THERMAL ENERGY EXCHANGE

Fernando Carreras[1], Peter Zellinger[2] , Johann Brandmayr[2], Gerald Steinmaurer[1,*]

[1]University of Applied Sciences Upper Austria, Energy Research Group ASIC, Stelzhamerstrasse 23, A-4600 Wels, Austria

[2]STIWA AMS Group, Salzburger Straße 52, A-4800 Attnang-Puchheim, Austria

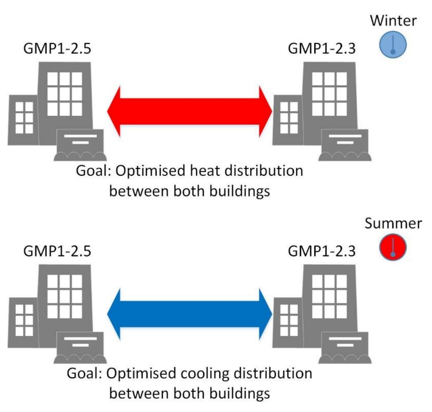
[a)]Corresponding author; Email: gerald.steinmaurer@fh-wels.at; Phone: +43 5 0804 46925

ABSTRACT

Aim of this poster is the presentation of a new implementation (March 2022) based on a new methodology to increase the energy efficiency by exchanging thermal energy between two buildings. This new methodology comprises several procedures. Firstly, all energy processes involved will be identified, classified, and modelled. Secondly, based on a graphical definition of energy flows, a hydraulic system can be software-independently defined. The solution can be directly exported into a control software programmed with the tool GML (Graphic Motion Language). This language allows the creation of SPS program of the processes defined by PPR (Product Process-model Resources-model). To achieve the objectives of the Paris Agreement [1], energy exchange in all its ways is a well proofed form of increasing the energy efficiency. Thermal exchange in industry plays an essential role in those contexts [2], where energy overflows can be integrated into different infrastructures or coupled with other industrial activities. Several EU projects have demonstrated the potential of energy saving by heat and cold exchange [3].

METHODS

Use Case Gampern



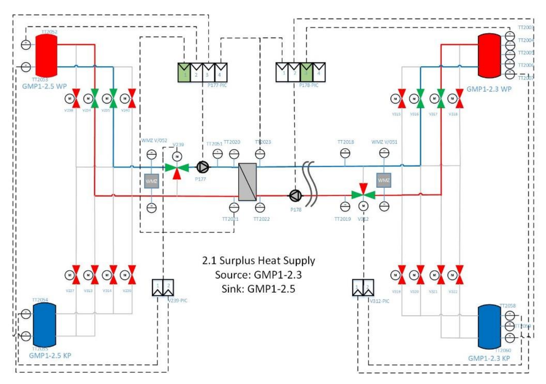
STIWA has developed a solution for one of its production sites located in Gampern. The main novelty of this development is the implementation of a heat and cooling fluid exchange system between two buildings.

Requirements:

- Supply of GMP1-2.5 by GMP1-2.3 with heat or cooling (support or entirely) and vice versa.
- Reduction of operating hours of gas boilers, primary supply by heat pumps of GMP1-2.5
- Reduction of CO2 emissions and surplus energy disposal
- Maintaining reliable energy supply to both buildings (building and machine operation)
- Protection of buffer storage against discharge by energy transport necessary (heat pumps)

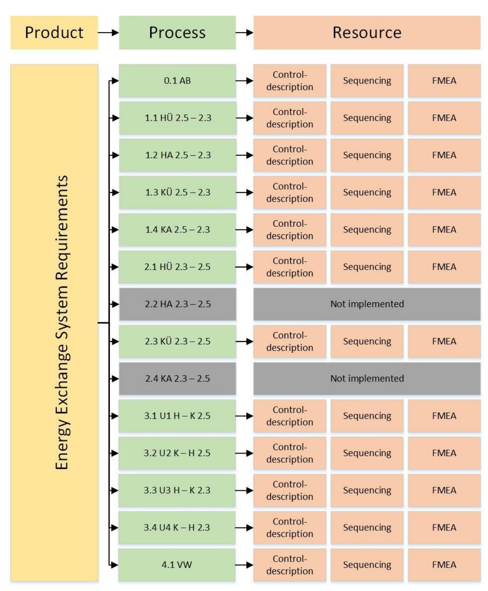
Description of the Solution

Hydraulic System



The proposed energy transport system is connected to the hydraulic systems of GMP1-2.3 GMP1-2.5 via heat and cooling water storages. In GMP1-2.5, there are heat pumps that provide thermal energy for the building and compressors with waste heat recovery systems. In GMP1-2.3, there is a gas boiler and cooling machines with waste heat recovery systems. The thermal energy produced is used in heating and cooling the building and providing the production machines with process cooling. Waste heat is, now, disposed of with free cooling devices in both buildings.

Control of the hydraulic



Overview of all the required documents of each process. Another important document made in resource modelling is a Failure Mode and Effect Analysis (FMEA). Implemented processes: heat and cooling energy transport from GMP1-2.3 to 1-2.5 and vice versa (surplus energy supply or sole energy supply)

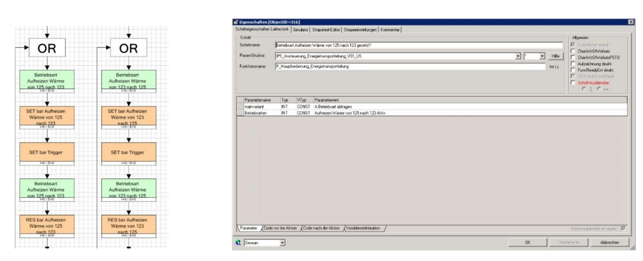
Software

- Software solution for the control of the system: Transcription of a system based on rule description in flow charts into a computer understandable language.
- Graphical programming tool GML (Graphic Motion Language): creation of SPS program of the processes defined by PPR (Product Process-model Resources-model). The workflow of these program is:
  1. Checking process parameters for status change (trigger)
  2. Decision-making in response to trigger (decision tree)
  3. Execution of the decision found (action)
  4. Waiting for a new trigger
- Trigger monitors the parameters of the system and determines the decision to be taken based on the decision tree.

RESULTS

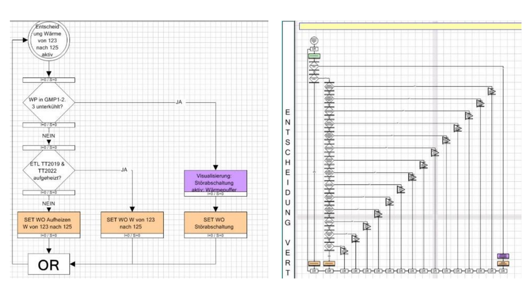
Software:

Trigger



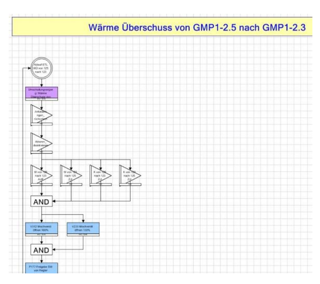
By overstepping one of the setup limits, the control system triggers firstly the decision tree to run through. The most suitable operating mode is found by querying various triggers. And finally, an action to operate this mode is requested

Decisions



Decision trees are based on binary yes/no decisions: divide processes into "small steps" to make many individual yes/no decisions, from which the modes of operation can be derived. This operability makes the system high flexible and scalable.

Actions



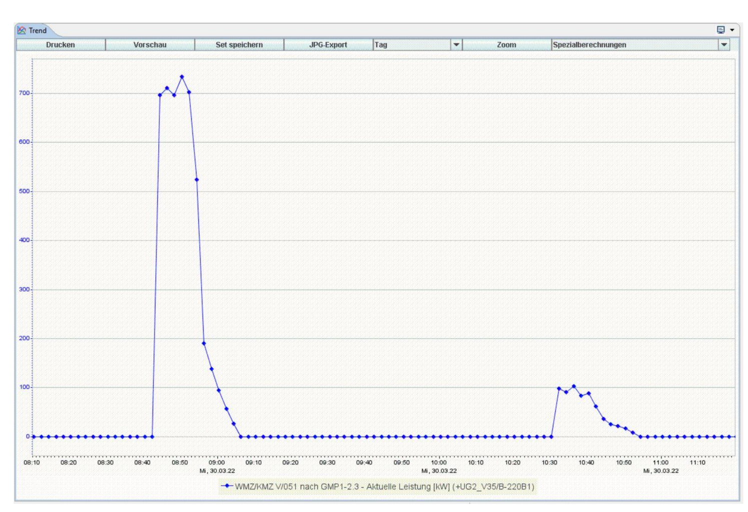
Each action includes:
(a) execution of an operating mode (OM)
(b) all components are brought into correct position
(c) possible setting of a time staggering or delay if necessary
d) Termination conditions can be defined during the action
e) OM remains active until the decision tree triggers other OM.

Measurement results

The energy transport system was implemented in late March 2022, with a pump unit having mechanical problems leading to a delayed commissioning in May. The prioritized processes to be commissioned by the customers were the heat exchange processes to reduce required gas. Therefore, in summer, cooling energy exchange was not in commission, and there was no requirement for heat in both buildings, so there was no significant energy transport between the two buildings possible as of September 2022.

There are, however, measurement data available for the energy transport system starting from March, which provide important results of the operation of the energy transport system.

The analyzed data is from late March and shows the power measured at a heat counter in the energy transport system in GMP1-2.3. Due to cold water in the pipe system, a significant power peak is detected. The cold water in the energy transport pipe system has 10° C, the water used to heat the energy transport pipe system has 45° C. Without the controlled three-way valve switch process, 700 kW of thermal power is transported through the system despite being only commissioned for 220kW. The possibility of those power peaks from early commissioning attempts were already described in the FMEA during the PPR planning process. In this test, it was proven to be a problem. Otherwise, it could have occurred during operation and have led to more severe problems.



CONCLUSION & OUTLOOK

✓ New methodology beyond the state-of-the-art to increase the efficiency of the energy usability for a bidirectional thermal exchange between two building based on a PPR modelling, based on:

- Identification of the requirements to satisfy
- Definition all the processes means energy flow diagrams
- Adequate control software

Further work is being conducted in following fields:

- Completion of the full implementation.
- Optimizing the digital twin of the system
- Scaling experience gained from this project to other projects
- Preparing the digital twin for semi-automatized GML program generation

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