CONTENTS

Year in Review

The New Year's Eve is the best time to take a look back and review the last 12 months. All of Rosatom's divisions performed well: some of the projects were completed, progress was made in delivering others, and new contracts were signed with business partners.

Akademik Lomonosov FNPP

The Akademik Lomonosov floating nuclear power plant (FNPP) was transported to Russia's northernmost city of Pevek. It is, perhaps, the most important international nuclear event of 2019.

In September, the FNPP made a record short 18-day journey from Murmansk to Pevek and was moored to a specially designed pier protecting Akademik Lomonosov from storms and other natural hazards.

The pier is also used to carry power cables and flexible pipes supplying electricity and heat to consumers. Having a capacity of 70 MWe and 146 Gcal/h, Akademik Lomonosov will replace the retiring coal-fired Chaun thermal power plant and later the Bilibino NPP. Replacing coal generation with nuclear will improve environmental conditions in Pevek and decrease energy tariffs 2.5-fold, from RUB 16 to RUB 6 per kilowatt-hour.

As the world's first floating power plant, Akademik Lomonosov will serve as a

reference model for other similar facilities. While supplying electric power and heat to large local mining sites and utilities in Pevek and nearby and later in Bilibino, it will demonstrate capabilities, advantages and reliability of floating nuclear power plants. On December 19, it began delivering first power to the port of Pevek.

New plants

Another important event for the nuclear industry was the start of construction at Unit 2 of Kursk II. In April, the first concrete was poured for the foundation slab of the unit. Unit 1 and Unit 2 at Kursk II are pilot units of the VVER-TOI design (VVER-TOI stands for Water-Water Energy Reactor Universal Optimized Digital), which is based on the technology used in Generation III+ VVER-1200 reactors and upgraded to include a digital cost and construction management system. This system is designed to enable effective strategic and day-to-day budgeting and monitor construction progress in real time. Kursk II units feature better maneuverability and boast more efficient capacity utilization. Materials and systems intended for the VVER-TOI design enable safe operation of the nuclear power plant anywhere, from the tropics to the Arctic.

Novovoronezh NPP Unit 7 is another story of Rosatom's success in the construction and operation of nuclear power plants. The new reactor unit was commissioned on October 31, a month ahead of schedule. Its compliance with the project design, technical standards and statutory regulations, including power efficiency requirements, was certified by Russia's Federal Service for Environmental, Technological and Nuclear Supervision (Rostechnadzor). Since the unit was connected to the grid on May 1, it had generated 2.5 billion kWh.

The new unit is the third one featuring a Generation III+ VVER-1200 reactor. What makes them different from the previous generation of reactors is a one-of-a-kind combination of active and passive safety systems making the nuclear power plant resistant to internal and external shocks. These systems include, among other things, a core catcher intended to catch the molten core material of a nuclear reactor and a passive heat removal system that releases excessive heat from the reactor core into the atmosphere even if the plant is cut off from power supply.

Generation III+ units are also more cost efficient: they generate 20% more power than Generation III VVER-1000 reactors but need 30% to 40% less staff. Core components of the machinery and equipment have two times' longer design life, reaching 60 years and could be extended by 20 more years. **"Now we have a two-unit nuclear power plant that can serve as a reference model for the nuclear facilities to be built abroad. We have accumulated extensive knowledge and experience in the construction, production, procurement, logistics, cost**

management and continuous performance improvement – everything we need to meet market challenges of today and solve ambitious tasks in nuclear construction," said Alexander Lokshin, First Deputy Director General for Operations Management at Rosatom.

Another milestone reached in 2019 was the connection of a new VVER-1200 reactor unit of the Leningrad NPP to the heating network of the neighboring town of Sosnovy Bor. The new unit replaced the capacity of a shutdown RBMK reactor.

Northern Sea Route

Atomflot, Rosatom's subsidiary in charge of the Russian nuclear fleet, celebrated its 60th anniversary in 2019. It was no ordinary celebration, though. In December 2018, Russian President Vladimir Putin signed a law appointing Rosatom as infrastructure operator of the Northern Sea Route (NSR). Russian nuclear corporation key tasks here are to maintain the year-round navigation and increase freight traffic to 80 million tons per year by 2024.

The first task could only be solved using icebreakers of different types and functions. In November, Atomflot acquired Ob, a diesel-electric powered icebreaker and the first non-nuclear vessel in Rosatom's fleet. Its function is to escort ships in the port of Sabetta.

Three Project 22220 series nuclear icebreakers are currently under construction. Two icebreakers of the same series – Ural and Sibir – are already afloat and expected to be commissioned in 2022. Arktika, the flagship Project 22220 icebreaker, is going through the first phase of sea trials

that started on December 12. As of early December, Arktika was 93% ready and expected to be commissioned in May 2020. Negotiations are underway to obtain funding for two more nuclear-powered icebreakers. Construction costs are planned to reach RUB 100 million. The Government will provide RUB 45 million, with the remaining portion provided by Rosatom. One of the possible sources of finance is long-term (10-year rather than usual 5-year) contracts with mining companies for icebreaking services. Taymyr and Vaygach, two nuclear-powered icebreakers currently in operation, are expected to be decommissioned by 2030.

In February, Rosatom acquired a valuable asset from the Russian Transport Ministry – Hydrographic Survey Company. It provides recommendations on navigation routes and ship positioning systems and manages infrastructure construction projects along the NSR.

As the NSR operator, Rosatom is already ahead of schedule in increasing the freight traffic. As Rosatom's Director General Alexey Likhachev said at Atomflot's anniversary celebration in Murmansk, the target set for 2019 (26 million tons) had been achieved already by 15 November 2019. It is expected

that the total freight transported on the NSR in 2019 will reach 30 million tons.

Rosatom established a special company, Rusatom Cargo, to increase traffic and get profit. Its primary function is to transport cargo for nuclear power plants constructed abroad and, what's more important, make money off providing cargo transportation services to third parties. The main advantage of the new route is a shorter traveling time and, consequently, lower costs of cargo transportation between the ports of Northern Europe and Asia. To fulfill this task, Rosatom made a deal to buy a share in Delo Group that had won the right to acquire a controlling stake in Russia's largest rail freight operator TransContainer.

Non-nuclear energy

In 2019, Rosatom started building a 210 MW wind farm in the Stavropol Krai (Russia). With 84 turbines with a capacity of 2.5 MW each, the farm is planned to generate 496.7 million kWh on the annual average. The estimated project costs exceed USD 350 million. Construction of the find farm is part of Rosatom's strategy to develop wind energy projects in the country.

Agreements and arrangements

Most of Rosatom's key agreements were made at large nuclear industry events and energy conferences. For instance, more than 40 agreements were signed at AtomExpo held in April 2019. More agreements were signed on the sidelines of the Eastern Economic Forum in September and at the Russian Energy Week. Some contracts, though, were signed at bilateral meetings, such as a contract for the supply of nuclear fuel to Chinese nuclear power plants.

Construction of power plants and NSTCs

Rosatom's engineering division ASE and subsidiaries of the China National Nuclear Corporation (CNNC) signed a construction contract for Units 7 and 8 of the Tianwan nuclear power plant and an engineering design contract for Xudabao Units 3 and 4.

Russia and Ethiopia signed a three-year roadmap that provides for developing designs of a nuclear power plant and a nuclear science and technology center (NSTC), training staff for the nuclear industry and raising public awareness of nuclear energy in the country.

Rosatom and the Republic of the Congo signed a two-year roadmap to look into the possibility of building an NSTC and staff training.

Rusatom Overseas and Russia's GHP Group signed a memorandum of understanding. The companies will team up to develop power supply solutions for the Suroyam iron ore deposit in the Chelyabinsk region (Russia) and explore the possibility of building a small-scale nuclear power plant based on a RITM-200 reactor.

ROSATOM NEWS

Back to contents

Rosatom and the Government of Sakha Republic (Yakutia) signed an agreement of cooperation in the construction of small-scale nuclear power plants with RITM-200 reactors. The parties will jointly work on a feasibility study, conduct engineering surveys, develop a financial model and select a site for the power plant.

Fuel supply

In July, Rosatom's TVEL Fuel Company signed a contract with CNSP and CNEIC (both are CNNC subsidiaries) to supply nuclear fuel for Tianwan Units 7 and 8.

In November, TVEL signed a similar contract with CNEIC, CNSP and CNLNPC (also a subsidiary of CNNC) to supply nuclear fuel for yet-to-be-constructed Xudabo Units 3 and 4.

TVEL and the Egyptian Atomic Energy Authority signed a contract for the supply of uranium components to be used in low-enriched nuclear fuel for ETTR 2 research reactor.

New materials

TVEL made an agreement with Germany-based Hermith on the joint production and sales of titanium products. The parties plan to establish a joint venture to manufacture aircraft titanium tubing, special wire for additive manufacturing, sonotrodes, car suspension parts, medical implants and prosthetic devices.

Rusatom Additive Technologies (a Rosatom Group company) and Ural Works of Civil Aviation signed a strategic cooperation

agreement to develop the EM 401 engine family, create a competency center for gas turbine manufacturing, and promote a broader industrial collaboration.

Rosatom and RusHydro signed an agreement to collaborate in the development of composite materials for core machinery, auxiliary equipment and structural elements of small hydro power plants, wind turbines and external reinforcement solutions.

Machinery and equipment

Rosatom's subsidiary AtomEnergoMash signed a memorandum of understanding with Egyptian Petrojet, a leading EPC company in the Middle East and Africa. The parties agreed to join their efforts in the production and supply of equipment for nuclear power plants, oil refining and petrochemical facilities.

Another subsidiary of Rosatom, Central Research Institute for Machine Building Technology, also made an agreement with Petrojet to certify materials, processes, equipment and laboratories, train staff and assess their performance in compliance with Russian national standards.

ROSATOM NEWS

Back to contents

ZiO-Podolsk and Swiss-based Hitachi Zosen INOVA (a subsidiary of Japanese Hitachi Zosen Corp.) signed an agreement to set up a consortium that will develop design solutions and supply equipment for waste recycling plants in the Moscow Region.

Rusatom Healthcare (a Rosatom Group company), Research Institute of Technical Physics and Automation (NIITFA) and Slovenia's Cosylab signed a memorandum of cooperation in the development of integrated software for NIITFA's radiation therapy and diagnostics systems. Cosylab will be involved in the implementation of a quality management system and international certification of the software.

Titan-2 (a group of companies providing construction services and supplying equipment for Hanhikivi 1) and a consortium of French Framatome SAS and German Siemens AG signed a contract for the supply of main I&C systems.

Rosatom and Rosseti (a Russian power grid company) agreed to cooperate in the construction of grid facilities abroad and use Rosatom's expertise in predictive analytics and digital twin technology.

Education and public awareness

Rosatom and the Ministry of Science, Technology and Environment of Cuba signed a memorandum of cooperation on training staff for the nuclear industry.

Rusatom International Network (RIN) and Hungary's University of Dunaújváros made an agreement to hold joint lectures and seminars, publish learning materials, set up a student exchange program, and cooperate in other areas.

Rosatom's Technical Academy signed a nuclear workforce training agreement with Uzbekistan's Nuclear Energy Development Agency (Uzatom) and a memorandum of cooperation with the European Nuclear Education Network (ENEN).

Digitalization

Rosatom, the Ministry for Development of the Russian Far East and Arctic, the Ministry of Digital Development, Communications and Mass Media, and the Far Eastern Federal University signed an agreement to establish an international research and development center for nuclear technology on Russky Island in Vladivostok and jointly deliver digital projects.

Rosatom, Russia's largest bank Sberbank and the Federal Biomedical Agency signed a memorandum of cooperation in the development of best practices for affordable and user-friendly healthcare services. The parties will join their efforts in creating a dedicated digital ecosystem.

Rosatom and the Foundation for Reforms in the Utilities Sector made a cooperation

agreement to upgrade the utilities infrastructure in cities and towns with the population of less than 500,000 people. Finance to be provided by the Foundation will be used by Rosatom to introduce advanced and innovative cost-efficient digital solutions.

Arctic

Rosatom and the Ministry of Natural Resources and Environment signed a cooperation agreement providing for joint delivery of federal programs and the Environment national project and developing proposals for implementation of the national policy in the Arctic region.

Focus On VVER

Partnership between Russian and Czech nuclear scientists and engineers was high on the agenda of the VVER 2019 Conference held in Prague in November. Representatives of the countries operating or planning to operate pressurized water reactors showed great interest in the speakers.

Longer life span

Reactor life span extension is a tendency that has been taking shape over recent years in the nuclear industry. This topic was discussed at a dedicated session where Artyom Ushakov, Head of Project Management Central and Eastern Europe at Rusatom Service (a Rosatom Group company providing upgrade services to VVER-based nuclear power plants

outside Russia), spoke about the company's expertise in reactor life extension projects both in Russia and abroad. In particular, he told the audience about the reactor vessel annealing technology for VVER-440 and VVER-1000 pressure vessels.

More power

Another modern tendency is growing power capacity of nuclear power plants. According to Leoš Tomíček, Senior Vice President for Nuclear Projects at Rusatom Overseas (a Rosatom Group company promoting NPP construction projects on foreign markets), power capacity of Loviisa NPP was increased from 420 MW to 520 MW. The capacity increase was achieved by upgrading some systems and verifying the existing designs of others with advanced calculation and safety validation techniques. An expert commission confirmed safety of every design change prior to licensing. Other nuclear power plants in Europe and the United States were improved in a similar way. For instance, Hungary's Paks NPP had its power capacity increased by 10%, and Czech Republic's Temelin NPP by 4%.

ROSATOM NEWS

Back to contents

New fuel

The development of new fuels is the area where TVEL (Rosatom's nuclear fuel manufacturing subsidiary) cooperates extensively with a number of Czech companies (ÚJV Řež, ŠKODA JS, and UJP PRAHA). The parties study fuel compositions and structural materials, validate feasibility of operational parameters and approve the use of new materials developed by TVEL.

Alexander Ugryumov, Vice President for R&D at TVEL, spoke about new fuel grades supplied to the Czech nuclear stations, Temelin and Dukovany. TVSA-T.mod.2 is an upgraded angle-designed fuel assembly for VVER-1000 reactors. Having a higher uranium density and a lower axial load, these assemblies improve stability of the reactor core. At present, TVSA-T.mod.2 assemblies are used at Temelin II and will be offered at the next tender. RK-3+ fuel assemblies for VVER-440 reactors differ from the previous generation assemblies in their design, which improves physical and thermal hydraulic properties of nuclear fuel. Along with other differences, the new modification has a spacer grid with larger spacings and therefore ensures an optimal ratio of water and uranium in the reactor core, boasting more effective fuel utilization in general. As a result, the improved fuel rods help extending refueling intervals.

Advanced materials

Development of new alloys for fuel assemblies is another area of cooperation between Rosatom and the Czech Republic. One of the joint projects entitled Tirclad is devoted to performing in-pile tests on a zirconium-based alloy. Launched in 2012, the project makes part of a broad material studies program financed by TVEL and ČEZ (a diversified group of companies specializing in energy production and distribution). Irradiation of material clusters in Temelin's VVER-1000 reactor started in 2014 and is to be completed in 2024. Samples from six different clusters will be studied to analyze changes induced by neutron flux. The primary goal of the project is to assess microstructural and bulk properties of materials and correlations between temperature and dose rate. It is assumed that results of the study will be used to license new fuel assembly designs, model cladding behavior during longtime dry storage, validate feasibility of longtime dry storage, and develop new safety criteria.

Reactors of the future

Alexander Katsman, Director of New NPP Operational Readiness Department at Russian nuclear power operator Rosenergoatom, demonstrated slides about the commissioning procedure for new reactor units. The presentation was meant for representatives of those countries that are building or going to build nuclear power plants, including the Czech Republic. According to Viktor Černý, Director at

Temelin II, the Czech government plans to approve the final construction program for new reactors at Dukovany by March 2020. Applications for construction permits could be filed the same year.

Small modular reactors (SMR) and medium-sized nuclear power plants (up to 600 MWe) were, perhaps, the key topic of the Prague conference. According to Alexander Katsman, medium-sized NPPs are more interesting than SMRs as they are more likely to meet the requirements for new or replacing power generation and do not need any major transformations of the existing power grid and distribution infrastructure. These nuclear plants were of particular interest for the representatives of Armenia.

There were many questions about specifications and capabilities of floating nuclear power plants (FNPPs). Nikita Rtischev, Senior Manager of Advanced Technology Department at Rusatom Overseas, stressed that a floating nuclear power plant was capable of controlling its output power within a 10% to 100% range of its installed capacity. He also noted that the concept design of an onshore SMR plant with two RITM-200 reactors and a total power capacity of 114 MW had been developed, and the next step was to develop detailed design for a particular site.

New generation of VVER reactors

Researchers from Rosatom's subsidiary OKB Gidropress will develop a concept design of VVER-S spectral shift control reactor by 2021.

The new reactor design will allow controlling the neutron spectrum and energy-based distribution of neutrons in the reactor core. VVER-S has a number of advantages over VVER-1200. First, VVER-S will consume less fuel while having the same power capacity. Second, VVER-S can operate effectively while being loaded with 100% MOX fuel. Third, VVER-S will be safer as no zirconium is used in the fuel composition. In addition, capital costs of VVER-S construction are expected to be 10% to 15% lower.

Time to replace research reactors

Research reactors are aging all around the world, says the November issue of the IAEA bulletin. The time has come to get prepared for new designs. Rosatom, which operates about 20% of research reactors globally, both replaces obsolete facilities and builds new ones. A recent example is an agreement with Rwanda to construct a nuclear science and technology center (NSTC) with a research reactor.

The November issue of the IAEA bulletin deals with different aspects of research

reactor operation, ranging from safety to government regulation. It is not a deep dive into the topic but rather a brief description. Nevertheless, the bulletin helps getting an understanding of research reactor operators and what they do and what problems could be solved with the involvement of IAEA representatives.

For example, the Agency suggests using a milestone approach to the development and construction of research reactors (RR), **"The research reactor development process is organized into three main phases: preparing a feasibility report to justify the need for a research reactor project; setting up for construction of the reactor, including the establishment of legal and regulatory frameworks; and commissioning and constructing the new reactor."**

Integrated Nuclear Infrastructure Review for Research Reactors (INIR-RR) missions conducted by the IAEA could be used to lay a foundation for the RR infrastructure. This is a relatively new practice: the first ever INIR-RR mission took place in Nigeria in February 2018. Our readers might remember that the Nigerian government signed an agreement with Rosatom in October 2017 to construct a nuclear science and technology center with a multi-purpose research reactor that will be used to produce radioactive isotopes, irradiate foodstuffs, and gain expertise in operating a reactor. The same mission took place in Vietnam in December. In June 2017, Vietnam signed a memorandum of understanding on the construction of a nuclear center and started consultations on the project. In May 2019, Rosatom and the Ministry of Science and Technology of Vietnam signed a memorandum to draft a construction schedule for the NSTC.

Jelmer Offerein, Operations Director at the Nuclear Research and Consultancy Group (NRG) in the Netherlands, said in an interview what should be done to set up safety culture. Among the recommendations he gave was one to lead by example and another rule that could be expressed as 'better less but better'. Although the saying is old, it sounds modern if compared with a multi-functional approach that was in trend just recently, **"We noticed that, in the past, we were doing a lot of things simultaneously. If people tend to do five or six things at the same time, quality decreases and, if quality decreases, safety levels can also decrease. It's smarter to do fewer things but do them better."**

Production of medical isotopes is what research reactors are often used for. The bulletin gives a clear picture of the medical isotope market, from irradiating uranium to obtaining Technetium-99 (99Tc), and tells a story of SAFARI-1, a South African research reactor playing a major role in the isotope production industry. The reactor is aging, though (this is a typical problem of many reactors irradiating uranium for the production of medical isotopes), so there is a pressing need to construct a new research reactor with a thermal power of 15–30 MW. If the go-ahead decision is made,

it will take about 10 years to build a new reactor, from preparing a feasibility study till commissioning. Its service life will be 60 years and can be extended if needed.

The bulletin keeps repeating that most research reactors were constructed in the 1960–1970s, so the experience gained since then needs to be revised and taken into account in future projects.

Russia's experience in this field is considerable as Rosatom has built over 120 research reactors, including 22 reactors abroad (in the Czech Republic, Hungary, Egypt, Kazakhstan, Uzbekistan and Vietnam).

There are many more countries where it can be applied. Apart from the above mentioned projects in Nigeria and Vietnam, Rosatom is building a nuclear science and technology center in Bolivia and signed an NSTC construction contract with Rwanda at the Russia-Africa Summit. According to the plans, the NSTC will be built around a water-moderated water-cooled research reactor with a thermal power of up to 10 MW. The Center will conduct research in radiobiology, produce medical isotopes and be used as a foodstuff irradiation facility. Another important function of the Center will be to provide training for would-be employees of the country's nuclear industry.

To the beginning of the section

Nuclear Alive is Nuclear Supported

S&P Global published a report on the current status of the nuclear energy industry. Provocatively entitled The Energy Transition: Nuclear Dead and Alive, the report makes it clear from the very beginning that the nuclear energy industry finds itself in a challenging situation. It is withering away in some countries but gaining more ground and earning trust in others.

Strictly speaking, analysts from S&P Global state the simple truth: nuclear industry grows where the government wants it to grow. China and Russia are the two countries that definitely belong to this group. If a country does not want to support the nuclear industry, it loses ground very quickly. This is what is happening in Western Europe, particularly in Germany and Switzerland. There is one more category, though. These are countries that do not want to lose what they already have. They work heavily on extending the service life of existing reactors. France and the USA are good examples of such countries. As for the USA, it is more correct to say that nuclear is supported by individual states rather than the entire country. News coming from the USA is both negative (premature plant shutdown) and positive (subsidies for the nuclear power plants).

One cannot say, therefore, that nuclear is dead or alive (the report's title is an allusion to Schrödinger's cat, according to S&P). It is more dead than alive in some countries and quite alive in the others.

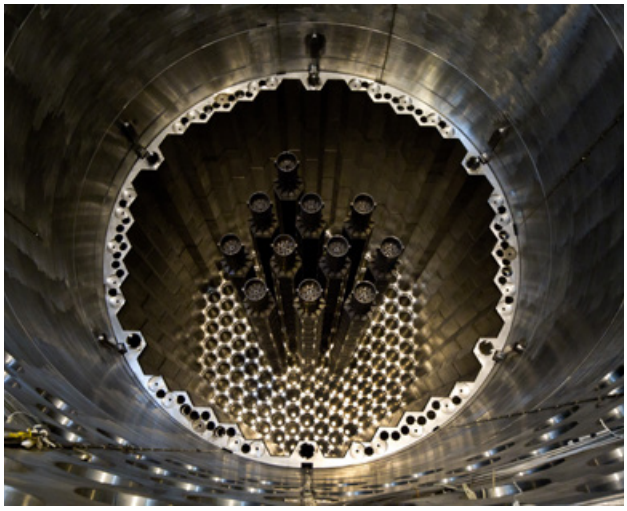
Old road, new traveler

The predicament nuclear found itself into is not unique. Renewable energy also makes

more progress in the countries where it is supported by the government and becoming cheaper and more widespread thanks to the economy of scale. **"Over the past two decades, the credit of many renewable financings have benefited from often-high-priced power purchase agreements (PPAs) or feed-in tariffs (FIT) and proven technology,"** reads another report, Energy Transition: Renewable Energy Matures With Blossoming Complexity, published by S&P Global a few days before the nuclear industry report. Knowing the milestones of nuclear industry development might help making forecasts about the development of renewable energy.

For instance, one can safely assume that the future of renewable generation will be directly affected by accidents, their scale and the speed of recovery. A massive power outage involving a large wind farm in the United Kingdom, power price hikes in Texas and an imbalanced energy mix in Germany are some of the events and processes that draw criticism of renewable energy sources and help identify associated risks. A six-hour potential blackout in a densely populated area, which is home to offices of reputable mass media, will spark no less than a broad public discussion having far-reaching political and economic consequences.

The nuclear energy industry has experienced both ups and downs. It is not unlikely that the renewable generation market will follow the same pattern. **"Despite the strong historical growth, in May 2019 the International Energy Agency (IEA) announced that renewable additions had plateaued in 2018; for the first time since 2001, there was no year-on-year growth. And recently, Platts Analytics announced a further reduction of over 10% year-on-year in 1H2019 across**



major markets (see S&P Global Platts Analytics' Global Solar PV Market Outlook (2019-2025), Aug. 16 2019)," reads S&P's Energy Transition: Renewables Energy Matures with Blossoming Complexity report.

Competition to follow

S&P Global's report views renewable generation and nuclear energy as direct competitors, with nuclear shown as dependent on the development of renewable technology, particularly stabilization of power output, **"The long-term outlook for nuclear post 2040 will in our view depend on the progress in mitigating the intermittency of renewables through smart grids and storage (such as wider deployment of batteries or hydrogen), while carbon capture solutions could help extend the life of fossil fuel."** Small modular reactors are also compared with renewables, **"However, they are still far too expensive and less scalable than renewables, and do not address fundamental nuclear safety and nuclear waste issues."**

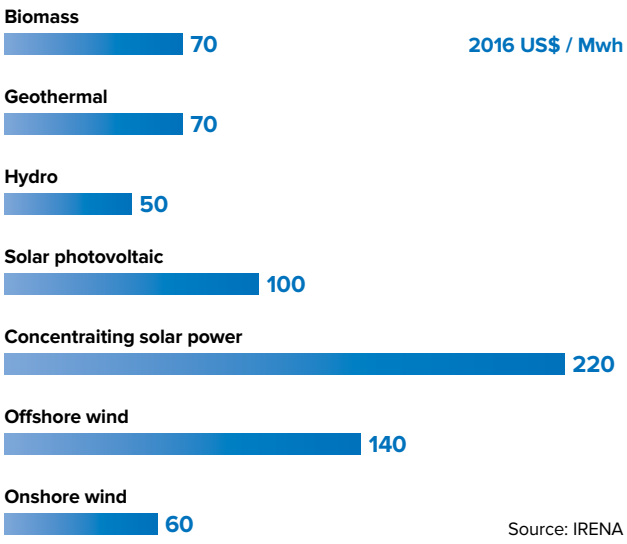
The report uses the LCOE (levelized cost of electricity) metric to compare the two types

of generation. As specified in the notes to the diagram, this metric is calculated as **"present value of lifetime costs (including capital costs, fuel costs, operations and maintenance costs) per unit over the asset's lifetime)".** However, measuring global LCOE values is a monkey business. As rightly mentioned in the report, the real costs of constructing a particular power source depend on the place of implementation. **"For Europe, the IEA's study shows LCOE significantly higher for renewables than in the U.S., ranging between $80-$110/MWh. This provides greater economic support for nuclear life extensions. However, LOCE values vary significantly by country."**

LCOE does not account for government subsidies, but this is a factor that should be definitely taken into consideration. The Status Review of Renewable Support Schemes in Europe for 2016 and 2017 published every two years by the Council of European Energy Regulators (CEER) says, **"The weighted average support for RES, on top of the wholesale price, decreased from €110,22/MWh5 in 2015 to an average of €96,29/MWh across 25 countries6 for 2017.This is a decrease of 12,6%. In 2017, the weighted average support ranged from a minimum of €12,87/MWh (in Norway) to a maximum of €198,29/MWh (in the Czech Republic)."** All that is left to do is to compare these data with LCOE.

Since electric power satisfies essential needs, its generation will never be just business – the government will always be involved as a distributor of benefits.

GLOBAL LEVELISED COST OF ELECTRICITY FROM UTILITY-SCALE RENEWABLE POWER GENERATION TECHNOLOGIES (2017)



The same CEER report reads that average payments for electric power from renewable energy sources in 2016 and 2017 made respectively 13% and 14% of household spending on electricity.

According to S&P, nuclear energy projects enjoy other forms of government support, **"Many new nuclear projects in emerging markets are therefore funded with loans from government-related banks or with intergovernmental loans, occasional equity contributions, or government guarantees. For example, Russia provided**

intergovernmental loans to Belarus, Hungary, India, and Bangladesh to support nuclear power plant construction by Russian companies […] In China and Russia, a large portion of nuclear liabilities rests with the government and not the nuclear operators."

Delays in commissioning and budget overruns are named by many as key drawbacks of nuclear power plant construction projects. This is not true, though: China's and Russia's experience shows that nuclear construction projects can be delivered in time and on budget, including abroad. What is more, positive experience (a timely built nuclear power plant and no cost overruns) directly depends on whether bureaucratic procedures for obtaining approvals and permits in compliance with IAEA requirements are adequate and not too complicated. **"Although all countries are subject to standard International Atomic Energy Agency (IAEA) safety requirements, local regulations and their actual implementation by country differ,"** S&P names that a factor of lower construction costs.

Another fact proving that nuclear energy is an attractive investment target is Bill Gates' project TerraPower dealing with two types of nuclear reactors, a traveling wave reactor (TWR) and a molten salt reactor (MSR). **"Nuclear is ideal for dealing with climate change, because it is the only carbon-free, scalable energy source that's available 24 hours a day. The problems with today's reactors, such as the risk of accidents, can be solved through innovation."** The

US businessman is sure of TerraPower's future although politics have interfered with the plans: the project providing for the participation of Chinese companies and construction of the first reactor in China was put on hold on the back of trade tensions between China and the USA.

Rosatom is also optimistic about the industry's future. The Russian nuclear corporation keeps working, patiently and consistently, upgrading technology, making it safer and more cost-efficient, signing contracts for the construction of new reactors, building and providing them with top-quality nuclear fuel. Rosatom is not the only beneficiary of nuclear construction projects – owners of nuclear power plants receive a long-term source of both electric power and money. Host communities also benefit from nuclear power plants. The local grid infrastructure grows; new jobs are created; people acquire new knowledge. According to S&P, nuclear power plants are built primarily in developing countries. So be it, this is a chance for them to develop faster since the knowledge-based economy is integral to a developed country.

To the beginning of the section