Power Grid

1 Start of Operations of Chubu Power Grid Hida Converter Station Hida-Shinano Frequency Conversion Facility

1 Hida converter station thyristor valves

The Hida-Shinano frequency conversion facility at Hida converter station run by Chubu Electric Power Grid Co., Inc., which is the first interconnection project between the Tokyo and Chubu systems, began operations in March 2021. Thanks to a collaboration system that enabled close coordination with the customer, the project was completed without issues essentially 24 months of work after the start of installation in August 2018 (excluding a construction pause).

This facility was constructed with the goal of providing a stable power supply, thereby preventing in advance the type of confusion that can occur when there is not enough power as happened during the Great East Japan Earthquake of March 2011. It contributes to the stabilization of the power supply between the Tokyo and Chubu regions using high-voltage direct current (HVDC) technology, and serves a vital role in enabling electricity transactions between east and west Japan during normal times. The facility offers the following features:

(1) Power interchange capacity of 900 MW, and a direct current line voltage of 200 kV

(2) Direct current power transmission equipment connected to alternating current (AC) and direct current (DC) conversion equipment with DC aerial power transmission lines totaling 89 km in length

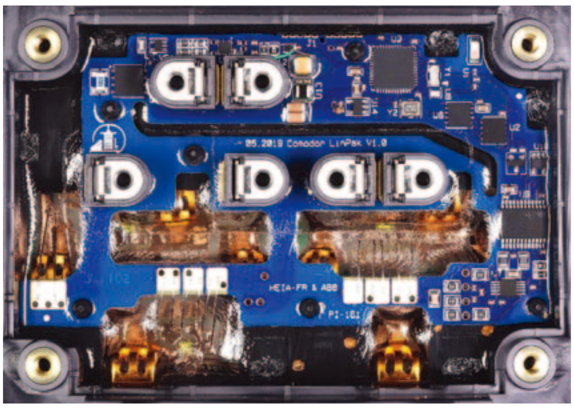
(3) First domestic use of foreign-manufactured air-insulated system filter in power AC/DC conversion equipment (currently manufactured by Hitachi Energy)

(4) System designed to withstand difficult weather conditions, including an outside air temperature between −30° and +35°C, an elevation of 1,085 m, and heavy snowfall in an area with 200 cm of snow coverage

Hitachi is positioning HVDC as one of its main areas of focus in the energy business, and in 2019 received an order for the frequency conversion equipment using self-commutating HVDC technology in the Chubu Power Grid Higashi Shimizu Substation currently under construction. Hitachi will keep contributing to the achievement of a decarbonized society by responding to needs for power system interconnection equipment as power system interconnections are strengthened both domestically and internationally, and renewable energy usage increases.

2 Health Management of Power Electronics Systems

Major developments in power semiconductors, together with the increased need for availability and capacity, have led to significant revolutions in power electronics (PE). PE applications have proliferated into the complete chain of existing grids from renewables, power transmission, to energy-efficient power consumption. These incorporations raise challenges for system reliability making the use of prognostics and health management a desirable target.



2 Hitachi Energy LinPak traction module with add-on condition monitoring platform

Thus, Hitachi Energy Ltd. is developing novel solutions across various PE hierarchy levels. A sensor-based example deals with a wireless condition monitoring platform for rail-traction semiconductor modules. The system is installed on a module-integrated circuit board and will be operated in pilot vehicles to assess and mitigate issues of moisture ingress and condensation.

A second example deploys data-driven analytics for Hitachi Energy's HVDC systems. Digital twins to predict and compare cooling system capacity, anomaly detection to identify degradation and faults, and high-frequency transient recording analysis to evaluate the impact of voltage and current disturbances are applied to allow for a condition-based, predictive, and cost-efficient asset management.

(Hitachi Energy Ltd.)

3 Flexible Power Link of UK Western Power Distribution

Generation is becoming increasingly decentralized through connections at distribution level rather than on the transmission system.

The flexible power link (FPL) method of network equilibrium project managed by Western Power Distribution plc. in the UK aimed to provide a connection between two bulk supply points (BSP) using a back-to-back AC-DC-AC converter. The FPL is installed in parallel to an existing normally open point. This enables the local control of voltage, using reactive power on both networks while providing a means to bi-directionally transfer real power between the networks unlocking additional network capacity. Fault current from either network will not flow through the converter, therefore acting as a fault current limiter and ensuring no assets are overstressed.

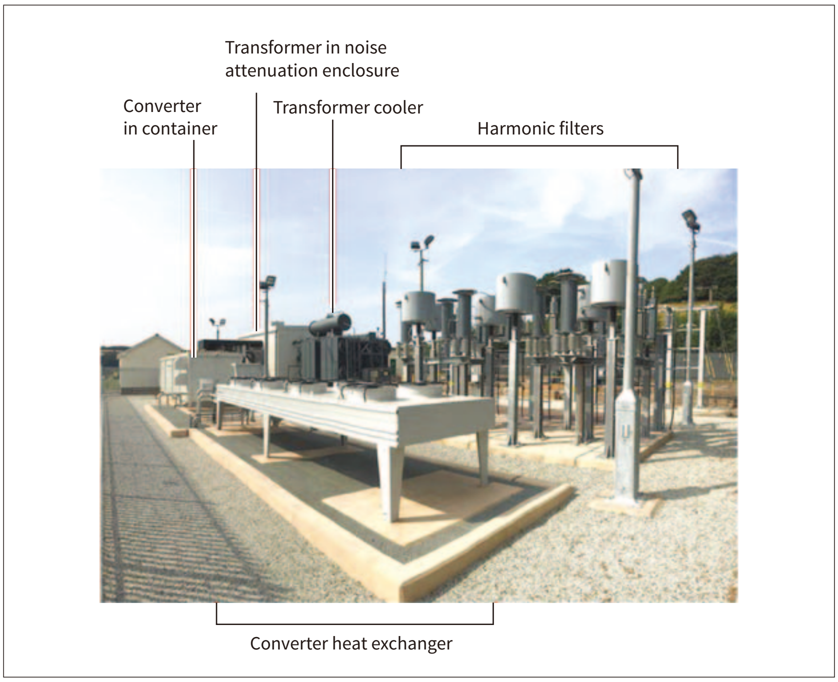
The principal requirement of the FPL is to deliver real (P, MW) and reactive (Q, Mvar) power to the system on both sides to manage the thermal and voltage issues in the network. Advanced functionality could additionally be applied such as automatic voltage control on either side, electrical line emulation or grid forming control. If energy storage will be added to the DC-link, the FPL could also provide an energy buffer between the two networks, with the possibility to provide inertia and frequency support as well as black start of their networks.

(Hitachi Energy Ltd.)

4 Kyushu Electric Power Transmission and Distribution System Electric Supply Control Station System

Hitachi delivered a new system electric supply control station to operate all trunk transmission power systems in the Kyushu area to Kyushu Electric Power Transmission and Distribution Co., Inc., with operations starting in July 2021.

This made it possible to consolidate the monitoring and control operations of four trunk transmission power systems with capacities of 500,000 V or higher each that



3 Flexible power link (AC-DC-AC converter)

4 Kyushu Electric Power Transmission and Distribution System Electric Supply Control Station System

were previously used in the Kyushu area into a single electric supply control station.

When the 500,000 V Hyuga trunk line starts operations in June 2022, it will secure performance through focused operation with a looped trunk transmission power system, and will require support functions in order to achieve rapid and accurate system operation. To this end, this system will introduce the new functions of reliability monitoring and voltage and reactive power control (VQC).

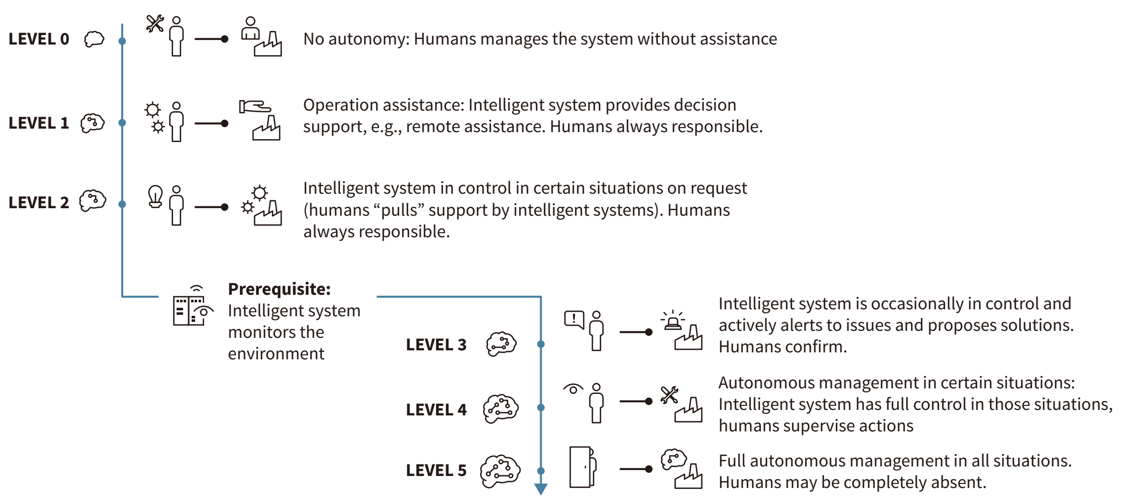
Also, in terms of security, in addition to basic features such as strengthened user certification and log connection functions, more robust measures are also provided with the latest security devices such as an unauthorized connection prevention device (NX NetMonitor) and unidirectional relay (NX Oneway-Bridge).

5 On the Path to Autonomous Power System Management

Lately, industry experts alongside wider society circles buzz around the implementation of autonomy and its benefits. Simultaneously, the power sector faces growing challenges related to faster dynamics, distributedness, and generation patterns ambiguity. It becomes increasingly difficult to manage the system relying solely on traditional automation. Autonomous systems can adapt to variable and non-anticipated conditions due to their capability of learning through interaction with the environment. To better structure the discussion of the transition to autonomous power system, basic taxonomy is introduced. On its path towards autonomy, certain requirements will have to be fulfilled to facilitate the leap from one level to the next. Fortunately, the rapid advance of digital technologies paves a way for opportunities, which seemed visionary only a few years ago.

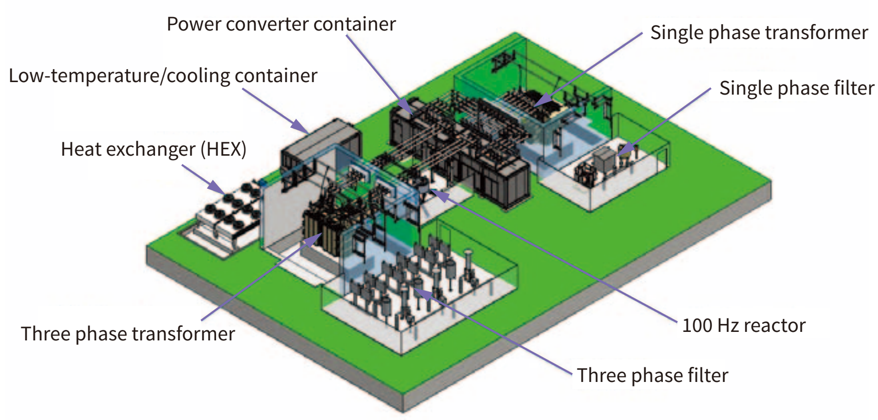
The autonomy should penetrate an entire lifecycle of the power system: offering proposals for expansion and modernization, for system operation, and finally for initiation of maintenance measures. Autonomy could be the technology enabling further advancement in productivity and resilience; it might offer new opportunities, business models, and value propositions to customers.

(Hitachi Energy Ltd.)



Proposed scale of six autonomy levels showing how the degree of autonomy could gradually increase in the power system domain. This high-level definition highlights two main dimensions: the scope of automated tasks, i.e., the system context in which autonomy is applied and the role of the human

5 Levels of autonomy in power system



6 Layout of the rail SFCs (PCS6000) for Lithuanian Railways (LTG Infra Ltd.)

6 World's Longest 50 Hz Railway Line Powered by SFC Technology

Hitachi Energy has successfully concluded a major contract for the supply of eight rail static frequency converters (SFC) with the total installed capacity of 360 MVA for the electrification of the main railway corridor in Lithuania. Rail SFCs will secure the 25 kV 50 Hz AC traction power supply for the 400-km long main railway line and the 800-km catenary line connecting the capital city of Vilnius with the Baltic Sea harbor in Klaipėda.

This is a historic milestone for Hitachi Energy, as Vilnius –Klaipėda will be the world's longest 50 Hz railway line fully fed by rail SFCs, utilizing a parallel feeding and autonomous traction load sharing system. Vilnius–Klaipėda is a pioneering railway electrification project for the 50 Hz traction as it will implement a future-oriented, energy-efficient, grid-supporting and fully redundant rail SFC system developed and supplied by Hitachi Energy, Global Center of Competence for Power Conversion in Turgi, Switzerland.

(Hitachi Energy Ltd.)

7 Transformers for Floating Offshore Applications

Building offshore power systems has great challenges. Only a small fraction of the full potential of offshore power has been exploited given that many offshore areas do not have a suitable seabed and beyond 60-meter depths are not feasible for bottom-fixed structures.

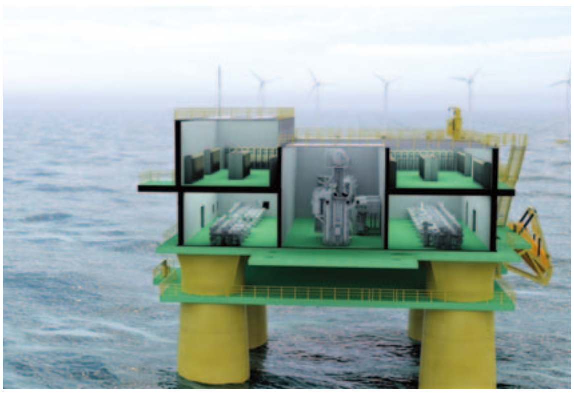
Offshore wind power parks (OWPPs) and wind turbines are rapidly emerging solutions for deep waters, but they introduce even greater challenges for the already demanding offshore segment. Floating structures are constantly in motion, exposed to vibrations and shocks from waves up to 15 m in height. This happens 365 days a year, for their whole lifetime.

Transformers and shunt reactors are key for the transmission of electricity generated in offshore wind parks, and Hitachi Energy has a complete and qualified range of this equipment for floating applications. The features are:

(1) Global expertise support and manufacturing footprint
(2) Deep understanding of grid requirements
(3) Optimized total cost of ownership (TCO) for increased sustainability
(4) Lightweight and modular design with smaller footprint

Additionally, its equipment is made up of specially-designed: active part, tank, tap changers, accessories, and external components.

(Hitachi Energy Ltd.)



7 An illustrative floating collector substation for an offshore wind park

8 Investigating Return on Online-DGA Investments for Service Aged Power Transformers

8 Hitachi Energy service colleague at work

Power transformers are critical assets that ensure successful operations of many different applications such as power transmission, commercial infrastructure, data centers, oil and gas plants, renewable energy, among others. During their operational years, these transformers are subjected to stress, which can be categorized as thermal, mechanical, and electrical. Each of these stresses contributes to transformer aging.

To maintain reliable operation, different strategies have been adopted: visual inspections, routine oil sampling, mechanical or electrical tests, refurbishments (oil filtering, etc.), and replacements (when necessary) to ensure continued operation of these transformers.

Dissolved gas analysis (DGA) is one of the best methods for detecting internal faults of the power transformers. Over the years, online dissolved gas analysis (O-DGA) has gained traction among power transformer asset managers. Many asset engineers have realized the technical benefits of the shift from traditional laboratory-based DGA to O-DGA.

(Hitachi Energy Ltd.)

9 Transformers Reducing Carbon Footprint, Protecting Ecosystems, and Enhancing Safety

The EconiQ transformers portfolio offers innovative solutions that go beyond industry standards. It enables Hitachi Energy to partner in the sustainability journey of its customers in key impact areas such as carbon footprint reduction, safety enhancement, protection of the surrounding ecosystems and responsible use of resources.

The foundational pillars of the EconiQ transformers portfolio are:

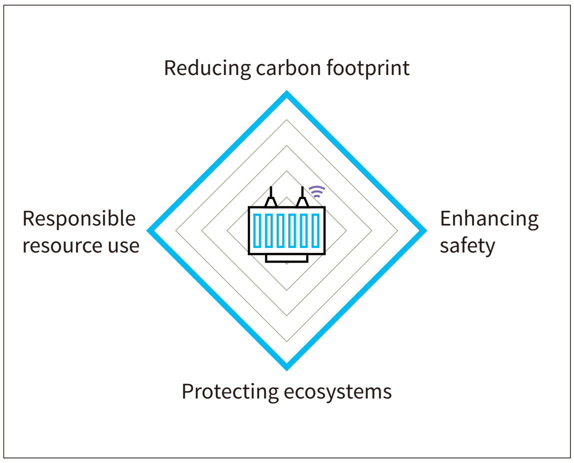
(1) Collaborative co-creation – With deep domain expertise in transformers and associated sustainability impacts, Hitachi Energy partners with its customers to fulfill their requirements for sustainable transformer solutions.

(2) Quantified benefits based on scientific evidence – The portfolio aims to provide quantitative transparency on sustainability impacts and associated benefits. These are derived using latest methodologies such as life cycle analysis studies.

(3) Life cycle focus – Impact analysis and initiatives to enhance sustainability performance run across the offering life cycle including supply chain, manufacturing, product-use and end-of-life-services.

The first offering in the EconiQ transformers portfolio comprises of liquid-filled power and distribution transformers with biodegradable fluids and energy efficiency higher than local regulations. Other features offering augmented benefits are dry bushings, the TXpand (explosion-proof transformer tank) and low noise designs.

(Hitachi Energy Ltd.)



9 Benefits of EconiQ transformers portfolio

10 Enhancing the Reliability of Offshore Wind Farm Transformers

10 Service personnel wearing personal protective equipment for sea transfer and work on an offshore substation

Work conditions at sea and the overall environment of offshore platforms translate into the need to develop dedicated technologies for the installation and servicing of power transformers. The process of supply and installation of transformers on an offshore windfarm substation is complex and technically demanding. Design of power transformers and shunt reactors needs to be customized, using maintenance-free, offshore-certified components.

Hitachi Energy has been manufacturing transformers for offshore wind farms for more than 15 years, delivering a wide range of power transformers and shunt reactors for different applications in the offshore wind sector for substations and windmills, including HVDC technology. With proven service technology, it is possible to replace components or perform inspections without exposure of insulating elements, oil and cellulose to harsh marine conditions. These specialized techniques help reduce the time-of-service activities or, for instance, eliminate the use of heavy-duty oil processing equipment, thus enabling quick execution of maintenance tasks, leading to shorter windfarm outage time.

(Hitachi Energy Ltd.)

11 TXpert Ecosystem Remote Services to Achieve Digitalization of Transformers through Secure Wireless Communications

Transformers are aging – the global average age is about 35 years, resulting in an increased risk of failures. To avoid these failures, Hitachi Energy offers a broad range of individual services, as well as short-term TXLife

11 Achieve wide range of transformer maintenance

service packages and long-term transformer care service agreements.

Included in the offering are remote services which play a key role in providing real-time remote visibility of transformer condition, minimizing the need to send service technicians to the site while saving cost. The range of remote services fully utilizes the open and scalable TXpert Ecosystem of sensing and monitoring solutions to gather real-time data to evaluate transformer condition. Four remote services have been developed: remote monitoring, remote consulting, remote trouble shooting and augmented reality (AR). Combining remote services into a long-term transformer care service agreement provides a cost-effective way to access knowledge and expertise to keep the transformers operating at the highest levels of performance.

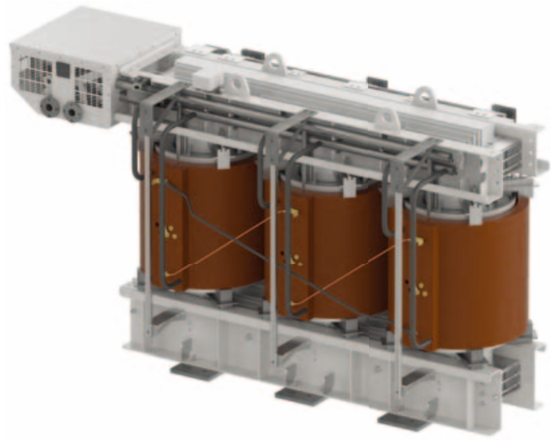
(Hitachi Energy Ltd.)

12 CompactCool Technology for Dry-type Transformer

CompactCool technology for transformers combines the advantages of both liquid-filled and dry-type transformers to introduce an innovative cooling technology. It retains the benefits of a dry-type transformer while reducing transformer size and weight by extracting losses in an innovative and controlled manner.

CompactCool leverages an advanced cooling mechanism where a liquid coolant is used inside the coils to extract losses from windings and circulate them through an external heat exchanger. The watts (heat) then get dissipated to an external ambience (to air or to a water circuit supply).

This makes CompactCool an ideal power transmission device for data centers and renewable energy segments, where factors such as optimized footprint, safety and low



12 CompactCool technology for dry-type transformers

maintenance are key to sustainable transformer operations. CompactCool technology combines dry-type air/solid insulation with direct liquid-cooling to infuse safety and reliability in transformers by providing:
(1) Up to 50% reduction in transformer footprint
(2) 98% reduction of cooling liquid
(3) Up to 90% of the losses captured in extraction
(4) Reduced power usage effectiveness (PUE)
(5) Low-cost maintenance and reliable operations
(Hitachi Energy Ltd.)

13 Innovative Rolling Stock Traction Transformers Designed to Improve Reliability and Reduce Total Operating Costs

(1) Natural Cooling Effilight Traction Transformer

Natural cooling effilight traction transformer (NCETT) replaces motorized fans in the cooling system with natural airflow caused by the train's motion. This unique design helps NCETT eliminate air-fans and risk of failures in cooling system to improve reliability by 20%, as well as eliminate energy cost and maintenance of motorized air-fans in the cooling system. The NCETT retains the benefits of an effilight traction transformer which include up to 20% weight reduction and up to 50% energy savings.

(2) RESIBLOC Rail 25 kV

Hitachi Energy successfully brought the safe and trusted RESIBLOC dry-type transformer technology to the world of traction propulsion systems with RESIBLOC Rail 6.5 kV in 2012 and has continuously upscaled this technology to now offer RESIBLOC Rail up to 25 kV. With an efficiency of up to 99% and up to 45% reduced winding losses at the same weight, RESIBLOC Rail can perform at nearly maintenance-free operation levels to reduce operating energy costs and associated carbon emissions of trains by up to 10%.
(Hitachi Energy Ltd.)

14 Protection and Control Device with Front Maintenance Structure

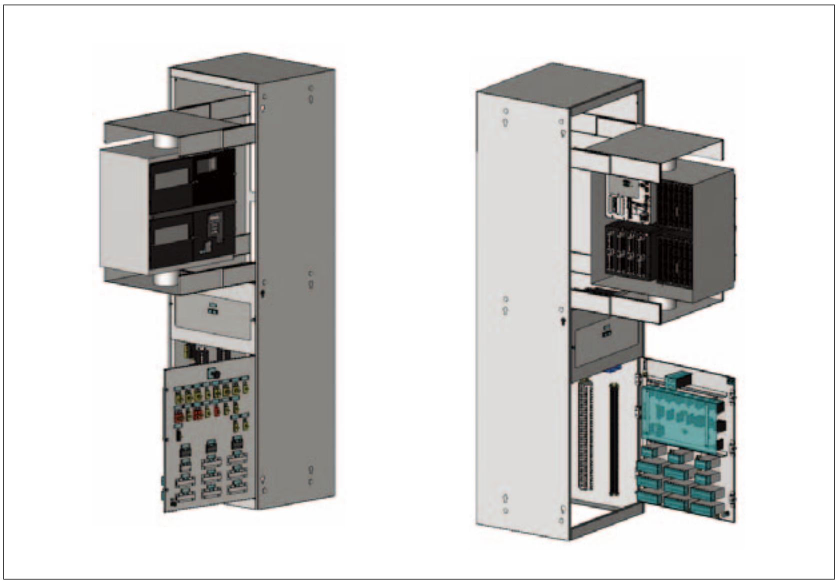
Although protection devices are usually installed in the relay room, allowing for both front and back maintenance, protection devices in underground substations and outdoor distributed layout substations need to be affixed to a wall at the back of the device in order to secure installation space, and therefore can only be maintained from the front. Hitachi has developed and productized a protection device with a front maintenance structure based on the assumption of maintenance only from the front.

Since domestic protection devices must fit within a standard width limitation of 700 mm, the front

Natural Cooling Effilight Traction Transformer

RESIBLOC Rail 25 kV

13 Traction transformers launched



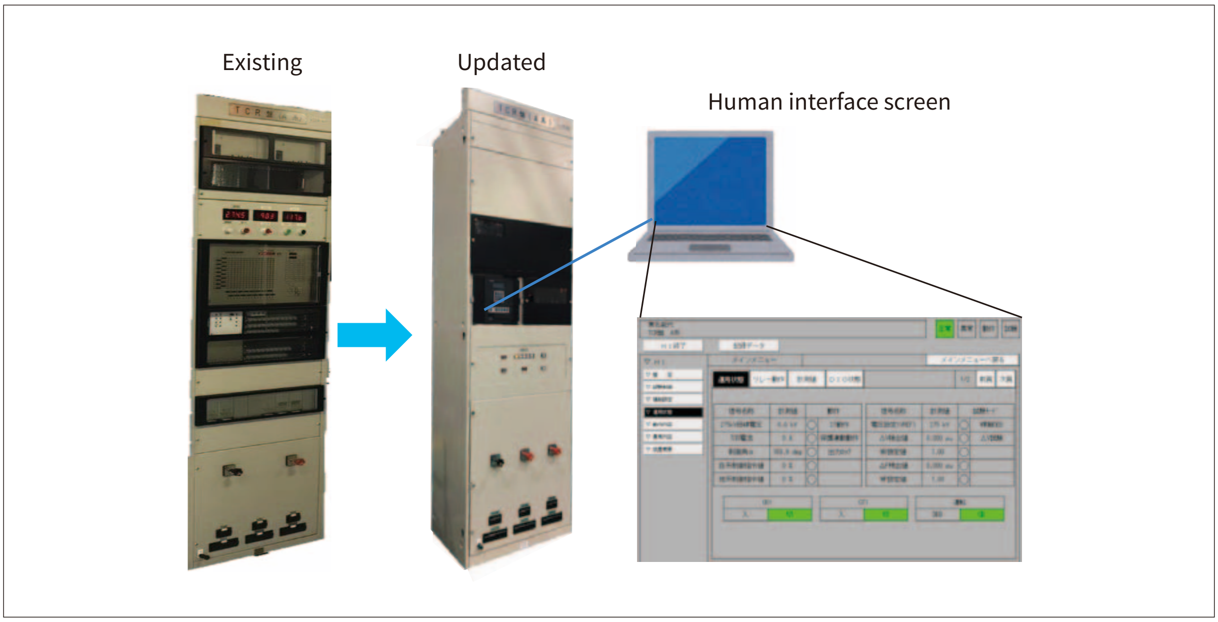
14 Structure of front maintenance structure protection device

maintenance structure of this device also had to support front maintenance without changing the width of 700 mm. Since a protection device requires many different components to implement, there are also a large number of cables that must be connected to the unit or terminal block, and this limits the possible routes for wiring. In order to overcome this challenge, a slide rail and rotation method was adopted that secures workability in a configuration that enables maintenance with only front access. In addition to vibration testing in compliance with the electrical standards (B-402), evaluation was also conducted using transport vibration, both achieving excellent results.

15 SVC Control and Protection System Applying Veuxbus Series

As the time has come to update the control and protection devices of static var compensators (SVC) installed for the sake of grid stabilization around the country in the 1990s, Hitachi has received an order for a project to update the control and protection devices on the Noshiro Thermal Power Station's 100 MVA SVC equipment.

In order to update the SVC control devices, Hitachi developed an SVC control and protection system that uses the latest digital relay (Veuxbus series) with a proven track record of operation in domestic HVDC systems, using a redundant communication [high availability seamless redundancy (HSR)] method. The high-accuracy,



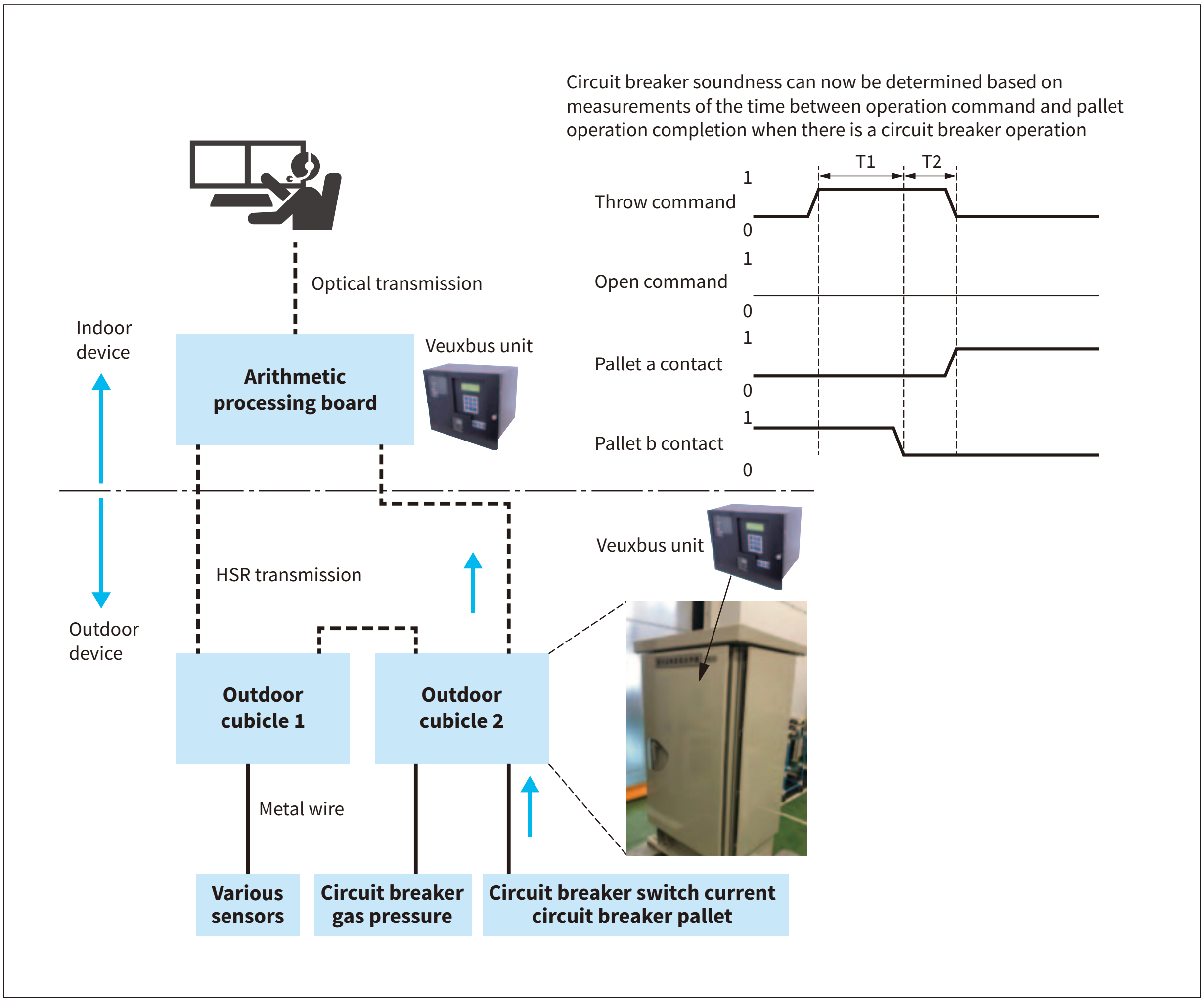
15 SVC control and protection system high-speed sampling performance demanded of an SVC device is greatly improved over previous equipment, reliability during communication faults is also improved, and the upgrade is expected to contribute to grid stabilization. This project is currently undergoing test operation before the start of on-site commercial operations in March 2022, after which it will also be applied to the demand for updates in line-commutated SVC control and protection devices.

16 Preventive Maintenance System Applying HSR Transmission

Hitachi has developed a preventive maintenance system for electric transmission-transformation equipment using HSR transmission, which is an application of the unit and Internet Protocol (IP) technology of the general-use Veuxbus series. It is comprised of an outdoor cubicle installed near the equipment to take in sensor information, and an arithmetic processing board that calculates the integrated information and sends it to the higher system.

To ensure the stable transmission-transformation of electric energy equipment, sensors monitor the state of running equipment in preventive maintenance systems that have been put to practical use to catch signs of equipment abnormalities since 1990, but due to the deterioration of these preventive maintenance systems, the time for an update has arrived.

Although the current equipment implemented a dedicated preventive maintenance platform using the star coupler transmission method, this development improved maintainability by using general-purpose parts and also enhanced reliability providing communication redundancy. Also, based on the sensor information (4 to 20 mA), it collects cable temperature abnormalities and 30 days of past data, calculates gas pressure change amounts for circuit breakers/disconnecting switches, etc., and provides the user with information useful for equipment inspection work by evaluating measurement abnormalities such as circuit breaker throwing commands and pallet operation times. This system is expected to contribute to future equipment preventive maintenance.



16 Configuration of preventive maintenance system for electrical transmission-transformation equipment

17 Hydro SFC Light Making Electricity Grids Fit for the Integration of Renewable Energy Sources

17 Hydro SFC Light converter

In April 2021, the first Hydro SFC Light converter, rated 80 MW, has been successfully handed over for commercial use at the Malta Oberstufe pumped storage hydropower station in Austria. The full-size converter enables variable speed operation of the reversible converter fed synchronous machines, lifting the operation scheme of the power plant to a new level in terms of flexibility and efficiency. The converter control features provide advanced grid stabilization functionality, supporting the integration of a large amount of renewable energy sources.

Hydro SFC Light is the world's first* direct modular multilevel converter (MMC) used for this application. The state-of-the-art converter technology, which has been developed for highly efficient and very safe and reliable operation with integrated redundancy, offers the solution of choice for machines of up to 300+ MW.

The team of the Global Center of Competence in Turgi, Switzerland is already executing the next Hydro SFC Light projects with an even higher power rating, for example the Kühtai 2 project in Austria with two units rated 95 MW, which is expected to start operation in 2025.
(Hitachi Energy Ltd.)

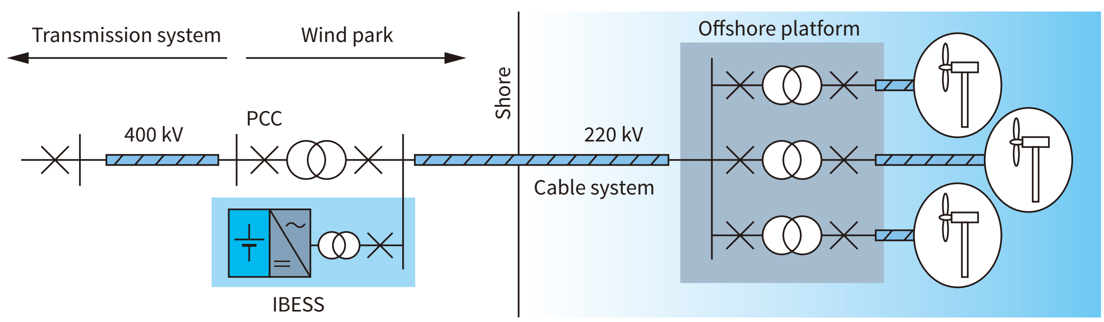
* Based on research by Hitachi Energy Ltd.

18 Islanded Operation of Offshore Wind Power Plant Using IBESS

The share of renewables in the power system is increasing rapidly. Large offshore wind power parks (OWPPs) are developed at a high pace and conventional fossil fuel-based plants are decommissioned. If the OWPP gets islanded due to any contingency or in the event of a blackout, the whole OWPP will be shutdown.

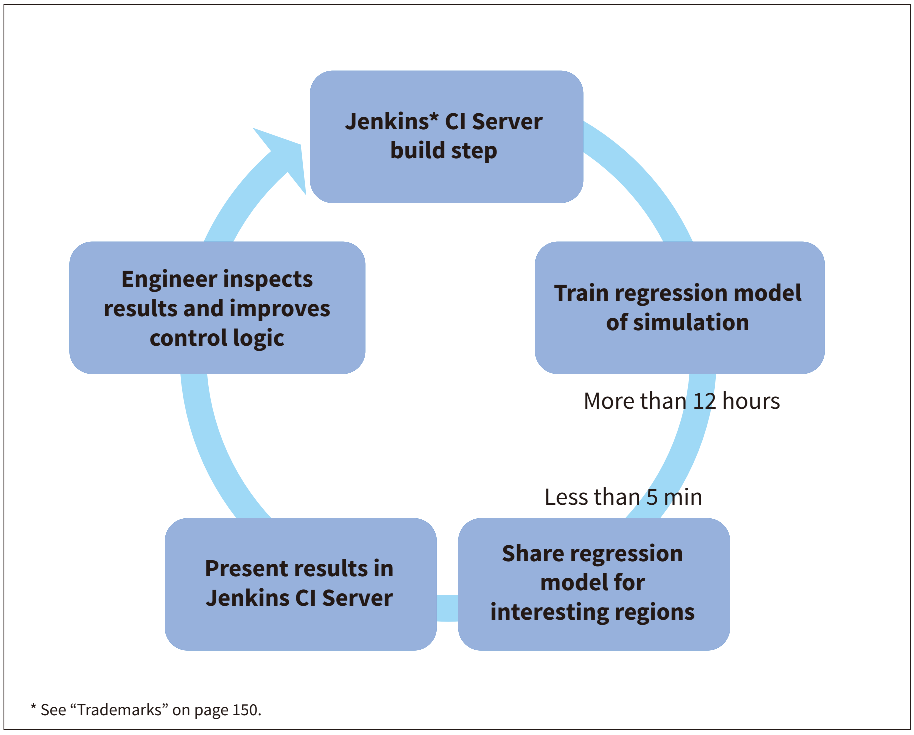
In this scenario, Hitachi Energy's static synchronous compensator (STATCOM) is proposed together with a battery energy storage denoted integrated battery energy storage and STATCOM (IBESS). The IBESS is located at the point of common connection to an OWPP to enable OWPP energization from a fully discharged state in the absence of any connection to the onshore grid into island operating mode. The STATCOM functionality provides fast and dynamic reactive power management, and the battery unit provides active power balancing capability to regulate the frequency in the island. The concept is demonstrated through time-domain simulations on an OWPP model in the simulation tool PSCAD*/EMTDC*. The results confirm the technical feasibility of the system.
(Hitachi Energy Ltd.)

* See "Trademarks" on page 150.



PCC: point of common coupling

18 Scheme of IBESS and offshore wind power park



19 Continuous integration (CI) workflow

19 Boosting Exploratory Testing of Industrial Automation Systems with AI

Testing of large and complex industrial control systems is challenging as the space of possible input and environmental parameters is large. Searching the entire space for potential failures is practically infeasible with conventional methods.

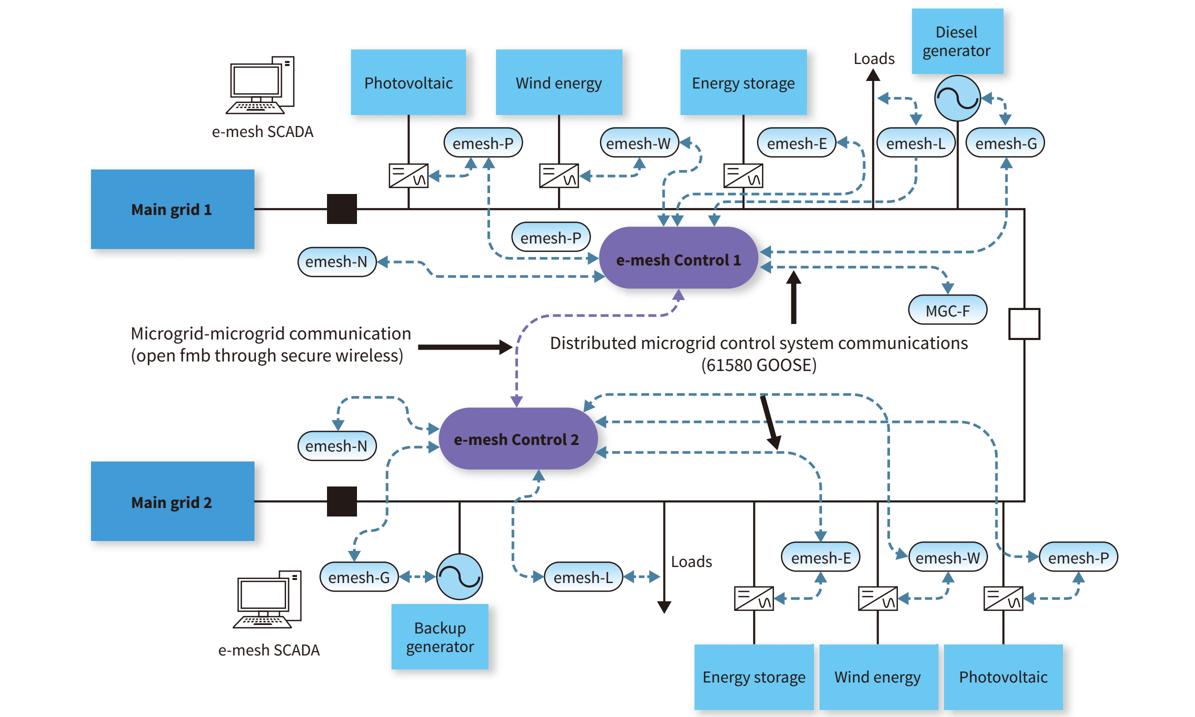
In response to this difficult problem, Hitachi Energy developed a method for automated exploratory testing that harnesses artificial intelligence- (AI-) based strategies to efficiently explore the space and to identify parameter sets that can cause the system to fail.

The proposed solution approach uses regression techniques to speed up the search and clustering methods to identify parameter sets that represent distinct system failures. The method is implemented as part of the continuous integration framework for testing the robustness of power grid converter systems. For such systems, Gaussian process regression with parameter space sampling based on Sobol sequences showed the best results. The framework is run overnight, and the engineer investigates the found critical parameter sets the next morning. The method is currently in use and helps engineer high-quality systems efficiently.
(Hitachi Energy Ltd.)

20 Cyber-Physical Resilient Interoperable Microgrid Networks

Multiple interconnected microgrids with significant renewable energy penetration may be used as basic building blocks for future resilient power grids, particularly considering the aftermath of natural events such as hurricanes, fires, and storms. However, the integration of individual microgrids into networks requires implementing new operational and management functions, which rely on additional layers of communications, both horizontal and vertical. The added flexibility comes at a cost of increasing the potential risks of widespread malfunctions of automation systems and may introduce additional cyber vulnerabilities.

Through an industry-academic collaboration among the University of Illinois at Urbana-Champaign and US utility Duke Energy Corporation, Hitachi Energy has researched, developed, and demonstrated a cyber-physical resilient control and protection architecture for a multi-microgrid system environment. The system has been tested in a controller hardware-in-the-loop (C-HIL) environment at Duke Energy and provides the framework for integrating distributed generation and storage in multiple microgrids and is resilient to false data injection attacks.
(Hitachi Energy Ltd.)



SCADA: supervisory control and data acquisition FMB: field message bus GOOSE: generic object oriented substation event MGC: microgrid controller agent

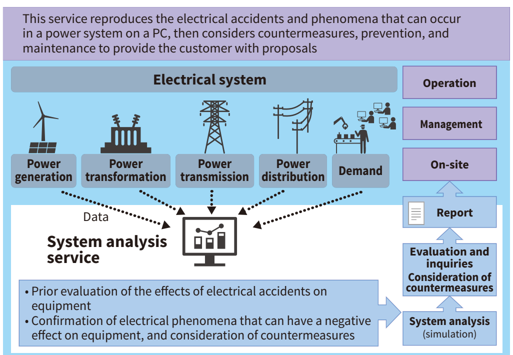
20 Multi-layered resilient microgrid network

21 Power System Analysis Service Supporting Power Resilience Improvements

A power system is a large-scale system configured with various types of equipment and systems used in electric power energy operations, all interconnected in a complicated fashion. When abnormalities such as voltage fluctuations, disconnections, or short circuit failures occur in a power system, in worse case scenarios this can lead to equipment failure or a suspension of operations. Hitachi released a power system analysis service to resolve these issues.

This power system analysis service collects operational data from the various types of equipment and systems that comprise a power system, and simulates potential system failures and other phenomena by analyzing this data on a PC. Based on the results of this simulation, the service considers countermeasures and makes proposals to the customer, providing one-stop support for this entire series of tasks.

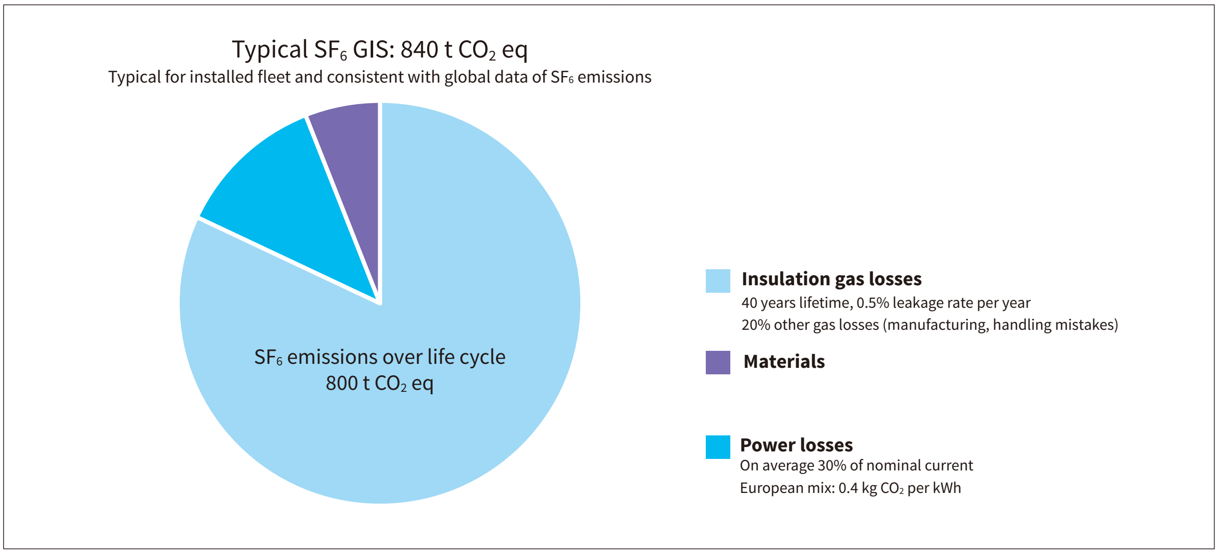
This power system analysis service provides three types of know-how: "technical strength," "knowledge," and "the user perspective." Hitachi has attained this know-how through its many years of experience in constructing and operating power equipment and systems while supporting the world's power infrastructure, and by building a track record with a wide range of system analysis from power generation to demand.



21 Overview of the power system analysis service

22 EconiQ High-Voltage Portfolio Accelerating the Transition Towards a Carbon-neutral Energy Future

For almost half a century, sulfur hexafluoride (SF_6) has been the norm in the electrical industry due to its excellent insulation and switching capabilities. However, it has a global warming potential 23,500 times higher than that of carbon dioxide (CO_2). Latest state-of-the-art transmission and distribution equipment offers impressive



22 Carbon footprint of a typical SF_6 GIS 145 kV

levels of gas tightness, but if there is leakage, SF_6 contributes to global warming. In a gas-insulated switchgear (GIS), the CO_2 equivalent emissions from SF_6 are the dominant contributors compared to other sources.

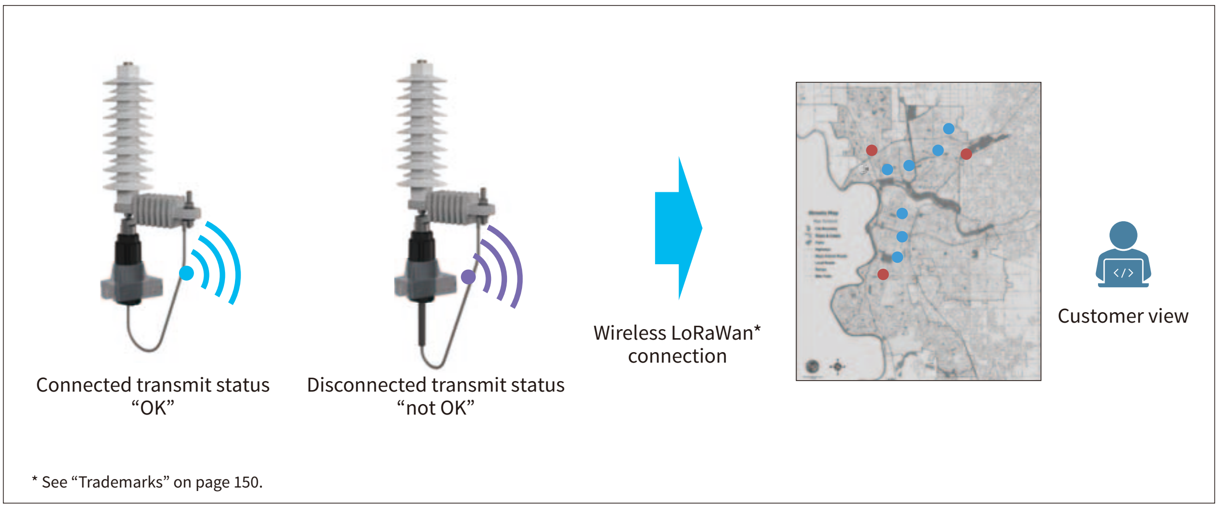
EconiQ is Hitachi Energy's eco-efficient portfolio designed to deliver superior environmental performance. The EconiQ high-voltage portfolio uses game-changing technology containing no SF_6, proven to significantly reduce its carbon footprint. Hitachi Energy published its EconiQ high-voltage roadmap, outlining the extensive switchgear and breakers portfolio in various voltage levels, demonstrating the technology's reliability and scalability. A key highlight is the EconiQ 420-kV GIS, which will be the world's first* commercial alternative to SF_6 for the transmission network, enabling its customers and the industry to rapidly transition to eco-efficient solutions. (Hitachi Energy Ltd.)

* Based on research by Hitachi Energy Ltd.

23 Wireless SPU Indicator: Online Monitoring Equipment in Power Grids to Reduce the Risk of Wildfires

In recent years, wildfires have intensified with increasingly devastating consequences. A potential cause that utilities have identified are surge arresters installed on distribution overhead lines traversing wildfire-prone areas. Since 2017, Hitachi Energy's spark prevention unit (SPU) provides a solution for utilities to disconnect surge arresters from the distribution grid when thermally overloaded, preventing any arcing, sparking, or emission of hot particles and thus reducing the risk of igniting a fire.

The newly developed wireless SPU indicator enables customers to remotely review and analyze the status of their SPU fleet. Once a triggered SPU is detected by the wireless indicator, the location of the triggered SPU is instantly transmitted via a long-range low power



23 Operation principle of wireless SPU indicator wireless network communication. The exact position is provided by the integrated Global Positioning System (GPS) module. The instant detection of triggered SPUs reduces wildfire risk in the distribution grid by enabling fast replacement of protective devices. A battery-based power autonomy of at least 10 years allows a maintenance-free operation of the wireless SPU indicator in remote areas.

(Hitachi Energy Ltd.)

24 Real-time Insights from Digital Enterprise for Secondary Assets

With the increasing implementation of digital substations, the amount of digital information has dramatically increased. The concept of a digital substation introduces a powerful set of new information and data coming from substation monitoring, automation, and communication systems. These systems feed online measurements into asset management and analytic performance platforms, allowing asset owners to improve the performance and lifetime of their assets.

The use of International Electrotechnical Commission's (IEC) 61850 is a key enabler to get the context and semantics of information right at the point of digitalization, while also allowing the flow of information from the field to the boardroom. The high-quality data fed into asset-specific performance models allows expert systems to provide asset owners with more guidance, improve planning of maintenance activities, and effectively utilize maintenance resources. Through digitalization in the substation, Hitachi Energy introduced a vast and growing number of digital assets like primary equipment sensors and control, protection, and communication devices that will need to be managed and will require a holistic view of asset management for primary and secondary equipment.

(Hitachi Energy Ltd.)

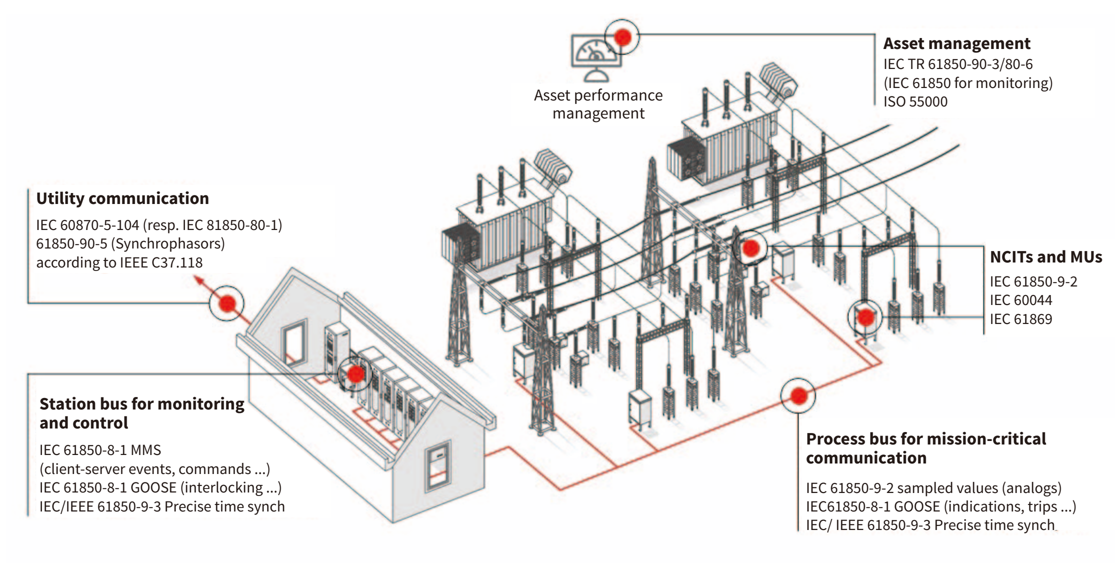
25 Launch of a Global Network of COCs for Grid Automation Solutions

Extending its global base of engineering and service centers, Hitachi Energy announced the opening of collaborative operations centers (COCs) for grid automation solutions at key regional centers around the world.

In addition, the company also announced its new lifecycle management program, dubbed the Grid Automation Shield program, which enables customers to map and track their installed assets. The program will provide up-to-date information about the product lifecycle and associated services required to optimize operations.

Working in harmony with engineering and service centers in more than 40 countries, the COCs in Malaysia, Australia, the USA, United Arab Emirates, Switzerland, and Italy will ensure that 24/7 world-class customer service is available locally and anywhere in the world.

(Hitachi Energy Ltd.)

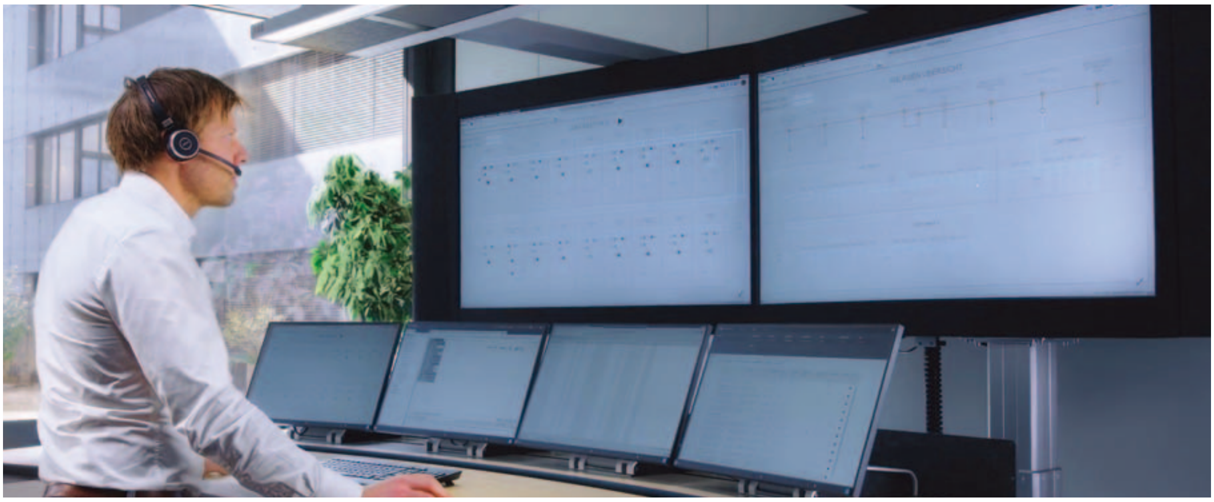


NCIT: non-conventional instrument transformer MU: merging unit

24 International standards inside a digital substation

Energy

Power Grid



25 Collaborative Operations Center

26 A Microgrid Platform for V2G: Lessons Learned from the Arlington Microgrid

Snohomish Public Utility District (SnoPUD), an electric utility in the fast-growing Pacific Northwest of the USA, looked at the region's long-term needs to develop an advanced microgrid that combines community solar photovoltaic generation, grid-forming battery energy storage system (BESS), and vehicle-to-grid (V2G) technology.

The Arlington Microgrid demonstrates the promise of an increasingly electrified future—from grid resilience to V2G integration, including the ability to run on 100% renewable power. Commissioned in 2021, the project marks a critical milestone for SnoPUD in their journey to maximize the value of microgrids and grid edge technologies across their service territory.

One challenge addressed is how utilities can leverage and support increasing electric vehicles. The V2G integration in the Arlington Microgrid reduces complexity and expands interoperability, streamlining two-way service between the vehicles and grid. In addition to hardened V2G infrastructure, the said microgrid hosts two facilities that are critical to SnoPUD operations: a modular data center and a new utility office. Both benefit from failsafe and secure renewable power provided by the microgrid, enabling SnoPUD to meet critical objectives related to disaster response.
(Hitachi Energy Ltd.)

26 SnoPUD's microgrid and solar array