1 Description of the use case

1.1 Name of use case

Use case identification		
ID	System configuration(s)	Name of use case
MENB-UC01	MENB-SC	Use case for multi-energy network benchmark

1.2 Version Management

ID	Date	Author(s)	Changes	Approval Status
0.1	2021-04-26	Edmund Widl (AIT)	Initial version	Preliminary
0.2	2021-09-01	Tran The Hoang (CEA)	Minor update	Preliminary
1.0	2021-11-19	Edmund Widl (AIT)	Update use case to represent the final implemented benchmark setup	Final

1.3 Scope and objective of use case

Scope	The aim of this use case is the increase of the collective self-consumption in a sub-urban area, where the local PV generation is utilized for operating a power-to-heat facility. This effectively implements a local energy community (LEC), enabled through a sector coupling approach on distribution network level.
Objective(s)	O1: Maximise local consumption of PV generation through the operation of a power-to-heat facility O2: Mitigate local voltage band violations during high PV generation and low load demands (overvoltage) or low PV production and high load consumption (undervoltage)
Belongs to use case group (if applicable)	N/A

1.4 Narrative of use case

Short description
The electrical energy generated by the PV systems connected to the electrical network is converted by a heat pump to thermal energy and stored in a hot water tank. The hot water tank serves as a decentralized heat source for supporting the local district heating network. At the same time, this power-to-heat facility can be used to improve the stability of the electrical network. The operation of the overall system is determined by two controllers:

- A **voltage controller** monitors the voltage in the electrical network and proposes a power consumption setpoint for the heat pump (controllable/flexible load) to keep the voltage within acceptable limits.
- The **flex heat controller** operates the power-to-heat facility and decides whether the power-to-heat facility supports the thermal network by discharging the tank (decentralized heat supply).

Complete description

Voltage controller

In periods of high PV generation and low load consumption, overvoltage and grid congestion may occur in the electrical network. In this case, the voltage controller will send a request to increase the heat pump's power consumption, if possible. Moreover, in periods of high load (peak load) resulting in an undervoltage, the voltage controller sends a request to decrease the heat pump's power consumption or even cease its operation.

Flex heat controller

The flex heat controller can influence the operation of the power-to-heat facility by controlling pumps in two separate thermo-hydraulic loops:

1. Hot water can be drawn from the storage tank and fed to the supply line of the thermal network with the help of a hydraulic pump. Simultaneously, an equal amount of cold water is drawn from the heating network's return line to refill the tank. This hydraulic pump is actuated based on the temperature levels in the storage tank.
2. Cold water is drawn from the bottom of the tank, heated up by the heat pump and fed back at the top of the tank with the help of another hydraulic pump. The mass flow rate through the heat pump's condenser determines the heat pump's electrical power consumption, which aims to heat up the water to a specified temperature (constant condenser outlet temperature). This allows to control the heat pump's power consumption through the activation of this hydraulic pump, based on the temperature levels in the storage tank and the power consumption request from the voltage controller.

From the perspective of the thermal network, the following operational modes can be supported through the flex heat controller:

- *Mode 1*: network supplies, heat pump and hot water tank inactive
- *Mode 2*: network supplies, heat pump charges the hot water tank
- *Mode 3*: hot water tank supplies, heat pump off
- *Mode 4*: hot water tank supplies, heat pump on
- *Mode 5*: network supplies, hot water tank supports, heat pump off
- *Mode 6*: network supplies, hot water tank supports, heat pump on

Multi-energy network dynamics

The thermal and the electrical networks show a strong coupling, where effects in one system influence the other and vice versa:

- the voltage control scheme determines the power consumption setpoint of the heat pump
- the power consumption setpoint of the heat pump influences the charging rate of the storage tank
- the thermal demand together with the charging/discharging rate of the storage tank determine the temperature of the storage tank
- discharging the storage tank affects the temperature of the return line and subsequently the efficiency of the heat pump (as the return line serves as source for the heat pump)

• the temperature of the storage tank and the efficiency of the heat pump determine the actuation of the heat pump by the flex heat controller • the actual power consumption of the heat pump (which can be less than the setpoint) directly affects the decisions of the voltage controller

1.5 Optimality criteria

ID	Name	Description	Reference to mentioned use case objectives
C1	Thermal energy savings	Maximization of conversion of electrical energy from PV generation for heat supply	O1
C2	Reverse power flow reduction	Minimization of power flow reduction of electrical energy from PV generation to higher network levels	O1

1.6 Use case conditions

Assumptions
• PV generation is very high and can occasionally cause power flow reversals to higher network levels. • Control signals are assumed to be ideal (no noise, no losses, no delays, etc.).
Prerequisites
N/A

1.7 General remarks

This use case provides a simple sector coupling scenario for a local energy community, intended for benchmarking the simulation of multi-energy systems. The authors are aware that it is based on several naïve assumptions, which would make its implementation infeasible in real-world conditions (e.g., due to economic constraints). For more information on real-world applications of energy communities (including sector-coupling), the reader may for instance refer to: https://www.ceer.eu/documents/104400/-/-/8ee38e61-a802-bd6f-db27-4fb61aa6eb6a

2 Actors

Actor name	Actor type	Actor description
Electrical network	System	The electrical network supplies power to its connected consumers.
Thermal network	System	The thermal network supplies heat to its connected consumers.
Power-to-heat facility	System	The power-to-heat facility comprises a heat pump connected to a thermal tank, which feeds into the thermal network's supply line to support its operation. By consuming local excess PV generation, the power-to-heat facility can be used

		at the same time to improve the stability of the electrical network and support the supply of the thermal network.
Flex heat controller	Device	The flex heat controller decides whether the heat supply is covered entirely through the external grid or whether the power-to-heat facility supports the local thermal network. The flex heat controller adjusts the power-to-heat facility's electrical power consumption based on the input from the voltage controller.
Voltage controller	Device	The voltage controller monitors the voltage in the electrical network. It coordinates with the flex heat controller to keep the voltage in the electrical network within acceptable limits.

3 Graphical representation of use case