Cogniplant
ACVA
Training session

23-05-2023
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TRAINING ACTIVITIES

COGNIPLANT Project has received funding from the EU Horizon 2020 Research and Innovation Programme, under Grant Agreement No. 869931

Content

- General overview of Cogniplant
- Use case: ACVA
- Developed solution

Content

- **General overview of Cogniplant**
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    - Digital Twin
- Use case
- Developed solution

Challenge

Shortage in raw materials, increased energy prices and environmental constraints require the EU process industry to improve its performance and flexibility, and therefore increase efficiency.

In this situation there are unexploited opportunities for digitising a large range of enterprises of very different size in the process industry.

Ambition

- Digitalization in the European process industry
- Digital retrofitting
- Collecting and structuring data from sensors and equipment for its further analysis
- Advanced data analytics: Big data, Process mining, Machine learning models of prediction & optimization
- Development and use of digital twin
- Cognitive Reasoning and Reactive scheduling

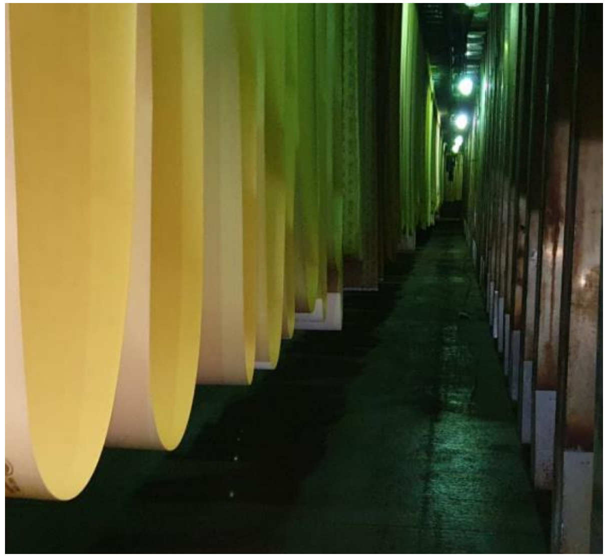
Key figures

- 1 Application domain: Industries with high consume of energy
- 4 Uses cases (Mining, Metal, Quicklime, Chemical)
- 14 partners
- 8 countries: ES,GR, IE, NL, IT, AT, DE, FR
- Total budget: 8.6 M€
- Requested grant: 6.7 M €
- Duration: 42 months

Consortium


Additional countries involved in COGNIPLANT:
NL, FR, DE, GR
Industrial use cases (demos) distribution per country:
ES, IE, IT, AT
Construction sector
Italy
Grigolin
Chemical sector
Austria
HERMES
Mining sector
Ireland
RUSAL
Metal sector
Spain
TUBACEX
Finland
Norway
Sweden
Estonia
Latvia
Lithuania
Rus.
Denmark
United Kingdom
Net.
Germany
Poland
Bel.
Lux.
Rep.
Slovakia
France
Lie.
Austria
Swi.
Hungary
Italy
Mona.
Por.
Spain
BH
Serbia
Kos.
Mont.
Mac.
Alb.
Greece
Morocco
Algeria
Tunisia
Malta
Cyprus
Leb.
Iraq
Iran
Aze.
Arm.

Industrial Consortium



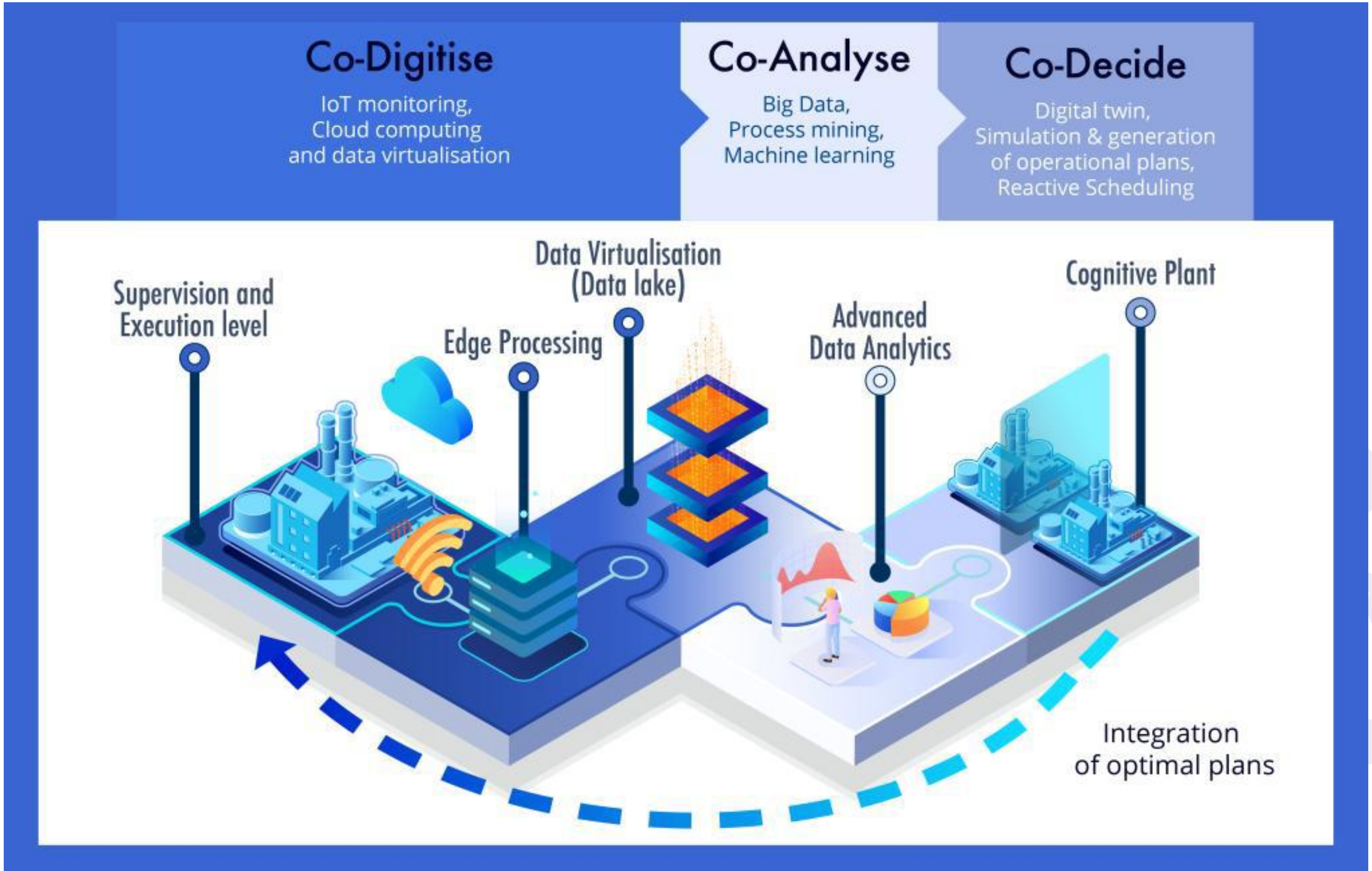
Energy consumption
CO2 Emisions
Quality

KPI

KPI	Actual	Target
Energy consumption	1.2 M€/year	948 T€/year
Production stops	384 h/year	288 h/year
Scrap material	2.05%	1.7 %

KPI	Actual	Target
Product quality: reduction of non-compliant lime production (big size)	10%	5%
Productivity: reduction of downtime in kiln AK601	5% downtime (438.4h/year)	4% downtime (350.7h/year)
Efficiency: fuel efficiency improvement	0.26 t sawdust / t lime	0.23 t sawdust / t lime

Concept


Co-Digitise
IoT monitoring,
Cloud computing
and data virtualisation
Co-Analyse
Big Data,
Process mining,
Machine learning
Co-Decide
Digital twin,
Simulation & generation
of operational plans,
Reactive Scheduling
Supervision and
Execution level
Edge Processing
Data Virtualisation
(Data lake)
Advanced
Data Analytics
Cognitive Plant
Integration
of optimal plans

Goals

Actual Situation

•Requirement of different target industries and productions systems.

•Expert’s knowledge and insights to define the solution.

•Definition of the KPIs and establishment of the baseline of the target use cases.

•Solution Architecture Framework.

Monitoring system.

•Enhancing the data acquisition system by means of new sensors and virtual sensors.

•Development a strong edge node for processing and management of real time multiple data streams.

•Development of the cloud based real time data system to manage the information

•Development of the data virtualisation platform, to store the information in a structured way.

Big data

•Process mining tool in combination with inference-based modelling framework.

•Online prediction framework in combination with an analytics dashboard for performance prediction and optimization support

Goals

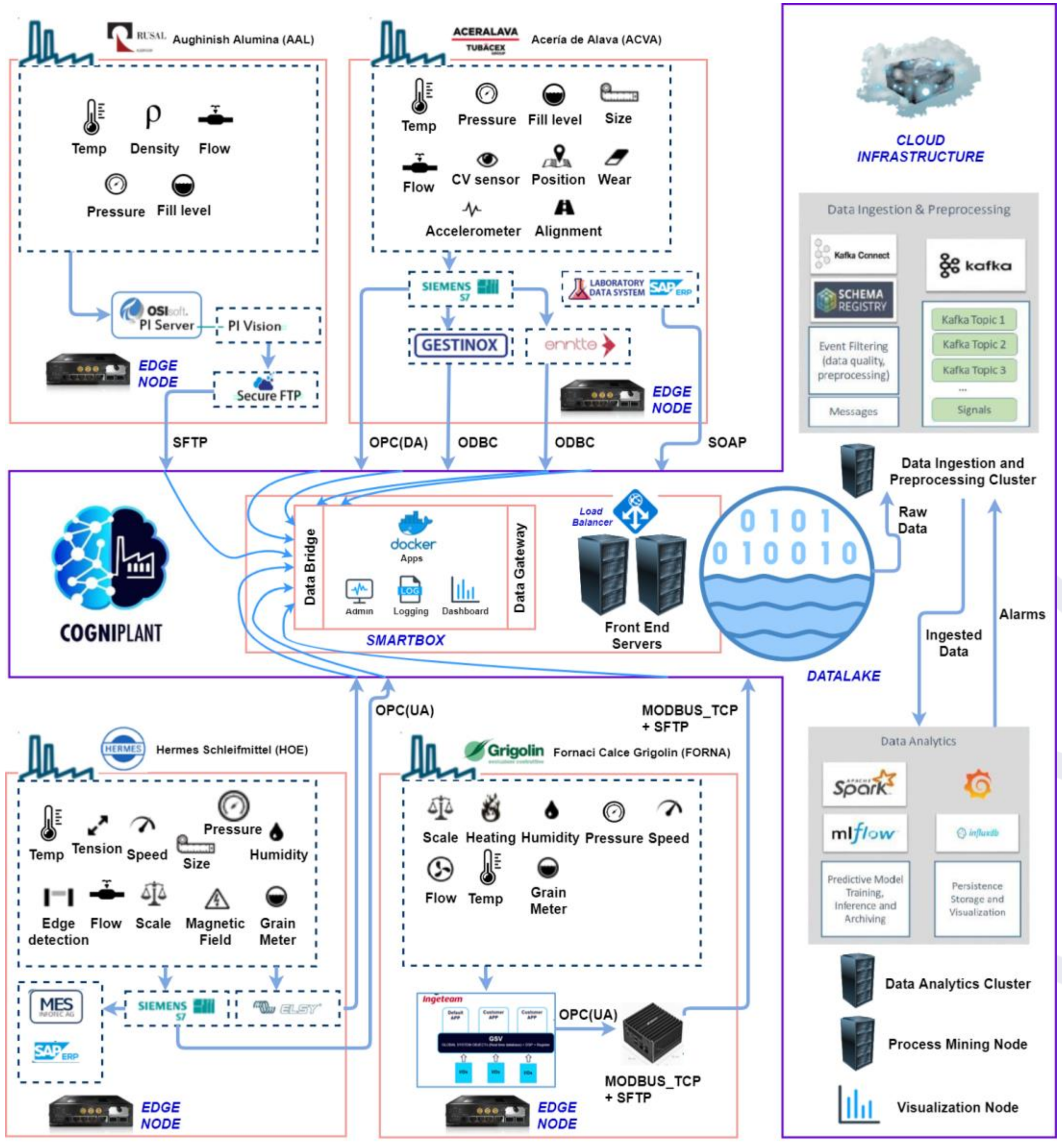
Cognitive Plant

• Integrating the different layers to create the Cognitive platform..
•Modelling the targeted demonstration cases by means of the Digital Twins .
•Development of the Co-Decide module for decision support.
•Developing Reactive scheduling modules to deal with dynamic changing production conditions

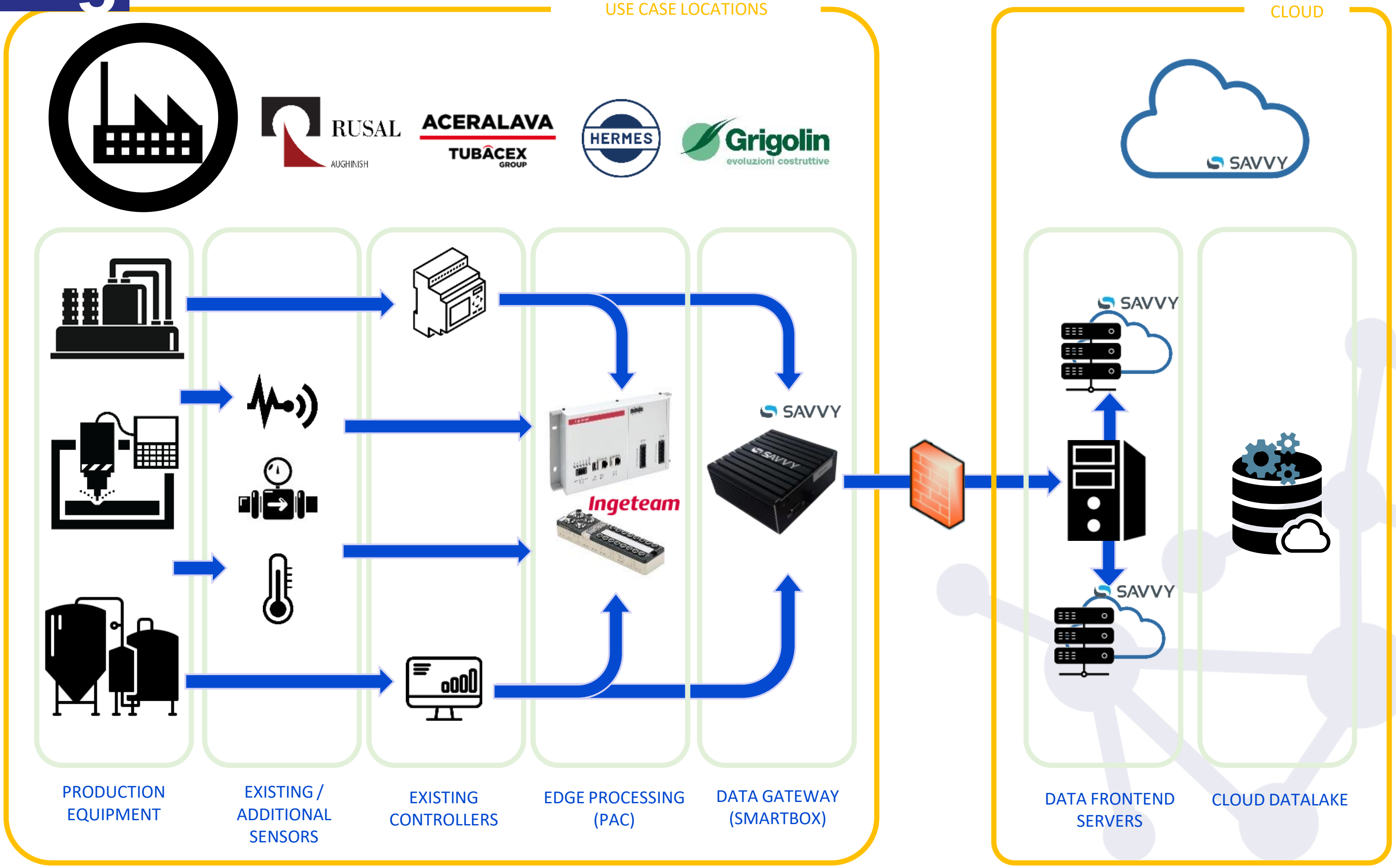
Real use cases

•Digitisation of the production plants
•Optimization of data acquisition, communication and automation, achieving the digital retrofitting of existing assets.
•Implementing the COGNIPLANT's overall solution in production plants of 4 different SPIRE industries.
•Monitoring of the demonstrators and validation of approach through the monitoring of the KPIs.

Cogniplant Deployment Overview

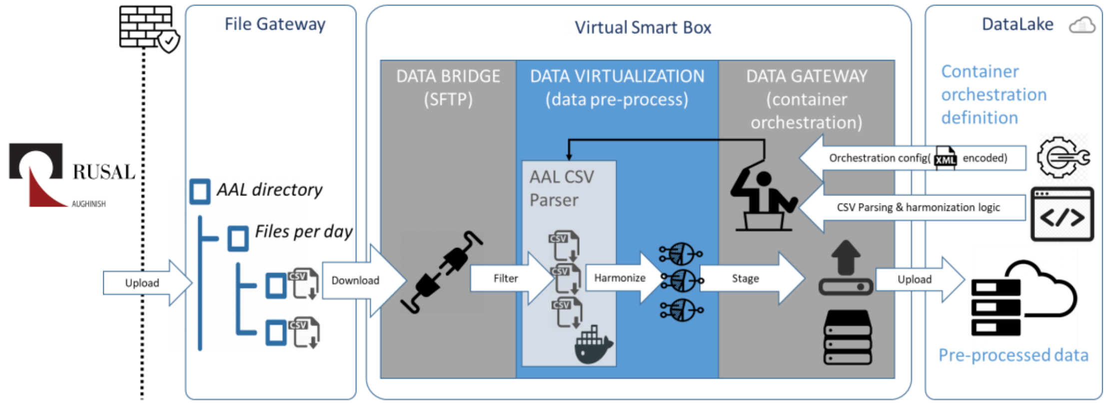


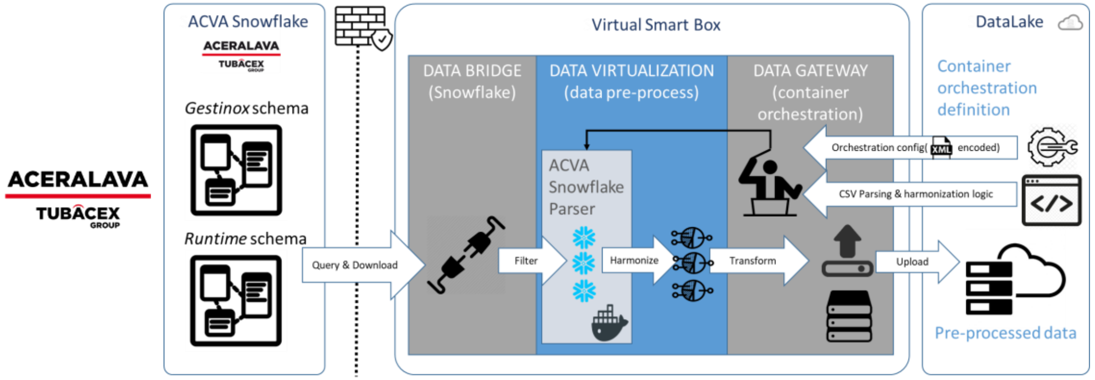
Data gathering



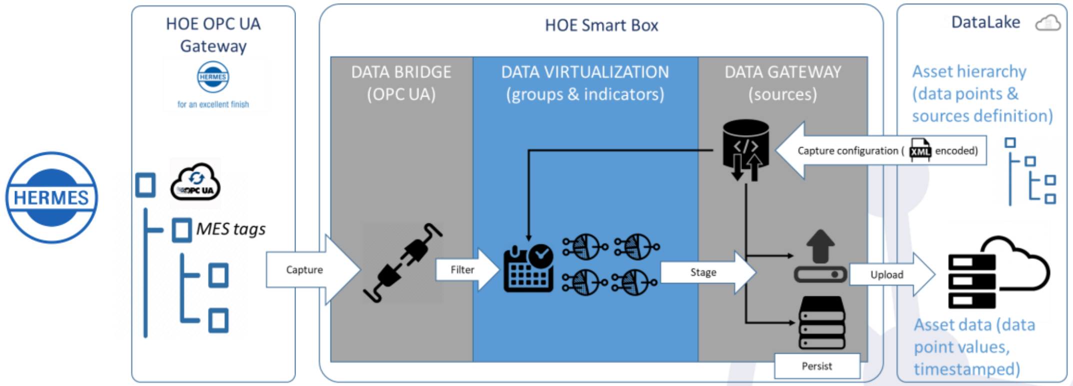
Data gathering

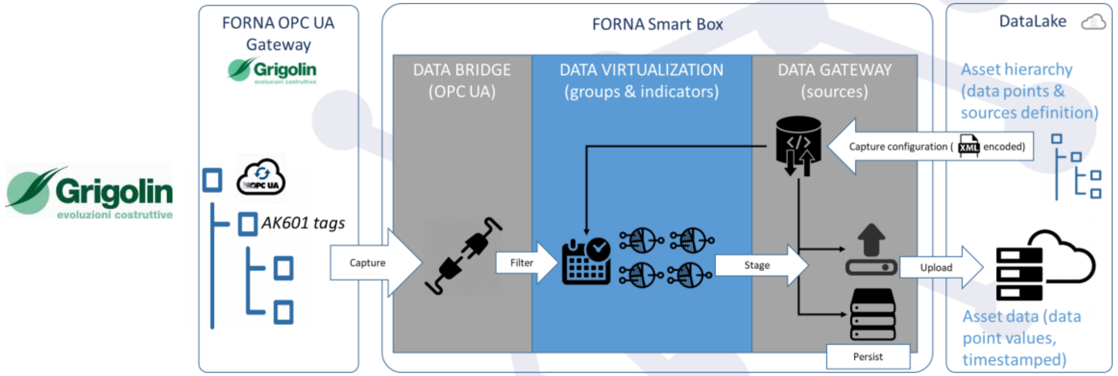
Live dataflows: **C2C**



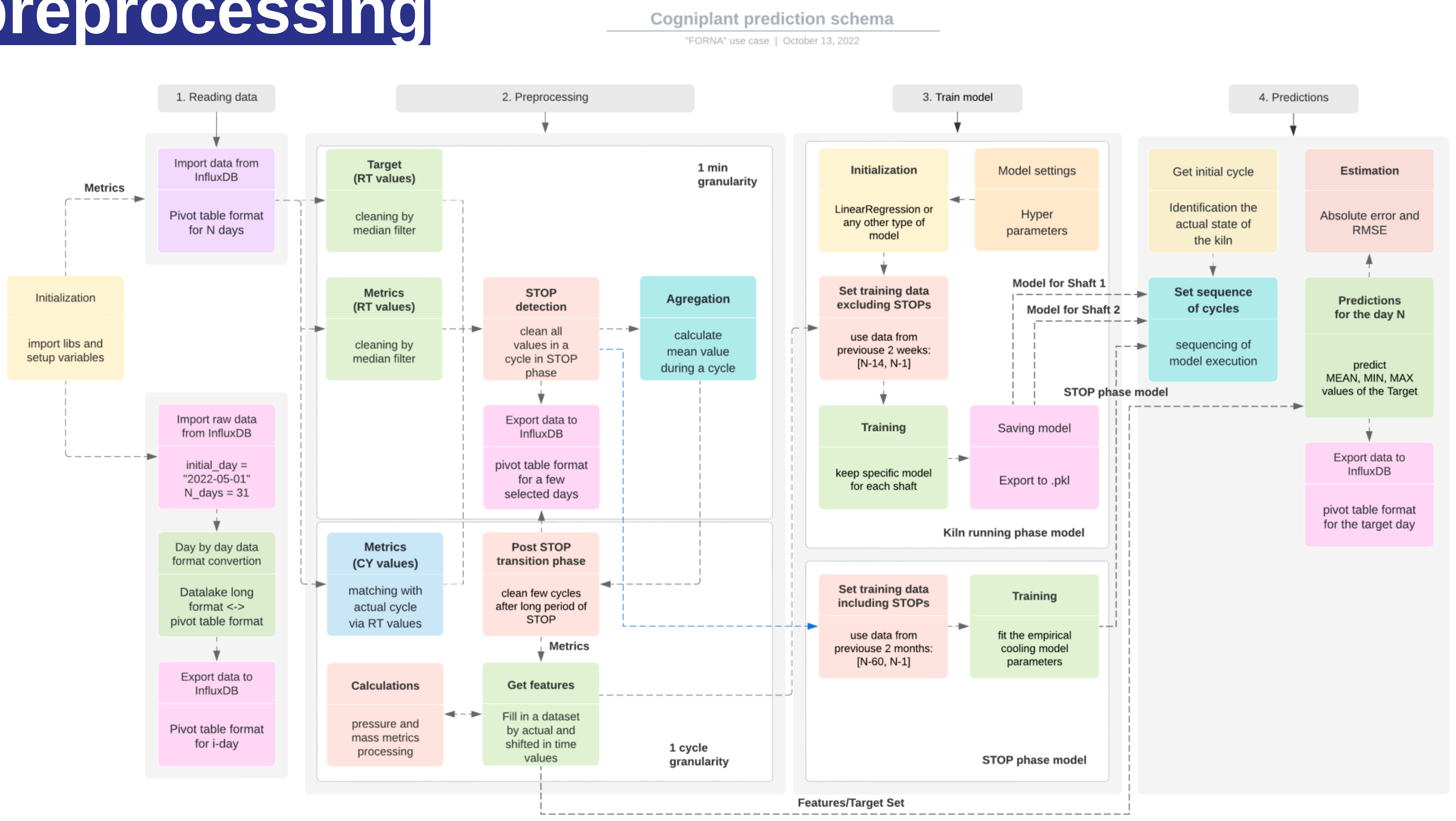


Live dataflows: **M2C**

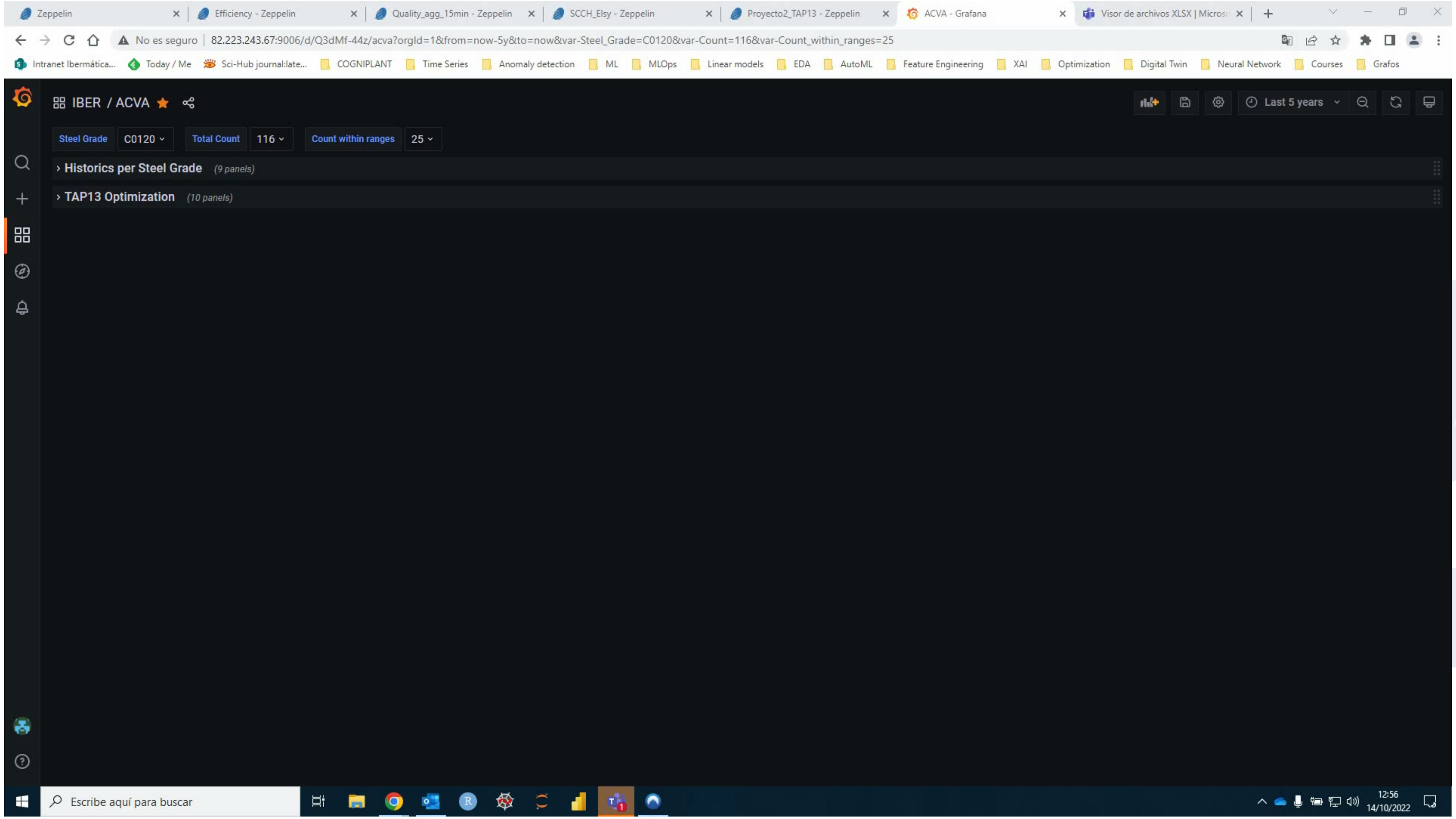




Data preprocessing



Machine Learning & Data Visualization

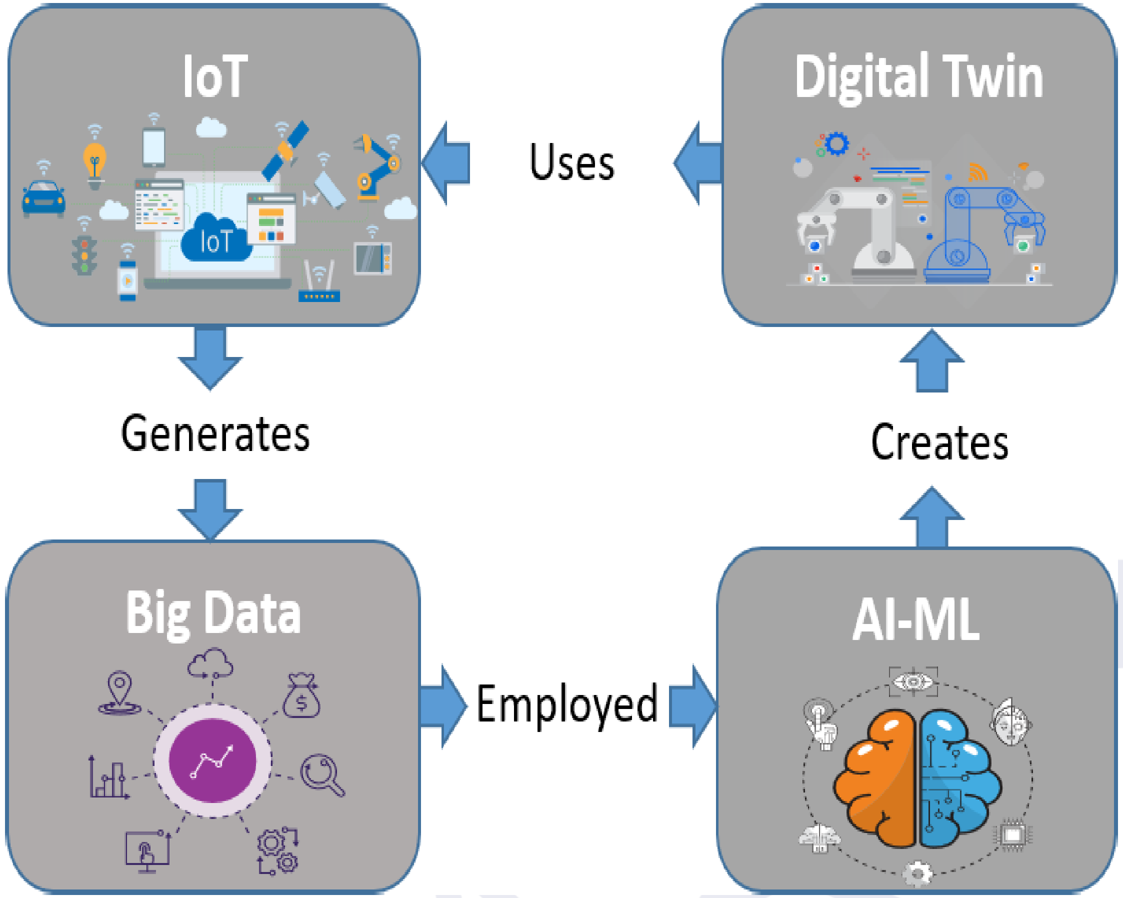


Digital Twin

- The **COGNIPLANT's Digital Twin** won't be a physical model of the plant based on equations, but a model based on data and how information flows throughout the life of the plant**.**

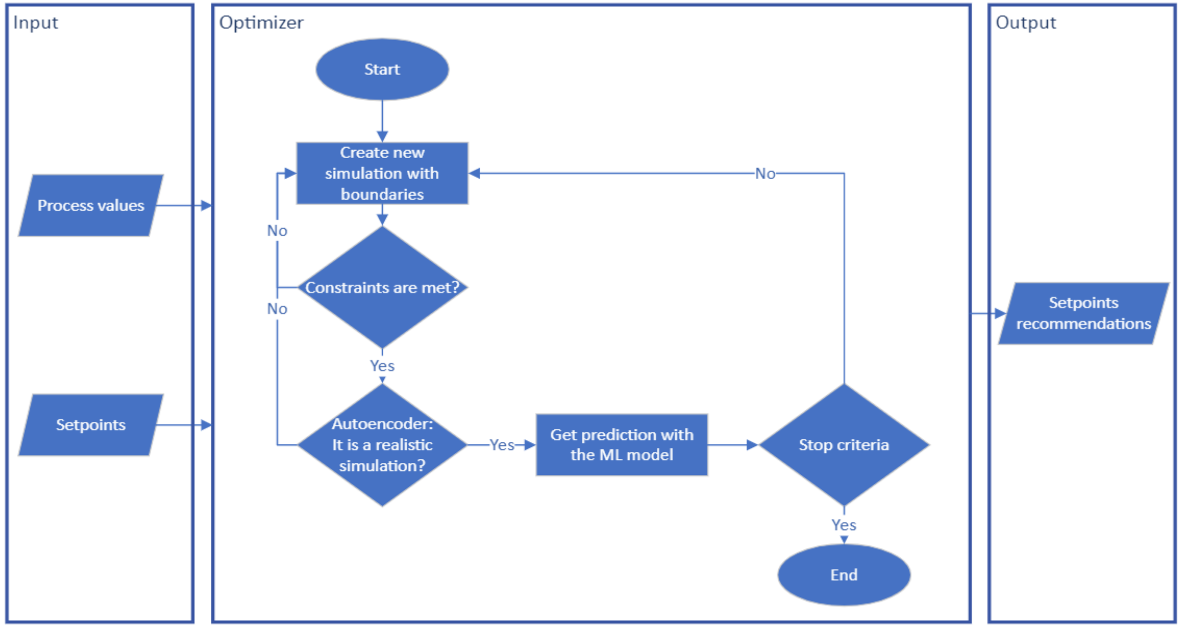
- ***Simulations*** of the **physical systems** behaviors will be done with a digital twin of the processes and the optimizations will be expressed in the form of ***prescriptive recommendations*** within the dynamic reactive schemes in plant.

- It is a model composed of models and other elements (constrains, variables and objective functions).



Digital Twin: Optimizer

- The optimization model is the core of the digital twin and consists of three elements:
  - **The objective function/s:** can be function/s or data model/s trained.
  - **Variables:**
    - Input: current process values and setpoint ➔ define the state of the process.
    - Output: setpoints recommendation.
  - **Constraints:**
    - Variables bounds.
    - Business constraints: can be predictive models or other constrains.
    - Autoencoder: model that discards unrealistic scenarios.



Content

- General overview of Cogniplant
- **Use case: ACVA**
- Developed solution

Partner description

1. ACERÍA DE ALAVA S.A. (ACVA)

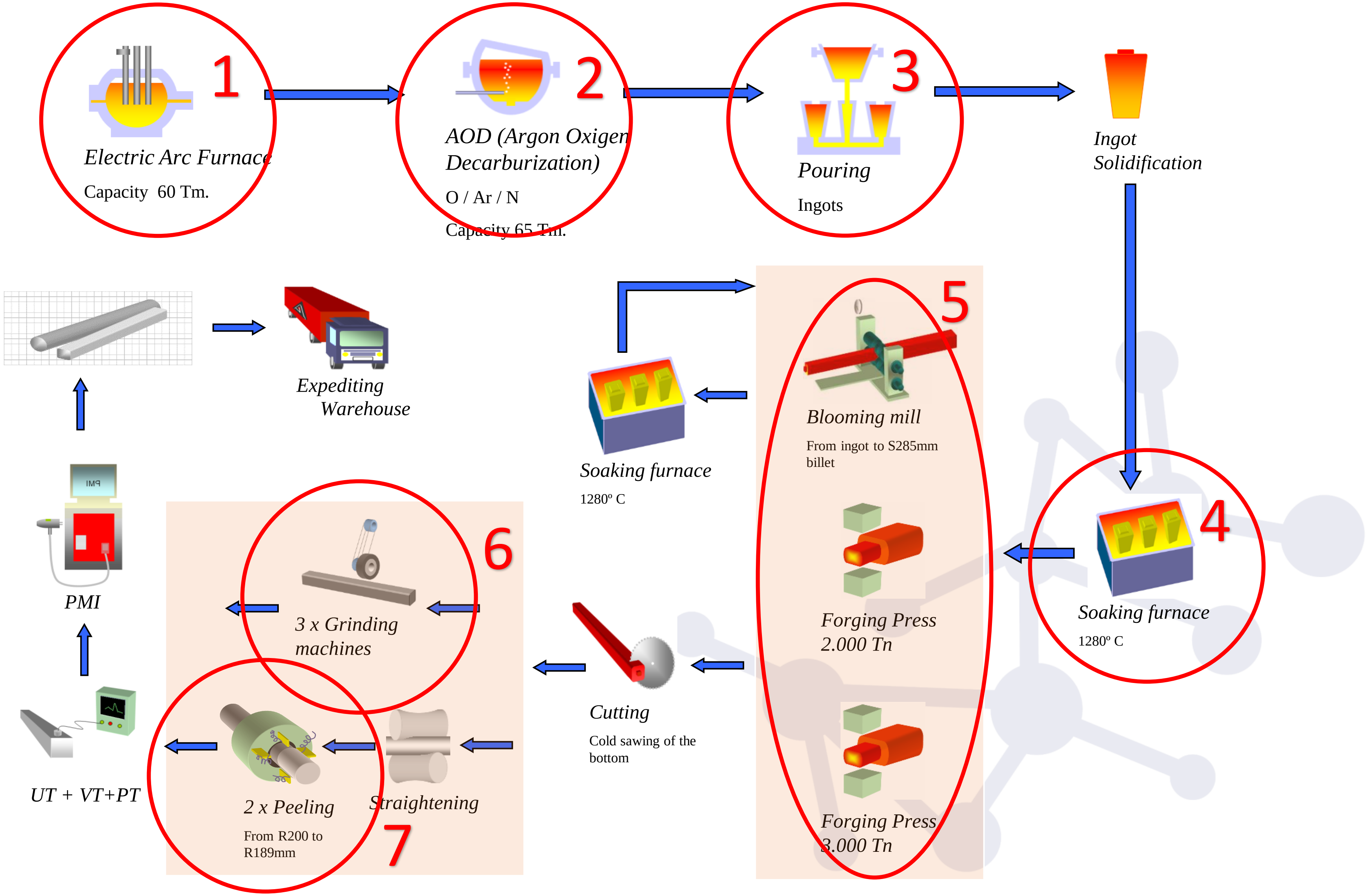
Acería de Alava S.A. (ACVA) is a stainless steel products' manufacturer in form of billets and rounds, located in Amurrio (Alava, Spain), and is part of TUBACEX Group, the world's largest manufacturer of stainless steel seamless tubes.

The process can be divided in 8 different steps: (1) Electrical arc furnace; (2) AOD converter; (3) Casting; (4) PIT furnaces; (5) Forging or Blooming; (6) Grinding; (7) Peeling. The main target of ACVA is to increase the Overall Equipment Effectiveness (OEE) of different steps in order to improve the product quality while minimizing production costs to maintain its market position. The OEE is the product of the quality, the availability and the performance of each device or step.

For that purpose, on of the tasks of COGNIPLANT approach must be the synchronization of the different IT systems installed on the plant. In this way, different data will be correlated, and it will help to identify dependencies and influences.

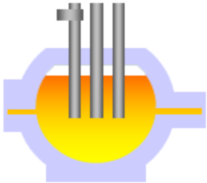
ACERALAVA
TUBACEX GROUP

Plant Overview

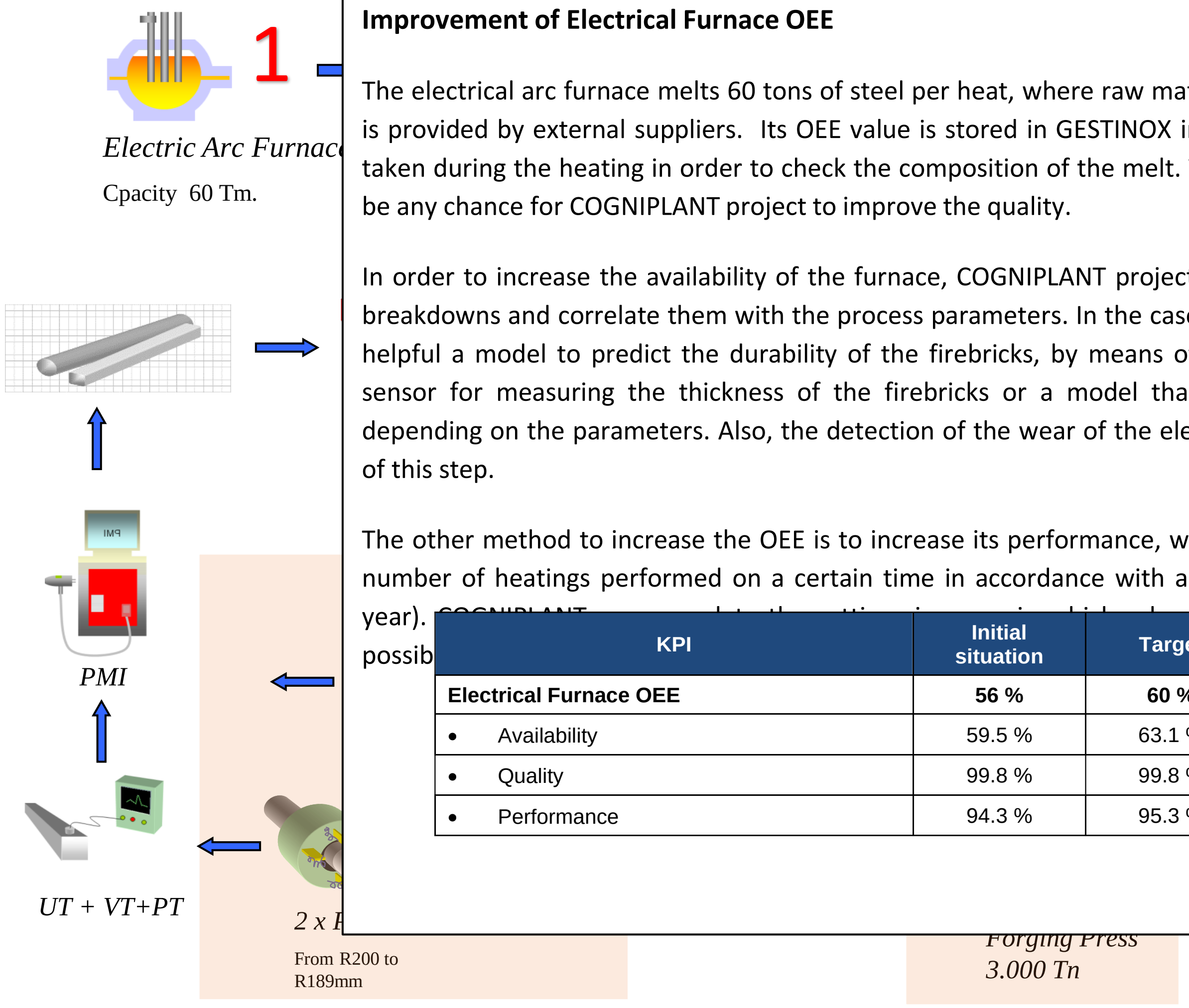


KPI`s achievement progress

- ELECTRIC FURNACE OEE (Overall Equipment Effectiveness)
- ELECTRIC FURNACE ELECTRICAL CONSUMPTION



KPI Improvement of Electrical Furnace OEE



Improvement of Electrical Furnace OEE

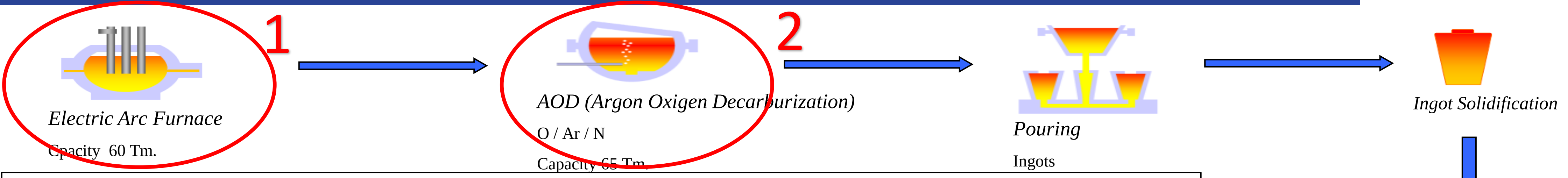
The electrical arc furnace melts 60 tons of steel per heat, where raw material is scrap metal from which 60% is provided by external suppliers. Its OEE value is stored in GESTINOX in real-time and samples are already taken during the heating in order to check the composition of the melt. Therefore, in this step there will not be any chance for COGNIPLANT project to improve the quality.

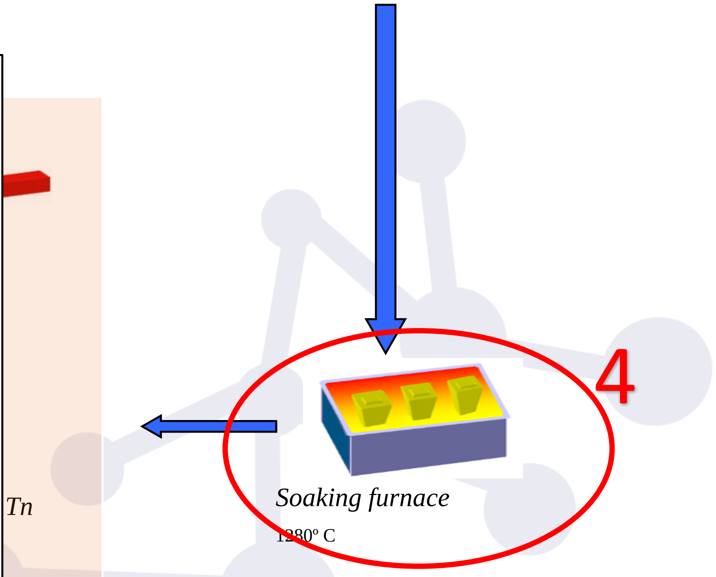
In order to increase the availability of the furnace, COGNIPLANT project should analyse the main causes of breakdowns and correlate them with the process parameters. In the case of the electric furnace, it would be helpful a model to predict the durability of the firebricks, by means of the vessel surface temperature, a sensor for measuring the thickness of the firebricks or a model that predicts the number of heatings depending on the parameters. Also, the detection of the wear of the electrodes can increase the availability of this step.

The other method to increase the OEE is to increase its performance, which is measured by the ratio of the number of heatings performed on a certain time in accordance with a standard reference (checked every year). and analyse a possib

KPI	Initial situation	Target	Improvement
Electrical Furnace OEE	**56 %**	**60 %**	**7 %**
• Availability	59.5 %	63.1 %	6.1 %
• Quality	99.8 %	99.8 %	0 %
• Performance	94.3 %	95.3 %	1.1 %

KPI Reduction of Energy consumption





Reduction of Specific Energy consumption

As in all process industry plants, the energy consumption is a major concern for ACVA. The energy consumption of ACVA can be divided mainly in three steps: the electric energy on the electric furnace, the gas energy on AOD converter, and the gas energy on PIT furnaces.

The energy consumption in the electric arc furnace and in the AOD converter depends mainly on the steel to be heated. Therefore, a better selection of scrap material to reach a certain composition could help in its reduction. The values of these consumptions are stored in real time in GESTINOX SAP system.

The gas consumption in PIT furnaces will depend directly in their performance. Currently, their scheduling is done manually based on the experience of the operator. COGNIPLANT project should address an intelligent scheduling model where different data bases must be considered in order to optimize the performance of the PIT furnaces and hence, reduce the specific energy consumption. Currently, this gas consumption is measured manually, but it will be on the MES soon.

KPI	Initial situation	Target	Improvement
Specific energy consumption	**172,425,586 kWh/year**	**164,496,277 kWh/year**	**4.6 %**
• Electric furnace energy consumption	45,975,000 kWh/year	43,676,250 kWh/year	5 %
• AOD gas consumption	15,971,764 kWh/year	15,412,752 kWh/year	5.5 %
• PIT furnaces gas consumption	110,478,822 kWh/year	105,507,275 kWh/year	4.5%

UT Tn Tn

DATA ANALYTICS

1.-To optimize the electrical consumption and time in order not to exceed 1600ºC in the EAF. The results show that high percentage of the castings exceed the optimum casting temperature, and therefore it is possible to improve the electrical consumption.

Three steel grades were identified and the problem has been detected which has allowed the optimisation of point 2 to be developed.

2.-Historical analysis of the EAF recipes to determine the optimal recipe (additions and heating stages) with the objective of reducing KWH.

-Due to the lack of data (scrap and origin) this objective had to be discarded.

-The objective was changed to the analysis of the last heating stage (TAP13) after the first temperature measurement.

-It has been difficult to understand the integrity and granularity of the data but once identified we can work to warn the operator about the necessary heating time to reach the optimal casting temperature reducing electricity consumption and CO2 emission.

- Stage: First model developed, under data validation and then production testing.
- The plant operator will have a console with real time model information and the actual decision of the operator will be analysed against the model optimisation.

Content

- General overview of Cogniplant
- Use case: ACVA
- **Developed solution**
  - P1: Analysis of historical EAF data
  - P2: Final temperature and consumption optimization in EAF

Developed solution

- **P1: Analysis of historical EAF data.**

  An exploratory analysis of historical data is carried out and a search for optimal casts by steel grade is performed.

- **P2: Final temperature and consumption optimization in EAF.**

  A decision support system is developed to recommend the minimum TAP13 consumption necessary to maintain the final temperature of the casting within the desired range (1580ºC-1600ºC).

Developed solution

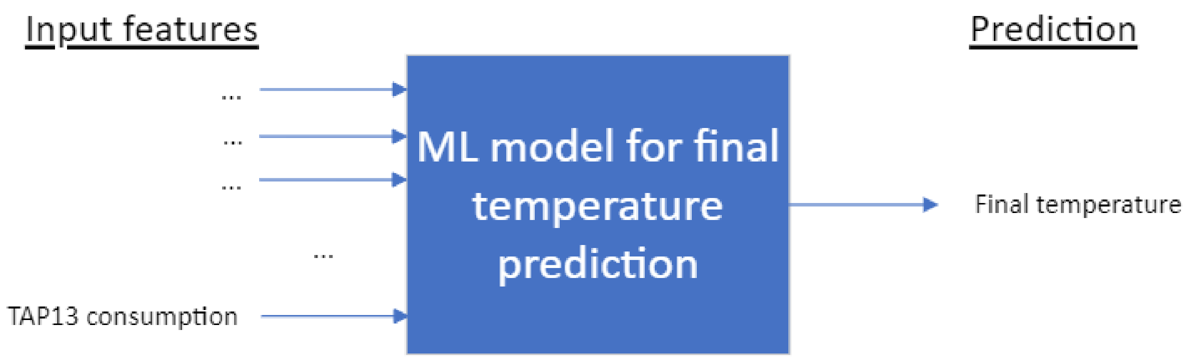
P1: Analysis of historical EAF data

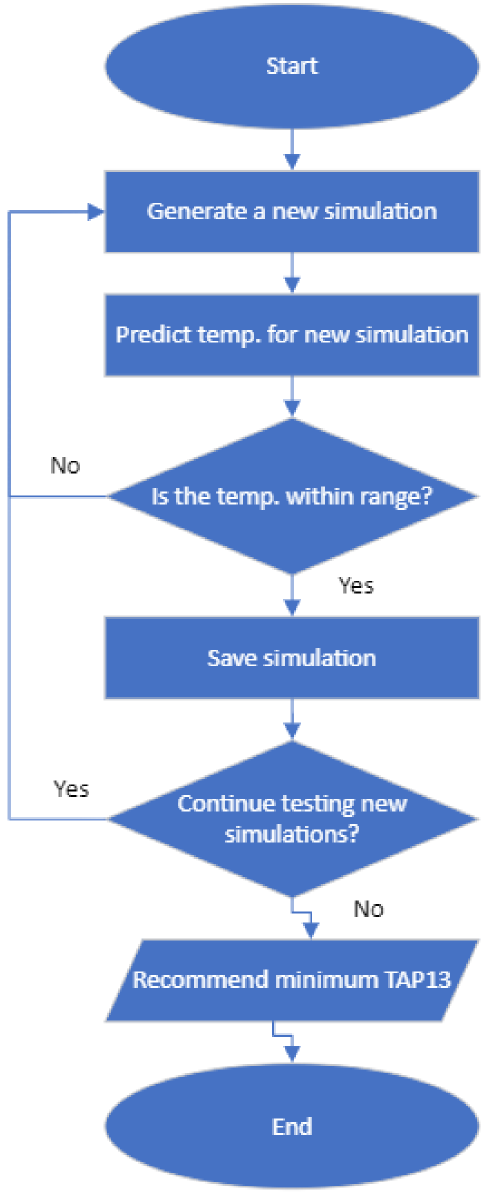
- **Descriptive analysis of historical data by steel grade.**
- **Search for optimum castings in historical data by steel grade**. Methods used:
  - P05
  - IQR

Developed solution

P2: Final temp. and consumption optimization

- A decision support system is developed to recommend the minimum TAP13 consumption necessary to maintain the final temperature of the casting within the desired range (1580ºC-1600ºC).
- **Development of a simulation-based optimizer.**

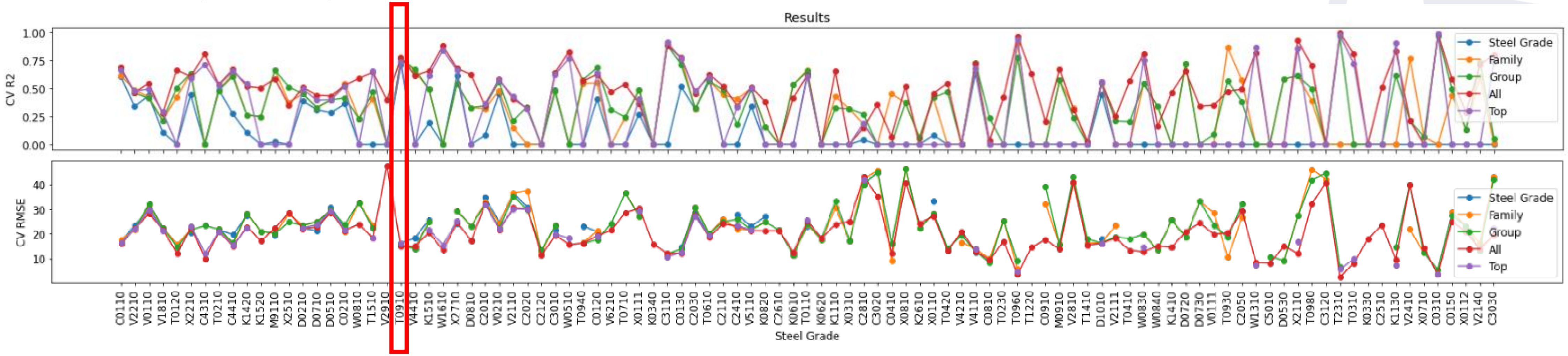




Developed solution

P2: Final temp. and consumption optimization

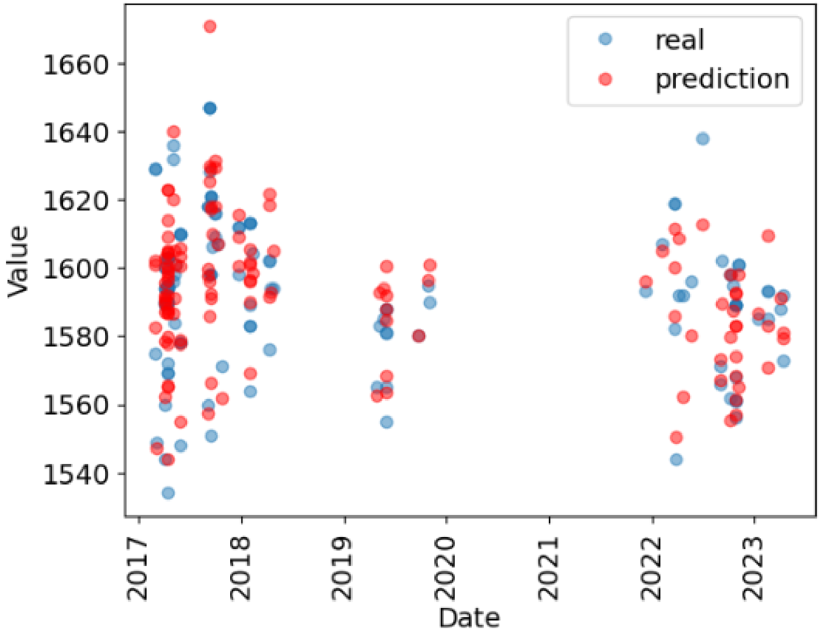
- **Predictive modeling strategies:**
  - Model steel grades independently: One model per steel grade.
  - Model by steel groups: One model per group.
  - Model by steel family: One model per family.
  - Model using all castings: One model for all castings.
  - Model using the steel grades that show the best results.

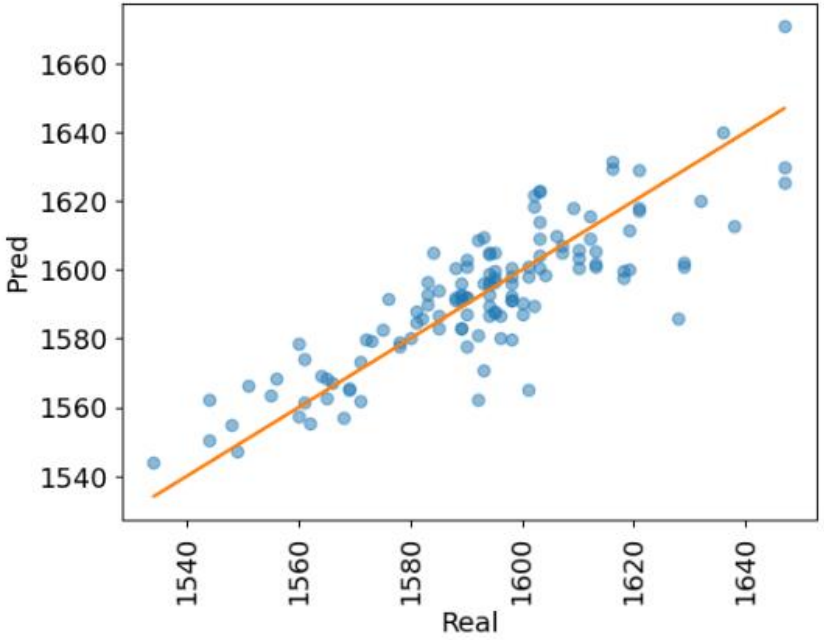


Developed solution

P2: Final temp. and consumption optimization

- **Modeling for temperature prediction of steel grade T0910:** 128 observations.
  - LOOCV MAE = 9.2 ºC
  - LOOCV R2 = 0.7





Developed solution

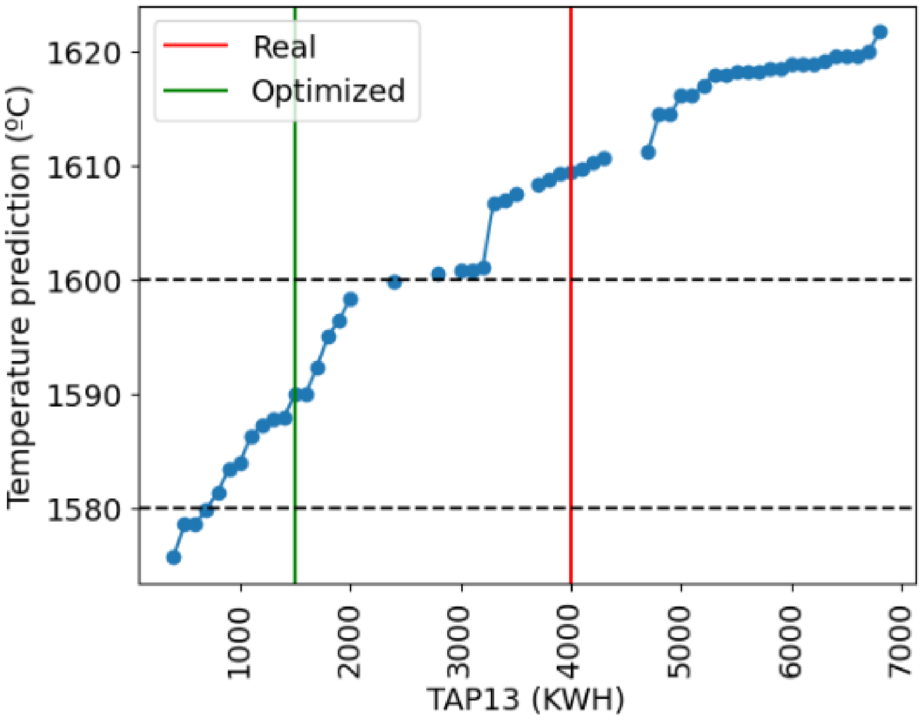
P2: Final temp. and consumption optimization

- **Elements of the simulation-based optimization model:**
  - **Target function**: Model for temperature prediction of steel grade T0910. 1590ºC is defined as the target temperature.
  - **Setpoints and limits**: TAP13. To define the limits, the minimum and maximum values of the historical data are used.
  - **Constraints**: Since we work with a non-linear predictive model, it may happen that, with the objective of reducing temperature, it may be recommended to consume more TAP13 instead of recommending to consume less. To avoid this inconsistency, a constraint is added.

Developed solution

P2: Final temp. and consumption optimization

- **Example: Optimization of casting 53328**

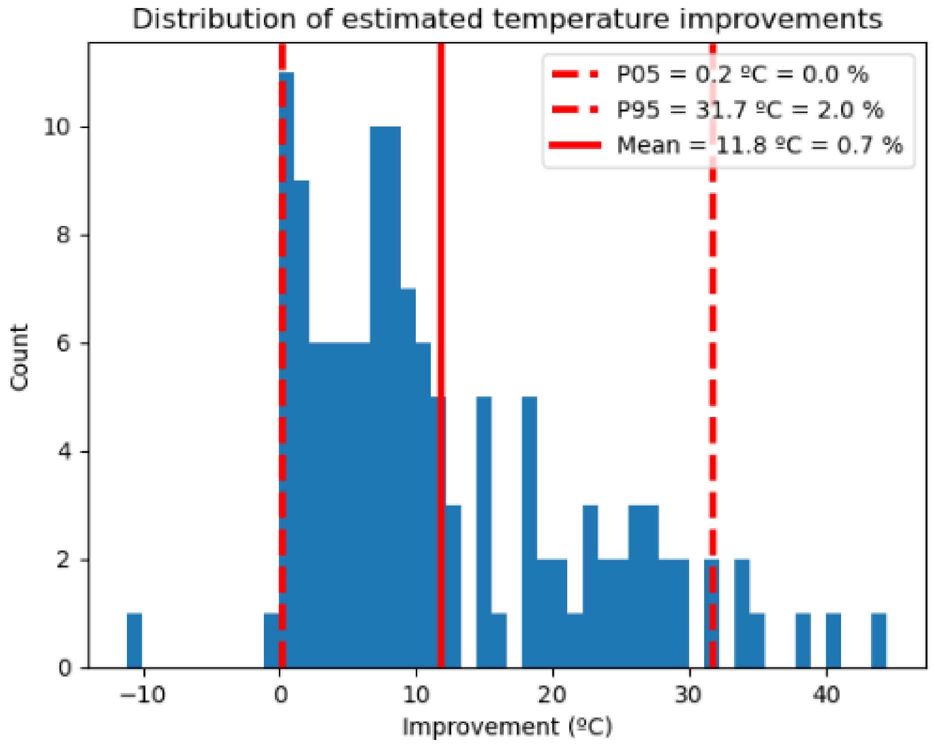


TAP13 original	3999KWH
Real temperature	1603ºC
Temperature prediction	1608.9ºC
TAP13 recommended	1500KWH
Optimized temperature	1590.1ºC
Estimated savings	2499KWH

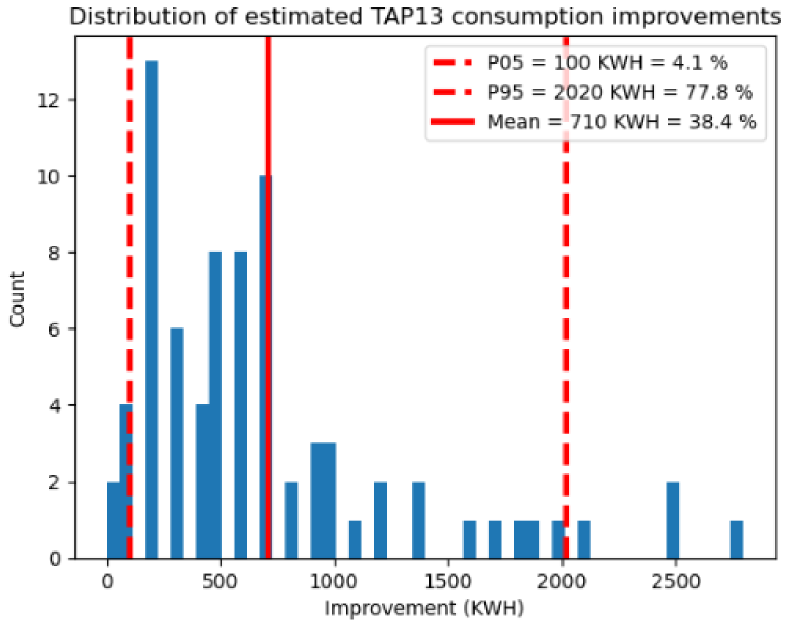
Developed solution

P2: Final temp. and consumption optimization

- **Optimization results:**



1. It is estimated that 51 observations do not reach the target temperature -> TAP13 consumption cannot be improved.
2. It is estimated that 77 observations exceed the target temperature -> Possible to improve TAP13 consumption.



Question & answer

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SPIRE
Sustainable Process Industry through Resource and Energy Efficiency