SHIP2FAIR

Solar Heat for Industrial Processes towards Food and Agro Industries commitment in Renewables

The SHIP2FAIR Control Tool

Webinar, 20/05/2021

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BEST – Bioenergy and Sustainable Technologies

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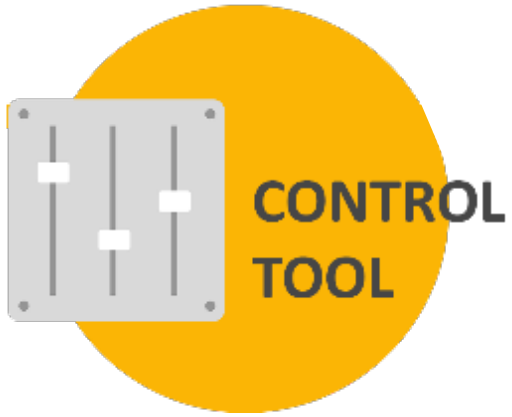
Control Tool



GOAL

The Control Tool is a tool able to optimize and improve the integration of solar heat into industrial processes during operation, regarding

- from low-level control aspects (e.g. control of temperature)
- through an high-level optimization of the whole system
- to advanced data-mining techniques (e.g. fault detection, forecasts, …)

DESIGN

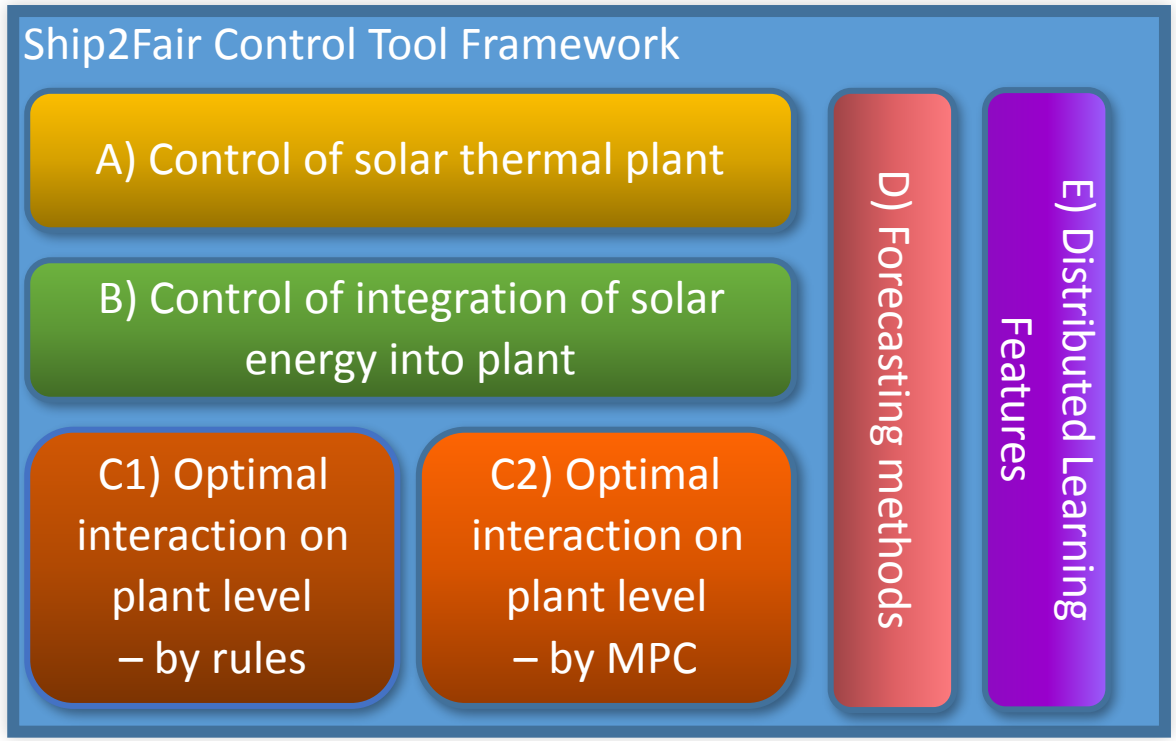
The design of the tool aims to be as flexible as possible in order to be applied to a multiplicity of systems, depending on

- user needs (e.g. control of only solar thermal system),
- plant design (e.g. available heat producers, storages) and
- level of automation (e.g. many sensors, digital recorded)

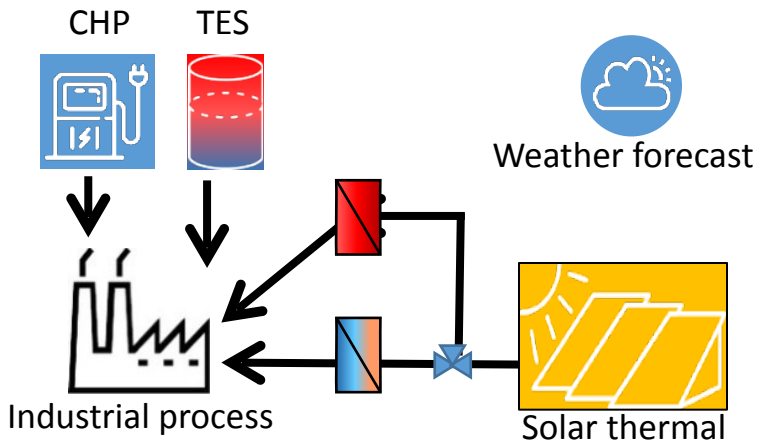
Design of the Control Tool

- Consists of a Framework of 5 MODULES which allow to make the most of the solar production.

- MODULES are chosen based on the possibilities available on-site
- Chosen MODULES form specific CONTROL TOOL for a plant

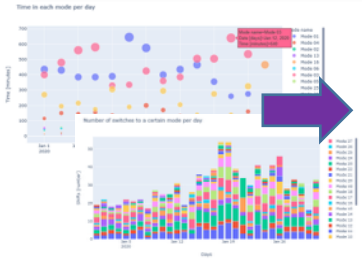


Control Tool Framework modules related to plant level



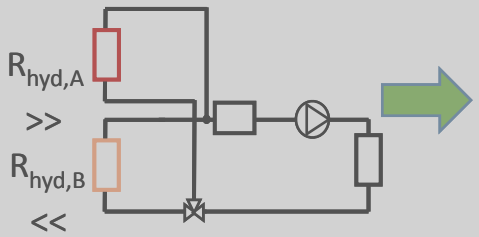
Control Tool Framework modules related to plant level

E) Distributed Learning Features



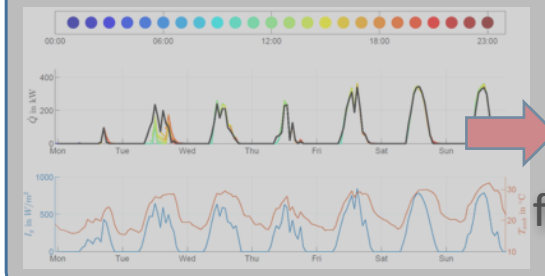
Goal: efficient & smart monitoring

B) Control of integration of solar energy into plant

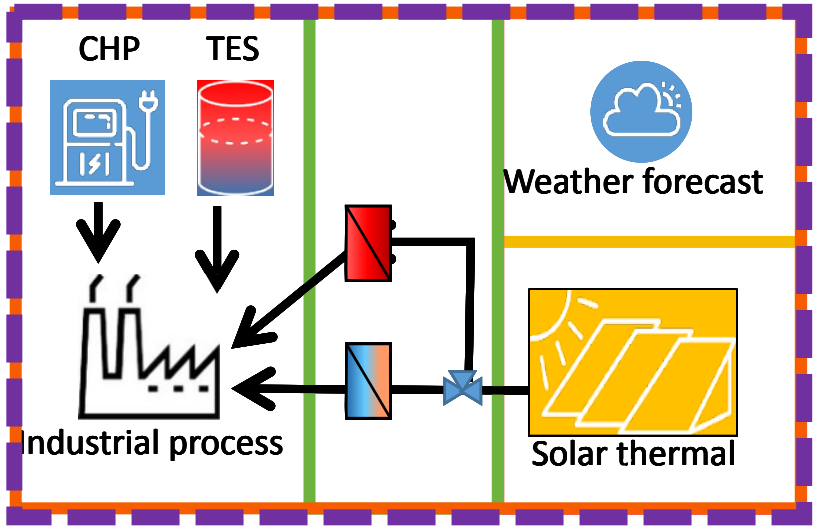


Goal: stable hydraulic condition

D) Forecasting methods



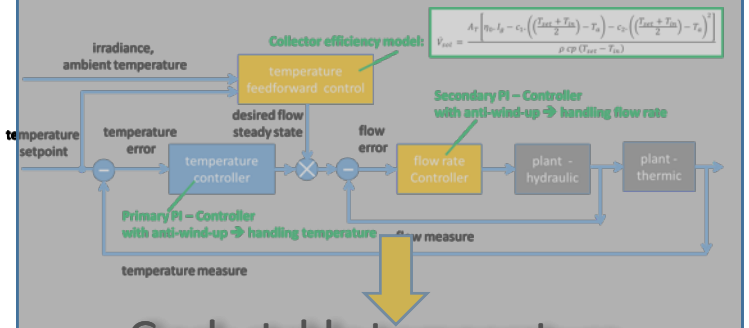
Goal: future heat forecast



C2) Optimal interaction on plant level

Goal: optimal overall control

A) Control of solar thermal plant



Goal: stable temperature

Summary of Control Tool

- Tool with the goal to optimize the system in operation and therefore addresses various control levels.

- Tool is based on a flexible design in order to be applied to a multiplicity of plants based on the possibilities on site.

- Level of implementation of Tool depends on the chosen modules (either on a programmable logic controller (PLC) or on a Server, resulting in a Web-Tool).

Thank you!

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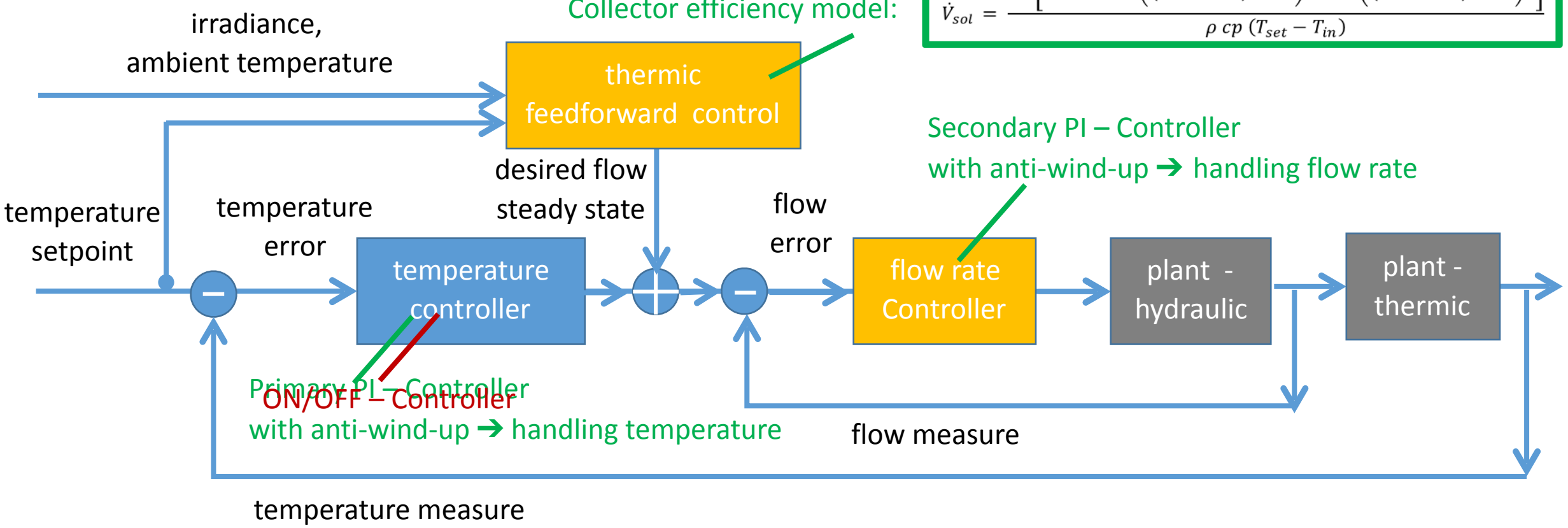
Further explanation Module A and Module C

Further explanation of Module A – Control of solar thermal plant

Model-based controller for non-concentrating collectors

Collector efficiency model:

$$\dot{V}_{sol} = \frac{A_T \left[\eta_0 . I_g - c_1 . \left(\left(\frac{T_{set} + T_{in}}{2} \right) - T_a \right) - c_2 . \left(\left(\frac{T_{set} + T_{in}}{2} \right) - T_a \right)^2 \right]}{\rho \, cp \, (T_{set} - T_{in})}$$



➔ MODULE A - focuses on the optimal operation of the solar plant, e.g. <u>control the outlet temperature</u> handles disturbances (e.g. fluctuating solar radiation), reacts in real time Implemented on PLC

Further explanation Module C – Overview

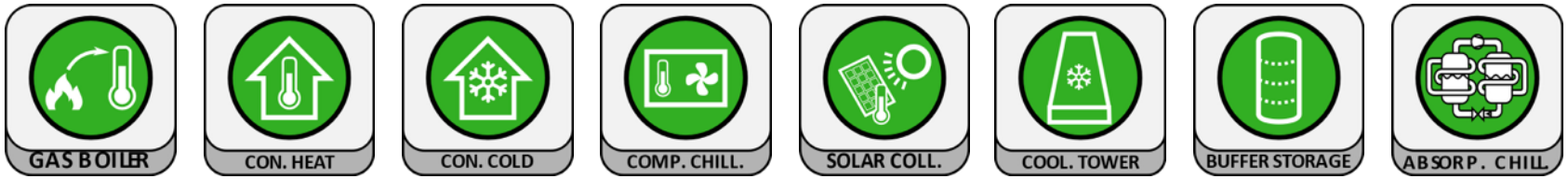
MODULE C focuses on the optimization of the whole plant, based on rules or by a Model Predictive Controller (MPC).

The MPC is

- considers a mathematical models of the whole system (including thermal storages, heat producers, etc.),
- takes into account forecast data (e.g. production and energy demand)
- and calculates the optimal operation strategy for a prediction horizon (e.g. 24h) based on a cost function (e.g. overall costs, CO_2 emissions)

Further explanation Module C – mathematical model for MPC

- Models developed for different components of a system and programmed in Julia (LINK)



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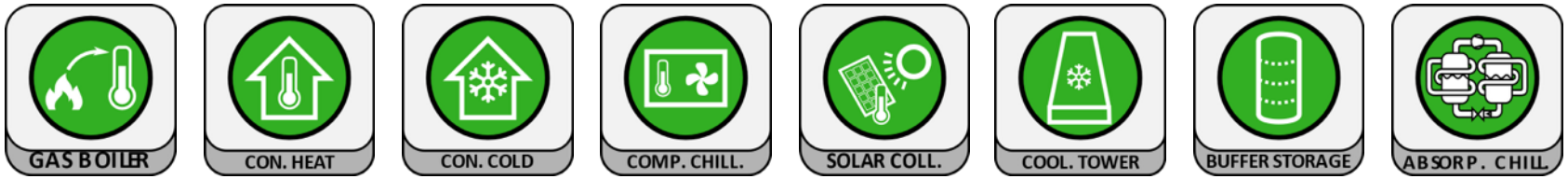

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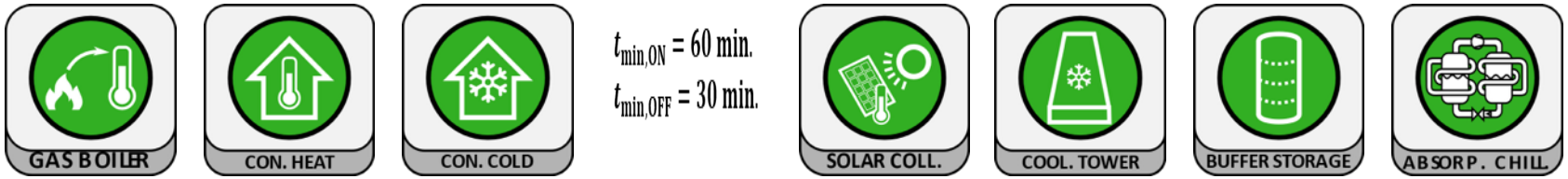
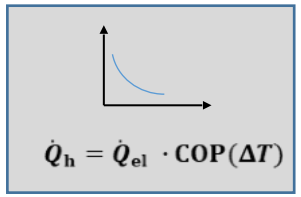


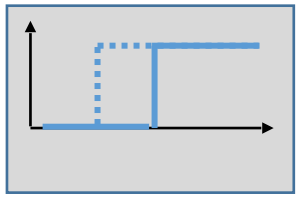
➔ for a modular approach these models can be combined to form a model of the whole system (see next slide)

- Models have to have a certain mathematical structure to be used in MPC and consider:

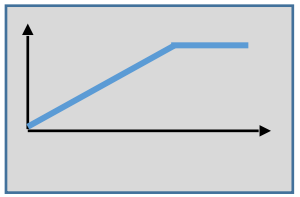
Input/output relationship



Transport delays



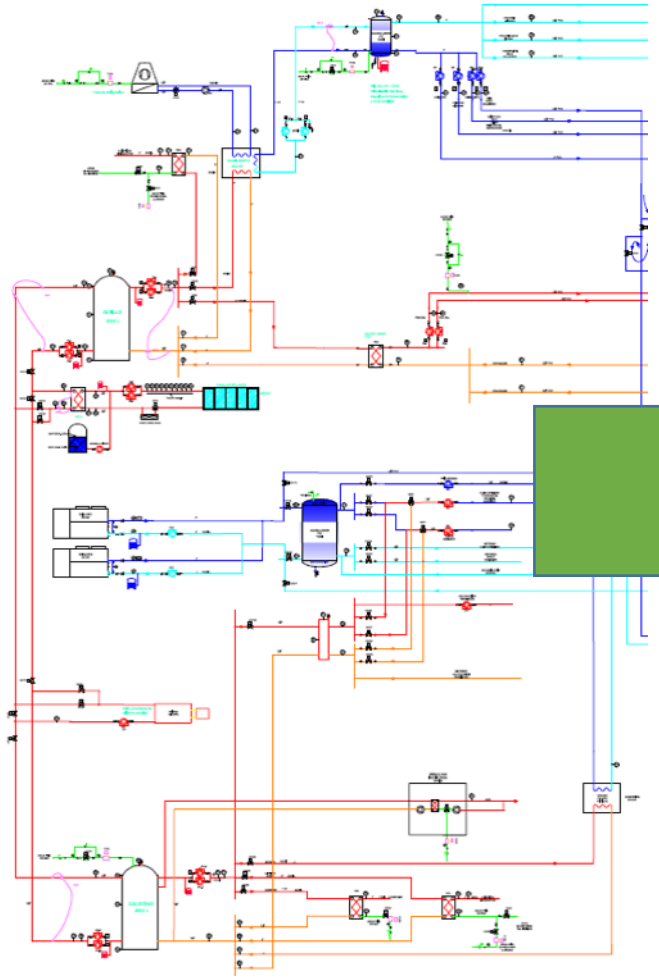
Ramp speed



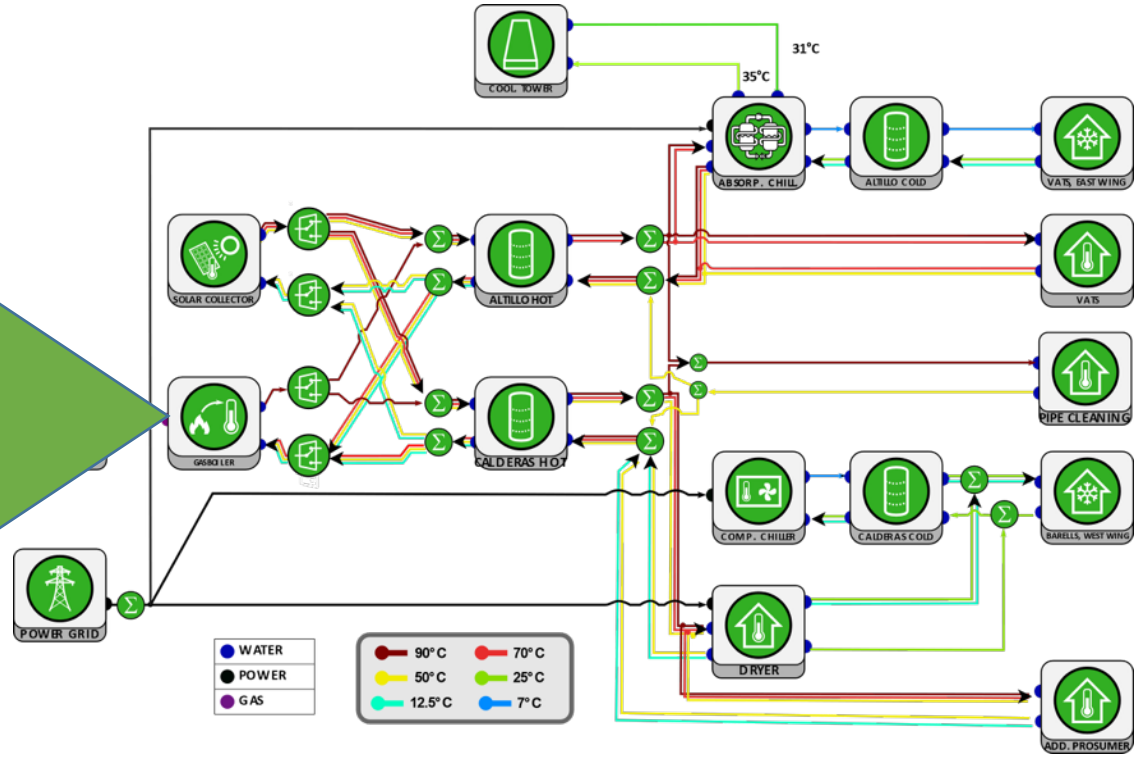
Constraints

$t_{min,ON}$ = 60 min.
$t_{min,OFF}$ = 30 min.

Exemplarily application of the MPC

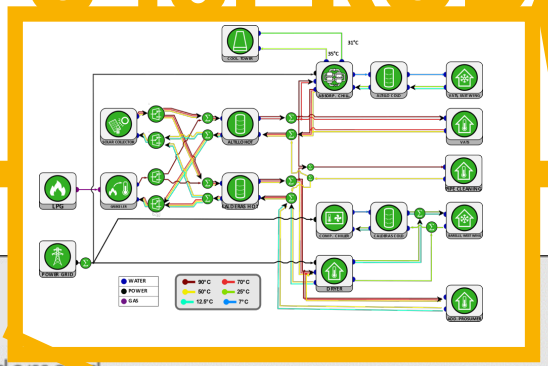


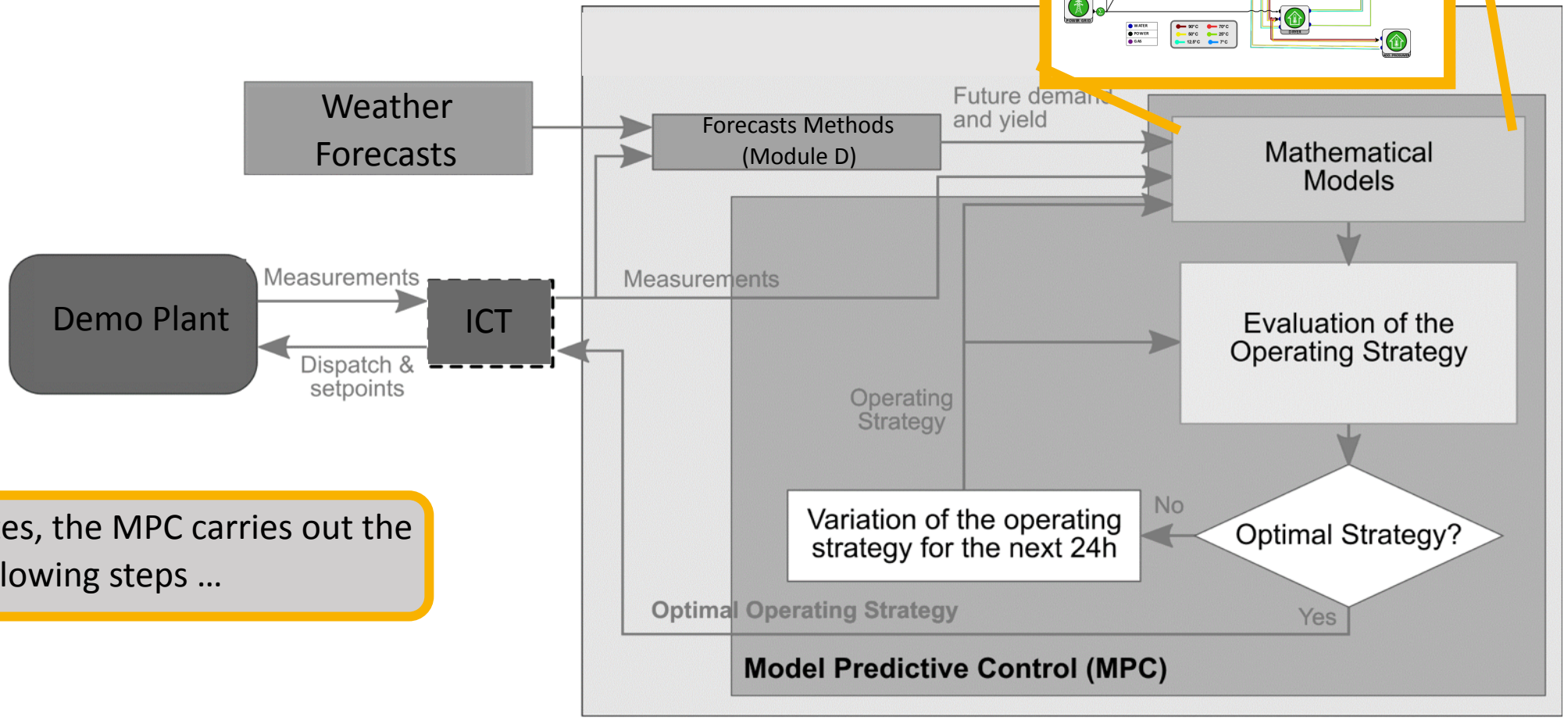
Based on the real structure of the system, the right models are combined



Model represents the whole system and its connections and considers prices for heat, gas, electricity, …

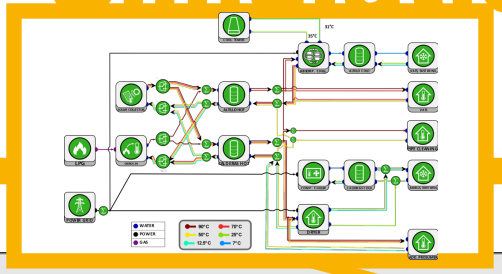
Simulation of MPC for RODA





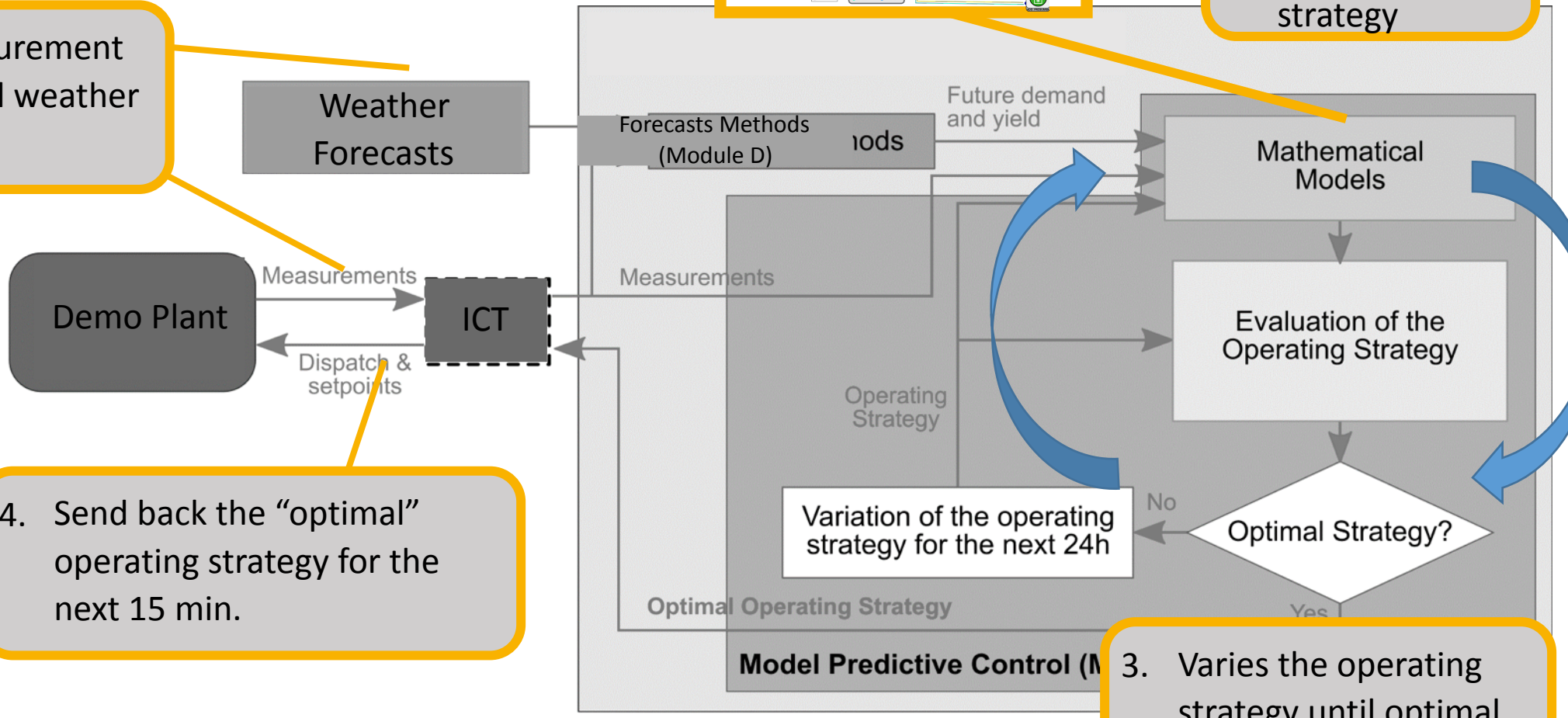
Every 15 minutes, the MPC carries out the following steps …

Simulation of MPC



1. receives measurement from plant and weather forecasts

2. Initialize the model and tries operating strategy



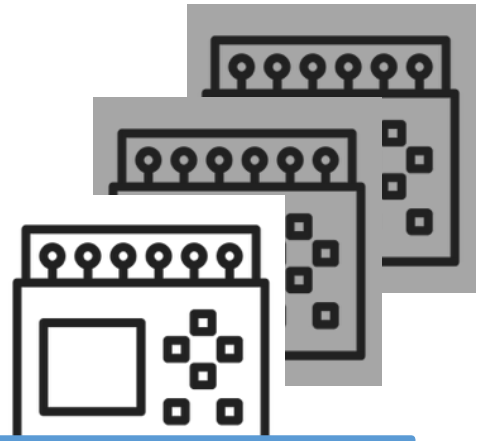
3. Varies the operating strategy until optimal one is found

4. Send back the “optimal” operating strategy for the next 15 min.

Implementation and Integration of the Control Tool

Planned integration of Control Tool

Frontend (=Browser)
Representation of Data for User



Server – BEST
Conn. Weather forecasts

MODULE C)Opt. whole plant by MPC

MODULE D) Forecasts solar prod.

Server – LINKS
Data handling/ICT

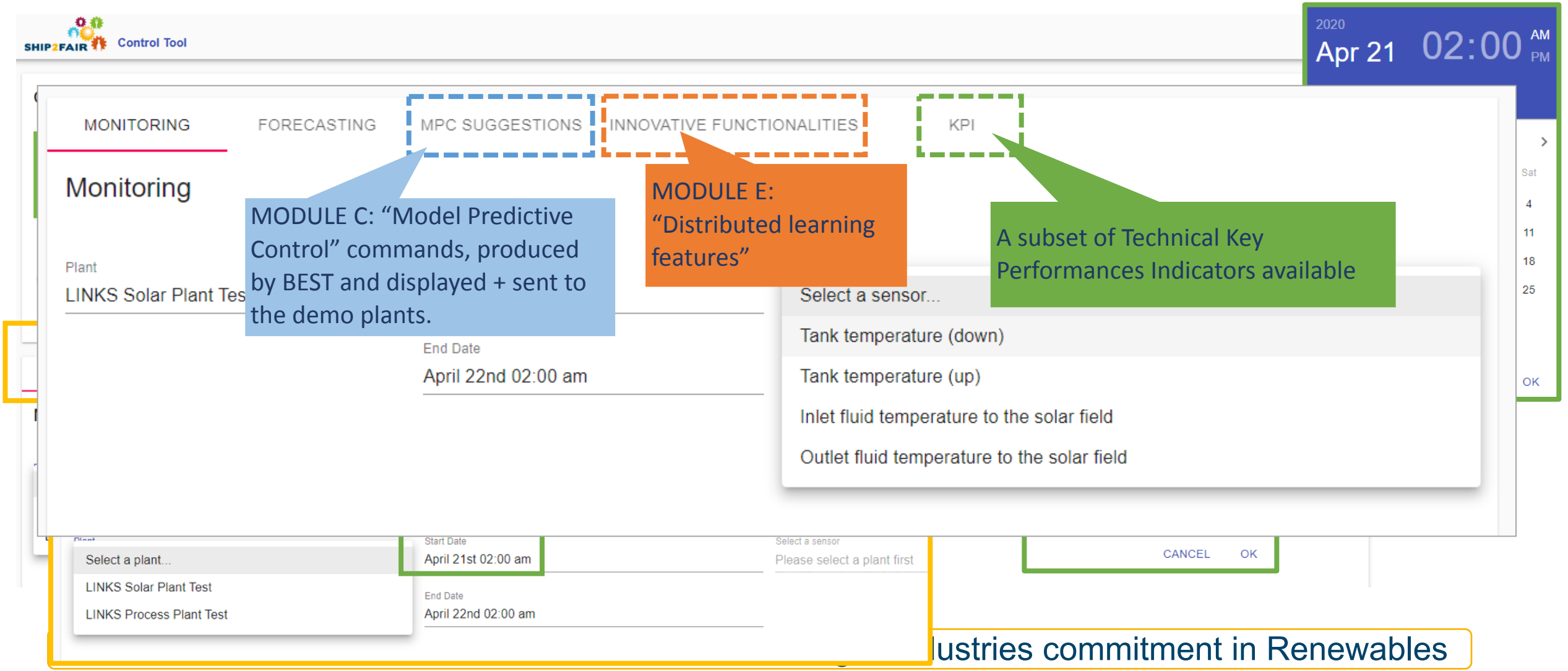
MODULE E) Distributed Learning Features

Plant Level (programmable logic controller =PLC)
Control of plant in real time

MODULE A) Control of Solar thermal plant

MODULE B) Control solar plant integration.

Example of Front-end - Current implementation



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Summary of the Control Tool

- The SHIP2Fair Control Tool consists of a modular framework of different MODULES A to E
- The different MODULES can be ‘plugged together’ to form a specific Control Tool tailored to the needs of the demo plants and the possibilities on-site
- Parts of this specific Control Tool has to implemented on plant level and some on a higher level (e.g. a server with access to large amount of data and higher computational resources)
- A front-end (GUI) can be accessed by the demo plant operator to investigate their data, see the forecasts and suggestions by the MPC
- The Control Tool will be implemented in the next months and tested on-site to evaluate its performance in practice.

Thank you!

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