

REPORT

Workshop on **Challenges and Opportunities Facing Nuclear Energy in an Energy Transitions Context: Innovation and Actions to Advance Clean Nuclear Energy**

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Ministry of Economy, Trade and Industry
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Foreword

International Framework for Nuclear Energy Cooperation (IFNEC)

IFNEC provides a forum for cooperation among participating countries to explore mutually beneficial approaches to ensure that the use of nuclear energy for peaceful purposes proceeds in a manner which is efficient and meets the highest standards of safety, security and non-proliferation.

IFNEC is a government-to-government organization with a membership of 65 countries, of which 34 are participant countries and 31 observer countries.

Member countries (34):

Argentina, Armenia, Australia, Bahrain, Bulgaria, Canada, People's Republic of China, Estonia, France, Germany, Ghana, Hungary, Italy, Japan, Jordan, Kazakhstan, Kenya, Korea, Kuwait, Lithuania, Morocco, the Netherlands, Niger, Oman, Poland, Romania, Russia, Senegal, Sierra Leone, Slovenia, Ukraine, the United Arab Emirates, the United Kingdom, the United States.

Observer countries (31):

Algeria, Bangladesh, Belgium, Brazil, Chile, the Czech Republic, Egypt, Finland, Georgia, Greece, Indonesia, Latvia, Malaysia, Mexico, Moldova, Mongolia, Nigeria, the Philippines, Qatar, Saudi Arabia, Singapore, the Slovak Republic, South Africa, Spain, Sweden, Switzerland, Tanzania, Tunisia, Turkey, Uganda, Viet Nam.

Challenges and Opportunities Facing Nuclear Energy in an Energy Transitions Context: Innovation and Actions to Advance Clean Nuclear Energy

The conference, "Challenges and Opportunities Facing Nuclear Energy in an Energy Transitions Context: Innovation and Actions to Advance Clean Nuclear Energy", held under the framework of IFNEC, elaborated on the dialogue started at the Clean Energy Ministerial (CEM) during the launch of the Nuclear Innovation: Clean Energy Future (N.I.C.E Future) initiative on 24 May 2018 in Copenhagen. It was held over two days and hosted by the Japanese Ministry of Economy, Trade and Industry and the Cabinet Office in Tokyo, Japan.

The objective of the conference was to explore the role that nuclear energy options can play in contributing to:

- economic growth;
- energy security;
- energy access;
- environmental stewardship in support of clean energy goals.

The conference addressed the main issues that IFNEC member countries face in the transition to clean energy systems, such as infrastructure development, financing, cost-efficiency, and public acceptance, which have been addressed by IFNEC since its inception. With this conference, the NICE Future initiative and IFNEC strengthened the partnership among countries with existing or planned nuclear programs, including those evaluating a range of low emissions options for the future, to keep moving towards cleaner energy systems.

The conference consisted of panel sessions to discuss the role of nuclear energy for innovative technologies, applications, and uses. Panelists discussed their perspectives on nuclear energy's role in the international energy community as a clean, reliable and resilient technology and advancements in its integration with other clean technologies.

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Executive summary

The key takeaway from the conference is that the nuclear community needs to innovate if nuclear energy is to be a part of achieving a clean energy future. This innovation must go beyond developing new reactor designs and nuclear technologies. What is needed is a new approach to support nuclear power in contributing to a low-carbon infrastructure. The strategy needs to consider standardization of reactor designs with consistent safety requirements, harmonization of supplier certifications, performance monitoring of nuclear grade system structures and components (SSCs), including a reliable supply chain, and policy support to nuclear energy project financing and export/import trade regulations.

The seven panel sessions addressed many important issues, including:

- Challenges to decarbonization in meeting the Paris Agreement.
- Nuclear energy crossroads and challenges faced by countries backing away from nuclear.
- Energy future and the contribution of nuclear in achieving clean energy.
- Cost-effectiveness/competitiveness of nuclear energy.
- Public perception and confidence in nuclear energy projects.
- Radioactive waste management and disposal – multinational repositories.
- International platforms to strengthen nuclear energy cooperation among countries.

Note: This report was developed from the notes of participants attending the workshop and is not a verbatim transcript. The following summarizes the major themes of the panels, conversations and questions.

PANEL SESSION I:

Nuclear energy's role in transitioning to low-carbon energy systems

The session began with a keynote speech from Kirill Komarov, Chairman of the Board, World Nuclear Association, followed by a panel of five speakers from around the world, moderated by Sarah Lennon of the United States Department of Energy, Office of Nuclear Energy.

The panelists were:

- Cesar Alejandro Hernandez Alva, Senior Energy Analyst at the International Energy Agency;
- Tomoko Murakami, Group Manager, The Institute of Energy Economics, Japan;
- Changxin Liu, Deputy Director-General, China National Nuclear Corporation;
- Mark Nelson, Senior Analyst, Environmental Progress;
- Alfred Ofori Ahenkorah, Executive Secretary, Energy Commission, Ghana.

Kirill Komarov, Chairman of the Board, World Nuclear Association

Mr Komarov's comments centered around a 2016 study by the Massachusetts Institute of Technology on Decarbonization of Power Systems (Sepulveda, 2016); he discussed the actionable goals of the WNA Harmony program. To meet the growing demand for sustainable energy, Mr Komarov noted that we would need nuclear energy to provide 25% of electricity before 2050 (globally) as part of a clean and reliable low-carbon mix. Achieving this means nuclear generation must triple globally by 2050.

The Harmony program is a global initiative of the nuclear industry that provides a framework for action, working with key stakeholders so that barriers to growth can be removed. Mr Komarov also referenced the IPCC 2014 and its discussion of decarbonizing options (IPCC, 2014), while reinforcing the need to include nuclear as one of the important pathways to low-carbon energy systems. His keynote address highlighted key points, including that:

- The pathway to low- or no-carbon energy systems needs nuclear to achieve goals and meet demand.
- The cost of construction will fall with experience, fleet improvements, volume, and manufactured construction rather than on-site custom building.
- Markets must be harmonized to be fair, and the regulatory processes must evolve to effectively meet the change in safety paradigm with new reactors.

Mr Komarov closed with an optimistic view of the opportunities nuclear has to be a large-scale, baseload energy source, although it must be cost-competitive.

Cesar Alejandro Hernandez Alva, Senior Energy Analyst at the International Energy Agency (IEA)

Mr Alva began by referencing *The World Energy Outlook 2010* (IEA, 2010) and reiterated that a strong reliance on efficiency, renewables, carbon capture and storage (CCS) and nuclear energy is necessary to achieve a decarbonized power supply by 2035.

The reduced costs of solar PV and wind make the cost competition fierce among low-carbon technologies. Nuclear has a huge variance in the cost of its energy, at USD 2 800 – USD 6 000/kW, and it can be risky, especially for non-OECD countries. The price of solar energy has fallen to less than USD 100/kW. The current share of wind and solar energy is larger than had been anticipated. The cost of nuclear energy is a strong incentive for non-OECD countries to utilize wind and solar as a large portion of their energy needs, although they still need a baseload source to ensure uninterrupted energy supply. It is expected that the cost of construction will be reduced with experience and fleet improvements. There is a need for fair markets, harmonized regulatory processes and an effective safety paradigm.

Global emissions increased in 2018, yet again. This is not going in the right direction.

The energy sector cannot solve the world's problems alone. Improvements in efficiency continue to add to the decarbonization effort, with a drop of 44% expected by 2040. Another industry that must also address the need to lower carbon emissions is the transportation industry. Much of the transport industry's contribution to decarbonization is expected to come from the adoption of electric and hydrogen vehicles. It is necessary to link the electricity and transportation sectors to achieve decarbonization goals.

Another question to consider is “how long will existing plants last?” Many plants are at risk of early shut down due to market costs and subsidies for alternative energy sources. Right now, the United States and the European Union are reducing the number of their domestic nuclear power plants and their ability to build plants globally, while China is increasing the number of its domestic plants and building more around the world.

When thinking about how we can decarbonize more quickly, a good example to consider is Ontario, Canada. In 2010, Ontario used 26% coal, 40% nuclear and 25% hydropower to generate electricity. By 2017, Ontario had dropped the use of coal to zero, slightly increased hydropower and dramatically increased the use of nuclear energy for electricity. Mr Alva used this case as a realistic example of a path forward.

Tomoko Murakami, Institute of Energy Economics, Japan (IEEJ)

Ms Murakami focused her comments around the key messages that we need efficiency measures, renewable infrastructure and nuclear energy to develop a realistic clean energy system. The fact is that 31 countries use nuclear energy today, providing roughly 10% of the world's energy mix. It is also a fact that many countries are employing renewables because of their low costs and carbon-free generation. However, this leaves a crucial reliability gap.

The *IEEJ Outlook 2019* (IEEGJ, 2018), released in October 2018, outlined three scenarios, including:

- a reference case;
- with advanced technologies and no new coal;
- with carbon capture and storage with hydrogen and nuclear energy.

The conclusion is that nuclear energy and renewables will mostly be introduced in non-OECD countries via technology transfers to create a very different portfolio by 2050.

Larger capacities will be necessary for nuclear energy, to generate the same amount of electricity (due to energy density).

Ms Murakami discussed the 5th Strategic Energy Plan of Japan for 2018 (METI, 2018). It includes an omnidirectional, multiple track scenario approach that aims at energy transitions and decarbonization and must pursue all options including renewables, hydrogen, carbon capture and storage as well as nuclear energy.

Changxin Liu, Deputy Director-General, China National Nuclear Corporation (CNNC)

Mr Liu began his presentation noting the carbon emissions per kWh using slides from the IEA: coal was on top and nuclear energy on the bottom, below solar and wind. China is the world's largest consumer of coal and second largest of oil, but it also leads in working on clean energy. China installed one third of the world's new wind and solar energy capacity, and has the largest nuclear energy program in the world, while coal is being reduced – from 70% to 60%.

Mr Liu's presentation continued on electric fuel sources, stating that China is rich in coal, weak in natural gas; coal will still be the main source, but play a decreasing role in coming years. It is expected that China will have substantial nuclear energy capacity growth (50 GW in operation, 17 GW under construction in 2021; by 2030 150 GW in operation). The China National Nuclear Corporation (CNNC) is the only Chinese conglomerate with a complete nuclear industrial chain – from uranium mining, fuel fabrication, R&D, nuclear power plant construction and operation, decommissioning, waste management and spent fuel reprocessing.

CNNC offers nuclear power plant options of 100, 300, 600, 1 000 MWe, depending upon the regional demand. The focus is on safety, economics and adaptability of the power adaptability. The safety culture has an emphasis on fuel innovation. It is anticipated that a high-temperature gas-cooled reactor (HTGR) will be completed within the coming year. Last year a 600 MW fast reactor started operational tests.

There is a focus on economics that seeks to optimize reactor design to upgrade functionality, reduce costs and shorten construction times while improving safety.

In addition to innovation for better economics, CNNC is adapting to find more markets for non-electric applications including heat, steam, power, desalination and hydrogen production. More provinces in northern China need heating enhancements. Most of these provinces use coal currently and are interested in transitioning to nuclear technology to provide heat. CNNC has already conducted an experiment to provide heating to the CNNC internal facilities with district heating reactor 400.

Development is globalized with many technologies being leveraged with international cooperation, and some technologies are developed by China domestically. There is a growing nuclear market within China.

Mark Nelson, Environmental Progress

Mr Nelson is an environmental advocate with Environmental Progress, a research and policy organization which aims to lift all humans out of poverty and save the natural environment. Environmental Progress is based out of Berkeley, California, United States. Mr Nelson noted that nuclear energy has been somewhat unpopular in the environmental community due to discussions that are often wrong about basic issues in energy. He said that experts who guided discussions in the environmental community were frequently off the mark. He suggested that the “expertise” is not coming from practical experience and is therefore more of an ideal, than a plan.

Mr Nelson noted that there have been a few successful energy transitions, such as in France. He said the French nuclear buildout took the economic implications into account. He said experts often miss the single point of economic viability in addressing energy in the future.

In discussing the global transition to clean energy, Mr Nelson also noted that:

- Energy use and energy demands in rich countries are essentially flat throughout the year.
- Countries often have a very limited view of energy systems in their entirety.
- When energy demand is essentially flat, energy supply should also be flat, but that is not always the case with popular clean energy sources.
- There is an intermittency in renewables – day/night and seasonal variations of supply; seasons are the big issue and nuclear energy solves that issue.

The challenge is that much of the clean energy transition conversation has been about replacing baseload energy with intermittent sources and has not included a carbon-free baseload source. Mr Nelson strongly suggested that true clean energy transition plans must include nuclear power in order to provide the needed energy supply.

Alfred Ofori Ahenkorah, Executive Secretary, Energy Commission Ghana (ECG)

Having a population close to 30 million, Ghana requires a stable, efficient and robust energy system. The energy mix in the country does not currently include nuclear energy. Ghana uses 1% solar; about 45% thermal power plants and over 50% hydropower. Renewable energy resources have potential, but cheap baseload energy is required for industrialization and economic development. The country does not currently have full access to reliable energy and that is necessary for future growth. The energy system transition must account for industrialization goals.

Ghana has many natural resources including bauxite, aluminum, and iron ore. Any energy transition plan needs to account for the industrialization goals, including a trans-regional railway network and the processing of raw materials into finished products. Mr Ahenkorah noted that only one African nation uses nuclear power and that is South Africa. The per capita electricity consumption for Ghana in 2014 was 355 kWh compared to 12 986 kWh in the United States.

In describing Ghana's approach to developing a nuclear power program, Mr Ahenkoraah said the primary question to ask is "Why nuclear?" The answers include that:

- There is a power generation deficit in west Africa.
- There is a need for high baseload for industrialization and economic growth.
- Nuclear power has negligible emissions.
- Nuclear power offers stable costs. Stable energy at a stable price is important for the economic foundation.

Ghana has been developing its nuclear power policy and a roadmap for energy foundations. This strategic policy initiative started in 2008 with the government's decision to evaluate nuclear power. Ghana created NEPIO (Nuclear Energy Power Implementing Organization) in 2012. The Nuclear Regulatory Authority (NRA) which Ghana established by the Nuclear Regulatory Authority Act, 2015 (Act 895) has replaced the Radiation Protection Board of the Ghana Atomic Energy Commission. As of this meeting, an owner/operator had not yet been established, but the foundation process was underway. Important objectives in the foundational plan are to develop manpower, promote plans to introduce nuclear, develop a structured stakeholder engagement plan, and seek public understanding. Both renewable energy and nuclear energy are expected to enhance Ghana's energy security and to serve as important tools for climate change mitigation.

Nuclear energy is suitable and competitive thanks to its economic and environmental advantages and the availability of nuclear waste management technology. Timely implementation of the energy policy will help fulfill the country's industrial and economic goals.

PANEL SESSION 2:

Electricity markets and the nuclear competitive landscape

Panel session 2 featured a diverse panel of interests, including non-government organizations, advocacy groups, government energy representatives and media focused on energy markets.

The panelists were:

- Kirsty Gogan, Executive Director, Energy for Humanity;
- Cesar Alejandro Hernandez Alva, Acting Head of Renewable Integration and Secure Electricity Unit, IEA;
- Miho Kurosaki, Head of Japan and Korea research for Bloomberg New Energy Finance (NEF);
- Ed Kee, Founder and CEO, Nuclear Economics Consulting Group (NECG);
- John Barrett, President and CEO, Canadian Nuclear Association (CNA);
- Zuzana Petrovicova, Head of Unit at European Commission, EURATOM.

Kirsty Gogan, Executive Director, Energy for Humanity

Kirsty Gogan is the co-founder and executive director of Energy for Humanity (EFH), a non-governmental organization (NGO) focused on decarbonization and energy access. Ms Gogan began by making the point that the market for energy is essentially for heat and power and that energy must be competitive in terms of reliability and affordability. However, she also said we face an urgency in terms of the climate, referencing a published report on climate change leadership. She reminded the group that the decision is not about nuclear versus coal, or about nuclear versus renewables – the decision is about creating a reliable, affordable energy system that is also environmentally sustainable.

The United Kingdom's energy production has a carbon intensity of 184 g – and other technologies are pushing coal off the grid (the country has a goal for carbon intensity of < 50 g). Germany is at 429 g carbon intensity, which is far off the target that was established as part of the German National Renewable Energy Action Plan (2020). Therefore, in the pursuit of heat and energy, one must also consider reliability, carbon generation and cost. Nuclear power new build costs are wide-ranging. Ms Gogan said that costs can drop if construction is slowed. She cited Japan, Korea and China. She also noted that low capital costs are being achieved around the world, but questioned whether this is possible with the designs from the United States and Europe.

The reason for the gap in costs has little to do with low labor rates. The countries that are keeping costs low are doing so consistently – by repeating designs and developing best in class practices. The cost of equipment is roughly the same, but indirect services costs and direct financing costs are highly variable. Financing costs go up with perceived risk and the uncertainty of cost and schedule increases in locations that have not built a nuclear power plant in decades. In most instances, we can address capital costs and cost of capital.

Looking beyond the power sector for inspiration, there is currently a disconnect between clean energy decision makers and the nuclear industry. The latest IPCC report has created potential for change by acknowledging the value of nuclear to the clean energy equation (IPCC, 2014).

Ms Gogan said the power sector's product is electricity and heat – not technology and safety, though they are baked into the industry. It needs to hardwire cost reduction into its processes and design decisions. She said the harmonization of international licensing would help increase the transferability of designs. The sector needs to understand the markets' and customers' needs and increase stakeholder awareness on the role of nuclear power in decarbonization.

Cesar Alejandro Hernandez Alva, IEA

“Are our markets ready for the challenge?” is the question posed at the launch of Mr Alva’s discussion. Renewables are enigmatic and enjoy support from most governments and the general public, he said. But the reality is that 53% of energy is generated in countries with wholesale markets. This will increase to 78% when China finishes implementing its power sector reform. It is important to get the market design right and that any energy source meets the actual, not perceived, market needs and parameters.

As decarbonization is a significant goal for many countries, we must consider what is necessary to achieve it, he said. We need to keep existing low-carbon sources, continue to innovate and be realistic about what achieves lower-carbon emission for the electric sector. We also need to keep existing assets, Mr Alva said, noting that 4-16 nuclear power plants will be losing money due to the shale gas revolution.

Some states in the United States are looking at Zero Emissions Credits (ZECs). To make this scheme work the carbon price should be around USD 10-15/tonne CO₂. Whatever the approach to market definition, it needs to adapt wholesale markets to new technologies. The following have been built into the market format to support renewable energy:

- Variable renewable energy (VRE) forecasting.
- Better system operations, such as dynamic generation scheduling; dynamic generation dispatch; dynamic use of grid (update interconnection schedules close to real time; sub-hourly scheduling); reward flexible operation (i.e. making payments for helping the system adapt to VRE, not just paying for MWhs).
- Many markets moving to 5-min level scheduling (vs hour).

To adapt a wholesale market to new technology every resource must be used. Adapting the market means making better use of existing assets, properly represented in markets with efficient mechanisms to procure ancillary services required by the system. In a right-sized market, the selection/combination of low-carbon sources must consider the value, not only the cost.

Mr Alva offered a Mexican Auction Adjustment Factor (Del Rio, 2019) as a technology neutral approach and described the Australian emission guarantee scheme where policy and market frameworks must seek to maximize value for the customer. In summary, he said we should keep advocating for meaningful carbon pricing. In the meantime, use smart – market-friendly – ways to keep existing low carbon sources. Variable renewables are part of the present and future, but energy systems need to adapt existing markets to new technologies. He said we should adapt our existing promotion programs to low-carbon schemes – ones that are technology-neutral and attract the best value for money.

Miho Kurosaki, Bloomberg New Energy Finance (NEF)

Miho Kurosaki is the head of research on Japan and Korea for Bloomberg NEF, providing insight on policy, economics and company strategy in energy markets. Ms Kurosaki’s discussion centered around power markets and nuclear energy’s role. Clean energy investment and annual installations are increasing – clean energy includes renewable energy and energy storage (smart tech). The cost of renewable energy is declining; solar and wind will be the cheapest forms of electricity in most countries by 2030.

The rise and success of renewable energy auctions is driving this adaptation. Future power systems will be renewables-led in an effort to meet carbon emissions goals and to minimize cost of power system. Current models show only 7% of global energy will be powered by nuclear by 2050 and 48% will be powered by wind and solar. Nuclear power is modeled differently due to connections to policy. Regardless, there is a need for sophisticated power market design to support the current nuclear fleet. Despite the market model, a clean, reliable, cheap system should be the goal. Power market design is challenging around the world. Because of cheap wind energy, the United States actually has negative power pricing in some markets. Nuclear power in the United States has modest margins or operates at a loss. Much of the US nuclear fleet is at risk of early retirement (3.5 GW by 2020; 29 GW more at risk). Japan liberalized markets in 2016. Kansai Electric has restarted four reactors and customers came back to use nuclear power.

In order to support nuclear energy, which is regarded as one of a base load sources in Japan, nuclear energy bundled with geothermal, hydro, and coal is offered on a year-ahead basis for the market. In conclusion, the value of nuclear can overcome much, even in a market like Japan.

Ed Kee, Nuclear Economics Consulting Group (NECG)

Mr Kee addressed “Nuclear Power and the Role of Government.”

Merchant generators depend on the market for revenue and are owned by a company. He discussed market structures that work and do not work.

What works: government/regulated reactors:

- Government ownership is similar to CO₂ regulation.
- Nuclear as part of vertically-integrated electric utility structure and should be properly valued within that construct.
- Certainty of revenue (or cost recovery).
- Generation investment is based on long-term planning, often with cost and carbon policy as the drivers.

What does not work: merchant reactors:

- Stand-alone generating companies with financial risk.
- Uncertainty about revenue/cost recovery.
- Impure merchant models: New projects in Turkey (PPAs), Finland (Mankala), and the United Kingdom (HPC CfD support) are not pure merchants.
- Risk model: Companies may have a view of markets for a few years, but these are 100-year assets...the short-term view is a risky venture.

Helping nuclear in market economies (without moving to central planning):

- Avoid electricity markets – create new or modify existing electricity markets to help nuclear remain competitive because of its reliability and low carbon energy production.
- Make nuclear regulated as a government asset – reregulate or nationalize merchant nuclear fleet.
- Provide support for merchant nuclear – ZEC payments, power contracts, clean energy mandates.
- Reward valuable attributes – clean air, reliable long-term operation, fuel diversity, low land use, resilience and other system benefits.

Maybe nuclear energy should be more of a valuable infrastructure asset owned by the government rather than in a market driven utility that is forced to compete with cheaper fuel sources, that have different benefits and drawbacks, but are not a reliable 24/7 baseload source, as well as a national security asset. After all, access to clean, reliable electricity should be an essential asset.

John Barrett, Canadian Nuclear Association (CNA)

Mr Barrett is President and CEO of CNA, he also served as the Canadian Ambassador to the IAEA.

Mr Barrett began his presentation by asking, “How do we put a value on nuclear and clean electricity?”

The NICE Future initiative opens the door to policy makers to consider this question in the context of the need for clean baseload power, while there is a public mandate for renewables based on their image as “clean energy” without consideration for reliable power 24/7.

This scenario opens door to government-industry collaboration to ensure that there is a baseload power source that can be acceptable within a clean energy infrastructure.

This idea often does not make it into the decision-making process. We need industry representatives in meetings such as this.

Secure, reliable energy sources are very important in northern climates. Many locations dependent on diesel and these communities are technology agnostic, they just need reliable power. Because there are many rural cold climate areas, nuclear energy has become a strategic asset for Canada:

- There are 19 CANDU reactors, which provide 15% of Canada’s electricity.
- Canada also supplies more than 70% of world’s nuclear isotopes for cancer treatment.

In Canada, and around the world there is a need to highlight “new nuclear”; this is not 1970s technology and nuclear energy can do many things today that was not possible 40 years ago when the “no nukes” movement was active. Younger generation is inspired by climate change, cancer treatment, and other non-electric applications of nuclear technology. Valuing nuclear energy is an important part of “Ontario Vision 2050: Canada’s Nuclear Advantage” (CNA, 2017). This policy initiative:

- sets a vision for all of Canada’s nuclear industry;
- proposes broad policy goals to be achieved by government and industry;
- SMRs offer distinct pathways that target 3 areas:
 - clean grid power (replacing existing coal);
 - natural resource extraction (heat and power for mining, oil sands);
 - remote communities (replace diesel in 80 communities suited to SMRs).

Canada’s SMR Roadmap is convened by federal government. This process brought together stakeholders, launched last week in Ottawa (conference on small reactors – October 2018) with the following pillars:

- Pillar 1: Demonstration and Deployment;
- Pillar 2: Policy, Legislation and Regulation;
- Pillar 3: Capacity, Engagement and Public Confidence;
- Pillar 4: International Partnerships and Markets.

More information is available at <https://smrroadmap.ca>.

Recommendations summarized include risk-sharing among stakeholders to fund/finance prototypes and demonstrations. He looked forward to a path forward for truly clean and reliable energy systems that includes nuclear energy as the baseload power source.

Zuzana Petrovicova, European Commission, EURATOM

Ms Petrovicova is the Head of Unit, Directorate-General for Energy, European Commission (EC). She began her presentation by discussing the current legislative package under consideration with the EC. She discussed the fact that energy system of tomorrow will look different and clean energy goals will be the driver. Boosting wholesale market flexibility and providing clear price signals to facilitate penetration of regulated energy is required. Regional cooperation is essential, interconnectivity between countries should increase.

Today active consumer participation is part of the decision-making process and consumers want clean energy choices, this is why they are so eager for renewables. Within the current legislative package there are eight legislative proposals under consideration with the goal of clean energy for all Europeans; the “right regulatory framework for post-2020”. The national plans are to be submitted by end of 2018.

The optimal strategy will include a long-term decarbonization strategy. This approach will be put forward this month, before COP24. The approach is consistent with the Paris Agreement. The EC is looking at energy holistically (not just electricity). The 2017 Report – *Nuclear Illustrative Programme (PINIC)* (EC, 2017), outlines the holistic approach and includes expected investments in the EU.

Ms Petrovicova closed by saying that Europe is committed to clean energy and creating an approach that will work for all countries in the EU.

PANEL SESSION 3:

Financing new-build and long-term operation of nuclear power plants

The objectives for panel session 3 include discussing options and new paradigms for financing new reactors as well as long-term operation of the existing fleet. Answering questions like, “What would a successful “private-public partnership” actually look like, or entail?”, “What does industry want or need from government?”, “What are the prospects for financing Small Modular Reactors (SMRs)”?

The session was moderated by Mr Michel Berthélemy, in charge of nuclear energy economics studies at the French Atomic and Alternative Energies Commission (CEA) and Vice-Chair of the “Economics and Energy Strategy” Technical Section of the French Nuclear Energy Society. The session’s panelists were:

- George Borovas, Head of Nuclear at Sherman and Sterling;
- Marcelo Salvatore, Head of Nuclear Technology Assessment at the Undersecretariat of Nuclear Energy, Ministry of Treasury, Argentina;
- Juho Korteniemi, Senior Specialist at the Ministry of Economic Affairs and Employment, Finland;
- Vincent Zabielski, Senior Lawyer at Pillsbury Winthrop Shaw Pittman LLP, United States;
- Boris Arseev, Deputy Director for Development and International Business – Director of International Business Department, Rosatom.

The panelists had a lively conversation that included the major themes around the role of government and the role of industry in creating a foundation and deploying truly clean energy systems that also are reliable 24/7. The panel agreed that it is the role of government to set the vision for outputs of the energy system including specific well-defined and consistent policy parameters to guide valuing various energy sources, and it is the role of industry to develop and deploy a system that executes on that vision and can operate within the policy construct.

There were many thoughts on what the optimal private-public partnership might look like, but a consistent theme is that the government determine the outcome and private industry can compete to develop the design that can meet those goals. Together, government and industry will share the risk in development, demonstration and some aspects of first of a kind deployment. Then, industry will be responsible for ongoing operations within the government-developed construct.

The prospects for financing SMRs was mostly optimistic as the expectation is that small modular reactors would cost less than traditional large reactors, although there are no firm estimates for what those prices would be. The panelists seemed to expect that it would take public financing in the initial phase, but eventually when there several SMRs coming into the market they would increasingly be privately financed.

PANEL SESSION 4:

Nuclear technology beyond electricity generation, hybrid energy systems

The objectives of this session were to increase awareness of the role of nuclear energy in non-electric applications, such as process heat, desalination, district heating and hydrogen production to help decarbonize sectors other than the power sector. The session also discussed the integration of advanced reactors to provide both electricity and heat in future low-carbon energy systems (hybrid energy systems), and their potential to shift economic paradigms.

Mr Henri Paillère, Deputy Head, Division of Nuclear Technology Development and Economics, Head of IFNEC Technical Secretariat, NEA moderated the panel. The panel speakers were:

- Josef Sobolewski, Director of the Department of Nuclear Energy at the Ministry of Energy, Poland;
- Dohee Hahn, Director of the Division of Nuclear Power at the International Atomic Energy Agency (IAEA);
- Shannon M. Bragg-Sitton, Manager of the Systems Integration Department in the Nuclear Systems Design & Analysis Division at Idaho National Laboratory;
- David Blee, President and CEO of the US Nuclear Industry Council;
- Juan Pablo Ordoñez, Deputy Director General at INVAP Applied Research;
- Akira Omoto, Project professor at the Tokyo Institute of Technology, Japan;
- Xingmin Liu, Deputy Chief Engineer of Deep Pool Low Temperature Heating Reactor (DHR, Yanlong), China;
- Zhi Gang, State Power Investment Corporation Central Research Institute, China.

This panel discussed the current and future non-electric applications of nuclear technology. The group focused on the technology applications and tried to paint a picture of how those applications can be beneficial in consumer and industrial environments.

Process heat was discussed as an obvious by product from nuclear power to heat commercial and residential facilities. It can be commoditized to be sold as part of an electricity contract or separately to industrial organizations.

Desalination in areas that are water scarce was an important non-electric use for advanced reactor designs. Africa was a featured location for this technology due to the high number of people without access to electricity and clean water.

Hydrogen production was discussed as a non-electric revenue stream to be sold to transit and other hydrogen reliant industries.

Throughout the conversations, the applications and benefits were clear, the area that is yet undefined are the markets for each of these applications. The panel agreed that it is important to define target users and how they would value and purchase these non-electric applications.

SIDE EVENT:

Millennial nuclear caucus: Nuclear innovations and careers in clean energy

The Japanese and United States representative to IFNEC, along with the NICE Future initiative and the International Youth Nuclear Congress (IYNC) co-sponsored an event for young generation professionals (under the age of 40) and students, as well as IFNEC community. The event was one of the Millennial Nuclear Caucus series designed to start a dialogue with young people to provide facts about nuclear technology, through an engaging, learning, networking program.

The Millennial Nuclear Caucus side event was held at the Tokyo Institute of Technology and had over 100 young people in attendance. The speakers were Suzie Jaworowski, Senior Advisor, Office Nuclear Energy, US Department of Energy; William D. Magwood, IV, Director-General, NEA; Julian Gadano, Secretary of Energy for Nuclear, Republic of Argentina and IFNEC Steering Group Chair; and Dohee Hahn, Director of the Office of Nuclear Power, IAEA.

Each speaker gave a brief presentation about how they developed their careers in nuclear energy and where they see the jobs of the future in the nuclear industry. Students asked questions about the industry and the essentials for developing a successful career. They also reinforced the importance of nuclear energy as a clean energy source for the environment.

The students were very intrigued by the impact of clean energy on the environment but also very interested in the non-electric applications of nuclear. Some students wanted to know what world governments were doing about climate change and integrating nuclear for clean energy systems. The students emphasized the need for sound policy to protect the use of nuclear energy, while also ensuring the ultimate safety and security of the plants.

After the presentation the students mingled with the IFNEC representatives. The students were all from the Tokyo Institute of Technology and they projected very positive impressions about the future of nuclear energy. They were impressed by the high-level leadership from around the world that was gathered to speak with them about the importance of nuclear technology for the world.

PANEL SESSION 5:

Innovation and new developments in the nuclear sector and in other high-tech industries

The objectives of this panel were to review the state of innovation in the nuclear sector and more generally, in the energy sector, and to discuss how the nuclear sector can learn from the experience in other fields of technology.

Mr John Barrett, President CEO, Canadian Nuclear Association facilitated the panel. Panel speakers were:

- Ignacio Peña, Founder of the think tank Surfing Tsunamis;
- Mark Nelson, Senior Analyst at Environmental Progress;
- Shinjiro Takeda, Director of Office for International Nuclear Energy Cooperation and Office for Nuclear Technology and Human Resources, Agency for Natural Resources and Energy at the Ministry of Economy, Trade and Industry, Japan;
- Tong Liu, Chief Designer at China Nuclear Power Technology Research Institute;
- Eric Ingersoll, Managing Partner at Lucid Catalyst.

The panelists agreed that the nuclear energy sector is on the verge of a major transition, between the new designs of advanced reactors and the non-nuclear applications of heat, hydrogen, desalination and flexible energy production. They compared the industry to the communications industry that changed so drastically with the invention of the cell phone, internet, smart phones all converging with the computer and television. They acknowledged that the nuclear transition will not be as personally present with citizens, but it can change their world similarly because of the lower costs of SMRs, the non-carbon energy production during operation, ability to desalinate water and lowered spent fuel – the future of nuclear energy can make the vision for clean energy and 24/7 access a reality.

The group also compared the nuclear transition to the space industry whereas the space industry needs government support, but with the right private sector partners, future nuclear reactor designs can become private assets. Because SMRs and micro reactors will not be as costly and will not take as long to construct, they can be privatized more easily than traditional designs.

The audience questioned the possibility of 100% private development and the panel agreed that this could be a possibility in the future. The examples of communications and space industries provided case examples of how nuclear development can evolve.

PANEL SESSION 6:

Communication and stakeholder involvement to foster a better understanding of nuclear energy's uses (or potential uses) and value

The goal for this panel was to discuss the role of stakeholder involvement, public participation and communication to raise the level of awareness on pros and cons of nuclear energy use and its diverse applications (or potential applications).

Mr Ignacio Peña, Founder of Surfing Tsunamis think tank acted as the moderator for this panel.

The speakers were:

- Kirsty Gogan, Co-founder and Global Director at Energy for Humanity;
- Suzanne Jaworowski, Senior Advisor, Office of Nuclear Energy, US Department of Energy;
- Bum-jin Chung, Professor in the Department of Nuclear Engineering in Kyung Hee University, Korea;
- Collins Juma, CEO of Kenya Nuclear Electricity Board;
- Michel Berthélemy, Vice-Chair of the “Economics and Energy Strategy” Technical Section of the French Nuclear Energy Society.

The moderator posed questions about the need for external communications and how it can impact the development of nuclear power plants. The panelists focused both on broad, consistent public education as well as transparent, direct communications with stakeholders about specific projects.

In the area of external public communications Kirsty Gogan gave great examples of the cultural transition of the environmental movement and how people around the world have realized the critical need for action on climate change. With the climate mandate in mind, Ms Gogan described the renewable revolution and how many environmentalists feel that renewables are the savior of the planet. Most do not understand the need for a baseload source and have a negative perception of nuclear power. She suggested that ongoing communications about the benefits that nuclear power can bring to the world is needed to create a cultural shift to embrace nuclear technology.

Suzanne Jaworowski discussed the approach that the US Department of Energy is taking for nuclear education and outreach. Secretary of Energy Rick Perry has set a goal to “make nuclear cool again” which will be done through an education and outreach program. The educational communications will focus on five channels:

- 1) General public through social media and digital communications.
- 2) The school systems through a k12 curriculum developed in partnership with the American Nuclear Society and the Discovery Education Network.
- 3) Policy makers through an “Atomic Wings” lunch and learn program on Capitol Hill.
- 4) Youth outreach through the “Millennial Nuclear Caucuses” which are networking and educational gatherings being held around the United States and the world.
- 5) Media relations by sending stories of nuclear technology applications to journalists for articles and broadcast coverage in mainstream media.

Collins Juma discussed the need for education about nuclear in Kenya, where there is an effort to bring nuclear power to the country for the first time. He focused on the importance of both direct stakeholder communications and broad public education to make a nuclear energy plant a reality. In the foundation development phase for planning, the government is keeping people informed about what a nuclear power plant will mean to the people of Kenya. He discussed identifying all of the stakeholders even those within the government, industry, educational sector and public.

The panel agreed that the nuclear industry had not “told its story” over the years, and had always been very “under the radar” but in order to evolve and move forward, now is the time to be organized with educating the public and stakeholders about the reality and the benefits of nuclear energy, especially with the need to decarbonize the planet.

PANEL SESSION 7:

Nuclear energy as a pillar for a successful energy transition to low-carbon energy systems

This final session of the conference was designed to wrap up the discussions of the previous panels and highlight the role that innovative nuclear technologies can play alongside other clean energy sources in the transitions to a low-carbon system. The panel reviewed the challenges that need to be overcome for nuclear energy to fulfill that role.

The moderator for this final session was Kirsty Gogan, Co-founder and Global Director at Energy for Humanity. The session speakers were:

- Jean-Philippe Davignon, First Secretary, Embassy of Canada, on NICE Future initiative;
- Francois Storrer, Policy Director, Generation IV International Forum;
- Kenta Horio, Member of the Board, International Youth Nuclear Congress (IYNC);
- Edward McGinnis, Principal Deputy Assistant Secretary for Nuclear Energy at US Department of Energy;
- Julián Gadano, IFNEC Steering Group Chair and Secretary for Nuclear Energy, Argentina.

This panel served as the capstone commentary to summarize the challenges and opportunities that lay before government and industry around the world to continue:

- Research and development efforts to keep nuclear evolving and improving.
- Evolving the regulatory framework to enable the industry to effectively, efficiently, safely and securely provide clean, reliable nuclear energy.
- Developing energy policy that values clean energy that is reliable at all times.
- Telling the world about the benefits of nuclear technology based on facts, not propaganda.

The panel reiterated the groundbreaking technology that is in place today and under development for the future of energy production. An area that was mentioned, which did not have much conversation over the course of the conference was the national security element that nuclear technology provides to a nation. The panel agreed that nuclear energy and nuclear technology are geopolitical assets that can be leveraged between two nations to encourage independence, national security and energy security.

The panel recognized the great work at the science labs around the world in partnering with governments, universities and private industry to create the next generation of advanced reactors. It was also noted that the young generation embraces nuclear as a technology that can solve some of the world's great challenges. It was a very optimistic panel of leaders who are working to bring the promise of nuclear technology to the world.

Closing remarks

IFNEC Chairman Julian Gadano delivered remarks to close the conference. He emphasized the importance of a continuous assessment of the nuclear industry and the need to seize the opportunities to innovate nuclear energy in combating climate change. In a time when climate change is upon us, decision making needs to be based on scientific facts. In this context, he concluded the conference by stressing the urgent need for effective dissemination of nuclear knowledge to the world and in advocating the benefits of nuclear energy and its contribution to our clean energy future.

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THE INTERNATIONAL FRAMEWORK FOR NUCLEAR ENERGY COOPERATION

The International Framework for Nuclear Energy Cooperation provides a forum for cooperation among participating states to explore mutually beneficial approaches to ensure the use of nuclear energy for peaceful purposes proceeds in a manner that is efficient and meets the highest standards of safety, security and non-proliferation.

The 34 IFNEC member countries are: Argentina, Armenia, Australia, Bahrain, Bulgaria, Canada, China, Estonia, France, Germany, Ghana, Hungary, Italy, Japan, Jordan, Kazakhstan, Kenya, Korea, Kuwait, Lithuania, Morocco, the Netherlands, Niger, Oman, Poland, Romania, Russia, Senegal, Sierra Leone, Slovenia, Ukraine, the United Arab Emirates, the United Kingdom and the United States.

The 31 Observer countries are: Algeria, Bangladesh, Belgium, Brazil, Chile, the Czech Republic, Egypt, Finland, Georgia, Greece, Indonesia, Latvia, Malaysia, Mexico, Moldova, Mongolia, Nigeria, Philippines, Qatar, Saudi Arabia, Singapore, Slovak Republic, South Africa, Spain, Sweden, Switzerland, Tanzania, Tunisia, Turkey, Uganda and Vietnam.

NUCLEAR ENERGY AGENCY

The OECD Nuclear Energy Agency (NEA) was established on 1 February 1958. Current NEA membership consists of 34 countries: Argentina, Australia, Austria, Belgium, Bulgaria, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Luxembourg, Mexico, the Netherlands, Norway, Poland, Portugal, Korea, Romania, Russia, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The European Commission and the International Atomic Energy Agency also take part in the work of the Agency.

The mission of the NEA is:

- to assist its member countries in maintaining and further developing, through international cooperation, the scientific, technological and legal bases required for a safe, environmentally sound and economical use of nuclear energy for peaceful purposes;
- to provide authoritative assessments and to forge common understandings on key issues as input to government decisions on nuclear energy policy and to broader OECD analyses in areas such as energy and the sustainable development of low-carbon economies.

Specific areas of competence of the NEA include the safety and regulation of nuclear activities, radioactive waste management and decommissioning, radiological protection, nuclear science, economic and technical analyses of the nuclear fuel cycle, nuclear law and liability, and public information. The NEA Data Bank provides nuclear data and computer program services for participating countries.

The Nuclear Energy Agency serves as technical secretariat to IFNEC.

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