

Case Study

# Development of a SIL Rated Control System for an Innovative Energy Storage Prototype

A technology client was developing a prototype medium scale energy storage system designed to capture excess electrical energy and return it to the grid on demand. The system utilised a combination of compressed air and thermal storage to achieve efficient energy retention and recovery.

To enable safe and reliable operation, the client required a fully integrated electrical control and safety system capable of managing complex process interactions across compression, storage and energy recovery phases.

Cetix were contracted to design, build and commission the control system, including PLC architecture, safety functionality and human machine interface.

## Project highlights

- SIL2 rated control and safety system for a first of kind compressed air and thermal energy storage prototype
- Safety rated PLC platform with segregated safety and process logic under a full IEC functional safety lifecycle
- State based control across safe, reserve, charge, discharge and diagnostic modes with automated sequencing
- Energy balancing using state of charge calculations across air, thermal and electrical models
- Safety Instrumented Functions validated from HAZOP and LOPA studies, with emergency stop and safe torque off
- Multi-day witnessed FAT following full plant I/O simulation on in house test rigs

# Challenge

The project presented several key engineering challenges:

- **Functional safety requirements:** The system required SIL2 compliance across critical safety functions, demanding rigorous design, verification and lifecycle management.
- **Multi mode operation:** The plant needed to operate across multiple states including safe, initialisation, reserve, charge, discharge and diagnostic modes with defined transitions.
- **Complex process control:** Precise pressure, temperature and energy balancing was required across multiple compression stages and thermal storage elements.
- **Prototype uncertainty:** As a first of kind system, design assumptions needed validation through testing and iterative refinement.
- **Integration of safety and standard control**: Separation and interaction between safety and non-safety PLC logic required careful structuring.
- **Instrumentation:** The system required instrumentation for extremes of temperature and pressure.

# Approach

Cetix were contracted to design, build and commission the control system, including PLC architecture, safety functionality and human machine interface.

A structured engineering approach was adopted to manage technical complexity and risk:

- **Functional design and planning**
  - Development of a detailed functional design specification covering system operation, control philosophy and safety requirements.
  - Implementation of a full functional safety lifecycle aligned with IEC standards and SIL2 requirements.
  - Regular design reviews and quality assurance processes under ISO compliant management systems.
- **System architecture**
  - Deployment of a safety rated PLC platform with segregated safety and process control tasks.
  - Integration of distributed I/O, variable speed drives, and dedicated engine control units via industrial Ethernet networks.
  - Provision of UPS backed power to ensure orderly shutdown during faults or power loss.
- **Control strategy**
  - Implementation of state-based control logic governing all operational modes.
  - Use of PID control loops for pressure management across compression stages and storage vessels.
  - Development of energy balancing algorithms using state of charge calculations based on air, thermal and electrical models.
- **Safety implementation**
  - Definition and validation of Safety Instrumented Functions derived from HAZOP and LOPA studies.
  - Integration of emergency stop systems and safe torque off functionality to remove motive power in hazardous conditions.

# Solution

The delivered solution comprised a fully integrated control and safety system:

**Control panel and hardware**

- Dual bay industrial control panel with safety PLC, redundant power supplies and distributed I/O.
- Integration of HMI, communications infrastructure and cybersecurity ready networking.

**Instrumentation**

- Cetix worked with the client and an instrument manufacturer to provide instrumentation suitable for the harsh conditions.

**PLC software**

- Structured program architecture with dedicated process and safety programs.
- Deterministic execution of control loops and separation of safety logic.

**Operator interface**

- Graphical HMI providing plant overview, alarm handling, control screens and diagnostic access.
- Role based access control for operational security.

**Operational capability**

- Controlled transitions between all system modes including automated charge and discharge sequences.
- Manual diagnostic capability for commissioning and maintenance.



## Testing

A comprehensive validation strategy was implemented:

- **In house testing**
  - Simulation of full plant I/O using test rigs to validate control logic and communications.
  - Early identification and resolution of functional issues prior to client testing.
- **Factory Acceptance Testing (FAT)**
  - Formal multi-day FAT witnessed by the client to verify system performance against specification.
- **Verification of safety functions, control sequences, alarms and interlocks.**
- **Ongoing validation**
  - Incorporation of commissioning observations and design modifications into revised system versions.

## Outcomes

The project delivered several key outcomes:

- **Validated prototype control system:** Enabled safe operation of a novel energy storage technology across all operational modes.
- **Compliance with safety standards:** Achieved SIL2 functional safety requirements through structured lifecycle management and validation.
- **Scalable architecture:** Designed with spare capacity and modularity to support future expansion and development.
- **Improved operational insight:** Implementation of state of charge modelling and HMI visibility enhanced operator understanding and control.
- **Foundation for commercialisation:** Provided a robust control platform to support further development and scaling of the technology.


Speak to one of our **experts**



**Martin Keay**
Technical Sales Director

**info@cetix.co.uk**

**+44 (0)1709 538 200**


cetix

**cetix.co.uk**


Cetix Ltd. Registered in England and Wales. Company number 02184213