YOKOGAWA

Co-innovating tomorrow™

Yokogawa Solutions for Renewable Energy

Bulletin 53T01A02-07EN

Sustainability goals

"Three goals and "Six contribution areas"

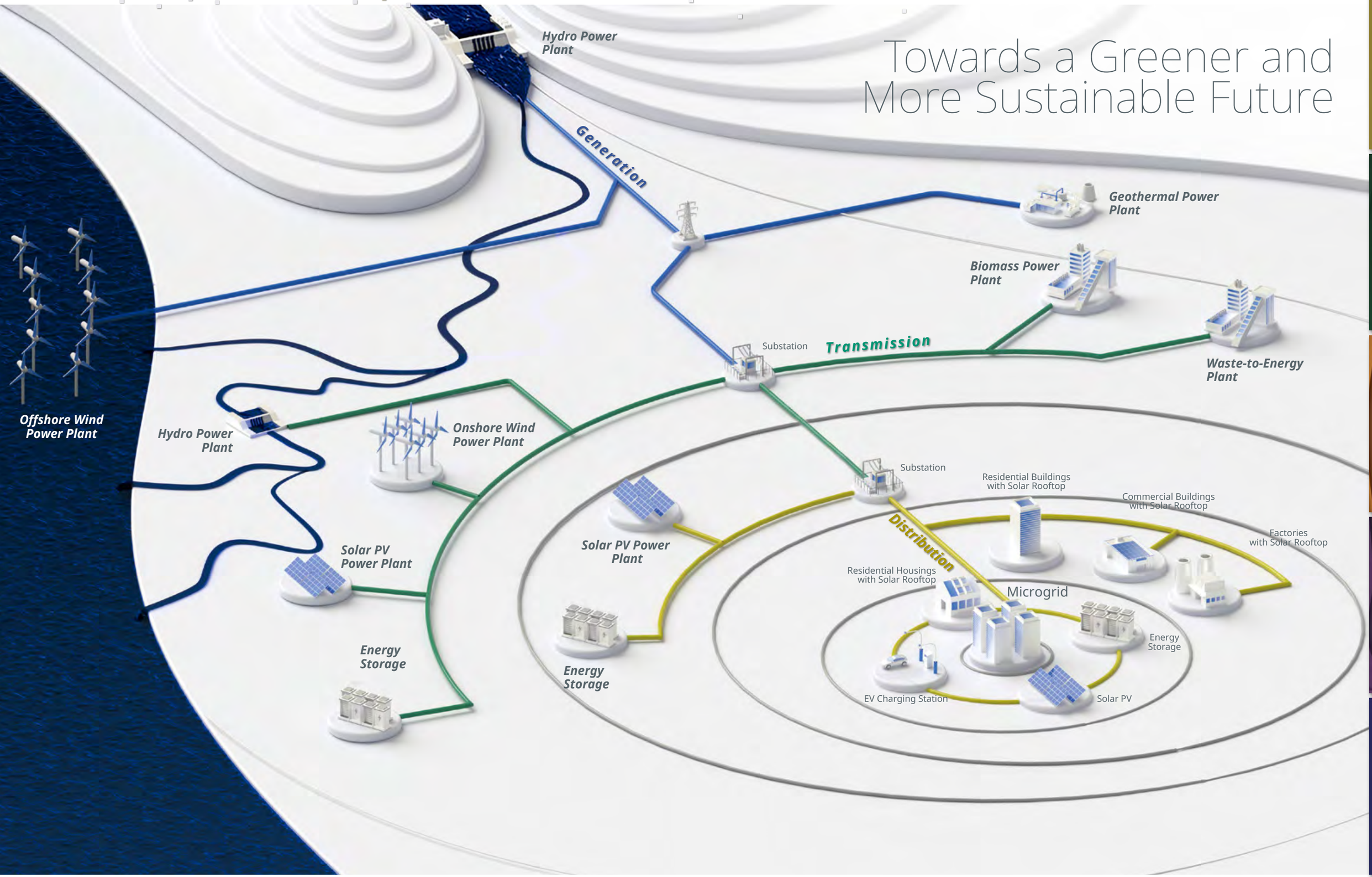
Three goals

Yokogawa has set three sustainability goals.
We will work to achieve net-zero emissions, ensure the well-being of all, and make a transition to a circular economy by 2050, thus making the world a better place for future generations.

Six contribution areas

Yokogawa will expand the contribution through six areas for achieving the Three goals.
We have defined indicators and targets for each focus area and are working to achieve them.

Towards a Greener and More Sustainable Future



Yokogawa offers comprehensive solutions for our customers transitioning to **renewable energy meeting decarbonization** and **ESG goals.**

Renewable Industrial Solutions

Solar | Wind | Geothermal | Biomass & WTE | Hydro

Applications and Services

Secure Operation
- C S — Cybersecurity

Operation Management
- APC — Advanced Process Control

Asset Management
- Surveillance — CCTV, Drones, Robotics
- CMPM — Condition Monitoring & Predictive Maintenance
- APM — Asset Performance Management

Supply / Value Chain Management
- EMS — Energy Management System
- P&S — Planning and Scheduling

Enterprise Solutions
- D L — IT/OT Data Lake
- A I — Enterprise AI
- ERP — ERP Solution
- CRM — Customer Relationship Management Solution

...more

Engineered Solutions
- Digital Transformation Consulting
- Process Consulting
- Lifecycle Services
- Field Assistance

Yokogawa Cloud

API | Visualization | Analytics & AI | Data Orchestration | Data Ingestion & Preparation

Customers Existing Cloud

Industrial Systems & Infrastructure

IIoT Network | PLC/PAC/RTU | Distributed Control System (DCS) | Safety Instrumented System (SIS) | SCADA

EDGE Systems

Customers Existing IT/OT Systems

Sensors, Actuators, Instruments

Smart Sensors | Field Instruments | Process Analyzers | Valves & Actuators

PV Panel | Wind Tower | Boilers | Turbine | Compressors | Rotating Equipment

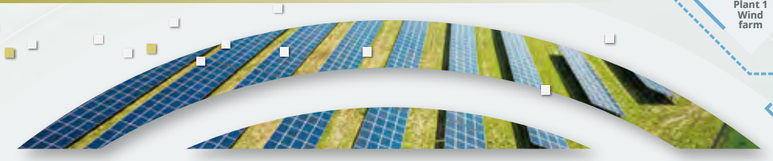
Customers Equipment and Assets

Solar Solutions
Wind Solutions
Geothermal Solutions
Biomass & WTE Solutions
Hydro Solutions

Solar Power Solutions

Best way to reduce the operation cost through direct, real-time asset monitoring and optimization in a single platform

■ ***Enabling cost-effective operation excellence through data analytics, pattern learning and predictions***



Plant 1 Wind farm

Plant 2 Solar farm

Plant 3 Hybrid Plant

Secure connection

CI Server

Solution A

Renewable Power Plant Controller

Weather Data

Sensors

PXiSE

SCADA

Junction box

Utility Scale Solar Power Plant

Inverter

Battery Energy Storage System

PCS + BMS

High speed feedback control

PMU measurement at POI

Power command from grid operator/ GSO/TSO/NLDC

Transmission Substation

Utility Grid

Distribution Substation

POI

Switchgear

Solution C

■ ***DERMS***

Distributed **E**nergy **R**esource **M**anagement **S**ystem

D E R M S

Solution B

■ ***Microgrid Controller***

PXiSE

SCADA

EMS

POI

Microgrid ***network*** 2

Microgrid ***network*** 1

PMU Phasor Measurement Unit

Phasor measurement units allow fast and accurate measurement of voltage, current, and their respective angles.
Due to their high speed and accuracy, PMUs are used at key locations such as the POI.

Data/Control Flow

Power Flow

POI - Point of Interconnection
PXiSE controllers can monitor and control the aggregated power flow of the system at the POI.

G S O - Grid System Operator
T S O - Transmission System Operator
NLDC - National Load Dispatch Center

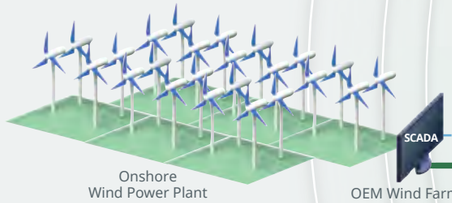
Wind Power Solutions

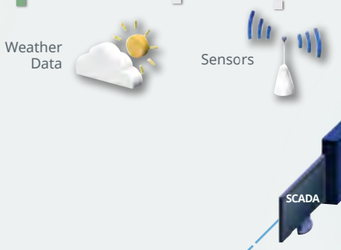
Best way to optimize the efficiency and stable power production of any combination of utility-scale renewable energy assets

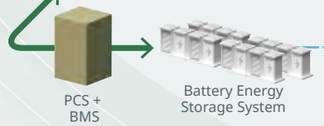
Solution A

- ***Wind Farm #1***
  Renewable Power Plant Controller

- ***Wind Farm #2***
  Renewable Power Plant Controller







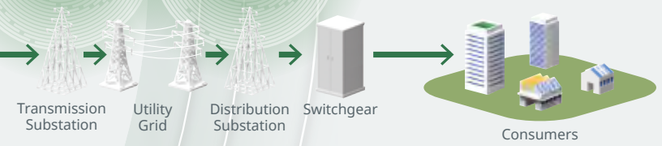
- ***Centralized Renewable Power Plant Controller***

- ***Communication and control over geographically dispersed plants***

High speed feedback control

PMU measurement at the POI

Power command from grid operator/ GSO/TSO/NLDC



Data/Control Flow

Power Flow

PMU Phasor Measurement Unit

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POI - Point of Interconnection PXiSE controllers can monitor and control the aggregated power flow of the system at the POI.

G S O - Grid System Operator
T S O - Transmission System Operator
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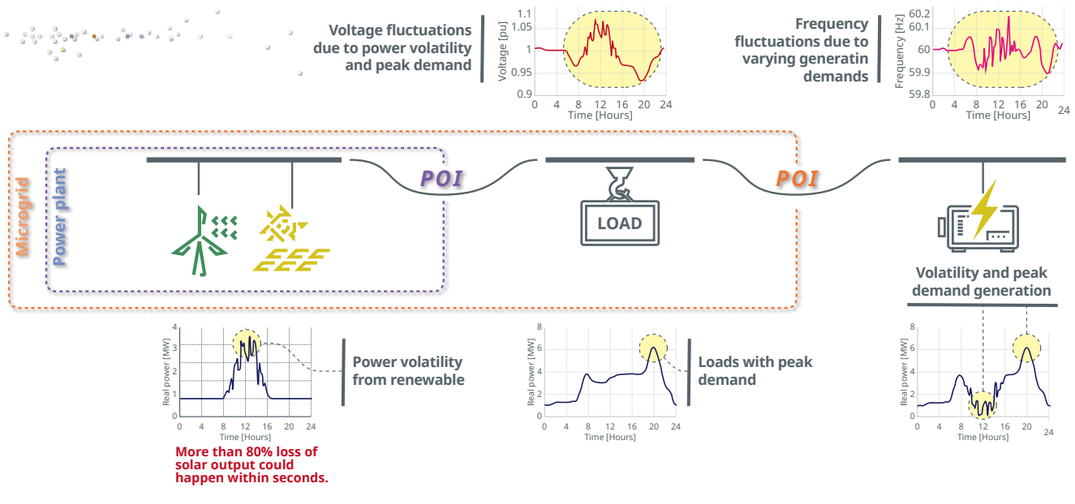
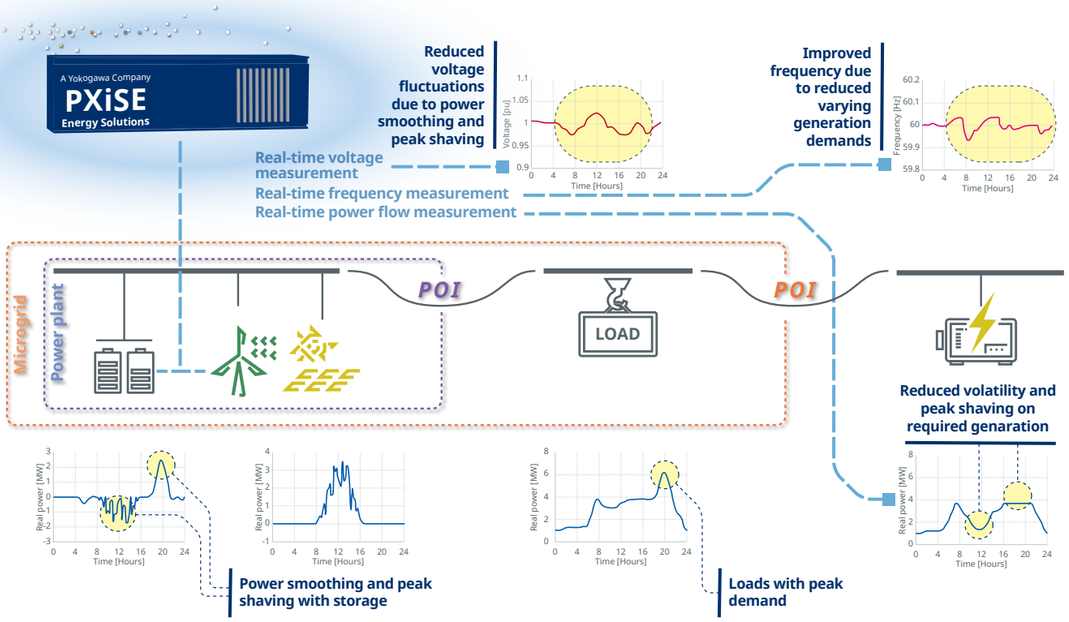
Challenges

Challenges with managing power quality with uncontrolled renewable power resources



Solutions

PXiSE solves customer challenges by providing patented high speed control at up to 60Hz



PXiSE software unlocks efficiencies not possible with legacy solutions

Hardware-based solution

Traditional Control

- Control without considering network characteristics
- Requires significant efforts in field deployment, system upgrades and plant expansion due to system limitations, including hardware

Poor system coordination | **Less flexibility and scalability**

- Uncoordinated frequency control of distributed energy resources
- Seconds to minute intervals of real power dispatch via slow data input

Uncoordinated control | **Slower control** (seconds to minutes range)

Challenging in dynamic operations with a high percentage of renewables and electric vehicles

Software-based solution

PXiSE (Technology)

- Independent real and reactive power control and frequency response to both local and distribution system level requirements
- Flexibility and scalability for phased renewable energy growth with software upgrade options

Better system coordination | **Higher flexibility and scalability**

- Time-coordinated frequency control of multiple distributed energy resources
- **Precise power dispatch across the power network using PMU data at up to 60 samples per second**

Timely coordinated control | **Fast and precise control** (millisecond range)

Remains effective as the power grid shifts towards 100% renewables

PXiSE (pronounced "pice") joined Yokogawa Group in 2021. PXiSE's highly innovative technologies address many of the issues related to the optimal production and integration of renewable and other energy sources. Combined, Yokogawa and PXiSE expertise help our global customers accelerate and enable the clean energy transition.

Solution Overview

Solution A

Renewable Power Plant Controller

The PXiSE Renewable Power Plant Controller helps large energy generation and storage portfolio owners, developers, and EPCs optimize the efficiency and production of any combination of front-of-the-meter and utility-scale behind-the-meter renewable energy assets.

Typical Use Case

- Guaranteed power production for a utility-scale renewable power plant with battery energy storage

Solution B

Microgrid Controller

The PXiSE Microgrid Controller helps utilities, campuses, and communities manage and coordinate localized distributed energy resources and loads by independently balancing real and reactive power, and efficiently dispatching the resources for resiliency, power quality, and economic benefit.

Typical Use Case

- Optimal distributed energy resource scheduling and dispatch for single-site through to campus or community-sized microgrids

Solution C

Distributed Energy Resource Management System [DERMS]

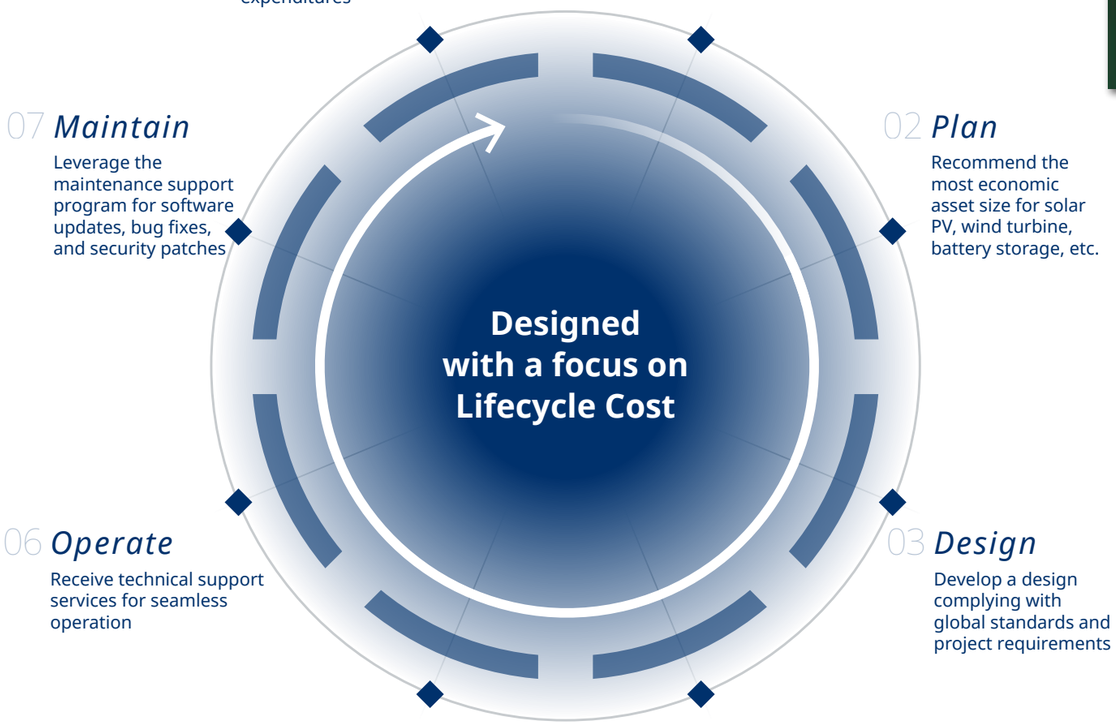
The PXiSE DERMS helps utilities control the increase in renewable energy assets, batteries and electric vehicles. It coordinates both front-of-the-meter and behind-the-meter distributed energy resources alongside traditional grid components on a single network through an integrated software platform that controls the dynamic two-way flow of energy.

Typical Use Case

- Integrate renewable and distributed energy resources across a distribution power network

Scan the QR code for solutions in details.

What is the right size of your plant assets and how can you optimize plant operations for the highest ROI?



Proven Success Cases

PXiSE Power Plant Controller

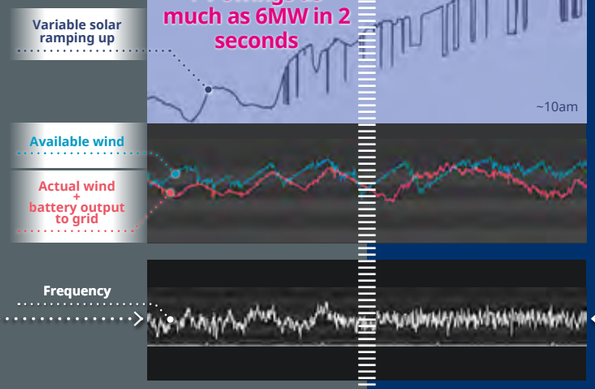
Before
Traditional Ramp Control

Requirements

Seven Regulating Generators

Three Existing Batteries

to achieve



After
Advanced Frequency Control by **PXiSE Power Plant Controller**

Requirements

One Battery

One Coordinated Generator

to achieve

Customer Benefits

Reduce capital investment on generators, batteries, fuel cost, O&M cost

Enable further increase of renewable mix

Achieve GHG reduction goal

PXiSE DERMS and Microgrid Controller

Before
Traditional Ramp Control

- **Power quality issues and power station blackouts**
- **Moratorium on additional rooftop solar connections**
- **Only 13% of homes with solar PV**
- **Required to run at least two fossil fuel generators at all hours**

After
Deployment of network wide DERMS and Microgrid Controller

- **Stable and balanced electricity system**
- **Removed limitation on rooftop solar integration**
- **Increased number of homes with solar PV by 55%**
- **Powered the entire community without fossil fuel generators during the day**

Customer Benefits

Reduce fossil fuel consumption

4x increase in renewable hosting capacity

Leader in implementing ground breaking technology

Geothermal Power Solutions

Best way to identify root cause of geothermal plant performance degradation

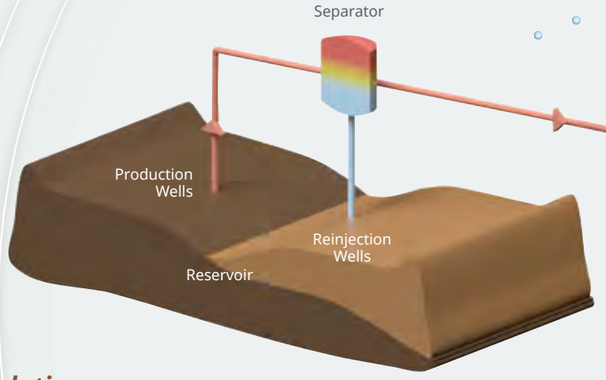
■ *Plant control system (DCS)*

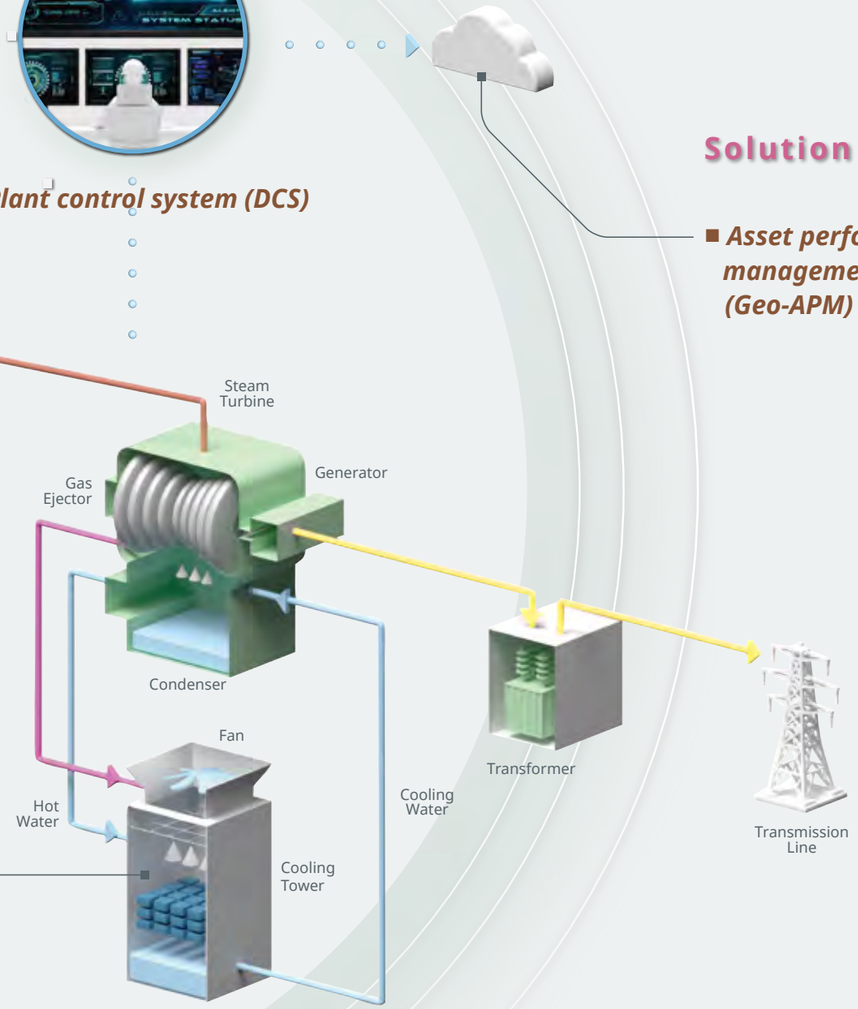
Solution A

■ *Asset performance management (Geo-APM)*

Solution B

■ *Cooling tower monitoring solution*





Steam
Water
Gas
Electricity

Challenges

Plant performance degradation

- *It is difficult to identify the root causes of the plant's performance degradation.*
- *Analysis potential from plant operation data is unrealized due to lack of analysis tools.*

Skills and knowledge transfer

- *Plant operation is highly dependent on the know-how of experienced operators/engineers, but how to transfer this knowledge to next-generation operators/engineers is a challenge.*

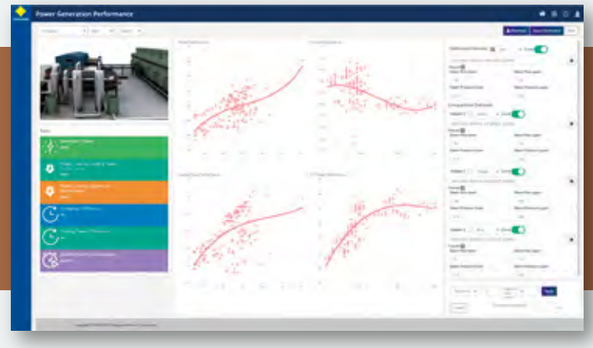
Solution

- *By using the Geo-APM tool, power plant operators/engineers can carry out plant performance analysis by themselves, using already-available plant operation data*
- *Reliable and easy analysis method (patented in Japan) which leverages geothermal power plant operation knowledge.*

Solution A

Geothermal Asset Performance Management (Geo-APM)

Geo-APM supports maximized electricity dispatch from geothermal plants.



01 Plant performance analysis

Geo-APM enables customer to analyze the state of plant performance and investigate the root causes of performance degradation using limited plant operation data.

02 Increased generation efficiency from optimized operational management

Geo-APM supports maximized generation efficiency through optimized plant operation and maintenance based on the analysis.

03 Helps to overcome the challenge of technical transfer

Following Geo-APM's reliable and easy plant performance analysis method, less experienced power plant personnel can carry out analysis tasks themselves and learn by doing so.

Challenges

Cooling tower performance degradation

- *It is difficult to identify the root causes of cooling tower performance degradation and know the best timing for maintenance.*

Complex structure of cooling tower

- *Due to its structural complexity, it is difficult to continuously monitor the condition inside cooling towers.*

Solution

- *Visualization of internal condition of cooling tower by utilizing fiber optic temperature sensor*

Solution B

Cooling Tower Monitoring Solution (CTMS)

CTMS visualizes the internal condition of cooling tower for optimized maintenance.

Monitoring screen

01 Cooling tower visualization

CTMS enables customer to monitor inside cooling tower continuously utilizing fiber optic temperature sensors.

02 Optimized maintenance

CTMS contributes to planning optimized maintenance by identification of specific deteriorated locations.

03 Minimized power generation loss

CTMS helps to minimize power generation loss through early detection of deterioration and optimize maintenance period.

Best way to optimize the combustion with less emission

Solution A

- *Overall plant control*
- *Safety management*

Solution B

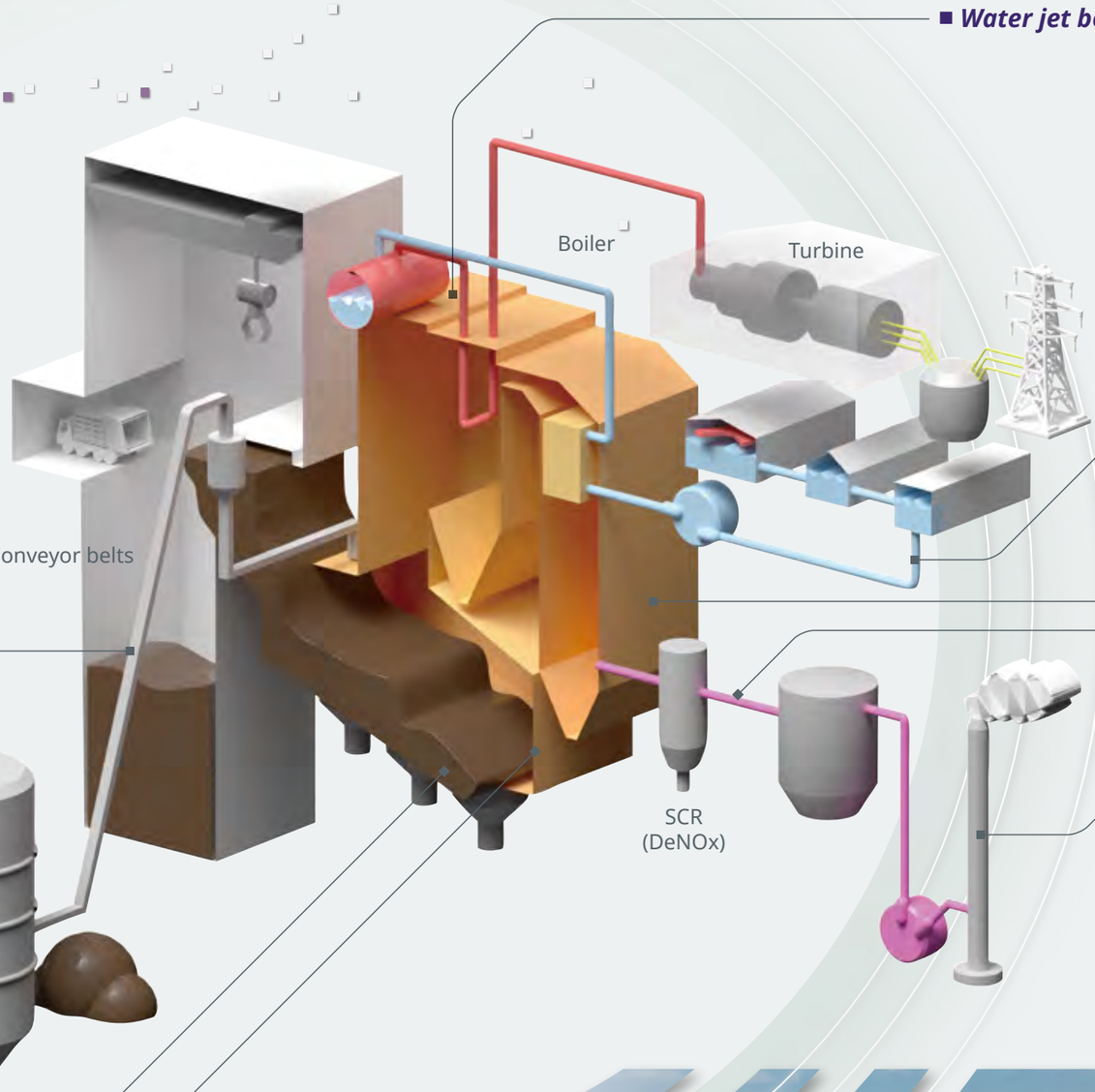
- *High level combustion control*

Solution C

- *Water jet boiler cleaning*

Solution D

- *O2/CO concentration measurement*
- *Ammonia slip measurement*
- *Flue gas emission monitoring*
- *Steam and water analysis*



- *Fire detection*
- *Grate replacement*
- *Fouling and corrosion prevention*

Steam
Water
Gas
Electricity

Solution A

Overall plant control and safety management

With Yokogawa's deep expertise and track record of more than 150 waste-to-energy/incineration plants and more than 100 biomass power plants worldwide, CENTUM VP distributed control system (DCS) is a trusted solution. It is suitable not only for conventional waste fuel firing furnaces but also for gasification melting furnaces including direct melting furnaces. The plant operation is even more secured with ProSafe-RS safety instrumented system (SIS). ProSafe-RS safety system is SIL2/SIL3 certified by TÜV and incorporates Yokogawa's own pair-and-spare technology just like its DCS. It is widely used in applications of burner management, boiler protection, turbine protection and emergency shutdown.

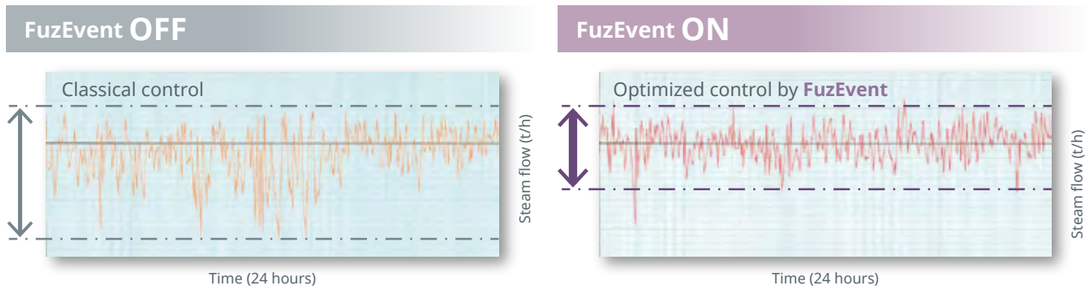
Solution B

High level combustion control

The FuzEvent® system of Dublix Technology is the ultimate operator assistant. The starting point for the design is to apply the same behavior as the best operators and thereby achieve unique results when it reacts correctly 24/7. Implementation of this system is always done in close collaboration with the operators from whom extremely important plant operational expertise is integrated into the control.

The FuzEvent® is able to provide substantial improvement in the combustion stability. A more stable operation can directly be reflected into increased plant performance generating;

- **More than 5% higher steam production,**
- **20% less flue gas temperature variations,**
- **20 % improved efficiency of the flue gas treatment system, and**
- **5% increased overall long-term plant efficiency!**

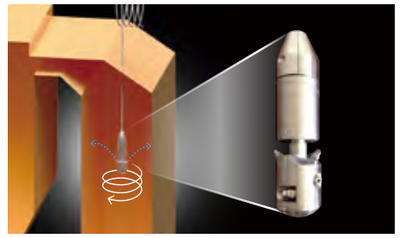


DUBLIX TECHNOLOGY A Yokogawa Company

Dublix Technology ApS joined Yokogawa Group in 2022. Dublix is offering engineered solutions to improve operation and maintenance of WTE and biomass plants. The puzzle piece in the logo stands for our solutions customized for the operator's needs to optimize production rates, availability and energy efficiency.

Solution C

Water jet boiler cleaning



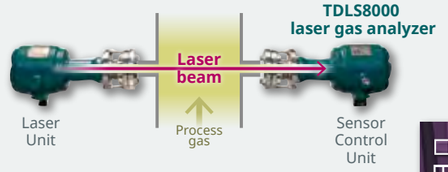
DD-Jet of Dublix Technology is an online boiler cleaner with turning water jets. It is equipped with a unique patented rotating nozzle designed to clean the boiler during full-load operation of the incinerator. The water-to-steam expansion provides a pressure wave, which is highly efficient to remove the fouling on the boiler surface. The system improves the efficiency of the furnaces and reduces the frequency of off-line maintenance. In addition, the DD-Jet system decreases the flue gas temperature at boiler outlet typically by 60 ℃, which reduces boiler corrosion.

Solution D

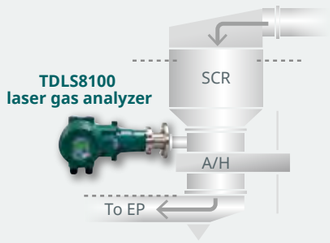
Multipoint gas measurement

O2/CO concentration measurement

It is essential to measure oxygen concentration accurately without delay for effective combustion control and Yokogawa's in-situ zirconia O2 analyzer is often used. It offers ease of sensor replacement and features a lead-less electrode design and a special coating to prevent deterioration. In many WTE, where the dust concentration is very high and may significantly affect the zirconia sensor's performance, Yokogawa's TDLS laser-based gas analyzer is widely used. It performs flawlessly thanks to its contactless laser sensor and measures O2 as well as CO and CH4 in near real-time.



Ammonia slip measurement



NH3 is injected into flue gas for the DeNOx process and must be measured downstream of the DeNOx equipment for limiting excessive ammonia slip. Direct measurement, immediately after the DeNOx would be ideal for minimal measurement delay. However, traditional measurement methods included "indirect", i.e. via sampling equipment, or measurement after the bug filter because of the large amounts of dust immediately after the DeNOx equipment. Yokogawa's TDLS can measure directly NH3 even in the high temperature or dusty and corrosive environment immediately after the dusty device, thus minimizing the measurement delay.

Flue gas emission monitoring

An online continuous emission monitoring system (CEMS) is mandatory in many countries. As a specialist in sensors and analyzers, Yokogawa offers total CEMS solution including our infrared gas analyzer to monitor CO, CO2, NO, SO2, CH4 and O2 concentrations in the flue gas, helping the user comply with environmental regulations.

CEMS cabinet

IR800G infrared gas analyzer

Hydro Power Solutions

Best way to achieve long-term operation with less maintenance cost

Solution A

- ***Control & remote monitoring***

Solution B

- ***Dam temperature monitoring***
- ***Generator stator temperature monitoring***
- ***Turbine control***
- ***Gate control***
- ***Penstock condition monitoring***

Solution A

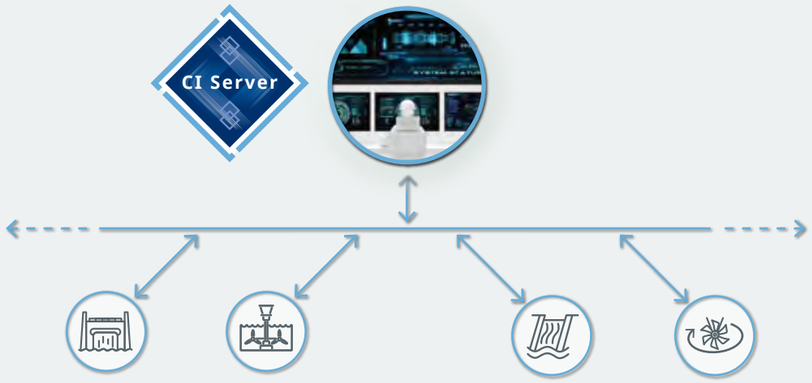
Control and remote monitoring

Yokogawa's control systems are suitable for hydropower plant control, and thanks to its reliability, the demand of retrofitting to aged plants with conventional system is increasing. The following features of Yokogawa's system will contribute to the power availability:

- Unrivaled reliability and long-term stability of turbine control both in regular and emergency situations thanks to the utmost reliable CPU modules with "seven nines" availability
- Minimized maintenance operations and maximized service intervals
- Turbine governor control with turbine specific modules for critical control
  - High speed governor position control
  - Turbine-specific I/O interfaces
  - All in one
- Turbine protection
- Auxiliary control
- Automatic turbine run-up
- State-of-the-art HMI with the latest technology
- Easy integration with asset management system
- Applicable to turbines of all manufacturers.

Hydro power plants are located in remote areas and require integrated remote monitoring for optimization of plant operation. Yokogawa's SCADA integrates multiple systems and contributes to:

- Monitoring the current conditions remotely in real time at administration office, headquarter, and/or some other area than the hydro power plant
- Taking actions in case of alarming quickly by remote monitoring and immediate status sharing
- Reducing local documentation by automatic reporting function.



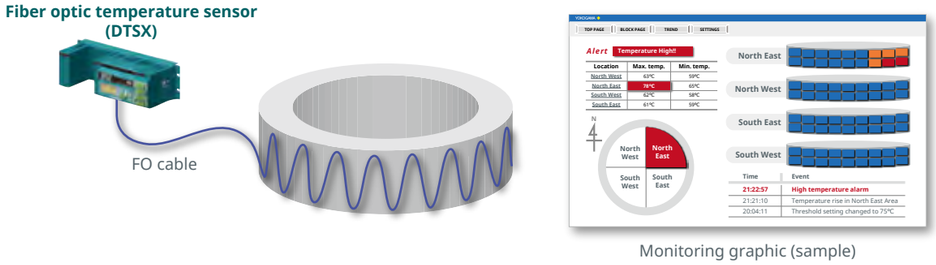
Solution B

Temperature monitoring for predictive maintenance

Distributed temperature sensing with fiber optics is an innovative solution as long-range and wide-area temperature monitoring. Yokogawa DTSX sensor can continuously measure the average temperatures at every 1-meter intervals along a fiber optic cable.

Generator stator temperature monitoring

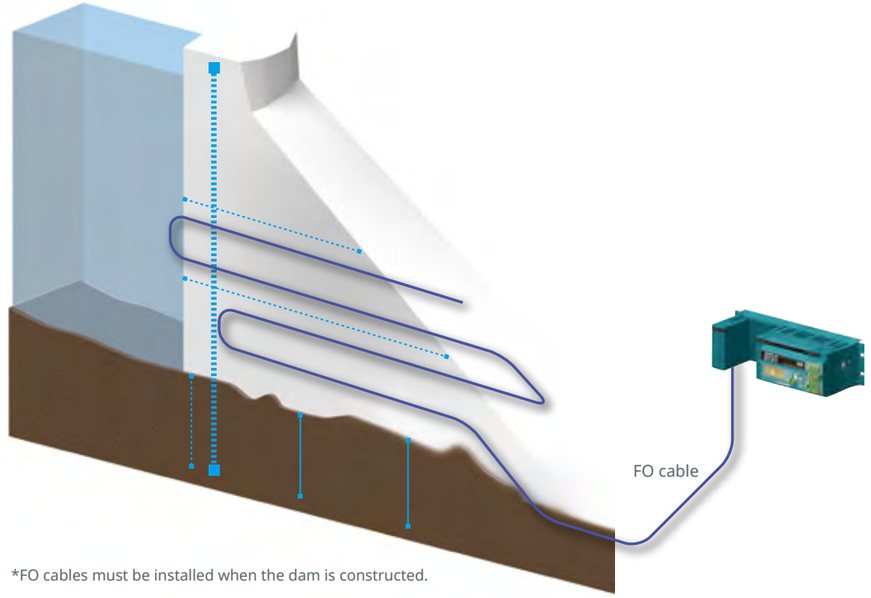
By installing the cable around the stator, the DTSX will provide a comprehensive view of temperature profiles of all stator coils and alerts the user when abnormality occurs. It thus enables stator coil temperature abnormalities to be detected and exactly located to help take countermeasures quickly.



Monitoring graphic (sample)

Dam temperature monitoring

DTSX enhances dam safety by providing continuous temperature measurement along the length of the fiber optic cable*. It thus enables monitoring of temperature profiles to allow detection of abnormalities such seepage changes.



*FO cables must be installed when the dam is constructed.

Yokogawa renewable energy projects

UK
23 MW
Waste-to-Energy

France
24 MW
Wind

France
16 MW
Waste-to-Energy

Poland
11 MW
Waste-to-energy

Russia
25 MW
Hydro

Russia
48 MW
Hydro

South Korea
2.5 MW
Solar + Wind + Energy Storage

China
79 MW
Waste-to-energy

China
Total 2100 MW
Wind

Japan
34 MW
Hydro

Japan
121 MW,
30 MW
Wind

Japan
Total 157 MW
Geothermal

Japan
Total 2500 MW
Biomass

Japan
Total 320 MW
Waste-to-Energy

Guam
56MW, 92MW
Solar + Energy Storage

Philippines
Total 500 MW
Geothermal

Singapore
1.2 MW
Solar

Indonesia
Total 720 MW
Geothermal

Indonesia
568 MW
Hydro

Thailand
Total 28 MW
Solar

India
38 MW
Biomass

New Zealand
48 MW
Wind

Australia
10 MW
Solar

Australia
12MW
Solar + Energy Storage

Spain
30 MW
Waste-to-Energy

Italy
Total 135 MW
Waste-to-Energy

UAE
100 kW
Solar

Kenya
575 MW
Geothermal

South Africa
100 MW
Solar

USA
30 MW
Hydro

USA
Total 1GW
Solar + Wind + Energy Storage + Generators

USA
21 MW
Waste-to-Energy

Mexico
Total 370MW
Solar

Mexico
720 MW
Geothermal

Brazil
120 MW
Biomass

- Solar Solutions
- Wind Solutions
- Geothermal Solutions
- Biomass & WTE Solutions
- Hydro Solutions

https://www.yokogawa.com/industries/renewable-energy/

OpreX™ Through the comprehensive OpreX portfolio of products, services, and solutions, Yokogawa enables operational excellence across the enterprise.

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