Configuration of Microgrid / Decentralized Energy System

Based on user defined system options, the solver of the tool determines the optimum system configuration. Since the system operation is optimized simultaneously, also the best fitting operational strategy can be extracted from the result. The optimization goal has to be defined by the user and can include economic and environmental aspects.

Definition of configuration options

The definition of options includes technical and economical constraints with respect to both configuration and operation of the total system and the respective building blocks.

What options do exist?

- Resources[1] → sources of energy,
- Domains → which energy carriers need to be considered with distinct system internal infrastructure depending on demand,
- Nodes → respecting the spatial distribution of existing infrastructure at the location,
- Technologies → all applicable components for energy generation, conversion and storage,
- Loads → all demand to be supplied (can also include flexible loads).

In general, all technology options are available at every node. Reasons for different options at distinct nodes are:

- Existing loads that needs to be covered, fixed at a distinct node,
- Existing coupling points to external infrastructure, if this type of infrastructure is not considered for system internal installation.

Example system: In the following figures, options for configuring an example microgrid are shown. The system can be configured considering 3 spatially distributed nodes. Several thermal loads – with and without flexibility – are attached to node 2. Electrical and cooling loads occur at node 3. The system can opt for coupling to the external power distribution grid at node 1 and natural gas network at node 3.

Following these conditions, the microgrid is regarded as a multi-energy system. The existence of the three types of loads is reflected by the energy domains options of electricity, heat, and cooling. With respect to the different voltage level of the external distribution grid and the microgrid itself, the electricity domain can be split into a medium voltage (MV) layer and a low voltage (LV) layer. Equally, due to different temperature levels of the heat loads, the heat domain can be separated into a medium temperature (MT) layer – about 65°C – and a low temperature (LT) layer.

A wide range of technology options is considered to supply the loads. There are generation, conversion, and storage technologies available for all three domains. The technologies are considered for the installation at every node. The only exception is the combined heat and power (CHP) device based on fuel cell technology. This co-generation unit needs to be fueled by natural gas. Since in this example the installation of system-internal infrastructure for transport and storage of natural gas is not part of the configuration options, the CHP can, if any, only be installed at node 3, where a coupling point to the external natural gas network exists.

The schematics in Figure 1 to Figure 3 show the available options for nodes 1 to 3.

[1] This document focuses on the system configuration and the options in terms of physical technologies and resources. Thus, economic resources like revenue options for selling energy are not depicted in the schemes provided here, but are of course an important factor for the resulting configuration.

Options for configuration of exemplary Microgrid / Decentralized Energy System
@ Node 1

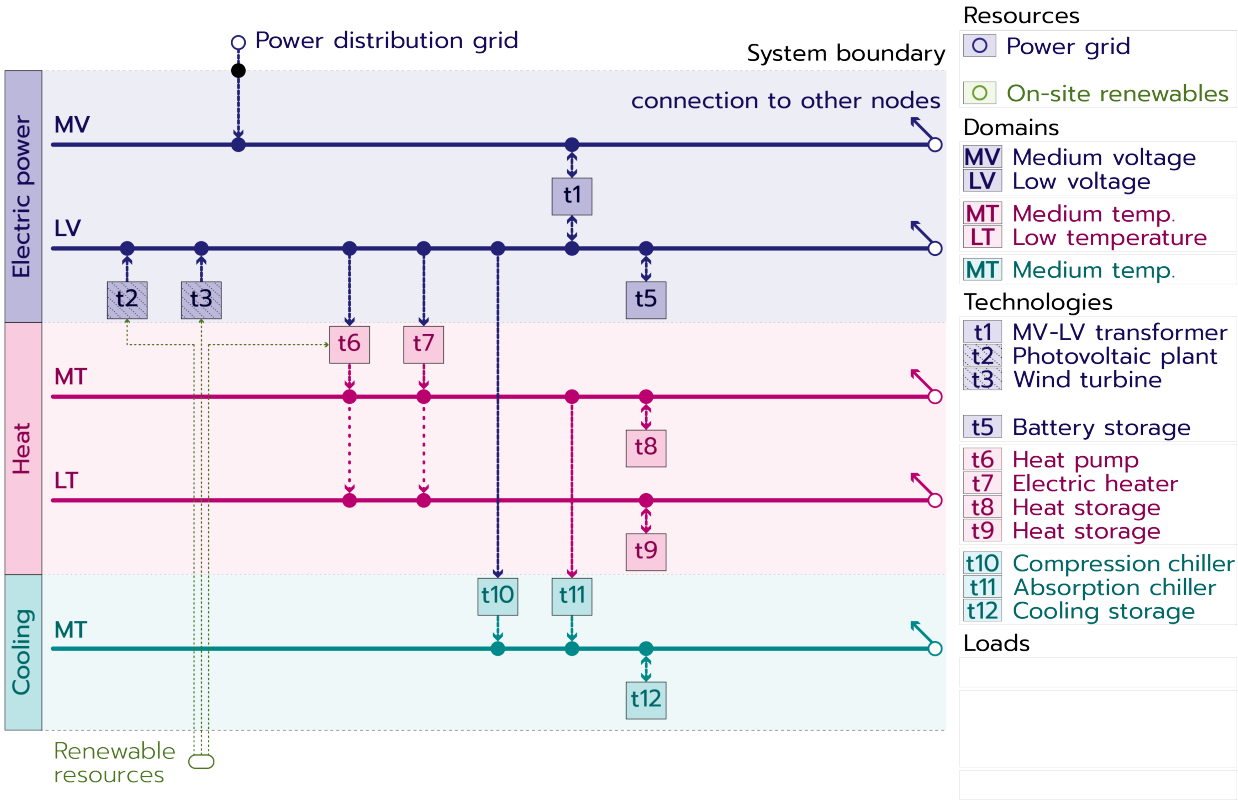

Figure 1: Configuration options – node 1

Options for configuration of exemplary Microgrid / Decentralized Energy System
@ Node 2

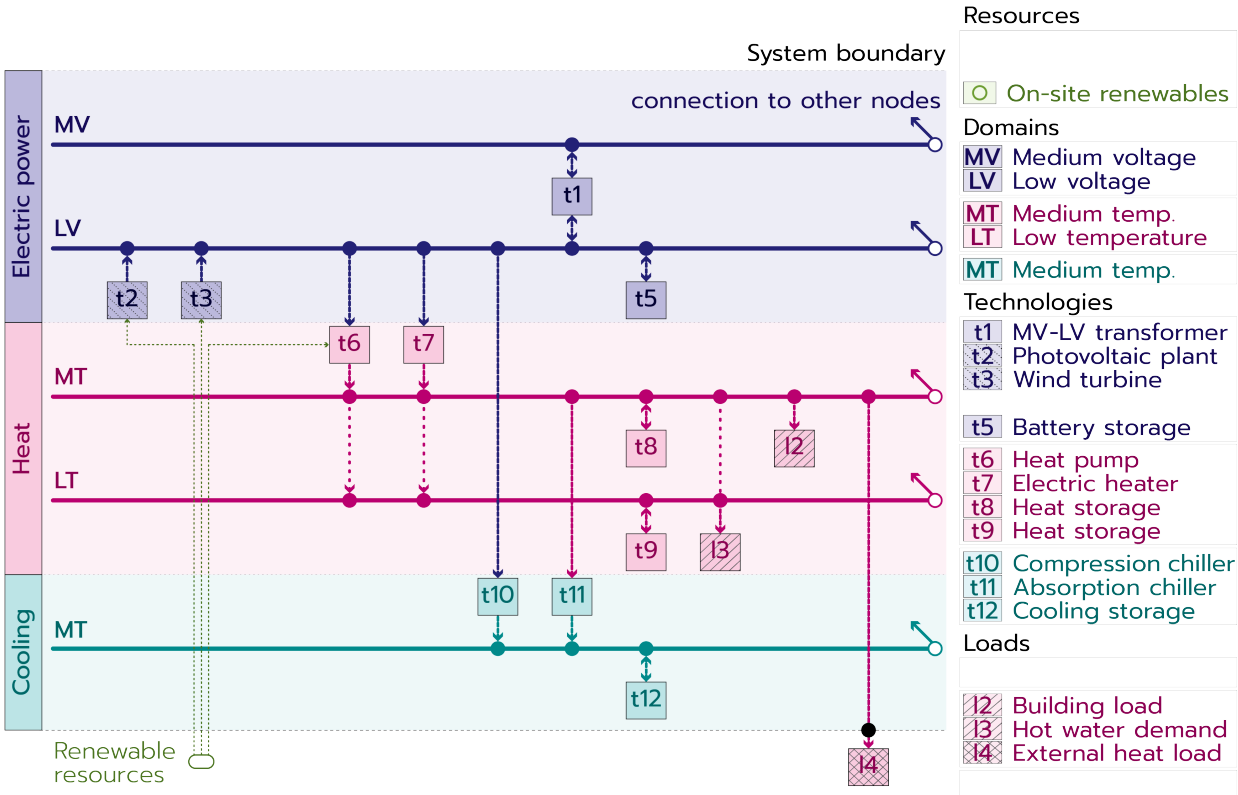

Figure 2: Configuration options – node 2

Options for configuration of exemplary Microgrid / Decentralized Energy System
@ Node 3

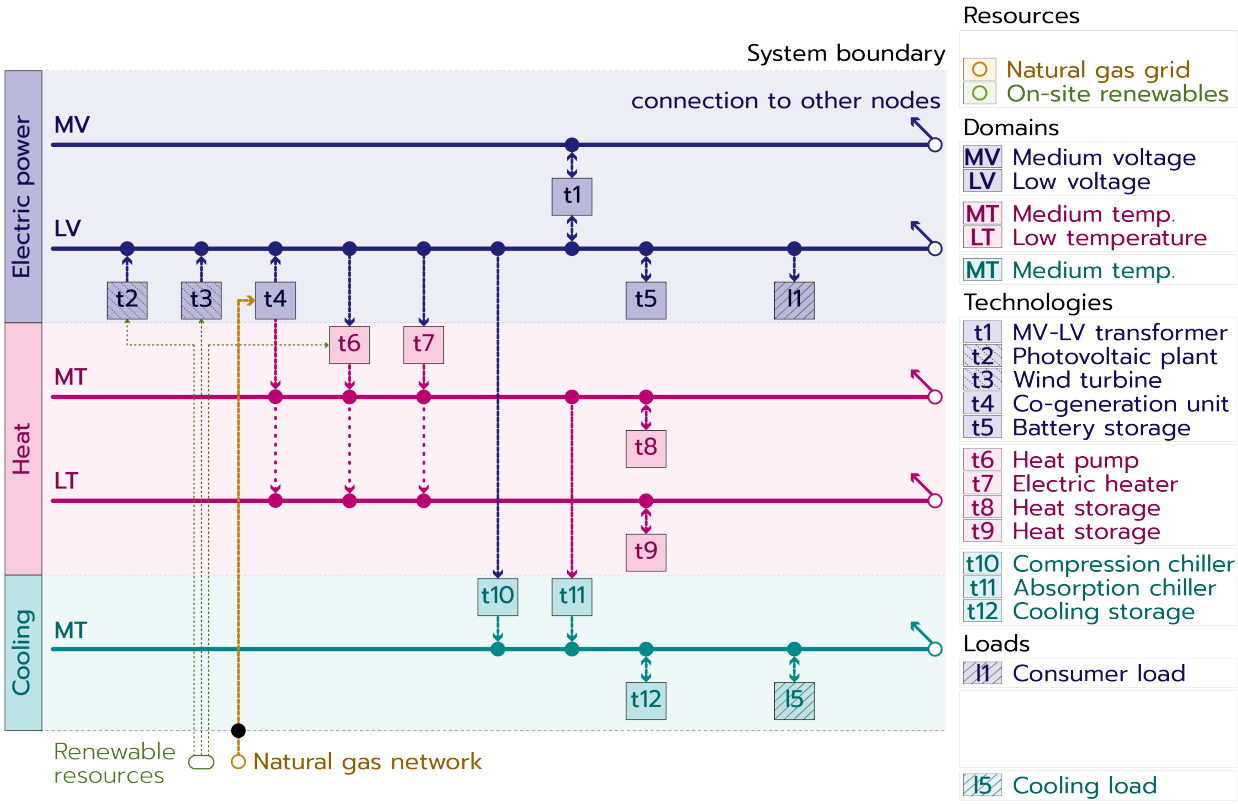

Figure 3: Configuration options – node 3

To simplify the parameterization of configuration options and also reduce the model complexity, the system can be depicted as a one-node-system. In this case, the spatial distribution of nodes and technologies is neglected, and thus the overlaying / underlying networks are not considered. This is a fair assumption in case of small distances between nodes. Also, if in a first step the user is only interested in knowing about fitting technologies, not in the network configuration, the modelling as one-node-system does make sense. The options for the exemplarily project aggregated into one single node are shown in Figure 4.

Options for configuration of exemplary Microgrid / Decentralized Energy System
aggregated view (one node only)

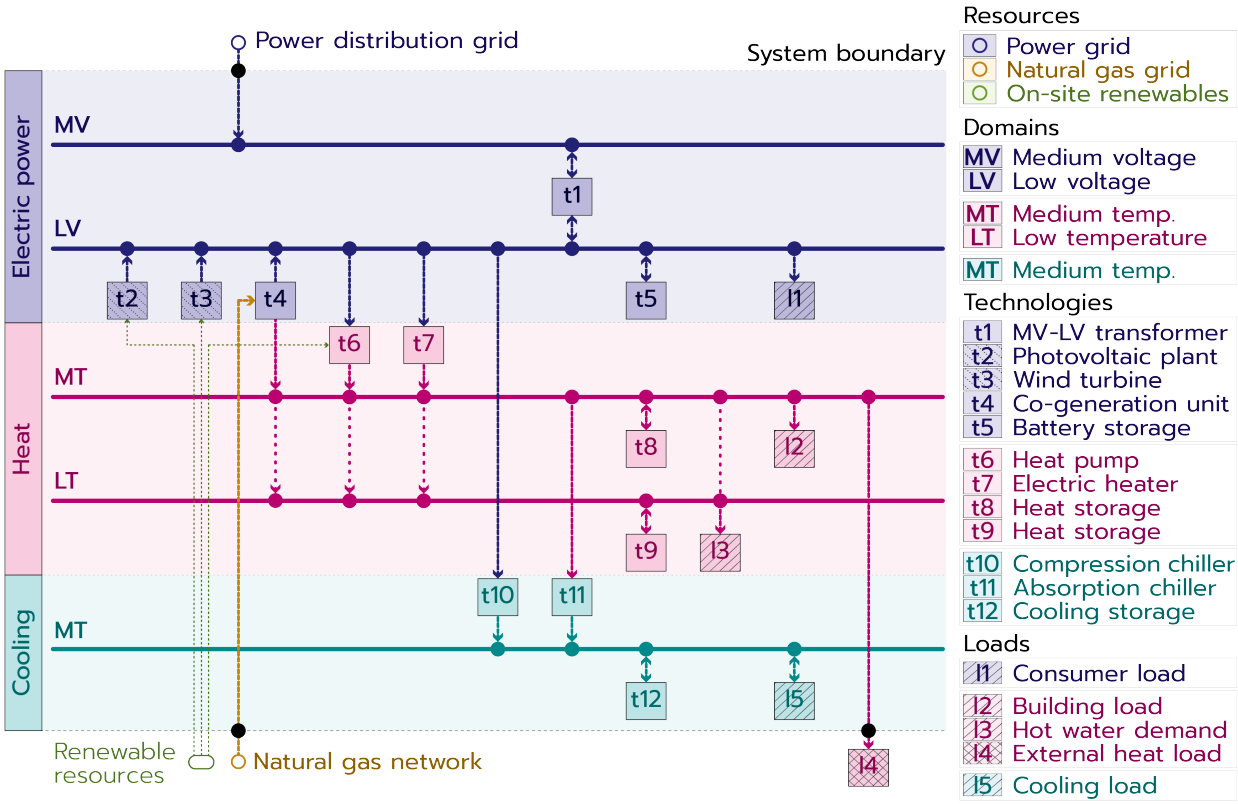

Figure 4: Configuration options – aggregated view (one node)

Resulting optimum system

The solver of the microgrid configurator issues an optimum assembling of components, with respect to installed capacities and location of deployment. For the given example, the results are depicted in the following figures.

As shown in Figure 5, at node 1 the two different voltage level buses are deployed. As installed technology, only the transformer between medium level and low voltage level is selected. Furthermore, there exist a connection from the LV bus to node 2.

At node 2, shown in Figure 6, both a photovoltaic (PV) system and battery storage are installed. There can be several reasons for selecting this specific node for PV installation in the exemplarily system which should be not specified here. As node 2 is the location where the thermal loads connect to the system, a heat bus is installed. Selected is the one with the higher temperature level. A heat pump using the environmental air as heat source is installed as a technology linking electrical and heat domains. The electrical LV bus of node 2 also connects to node 3, as does the heat bus.

Finally, at node 3 the existing electrical and cooling loads lead to the installation of both an electric LV and a cooling bus. A co-generation unit, fueled by the coupled natural gas network, provide both electricity and thermal heat. Part of the heat is used by an installed absorption chiller system that supplies the cooling load. A storage connected to the cooling bus provides some flexibility.

Optimum configuration of exemplary Microgrid / Decentralized Energy System
@ Node 1

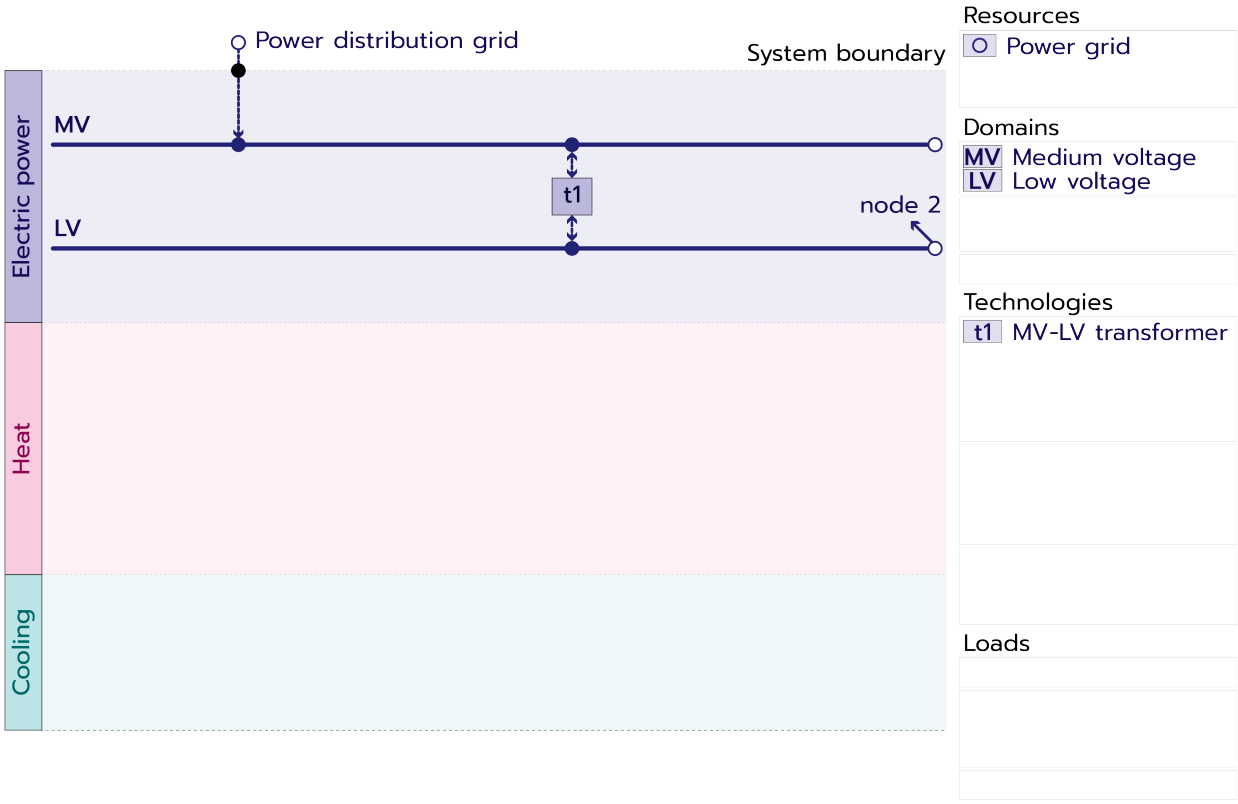

Figure 5: Optimum configuration – node 1

Optimum configuration of exemplary Microgrid / Decentralized Energy System
@ Node 2

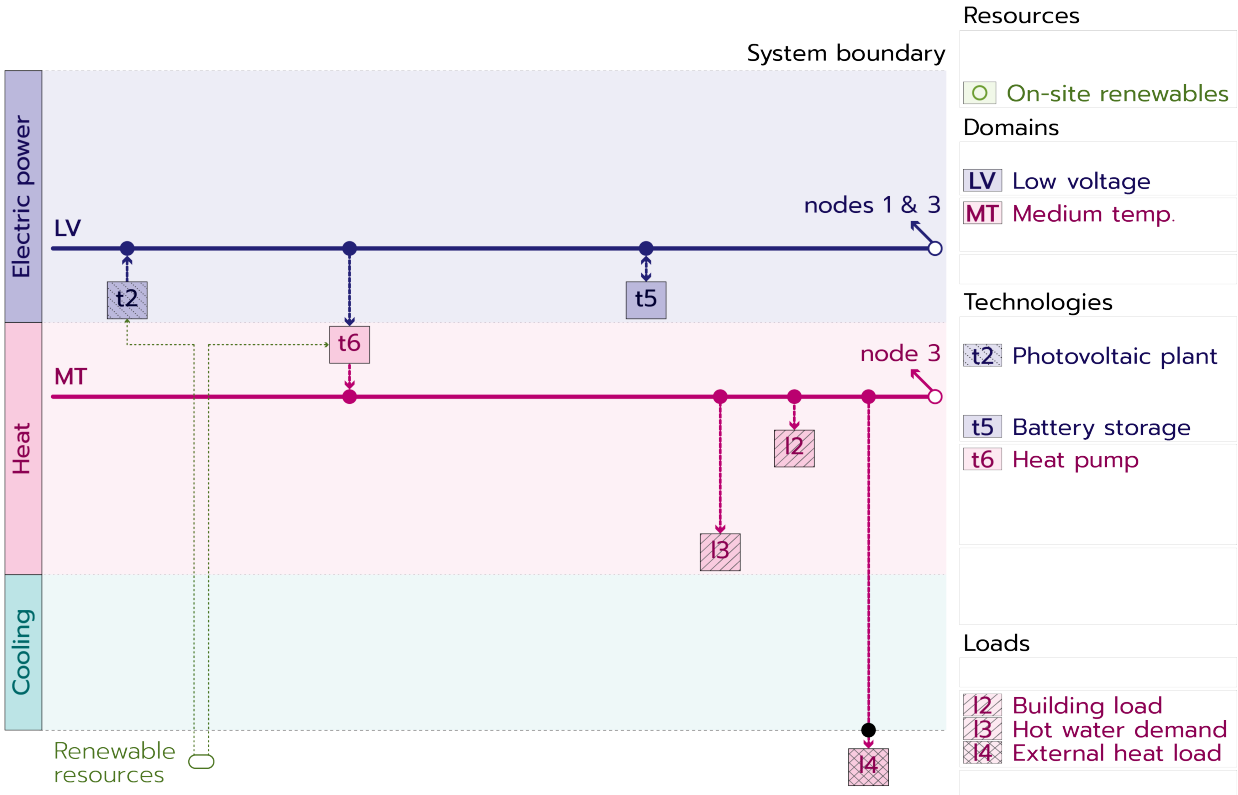

Figure 6: Optimum configuration – node 2

Optimum configuration of exemplary Microgrid / Decentralized Energy System
@ Node 3

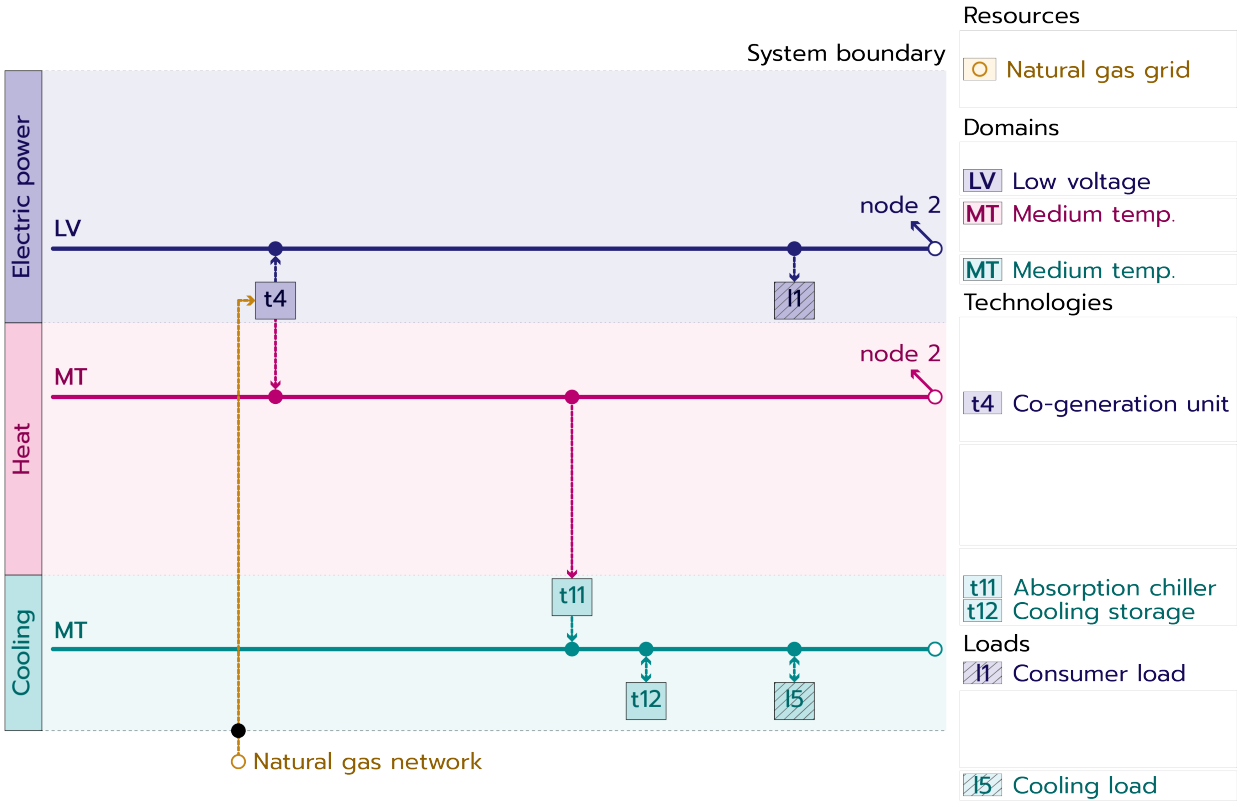

Figure 7: Optimum configuration – node 3

Again, this system can be displayed as a one-node-system, as shown in Figure 8. It should be noted, that when simulating the simplified one-node-system the simulation result might differ depending on the user's objective, and applied values for economics and environmental characteristics, respectively.

Optimum configuration of exemplary Microgrid / Decentralized Energy System
aggregated view (one node only)

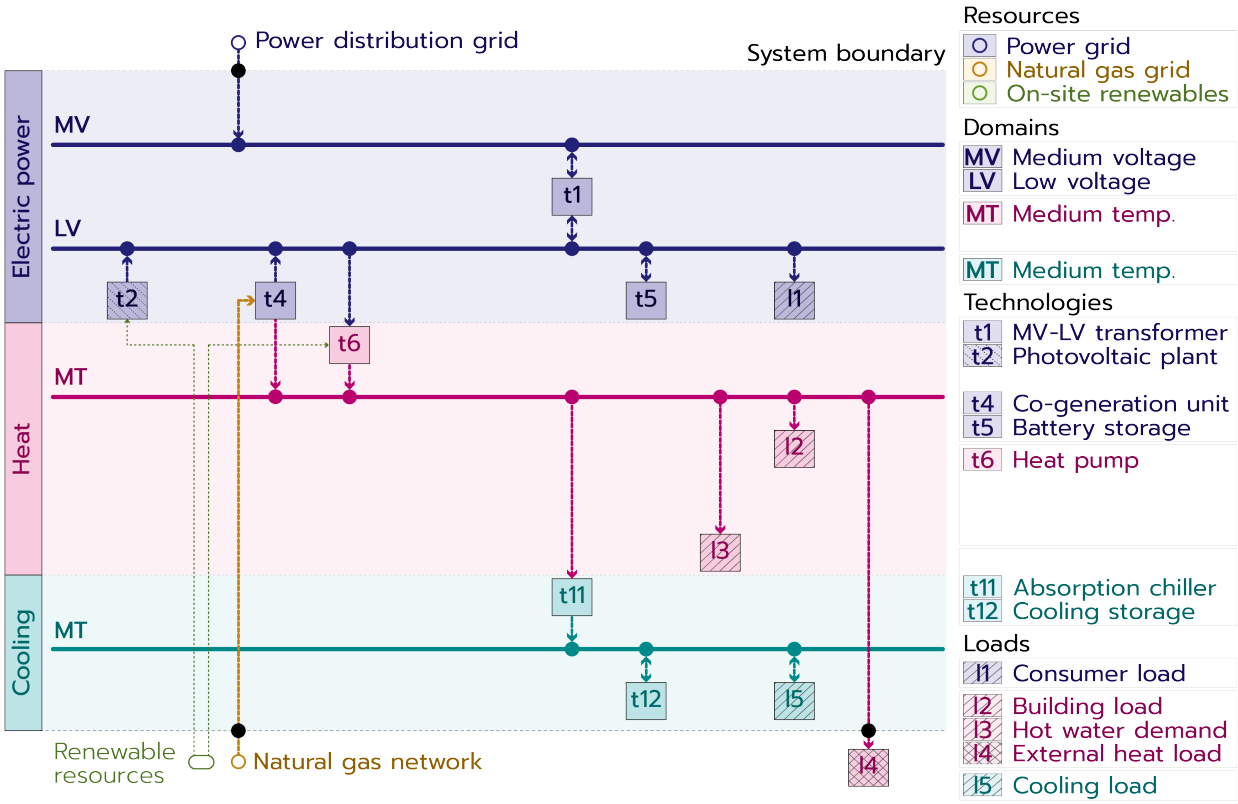

Figure 8: Optimum configuration – aggregated view (one node)

The following Figure 9 provides an overview of the total system, as shown in Figure 5 to Figure 7, with a 3-dimensional rendering. This kind of representation allows for a more intuitive understanding of the resulting system configuration and its spatial distribution.

Optimum configuration of exemplary Microgrid / Decentralized Multi-energy System
showing system boundaries, energy domain layers, nodes, interconnections, and components

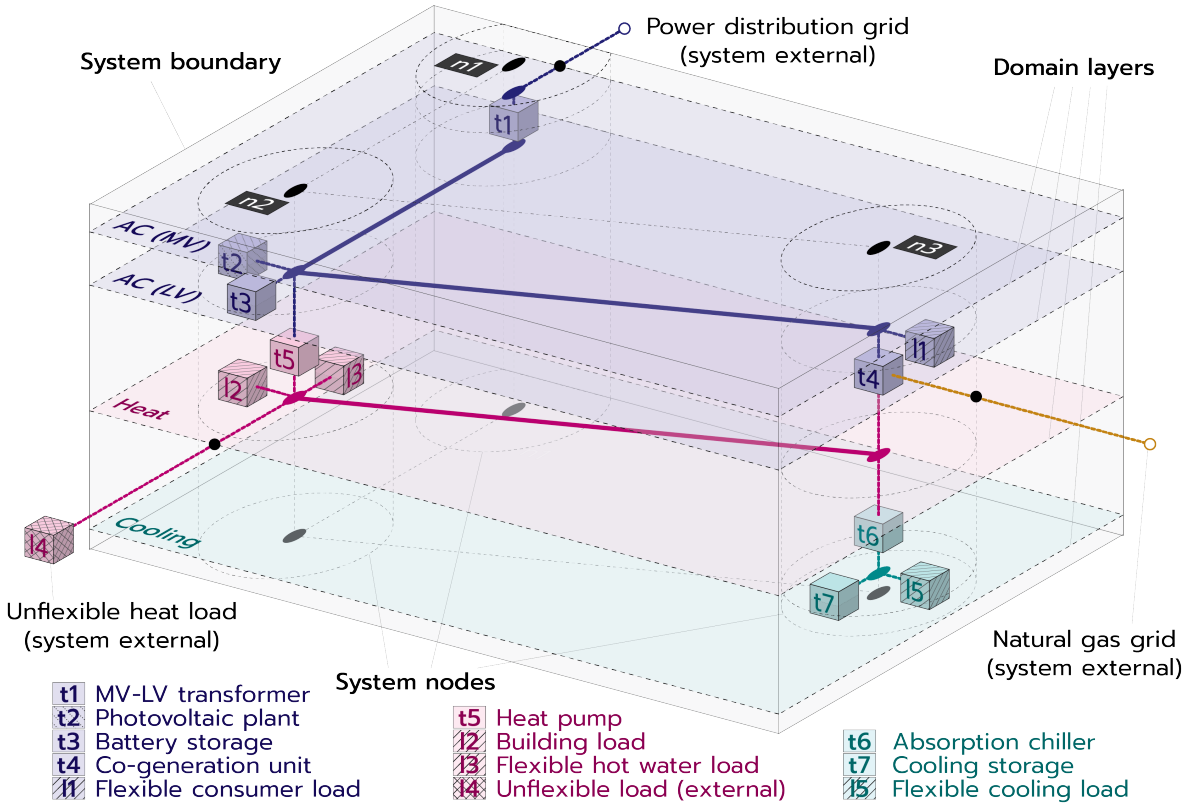

Figure 9: Optimum configuration – 3D schematic showing the total system