3 Country reports

Australia

Australia remains an active and enthusiastic member of the Generation IV International Forum (GIF). It continues to increase its engagement in the activities of the forum, via the full signing of the amendment to the project agreement, when Australia's Nuclear Science and Technology Organisation (ANSTO) became a full member of the GIF Very-High Temperature Reactor (VHTR) Materials Project. In a similar vein, Australia continues to support the move of the molten salt reactor (MSR) provisional System Steering Committee (pSSC) to a system arrangement through the development of its Materials and Components Project and the Advanced Manufacturing and Materials Engineering Task Force (AMME TF). Following the successful February workshop at the Nuclear Energy Agency (NEA), the Policy Group supports changes to the time frame and scope of this task force.

There has been significant progress in the establishment of Australia's National Radioactive Waste Management Facility. In September, a Federal Parliamentary Committee concluded its inquiry into proposed legislative amendments, which are an essential precursor to the establishment of such a facility, and recommended that the amended legislation pass without changes. The Federal Government Parliamentary Inquiry had three main recommendations:

- that the Australian government consider the prospect of nuclear energy technology as part of its future energy mix;
- that the Australian government undertake a body of work to progress the understanding of nuclear energy technology;
- that the Australian government allow partial and conditional consideration of nuclear energy technology by maintaining its moratorium on nuclear energy in relation to Generation I, Generation II and Generation III nuclear technology; but by lifting its moratorium on nuclear energy in relation to Generation III+ and Generation IV nuclear technology, subject to the results of a technology assessment and a commitment to community consent as a condition of approval.

An official government response to the recommendations of this parliamentary inquiry is expected to be delivered in the near future.

The New South Wales government's inquiry into the repeal of a state-wide ban on uranium mining and nuclear power was released in September. That government response supported the repeal of the uranium mining prohibition but stopped short of endorsing a move towards nuclear power – although it did also express a continuing interest in overseas developments in nuclear technologies, such as those advanced through this forum.

The Victorian government's Legislative Council's inquiry to examine the merits in lifting the state's ban on nuclear power is currently ongoing.

In 2020, the Australian government published the "Technology Investment Roadmap Discussion Paper", which states that new nuclear technologies have potential but require R&D and identified deployment pathways. Its more recently published "First Low Emissions Technology Statement 2020" has identified small modular reactors as a prospective low-emission technology that could play an important role over the long term.

Canada

COVID-19 pandemic response: Canada's nuclear energy sector continues to play an important role in responding to the COVID-19 pandemic. A combination of national and sub-national government measures and private sector action has ensured that Canada's nuclear power fleet has continued to operate at full capacity despite the pandemic. It is important to note that 40% of medical devices around the world are sterilized with Cobalt-60, over 50% of which is supplied by Canada. Measures have been taken to ensure strong and resilient nuclear supply chains in Canada, which include hundreds of small- and medium-sized enterprises. Moreover, Canada's nuclear sector has stepped forward to help in the pandemic response, for example by re-tooling manufacturing and making donations of critical personal protective equipment, masks and face shields. Canadian Nuclear Laboratories (CNL) is contributing its world-class facilities and expertise to Canada's response, including in an effort to develop an easy-to-produce ventilator using easily accessible parts. The CNL is also producing face shields using 3D printing technology.

Nuclear Power in Canada: A total of 19 CANDU nuclear power reactors currently operate in Canada, generating 13.7 gigawatts electric (GWe) of power in two provincial jurisdictions. Of these 19 reactors, 18 supply 60% of the Province of Ontario's electricity, and one reactor supplies 36% of the Province of New Brunswick's electricity demand. Nuclear energy displaces over 50 million metric tonnes of carbon emissions a year across

Canada, and Canadian exports of uranium displace global emissions by up to 551 million tonnes of carbon dioxide per year.

Nuclear energy remains an important contributor to Canada's electricity mix. While the government of Canada has important responsibilities with respect to nuclear energy, investment decisions on the energy supply mix and generation capacity, including the construction of new nuclear power reactors and the refurbishment of existing reactors, fall under provincial jurisdiction. In a speech given by the Honourable Seamus O'Regan, Canada's Minister of Natural Resources,[1] he delivered a clear message that nuclear power is a priority for Canada and a necessary source of clean energy to meet Canada's climate change objectives.

In October 2020, Canada's Federal Minister of Innovation, Science and Industry announced that the government of Canada would invest CAD 20 million in Canada-based company, Terrestrial Energy, to accelerate development of the company's integral MSR, representing the first such investment support for an SMR in Canada. Also in October 2020, Ontario Power Generation (OPG) announced that it is advancing engineering and design work with the SMR developers, GE-Hitachi, Terrestrial Energy and X-energy. X-energy is developing the Xe-100 SMR (80 megawatt-electric [MWe] high-temperature reactor), and has initiated a vendor design review (VDR) for the reactor with the Canadian Nuclear Safety Commission (CNSC). Terrestrial Energy's 192 MWe integral MSR has completed the first phase of the CNSC's review process. GE-Hitachi also entered the CNSC's VDR for its BWRX-300 water-cooled SMR. GE-Hitachi announced that it had signed memoranda of understanding with the Canadian companies, Aecon Nuclear, BWXT Canada, Hatch, Black & Veatch and Overland Contracting to establish a Canadian supply chain covering cooperation in construction, engineering, modularization and manufacturing of safety-related components, and to support potential BWRX-300 construction, as well as provide future services and components.

Ontario Power utility, Bruce Power, and Westinghouse Electric Company announced an agreement to pursue applications of Westinghouse's eVinci micro-reactor program within Canada. Work between Bruce and Westinghouse will focus on furthering the public policy and regulatory framework; assessing the economic, social and environmental contribution of the eVinci technology compared to alternatives such as diesel or other fossil fuels; identifying potential industrial applications; and accelerating the roadmap for Canada to host a globally recognized demonstration.

Global First Power, Ultra Safe Nuclear Corporation (USNC) and OPG announced the formation of a joint venture, the Global First Power Limited Partnership, which will build, own and operate the proposed micro modular reactor project at the Chalk River Laboratories site. The joint venture is owned equally by OPG and USNC-Power, the Canadian subsidiary of USNC.

Small modular reactor activities: Since the release of *A Call to Action: A Canadian Roadmap for Small Modular Reactors*, the federal government and other essential, enabling partners have moved forward both individually and collaboratively on priority areas, such as advancing SMR R&D and exploring business partnerships for potential deployment in the late 2020s. In early 2020, the Minister of Natural Resources, Seamus O'Regan, announced that, with partners from across the country, Canada would launch its SMR Action Plan to position Canada as a world leader in an emerging global SMR market that is expected to exceed CAD 150-300 billion per year by 2040. The SMR Action Plan will report on actions taken by governments and partners, and chart a path forward for the next wave of nuclear innovation in Canada. It brings together more than 100 organizations to outline the progress and ongoing efforts across Canada to be the world leader on this emerging clean energy technology. It will be launched by Minister O'Regan at Canada's 2nd International SMR Conference on 18 November 2020.

The CNSC continues to work towards ensuring its readiness for SMRs in Canada. As noted above, the CNSC undertakes an optional preliminary step before the licensing process called a vendor design review (VDR). The VDR is completed at a vendor's request and expense to assess their understanding of Canada's regulatory requirements and the acceptability of a proposed design. There are currently 12 SMR proposals in the VDR process – ten VDR service agreements in force between vendors and the CNSC and two under development. Vendors include ARC Nuclear, GE-Hitachi Nuclear Energy, LeadCold Nuclear, Moltex Energy, NuScale, SMR (Holtec), StarCore Nuclear, Terrestrial Energy, U-Battery Canada, Ultra Safe, Westinghouse and X-Energy.

Global First Power is seeking CNSC approval for a license to prepare a site for a micro modular reactor at Chalk River Laboratories in Renfrew County, Ontario. In June 2020, the CNSC held its first hearing on this application, which focused on the scope of the environmental assessment. After taking into consideration public comments, the CNSC has outlined the factors to be considered in the environmental assessment project.

Over the past six months, the CNL, Canada's premier nuclear science and technology organization, entered into several collaboration agreements with SMR developers under CNL's Canadian Nuclear Research Initiative. Earlier in 2020, CNL and Moltex Energy partnered on SMR fuel research to explore innovative fuel processing and development. Then,

1. For a copy of the speech, see www.nrcan.gc.ca/keynote-address-minister-seamus-oregan/22882.

in September 2020, the CNL announced that it would work with Kairos Power and Terrestrial Energy on two distinct SMR research projects to enhance tritium safety, storage and management, and to study molten salt fuel behavior, respectively.

Internationally, in March 2020, Natural Resources Canada (NRCan) led a Canadian delegation to London, United Kingdom for a week-long Canada-UK Nuclear Energy Dialogue. The program was anchored around the Canada-UK Nuclear Energy Summit and the UK Department of International Trade's Civil Nuclear Showcase. The Canada-UK Nuclear Co-operation Action Plan, launched in November 2019, was signed in 2020. It focuses on enhancing collaboration on SMRs, with identified key areas of partnership including waste minimization, SMR fuel supply chain, regulatory collaboration, advanced manufacturing and financing. In addition, a memorandum of understanding between the Canadian Nuclear Association and the UK Nuclear Industry Association was signed, focusing on nuclear collaboration.

Other nuclear advancements: In May 2020, Alternative Radioisotope Technologies for Medical Science (ARTMS) Inc., a leader in isotope production technology, announced USD 19 million financing from a consortium led by Deerfield Management Company and Quark Ventures. This funding builds on a USD 3 million seed investment made in 2017 by Quark Ventures and GF Securities. ARTMS is a spin-off of TRIUMF, which is a Canadian particle accelerator centre that received government funding to develop cyclotron methods so as to produce molybdenum-99.

With the current interest in SMRs in Canada, NRCan has conveyed its interest in signing the MSR System Arrangement and is considering re-joining the VHTR system. For better alignment of project responsibilities, NRCan reassigned the supercritical-water-cooled reactor (SCWR) project arrangements to performing organizations, namely Atomic Energy of Canada and Canadian Nuclear Laboratories.

People's Republic of China

Nuclear energy policy: On 10 April 2020, the "Energy Law of the People's Republic of China (Draft)" was announced by the National Energy Administration for public comment. In terms of nuclear power, it is clearly stated in the Energy Law Draft that the country adheres to the following principles: safe and efficient development of nuclear power with safety as the priority, reservation of potential nuclear power sites for future new build, promoting R&D and the innovation of advanced nuclear power technology and equipment, as well as proven nuclear power technology to achieve safer and more economic performance, advancing nuclear power technology and industrial development, and accelerating the training of nuclear power professionals.

In order to standardize the disclosure of nuclear safety information and protect the rights of citizens, legal persons and other organizations to know participate express and supervise, in accordance with the relevant provisions stipulated by the Nuclear Safety Law of China the Ministry of Ecology and Environment has formulated "The Measures for Disclosure of Nuclear Safety Information", which is effective from 1 October 2020.

Nuclear energy development: As of the end of September 2020, there were 48 nuclear power units in operation with a total installed capacity of 49.87 GW, 13 nuclear power units under construction with a total installed capacity of 14.93 GW. In September 2020, Hainan Changjiang phase II and Zhejiang San'ao phase I were approved by the State Council.

Fuqing unit 5, the first reactor of the HPR1000 technology in the world, started to load fuel on 4 September 2020 and reached criticality on 21 October.

China's first commercial nuclear heating project entered into service at the Haiyang nuclear power plant in Shandong province on 15 November 2019. The system will initially heat 700 000 square metres of housing during the winter, including the dormitory for the staff of the nuclear power plant and some residents in Haiyang city. The Haiyang Nuclear Energy Heating Project is expected to eventually provide heating to the entire city of Haiyang by 2021. In addition, the Haiyang nuclear power plant had reached a strategic cooperation framework agreement with the Yantai city government regarding desalination and clean energy use of nuclear power.

Radiation technology has played an important role in the sterilization of personal protective equipment, which has been in high demand during the COVID-19 pandemic. The irradiation sterilization technology was used to replace the traditional ethylene oxide sterilization method, and efficiently shortened the sterilization time of individual medical protective clothing from seven to ten days to about one day. In addition, nuclear technology will continue to play a greater role in the treatment of medical waste in the later stages, making its own contribution to pandemic prevention and control.

Gen-IV nuclear energy system activities: sodium-cooled fast reactor (SFR) – the China experimental fast reactor (CEFR) restarted and reached full power operation after finishing the related operational commissioning tests; the construction and installation of the CFR-600 are proceeding as planned.

VHTR – the full commissioning of the High-temperature gas-cooled reactor power module (HTR-PM) demonstration project started on 25 July 2020, with the cold functional test starting on 6 October and successfully ending on 19 October. It will be connected to the grid in 2021 and reach full power operation in 2022. The R&D in the VHTR fuel and fuel cycle (FFC) and MATerial Project Management Board (MAT PMB) is going as planned, joining the Hydrogen Production-Project Management Board (HP-PMB) is still in progress.

SCWR – the pre-conceptual design of the CSR1000 and the small SCWR, called the CSR-150, is ongoing. In terms of cooperation on the SCWR, some new international benchmark exercises have been discussed among the members on thermal-hydraulic behavior in complex structures. Two research projects funded by the Ministry of Science and Technology (MOST) have been started by Chinese universities and institutes the 2020 year. China joined the Joint European Canadian Chinese Development of Small Modular Reactor Technology (ECC-SMART) project led by Europe, and attended the kick-off teleconference in September 2020.

Lead-cooled fast reactor (LFR) – on 6 October 2020, The Institute of Nuclear Energy Safety Technology (INEST) attended the 27th LFR pSSC teleconference to discuss and promote the finalization of the LFR proliferation resistance and physical protection (PR&PP) system safety assessment (SSA) and other technical documents. Two small LFR projects have been funded by MOST, which aim to explore innovative, small LFR concepts to provide a flexible energy supply.

Euratom

Policy: On 1 December 2019, Ms Ursula von der Leyenn, the new President of the European Commission (EC), took office with a new program focused on six main priorities: 1) a European Green Deal; 2) an economy that works for people; 3) a Europe fit for the digital age; 4) a protection of the European way of life; 5) a stronger Europe in the world; and 6) a new push for European democracy.

On 11 of December 2019, The European Commission issued a communication that sets out the European Green Deal for the European Union (EU) and its citizens, towards a European climate-neutral economy by 2050, aimed at mobilizing at least EUR 1 trillion of public/private investment over the course of ten years to achieve net zero greenhouse gas emissions for EU countries as a whole. Several initiatives have been launched by the European Commission in the frame of the implementation of the EU Green Deal towards a European climate-neutral economy by 2050. The most important initiative is the European Commission's proposal to cut greenhouse gas emissions by at least 55% below 1990 levels by 2030. This is a substantial increase compared to the existing target, upwards from the previous target by at least 40%. It is in line with the Paris Agreement objective to keep the global temperature increase to well below 2°C, and pursue efforts to keep it to 1.5°C.

In the context of implementing the green deal, the EU Council and Parliament also adopted a regulation (EU-2020/852) in June that establishes the general framework for determining whether an economic activity qualifies as environmentally sustainable for the purposes of establishing the degree to which an investment may be environmentally sustainable (the so-called "Taxonomy"). The regulation empowers the commission to establish, for each of the environmental objectives laid down in that regulation, the technical screening criteria for determining the conditions under which specific economic activities qualify as contributing substantially to that objective and ensuring that those economic activities cause no significant harm to any of the other environmental objectives.

The group that supports the EC in the technical screening for economic activities in relation to their environmental sustainability, called the Technical Expert Group on Sustainable Finance (TEG), has recommended in its report of 10 March 2020 that in-depth technical work be undertaken on nuclear life-cycle technologies and on existing and potential environmental impacts (the so-called "Do No Significantly Harm" [DNSH] criteria). The TEG has recommended that the EC attribute the technical work to an independent group with real technical expertise in the field. The work has thus been attributed to the EC Joint Research Centre (JRC). The JRC will produce a report that will be reviewed by two independent expert groups.

Budget: The EU has been very busy with the adoption of the Multiannual Financial Framework 2021-2027 in the context of COVID-19. EU leaders agreed on an overall budget of EUR 1 824.3 billion, EUR 1 074.3 billion for the multiannual financial framework and an additional EUR 750 billion (known as the Next Generation EU) to help the EU recover from the COVID-19 pandemic.

They agreed on a proposed budget in current prices for "The Horizon Europe" framework program for research and innovation (2021-2027), with a budget of about EUR 84 billion, complemented by EUR 1.98 billion for Euratom research and training and about EUR 5.6 billion for the ITER project. The text of the Euratom research and training program, as well as the ITER text, are being finalized in the EU Council with member states.

The objectives of the Framework program for Euratom research and training remain the same as those for the precedent framework program: to improve and support nuclear safety, security, safeguards, radiological protection, safe spent fuel and radioactive waste management and decommissioning, including the safe and secure use of nuclear power; maintain and further develop expertise and competence in the nuclear field, develop fusion energy, and support the policy of the EU and its member states to continuously improve nuclear safety, safeguards and security. The EU had added a new objective on the safe and secure use of non-power applications of ionizing radiation. The program will also strengthen activities on training, education and open access to nuclear facilities, including the JRC nuclear facilities.

Research activities: Under the current Euratom Research and Training Programme, the selected projects for 2019-2020 amounted to a budget of EUR 140 million. All winning projects have started.

Five projects on advanced system proposals will be co-funded on topics such as: fuel cycle Pu management, safety of Gas Fast Reactors, partitioning and transmutation, safety of SCWR SMR, and the high-performance computing safety evaluation of SMRs. Research Infrastructures Material Testing Reactors include two actions on the Jules Horowitz Reactor (JHR) that will allow for innovative fuel and material testing:

- access rights for Euratom researchers (EUR 6 million, leading today to about EUR 40 million from Euratom in total, about 6% JHR irradiation time);
- the Jules Horowitz operation plan 2040, and optimized use of research reactors (EUR 2.2 million, and EUR 2.6 million in total) to plan Euratom specific irradiations.

The Supplementary Programme for the high-flux reactor (HFR), supported by about EUR 30 million from the governments of the Netherlands and France, has been adopted. The Sustainable Nuclear Energy Technology Platform (SNETP), composed of the Nuclear Generation II & III Alliance (NUGENIA) pillars, the European Sustainable Nuclear Industrial Initiative (ESNII) and the Nuclear Cogeneration Industrial Initiative (NC2I), have evolved to form an International non-profit legal association last October 2019. It is now in the process of updating its Strategic Research and Innovation Agenda.

The JRC has consolidated its activity in the domain of Gen-IV through three major projects. The Safety of Advanced Nuclear Systems and Innovative Fuel cycles (SEAT-GEN-IV), System Analysis of Emerging Technologies (SAITEC) and Waste from Innovative fuel (WAIF). The topics covered are: reactor safety of Gen-IV reactor designs, including modular reactors (severe accident modelling), materials R&D program, safety of fuel: SFR, LFR, VHTR, MSR systems, conditioning matrices for waste from innovative fuels, and safeguards. Activities in support of the GIF-Proliferation Resistance and Physical Protection Working Group (PRPPWG) are carried out in the Methods, data analysis and knowledge management for Nuclear Non Proliferation, Safeguards & Security (MEDAKNOW) project. The JRC has signed the GIF Project Arrangement on Fuel and Core Materials for the International Research and Development of the Gas-Cooled Fast Reactor Nuclear Energy System and is now finalizing the process for the new MSR system arrangement.

France

COVID-19 crisis and recovery plan: French nuclear energy generation has proven resilient through the COVID-19 crisis. Projected production was reduced by nearly 20% in the April-June period (from 375 to 390 TWh, down to 300 TWh), due to revised maintenance-shutdown planning. However, EDF has raised its forecast upwards for 2020 to 325-335 TWh.

In September, the French government presented a recovery plan called “France relance”, intended to support the national economy, which has been deeply impacted by the health crisis. This plan identifies three major domains (i.e. ecology, competitiveness and cohesion). Alongside a major program on hydrogen, it includes a significant state budget dedicated to the nuclear industry, to maintain essential nuclear skills and to enhance industrial modernization. More precisely, this budget addresses three challenges: 1) training and skills development; 2) supply chain robustness; and 3) R&D and SMRs (conceptual design of the NUWARD™ product).

Nuclear fleet: Fessenheim power plant unit 1 was definitively shut down in February, which should be followed by unit 2 in June, resulting of the industry’s strategic contract, signed by the government and the nuclear industry in January 2019.

CEA Energy Division: A reorganization took place at the French Alternative Energies and Atomic Energy Commission (CEA) in February, that saw in particular the evolution of the Nuclear Energy Division into a new Energy Division, with the ambition of better addressing the comprehensive energy system.

Status of the French Fast Reactor program: The CEA is implementing its new fast neutron reactor (FNR)-related activities. It is focused on a strong R&D program dedicated to further progress on fast-reactor technology and the associated fuel cycle. The priority is still being given to the sodium-cooled fast-reactor technology, which is considered the most mature. The program also includes other FNR-concept assessments.

The overall objective is to increase the maturity of the SFR technology. The five-year work plan focuses on high-stake topics: 1) basic physics, modelling and simulation, especially the physics of severe accidents, sodium chemistry and sodium risks assessments; 2) increase of fuel performance, structural materials in service behavior and codification, qualification and the 60-year lifetime justification; and 3) technological developments of some components, especially monitoring and inspection techniques.

Another pillar is sketch studies, focusing on power threshold effects from a safety and economics point of view (assessment of SFR breakthrough designs with intrinsic safety). Other concepts of FRs (e.g. fast spectrum molten salt reactors) will be studied in order to identify key feasibility issues, as well as their specific features and potential performance.

In this newly oriented endeavour, partnerships and collaboration remain essential for further skill and capability development. The CEA will play a role in the GIF and push bilateral collaboration among leaders of the SFR development. The program benefits from the large feedback of the Advanced Sodium Technological Reactor for Industrial Demonstration (ASTRID) program,

which is significant from different perspectives. New design solutions for the prevention and mitigation of severe accidents have been proposed. Innovations have been introduced in the design, for example concerning the core, reactor components, power conversion system, fabrication processes and in many other areas. Digital modelling has been improved in several fields, based on the phenomenological approach. Methodologies for verification, validation and uncertainty quantification (VVUQ) and safety demonstration have been formalized. New experimental platforms have been put into operation to run model validation and "proof of concept" tests. A large collaboration with industrial partners has been implemented, as well as methodologies for simultaneous engineering, interface data consistency and product life-cycle management.

SMRs: The French NUWARDTM initiative is based on the pressurized water reactor (PWR) technology. It is being designed to meet the growing needs of a low-carbon, safe and competitive electricity market worldwide, in the 300-400 MWe power range. NUWARDTM is a concept that combines proven solutions, innovative licensing and manufacturing, innovative solutions to gain competitiveness: simplicity and compactness of an integrated design, flexibility in the construction and operation phase, an innovative approach to compliant safety to the best world standards. The ambition is to offer the world market a competitive product by 2030. Being open to international cooperation in the field of SMRs can thus be a key milestone on the path towards regulatory harmonization, and the standardization and optimization of design.

Japan

Current energy and nuclear policy: Japan has started reviewing its Basic Energy Plan. On 13 October, an advisory committee for natural resources and energy to the Ministry of Economy, Trade and Industry (METI) kicked off discussions on how Japan can reach this goal. As a result, first, they will identify issues that need to be solved in order to achieve the concept of the Basic Energy Plan. It is being called 3E+S, which represents energy security, economic efficiency, the environment and safety. Second, they will identify issues that need to be solved to achieve a zero-carbon society at the earliest possible time in the latter half of this century. Finally, they will verify the progress of the energy mix targeted for the year 2030 and how efforts towards each energy source have progressed. Then, further efforts or approaches will be discussed.

In the meantime, Japan has continued to reform its electricity market: fossil fuel and non-fossil fuel electricity were treated uniformly in the past, but Japan opened a dedicated non-fossil fuel electricity market in May 2018 — the values of non-fossil fuel electricity have thus emerged. This suggests a growing role for nuclear energy in energy conversion and decarbonization.

Development of advanced reactors: Regarding R&D of advanced reactors, a governmental initiative called Nuclear Energy Innovation Promotion is being carried out to promote nuclear technology innovation in the private sector. A new initiative entitled Nuclear Energy x Innovation Promotion (NEXIP) aims to boost this development. It adopted 28 inventive proposals from the private sector in September 2019. For advanced non-light water reactors, the government is looking at proposals for high-temperature gas-cooled reactors (HTGRs), SFRs, and MSRs.

The Energy Plan has demonstrated that Japan is further advancing the technologies of HTGRs and fast reactors in cooperation with international partners. To achieve this, the Japan Atomic Energy Agency (JAEA) plays an active role in developing safer fast reactors and HTGRs, and in establishing global standards in the safety and the design of high-temperature structures.

Current status of Fukushima Daiichi Nuclear Power Station: All of the reactors at the power station have been in a cold shutdown state since the accident in 2011. Based on the "Mid-and-Long-Term Roadmap" for the station, which was updated in December 2019, Tokyo Electric Power Company Holdings (TEPCO) is working towards decommissioning. TEPCO is removing fuel pins from the spent-fuel pool in unit 3, and expects to complete this work in March 2021. TEPCO will provide examinations in relation to fuel debris removal from unit 2, which would start in 2021, and the handling of water from the Multi-Nuclide Removal Facility (ALPS), produced through purifying contaminated water.

Safety review of nuclear power stations and nuclear fuel cycle facilities by the Nuclear Regulation Authority (NRA), and regulatory inspections under the state of emergency over the COVID-19 pandemic: To date, the NRA has given its green light to 16 units at 9 sites, among 27 units at 16 sites, that have applied for the new conformity assessment. As of October 2020, three units are in operation. On 13 May 2020, the NRA approved the review report that certifies the compatibility of the Rokkasho reprocessing plant of Japan Nuclear Fuel Limited (JNFL) with the conformity assessment. The JNFL will address public comments, reinforce the construction, and explain the plant to the community before they begin operation.

Current situation of JAEA facilities: the JAEA is preparing to restart the high-temperature engineering test reactor (HTTR) and the experimental fast reactor, Joyo. The NRA completed the assessment of HTTR conformance to Japan's new regulatory requirements, and issued an amendment to the reactor installation permit in June. The JAEA will reinforce the HTTR against internal and external events, aiming at restarting it as early as possible. Once restarted, the JAEA will carry out a loss of forced coolant (LOFC) experiment in international cooperation under the framework of the NEA.

The JAEA submitted the amendment to the reactor installation permit for Joyo to the NRA in October 2018. The NRA is currently reviewing the amendment in terms of beyond-design-basis analyses (BDBA) and internal fires, as well as other factors.

Regarding Monju, which will be undergoing decommissioning, a new experimental research reactor with an output capacity of about 10 000 kilowatts (kW) will be constructed at the Monju site. Designing of the new reactor will start in detail during Japanese fiscal year 2022.

The JAEA will restart the Japan research reactor number 3 (JRR-3) in 2021. The NRA issued an amendment to the reactor installation permit in 2018. Since then, the JAEA has been implementing work for seismic resistance and reinforcement of the reactor. In August 2020, the JAEA announced that the operation schedule for three years from the restart. The JAEA is striving to ensure the restart.

The JAEA is also working on the development of an evaluation platform called the Advanced Reactor Knowledge- and AI-based Design Integration Approach (ARKADIA), which will cover the entire plant lifecycle, and on innovative technology to further enhance safety and economic efficiency. In addition, it is supporting the private sector to develop innovative technologies. Using ARKADIA platform, in March 2020, the JAEA coupled the analysis codes of the core, heat, and (deformed) structure of an SFR and successfully developed an analysis method for transient characteristics in an SFR core.

Korea

Nuclear power in Korea: Twenty-four nuclear power plants (20 PWRs and 4 CANDU reactors) are in operation as of July 2020, providing 13 721 GWh of electricity, which corresponds to 29.3% of total electricity production in Korea, a 2% increase from last February. The installed nuclear capacity of 24 NPPs accounts for 18.2% (23 250 MWe) of total capacity. Four PWRs (i.e. Shin-Kori units 5 and 6; and Shin-Hanul units 1 and 2) are under construction. Construction is expected to be completed for Shin-Hanul units 1 and 2 by August 2021.

Nuclear energy policy and R&D in Korea: The goal of the national energy policy in Kora has changed to increasing the portion of power generation from renewable energy sources to 20% by 2030, as well as to gradually reducing the share of nuclear and coal-based electricity production. On the other hand, the government will support both an export promotion of nuclear power plants, and R&D activities relevant to enhancing nuclear safety and nuclear dismantling and disposal technology.

The national policy for spent nuclear fuel (SNF) management in Korea remains undecided. An SNF management policy re-examination commission was launched in May 2019 to review the previous national policy. The commission regularly opens online meetings and has begun to collect public opinions about NPPs. Construction of the MACSTOR SNF dry-storage facility was recently decided in August 2020.

Sodium-cooled fast reactor (SFR): As for SFR development, SFR R&D activities until the end of 2020 focused mainly on obtaining a technical database to support a back-end fuel cycle design option. At present, there is no engineering design development of SFRs. For the purpose of certifying key SFR technologies, ten topical reports (TRs) dealing with key design technologies and safety-related issues have been submitted to the Nuclear Safety and Security Commission (NSSC) and are now under review. For license support and the integral safety validation of the prototype Generation IV sodium-cooled fast reactor (PGSFR), an integral sodium thermal-hydraulic test facility, STELLA-2, has been constructed and the demonstration of the integral effects will be completed. SFR development is focusing on the new nuclear market. One of the main targets is the SMR market. A new SFR project will deal with key technology development on advanced types of SMRs.

Very-high-temperature gas-cooled reactor (VHTR): The Korean government announced its national plan for a hydrogen economy, which centred on the two axes of hydrogen-powered vehicles and hydrogen fuel cells in early 2019. Hydrogen demand in 2040 is expected to reach 5.26 million tons per year. Nuclear hydrogen production using VHTRs was evaluated as one of cleanest hydrogen production technologies.

Key technology developments for VHTR performance improvement were completed in 2019. These developments include design and analysis codes, thermo-fluid experiments, tri-structural isotropic (TRISO) fuel, high-temperature materials database, and high-temperature heat applications. A subsequent project, called "Very-High-Temperature System Key Technology Development", was launched in April 2020 to develop the performance evaluation technologies of design and analysis codes, the performance verification technologies of high-temperature materials, and the coupled analysis technologies between very-high-temperature systems and a high-temperature steam electrolysis (HTSE) hydrogen production system.

Russian Federation

This year of 2020 is a jubilee year for the Russian nuclear sector. The 20th day of August in 1945 became the starting point of the history of the national nuclear industry, which for more than 75 years has provided global nuclear arms balance, fed cities with energy, and fostered the development of science and technology far beyond traditional "nuclear" objectives.

By 1 September 2020, nuclear electricity generated by Russian nuclear power plants (NPPs) made up 136.5 billion kWh, and aimed to reach 214 billion kWh by the end 2020. This will bring growth up by 2.4% compared to 2019, in spite of the global COVID-19 pandemic. The load factor by the beginning of September was 77.9%, (the 2019 figure was 78.4%).

In total, 38 power units are currently in industrial operation at 11 NPPs in Russia. The total installed capacity of all Russian NPPs is 30.3 GW. Total capacity of nuclear power units in operation is 26.3 GW. The share of nuclear energy in total energy generation in Russia is 19%, with European and north-western parts of Russia having 30% and 37% of nuclear generation, respectively.

In August 2020, a physical start-up of a new nuclear reactor took place at the Leningradskaya NPP-2. Its commissioning is planned for the beginning of 2021. This will be the last nuclear power unit of the first series of VVER-1200 power units of the Russian "AES-2006" design developed in the 21st century. NPPs with VVER-1200 power units are today the main product exported by the State Atomic Energy Corporation, Rosatom.

Test operations of the floating nuclear thermal and electric power plant (FNPP) "Akademik Lomonosov" are underway, and are showing stable and accident-free operation at design parameters. More than 80 million kWh of electricity have been generated by 1 September 2020. The FNPP is recognized as a base element of the Northern Sea route. Rosatom also commenced development of the second generation of FNPP – an optimized floating nuclear power plant (OFNPP), which is planned to be smaller than its predecessor and equipped with two RITM-200M type nuclear reactors of 50 MW each.

Within the Northern Sea route development program, the series-leading ice-breaker, "Arctica", came out of the shipyard of the Joint Stock company, "Baltiyskiy Zavod" (Saint-Petersburg), in September 2020, and will pass the acceptance "ice-breaking" tests. After passing these tests, Arctica will go to Murmansk in the context of a transfer to Rosatom's Atomflot company. Two other ships, the "Sibir" and "Ural" icebreakers, are scheduled to be commissioned in 2021 and 2022, ensuring that tank ships are carrying hydrocarbons from Yamal, Gydan peninsulas to Asia-Pacific region markets year-round.

Russia is today a world leader in new nuclear construction abroad. Rosatom also ranks first in the number of simultaneously implemented projects for the construction of nuclear power units (3 in Russia and 36 abroad). The current Rosatom portfolio includes: Hanhikivi-1 (Finland), Akkuyu NPP (Turkey), Kudankulam (India), Paks-2 (Hungary), Ruppur NPP (Bangladesh), Cuidapu (China), Tianwan (China), El Dabaa NPP (Egypt), Belorusskaya NPP (Belorussia) and Busher (Iran). In August 2020, nuclear fuel loading started at the first power unit of Belorusskaya NPP in Ostrovets (Grodno region). Commissioning of the first unit is scheduled for the beginning of 2021, and the second unit in 2022. With both power units in operation, Belorussia will have an additional 2 400 MW of generating capacity.

Russian NPP designs are based on Gen-III+ reactors, equipped with both passive and active safety systems, and in full conformity with the modern international requirements and recommendations of the International Atomic Energy Agency (IAEA). Russia is further improving the VVER technology to enable transition from the open to closed nuclear fuel cycle, and to ensure efficient operation of two-component nuclear power. The VVER-1200 is a flagship nuclear reactor and the main product of Rosatom's complex offer. Evolving from the VVER-1000 design units that were recently built in China, India, Iran VVER-1200 design units have improved characteristics in all design parameters.

Perspectives of nuclear technologies: Russia is a recognized leader in the field of sodium-cooled fast reactors (BN or SFR). At present, two power units of the Beloyarsk NPP, with the BN-600 and BN-800 reactors, as well as the BOR-60 research reactor in NIIAR, Dimitrovgrad, are in operation. The total BN operation experience accumulated in Russia and the former Union of Soviet Socialist Republics (USSR), as of September 2020, exceeds 160 reactor-years. The lifetime of the power unit with the BN-600 reactor has reached 40 years.

To solve the task of closing the nuclear fuel cycle, along with the transmutation of long-living isotopes, the hybrid core of the BN-800 was designed to have both uranium and uranium-plutonium mixed oxide (MOX) fuel assemblies. The first serial batch of 18 MOX fuel assemblies was loaded into the BN-800 in December 2019, and during 2020 demonstrated an incident-free operation without degradation of economic performance. In July 2020, at the Mining-Chemical Combine (Krasnoyarsk region), a full reload batch of 169 MOX fuel assemblies for the BN-800 was manufactured and tested. Transition of the BN-800 at Beloyarsk NPP to 100% MOX fuel operation is planned for 2022.

In the framework of the PRORYV Project (proryv means breakthrough in Russian), construction of the lead-cooled fast neutron BREST-OD-300 reactor commenced. Irradiation tests continued for the innovative mixed nitride uranium-plutonium (MNIT) fuel; its manufacturing is planned to start in 2022 at the BREST-OD-300 site in Seversk. This type of fuel is aimed to be used for both the BREST-OD-300 and BN-1200 reactors. All of the MNIT fuel elements irradiated in the BN-600, under close to design conditions, have reached 6% burn-up levels, which is a target level for the first loading of the BREST-OD-300. Safe fuel operation up to 8.5% burn-up of heavy atoms has been demonstrated, and testing continued to reach a 9.2% burn-up level. The fuel-element cladding damage dose reached a record value of 110 displacements per atom (dpa).

At the NIIAR site in Dimitrovgrad, the MBIR fast research reactor with sodium coolant is being constructed, which is intended to replace the BOR-60 reactor whose operation lifetime has already reached 50 years. Russia established the International Research Center on the basis of the MBIR reactor (IRC MBIR), and has approved the new construction schedule for full development. Construction work of the research reactor thus started at the construction site in accordance with this new schedule. Key research directions enabled by the IRC MBIR are materials science (e.g. new fuel, structural materials, coolants, data verification), safety (e.g. justification of new safety systems, transients and beyond-design conditions research), physics (e.g. closed cycle studies, minor actinides and long-lived fission product treatment, reprocessing, computer code verification), resource tests (e.g. fuel, control system elements, core elements, cooling loops monitoring and diagnosis systems).

An important addition to the IRC MBIR research capacity is the inclusion of the poly-functional radiochemical complex, which will be able to carry out a series of irradiation tests and post-irradiation investigations at the same site.

Under the strategic framework of the future of Russian nuclear scenarios, two-component nuclear power development, with closed fuel cycle based on fast neutron reactors and standard VVERs with thermal neutrons, are scrutinized. Options assuming the use of MSRs are also under consideration.

Transition to the closed fuel cycle and its transient phase (i.e. two-component nuclear power) puts a stop to the accumulation of SNF from thermal reactors and eliminates any increase in the growth of corresponding costs of spent-fuel management. Substituting a thermal reactor with a fast neutron reactor leads to: the elimination of approximately 1 000 tonnes of spent fuel (i.e. for the VVER reactor operating for 60 years) and expenditures for its storage before reprocessing; an increase by 15 times of the plutonium from spent-fuel reprocessing which is used back as a fuel (15% of plutonium in fast reactor spent fuel). Use of nuclear materials from spent-fuel reprocessing for the commissioning of fast reactors, as well as the closed fuel cycle, is an efficient way of coping with the problem of accumulated spent fuel from VVERs: one fast reactor is capable of using a lifetime of spent fuel from one VVER; substitution of 10 GW of thermal reactors by fast reactors almost completely resolves the problem of all accumulated spent fuel from Russian VVERs (~10 thousand tonnes), while at the same time ensuring economical results from fuel reprocessing.

Generation 4: Rosatom is considering the possibility of signing the system agreement on MSRs, as well as taking part in the project agreement for the thermo-hydraulics and safety of supercritical reactor, and the project agreement for fast reactor equipment and conversion module design of SFRs.

In 2019, Rosatom agreed to extend for the next 10 years the validity of the GIF project agreement on safety and operation of SFRs.

South Africa

As part of the implementation of the Integrated Resource Plan 2019-2030, in June 2020 South Africa issued a non-binding request for information (RFI) for 2 500 MW of nuclear energy. The request for information is part of nuclear vendor engagement aimed at obtaining information on the feasibility of the program, for example to assess the financing model, schedule and costs associated with the procurement of conventional NPPs and SMRs that are coming online for the delivery of 2 500 MW capacity of nuclear energy.

South Africa is considering the revival of its High-Temperature Power Reactor Programme based on the pebble bed modular reactor (PBMR) technology.

Eskom's implementation of the Koeberg Long-Term Operation Programme is on track as guided by requirements of the nuclear safety authority that is the National Nuclear Regulator, and supported by the IAEA expert Mission on the Safety Aspects of Long Term Operation (SALTO). In September 2020, the first of six replacement steam generators arrived at Koeberg. These steam generators are designed by the French company, Areva (now Framatome) and manufactured in China under a subcontract with Shanghai Electric Power Equipment Company. In order to enable the long-term operation of the Koeberg NPP, in June 2020 South Africa published regulations on the long-term operation of nuclear installations. These regulations have gone through public consultation and are now in preparation for Gazetting by the Minister of Mineral Resources and Energy.

South Africa is implementing a multi-purpose reactor (MPR) Project aimed at replacing the SAFARI-1 research reactor. The Project Initiation Report for the multi-purpose reactor has been approved by the Necsa Board and endorsed by the Minister of Mineral Resources and Energy for presentation in Cabinet. The Ministerial Task Team is currently working on the pre-feasibility phase of the project, which will later be followed by fully-fledged feasibility, indicating the bankability of the program.

Through the National Radioactive Waste Disposal Institute (NRWDI) and under the oversight of the Ministerial Steering Committee, South Africa is implementing a Centralized Interim Storage Facility project for SNF. The project is currently in the pre-feasibility phase. This project will be linked to Eskom's internal spent-fuel storage facility, the Transient Interim Storage Facility (TISF). In the long run, the idea is to store spent fuel off-site in an above ground storage facility, in line with government policy and decisions aligned with lessons learnt from the Fukushima Daaichi NPP accident.

The Radioactive Waste Management Fund bill is being developed to achieve the polluter-pays principle and to "ensure that the financial burden for management of radioactive waste is borne by the generator of that waste" as per Radioactive Waste Management Policy and Strategy for the Republic of South Africa, 2005. The National Nuclear Regulator Amendment bill is under development to close some gaps in the legislative framework. These bills will strengthen South Africa's nuclear regulatory framework in general.

Switzerland

Operation of the Swiss nuclear power plants and waste management: The Mühleberg boiling water reactor (BWR) was the first Swiss power reactor to be shut down definitively on 20 December 2019. The decommissioning of the plant is ongoing as planned and was approved by the regulator. All other reactors are in operation and running at nominal power. The revision of the reactors were realized on time and according to plan despite the COVID-19 crisis.

Nagra, the company in charge of realizing the final repository for nuclear waste in Switzerland has obtained all the necessary authorizations for deep drillings designed to acquire detailed information on the geology of the three possible locations for a geological waste repository. The results of these studies are meant to determine the detailed geological differences between the possible sites and act as back up of the final choice for the location of the repository.

Nuclear power related research in Switzerland: A new professor and group leader at the Reactor Physics and Thermal-Hydraulics Laboratory of the Nuclear and Safety Division at Paul Scherrer Institute (PSI) has been nominated and will support professor A. Pautz in maintaining and improving the Nuclear Engineering Master's degree in Switzerland. The nomination of two professors and laboratory leaders for the Energy System Analysis and Scientific Computing and Modelling Laboratories has been impacted by the COVID-19 pandemic and is still ongoing.

Some specific capabilities (modelling) of the Nuclear Energy and Safety Division of PSI have been used to realize specific studies on COVID-19.

GIF activities: Operations at PSI, where most GIF research activities are taking place, were maintained at all times in spite of the COVID-19 pandemic. A summary of the main activities during the period on the MSR and SFR research includes:

- The major focus of MSR research was on MSR safety, with no preference for a specific MSR concept. However, the MSFR is considered as a reference system and the molten chloride salt fast reactor (MCFR) as the potentially most promising system for fuel cycle simplicity. Research in 2020 was dedicated to thermo-dynamics modelling of the salt properties and to MCFR fuel cycle and thermal-hydraulic layout.
- SFR research also focused on safety and corresponding investigations of design improvements. PSI is contributing work to two international frameworks: 1) the IAEA Technical Working Group on Fast Reactors (Co-ordinated Research Projects on the United States Fast Flux Test Facility and Chinese Experimental Fast Reactor); and 2) Horizon-2020 European Sodium Fast Reactor Safety Measures Assessment and Research Tools (ESFR-SMART) project co-ordinated by PSI. After three years of participating in the ESFR-SMART project, discussions on a follow-up project have been initiated.

Summary of the main activities during 2020 on the materials side:

- thermal conductivity measurements on silicium carbide (SiC) irradiated materials using laser and infrared based equipment (PhD work) has been completed. The emphasis was on the micro/macro-structure analysis of SiC material, based on X-ray tomography. The existence of very long pores along the fibres has been observed.
- PSI creep data will be included in the materials handbook.
- three virtual VHTR Materials Project Management Board meetings were held virtually, where Mr Pouchon acted as a co-chair and gave an update on the Swiss situation and Gen-IV related materials research. It was decided that the lead of the Ceramics Sub-Working Group would rotate between the main actors, and that Switzerland will start with the next term.

United Kingdom

Nuclear energy: Nuclear energy continued to be one of the United Kingdom's largest low-carbon energy sources, producing around 10% of primary energy and around 40% of the United Kingdom's clean electricity. The United Kingdom has set into law a move to zero net emissions by 2050. This government, legislative commitment to zero carbon is the priority policy driver, and along with the recent rise in UK solar photovoltaics (PV) and wind power, the United Kingdom is planning a significant amount of low-carbon energy in future.

The Prime Minister recently set out further commitments to ensure that, within the decade, the United Kingdom would be at the forefront of the green industrial revolution, as we accelerate our progress towards net zero emissions by 2050. Confirming offshore wind will produce more than enough electricity to power every home in the country by 2030, based on current electricity usage, boosting the government's previous 30 GW target to 40 GW.

These commitments are the first stage outlined as part of the Prime Minister's ten-point plan for a green industrial revolution, which was set out fully

in 2020. The plan includes ambitious targets and major investment into industries, innovation and infrastructure that will accelerate the UK path to net zero emissions by 2050, and also includes plans for deep decarbonization, covering domestic and process heat and hydrogen production.

The government recognizes the potential for the United Kingdom to become a world leader in developing the next generation of nuclear technologies. The Nuclear Sector Deal (NSD) signalled a significant step up in ambitions and the pace of policy initiatives towards advanced nuclear technologies.

Small and advanced reactors have the potential to deliver the cost reductions outlined in the NSD through technology and production innovations, while creating high-skilled jobs and helping the United Kingdom meet clean growth targets. To help enable the development of small reactors, the government has outlined a new framework in the NSD, designed to encourage industry to bring technically and commercially viable small reactor propositions to a vibrant UK marketplace.

COP26: The delayed COP26 United Nations (UN) Climate Change Conference will now take place between 1-12 November 2021 in Glasgow. This decision was taken by the COP Bureau of the United Nations Framework Convention on Climate Change (UNFCCC), with the United Kingdom and its Italian partners. This rescheduling will ensure that all parties can focus on the issues to be discussed at this vital conference and allow more time for the necessary preparations to take place. The COP26 President and Secretary of State for the Department of Business, Energy and Industrial Strategy, Alok Sharma, has said:

> "While we rightly focus on fighting the immediate crisis of the Coronavirus, we must not lose sight of the huge challenges of climate change. With the new dates for COP26 now agreed we are working with our international partners on an ambitious roadmap for global climate action between now and November 2021. The steps we take to rebuild our economies will have a profound impact on our societies' future sustainability, resilience and well-being and COP26 can be a moment where the world unites behind a clean resilient recovery.... Everyone will need to raise their ambitions to tackle climate change and the expertise of the Friends of COP will be important in helping boost climate action across the globe."

UK Nuclear Innovation Programme:

Advanced manufacturing and materials: A series of contracts have been placed under the Advanced Manufacturing and Material Programme since 2017 with the overall aim of introducing new manufacturing methods and reducing costs in the construction of new nuclear reactors with a focus on SMRs and advanced modular reactors (AMRs). Government is investing GBP 5 million with companies under phase 2 of this program, which was launched in 2020 and with work now underway.

Advanced Fuel Cycle Programme (AFCP): The AFCP is progressing well with both the Programme Board and Strategy and Technical Board meeting regularly. Potential new products are being developed to enable commercial opportunities to be realized in the fuel area of the program; recycle capability is being further underpinned through cutting edge experimental activities. The program has seen advancements in a number of areas from coated-particle fuels and advanced technology fuels to recycling of used nuclear fuel.

AMRs: The UK government believes that advanced nuclear technologies have the potential to support a secure, affordable decarbonized energy system, alongside other low-carbon generation sources. The AMR Feasibility and Development (F&D) project aims to fund applied R&D to progress AMR technologies towards commercial deployment. Based on a competitive selection process, three participants have been successful and been awarded around GBP 10 million each to progress to phase 2. These are: 1) Tokamak Energy Ltd (SME), Oxfordshire; 2) U-Battery, Buckinghamshire; and 3) Westinghouse Electric Company, Lancashire. In addition, nuclear regulators have developed their capability and capacity for assessing AMRs and cultivating a regulatory environment that encourages the development of a domestic AMR supply chain. The government is also investing a further GBP 5 million to nuclear regulators in an effort to help build their advanced nuclear capabilities and capacity when assessing advanced nuclear technologies (ANTs).

Energy white paper: An Energy White Paper (https://www.gov.uk/government/publications/energy-white-paper-powering-our-net-zero-future) was published in 2020, discussing, among other things, new nuclear financing and the question of siting for small reactors.

UK SMR and low-cost nuclear energy: The UK SMR Programme has the potential to support two of the UK government's top priorities: high value manufacturing and engineering has real potential to boost the UK economy, while low-carbon technologies will be crucial for a successful transition to net zero emissions by 2050.

The Rolls Royce led UKSMR Consortium are looking to commercially deploy a fleet of small modular PWRs from early 2030. Progress in phase 1 of the match funded "Low-Cost Nuclear Challenge" is progressing well, with the intention of phase 1 to increase technical and commercial certainty of the program, which will enable robust entry into the next phase of the Low-Cost Nuclear Challenge program, subject to business case approval.

The program aims to develop a SMR designed and manufactured in the United Kingdom, and which is capable of producing cost-effective electricity. An initial GBP 36 million joint public and private investment will enable the consortium to further

develop their design. This is part of a greater bid into the Industrial Strategy Challenge Fund worth around GBP 500 million (a joint investment with the private sector), subject to future approvals and a final decision on public investment. The consortium believes that a UKSMR program can support up to 40 000 jobs at its peak with each SMR capable of powering 750 000 homes.

Nuclear Innovation Research Advisory Board (NIRAB) report and UK Nuclear Landscape review: NIRAB was reconvened in 2018 to provide independent expert advice to government. The NIRAB *Annual Report 2020 – Achieving Net Zero: The Role of Nuclear Energy in Decarbonisation* was published in June 2020. NIRAB believes it is time to move forward towards demonstration of both SMR and AMR systems with appropriate underpinning R&D programs to support the decarbonization of the UK economy. The 2020 UK Nuclear Landscape review was completed and issued in March 2020. This report is published on a three-yearly cycle, tracking the development of the UK's nuclear R&D capability and capacity since the publication of the 2013 Beddington Review by the House of Lords.

Progress on Hinkley Point C: The project has made significant progress in the early stages of construction. In June 2020, EDF Energy confirmed that the 49 000-tonne concrete base for the second reactor at Hinkley Point C had been completed on time. In September 2020, it confirmed that the second reactor at Hinkley Point C had passed a major milestone with the lifting of the first part of the massive steel containment liner, just nine months after the same lift for the first reactor. Construction of the 170-tonne "liner cup" was 30% quicker than the identical part on unit 1. Work at the Somerset site has been continuing during the COVID-19 lockdown with social distancing measures in place to protect workers. EDF Energy's Delivery Director for Hinkley C, Nigel Cann, said: "We've been really able to learn lessons and be much more efficient the second time round." The site should be completed by 2025.

Updates on membership in GIF committees: The United Kingdom is continuing to present project proposals for engagement with the GIF SFR and VHTR project arrangements and working groups and task forces, and will be seeking formal agreement from the other partners to join these arrangements as soon as possible. This progress was reported at the System Steering Committee (SSC) WG–TF reporting meetings on 21-22 October 2020.

United Kingdom COVID-19 nuclear update: The United Kingdom is supporting efforts to ensure that the COVID-19 pandemic has a minimal impact on nuclear operations, as reported at the 64th IAEA General Conference. This includes guidance on social distancing and personal hygiene measures, tracking the health of workers, prioritization of tasks, identification of essential staff, provision of physical protection of equipment, temperature screening, contact tracing from the start of the pandemic, as well as proactive increased communication with staff, external stakeholders and the host communities during this unprecedented time. Nuclear electricity production in the United Kingdom has continued uninterrupted during this period.

Updates from the UK Nuclear Industry Council (NIC) and Nuclear Industry Association (NIA): The NIA produced the report, *Forty by '50: The Nuclear Roadmap*, for the industry-government NIC. It was released ahead of the annual progress update from the government's Committee on Climate Change. According to the report, an ambitious program based on existing and new technologies could provide up to 40% of clean power by 2050 and drive deeper decarbonization. It could eventually bring as many as 300 000 jobs and GBP 33 billion of added annual economic value. In the United Kingdom, nuclear energy currently contributes 40% of the UK's clean electricity, but demand is expected to quadruple from the replacement of fossil fuels and a boom in the electric vehicles and heating sectors.

United States

Nuclear energy continues to be a vital part of the United States' energy development strategy for an affordable, secure and reliable energy future. The Department of Energy (DOE) is aggressively working to revive, revitalize and expand nuclear energy capacity. One of the DOE's top priorities is to enable the deployment of advanced nuclear energy systems, including advanced light water and non-water-cooled reactor concepts being pursued by US nuclear developers. The following summary briefly highlights some of the more recent activities that the Office of Nuclear Energy supports.

The versatile test reactor (VTR): The VTR was formally launched in February 2019 as a part of efforts to modernize the nuclear R&D user facility infrastructure in the United States. The VTR will provide a leading-edge capability for accelerated testing and qualification of advanced fuels and materials. The VTR is proposed to be a 300 MWth sodium-cooled, fast spectrum reactor capable of testing advanced nuclear fuels and materials for the next generation of nuclear reactors.

On 11 September 2020, the DOE approved Critical Decision 1 for the VTR project. Critical Decision 1, known as "Approve Alternative Selection and Cost Range," is the second step in the formal process that the DOE uses to review and manage research infrastructure projects. As part of Critical Decision 1, federal committees reviewed the conceptual design, schedule, and cost range, and analyzed potential alternatives. The VTR project will move to the engineering design phase as soon as Congress appropriates funding. The DOE has requested USD 295 million for fiscal year 2021 for the VTR project.

Hydrogen production: The DOE continues to evaluate and demonstrate integrated energy systems that competitively produce electricity and non-electric products, such as hydrogen production, to optimize revenue generation by NPPs. Two NPP projects were awarded during the fiscal year 2019. The first award was to Exelon Corporation, through the Office of Energy Efficiency and Renewable Energy (EERE), to install a 1 MW proton exchange membrane (PEM) electrolyzer, storage and controls at one of their sites for on-site hydrogen needs. The second award was made to Energy Harbor, Xcel and Arizona Public Service (APS) to install a similar PEM electrolyzer at Energy Harbor's Davis Besse Nuclear Power Station for both on-site and off-site uses. The project will also develop technical and economic assessments for hydrogen generation at an Xcel and APS site.

In the fiscal year 2020, a total of USD 21 million was identified for hydrogen demonstrations in support of the existing fleet of nuclear reactors, with USD 11 million from the Office of Nuclear Energy (NE) and USD 10 million from the Office of Energy Efficiency and Renewable Energy (EERE). The funding was made available through NE's Industry Funding Opportunity Announcement. On 8 October 2020, the DOE announced that Xcel Energy and FuelCell Energy Inc. were awarded the funds to advance flexible operation of light water reactors with integrated hydrogen production systems.

Advanced Reactor Demonstration Programme (ARDP): As a part of its mission, the NE supports the development of advanced reactor designs and capabilities over a continuum of technology maturity levels. The DOE currently supports R&D activities for a variety of advanced reactor technologies that are expected to improve on the safety, security, economics and/or environmental impacts of current nuclear power plant designs. The DOE undertakes these activities in support of the Administration's objectives to maintain the nation's technological leadership position in the global nuclear industry and ensure national energy security. As part of the fiscal year 2020 Further Consolidation Appropriations Act, (H.R. 1865), Congress has provided funding for the NE to address advanced reactor development through the ARDP.

The NE released a funding opportunity announcement (FOA) that is comprised of three separate pathways. The ARDP has a goal of focusing DOE and non-federal resources (through cost-sharing agreements with industry) on the actual construction of real demonstration reactors that are safe and affordable to build in the near to midterm. The ARDP has identified two separate pathways to meet this goal: 1) Advanced Reactor Demonstration awards, which support two reactor designs to be operational in five to seven years; and, 2) the Risk Reduction for Future Demonstration awards, which supports two to five additional diverse advanced reactor designs that have a commercialization horizon that is approximately five years longer than the Advanced Reactor Demonstration awards. A third pathway, identified in H.R. 1865, Advanced Reactor Concepts-20, will support development of at least two new public-private partnership awards focused on advancing reactor designs towards the demonstration phase; these have a commercialization horizon that is approximately five years longer than the Risk Reduction for Future Demonstration awards.

On 13 October 2020, the Secretary of Energy announced that the DOE is awarding TerraPower LLC (Bellevue, Washington) and X-energy (Rockville, Maryland) USD 80 million each in initial funding to build two advanced nuclear reactors that can be operational within seven years. TerraPower will demonstrate the Natrium reactor, an SFR that leverages decades of development and design undertaken by TerraPower and its partner, GE-Hitachi. X-energy will deliver a commercial four-unit nuclear power plant based on its Xe-100 reactor design. The Xe-100 is a high-temperature gas-cooled reactor that is ideally suited to provide flexible electricity output, as well as process heat for a wide range of industrial heat applications, such as desalination and hydrogen production.

The Advanced Reactor Demonstration awards are cost-sharing partnerships with industry that will deliver two first-of-a-kind advanced reactors to be licensed for commercial operation. The department will invest a total of USD 3.2 billion over seven years, subject to the availability of future appropriations, with industry partners providing matching funds. Additionally, awards for Risk Reduction for Future Demonstration and Advanced Reactor Concept-20 (ARC-20) projects are expected to be announced in December 2020.

The National Reactor Innovation Center (NRIC): The NRIC, which was authorized by Congress in 2018 and established by the DOE in 2019, is working on behalf of NE and in partnership with the US advanced reactor development community to define NE's role of innovative nuclear reactor technologies in the clean energy economy. The NRIC strives to empower innovators with access to facilities, sites, materials and expertise to demonstrate reactors and support the demonstration of cost-cutting technologies.