Research & Development

Energy

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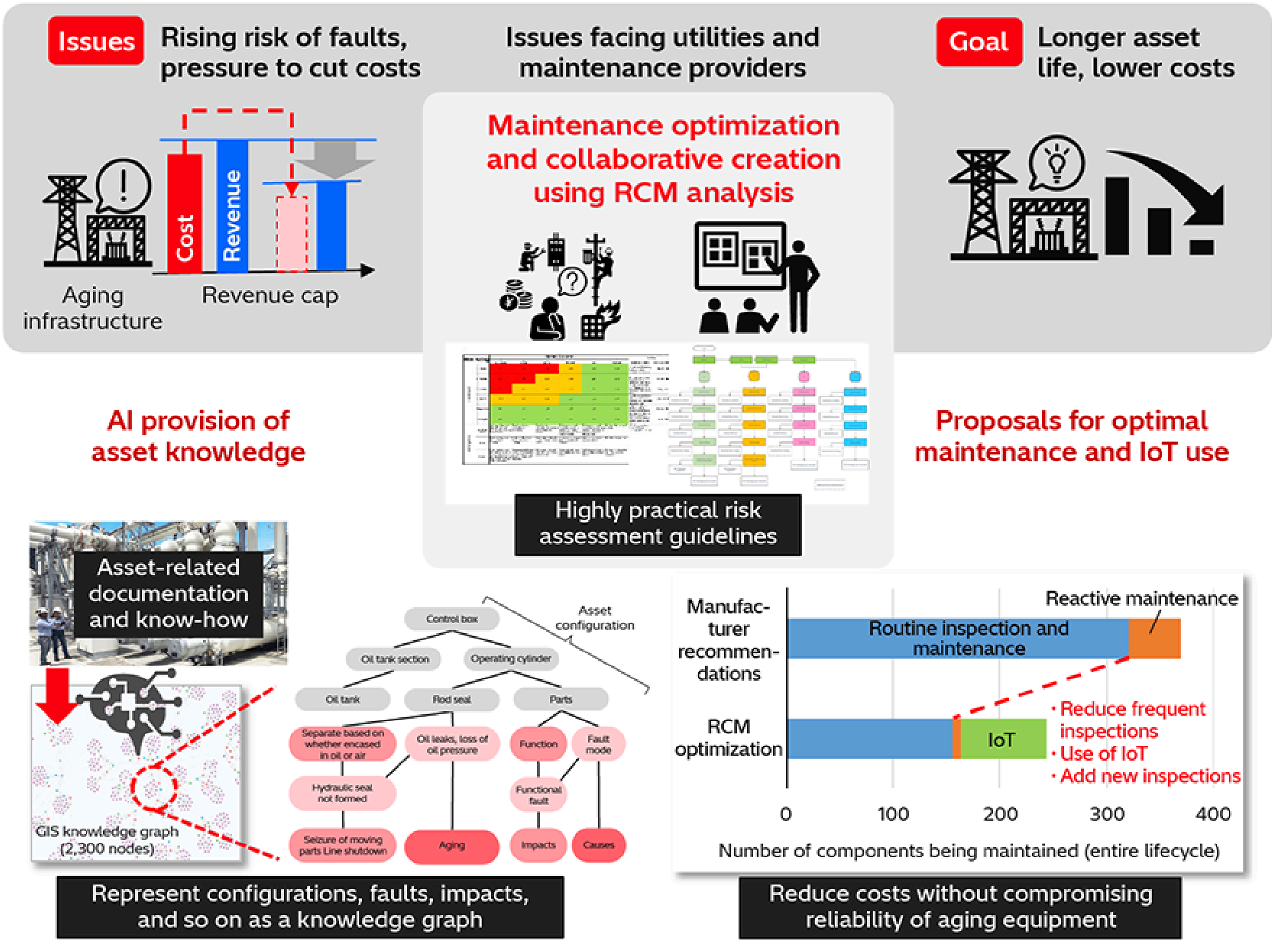
Innovation & R&D, Energy

1. Asset Life Extension Service with Digitalization of Asset Knowledge and Reliability-centered Maintenance

To address societal challenges such as the aging of electricity supply infrastructure and workforce shortages, Hitachi is developing maintenance planning techniques that extend the life of transmission and distribution assets and optimize upgrade planning. These techniques deliver highly reliable and efficient maintenance by using artificial intelligence (AI) to build asset knowledge with minimal work and high coverage and by optimizing planning on the basis of risk assessments made using reliability-centered maintenance (RCM).

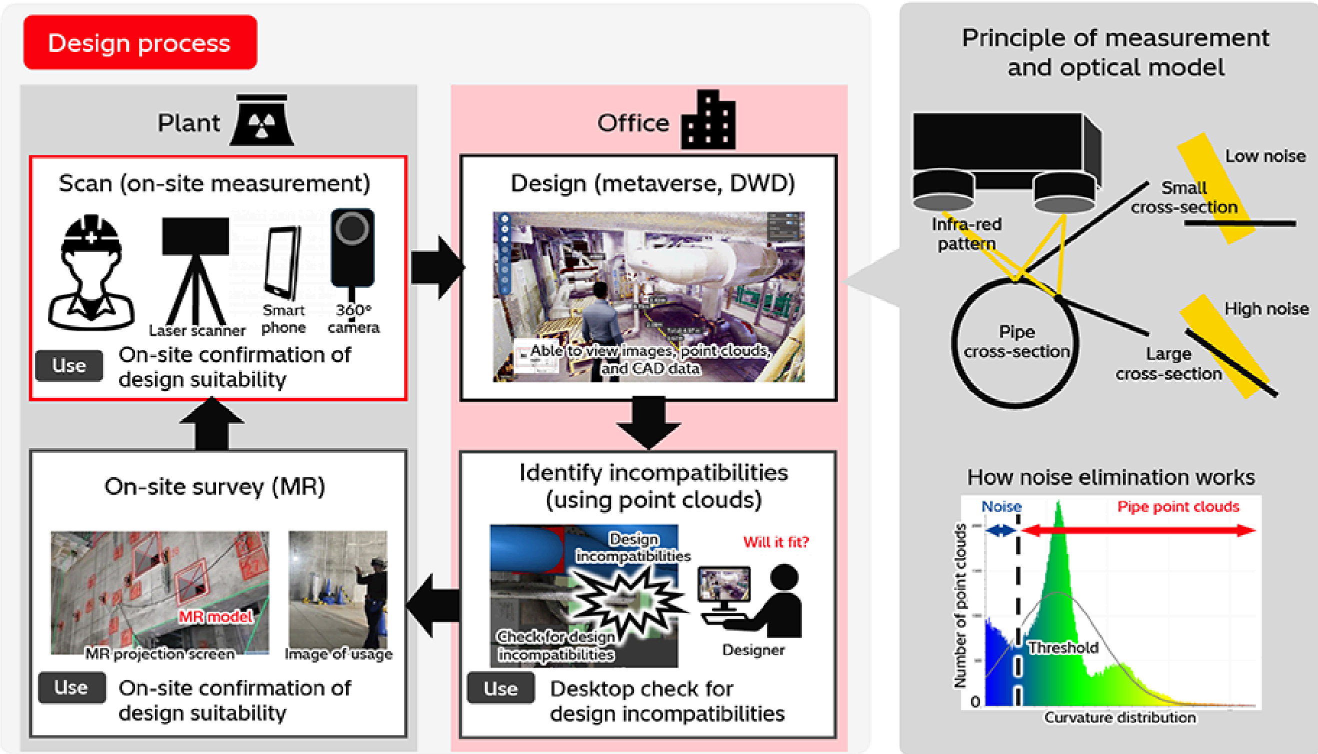
A key feature of asset knowledge construction is its use of AI to create large knowledge graphs at low cost by using large language models (LLM) and a reliability knowledge ontology derived from asset-related documents and other knowledge. This succeeded in establishing five times as much knowledge while also reducing the amount of work required to build knowledge crucial to the Integrated World Infrastructure Model (IWIM) by 70% compared to doing so manually. In a trial, the technique was used to formulate an optimal maintenance plan for aging gas-insulated switchgear (GIS) used in substations that took account of asset fault characteristics based on asset knowledge and RCM practices. The quantitative results indicated that, by reassessing risks and utilizing the Internet of Things (IoT), it successfully reduced the amount of maintenance without compromising reliability.



[1] Digitalization of Asset Knowledge and Reliability-centered Maintenance

2. Digital Technologies Underpinning Entry by Lumada into Nuclear Power Industry

One of the challenges in the refurbishment work associated with adding new piping and machinery in preparation for restarting idled nuclear power plants is rework in the installation stage due to the incompatibility of the design with the existing plant. To prevent this, Hitachi is developing Digital WalkDown (DWD) that helps identify incompatibilities by obtaining point cloud measurements of the existing plant during the design stage and integrating this information into Computer-Aided Design (CAD), and the use of Mixed Reality (MR) to show the CAD data overlaid on the actual plant. The identification of incompatibilities is done by aligning point clouds with CAD data based on the location of equipment that is present in both and then determining where overlaps occur. Unfortunately, the presence of measurement noise in point clouds can make it difficult to identify landmark equipment to use for alignment, and this risks incompatibilities being missed due to poor overlay accuracy. In response, the work done by Hitachi has included the development of a technique for distinguishing between pipe point clouds and noise based on how laser scanners work and using optical model analysis of pipe geometry. When tested on actual data, the technique performed at a level that would be adequate for identifying incompatibilities, achieving reliable overlay accuracy even when point clouds were noisy. This work will prevent rework between the design and installation phases and help to ensure that the restarting of nuclear power plants proceeds smoothly.



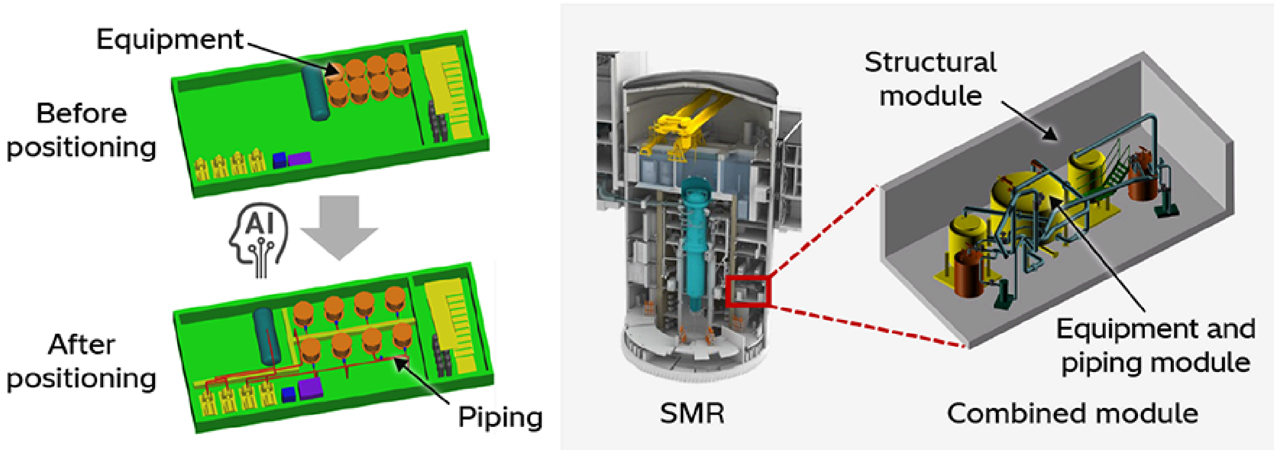
[2] Use of Digital Technology in Pipe Installation Design Process

3. SMR Design Technique for Shortening Construction Lead Time

Given the projections for rapid growth in demand for electric power as generative AI becomes more widely used, small modular reactors (SMRs) that combine reliability of supply with decarbonization are expected to play a key role. One of the challenges to realizing this is how to dramatically shorten the design and construction lead time for SMRs in order to keep up with this demand, and to do so without compromising safety.

In response, Hitachi has developed an automatic design technique for shortening design lead times that works by using an AI and genetic algorithm to optimize the positioning of power plant equipment (such as pumps, tanks, and electricity distribution boards) and the routing of the pipes that run between them. A technique is also being developed to shorten construction lead times by expanding the extent to which modules are fabricated in the factory and installed on site as single units so that schedules can be shrunk and quality improved. This is done by integrating structural modules with equipment and piping modules together in a single combined module.

By using combined modules and automatic design in tandem, and with additional consideration for ease of fabrication and installation, Hitachi intends to contribute to the future rapid deployment of SMRs and to the reliability of electricity supply through the joint optimization of all steps from design to construction.



Automatic design (equipment positioning and pipe routing)

SMR modularization

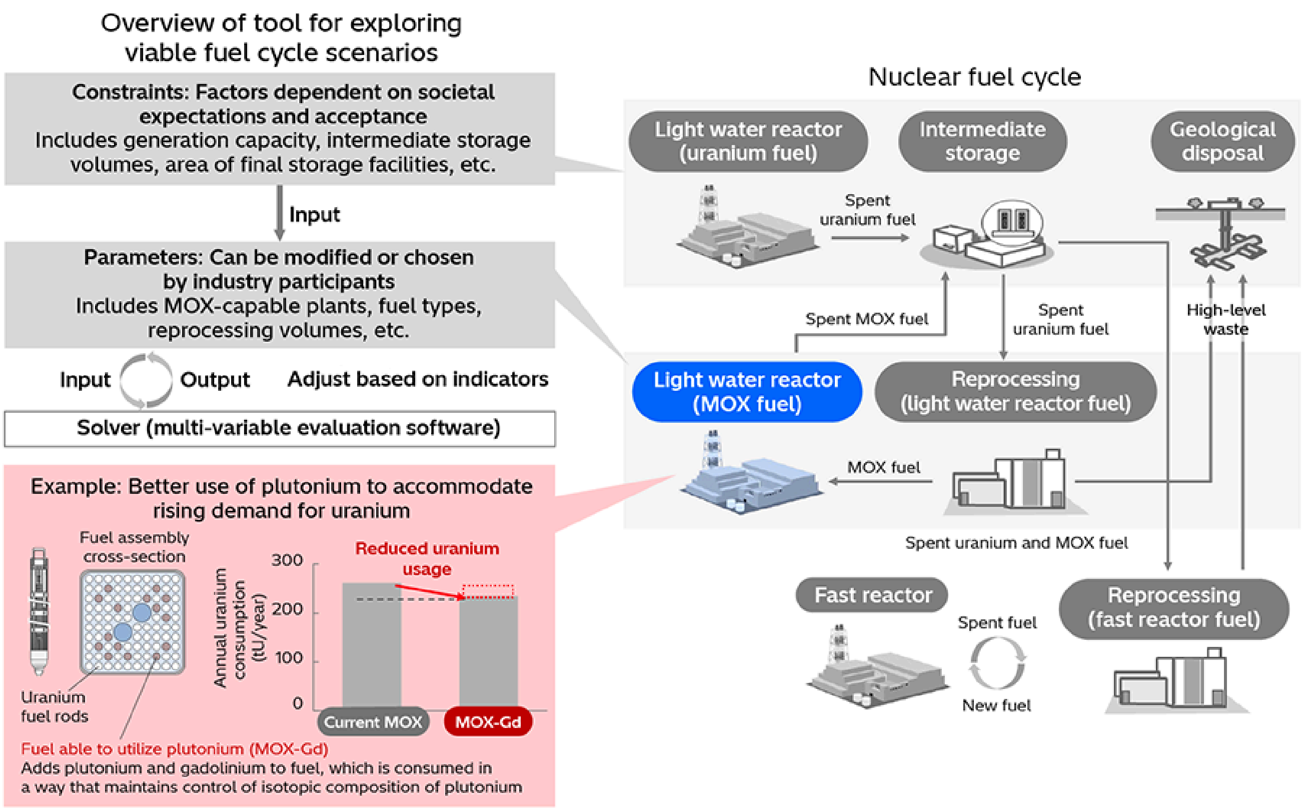
[3] Automatic SMR Design and Use of Combined Modules

4. Work toward Achieving Sustainable Nuclear Power

With the goal of turning nuclear power into a sustainable source of energy, Japan, like France, in addition to making the most of its existing light water reactors, is seeking to make a future transition to fast reactors that can repeatedly re-use the residual plutonium present in the spent fuel from its light water reactors. Practical deployment of fast reactors is not expected until the latter half of this century at the earliest. Until then, nuclear non-proliferation considerations make it necessary to use light water reactors to burn the plutonium recovered from spent fuel when it is reprocessed to reduce its volume.

To clarify how reprocessing and the use of plutonium should be carried out on the assumption that light water reactors will continue to be used long into the future, Hitachi is developing a tool for exploring scenarios that offer the best economic outcomes while also satisfying the requirements. These requirements include constraints that are dependent on societal expectations and acceptance, such as the amount of intermediate spent fuel storage, and parameters that can be modified or chosen by the industry, such as the reprocessing volumes and the choice of fuel and reactor types to enable the burning of plutonium. The tool is being used to assess the benefits of adopting the resource-renewable boiling water reactor (RBWR), a light water reactor under development by Hitachi that is suitable for burning plutonium. To take pressure off the rising demand for uranium, it is also being used to assess how much uranium usage can be reduced by using fuels that make efficient use of plutonium.

By putting the tool to use in this way, Hitachi intends to use it for collaborative creation with stakeholders, including to identify which technologies will be required under a range of different scenarios and the benefits of their adoption.



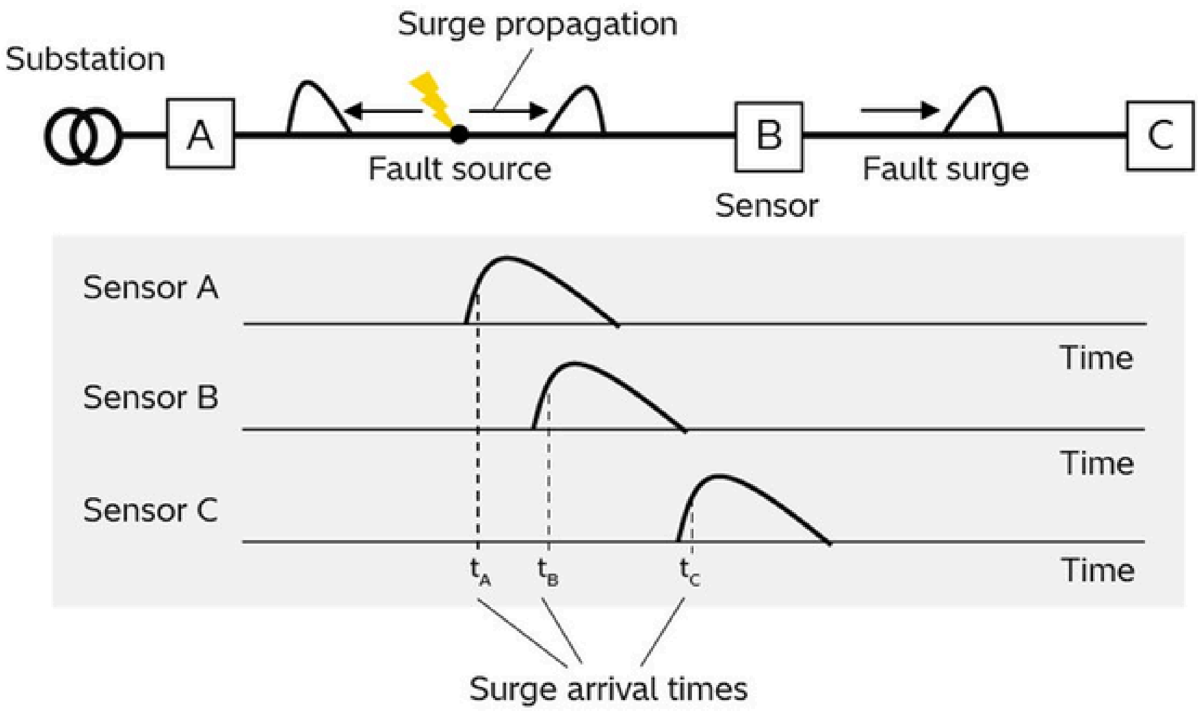
[4] Overview of Tool for Exploring Viable Fuel Cycle Scenarios and Example Use

5. Improvements to Fault Localization Accuracy in Electricity Distribution Systems

Electricity distribution systems are at risk of outages due to grid faults caused by equipment failures or contact with plants or wildlife. When such a fault occurs, staff need to isolate its location and resolve whatever caused it. Fault localization works by using the arrival time of a fault surge to triangulate its source and is mainly used in transmission systems. It is more difficult to use in distribution systems where the small size of fault surges degrades localization accuracy.

Acknowledging this problem, Hitachi has worked with Kansai Transmission and Distribution, Inc. to develop a new method for distribution systems called “waveform matching.” A feature of this method is that it compares the shape of the entire waveform to determine the arrival time, allowing it to accurately discriminate signal from noise even for small surges. When evaluated using field-test waveforms, the new method succeeded in reducing the average calibration error to only 36 m (compared to 79 m previously).

Details of the research were published jointly by Kansai Transmission and Distribution and Hitachi at the Conseil International des Grands Réseaux Électriques (CIGRE) 2025 International Symposium held in Montreal, Canada in October 2025 where it won a Best Paper Award in the Next Generation Network category. These awards are presented for 10 papers that are recognized as being the best in their respective fields among those with lead authors ages 35 or younger.



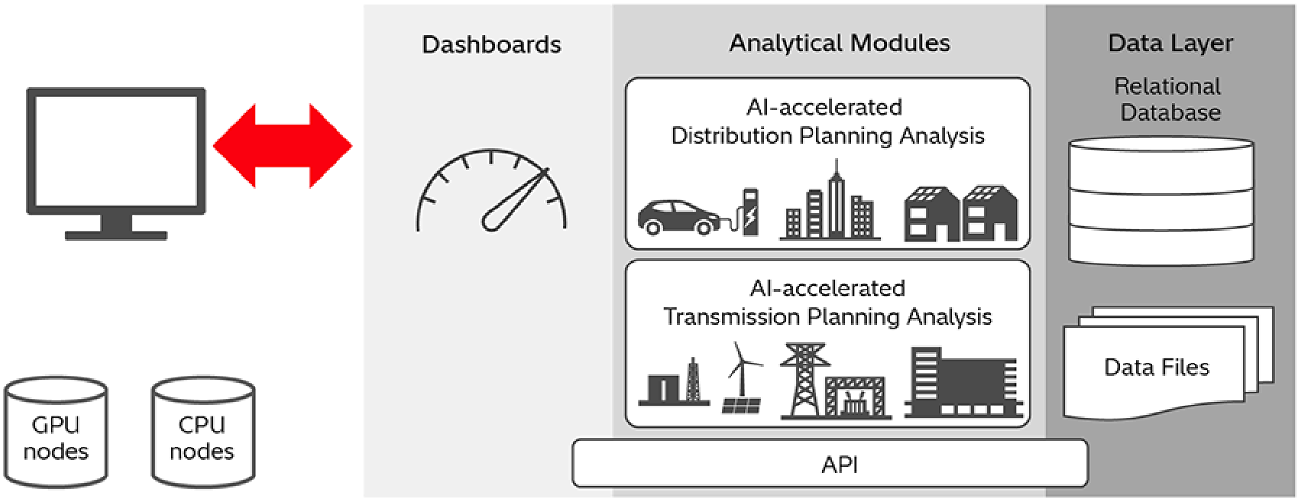
[5] Example Surge Propagation and Arrival Times

6. AI Grid Simulation Solutions for Social Digitalization

Data centers (DCs) are a critical pillar of digital infrastructure, with individual facilities often exceeding 100 MW in power demand. Integrating such large loads can require new generation capacity and extensive grid studies covering stability, reliability, and economic efficiency. These assessments are mandatory and often take more than a year, creating a major barrier to rapid DC deployment.

Hitachi has been developing a scalable AI accelerated grid simulation solution platform in collaboration with grid operators in the U.S. In 2024, it introduced AI-powered fast power-flow analysis for distribution networks. In 2025, this capability was extended to transmission systems through a partnership with Southwest Power Pool (SPP).

The goal is to achieve up to an 80% reduction in grid study time by combining physics-driven AI with deep power-system expertise, enabling faster interconnection and early commercialization through this partnership.



[6] Architecture of AI Accelerated Grid Simulation Solution Platform

GPU: graphics processing unit, API: application programming interface