



Hydropower Solutions

Optimizing Your Plant for the Future

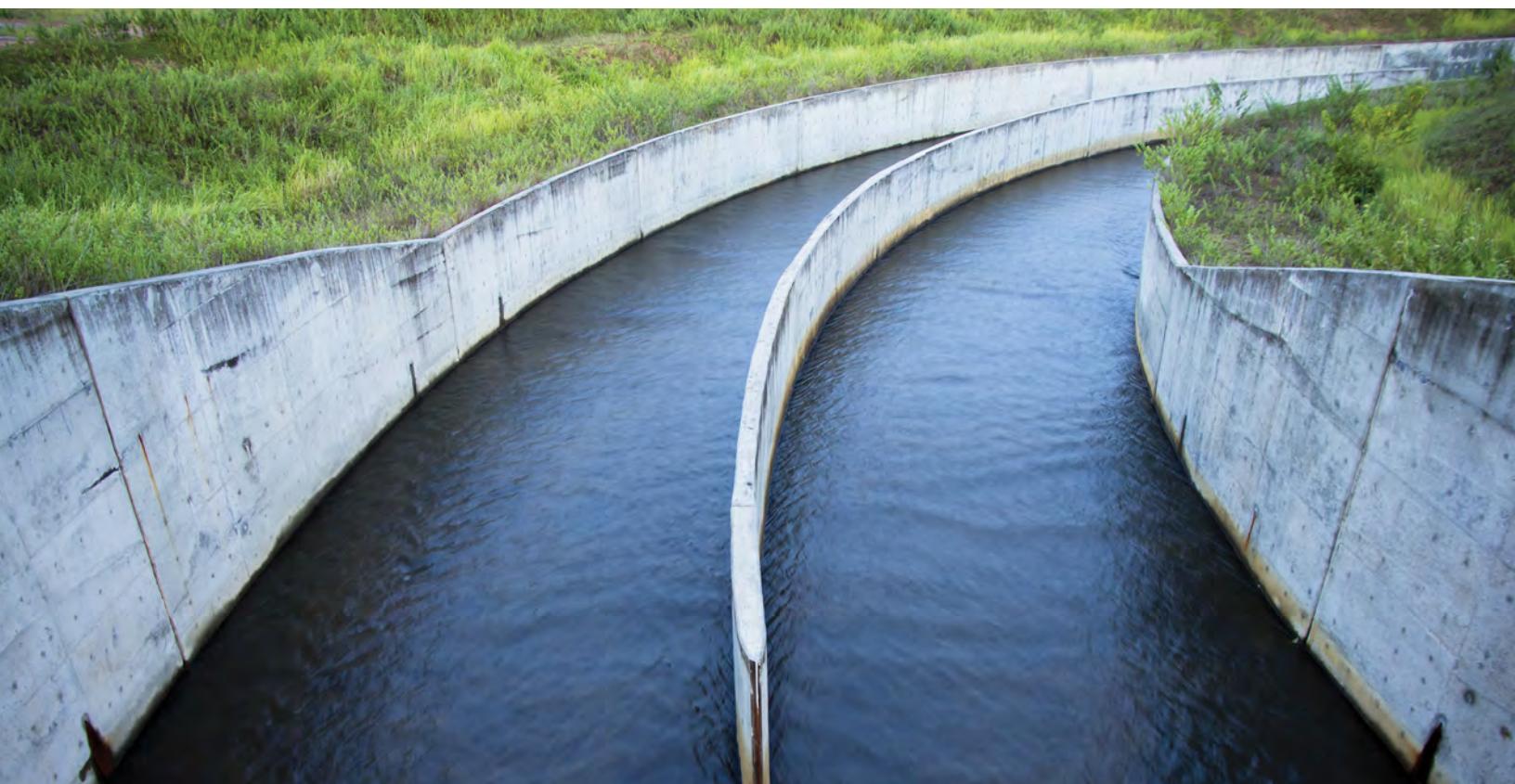


Building on a rich history of innovation and technology leadership, GE is a global industry leader in efficient, clean, and cost-effective conversion of fuels to power.

GE is responsible for the automation and control of processes that generate one-third of the world's power. For more than 130 years, we have delivered energy where it is needed most.

We are a leading provider of automation and control products and services for equipment and plant control across the Power Generation industry, including the growing renewable energy sector. GE is at the forefront of renewable power generation technology, providing efficient and secure hydropower control solutions.

Regardless of the fuel source, we can help optimize your equipment performance and increase the reliability and efficiency of your operations by connecting your machines, data, insights, and people.



Industrial Internet Control System for Hydropower



Hydropower is the predominant renewable energy source. As demand grows for renewable energy generation capacity, more hydropower and pumped storage stations will be built or modernized, requiring efficient and reliable control.

Solutions to Meet Today's Challenges

You need a controls solution to fit your hydropower station's specific demands for capacity, security, and data accuracy. Whether your total capacity is 25 MW or 2500 MW, our high availability control solutions can be scaled to fit your station's requirements, whether new or retrofit. Our solutions are also designed with defense-in-depth security features, helping guard your control system against attack. And support a variety of open communication protocols like IEC 61850 and IEC60870-5-104 means we can interface with a variety of existing legacy and vendor control solutions.

We know how critical uptime is and provide high availability systems so that there is no single point of failure. Data accuracy and speed requirements have grown and our solutions have grown with them, offering true 1ms of accuracy for SOE (Sequence of Events) which includes remote IO drops over PROFINET using multiple time sources such as PTP, SNTP and IRIGB. We also offer a GPS timing system and a fast gigabit of network speed to provide reliable control.

Why GE?

We have extensive expertise with hydropower and pumped storage stations, owning more than 30% of China's small hydro plant market. With more than 100 hydro project wins in the past 3 years, our solutions have encompassed small-, mid-, and large-scale stations offering plantwide control, reliable redundant systems, and seamless migration.

- Domain expertise – Producing more than 10GW of hydropower globally
- Plantwide control provides a historical server, operator and engineer workstations, plant communication device, and scheduling machine
- High-availability architecture designed to handle large amounts of data
- Simple and flexible network topology for future expansion
- Easy diagnostics and simplified maintenance
- Open industry-standard protocols including: PROFINET, OPC UA, IEC 6870-5-104, IEC 61850, and Modbus/TCP
- HTML5 graphics using CIMPACT 10.0 for display in any modern web browser
- Defense-in-Depth security to help protect from internal and external attack
- Achilles Certification for PACSystems RX3i controllers
- True 1ms SOE support allows for improved troubleshooting which includes remote IO drops with multiple source of timing inputs suchs as PTP, SNTP, and IRIGB.

Take your industrial control system to the next level.

The Industrial Internet Control System (IICS) helps to improve your operational efficiency by providing the ability to access and use data from your facilities to better understand patterns, trends, and disparities in your control systems. This helps to lower overall risk, total cost of ownership, maintenance expense, and unplanned downtime while increasing overall performance and productivity. Outcome Optimizing Controllers combine reliable and secure controls with data acquisition management in a single unit.

Choose to send and manage data on-premise or in the cloud with the flexibility to use convenient Predix*-enabled Embedded Field Agent technology or embedded PACEEdge technology, which enables specific Linux-based applications on the edge or provides connectivity to your preferred cloud environment.

48%

Of customers said they have a talent gap for gathering and consolidating disparate data

70%

Of industrial companies believe it's important to adopt an Industrial Internet of Things Strategy the next over the next 5 years

80%

Of industrial companies indicate big data analytics is the TOP priority for their company, or in the top 3

(Sources: Morgan Stanley Research; Global Capital Goods, "Insight: Cloud Control – The Future of Industrial Automation", March 15, 2016")



Unlock Hidden Value Through Controls



Optimize Asset & Process Performance

- Securely collect and integrate data across the plant
- Analyze data on-premise or in the cloud



New Revenue Opportunities for SIs and OEMs

- Develop new data-driven service offerings for end customers
- Maintain competitive advantage through continuous software-based innovation



Maximize Productivity

- Drop in complete, cyber-secure IIoT solutions or use our Linux-based platform to develop your own scripts and applications in a standard Linux environment
- Reduce maintenance cost through monitoring and diagnostics

Transform the Equipment Lifecycle

- Select the right on-ramp to the Industrial Internet for either greenfield or brownfield applications (no retrofit required)
- Eliminate the impact of component obsolescence through modular hardware, firmware, and software



Choose from Two Outcome Optimizing Control Options:

CPE400 + Embedded Field Agent

Predix Machine provides:

Automated OPC UA Client for data collection from CPE400 PLC runtime

Hoover data collection and aggregation

REST for secure cloud connectivity to PREDIX cloud

Predix enabled Edge Applications

JAVA/C/C++ support for Predix Apps

Predix Edge Manager to deploy and manage your devices

CPL400 + PACEdge for Linux

PACEdge with Linux provides:

OPC UA Client for data collection from CPL400 PLC runtime

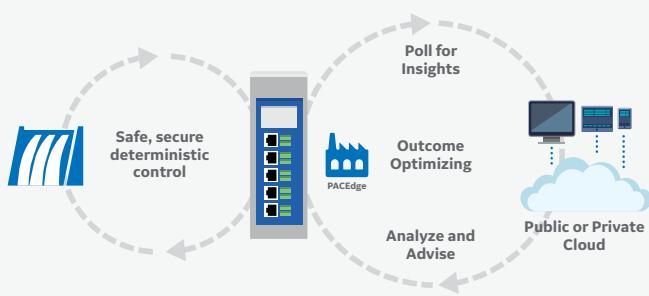
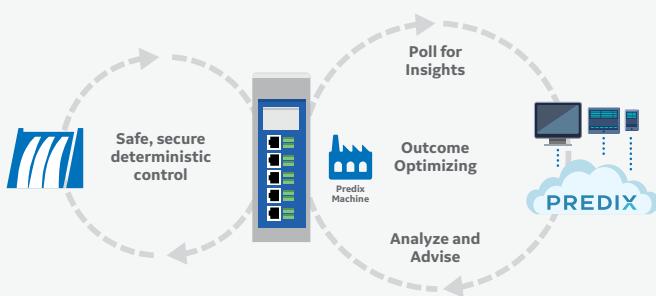
SQL_Lite database for data collection and aggregation

Webserver with HTTPS Support to connect to your preferred cloud

Develop your own scripts and applications in a standard Linux environment

C/C++/Python development environment for Edge Apps

Connect directly to your local storage solution or download standard tools to connect to your choice of cloud services.





Open Communication Protocols

Open standards allow for equipment from multiple vendors to work together seamlessly for the end application. This ease of interoperability allows for systems to be combined, and reduces the skill level required to do so.

Development, deployment, & commissioning become easier

- Code can be reused with the ability to define standard objects and a fixed, yet flexible, API allows for rapid development and modifications.
- Metrics and historical data from disparate vendors and systems are integrated

Provisions are built-in for communications security

- Data and associated attributes are transferred collectively to reduce the likelihood of a data mix-up
- Common APIs reduce the likelihood of coding errors, reducing vulnerabilities in the application

Cyber Security

We understand the risk involved in securing our customers' assets and believe in a defense-in-depth architecture to help secure from the hardware layer up, guarding against potential cyber threats. Our PACSystems platform has earned Achilles and TRIMPS certifications. GE implements a secure design lifecycle, scrutinizing each components' hardware and software through testing and reviews.

At GE, we realize that the control system must be secure by design and should have a hardware root of trust as the foundation of all the security constructs in the control system. For our IICS portfolio, all our controllers now come with Trusted Platform module (TPM) technology that enables hardware root of trust. All boot firmware is signed by GE with the private key stored in the TPM module to ensure only GE signed firmware will run on the hardware. GE supplied patches are also signed for verification purposes prior to loading.

Achilles Level 2 Certification

RX3i has been industry-certified to meet rigorous standards for reliability and communications robustness. Its cyber-hardened platform is designed to help prevent cyber attacks, reducing operational risks.

Role-Based Access Control

Privileges assigned to users are based on pre-defined levels of authorization, enhancing system security. This provides layered user access, allowing only specific user access to critical competitive and customer data.

Secure User Authentication

Access to the controller is implemented using an authentication process that does not require passwords to be passed over the network. This helps prevent an attacker from eavesdropping and collecting credentials from the network that would provide unauthorized access to the controller.

Signed Firmware Updates

Signed firmware updates help ensure only core operating system software supplied by GE will run on the PLC and that it has not been tampered with since it left the factory. This prevents code that has been compromised from entering the controller, protecting system availability and valuable operation information.

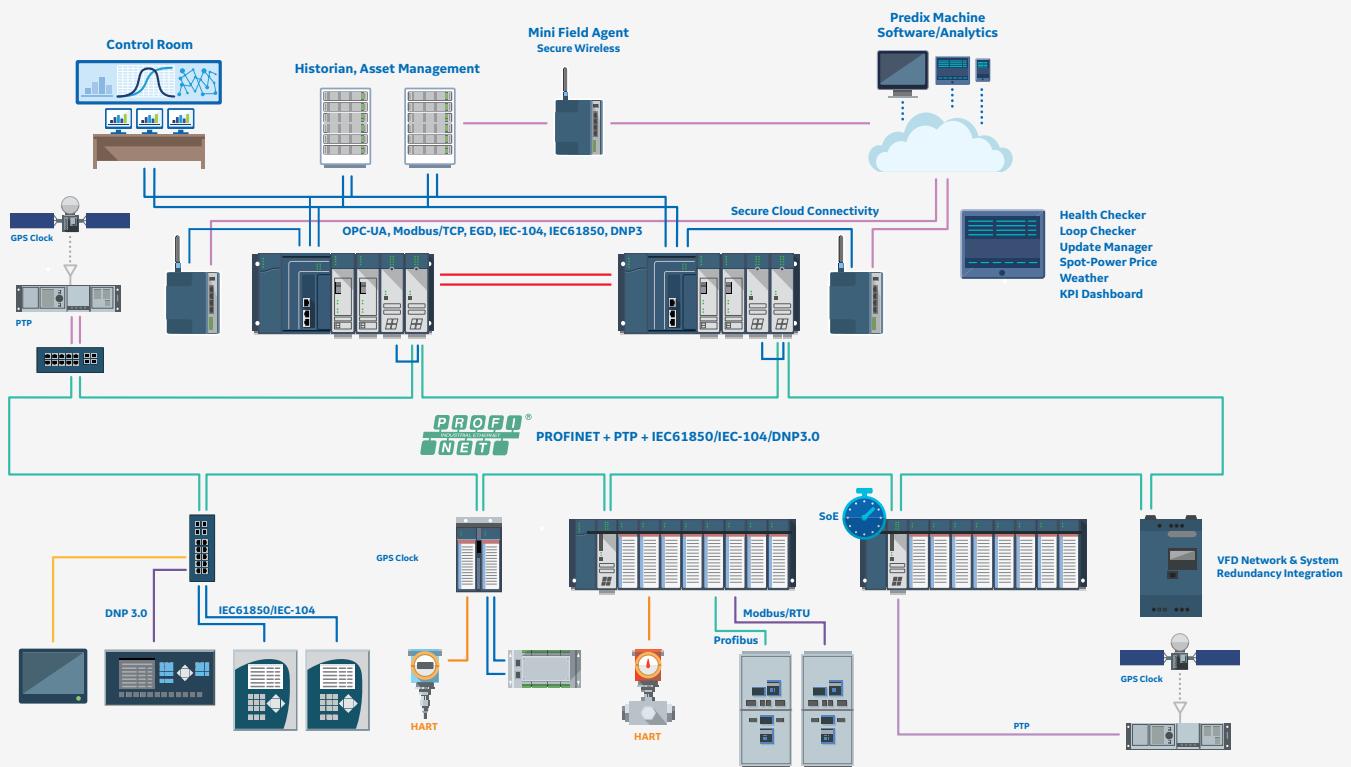


Flexible Architectures to Fit Your Needs

Flexible and scalable solutions allow a for multitude of existing infrastructure and applications to reap the benefits of our hydropower solutions.

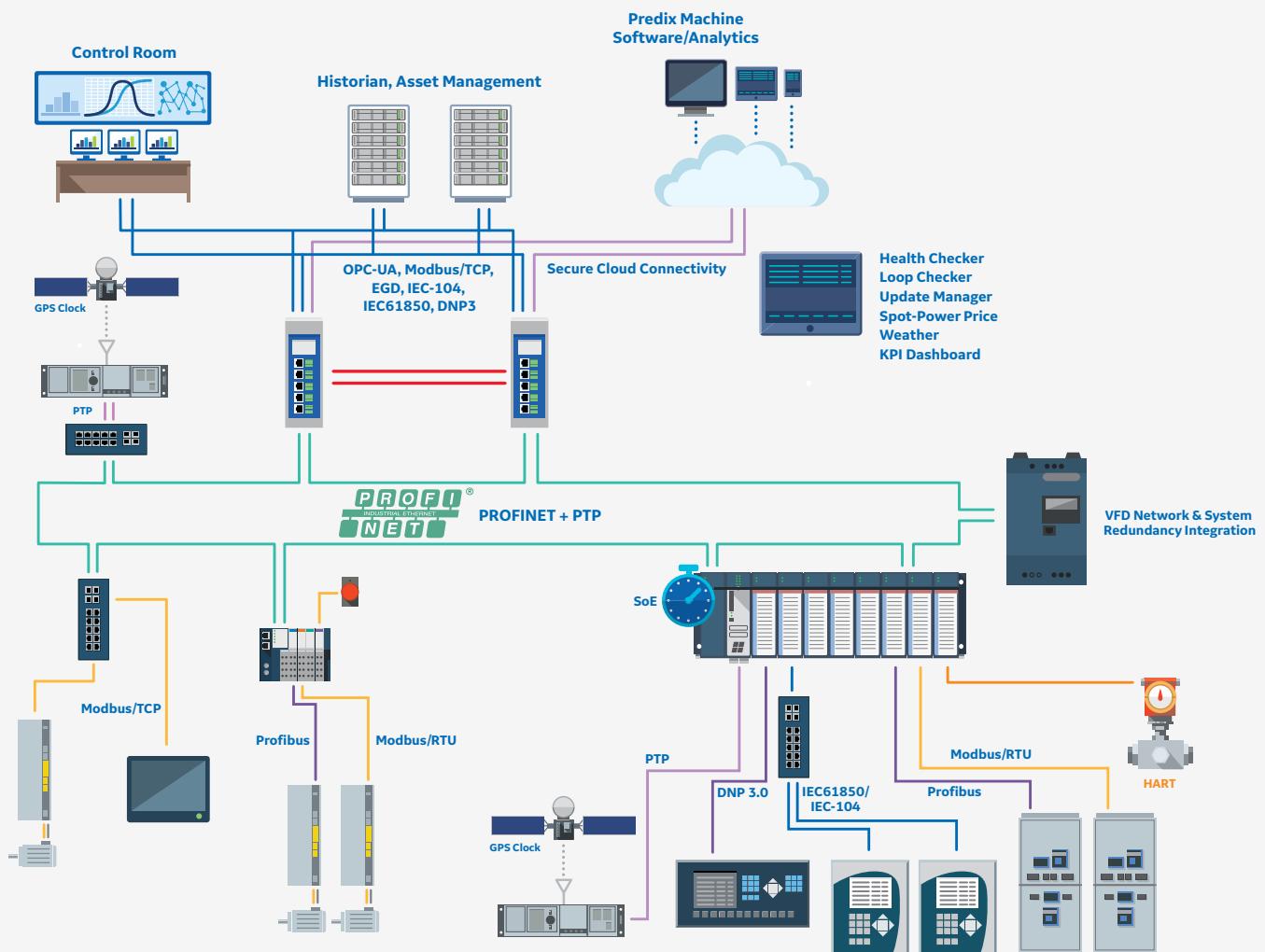
- Same tool chain across our solutions
- Sequence of Events (SoE) integrated over the PROFINET network, simplifying infrastructure and lowering cost
- Outcome Optimizing Control
- Integrated power protocols. Supports IEC-104 and IEC 61850

Large to Mid IICS Hydropower Solution





Small IICS Hydropower Solution



Customer Successes

GE customers have successfully deployed our flexible and scalable hydropower solutions around the globe.

Large Hydrostation with Flexible Design

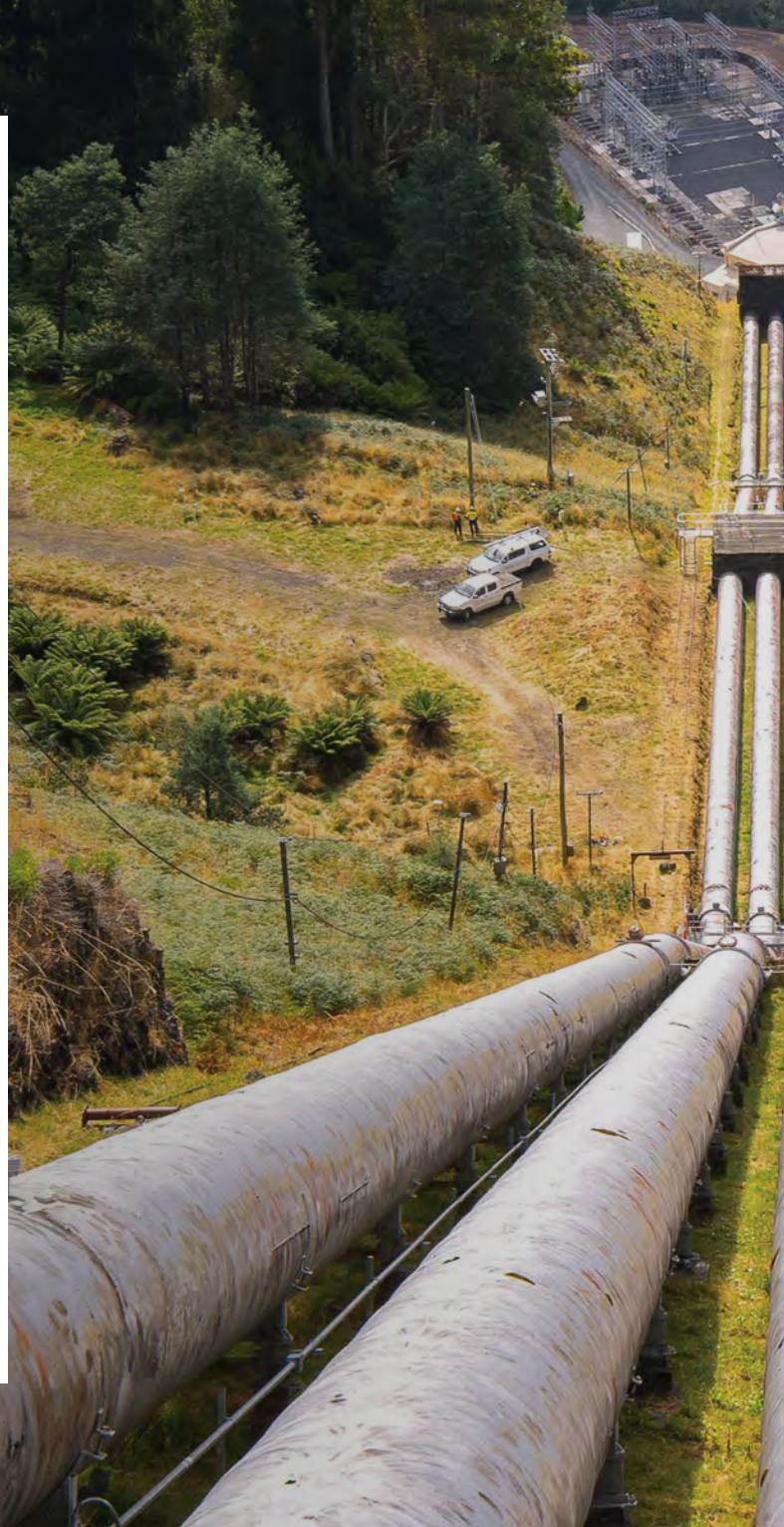
With a total installed capacity of 600MW, PACSystems RX3i provided a reliable and redundant system with a single high-availability architecture. The system design includes a flexible network topology that can currently handle large data, with ability to expand in the future.

Multiple Sized Hydrostations

To fulfill customer needs for 4 large 200MW generation units and 2 smaller 25MW generation units, reliable redundant controls were deployed, scaling the solutions to fit the two sizes of the generation units. The solution provided plantwide control, including 1ms of SOE, GPS timing system, and generator protection.

Seamless Migration

Migrated legacy RX7i controllers and 90-70 I/O to PACSystems RX3i controllers and I/O for a very large cascade hydropower plant consisting of 5, 300MW generation units. Migration was seamless and did not require software reprogramming of the application, configuration, or the HMI/SCADA data. By keeping most of the existing wiring in place, the impact to the footprint was minimal. With this upgrade, productivity increased, allowing for improved performance and profitability.







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