Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Federal Department of the Environment, Transport, Energy and Communications DETEC

Swiss Federal Office of Energy SFOE
Energy Research and Cleantech Division

Interim report dated 16.12.2022

OPERA

Source: ©XY 2021

Date: 16.12.2022

Location: Bern

Publisher:
Swiss Federal Office of Energy SFOE
Energy Research and Cleantech
CH-3003 Bern
www.bfe.admin.ch

Subsidy recipients:

- CSEM : Jaquet-Droz 1, 2002 Neuchâtel
- prevoyance.ne : Rue du Pont 23, 2300 La Chaux-de-Fonds
- SOLECO : Hubrainweg 18, 8124 Maur
- Heliotherm Wärmepumpentechnik GmbH : Sportplatzweg 18, 6336 Langkampfen, Austria
- ThermoClima AG : Industriestrasse 15, 4554 Etziken
- Loxone electronics GmbH : Seestrasse 161, 8266 Steckborn
- Gerber Elektro : Allmendingenweg 11, 3073 Gümlingen
- Haute école spécialisée de Suisse orientale : Werdenbergstrasse 4, 9470 Buchs
- Verein Smart Grid Ready Schweiz : Falkenplatz 11, Postfach, 3001 Bern
- Fachvereinigung Wärmepumpen Schweiz : Steinerstrasse 37, 3006 Bern
- Service de l'énergie et de l'environnement NE : Rue du Tombet 24, 2034 Peseux

Authors:

- Yves, Stauffer, CSEM, yves.stauffer@csem.ch
- Tomasz, Gorecki, CSEM, tomasz.gorecki@csem.ch
- Max, Boegli, CSEM, max.boegli@csem.ch
- Alain, Aerni, SOLECO, alain.aerni@soleco.ch
- Michael, Uhlmann, OST, michael.uhlmann@ost.ch
- Christoph, Brönnimann, SGR, Christoph.broennimann@smartgridready.ch

SFOE project coordinators:

- Karin, Södörström, karin.Soederstroem@bfe.admin.ch
- Stephan, Renz, info@renzconsulting.ch

SFOE contract number: SI/502220-01

Zusammenfassung

Trotz der vielen bereits auf dem Markt befindlichen Lösungen ist die Integration von erneuerbaren Energien - insbesondere die Kombination von Photovoltaik mit Wärmepumpen - noch nicht optimal (Einbeziehung von Prognosen, angepasste Steuerung mit Energiespeicherung im Gebäude). Gleichzeitig besteht bei der Bewirtschaftung von Mehrfamilienhäusern noch ein großes Potenzial zur Steigerung der Effizienz von Wärmepumpen. OPERA wird technische Lösungen für beide Aspekte entwickeln und validieren und die Steigerung der Energieeffizienz am Pilotstandort des Projekts, einem Gebäude, das derzeit renoviert wird, demonstrieren. Die wirtschaftlichen Vorteile, die sich aus der technischen Lösung des Projekts ergeben, sowie die Bewertung ihres Potenzials auf schweizerischer Ebene werden den Multiplikatoren zur Verfügung gestellt, um die Lösung in größerem Maßstab zu replizieren. So wird das Projekt die Attraktivität von PV+-Wärmepumpensystemen, insbesondere für zu renovierende Gebäude, fördern und damit einen Beitrag zur Schweizer Energiestrategie 2050 leisten.

Résumé

Malgré des nombreuses solutions déjà disponibles sur le marché, l'intégration des énergies renouvelable – spécialement la combinaison du photovoltaïque avec des pompes à chaleur (PAC) – n'est pas encore optimale à l'heure actuelle (inclusion des prévisions, contrôle adapté avec stockage de l'énergie dans le bâtiment). En même temps, la gestion des bâtiments à multiples habitations présente encore un gros potentiel pour augmenter le rendement des PAC. OPERA va développer et valider des solutions techniques pour ces deux aspects et démontrer l'augmentation de l'efficacité énergétique sur le site pilote du projet, un immeuble actuellement en rénovation. Les avantages économiques qui découlent de la solution technique du projet, ainsi que l'évaluation de son potentiel au niveau Suisse, seront fournies aux acteurs de multiplication afin de répliquer la solution à plus grand échelle. Ainsi, le projet va promouvoir l'attractivité des systèmes PV+ PAC, surtout pour les immeubles en rénovation, et faire ainsi une contribution pour la Stratégie Energétique Suisse 2050.

Summary

In spite of the many solutions already available on the market, the integration of renewable energies - especially the combination of photovoltaics with heat pumps (heat pumps) - is not yet optimal (inclusion of forecasts, adapted control with energy storage in the building). At the same time, the management of multi-family buildings still has a great potential for increasing the efficiency of heat pumps. OPERA will develop and validate technical solutions for both aspects and demonstrate the increase in energy efficiency at the project's pilot site, a building currently under renovation. The economic benefits resulting from the technical solution of the project, as well as the evaluation of its potential at the Swiss level, will be provided to multiplication actors in order to replicate the solution on a larger scale. Thus, the project will promote the attractiveness of PV+ heat pump systems, especially for buildings under renovation, and thus contribute to the Swiss Energy Strategy 2050.

Contents

Abbreviations

BWP	Bundesverband Wärmepumpe
DHW	Domestic Hot Water
GFH	Ground Floor Heating
HP	Heat Pump
MFH	Multi Family Housing
MPC	Model Predictive Control
SH	Space Heating

1 Introduction

1.1 Background information and current situation

The current status is summarized by the following points:

a) PV installation not growing fast enough: initial objectives set by the government were 4.4TWh in 2020 and about 24TWh in 2050[1], the potential is around 67TWh[2]. In 2019 only 39MW[3] were installed, the goals will thus not be reached. In Switzerland a majority of residents live in multi family housings[4] (MFH) built before 2000[5], which a high potential for renovation. Which is the target group of the project. With surfaces of at least 200m^2 which lead to systems of 20 to 30kW$_p$.

b) Air/water HP for MFH is lagging behind: Switzerland has a good track record for HP in single family houses (SFH). Nevertheless, installation in MFH has been shown as successful[6]. In 2019 there were mor HP sold than gas/oil burners[7].

c) HP control not optimal: in order to enhance economic viability, HP shall be controlled to: i) run at the highest possible efficiency (i.e. based on favorable outdoor conditions) ii) run in synergy with PV production. For this the HP needs to have a standardize interface to allow proper power control. Indeed, simple ON/OFF modulation has been proved to lead non satisfactory results as shown in PROSUMERLAB[8]. This will be made possible thanks to the SmartGridready (SGr) interface. In addition, the heat production needs to be demand based and further optimized based on PV production. This is possible thanks to the combination of smart thermostatic valves from Loxone to model predictive control from SOLECO/CSEM.

1.2 Purpose of the project & objectives

The purpose of this project is to address the non optimal HP control (point c of the previous chapter). This will be done thanks to improved HP and building control. To that purpose, the following steps will be taken:

- Model predictive energy management ➔ **Objective 1**
- Standard interfaces ➔ **Objective 2**
- Validation of concept ➔ **Objective 3**

---

[1] P. Previdoli, 'Energiestrategie 2050: 1. Massnahmenpaket', Nat. Photovoltaik-Tagung 2014.
[2] BFE, 'Schweizer Hausdächer und -fassaden könnten jährlich 67 TWh Solarstrom produzieren'.
[3] '2.5 GW de puissance solaire installés – il nous en faut 20 fois plus'. Swissoar, Jul. 2020
[4] 'Wohnverhältnisse in der Schweiz: Mieter und Eigentümer', BFS, 2017.
[5] 'Gebäude nach Gebäudekategorie sowie Bauperiode und Geschosszahl', BFS, 2018.
[6] A. Hausmann, 'Kurzdokumentation zweier Luft/Wasser-Wärmepumpen im städtischen Umfeld', Energie Schweiz, Jan. 2020.
[7] Wärmepumpen Statistik 2019', FWS, Apr. 2020.
[8] Prosumer-Lab: Influence of novel strategies and components of the energy management of grid-integrated, smart buildings on the stability and quality of the house and distribution grids, Aramis, OFEN P&D, 2019.

This will be validated in simulation and on a real site and will allow the unlocking of HP/PV installation in MFH in particular as illustrated in Figure 1.

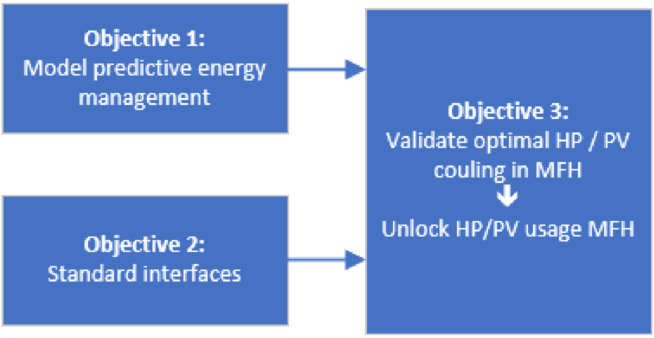

Figure 1: main project objectives

2 Description of the pilot site

An illustration of the test site before renovation is provided in Figure 2.

After renovation, the heating (SH and DHW) will be provided by three HP as illustrated in Figure 3. The two HP on the left are dedicated to SH and DHW, using fresh air as source. Whereas the 3rd HP on the right is using ventilation air as a source to produce DHW.

During the renovation process, PV will also be installed.

In addition, ground floor heating (GFH) will be installed, the latter will be controlled using the self learning system from Loxone

Figure 2: test site before renovation

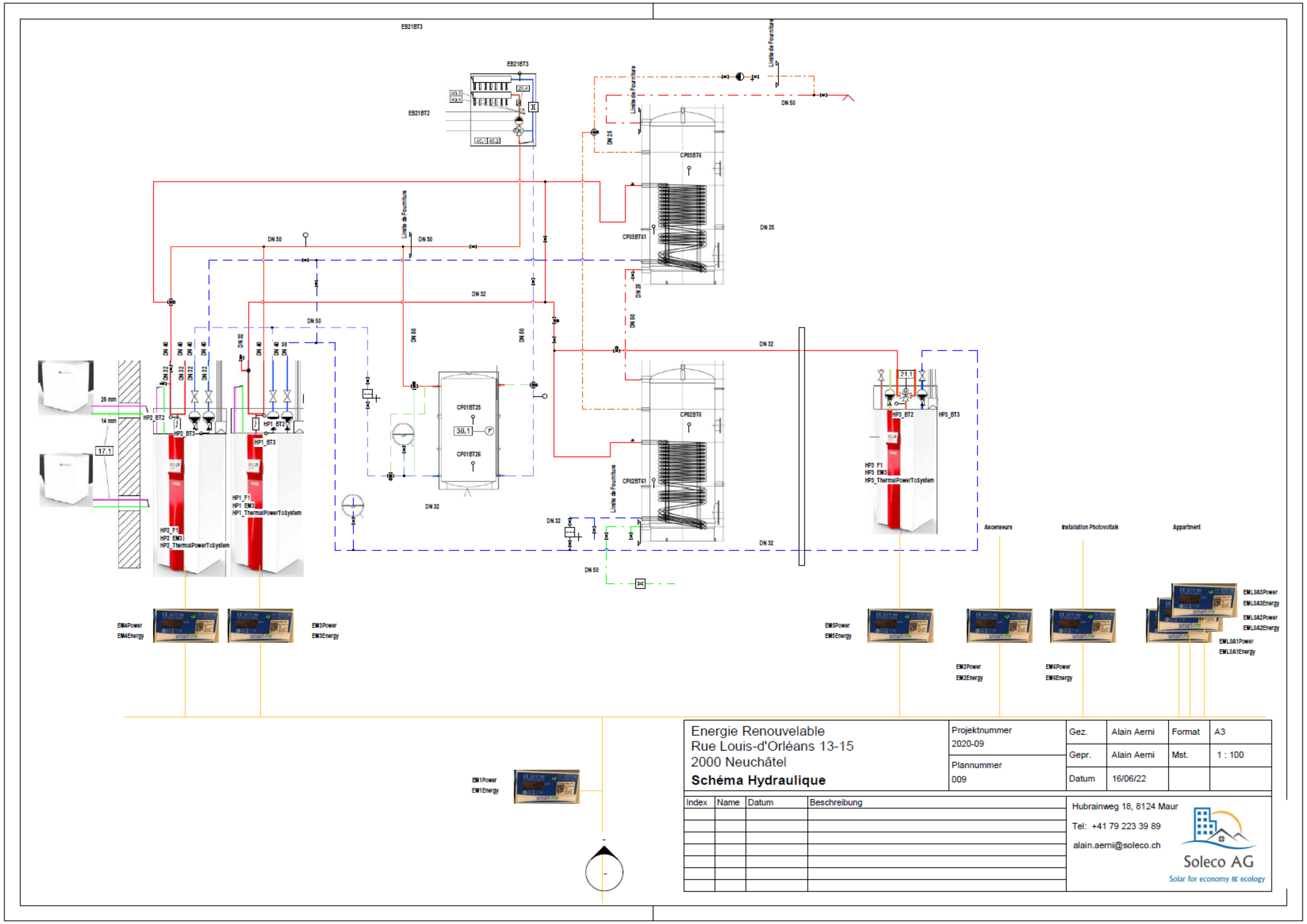

Figure 3: test site HP layout

3 Procedures and methodology

To achieve the objectives mentioned in Figure 1, the work was broken down as illustrated in Figure 4.

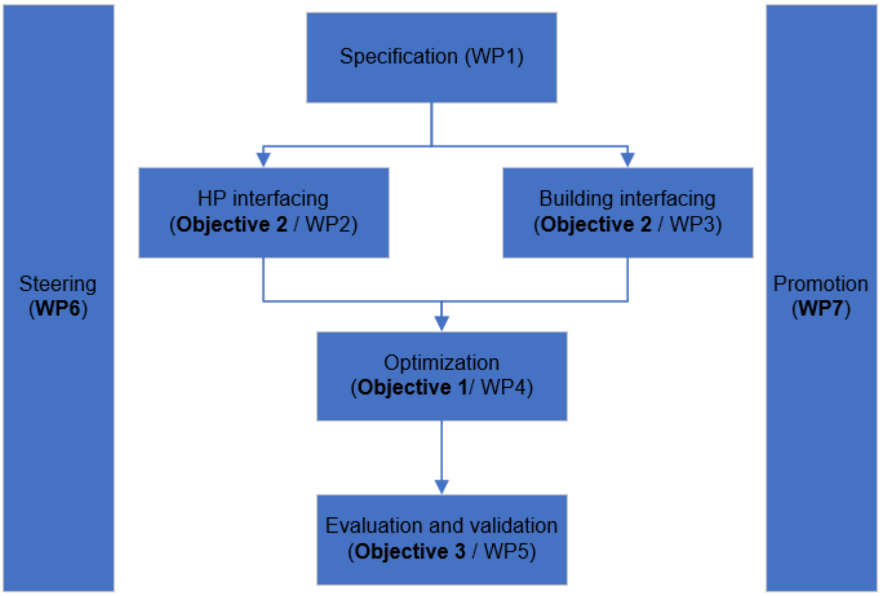

Figure 4: overall methodology and links to WP and objectives

4 Activities and results

4.1 Objective 1: optimization

For this objective, we first had to understand how to adapt the existing MPC to handle such large buildings and how to take into account user requests (in terms of temperature and its flexibility).

As illustrated in Figure 5, there are two level of inputs: facility manager and user. As thermal comfort is very user specific, we identified with the help of Loxone a new product, illustrated in Figure 6.

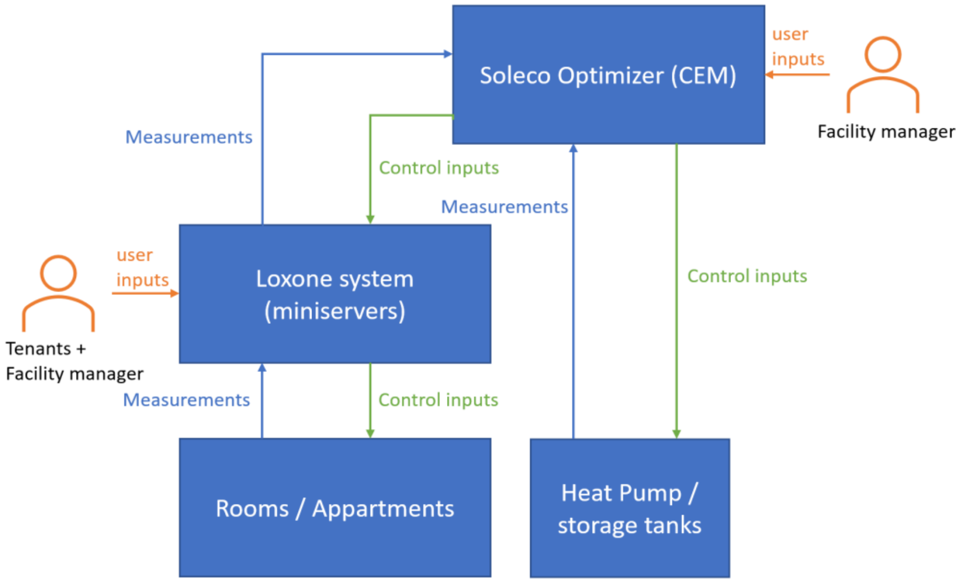

Figure 5: control concept and user interaction overview

Each room is equipped with individual room temperature control. The room temperature control is achieved through closing and opening the Loxone valve(s) of the rooms. We will **offer tenants an interface to Loxone only through physical input devices (Touch flex Pure and a tablet at the entrance of each apartment, a preliminary illustration of these interfaces is provided in Figure 6)**.
Each tenant of an apartment will be able on one touch flex per room to set the ideal temperature of the rooms of the apartment. Additionally, an admissible deviation on the positive side and on the negative side (single value for the apartment) can be entered through a fixed tablet at the entrance of the apartment. This deviation for the apartment will also be used in the other rooms of this apartment to set the max and min temperature of each room based on the set temperature by the user of that room and the deviation set for the apartment.

Figure 6: Touch flex pure conceptual illustration for temperature, blind and lighting control (left), preliminary map view on the tablet to illustrate the status of the different rooms. The control interface is to be agreed on (right)

Then as illustrated in Figure 7: data flow for room temperature control, the resulting setpoint temperature in each room needs to be disaggregated from the predicted optimized temperature from the optimizer. This is done by using each room temperature setpoint with a deviation that is proportional to the average deviation for the aggregate building model

Based on the individual room min, max and ref set points of the complete building an average min temperature and max temperature is calculated. This calculation is ideally triggered if a user changes the admissible deviations per apartment or a new ref room temperature value

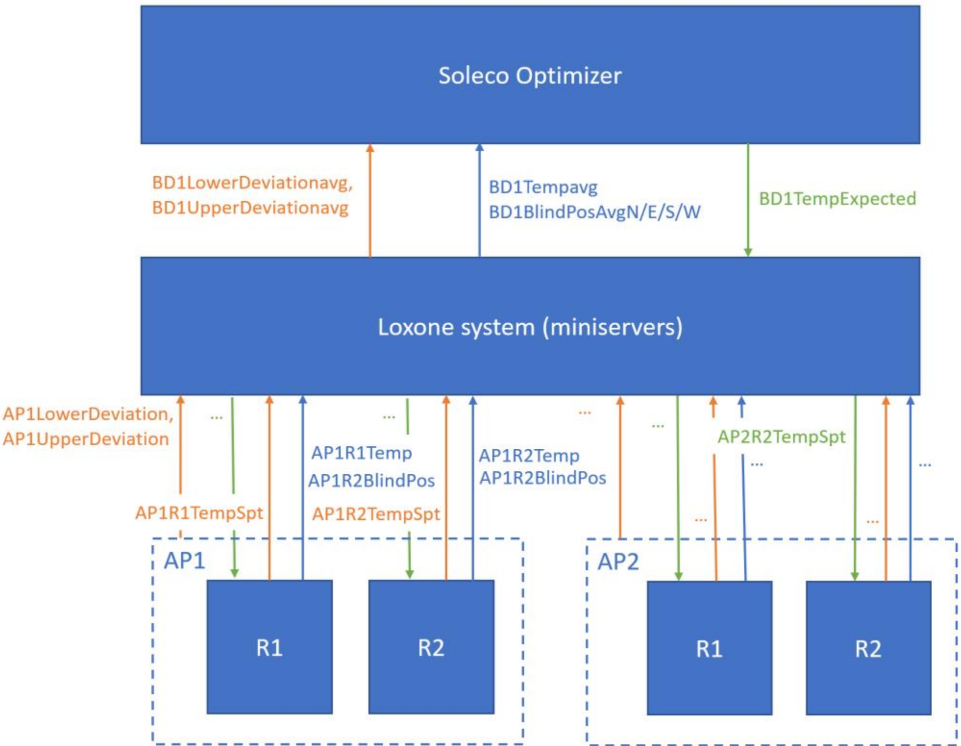

Figure 7: data flow for room temperature control

A first version of the MPC was then developed and tested in a preliminary simulation enviornment. This was mainly done to assess the coupling capability between the simulation tool and the optimizer. This link was shown to operate as expected. The updated version of this simulation envorinment will be used both for the MPC development but also for valisating cases that can't be carried out in the real site (see section: objective 3: evaluation and validation, Table 1).

4.2 Objective 2: interfacing

Work was carried on the HP interfacing and more particularly on the development of the SGr profile for the Heliotherm HP. Note that no heat pump from those manufacturers is currently capable to satisfy the full specifications but that it still constitutes an important step towards standardization. The developed Device profile is a machine-readable document (xml format) that contains all information allowing to control the heat pump through modbus transport protocol (list and description of relevant registries for different scope of communication). This was done partly based on previous experimentation of Soleco on a heat pump of the same model. The device profile has been uploaded on the repository of SmartGridready interface at https://github.com/SmartgridReady/SGrSpecifications/blob/master/XMLInstances/ExtInterfaces/SGr_04_0020_xxxx_Heliotherm_HeatPumpV0.2.1.xml (accessible to SmartGridReady member organizations) and an excerpt is illustrated in Figure 8.

Datapoint	Unit	Type	MRO	RWP
HPOpModeCmd	NONE	unsigned short	M	W

SGr label V1 (legacy)	HPOpModeCmd
0=AUS, 1=Automatik, 2=Kühlen, 3=Sommer, 4=Dauerbetrieb, 5=Absenkung, 6=Urlaub, 7=Party, 8=Ausheizen, 9=EVU Sperre, 10=Hauptschalter AUS	
0=off, 1=automatic, 2=Cooling, 3=Summer, 4=Continuous(?), 5=setback (?), 6=Vacation, 7=Party, 8=Ausheizen, 9=?, 10=?. 8 to 10 only informational	

Modbus

Data Type	short
Register	HoldRegister 100 (Size 1)
Supports	Primitives
Modbus Scaling	1 x 10e 0

```xml
<sgr:dataPoint datapointName="HPOpModeCmd"
   mroVisibilityIndicator="M" rwpDatadirection="W" unit="NONE">
   <sgr:basicDataType>
      <sgr:int16U>0</sgr:int16U>
   </sgr:basicDataType>
   <sgr:dpNameList>
      <sgr:nameType>DataPoint</sgr:nameType>
      <sgr:sLV1Name>HPOpModeCmd</sgr:sLV1Name>
   </sgr:dpNameList>
   <sgr:dpLegibDesc>
      <sgr:textElement>0=AUS, 1=Automatik, 2=Kühlen, 3=Sommer, 4=Dauerbetrieb, 5=Absenkung, 6=Urlaub, 7=Party, 8=Ausheizen, 9=EVU Sperre, 10=Hauptschalter AUS</sgr:textElement>
      <sgr:language>de</sgr:language>
   </sgr:dpLegibDesc>
   <sgr:dpLegibDesc>
      <sgr:textElement>0=off, 1=automatic, 2=Cooling, 3=Summer, 4=Continuous(?), 5=setback (?), 6=Vacation, 7=Party, 8=Ausheizen, 9=?, 10=?. 8 to 10 only informational</sgr:textElement>
      <sgr:language>en</sgr:language>
   </sgr:dpLegibDesc>
</sgr:dataPoint>
```

Figure 8: Excerpt from Device Profile in machine-readable and human-readable form

In addition, a comparison of the scope of control required and used by Soleco in their past deployment and the control enabled by the specifications provided by SGready. The main differences identified are the following:

- The notion of mode control included in the SGready compromise falls short compared to what the Soleco optimizer would expect for heat pump control : most heat pump include a notion of mode control which pilots the operation mode of the heat pump, which allows to switch between different operating logic, e.g. cooling, party mode, vacation mode, etc for the Heliotherm heat pump. The explicit control of the switching between heating circuits, e.g. between heating and domestic hot water, or even to start stop in some cases, is not included in this mode control and follows from decisions of the internal heat pump controller based on its measurement. Soleco (and other predictive controllers) on the other hand would explicitly require to control e.g. the production of hot water as it effectively forecasts and optimizes that and would suffer from wrong forecasts if this control is not explicit.
- Experience from Soleco has shown that the information included in the SmartGridready profiles is necessary but not sufficient as it is also needed to know a number of “tricks” (some documented, some undocumented). E.g. under which conditions the values to some registers will be applied or not, etc. Some known “tricks” have been included in the Device profile as comments for developers, but as such they still reduce the potential for full automatizing of the control of the heat pumps if they are not known machine-readable fashion. To some extent, this can only be solved through internal heat pump controller update to explicitly expose this information.
- Soleco has implemented the latest Modbus TCP interface with Heliotherm in the summer of 2022 in a commercial project with the exact same heat pumps (HM-HP20L-M-BC).

In order to validate the developed SGR profile, a HP emulator was produced by Heliotherm (Figure 9).

Figure 9: HP emulator (middle) and Soleco optimizer (right)

In parallel to the work done for the HP, building element interfacing, in particular for the thermostatic valves was also carried out. A temperature sensor and a Loxone miniserver have been shipped and installed at CSEM for communication tests. The concept of data aggregation and collection from the Loxone interface has been tested. It will rely on the HTTP API of Loxone which exposes on the local network or through remote server access signals or groups of signals. A template configuration for Loxone was prepared by CSEM as a starting point for the final deployment. It includes elements for the user interface devices Loxone Touch Pure Flex which will allow lighting, blinds and temperature setpoints control in the rooms.

4.3 Objective 3: evaluation and validation

In order to assess the scientific results of the project, the selection and location of additional sensors was carried out as illustrated in Figure 10. Technical challenge chalenges such as space, access and costs were faced.

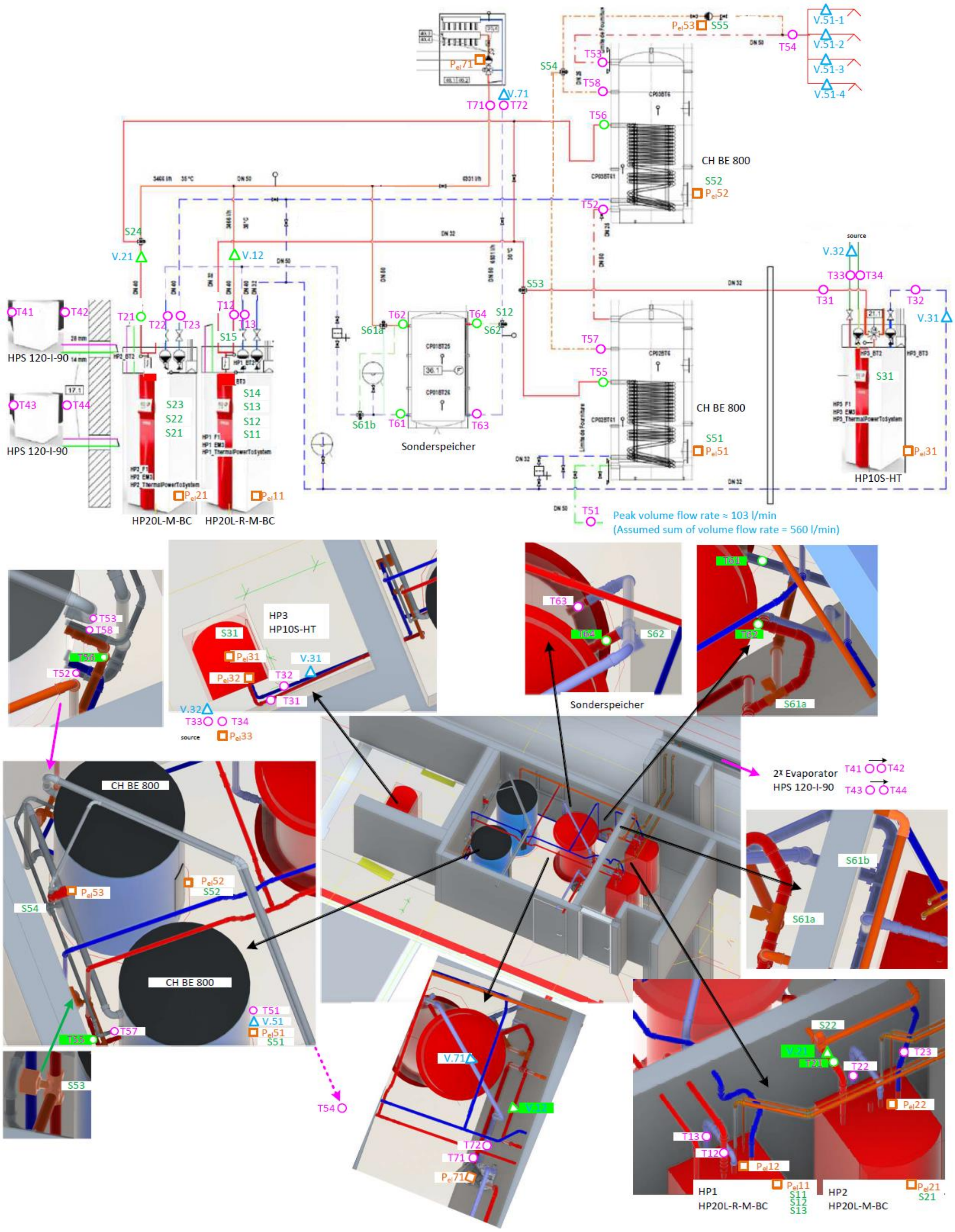

Figure 10: sensor layout concept. Top: overall schematic. Bottom: zoom on key mechanical locations

With these additional sensors, a precise quantification of the consumption and system efficiency, breakdown by SH and DHW. COP, WNG and SNG (Figure 11) can be carried out.

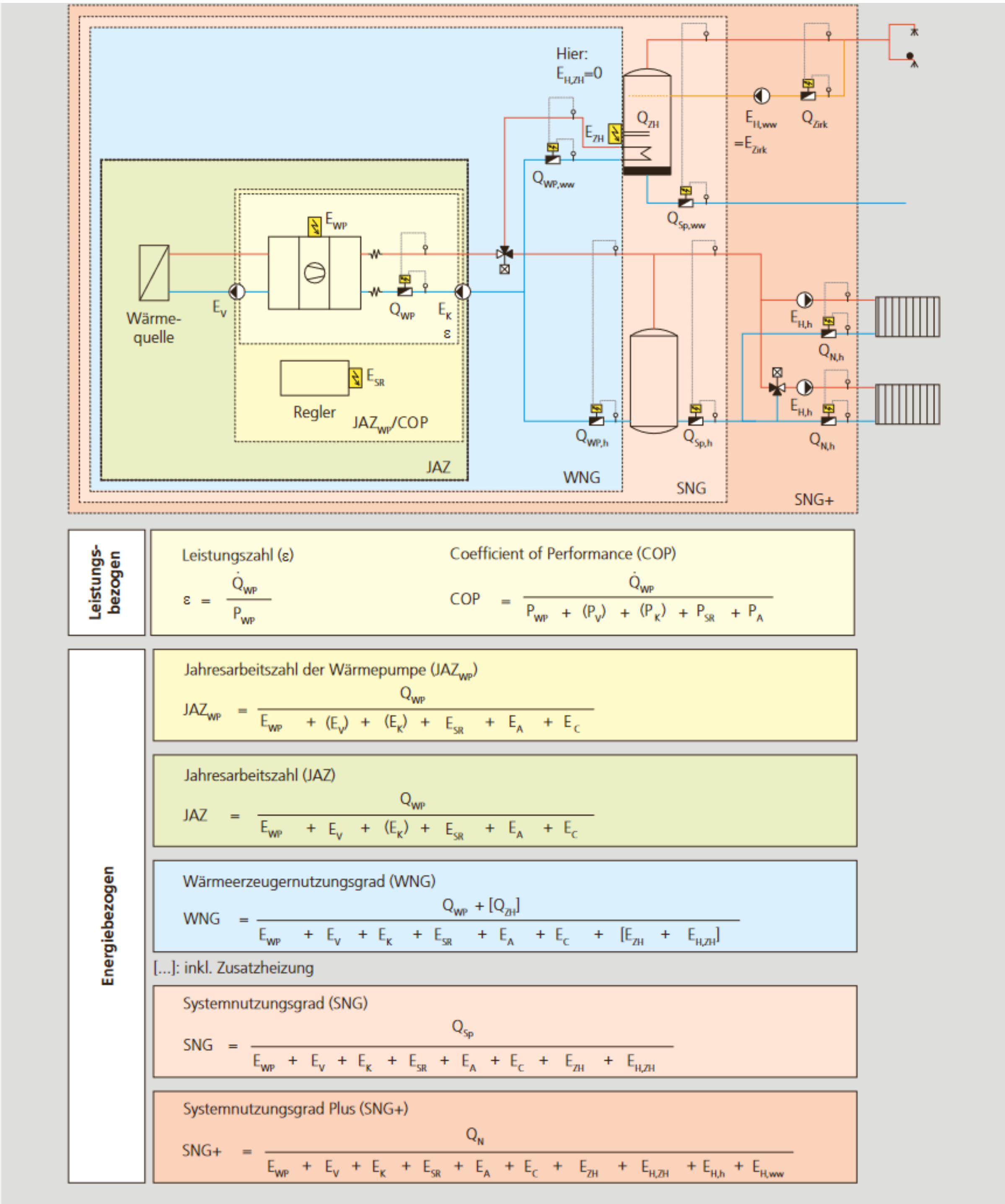

Figure 11: efficiency computation chart

In addition to the energy and efficiency KPI mentioned above, we will also compute:

- Energy costs: we recall that the default behavior of the Soleco Optimizer is to minimize the cost of operation while maintaining comfort, most importantly the net cost of purchasing/selling electricity. With standard tariffs, optimizing for cost leads to balancing improvements in both energy efficiency and self-consumption (two objectives which can be sometimes in competition)
- Comfort: absolute deviation w.r.t the temperature set-point. Also broken down into over/under-heating.
- Self-consumption and autarky

These KPIs will be computed for OPERA mode as well as the “standard” mode (Table 1). The “standard” control will be using a regular heating curve for the heat pump and letting the distribution system valves operate independently of the heat pump. The PV production is not taken into account for the HP operation. The remaining modes of Table 1 will be validated in simulation only.

In order to perform a meaningful comparison, the system should be operated in similar conditions (most importantly, weather) for sufficiently long period of times. We plan to operate in each setup for a minimum of 6 months. Switching from one control mode to another every 2 weeks is proposed.

Regarding energy consumption, it is notable that energy consumption and efficiencies are dependent on various external factors including heat demand for DHW, space heating respectively, and outside conditions. This will need to be considered for a fair comparison on the test sites. For this comparison taking into account the following factor will be considered:

- **Outside temperature** which will impact heat demand for space heating and heat pump COPs. Our preferred way of conveying the relation between consumption and outside temperature is by charting the considered metric (e.g. primary energy consumption for heating) against outside temperature. You can see an illustrative example in Figure 12. To summarize the data into a single KPis, normalization by heating degree days are usually used. They however assume a linear relationship between consumption and outside temperature which is only approximately true, especially for heat pumps where the COP depends also on the outside temperature
- **Solar irradiance** impacts heat demand significantly, although in our experience to a lesser extent than outside temperature during the heating season. The impact of solar irradiance is also dependent on blind use. The current plan includes blind position monitoring and a simple, active blind control.
- **Indoor temperatures**: higher setpoint lead to higher heat demand, everything else being equal
- **Hot water consumption**: this obviously leads to higher heat needs for DHW

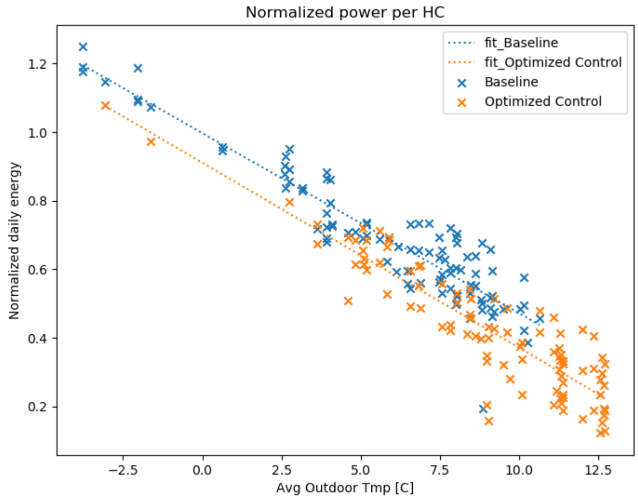

Figure 12: illustrative example of normalized daily usage vs outdoor temperature

Table 1: considered test cases. The ones that will be tested on the real site are highlighted in red (updated baseline ➔ shortened to baseline, standard or reference in the rest of the document and green (OPERA or optimized operation).

#	Name	Building	PV	HP control	Zone control	Measured
1	**Historic**	Old	No	-	Fixed setpoints	yes[9]
2	**Baseline**	Renovated	No	Heating curve	Fixed setpoints	-
4	**Standard mode**	Renovated	Yes	Heating curve	Fixed setpoints	yes[10]
5	**OptiClassic-PV**	Renovated	Yes	Self-consumption optim[11]	Fixed setpoints	-
6	**OPERA control**	Renovated	Yes	MPC (SOLECO)	Range of setpoints used by SOLECO (enabled by Loxone)	yes

[9] Yearly data available (not detailed timeseries)
[10] To measure this case, we must agree to be less energy efficient for a given time (typically a few months)
[11] Rule based (SmartFlox like)

5 Evaluation of results to date

5.1 Objective 1 (optimization)

Results:

The building control concept was defined, in particular how to adapt the MPC to handle such large buildings with multiple zone. Related to this, we defined the necessary sensors and communication concept. A first version of the MPC was deployed on a preliminary simulation environment to assess the functionality of the coupling.

Challenges:

The main challenges faced are linked to the scaling up from single family houses (or smaller MFH). This impacted the modeling aspects in the MPC. Where the solution was to aggregate the thermal zones and associated user temperature set-points. From a control point of view, the multiple HP and tanks also creates new challenges.

A second challenges was the user interaction, indeed finding a suitable mean to give enough control to the user, without over complexifying the system was needed. The solution was found in the new touch pure flex (from LOXONE) coupled to a tablet like user interface.

5.2 Objective 2 (interfacing)

Results:

The SGR profile for the HP was created. This collaborative work was done over two workshops as well as ad-hoc meetings. In parallel, a HP emulator was also developed which will be used to validate the work. We also focused on the LOX valves and associated environment. A system composed of several valves and temperature sensors was deployed at CSEM to validate the performed work. Bidirectional communication as required was demonstrated.

Challenges:

Two interrelated challenges were faced, that are linked to getting the right HP data as well as getting the HP to operate to serve flexibility needs for energy optimization and grid friendly behavior. For that we, created a common information model based on machine readable interface description of control devices for HP's. This information must fit for different stakeholders: specifiers, system integrators, programmers and end customer. The machine readable interface description needs information filters to tailor contents towards the stakeholders knowledge level. Like hints as example for programmer when looking for a datapoint like "this Setpoint works only in Mode ECO".

This also imposed, developing common procedures & support in a structured way in order to enable manufacturers for to satisfy theses needs, which are of scope for their existing business cases & procedures.

5.3 Objective 3 (evaluation and validation)

Results:

We defined the sensing concept to assess the HP efficiency and overall energy savings with the associated test and normalization procedure.

Challenges:

The main challenges are linked to the space constraints imposed by the site (see Figure 13):

1. Comply with the specifications for the volume flow sensors. To achieve accurate measurements, it’s important to meet the requirements for the entry- and outlet length given by the manufacturer. At some of the measurement points the available tube length between two adjoining sockets, valves or pipe bends are not sufficient to fulfill the required entry- and outlet length.
2. To install the temperature sensors, clamping-connections are used to bring the sensors in direct contact with the water. This results in precise measurements. The clamps are soldered into brass tubes with an appropriate diameter and length (see figure below). At some of the measurement points the available tube length between two adjoining sockets, valves or pipe bends are not sufficient to install the brass tubes with the sensors.

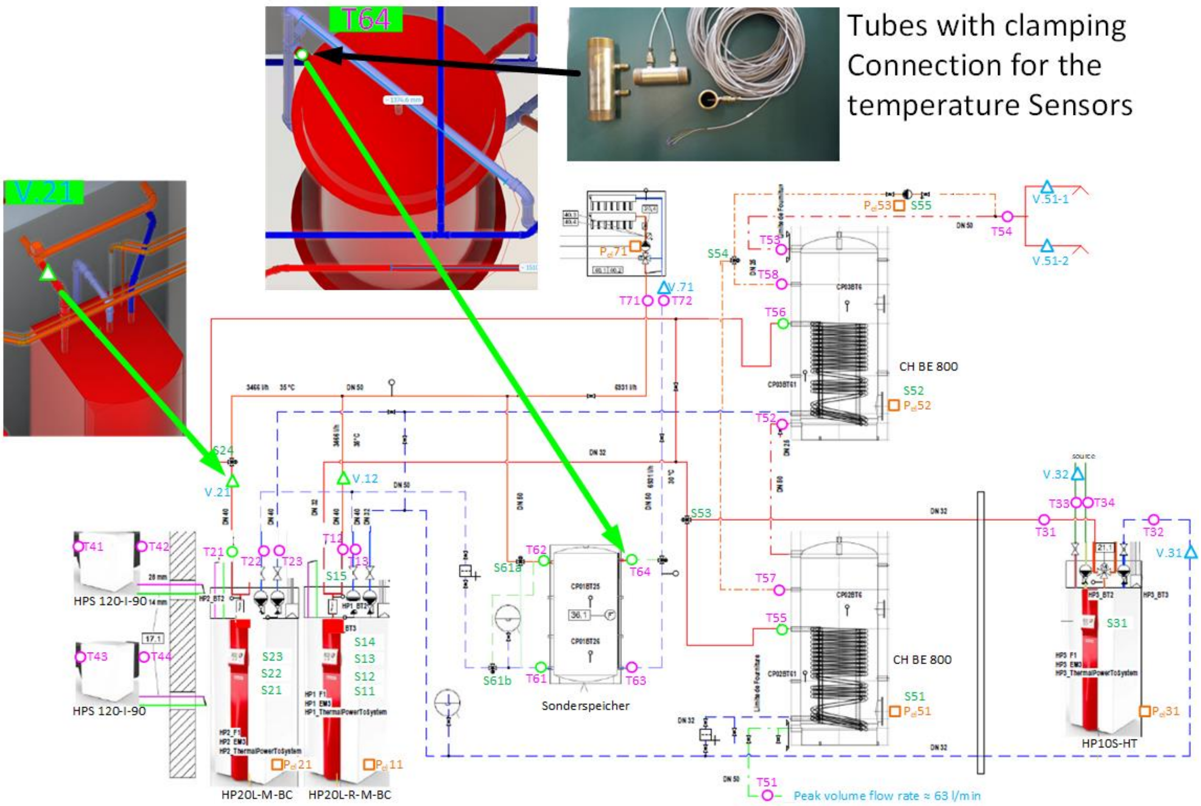

Figure 13: example of the installation of a volume flow sensor and a temperature sensor.

5.4 Deliverables

ID	Name	Responsible	due date (initial) M1: Aug. 2021 M40: Nov 2024	Due date (upated)	Due date (effective)	Comment
D1.1	Control and communication concept for optimized thermal management	SOL	M6 → Jan. 2022	Nov. 2022	Nov. 2022	Was delayed due to uncertainty on site equipment (cooling, user interfaces, shading, …)
D1.2	SGr Profiles for PAC proposed for approval to SGr standard	CSEM	M6 → Jan. 2022	Nov. 2022	Nov. 20221	Available, currently available withing the SGready community
D1.3	Test and verification plan for the pilot site	OST	M6 → Jan. 2022	Nov. 2022	Nov. 2022	
D2.1	Reference implementation for RM4 and RM5 according to SGr profile for HEL HP	CSEM	M10 → May 2022	Feb. 2023		
D2.2	Guidelines and best practices for implementing SGr for HP	CSEM	M12 → July. 2022	Feb. 2023		Propose to merge with D2.1
D2.3	Validation report of additional HP sensors	OST	M12 → July. 2022	Oct. 2023		
D3.1	Reference implementation of RM2 and 6 according to SGr profile for LOX building automation system	CSEM	M15 → Oct. 2022	Aug. 2023		
D4.1	Object code and documentation of simulation environment	CSEM	M10 → May 2022	Feb. 2023		First online version available (access via API).
D4.2a	object code and documentation of energy manager	CSEM	M18 → Jan. 2023	June 2023		First version of energy manager available, tested with preliminary environment of D4.1. No detailed documentation yet.
D4.2b	object code and documentation of optimized energy manager	CSEM	M30 → Jan. 2024	Unchanged		
D4.3	Evaluation report on full system optimization potential	CSEM	M30 → Jan. 2024	Unchanged		
D5.1	Intermediary report on system performance	OST	M30 → Jan. 2024	Unchanged		
D5.2	Final report on system performance	OSC	M40 → Nov 2024	Unchanged		

6 Next steps

The main activities for each WP are provided below:

1. Specification (**WP1**): no activity foreseen
2. HP interfacing (**Objective 2 / WP2**): validate the SGR profile on the HP emulator. Replicate on the tests site.
3. Building interfacing (**Objective 2 / WP3**): validate on test site and interface with optimization (WP4)
4. Optimization (**Objective 1/ WP4**): prepare final simulation environment. Adapt the optimizer and validate in simulation. Deploy on the site.
5. Evaluation and validation (**Objective 3 / WP5**): obtain preliminary results from HP monitoring and SOLECO optimizer (MPC)
6. Steering (**WP6**): organize a steering meeting.
7. Promotion (**WP7**): promote simulation results, if possible (test site results will not yet be available).

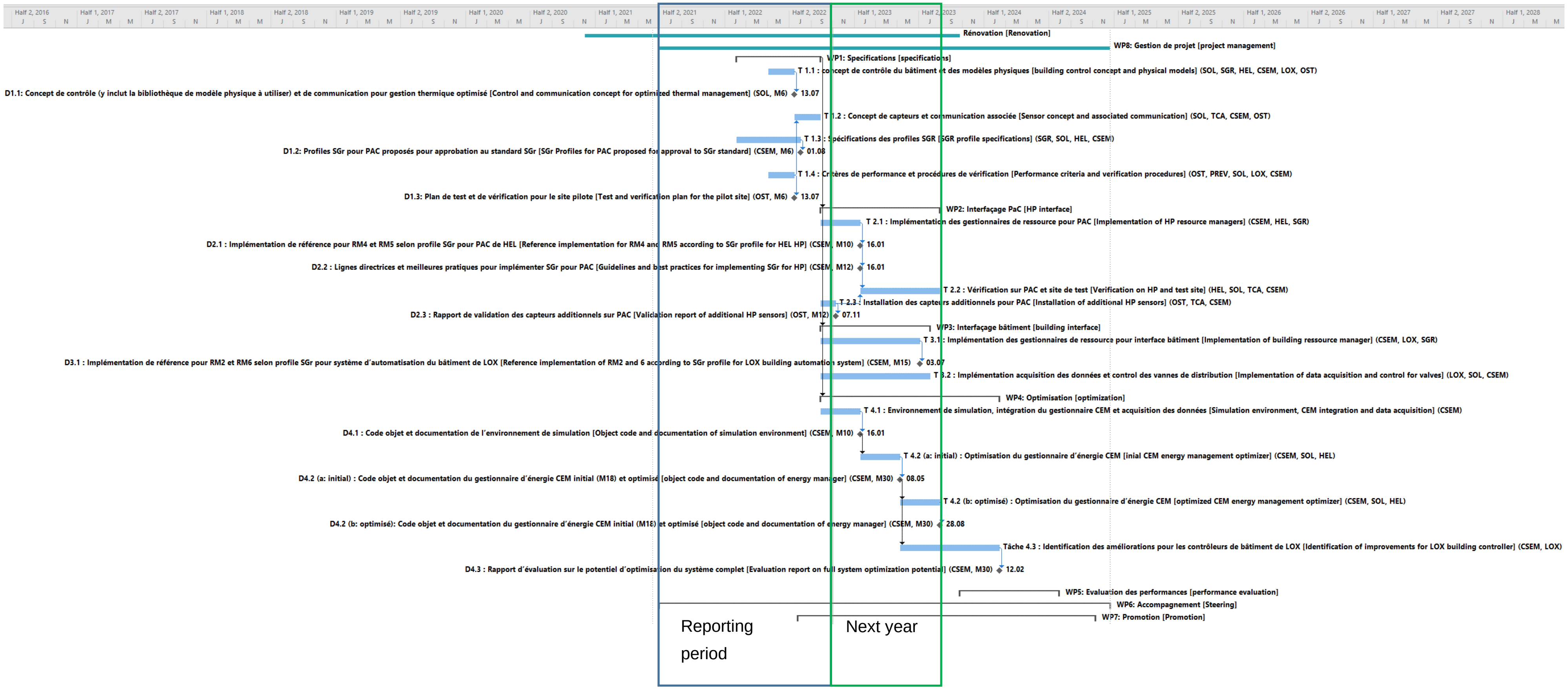

Figure 14: updated Gantt

7 National and international cooperation

Not applicable.

8 Communication

Not applicable (flagship projects only)

9 Publications

No publication yet.

10 References

References are embedded in the text.

11 Appendix

Not applicable