

Presentation:

Nuclear Reactor Technology: The Next 50 Years

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ABSTRACT

In light of the growing awareness of the environmental externalities of fossil fuel combustion, alternatives for electric power generation such as solar, wind and nuclear energy are becoming more desirable. In developed countries, large power markets are currently served by a centralized energy system through well inter-connected electricity grids. However, as shares of variable renewable energy sources (mainly wind and solar power) are increasing in the future; larger fluctuation in power generation can be expected which lead to higher risk of grid instabilities. Less-capital intensive small and medium sized nuclear reactors (SMR) are emerging as an important element of alternative power generation system to fossil fuel, with a unique additional role of balancing the power generation fluctuation caused by the solar and wind power generation.

In regions not served by large electricity grids, including many parts of the developing countries with increasing demand for energy at rates above world's average, power generation using locally available energy sources including renewable energy is the practical means of providing basic energy needed for social and economic development. The integration of locally supportable SMR and local renewable energy system in a hybrid fashion can reduce the relative scale but not eliminate the fluctuation in power generation caused by the irregular availability of solar and wind energy. Without the use of commercial electricity trading that is only available in regions served by large inter-connected electricity grids, further minimization of power generation fluctuation can be done by the installation of local energy (electricity and/or heat) applications and/or energy storage device. The operation of these applications and energy storage can be done in synchronization with the availability of excess power throughout the fluctuation of the overall power generation in the region. Under these conditions, SMRs utilization as part of hybrid energy systems therefore have the potential to be a key solution to meet the energy needs of the emerging economies in the next few decades.

In order to be operated as part of distributed hybrid energy systems, SMRs should be available in various power rating and be able to be engineered for multiple-applications. They should also be user-friendly, and able to be integrated easily with renewable energy systems as well as, if necessary, with adjacent energy application/storage systems. With these considerations, a number of special design requirements for SMR have been identified.

The multiple-applications of the SMR may include provision of neutron utilization for industrial applications and research in the future, depending upon the needs in the region where they are built. The difference between a research reactor and such SMR may therefore become indistinct. In any case, operating and utilizing research

reactor and small and/or prototype SMR can be taken as a first step in the preparation for a larger nuclear power program, as both the small nuclear systems and the large nuclear power systems require personnel with similar skills sets and the support of the same/similar infrastructure including regulatory body. A strive-for-excellence culture normally required for the operation of a large nuclear system should therefore be cultivated starting with the deployment of the small nuclear systems including the research reactors. Organization well-embedded with such culture put a strong emphasis on safety, health and environmental protection. They are disciplined and well-motivated to perform work systematically, according to plans and established procedures. They communicate effectively within the organization and with stakeholders, and have a continuous drive to improve quality.

These considerations should be included in the design of SMRs and research reactors to be deployed in the next 50 years.