Energy Agency (IAEA) has announced that a three-year Coordinated Research Project which focuses on the economics of SMRs. The project participants will do market research and competitive landscape analysis while they are doing the planning, forecasting and financial valuation.

In general, nuclear industry faces with some main nuclear-specific risk factors such as unstable public support (sometimes negative public acceptance), risks from the policy and regulatory body, the uncertain cost of decommissioning and radioactive waste. All these, naturally, put some pressure on the investors even if the nuclear energy is known as advanced and clean technology. But on the bright side, they are designed for a high level of safety in the event of malfunction. It means small and modular size and more passive safety features contribute to the countries that have smaller grids and with less experience of nuclear power like Turkey. But, this is incompatible for the large NPPs.

In 2018, the IAEA has organized an advisory group as known as Technical Working Group on Small and Medium Sized or Modular Reactors to discuss the future of SMRs. In addition to these efforts, in 2019, the US Nuclear Regulatory Commission has authorized an early site permit to Tennessee Valley Authority for the possible construction of SMRs; and Saskatchewan and New Brunswick agreed to promote the SMRs and elaborate the economic potential of Canada. It wouldn't be wrong to say that American company Nuscale became the pioneer of the SMR studies when it took first and only design certification review by a regulatory body-the NRC. Moreover, in March 2020, Rolls-Royce and EUAS International ICC have signed a Memorandum of Understanding to carry out a study to evaluate both the technical, economical and legal applicability; and also the possibility of joint production of the SMRs. This is one of the big progresses Turkey achieved.

As it is seen, SMR is a new and high-level topic, but at the same time it is an emerging technology that will play an incredible role in nuclear power industry and meeting increasing global energy demands with cleaner and safer ways. We will see what will happen in the coming years that are shaped by these reactors. Who knows maybe in the future, all cities will have their own SMRs…

LINK: https://medium.com/@yazgiakin/towards-a-different-future-small-modular-reactors-b652c46b4b62

FROM YALE'S… Climate Connections

What role for small modular nuclear reactors in combating climate change?

Time, a steep 'learning curve,' and, of course, costs pose daunting challenges for those backing small modular nuclear reactors.

Read this and other articles at: https://yaleclimateconnections.org/2021/09/what-role-for-small-nuclear-modular-reactors-in-combating-climate-change/

by **PETER SINCLAIR**, SEPTEMBER 14, 2021

From YCC…Does the potential of small modular nuclear reactor technology make it a viable approach to help solve climate change challenges not fully met by renewable energy sources such as wind and solar?

Experts interviewed in this Yale Climate Connections “This is Not Cool” original video in some cases hold out hope. But they also see timing, economic, and communications obstacles as potentially prohibitive.

The concluding remark at the end of the article reflects an acknowledgement that nuclear power has potential that still needs work: politically and fiscally…“Convincing people of that may be just as hard as actually building it,” Gates tells CNN’s Anderson Cooper. But nuclear power “may be necessary because of climate change, so we shouldn’t give up.”

Other Lab Chief Executive Officer Saul Griffith voices what he characterizes as “an extraordinary position … but hopefully not too extraordinary a postilion.” Nuclear energy, Griffith says, “has been pretty reliable and very safe and compared to other energy sources, all told, reasonably priced …. and good.” But he backtracks some: He readily acknowledges “huge political headwinds” and concerns about availability of adequate cooling water supplies, a view expressed also by water resources expert Peter Gleick. Griffith points to what many – among them proponents of nuclear energy – fear may be an Achilles heel: “It’s unclear if safe and reliable nuclear energy can compete with just where solar and wind are going …. That’s the reality.”

University of California Berkeley nuclear engineering professor Daniel Kammen says he’s hoping nuclear energy can fill some needs that renewables may not resolve. But he points to a stiff “learning curve.” In addition, Kammen says “There’s more work to be done on nuclear than on any other area for it to be a competitor.”

Less optimistic on the new nuclear technology is Arjun Makhijani of the Institute for Energy and Environmental Research. He says small modular reactors are attracting a lot of interest in part because “big ones have failed.” He is concerned by projections that the reality of small modular nuclear reactors may be close to a decade away. Too long a wait, Makhijani says: “We must have overwhelming momentum to zero carbon energy by that time.”

In the other corner, as one might say of a prize fight, is Microsoft founder Bill Gates, a bit more optimistic – or at a minimum more hopeful – than the others: “Nuclear power can be done in a way so that none of those nuclear failures of the past would recur because of just the physics” of small modular nuclear design.

Read this and other articles at: https://yaleclimateconnections.org/2021/09/what-role-for-small-nuclear-modular-reactors-in-combating-climate-change/

From…*Management of Spent Fuel from Nuclear Power Reactors*.

France's Efficiency in the Nuclear Fuel Cycle: What Can 'Oui' Learn?

The International Atomic Energy Agency [IAEA] recently published an article in their Bulletin describing the French approach to nuclear power generation for electricity. See the article by Shant Krikorian, IAEA Department of Nuclear Energy, 04 Sep 2019. *This article was featured in the June 2019 Bulletin edition on Management of Spent Fuel from Nuclear Power Reactors.*

LINK: https://www.iaea.org/newscenter/news/frances-efficiency-in-the-nuclear-fuel-cycle-what-can-oui-learn

The Orano La Hague reprocessing facility. More than 34,000 metric tons of used fuel has been treated here since the site's operation in 1976. (Photo: Orano)

With 58 nuclear power reactors producing nearly 72% of France's electricity in 2018, France is one of the countries with the highest share of nuclear power in its energy production. Along with this energy, however, France's nuclear fleet is also responsible for producing a significant amount of spent fuel and radioactive waste.

The strength of France's national spent fuel policy, in addition to tight legislation and a strong regulatory body, can be attributed to the standardization of its nuclear fleet and the policy of recycling its spent fuel, French experts have said. This leads to an efficient and secure supply and a reduced radioactive waste burden.

> *The recycling of spent fuel is a major element of the strategy of the French nuclear sector, which has more than 30 years of industrial experience. Denis Lépée, Senior Vice President and Head, Nuclear Fuel Division, EDF*

In France, all operating units are pressurized water reactors of just three standard types, all designed by Framatome: three-loop 900 MWe (34 reactors), four-loop 1300 MWe (20 reactors) and four-loop 1450 MWe (4 reactors). French nuclear power reactors, therefore, have the highest degree of standardization among countries with large nuclear fleets. This also translates into a standardized approach when dealing with the back end of the nuclear fuel cycle, which involves spent fuel and waste management, decommissioning, and environmental remediation.

To manage the nearly 1150 tonnes of spent fuel it produces every year, France, like several other countries, decided early on to close its national nuclear fuel cycle by recycling or reprocessing spent fuel. In doing so, the French nuclear industry can recover uranium and plutonium from the used fuel for reuse, thereby also reducing the volume of high-level waste.

The nuclear fuel recycling process involves converting spent plutonium, formed in nuclear power reactors as a by-product of burning uranium fuel, and uranium into a “mixed oxide” (MOX) that can be reused in nuclear power plants to produce more electricity.

“The recycling of spent fuel is a major element of the strategy of the French nuclear sector, which has more than 30 years of industrial experience,” says Denis Lépée, Senior Vice President and Head of the Nuclear Fuel Division at EDF, the French electric utility company that operates the country’s nuclear power plants.

“This makes it possible to limit the volume of materials and to minimize waste, while conditioning it in a safe way. This strategy, which is an important pillar of France’s overall nuclear electricity production, makes a significant contribution to the country’s energy independence.”

Through recycling, up to 96% of the reusable material in spent fuel can be recovered. In its 6th National Report under the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, France states that the national policy of recycling spent fuel has meant that it needs 17% less natural uranium to operate its plants than it would without recycling.

Orano, the French company in charge of nuclear fuel cycle activities that provides the fuel for and manages the waste from the country’s nuclear power plants, has stated that its strategy is to reprocess spent fuel while optimizing the energy yield of nuclear fuel. Reprocessing is carried out at the La Hague reprocessing plant and at Marcoule MOX fuel manufacturing plant.

Map of French nuclear facilities (Source: EDF, CEA)

Since the start of operations in the mid-1960s, the La Hague plant has safely processed over 23 000 tonnes of spent fuel — enough to power France's nuclear fleet for 14 years.

Used fuel assemblies from various nuclear power plants are transported to La Hague, where they are kept in a storage pool. Components from the spent fuel are then separated and recyclable materials are recovered. At the Melox facility, plutonium is remixed with depleted uranium to produce MOX fuel. This reprocessing–recycling strategy requires close and regular coordination between the various industrial actors, said John Czerwin, Senior Vice President of Marketing and Sales Support at Orano. These actors include those who manage reactors, fuel and disposal infrastructures, ensuring the coherence of the integrated industrial system.

"This confirms the benefits of this strategy: first, maintaining limited nuclear waste; second, saving uranium resources by enhancing the reuse of materials; and finally, preparing for the future in order to strengthen France's energy independence and guarantee the sustainability of nuclear energy," Czerwin adds.

The French Safety Authority (ASN) regularly assesses the safety impact of this approach.
This article was featured in the June 2019 Bulletin edition on Management of Spent Fuel from Nuclear Power Reactors.

LINK: https://www.iaea.org/newscenter/news/frances-efficiency-in-the-nuclear-fuel-cycle-what-can-oui-learn

FROM… IAEA International Atomic Energy Agency

Small Modular Reactors: A Challenge for Spent Fuel Management?

From CT.org…SMRs, like conventional nuclear plants generate hazardous waste. The IAEA article below discusses the smaller quality of fuel used by SMRs which reduces the number of times the fuel must be handled. Use of the French method of recycling, see the previous article.

From the IAEA Bulletin

08 Aug 2019

Irena Chatzis, IAEA Department of Nuclear Energy

LINK: https://www.iaea.org/newscenter/news/small-modular-reactors-a-challenge-for-spent-fuel-management

An illustration showcasing a Rolls Royce reactor module, one of the many SMR designs currently being developed, on a truck. Many such modular reactors are designed to be small enough to transport by truck or shipping container. (Rolls Royce)

Small modular reactors (SMRs) have been the talk of scientists and researchers in the nuclear industry for many years — but to what extent will their debut, expected next year, create challenges in spent fuel management? It depends, say experts, on the particular SMR design and a country's existing spent fuel management practices.

SMRs are relatively small and flexible: they have a power capacity of up to 300 MW(e) and their output can fluctuate in line with demand. This makes them particularly attractive for remote regions with less developed grids, but also for use as a complement to renewables and for non-electric applications of nuclear power. SMRs can be manufactured and then shipped and installed on site, so they are expected to be more affordable to build.

Globally, there are about 50 SMR designs and concepts at different stages of development. Three SMR plants are in advanced stages of construction or commissioning in Argentina, China and Russia, which are all scheduled to start operation between 2019 and 2022.

Countries with established nuclear power programmes have been managing their spent fuel for decades. They have gained extensive experience and have proper infrastructure in place. For these countries, management of spent fuel arising from SMRs shouldn't pose a challenge if they opt to deploy SMRs based on current technologies, said Christophe Xerri, Director of the Division of Nuclear Fuel Cycle and Waste Technology at the IAEA.

"Since this type of small modular reactor will be using the same fuel as conventional, large nuclear power plants, its spent fuel can be managed in the same way as that of large reactors," Xerri said. Even for SMRs based on new technologies, such as high temperature gas cooled reactors, which will use fuel packed in graphite prismatic blocks or graphite pebbles, countries that have nuclear power plants will already have solutions in place for storing and managing spent fuel. "They can either use existing infrastructure or adjust it for the new radioactive waste streams," Xerri said.

Countries that are new to nuclear power should carefully consider spent fuel management and establish a relevant infrastructure as they work on introducing nuclear energy. They will need to do this even if they choose conventional nuclear power plants or SMRs based on current technologies. "They will face more challenges if they opt for first-of-a-kind or less-established technology, as there will be less experienced and [with] fewer benchmarks for managing the entire fuel cycle," Xerri said. "Solutions for managing spent fuel and radioactive waste arising from SMRs will be one of the most important factors to take into account when choosing a technology, along with the security of fuel supply."

Some SMR designs have features that could reduce the tasks associated with spent fuel management. Power plants based on these designs require less frequent refuelling, every 3 to 7 years, in comparison to between 1 and 2 years for conventional plants, and some are even designed to operate for up to 30 years without refuelling. Nevertheless, even in such cases, there will be some spent fuel left, which will have to be properly managed.

To address these issues and support newcomer countries, more research and development work is required on the fuel cycle for some SMR technologies. Engineers and designers have a unique opportunity to work on solutions for the improved management of spent fuel and radioactive waste for SMRs in the early stages of development, Xerri highlighted. "This approach will help address uncertainties related to the back end of the fuel cycle, reduce costs and enhance societal acceptance of nuclear power," he said.

The IAEA is involved in several ongoing activities on SMRs and is intensifying its efforts to support Member States' research and development in this area.

This article was featured in the June 2019 Bulletin edition on [Management of Spent Fuel from Nuclear Power Reactors](#).