Development of a certifiable and Industry 4.0-capable burner

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GEFÖRDERT VOM

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für Bildung
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RWTH AACHEN UNIVERSITY

Agenda

- Motivation
- Requirements for the burner control system
- Implementation and Validation
- Hardware and Software design
- Evaluation and monitoring of the developed concepts
- Summary and outlook

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Motivation


2030 VISION
FOR INDUSTRIE 4.0
Shaping Digital Ecosystems Globally
More Information
PLATTFORM INDUSTRIE 4.0
Autonomy
Interoperability
Sustainability
DE | EN

Motivation

- Increasing demands for future-oriented production systems and resource-efficient solutions have driven significant advancements in industry
- Flexibility in terms of multiple products being produced using the same production line
- Achieving high levels of resource and energy efficiency is essential for sustainable industrial development
- Smart burners are a necessity for many industrial processes, but their control systems often rely on proprietary software, limiting energy optimization

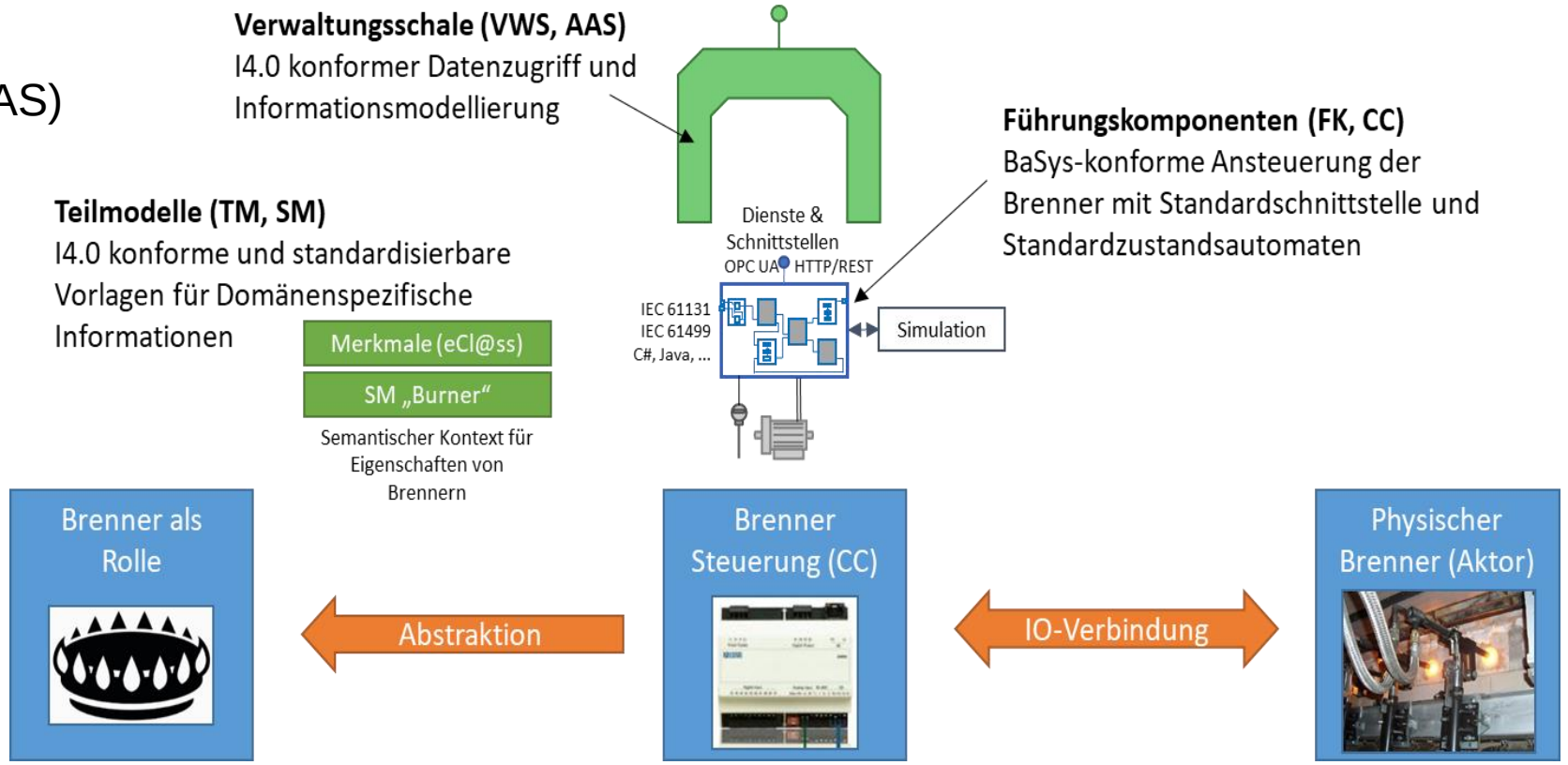
➢ Objective

  – To establish highly flexible production systems through a component-based architecture, promoting modularity

  – Creating an Industry 4.0-compatible burner control system based on the BaSys concepts

BaSys Components

- Control Components (CC)
- Asset Administration Shells (AAS)



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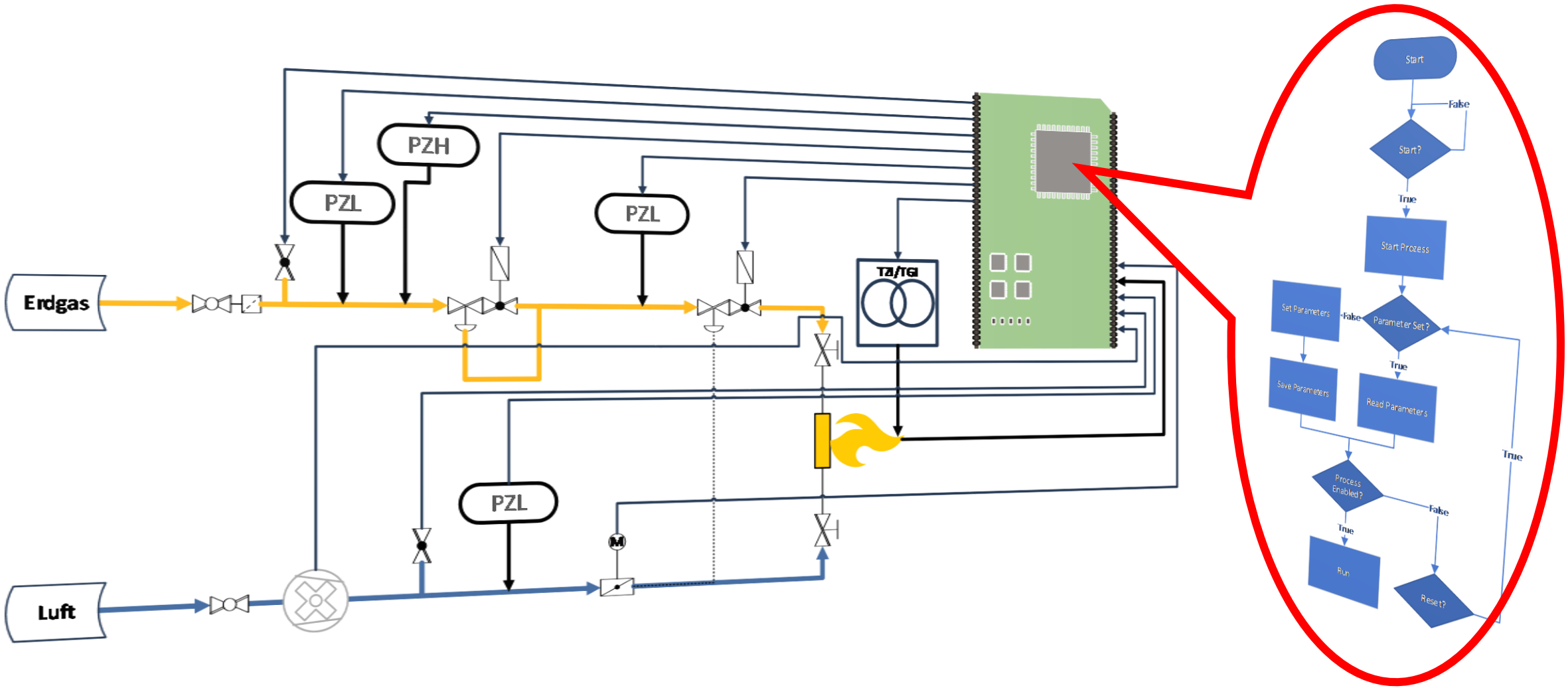
Our Goal: A BaSys Burner Control



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Basys4Brenner – Project Partners

IAT Lehrstuhl für Informations- und Automatisierungssysteme für die Prozess- und Werkstofftechnik → Knowledge transfer from BaSys, network coordination, software development support

IOB Institut für Industrieofenbau und Wärmetechnik | RWTH AACHEN UNIVERSITY → Test bench, industrial standards workshop

ZANDER AACHEN → Development and implementation of burner control as a prototype

HANS HENNIG smart combustion → Supporting requirements analysis and sharing certification experiences

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Requirements for the burner control system

- Stringent requirements for safety and efficiency in industrial applications with key standards
- **DIN EN 298:** addresses automatic gas burner control systems, emphasizing the importance of safe startup, operation, and shutdown, along with reliable flame detection and monitoring
- **DIN EN 746-2:** focuses on general safety requirements for industrial thermoprocessing equipment, including aspects like temperature control, ventilation, and fuel supply
- **DIN EN 746-11:** specifies requirements for thermal process components, highlighting functional safety and environmental protection

➢ Demand for comprehensive burner control systems that prioritize
  - ➢ operational safety
  - ➢ Efficiency
  - ➢ environmental responsibility

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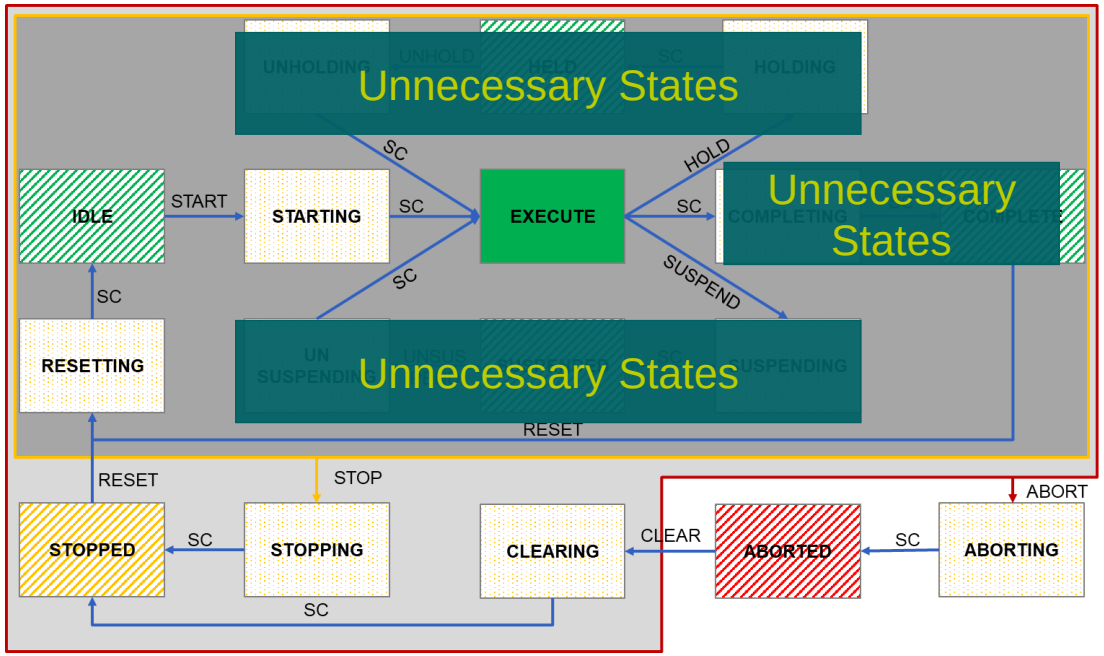
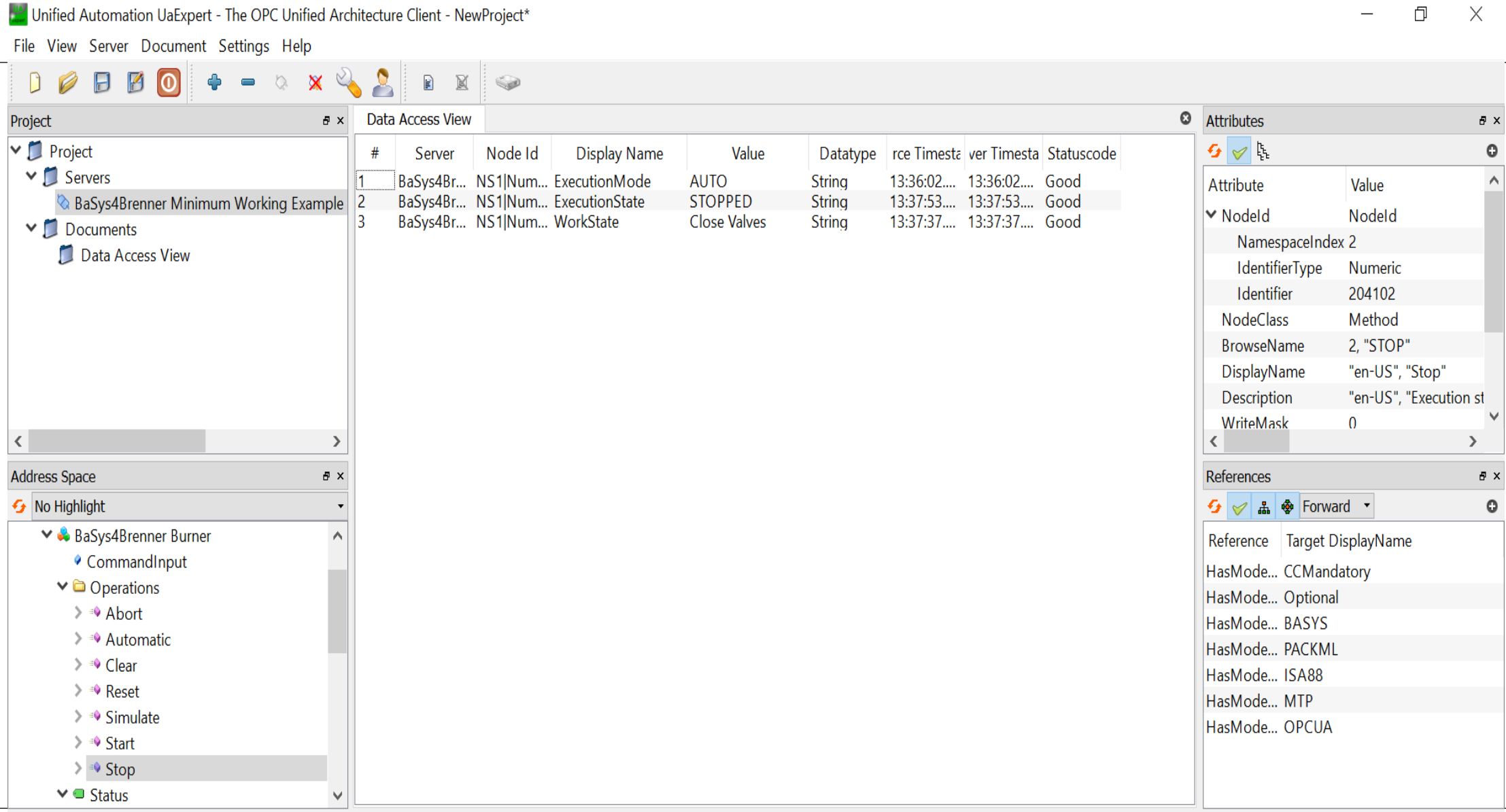
Implementation and Validation

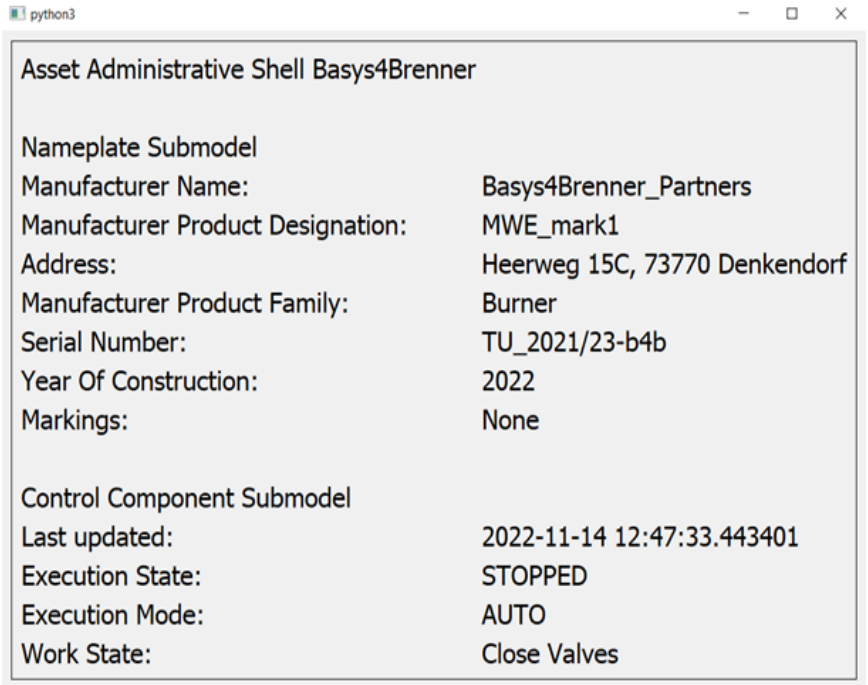
- Implementation of Control Component
  - Implementation of CC required selecting and procuring suitable demonstrator hardware and designing software requirements
  - Programming language "C" for the entire CC implementation
  - Execution state machine used the Packaging Machine Language (PackML) as the execution state automaton
  - Operation modes for the burner control system were programmed, deployed, and tested with a real burner
  - Implementation results were validated using an OPC UA Client, specifically UA Expert
  - Validation process included observing and confirming different possible operations for burner control, execution mode & state, current work state




Unified Automation UaExpert - The OPC Unified Architecture Client - NewProject*
File View Server Document Settings Help
Project
Project
Servers
BaSys4Brenner Minimum Working Example
Documents
Data Access View
Address Space
No Highlight
BaSys4Brenner Burner
CommandInput
Operations
Abort
Automatic
Clear
Reset
Simulate
Start
Stop
Status
Data Access View
Server Node Id Display Name Value Datatype rce Timesta ver Timesta Statuscode
1 BaSys4Br... NS1|Num... ExecutionMode AUTO String 13:36:02.... 13:36:02.... Good
2 BaSys4Br... NS1|Num... ExecutionState STOPPED String 13:37:53.... 13:37:53.... Good
3 BaSys4Br... NS1|Num... WorkState Close Valves String 13:37:37.... 13:37:37.... Good
Attributes
Attribute Value
NodeId NodeId
NamespaceIndex 2
IdentifierType Numeric
Identifier 204102
NodeClass Method
BrowseName 2, "STOP"
DisplayName "en-US", "Stop"
Description "en-US", "Execution st
WriteMask 0
References
Forward
Reference Target DisplayName
HasMode... CCMandatory
HasMode... Optional
HasMode... BASYS
HasMode... PACKML
HasMode... ISA88
HasMode... MTP
HasMode... OPCUA

Implementation and Validation

- Asset Administration Shells submodels for burner controls
  - AAS submodels were instantiated for the burner using AAS Manager
  - Name Plate submodel serves as a digital nameplate, providing general information
  - CC Submodel describes the execution state & mode, work state of CCs
  - Additional burner AAS to dynamically showcase the different states and modes of the CC within the current time period
  - Development of third submodel to parameterize burner control systems, serving as a foundation for standardizing parametrization submodel templates



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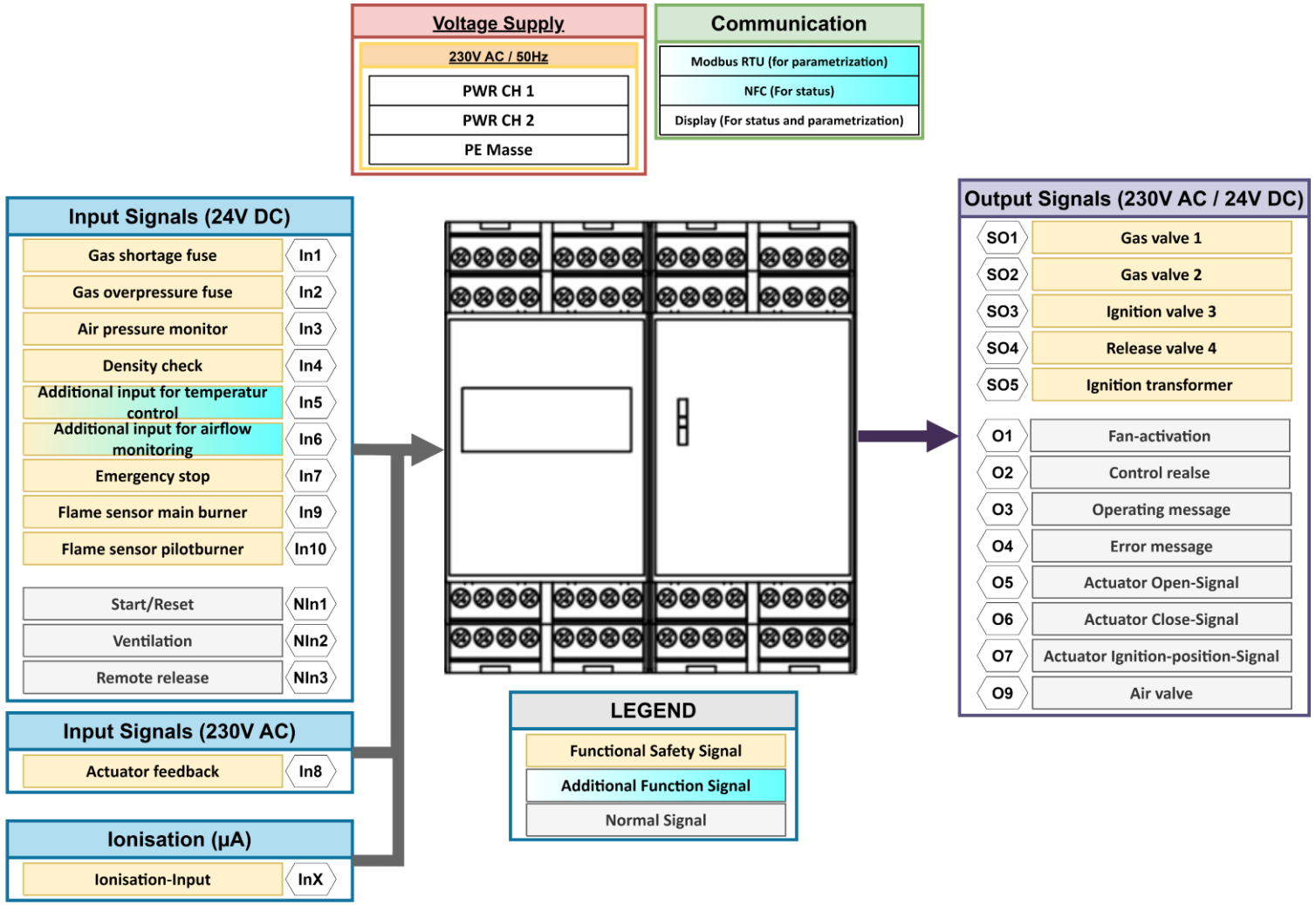
Hardware and Software design

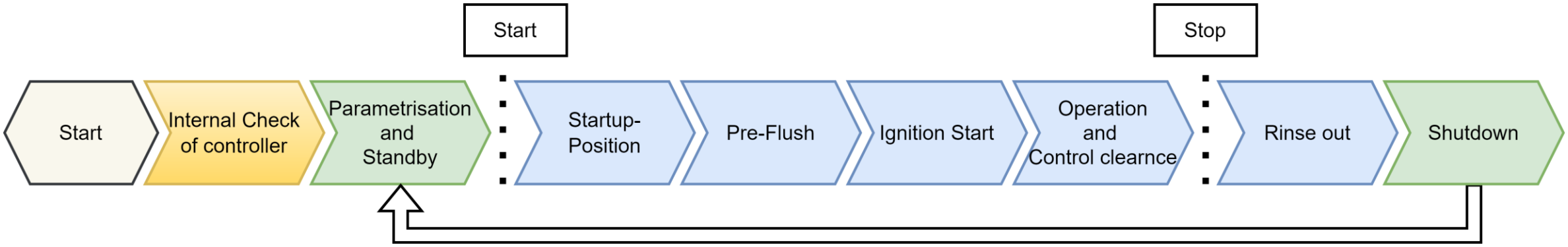
- Development and Design of **hardware**
  - based on industry demands, requirements, and relevant standards and guidelines
  - designed to be versatile for various burner applications
- Inputs and outputs
  - multiple digital inputs and outputs for secure burner process management up to SIL 3 standards
  - inputs include signals for monitoring and controlling gas and air lines, as well as flame detection
  - supports up to two digital safety inputs for flame sensor connections to monitor main and pilot burner flames
  - allows integration with an actuator for air supply or output control
- Communication
  - display for user interaction
  - includes a Modbus RTU interface for configuration and status updates
  - NFC interface for reading status information
  - Modbus interface for communication with AAS of the BaSys management system, which hosts an OPC-UA server

Hardware and Software design



Hardware and Software design

- Development of the burner control software (CC & AAS)
  - Development firmly aligned with burner control and installation standards and guidelines
  - Precise procedures for safe starting and stopping of burner systems
  - Quick and reliable error evaluation and system response to prevent accidents
  - Strong focus on functional safety in the software
  - Redundant signal evaluation and routine checks align with standards and guidelines
  - Real-time system status monitoring facilitated through interfaces, including a display, Modbus RTU, and NFC interfaces
  - Users can easily determine the system's current state using these interfaces
  - Steps can be assigned with BaSys system states, providing a comprehensive view of the plant's condition within the BaSys AAS



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Evaluation and monitoring of the developed concepts

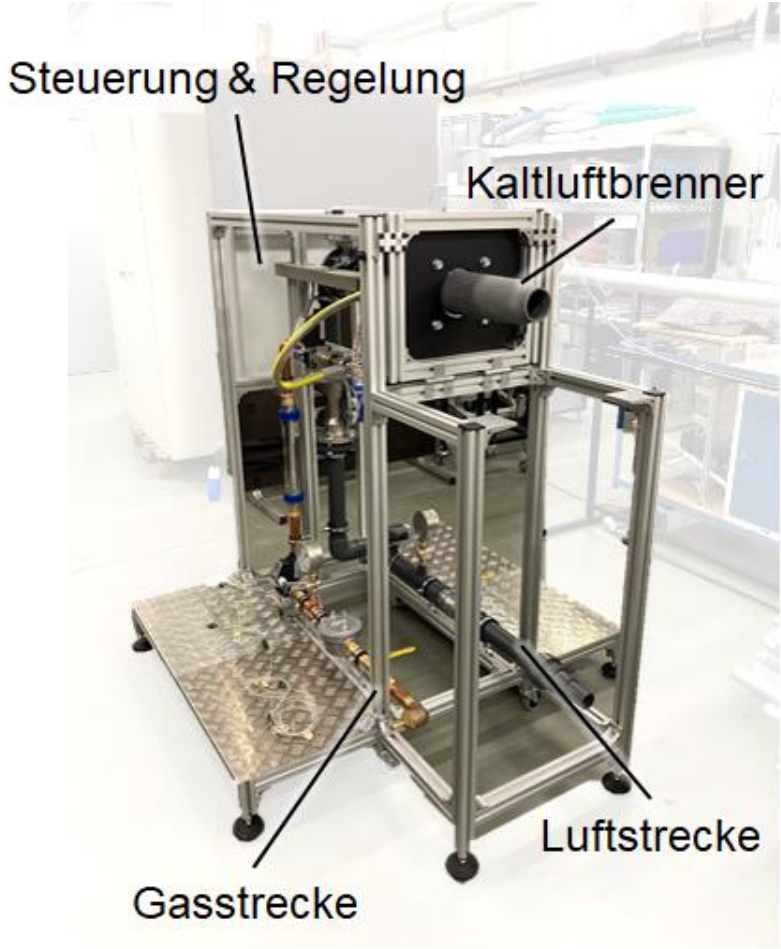
- Testing conducted at a burner test stand at IOB

- Natural gas safety line acc. to DIN EN 746-2
- Combustion air supply by a fan
- Flame monitoring executed by a commercial flame monitoring device

- System shutdown initiated by pressing the corresponding hardware switch, closing the gas valve, and entering stand-by mode
- Safety shutdowns were verified by simulating different errors
- All simulated errors were correctly detected, resulting in either burner shutdown or the prevention of startup

- Additional prototype testing at industrial system by Hans Henning

- Evaluation of the planned concept and final TÜV certification are currently in progress



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Summary and outlook

- Development of a certifiable burner control system with BaSys concepts implementation
- Creation of prototype Industry 4.0-capable burner control system with a standardized AAS and flexible CC
- Presentation of implementation results, hardware and software design, evaluation
- Comprehensive overview of the project's outcomes and achievements
- Ongoing work to enhance the prototype's parameterizability and functionality, including the installation of flame detection using an ionization input
- Exploration of a potential extension to program a flameless mode of operation

Thank You

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