Small Modular Reactors (SMRs) are emerging as a promising technology within the nuclear energy sector, designed to provide a safer, more flexible, and scalable alternative to traditional large-scale nuclear reactors. The development and deployment of SMRs have gained significant momentum in recent years due to the need for cleaner energy sources, grid stability, and energy security. Here's a detailed overview of the current status of SMR development as of 2024:

1. Global Regulatory and Policy Support

- **United States**: The U.S. Nuclear Regulatory Commission (NRC) approved the design certification for NuScale Power's SMR in 2022, marking a major milestone for the industry. NuScale's first commercial SMR power plant, VOYGR, is set to be operational by the end of the decade. Other companies, such as TerraPower and X-energy, are advancing their SMR designs with Department of Energy (DOE) support.

- **Canada**: Canada has been a strong advocate of SMRs, integrating them into its Net-Zero Emissions Strategy by 2050. The Canadian Nuclear Safety Commission (CNSC) is currently reviewing several SMR designs, including those by GE Hitachi and

Terrestrial Energy, with plans to deploy SMRs in Ontario by the late 2020s.

• **United Kingdom**: The UK is investing heavily in SMRs as part of its Energy Security Strategy. Rolls-Royce's SMR design is advancing through regulatory assessment, with a target to deliver its first operational units by the early 2030s. The UK government aims to build multiple SMRs as part of its plan to reduce dependence on fossil fuels.

• **Europe**: The European Union, particularly countries like Poland and Estonia, is exploring SMRs to replace coal plants and reduce greenhouse gas emissions. The International Atomic Energy Agency (IAEA) has been working with European nations to streamline regulatory frameworks for SMRs.

• **Asia**: China and South Korea are advancing their own SMR designs. China has already begun constructing its first SMR project, the Linglong One (ACP100), on Hainan Island, expected to be operational by 2026. South Korea's SMART (System-integrated Modular Advanced Reactor) design has received significant interest from other countries looking to adopt SMR technology.

2. **Technology and Design Innovations** SMRs are characterized by their compact design, modular

construction, and enhanced safety features. Here are some of the key SMR technologies under development:

• **NuScale Power Module**: A light-water reactor (LWR) design, with each module generating up to 77 MW (with potential scalability up to 12 modules per plant). NuScale's design is unique in that it uses natural convection cooling, reducing the need for external power sources.

• **TerraPower's Natrium Reactor**: A sodium-cooled fast reactor with integrated energy storage, providing up to 345 MW with the ability to scale to 500 MW for peak power demands. TerraPower, co-founded by Bill Gates, aims to demonstrate its first reactor in Wyoming by 2030.

• **Rolls-Royce SMR**: A 470 MW pressurized water reactor (PWR) design that emphasizes modular construction to reduce costs and construction time. The UK government has committed significant funding to accelerate its deployment.

• **Moltex Energy's Stable Salt Reactor (SSR)**: A molten salt reactor design aimed at using recycled nuclear waste as fuel, targeting deployment in New Brunswick, Canada, by the 2030s.

• **GE Hitachi BWRX-300:** A boiling water reactor with a simplified design that leverages proven technology. It is one of the front-runners for near-term deployment in Canada, Poland, and the United States.

3. **Benefits of SMRs** • Safety: SMRs incorporate passive safety systems, reducing the risk of meltdowns and improving overall safety.

   • **Scalability**: SMRs can be constructed modularly, allowing utilities to add capacity as demand grows.

   • **Flexibility**: Their smaller size makes them suitable for remote locations, industrial applications, or integration with renewable energy sources.

   • **Lower Capital Costs**: The reduced scale and modular nature of SMRs lower upfront investment compared to traditional reactors.

4. **Challenges and Hurdles** While SMRs offer significant promise, there are several challenges to overcome:

   • **Regulatory Approvals**: Navigating the regulatory process remains complex and time-consuming, as many regulators are still adapting frameworks to accommodate new reactor designs.

• **Cost Competitiveness**: While SMRs are expected to reduce construction times and costs, the technology is still emerging, and initial units are likely to be expensive.

• **Supply Chain and Manufacturing**: The ability to mass-produce SMR components in factories is crucial for cost savings, but the infrastructure for this is still being developed.

• **Public Acceptance**: Despite improved safety, public skepticism toward nuclear energy remains a significant barrier in some regions.

5. **Future Outlook** The next decade is critical for the commercialization of SMRs. A few key trends to watch include:

   • **First Operational Plants**: NuScale and China's Linglong One are on track to be some of the first SMRs to become operational by the late 2020s.

   • **Increased Investment**: Governments and private investors are pouring resources into SMR projects, with estimates suggesting **a $100 billion global market by 2035**.

• **Deployment in Developing Countries**: SMRs offer a feasible solution for countries with limited energy infrastructure to transition to low-carbon power sources.

• **Hybrid Energy Systems:** SMRs could be paired with renewables to provide consistent baseload power, helping to stabilize grids with high levels of intermittent solar and wind energy.

Overall, while the technology is not yet widely deployed, SMRs are gaining traction as a potential solution for the future of clean, reliable, and flexible energy production.

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