



Kozloduy NPP Implements Radiy ESFAS Digital Safety System

DIGITAL CONTROL SYSTEM SOLUTIONS

Organization

Kozloduy, a nuclear power plant operating in Bulgaria.

Challenge

Aging safety systems needed to be replaced to maintain plant health and safety.

Solution

Upgrade existing systems using Radiy's platform to increase safety, availability, and long-term operational stability of the plant.

Results

The plant has been operating with this system for 12 years now with no reactor shutdowns due to faults or failure of the ESFAS systems or from the related electronics equipment.

Curtiss-Wright has partnered with Radics, LLC—an international nuclear engineering company specializing in advanced, customized I&C solutions—to bring the RadICS digital instrumentation platform to the U.S. nuclear power market.

Kozloduy is the only nuclear power plant in Bulgaria. It is the country's main electricity generating plant, providing affordable electricity totaling approximately one third of the country's annual electrical output. The plant has been operational since 1974 and has brought six units online: four VVER-440 units and two VVER 1000 units, a style of pressurized water reactor common in Eastern Europe. Since 2007, only the VVER-1000 units have been operational, with a capacity of 1000MW each, and from 2017 to 2019, the lifetime of these two units was extended for another 30 years.

Radiy has supplied new Engineered Safety Factors Actuation Systems (ESFAS) at Kozloduy Nuclear Power Plant (NPP) based on Radiy's I&C platform, incorporating the main design principles and QA approaches that were later used to develop the RadICS platform. The main drivers of this project were increased safety, availability of parts, and long-term operational stability of the plant. Secondary objectives included improving the human-machine interface (HMI), as well as simplifying diagnostics and maintenance activities by delivering detailed performance indicators for operations and maintenance staff.

ADDRESSING OBSOLESCENCE ISSUES

According to Dragomir Dragolov, chief power and maintenance engineer at Kozloduy NPP, prior to this digital modernization initiative Kozloduy NPP depended on ESFAS hardware and software manufactured in the Soviet Union. These systems provide cooling for the reactors and reduce the potential for offsite release of radioactive materials. They also perform actions related to shutting down the reactor, mitigating the effects of loss of coolant accident (LOCA), and minimizing offsite release, including: emergency cooling of the reactor core; closure of valves that do not serve an emergency safety function; emergency ventilation system startup and shutdown;



Kozloduy NPP Implements Radiy ESFAS Digital Safety System



Midway Through the Installation

closure of ventilation system dampers to reduce the potential for offsite release of radiation; emergency diesel generator startup to provide a backup power source; and the opening of pressure relief valves in the reactor cooling system.

Kozloduy NPP is overseen by the Nuclear Regulatory Agency at the Bulgarian Council of Ministers, and its safety record has received strong international scrutiny by teams from the International Atomic Energy Agency, World Association of Nuclear Operators (WANO), and the Atomic Questions Group at the European Commission. Over time, the service life of Kozloduy's ESFAS hardware and software systems had become obsolete, and reliability had gone down in tandem. "The number of failures and faults increased," Dragolov confirms. "We witnessed a decrease in operational reliability with the safety systems and obsolescence of key components."

The overall goals of this modernization project were to increase the overall safety and availability of critical plant infrastructure; assure long-term operational reliability of the plant; improve human-machine interface for control, diagnostics, and maintenance; instigate electrical and physical separation between safety divisions; assure lifetime service and maintenance; comply with regulatory requirements; achieve systematic improvements with digital technology; and minimize reconfiguration of existing

equipment.

A FLAWLESS IMPLEMENTATION BASED ON EXTENSIVE INDUSTRY EXPERTISE

Kozloduy NPP selected the Radiy I&C system for the flexibility of its architecture, logical design, exceptional diagnostic coverage, channel redundancy, and compliance with the latest nuclear regulatory requirements. "Digital systems are more informative, they provide intelligent diagnostic data to operators, and they are simpler to maintain," Dragolov reports. "Digital systems also decrease operational costs since many routine tasks are eliminated."

Radiy spearheaded the implementation of the new ESFAS in conjunction with the Kozloduy NPP team, while a Bulgarian subcontractor assisted with hardware assembly, installation, and cabling. Throughout the project, Radiy helped the team identify issues and formulate solutions based on cumulative experience gained from other digital safety system installations, providing prompt assistance as issues arose.

The Radiy team also established fiber-optic cable runs, set up the ESFAS equipment, and assisted with testing. The modernization project included ESFAS design, production, acquisition, and commissioning. All phases were completed in an extremely short timeframe, a testament to Radiy's strong managerial practices, which optimize the process

Kozloduy NPP Implements Radiy ESFAS Digital Safety System

“Digital systems are more informative, they provide intelligent diagnostic data to operators, and they are simpler to maintain.”

— Dragomir Dragolov, Chief Power & Maintenance Engineer at Kozloduy

via thorough preparation of basic data to inform the design, precise definition of the procedures and persons responsible for their execution, and application of FPGA-technology, which maximized flexibility and minimized risks.

“We replaced six old hardware and software systems with ESFAS systems,” Dragolov recalls, adding that the team got more efficient with each installation. “It took 21 days to replace the first system and only 14 days to replace the sixth system, including dismantling the old systems and installing the new ones, along with all set up, checkout, and commissioning. There were no unexpected problems or challenges that jeopardized the project schedule.”

Today, these ESFAS systems include functions that are necessary for safe operation, such as: data acquisition and control; data collection and distribution; signal conditioning and control of safety signals, detectors, and sensors; and full-scope systems diagnostics.

In addition to the new ESFAS I&C systems, Radiy developed and supplied switches and electrical distribution cabinets for Kozloduy NPP. Fewer modules means fewer spare parts need to be stocked in the warehouse.

A FLEXIBLE AND CONFIGURABLE ARCHITECTURE

The Radiy platform incorporated many of the same design principles and QA approaches incorporated into the RadICS platform. For example, the RadICS platform includes Field Programmable Gate Array (FPGA) chips as computational engines, which are highly regarded for their ability to support both discrete and analog input/output (I/O) modules, delivering responses as fast as 10 milliseconds. These general-purpose building blocks can be configured according to the needs of each project and system—in Kozloduy’s case, the system was configured to protect, block and monitor all automated actuator operation; to provide automatic process control; and to give manual remote control of the actuators.

These platforms continuously monitor system status through

signals that are received from field sensors, then perform logic computations to create control commands. They also convert control commands to output signals that are then applied to field actuators. Both the Radiy and RadICS platforms have these same functions, but RadICS offers wider diagnostic coverage (99% coverage). Their IEC 61508 SIL 3 certification ensures high reliability and fault tolerance.

CONTINUOUS MONITORING AND PROCESS AUTOMATION

The human-machine interface of the Radiy platform allows Kozloduy NPP to easily monitor all on-line diagnostic functions and perform surveillance testing of the plant’s safety systems. The software has allowed for greater automation of key processes and procedures, and engineers spend less time on technical maintenance. These automated capabilities eliminate the need for scheduled online surveillance activities and facilitate condition-based maintenance, boosting the efficiency of the maintenance staff.

“All algorithms are implemented using FPGA technology, which improves the reliability of the safety systems,” Dragolov explains. “In addition, the new system has strong self-diagnostics and is cyber secure.”

The RadICS platform has inherited the basic HMI principles of the Radiy platform, including features that minimize the potential for operator error. For example, every RadICS module has a non-interfering local status display, comprehensive diagnostics relayed to the Monitoring and Tuning Station, and auto-detection of some maintenance errors (such as if the wrong module is placed in a slot).

AN EFFICIENT, COST EFFECTIVE PLATFORM THAT COMPLIES WITH MODERN SAFETY STANDARDS

Kozloduy NPP now has a more modern, efficient, and cost-effective digital safety platform. According to Dragolov, the digital ESFAS is highly reliable and performs its functions as intended. These new digital safety systems meet all important safety standards from the IEC/IAEA, including: reliability;

Kozloduy NPP Implements Radiy ESFAS Digital Safety System



ESFAS Digital Racks (Left) and ESFAS 2 Control Systems (Right)

single failure; redundancy; independence; common cause failure protection; technical diagnostics and monitoring availability; functional quality; functional stability; resistance to power parameter variations; electromagnetic compatibility and emission restriction; human error prevention; unauthorized access protection; and cybersecurity.

“Operational reliability of our control systems and safety systems has increased considerably as the number of faults and failures decreased,” Dragolov concludes. “In nearly 12 years since the project was completed, we have not experienced any reactor shutdown due to faults or failure of the ESFAS systems or from the related electronics equipment that Radiy supplied. This is due to the highly reliable components that are used in the Radiy platform.”

INTEGRATED DIGITAL SAFETY SOLUTIONS FROM CURTISS-WRIGHT

Based in part on Radiy’s successful implementations in Ukraine and other sites around the world, RadICS has become an essential component in a new set of digital safety systems that Curtiss-Wright offers to the U.S. market. As a systems integrator, Curtiss-Wright brings together the best available hardware and software components for each project. The RadICS platform forms the basis of Curtiss-Wright’s NRC-approved Digital Safety System, a functionally and technologically diverse replacement for analog and digital safety-related systems at nuclear power plants throughout the United States. The July 31, 2019 U.S. Nuclear Regulatory Commission approval of the RadICS I&C platform for use in safety-related systems in nuclear power plants paves the way for this technology at U.S. nuclear power plants.

CONTACT INFORMATION:

1350 Whitewater Dr., Idaho Falls, ID 83402 USA
Tel: +1.208.497.3535 | DSS-Sales@curtisswright.com