



Technical Meeting on Economics of Flexible Operation in Nuclear Power Plants

Hosted by the

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through the

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Information Sheet

Background

The majority of existing NPPs are optimised to operate at steady full power, known as ‘baseload’ operation due to more beneficial economic reasons and less complexity of operation. Where NPPs are operated in baseload mode, other generating units (such as hydroelectric, coal- or gas-fired) operate flexibly to balance generation and demand. This has been a typical operation mode for NPPs (with only a couple of Member States (MS) have operated their nuclear flexibly); however, there is an increasing number of NPPs in many MSs that are implementing or preparing for nuclear units to be able to operate flexibly. In order to address that trend and associated MS needs, the IAEA publication NP-T-3.23, Non-Baseload Operations in Nuclear Power Plants: Load Following and Frequency Control Modes of Flexible Operations, was prepared and published.

As discussed in NP-T-3.23, although more beneficial economic reasons and less complexity of operation makes the “baseload” mode of operation preferable by the operating organizations and the regulatory bodies, there is an increasing need for NPPs to operate in ‘flexible’ modes, i.e. load following, frequency response or abrupt changes to electrical output upon requests from grid operators. This is mainly due to one, or combination, of the following factors resulting from changes to the structure of electricity supply system and the electricity market during the long operating lifetime of an NPP:

- Large or growing percentage of the nuclear generating capacity;
- Growth in generating capacity of variable renewable generation;
- Deregulation of the public electricity supply system;
- Overcapacity of new-built NPPs.

An electric utility (or a country) that is considering (e.g. because of market deregulation) or required (e.g. because of new grid regulation) to operate individual NPPs (or NPPs that are part of a fleet of various energy sources) flexibly faces a complicated situation in technical and economic aspects. This situation is further complicated due to the current electricity market conditions, economic pressure on the energy and electricity generation and transmission system reliability and stability.

Therefore, the issue of economic impacts has become a central challenge in the future electricity system, particularly where the nuclear units might/will coexist with high, and even growing, amounts of variable renewable energy. Although the integration of renewables may represent the central case for flexible operation of NPPs in many grid systems, it is not the only driver of flexible operation of nuclear generating units.

On the other hand, from the economic perspective, reciting the number of reasons mentioned above, the non-baseload operation may add value to the power system in cases of: integration of renewables; power oversupply (over-generation); and, low degree of trans-border electricity grid interconnections. A profound economic analysis calls for a comparison of impacts resulting from flexible operation with those from a baseload operation mode. The costs and benefits associated with flexible operation have to be considered in a comprehensive and integrated manner as they may be mutually exclusive at different scales as well as mutually dependent in specific interfaces.

The IAEA's Planning and Economic Study Section (PESS) had prepared an economic study to quantify the cost–revenue aspects for NPP operations in mixed energy systems, including flexible operations. The purpose of this study was to explore economic opportunities for using nuclear energy in future power markets with increasing deployment of renewable energy. As a specific case to support NP-T-3.23, the study established a case study based on a large-scale country level power plant dispatching model, the IAEA study assessed the requirements for nuclear flexibility in the European Union (EU) up to 2050.

This simulation study observed that integration of renewables may not be the only reason driving the provision of flexible nuclear and the effect of a lower interconnection degree and an inflexible generation mix are also the drivers. It also observed that flexibility needs may not be resolved in some regions, even with flexible nuclear, and particularly noted that revenue impacts from flexible operation need to be understood in detail, as revenue is dependent upon specific market arrangements or volatile electricity prices.

Furthermore, Member States, through the Technical Working Group on NPP Operations (TWG-NPPOPS) which consist of utility executives of operating NPPs, recommended to the IAEA Secretariat to study the impact/value of NPP contributions to the grid security and reliability at the plant, fleet, grid, national economy and global levels, in order to address the return, expenditure and socio-economic benefits of nuclear generation. Recognizing that the revenues are a product of how much energy is generated, what portion of it converted into useful commodity (and service) and the price of that commodity (or service) TWG-NPPOPS particularly noted that:

- At the grid level, not only the supply of commodity (electricity), the value of goods and services that are provided, particularly those that contribute to the reliability, stability and resilience of grid system (e.g., frequency, inertia are not traded commodities, but they are important factors for grid stability) should be considered and studied.
- Also, at the grid level, the competition with intermittent renewables should be considered as supplementing and complementing each other. This needs to consider the value of reliable and

dependable generation by nuclear for the reliability, stability and resilience, and associated payment for such services.

- At the economy level, value of the low-cost and low carbon emission needs to be considered and adequate incentive (or penalties) implemented in the energy markets and regulations.

Therefore, the variability in the economic drivers and revenue/cost impacts that vary necessitated expansion of the pilot study, which was performed in support of NP-T-3.23 and with limited cases, to a larger and more comprehensive and comparative study encompassing more diverse electricity and energy markets, demand and generation models in the Member States in support of optimization of those.

Objectives

The purpose of this meeting is to discuss potential economic consequences of flexible operation in NPPs in different market, energy mix and grid structures. It is intended to explore methods and model needed to estimate economic consequences of flexible operation by reviewing and exchanging expert views. The particular goals of the meeting are as follows:

- To discuss case studies and modelling;
- To understand gaps and limitations of existing models and methods and to determine potential ways to close them;
- To collect good practices, identified issues and lessons learned in economic modelling of flexible operation;
- To provide a forum in which participants can discuss common challenges, opportunities for cooperation, concerns and issues that their countries/organizations are facing or likely to face when conducting such an analysis; and
- Collect feedback on a draft IAEA publication, “A Study of Flexible Operation of NPPs Regarding Economic Quantification, Issues and Solutions”.

Target Audience

The meeting is aimed at current and future nuclear industry and grid system stakeholders, particularly NPP and grid owner/operator organizations, grid and energy planners, policy makers, regulators. The participants should possess a high-level understanding of energy and electricity sector and market development issues, as well as previous experience in energy and electricity planning, policy and economic analysis, particularly regarding the flexible operation of NPPs owing to the electricity and energy market structure, generation mix and grid security and reliability needs/requirements.

This meeting is open to IAEA Member States considering the sustenance, expansion or re-establishment of their nuclear programme and generation in their energy mix. As such, they should be capable of describing or discussing, in depth, the experiences and challenges, as well as the roles, responsibilities and involvement of entities for the economic reliability and stability of energy markets, grid systems and a safe and sustainable nuclear generation within specific market arrangements or volatile electricity prices.

Depending on the number of designations that are received, the meeting may be open to up to three participants from each invited Member State. Participants will be asked to give a presentation on their personal/organizational/national/international experience, as well as to take part in the discussions organized during the breakout sessions. This will ensure a common understanding of issues from each organization's perspective in an integrated manner.

Working Language(s)

The meeting will be conducted in English. No interpretation will be provided.

Topics

The topics of this meeting are to cover the areas of economics of flexible operation of NPPs in various market structure and electricity and energy infrastructure and associated plans. As such, the meeting will specifically investigate the following:

- What type and how much grid services (e.g. load following, frequency control, reactive power, etc.) could NPPs support and at what penalty?
- What is the economic value/impact of being able to provide grid services?
- What type of flexibility nuclear generation is required by the grid — larger down power and faster ramp rate for load following or increased start/stop capability? What is the optimal level of flexible capacity in a system?
- How can nuclear be used in different grid environments (i.e. size, complexity) to cope with variable power demand and fluctuating supply from renewables?
- What are the economic implications (including different revenues streams) for using large-scale reactors?
- How does market regulation and real-market interaction affect the economic viability of using nuclear under the various markets?

Participation and Registration

All persons wishing to participate in the event have to be designated by an IAEA Member State or should be members of organizations that have been invited to attend.

In order to be designated by an IAEA Member State, participants are requested to send the **Participation Form (Form A)** to their competent national authority (e.g. Ministry of Foreign Affairs, Permanent Mission to the IAEA or National Atomic Energy Authority) for onward transmission to the IAEA by **1 September 2019**. Participants who are members of an organization invited to attend are requested to send the **Participation Form (Form A)** through their organization to the IAEA by above deadline. Designations received after that date or applications sent directly by individuals or by private institutions may not be considered.

Selected participants will be informed in due course on the procedures to be followed with regard to administrative and financial matters. For Member States requesting financial assistance through technical cooperation funds, applications for financial support should be made at the time of designating the participant(s).

Expenditures and Grants

No registration fee is charged to participants.

The IAEA is generally not in a position to bear the travel and other costs of participants in the event. The IAEA has, however, limited funds at its disposal to help meet the cost of attendance of certain participants. Upon specific request, such assistance may be offered to one or two participants per country, provided that, in the IAEA's view, the participant will make an important contribution to the event and that they represent different national organizations.

The application for financial support should be made using the **Grant Application Form (Form C)** which has to be stamped, signed and submitted by the competent national authority to the IAEA together with the **Participation Form (Form A)** by **1 September 2019**.

Visas

Participants who require a visa to enter United States of America should submit the necessary application as soon as possible to the nearest diplomatic or consular representative of United States of America. Visa arrangements, including transit visas, are the sole responsibility of the participant. He/she should initiate the necessary actions for obtaining a visa prior to departure.

Additional Information

Designating Governments will be informed in due course of the names of the selected candidates and will at that time be given full details on the procedures to be followed with regard to administrative and financial matters.

The costs of the meeting facilities and meeting logistic support will be borne by the host organization, with IAEA allowance.

It should be noted that compensation is not payable by the IAEA for any damage to or loss of personal property. The IAEA also does not provide health insurance coverage for participants in meetings, workshops or training courses or for consultants. Arrangements for private insurance coverage on an individual basis should therefore be made. The IAEA will, however, provide insurance coverage for accidents and illnesses that clearly result from any work performed for the IAEA.

Local Arrangements

The meeting will be held in Phoenix, Arizona, USA and will start at 9:30 on 3 December 2019, and end at 12:00 on 5 December 2019. There will also be a technical tour of the Palo Verde Generating Station in the afternoon of the last day, 5 December 2019.

Participants are kindly requested to arrive at the The Wigwam, 300 East Wigwam Blvd., Litchfield Park, Arizona 85340, USA, at least one hour before the meeting starts on 3 December 2019, in order to allow adequate time for registration. Participants should bring some form of personal identification, such as a national passport, in order to identify themselves to the security officers.

Participants who would like to participate in the plant tour on the last day will be requested to provide a copy of their national passport to the local authorities at least three weeks before the meeting.

Organization

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Subsequent correspondence on scientific matters should be sent to the Scientific Secretary/Secretaries and correspondence on other matters related to the event to the Administrative Secretary.