Generalized Operational FLEXibility for Integrating Renewables in the Distribution Grid (GOFLEX)

D9.1 Report on Requirement and Prosumer Analysis – Use Case 3

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Project: Generalized Operational FLEXibility for Integrating Renewables in the Distribution Grid (GOFLEX)

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Legal disclaimer

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Executive Summary

This document D9.1 represents the first deliverable of *GOFLEX Work Package 9.*

Document D9.1 summarizes the basic requirements, boundary conditions and constraints of the German demo site necessary for the solution partners to develop, install, test and run the GOFLEX deliverables in the territory of the SWW Wunsiedel GmbH. Technical details of requirements will be specified in separate working documents, developed for internal use only. The requirements specified here stem from three reference participants, which should cover all technical challenges of flexibility and prosumers in SWW's territory. All technologies installed in Wunsiedel field environment have to fit into SWW's technology roadmap (see attachment A1) and business strategy (see Section 3.2). The document gives an impression what kind of changes to SWW's organization might be necessary, if the GOFLEX solution was adopted at the end of the project (see Section 3.1).

As a response to this document a system design specification shall be supplied by the GOFLEX Technical Architect reflecting how the solution partners intend to fulfil the requirements specified here.

Document History

Version	Date	Status	Author	Comment
V1.0	30.04.2017	Released	Kleineidam et.al.	Milestone M6

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List of Acronyms and Abbreviations

Short	Definition
BRP	Balancing Responsible Person
BDEW	BDEW – Bund der Deutschen Energie Wirtschaft; engl.: Association of the German Energy Market
BNE	Bundesverband Neue Energiewirtschaft e.V. engl.: Association of Energy Market Innovators. The BNE represents the interests of grid-independent energy suppliers and energy service companies in Germany. http://www.bne-online.de/de/content/branchenleitfaden-drittpartei-aggregatoren
BSI	Bundesamt für Sicherheit in der Informationstechnik, engl.: Federal Office for Information Security www.bsi.bund.de
CA	Consortium Agreement
CHP	Combined Heat and Power
CN	Energy trading unit capacity [kWh]
cos ϕ	Physical unit power factor [-]
DoA	Description of Activities
DSO	Distribution System Operator
EEG	Erneuerbare Energien Gesetz – German Renewable Energy Act
EEX	European Energy Exchange
EMS	Energy Management System
EnWG	Energie Wirtschaftsgesetz – German Energy Act
EV	Electric Vehicle
FAT	Factory Acceptance Test at system integrator site
FO	Fibre Optic
GA	Grant Agreement
HV	High Voltage
HW	Hardware
I	Physical unit for current amperage [A]
IAT	Initial Acceptance Test
IoT	Internet of Things
ITI / IFI	Intelligent Flexible Trading Interface – also: Flex-Offer Agent Interface
LV	Low Voltage
MV	Medium Voltage
P	Physical unit power [kW]
PLC	Programmable Logic Controller, eventually used for Power Line Communication (refer to the context)
Q	Physical unit reactive power [Var]
S	Physical unit complex power [VA]
SAT	Site Acceptance Test
SCADA	Supervisory Control and Data Acquisition
SP5	Spectrum Power® 5 – Siemens of the shelf SCADA system for utilities and DSOs

SW	Software
SWW	Strom-Wasser-Wärme Wunsiedel GmbH
TSO	Transmission System Operator
U	Physical unit for voltage [V]
UML	Unified Modelling Language
W	Physical unit work [Wh]
WP	GOFLEX Work Package
XML	Extensible Markup Language
xEMS	Energy Management System where x stands for: H Home; B Building; F Factory; C Charging; T Thermal

1 Introduction

1.1 Purpose and How this Document fits into GOFLEX Strategy

The GOFLEX project innovates, integrates, and demonstrates a group of electricity smart-grid technologies for managing flexibility in energy production and consumption. GOFLEX focuses on active use of distributed sources of flexibility to provide services for grid operators, balance electricity demand and supply, and optimize energy consumption and production at the local level. The SWW Work Package 9 (WP9) installed GOFLEX demo platform is an embedded system, because it not only interacts with software but also with the outside world. Defining requirements to establish specifications is the first step in the development of an embedded system. It is necessary that requirements are established in a systematic way to ensure their accuracy and completeness. The challenge in specifying requirements for GOFLEX demonstration sites vests in the fact that user scenarios have never been defined before and many of the components, which shall be installed and integrated to the life system of the utility and Distribution System Operator (DSO), are not yet developed. This document specifies the general and most important requirements. It may be, regarded more a requirement guide with a very high level of abstraction than a real requirement specification (a real requirement specification is meant to be e.g. a software requirements specification according to IEEE 830). This may cause problems when ambiguities in requirements surface in operation or later in the life cycle, and more time and money is spent not only in fixing these ambiguities but also in keeping SWW's customers happy and loyal to the project. Accuracy and the details of requirements for SWW WP9 demo site will have to be mutually specified in detail and documented in additional specification documents to ensure that the GOFLEX solution does not enter an undefined state.

1.2 Related Documents and Projects

At the Siemens Supervisory Control and Data Acquisition (SCADA) user conference the German SmartEco project has been presented see [KLEI-2016], which demonstrates how smart homes and electric vehicles can contribute to balance fluctuation within the grid by offering positive or negative load capacities to the DSO. Building or electrical car owners can benefit from a DSO controlled energy management through flexible tariff models and the use of extended services, like facility and energy management services, weather forecast, or infotainment.

Mandátova [MAND-2017] provides an overview of project examples of early-adopters of the Internet of Things(“IoT”) based business cases for the energy / electricity market, which are worth to be mentioned:

“… *Eneco* (Eneco is a Dutch energy supplier http://www.eneco.com/about-us/) *focuses on new business cases enabled by the IoT technology within four domains: smart home, smart buildings, e-mobility and smart cities. Fonger Ypma, responsible for Eneco’s Smart Energy Lab presented a smart thermostat Toon (bought by 300 000 customers so far) which mainly acts as a platform in the home to have a more meaningful conversation with customers. It allows the retailer to provide customers with real-time insight into energy usage, benchmarking with peers, as well as giving advice on energy saving. Eneco provides based on a subscription. Customer satisfaction is very high and this in turn leads to loyal customers (churn reduction about 60%). On this basis, Eneco can build value-added services for Toon, from energy-related services such as insight in solar PV performance and remote boiler management, to non-energy-related services such as home security and smoke detection. This allows them to transition into a service provider. Eneco also founded a company called Jedlix* (see: Start smart charging at home https://jedlix.com/)*, which provides smart charging for electric vehicles. Jedlix can connect directly with the car or the charging pole and optimise the charging schedule, based on the availability of renewable energy, or on the wholesale power prices. Jedlix has developed a unique new feature for Tesla drivers. As of January 2017, their users can also smart charge at their home charge point using the connected car. Eneco Crowd Nettis a network of Tesla Powerwall home batteries that can charge or discharge at any desired time. This means that together they form the reserve capacity for the national power grid (frequency reserve) and make it possible to maintain system balance. Therefore, it’s actually a ‘virtual power plant’.*

Frédéric Castaldo, CEO of Swisscom Energy Solutions, pointed out that the willingness to opt for ownership of the device versus subscription depends on country habits and that customers are not willing to pay a monthly fee above a couple of euros for a smart home (Note: Swisscom Energy Solutions has installed the so-called Tiko network. Tiko has been managing tens of thousands of residential loads to provide ancillary services to the Swiss national grid since 2012, see https://tiko.ch). *Swisscom used their IT and telecom know-how and developed tiko* *power, a hybrid product/platform targeted at residential consumers that allows for the connection of millions of homes and creates value by facilitating transactions across markets. Swisscom does not directly approach customers. They work with partners, who would offer a free-of-charge power delivery to consumers that installs the company's integrated solar PV and home storage systems in a number of markets. The flat rate is financed with revenues that the company receives from offering its customers some storage capacity in the balancing power market."*

Another important activity is the USEF project. USEF was founded by seven key players, active across the smart energy industry.

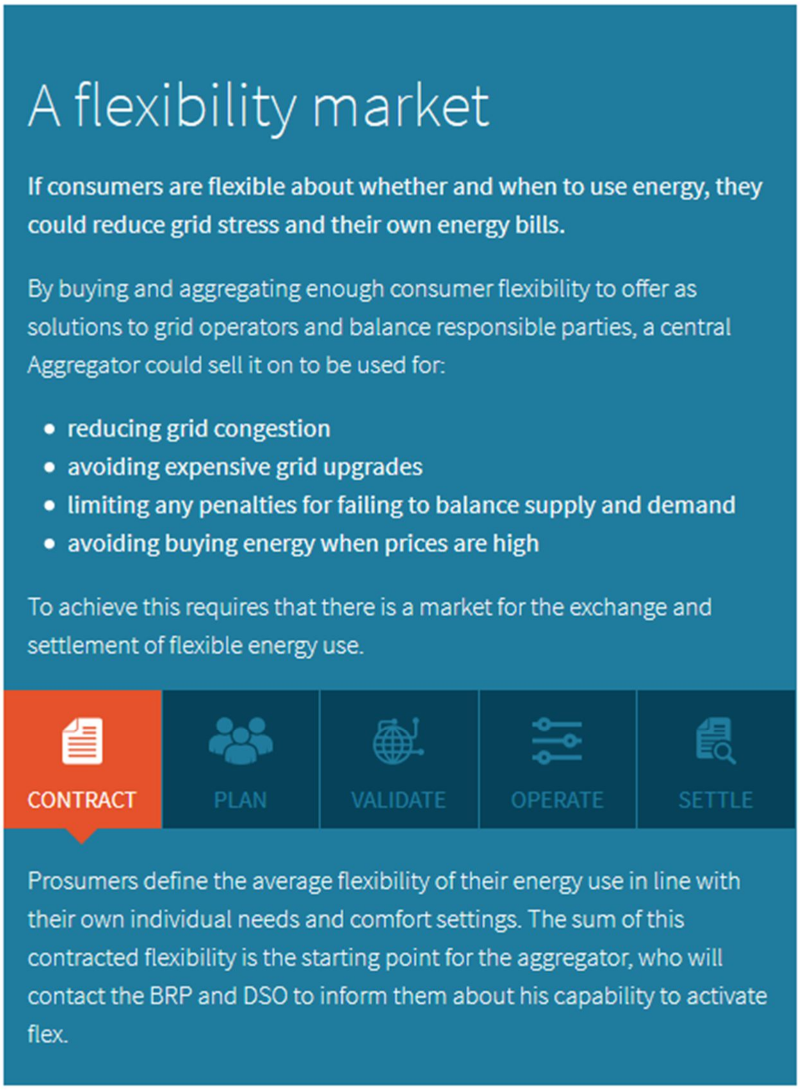

Figure 1: This USEF's goals comply to the requirements specified in this GOFLEX document

- i) USEF mainly concerns the technical providers of GOFLEX and it is good to have a common ground on cyber-security, aggregation of flexibility, interoperability and standardization with USEF.
- ii) The cloud-based platform, the developed software and hardware flexibility solutions provided to the DSOs, the three-phase state estimation and observability are tools that should be included within USEF.
- iii) A field for further study, which has already started in the GOFLEX Business skype discussions, is the interoperability of GOFLEX solutions with other commercially developed solution. In this way, the provided solutions should not be used in a proprietary way, but have the ability to be reshaped, according to other requirements. The GOFLEX Business discussion was focused on the possibility of providing an open-access solution.

The GOFLEX project provides a framework consisting of guidelines and even some sample coding, which can be downloaded for free use – see: https://www.usef.energy/download-the-framework/.

1.3 Document Structure

In Chapter 2, the work package WP9 with the respective tasks are described, as they have analytically presented in the main text of the DoA.

In Chapter 3, the SWW organization and those business processes have been described, which need to be changed in case the GOFLEX solutions will be set effective after successful acceptance. Applicable standards and regulations valid for Germany have been listed, details or contradictions in legislation will have to be discussed in the course of the project.

In Chapter 4, the dispersed prosumers within SWW's territory are presented. The basic process on how to contract individual participants has been described.

In Chapter 5, the technical requirements of SWW's grid and ICT infrastructure have been specified. Reference participants provide requirement specification for prosumers and other flexibility providers. Finally the existing R&D SCADA system has been proposed to serve as a platform for the GOFLEX trading solution on utility site with a direct link of the trading software to the grid management module.

In Chapter 7, a summary statement to the Wunsiedel demonstration has been provided, while in Chapter 8 the References are presented.

2 Work Package Description

WP9 demonstrates the GOFLEX system and solutions in Wunsiedel (Germany). SWW is in the lead of WP9 and has organized the project and tasks according to Figure 2. WP9 has been divided into six tasks, which will be described in the following.

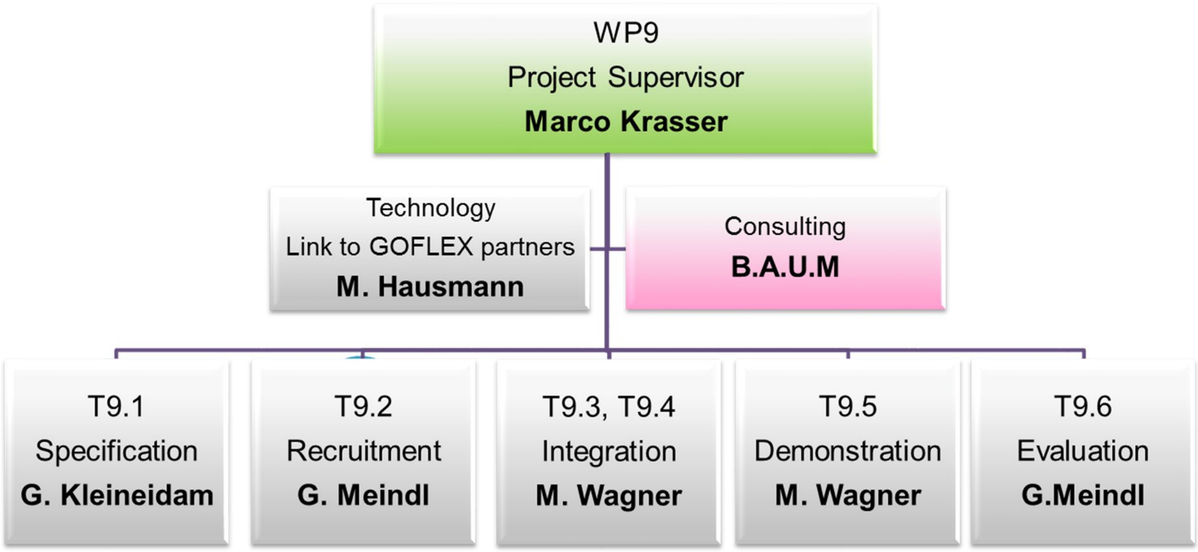

Figure 2: Roles and Responsibilities of work package GOFLEX WP9

T9.1 Requirement Analysis, Business Models & KPIs. It has been necessary to look at all the critical technical, economical and administrative aspects of SWW organization, territory and infrastructure to prepare the demonstration site in Wunsiedel and to forward requirements to the solution partners. These critical points encompass but are not limited to the business models used with the prosumer engaged in the pilot phase, contract between SWW and its clients, data privacy, system security, system monitoring, communication, and getting prosumer engaged in the process. All these aspects will be investigated and discussed with the required key people (clients, data protection commissioner, lawyers…). This phase will be critical to ensure that neither technical nor non-technical aspects will block the installation and trial phase of the GOFLEX solution. I shall ensure that the solution deployed during the pilot phase is durable.

T9.2 Prosumer Recruitment. During the demonstration phase, two types of prosumers will be participating: private households and companies. To recruit the required number of prosumers, a great deal of work will be required, especially for the industrial clients of SWW. This task will thus focus on the recruitment of the pilot participants. At the beginning, the main effort will be made by contacting major industrial clients in SWW's territory and investigating their consumption flexibility. The goal is to acquire at least 2 willing industrial partners with interesting flexibility in electricity consumption and if possible production, to get a sufficient amount of flexible energy to control. Then, the task will focus on the recruitment of the 50 prosumers (PV producing households with flexible consumption), defining also the exact contract and services offered to the prosumers to recruit them willingly. In parallel, the location of the distribution grid experiment will be investigated and the local inhabitants contacted. The goal is to recruit at least 25 local households that possess flexible electrical consumption to get a sufficient lever of action to observe the impact on the distribution grid. In parallel, the task will aim at getting 5 electric car owners participating to the pilot.

T9.3 Preliminary Measures and Experiments. Running a pilot phase of 12 months will be really difficult without some foreknowledge. As a result, this task will focus on measures done in the field to get a good insight of what will happen during the pilot phase. Likewise, preliminary tests of interfacing buildings and controlling some flexible appliances will be done, to be able to test the material, and especially discover the problems linked to the installation of such material in the field to control the flexible electrical appliances. It will also focus on gathering data before the running of the pilot phase to get a point of comparison for the pilot phase and training data for the solution developed in the previous WPs. Additionally, the cost elements of the CBA analysis will be built in detail in this task. This might include a preliminary CBA with anticipated costs and benefits.

T9.4 Material Installation. This task mainly will focus on the installation of the GOFLEX solution on top of the future SWW master controller which is based on a Siemens Spectrum Power® 5 SCADA application, which is running as a clone to the operational master controller. SWW will focus on the electrical installation and handle the communication with the consumers/ prosumers. Furthermore, connector software modules to realize the various communication interfaces in order to realize a bi-directional communication between SWW's master controller, the Energy Management System (EMS), and the field devices on prosumer side have to be written.

T9.5 Demonstrations. This task will handle the whole pilot phase. Multiple aspects will have to be taken care of to keep the prosumers happy during this testing period. A first aspect will be the communication to the participants, with information regularly sent to keep them entertained during the whole phase. Likewise, a problem handling service will have to be setup for the whole duration of the pilot phase to handle technical or other kind of problems. An intervention group has also to be created to make the required reparations when problems arise in the field. Finally, the task will also focus on the following of the experiments themselves, planning them, monitoring the results and their effect on the distribution grid and on the aggregated load curve. An important subtask will be to get regularly in touch with the providers of the deployed solutions developed in the previous WPs to keep them informed about the field results and help them optimized their tools.

T9.6 Demonstration Results and Evaluation. This task will focus on life demonstration with all the functionality available specified in T9.4 and T9.5. A technical analysis of the experiments will be done to verify that the foreseen effect of controlling flexible sources (DSM) is able to achieve what was foreseen during T9.1. An economic analysis of the gains of deploying such a solution in comparison to the costs will also be done to verify that the business models investigated are correct. The CBA analysis will be completed in this task and the quantified benefits will be reported using actual costs.

2.1 GOFLEX Activities Fit into SWW's Technology Roadmap

SWW's has developed a technology roadmap (see **Attachment A1**) based on the vision described in Figure 3. By 2030, SWW will be able to shift and shape loads so that at any time customers in their territory can be supplied leaving a +10% / -5% flexibility to serve the neighbouring grid or the next level Distribution System Operator (DSO).

The vision is not only to shape load profiles and balance energy consumption or supply locally but also to provide a bandwidth of power source or drain capacity to the external energy market. To achieve this vision it is necessary to invest into (i) renewable energy generation, (ii) storage solutions, and (iii) advanced ICT to intelligently manage fluctuation, which is what GOFLEX will provide. Figure 4 shows the concept of load balancing and the related IT architecture for monitoring and control of distributed energy systems, where smart xEMS technologies play a key role in the smart grid of the future [KLEI-2016/2].

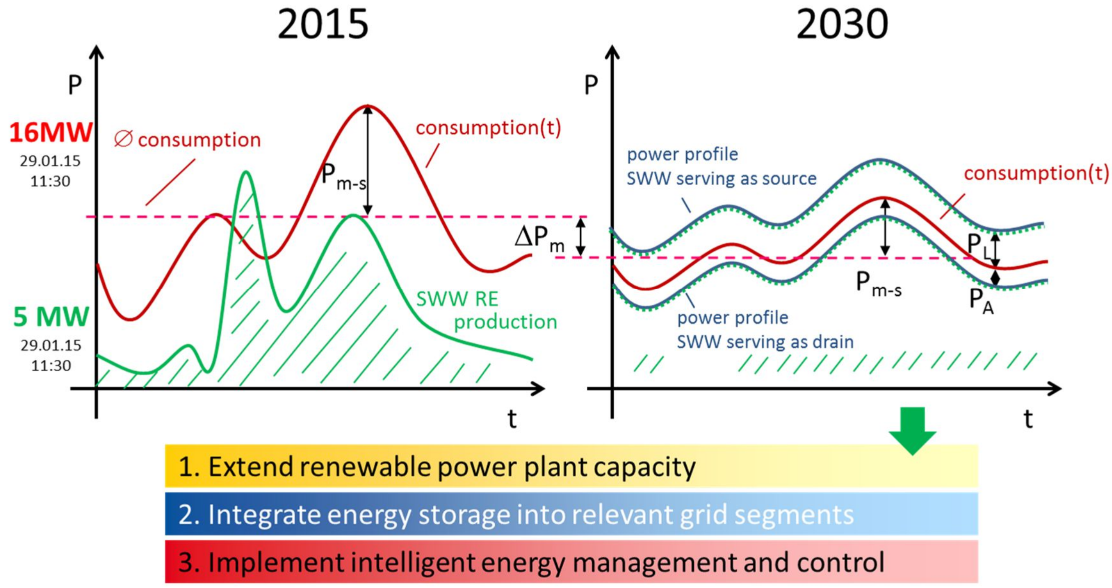

Figure 3: Vision: Reliable load profiles and a bandwidth of power source or drain capacity will provide our region prosperity and independence

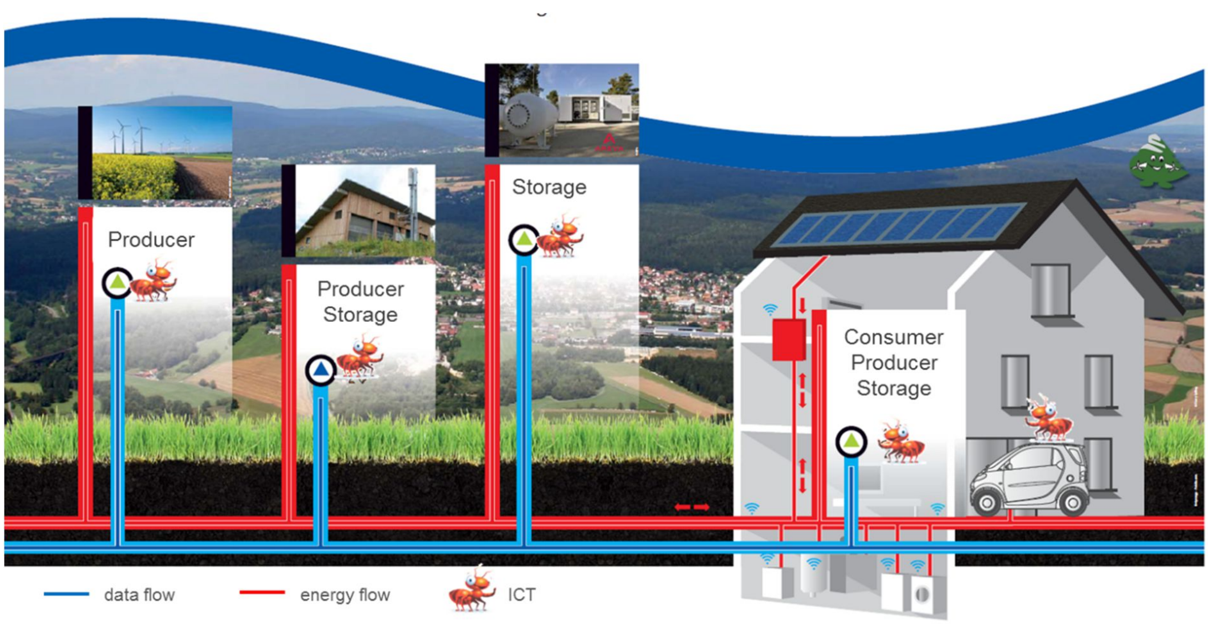

Figure 4: Data acquisition and communication from energy producers, consumers and storages is the platform to manage fluctuation and commercially use flexibility.

2.2 GOFLEX Will Help to Improve the Business Processes at SWW

GOFLEX will help SWW to invent new business models. In Section 0 the situation and business processes effective are described. Dynamic pricing or other kind of contracts to get flexible consumers will help to shape their load in accordance to SWW needs, for both reducing the intra-day corrections costs and reducing the upgrading investments in the distribution grid. Moreover, maximizing self-consumption will also be investigated with private and public customers. Another business model that will be investigated is to sell the aggregated flexibility to the Transmission System Operator (TSO) for tertiary reserves (ancillary services for TSO).

3 Demonstration Site Settings

SWW is a municipal, highly innovative utility company and DSO that ensures an affordable, especially environmentally responsive supply of the metropolitan area of Wunsiedel and seven other municipalities. The SWW Wunsiedel GmbH has set itself the goal of fully ensuring the energy needs by using renewable and regionally produced energy forms. Additionally they want to be a supplier of balancing power for higher grid levels and external supply areas as well. With their "field laboratory of the energy transition" SWW is a model and pioneer for other utilities in Germany. SWW will provide sustainable growth, prosperity and environmental protection to the region by creating an attractive leisure, living and economic environment for people and businesses in the Fichtelgebirge. SWW supplies about 20,000 people in the region with electricity, heat, water, gas, and communication services based on fiber optics. SWW has developed the roadmap “WUNSiedler Weg – Energie” where a generic smart grid ICT architecture provides load balancing by a cellular approach [VDE-2015] based on self-controlled smart micro-grids – see **Attachment A1**.

3.1 Business Management – SWW Organization and Administration

Figure 5 shows the organization of SWW and the roles involved in the GOFLEX project. From this figure, one can see that the Customer Center is the most affected department. Setting the GOFLEX trading platform effective means changing roles, responsibilities and business processes for the following functions:

1) *Technology and IT* have to install new services to operate and maintain the GOFLEX trading solution. Remote access and control (diagnostics, reset, restart, repair, update, upgrade services) to customers equipped with GOFLEX ICT and automation components has to be installed. Definitely, the personnel staff has to be extended.

2) *Energy Procurement*: Procurement from next level energy supplier EON-Bayernwerk have to be adapted, while new agreements have to be settled in cooperation with the Customer Relations group.
3) *Service Center:* A special hotline for customers equipped with GOFLEX ICT and automation components has to be installed. Personnel has to be trained to understand customer complaints and to initiate corrective action together with the IT technicians – see a).
4) *Customer Relations*: New form of contracts have to be developed and negotiated with SWW customers and prosumers in particular.
5) *Sales* has to extend its product and service portfolio.
6) A *NEW* function for energy trading has to be installed

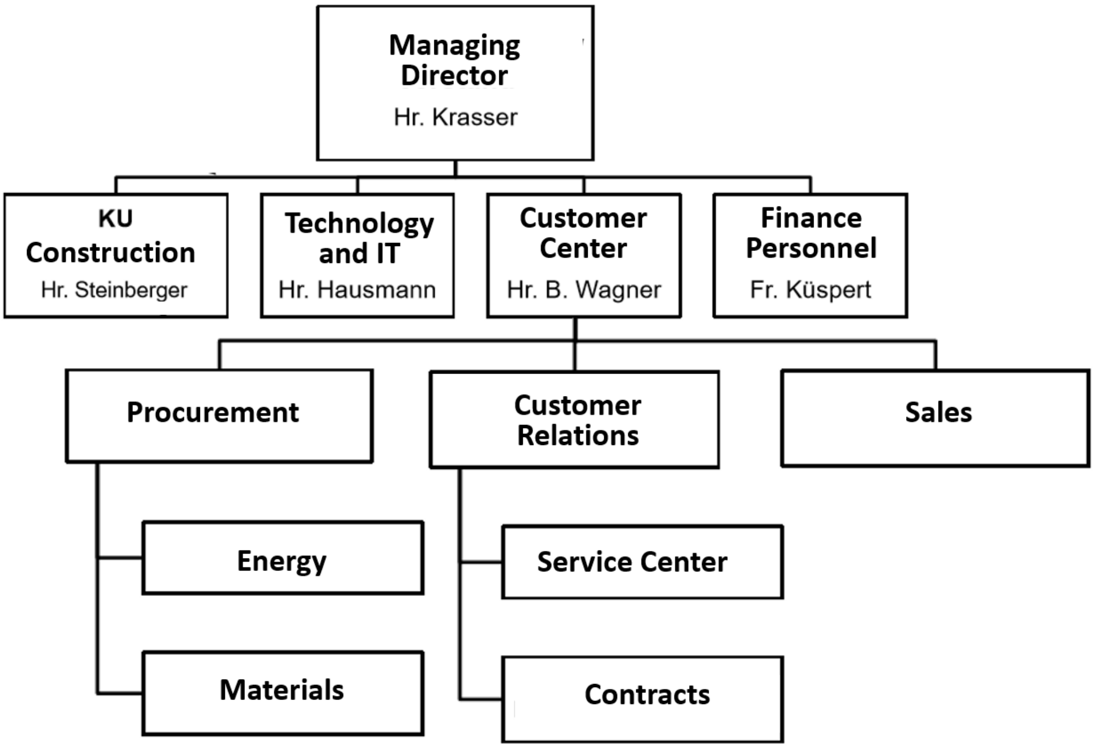

Figure 5: SWW organization and parties involved into GOFLEX

3.2 Business Process Requirements – User Scenarios and Use Cases

GOFLEX aims to test use cases for present and future energy scenarios and SWW will demonstrate how the GOFLEX solution can be used under current German regulations and derive the requirements to regulators and policy makers to improve the market framework.

SWW will integrate the GOFLEX solutions into the SWW roadmap "Wunsiedler Weg 2.0" (see **Attachment A1**), which persuades long-term goals. It is deeply connected to the issue, what the future role of small utilities can be.

The GOFLEX solution will be integrated in several steps in parallel to the developing role of SWW. Starting from today's situation a specific development of business procedure scenarios is planned from which the requirements to the GOFLEX solution are derived. The planned related business models will be developed together with SWW customers and will be described in detail in D9.2 "Business Model Design and KPI Definition - Use Case 3".

3.2.1 Today's Energy Trading Process: SWW as Fractured Multi-Service Provider

SWW takes several roles in the area of Wunsiedel today:

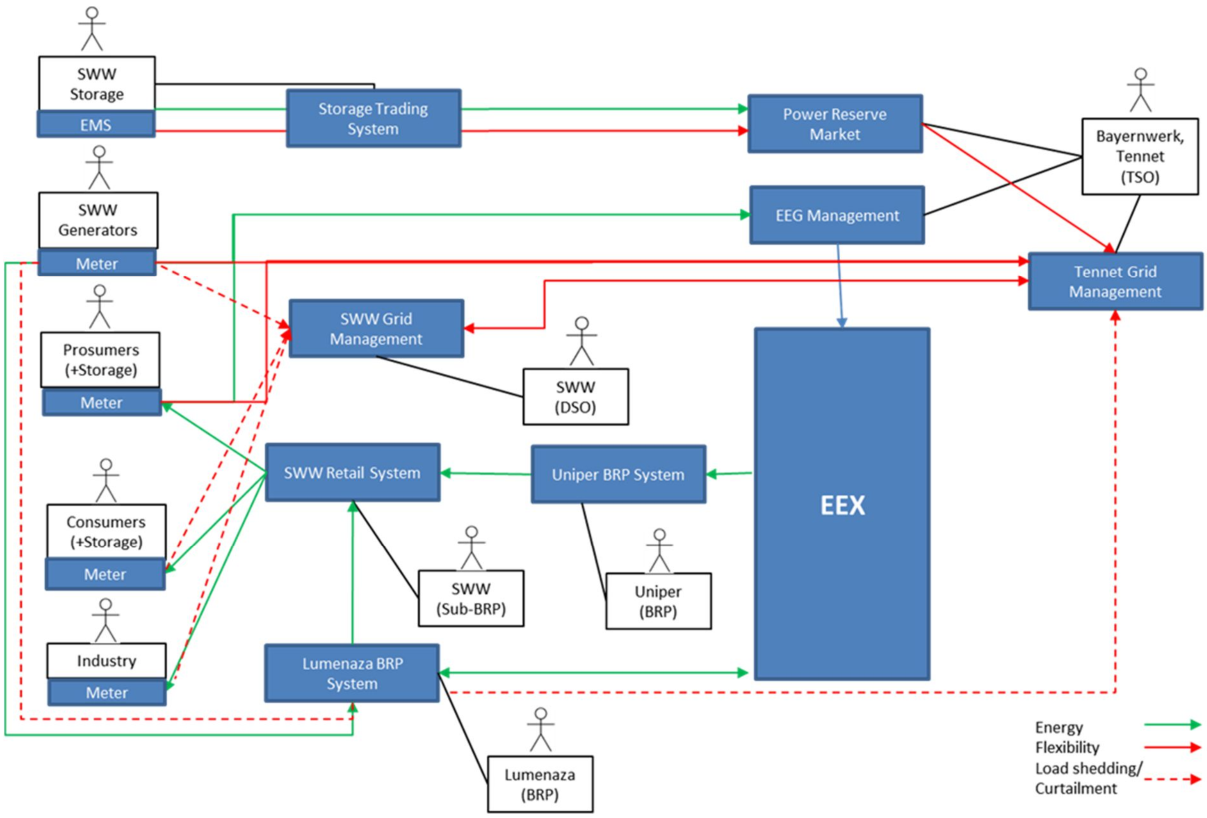

Figure 6: UML-Diagram for scenario "SWW today's situation"

Table 1: List of actors and systems for scenario "SWW today's situation"

Name	Actor/System	Description
SWW Storage	Actor	SWW Spin-off to manage the … MW Battery storage
Storage Trading System	System	System to offer flex offers to the Tennet power reserve market
SWW Generators	Actor	SWW spin off companies that own energy generators (wind turbines, CHPs etc.)
Meter	System	Metering Systems for production and consumption
EMS	System	Energy Management System (managing the flexibility options)
SWW DSO	Actor	SWW distribution grid management department
SWW Grid Management	System	System that comprises all devices and applications for SWW to manage the LV distribution grid
SWW Sub-BRP	Actor	SWW Retail department
SWW Retail system	System	System of appliances which handles the retail transactions (purchasing form BRPs, selling to SWW customers)
Prosumers (+Storage)	Actor	All private and public consumers who also generate energy (via PV, CHP etc.) and are able to store energy (via battery, thermal storage etc.)
Consumers (+Storage)	Actor	All private and public consumers who are also able to store energy (via EVs, thermal storage, etc.)
Industry	Actor	All industrial plants in the area
Reserve Power Market	System	Market for flexibility options for the TSO (primary, secondary and tertiary reserve)
Tennet	Actor	Responsible TSO (high voltage) for the SWW grid (low voltage)
Bayernwerk	Actor	Responsible DSO (medium voltage) for the SWW grid (low voltage)
Tennet grid management	System	System that comprises all devices and applications for Tennet to manage the HV transmission grid
EEG management	System	System to organise and the feed-in from electrical generation under the EEG regulation (providing fixed feed-in tariffs to generators of renewable energy)
Uniper	Actor	BRP for the balance group in which SWW is a subgroup
Uniper BRP System	System	System handling the balancing requirements of the Uniper balancing group
Lumenaza	Actor	BRP handling the renewable generators of SWW which are marketed directly
Lumenaza BRP System	System	System handling the balancing requirements of the Lumenaza balancing group
EEX	System	European Energy Exchange

SWW works as energy retailer and buys electricity directly from of Uniper (former EON) using Uniper's services as Balance Responsible Party (BRP). SWW is also involved in energy generation and the energy is traded by Lumenaza, another BRP which is specialised in trading renewable energies according to the German "Marktprämienmodell" (market bonus scheme). Some generation plants are still remunerated according to the German "EEG-Umlage" (a feed-in tariff).

SWW retail also buys energy back directly from Lumenaza and sell it as regional energy product "Fichtelstrom" to its customers. Lumenaza trades the surplus at EEX.

SWW is also the local DSO (since there are less than 100.000 costumers for SWW, the unbundling is not applied) with grid connection to the Bayernwerk (DSO MV) and Tennet (TSO HV) as upstream networks.

Tennet is authorised to use a special measure for grid emergency, the so called "BDEW Kaskade" [Mehl-2013] which describes the merit order of DSOs who have to provide load shedding in such an emergency case, which the TSO cannot handle. SWW has currently no flexibility scheme in place to respond to such requests apart from switching off consumers and handle the consequences.

SWW is also provider of a 8 MWh storage which is currently under construction and will be used to trade flexibility at the power reserve market (primary and secondary power reserve) owned by the TSO Tennet. The storage cannot be owned and used by the DSO under current German regulation.

All existing prosumers in Wunsiedel are currently remunerated according to the EEG. A few of them have storage solutions in place. Industry mainly purchases energy from SWW retail and partly uses flexibility internally to avoid costs for peak loads. The current situation is typical for a small active utility in Germany.

SWW aims to improve the situation and take a full position as regional energy service provider guaranteeing security of supply and grid security for *all citizen* independent of the energy retailer which the citizen has chosen. As a retailer, it aims to provide 100% localal renewable energy ("Wunsiedler Weg - Energie" – see **Attachment A1**).

The SWW grid is considered as cell within the European energy system which aims to achieve energy autonomy (balancing regional demand and supply) and is able to operate in isolated operation in emergency. The utilisation of regional flexibility is key for this vision.

Several steps will be implemented and the GOFLEX solution plays a prominent role in these steps.

3.2.2 SWW as DSO Builds the Infrastructure to Facilitate Regional Flexibility

In this step GOFLEX will be utilised as aggregator platform for the DSO. This scenario shall be implemented during GOFLEX with the prosumers identified for the project.

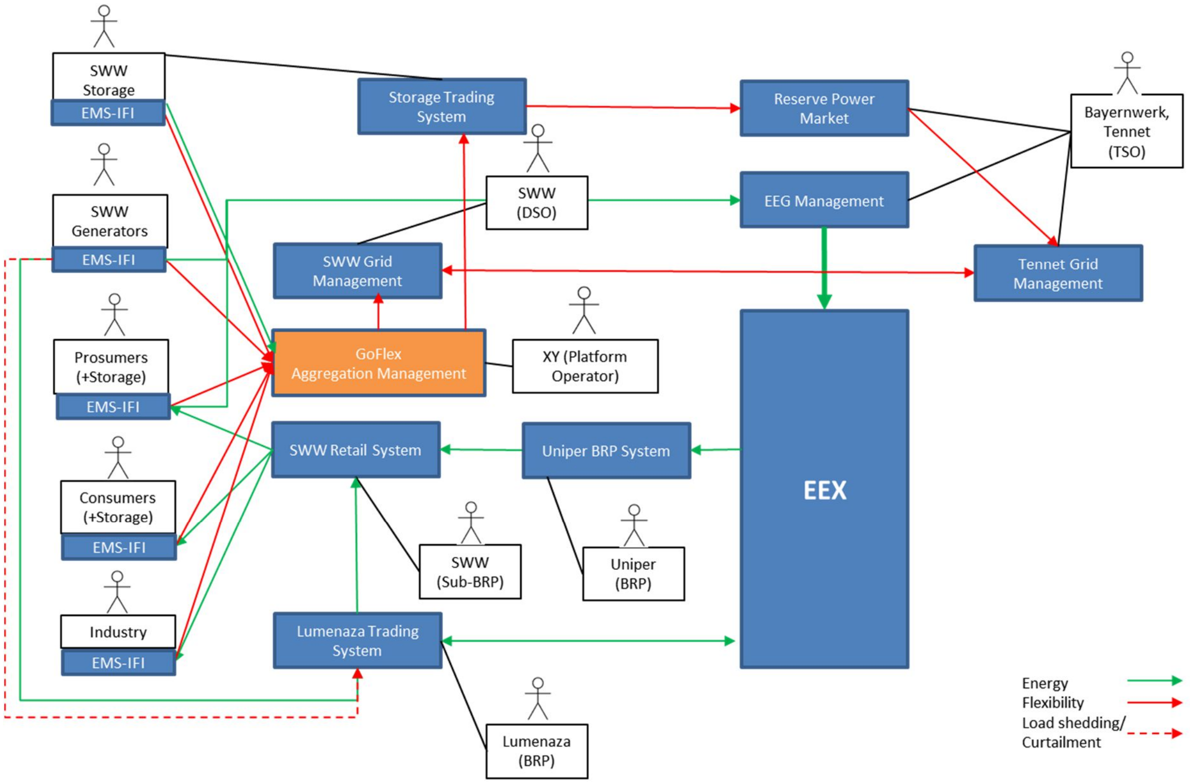

Figure 7: UML-Diagram for scenario "SWW using GOFLEX as DSO aggregator platform"

Table 2: List of actors and systems for scenario "SWW using GOFLEX as DSO aggregator platform"

Name	Actor/System	Description
SWW Storage	Actor	SWW Spin-off to manage the … MW Battery storage
Storage Trading System	System	System to offer flex offers to the Tennet power reserve market
SWW Generators	Actor	SWW spin off companies that own energy generators (wind turbines, CHPs etc.)
Meter	System	Metering Systems for production and consumption
EMS-IFI	System	Energy Management System (managing the flexibility options) with flexibility trading interface (IFI)
SWW DSO	Actor	SWW distribution grid management department
SWW Grid Management	System	System that comprises all devices and applications for SWW to manage the LV distribution grid
SWW Sub-BRP	Actor	SWW Retail department
GOFLEX Aggregation Management	System	System managing the aggregation of flexibility of the connected generators, prosumers, consumers and industry plants
Platform Operator	Actor	Platform Operator could be a SWW spin-off or the municipality or any other trusted party
SWW Retail system	System	System of appliances which handles the retail transactions (purchasing form BRPs, selling to SWW customers)
Prosumers (+Storage)	Actor	All private and public consumers who also generate energy (via PV, CHP etc.) and are able to store energy (via battery, thermal storage etc.)
Consumers (+Storage)	Actor	All private and public consumers who are also able to store energy (via EVs, thermal storage, etc.)
Industry	Actor	All industrial plants in the area
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Tennet	Actor	Responsible TSO (high voltage) for the SWW grid (low voltage)
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Tennet grid management	System	System that comprises all devices and applications for Tennet to manage the HV transmission grid
EEG management	System	System to organise and the feed-in from electrical generation under the EEG regulation (providing fixed feed-in tariffs to generators of renewable energy)
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Uniper BRP System	System	System handling the balancing requirements of the Uniper balancing group
Lumenaza	Actor	BRP handling the renewable generators of SWW which are marketed directly
Lumenaza BRP System	System	System handling the balancing requirements of the Lumenaza bal-ancing group
EEX	System	European Energy Exchange

All actors and business process remain the same, but the DSO uses the GOFLEX Aggregation Management System to aggregate flexibility.

All relevant systems of storage providers, generators, private/industrial prosumers and flexible private/industrial consumers which potentially can offer flexibility to the system shall be connected to the GOFLEX Flex-Aggregation management. A remuneration mechanism for the flexibility offers of these actors will be developed within the project time.

The purpose of the system at this stage is the possibility for the DSO to use flexibility either for emergency (to fulfil the requests of the BDEW Kaskade [Mehl-2013]) or to offer flexibility to the power reserve market. Flexibility is aggregated from prosumers and from the large-scale storage via the storage trading system (as emulated scenario, since DSO operating such storage is currently prohibited by German regulation).

3.2.3 Regional Market for Energy and Flexibility

In an energy system based on 100% renewable energy the balancing of supply and demand of energy is a key challenge. The requirements to an energy remuneration schemes are vastly different from the current schemes. It could be divided in 3 parts:

- Work (W),
- Power (P),
- Flexibility or Capacity (CN)

All components can be priced differently and traded as separate products in a regional market (P is represented by the grid fee, and excluded form dynamic pricing in this scenario due to German regulation schemes)

In this scenario, a regional market platform will allow for trading all 3 components. Depending on the progress with all actors involved, this scenario is partly in the scope of the GOFLEX project and can be built on top of the GOFLEX platform as used for the previous scenario.

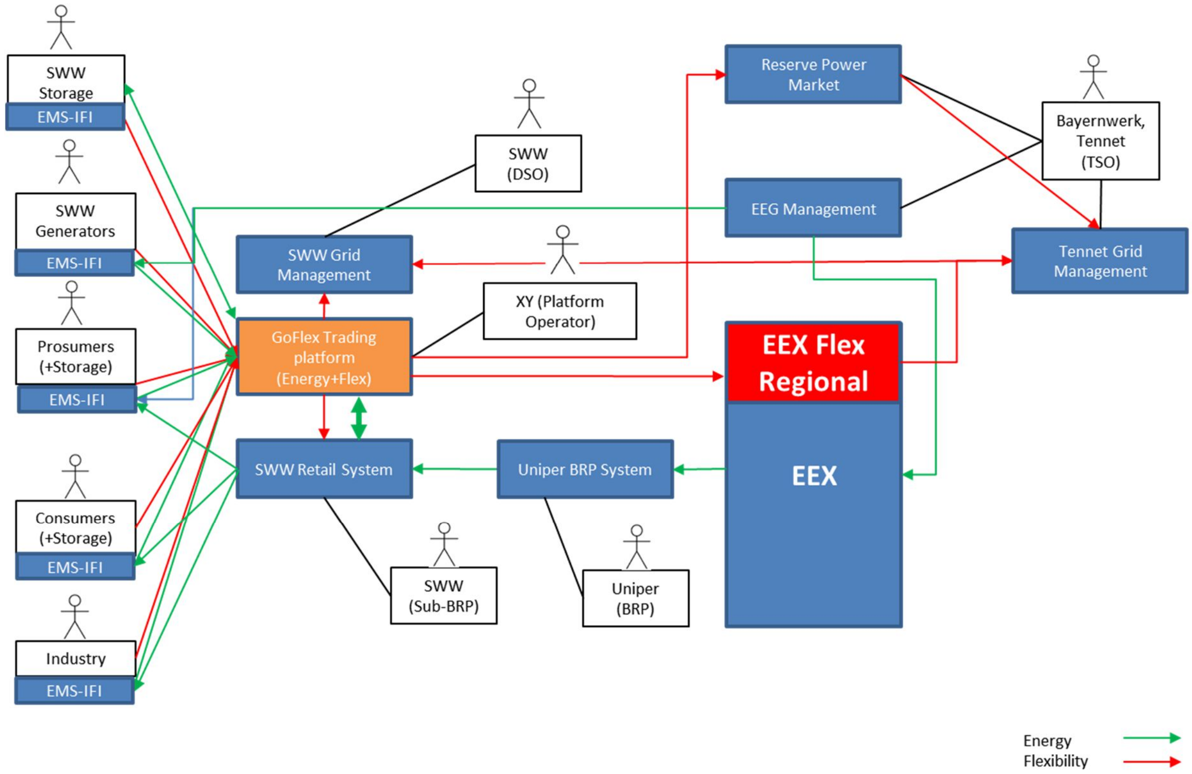

Figure 8: UML-Diagram for scenario "SWW using GOFLEX as trading platform"

Table 3: List of actors and systems for scenario "SWW using GOFLEX as trading platform"

Name	Actor/System	Description
SWW Storage	Actor	SWW Spin-off to manage the … MW Battery storage
SWW Generators	Actor	SWW spin off companies that own energy generators (wind turbines, CHPs etc.)
EMS-IFI	System	Energy Management System (managing the flexibility options) with flexibility trading interface (IFI)
SWW DSO	Actor	SWW distribution grid management department
SWW Grid Management	System	System that comprises all devices and applications for SWW to manage the LV distribution grid
SWW Sub-BRP	Actor	SWW Retail department
GOFLEX Trading Platform	System	System trading the flexibility of the connected generators, prosumers, consumers and industry plants and offer the aggregated flexibilities to DSO and BRPs, the Reserve Power Market (and the EEX flex regional)
Platform Operator	Actor	Platform Operator could be a SWW spin-off or the municipality or any other trusted party
SWW Retail system	System	System of appliances which handles the retail transactions (purchasing form BRPs, selling to SWW customers)
Prosumers (+Storage)	Actor	All private and public consumers who also generate energy (via PV, CHP etc.) and are able to store energy (via battery, thermal storage etc.)
Consumers (+Storage)	Actor	All private and public consumers who are also able to store energy (via EVs, thermal storage, etc.)
Industry	Actor	All industrial plants in the area
Reserve Power Market	System	Market for flexibility options for the TSO (primary, secondary and tertiary reserve)
Tennet	Actor	Responsible TSO (high voltage) for the SWW grid (low voltage)

Bayernwerk	Actor	Responsible DSO (medium voltage) for the SWW grid (low voltage)
Tennet grid management	System	System that comprises all devices and applications for Tennet to manage the HV transmission grid
EEG management	System	System to organise and the feed-in from electrical generation under the EEG regulation (providing fixed feed-in tariffs to generators of renewable energy)
Uniper	Actor	BRP for the balance group in which SWW is a subgroup
Uniper BRP System	System	System handling the balancing requirements of the Uniper balancing group
EEX	System	European Energy Exchange
EEX flex regional	System	Exchange platform for regional flexibility

The provision of a regional market for energy and flexibility has a strong impact on the regional energy system. A large portion of the energy supply will be procured by SWW retail on this regional market. Generators and prosumers (pooling is an option) offer their energy supply, all actors offer their flexibility. The market will probably be operated by a separate entity (possibly owned by the municipality or SWW). The owner of the platform can also act as an aggregator and offer the flexibility to the DSO as well as to a national flexibility market for local flexibilities (which is currently under consideration by EEX) and act as agent for the SWW storage and trade the flexibility at the Tennet Reserve Power Market.

3.2.4 The Autonomous Cell

The autonomous cell is a targeted emergency mode for the SWW grid e.g. when the overlay grid faces congestions. In this scenario the SWW grid will be able to balance supply and demand of *all* parties (including service to those customers, which are not clients of SWW).

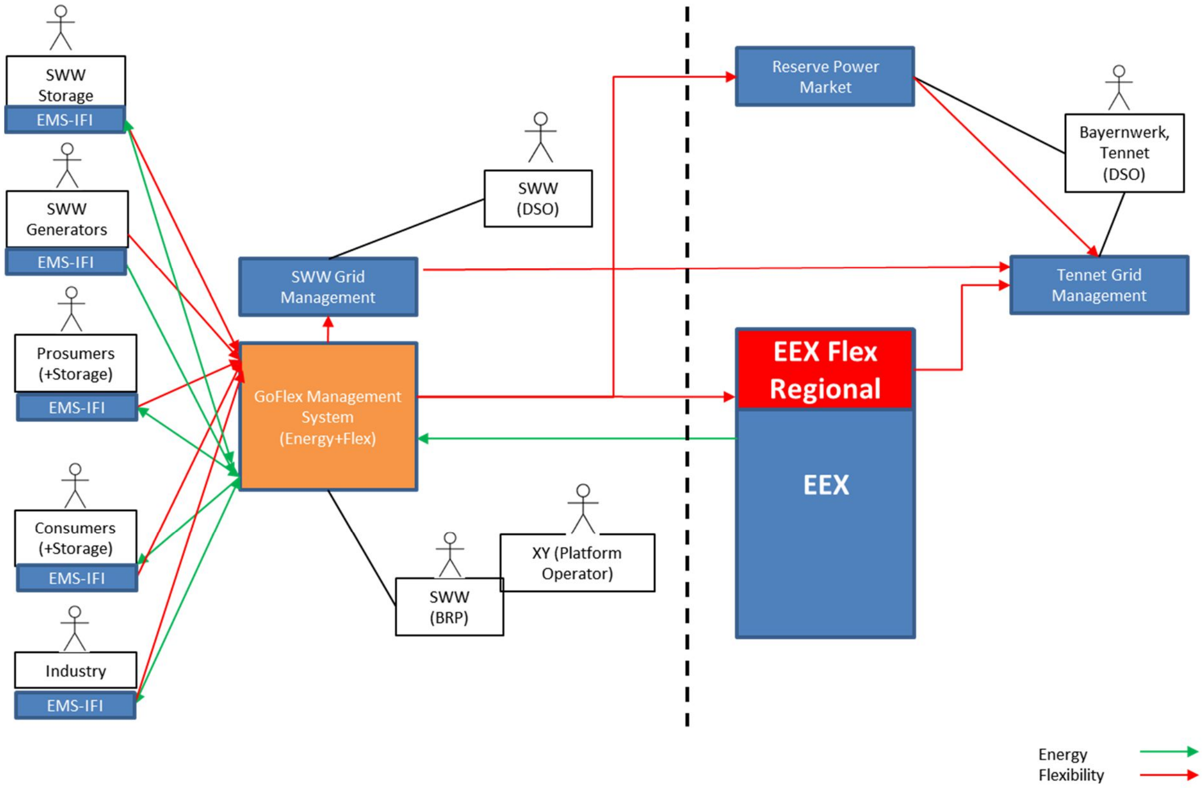

Figure 9: UML-Diagram for scenario "SWW using GOFLEX to act as autonomous cell"

Table 4: List of actors and systems for scenario "SWW using GOFLEX to act as autonomous cell"

Name	Actor/System	Description
SWW Storage	Actor	SWW Spin-off to manage the … MW Battery storage
SWW Generators	Actor	SWW spin off companies that own energy generators (wind turbines, CHPs etc.)
EMS-IFI	System	Energy Management System (managing the flexibility options) with flexibility trading interface (IFI)
SWW DSO	Actor	SWW distribution grid management department
SWW Grid Management	System	System that comprises all devices and applications for SWW to manage the LV distribution grid
SWW BRP	Actor	SWW Retail department with BRP function
GOFLEX Management System (Energy and Flexibility)	System	System trading flexibility with the connected generators, prosumers, consumers and industry plants and using the aggregated flexibility for the autonomous cell (for BRP and DSO needs)
Platform Operator	Actor	Platform Operator could be a SWW spin-off or the municipality or any other trusted party
Prosumers (+Storage)	Actor	All private and public consumers who also generate energy (via PV, CHP etc.) and are able to store energy (via battery, thermal storage etc.)
Consumers (+Storage)	Actor	All private and public consumers who are also able to store energy (via EVs, thermal storage, etc.)
Industry	Actor	All industrial plants in the area
Reserve Power Market	System	Market for flexibility options for the TSO (primary, secondary and tertiary reserve)
Tennet	Actor	Responsible TSO (high voltage) for the SWW grid (low voltage)
Bayernwerk	Actor	Responsible DSO (medium voltage) for the SWW grid (low voltage)
Tennet grid management	System	System that comprises all devices and applications for Tennet to manage the HV transmission grid
EEX	System	European Energy Exchange
EEX flex regional	System	Exchange platform for regional flexibility

The GOFLEX trading platform turns automatically into a management platform which balances supply and demand of the cell and takes the needs of the grid as priority consideration into account. SWW customers and grid users will have contracts that allow the local system manager to access and use their flexibilities as needed to manage and optimise the local system,

Services to the overlay grid can be offered but a full islanding mode can be performed as well To that end, autonomy means that the local system operator can decide on technical or business reasons if and when to operate in the integrated mode or in the island mode.

This scenario is in the scope of the GOFLEX project (at least as a simulated scenario).

3.2.5 The Cellular Model

The cellular model describes a new energy system, which is organised bottom-up.

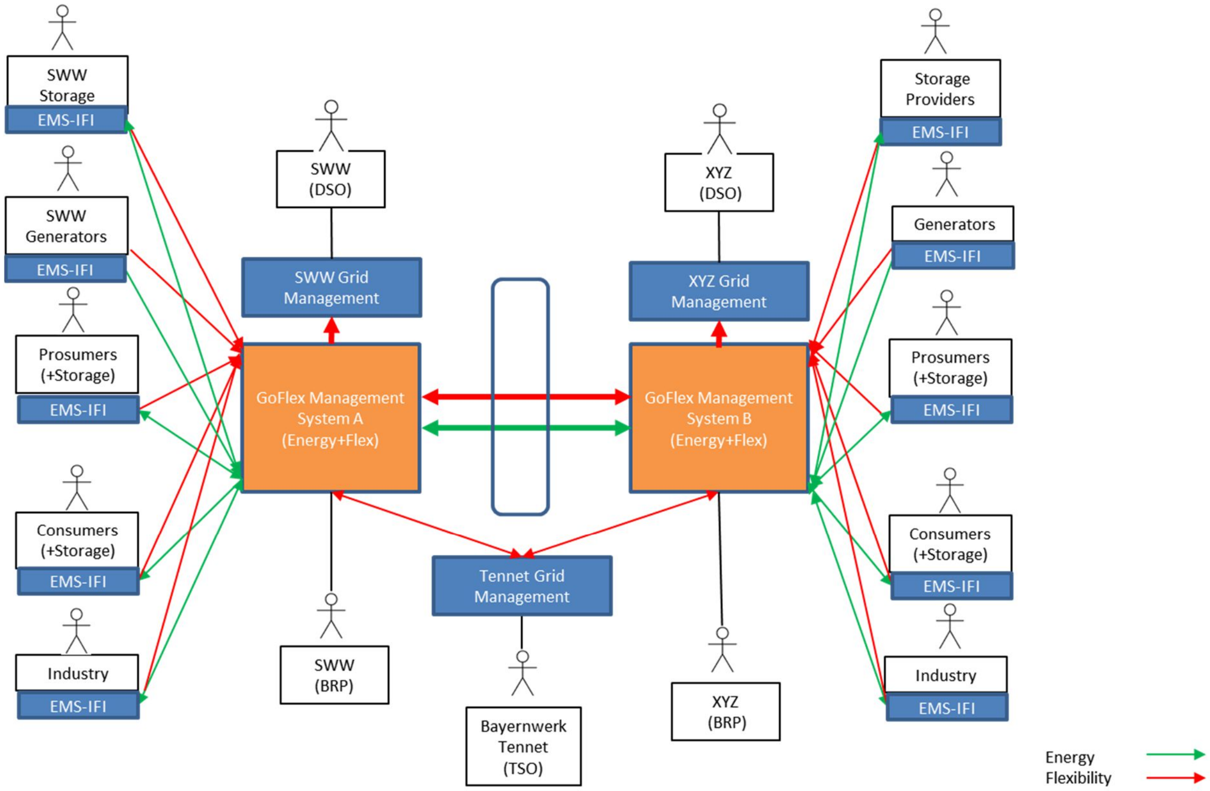

Figure 10: UML-Diagram for scenario "The cellular model enabled by GOFLEX"

Table 5: List of actors and systems for scenario "The cellular model enabled by GOFLEX"

Name	Actor/System	Description
SWW Storage	Actor	SWW Spin-off to manage the … MW Battery storage
SWW Generators	Actor	SWW spin off companies that own energy generators (wind turbines, CHPs etc.)
EMS-IFI	System	Energy Management System (managing the flexibility options) with flexibility trading interface (IFI)
SWW DSO	Actor	SWW distribution grid management department
SWW Grid Management	System	System that comprises all devices and applications for SWW to manage the LV distribution grid
SWW BRP	Actor	SWW Retail department with BRP function

GOFLEX Management System (Energy and Flexibility)	System	System trading flexibility with the connected generators, prosumers, consumers and industry plants and using the aggregated flexibility for the autonomous cell (for BRP and DSO needs), communicating surplus or lack of power to other cells and handle the transaction
Platform Operator	Actor	Platform Operator could be a SWW spin-off or the municipality or any other trusted party
Prosumers (+Storage)	Actor	All private and public consumers who also generate energy (via PV, CHP etc.) and are able to store energy (via battery, thermal storage etc.)
Consumers (+Storage)	Actor	All private and public consumers who are also able to store energy (via EVs, thermal storage, etc.)
Industry	Actor	All industrial plants in the area
Tennet	Actor	Responsible TSO (high voltage) for the SWW grid (low voltage)
Bayernwerk	Actor	Responsible DSO (medium voltage) for the SWW grid (low voltage)
Tennet grid management	System	System that comprises all devices and applications for Tennet to manage the HV transmission grid

The main responsibility for the grid is with the local DSOs which have installed systems (like GOFLEX) to manage their grid locally. Regional energy markets organise the local supply and demand completed by decentral power plants based on renewables and local storage systems.

Cells are interconnected and communicate surplus or lack of power to their neighbouring cells and negotiate solutions, in case of emergency or when the internal flexibility options are not sufficient.

The TSO and the overlay grid organises the exchanges between the cells and assumes the role of an insurance operator that can stand in when the local system of systems fails.

This scenario is out of the scope of the GOFLEX project but shall be realised based on GOFLEX solutions after the project time with neighbouring partner DSOs.

3.3 Applicable Standards and Legal Constraints

The following regulations and standards shall apply for any solution or installation supplied to SWW's territory. This is important to receive the necessary certificates to run and operate the systems in a real environment. Furthermore, solution providers and the integrator shall be responsible for full compliance with all relevant safety—and protection—related provisions, norms, rules, guidelines (UVV, DIN, EN, etc.) and with orders of Accident Prevention and Insurance Associations and other specialized associations in Germany at the place of use. The GOFLEX partners shall ensure that the personnel it uses comply with the applicable safety and accident prevention provisions, including the applicable local provisions. They shall comply with all workplace and environmental protection provisions.

> Note: SWW has to be certified according to IEC27001 by 31.01.2018 and thus GOFLEX installations have to fit.

In Germany, a comprehensive legislation was created within the past years. In addition to enacted ordinances, administrative regulations and technical guidelines this all has reached a diversity, which - even for experts – is difficult to overview. The correlation of the Acts and Ordinances will be clear by the Overview of legalisation from the Federal Ministry for Economic Affairs and Energy.

Knowing that there is a hierarchy and even some contradictions among the numerous regulations, we thought it will be useful to list them here. SWW's experts exactly know the relevance of these regulations and will explain this to during the course of this project. Therefore the design specification of any and all components which have to be installed in Wunsiedel need to be released by SWW early enough to receive required certificates.

3.3.1 Overview of Legislation Governing Germany's Energy Supply System

See:
https://www.bmwi.de/Redaktion/EN/Publikationen/gesetzeskarte.pdf?__blob=publicationFile&v=4

European Level/ Regulations / Directives

- INTERNAL ELECTRICITY MARKET DIRECTIVE (DIRECTIVE 2009/72/EC)
- EMISSIONS TRADING DIRECTIVE (DIRECTIVE 2009/29/EC)
- ENERGY EFFICIENCY DIRECTIVE (DIRECTIVE 2012/27/EU)
- ENERGY LABELLING CONSUMPTION DIRECTIVE (DIRECTIVE 2010/30/EU) REGULATION (EC) No 715/2009 ON
- RENEWABLE ENERGY SOURCES (RES) DIRECTIVE (DIRECTIVE 2009/28/EC)
- INTERNAL MARKET IN NATURAL GAS DIRECTIVE (DIRECTIVE 2009/73/EC)
- ENVIRONMENTAL IMPACT ASSESSMENTS (EIA) DIRECTIVE (DIRECTIVE 2011/92/EU)
- HABITATS DIRECTIVE (DIRECTIVE 2011/92/EU) AND BIRDS DIRECTIVE (DIRECTIVE 2009/147/EC)
- INDUSTRIAL EMISSIONS DIRECTIVE (DIRECTIVE 2010/75/EU)
- EU ENERGY PERFORMANCE OF BUILDINGS DIRECTIVE (DIRECTIVE 2010/31/EU)
- PLANNED INVESTMENT IN ENERGY INFRASTRUCTURE
- CONNECTING EUROPE FACILITY REGULATION
- CRITICAL INFRASTRUCTURE PROTECTION DIRECTIVE (DIRECTIVE 2008/114/EC)
- ECODESIGN DIRECTIVE (DIRECTIVE 2009/125/EC)

- REGULATION (EC) No 714/2009 ON TRADING CROSS-BORDER
- REGULATION ON GUIDELINES FOR TRANS-EUROPEAN ENERGY INFRASTRUCTURE
- DIRECTIVE FOR A SECURE SUPPLY OF ELECTRICITY (DIRECTIVE 2005/89/EC)
- EMISSION PERFORMANCE STANDARDS REGULATION
- ALTERNATIVE FUELS DIRECTIVE (DIRECTIVE 2014/94/EU)
- TAXATION OF ENERGY PRODUCTS AND ELECTRICITY DIRECTIVE
- INTER-TSO COMPENSATION MECHANISM (REGULATION (EU) No 838/2010)

National Level/ Acts

- POWER GRID EXPANSION ACT
- GRID EXPANSION ACCELERATION ACT
- FEDERAL REQUIREMENTS PLAN ACT
- ENVIRONMENTAL IMPACT
- ASSESSMENT ACT
- ACT ON ENERGY CONSUMPTION LABELLING
- ENERGY AND CLIMATE FUND ACT
- FEDERAL IMMISSION CONTROL ACT
- RENEWABLE ENERGY SOURCES ACT
- RENEWABLE ENERGIES HEAT ACT
- ENERGY-RELATED PRODUCTS ACT
- ATOMIC ENERGY ACT
- FEDERAL WATER ACT
- FEDERAL MINING ACT
- ENERGY INDUSTRY ACT
- ENERGY SECURITY OF SUPPLY ACT
- CARBON CAPTURE AND STORAGE (CCS) ACT
- GREENHOUSE GAS EMISSION TRADING ACT
- FEDERAL NATURE CONSERVATION ACT
- COMBINED-HEAT-AND-POWER ACT

- ELECTRICITY DUTY ACT
- ENERGY SERVICE ACT
- ENERGY DUTY ACT
- ELECTRIC MOBILITY ACT
- METERING ACT
- OFFSHORE WIND ENERGY ACT
- ENERGY SAVING ACT

National Level/ Ordinances

- ORDINANCE TO ENSURE THE SUPPLY OF ELECTRICITY IN A SUPPLY CRISIS
- ELECTRICITY NETWORK ACCESS ORDINANCE
- ELECTRICITY NETWORK CHARGES ORDINANCE
- GAS NETWORK CHARGES ORDINANCE
- GAS NETWORK ACCESS ORDINANCE
- DISCONNECTABLE LOADS REGULATION
- ORDINANCE ASSIGNING PLANNING APPROVAL PROCEDURES
- ORDINANCE ON ACCESS TO METERS
- INCENTIVE REGULATION ORDINANCE
- CONCESSION-FEE ORDINANCE
- LOW-VOLTAGE-CONNECTION ORDINANCE
- ORDINANCES IMPLEMENTING THE FEDERAL IMMISSION CONTROL ACT
- ORDINANCE ON THE CONNECTION
- OF POWER STATIONS TO THE NETWORKS
- ORDINANCE ON GRID SYSTEM STABILITY
- ELECTRICITY DEFAULT SUPPLY ORDINANCE
- GAS DEFAULT SUPPLY ORDINANCE
- LOW-PRESSURE-CONNECTION ORDINANCE
- RENEWABLE ENERGIES ORDINANCE
- SYSTEM SERVICE ORDINANCE

- BIOMASS ELECTRICITY SUSTAINABILITY ORDINANCE
- BIOMASS ORDINANCE
- ENERGY SAVING ORDINANCE
- HEATING COST ORDINANCE
- PROTECTION OF TRANSMISSION NETWORKS ORDINANCE
- HIGH-PRESSURE GAS PIPELINE ORDINANCE
- GRID RESERVE ORDINANCE
- ON ENERGY ORDINANCE CONSUMPTION LABELLING
- ORDINANCE ON THE ENERGY LABELLING OF CARS
- CROSS-BORDER RENEWABLE ENERGY ORDINANCE
- CHARGING STATION ORDINANCE
- AVERAGE ELECTRICITY PRICE ORDINANCE
- ENERGY-RELATED PRODUCTS ORDINANCE
- ORDINANCE TO ENSURE THE SUPPLY OF GAS IN A SUPPLY CRISIS

Sector specific rules and regulations

- VDE – The electrotechnical DIN standards issued by the DKE (Deutsche Kommission Elektrotechnik Elektronik Informationstechnik in DIN und VDE) are part of the German standards collection. These electrotechnical safety standards receive a VDE classification number and are included in the VDE Specifications Code of Safety Standards
- CE – All components which used and integrated in the Grid of SWW must be signed with the CE Mark. For Example the Regulation 73/23/EWG for electric equipment or the Regulation 91/263/EWG for telecommunication
- TAB SWW in addition to the Low-Voltage-Connection Ordinance (see: http://www.s-w-w.com/cms2/fileadmin/inhalte/sww/strom/vertraege_u_formulare/ergaenzende-bedingungen-nav-strom-preisblatt_20070618.pdf)

Specific Acts, Ordinances and Standards in detail

EnWG – Energie Wirtschaftsgesetz (German energy act – see: https://www.gesetze-im-internet.de/enwg_2005/index.html#BJNR197010005BJNE004208123). The Energy Act regulates the electricity and gas market and serves to implement and enforce the energy rights of the European Community (§ 1 EnWG). It is the basis for defining role and responsibilities in the energy sector. For all the actors listed in the document above (3.2 business procedure) there are role specified – except for the aggregator. The current situation regarding legal constraints and applicable standards will be addressed at the end of this chapter.

Within the EnWG of particular importance to implementing DSM mechanisms and making use of a platform like GOFLEX are:

Unbundling regulations – section 2 in the EnWG: Vertically integrated energy supply companies and legally independent operators of electricity and gas supply networks, are obliged to ensure transparency and non-discriminatory design and management of the network operation. To achieve this objective, they must ensure the independence of network operators from other areas of energy supply as defined in § 6a to 10e.

> when participating in the GOFLEX project and using flexibilities, SWW must be carefully about its role it takes

Tasks for the network operators – section 3: in §§ 13-14 clarification of the system responsibility. Pursuant to section §13 (2) sentence 1 of the EnWG, the TSOs are entitled and obliged to adapt all electricity feeds, current transits and current reductions in their control zones to the requirements of a secure and reliable operation of the transmission network, or to adapt this adjustment if a threat or disruption to the safety or reliability of the electricity supply system in the respective control zone cannot be remedied or cannot be rectified in time by means of measures pursuant to § 13 (1) EnWG.

§ 13 (2) EnWG thus provides the basis for intervening urgent measures by the TSO which grants him a margin of discretion with regard to the nature and scope of the measures to be taken, and behind which contractual obligations reside until the disturbance or threat is eliminated.

In parallel to this, all DSOs are obliged (see: § 14 paragraph 1c sentence 1 EnWG), to implement measures of the TSOs or measures of a DSO responsible, in whose network they are directly or indirectly involved, according to their specifications and the reasons given by an upstream DSO by their own measures, insofar as these are necessary Hazards and disturbances in the electricity supply networks with the least possible interference with the supply. With this regulation, the cascade is in the Law.

> Note: to meet the demands of the cascade is an essential requirement for a DSO in Germany. The GOFLEX platform can be used to fulfill this requirement.

The responsibilities for the various system services are clearly divided between the TSOs and the DSOs of the various networks. In addition to the EnWG this is specified in the actual versions of the Transmission Code 2007 and the Distribution Code 2007. By German regulation the TSO have greater scope for actions, as they are responsible for the stability of the system

(§ 13 Systemverantwortung der Betreiber von Übertragungsnetzen – see https://www.gesetze-im-internet.de/enwg_2005/__13.html and services such as the frequency stability. For this they use the Electricity Balancing Market (see: https://www.regelleistung.net/ext/) where flexibilities are the core commodity. More details to this market following.

Voltage stability is a system service which lies in the responsibility of the local network operator who coordinates actions. To achieve it, the operator can use generating plants, reactive power compensation systems, the grading of transformers and the change of the power topology.

When it comes to identifying suitable plants or customers to help managing the grid, operators of electricity distribution networks offer a reduced grid charge to those customers. In fact they are obliged to do so to those suppliers and final consumers in the low-voltage area with which they have concluded grid utilization contracts. In return, they agreed on the grid-based control of controllable consumption devices, which have a separate metering point (see: Gesetz über die Elektrizitäts- und Gasversorgung EnWG § 14a Steuerbare Verbrauchseinrichtungen in Niederspannung). A controllable consumption device also applies to electric vehicles.

> <u>Note: SWW as a local DSO could use the GOFLEX-Platform to manage voltage stability in its grid.</u>

When doing so, the DSO has to pay attention to other legal contraints and regulations as well. The Erneuerbare Energien Gesetz (EEG) is another law in Germany, which was introduced to foster renewable energy production. Besides feed-in tariffs with guaranteed revenues over 20 years, one of its basics is that RES has a priority in the german energy market. The priority for EEG and cogeneration also applies in the context of the operational cascade. The measures included in the measures pursuant to § 13 (2) § 14a: EnWG must ensure the priority acceptance of EEG and cogeneration electricity at every level, even in such dangers and disturbances.

While the EnWG act specifies who is in charge for what kind of tasks, there are further regulations that specify how to proceed. Following are the most relevant ones:

Stromnetzzugangsverordnung (StromNZV - http://www.gesetze-im-internet.de/stromnzv/):

Ordinance on network access provides the basis for the capacity energy market and the responsibilities of the balancing group manager. According § 4 Abs. 2 StromNZV the Bilanzkreisverantwortlicher (balancing group manager) is responsible for a balance between feed-in and withdrawal in a balancing group for each accounting period.

Stromnetzentgeltverordnung (StromNEV - http://www.gesetze-im-internet.de/stromnev/index.html):
This Regulation serves to regulate network charges for access to electricity transmission and electricity distribution networks (grid charges), including the determination of charges for decentralized feed-in.

In Germany the current structure of network tariffs is a barrier for implementing demand response schemes. By receiving substantial reductions in their network tariffs, large industrial customers are encouraged to a have a flat consumption pattern. If they increase their peak load, they risk an increase of the capacity fee component of their network tariff, thereby counterbalancing any cost advantages arising from flexible electricity demand.

Gesetz für die Erhaltung, die Modernisierung und den Ausbau der Kraft-Wärme-Kopplung (KWKG - http://www.gesetze-im-internet.de/kwkg_2002/index.html):
The objective of the Combined Heat and Power Generation Act is to reduce CO2 emissions in the long term. The aim is to support modernization and further expansion. By 2020 the share of electricity from cogeneration should be 25%. Similar to the Renewable Energy Sources Act, operators of cogeneration plants receive a subsidy which is transferred to the electricity price.

Erneuerbare-Energien-Gesetz (EEG - http://www.gesetze-im-internet.de/eeg_2009/index.html):
The Renewable Energy Sources Act is designed to enable a sustainable development of energy supply. Renewable energies are to be further expanded and fossil energy resources spared. The aim of this act is to increase the share of renewable energy in the electricity supply. In addition, the economic costs of energy supply should be reduced.

Anreizregulierungsverordnung (ARegV):
Regulation on the grid fees of energy networks. Based on the regulation, network tariffs are regulated. This is relevant in light of the fact that improved efficiency - through the use of flexibility - could lead to a better net-charge situation and thus to higher revenues.

BSI Rules and Regulations:
The German Federal Office for Information Security as the national cyber security authority shapes information security in digitisation through prevention, detection and reaction for government, business and society. Utilities and DSOs are regarded as ‘critical infrastructure’, therefore there is a special need to take care of the implementation of ICT solutions – refer to BSI.

Note: SWW has to be certified according to ISO/IEC27001 by 31.01.2018. The BDEW has also issued a White Paper specifying requirements for safe ICT systems, which refers to ISO/IEC 27002.

3.3.2 Applicable Standards to the Role of an Aggregator

When it comes to applicable standards to the role of the aggregator there are important specifications missing in the German regulations. There is basic framework regarding the use of flexibility options, but when this is done by the so called (independent) aggregator, the clarification of roles and responsibilities, including standardized processes as well as an ascribed value that corresponds to the benefits provided by flexibility are missing.

With the adoption of the Strommarktgesetz (StromMG) in the summer of 2016, the balancing group managers (BKV) were obliged to open their balancing group for so-called independent aggregators for the purpose of participating at the capacity market and marketing their services there.

At the capacity market – with highly specified standards and procedures - there are aggregators participating for a longer period of time and they have various business models. All in common are specific competencies like identifying flexibilities in different industries, the technical capability to physically connect the customers and integrate their load into an aggregated pool as well as a sophisticated communication and control infrastructure (hardware and software).

Some aggregators are integrated energy companies that support their company regarding sales apartments or the balance group managers. Others are independent and do neither sell electricity nor have the role and function of a balance responsible party (BRP). Thus, the independent aggregator represents a new role. How does this role participate in the existing regulation? Are there standards that can be applied?

Still this role in terms of responsibilities and processes has not been determined yet – although on the EU-level some recommendations have been made in 2015 by EG3 "Regulatory Recommendations for the Deployment of Flexibility". Further Standardization efforts have been taken on the EU level and there are ongoing consultations (e.g. the Bundesverband Neue Energiewirtschaft e.V (BNE) coordinates certain activities and publishes the position paper »Recommendations for Deployment of Flexibility in the German Electricity Market« - see: http://www.bne-online.de/de/content/branchenleitfaden-drittpartei-aggregatoren). For example there is a basic agreement on the need for data exchange because the electricity supplier/BRP needs to know what is happening within his portfolio to accurately forecast the consumption of his customers and procure energy accordingly. Another agreement exists on the necessity to define compensation rules for BRPs when DR events cause imbalance penalties.

And although there seems to be common sense on what to do, there are further details, which might stop a quickly prospering flexibility market. One could be the technological expectation requested by the BDEW that all accounting-relevant controllable units, which provide flexibility, must be integrated into automated processes (e.g. the smart meter gateway). Technical units which are already under contract by aggregators and for which there is as yet no obligation to comply with the requirement of a metering point (calibrated meters, specifications of the metering point operating regulations) should also be subject to a corresponding obligation.

If this will become an official requirement, the GOFLEX platform should be prepared.

4 Prosumers and Flexible Consumers

In the Wunsiedel demonstration case, the GOFLEX project aims at involving the following number of active participants:

Table 6: Targeted number and categories of pilot customers for the GOFLEX demonstration case in Wunsiedel

Category	no. of participants	max. installations if needed
Residential prosumers and flexible consumers (households)	50	22 HEMS, 150+ direct control
Industrial customers	2	10 FEMS
Electric car owners	5	5 CDEMS

According to the Grant Agreement, this set of targeted participants is considered the minimum requirement of participants for the demonstration case in Wunsiedel. As additional prototypes are available (see Table 6), recruitment efforts will extend beyond the minimum requirement for the demonstration case.

4.1 Analysis & Recruitment

The SWW Wunsiedel is implementing an ambitious roadmap for the development of regenerative energy systems in their supply area called the 'Wunsiedler Weg Energie' (see **Attachment A1**). In preparation of implementing this framework, the SWW Wunsiedel has been part of several national and European research projects, such as KomMA-P (Strengthening the acceptance for the energy transition [SONN-2016], SPARKS (Smart Grid Protection Against Cyber Attacks, https://project-sparks.eu/), installation & expansion of fibre optic network, etc. As in GOFLEX, these projects directly involved customers of the SWW Wunsiedel. From the experience gained from engaging customers in previous projects, first conclusions about the most promising customers for participation in the project as well as local conditions in the demonstration area could be drawn.

In addition to that, the recruitment and later customer engagement strategy is built on experiences from the EU FP7 funded project S3C, in which a web-based toolkit with practical tools and guidelines for engaging residential and commercial customers in smart energy projects was developed (S3C-Toolkit: www.s3c-toolkit.eu).

One central finding of the S3C project was that there is not one typical customer and therefore, there is no single successful strategy to engage customers [S3C-2015/1], [S3C-2015/2], [S3C-2015/3]. However, a number of cross-cutting success factor and opportunities to apply in smart energy projects were identified, some of which will be applied directly during the recruitment phase for the GOFLEX demonstration case in Wunsiedel. One of the identified cross-cutting success factors is to obtain a thorough understanding of the target group regarding e.g. attitudes, perception or technology interactions. While surveys and other forms of self-reports are often applied at the start of a project, more innovative and effective methods exist to get an in-depth understanding of the target group, such as contextual inquiries, gamification or co-creation workshops. In regionally-oriented initiatives, such as the Wunsiedel demonstration case, emphasising a sense of place and drawing upon the local community dynamics has proven to be an important success factor. A sense of community can act as a powerful driver, especially in a regionally oriented project. Community dynamics not only have the potential to support recruitment efforts, but can also generate motivation and long-term commitment. In order to build on community dynamics, a strong interactive approach throughout the project is needed. Additionally, local non-energy partners should be involved as project ambassadors, e.g. local mayor, non-profit organisations, etc. [S3C-2015/1], [S3C-2015/2], [S3C-2015/3].

Overall, successful recruitment of pilot customers for the GOFLEX demonstration case in Wunsiedel depends on three main action points: choosing the right communication channels, sending the right messages and choosing the right incentives corresponding to the project's target group [REISS-2016].

4.1.1 Key 'GOFLEX' Messages for Recruitment in Wunsiedel

Relating to the 'Wunsiedler Weg - Energie'(– see **Attachment A1**) as well as previous projects and communication activities of the SWW Wunsiedel, overall key messages for the recruitment and project communication in Wunsiedel have been formulated (see Table 7 below). For further information on project communication, please refer to Deliverable 10.1 (Business and Marketing Plan – Year 1).

Table 7: Key messages for customer recruitment & communication

Phase	Description
Year 1 & 2	We take the next step towards 100% self-supply with regional and green energy for Wunsiedel. Together with our customers, we prepare for the coming termination of the EEG feed-in compensation.
Year 3	We prepare a regional marketplace where our customers can locally trade energy as well as flexibility.

4.1.2 Customer Groups Considered for Recruitment

For the purpose of recruitment and later customer engagement, different customer groups have been identified (see Table 8). For each of the customer groups, specific opportunities and the desired outcome after the project are defined. Furthermore, communication targets, specific key messages and corresponding communication tools and channels are developed.

Table 8: Identified customer groups considered for recruitment and communication purposes for the GOFLEX demonstration case in Wunsiedel

Customer group	Description
Pioneer Prosumer	Pioneer prosumers are residential customers of the SWW Wunsiedel GmbH that not only produce energy (most often PV, EEG feed in compensation), but also already have a storage system installed. Pioneer prosumers are further characterized by a high interest in the topic of energy & self-supply and are considered to have a considerable readiness for active participation in trial projects, such as GOFLEX.
Type 1 Prosumer	Type 1 prosumers are residential customers of the SWW Wunsiedel GmbH that own and operate a renewable energy plant (most often PV, EEG feed in compensation). For Type 1 Prosumers, the (German) EEG-feed-in compensation will terminate within the next five years.
Type 2 Prosumer	Type 2 prosumers are residential customers of the SWW Wunsiedel GmbH that own and operate a renewable energy plant (most often PV, EEG feed in compensation). For Type 2 Prosumers, the (German) EEG-feed-in compensation will terminate within the next five to ten years.

Type 3 Prosumer	Type 3 prosumers are residential customers of the SWW Wunsiedel GmbH that own and operate a renewable energy plant (most often PV, EEG feed in compensation). For Type 3 Prosumers, the (German) EEG-feed-in compensation will terminate in more than ten years.
Flexible Consumer	Flexible consumers are residential customers of the SWW Wunsiedel GmbH. While not having installed a generation unit (non-prosumers), preferred flexible consumers are those with expected high flexibility potential, e.g. customers with night storage heating (see Table 9: SWW customers considered most promising for successful recruitment & participation in GOFLEX).
Commercial customers	Preferred commercial customers of the SWW Wunsiedel are those with expected high flexibility potential. A first list of commercial customers to approach has been identified (see Table 9).

4.2 Identification of Most Promising

Based on experience from previous projects and available flexibility potential, a number of customers per customer group have been identified as most promising candidates for participation in the GOFLEX project (see Table 9 below).

Table 9: SWW customers considered most promising for successful recruitment & participation in GOFLEX

Participants	Description
Reference Sites	• 3 experienced and highly motivated entities, representing all technical requirements specified in this document, and willing to accept challenges during development phase
Pioneer Prosumers	• Approx. 35 prosumers (PV system, EEG feed in compensation) with installed storage systems • Prosumers & flexible consumers in Schönbrunn (participation in previous projects) • EV owners
Type 1-3 Prosumers	• All approx. 600 prosumers (PV system, EEG feed in compensation) in the supply regions of the SWW • Customers in Schönbrunn (participation in previous projects) • Customers of WunSolar (Partner for planning and installing PV systems)

	• Customers with self-consumption concept (few) • Approx. 10 privately owned cogeneration plants • Showcase flat (Smart home equipped flat from previous project) • EV owners
Flexible Consumers	Approx. 400 customers with electrical storage heating and boilers, plus approx. 100 customers with radiant heating, marble heating, etc.
Commercial Prosumers	• Lamberts (local glass production factory) • Daubner (petrol station, installed PV, plans to install EV charging stations; H_2 Mobility) • Local brewery • Local grocery store (EDEKA)

4.3 Requirements for Interaction

4.3.1 First set of requirements for interaction for GOFLEX consortium partners

- First set of marketing materials in the local language (German) (including e.g. leaflet with general project information, standardised mailing template, demonstration site related press release, etc.)
- All deployed human-technology interfaces must be easily understandable, usable and available in German language
- First presentation of GOFLEX and its consortium partners at the kick-off meeting (planned for 16th of September 2017)
- Training regarding installation of GOFLEX equipment for on-site installers (to enable communication between installers and participating customers)
- Provision of GOFLEX app or web interface; programming should be flexible enough to include potential engagement features at later project stage, e.g. quizzes, social comparison feature, etc.
- Provision of incentives to GOFLEX participants; both monetary and non-monetary incentives are considered; incentivation scheme to be discussed.
- Development and implementation of a concept paper for a Design Thinking approach for the GOFLEX demonstration case in Wunsiedel. Design Thinking is applied as a participative process to develop new products and services that focus on user needs and expectations.

The requirements for interaction regarding prosumers and flexible consumers focus, at this point, mainly on the recruitment process. The requirements will be updated once a detailed plan for ongoing customer engagement is developed. This plan will, in part, be based on the outcome and experiences gained in the design thinking approach.

4.3.2 First Set of Requirements for Interaction for GOFLEX Participants

GOFLEX document D11.2 will specify personal data protection and ethics requirements in detail. SWW particular requirements have been specified in the following. Humans participate in the GOFLEX project either as individual participants. A participant can give their informed consent when: 1) they are informed about the specifics of participating in the project; and 2) they freely agree to participate in one of the available roles. The following sections outline procedures that will be followed on the project for people participating as individuals.

GOFLEX is an innovation project funded by the European Commission to increase usage of renewable energy. Participation of people from outside the project team is essential to help understand the acceptability and effectiveness of GOFLEX solutions. An individual person may participate in GOFLEX as a producer-consumer (prosumer) or as a flexible consumer. In both cases, participating means:

- allowing the installation of equipment in its premises;
- allowing the equipment to adapt the dynamics of the operation of electrical loads based on criteria to be agreed;
- providing data collected at its premises to the project team; and,
- gaining access to detailed information about its energy use.

Questions and answers, which should be addressed so that participants may give their informed consent are listed in Table 10. Note that the detailed information provided here is prepared at month 6 of the project and may change at the time of actual engagement with project participants scheduled for month 18. Any changes will be carried into adapted versions of this information prepared specifically for the case studies, including translation to the local language.

Table 10: Information for Informed Consent

Topic	Response
Purpose of project	Increase use of decentralised renewable energy by trading flexibility on a regional basis and to use such flexibility for electrical grid management (load balancing)
Nature of participation	Participation is completely voluntary. The expected duration of participation is 18 months with an option to continue for a further two years. Participants may withdraw at any time.
Project Organizer	Demonstrations are organized by SWW
Contract	A contract will be settled between SWW and each participant, where terms & conditions are clearly defined
Benefits of participation	Participants contribute to a regional energy system based on renewables and gain access to detailed data on their own energy use.
Data protection	Steps for data protection are outlined in project deliverable D11.2.
Contact Person	SWW's has delegated a person responsible for data protection

Participants shall sign a customer consent agreement for gathering, processing and use of personal data for research purposes (see **Attachment A2**). In addition to that, there will be an individualized contract between SWW and each volunteering participant. This contract will comprise but not limited to the following: (i) object of contract, (ii) duties and compensation, (iii) property rights, (iv) obligations and responsibilities, (v) warranties, liability, liquidate damages, (vi) limitations, (vii) attachments: specification of interfaces, installation requirements, and related services.

5 Demonstration Requirements

During the GOFLEX Kick Off Meeting in Dublin it has been decided, that the trading mechanism developed shall not only simulate changes in energy flow and load. Flexibility offers collected from the xEMS systems implemented at various SWW customers shall lead to an active control of energy flow. In addition to that also SWW's grid management needs to be connected to the trading platform to grant priority to grid management if economic optimization of trading endangers grid stability. Thus, this decision raises the requirements to the systems, which will be installed – see Table 11. System quality in terms of performance, safety, security and maintainability has to strictly follow German rules and standards. Institutional customers might be easy to deal with, because they are used to close contracts where they accept taking over some responsibility and risk, but not so private customers. There is poor understanding of technology and a private customer will call you at any time during the weekend if there was any unusual behaviour in his house. There is no chance to recover service costs even if you found out that the kids have simply pulled the plug somewhere.

Due to this reason SWW has decided to start with reference customers and permit the roll out of any of the GOFLEX solution after having passed a thorough acceptance and test procedure, which will be done in several steps.

Table 11: ICT components to be integrated after successful Acceptance tests - quantities to be mutually agreed upon

Objective O	Use Case 3: Germany – SWW Demo Site Wunsiedel
O1: Trading	BRP level
O2: Storage	10 FEMS, 22 HEMS 150+ direct control
O3: DR ready xEMS	22 residential EMS, 10 factory EMS, 10 micro power plants EMS
O4: EVs	5 Public (charging)
O5: Distribution Observability	Localised effect of DR on HV distribution and several primary substation feeders: 500+ buses/branches
O6: Cloud data services	SCADA: 1k points, AMI: 200 points Weather: public gridded data 500+ Forecasting Models

Figure 11 describes the systems, which shall be installed, integrated and tested in the first step. Smart meter data a) will be collected from an external server according to Figure 19, where also the reference site Nagel, Seeblick 39 shall be newly equipped with such a metering system. Note – today there is only installed a HT/NT two tariff Ferraris electricity meter at Nagel, Seeblick 39. Substation grid data can be derived according to Figure 17 and Figure 18 described in Section 5.2.1.

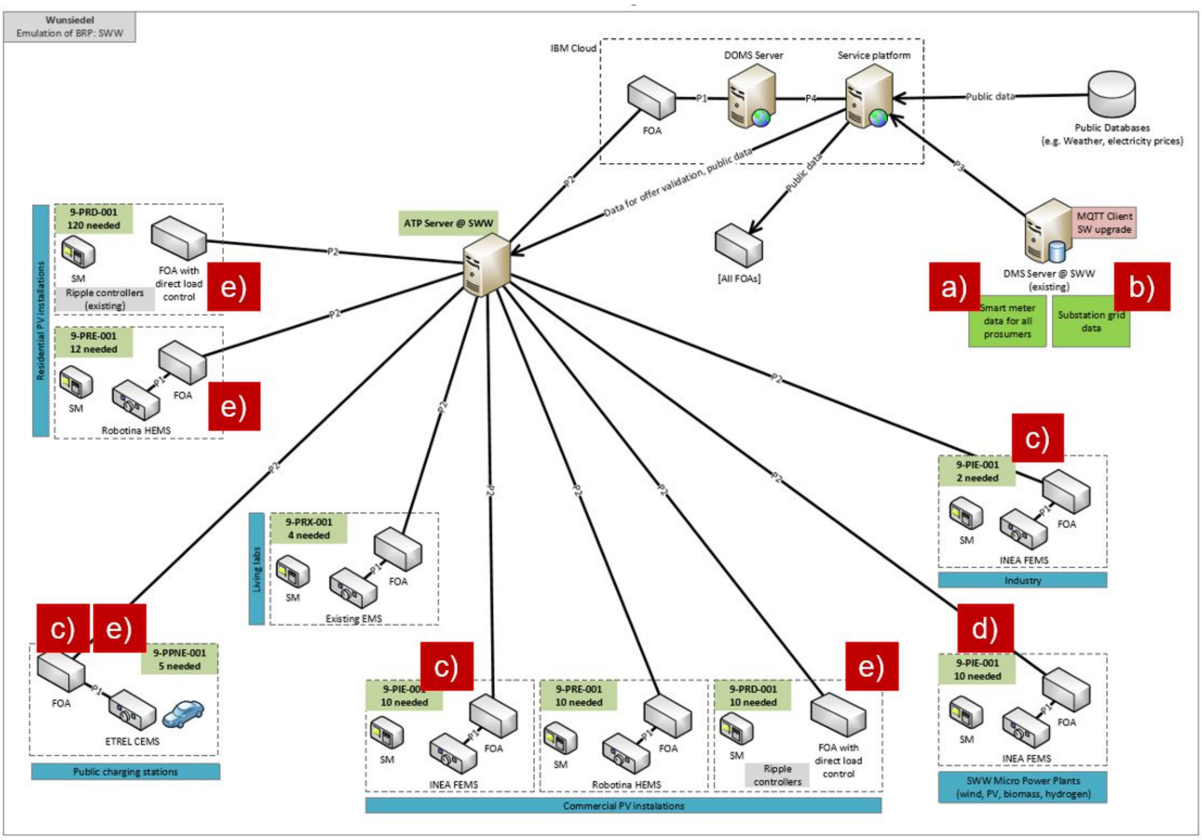

Figure 11: WP9 - GOFLEX SWW demo site ICT architecture (general)

The xEMS systems are connected via ITIs (=Intelligent Trading Interfaces) or Flex-Offer Agent Interfaces to the GOFLEX trading platform. Table 12 maps the reference sites to xEMS installations.

Table 12: Reference installations for GOFLEX components – related. to Figure 11

ID	Representative – sample installation sites
a)	150 smart meter data to test data processing retrieved from Schröder server – see Figure 19
b)	online data from Neusorg grid at 110kV / 20 kV station Neusorg – see Figure 18
c)	FEMS and CEMS installation at company Daubner: Industriestraße 5, 95700 Neusorg – see Section 5.3.2
d)	PV and Biomass electrical power and heat generation, heat storage. Satellite power plant: Am Luxbach 18, 95632 Wunsiedel – Breitenbrunn see Section 5.3.3
e)	HEMS, TEMS, CEMS and ripple control installations at domestic building Seeblick 39, 95697 Nagel – see Section 5.3.1

5.1 Existing Grid Infrastructure

Prosumers and infrastructure: SWW maintains about 420 kilometres of medium and low voltage lines, and about 6200 grid connections and 200 transformer stations. In 2015, SWW supplied 84 GWh of electricity (43% from renewable sources) and 5 GWh of heat mainly from biomass for district heating.

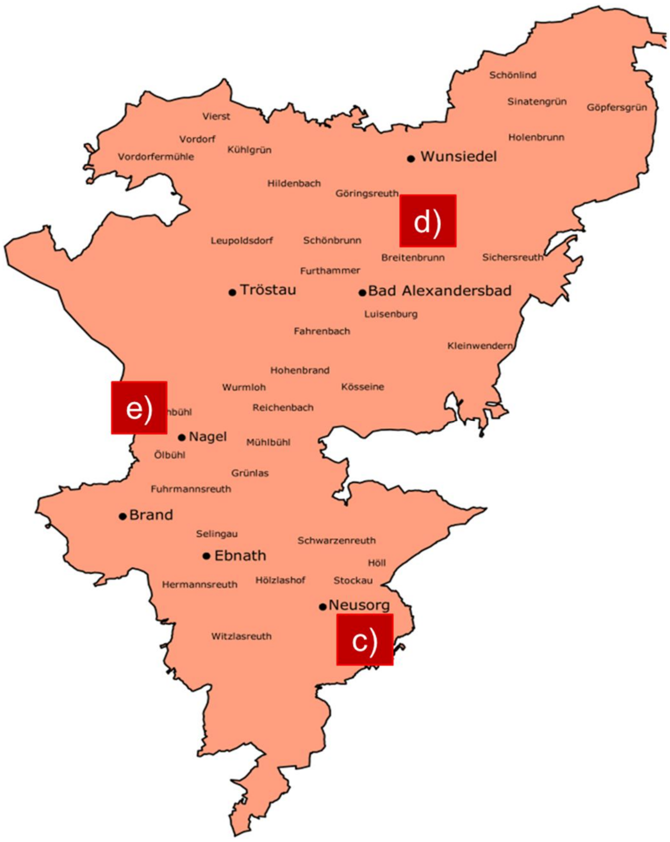

Figure 12: SWW supply territory and reference sites

An overview of the generation facilities is given in Figure 13. SWW operates the electrical, gas and heat networks depicted in blue, yellow and red, respectively. Unique for the Wunsiedel infrastructure are the manifold coupling points between these three networks. The biomass cogeneration plant couples gas, electricity and heat network. The methanisation plant couples electricity and gas network. Local industry couples electricity and gas network with remote heating. Waste heat can also be converted to electricity using the "local industry waste heat OCR (Organic Rankine Cycle)." The overall power system is shown in Figure 13. Table 1 lists key figures of the system.

Biomass - With biomass, electricity and heat are produced in the biomass cogeneration plant. The ORC turbine produces about 6.000 MWh of electricity. This produced regional green energy is fed into the grid of the SWW and covers the energy demand of about 1.600 average households. As a "by-product" of the electricity generation from renewable sources, about 16.000 MWh of heat are produced and the adjacent pellet plant uses the heat from the power plant to dry and press wooden chips for pellet production.

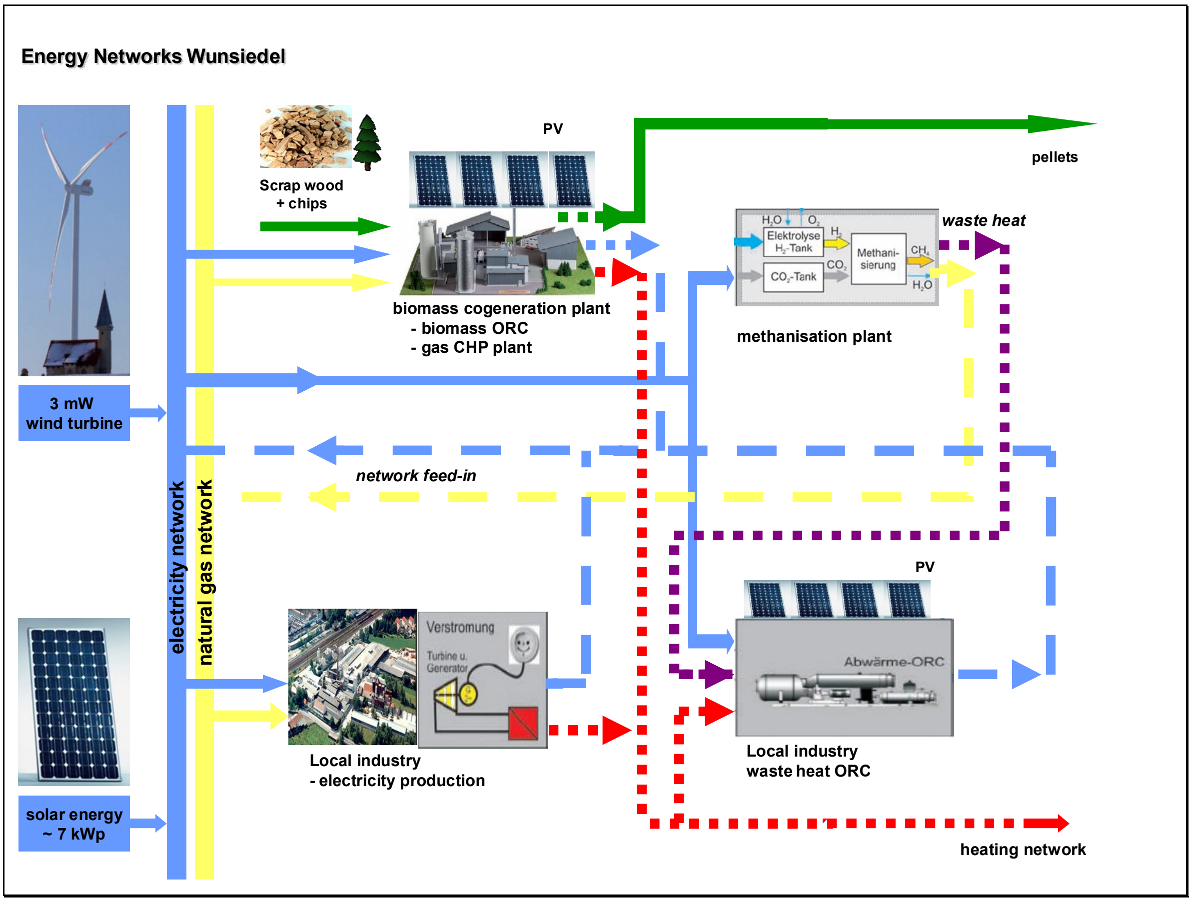

Figure 13: Power system generation SWW

Photovoltaics - The SWW Wunsiedel (WUN Solar GmbH) builds, finances and operates photovoltaic systems. Since 2008, 223 photovoltaic systems with a total area of approximately 50.000 square meters have been realized installed by WUN Solar. The overall performance of all PV systems installed since 2008 to the power grid of the SWW in case of maximum sunshine is approximately 7.000 kWp (kW peak). Among others, the SWW operates a publically financed photovoltaic installation (80 kWp) that produces approximately 70.000 kWh p.a.

Wind energy - With the wind energy generated annually by the local wind turbine (3 MW), around 2,400 three-person households can be supplied with energy.

Table 13: Key data of SWW electrical power network

Length of overhead wire system	
Medium-high voltage:	44,187 km
Low voltage 400V:	50.407 km
Length of underground cable	
Medium-high voltage:	111,075 km
Low voltage 400V:	213,879 km
Installed power in electrical power transformation:	
Transformed power total:	55590 KVA
Number of access points:	
Medium-high voltage:	18
Low voltage 400V:	11606
SWW territory key data:	
Residents / users:	18656 persons
Supplied area:	22,26 km²
Geographical area:	161,5 km²

More electrical grid facts & figures according to EnWG can be found here:
http://www.s-w-w.com/cms2/index.php?id=140

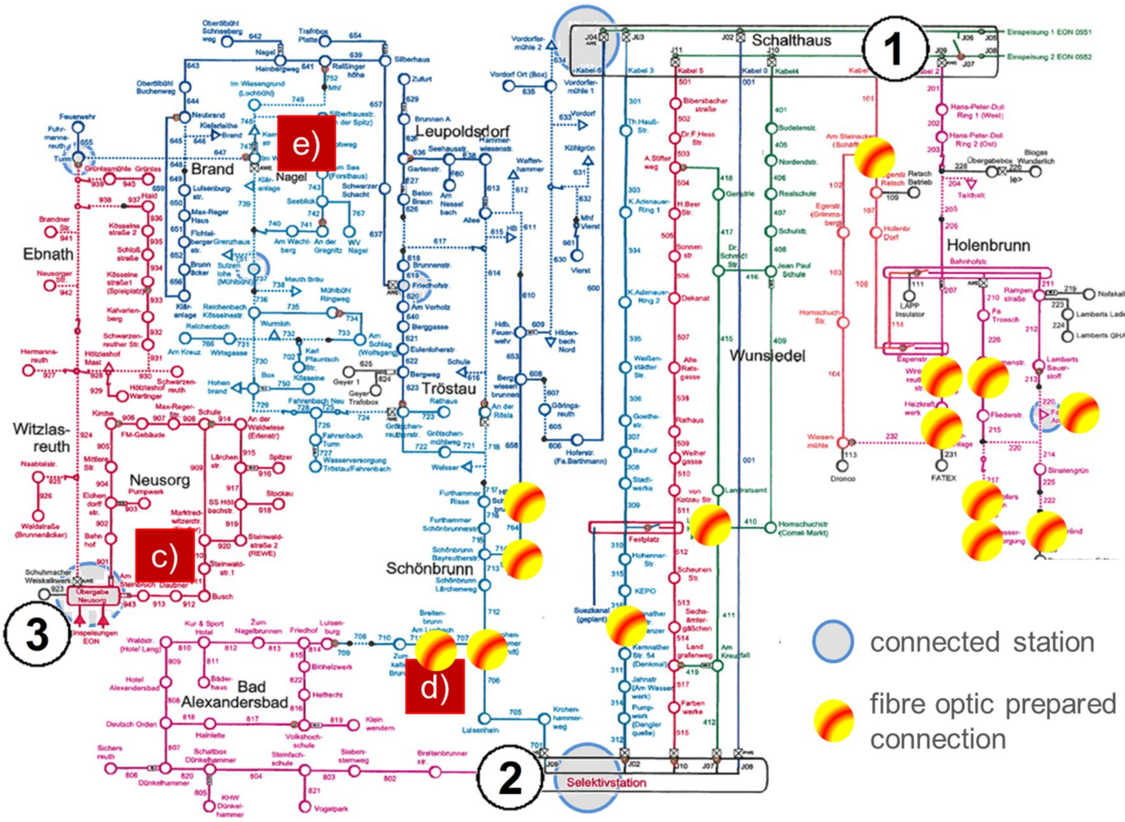

Figure 14: SWW power system and grid with stations connected to SCADA – reference sites c), d), e).

Electrical parameters – I; U; P; Q; S; cos ф – and status information can be read from the stations highlighted with a blue circle in Figure 14. A description of the communication can be found below see Figure 17 and Figure 18.

The SWW maintained distribution grid consists of two 110/20 kV feeders from EON – Bayernwerk (Energy supplier Bayernwerk – see: https://www.bayernwerk.de). One is located in Wunsiedel, one in Neusorg. At these feeding points power is distributed via some 20kV meshed networks and some 20kV networks design as open rings. Special customers are directly supplied with 20 kV substations, some of them even owned by these customers. Most customers are connected through service mains with a 20kV/400V transformer station serving as a feeder. Figure 15 describes the 20 kV electrical power distribution system to regular customers. From the 20kV / 400 V transformer station it shows the circuitry to and from the individual consumer premises.

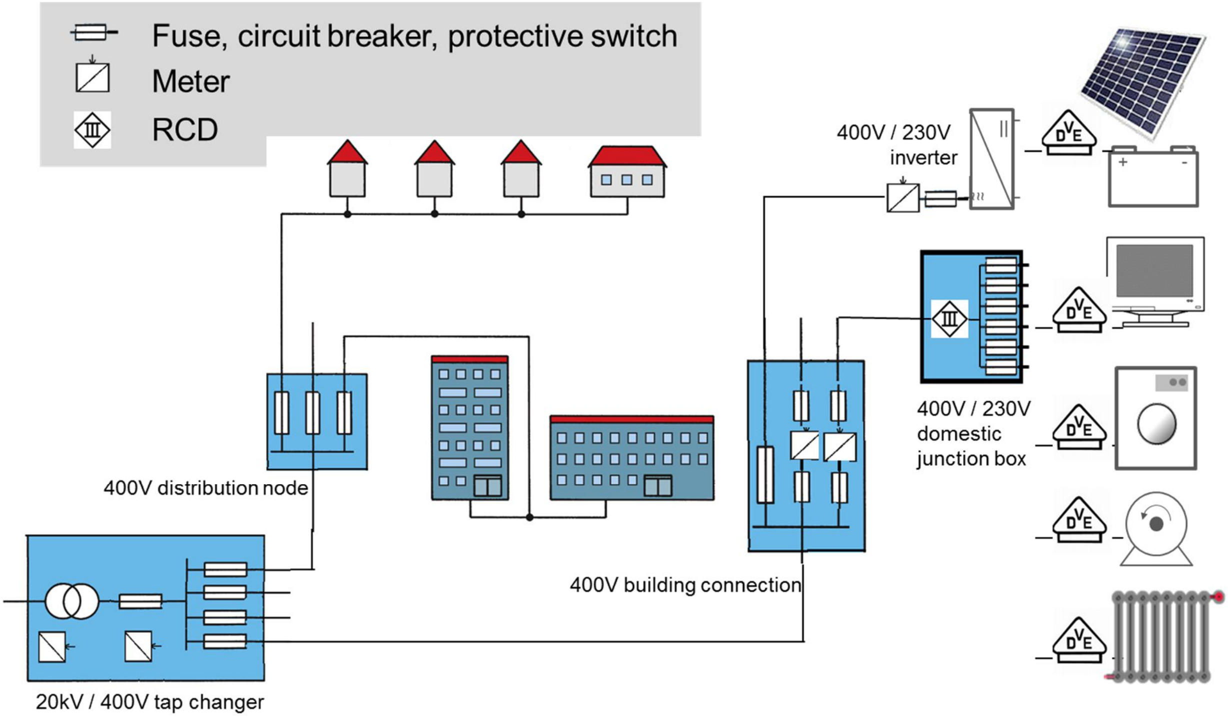

Figure 15: Electrical connection from 20kV transformer station to 400V / 240V appliances and domestic installations.

5.2 Existing ICT Infrastructure

SWW offers a variety of measuring and metering facilities to its customers. SWW also provides a smart home solution, which are essential element to this project. Siemens has licensed the SCADA system Spectrum Power® 5 to SWW with its IEC 61850 interface providing the ideal platform for the development, implementation, and testing of new smart energy features [KLEI-2016/1]. Demonstration objectives and use-cases:

- Feasibility of the cellular ICT architecture and computer controlled load balancing in a field test environment to proof the effectiveness of distributed intelligence and decentralized automation capabilities in energy supply
- Optimization of the balance for SWW to reduce corrective costs and losses
- Use of smart methods and distributed ICT to reduce peak loads on the distribution grid, thus reducing the need of upgrading the infrastructure in an area where decentralized PV production is increasing.

5.2.1 SWW ICT Landscape – Operational

Active power network management is a prerequisite for any smart grid of the future. These grids will have to incorporate and manage centralized and distributed power generation. Intermittent sources of renewable energy, such as wind and solar power, allow consumers to become producers and export their excess power. Bi-directional power flows from many different sources will occur. In order to avoid heavy investments in grid reinforcement, the existing grid infrastructure has to be adaptive to cope with these new requirements. This means that monitoring, remote activation and control systems have to be implemented step by step. The management systems have even to integrate real-time pricing and load management data. SWW plans to replace its master controller, which consists of two software components and proprietary developed user applications. The currently installed monolithic "Elipse E3" SCADA system comprises all relevant processes and algorithms. Measured data is processed, reported and stored with the ARCON software. In lack of any commercial system SWW has developed its own monitoring and intelligent supervisory control system basing on this two basic software components. Note: SWW's monolithic home-grown SCADA system is likely to be replaced by the new Siemens Spectrum Power 5 system from, which currently has been installed for R&D field tests. The system architecture and basic elements are shown in Figure 16 below.

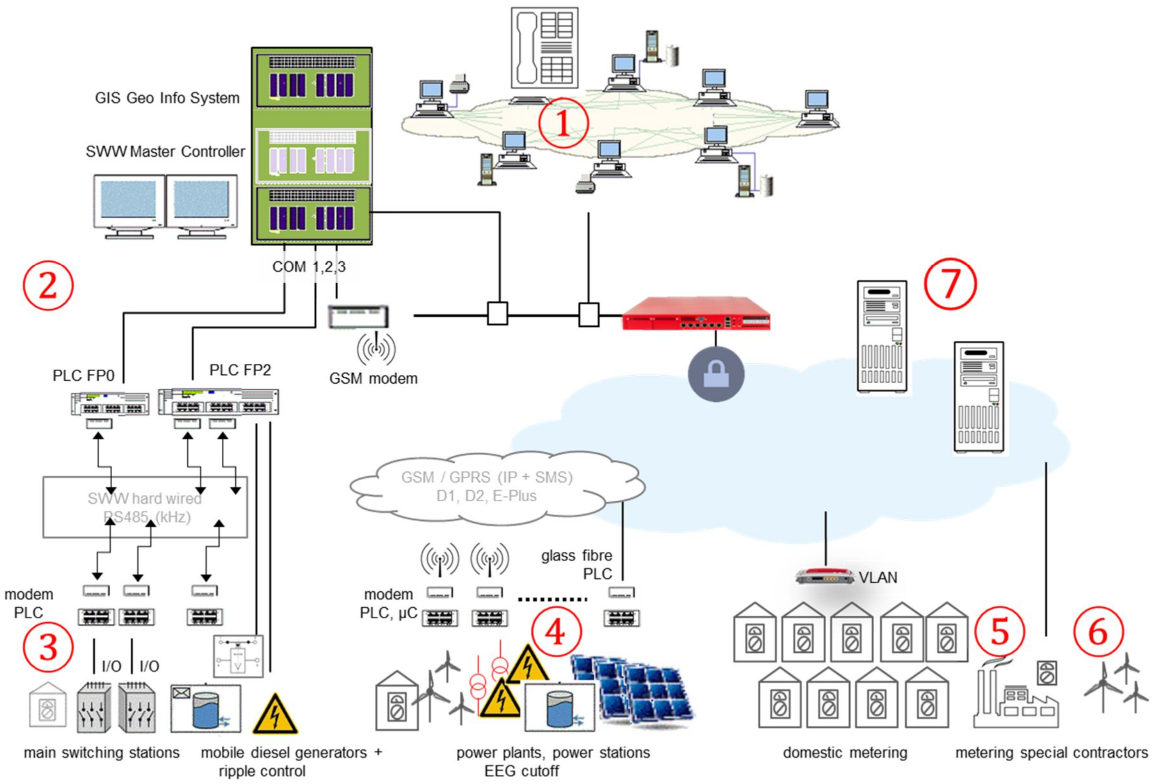

Figure 16: SWW ICT and Smart Grid Components

③ Main switching stations, ripple controller and balancing power generation are controlled by the SWW Master Controller PLCs (Note: for security reasons no remote control or automatic switching is implemented today). The communication is hardwired via a proprietary PLC communication protocol or simple digital or analog PLC signals (4-20mA). Data from these components can be received from SWWs Master Controller via file transfer (.csv files) to any FTP folder or cloud. Time stamps and intervals will be set to 15min for the data transferred. GOFLEX applications shall import such data from said FTP folders or cloud – see Figure 17.

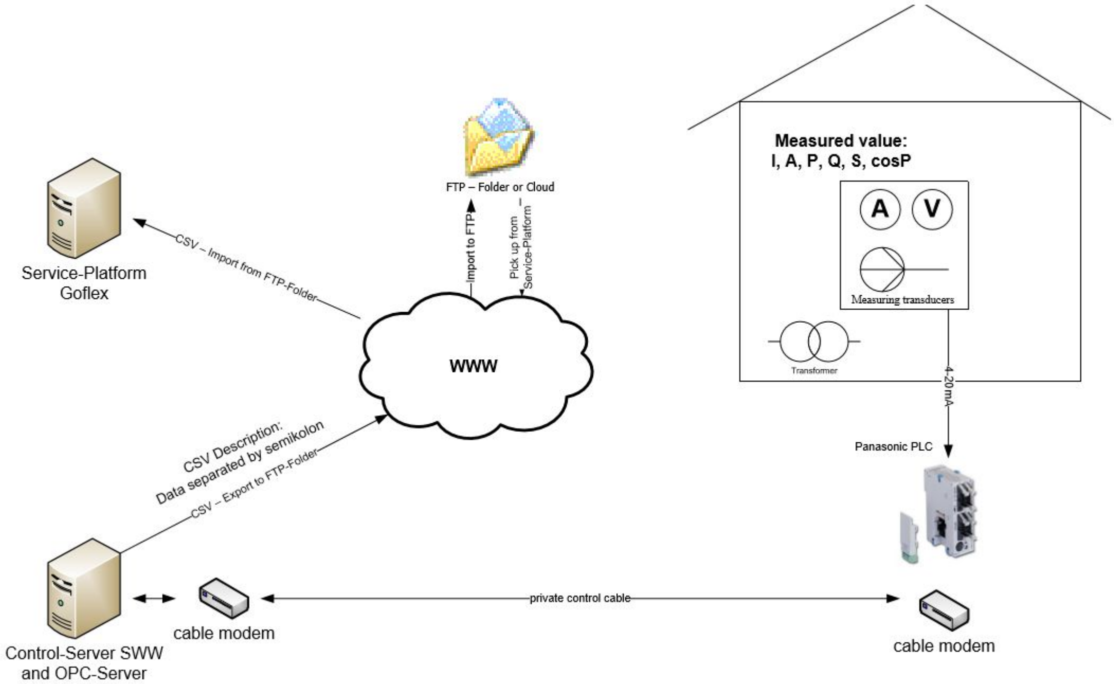

Figure 17: Communication to SWW feeder /transformer Station 110kV / 20kV Schalthaus and Selektivstation.

The "Schalthaus" – see (1) in Figure 14 – is one of the two 110 kV/20 kV feeders to the next level DSO (Bayernwerk). Today SWW can monitor the current equipment status and the following physical parameters: I; U; P; Q; S; cos ϕ.

Within GOFLEX it is required to install the measurement and monitoring of reactive power in order to ensure grid protection when manipulating the flow of electricity through automatic trading mechanism.

The "Selektivstation" – see (2) in Figure 14 – has been installed to avoid too long cables and a possibility to bridge outages in case of n-1 (redundancy).

④ Power plants, power stations, some water stations and special utilities are controlled by the SWW Master Controller via GPRS. Alarms and error messages are sent to the SWW Service Center via SMS. Despite sending alarms, events or process data, the field devices receive power cutoff signals via the GPRS interface (EEG

Abschaltung). The IP-based communication interface of the SIM cards is used. Data from these components can be received from SWWs Master Controller via file transfer (.csv files) to any FTP folder or cloud. Time stamps and intervals will be set to 15min for the data transferred. GOFLEX applications shall import such data from said FTP folders or cloud – see Figure 18.

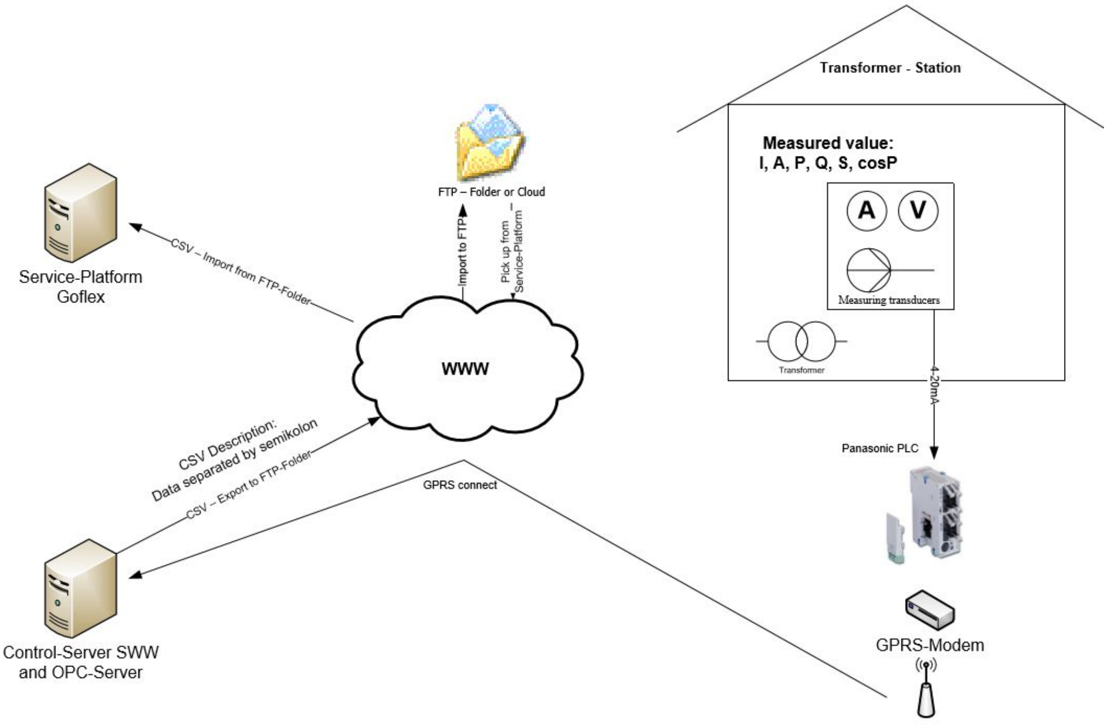

Figure 18: Communication to SWW feeder and transformer station 110kV / 20kV Neusorg.

The station in Neusorg – see (3) in Figure 14 – is the second 20 kV feeder to the next level DSO (Bayernwerk). It is possible to connect the Neusorg grid segment manually to the much huger Wunsiedel grid segment in case of emergency. Today SWW can monitor the current equipment status and the following physical parameters: I; U; P; Q; S; cos ϕ.

<u>Within GOFLEX it is required to install the measurement and monitoring of reactive power in order to ensure grid protection when manipulating the flow of electricity through automatic trading mechanism.</u>

The communication from SWW's master controller to this station in Neusorg is based on MODBUS protocol via GPRS modem.

⑤ Smart metering for domestic customers is done via VLAN. Metering data (consumption) is time stamped and sent to the server of an external accounting service provider. Potential risks due to cyber-attacks may cause loss and violation of personal customer data. The effects could include: a) spied customer data b) gaps in metering. The installed VLAN (Virtual Local Area Network) allows only reading of data with the only write exception of time setting.

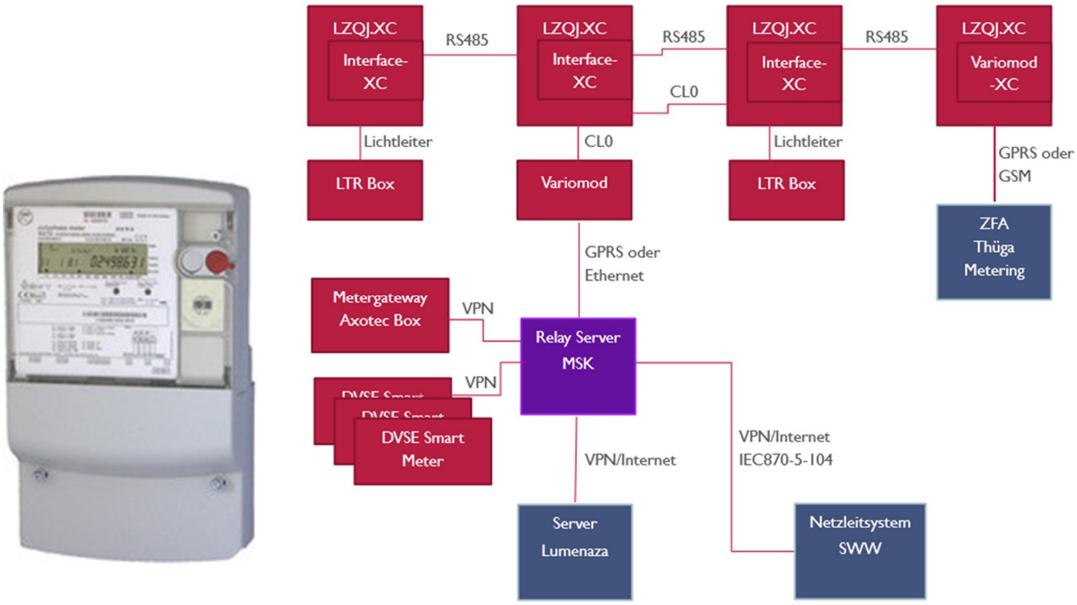

Figure 19: NXT4 – 4 Quadrant Meter LZQJ-XC and VPN access available to the data server.

http://emh-meter.de/en/products/nxt4/

⑥ Special customers (e.g. industry, or external power plants) are connected via modem to forward metering data to the server of a contracted accounting service provider. The potential risk stems from the IP-based communication interface of the SIM cards used. The effects of a cyber-attack could be a) fake or blocked alarms, b) fake data and information c) EEG cutoff of single power generators. There is no damage expected to consumer systems, which are protected by individual security measures.

⑦ SWW uses several external services like weather forecast, market prices, accounting and billing services, etc. via Internet. The risk is to receive a) Spam or b) wrong / fake information. Only instructions from the higher level DSO (Bayernwerk – system OSKAR) may cause some irritation to SWW's service resources.

5.2.2 SWW ICT for Research and Development

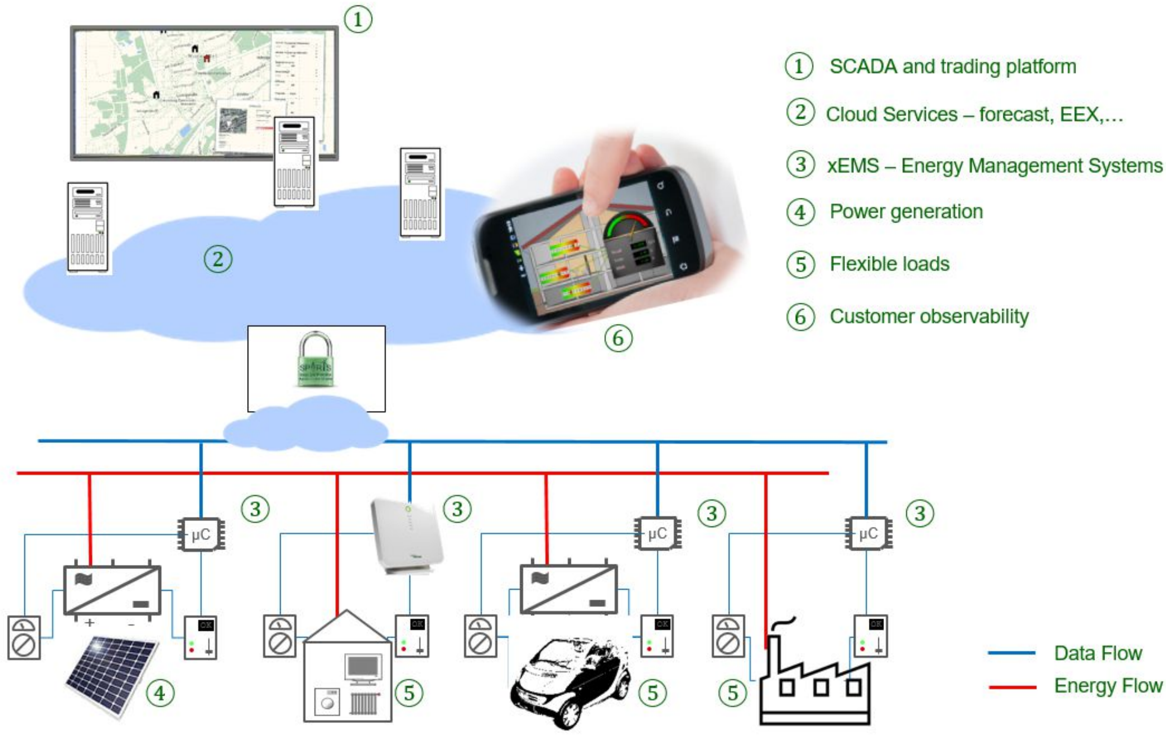

Figure 20: intelligent subsystems (xEMS) can provide load balancing and energy trading capabilities within a micro smart grid according to IoT or Industry 4.0 paradigms.

Due to the permanently increasing portion of distributed energy generation, energy management systems become more important to allow a stable operation of the grid at its limits. Future Smart Grid ICT systems shall be able to monitor behavior and to predict the utilization and the state of the grid more precisely than today. Following this idea, SWW has decided to develop a new energy management system not only to handle the volatility of electricity generation and consumption in a decentralized power grid but also to manage all other services provided by a utility company. The new Supervisory Control and Data Acquisition ("SCADA") system installed shall operate as an ICT service provider which collects data and provides diagnostic functionality and forecast services. Instead of actively controlling field level systems top down the new master controller focusses on exception handling, data monitoring and information or energy brokerage. Energy management shall be done decentralized providing flexibility offers to the utility. Conventional SCADA control systems have started to come into wider use more than two decades ago. Based on the experiences with the actually installed off-the-shelf SCADA system SWW has defined some major requirements for future energy management and smart grid control systems following the paradigms of IoT or Industry 4.0:

- SCADA systems have to be transformed into a multi-platform tool that can be accessed with lighter clients, such as web browsers.
- Communication with field components shall use various protocols allowing the transfer of semantic information, like equipment self description, data collection plans – e.g. via Extensible Markup Language (XML).
- SCADA systems shall support usage of different devices, like personal and tablet computers, smartphones, etc..
- Advanced safety and security installations, like online authentication and authorization mechanism shall be mandatory.

Together with Siemens SWW is pioneering strategies and innovative solutions for energy generation and intelligent power supply in Wunsiedel. In a first step the SCADA software system SPECTRUM Power™ has been installed and connected to several smart home controllers in Wunsiedel's so called "living labs".

This new SCADA system runs independently from SWW's master controller allowing testing energy systems and grid components under development. Figure 20 shows the generic smart grid ICT architecture able to provide the required feature according to the cellular approach [VDE-2015] based on a system of self-controlled smart microgrids. Functionality and use of this SCADA installation will be extended in order to replace the monolithic master controller step-by-step.

Figure 21 is a screenshot from the SCADA system, which provides an overview of the electrical storage heaters in one of SWW's living labs. The lower part of the screen (1) shows the key parameters of the modern storage heaters installed in the house, like loading states, capacity, available storage capacity in hours and kilowatt, etc. and the room temperature. The upper part of the screen (2) provides storage capacity for the whole apartment – which is the sum of capacities from all electrical heaters [kWh] and the outdoor temperature in [°C].

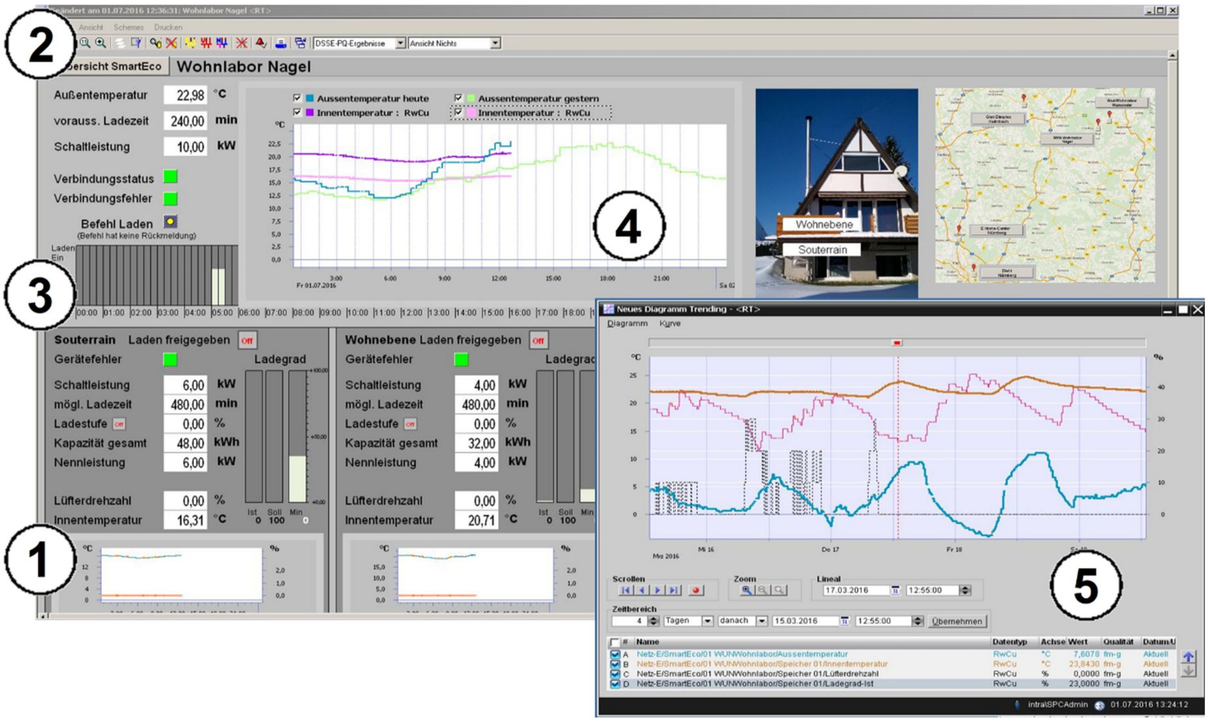

Figure 21: Based on an off-the-shelf SCADA system it is possible to shed, shift, or shape loads using remote controllable power generators, electrical heaters, or coolers [KLEI-2016/1].

In the middle part of Figure 21 (3) default settings for loading (loading plan) can be parametrized in case that automatic control of the heaters is down. System behaviour is monitored real-time (4) – here the room temperatures, outdoor temperature and forecast are visualized. At any time it is possible to analyse data from the data base (5) – figures analysed provide information from a week with volatile outdoor temperatures (blue) and the behaviour of room temperature (orange), the loading stage of the heater (red) and the warm air flow rate (dotted black). SWW's has installed its new master controller for all research projects (see Figure 22), which in the near future shall serve as the new SCADA system to manage its territory as a self-sufficient energy island capable of independent isolated operation and black start mechanism.

Besides electrical storage heaters many other electrical grid relevant applications could be managed via a connected smart home controller. Figure 23 shows the possibility of charging electric vehicles (EV) wherever a smart home controller has been installed.

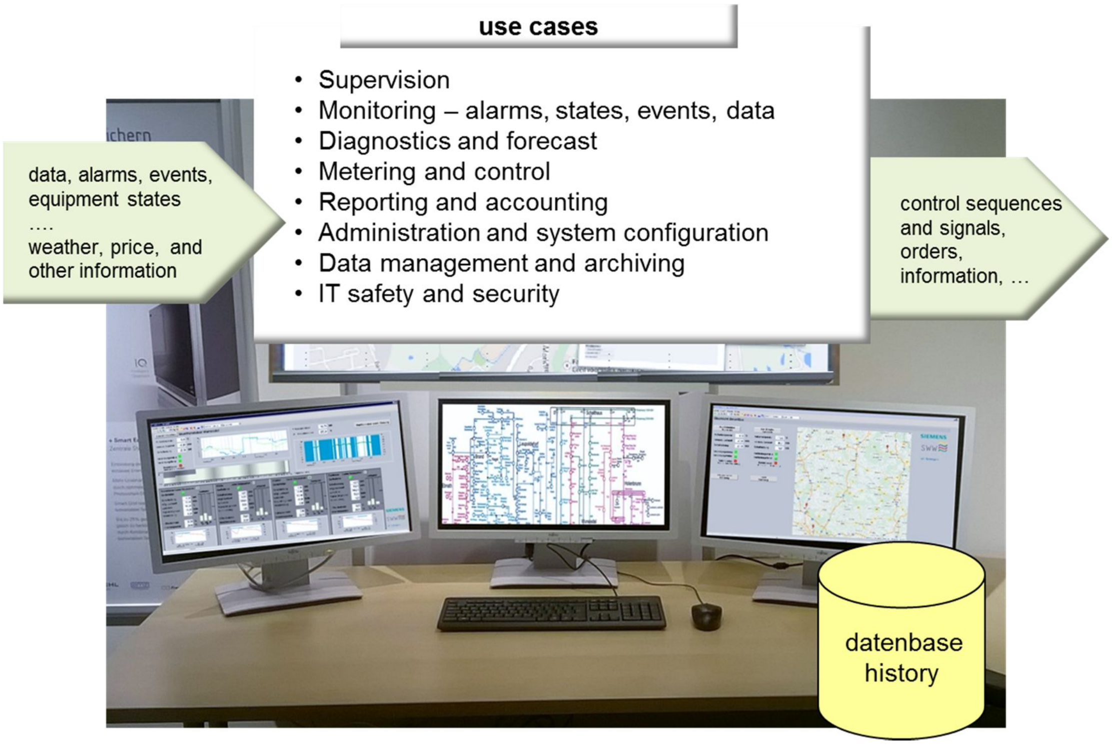

Figure 22: Future SCADA systems for decentralized energy systems shall monitor all relevant business processes with minimum control mechanism but efficient exception handling capabilities.

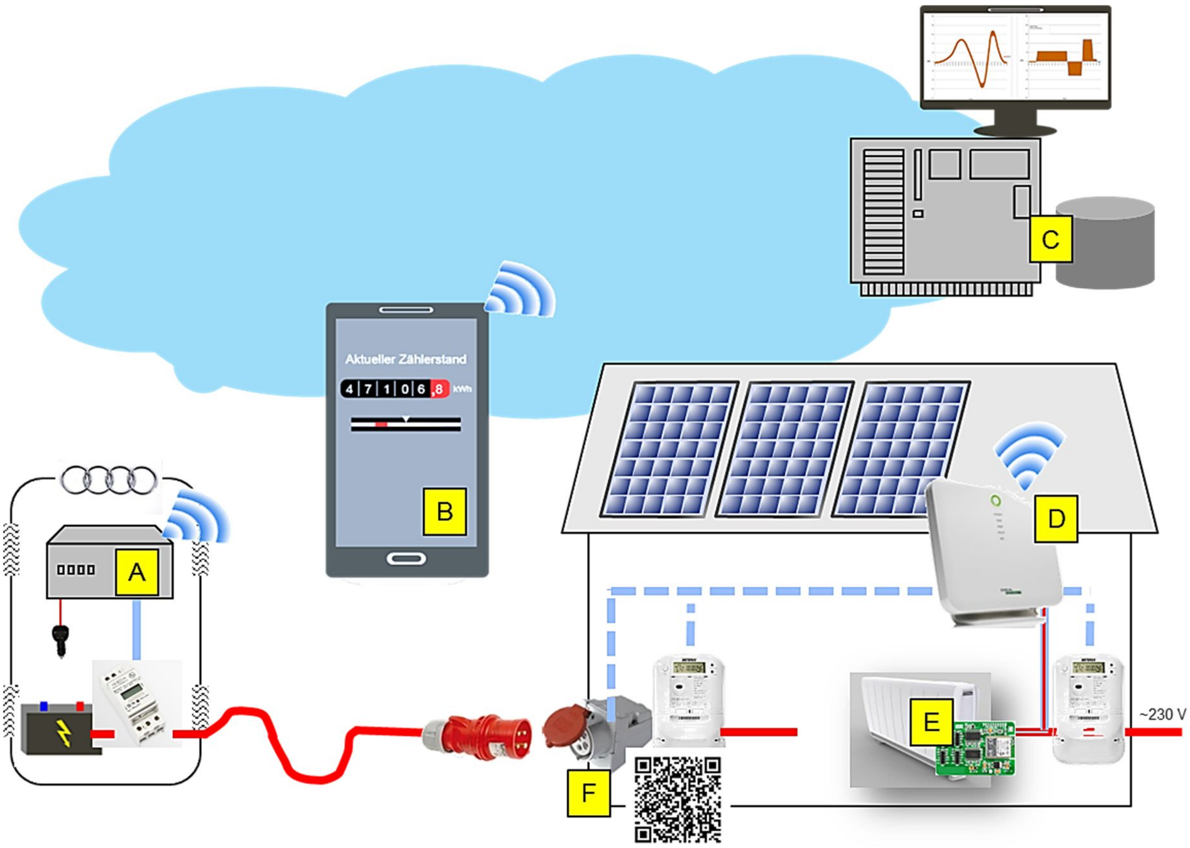

Figure 23: Smart home controllers can be used for many electrical grid relevant applications – power self-consumption, P2H, or electrical charging everywhere.

5.3 Technical Description of Reference Sites

5.3.1 HEMS / TEMS / CEMS Installations – Reference Site Seeblick 39 in Nagel.

Figure 24: Domestic home Seeblick 39 in Nagel serving as representative e) for HEMS and CEMS

Nagel, Seeblick 39 is a little house usually used for vacation – see Figure 24. It is connected to the 20kV/400V transformer station "Seeblick", which is part of the 20kV cable 3 – see Figure 14 "SWW electrical grid". It is owned by Dr. Gerhard and Gisela Kleineidam who both are involved in the GOFLEX project and thus are willing to take over some costs and project risks. SWW and Kleineidam will sign a contract, where terms and conditions shall be defined using their house as a reference site to install prosumer and e-mobility capabilities required in the GOFLEX project. Today there is already installed a TEMS and smart home system from another research project, which does not work properly – see Section 5.2.2, Figure 22. To prepare the house for GOFLEX the following work packages have to be done upfront:

- Drive way and paving for parking Kleineidam's e-car in front of the house
- Installation of ETREL charging station – North East side of the house see Figure 25
- Roof top PV and battery
- New hot water boiler and controller installations

- Replacement of SmartEco controller including connections to electrical storage heaters and temperature sensors
- Replacement of electrical installations – see Figure 28. New electrical cabinet and wiring including: new smart meter, 400V connection to the charging station, rectifiers and inverters for PV and battery.

Figure 25: Front view with position for the ETREL charging station

Electromechanical Installations – Nagel, Seeblick 39

NEW: PV System planned. Today SWW offers the following components to their clients but which may be substituted by GOFLEX partner solutions

- 4 kWp Solar PV to be installed. 14 modules Luxor (see: www.luxor-solar.com) ECO Line M60 290Wp with power optimizer to handle partial shading.
- SE 4K Solaredge (see: https://www.solaredge.com/de/solutions/residential#/) and Inverter (see: http://www.solaredge.com/sites/default/files/se-three-phase-inverter-datasheet.pdf)

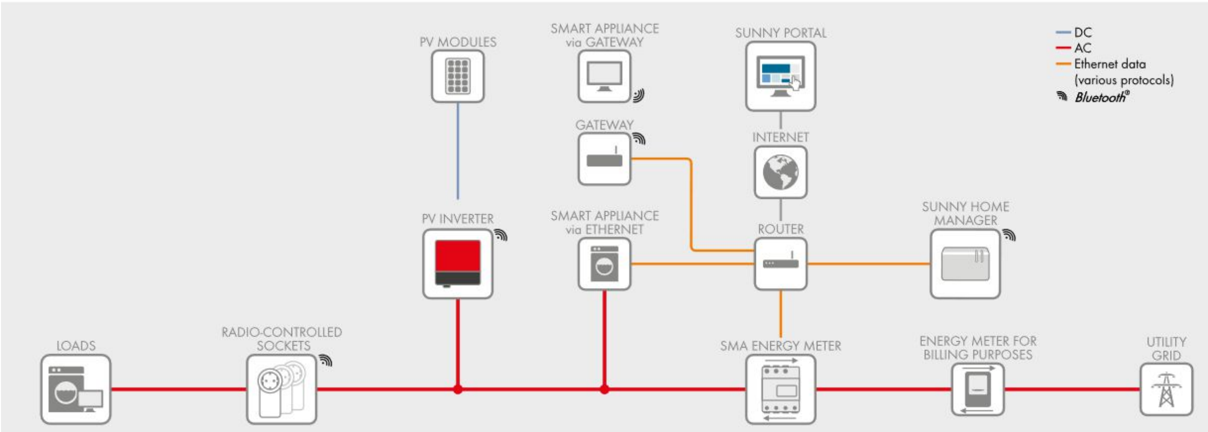

Figure 26: SWW expects that instead of the SMA Sunny Home Manager a Robotina HEMS solution will be applied.

NEW: Electrical storage. Today SWW offers the following components to their clients but which may be substituted by GOFLEX partner solutions :

- LG Chem (http://www.lgesspartner.com) LiOn battery LI-IO RESU 10 8.8 kWh to be installed – data sheet http://www.lgesspartner.com/uk/front/prod-uct/productInfo.dev
- SMA Sunny Island 6.0H11 battery inverter http://www.sma.de/en/prod-ucts/battery-inverters/sunny-island-60h-80h.html
- SMA Energy Meter and Home Manager – see Figure 26 http://files.sma.de/dl/21477/ENERGYMETER-DDE140822W.pdf , http://files.sma.de/dl/15583/HOMEMANAGER-DEN1603-V21web.pdf

Heat storage and other flexible consumers today controlled by GlenDimplex Smart Eco System SES: http://www.dimplex.de/en/news/new-products/smart-eco-system/ses-ze-ses-di-zw.html

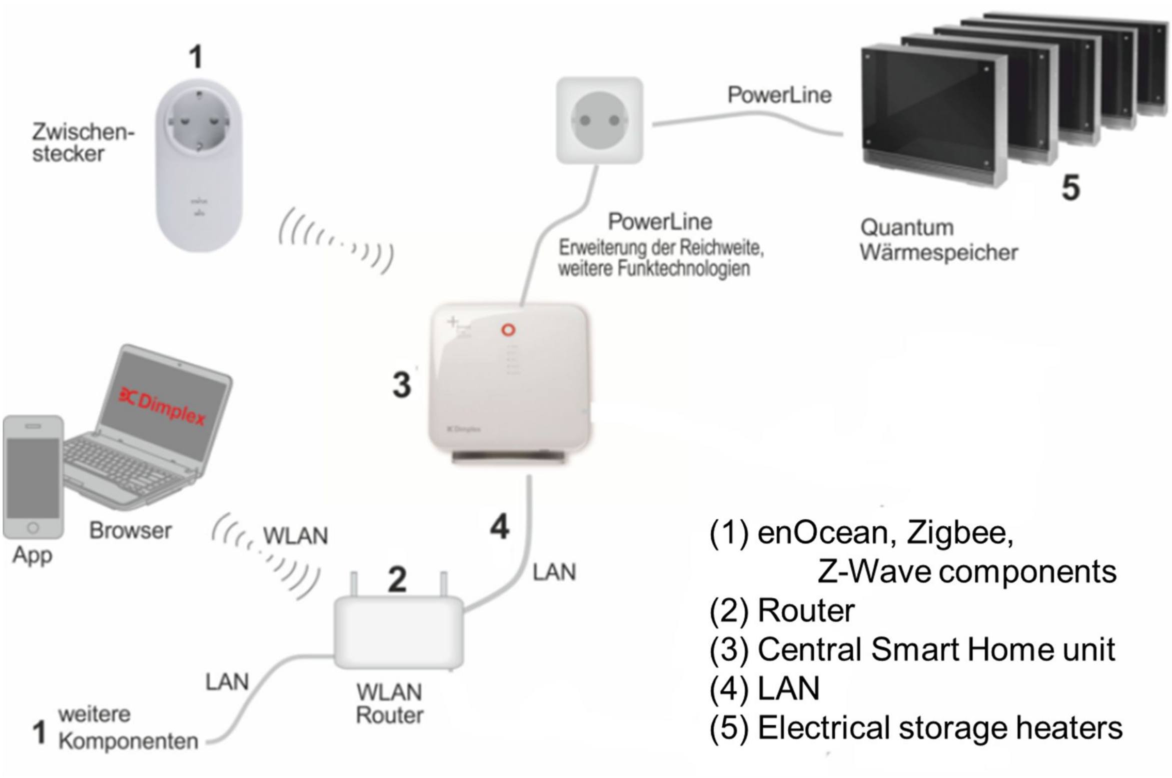

Figure 27: SWW expects that the central smart home unit (3) will be replaced by a Robotina HEMS solution.

- Electrical storage heater Glen Dimplex Quantum FSR 6GS 6 kW max. 8h charging (basement) equipped with communication module SES KM1 power line controller http://www.dimplex.de/wiki/index.php/SES_KM_1
- Electrical storage heater Glen Dimplex Quantum FSR 4GS 4 kW max. 8h charging (living room) equipped with communication module SES KM1 power line controller http://www.dimplex.de/wiki/index.php/SES_KM_1
- NEW: 80l water boiler to be installed and controlled by the new GOFLEX HEMS.

Electrical cabinets, wiring, switching:

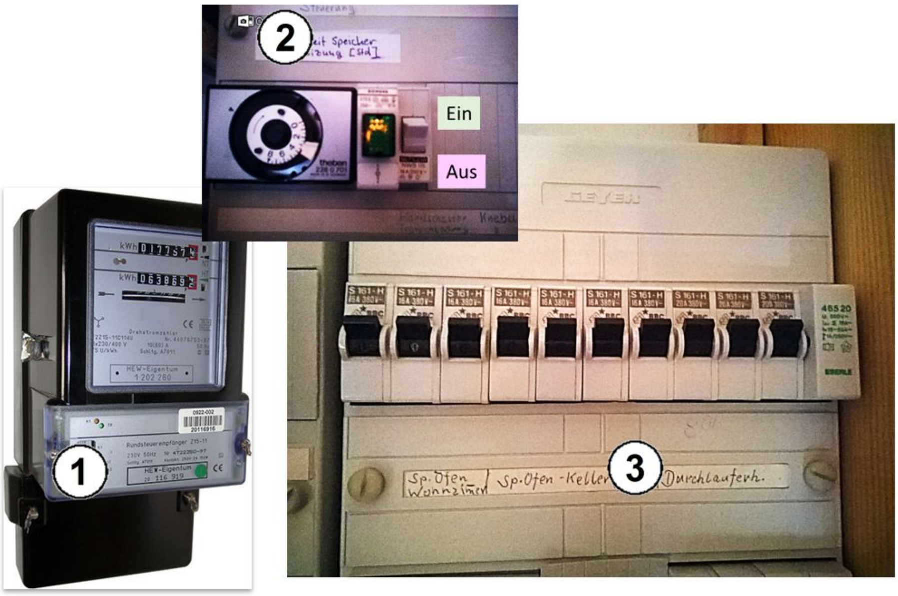

Figure 28: Components of the electric junction box, which will be upgraded with smart technologies.

Sensors:

- 2 Room temperature sensors Glen Dimplex RTV 101EO with wireless and battery less enocean communication http://www.dimplex.de/wiki/images/0/0f/RTV_RTF101EO_06_15_C.pdf
- 1 outside temperature sensor Glen Dimplex FG101EO with wireless and battery less enocean communication http://www.dimplex.de/wiki/images/5/53/FG101EO.pdf

Computing Hardware and Communication

Figure 29: Targeted new system configuration with actual HEMS to be replaced and new components to be installed.

- A WLAN FritzBox router with access to the Internet is available.
- Electrical storage heaters are connected to HEMS via powerline. Sensors (temperatures) communicate via enOcean protocol. The actual HEMS solution (see Figure 27) shall be replaced by ROBOTINA.
- A new hot water boiler will be installed, which shall be controlled by ROBOTINAS HEMS solution.
- An ETREL charging station (G5404-0-01) will be installed with a CEMS solution. A BMW 225xe will be charged regularly through a Type 2 cable.
- A new PV system with battery will be installed – ICT data connection is not yet defined but preferably should run on the ROBOTINA HEMS application (see Figure 26).
- The classic ripple controller is still available and shall serve as fall back if the GOFLEX HEMS does not work properly.
- The existing Ferraris meter will be replaced by a smart meter (see Figure 19).

5.3.2 Factory FEMS, CEMS, PV, Battery Installations – Reference Site Company Daubner

The company Karl Daubner is a mineral oil trader with a public gas (fuel) station on its estate located at Industriestraße 5, 95700 Neusorg. Karl Daubner has invested in renewable energy generation. He gets himself prepared for the time when PV energy supply will not be funded anymore by having installed batteries to optimize self consumption. Energy is his business , so he personally is motivated to support activities like the GOFLEX project and thus is ready to invest into future technologies if it fits into his vision.

SWW and Karl Daubner will sign a contract, where terms and conditions shall be defined using his facilities as a reference site to install prosumer and e-mobility capabilities required in the GOFLEX project.

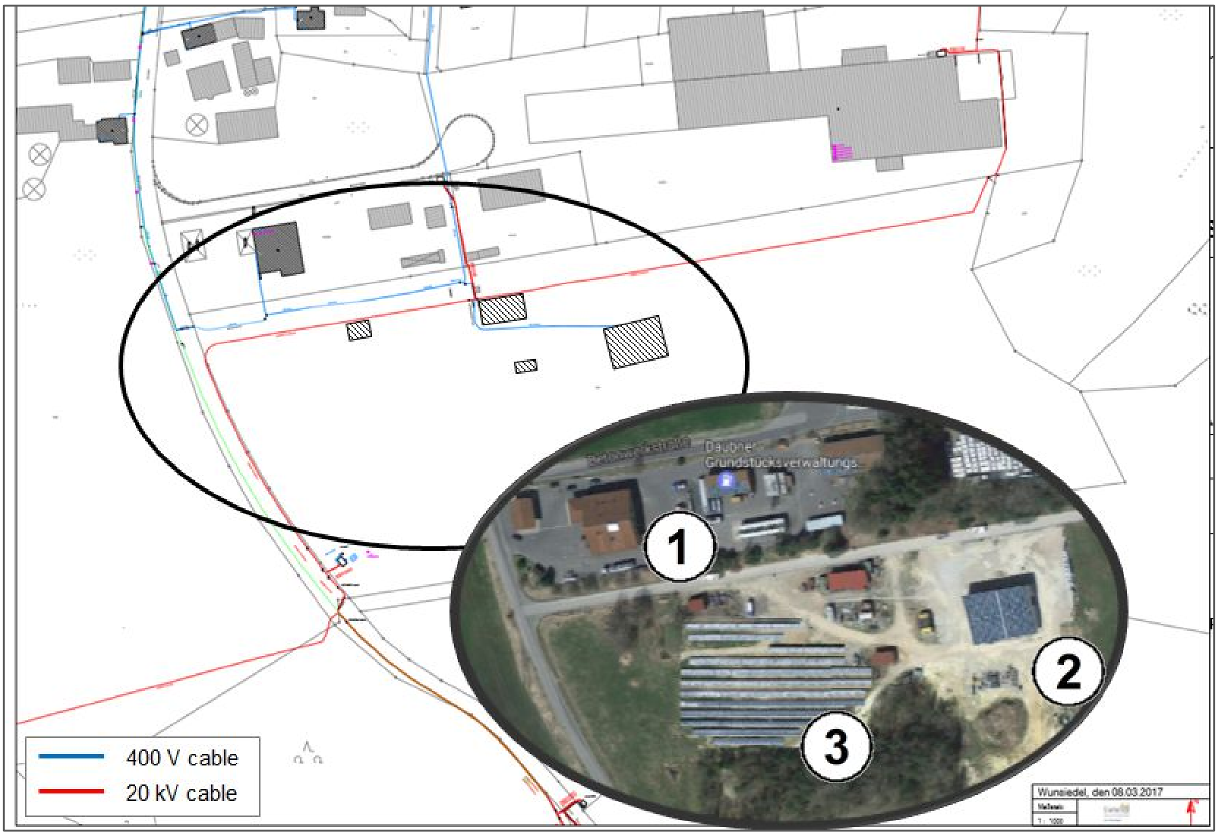

Figure 30: Company Daubner serving as representative c) for FEMS, CEMS and PV power generation.

Electromechanical Installations

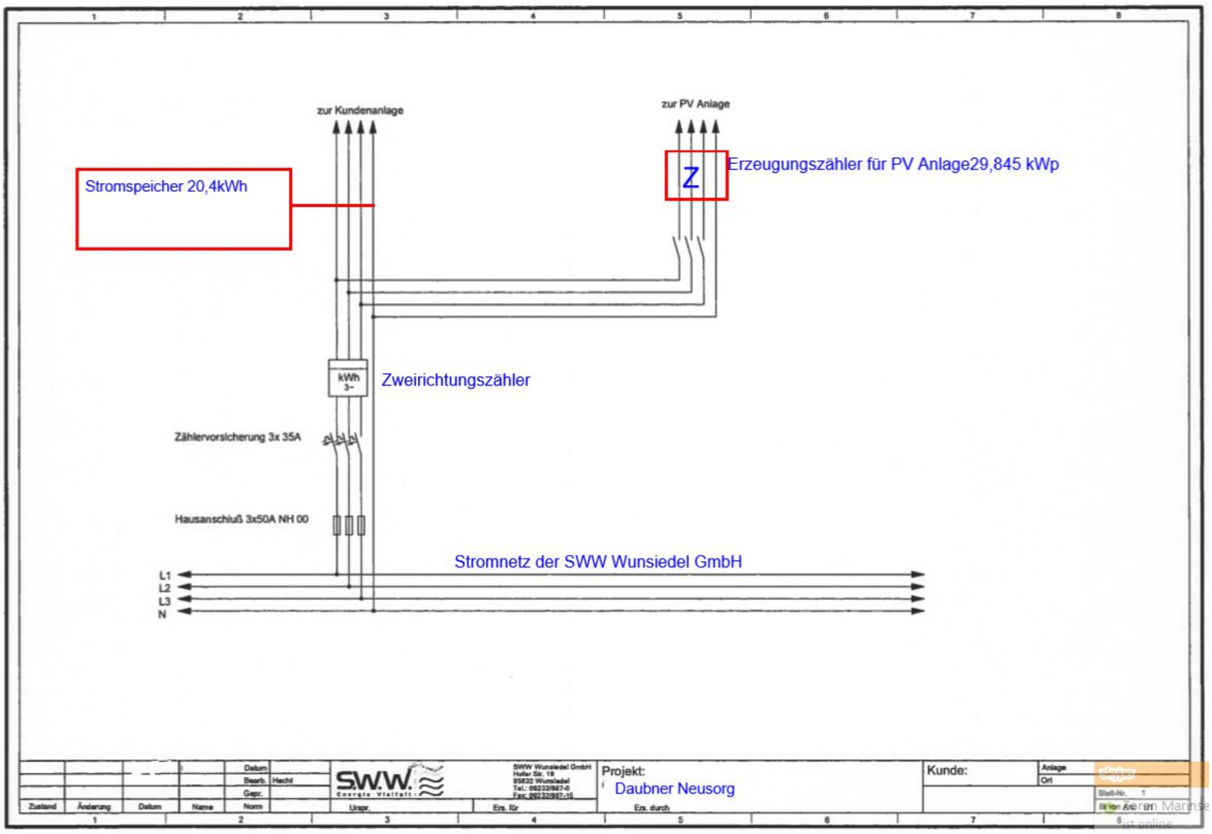

Figure 31: Circuit diagram – Daubner 30 kWp roof-top solar power plant with 20.4 kWh electrical storage ①.

① Company Building

- 29.845kWp PV roof-top with self-consumption capability
- Electrical storage 20.4kWh net installed
- LAN connection available

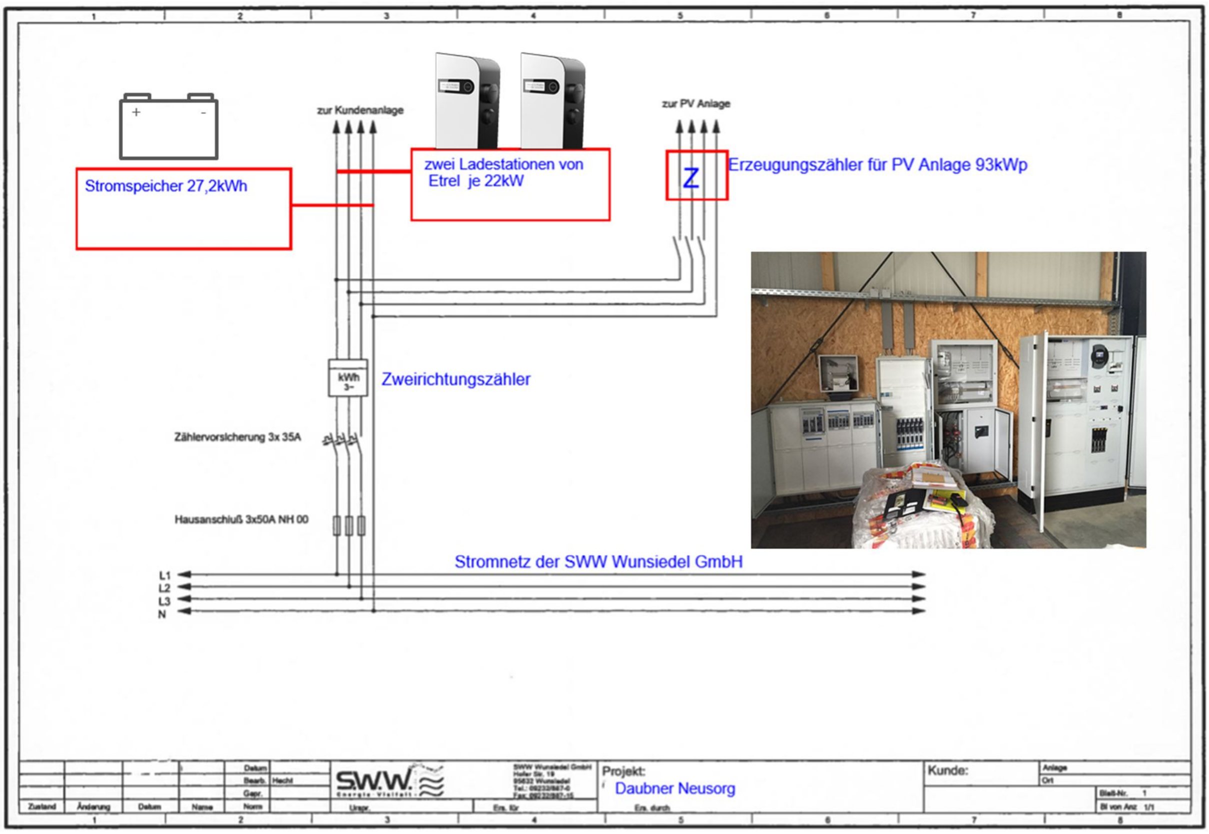

Figure 32: Circuit diagram – Daubner 93 kWp roof-top solar power plant with 27.2 kWh electrical storage and two 22kW ETREL charging stations ②.

② Hangar

- 93kWp PV roof-top with self-consumption capability
- Electrical storage 27.2kWh net installed
- Two 22 kW charging stations (ETREL?) planned
- Powerline communication available (DLAN)

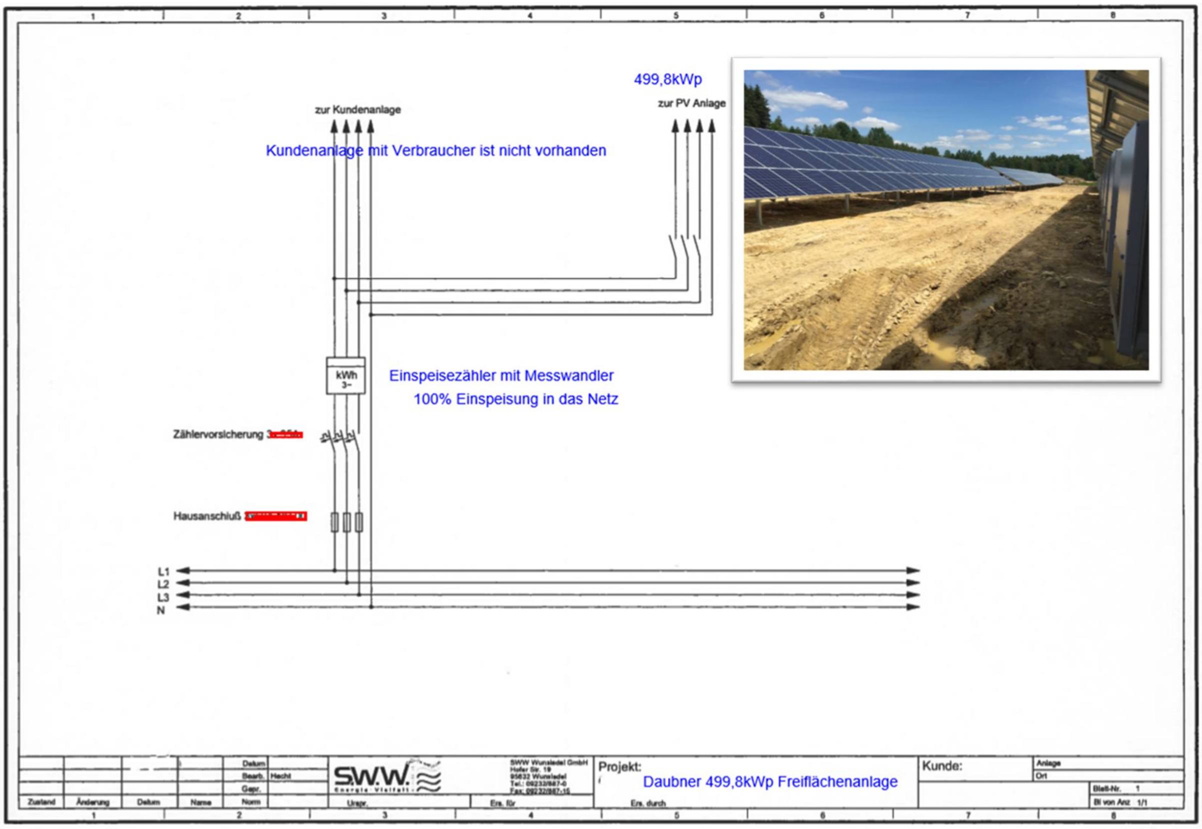

Figure 33: Circuit diagram – Daubner 499.8 kWp free-field solar power plant ③.

③ Free-field solar power plant 499,8kWp

- 100% feed to separate 20kV station
- Data monitoring and communication via GSM modem.

Computing Hardware and Communication

The ICT architecture of Daubner is almost the same as described in Section 5.3.1 using many of SMAs components according to Figure 26 but with an advanced backend for extended monitoring with "Solar-Log^{TM}" from company Solare Datensysteme GmbH – see: http://www.solar-log.com. The PV solution of Daubner has been provided by the German turnkey PV system supplier ILIOTEC – see: https://www.iliotec.de/.

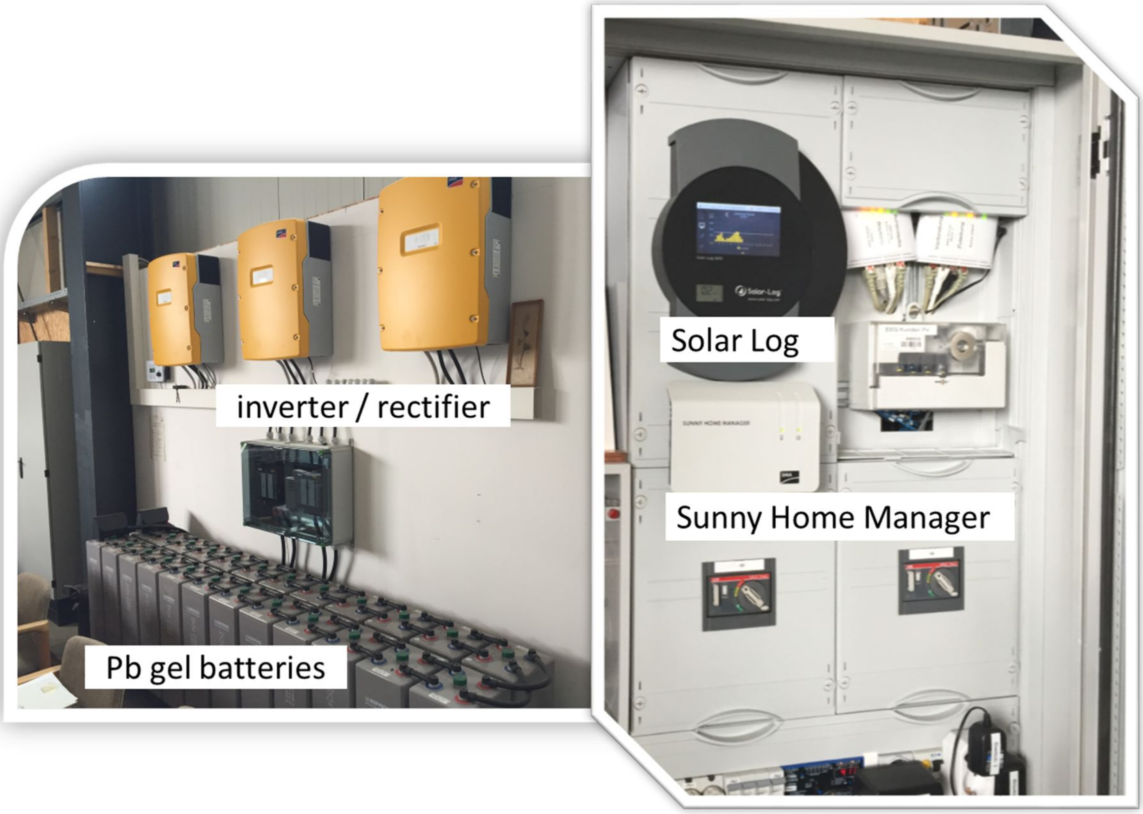

Figure 34: Daubner's controller cabinet for PV solar power generation and management

5.3.3 Generation Installations – Reference Site Cogeneration Plant Breitenbrunn, Luxbach 18, Wunsiedel

Figure 35: Micro power plant Breitbrunn serving as representative for power generation and p2h storage.

- BHKW 50 kW el and 80 kW thermal
- Wooden pellets carburetor technology
- Hot water storage $80m^3$
- PV roof top system 9.6 kWp (year 2011)
- LAN available

Figure 36: CHP generation 50 kW (el.) and 80 kW (thermal) Breitenbrunn

Electromechanical Installations

- Combined Heat and Power ("CHP") generation – see Figure 36
- Control, Communication
- Electrical cabinets, wiring, switching
- Sensors

Computing Hardware

See Figure 16 number (4) equipped with a Panasonic PLC.

5.3.4 Trading Platform Installation on R&D Master Controller

SWW has installed the Spectrum Power 5 (SP5) SCADA system, which shall replace the existing grid management solution currently installed at SWW – see Section 5.2. SWW will settle a service agreement with Siemens to acquire support for using SP5 as the database and evaluation tool for the GOFLEX trading platform. Figure 37 gives an impression how the trading monitor GUI based on the Information Model Manager ("IMM") – a module of SP5 – should look like.

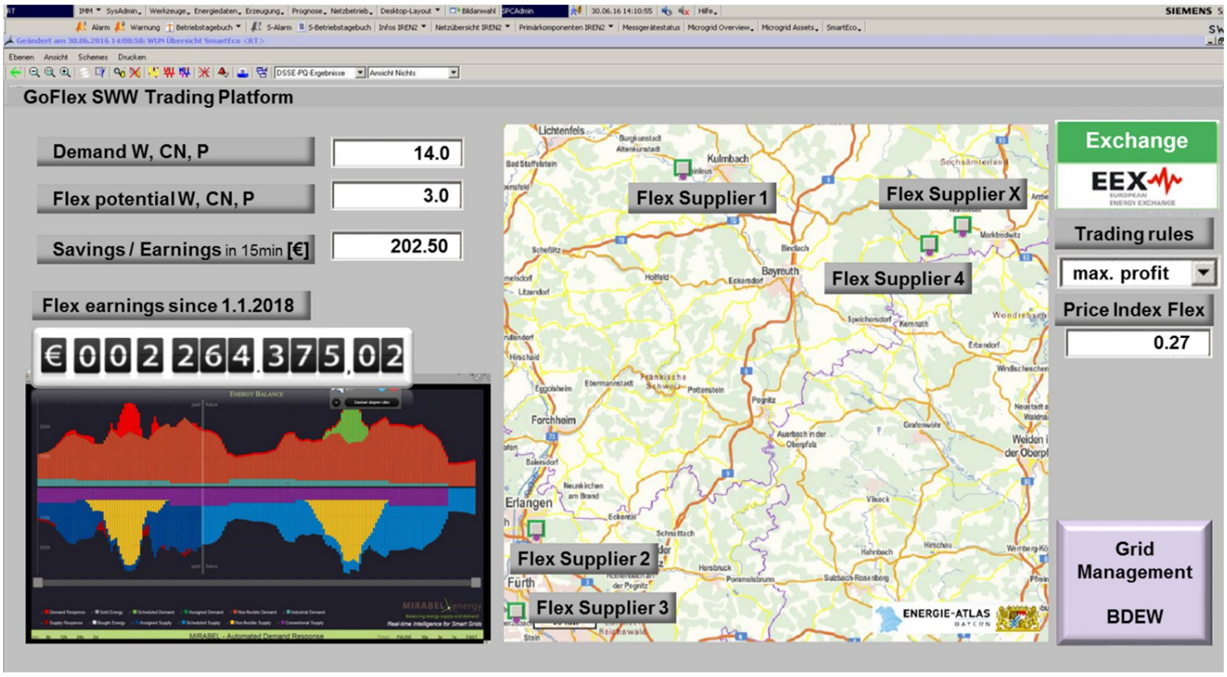

Figure 37: SWW GOFLEX trading platform main menu – example to be discussed

This GOFLEX trading monitor GUI consists of (a) the visualization of actual demand and demand response, (b) the forecast and history of demand and flexibility offers, (c) a map highlighting corresponding flexibility suppliers, (d) current market prices and the selection of trading constraints. The most important part is (e) the button to switch from the trading monitor to the Grid Management module.

Computing Hardware and Communication

There is currently a server rented from Siemens running two virtual machines for (i) the data management modules of SP5 and (ii) the HMI module of SP5 – see Figure 38. This server is located at the living lab WUNWohnlabor, Dr. Schmidt Straße 7, Wunsiedel. There is a VPN connection to SWW's ICT system available. The Siemens server will be replaced by a new hardware which will be preconfigured with SP5 and made available to the GOFLEX integration partner to develop the GUI and the necessary software components for the trading platform.

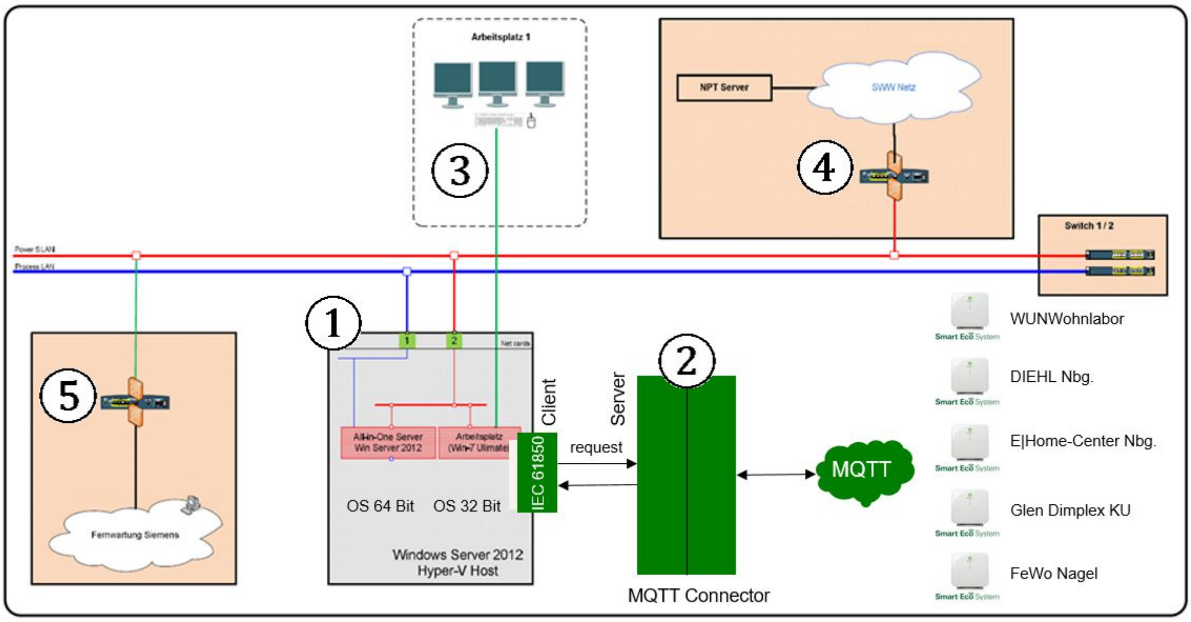

Figure 38: ICT configuration of the existing SWW research SCADA system with IEC61850 and MQTT connections.

5.4 Testing and Acceptance of Systems to be Installed

GOFLEX system installation and acceptance shall be made in three steps. First, there will be the installation of single GOFLEX components, like xEMS, direct control or metering data collection with reference pilots on SWW site. This step will be concluded by an Initial Acceptance Test "IAT". The IAT specification shall be provided by the single solution providers. IAT shall be performed mutually by the solution provider and SWW experts. Second, the whole GOFLEX solution shall be installed and tested in Ljubljana on integrator site. This test is called Factory Acceptance Test (FAT), which shall serve as a quality gate to verify the proper functionality and performance of the whole GOFLEX integrated system solution before shipment to SWW. The integrator shall provide a proper FAT specification to SWW and requests experts from SWW to be trained for performing the tests in Ljubljana. SWW will provide a "ready for shipment" only after successful conclusion of FAT. The final and third step will be the Site Acceptance Test (SAT) at SWW. The integrator shall provide a proper SAT specification to SWW. The SAT will be performed by SWW operators.

Any of the acceptance and test specification shall include but may not be limited to the following:

1. Definition of KPIs, including pass – fail criteria
2. Definition of test scenarios including a bunch of test cases for each scenario
3. The test and acceptance procedures (at least SAT)
   - Functionality tests
   - Performance tests
   - Quality tests incl. availability, reliability, maintainability
4. Specification of parameters to be measured or evaluated
5. Definition of evaluation algorithm
6. Definition of measurement instruments and methods
7. Evaluation and documentation guide for acceptance test results

SWW may propose additional test cases to IAT, FAT, and SAT. In case of any notice of defect during SAT and during the complete demo phase (= third year of this project) the integrator shall get SWW into the position to provide immediate corrective actions – even on weekends this might become an issue. A hotline service shall be available with the "ready for SAT" announcement.

5.4.1 HEMS Test Specification – Software, HMI and GUI

The functionality and the GUI shall be comparable to the SmartEco App (Glen Dimplex: http://www.dimplex.de/wiki/index.php/SES_APP) – see Figure 39. Note: actual date and time is missing on the home page of this app.

All GUIs have to follow a common style guide, which has to be provided to WP9 project management before the start of development. The language for GUIs shall be German.

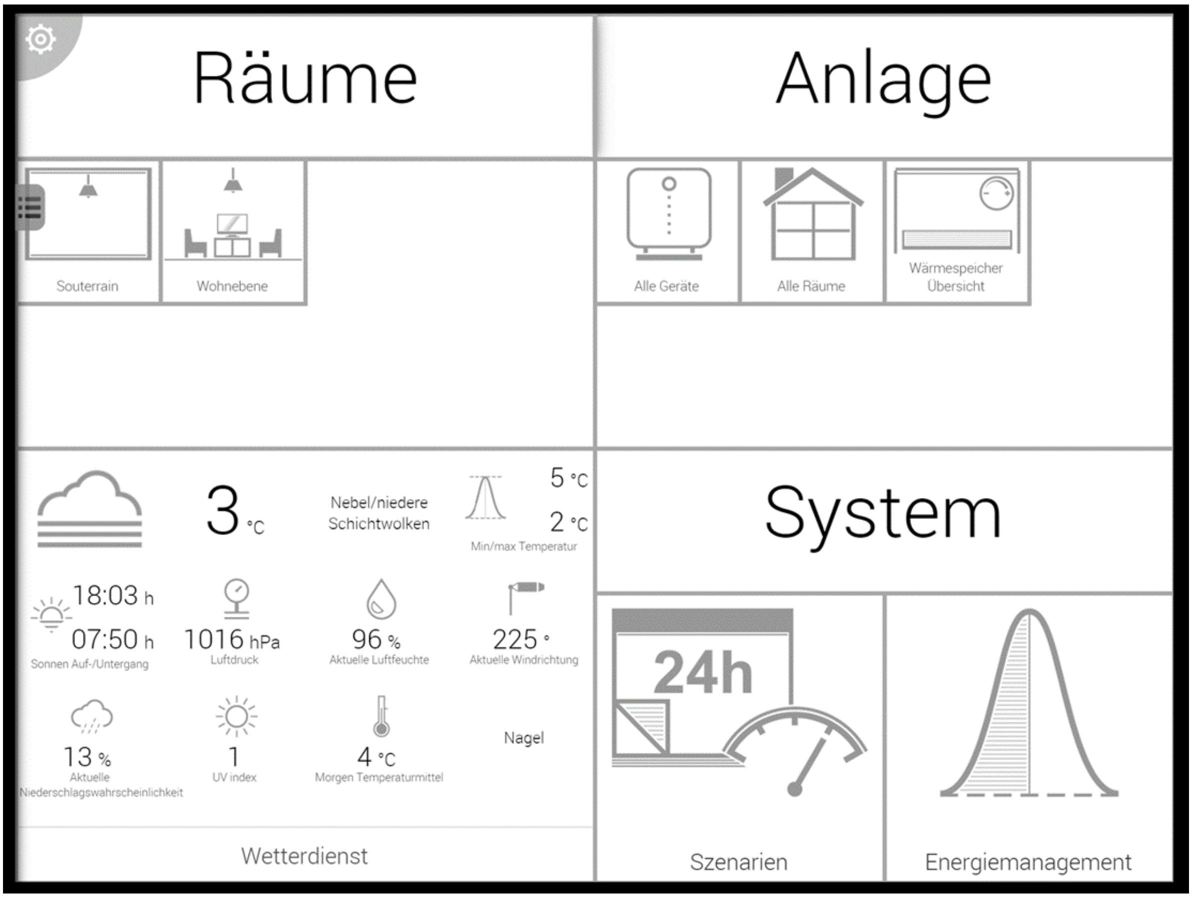

Figure 39: Example – Main menu for smart home remote control (screenshot from the actual HEMS solution)

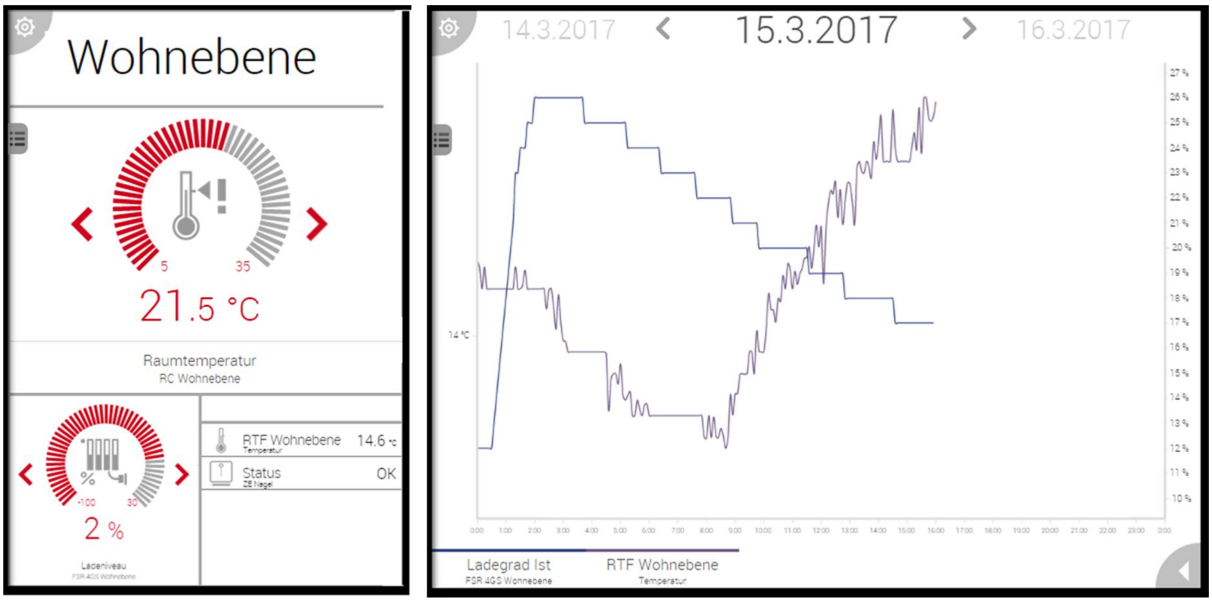

Figure 40: Minimum controls and visualization required by the customer to operate the home in terms of heating.

The functionality and GUI provided to residential customers shall include at minimum the following:

- The user shall be able to switch to manual mode at choice assuring that especially heating can be controlled manually without using the HEMS GUI.
- processing/operating parameters for heating shall at least comprise (i) degree of heat charging and required room temperature – see Figure 40
- provide actual and historical data charts at least for room temperature, heat charging, flexibility supply to SWW.
- to visualize the status and communication status of all components connected to the HEMS controller
- auto restart capabilities e.g. after cut off.
- Self diagnostic functionality with auto repair or at least service call functionality
- Online user manual available

5.4.2 FEMS Test Specification – Software, HMI and GUI

Has to be mutually defined together with Daubner serving as the lead customer. SWW's requires a minimum of GUI functionality to institutional (= non residential) customers.

5.4.3 Flexible Power Plant Test Specification – Software, HMI and GUI

The functionality and GUI provided to SWW as owner of this power plant shall include at minimum the following:

- to visualize the status and communication status of all components connected to the GOFLEX controller
- Exceptions or alarms have to be displayed with qualified text messages.
- Event and alarm history shall be available at choice.
- auto restart capabilities e.g. after cut off.
- Self diagnostic functionality with auto repair or at least service call functionality

5.4.4 Trading Platform Test Specification – Software, HMI and GUI

Software and GUI design shall follow the Siemens SP5 style guide. Examples of the GUI are given in Figure 21 and Figure 41. Please note that SP5 has strong tools available (i) database, (ii) HMI and component modeller, (iii) evaluation tools including access to weather forecast systems, (iv) reporting and archiving and (v) communication interfaces e.g. IEC 61850, which is SWW protocol of choice.

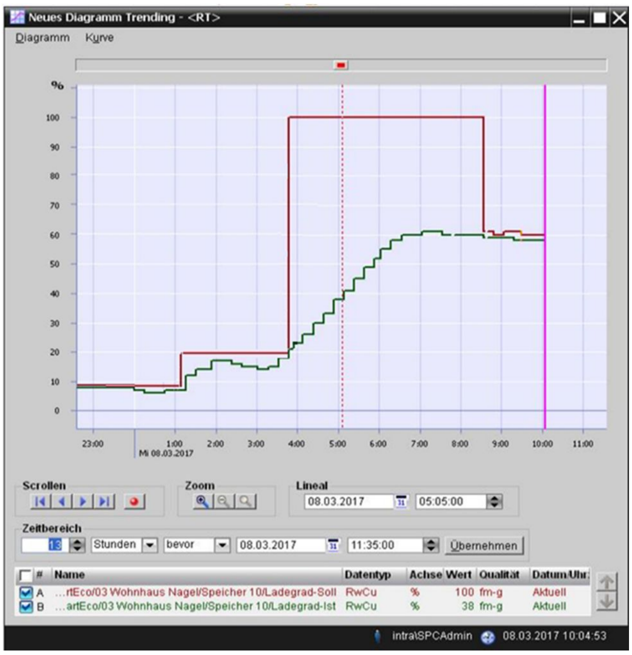

Figure 41: Example - Flexibility monitoring electrical storage heater. Heat load required (brown), actual load (green).

The GOFLEX trading platform shall at least cover the following features:

- The integration of a new flexibility supplier to the trading platform should maximum take half an hour. Optimum would be an automatic integration with equipment self description, authentication and authorization mechanism available
- Flexibility offers from suppliers shall be given in physical units W, P, CN
- Prices from the EEX shall be available online
- Weather forecast shall be available online
- The communication status of each flexibility supplier shall be highlighted. Status information should at least describe the following states: communication up, communication down, or idle. The color indication shall be implemented according to IEC/EN 60204-1
- Exceptions or alarms have to be displayed with qualified text messages.
- Event and alarm history shall be available at choice.
- An online help or documentation shall be available.

5.4.5 After Installation Services Required

xEMS operation and maintenance (services) shall be available 24/7 accessible via hotline. Remote diagnostic and repair shall be possible. Automatic download for updates shall be available. The development partners shall get SWW into the position to provide immediate corrective actions in case of failure. For standard products (e.g. HEMS or CEMS) a roadmap shall be provided highlighting extensions or upgrades of the current installation.

All after installation services shall be available at least 10 years after acceptance SAT.

6 Conclusion

This document and deliverable is focused on the requirements of the demonstration case in Wunsiedel, Germany. The current infrastructure and the future installations are analysed concerning both SWW's grid territory, its ICT infrastructure and the prosumers. From this deliverable, the GOFLEX specific requirements are identified, while a presentation of new infrastructure of GOFLEX technology advancements is carried out. Therefore, the specifications of the Wuhnsiedel demonstration case are recognized, aiming at providing the necessary input to the technology providers of GOFLEX project. As a response to this document a system design specification shall be provided which specifies the solution delivered and integrated by WP6. While the requirements document specifies the what, the system design specifications shall describe how a system performs said requirements. At minimum there shall be available: input and output to the system, architecture and components (HW and SW), interfaces ICT as well as physical ones, functionality, work or process flow.

7 References

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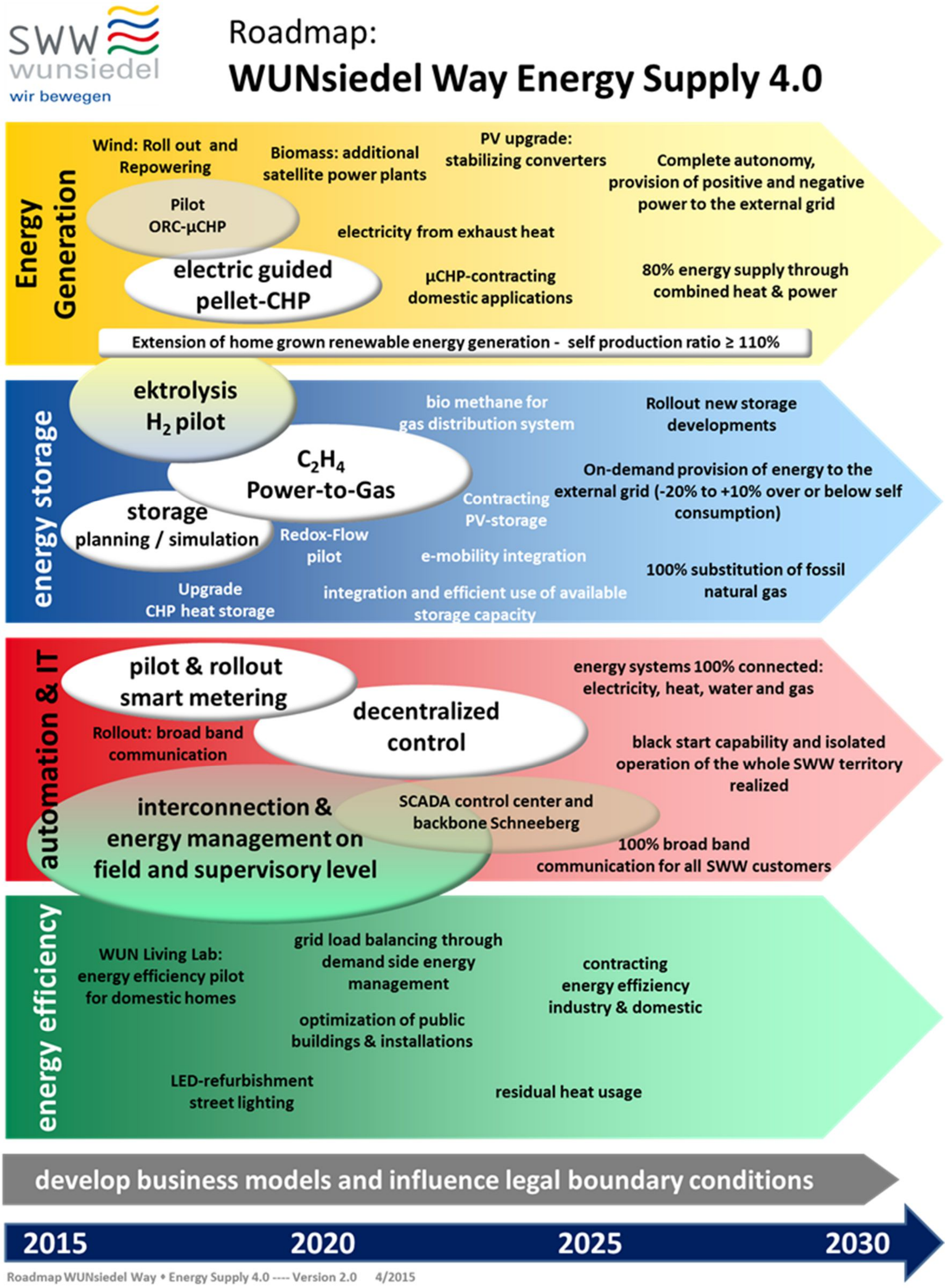
Attachments:

A1 – Roadmap 2030 "Wunsiedler Weg – Energie"

A2 – Customer Consent Agreement

A1 – Roadmap 2030 "Wunsiedler Weg – Energie"



A2 – Customer Consent Agreement

Einwilligungserklärung

zur Erhebung, Verarbeitung und Nutzung personenbezogener Daten
zu Forschungszwecken

Die SWW Wunsiedel GmbH (im Folgenden: **SWW**) ist an einem Konsortium (bestehend aus: IBM IRELAND LIMITED, Irland; INEA INFORMATIZACIJA ENERGETIKA AVTOMATIZACIJA DOO, Slowenien; AALBORG UNIVERSITET, Dänemark; TECHNISCHE UNIVERSITAET DRESDEN, Deutschland; ETREL SVETOVANJE IN DRUGE STORITVE DOO, Slowenien; ROBOTINA D.O.O., PODJETJE ZA INZ ENIRING, MARKETING, TRGOVINO IN PROIZVODNJO, Slowenien; B.A.U.M. CONSULT GmbH, Deutschland; UNIVERSITY OF CYPRUS, Zypern; ARCHI ILEKTRISMOU KYPROU, Zypern; HAUTE ECOLE SPECIALISEE DE SUISSE OCCIDENTALE, Schweiz; L'ENERGIE DE SION-REGION SA, ESR, Schweiz) beteiligt, welches mit der Durchführung eines europaweiten Forschungsprojekts betraut worden ist, welches durch die Europäische Union gefördert wird. Das Projekt trägt den Titel H2020 – Generalized Operational FLEXibility for Integrating Renewables in the Distribution Grid (Kurzbezeichnung: GOFLEX) und befasst sich mit der Entwicklung und Erprobung einer flexiblen Handelsplattform für Verteilnetzbetreiber (im Folgenden: Projekt).

Im Rahmen des Projekts werden zum Zweck des „Handels mit Flexibilität“ (positive/negative Last) meine nachstehenden Daten genutzt:

Name, Vorname, Anschrift, Zählerdaten (Last)

Ich bin damit einverstanden, dass durch die SWW meine oben genannten Daten im Zusammenhang mit dem Projekt erhoben, verarbeitet und genutzt werden.

Soweit für die Durchführung des Projekts eine zweckgebundene Weitergabe / Übermittlung der Daten an das am Projekt beteiligte Konsortium erforderlich ist, willige ich dieser zweckgebundenen Übermittlung hiermit ebenfalls ein.

Ich bin zudem darauf hingewiesen worden, dass die Erhebung, Verarbeitung und Nutzung meiner Daten auf freiwilliger Basis erfolgt. Ferner, dass ich mein Einverständnis ohne für mich nachteilige Folgen jederzeit gegenüber der SWW Wunsiedel GmbH, Rot-Kreuz-Straße 6, 95632 Wunsiedel mit Wirkung für die Zukunft widerrufen kann

______________________ [Ort / Datum] ____________________________________

Name: