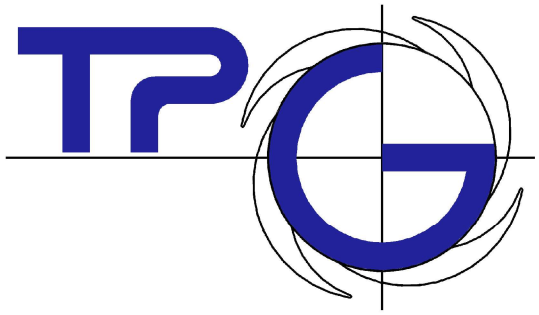


# INTELLIGENT PREDICTIVE CONTROL OF A PUMP-HEAT COMBINED CYCLE

*Authors: I. Rossi[1], A.Reveillere[2], F. Planchon[3]*

*Presenter: A. Sorce[1]*

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# Motivations and Background

University of Genoa

MOTIVATIONS

- Improving power plant flexibility is a key change in the near-mid term energy environment
- The Pump-Heat Combined Cycle (PHCC) aims to improve flexibility of existing power plant by coupling the GTCC with a HP plus a storage
- To control such complex system a multi-level control logics have been developed

BACKGROUND

- Analysis of performance impact of HP on GTCC has been carried out beforehand
- Off-design analysis gave light to a precise hierarchy in system response to enhance global efficiency

# Background analysis PHCC

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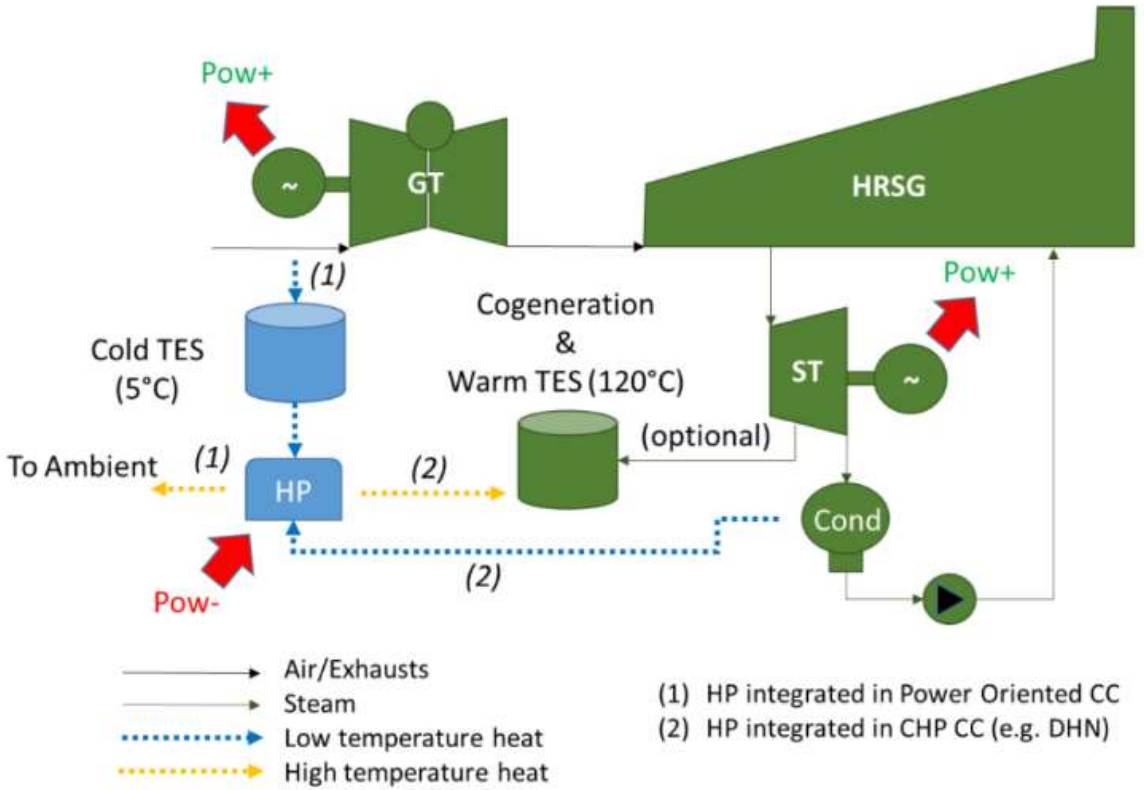
- Two different layouts have been developed: Power Oreinted (PO) and Cogenerative (CHP)

POWER ORIENTED

COGENERATIVE



# Background analysis PHCC - PO

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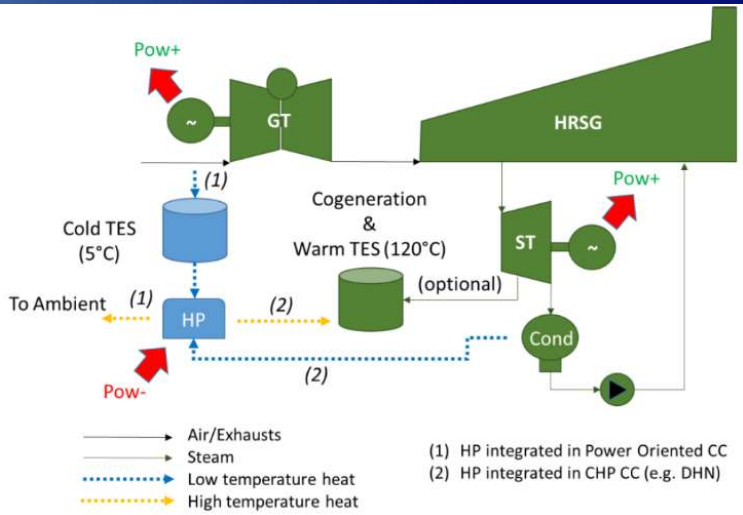
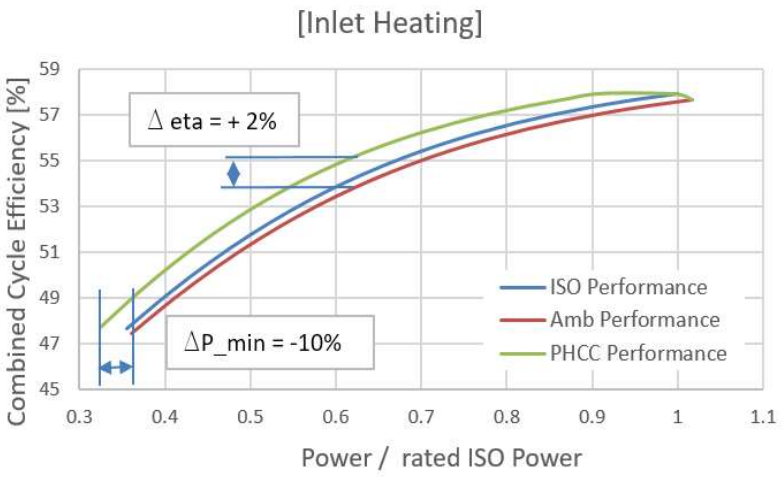
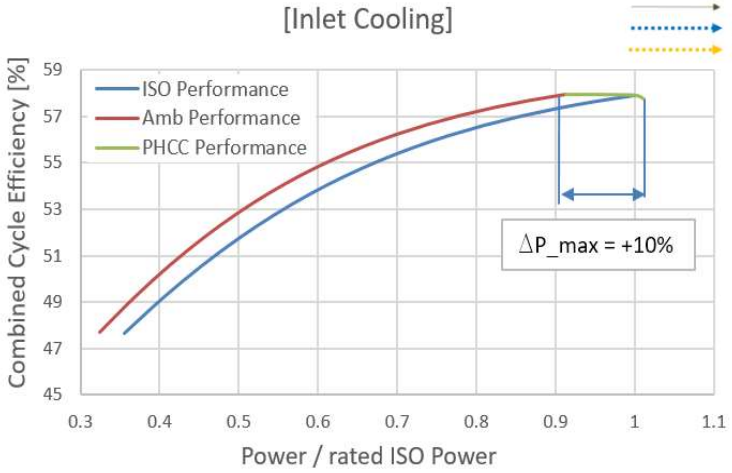
- PO is devoted to production of electric energy and heat pump is used to influence compressor intake temperature
- Here off-design results for PO are reported
- In the project, the PO demo will be held at laboratory scale through T100 micro gas turbine



# Background analysis PHCC - CHP

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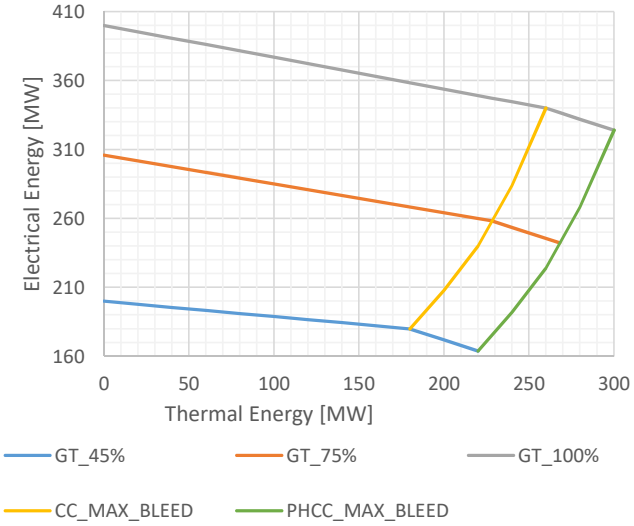
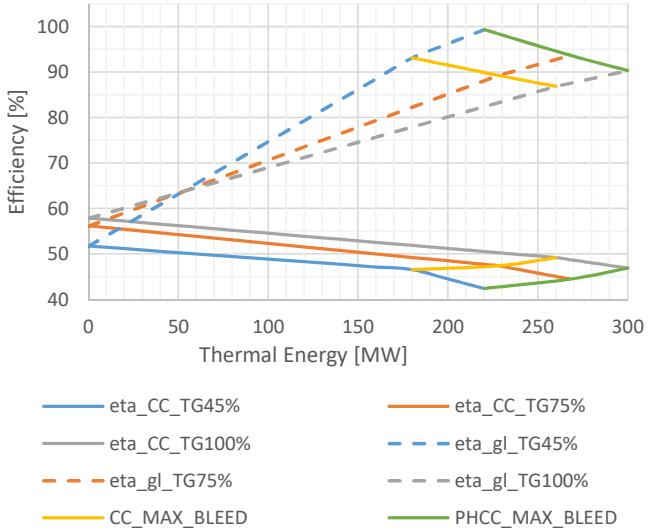
- CHP is devoted to production of electrical and thermal energy
- Here the heat pump is used to enhance the flexibility of GTCC by improving heat prediction
- Iren Energia Moncalieri GTCC 370MW power plant will be the demo site for the CHP configuration



# Model of target plant

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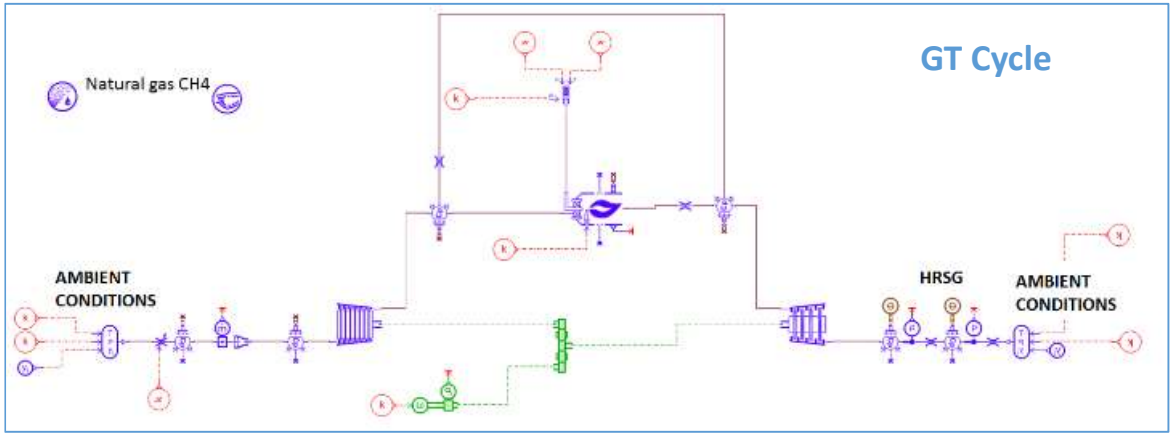
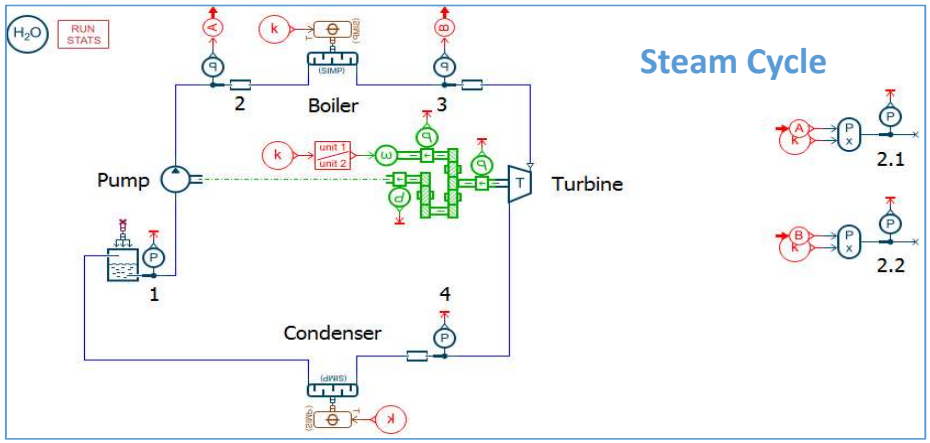
- Development of control goes alongside with development of plant model
- The control will be verified in model-in-the-loop configuration before installation on power plant
- The model is developed within Amesim Center and includes
  - Gas Turbine system
  - Steam cycle
  - Thermal storage
  - DHN
  - Heat Pump



# Control structure: introduction

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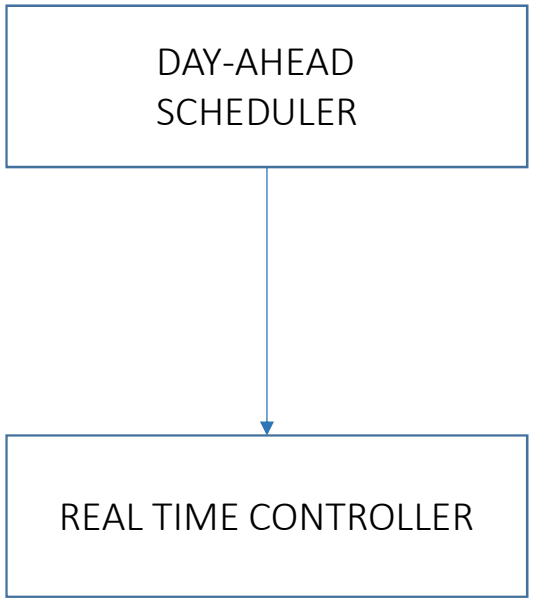
- The implementation must face several constraints and must embed the developed control logics
- The control system hardware should be integrated with the existing hardware
- The goal is to use properly the HP in order to improve the GTCC efficiency and productivity

- Currently in the power plants, a day-ahead programmer plans the next 24 hours
- A controller governs the system consistently

- In the PHCC control architecture a new level has been placed in between the two, looking at the 15 minute interval



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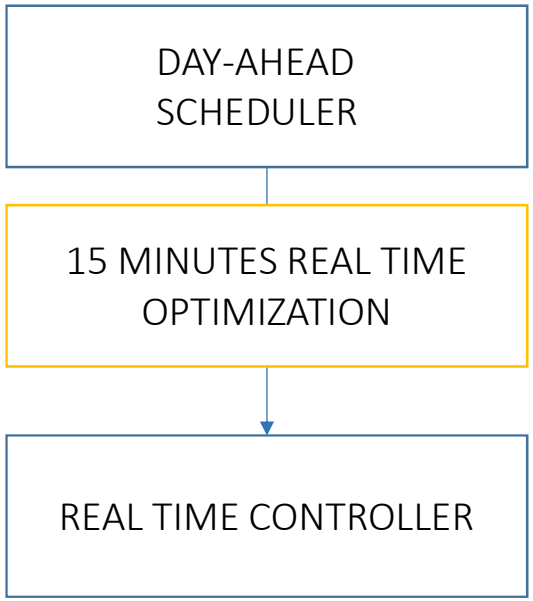

# Control structure

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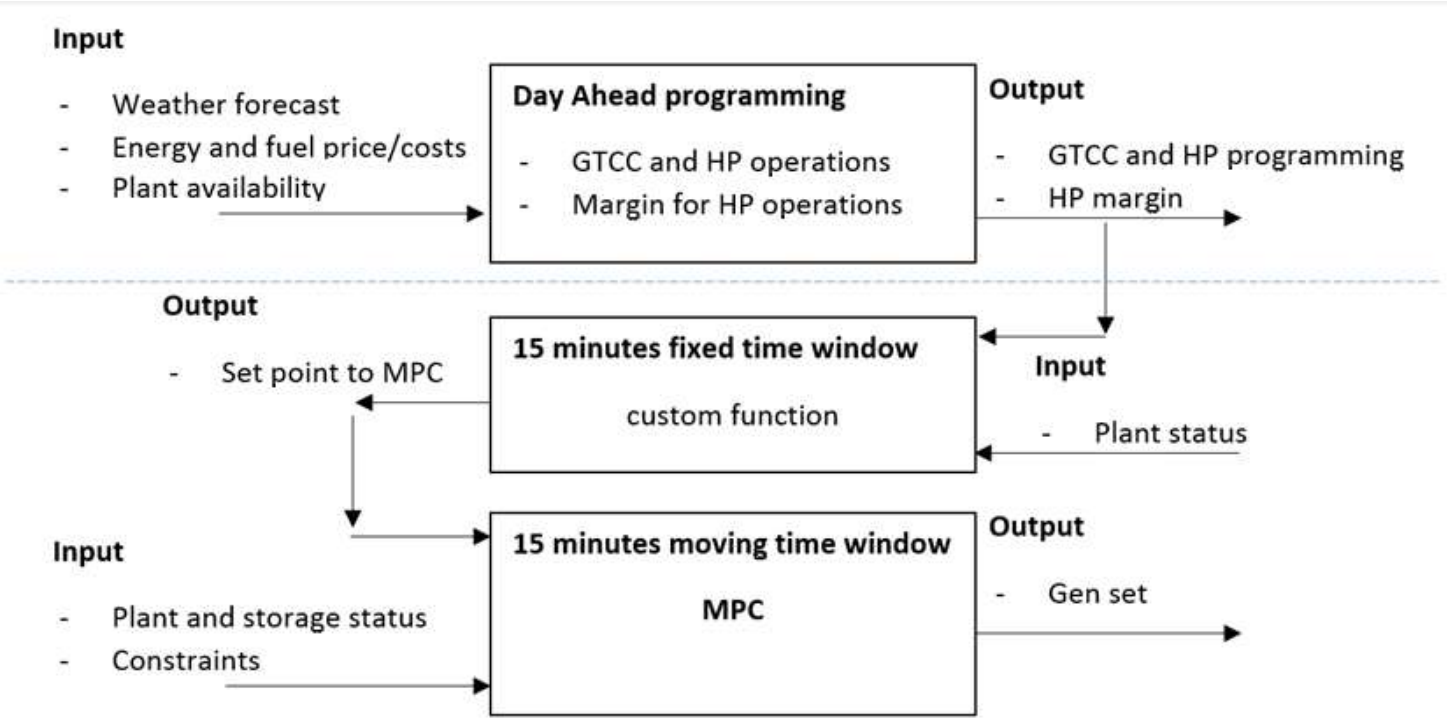
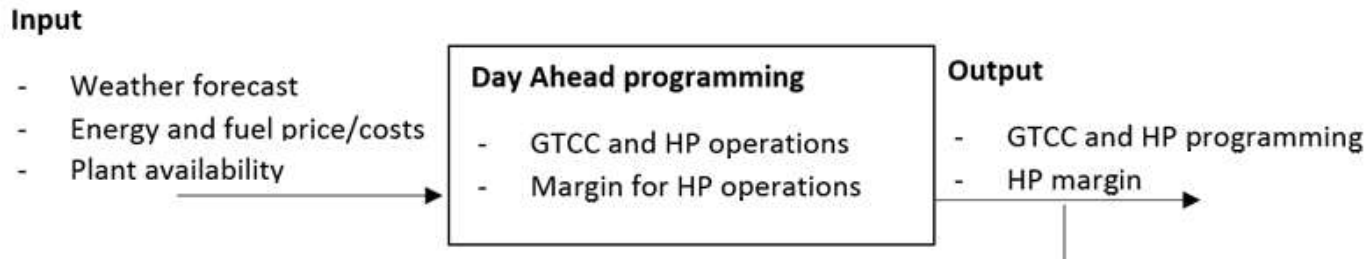
- The control structure is based on a multi-level approach
- Decisions are taken considering different time horizons
- The architecture can be applied both to PO and CHP with marginal adjustments
- It starts with the day-ahead programmer



# Control structure




- The day-ahed programming determines the load profile for both GTCC and HP
- The HP programming should include a margin for operation i.e. a degree of freedom for controller

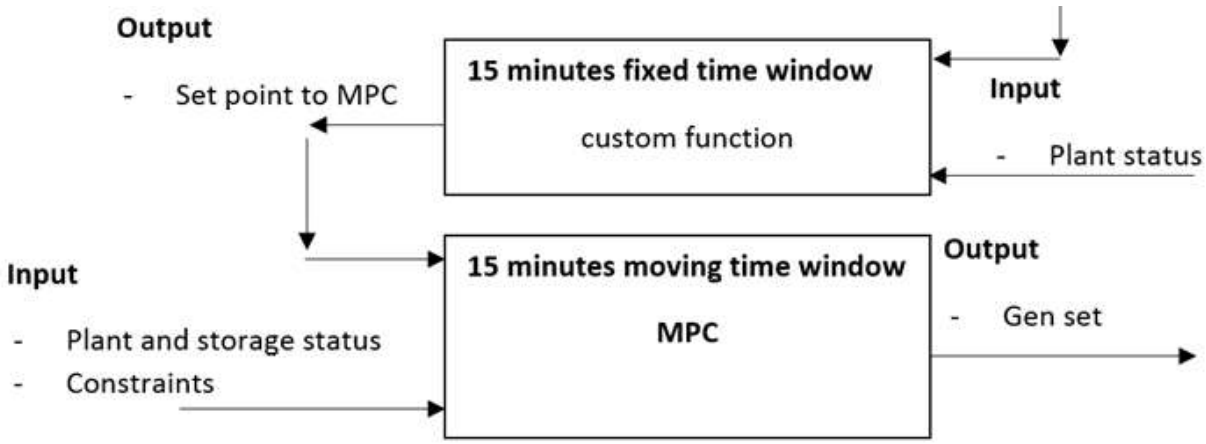
- A margin for the HP means the lower levels have degree of freedom in the control process
- Optimization defines the plant status and operation every 15 minutes

- No margin for HP: this implies lower level can intervene only on rapid regulation (frequency)
- In this way the day-ahead plan is followed with less initiatives

# Control structure

University of Genoa

- This is the real time controller, which is based on a hierarchical approach
- The approach is based on a higher function which determines an optimal trajectory for the MPC
- The MPC intervens consequently and tracks the demands
- The function of the MPC is to operate within the bounds



# Control structure

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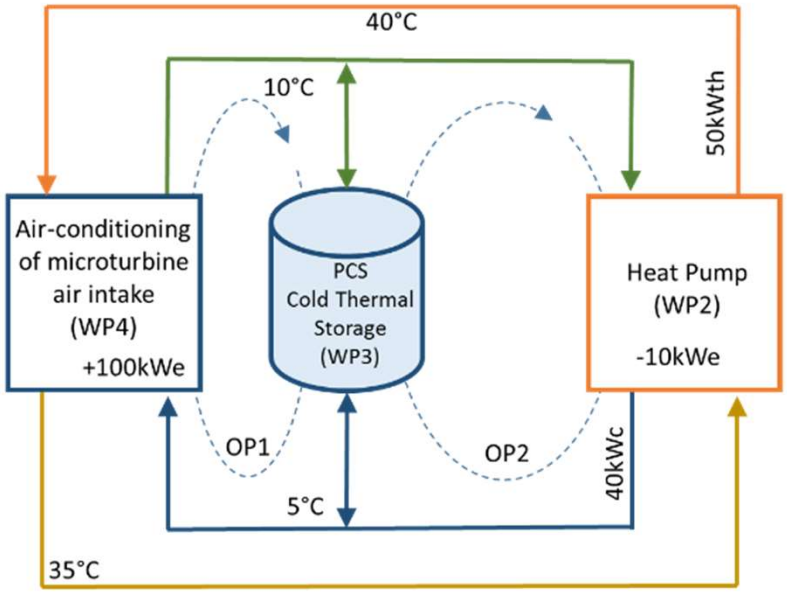
- The control system will be developed and implemented on the test rigs
- First implementation will be held for the PO demo, after which will be the turn of the CHP

- Basically the system consider:
  - Interface existing plant control system
  - Interface with heat pump and TES
  - Implement the MPC
  - Produce HMI for control of heat pump and TES
  - Store and show results into a specific control

- A multi-purpose computer integrating
  - I/O for interfaces, PLC-types
  - Double network attachment
  - One CPU per running code, HMI server, storage…

# Validation and Demostration site

University of Genoa

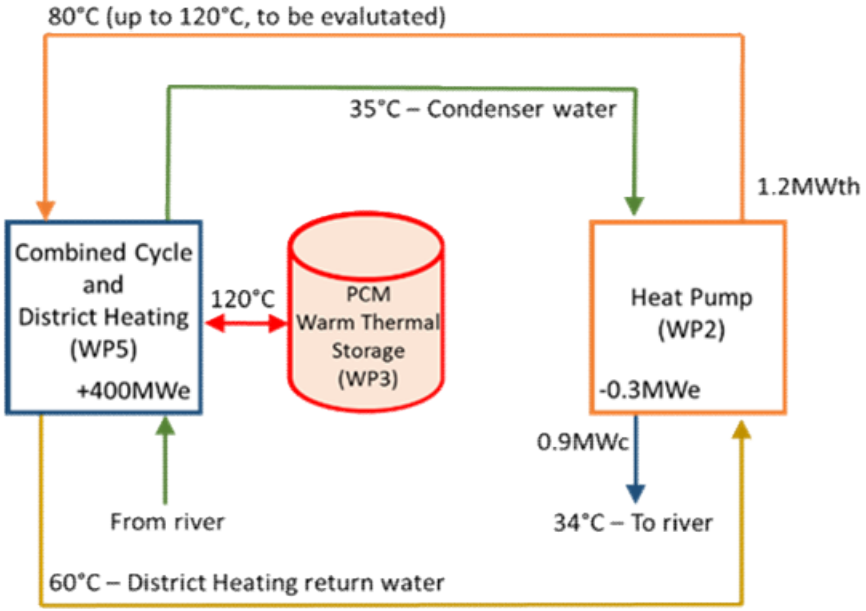


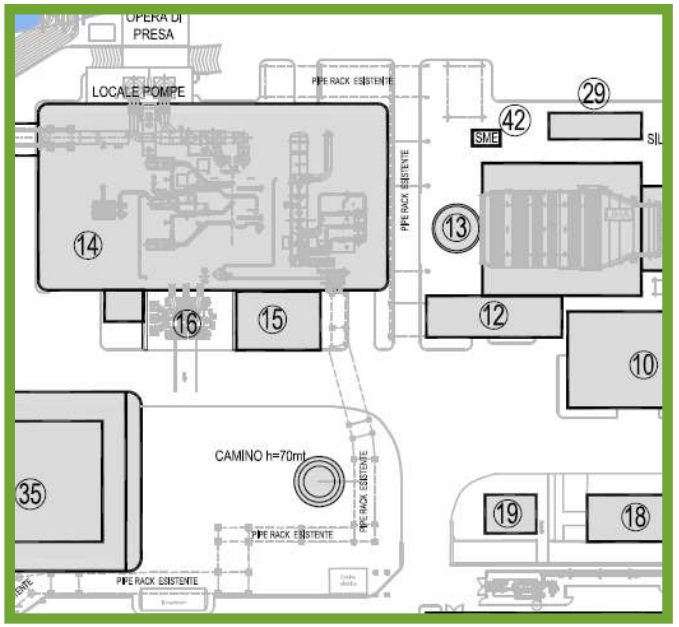

OP1: Air intake cooling (HP is off) – Max net power output
OP2: Air intake heating (HP is on) – Min net power outut

The validation phase will require the installation of cold thermal storage, fast-response HP (10 kWe), and compressor inlet heat exchangers arranged as in the picture to realize an Integrated Inlet Conditioning System.

# Validation and Demostration site

University of Genoa




The testing site will be the power plant of Moncalieri, a 2x400 $MW_{el}$ CC facility connected to the DH network of Turin

IREN DHN is already **equipped with 14.000 m³ heat storage capacity (and it is going to add additional 7.500 m³ in the next years)**

# Control structure

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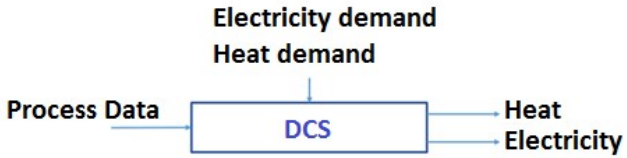
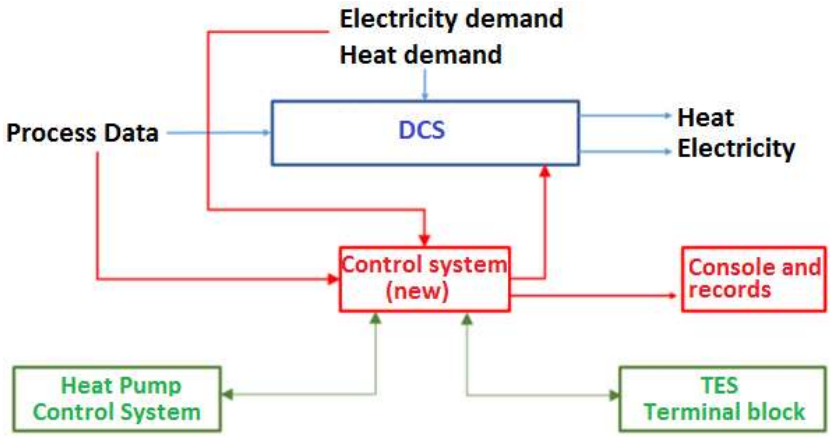
- Most critical is installation on CHP demo as it is the real GTCC
- This means to interact with an existing DCS
- Current DCS confirguration




- This system will be integrated with the new control system
- The control governs the HP only and the storage consequently
- No way for direct interaction with existing DCS

# Conclusions

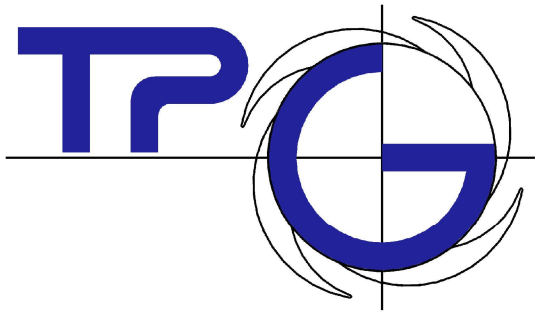
- This work was focused on definition of control system architecture for the PHCC layouts
- The control takes into consideration the GTCC and governs a HP and a TES to enhance efficiency of power plant
- The core of the controller is based on velocity form of MPC
- Implementation of control will be held at software level through Amesin Center
- This first part of testing will give light to a control hardware governing the PO
- Then the controller for the CHP demo will be delivered and implemented

- The final goal is to create a controller able to exploit the advantage offered by the PHCC layouts
- The controller must be capable for integration into existing power plants DCS.

# Acknowledgments

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 764706

http://www.pumpheat.eu/

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