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EnEff:Wärme: HybridBOT_FW - Transformation of the urban district heating supply

Key definitions of the project

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Key definitions of the project

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1 Introduction

The main target of the HybridBOT_FW project is to demonstrate the options to optimise the operation of heat grids as a part of a hybrid energy system.

1.1 Overall method

Specifically, this is to be achieved by developing an output-oriented or grid-supporting operation of two existing energy systems, which are physically separate from each other. The first energy system originates from the "electricity" sector (electrical energy systems). The second energy system originates from the "heat" sector (thermal energy systems).

Approaches for an optimised and integrated operation are being developed, tested, evaluated and implemented. Specifically, this is done by combining electrical distribution networks and district heating networks.

1.2 Relevant terms including hierarchy

In the context of the research project, the following terms are important:

- Hybrid energy systems
- Hybrid grids
- Hybrid grid structures

- Sector coupling
- Transformation scenarios

- Grid-supportiveness
- Grid-supportive operation strategy

- Coupling technologies

- Design methodology

- Regulatory framework

- Functional energy storage

The relevant terms are hierarchically related. Figure 1 shows this and provides a keyword-like reference to the respective terms. Figure 1 is to be read in detail from outside to inside or left to right in connection with the definitions.

In general, the framework is the hybrid energy system, in which different sectors are coupled. Specifically, this takes place in hybrid grids with associated grid structures. The resulting sector coupling makes cross-sector energy conversion possible. For this purpose, energy systems must be transformed into hybrid energy systems. In the specific case, the decisive guiding aspect is grid efficiency, which is achieved by an operating strategy that serves the grid. This requires customised coupling technologies for the individual case, which in turn require a design methodology. The hybrid energy system underlies regulatory framework conditions.

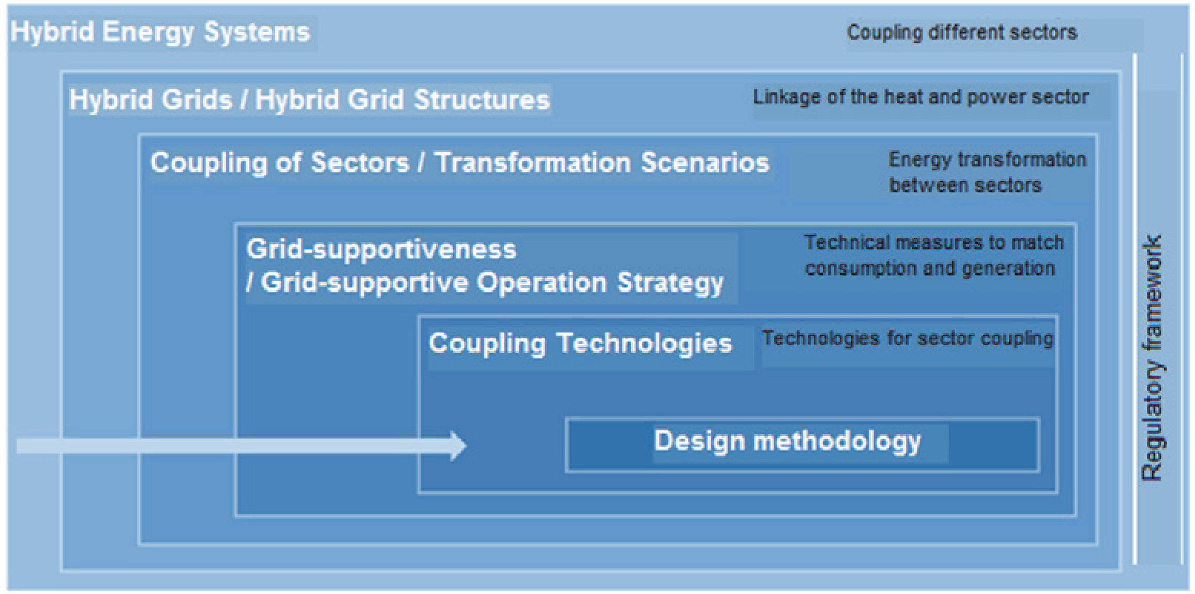

Figure 1: Hierarchical terms

1.3 Objective of the definitions of terms

Definitions determine the meaning of a term in such a way that one learns its meaning without prior knowledge of the term. Among other things, definitions do not claim to be exhaustive, they represent a consensus regarding the understanding of terms, and they are useful.

In this document, the definitions of the terms listed in Section 1.2 are included in a project-specific context, i.e., they are clearly aligned with the understanding of the project. The requirements from the triangle of energy policy objectives (economic efficiency (affordability), environmental sustainability, and security of supply) as goals are guidelines for the project. Therefore, these are not considered separately in the definitions.

2 Term definitions

The definitions are based on the empirical knowledge of the project participants, and on literature; the literature used is indicated with the respective definitions.

2.1 Hybrid energy systems

By **hybrid energy systems**[1] we understand an energy system resulting from the coupling of generators, consumers and storage facilities from different sectors. The coupling of the generators, consumers and storage options as well as the conversion of the energy takes place with centralized and/or decentralized plant technology in the hybrid grid. The generation[2] is based on renewable energy sources and/or unconventional, decentralized energy generation.

2.2 Hybrid grids

By **hybrid grids**[3] we specifically understand linking the physically separate power and heat grid into a functional power and heat storage system for generation, transport and consumption using different coupling technologies.

The goal of the linkage is to transform the heat grid into a functional energy storage system that can store larger amounts of energy.

2.3 Hybrid grid structures

By **hybrid grid structures** we understand the topological information of a hybrid grid with, if applicable, its representation on the corresponding observation levels, such as for example

- Network area (for example: city, district)
- Voltage level (for example: medium voltage, low voltage)
- Network structure (for example: beam network, ring network)
- Generation and load situation (for example: location and dimensioning of generation plants, location and demand of consumers)

[1] With consideration of [2] and [3]

[2] It is physically correct that energy cannot be generated, but only converted. The term energy generation, for example - actually energy conversion in a form usable by humans - and others such as energy consumption are to be understood within a context and have become naturalized in this context.

[3] With consideration of [2] and [3] and [4]

- Coupling points (centralized, decentralized)

The goal of hybrid grid structures is to evaluate the existing state / the situation of the grid with regard to the following purposes:

- Integration capability of producer-consumer and storage structures
- Applicable coupling technologies

2.4 Sector coupling

By **sector coupling**[4] we understand the linking of the electricity, heat and transport[5] sectors, in which one sector provides the energy that is used in another sector, with the possibility of a new conversion of the energy between the sectors.

The aim of sector coupling is

- Decarbonisation with accompanying substitution of fossil energy sources and thus reduction of greenhouse gas emissions,
- Increasing the flexibility of the underlying energy system, and
- Increasing the efficiency of the underlying energy system

2.5 Transformation scenarios

By **Transformation scenarios**[6] we understand possible future developments of an energy system that leads to a hybrid energy system, considering

- the goal of decarbonisation,
- the levels of generation, consumption and storage with generation options and plant technology,
- the available coupling technologies,
- the options
  - Coupling of existing grids
  - Further development to/conversion to new grids
  - Combination with newly built grids of the latest generation,
- the requirements of the stakeholders, and
- grid serviceability, reflected in the grid serviceable operation strategy,

[4] With consideration of [6] und [9]

[5] In principle, the transport sector is taken into account in the modelling of the research project, but is only represented in a very simplified form in the modelling.

[6] In the research project, the transformation of heat networks is the topic of interest.

whereby the research project for district heating applications/district heating systems and power-heat interaction will specifically develop the following innovations:

- Grid-serving and economic operation of the heating grid by using heat storage capacities.
- Reduction of load peaks both on the heating network side and on the electricity network side through cross-sector control technology.
- Innovative supply models by lowering the network temperatures, in particular through a high sliding mode of operation (reduction of heat losses and integration of renewable heat generators) in the context of the operation-optimised and grid-supporting interaction "electricity-heat".

In the in-depth analysis, economic considerations and thus also the consideration of electricity market scenarios and price changes in the currently volatile situation will play a role in individual cases.

2.6 Grid-supportiveness

By **Grid-supportiveness**[7] we understand

- positive technical effects on the grid through the hybrid energy system. This can be achieved, for example, by smoothing peak loads in the power or heat grid or by (exploiting) load shifts.
- the avoidance of local grid bottlenecks caused, for example, by single or multiple electrical plants or by the failure of operating equipment.
- the long-term reduction of grid expansion, the reduction of grid costs and thus the increase of economic efficiency.

2.7 Grid-supportive operation strategy

By **Grid-supportive operation strategy**[8] In the complex hybrid energy system, which is subject to mutual interactions, we understand the process of identifying and planning the selection of the most sensible operating options or the optimum operating point, including implementation. This is done in particular through context-appropriate technical measures for balancing consumption and generation through appropriate control and regulation with the most optimal exploitation and use of operating resources. The overriding objective is grid supportiveness, including the criteria applied there (see Section 2.6), which also includes

[7] With consideration of [5]

[8] With consideration of [7]

economic efficiency; in particular, the economic optimization of heat generation and energy procurement costs for the customer and the utility.

2.8 Coupling technologies

By **coupling technologies**, we understand technologies for sector coupling, including the technical equipment and associated software required in each case, which are geared to the hybrid energy system with the associated hybrid grid in the specific individual case. Specifically, in the research project, these include technologies for coupling photovoltaic systems, CHP units, heat pumps, electric heating rods and heat transfer technology with buffer storage.

2.9 Design methodology

By **design methodology**, we understand the systematic approach to the design and dimensioning of coupling technologies, including the required technical equipment, that is tailored to hybrid energy systems and hybrid grids. Although these are based on the standard design for previously separate systems, they take into account the necessities and changes as well as additions resulting from coupling. The aim is to achieve technically and economically reliable operation in the long term and, in particular, to avoid oversizing.

2.10 Regulatory framework

By **regulatory framework**, we understand the legislative environment that influences

- the planning and implementation of business strategy, and
- the design of business models to implement the grid-supporting operating strategy, and
- the planning, construction and operation of hybrid networks, and

that inhibits or incentivizes economic viability. In a broader sense, this also includes support programs such as the Federal Support for Efficient Heat Networks (BEW), the Federal Support for Efficient Heat Networks (Wärmenetze 4.0 of 11 December 2019) [1] and other relevant federal subsidies, in particular those relating to new construction.

2.11 Functional energy storage

By a **Functional energy storage**[9] we primarily understand centralized or decentralized, electrical or thermal storage facilities that allow the coverage of non-simultaneous supply and demand of energy through storage at the time of supply and provision at the time of demand. This is complemented by load management and flexibilisation of energy generation and consumption.

Figure 2 shows the flexibilisation through functional energy storage in the interaction of conventional storage, generators and consumers. Examples can be given, also in connection with Figure 2, beyond well-known, purely conventional storage systems as functional energy storage systems (load management and flexibilisation):

- Power2Heat applications
- Heat storage in connection with CHP plants
- Controlled charging and discharging of electric vehicles
- Flexibilisation with heat pumps by, for example, using the building mass

By decoupling supply and demand over time, functional energy storage systems contribute to peak load smoothing and load flexibilisation, thus supporting the grid.

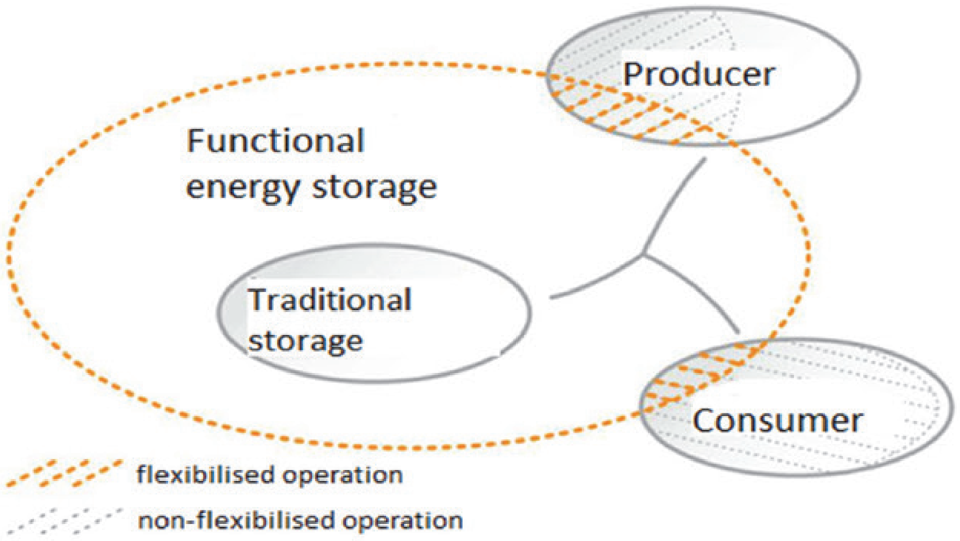

Figure 2: Illustration of the conceptual space of functional energy storage ([8], Figure there 2-1)

[9] With consideration of [10]

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