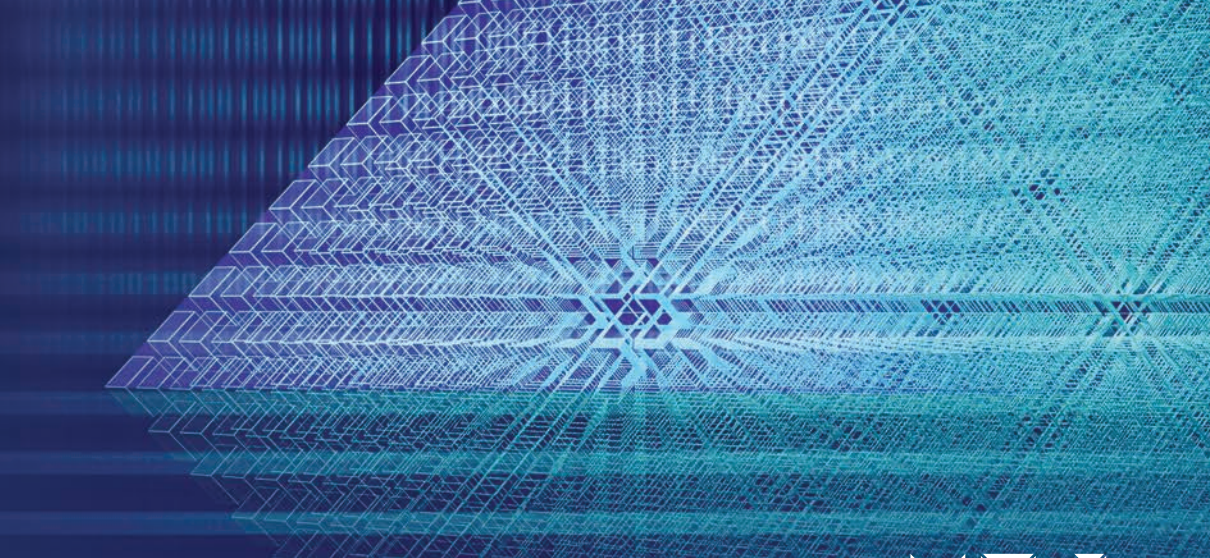

TECHNICAL REPORTS SERIES NO. 491

Member States' Experiences and Insights from Maintaining Safety, Security and Reliable Nuclear Industry Operations During the COVID-19 Pandemic

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MEMBER STATES' EXPERIENCES AND INSIGHTS FROM MAINTAINING SAFETY, SECURITY AND RELIABLE NUCLEAR INDUSTRY OPERATIONS DURING THE COVID-19 PANDEMIC

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IAEA TECHNICAL REPORTS SERIES No. 491

MEMBER STATES' EXPERIENCES AND INSIGHTS FROM MAINTAINING SAFETY, SECURITY AND RELIABLE NUCLEAR INDUSTRY OPERATIONS DURING THE COVID-19 PANDEMIC

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FOREWORD

The ability of the nuclear industry, including facilities and activities involving the use of nuclear and other radioactive material, to continue to operate safely, securely and reliably during special circumstances such as a pandemic depends upon the effectiveness of preparation, response and recovery plans as well as the ability of relevant organizations to adapt to unforeseen situations and respond in a responsible manner. The effective sharing of operating and regulatory experience among the various interested parties worldwide has a positive influence on the response to, and recovery from, a global event such as a pandemic. In 2020, the coronavirus disease 2019 (COVID-19) pandemic caused significant economic and social disruption, posing specific challenges to the nuclear industry. Operating organizations, regulatory bodies and other competent authorities adopted measures to mitigate the impact of the pandemic on the management and safety of facilities and activities while protecting the health of their employees and maintaining essential functions and services.

A review of feedback from Member States regarding operating experience during the pandemic showed that the plans adopted by the operating organizations of nuclear and radiation facilities and activities varied, and that some plans did not address the full range of common considerations, such as the capacity of information technology resources to support remote work, arrangements to ensure continuity of the supply chain and availability of adequate human resources.

The purpose of sharing lessons identified and operating experience with regard to managing and regulating facilities and activities during the pandemic is to assist Member States in considering further actions to improve preparedness and response in relation to the ongoing COVID-19 pandemic and any future pandemics. Operating organizations, regulatory bodies, competent authorities, research and technical support organizations, other authorized parties, contractors and vendors as well as international nuclear organizations are among the key interested parties to benefit from such sharing of experience.

The Commission on Safety Standards requested that this publication be prepared to help address gaps identified in the IAEA safety standards and nuclear security guidance, which currently only establish requirements and provide recommendations on general aspects applicable to pandemics, for example on ensuring sufficient staff for safety, security and reliable operation.

This Technical Report supports Member States in ensuring the safety, security and reliability of facilities and activities by bringing together relevant international experience and good practices in responding to the COVID-19 pandemic.

The IAEA wishes to thank the contributors to this publication for their efforts and valuable assistance. The IAEA officers responsible for this publication

were D. Zahradka of the Division of Nuclear Installation Safety and E. Bradley of the Division of Nuclear Power.

CONTENTS

1. INTRODUCTION

1.1. BACKGROUND

Since the beginning of the coronavirus disease 2019 (COVID-19) pandemic, the IAEA has collected and shared information on the measures taken by operating organizations, regulatory bodies and other competent authorities to ensure the continued safety, security and reliable operation of facilities and the conduct of activities in a manner consistent with the IAEA safety standards, security guidance publications and national regulatory requirements during the pandemic.

The IAEA administers the International Reporting System for Operating Experience for nuclear power plants (NPPs), the Incident Reporting System for Research Reactors and the Fuel Incident Notification and Analysis System for nuclear fuel cycle facilities to collect, analyse and distribute reports from participating countries. These reporting systems remained available to Member States during the COVID-19 pandemic for the sharing of operational experience and reporting of plans established and actions taken to mitigate the impact of the pandemic.

Member States provided information on the pandemic's effects on NPP performance, including details of the scope, schedule and timing of planned outages through the network of data providers linked to the IAEA's Power Reactor Information System.[1] The country nuclear power profile resources were used to gather, collate and summarize open source information related to the pandemic's influence on operating NPPs as well as on advanced new build projects. The scope of this effort extended to effects on the supply chain and NPP operation as a result of the decline in electricity demand.

Through its Technical Working Group on NPP Operations, the IAEA rapidly developed and piloted an international peer to peer network called the NPP COVID-19 Operating Experience Network. This network was established for the sharing of information and experience among operating organizations, regulatory bodies, technical support organizations, international nuclear organizations and other interested parties. While the focus was on the safety performance of operating NPPs and the effects on electricity markets, new construction projects were also taken into account.

The IAEA also set up a webspace for research reactors, sharing information on the status of the research reactors and the mitigation measures being

[1] The Power Reactor Information System database is available at https://pris.iaea.org/PRIS/home.aspx.

implemented. The IAEA also reached out to the national coordinators of the Fuel Incident Notification and Analysis System to collect and share experience from the operation and regulation of nuclear fuel cycle facilities during this period.

Information on the pandemic's effect on training activities and human resources policies, gathered through the IAEA's Technical Working Group on Managing Human Resources in the Field of Nuclear Energy, was shared in the Nuclear Energy Capacity Building Hub hosted on the NUCLEUS platform and discussed at a special Technical Working Group Meeting.

The International Network for Nuclear Security Training and Support Centres (NSSC Network) was established by the IAEA in 2012 to facilitate cooperation, identification of best practices and sharing of information among Member States with a Nuclear Security Support Centre (NSSC) or those interested in developing one. A survey of the NSSC Network members was conducted to better understand the ramifications of COVID-19 on the role and functions of NSSCs and to share related good practices. Of the 64 NSSC members invited to participate, 42 responded, with many providing details on how the COVID-19 pandemic had affected their nuclear security core functions and how members had mitigated the effects.

In addition, the IAEA conducted a survey of radiation safety regulatory bodies with the objective of gaining a firsthand overview of the effect of the COVID-19 pandemic on the safety of radiation sources and their regulatory oversight. The survey was launched in April 2020, and responses were received from 93 regulatory bodies.

In October–November 2020, the IAEA also conducted a survey through the Emergency Preparedness and Response Standards Committee to assess the impact of the COVID-19 pandemic on the emergency preparedness arrangements and capabilities of Member States. Thirteen detailed responses were received.

This Technical Report summarizes the information gathered during the period from March 2020 to March 2021, in the form of operating experience and lessons learned, for the benefit of Member States in responding to pandemics. The information was reviewed by a team of experts from the IAEA, regulatory bodies, operating organizations, competent authorities and other authorized parties.

The IAEA continues to collect information on the ways the pandemic affected facilities and activities through its various reporting systems.

1.2. OBJECTIVES

The objectives of this Technical Report are to:

(a) Describe the impact of the COVID-19 pandemic on human capacity, essential functions and services, the supply chain, electricity markets and nuclear power programmes in Member States, with regard to the operation and regulation of nuclear and radiation facilities and activities.
(b) Summarize the strategies and approaches developed by various interested parties (operating organizations, regulatory bodies, competent authorities and other authorized parties, including contractors and vendors) in Member States and by international nuclear organizations to support their members, in order to manage the risks posed by the pandemic and ensure safe and reliable continued operation of facilities and conduct of activities.
(c) Share identified good practices, operating and regulatory experience, and lessons learned to promote the enhancement of plans for pandemic preparation, response and recovery. The lessons learned during the COVID-19 pandemic may also be useful during other global scale unexpected events that affect human health and wellbeing.

The intended audience of the publication includes operating organizations, regulatory bodies, international nuclear organizations, competent authorities and other authorized parties for nuclear and radiation facilities and activities, including technical services providers, contractors and vendors.

Guidance provided here, describing good practices, represents expert opinion but does not constitute recommendations made on the basis of a consensus of Member States.

1.3. SCOPE

This Technical Report considers the implications of the pandemic for the following areas:

(a) Safety, security and reliable operation of various types of nuclear and radiation facility;
(b) Safe, secure and reliable conduct of activities involving the use of nuclear and other radioactive material;
(c) Performance of functions of regulatory bodies;
(d) Emergency preparedness and response;
(e) Sustainability of the supply chain;

(f) Supply of radioisotopes;
(g) NPP construction projects;
(h) International cooperation;
(i) Communication and engagement with interested parties.

Information is provided about experience in conducting specific activities in response to the pandemic. These activities include:

— Maintaining essential functions in regulatory bodies (e.g. authorization, enforcement, inspection), operating organizations (e.g. safety, emergency preparedness and response, security), competent authorities and other authorized parties (e.g. production of radioisotopes and use of nuclear and other radioactive materials);
— Ensuring adequate staff coverage on the site and through remote work;
— Planning and implementing maintenance and outages;
— Implementing physical distancing and disinfection and hygiene measures;
— Ensuring sustainability of essential supply chain and inventories;
— Ensuring the continuation of major refurbishment, life extension and new build projects;
— Adapting to the effects on energy demand and markets (e.g. reduction in electrical power).

In addition, case studies are presented that highlight specific measures and special arrangements undertaken by several contributing Member States and international nuclear organizations. A template was provided to contributors for the sake of consistency and was structured as follows:

(1) Background (e.g. concise information about the organization, its member base, traditional support mechanisms).
(2) Impact of the pandemic (i.e. how the pandemic manifested itself via perceived or actual risks as well as real implications — for the organization as well as the members it serves).
(3) Mitigating actions and their effectiveness, including the role of the contributing State or organization:
    (i) Immediately;
    (ii) In the interim period;
    (iii) In the long term.
(4) Interactions with peer international or regional organizations, especially where novel engagements were developed to address evolving needs.
(5) Recovery (as appropriate — actual or planned).
(6) Conclusions.

Information and experiences collected from Member States and international nuclear organizations between March 2020 and March 2021 and during the Technical Meeting held on 7–8 July 2021 are presented in the annexes.

1.4. STRUCTURE

The report is structured into eight sections and three annexes, as follows.

Section 2 describes the effect of the COVID-19 pandemic on the continuity of safety, security and reliable operation of facilities, conduct of activities and performance of regulatory functions, as well as its influence on energy demand and markets, together with other implications for nuclear power programmes and the peaceful applications of nuclear technology.

Section 3 describes the strategies and approaches developed to manage the effects of the pandemic on operating organizations, regulatory bodies and other authorities and bodies, as well as on the supply chain.

Section 4 provides a summary of operating experience in planning, organizing and applying COVID-19 prevention and mitigation measures to ensure that essential personnel were available and protected, that the crucial supply chain was functional and that necessary changes in work practices did not create excessive challenges in decision making and maintaining organizational resilience.

Section 5 provides a summary of regulatory body experience in responding to the pandemic in terms of adjusting compliance oversight activities and developing strategies for implementing the essential regulation of licensed facilities and activities.

Section 6 provides a summary of the experience of international nuclear organizations in maintaining cooperation, exchanging information and sharing best practices to support members' implementation of prevention and mitigation measures during the pandemic.

Section 7 summarizes the lessons learned so far from the pandemic, related to prevention, mitigation and control of COVID-19 outbreaks in Member States' nuclear facilities and activities.

Section 8 provides concluding remarks on some of the challenges that will have to be examined and addressed effectively to minimize the potential consequences of any future pandemics on the safety, security and reliability of nuclear and radiation facilities and activities.

Annexes I, II and III contain case studies from Member States and international nuclear organizations, respectively, that highlight the specific activities and measures undertaken in responding to the COVID-19 pandemic.

2. IMPACT OF COVID-19 PANDEMIC ON OPERATION OF FACILITIES, CONDUCT OF ACTIVITIES AND PERFORMANCE OF REGULATORY FUNCTIONS

The COVID-19 pandemic presented potential adverse consequences for the operation of nuclear and radiation facilities, the conduct of activities and the performance of regulatory functions. Member States reported consequences or concerns related to the effects of the pandemic on human capacity and the supply chain, in particular for large scale activities such as planned outages, major refurbishment of nuclear facilities and new builds, as well as the economic impact on markets, specifically for electricity and radioisotope production.

2.1. IMPACT ON PERSONNEL AVAILABILITY

A primary concern for both operations and regulatory functions was personnel availability. There were four main reasons for a sudden and significant reduction in personnel availability during the pandemic in all industries globally:

(a) Personnel absence — workers were absent from work due to illness, quarantine, self-isolation, family obligations or the furlough of non-essential personnel.
(b) Personnel underperformance — workers were present but underperforming due to isolation (e.g. resulting from physical distancing measures or limitations on number of people present), mental health issues or stress (e.g. resulting from school closures combined with working from home or fear of infection).
(c) Personnel mobility — personnel, including contractors, regulatory inspectors and service providers, were affected by travel restrictions and lockdowns.
(d) Shifting service priorities — personnel were redirected from everyday tasks to more urgent areas. An example from the COVID-19 pandemic was medical staff in radiotherapy and nuclear medicine facilities who were moved to assist with COVID-19 patients. This resulted in the postponement of treatments, with workloads expected to increase after the end of the crisis.

Reduced availability among essential personnel at both operating organizations and regulatory bodies could increase risks to safety and security, reduce emergency response capabilities or disrupt normal operations.

2.2. IMPACT ON OPERATION OF NUCLEAR AND RADIATION FACILITIES

Some of the more immediate effects on operations at nuclear and radiation facilities during the COVID-19 pandemic were due to a reduction in face to face availability of personnel.

While this reduction was prudent when the pandemic initially struck, there was a cascading adverse effect on nuclear facility processes that had the potential to affect operations as more people worked remotely for a prolonged period. Remote work requires reliable hardware, necessary information technology (IT) security, stable internet connectivity, suitable applications and acquired skills. At the onset of the COVID-19 pandemic in particular, there were issues with all of these requirements.

In addition, remote work resulted in a decline in face to face teamwork, with a potential adverse effect during situations when timely and clear communication was needed, such as during abnormal conditions or situations that required prompt team brainstorming, analysis and decision making. However, there were some working activities that could be performed more conveniently and more easily from home or remotely.

Details concerning the results of the COVID-19 pandemic on operations at specific types of facilities and on the transport of nuclear and other radioactive materials are provided in the subsections below.

2.2.1. Nuclear power plants

Organizations that supply contractors, site services and auditing, inspections, testing and other types of verification to support the operation of NPPs were severely affected by mobility problems. The reduced availability of external technical services and contractors had a direct effect on construction projects, planned outages and maintenance of systems and components. In some Member States, internal and external oversight bodies (e.g. nuclear safety review boards, national regulatory bodies, the IAEA) were no longer able to perform in-person reviews at the NPPs.

In some cases, contractors with special skill sets (e.g. testing, inspection, installation and commissioning of special equipment) were able to gain access to sites by negotiating special conditions with the authorities or by using private transport (e.g. charter flights).

In other cases, verifications and audits that did not necessitate local presence were carried out virtually. Where local presence was necessary, a hybrid approach — a combination of in-person attendance and virtual participation — was used to minimize the number of persons travelling. Such

practices are expected to continue in some form after the pandemic ends and may become part of the 'new normal'.

2.2.2. Nuclear fuel cycle facilities

Nuclear fuel cycle facilities that were identified as providing non-essential services (e.g. nuclear fuel cycle research and development facilities) initiated a precautionary safe shutdown of production operations in anticipation of challenges in maintaining an adequate workforce.

As the nuclear fuel cycle facilities at the front end of the nuclear fuel cycle (e.g. conversion, enrichment and fuel fabrication facilities) supply fuel that is needed for NPP operations, they were identified as providing essential services. The immediate response in the first two months of the pandemic (March–April 2020) was to limit operations to the bare minimum to keep workers safe; later, when the situation stabilized, operations were resumed with a progressively increasing rate of production. In some cases, nuclear fuel cycle facilities at the back end of the nuclear fuel cycle (e.g. spent fuel storage facilities) were also categorized as essential facilities for keeping NPPs functional.

Member States reported that, despite lockdown conditions and travel restrictions, essential fuel and other supplies continued to be delivered to reactor sites through effective coordination among those responsible for production, security, and medical and radiological safety at reactor sites and local authorities; all of this was carried out in compliance with government and regional guidelines (e.g. quarantine).

Waste treatment activities in a number of nuclear fuel cycle facilities were temporarily suspended, and waste producers were requested to reduce transport of waste to the waste treatment facilities. Nuclear fuel cycle facility sites maintained their waste storage capacities. One Member State reported that work at a fuel encapsulation plant for waste disposal had been delayed because ventilation and pumping systems had not been delivered.

2.2.3. Radioisotope production facilities and research reactors

Most radioisotope production facilities continued operations during the COVID-19 pandemic, although some were shut down temporarily. Radioisotope production was declared to be an essential service, and almost all research reactors producing large quantities of radioisotopes continued to operate, albeit at a lower production rate. The reduction was in response to decreased demand because of postponed medical procedures as well as supply delays due to transport bottlenecks. However, one Member State reported an increase in production rate to meet the local demand for radioisotope production.

The Nuclear Medicine Europe Emergency Response Team monitored the situation concerning global production of ^{99}Mo and other radioisotopes at six research reactors (the Open Pool Australian Light Water Reactor in Australia, Belgian Reactor 2 in Belgium, the LVR-15 research reactor in the Czech Republic, the Petten High Flux Reactor in the Netherlands, the MARIA research reactor in Poland and the SAFARI-1 reactor in South Africa) and coordinated the adjustment of production to cope with changes in demand. Some research reactors at universities and research institutes were temporarily closed in many Member States.

2.2.4. Other facilities

The continued functioning of nuclear and radiation facilities that were considered to be part of critical national infrastructure, such as medical and certain industrial facilities, was reported by almost all regulatory bodies. Member States continued their production of radiopharmaceuticals, management of disused sources, research activities and security checks. Technical services (e.g. dosimetry, monitoring, calibration, emergency response, return of disused sources, training) were often provided at a reduced capacity, especially those coming from other countries. Additionally, due to COVID related logistical and supply chain issues, some Member States practised recycling and conditioning activities to extend the life of radioactive sources in key applications. In some Member States, the use of radiation sources for the sterilization of protective equipment, veterinary, educational and dental purposes, and the use of gauges was continued during the pandemic crisis.

2.2.5. Transport of nuclear and other radioactive material

The transport of radioactive sources was disrupted, with many Member States reporting delays in shipments, including of radiopharmaceuticals and industrial radiography devices, and delays in the return of disused sources to the supplier. More than half of the Member States reported the temporary shutdown of radiation facilities and suspension of activities involving radiation sources. Movement restrictions on certain sources (e.g. industrial radiography devices used to examine the condition of welds in pipelines) might lead to industrial safety problems. Some Member States began developing durable compensatory measures for disruptions in the transport of radioisotopes and radiopharmaceuticals.

2.3. IMPACT ON SUPPLY CHAIN

The supply chain was also affected by personnel availability, government lockdown rules, travel restrictions and border closures. As a consequence, some suppliers could not ensure the continuity of their support to nuclear facilities. In particular, this affected contractors with specialist skill sets, such as third party testing and inspections. Another consequence was the inability of operating organizations to perform their usual on-site, in-person quality assurance activities at supplier facilities due to travel restrictions and physical distancing.

Delays and shortages in the supply chain had direct and immediate implications for operations. While many facilities were ready to manage the situation because of robust supply chains and on-site inventory, facilities that had not already done so had to analyse their supply chain promptly to mitigate disruptions.

Interruptions in the supply of consumables, such as oil for emergency diesel generators, gases, chemicals and critical spare parts required for continued, reliable plant operation could have affected the availability of systems, structures and components and resulted in the shutdown of operations.

Personal protective equipment (PPE) such as gloves and appropriate masks (e.g. FFP2), as well as disinfectants and paper towels, are standard supplies for nuclear operations. During the pandemic, PPE suppliers experienced an increase in demand and had to adapt their production and delivery capabilities. Additional challenges were posed by stricter customs requirements. As a result, delays led to local shortages of PPE in some cases.

The operating organizations delivering essential nuclear fuel cycle services (fuel fabrication, spent fuel storage, radioactive waste predisposal) took immediate actions to mitigate the potential ramifications of these delays and shortages, for example by packing and transporting fuel to NPPs and ensuring an adequate inventory of spare equipment (e.g. high efficiency particulate air (HEPA) filters) and consumables (e.g. chemicals), by way of urgent procurement or redistribution of items available within the facility for different purposes or at other locations. In some cases, fuel supply delivery schedules were adjusted in response to financial problems as a result of non-payment by the buyers of electricity supplied by the company.

Some NPPs that were under construction were also affected by delays in the supply chain, which reduced the availability of materials, labour and specialists, thereby resulting in delays to the associated construction schedules.

2.4. IMPACT ON ENERGY SUPPLY AND DEMAND AND ECONOMIC IMPACT

Market fluctuations in the demand for and supply of energy affect the financial resilience and economic viability of operating organizations. During the COVID-19 pandemic, personnel furloughs for prolonged periods, restrictions on economic and social activity and business closures were economic disruptions that triggered a significant drop in energy demand, which led to falling wholesale electricity prices, and in some cases led to requests from grid operators to reduce the power output of NPPs to ensure grid stability.

The International Energy Agency Electricity Market Report — December 2020 [1] on the impact of the COVID-19 pandemic on electricity markets indicated that global electricity demand in 2020 was projected to fall by around 2%; specifically, nuclear power generation was set to decline by around 4% in 2020. Loss of revenue as a result of the pandemic might dramatically affect the industry's response, recovery and future.

According to Standard and Poor's mid-year update [2], the large price drops in Europe were due to unusually warm weather in 2020, increased supply from renewables and carbon dioxide allowances. Such low prices further exacerbated the challenging environment faced by many electricity generators, including NPPs.

Due to the significant decrease in electricity demand, many generators had to reduce their overall output significantly. Several grid operators announced a reduction in their revenues due to the reduction in electricity demand. Nonetheless, the competitiveness and resilience of low carbon technologies resulted in higher market shares for nuclear and other low carbon sources of power in many countries during the lockdown phases. Nuclear power generation was reduced by only 2% overall (4% in 2020). In some countries, coal fired electricity generation saw a significant decline for a period of several months.

Nuclear power generation proved to be resilient, reliable and adaptable. Licensees adapted quickly to the change in electricity demand. Some grid operators curtailed nuclear power generation sporadically to secure electricity supply for consumers. The benefits of these higher shares of clean energy in terms of reduced emissions of greenhouse gases and other air pollutants were observed worldwide over several months, particularly around large metropolises.

2.5. IMPACT ON REGULATORY FUNCTIONS

During the COVID-19 pandemic, the majority of regulatory bodies were unable to implement their planned full scope oversight programmes. In most

cases, regulatory bodies significantly reduced personnel on their premises and in site offices, with only critical personnel working from the office as a preventive measure. Inspectors, including resident (site) inspectors, worked from home and continued to have access to licensed facilities as needed to respond to events or emergencies. In some Member States, regulatory bodies conducted only important or critical inspections, using remote and virtual methods when possible. Field activities for site personnel resumed after a brief initial hiatus (following a risk evaluation), particularly where face to face interactions with licensee personnel could be minimized.

National regulatory processes involving engagement with interested parties proved to be very lengthy in a lockdown situation. Some regulatory bodies put the development of certain regulations and guides on hold, whereas others reported active work on national regulations.

Another concern was the cancellation of training events for radiation source users and radiation protection experts. Regulatory bodies reported that converting training into a remote format involved significant effort.

The stretching of government infrastructure capacity, including the capacity of regulatory bodies, could also potentially have an effect on emergency preparedness and response in relation to nuclear and radiation facilities.

3. PANDEMIC STRATEGIES AND APPROACHES

Prior to the COVID-19 pandemic, most operating organizations, regulatory bodies and other relevant organizations and authorities in Member States had already developed business continuity plans designed to ensure the safety, security and reliability of operations in case of an unexpected or unprecedented event. These business continuity plans typically included pandemic plans, which built on lessons learned from previous pandemics (e.g. influenza A (H1N1) in 2009). With the onset of the COVID-19 pandemic, these plans were implemented, adapted and amended to address specific immediate and emergent needs as the pandemic evolved. Where there were no previously developed plans, these were developed promptly after the pandemic outbreak.

Generally, business continuity plans provide for a full range of events besides a pandemic, including extreme adverse weather conditions (e.g. hurricanes), terrorism, and other external and internal hazards. These plans include the identification and prioritization of essential functions, services and personnel, and measures to ensure the security of the supply chain for consumables and spare parts needed for the operation of nuclear facilities. In

addition, business continuity plans cover the delegation of authority and internal and external communication.

The essential functions needed to sustain operations during a pandemic, as identified by Member States, include the following:

— Emergency preparedness and response;
— Control and supervision of operations;
— Inspection, maintenance and testing (priority based on importance for continued safe, secure and reliable operation);
— Outage management (in some cases postponement within applicable limits);
— Personnel planning, training and qualification to support operation, maintenance and emergency preparedness and response;
— Ensuring compliance with operating rules and licence conditions;
— Site security;
— IT support (maintaining vital IT systems and remote work);
— Management of essential supply chain and inventories;
— Quality assurance (e.g. work management system, vital records);
— Logistics (e.g. transportation, catering).

Typically, one of the first priorities in a pandemic is to convene a response management unit (comprising management response teams) that applies good practices from lessons learned in domestic or international events. The teams assess pandemic hazards and actions to be taken and monitor changes in line with national, regional and international protocols in order to develop contingency plans aligned with the pandemic action level (e.g. based upon World Health Organization alert phases for the local pandemic) that may affect the continuity of operation.

It is good practice to prioritize the identification of essential activities and personnel and to establish virus prevention and mitigation measures. Activities to optimize human capacity while minimizing risk of transmission can then be implemented (e.g. reducing the number of operating personnel, work from home arrangements for non-essential staff, reducing the contractor presence on-site, physical distancing measures, applying hygiene protocols as required by the national or local health authorities).

Experience shows that strong leadership backed by effective, transparent and timely communication ensures a sustainable organizational culture with high morale during pandemic conditions. Special attention needs to be paid to the cumulative effect of temporary changes in work arrangements on human performance. The stress generated by the pandemic itself and by modifications to work processes can lead to challenges in accurate information flow and decision

making and to mental and physical fatigue. Therefore, many organizations include leadership strategies to manage such effects in their pandemic response plans.

3.1. OPERATIONS — PANDEMIC STRATEGIC PLANNING

The mandate of operating organizations of nuclear and radiation facilities is to ensure the safety, security and reliable production of goods and provision of services such as electricity production and grid stability (at NPPs), nuclear fuel fabrication (at nuclear fuel cycle facilities) and the production of radioisotopes (at radioisotope production facilities).

Although most of the information provided in the following sections originated from the operating organizations of NPPs (or sometimes specific radiation facilities), the operating experience and good practices shared can be applied to all activities involving the use of nuclear and other radioactive material.

3.1.1. Business continuity plans in operating organizations

The overall objective of various business continuity plans adopted by operating organizations and other authorized parties is to ensure the continued safety, security and reliable operation of facilities and the conduct of activities consistent with international standards (e.g. IAEA safety standards), industry standards and national regulatory requirements. Activities include day to day operations as well as planned outages and major construction projects (e.g. life extension or refurbishment projects).

Given the expected duration and potential multiple waves of the COVID-19 pandemic, operating organizations reviewed and adapted their strategies for carrying out essential functions to develop or improve plans that would mitigate the effects of the pandemic while maintaining continuous safety, security and reliable operations. Some operating organizations reported that a pandemic response organization and plans had been established in the early stages of the pandemic.

3.1.2. Response management unit

Operating organizations typically convene a response management unit comprising dedicated teams to manage and oversee the following activities:

(a) Activation of the pandemic response plan applicable to the local situation at the nuclear facility and in the region or country;
(b) Daily monitoring of the situation and evaluation of the potential risks;

(c) Prevention and mitigation of spread of the virus;
(d) Reallocation of human and material resources to ensure the continuation of essential services;
(e) Communication with all staff members, contractors and authorities under pandemic conditions.

Typical roles and responsibilities assigned to the members of the response management unit are as follows:

— Senior managers — secure resources, monitor the effectiveness of the plan and adjust or prioritize countermeasures when necessary;
— Emergency preparedness and response team — support the development and maintenance of the pandemic response plan, ensure that on-site emergency preparedness and response arrangements and capabilities continue to be met in the context of pandemic response activities and coordinate with off-site response organizations on any changes to arrangements or capabilities;
— Safety team — coordinate and oversee the implementation of the pandemic response plan and virus prevention and mitigation activities;
— Medical health team — collect pandemic related information from official channels; assess the infection risk level of staff, track epidemic prevention and control requirements of governmental departments, manage occupational health and epidemic prevention health archives, follow up suspected or confirmed cases and interface with local public health departments and medical institutions;
— Human resources team — act as coordinator between safety and security to ensure minimum staffing requirements;
— Materials supply team — ensure availability of inventories and materials needed for safe operation or outage of the facility and special materials related to virus prevention in the plant;
— Logistics team — take responsibility for logistics in the facility;
— IT team — provide information security, infrastructure and software support to allow for remote work and other IT support for the response to the pandemic;
— External interfacing teams — communicate with local government, regulators, headquarters, critical infrastructure organizations (e.g. electric grid operators) and suppliers to ensure that all reasonable measures are taken.

3.1.3. Delegation of authority

Pandemic response plans include guidance on delegation of authority to ensure a formal chain of authority to lead and manage operations during a pandemic. This ensures that specific actions are taken in a timely manner and establishes the level in the organization at which they are taken and under which conditions. A formal delegation of authority process is undertaken when any member of essential personnel is unable to perform their duties (e.g. due to quarantine, on-site staffing changes, symptoms or a positive test). If such a situation occurs, the pandemic response plan includes guidance on how to ensure that replacement personnel are able to perform functions at a sufficient level to maintain the continuity of safe and secure operations.

3.1.4. Emergency preparedness and response strategies

In some Member States, the emergency preparedness and response plans include guidance to perform just in time drills during indications of a potential pandemic to prepare for a lack of available first responders and to assess capabilities to conduct emergency operations during different pandemic phases, such as the ability to staff emergency response facilities and the ability of law enforcement to respond to off-site emergencies.

3.1.5. Pre-pandemic planning for supplies and logistics

Planning for and acquisition of supplies by the operating organization is a crucial aspect of surviving a pandemic without the loss of business continuity. Through this activity, the operating organization ensures a reliable supply chain for critical support by assessing needs and stockpiling non-perishable consumables as needed at the start of the pandemic. Key areas for supply chain consideration in pre-pandemic planning are as follows:

— Operational consumables and spare parts — consumable procurement as per normal on a just in time basis may not be possible under pandemic circumstances;
— Unique equipment or items associated with a pandemic, such as appropriate masks, gloves and disinfectants;
— Support for employees sequestered in situ — this is more relevant to extreme weather conditions such as hurricanes or flooding, during which a large number of employees may be retained at the site for extended periods of time;
— Medical supplies and facilities for critical or essential employees.

3.2. REGULATORY FUNCTIONS — PANDEMIC STRATEGIC PLANNING

The mandate of regulatory bodies is to ensure that the health and safety of the public and the environment are protected. Regulatory bodies have organizational and technical measures in place to ensure that, in a pandemic, any safety and security activities conducted during the operation of the facilities are in adherence with the requirements of the national regulatory bodies and authorities.

3.2.1. Business continuity plans in regulatory bodies

Most regulatory bodies have business continuity plans for maintaining their regulatory functions and fulfilling their mandates. The business continuity plans are primarily based on the identification and execution of essential compliance and verification activities to ensure continuous safe and secure operation of the regulated facilities. These plans include strategies to accomplish the following:

- Ensure the health and safety of regulatory personnel by implementing appropriate physical distancing measures, minimizing physical presence at the headquarters and regional offices and using protective equipment;
- Identify critical regulatory oversight and verification activities;
- Strengthen and enhance remote communication with operating organizations to enable personnel to work remotely when appropriate;
- Approve requests from licensees and operating organizations for regulatory flexibility and relief (temporary waivers) in meeting regulatory commitments while ensuring no reduction in levels of defence in depth for nuclear safety or security through the application of a risk informed approach in regulatory decision making;
- Develop special procedures and innovative means for the conduct of regulatory oversight activities such as remote inspections and personnel authorization processes.

3.2.2. Risk informed decision making and regulatory relief

Risk informed approaches to regulatory decision making have been developed in recent decades to supplement the regulatory framework through a more methodical assessment of risk. The approach represents a methodology whereby risk insights are considered together with other factors to establish requirements that better focus licensee and regulatory attention on design and operational issues commensurate with their significance to radiological risk.

In the case of a pandemic, the risk informed decision making approach is applied in order to evaluate requests from operating organizations for temporary relief from regulatory requirements (also referred to as temporary waivers). In some cases, the regulatory body's strategy includes convening a pandemic response team to evaluate such requests in a risk informed manner to ensure continuous safe operations during the pandemic.

Examples of areas in which operating organizations may apply for regulatory relief to support their critical functions include the following:

— Licence amendments and implementation of compensatory measures;
— Implementation dates for new standards;
— Acceleration of regulatory reviews for certain applications;
— Maintaining operator qualifications with no requalification training over a longer period than the specified time interval;
— Extension of examination cycles to allow more time to conduct certification and requalification testing;
— Requirements for physical and medical testing;
— Equipment and surveillance testing intervals (risk informed maintenance intervals) beyond the technical specification limits;
— Deferral of commitments such as planned maintenance outages, execution of design modifications, safety upgrades and refurbishment activities;
— Deferral of generic or regular submissions such as weekly or quarterly reports.

4. OPERATING EXPERIENCE IN RESPONDING TO THE COVID-19 PANDEMIC

Member States reported a number of specific responses to the pandemic to maximize personnel availability and capacity, to prevent and mitigate the spread of the virus and to manage work to mitigate the impact on the safety, security and reliability of their facilities and activities.

Existing pandemic response plans containing general responses and identifying the impact on existing procedures and work instructions were updated using the corporate and/or site document change control processes and then authorized by the appropriate corporate and/or site authorities. These response plans were made available to staff, regulators and contractors.

In some Member States, operating organizations analysed their requirements and worked with regulatory bodies to obtain regulatory relief related to staffing matters, such as working hours and shift complements. Operating organizations,

regulatory bodies and off-site response organizations also took measures to ensure the continued availability of both response personnel and facilities in case they were needed in a nuclear or radiological emergency.

4.1. PROTECTION OF ESSENTIAL PERSONNEL AND ENSURING PERSONNEL AVAILABILITY

During the COVID-19 pandemic, most measures taken by operating organizations focused on minimizing potential transmission of the virus among personnel by physical distancing. Examples of the measures taken included limiting personnel gatherings such as face to face meetings, training sessions or workshops; marking safe distances in common areas (e.g. elevators) and reorganizing office spaces; allowing working from home for personnel in vulnerable categories (e.g. pregnant women, the elderly, those with certain illnesses); maximizing the use of video and audio communication tools; and minimizing the use of paper to avoid physical interactions. Personnel working from home remained available to go to the workplace should their physical presence be needed for any justified reason.

Personnel duty travel and on-site visits to facilities by external organizations and visitors were restricted in the early stages of the pandemic. Most facilities mandated quarantine measures for employees returning from outside the country.

Various distancing measures were implemented at facility access points, including restricting the number of access points into the protected and inner or vital areas to the minimum necessary; appropriately securing the points of potential access (including contactless security procedures); minimizing the entry of vehicles or limiting them to designated parking areas; maintaining appropriate signage and marking on entry lanes to maintain physical distancing; verifying the identity of authorized persons entering the protected or inner or vital areas and ensuring their adherence to the appropriate prevention, hygiene and physical distancing measures within; ensuring physical distancing at visitor badge issuance and waiting areas; minimizing access to central alarm stations; and using intercoms to communicate physical distancing measures.

Special distancing arrangements were introduced in common areas such as cafeterias, for example limiting the number of personnel using the cafeteria at the same time or organizing meal delivery to personnel.

To maximize the capacity of workers while isolating them from the virus, in some cases essential personnel were provided with exclusive transportation services, or they and their families were housed on-site and provided with housing, food and medical services.

Some operating organizations reported that the operating personnel worked in isolation in the main control room. Communication with the main control room was through intercom systems, and access was reduced to strictly necessary levels. Shift hours were extended to reduce shift turnover and staff interactions (e.g. two 12 hour shifts per day rather than three 8 hour shifts).

Main control room and standby shifts were established to ensure operational continuity in case of an unanticipated outbreak of COVID-19 on-site. Former operating personnel and maintenance workers were relicensed to expand the worker pool.

In some cases, the mobility of critical workers with special skill sets (e.g. testing, inspection, installation and commissioning of special equipment) and technical service providers was assured during lockdown periods by special government permissions and the use of private transport (e.g. charter flights).

4.2. USE OF PERSONAL PROTECTIVE EQUIPMENT AND HYGIENE AND DISINFECTION MEASURES

The use of PPE, along with hygiene measures and the disinfection of hands and surfaces, was critical to preventing and mitigating the spread of COVID-19.

Operating organizations ensured a stock of appropriate PPE and its use by personnel to decrease the risk of infection with the virus or its further spread. The PPE distributed to facility personnel and contractors typically included gloves and masks (e.g. N95 or FFP2).

Examples of hygiene measures to be followed by employees included washing hands frequently with soap and water and using hand sanitizers; minimizing contact with surfaces, door handles, etc.; avoiding touching the face and mouth; following cough etiquette and using disposable personal hygiene products; and maintaining workplaces in a clean condition. Gloves were used in areas with high staff turnover, in the training simulator and in control rooms. Some facilities also introduced changes to the use of biometrical devices and fingerprint scanners for plant access control. Expectations concerning hygiene measures and the use of PPE were communicated to personnel and frequently reinforced to ensure that they were consistently observed.

Site premises and surfaces were disinfected frequently, especially in high traffic areas, such as facility entrances, turnstiles, security gates, radiation monitors, corridors, elevators, stairways, cafeterias and kitchens, cloakrooms, toilets, commuting buses and control rooms. Hygiene stations and disinfection columns were installed near personnel working places and in highly frequented areas. Some operating organizations reported the production of disinfection

liquids on the facility premises to meet in-house demand because of their unavailability on the market in the early stages of the pandemic.

The following measures were typically taken to maintain the disinfection of surfaces such as tables, desks, switches, keypads, fingerprint sensors, doorknobs, handles, handrails, telephones, keyboards, sinks, elevator buttons and maintenance tools:

— Increased frequency of cleaning and disinfection in common areas, commensurate with the level of use;
— Collection and management of waste from potentially virus contaminated areas in such a way as to reduce the risk of virus spread;
— Use of appropriate PPE (e.g. N95 masks, eye protection, disposable gloves) by cleaning personnel to reduce the risk of virus spread.

Some Member States introduced a methodology for cleaning and disinfecting the soles of shoes before entering the facility, which involved placing the feet in a solution of water and 10% sodium hypochlorite.

No specific measures were reported for soft surfaces such as carpeted floor, other than increased frequency of cleaning. For clothing, towels and other items (e.g. from radiologically controlled areas), the standard method for washing was considered to be sufficient; however, special precautions were taken by personnel handling dirty laundry, for example the use of PPE and frequent handwashing.

Other methods of disinfection were introduced, such as germicidal ultraviolet lamps for air disinfection, and air conditioning systems were cleaned with increased frequency. Measures were also taken to increase ventilation in offices by working with open windows when appropriate and ensuring cross-ventilation in public spaces such as cafeterias.

4.3. MONITORING OF PERSONNEL HEALTH AND CONTACT TRACING

Restrictions on mobility and access are among the best practices in preventing and mitigating the spread of a virus, but it is also important to identify contagious workers and to care for those who become ill (i.e. personnel health monitoring).

During the COVID-19 pandemic, operating organizations established internal surveillance protocols to monitor the health of workers and business stakeholders and to keep local public health officials informed of the situation.

Some operating organizations reported checking the body temperature of all personnel entering facilities using thermal imaging cameras and contactless

handheld thermometers, requesting personnel to self-isolate in the event of contact with someone diagnosed with the virus, requesting personnel who developed typical symptoms to remain at home and notify their supervisors and performing frequent medical checks of personnel in direct contact with others (e.g. security or radiation protection staff). Contact tracing for positive cases and quarantine for potentially infected employees were applied. Most infections of personnel occurred off-site, and the spread of the virus was exacerbated by supplemental workers.

Additionally, some operating organizations implemented testing to identify employees infected by COVID-19, arranging a separate area for the collection of samples and forwarding them to a testing facility. At some facilities, contactless health booths were established for monitoring the health of personnel. Some Member States arranged on-site vaccination of personnel.

4.4. PRIORITIZATION OF MAINTENANCE AND OPERATIONS

Some Member States reported reviewing their plans for maintenance and operations in order to prioritize planned activities and identify those that could be postponed without an adverse effect on safety, security, reliability and regulatory compliance. These reviews took into account the availability of critical workforce, necessary materials and spare parts.

Examples of specific actions taken at NPPs included the reduction or postponement of planned reactor power changes, system configuration changes, switchovers of equipment, periodic surveillance testing, preventive maintenance and corrective maintenance focusing on critical defects.

Most Member States with operating NPPs reported that the COVID-19 pandemic had an impact on outages. Some operating organizations reduced the scope of planned outages to high priority or essential tasks such as refuelling and important maintenance of safety related structures, systems and components. For the most part, this was done to limit interactions among personnel, but in some cases it was due to the unavailability of contractors as a consequence of travel restrictions or virus outbreaks. In one Member State, the duration of a refuelling outage was extended to enable all planned safety related maintenance and repairs, as well as periodic in-service inspection work, to be completed with fewer personnel simultaneously present on-site, thus facilitating physical distancing and contact tracing in the event of an infection.

The reduced scope of outages tended to result in their completion faster than anticipated, with a few NPPs reporting record breaking outage times. In such cases, all other factors being unchanged, the reactors would be expected to generate more electricity than originally planned. In other cases, outages were

extended to allow work to proceed at a slower pace to accommodate physical distancing constraints. In at least one instance, NPP managers had to implement a mid-outage, three day safety stand down as a result of a high number of infections. Elsewhere, entire outages were deferred to 2021.

Some major construction projects (e.g. NPP life extension or refurbishment projects) were rescheduled. Such decisions typically required approval by the relevant regulatory body and increased monitoring of structures, systems and components.

Some nuclear fuel cycle facilities anticipated challenges in maintaining an adequate workforce during the pandemic and, as a precaution, initiated the safe shutdown of production operations and postponed summer maintenance where possible. Most radioactive waste management facilities (for predisposal treatment) were shut down to minimize the infection of personnel.

The full impact of deferred maintenance and operations on safety, work plans and human performance will play out over time as the pandemic subsides.

4.5. EMERGENCY PREPAREDNESS AND RESPONSE

While no Member States declared nuclear emergencies directly related to the pandemic, operating organizations, regulatory bodies and off-site response organizations took several measures to ensure continuity of adequate emergency preparedness and response capabilities as a result of the pandemic and its associated influences. For instance, more than half of Member State regulatory bodies activated their emergency operations centres. Conducting an emergency management exercise simulating a nuclear or radiological emergency during pandemic conditions was recognized as a good practice.

Measures to maintain essential functions and services in Member States during the pandemic included ensuring the availability of critical off-site infrastructure (e.g. coordinating off-site emergency response), including local health care, electric grid operators, transport of material to and from the site, and telecommunications. Some Member States reported that the depletion of national PPE stockpiles for pandemic response purposes would have left them short of PPE in the event of a nuclear or radiological emergency.

Hygiene and disinfection measures were instituted broadly at response facilities. The roles and responsibilities of responders were analysed and reworked to ensure that appropriate personnel would be available in an emergency. In some cases, shift turnover procedures were modified to minimize the physical interaction between people on different shifts and, in other cases, personnel were directed to avoid any personal interaction with members of other shifts in an effort to minimize the spread of infection.

Some Member States began to re-evaluate their response arrangements in case of a nuclear or radiological emergency during a pandemic. Guidance on the use of reference levels was placed under review, along with the generic criteria used within the protection strategy. Such a re-evaluation could result in changes to protective action decision making criteria and to the protective actions themselves in case of an emergency. The capability of off-site response organizations to take protective actions and other responses could be affected by pandemic conditions, such as:

— Reduced number of personnel available to support evacuation or relocation transportation, due to quarantine or self-isolation;
— Difficulty accommodating evacuees due to physical distancing requirements;
— Difficulty providing medical screening or evaluation to affected populations due to pandemic response;
— Shortage of human resources to urgently distribute stable iodine in the event of a nuclear emergency, due to quarantine or self-isolation;
— Reduced fire brigade capacity due to personnel in quarantine or self-isolation.

One concern of high importance was the ability of various organizations to function properly and carry out their duties during an emergency occurring in a pandemic situation. Some Member States reported conducting emergency drills to prepare for possible simultaneous accidents at NPPs. The drills involved evacuating multiple municipalities and were based on the scenario that a nuclear accident had occurred in an area affected by a virus outbreak.

4.6. ESSENTIAL SUPPLY CHAIN AND INVENTORY MANAGEMENT

Continuous communication within the supply chain was needed in order to monitor and re-evaluate the capability of critical suppliers. Some operating organizations had already conducted a review of the supply chain as a part of their business continuity plans, while others addressed the issue during the COVID-19 pandemic. In addition, some organizations planned the earlier announcement of procurement procedures for supplies, services and construction work, considering the possibility of a longer lead time than anticipated.

Many operating organizations reviewed their inventories of essential supplies and vital components and determined the levels to stock in the early phases of the pandemic. The review included consumables such as PPE (e.g. respirators, gloves) and disinfection liquids or hand sanitizers. For facilities where personnel were quarantined on-site, essential supplies also included food and medication.

In the case of nuclear fuel cycle facilities, the use of remote inspection methods decreased the use of essential consumables, so these items could also be borrowed from other facilities. As fuel fabrication facilities were declared an essential service to cater for the continuous operation of NPPs, supplies were needed for the operation and inspection of these facilities and the packing and transport of nuclear fuel to NPP sites.

Disruptions were most commonly observed in areas such as quality assurance activities, audits and source verification at manufacturing sites. Physical distancing, lockdowns and travel restrictions hampered traditional on-site, in-person oversight activities of suppliers and sub-suppliers.

4.7. EDUCATION AND TRAINING

In general, a large percentage of classroom training was either postponed or converted to distance learning, including blended (hybrid) learning, virtual instructor led training and asynchronous or self-paced learning. New approaches and infrastructure were introduced, new methods were communicated, and training on them was provided. This posed initial challenges, as some personnel were unfamiliar with certain learning tools, for example, and therefore took additional time to complete the training. There were also difficulties in determining how well trainees had understood material.

Common practices in the increased use of distance learning and e-learning included prerecorded videos demonstrating practical exercises and laboratory tasks, as well as recorded lectures and webinars. Further measures to improve distance learning included plans to build a studio to conduct distance learning and the sharing of good practices and lessons learned on how to convert face to face training to training led by virtual instructors, including how to identify which aspects of training could or should be converted to asynchronous learning.

Where necessary and feasible, face to face training continued with specific mitigation measures in place, such as limiting the number of trainees to ensure physical distancing in the classroom; preliminary COVID-19 testing for admission to the training (at the training institution or the main place of work); revising training curricula to combine self-paced (self-directed) training with classroom training; and establishing staggered break times to avoid gatherings of trainees in common areas.

Many Member States shifted as much emergency preparedness and response training as possible to a virtual format and either reduced the scope of in-person drills and exercises to minimize interpersonal contact or delayed these events entirely.

For outage training, videos with plant managers and different professionals were recorded in order to demonstrate safety culture and expectations in the workplace. Virtual reality and virtual scenarios were also used.

Some facilities started implementing control room training with desktop full scope simulator operation tools. The testing of new integrated control room operation training began to be done either virtually or in person, with appropriate protection measures.

The following measures were also taken in connection with training:

— Virtual instructions were provided to all personnel on specific or flexible work arrangements;
— Simulator training was identified as an essential function; therefore, the same rules for the protection of simulator instructors were applied as for other essential staff;
— The training of essential staff needed to be modified to ensure that they maintained the required qualifications while minimizing contact;
— Personnel who might be required to cover a colleague's tasks were provided with additional training;
— Job interviews and initial training were generally conducted virtually by video conference. If a face to face meeting was unavoidable, established physical distances were maintained, or masks (e.g. N95 or FFP2) were worn.

4.8. SAFETY AND SECURITY CULTURE, LEADERSHIP AND COMMUNICATION

During the COVID-19 pandemic, the promotion of strong safety and security cultures among operating organizations and regulatory bodies became more important than ever before. The introduction of forced changes to working practices created challenges in decision making and maintaining organizational resilience. In some cases, these challenges fostered and strengthened human and organizational resilience, stimulated innovation, encouraged emergent decision making and raised awareness of the critical role human factors have in realizing operational safety. Strong and shared leadership, with significant emphasis on the wellbeing and mental health of employees during such unprecedented times, was essential to maintaining safety, security and reliable operation of nuclear and radiation facilities and conduct of activities.

Clear, reliable and transparent communication internally with staff and externally through engagement with interested parties was an essential tool for managing the COVID-19 pandemic.

4.8.1. Management and internal communication

The significant volatility, uncertainty, complexity and ambiguity caused by a pandemic are a challenge to mental wellbeing and may consequently put operational safety at risk. Employee absences combined with the need for flexible working arrangements may cause staffing shortages and gaps that could lead to increased stressors such as a greater workload and mental fatigue. Lack of experienced personnel could also result in assigning the available workforce to unfamiliar tasks. Limiting interactions with distancing measures also has the potential to degrade critical communications such as shift handover or pre-job briefings. As a result, the organization might experience gaps in supervision and coaching and weakened adherence to standards and safe practices. This all has the potential to increase the frequency of human errors and violations.

Most Member States reported the need for strong leadership from line and senior management and personal accountability for safety on the part of all individuals, supported by managers' proactive, open and frequent communication to ensure high standards and morale during the pandemic. On the basis of experience reported by Member States, the following are examples of managers' behaviours and actions to maintain a strong safety culture during the pandemic:

— Ensuring continuous and up to date communication among supervisors and employees, including those working remotely. Employees needed to know how any temporary changes resulting from prevention and mitigation measures might affect their work situation, roles and responsibilities, as well as other information related to their salary or benefits, and how the organization would protect and support them. Leaders reinforced trust with their personnel by communicating the ethics and bases upon which decisions were made.
— Keeping the 'virtual' workforce engaged and committed to the organization by making use of virtual meeting tools, video conferencing, email and texting to simulate a face to face environment.
— Leading by example and demonstrating a commitment to comply with the prevention and mitigation measures described in previous sections and to align the organization and its employees.
— Providing personnel with the support and resources they needed to navigate various issues faced during the pandemic, including encouraging employees to report when they felt unfit for duty due to illness, fatigue, stress or any other reason.
— Providing personnel with additional training or education as needed, especially in the area of stress and fatigue management (e.g. training on

error reduction tools), to assist personnel in managing additional stressors for effective mitigation strategies.

4.8.2. Communication and coordination with external interested parties

The importance of consistent and reliable engagement with external interested parties and the process of building and maintaining trust among key organizations in responding to the COVID-19 pandemic were highlighted. Operating organizations and regulatory bodies reported to the IAEA that they continued their efforts to engage with interested parties and adapted, as necessary, to virtual means in order to minimize in-person activities and maintain openness and transparency in their decision making.

Operating organizations and regulatory bodies established a number of communication pathways to facilitate information exchange on regulatory issues and regular updates on corrective actions. Engagement was focused both internally on communication with employees and externally with other interested parties (e.g. members of the public).

Member States emphasized the diversity of mechanisms through which operating organizations and regulatory bodies could engage with the public, including web sites and online platforms (e.g. virtual public hearings and meetings), news media, social media, mobile loudspeakers and short message service (SMS) messages.

Effective and timely communication and coordination with certain external interested parties might be needed to verify the availability of or to maintain essential functions for continued safety, security and reliable operation (e.g. if an emergency situation arose in the area during the pandemic). Examples of external interested parties that constitute critical off-site infrastructure include off-site emergency response organizations, local health care facilities, external fire protection services, electric grid operators, dam operators, transporters of material to and from the site and telecommunications providers.

4.9. APPROACHES ADOPTED AT NPPS UNDER CONSTRUCTION IN EMBARKING COUNTRIES

Since new NPP construction projects often involve thousands of local and foreign workers, usually working in shifts and frequently travelling abroad, the risk of virus spread can be high.

Observations from construction sites in embarking countries showed that while the COVID-19 pandemic disrupted the flow of resources and procurement activities, the overall construction schedules were not affected significantly. In

one Member State, an NPP unit became critical and was connected to the grid during the pandemic period. The ability to minimize the impact on schedules in some Member States was attributed to the formation of response teams or operation centres at the construction sites to assess and monitor COVID-19 risk, provide guidance and ensure implementation of all necessary precautionary and preventive measures, including the provision of on-site medical surveillance and testing (see e.g. the case studies for Bangladesh and Turkey in Annex I). In addition, during the suspension of international commercial flights, chartered flights were arranged between the embarking country and the vendor or designer country so that special skilled workers, trainees and quality control inspectors could travel to and from the construction sites. This was achieved through coordination between local and intergovernmental organizations and in compliance with the rules for quarantine and national travel restrictions.

In 2020, the issuance of regulatory permits and operating licences for new builds was treated as a critical activity, and a hybrid approach that combined the virtual and physical presence of inspectors at the sites was adopted as a means of issuing licences or permits with minimum delay. For example:

— In Belarus, an operating licence for Unit 1 of the Belarusian NPP was granted by the Ministry of Emergency Situations of Belarus using remote authorization and on-site inspectors;
— In Turkey, a construction permit was granted for Unit 3 of the Akkuyu NPP using remote authorization and on-site inspectors. Construction activities at Units 1 and 2 as well as shipment and acceptance of long lead equipment continued on schedule;
— In Bangladesh, the construction of Units 1 and 2 of Rooppur NPP continued according to schedule, with a limited number of on-site COVID-19 cases, which were immediately isolated. Long lead equipment was shipped successfully and received at the site.

5. REGULATORY EXPERIENCE IN RESPONDING TO THE COVID-19 PANDEMIC

To discharge their mandates, regulatory bodies reviewed and prioritized their regulatory oversight activities and developed strategies for implementing essential regulatory functions either remotely or with limited on-site presence.

5.1. REVIEW OF REGULATORY FRAMEWORK

Many regulatory bodies reviewed their regulations, guides and regulatory documents to determine whether they provided mechanisms for the oversight of nuclear and radiation facilities and activities during emergency conditions such as the COVID-19 pandemic. These reviews, which drew upon feedback from national and international experiences, and many of which were performed as a result of specific requests from licensees for regulatory relief, led to the development of special regulatory oversight procedures and guidelines for staff and inspectors.

In some Member States, the regulatory bodies concluded that they needed to update the existing regulatory and operational procedures that formed part of their management system, to be better prepared for oversight activities in non-radiological crises and to incorporate best practices and lessons learned from the COVID-19 pandemic into their processes.

5.2. MODIFICATION OF REGULATORY COMPLIANCE AND OVERSIGHT PLANS

In several Member States, government decisions were taken to impose a moratorium on all types of on-site and in-person inspections. To maintain essential regulatory oversight activities, some regulatory bodies rescheduled, cancelled or modified the scope of in situ inspections to support physical distancing measures. In some countries, inspections continued only for radiological activities with medical applications. These postponements and cancellations were expected to increase the inspection workload after the pandemic.

Many regulatory bodies decided to limit physical inspection visits using a risk informed decision making approach for reasons such as inspectors or facility staff staying at home, physical distancing, temporary facility lockdowns, duty travel restrictions, transport limitations and prohibitions on entering the facility (e.g. medical facilities).

For routine inspections and other normal oversight activities that could be suspended, it was possible to compensate with a desktop review of documents, additional reporting measures by the licensees or other assurance mechanisms, such as remote visual support through requests to the licensees to take photographs or videos, or the use of fixed cameras for remote monitoring.

Reactive inspections in response to events requiring regulatory intervention remained available on a per need basis, with the support of essential staff and resident inspectors. In such cases, the licensees were required to inform the

regulatory bodies of all protective measures undertaken at the site to prevent the spread of infections.

5.3. AUTHORIZATION AND REGULATORY RELIEF

Most of the regulatory bodies required operating organizations to continue to submit normal update and event reports. These reports contained information specifically related to the implementation of pandemic measures.

In some cases, operating organizations submitted requests to their respective regulatory bodies for temporary relief or flexibility in meeting regulatory requirements to manage the effects of COVID-19 and ensure continuity of safe operations. For example, requests for regulatory relief from specific requirements included exemptions from or changes to:

— Minimum shift complement or hours of work;
— Preventive maintenance due to unavailability of necessary equipment, supplies or services;
— Planned maintenance or refuelling outages to reduce the number of personnel present simultaneously on-site;
— Medical and physical testing of certified personnel and fire protection officers;
— Control room operator examinations;
— Emergency planning drills and exercises.

Some operating organizations requested (and regulatory bodies provided) regulatory relief from non-critical emergency preparedness and response activities, mainly physical or in-person inspections, in-person training and large scale drills and exercises.

Several regulatory bodies established specific reporting requirements to optimize or avoid in-person inspections during the quarantine period, such as self-assessments performed by licensees to verify compliance with regulations and authorization conditions; reporting on the status of the radiation protection programme; reporting on workforce management, oversight of activities during facility shutdowns, and safety and security; and reporting on any challenges experienced or foreseen with respect to safety due to the implementation of COVID-19 prevention measures.

In several instances, the validity of authorizations or licences with an expiration date during the crisis was extended, and temporary licences were granted with no official request, on the condition that the licensees submit a request and supporting documentation at a later date. Some Member States

issued a national decree whereby authorizations with an expiration date during the emergency period would remain in force until one month after the end of the emergency.

Other measures taken by regulatory bodies included holding video conferences to review documents and conduct interviews, using information from reviews by other authorities, communicating with operating organizations by email or telephone, remotely analysing information such as quality control reports and dose rate measurement results and using radiation source tracking systems.

Some Member States made use of an existing remote inspection technique to monitor plant parameters via a remote monitoring system. Using plant data transfer tools, the essential operational parameters (e.g. reactor power, emergency power supply, position of important valves, radioactive emissions) could be transmitted electronically to the regulatory body.

In general, electronic authorization systems (e.g. electronic signatures), supported by secure and user friendly remote systems to access documentation and applications electronically, allowed regulatory bodies to sustain the resilience of their authorization programmes during the pandemic.

6. EXPERIENCE OF INTERNATIONAL NUCLEAR ORGANIZATIONS IN RESPONDING TO THE COVID-19 PANDEMIC

International nuclear organizations continued to support their members through sharing of information on the global impact of the pandemic, operating experience, mitigation measures to best protect workers and strategies to maintain safety and reliable operation.

Government travel restrictions prevented international nuclear organizations from completing planned on-site, in-person peer reviews and support missions for their members, which remained on hold in most cases until deemed feasible.

6.1. ADAPTATIONS TO SUPPORT MEMBERS

International nuclear organizations adapted their strategies to support members via virtual technologies that served as a platform for information sharing. For instance, some peer review missions were conducted either virtually

or in a hybrid format, with part of the mission team physically present at the site and other team members supporting them remotely.

Throughout the pandemic, international nuclear organizations continued to engage with their members and facilitate discussions, as often as weekly, to exchange information about how operating organizations worldwide were dealing with key issues. Discussions regularly focused on topics such as maintenance outages, risk management, sequestering of personnel (including control room operators), cleaning and disinfection measures to prevent COVID-19 outbreaks, use of thermographic cameras to detect possible cases, shift and emergency response planning, and operations strategies to maintain sufficient equipment reliability and power production and supply.

The global COVID-19 pandemic led to major restrictions on domestic and international travel to prevent the spread of the virus between and within States. Despite these difficulties, the IAEA continued to meet its safeguards commitments throughout the pandemic. However, many international activities, such as international peer review missions, had to be postponed or cancelled. The IAEA's scheduled Integrated Nuclear Infrastructure Review (INIR) missions were postponed to late 2021 on the basis of Member State requests, but the preparatory steps, such as self-evaluation support and pre-INIR missions, were conducted in a virtual format. The IAEA completed its first virtual follow-up Integrated Regulatory Review Service mission since the start of the pandemic in Lithuania in December 2020.

The World Association of Nuclear Operators (WANO) (see Annex II) launched a COVID-19 resource centre web site for its members to facilitate a worldwide exchange of information among the operating organizations of NPPs and nuclear facilities. The resource centre was a source of consolidated information for members' planning, preparation and response strategies. Further, WANO conducted a series of online events, including several to share best pandemic practices, one on maintaining human performance and one for senior management on the importance of strong leadership.

Moreover, several international nuclear organizations (e.g. the Nuclear Energy Institute (NEI); see Annex II) facilitated discussions between operating organizations and national regulatory bodies to identify the regulatory relief needed to manage continued plant safety and security while maintaining adequate regulatory oversight.

6.2. SUPPORT FOR MEMBERS IN PREVENTION AND MITIGATION ACTIVITIES

International nuclear organizations monitored the implementation of prevention and mitigation activities by their members with the objective of avoiding events with causes or contributing factors related to COVID-19. Experience and best practices were shared in the following areas, among others:

— Human performance monitoring with the objective of avoiding events caused by distracted operators, unusual shift turnovers or unusual compositions of maintenance or operations teams. For instance, WANO monitored trends in the human performance area by encouraging its members to be vigilant for such trends and to promptly report back on any events related to human performance. The WANO Human Performance Industrial Working Group summarized lessons learned and made them available to WANO members.
— Research and development to support the nuclear industry by ensuring that it had the information it needed to manage the pandemic while maintaining safe and reliable operation. For instance, the Electric Power Research Institute (EPRI) focused its research on emerging technologies for surface and air disinfection, such as light based disinfection technologies, as an option for electric utilities to consider in order to complement their conventional disinfection practices for reducing the risk of infection from airborne and surface pathogens.
— Development of acceptable alternatives such as the guidance provided by the EPRI to its members and their suppliers on information and communication technologies to perform remote source verification in a pandemic situation where on-site verification might have an effect on workers' health and safety. As another example, the NEI supported operating organizations in their requests for regulatory relief from national authorities and in the consistent implementation of these temporary exemptions while maintaining an adequate level of regulatory compliance.

International nuclear organizations continued to support their staff and members in preparing for recovery and carrying over certain mitigation measures and good practices developed during the COVID-19 pandemic to shape the new normal.

7. PRELIMINARY LESSONS LEARNED AND GOOD PRACTICES

In this section, a list of preliminary lessons learned and good practices in the operation and regulation of nuclear and radiation facilities during the COVID-19 pandemic is provided, with the objective of offering guidance to Member States on fostering organizational resilience in responding to the COVID-19 pandemic and ensuring preparedness for future pandemics or similar crises.

Key considerations:

— **Effective business continuity plans** can serve as proactive tools to identify essential workers, functions and measures needed to mitigate risks and overcome disruptions to operations caused by pandemics while ensuring radiation safety and protecting employee health. Such planning for potential future pandemics or similar emergencies is essential in order to identify risks and determine measures and strategies to mitigate them.

— Organizations need to support initiatives to **use IT and remote tools** that include establishing new norms for incorporating elements of virtual environments, developing necessary skills, and keeping workers connected, engaged and productive. To achieve this, effective and reliable IT is required to allow continued communications internally and externally and also to permit e-learning and certain aspects of remote or hybrid oversight activities.

— Building **resilience in the supply chain** to overcome pandemic related disruptions is critical for sustaining the continuity, quality and reliability of services and products for the safe operation of nuclear and radiation facilities.

— Healthy **safety and security cultures through strong leadership** create consistent expectations that staff will react appropriately to threats to both physical and psychological safety. As the COVID-19 pandemic has continued for a long period, managers have focused on employees' overall safety, supporting employee mental health and self-care practices as much as their physical wellbeing. Attending to all aspects of wellbeing is essential to the resilience of an organization. Changes in normal practices and plans (e.g. deferral or cancellation of maintenance and oversight activities) have to be made, taking safety in the short, medium and long term into consideration. The COVID-19 pandemic highlights the need for organizational agility and flexibility. Disruptions may be unexpected, and situations may change quickly; flexible organizational structures can adapt swiftly and effectively

to reallocate resources to meet changing priorities with the primary focus on safety.

— During the COVID-19 pandemic, **regulatory bodies** needed to prioritize their normal regulatory responsibilities. Some of the changes implemented in Member States might have influenced the regulatory body's ability to maintain effective oversight of licence holders. To avoid this to the extent possible, regulatory bodies need to modify their methodologies or approval processes to evaluate, approve and monitor licensee requests while ensuring that safety, security and reliability of operations are not compromised.

7.1. BUSINESS CONTINUITY PLANS

With regard to planning for continuity in the operation of nuclear and radiation facilities and the conduct of activities, the following actions for improving the response to the COVID-19 pandemic and preparing for future pandemics might be considered:

(a) Learn from past experience and use operating experience from other Member States to strengthen the ability of the industry to face uncertainties created by the pandemic more proactively;
(b) Benchmark against other facilities and activities and use available industry standards to either develop or enhance existing business continuity plans;
(c) Review and identify critical staff and essential functions to ensure safety, security and reliable operation;
(d) Establish and practise virtual work competences in advance of a crisis, and check in with staff to see what is and is not working well while they are working remotely in order to assess where new processes and procedures are needed to communicate with and support staff;
(e) Identify interfaces and develop coordination strategies with external authorities and organizations to ensure the availability of critical on-site and off-site infrastructure, such as coordination of the off-site emergency response with municipal and provincial authorities (including local healthcare authorities) and coordination with electric grid operators, transporters of radioactive waste, those involved in the fuel supply chain and telecommunications providers;
(f) Ensure appropriate PPE, disinfection liquids, beds, sleeping bags and food to prepare for essential workers to shelter in place at work for continued safety, security and reliable operation while preventing exposure to the virus.

7.2. USE OF IT AND REMOTE TOOLS

Information technology, including communications, critical applications, systems and databases, proved to be the foundation for performing many essential tasks and functions during the COVID-19 pandemic. A shift from in-person to digital activities, and the subsequent increase in remote work arrangements, forced many organizations to immediately create or improve existing IT infrastructure to maintain essential functions and allow for virtual communication. The following actions for improving the response to the COVID-19 pandemic and preparing for future pandemics might be considered:

(a) Implement essential tools for remote work in virtual environments, for example adequate broadband, software platforms and virtual desktops;
(b) Develop policies and guidelines to support personnel working in virtual environments, for example on training for employees in virtual skills and necessary competences for new staff;
(c) Allow for virtual and hybrid coordination of teams to support essential functions and continuity of operations;
(d) Analyse security threats and improve information and computer security while maintaining productivity of personnel;
(e) Continue enhancing IT infrastructure on the basis of operating experience and ensure the availability of IT and computer security experts to maintain operability and security.

Although it posed serious challenges, the pandemic also provided new opportunities in regulatory activities by facilitating a risk informed approach and promoting remote techniques and new information technologies. As a result, remote techniques may be used routinely in future inspections as part of the new normal. Remote instruments could also be used to provide timely support in resolving technical and scientific issues on demand. However, when defining the new normal, it is important to bear in mind that the most sophisticated IT solutions cannot replace human intervention and interaction.

7.3. SUPPLY CHAIN

Disruptions in supply chains challenged many large scale projects, such as refuelling outages, major refurbishments and construction of new NPPs. Shortages in materials or supplies and the availability of appropriate suppliers or subcontractors were highlighted as potentially the biggest challenges for the nuclear industry to ensure the continuity of operations. The following actions

for improving the response to the COVID-19 pandemic and preparing for future pandemics might be considered:

(a) Review the entire supply chain (going far beyond the first or second tiers), including distribution facilities and transportation services, to prevent and mitigate unexpected disruption in supplies;
(b) Consider diversifying the supply base to reduce full dependence on a single supplier; if alternative suppliers are not available, determine what and how much extra stock of critical spare parts and consumables are needed and can be built;
(c) Qualify additional or alternative suppliers where there are concerns over existing suppliers and cultivate relationships with them to help mitigate the unavailability of material or services;
(d) Consider modified quality assurance audits of suppliers such as virtual auditing, inspections and consultations in lieu of traditional on-site, in-person activities to ensure that high standards are being followed and quality is not compromised.

7.4. SAFETY AND SECURITY CULTURES AND LEADERSHIP

During the early stages of the COVID-19 pandemic, information was unavailable, incomplete or inconsistent, resulting in uncertainty, stress and anxiety among personnel. Effective communication by managers was imperative to reduce elevated stress levels when unexpected changes in standard working arrangements occurred, for instance, and to mitigate error drivers such as increased fatigue. The following actions for improving the response to the COVID-19 pandemic and preparing for future pandemics might be considered:

(a) Promote a strong safety and security culture by communicating a clear vision and strategy for coping with the pandemic and associated risks; prioritize and value both physical and psychological safety and security over all other competing interests during the pandemic and beyond; and provide personnel with up to date information as the situation evolves. Use multiple forms of information sharing to help personnel to stay safe, cope mentally and develop trust and confidence. Communicate important information clearly and frequently.
(b) Identify what works best for the organization when managing remotely — virtual meetings are essential for keeping teams engaged and motivated, but remote work and physical distancing measures challenge the standard ways of leading personnel.

(c) Encourage and create conditions and tools for personnel to report any issues related to their fitness for duty and take appropriate measures to mitigate error drivers and stressors such as increased fatigue or mental burnout.
(d) Take additional measures such as the provision of virtual just in time training or coaching to support personnel in preparation for the conduct of critical activities when the use of standard error reduction tools is not possible or is compromised due to physical distancing and other pandemic related measures.
(e) Provide training to further develop the knowledge, skills and behaviours associated with human resilience, including emergent and risk based decision making, psychological and physical safety awareness and critical thinking.

7.5. REGULATORY FUNCTIONS

A number of licensees requested regulatory relief or temporary waivers from national regulatory bodies, such as changes to shift rotation, minimum composition of shifts and refuelling work schedules or postponement of in-service inspections. Some of these changes might have affected the regulatory body's ability to maintain effective oversight of safe operation, including the safety of essential workers, the public and the environment. The following actions for improving the response to the COVID-19 pandemic and preparing for future pandemics might be considered:

(a) Develop a methodology or a formal process by which the regulatory body approves or extends regulatory relief from specific regulatory requirements, including identifying risk significance related to the exemption, and the criteria or approach (e.g. risk informed or performance based) to be followed to evaluate and approve exemption requests while ensuring continued safe operation and maintaining defence in depth.
(b) Ensure effective oversight to verify and monitor that approved exemptions (and, if applicable, the implementation of compensatory or temporary measures) will not compromise the safety, security and reliability of operations in the short, medium or long term.
(c) Document regulatory decisions, taking into account the relevant technical and scientific bases and regulatory requirements, compensatory actions and recovery plans.
(d) Prioritize the services and regulatory reviews provided by the regulatory body during lockdowns.

(e) Request licensees, applicants or an authorized third party to perform (self-) assessments of compliance with regulatory requirements and authorization conditions.
(f) Conduct remote inspections and provide advice on alternative oversight mechanisms to be used during crises. Oversight might include how the licensees manage the repercussions of a pandemic, implement their business continuity plans and maintain human performance and competences during the crisis.
(g) Provide alternative means of reporting to the regulatory body during a crisis, other than in situ inspections.
(h) Develop scenarios to determine when activities with radiation sources need to be halted and which corrective actions need to be taken.
(i) Develop strategies for internal and external communication or engagement with personnel and interested parties in pandemic situations.
(j) Establish means of facilitating communication with neighbouring countries to ensure the import and export of radioactive sources during a pandemic.

8. CONCLUDING REMARKS

Throughout the COVID-19 pandemic, operating organizations and regulatory bodies proved to be resilient, reliable and adaptable. The nuclear industry rapidly implemented special measures to avoid the need to shut down operation or halt safety and security related activities when the pandemic affected the workforce and the supply chain. NPP operating organizations and grid operators swiftly adapted to reduced demand in electricity and curtailed electricity generation to maintain a secure supply for consumers.

Organizations prioritized the protection of the health of their workforces, and in some cases redirected staff from everyday tasks to more essential or urgent services. Operating organizations shortened or postponed planned outages, scheduled maintenance, design modifications and personnel training and adopted other measures to decrease the mobility of personnel and the frequency of in-person interactions. Requests were made to regulatory bodies for regulatory relief while maintaining adequate levels of safety and security.

As the COVID-19 pandemic continues and efforts are under way towards recovery, it is critical to prevent adverse consequences for the nuclear industry and regulatory functions in the medium and long term in order to maintain the safety, security and reliable operation of nuclear and radiation facilities and

conduct of activities. In particular, the following challenges or impacts will have to be examined and addressed effectively:

(a) **Impacts of deferred outages and maintenance on safety:** the identification of potential safety issues resulting from postponed or cancelled activities such as equipment maintenance, periodic surveillance testing, plant modifications and timely implementation of safety upgrades.

(b) **Impacts of changes in the operating environment and management systems:** some operating organizations and regulatory bodies modified or updated their operating procedures and management systems to manage negative effects and incorporate best practices from the COVID-19 pandemic. They need to monitor and manage the risk resulting from these changes to management systems and processes.

(c) **Impacts on human wellbeing and performance:** understanding the impact on human performance related to:
    (i) Succession planning and loss of tacit knowledge as a consequence of physical distancing measures, for example the retirement of experienced personnel during the pandemic without knowledge transfer to their successors;
    (ii) Skills and knowledge degradation due to lack of recent practice and backlogs in training and deferral of emergency response plan exercises and procedure updates, combined with extended periods between certificate examinations and personnel training or requalification;
    (iii) Effect of accumulated stress and fatigue on the wellbeing and mental health of employees (e.g. extended working hours for operators, additional stressors from family life challenges), reduced or limited collaboration and communication;
    (iv) Work overload to compensate for postponed activities after the end of the pandemic.

(d) **Sustainability of the supply chain:** the broad implications of the pandemic for the global economy and industrial activity will continue to challenge the global supply chain for months or years to come. These effects may endanger nuclear and radiation facilities and activities that use radioactive sources over the medium to long term.

(e) **Impact on oversight by regulatory bodies:** a number of Member States requested regulatory relief from national regulatory bodies. In addition, most regulatory bodies were unable to implement a normal, full scope compliance and oversight programme and had to either reschedule, cancel or modify the conduct of planned inspections. Some of these changes might have affected the regulatory body's ability to maintain effective oversight of safe operation and the validity of previous risk assessments (e.g. different

shift arrangements and operating conditions from those considered in the original risk assessments), including the safety of essential workers, the public and the environment.

(f) **Postponement of international peer reviews and member support missions:** deferring third party audits and international missions (e.g. IAEA or WANO missions) can affect continuous improvement (e.g. of management systems and operating processes).

(g) **IT and computer security:** the pandemic underscored the need to analyse computer security threats and improve computer security while maintaining productivity.

(h) **Analysis of electricity demand and economic impacts:** low demand for electricity during the COVID-19 pandemic affected the financial resilience and economic viability of operating organizations. Personnel furloughs for prolonged periods, restrictions on economic and social activity and business closures were economic disruptions that triggered a significant drop in energy demand, leading to falling wholesale electricity prices and in some cases requests from grid operators to reduce the power output of NPPs to ensure grid stability. NPP operating organizations and grid operators managed the challenge successfully and ensured that energy supplies remained reliable. The challenges created by the pandemic have focused attention on the importance of the nuclear industry in ensuring stability in energy systems as well as the need to develop improved operability measures to manage grid stability and load forecasting during a broader range of external events.

Along with creating the aforementioned challenges, the pandemic also provided new opportunities, for instance in shaping the development of post-crisis regulatory functions through the application of a risk informed approach, promotion of remote techniques and new information technologies. Specifically, remote techniques may be used routinely in future inspections. Some measures, such as the use of video recordings, may be challenged by the privacy concerns of licensee staff, necessitating new rules and practices in this regard.

The COVID-19 pandemic has transformed the operation of power systems across the globe and offered a glimpse of a future electricity mix dominated by low carbon sources. The performance of nuclear power in particular during this period demonstrates how it can support the transition to a resilient, clean energy system well beyond the pandemic recovery phase.

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Annex I

CASE STUDIES — MEMBER STATES

I–1. INTRODUCTION

Annex I presents case studies from several Member States, highlighting specific measures that were taken and special arrangements that were made in response to the coronavirus disease 2019 (COVID-19) pandemic. Member States were asked to provide information concerning the following aspects of the pandemic:

(a) Background.
(b) Impact (i.e. how the pandemic manifested itself via perceived or actual risks as well as real impact).
(c) Mitigating actions and their effectiveness, including the role of the State:
    (i) Immediately;
    (ii) In the medium term;
    (iii) In the long term.
(d) Interactions with peer international or regional organizations, especially where novel engagements were developed to address evolving needs.
(e) Recovery (as appropriate — actual or planned).
(f) Conclusions.

The responses provided by Member States reflect the situation as it stood in March 2021.

I–2. BANGLADESH — ROOPPUR NPP CONSTRUCTION

I–2.1. Background

In March 2020 Bangladesh confirmed its first case of COVID-19. Preventive measures, including lockdown, followed shortly after to mitigate the spread of the disease. The pandemic situation presented huge potential risks for the implementation of the Rooppur NPP project, with two WWER-1200 units to be put into operation by 2024.

The Rooppur NPP construction is in its active phase. Approximately 15 000–20 000 local and foreign workers are involved in the project. Since the

workers usually work in shifts and frequently travel abroad, the risk of COVID-19 infection is higher than for other projects.

I–2.2. Impact of the pandemic

Throughout the year it was reported through official statements and press releases that the pandemic situation had almost no effect on the Rooppur NPP construction process. From March 2020, the construction work at the NPP was run under medical control, including obligatory home quarantine for workers travelling from abroad, wearing of masks and maintenance of physical distance for everyone inside the project area. A medical camp was established at the site to check the staff daily upon their entry and exit. In July 2020, mandatory reverse transcription polymerase chain reaction (RT-PCR) testing was introduced for new personnel coming to the site (both those coming from abroad and those resident in Bangladesh), and a well equipped isolation centre for suspected COVID-19 infected personnel was activated.

I–2.3. Mitigating actions

The Bangladesh Atomic Energy Commission and Nuclear Power Plant Company Bangladesh Ltd, along with Nuclear Security and Physical Protection System Cell, responsible for security of the Rooppur NPP project, worked in close coordination with the vendor, Rosatom, and its subsidiary companies and formed a quick response team at the site to assess and monitor COVID-19 risk, provide guidance and ensure treatment. In March and April 2020, contingency plans for various scenarios of the COVID-19 pandemic were also developed. Together with Atomstroyexport, the general contractor for the project, Nuclear Power Plant Company Bangladesh Ltd, arranged personal protective equipment (PPE) and hygiene related products for the construction site in an effort to strengthen the preventive measures. From April 2020, due to the suspension of international commercial flights, chartered flights were used to bring workers from the Russian Federation to the construction site and to send trainees and quality control inspectors to the Russian Federation from Bangladesh. The workers went through a 14 day home quarantine procedure before entering the site. It has since been made mandatory that only persons (both foreign and Bangladeshi) with a COVID-19 negative certificate can enter Bangladesh. Upon arrival, personnel have to stay under quarantine for two to three days before going for another COVID-19 test in Bangladesh. If the test result is negative then they can enter the Rooppur NPP site, otherwise they are sent for isolation and treatment. In addition to the existing medical facilities, another four booths for COVID-19 have been set up for sample collection and subsequent testing. Posters, banners and leaflets

on precautionary and preventive measures are displayed at the site as well as in adjacent areas.

I–2.4. Conclusions

In her annual speech in 2020, Prime Minister Sheikh Hasina stated that 80% of the construction work for the 1200 MW first unit of Rooppur NPP, the largest development project in the history of the country, had been completed. This unit would be connected to the national grid on time — in April 2023. The Rooppur NPP will bring about a revolutionary change in the technological sector of the country.

In August 2020, Bangladesh put Padma water port into operation to receive equipment shipped by the vendor, including the WWER-1200 reactor pressure vessel, steam generator and steam collectors for Unit 1 of the Rooppur NPP. Visual inspection, laboratory testing for quality control of equipment and construction work for Rooppur NPP also continued despite the pandemic. Among other activities, the civil construction of a water intake structure, training centre and permanent fire station are nearing completion, and significant progress has been achieved in the construction of other civil structures.

Along with building the new NPP, Bangladesh continued to develop its nuclear infrastructure, concentrating on human resource training and stakeholder involvement, among other areas. In October 2020 the web page of the Public Information Centre on Nuclear went live, with the physical office being put into operation in November. Due to the current measures the centre is focusing on delivering its activities through online media such as Facebook, YouTube, Zoom, etc. Despite the pandemic, Bangladesh had the opportunity to host a team of IAEA safeguards inspectors in December 2020.

I–3. CANADA — CANADIAN NUCLEAR SAFETY COMMISSION

I–3.1. Background

The Canadian Nuclear Safety Commission (CNSC) is the regulatory body in Canada that regulates the use of nuclear energy and material to protect health, safety, security and the environment and upholds Canada’s international commitments on the peaceful use of nuclear energy.

COVID-19 pandemic protocols and measures put in place by governments around the world have had a notable influence on the conduct of regulatory activities of nuclear and radiation facilities. Many international nuclear regulatory bodies have had to adjust their regulatory activities in light of accentuated

health and safety measures to protect the staff of both the regulatory body and the licensee.

Similar to other regulatory bodies, one of the most important adjustments CNSC made was in relation to the inspection programmes, which included:

— COVID-19 pre-job briefing;
— COVID-19 PPE;
— Rescheduling inspections;
— Cancelling inspections;
— Modifying inspection scope;
— Applying remote and virtual methods to conduct inspections when possible.

I–3.2. Impact of the pandemic

In the initial phase of the pandemic, the CNSC activated its business continuity plan, and only 125 of the 850 CNSC employees were assigned to work for a period of approximately three weeks. On 6 April 2020, the CNSC resumed normal operations, with most employees working from home. The CNSC's efforts to procure tablet devices, achieve additional server capacity and leverage video conference software allowed its workforce to continue to work remotely, while entry to the office building required prior approval from CNSC management.

CNSC management requested its workforce to avoid non-essential travel outside of Canada. The CNSC recommended that its employees adopt a variety of self-care practices to promote mental wellness. In accordance with Part II of the Canada Labour Code, all employees have to disclose to the CNSC if they have tested positive for COVID-19.

I–3.3. Mitigating actions

The CNSC was agile in facing several challenges during the pandemic:

— Handling licensee requests for regulatory flexibility and relief in meeting regulatory commitments while ensuring no reduction in levels of adequacy of nuclear safety or security;
— Ensuring that staff have reliable access to information and equipment to work remotely;
— Ensuring that site inspectors have appropriate PPE;
— Conducting and modifying scheduled compliance activities in order to maintain regulatory oversight while respecting licensee restrictions on non-essential personnel;

— Adjusting workforce management practices to widespread teleworking situations.

To mitigate some of these challenges, the CNSC was proactive early on during the COVID-19 pandemic in developing and implementing modified compliance activities, pre-job briefing for inspectors and an inspection plan.

The CNSC suspended its on-site presence and on-site inspections from 16 March to 4 May 2020, thereafter reinstating its on-site presence and on-site inspections on a voluntary basis and in a limited capacity. The CNSC has established a framework for conducting remote oversight activities and enhancing the number and capabilities of site inspectors to work remotely. CNSC staff have worked with licensees to assure remote access for inspectors working from home or at the site office to site information systems, including actual plant data, and participation in key plant management meetings.

During the COVID-19 pandemic, the CNSC began conducting inspections remotely (meeting with licensees and accessing licensee data), supplemented with on-site verifications when required. Other supplementary measures included requests to licensees to take specific photographs on the site, the use of cameras for remote monitoring and the relocation of meetings off-site.

Concerning the health and safety of the inspectors, all CNSC staff accessing licensees' facilities have to respect the directions of the Government of Canada, provincial governments, the CNSC and licensees on COVID-19. Moreover, in addition to limiting the number of regulatory body staff on-site at any given time, CNSC staff have adopted the following protection measures:

— Hygiene practices;
— PPE;
— Physical distancing;
— Limiting the number of persons in a room;
— Avoiding in-person meetings when possible.

These protection measures have been emphasized through pre-job briefing. Additionally, the CNSC issued travel guidance during COVID-19 reflecting the direction and guidance from the federal government. The purpose of this guidance was to describe the controls in place to travel safely when CNSC staff are required to do so.

I–3.4. Interactions with peer, international or regional organizations

CNSC staff continued to communicate with the IAEA to:

(a) Support its ongoing and future safeguards mission;
(b) Conduct gap analysis of the IAEA safety standards framework;
(c) Incorporate lessons learned by governments, industry and regulators on the COVID-19 response.

In April 2020, CNSC staff launched a benchmarking exercise with 19 countries concerning their inspection practices during COVID-19. The CNSC received responses from 16 countries, including France, the United Kingdom (UK) and the United States of America. The CNSC considered this information during the development of its own procedures on planning and conducting inspections during COVID-19 and during the revision of its inspection pre-job briefing.

On 24–25 February 2021, under the auspices of the Nuclear Energy Agency's Committee on Nuclear Regulatory Activities, the Working Group on Inspection Practices, the Working Group on Human and Organizational Factors and the Vendor Inspection and Cooperation Working Group hosted conference calls during which the effects of the pandemic on regulatory inspection programmes and practices were discussed. Approximately 20 countries participated, 10 of which gave presentations followed by a question and answer period. A summary report will be prepared and presented by Working Group on Inspection Practices.

I–3.5. Recovery

The CNSC developed a plan for the return to workplace using guidance from Public Health and Central Agencies, the Office of the Chief Human Resources Officer and the Treasury Board of Canada Secretariat.

The return to workplace plan was based on several principles, such as:

— Setting employee health and safety as the number one priority;
— Basing decisions on guidance from public health agencies and central agencies within the Treasury Board of Canada Secretariat;
— Factoring in best practices from industry and the government;
— Taking a gradual, phased and measured approach;
— Maximizing work from home arrangements;
— Staying home when sick or experiencing symptoms.

The gradual approach to return to workplace includes four phases, whose timing will be determined by the CNSC management on the basis of the guidance from public health authorities. Each phase has a corresponding occupancy load of the office spaces (up to 10%, 20%, 35% and over 35%), number of employees who would be eligible to return to work and an office access criterion.

The preparation of the workforce and workplace includes hazard identification, risk assessments, guidance implementation and a readiness assessment. A series of protocols are being developed concerning screening assessments, sickness, access to common areas, physical distancing, conduct of meetings, visitors' access and emergencies.

I–3.6. Conclusions

The COVID-19 related response within the CNSC and the support the CNSC provided to nuclear and radiation facilities and activities continue to follow the protocols and measures put in place by the Canadian Government. COVID-19 had a notable effect on the conduct of regulatory activities in light of accentuated health and safety measures to protect staff of both the regulatory body and the licensee.

One of the most important adjustments the CNSC made was in relation to the inspection programmes, but other adjustments were made concerning workforce management, protection measures and access to office buildings.

The CNSC developed a plan for the return to workplace using the guidance from the public health authorities on the basis of a phased approach while taking into consideration future developments. A series of protocols are being developed to prepare the workforce and the workplace for a smooth return to work.

I–4. FRANCE — THE IMPACT OF COVID-19 ON THE FRENCH NUCLEAR FLEET: FEEDBACK AND PROSPECTS

The COVID-19 crisis is exceptional — for its duration, for the external context of the lockdowns, for its impact on all Électricité de France (EDF) nuclear sites and for the real risk posed to staff.

Faced with the COVID-19 crisis from February 2020, EDF nuclear production management, taking advantage of feedback from Chinese plant operators who had already adopted COVID-19 protocols, quickly set up a national crisis organization to manage the crisis and cope with it over time. A forward looking unit was set up, making it possible to stay ahead of the curve in giving warnings and making recommendations at a time when all managers were focused on current difficulties. This unit was a success, as it included specialists

in various fields (e.g. civil security experts, department experts, doctors, experts in training and human resources) and decision makers (e.g. NPP directors).

I–4.1. A specific crisis organization

A steering organization was set up to manage uncertainty in the face of the lack of knowledge about the virus and the fear of operators (especially on-site) of falling ill. It had two objectives: to protect staff and service providers on EDF sites and to ensure the continuity of electricity generation and public service at nuclear facilities in complete nuclear safety.

Relying upon crisis organizations in the nuclear industry, EDF nuclear production management set up a dedicated national crisis unit with eight specialized units, including one specifically for the health arrangements required, another for the management of technical matters, another for coordination with the nuclear safety authority, another for coordination with service providers and one for human resources (which allowed, in particular, specific arrangements to be put in place on sites, such as maintaining voluntary working from home and setting up team rotas to be able to rely on reserve teams if one team was more badly affected than another). The communication unit has played a very important role because, during a crisis, communication is essential to restore the confidence of all employees and service provider partners.

Finally, for the first time, EDF specifically established a forward looking unit, similar to what the army usually puts in place; that is, a 'heads up' management body that works with scenario reasoning to prepare for the future and constantly draw on lessons learned, with the ability to quickly come up with recommendations to contribute to decision making in different areas, for example to protect workers, maintain safety and ensure continuity of nuclear power generation. The important thing is having the ability to work outside real time to anticipate what might happen in the nuclear fleet. This is fully in line with the French Civil Safety Emergency Response Plan. At every turn, EDF have called on outside experts, when necessary, including from other international companies. Chinese colleagues, for example, provided EDF with photographs of the arrangements they had made during the crisis (for workstations and canteens, in particular). This cooperation saved time and has been a real success.

I–4.2. Main resilience factors

The main resilience factors identified were as follows:

— Flexibility and adaptability of the national operating organization and the sites, which have been reconfigured to manage the crisis, to monitor and

anticipate potential developments, to reorganize the operating teams, site and crisis protection.
— Establishment of protocols, benchmarks and working procedures related to occupational health, human resources and communication.
— Rapid structuring of communication methods to facilitate transfer of information at the peak of the crisis.
— Flexibility and rallying together to ensure logistics (in terms of masks, hand sanitizer gel, etc.).
— Skills of the players in terms of expertise in crisis management, knowledge and awareness of risks as well as the ability to prioritize activities. Staff empowerment has also played a key role in the success. Placing trust in employees produces extraordinary results, leading us to go even further in this process of changing management methods.
— Collective skills allowing all staff to rally together to find solutions.
— Management skills that promote the development of social dynamics and managerial practices that facilitate collective operation and decision making.
— An organization that combines centralization of strategic decisions with decentralization of operational decisions and has put itself 'at the service' of the real work of staff.

The discussion has always been transparent and responsible: EDF has always adopted a straight talking approach with its employees by constantly adapting to the means available. From a very practical point of view, it was also necessary to adapt the facilities, including the changing rooms and canteens, to avoid areas of concentration by organizing checks at entrances and exits. All of these issues were dealt with by giving priority to ensuring the health of employees and their trust in the company.

An NPP is a workplace unlike any other. Nuclear safety is paramount and has to be ensured even during a pandemic. It has been noted that safety results have been maintained or even improved. The number of safety events has decreased. This is not by chance but the result, among other things, of establishing a management charter, prepared jointly and shared by all nuclear sites.

A final point on safety was weekly international sharing with WANO and an IAEA briefing. Through an audio meeting, there were opportunities to explain what the EDF fleet was doing and in return learn from the practices of British, Chinese, German, Spanish and other European NPP operators.

I–4.3. Three main effects of the crisis

The first effect was that on the staff: EDF quickly adapted by having two thirds of the staff of its nuclear fleet put on teleworking in March 2020 for a prolonged period.

The second main effect was on electricity generation, with 20% less production in 2020 and not insignificant consequences over several years, with rescheduling that applies not only to 2020 but also to 2021, 2022 and 2023. In 2020, production losses were estimated at 600 days. These are cumulative days across the entire fleet; 50% were due to delays with outages, and 50% because of fuel savings EDF had to make and power modulation due to lower national demand. Industry consumed less energy in 2020, and hence the demand for energy fell. Here too, the fleet has been able to modulate its power and prove its flexibility. In total, 200 reactor maintenance outages have been rescheduled for 56 reactors, so this is a major impact on future production.

The third main effect was on health, but in the end, following the measures taken, it has been a relatively limited impact, with a limited number of people falling ill, a few cases of hospitalization and fortunately no deaths. The change in the number of cases on EDF sites roughly followed that seen in France in each of the regions, with infection mainly occurring in the family sphere. During the first wave of the crisis and the first lockdown, the total number of COVID-19 cases represented about 1.5% of all staff. The effectiveness of preventive measures was shown, with an infection risk that was ultimately very low on the sites. The priority is, and always will be, the protection of staff.

I–4.4. A health organization promoted to guarantee the safety of all employees

On the ground, the workplace has to provide protection. To earn the trust of EDF employees, it was necessary to put preventive measures in place very quickly, to adopt a health charter for all, without any difference between EDF employees and service providers, and to maintain a very clear discussion on the choice to always prioritize health protection over the activities to be carried out.

EDF also drew strongly on how test campaigns and contact tracing were carried out by other NPPs internationally when making its March 2020 recommendations. The principle of a vaccination campaign is nothing new at EDF because each year flu prevention is communicated, and related vaccination campaigns are implemented with the help of the occupational health department.

I–4.5. Some lessons from the feedback

The EDF fleet needs to learn from crises to create more diverse simulation and training scenarios in the future, incorporating uncertainty and the unexpected. Work is also likely to be needed on collaborative communication tools and on sharing and passing on information in real time, adapted to crisis management.

The importance of having a specific forward looking unit is one of the major lessons, and this can be adapted to other crises such as cyberattacks or exceptional climate events.

I–4.6. Conclusion

EDF plays a major role in the French economy due to its mission of generating electricity, and not only of nuclear origin. During the COVID-19 crisis, the nuclear fleet has proven its worth through its basic mission of electricity generation and its ability to adapt to demand by modulating the power of its reactors very quickly. Thanks to nuclear power, which does not emit carbon dioxide, it has been possible to compensate for the intermittent nature of renewable energies at any time and to modulate power to match demand in order to achieve permanent carbon neutrality.

Priority has always been given to the safety of the facilities, especially in a complex context with strict health measures necessary to protect workers. All staff have acquired a health culture in addition to a radiological culture. The margins for manoeuvre in the first phase of replanning activities are small, but the resilience of the organization is facilitated by its adaptation to the situation. The lessons of this crisis have to be kept carefully in mind.

I–5. GERMANY — GESELLSCHAFT FÜR ANLAGEN- UND REAKTORSICHERHEIT (GRS)

I–5.1. Background

Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) GmbH is a non-profit and independent organization that performs research and analysis for reactor safety, radioactive waste management and radiation and environmental protection. GRS was established in 1977 and is one of Germany's leading expert organizations in the field of nuclear safety. GRS currently employs approximately 420 people, 350 of whom work in the technical–scientific sector, at four offices in Berlin, Braunschweig, Cologne (headquarters) and Garching near Munich.

GRS's main customers are German federal ministries and offices, the European Union and several foreign nuclear authorities. The aim of the international cooperation of GRS is to contribute to the highest possible safety of nuclear installations worldwide. This is achieved by participating in working groups (e.g. of the IAEA or the OECD Nuclear Energy Agency) and through networking (e.g. through the European Technical Safety Organisation Network). This is to ensure a constant exchange of information about the development of new methods and the advancement of the state of the art in science and technology.

I–5.2. Initial measures

GRS management provided its first advisory on 4 February 2020. It contained information on COVID-19 and a request to take no more business trips to China. The following month, GRS senior management informed employees about rules set by the German Foreign Ministry, the Federal Ministry of Health and other State ministries, as well the advice of the occupational health service and other related institutions. The GRS management adopted these rules and advised on practical measures to be followed by GRS employees. On the basis of a specific risk assessment for the COVID-19 pandemic, which was discussed with representatives of the company's medical service and the workers' council, a series of measures and rules of conduct were defined and continuously adapted to the pandemic situation. They were announced in the GRS portal and regularly updated.

The first measures comprised the installation of germicide dispensers at the entrance area and in the washrooms with brief guidance on how to sterilize hands effectively. In addition, employees were asked to avoid direct contact with other colleagues (e.g. no shaking hands) and to respect further general hygiene measures. In mid-March 2020, working from home became customary.

I–5.3. Detailed measures

Various measures were put in place at GRS to reduce the risk of COVID-19 infection. The main objectives were the prevention of infections within GRS's area of responsibility and the continuity of business operations (especially the availability of the GRS emergency centre).

The first measures were implemented at the end of February 2020:

— Appointment of a COVID-19 officer (contact person for employees and external partners);
— Establishment of a crisis management core group (both GRS directors, COVID-19 officer, Head of Central Service Division, Head of IT Department, Head of Communication Department).

Additional measures were announced in mid-March 2020. These measures were frequently updated and supplemented as necessary:

(a) Working environment:
    (i) Employees free to work at GRS offices; no mandatory attendance (exceptions: employees needed to ensure continued business operation at GRS offices); during lockdown periods >90% teleworking, other periods about 75% teleworking;
    (ii) Flexible working time to support employees to manage work and changing personal obligations (especially childcare) as well as to avoid commuting on public transport at rush hour.
(b) Sanitary measures:
    (i) Enhanced hygiene measures;
    (ii) Minimum distance between employees (1.5 m) within the GRS premises, including kitchens and washrooms; lounges closed;
    (iii) Mandatory online training on occupational health and safety for employees, with a focus on COVID-19;
    (iv) Only single occupation of offices (approximately half of the offices are shared by two employees at GRS);
    (v) FFP-2 masks provided to inspectors and the GRS emergency centre.
(c) Precautionary measures:
    (i) Suspension of non-essential business trips;
    (ii) No meetings with external participants in GRS offices;
    (iii) Internal meetings only via telephone or video conference;
    (iv) Other meetings via telephone or video conference as far as possible;
    (v) Enhanced internal communication about ongoing developments (e.g. intranet, frequently asked questions);
    (vi) Establishment of virtual desktop infrastructure (i.e. permitting the use of private computers).
(d) Emergency related measures:
    (i) Plans for essential and emergency staffing (organized by functional divisions).

I–5.4. Findings

(a) The COVID-19 infection rate at GRS was much lower than the average infection rate in Germany.
(b) Due to the continuous use of modern communication means at GRS, there was no situation in which GRS was not able to deliver as planned. All national projects could be continued as planned. Some international projects were slightly affected, but only because of preventive anti-pandemic measures in Germany and other countries.
(c) An emergency situation in a foreign country could be handled remotely as planned.
(d) The strict compliance by GRS employees with the rules set by the GRS senior management in reaction to the pandemic and the common use of work from home were key issues in the successful management of the pandemic. With the high sense of responsibility and discipline of GRS employees, there were no major issues regarding motivation and performance.
(e) Senior management at GRS reacted promptly and comprehensively to the new situation and set rules of behaviour very quickly. These rules were updated as necessary.
(f) Greater effort is required from managers to communicate with and manage personnel.

I–5.5. Lessons learned

GRS managed the challenges of the COVID-19 pandemic effectively, as proven by the project execution results and the very low number of infected employees. There are two main lessons to be learned:

(a) Communication and compliance. Fast and comprehensive communication of behaviour rules by senior management helped personnel to act properly. In addition, the employees followed the rules strictly and in a responsible manner. Thus, it was possible to keep the overall performance of GRS at a high level.
(b) Working environment. Even though employees missed direct contact with their colleagues, it was possible to organize work from home nearly as effectively as working at the GRS premises. The basic requirement for this success story was the modern technological infrastructure at GRS. Continuous high investment in hardware such as desktop computers, laptops, storage capabilities and means of communication, as well as in software such as databases and portals, allowed the creation of the effective working environment that was necessary to deal with the COVID-19 pandemic successfully.

I–6. INDIA — NUCLEAR FUEL COMPLEX, HYDERABAD

I–6.1. Background

The first case of COVID-19 in India was announced in February 2020, and subsequently a nationwide lockdown was announced by the Government of India on 23 March 2020 to contain the spread of COVID-19 among the public. Subsequently, all activities at the Nuclear Fuel Complex were also shut down safely. The operational personnel from essential services such as security, fire, medical, industrial and radiological safety, engineering services, backyard water management and effluent management were only permitted to monitor the plant areas and surroundings to ensure safety. Necessary emergency passes were obtained for these personnel, as per local government regulations, to attend to their round the clock duties. Special COVID-19 teams were formed to control and manage the situation on a regular basis without compromising the safety and quality aspects of operations. The main task during the pandemic was to protect the lives and health of employees and their family members and prevent the further spread of COVID-19. In addition to this, several measures were taken and implemented at all levels of society, including operating plants and medical facilities, to contain the spread of the novel coronavirus within the premises.

I–6.2. Mitigation measures

I–6.2.1. Plant management

During the entire lockdown period, all plant areas and offices were regularly disinfected using in-house prepared hypochlorite solution and hand sanitizer solution. Face masks were also issued to all employees, who were required to wear them while at work. All staff entering the Nuclear Fuel Complex premises were subjected to thermal screening, and physical distancing was practised. These COVID-19 related materials were issued on a regular basis during the lockdown, and this has continued to date. Further, in-house fabricated, foot operated handwashing equipment was installed at all entrances to plant buildings for personnel to sanitize their hands before entry. In addition, sensor activated hand sanitizer dispensing machines were developed and installed inside the plant.

Regular weekly meetings were conducted to review and assess the situation with respect to operational safety and preparedness. Further, most employees were given the option to work from home, except for essential services.

Essential fuel and other supplies were delivered to reactor sites even during lockdown conditions, through coordination among production, procurement, security, medical, radiological safety, reactor site and local government bodies.

Government recommendations on quarantine for travelling personnel were observed for all these shipments to ensure safety.

Pamphlets, instruction boards, banners, display stands and videos were produced for COVID-19 awareness and made available to employees. Regular briefings on COVID-19 were also given to employees to communicate suitable measures depending upon the prevailing conditions.

Soon after receipt of permission to resume operations, all plant systems were verified using prepared checklists. After verification of safety, activities were gradually resumed in compliance with the Government's attendance requirements. Briefings were given by the plant management to personnel working on the shop floor. Staggered entry times, restricted use of changing rooms, specially packed lunches instead of food consumption at canteens, etc., were enforced.

To ensure contactless activities, digital tools such as e-Office, video conferences and remote inspections were introduced and implemented effectively during this period. Special travel arrangements as per local government regulations were also made for staff to travel to the office and back home during the lockdown period.

I–6.2.2. Medical management

Arrangements for emergency medical treatment were made at the Occupational Health Centre and Colony Health Centre; guest houses and security barracks were used to provide isolation and for monitoring requirements for employees and security personnel.

Special arrangements were made with city based hospitals for outpatient and inpatient treatment as and when required. They included reserving beds for COVID-19 patients from the Nuclear Fuel Complex, thereby avoiding critical waiting periods for them.

In order to avoid the movement of employees and their family members to the Occupational Health Centre or Colony Health Centre during the pandemic, provisions for teleconsultation were made, and medicines for chronic patients were issued for three months instead of one month. In addition, patients were given permission to purchase medicines from pharmacies near their homes and still claim for reimbursement.

COVID-19 kits containing masks, gloves, a pulse oximeter, essential medicines and trilingual instructions were issued to the affected employees. All affected staff were subjected to strict quarantine guidelines as per government orders and underwent recommended fitness tests before returning to duty. The Nuclear Fuel Complex medical team was in contact with these persons by

telephone on a daily basis for treatment and counselling. Special helpline desks were established for the benefit of staff and their families.

Further, several new facilities were established for the safety of employees; new doctors and paramedical staff were recruited, and the following facilities were established during the pandemic:

— Contactless booths or cubicles for safe examination of patients at the Occupational Health Centre and Colony Health Centre;
— A fever console for examination of patients;
— A covered area for distribution of medicine to patients;
— A triage area for segregating patients into acute cases for the fever block and chronic cases;
— Newly constructed blocks for acute fever and chronic cases;
— Specially constructed covered areas for patients waiting;
— New microwave and ultraviolet based sterilization machines;
— A newly constructed administration block for medical beneficiaries.

I–6.3. Conclusions

With effective COVID-19 control measures and management (which have continued to date), the spread was contained well, and the recovery rate was close to 98%. It is observed that there was no spread of COVID-19 due to Nuclear Fuel Complex activities. Personnel were affected mainly due to contacts in their outside lives. Further, safe production was ensured while complying effectively with government guidelines to address the pandemic situation.

I–7. RUSSIAN FEDERATION — ROSENERGOATOM JSC

I–7.1. Background

Rosenergoatom Joint Stock Company (JSC) is one of the largest enterprises within the Russian electric power industry and the only nuclear power operator in the Russian Federation.

Rosenergoatom's core businesses are the generation of power and heat by its NPPs and the operation of NPPs, sources of radiation and nuclear material and radioactive substance storage sites, pursuant to the procedures set forth by legislation of the Russian Federation.

Rosenergoatom JSC comprises 11 NPP sites with:

— Thirty-seven nuclear power units in operation with total installed capacity of 29 386 MW;
— Three nuclear power units under construction, of which Unit 2 of Leningrad-II NPP is in the trial operation phase with the expected start of commercial operation scheduled to begin in March 2021.

Rosenergoatom is the world's second largest nuclear utility in terms of both installed capacity and electricity generation.

Rosenergoatom is the largest electricity producer in the Russian Federation. Russian NPPs generated 215.745 billion kWh in 2020 and 208.8 billion kWh in 2019. The nuclear share of electricity generation in the Russian Federation was 20.28% in 2020.

I–7.2. Impact of the pandemic

One example is related to the accomplishment of adjustment supervision works at the emergency diesel generator of Unit 2 of Leningrad-II NPP during the period of pandemic related restrictions. It concerns the interaction between Rosenergoatom and MAN Energy Solutions France/Leroy Somer.

Emergent risks:

— Risk of failure to meet the Leningrad-II Unit 2 commissioning schedule;
— Leningrad-II Unit 2 downtime.

Measures:

— Communication via the channel Rosenergoatom–State Corporation Rosatom–Government of the Russian Federation–Government of France was arranged;
— Agreements were made on the terms and conditions for travel by MAN Energy Solutions France/Leroy Somer specialists to the Russian Federation as well as the scope of their observation, accommodation and crossing of the Russian State border;
— A special air flight from Paris to St Petersburg was organized for the adjustment supervision engineers' transportation.

Outcome:

— The MAN Energy Solutions France/Leroy Somer specialists arrived at the Leningrad-II Unit 2 site;
— The adjustment supervision works were performed, and the emergency diesel generator equipment was put into operation;
— The State order on Leningrad-II Unit 2 physical startup commencement was duly executed.

The decrease in electricity demand in the Russian Federation resulting from the lockdown measures led to a situation where as many as six NPPs (Leningrad, Kola, Balakovo, Novovoronezh, Rostov, Smolensk) were affected by relevant limitations from the grid operator.

I–7.3. Mitigating actions

Immediate actions:

— Establishing operational headquarters at the corporate office and each NPP with the aim of preventing the introduction and spread of COVID-19 and the main objective of coordinating the activities of the corporate office with NPPs, industry leaders and Rosatom divisions and responding promptly to any possible NPP safety risks arising due to the spread of COVID-19;
— Daily monitoring of the epidemiological situation at NPPs and control of implementation of measures aimed at preventing the spread of COVID-19;
— Ensuring constant availability of all warning systems of the OPAS group (a dedicated team to support the NPP in an emergency) in the context of coronavirus situation development;
— Ensuring constant availability of all existing communication means, including the information systems of the Rosenergoatom Crisis Centre, corporate email and IT systems with due regard to measures to prevent the spread of COVID-19.

Mid-term actions:

— As many staff members as possible have been transferred to work in remote mode;
— Working meetings have been switched to video conference formats;
— In-person contact and manager walkdowns have been reduced to a minimum;

— The separation of personnel routes, safe catering, the use of PPE, disinfection and additional sanitary treatment of workplaces and shared equipment and physical distancing of staff members have been organized;
— Safe shift changeover processes have been organized for operating personnel to keep a safe distance between operators;
— Regular testing of essential personnel for COVID-19 infection has been ensured at NPPs and the corporate office;
— All operators not infected with COVID-19, as confirmed by laboratory tests, have been isolated at special facilities;
— The isolated personnel have been fully provided with necessary living, sanitary and hygiene conditions; their contact with outsiders has been completely cut off;
— The transport of operating personnel to their workplaces and back has been arranged using separate dedicated vehicles;
— The following measures ensuring reliable plant systems and equipment operation have been brought into effect:
    - Temporary prohibition of any planned alterations or switching at NPPs (including the floating NPP), except for testing safety systems;
    - Temporary prohibition of any scheduled repairs to be carried out in the period between two consecutive outages;
    - Briefing of all personnel on the working regime and how to comply with the NPP safety regulations, taking into account all current restrictions;
    - Increased frequency of rounds of systems and equipment by operating personnel, while complying with the established restrictions to prevent mutual infection of personnel.

Long term actions:

— Transferring susceptible categories of employees (those aged 65+, mothers with many children, pregnant women, employees with disabilities, employees with chronic diseases) to a remote work mode.
— Identifying essential employees at the corporate office and NPPs from the viewpoint of ensuring that the operating organization functions in a manner necessary for the safe operation of NPPs; providing additional measures for protection against coronavirus infection for essential employees.
— Providing employees with PPE against COVID-19.
— Ensuring measurements of body temperature of employees entering buildings, with obligatory suspension from work for people with an elevated temperature.

— Organizing periodic (10–14 day intervals) testing to identify employees with COVID-19.
— Implementing additional sanitary and hygiene measures by employees (wearing disposable masks in public places and on public transport; using disposable personal hygiene products; cleaning hands with a skin sanitizer; keeping workplaces clean) as well as physical distancing.
— Installing contactless dispensers for disinfecting hands with solutions that do not require rinsing — in public places, on each floor level and in process premises.
— Carrying out preventive disinfection of office buildings and process premises.
— Organizing catering and transport services for employees with due regard to safety principles for preventing the spread of coronavirus.
— Cancelling or postponing all corporate events and international and local business trips.
— Requiring employees of the corporate office, NPPs or subsidiaries to report their return to the Russian Federation from abroad and to ensure self-isolation at home for up to 14 calendar days from the date of return until obtaining the results of two consecutive PCR tests, three days apart.
— Tightening rules for access to the corporate office and NPP sites. A negative test result for COVID-19 not older than three calendar days is a mandatory access requirement for the following personnel categories:
    - Employees returning to the office after a vacation time longer than six calendar days;
    - Employees returning to the office from duty travel;
    - Employees who have been absent due to sick leave;
    - Employees of external organizations.
— Limiting meetings — only critical meetings to be held in person, attended by no more than ten participants maintaining a physical distance of at least 2 m.
— Using remote communication means for meetings (video conferencing, teleconferencing, Skype, etc.).
— Developing a contingency plan for any negative scenario of COVID-19 spread.

Measures to ensure rapid and reliable communication with all Rosenergoatom staff members as well as contractors and authorities under the pandemic conditions:

— Regular communication regarding the situation related to COVID-19 and measures taken to prevent its spread to employees of Rosenergoatom and

subsidiaries by means of email, the Rosenergoatom intranet and the official web site, video displays and social media;
— Creation of a dedicated COVID-19 web page on the Rosenergoatom intranet for the centralized management of information, where the operational headquarters uploads current information and instructions to follow;
— Organization of a hotline in the corporate office and at NPPs, and appointment of persons responsible for providing COVID-19 related information in the corporate office and at NPPs;
— Interaction with local authorities of the agency in charge of State sanitary and epidemiological surveillance at Rosenergoatom facilities and in their locations;
— Cooperation with municipalities in the NPP locations;
— Interaction with State Corporation Rosatom to help execute orders and instructions to prevent the spread of COVID-19 and to provide information about the current situation and measures implemented.

Contingency plans have been developed for each NPP for the case of a negative scenario regarding the spread of COVID-19, including the following measures:

— Subdivide employees into groups according to their impact on production processes;
— Isolate employee groups from each other;
— Be ready to transit operators to a four shift mode (12 hours each);
— Implement plans to isolate all personnel within each NPP territory as well as using the infrastructure of satellite cities.

To ensure the safety of NPPs under construction, including facilities under construction at existing NPP sites, basic principles for preventing COVID-19 spread similar to those at existing NPPs have been set and are followed.

New forms of utilization of the available resources (such as laboratories for psychophysiological support) are being implemented. This kind of consultative support has been helpful for the mitigation of raised anxiety in working collectives. It is especially important for essential workers isolated at NPPs.

The critical product supply schedule for 2020 has been approved and implemented, including:

— Delivery of pilot operated safety valves, spare parts, pumps, control rod drive mechanisms, high pressure valves, controlled area conditioners, accident instrumentation and control equipment;
— A three month reserve of priority items has been ensured, and a strategic reserve of medical supplies has been created.

The minimum supply level has been determined as a two month reserve and is maintained at NPPs for commodities and materials used for anti-epidemic operations. It is replenished taking into account the shelf lives of stored materials.

The measures implemented during 2020 at the corporate and plant levels to prevent the spread of COVID-19 have made it possible to:

(a) Reach all the performance targets set;
(b) Implement all of the planned maintenance and repair outages without any schedule disruptions;
(c) Implement the planned scope of NPP modernization and life extension activities.

I–7.4. Interactions with peer, international or regional organizations

Interaction with the regulator (Rostechnadzor):

(a) Risks related to document delivery time extension (admissible only via the national postal operator Russian Post). Response: adjustment of the documentation dispatching schedule taking into account the terms of delivery by the Russian Post.
(b) A longer time needed for formal authorization paperwork in Rostechnadzor. Response: regular working contacts with Rostechnadzor specialists and managers.

International activities:

Various international events planned for 2020 have been implemented in video conference mode.

Some international activities that include in-person visits to the sites such as international peer reviews have been postponed, including:

— Preliminary visit of WANO corporate peer review expert team to Kola NPP — to August 2020;
— WANO corporate peer review — to May 2020;
— Corporate operational safety review team (OSART) follow-up visit — to October 2021;
— OSART mission to Kalinin NPP — to November 2021.

Interactions with international organizations and the use of international experience:

— Rosenergoatom's participation in, and provision of relevant information to, the IAEA Department of Energy's database on COVID-19 related operating experience;
— Provision of information on Rosenergoatom's experience in responding to the COVID-19 pandemic to the IAEA's International Reporting System for Operating Experience;
— Provision of information on Rosenergoatom's experience in responding to the COVID-19 pandemic to WANO's COVID-19 centre;
— Establishment and maintenance (during the first peak period of the pandemic in April–July 2020) of a database on international experience in responding to the COVID-19 pandemic (information sources — IAEA, WANO) accessible to all Rosenergoatom personnel on the intranet.

I–7.5. Recovery

The COVID-19 situation remains a challenging one in view of the current infection rate. In this context, Rosenergoatom was one of the first enterprises in the country to offer vaccination upon receiving a batch of Sputnik V vaccine. During the first stage of the process, more than 2500 staff members (operators and supervisors with special licences for NPP operation) were vaccinated in December 2020 and January 2021.

As of 10 March 2021, 35% of all NPP workers have been vaccinated, including 96% of the overall workforce of control room operators. The vaccinated people are returning from isolation to normal life with their families.

Approximately 20 500 vaccine doses were delivered to NPP satellite town hospitals in January 2021 and more than 34 000 doses in February 2021. This marks the transfer to a mass vaccination phase where not only NPP workers, but also other town inhabitants, can receive the vaccine.

Such mass vaccination is expected to help end the spread of COVID-19 and help restore normal working and living conditions. It is planned to extend the vaccination coverage to the maximum possible number of workers, taking into account the principle of voluntariness.

Because of the mass vaccination, collective immunity to COVID-19 ought to be achieved, leading to a further relaxation of restrictions.

Taking into account the specific epidemiological situation and its evolution in different NPP areas, a stepwise easing of COVID-19 prevention measures at NPPs is ongoing. However, until the epidemiological situation improves and the vaccination takes effect, the facility operation modes and protection measures that have been actively implemented during the last year will continue to be applied.

I–8. TURKEY — AKKUYU NPP CONSTRUCTION

I–8.1. Background

The first case of COVID-19 was announced in Turkey in March 2020. At the same time, an operation centre to combat COVID-19 was urgently established within the Akkuyu Nuclear Joint Stock Company (JSC) to control and manage all operational activities and to take quick decisions in order to control the situation.

The main tasks and objectives of the operation centre are the following:

— Protect people's lives and health and take necessary measures to prevent the pandemic from spreading any further.
— Follow closely the measures taken by the governmental authorities, to inform employees and implement measures quickly both at the NPP site and at the other branch offices of the company.
— Facilitate coordination with the Ministry of Energy and Natural Resources, Ministry of Health, regional and local administrations and institutions.
— Hold regular meetings and inform all employees about all necessary decisions within the company.
— As Akkuyu Nuclear JSC is a Rosatom subsidiary, the operation centre also follows COVID-19 measures taken in the nuclear energy sector, working in coordination with Rosatom to find and maintain a balance between the implementation of the construction programme in the nuclear sector and the necessary quarantine restrictions.
— In accordance with Rosatom's policy of providing transparent information to nuclear energy sector employees, Akkuyu Nuclear JSC shares up to date COVID-19 data and information concerning the measures taken. Rosatom regularly informs all sector employees about the current status and measures planned to be taken.
— During the implementation of flight bans and customs closures both in the Russian Federation and in Turkey, special flights were organized between the Russian Federation and Turkey for business trips and to transport the special skilled workers who needed to start working at the project site. All coordination with the local and intergovernmental organizations was established, and all necessary permits for the flights and the people were obtained in order to comply with the rules for the quarantine processes in the Russian Federation and Turkey. Employees started to work after their quarantine periods expired and all medical checks were completed.
— All necessary checks and controls were established with the local authorities to continue the construction works on site during the curfew periods. Special permits were obtained for all workers at the project site.

I–8.2. Mitigating actions

The measures taken by the operation centre to prevent the spread of COVID-19 in line with the above mentioned tasks and purposes are as follows:

(a) An advanced medical surveillance regime has been implemented. The temperature of all employees is measured periodically, and if there are any signs of a cold or fever, they are sent home on the condition that they see a doctor and enter isolation accordingly.
(b) Free face masks are provided to all employees. The use of masks on the construction site and in all offices is mandatory. The use of masks is monitored regularly.
(c) Warning signs indicating physical distances have been placed in the workplaces in order to maintain physical distance as a precaution.
(d) Within the framework of compliance with physical distancing rules, the number of serving cars has been increased and fewer employees are transported on the bus.
(e) In order to reduce the density of the number of employees eating in the cafeterias, markings have been made on the tables, the number of chairs has been reduced, and the working hours of the cafeteria have been extended.
(f) Employees' meals are served separately in a package with single use materials.
(g) In dining halls, employees work with medical masks and gloves.
(h) Contactless devices have been installed in offices and in social areas for washing hands with disinfectant solutions.
(i) Disinfection works are carried out periodically in common use and office areas.
(j) Face to face meetings and movements of employees between the construction site and the Ankara and Mersin offices are restricted. Most meetings are organized via a video conferencing system. However, online meetings between the parties are challenging due to infrastructure issues related to the intense use of bandwidth and the multilingual nature of these meetings, with interpretation requirements.
(k) In addition to all mass events in the company, employees' business trips, other than those that are absolutely necessary, have been cancelled, and all travel is subject to the operation centre's approval. Home based, out of office working is allowed.
(l) Two weeks of quarantine is implemented on return from mandatory business trips abroad.
(m) The operation centre's representatives are in close contact with the Ministry of Health, including regional and local health organizations, to intervene

quickly in case of signs of COVID-19 and other respiratory infections in employees.

(n) Employees are informed periodically by email about the status and number of COVID-19 cases. Rosatom also periodically informs employees about the number of cases among all nuclear energy sector employees.

(o) Employees who are pregnant, have chronic diseases, have young children or are over 65 are provided with remote, flexible working conditions, or they are placed on administrative leave (paid leave).

(p) The seating arrangements in service vehicles have been rearranged so that only one seat per row is occupied. All passengers are seated in designated seats in order to allow for contact tracing of each person in the vehicles.

(q) Rapid COVID-19 tests are carried out periodically at the project site and in all offices. A person with a suspected or positive test result is immediately sent to the hospital for a PCR test and then placed in quarantine as a precaution.

(r) Employees are required to inform the operation centre about their business trips and personal travel. A COVID-19 test is required for employees returning from business or personal travel before starting work. For business trips, a rapid COVID-19 test is performed before entering the workplace. This process is repeated when they return to their own workplace.

(s) Employees who come into contact with a person diagnosed with COVID-19 are identified and immediately quarantined for 14 days. These employees are also followed up by the workplace doctor. Employees who show symptoms within 14 days are immediately referred to the hospital, and necessary screening is provided. Employees who do not show symptoms for 14 days are referred to the hospital and at the end of the 14th day have a PCR test and may start work upon a negative result.

(t) Employees who come into contact with a person with suspected COVID-19 have to inform the operation centre. These employees are also checked by the workplace doctor. If the contact is confirmed as COVID-19 positive, the above rules for employees who have been in contact with COVID-19 positive cases are applied. If the suspected person receives a negative result, the employee is transferred to the hospital to have a PCR test, and if the result is negative, the employee returns to work. During this period, the worker stays in quarantine.

(u) Even if there are no situations such as those mentioned above, rapid COVID-19 tests are performed at regular intervals.

(v) The psychological effects of the pandemic are also very important. For this reason, expert opinions and suggestions are shared at regular intervals in order to make employees feel comfortable and to minimize the negative effects of the pandemic.

(w) In the offices, the shift hours of the departments have been changed in order to reduce the intensity of working hours.

(x) The measures taken by the government are translated into English and Russian, and employees are notified by email.

(y) The operation centre may decide to make any measure mandatory; in this case, all employees are informed.

(z) Informative posters about preventive measures are posted in the office and common areas (samples of the posters are in shown in Figs I–1 to I–6).

FIG. I–1. The latest announcements and information are posted on the information board.

FIG. I–2. Meals are served separately and in closed packages.

FIG. I–3. To reduce the density and number of employees eating in the cafeteria, markings have been made on the tables, the number of chairs has been reduced, and the working hours of the cafeteria have been extended.

FIG. I–4. Guide for personal hygiene rules to protect against COVID-19.

FIG. I–5. Guide to preventive measures taken at the Akkuyu NPP site.

FIG. I–6. Poster showing decontamination measures at the Akkuyu NPP site.

I–8.3. Conclusions

Since the beginning of the pandemic, the company has closely followed all recommendations and restrictions announced by government authorities, Rosatom and the World Health Organization. Furthermore, their strict implementation is closely monitored and implemented. Due to these strict practices and implementations, all measures and actions have been effective.

Intensive works and activities have been continuing within the scope of the Akkuyu NPP project. Since March 2020, there have been more than 6000 people working at the project site, and the number of people working on the project has been increasing day by day since then. Currently, over 10 000 people work at the project site. With the help of planning, efficient and good coordination with the authorities and with all companies and people working on the project,

as well as the implementation of necessary precautions and proactive measures and the well established control and organization of all activities by the operation centre, there has been no delay to or severe impact of COVID-19 cases on the project activities or on people working on the project. All necessary measures, precautions and actions have been implemented, and all activities have continued in line with the construction schedule.

Posters are placed in work areas and public areas for information purposes (in Turkish and Russian).

I–9. UNITED KINGDOM — OFFICE OF NUCLEAR REGULATION

I–9.1. Purpose

This statement provides the independent regulatory assessment by the Office of Nuclear Regulation (ONR) of the status and resilience of licensed sites across civil nuclear industry in the United Kingdom (UK) in light of the ongoing COVID-19 pandemic. This statement specifically explains:

(a) The current status of the UK's civil nuclear estate and preparations for phased recovery over the coming months;
(b) ONR's three phase approach to securing assurance as to the safety and security of industry;
(c) ONR's approach on generic aspects relating to antigen testing, risk assessment and ensuring physical distancing and its approach to potential areas of non-compliance in relation to statutory duties.

I–9.2. Status of the civil nuclear industry

During March 2020, the civil nuclear sector responsibly and progressively pared back non-essential operations in order to sustain focus on activity essential to protect the workforce, the UK's critical national infrastructure and the public.

I–9.2.1. The UK's operating reactor (NPP) fleet

The current operational status of EDF Energy's 14 advanced gas cooled reactors and single pressurized water reactor is set out in Table I–1. The pandemic has not directly affected the operational status of any of the UK's 15 NPP units.

COVID-19 related absence at the NPP stations currently ranges from 1–8% from a peak of 20% in late March 2020 across the NPP sites, with evidence of previously self-isolating staff already returning to post.

TABLE I–1. OPERATIONAL STATUS OF EDF ENERGY'S REACTORS ON 24 APRIL 2020

Station	Reactor/unit	Comments
Hinkley Point B	R3	Operational
	R4	Shutdown
Hunterston B	R3	Shutdown
	R4	Shutdown
Heysham 1	R1	Operational
	R2	Operational
Hartlepool	R1	Operational
	R2	Operational
Heysham 2	R7	Operational
	R8	Operational
Dungeness B	R21	Shutdown
	R22	Shutdown
Sizewell B		Operational
Torness	R1	Operational
	R2	Operational

NPP emergency schemes and supply chains remain demonstrably resilient. From the outset, EDF Energy implemented arrangements to split on-site personnel and optimize shift patterns to improve resilience, in addition to physical distancing and other mitigating measures to protect staff. ONR is satisfied that the minimum staffing levels necessary to secure electricity generation and staffing levels for the emergency scheme are being maintained and are likely to be maintained into the foreseeable future.

I–9.2.2. Pandemic recovery plan

EDF Energy is currently operating to a systematic pandemic response plan, now at a stage that gives a degree of station level autonomy, such that they have flexibility to adapt and focus solely on essential maintenance and to

optimize shift patterns to safeguard margins in the emergency scheme. EDF Energy is currently considering the timeline and trajectory with which it will respond to the ongoing pandemic into the transition and recovery phases of the UK's response. As the company's response develops, it intends to retain all the protection measures introduced so far, introducing progressive flexibilities as risk of transmission reduces.

ONR remains assured that EDF's NPPs will continue to maintain sufficient resilience during the ongoing pandemic and considers there to be no discernible cliff edge to that resilience if the national situation deteriorates further. ONR anticipates no immediate COVID-19 threat to continuation of generation of electricity in the reactors that are currently operating.

I–9.2.3. UK civil nuclear legacy and wider fuel cycle sites

(a) Sellafield

Operations on the Sellafield site are complex and hazardous and present one of the most significant environmental remediation challenges in Europe. The site has been proactive since the early stages of the pandemic, minimizing operations on the site to those that are of an essential nature in a controlled manner. In response to the pandemic, Sellafield Ltd has already implemented a controlled shutdown of many complex operational facilities and temporarily paused project and supply chain work that does not directly impact on nuclear safety and security.

(i) Phase 1

The site has prioritized its available resources to maintain a safe and secure envelope for the site and protect the environment; examples include:

— Utilities and key infrastructure — electricity, water (including treatment plant), steam and laundry;
— Essential effluent capability (e.g. pond purge and sea discharge treatment capability);
— Safety critical detection capabilities — radiometrics;
— Analytical laboratories — minimum sampling for safety and environmental compliance reasons;
— Site security capability;
— Critical asset care and maintenance tasks or projects.

(ii) Subsequent phases

Sellafield Ltd is actively planning to reintroduce work on those activities that support any critical national infrastructure. In addition, this will continue to enable Sellafield to maintain the ability to receive advanced gas cooled reactor fuel so EDF plants can continue to operate. The site also plans to progressively reinstate work on legacy, high risk facilities, for example:

— Commencing retrievals from the site's legacy ponds and silos;
— Reintroducing those projects that have a direct and immediate effect on licence conditions and other legal obligations;
— Reintroducing those projects that progress delivery of the wider Nuclear Decommissioning Authority strategy (e.g. material consolidation at Sellafield).

If a second wave of the pandemic occurs at any stage during subsequent phases, the site plans to respond by discontinuing work again to manage with the available resources.

ONR remains assured that Sellafield will continue to maintain sufficient resilience in light of the ongoing pandemic and considers there to be no discernible cliff edge to that resilience if the national situation deteriorates further.

(b) Other decommissioning, waste and fuel cycle sites

The UK's decommissioning, fuel and waste sites have implemented arrangements to put facilities into a non-operational safe state:

— The production facilities at Springfields and Capenhurst remain operational in order to supply new fuel to the operating NPPs;
— The Dounreay site has substantially reduced its on-site workforce, and all facilities have been placed into a safe, quiescent state, augmented by sufficient guard force capability;
— The decommissioning Magnox reactor fleet has minimal requirements for site attendance other than guard force capability to support ongoing security resilience.

I–9.2.4. Civil nuclear security

ONR remains assured that sites across the civil estate remain compliant with approved arrangements for physical, personnel and cybersecurity.

ONR has approved temporary security arrangements under the Nuclear Industries Security Regulations 2003 to allow duty holders flexibility in the execution of their contingency plans. These temporary arrangements set out agreed parameters for security and will be reviewed at defined periods. ONR is continuing to work with approved carriers to ensure that the transportation of nuclear material essential to the UK's national interests is maintained. All non-essential movement of Category III civil nuclear material has been suspended, recognizing the need to reduce the potential burden on the emergency services.

I–9.2.5. Nuclear safeguards

UK operators are continuing to complete their nuclear material accountancy reporting to Euratom whilst working remotely.

ONR's safeguards team is maintaining active dialogue with Euratom, the IAEA and UK operators about its ability to continue to meet current UK safeguards obligations. International safeguards continue to be implemented by Euratom and the IAEA. Their implementation, however, is currently adjusted to the COVID-19 situation in order to protect the health and safety of safeguards inspectors. The IAEA has postponed or deferred all meetings and non-essential travel until 1 June 2020.

I–9.2.6. Hinkley Point C construction

The Hinkley Point C site is now in phase 2 (reduce and optimize) of a phased approach to managing and operating the site. The current level of workers has been reduced to just over 2000. Those numbers mean that the site can maintain the enhanced and robust physical distancing and other preventative measures established on-site, as well as in the transport infrastructure and accommodation service. ONR is actively seeking assurance that appropriate surveillance of construction on-site and in the supply chain is taking place. ONR has observed some factory testing remotely through video links, which worked well, and is looking for opportunities to expand such activities more widely.

I–9.3. ONR's three phase approach to securing assurance as to safety and security of industry

I–9.3.1. Pandemic phase — remote regulation

Since the introduction of restrictions in response to COVID-19 in March 2020, ONR stopped routinely deploying inspectors to civil and defence nuclear sites; this has meant no on-site presence since then, as ONR does not have

resident inspectors on nuclear sites. This was necessary, in the short and medium term, in order to protect staff and their families and also to minimize the potential for ONR to be the source of an outbreak of coronavirus on a nuclear site during the initial phase. This is appropriate as nuclear licensees:

— Are mature and responsible;
— Have good overall safety records;
— Have suspended a significant number of non-essential operations;
— Have generally effective internal assurance functions, from which ONR can obtain credible short term assurance.

The priorities during this phase have been to:

— Gain assurance, via regular licensee submissions, regarding the effectiveness of duty holder pandemic responses, including staffing levels, supply chain resilience, continuing safety related maintenance, security resilience and physical distancing.
— Carry out remote interventions to oversee site operations, which, under very specific circumstances, can be augmented by a site visit if it is essential for providing the necessary assurance.
— Undertake remote, targeted compliance inspections where these can be meaningfully delivered.
— Progress safety case and security plan assessments, permissioning assessments, modifications, permissioning of delays to statutory maintenance where unavoidable due to pandemic restrictions and related remote meetings.
— Continue to conduct investigations or enforcements, where these are of an acute nature, are significant and cannot be delayed for safety or evidential reasons. For example, a small team of inspectors attended the Sellafield site to undertake preliminary enquiries following an industrial safety related incident on the site.
— Maintain close liaison with duty holder internal regulatory and challenge functions.

(a) Basis of assurance during the initial phase

ONR has successfully trialled remote inspections across the industry looking at evidence of compliance with site licence conditions, for example on maintenance of critical systems, training, control and supervision of operations and emergency response capability. Where this approach has been viable, it

has generated broadly equivalent levels of assurance to those obtained through site attendance.

As a result of ongoing remote regulatory activities during the initial phase, ONR remains satisfied that the industry is sufficiently resilient in light of the ongoing pandemic such that safety and security is assured and considers there to be no discernible cliff edge to that resilience if the national situation escalates further.

Although remote inspections are useful, they have limitations compared to on-site visual inspections and the ability to provide effective regulatory oversight of certain important aspects of safety and security; notably, verification of maintenance, defect management, plant modifications, plant status, culture, physical distancing, etc. As time progresses, ongoing non-attendance at sites would:

— Affect the ability to obtain reliable assurances regarding safety and security consequently;
— Affect the ability to regulate such matters effectively;
— Affect ONR's credibility as the statutory regulator of the nuclear industry.

For this reason, ONR has proposed a phased, proportionate and targeted approach to the recommencement of regulatory attendance at sites.

I–9.3.2. Transition phase — targeted re-engagement

The transition phase will be an intermediate step, which recognizes that some (albeit still minimal) additional and targeted ONR inspector attendance at sites is necessary. The timing for entry into the transition phase and subsequent phases will be informed by:

— Government and World Health Organization advice and information on when it is appropriate to relax physical distancing;
— The timing of and process by which sites implement their own recovery plans and begin a return to their normal practices;
— ONR's judgement and any operational or emerging needs requiring site attendance that are considered to be necessary in the national interest.

ONR's priorities during this phase will be to:

— Ensure that standards of safety and security are being maintained at a time of enduring social distraction (and the potential for becoming detached or

desensitized to safety and security risks, with the potential for degradation of standards over time);
— Maintain stakeholder confidence in ONR as an effective and credible statutory regulator, especially regarding areas of plant operations or capability that may have been affected during the pandemic;
— Support delivery of important permissioning activities that are not suitable for remote delivery alone (e.g. resumption of hazard and risk reduction activity at Sellafield, reactor restarts after statutory outages, significant plant modifications);
— Continue to conduct investigations or enforcements, where necessary.

Site based activity will be subject to risk assessment and strengthened internal governance to ensure that risks to ONR and industry staff are tolerable and that viral transmission risks associated with the visit are controlled as far as is reasonably practicable.

I–9.3.3. Interpandemic phase — re-establishing regulation as normal

ONR currently expects to implement the next phase at the start of the 'interpandemic phase' of the UK's response to the COVID-19 pandemic. It is planned to run for six months but could extend for longer if required.

During the interpandemic phase, ONR's site based activities will be prioritized and targeted to ensure that they relate to those aspects of safety and security judged to be most significant.

Implementation of these revised plans will result in the restoration of a more typical and routine level of ONR regulatory oversight of site operations, maintenance, outages, etc. This will constitute a balanced portfolio of compliance themed inspections, systems based inspections, inspections essential to allow permissioning to progress and inspections targeted at driving specific improvements to duty holder arrangements or operations. However, ONR recognizes that lessons arising from the ways of working during the pandemic may lead to a different, more effective and efficient 'normal' for regulation in the future.

I–9.4. ONR's general regulatory approach during the pandemic

I–9.4.1. Risk assessments to permit future resumption of on-site regulatory activity

ONR has developed, in consultation with the UK's Health and Safety Executive, a risk assessment and governance framework to support deployment

of its inspectors and enable targeted and limited resumption of on-site inspections. Such activity will resume only in circumstances necessary to secure ongoing regulatory assurance as to the continued safety and security of duty holder undertakings as they prepare to restore operations in a phased manner.

I–9.4.2. Antigen testing

The government has announced that it has extended the eligibility for antigen testing to all key workers. This includes those in the civil and defence nuclear sectors. The test is to confirm whether individuals showing symptoms have COVID-19.

ONR has issued letters to some of its staff designating them as key workers. However, ONR does not expect that those staff will need to access this testing provision, given current arrangements to work from home. This will enable testing resources to be focused on other frontline staff, such as National Health Service and social care workers. ONR will consider this position further when it begins to plan on-site interventions.

I–9.4.3. Physical distancing at nuclear licensed sites

ONR is supporting national efforts to ensure that physical distancing and welfare arrangements are being properly observed at licensed nuclear sites. Its regulatory focus includes assurance, where appropriate, from site licensees that they are applying the public health measures introduced to reduce the spread of COVID-19. This assurance has been obtained from a range of sources, including daily interactions between ONR's site facing inspectors, the use of photographic evidence and increased use of intelligence from licensee internal regulatory and assurance teams.

The UK's nuclear industry is mature and responsible, with an excellent nuclear safety record. It has responded appropriately to the COVID-19 pandemic to date, and ONR expects it to continue to make responsible and conservative decisions as it responds to the challenges of the pandemic. ONR is applying its regulatory influence, based on long established health and safety legislation, to assure itself that licensed sites protect the health, safety and welfare of their employees at work, in line with guidance from Public Health England.

If ONR identifies instances where sites are failing to apply the relevant Public Health England guidance, it will consider taking action guided by its Enforcement Policy Statement and engage with the enforcing authorities designated in the new emergency health protection legislation if required.

I–9.4.4. Regulatory position on potential non-compliance with certain statutory duties

The unprecedented scale of this national emergency has prompted ONR to consider the implications of certain statutory duties on licensees and other duty holders, particularly where they place specific absolute requirements.

ONR has identified a number of areas of legislation where it will be sympathetic if duty holders approach it to say they cannot reasonably achieve the required standards. In considering such approaches, ONR will apply its Enforcement Policy to balance the need to enforce compliance against the need for the sites, etc. in order to maintain focus on safe and secure operations in the national interest. Each case will be subject to a rigorous and transparent basis of governance, taking into account the level of risk posed and evidence that safety will not be degraded in any material way. To date, ONR has agreed a framework for considering the following:

— **Duties under Pressure Systems Safety Regulations 2000 (PSSR)** — and ONR's stance if it receives any requests for deferrals of pressure system inspections consequent to the COVID-19 pandemic, which may not be allowable under the regulations. This easement has not yet been applied in practice and no such requests have been received from industry.
— **Ionising Radiation Regulations (IRR17) 2017** — ONR has worked with the Health and Safety Executive to develop joint temporary guidance for duty holders in relation to IRR17 compliance during COVID-19. This relates to a wide range of elements of the Approved Code of Practice and supporting guidance.
— **Lifting Operations and Lifting Equipment Regulations 1998 (LOLER)** — for example, in relation to duties on duty holders to conduct thorough examinations and inspections of lifting equipment.
— **Control of Major Accident Hazards Regulations 2015** — in relation to duties on operators if sites transition from lower to upper tier establishment status as a direct result of the COVID-19.

ONR is further developing a regulatory position statement on:

— **Radiation (Emergency Preparedness and Public Information) Regulations 2019 (REPPIR 2019)** — the UK response to the COVID-19 pandemic has had a significant effect on emergency planning resources within the nuclear industry, local authorities and other response agencies, making full implementation of REPPIR 2019 extremely unlikely within the formal regulatory timeframe. ONR is currently developing a framework for use by

the local authorities to allow them to report the extent of their compliance with REPPIR 2019. This approach, which has been communicated to the UK Government (Department for Business, Energy and Industrial Strategy), is intended to ensure that any gaps in full compliance are fully defined, appropriate mitigations are put in place, and a forward programme to complete the outstanding work is agreed with ONR.

I–10. UKRAINE — MEASURES TAKEN DURING COVID-19

To ensure the safe operation of Ukrainian NPPs during the COVID-19 pandemic crisis, the following measures have been taken:

(a) Organizational arrangements;
(b) Ensuring the production process during the COVID-19 pandemic;
(c) Sanitary and anti-epidemic measures;
(d) Providing staff with food;
(e) Working in remote mode;
(f) Vaccination of staff.

I–10.1. Organizational arrangements

The headquarters for the coordination of quarantine and anti-epidemic measures and cooperation with local authorities of NPP satellite cities has been established in the head office of Energoatom. Accordingly, the NPPs have established headquarters that are subordinated to the Energoatom headquarters.

Plans for activities have been developed by the headquarters using the Pandemic Threat Planning, Preparation, and Response Reference Guide [I–1]. Information about acute respiratory viral infections is submitted to the Department of Occupational Medicine of the company.

Staff training, qualification upgrading and participation in training seminars have been suspended. Staff training is performed using remote learning tools. The work of certain categories of personnel has been performed in the remote mode. A shift at the beginning of the working day without changing its duration has been allowed for certain categories of staff. Maintenance works that do not affect the safe operation of NPPs have been postponed. It is forbidden to hold public events. Business trips are prohibited.

I–10.2. Ensuring the production process during the COVID-19 pandemic

The critical personnel necessary for stable NPP operation have been identified and transferred to a special work schedule and isolated at separate premises (e.g. hotels). Transportation of operating personnel and isolated passage to workplaces without contact with other personnel has been provided. Continuous medical monitoring of the staff with documentation of the results is performed.

I–10.3. Sanitary and anti-epidemic measures

Staff have been provided with PPE. An enhanced sanitary access regime has been established for all NPP personnel, pre-shift control of personnel has been strengthened, and additional medical personnel have been involved. Sanitary barriers have been created for temperature screening of staff and disinfection.

I–10.4. Providing staff with food

The staff at the dining establishments undergo medical examination before they start work. Changes to the staff dining schedule have been introduced to prevent congestion and queues. Distancing has been introduced in the canteens — one person at a table for four people. The diet includes immunity increasing products (e.g. wild rose, spirulina, fresh vegetables and fruits).

I–10.5. Remote work

A list of personnel who can perform their duties remotely has been defined. Technical support is provided. Employees caring for a child under 14 years of age may take leave without adhering to the leave schedule.

To minimize physical contact, the necessary information has been published on official web sites and web pages. Technical support has been provided to staff working remotely.

I–10.6. Vaccination of staff

The company and the NPPs have started vaccinating personnel against COVID-19 with their consent.

REFERENCES

[I–1] NUCLEAR ENERGY INSTITUTE, Nuclear Sector Coordination Council, Pandemic Threat Planning, Preparation, and Response Reference Guide, NEI 06-03 (Rev. 2), NEI, Washington, DC (2006).

Annex II

CASE STUDIES — INTERNATIONAL NUCLEAR ORGANIZATIONS

II–1. INTRODUCTION

Annex II presents case studies for several international nuclear organizations, highlighting specific measures that were taken or special arrangements that were made in response to the COVID-19 pandemic. The organizations were asked to provide information on the following:

(a) Background (e.g. concise information about the organization, its member base and its traditional support mechanisms);
(b) Effect of the pandemic (i.e. how the pandemic manifested itself via perceived or actual risks, as well as real impact, for the organization as well as the members it serves);
(c) Mitigating actions and their effectiveness, including the role of the contributing organization:
    (i) Immediately;
    (ii) In the medium term;
    (iii) In the long term.
(d) Interactions with peer international or regional organizations, especially where novel engagements were developed to address evolving needs;
(e) Recovery (as appropriate — actual or planned);
(f) Conclusions.

The responses provided by organizations reflect the situation as it stood in March 2021.

II–2. ELECTRIC POWER RESEARCH INSTITUTE

II–2.1. General measures and disinfection technologies

II–2.1.1. Background

The Electric Power Research Institute (EPRI) is an independent, non-profit organization that conducts research, development and demonstration projects for the benefit of the public. EPRI's membership consists of utilities and other participants within the electricity sector and comprises more than 1000

organizations. While most members are electric utilities, others are businesses, government agencies, regulators and public or private entities engaged in some aspect of the generation, delivery or use of electricity. Through their advisory roles in EPRI and its research sectors and programmes, EPRI members help inform the development of EPRI's annual research portfolio, identify critical and emerging electricity industry issues and support the application and technology transfer of EPRI's research and development.

II–2.1.2. Impact of the pandemic

As governments and health care workers around the globe tried to contain COVID-19, the world slowed to a near standstill and the effect of COVID-19 was felt by the commercial power industry in numerous ways. This effect included a reduction in electricity peak demand and the need to enhance communications and protect a critical workforce while continuing operations. In particular, the pandemic required communication between corporate and plant staff regarding COVID-19 infection status and response planning, further investigation into cleaning methods for disinfection of controlled areas, and personnel screening for entry into and exit from facilities. Staffing was also affected, as many organizations, including EPRI and its members, practised physical distancing and transitioned portions of their staff to remote work to minimize physical interactions and prevent spread of the virus.

II–2.1.3. Mitigating actions

As the world's pre-eminent energy research and development organization, EPRI has been analysing electric power sector trends in real time, soliciting member company feedback and engaging in global discussions to inform energy providers regarding pandemic preparation, repercussions and response practices. EPRI used its global reach to gain insights into energy sector trends around the world and shared this information with a wider audience to facilitate a coordinated response to address the pandemic. EPRI also took several pre-emptive actions to minimize the spread of COVID-19 and do its part to help protect employees, members, stakeholders and communities.

EPRI's research into chemical solutions and technologies for cleaning and disinfecting controlled areas (e.g. a nuclear control room) provided a timely and succinct set of reference materials to understand the benefits and limitations of various cleaning practices and how they can be used to disinfect an area or surface. The primary focus of EPRI's work was on the use of ultraviolet germicidal irradiation (UVGI). UVGI is an established and effective means of inactivating pathogens including viruses, bacteria and fungal spores using

ultraviolet light. This research investigated potential electromagnetic interference vulnerabilities introduced by UVGI devices, as well as practical considerations and best practices to support the use of UVGI in an energy facility. This work also investigated the potential effects of UVGI on several polymeric materials commonly found in plant equipment following prolonged exposure to ultraviolet C light. Occupational health and safety practices were summarized, and a short video was developed on the use of thermography to monitor personnel access into controlled spaces. This research is publicly available on the EPRI web site[1] via multiple short technical briefs and reports [II–1].

Utilities, as trusted partners for a wide range of customers, needed reliable information about the safe, effective application of these methods and technologies to assist with emergency response planning and ensure personnel safety. EPRI was able to deliver this information in an expedited manner and lead discussions on the topic to support a coordinated industry response to the pandemic. Most companies have enacted business continuity plans or pandemic response plans and communicated or benchmarked practices for emergency response operations around the world (see interaction discussion below). Many have also adhered to strict cleaning, physical distancing and screening practices to prevent further spread of the virus.

(a) Interim and long term

A variety of existing and emerging technologies are available for surface and air disinfection. EPRI intends to provide a comprehensive evaluation of promising technologies to inform utilities and their customers about the efficacy of these platforms in electric utility applications. The project seeks to examine up to ten disinfection technologies over the project period. The plan is for each technology to be evaluated on the basis of six primary areas of performance:

(1) General operation — evaluation of set-up, operation and maintenance;
(2) Biological efficacy — testing against a variety of pathogens;
(3) Safety — focus on human safe operation of technologies;
(4) Materials effects — evaluation of degradation on various materials;
(5) Electromagnetic interference or radio frequency interference emissions — evaluation of potential radio and other interference radiation;
(6) Effective spectral output — evaluation of useful ultraviolet or other spectral output.

[1] EPRI's work on the use of ultraviolet germicidal irradiation is available on its web site: https://www.epri.com/covid-19.

Improved understanding of these six areas could help guide effective technology deployments in a variety of building types and applications.

In addition to evaluating these technologies, EPRI has identified several other medium and long term research needs geared toward future pandemic response and maintaining operational continuity of electric utility assets. These topics include the following:

— Pandemic operational strategies — identify and evaluate tools and processes to allow for remote, decentralized grid operations and automation;
— Telecommunications and cybersecurity — identify cybersecure solutions to allow for remote grid operations and identify potential impacts on and solutions to current telecommunication network bandwidth concerns that result from remote work strategy execution;
— Demand analysis and load forecast impacts — explore load forecast impacts and develop improved methods and algorithms to identify and potentially predict economically disruptive events;
— Impacts of deferred outages and maintenance — examine the impact deferred outages and maintenance had on infrastructure health, work planning and safety following the pandemic.

(b) Interactions with peer, international or regional organizations

In the first months of the pandemic, EPRI engaged its members through focused communications, including conference calls, webcasts, white papers, PowerPoints and videos, to provide information on the global impact on the peak demand and use of electricity and to discuss the industry's options to protect its critical workforce. EPRI was able to provide insights into effects on demand across the globe and lead weekly discussions with its members to obtain the latest updates on infection status, outbreak prevention practices, emergency response planning and research and development requirements to address the current and future pandemic. These discussions fostered a collaborative environment whereby utility staff around the globe were able to benchmark implications for the energy sector, best practices to control and address the pandemic and operations strategies to maintain sufficient equipment reliability, power production and supply.

II–2.1.4. Recovery

Recovery efforts are ongoing, as EPRI and many utilities are still employing their pandemic response strategies for the foreseeable future. Considering this new normal, EPRI has committed to increased virtual interactions with

its members and additional research geared toward improving the pandemic response capabilities of the electric power industry.

II–2.1.5. Conclusion

As the COVID-19 pandemic brings a renewed focus on what is most important to families and communities, the combination of the pandemic's health and economic challenges, as well as ongoing social unrest, represent a leadership moment for companies around the world. Just as ingenuity, innovation and agility have helped society adapt and respond, electric utilities have intensified their commitment to the resilience and wellbeing of their customers and society. In this effort, EPRI has led the way with its leadership and research focused on addressing needs in a pandemic. The use of UVGI and other light based disinfection technologies is an option for electric utilities to consider, in addition to conventional disinfection practices and general housekeeping for reducing the risk of infection from airborne and surface pathogens, including viruses, bacteria and fungal spores. This type of research conducted by EPRI supports the industry by ensuring that it has the information it needs to provide safe, affordable and on demand electricity.

II–2.2. Remote source verification

II–2.2.1. Impact of the pandemic

In the first quarter of 2020, many parts of the world began to experience an unprecedented pandemic due to the rapid spread of COVID-19. The global supply chain was affected in a number of ways. Manufacturing facilities worldwide temporarily closed or experienced reduced capacity as stay at home orders restricted employees from travelling to work. Although certain nuclear suppliers and manufacturers were categorized as essential by regulatory agencies and were able to remain open, some experienced occasional shutdowns to disinfect facilities after employees tested positive for the disease or came into contact with someone who had tested positive.

Due to robust supply chains and on-site inventory, the ability of nuclear plant supply chain organizations to provide the spare and replacement items needed to operate and maintain plants experienced relatively low impact, even as the spring outage season approached. One consequence, however, was the inability to perform quality assurance activities such as audits, commercial grade surveys and source verifications at suppliers' facilities. Travel restrictions prevented nuclear facility operators from being able to provide these types of traditional on-site, in-person supplier oversight activities. Without an alternative

to on-site source verification, NPP operators were unable to grant approval for suppliers to ship completed items needed to support plant operations, maintenance and construction. Primary suppliers were similarly unable to grant approval for sub-tier suppliers to ship them completed items needed to support primary supplier activities. Inability of nuclear facility operators and suppliers to perform audits and commercial grade surveys challenged their ability to maintain approval of important suppliers.

II–2.2.2. Mitigating actions

In early March 2020, concern was expressed during discussions between EPRI, EPRI member utilities and nuclear suppliers that pandemic travel restrictions were affecting the source verification needed to provide items necessary for upcoming spring outages. EPRI quickly assembled a team that included representation from EPRI member utilities, nuclear suppliers and nuclear regulators.

The team developed a report to provide EPRI members and their suppliers with guidance for using information and communication technology to perform remote source verification in exigent conditions where it is not possible to perform on-site source verification due to conditions that would endanger the health and safety of individuals performing the verification.

Although remote source verification cannot replace the ability to observe and verify activities at the source, available technologies can be effectively applied to verify certain activities sufficiently and successfully in extreme circumstances. Source verifications are typically performed to verify successful completion of certain fabrication and testing activities related to equipment that is complex, expensive or designated for use in nuclear safety related applications.

(a) Immediate

Remote Source Verification During a Pandemic or Similar State of Emergency (EPRI Technical Report 3002019436) [II–2] was published in April 2020 and was used by licensees and suppliers to successfully conduct remote source verification during the COVID-19 pandemic.

(b) Interim and long term

In July 2020, the United States Nuclear Regulatory Commission (NRC) issued a safety evaluation report that approved a request by a US licensee to accept the methodology in EPRI Technical Report 3002019436 [II–2]. In September 2020, the NRC issued a safety evaluation to approve EPRI Technical

Report 3002019436 as a topical report. EPRI updated the report to include the safety evaluation and updated the product identification to 3002019436-A [II–3].

The updated EPRI report that addresses the use of remote techniques to perform assessments (such as audits) of supplier quality programmes is currently in the final stages of development [II–3]. This report will provide a methodology that can be used to determine the best approach to remote assessment of suppliers during exigent conditions, and guidance on techniques that can be used for remote assessment to obtain similar results to those from on-site, in-person assessments. The report describes three types of assessments:

(i) Hybrid assessments, where one or more assessor is present on-site and other assessors are remote.
(ii) Provisional remote assessments, where all assessors are remote, can be used in cases where on-site presence is necessary, but is not possible due to exigent conditions. The results of a provisional remote assessment are evaluated to determine if approval of the assessed organization can be provisionally renewed with appropriate restrictions applied to each order during the provisional approval period.
(iii) Fully remote assessments, where all assessors are remote, can be used in limited cases when on-site presence is not necessary, such as when the supplier does not have a production facility.

(c) Interactions with peer, international or regional organizations

EPRI presented on the remote source verification report [II–3] in IAEA supply chain webcasts and industry meetings and worked with several suppliers and licensees implementing the methodology. During development of the remote assessment report [II–4], input was provided by Nawah Energy Company, the CANDU Owners Group and other international entities.

II–2.2.2. Conclusion

Although remote source verification cannot replace the ability to observe and verify activities at the source, available technologies can be effectively applied to verify certain activities sufficiently and successfully during exigent conditions.

Remote techniques are currently being used by nuclear licensees, suppliers and regulators in jurisdictions including Canada, Finland, the United Arab Emirates and the United States of America (USA). Remote techniques can be used to complete supplier assessments during exigent conditions with appropriate planning, communication and use of information and communication technology.

II–3. NUCLEAR ENERGY INSTITUTE

II–3.1. Background

The Nuclear Energy Institute (NEI, founded in 1994), located in Washington, DC, is the policy organization of the US nuclear technologies industry. Nuclear power accounts for about 20% of the USA's overall carbon free electricity capacity and over 50% of its carbon free energy. In 2020, nuclear energy was the second largest electricity generation source in the USA, second to natural gas.

The NEI's members include companies that own or operate NPPs, reactor designers and advanced technology companies, architect and engineering firms, fuel suppliers and service companies, consulting services and manufacturing companies, companies involved in nuclear medicine and nuclear industrial applications, radionuclide and radiopharmaceutical companies, universities and research laboratories, law firms, labour unions and international electric utilities.

II–3.2. Impact of the pandemic

In March 2020, there were 94 reactors operating at 55 sites across the USA. Thirty reactors were in some phase of the spring 2020 refuelling outage season (e.g. planning and execution).

The USA considers nuclear power facilities to be critical infrastructure and relies on them to generate electricity reliably during public emergencies. The operation of current NPPs requires a large number of workers on-site. When COVID-19 appeared in the USA, the industry was required to respond to a rapidly evolving situation to protect employees. Furthermore, protecting the health and safety of nuclear workers is foundational to assuring nuclear safety and security while supporting the mission of providing a reliable source of electricity.

In comparison to other subsectors of the electrical industry, the number of workers needed to operate US NPPs is much greater than is needed to operate non-nuclear generators. The number of workers required at a nuclear generating facility is mandated by a number of requirements, including:

(a) Licensee technical specifications.
(b) US Code of Federal Regulations governing:
    (i) Emergency planning;
    (ii) Physical protection requirements;
    (iii) Security programme;
    (iv) Limits on work hours for certain workers.

It was imperative for the US nuclear industry to adapt to evolving guidance from federal and state health authorities to mitigate the effects of the pandemic on essential workers, allowing sites to operate safely, securely and effectively during the public health emergency. In order to accomplish this, US nuclear plants needed to seek temporary relief from certain regulations to minimize the risk of COVID-19 exposure to essential workers while still ensuring plant safety and security. The specific regulatory relief is presented in the next section.

II–3.3. Mitigation actions

In the weeks leading up to the declaration of the global pandemic, US nuclear plants implemented their pandemic plans. These plans, originally developed in 2006, provided a framework for responding to the rapidly evolving situation in which the virus was spreading at different rates across the USA. The initial response actions included evaluating and modifying non-essential refuelling outage work scope, having essential staff continue to work at the plant and assigning support staff to work remotely.

Once the global pandemic was declared in March 2020, the NEI served as the convener of the Canadian and US fleet of operating plants and suppliers, sharing current information on the status of the spread of COVID-19 to prepare for and respond to the impact on the nuclear industry. On weekly conference calls, Canadian and US utilities shared their current status of response and notable practices and identified assistance or additional information needed to respond to the outbreak.

The NEI facilitated discussions with the US Nuclear Regulatory Commission (NRC) to keep US power reactors operating while ensuring that adequate oversight of the plants was maintained. One focus area for these discussions with the NRC was identifying and describing the regulatory relief needed during the public health emergency and justifying continued plant safety and security. The regulatory relief sought is summarized in Table II–1.

The NEI's role was to ensure that there was consistent implementation of these exemptions across the industry, as well as acting as a clearing house for sharing of lessons learned.

Many NPPs requested to defer key outage inspections to the next refuelling outage. Because these were plant specific, the NEI's role was to apprise the NRC of the pending volume and schedule of these requests and to develop generic templates used by licensees to request relief.

TABLE II–1. REGULATORY RELIEF SOUGHT FROM THE NRC

Regulation	Subject	Issue	Resolution
10 CFR 20	Radiological respirator protection	Medical doctors not available to perform required physicals	NRC endorsed a template developed by NEI to allow the stations to request an exemption from the regulations, crediting a medical screening questionnaire reviewed by a qualified nurse, physician's assistant or medical doctor in lieu of a physical examination
10 CFR 50.48	Fire protection brigade physicals		
10 CFR 55	Control room operator physicals		
10 CFR 50.48	Fire brigade training	Social distancing, enhanced hygiene practices and off-site support (e.g. live fire facilities) made training impractical	NRC endorsed a template developed by NEI to allow the stations to request an exemption from classroom training by using the INPO National Academy for Nuclear Training endorsed Systematic Approach to Training to develop alternative training
10 CFR 55	Control room operator training		
10 CFR 73.55	Security officer training		
10 CFR 50.47	Emergency planning drill	Social distancing in emergency response facilities, along with the presence of drill controllers, evaluators and observers from NRC, Federal Emergency Management Agency and local government, make conducting biennial drills impractical	

TABLE II–1. REGULATORY RELIEF SOUGHT FROM THE NRC (cont.)

Regulation	Subject	Issue	Resolution
10 CFR 26	Work hour rule limits	Existing work hour rule limitations do not support techniques such as isolating crews from one another (sequestering) to prevent cross-crew spread	NRC endorsed a template developed by NEI to allow the stations to request an exemption from the regulations, crediting a medical screen questionnaire reviewed by a qualified nurse, physician's assistant or medical doctor in lieu of a physical examination

Apart from coordinating regulatory exemptions, the NEI also coordinated with the NRC to ensure its independent oversight programme, known as the Reactor Oversight Program, could still be performed. Actions taken by the NEI for this purpose included:

— Supporting the ability of the NRC to perform remote inspections. For example, some US nuclear plants supplied company laptops to allow the NRC inspectors remote access to plant data they would normally obtain through on-site inspections or on-site personnel.
— Sharing remote inspection challenges and best practices and challenges with members and the NRC. For example, prior to the public health emergency, each site maintained two or more inspectors assigned continuously to oversee the plant. Accommodation provided by US nuclear plants included providing virtual updates on plant status in lieu of inspectors on-site to perform control board walkdowns.
— Some NRC inspections, such as operator licensing, were deferred for a period of time until they were deemed vital. The NEI supported members in maintaining close coordination with the NRC chief examiner.
— The security programme triennial force on force exercises, where a mock adversary force challenges the plant's security force, could not be conducted because of physical distancing requirements, and they were deemed not safe to implement during the public health emergency. The NEI coordinated with the NRC to develop an acceptable alternative inspection that met the NRC's legal requirements while adhering to health and safety protocols.

On behalf of the industry, the NEI collaborated with key government agencies to gain recognition of nuclear workers as essential. In the USA, the

industry deals not only with federal guidance but also with 50 different states' public health orders and numerous local public health authorities' requirements regarding physical distancing, business closures and openings, travelling across state lines, quarantining, etc. This federal essential worker designation instructed state decision makers to recognize NPP workers and supplemental outage workers as essential. This was of particular importance during the spring 2020 outage season to enable supplemental outage workers to travel between different states. This is also now having a positive effect in the current prioritization of vaccine deployment.

On 20 May 2020, the NEI issued Preventing and Mitigating the Spread of COVID-19, A Resource Guide [II–5], which provided lessons learned on worker protection and mitigation actions identified in the initial response to the onset of the virus.

The plants that were in refuelling outages faced several challenges: processing large numbers of supplemental workers, supplier logistics, conducting work safely and identifying and responding to positive cases. On the basis of the experience and lessons learned from the utilities that had spring refuelling outages, the NEI conducted four virtual workshops to share this information with the utilities who were preparing for autumn 2020 refuelling outages.

II–3.4. Interactions with peer international or regional organizations

Throughout the pandemic response the NEI, as the chairing organization for the US Nuclear Sector Coordinating Council and member of the US Electric Sector Coordinating Council, routinely interacted with all levels of the US Departments of Homeland Security and Energy. These engagements ensured recognition and protection of the nuclear industry as critical infrastructure.

The Institute of Nuclear Power Operations (INPO) participated in the NEI led industry calls and served as a liaison to the international nuclear community via the World Association of Nuclear Operators (WANO).

II–3.5. Recovery

The NEI continued to convene biweekly calls with the Canadian and US utilities as the plants prepared to vaccinate their essential workers, responding to continuing local surges in positive COVID-19 cases and surges in the new strains of the virus. In March 2021, the NEI discontinued regular calls and will schedule them when needed. Although the US industry has developed 'return to work' plans for its sites, remote work for support personnel remains in effect. Workforce protection and vigilance in managing the risk as the conditions continue to change will remain top priorities for 2021. The industry has been able to operate

the plants safely, and refuelling outages have been executed successfully while experiencing no significant challenges related to employee absence.

While the US industry and the NRC have adapted to working under the conditions of the public health emergency, the need for regulatory relief continues. The NEI's role has shifted from coordinating the exemption requests with the NRC to being a forum for sharing lessons learned and challenges in working under the regulatory exemptions and with remote inspections.

II–3.6. Conclusion

The US nuclear industry continues to demonstrate its capability to effectively mitigate the effects of the COVID-19 public health emergency and maintain safe, secure and reliable operations. The industry's culture of collaboration, effective practice of sharing operating experience, and a disciplined adherence to procedures in the workplace as a result of pre-existing safety culture and training in dealing with radiological hazards proved essential during this prolonged public health emergency.

Depending upon the pace of vaccine deployment in the USA and the emergence of new strains of the virus, it is very likely that full recovery from the consequences of the public health emergency on normal business operations will not occur until later this year.

II–4. WORLD ASSOCIATION OF NUCLEAR OPERATORS

II–4.1. Background

WANO is an international, not for profit member organization with a mission to maximize the safety and reliability of the world's commercial NPPs. WANO has offices in London and Shanghai and regional centres in Atlanta, Moscow, Paris and Tokyo.

The majority of WANO's members are owners and operators of NPPs and facilities. They operate more than 440 commercial NPPs and facilities in over 30 countries worldwide. Every NPP operator is a member.

WANO delivers its mission by working with members to assess, benchmark and improve performance through mutual support, exchange of information and emulation of best practices. WANO supports its members through five highly regarded programmes, namely Peer Review, Member Support, Performance Analysis, Industry Learning and Development and Corporate Communications.

II–4.2. Impact of the pandemic

II–4.2.1. Implications for WANO

The global COVID-19 pandemic has led to major restrictions on travel and business activity in an attempt to prevent the spread of the virus between and within States. This has affected many of WANO's activities, resulting in postponements to peer review and member support mission schedules at its regional centres.

WANO has ensured that the safety of its staff and that of its members has been its key priority during this period. WANO's regional centres have been ready and willing to recommence visits as soon as it has been safe and practicable to do so and have adapted their approach to support members. For instance, in many parts of the world, WANO has restarted and successfully conducted some peer reviews and member support missions by ensuring that additional quarantine and safety protocols are in place. These meet the requirements stipulated by each member and the country or area where it is located. In some cases, WANO has been able to provide support virtually, and in other cases WANO has developed hybrid approaches with a combination of in-person and virtual support.

In some areas, government travel restrictions are still prohibitive and mean that peer review and member support missions remain on hold.

II–4.2.2. Implications for WANO members

The global pandemic has caused disruptions to normal working practices within plants, resulting in new protocols being implemented to protect staff and ensure safe plant operations. These include new shift patterns, reduced site staffing, working remotely and new operational protocols.

The additional pressures created by these changes, as well as the distractions of personal and family life during the pandemic, need to be understood and managed effectively in order to reduce the likelihood of human performance errors.

In previous years, WANO has observed adverse trends in the area of human performance following significant non-nuclear related events; throughout the pandemic, WANO and the industry have taken steps to use that previous experience, apply lessons learned and anticipate and remediate issues early.

II–4.3. Mitigating actions

II–4.3.1. Actions taken by WANO

Due to the restrictions on travel and the additional time required for quarantine, WANO has focused its support on those members that are in greater need. In a number of countries, WANO has been able to continue to deliver peer reviews and support missions face to face by following both the local government and utility testing and quarantine requirements. In some cases, hybrid support has been provided, with a small number of team members physically present and other team members supporting via virtual technology. In addition, a significant number of support activities have taken place utilizing virtual technology.

WANO continues to support members to operate safely and reliably by providing information that helps them prevent events in the short term and aids them in the long term by helping them understand and improve their own performance. WANO continues to analyse and publish operating experience and performance indicator statistics.

As many stations are in a highly unusual and challenging situation, WANO is monitoring this closely. Now more than ever, using operating experience is essential in helping to prevent events from happening. Consequently, a key focus is to be alert for events with causes or contributing factors that are related to the current COVID-19 pandemic. This includes events related to human performance that are caused by distracted operators, unusual shift turnovers or unusual compositions of maintenance or operations teams. WANO encourages its members to be vigilant for such events and to report back on them. Trends in this area will be highly relevant for members and will be brought to their attention promptly.

WANO has adapted and innovated in order to facilitate information sharing among its members. For example, it launched a COVID-19 resource centre on its member web site to facilitate a worldwide exchange of information between member plants and facilities on how to deal with the COVID-19 pandemic. The resource centre contains information on the pandemic planning, preparation and response strategies by member utilities and plants. It facilitates the sharing of experience on how utilities and plants worldwide are dealing with key issues related to the pandemic, such as outages, risk management, sequestering staff, cleaning and disinfection practices, the use of thermographic cameras, shift planning and many more.

WANO also conducted a series of well attended online events, including forums for medical officers to share best pandemic practices, forums on maintaining human performance and a virtual Site Vice Presidents and Plant Managers Conference on the importance of strong leadership throughout

challenging times. A secure event portal streamed the event live in five languages, and more than 245 senior industry leaders from across the word attended the conference.

Feedback has indicated that members appreciate the opportunity to attend virtual events, which provide a safe, effective and efficient platform for information sharing. As pandemic related restrictions continue, WANO will organize further online events to enable members to share information and best practices on nuclear safety and performance.

II–4.3.2. Actions taken by WANO members

Human performance, coaching and oversight programmes have been a key focus for WANO members, ensuring safe and reliable operations while staff adapt to new ways of working that were created by the pandemic.

Ensuring an increased presence of managers 'in the field' has been one of the challenges experienced by plants. Actions by members have included managers working from home covering extra routine plant meetings in order to allow those on site to spend more time observing work activities and interacting with workers, and arranging rotas for leaders outside of normal working hours in order to observe different work activities not possible in daytime hours.

Weekly, rather than monthly, management team coaching reviews have been beneficial in some plants, resulting in rapid course correction in areas needing attention.

There is a greater emphasis on mental wellbeing, with meetings that focus on raising awareness around mental health and supporting staff. Some plants are also completing fitness for duty assignments and encouraging staff to take annual leave to recharge when there are signs of staff becoming more tired due to increased pressure and workloads.

Communicating in noisy environments while adhering to physical distancing rules is a very common challenge, and some members have introduced close communication devices and noise cancelling headsets to mitigate this issue.

Communicating clearly in the control room while wearing masks can also be problematic, and so enhanced communication, including increased eye contact and effective three part communication, have been practised on simulators at some sites.

Measures have been applied to mitigate or eliminate issues related to fatigue and heat stress caused by wearing masks, such as granting lower level leadership the authority to make exceptions for mask use. One utility uses a tool that allows staff to recognize the signs of physical and mental fatigue in themselves and others in order to take appropriate action. Anti-fogging sprays have helped to prevent glasses fogging while using masks.

Most importantly, leaders need to ensure that staff are engaged and motivated during a crisis by prioritizing staff safety and building trust among the workforce through clear and robust communication. Ensuring a two way dialogue between leaders and their employees is essential to maintaining a strong sense of morale and, as a result, high levels of performance.

II–4.4. Interactions with peer, international and regional organizations

All organizations have rapidly adapted to the use of virtual technology, in many cases from individuals' homes. This has enabled WANO to continue interactions with other organizations, and in a number of cases it has increased them (e.g. biweekly short virtual meetings with the IAEA and OECD Nuclear Energy Agency). The biggest challenge for global events is the time zone differences. This restricts WANO global meetings to two or three hours per day or to having global events repeated to allow those in different time zones to participate at a reasonable time of day.

II–4.5. Recovery

COVID-19 will remain with us for the foreseeable future. Vaccine delivery across the world will continue well into 2023. Therefore, WANO and its members are preparing for the long term with the expectation that some elements of protection against COVID-19 will continue for a very long time.

WANO and its members are now looking to incorporate elements of working during the COVID-19 pandemic into future working arrangements, including greater use of virtual technology and remote work to provide more efficient and effective support to members. Some members are already in the process of relocating to smaller offices with greater use of home working and virtual technology.

II–4.6. Conclusion

Although the COVID-19 pandemic has undoubtedly been a challenging time, WANO is enabling its members to share information and learn from and support each other in order to maintain high levels of performance. WANO has adapted its services so that members can exchange information and best practices securely online. A strong emphasis has been placed on leadership and human performance in this period with the aim of ensuring that plants are in a strong position to maintain and build upon their performance.

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Annex III

CASE STUDY — INTERNATIONAL NETWORK FOR NUCLEAR SECURITY TRAINING AND SUPPORT CENTRES SURVEY ON THE IMPACT OF COVID-19

III–1. BACKGROUND

In response to requests for IAEA support in developing, implementing and sustaining an effective national nuclear security regime, and drawing on the experience of some Member States, the IAEA developed a concept for the establishment of a national Nuclear Security Support Centre (NSSC) as a means to strengthen the sustainability of nuclear security in a State [III–1]. The role of an NSSC is to support competent authorities, authorized persons and other organizations with nuclear security responsibilities in sustaining the national nuclear security regime at both the national and operational levels through programmes in human resource development, technical support and scientific support. In realizing these objectives, an NSSC also fosters a culture of nuclear security and enhances national coordination and collaboration among the various competent authorities involved in nuclear security.

In 2012, the IAEA established the International Network for Nuclear Security Training and Support Centres (NSSC Network) to facilitate cooperation, identification of best practices and sharing of information among Member States with an NSSC or those with an interest in developing one. While the primary role of an NSSC, as a national institution, is oriented toward sustaining the nuclear security regime, NSSCs can benefit from regular or periodic exchange with centres in other Member States. Member States may be able to conserve resources and make further improvements to an NSSC by learning from internationally recognized good practices and lessons learned. The IAEA provides a range of support to Member States in facilitating such cooperation at regional and international levels, in particular through the NSSC Network.

In order to better understand the effect of COVID-19 on the role and functions of an NSSC and to share related good practices, Working Group C of the NSSC Network, which focuses on information sharing, conducted a survey of members. Of the 64 members who received the survey, 42 provided responses. The geographical distribution of respondents and the core functions of the respondent NSSCs are captured in Fig. III–1.

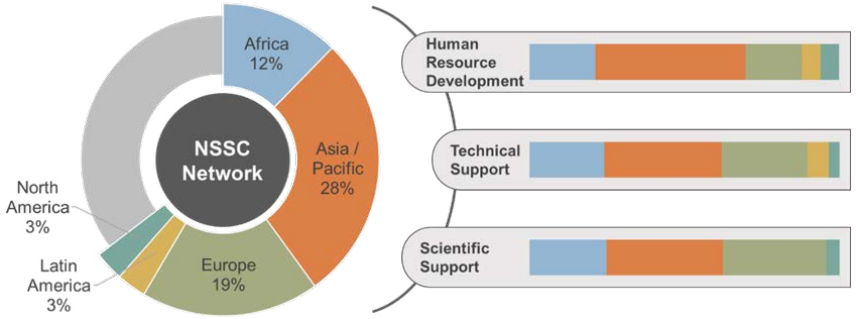

FIG. III–1. Survey respondents by region and NSSC core function.

III–2. IMPACT OF THE PANDEMIC

Of these 42 respondents, 28 provided details about how their activities were affected and their mitigation responses. According to the responses, all NSSC core functions were affected, including human resource development, specifically through a national nuclear security training programme; technical support services for nuclear security equipment life cycle management; and scientific support services for provision of expert advice, analysis and research and development for nuclear security.

Survey respondents reported that the immediate effect of the pandemic primarily resulted in either the cancellation or postponement of their activities (see Fig. III–2). The core functions of the NSSC include day to day management and operations that have been affected by the pandemic. In the 'other' category, one NSSC reported that financial support for the NSSC was diverted to pandemic response. Although only one NSSC shared this impact, this may become a more

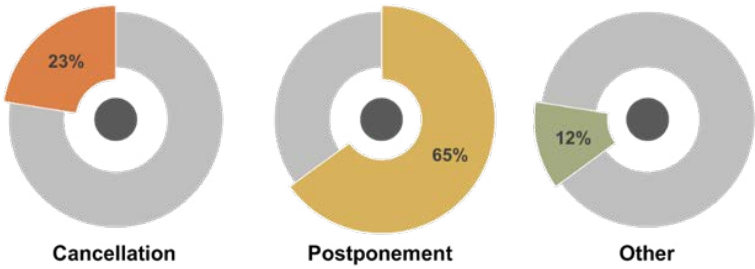

FIG. III–2. COVID-19 impact on NSSC activities.

common issue among NSSCs. Several NSSCs reported a transition to work from home arrangements for their staff that has added an adjustment period beyond the need to transition NSSC activities to a virtual approach.

For NSSCs in the planning phase, the pandemic has resulted in delays in construction and equipment installation, as well as limited success using virtual meetings to coordinate with national stakeholders on NSSC development activities.

NSSCs also reported an identified need to reduce the number of trainees for face to face or classroom based training to accommodate physical distancing requirements. NSSCs have experienced issues with the availability of subject matter experts and instructors to support training courses due to travel restrictions. Overall, the pandemic has resulted in reduced staffing that has affected the number of training courses NSSCs are able to conduct. All of these immediate consequences particularly affect the hiring of new staff and the ability of NSSCs to prepare new staff for the conduct of their duties.

Survey respondents reported that pandemic related travel restrictions have affected their activities associated with conducting on-site inspections. Travel restrictions have also impacted on the support provided by contracted equipment maintenance providers, including routine and corrective (repair) maintenance and equipment calibration.

III–3. MITIGATING ACTIONS

NSSCs have postponed operational level activities in order to adjust to working remotely and address related issues, including connectivity issues and providing platforms that promote communication and collaboration among staff members. One NSSC reported the development of an online platform specifically for the purposes of internal coordination and communication.

In training, respondents highlighted the transition to distance or virtual training events. NSSCs reported using virtual training platforms to reach multiple small groups of trainees simultaneously. NSSCs have developed new tools and equipment to facilitate the virtual approach to training. NSSCs also reported the development of e-learning courses and computer based simulator training as well as novel approaches to conducting virtual hands-on training.

Where virtual or distance learning cannot achieve training objectives, NSSCs have developed new procedures that promote the use of barriers to infection, such as hand washing, physical distancing and mask wearing. NSSCs have also developed detailed procedures to replace on the job training where achievable. These detailed procedures incorporate stepwise instructions with

images or illustrations and videos demonstrating conduct of the duty or task. These materials are available directly at the duty station for ease of use.

In order to address the gaps resulting from the lack of training, one NSSC developed a 24/7 call centre where consultations related to detection and response are provided in real time.

Several survey respondents also reported that they are continuing their involvement in international activities when they are conducted virtually.

III–4. RECOVERY

In 2021, NSSCs expect they will continue to face the decision of whether to cancel or postpone events and activities. Survey respondents indicated that they expect continued financial support issues to adversely affect their ability to conduct postponed events and activities.

NSSCs reported that the mitigating actions they have already implemented have been incorporated into their intermediate term strategy to stay safe and strengthen their commitment to providing services to their stakeholders. NSSCs reported a commitment to adhering to their guidelines for implementing strategies on barriers to infection. NSSCs also reported a plan to expand distance or virtual learning activities.

One NSSC reported that its State has managed to control the spread of COVID-19, that it has been able to initiate a limited return to normality for its activities and that it is already continuing its capability development work. Several NSSCs expect that they will also return to normal operating conditions in the second half of the year and are planning to conduct face to face events and training sessions to strengthen or reinforce the distance or virtual training activities conducted throughout the pandemic.

III–5. CONCLUSION

The NSSC Network and the IAEA have used the results of this survey to develop long term strategies, activities and guidelines to support Network members' events and activities.

In 2020, the NSSC Network newsletter introduced a new 'In Focus' article series that highlights the good practice activities of a Network member (see Fig. III–3). The In Focus article for Issue 6, published in October 2020, highlighted Japan's experience in mitigating the effects of COVID-19 on NSSC operations.

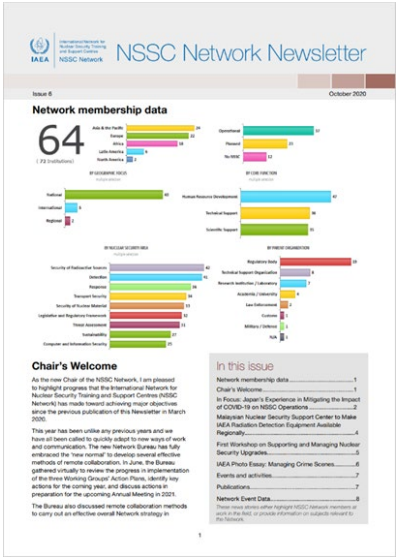

FIG. III–3. NSSC Network newsletter.

Through its activities with the NSSC Network, the IAEA is developing a Library of Lessons Learned and Case Studies that will include highlighting those strategies applied by NSSCs during the pandemic that can be adapted for long term use or implementation.

The IAEA published Establishing and Operating a National Nuclear Security Support Centre (IAEA-TDL-010) [III–1] in June 2020 and conducted a webinar in September 2020 to familiarize the Network with the guidance provided in this publication.

The IAEA has also developed strategies for conducting NSSC support activities virtually, including expert missions, technical exchanges and consultancy meetings on the development of a national NSSC.

To support NSSCs whose core function is human resource development, the IAEA is developing training on transitioning face to face or classroom based nuclear security training to virtual training, as well as good practices in facilitating virtual training.

To support NSSCs whose core function is technical support, the IAEA has conducted webinars related to detection equipment, including a webinar on the application of high purity germanium detectors for nuclear security and an overview of passive and active detection technologies for detection of chemical, biological, radiological and nuclear hazards and explosives and other contraband.

To support NSSCs whose core function is scientific support, the IAEA is working to develop virtual training related to radiological crime scene management, including instructor training to develop the capabilities of the NSSCs in this area.

The NSSC Network survey on the effects of COVID-19 has resulted in a recognition of the effects on NSSC activities, promoted sharing of good practices across the Network and helped the IAEA to better understand the ways in which it can focus its activities to further the support provided to NSSC Network members.

REFERENCES

[III–1] INTERNATIONAL ATOMIC ENERGY AGENCY, Establishing and Operating a National Nuclear Security Support Centre, IAEA-TDL-010, IAEA, Vienna (2020).

LIST OF ABBREVIATIONS

CNSC	Canadian Nuclear Safety Commission
EDF	Électricité de France
Energoatom	National Nuclear Energy Generating Company 'Energoatom', Ukraine
EPRI	Electric Power Research Institute
GRS	Gesellschaft für Anlagen- und Reaktorsicherheit gGmbH
INPO	Institute of Nuclear Power Operations
IT	information technology
JSC	joint stock company
NEI	Nuclear Energy Institute
NPP	nuclear power plant
NRC	United States Nuclear Regulatory Commission
NSSC	Nuclear Security Support Centre
NSSC Network	International Network for Nuclear Security Training and Support Centres
OECD	Organization for Economic Co-operation and Development
ONR	Office for Nuclear Regulation, United Kingdom
PCR	polymerase chain reaction
PPE	personal protective equipment
Rosatom	State Atomic Energy Corporation 'Rosatom', Russian Federation
UVGI	ultraviolet germicidal irradiation
WANO	World Association of Nuclear Operators

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The ability of the nuclear industry to continue to operate safely, securely and reliably during special circumstances such as a pandemic is essential and depends upon the effectiveness of its preparation, response and recovery plans, as well as the ability of relevant organizations to adapt and respond to unforeseen situations. The purpose of this publication is to share experience with regard to managing and regulating facilities and activities during the COVID-19 pandemic and to assist Member States in considering further actions to improve preparedness and response in relation to the ongoing pandemic and any future ones. The effective sharing of operating and regulatory experience is intended to have a positive influence on the response to, and recovery from, such global events. This publication is therefore written for operating organizations, regulatory bodies, competent authorities, research and technical support organizations, contractors and vendors.

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