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White Paper

KNX Demand Side Management

Contents

1 Introduction [1]

In 2011 the European Commission issued Mandate M/490 and requested the three European Standards organisations (ESOs) CEN, CENELEC and ETSI to develop a framework to enable European Standardisation Organisations to perform continuous standard enhancement and development in the field of Smart Grids, while maintaining transverse consistency and promote continuous innovation." As a result the ESOs established the Smart Grid Coordination Group (SG-CG), which is responsible for the working groups Reference Architecture, First Set of Standards, Sustainable Processes and Group Security. The work of M/490 was especially linked with the work of M/441 (smart metering) and M/468 (charging of electric vehicles). In 2012 and 2013 the working groups presented their reports.

Within M/490, a Smart Grid Architecture Model (SGAM) was developed onto which over 450 collected use cases were mapped. [2] Based on the collected use cases the working group Sustainable Processes identified the main task for buildings in providing so called ‘flexibilities’ to smart grids. The concept of flexibilities describes the adjustment of loads or energy generation in buildings depending on e.g. smart grid events. The concept is also known by the name Demand Response. The border between buildings and smart grid is represented by the so called smart grid connection point (SGCP). Beyond the SGCP inside the building a customer energy management (CEM) is responsible for providing flexibilities. The CEM is a logical function optimising energy consumption and / or energy generation based on signals received from the grid, consumer settings, contractual arrangements and devices. Figure 1 shows the reference architecture for CEMs including the smart meter infrastructure responsible for billing processes.

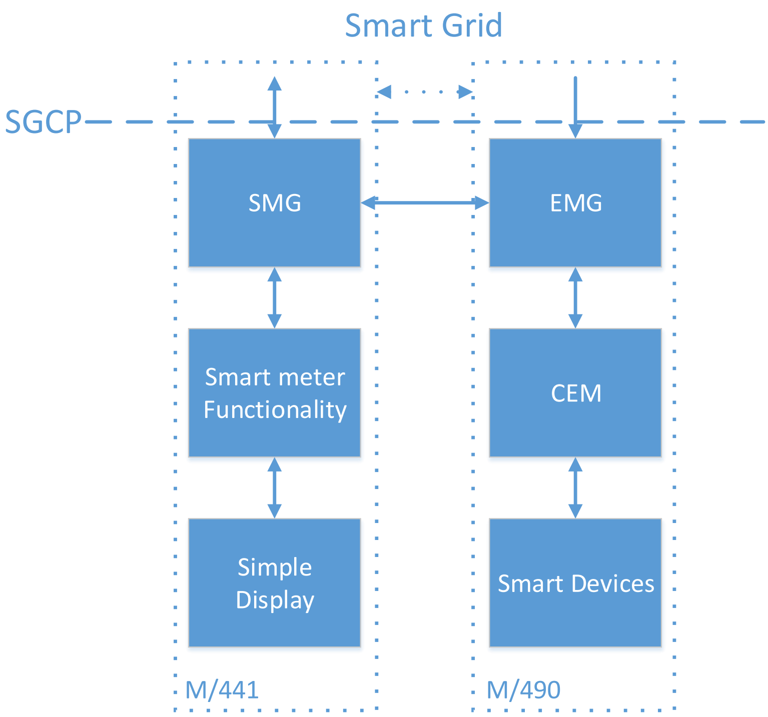

Figure 1: Smart metering and CEM system behind the SGCP inside the building

2 Scope

The scope of this paper is to introduce in compliance with the EN50090 series

- a Demand Side Management, and
- control strategies and algorithms for load adaptions, and
- the KNX solutions for providing flexibilities.

3 Smart Grids

3.1 Demand Response [3]

A common smart grid use case in terms of buildings is the ‘Demand Response’ use case. Demand Response (DR) follows a ‘bottom-up’ approach. The customer becomes active in managing his/her consumption in order to achieve efficiency gains and monetary benefits. [2] DR can be defined as “the changes in electric usage by end-use customers from their normal consumption patterns in response to changes in the price of electricity over time. [2] Further, DR can be also defined as the incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized. [2] DR includes all intentional modifications to consumption patterns of electricity of end use customers that are intended to alter the timing, level of instantaneous demand, or the total electricity consumption”. [2]

In the context of the Demand Response use case, an actor within the electrical grid transmits a tariff to the end-use customers inside the buildings. The customers adapt their loads to the tariff. Two important tariffs can be distinguished:

- Time-of-use (TOU)

  Time-of-use tariffs are usually static tariffs and provide different price levels for different fixed time periods. The customers have knowledge in advance about the tariff levels as well as the associated price levels.

- Real-time-pricing (RTP)

  Real-time-pricing tariffs provide different tariff levels that can be changed in real time depending on occurring events in the power grid. Thus RTP tariffs can depend of the renewable generation in a power grid and provide an appropriate incentive for customers to adapt their loads indirectly to this.

As a result Demand Response use cases lead to an increased consumption of renewable energies by end-use customers and thus of buildings. In turn the increased consumption of renewable energies leads to better cope with the volatility of renewable energies and helps solve current challenges in power grids.

Tech talk: Use Cases

A use case describes the interaction of different actors and stakeholders in order to achieve the primary actor’s goal. Actors and stakeholder can be persons, systems or hardware devices.

Use case: Demand Response

A Smart grid actor e.g. a utility or aggregator transmits a multi-level-tariff to its customers in order to motivate them to adapt their loads to the transmitted tariff. Tariff levels (prices) can be updated monthly, daily or in real time. Examples for this are time-of-use (TOU), critical-peak-pricing (CPP) and real-time-pricing (RTP). Especially RTP tariffs are particularly suited to reflect the current total renewable generation in a power grid section and allow customers to consume electricity when renewable energies are generating.

4 EN50090 based Demand Side Management

In terms of Demand Response use cases the technical objective of a building load management is to implement the control – and actuating elements for changing the load behaviour depending on the transmitted tariffs such as e.g. TOU or RTP. Therefore inside the buildings it is necessary to implement a Demand Side Management (DSM) in order to be able to adapt loads. Figure 2 shows an overview of the Demand Side Management beyond the SGCP. Beside tariffs some Demand Response use cases or Demand Response programs foresee also the possibility of a direct load control.

- A direct load control is based on bilateral contracts between a customer and a smart grid actor and is already implemented in some countries. This approach is only convenient for non-household loads that can be controlled easily and independently from any boundary conditions. As example, utilities in Germany can decrease in some cases the power feed-in of big photovoltaic systems via a ripple control.
- For loads of which the behaviour depends on local boundary conditions, tariffs are more suitable incentives. E.g. the decision to lower the cooling capacity of an air conditioning system and thus the electrical load depends on the local room temperature and is therefore not suitable for a direct load control.

The load management according EN50090 therefore considers both cases, although the focus is on load adaption depending on tariff information. The evaluation of tariff and determination of the resulting setpoint information for load management is in the following named tariff based management. The process of adapting loads is named load management. The process to handle a generation is named generation management.

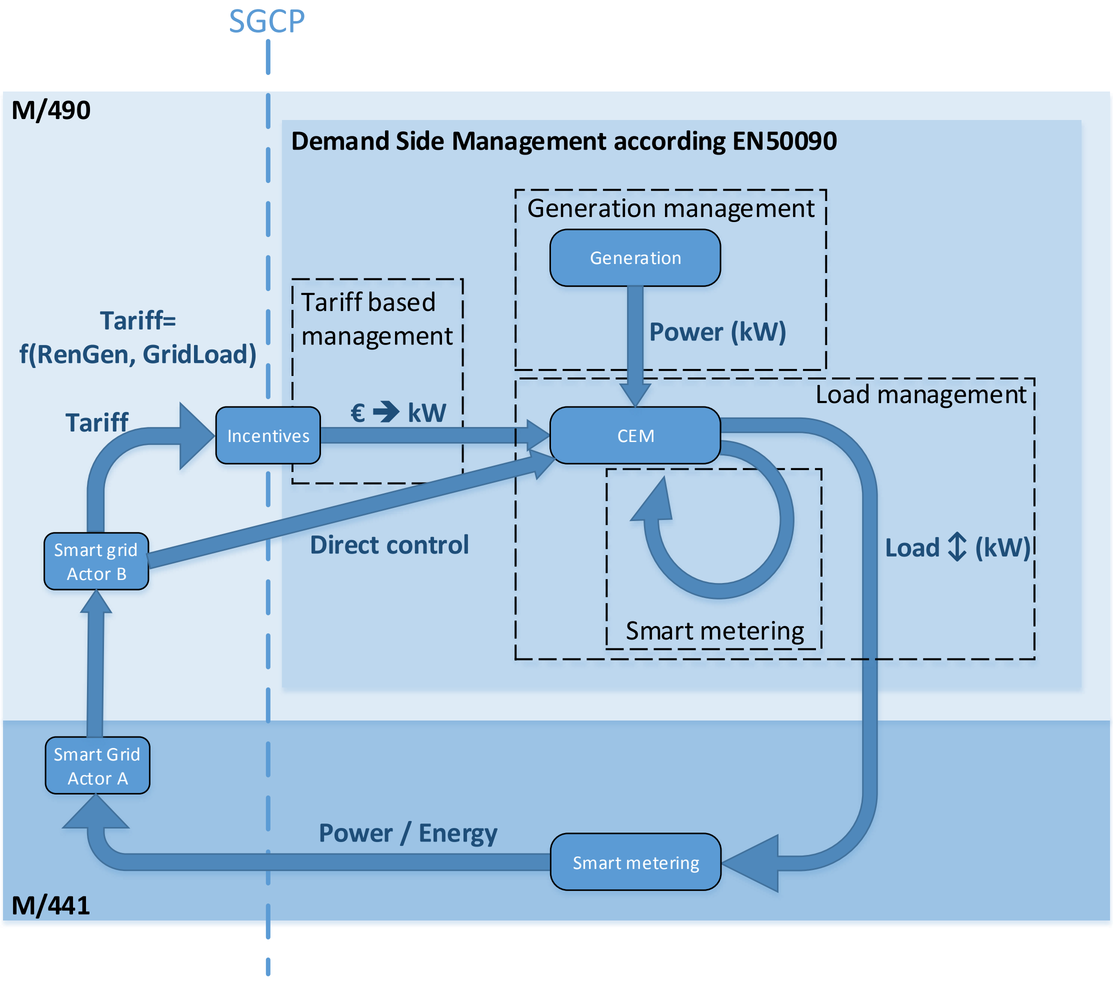

Figure 2: Demand Side Management according the EN50090 in the Demand Response use case

4.1 Tariff based management

M/441 foresees a Smart Meter Gateway (SMG) for providing a digital access path from a smart grid operator or utility or other smart grid actor into the building. In order to implement a tariff based management in accordance to the EN50090 series, the new Datapoint types (DPTS) DPT_Tariff and DPT_TariffNext can be used to provide the tariff information to KNX. Figure 3 shows a recommended implementation containing the functional blocks (FBs) FB Electricity Tariff Server (ELTS) and FB Tariff Handler (TH). The objective of the electricity tariff server is to evaluate the tariff levels and to translate those into the Datapoints 'TariffPrice' and 'TariffPriceNext'. These Datapoints contain information about the price levels as well as about the time periods of validity, price base, commodity etc. The objective of the tariff handler is to translate this information into power setpoint values, which can be used as reference values for the load adaptions. Conform to M/441 the tariff server can be implemented e.g. in a smart meter, SMG or any other gateway between meter and building automation. Conform to M/490 the tariff handler can be implemented e.g. in an energy management gateway (EMG). All used DPTs provide potential support for gas, water, heat or other tariffs as shown in **Figure 4**, although then new Functional Blocks need to be specified.

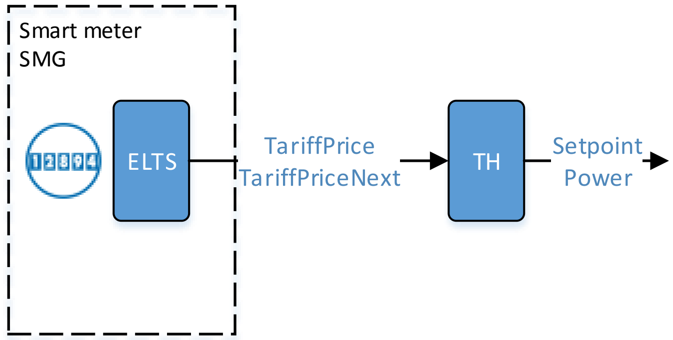

Figure 3: New DPT_TariffCommodity for TOU and RTP tariffs

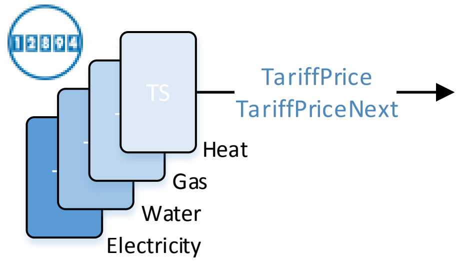

Figure 4: DPTs are ready for also other tariff servers such as a heat tariff server

> **Tech talk: Tariff**
>
> A wide variety of tariff definitions exist worldwide. The tariff information is interpreted by the FB Tariff Handler (communicated to the KNX installation via DPT_Tariff (DPT_ID = 5.006) or DPT_TariffNext (DPT_ID = 236.001), which through its parameterisation suggests load management adjustments to the KNX network.

4.2 Generation Management

Generation Management according to EN50090 describes the evaluation of the own building's energy generation. Three options can be distinguished.

1. *Generation Measuring*
   The current power generation in kW is measured either by KNX or by an external system and is transmitted via datapoints (e.g. DPT_PowerKW) to a KNX Generation Manager (GM).
2. *Generation forecast*
   A forecast generation mean value, valid for a specific time period Δt, is transmitted to KNX. DPT_PowerKW and DPT_TimePeriod can be used for this.
3. *Generation schemes*
   A forecast generation for a longer time period is known.

Figure 5 shows the related scheme. The functional block FB Generation Manager (GM) aggregates the different generation sources. As some DR use cases foresee the function to reduce the generation (in the case of a utility request due to grid problems) the FB Generation Manager also foresees a setpoint to implement this. DPT_Power can be used for this. It shall be noted that the limiting of the generation should not be the preferred method. A better method is to increase the load, which has the same effect to the power grid.

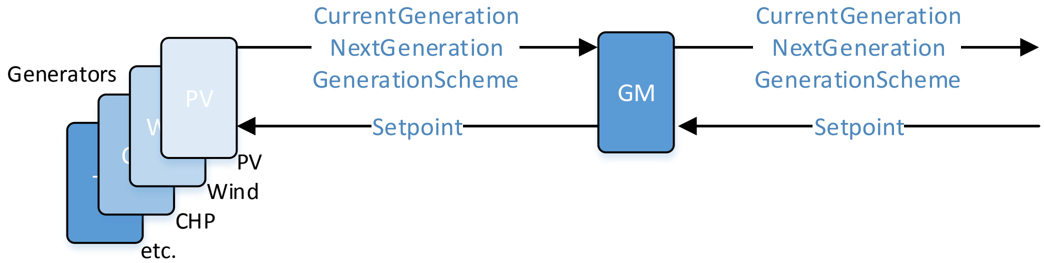

Figure 5: A Generation Manager aggregates the different generations of different generators

4.3 Load Management

Load Management according to EN50090 describes the process and automation in order to increase or decrease the total load of a building depending on any given setpoint. A CEM conform to M/490 describes an internal automation function of the role customer for optimisations according to the preferences of the customer, based on signals from outside and internal flexibilities. [2] Therefore the CEM can be understood as a central decider for load adaptions, of which the task is to evaluate the tariff based management and generation management and to create a setpoint for the DSM. Two DSM approaches can be distinguished:

1. *Decentralised load management*
   The CEM recommends new load behaviour. Whether the load behaviour is taken over or not is decided by KNX application managers depending on local parameters and boundary conditions.

   EXAMPLE : The KNX application manager can be an HVAC manager, or a lighting manager, or another KNX application controller.

2. *Centralised load management*
   The CEM has direct access to the actuator of the load and can increase, decrease the load or simply switch it on or off.

The decentralised load management is the preferred method for DSM as this does not go against local customer preferences.

4.3.1 Decentralised load management

For a decentralised load management KNX provides the general use case ‘Mode Based Load Management’ for operating different CEM actors in combination with KNX actors for thus ensuring flexibilities. Figure 8 shows the UML sequence diagram of this use case. This can be implemented with DPT_Prioritised_Mode_Control, which contains both priority level and priority mode as parameters.

General Use Case: KNX decentralised load management

Different CEMs request a KNX application manager to change its mode in order to increase or decrease the load. Only the CEM with the highest priority level *p* will affect the KNX application manager. This CEM requests a mode level *m* with a certain priority level from the KNX application manager. The KNX application manager will only follow this request, if the requested priority level is higher than the currently active priority. The KNX application manager determines the MDT internally based on received parameters from the connected KNX application controllers. In this way it is possible to consider local boundary conditions.

Tech talk: Prioritised Mode Control

Prioritised Mode Control defines its own DPT Prioritised Mode Control (236.001), which can transport an activation or deactivation, a priority level and a mode level. The mode level furthermore allows for a differentiation of reactions to a given command within each load individually.

Figure 6 and Figure 7 give an example scenario for this use case with an air conditioning system: Following a high photovoltaic surplus generation a CEM requests to increase the electrical load of an air conditioning system (which is operating currently in comfort mode 2), thus thereby further increasing the mode. The HVAC application manager follows this request as this mode 3 is allowed (MDT). As a result the room, in which the air conditioning system is mounted, cools down rapidly. After a while and depending on the measured room temperature, which is lower now, the application manager reduces the MDT. Because of the room temperature situation, lower cooling modes are now allowed. If the surplus energy disappears (e.g. due to cloudy weather) the CEM requests to decrease the mode again. The HVAC application manager follows and decreases the mode until the requested mode or the minimum allowed mode (MDT) is reached. Thanks to the Prioritised Mode Control, the CEM uses on the one hand the heat storage capacity of the room, on the other hand it ensures that decentralised boundary conditions are processed by the application manager and no actions are taken that violate these boundary conditions. Please note, that the response from KNX application managers to the Prioritised Mode is not mandatory. Prioritised Mode Control provides recommendations for load behaviours.

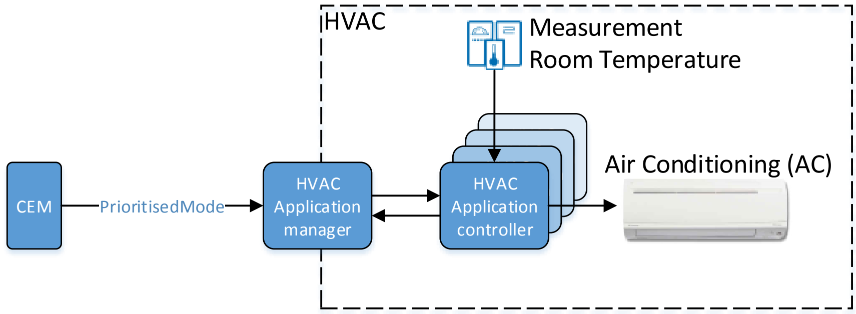

Figure 6: Example Prioritised Mode Control of an air conditioning system

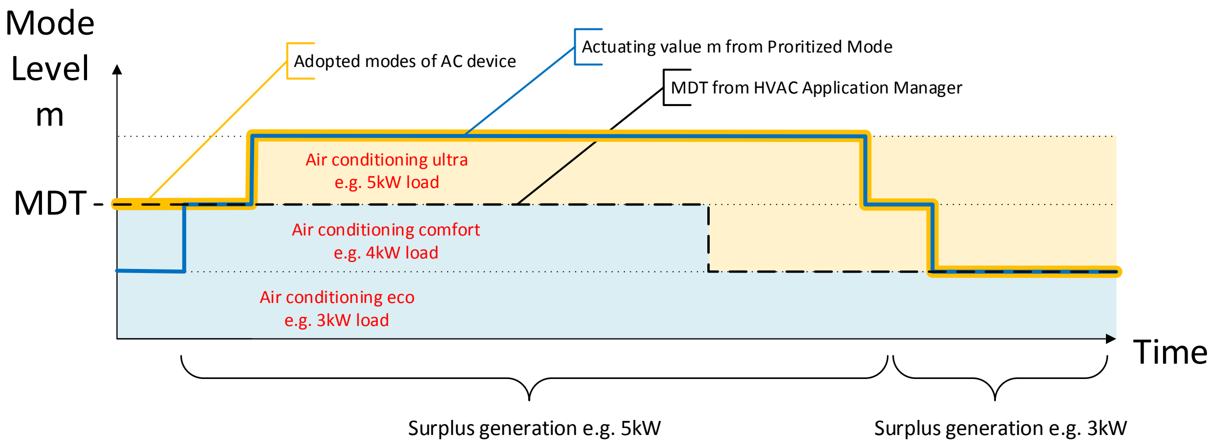

Figure 7: Example: Different modes of an air conditioning system.

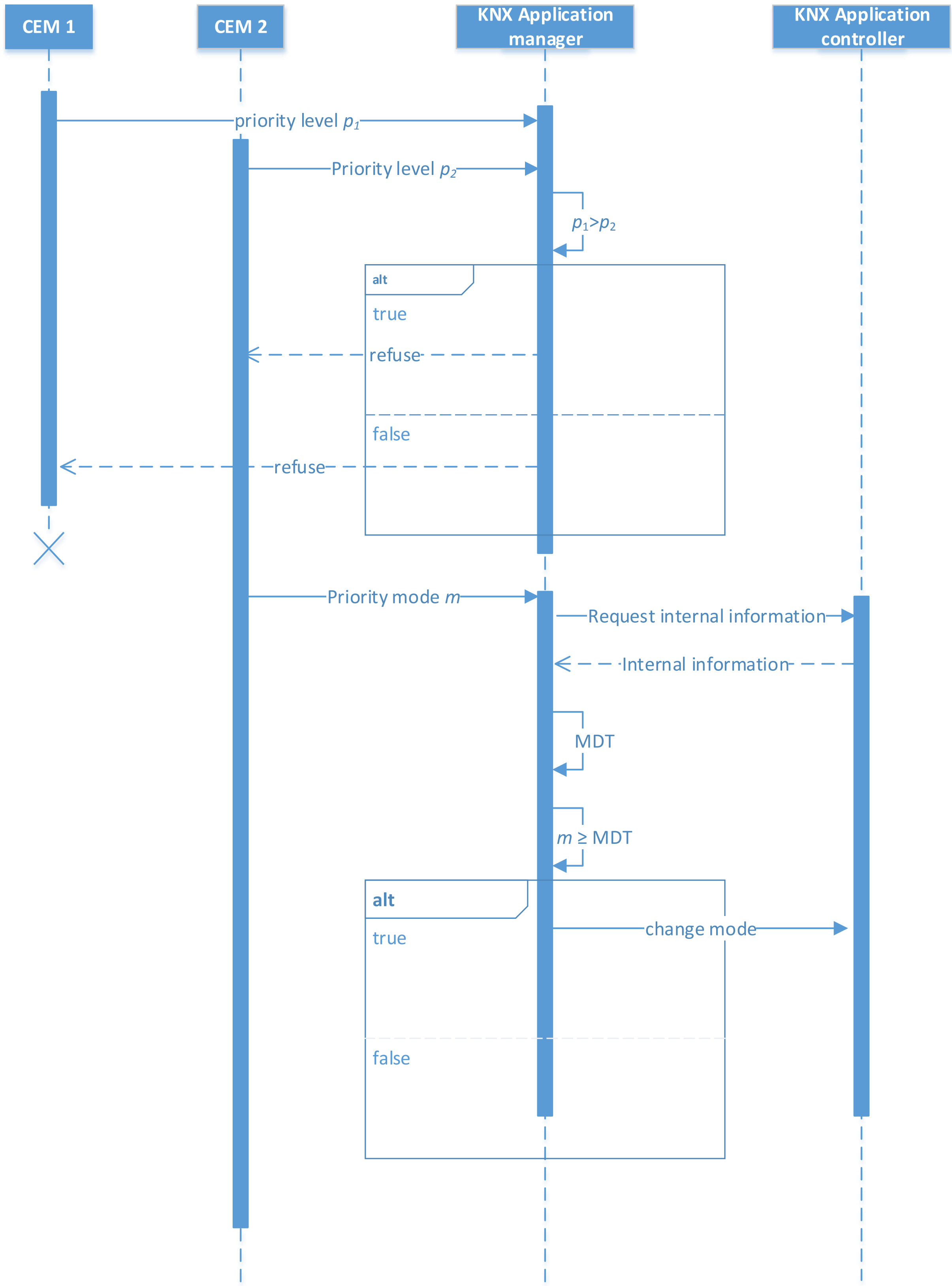

Figure 8: Use case: KNX Mode Based Load Management, Example for CEM1 with higher priority level

4.3.2 Centralised load management

The centralised load management can still be used for applications that do not provide an application manager or do not support the Prioritised Mode Control. A typical scenario can be a switching application, e.g. an electric bike (eBike) shall be charged only in case of a surplus generation of the buildings' photovoltaic system. KNX devices (e.g. the energy actuator) are already on the market that provide the switching and measurement function in one device. Figure 9 shows an example for a centralised load management.

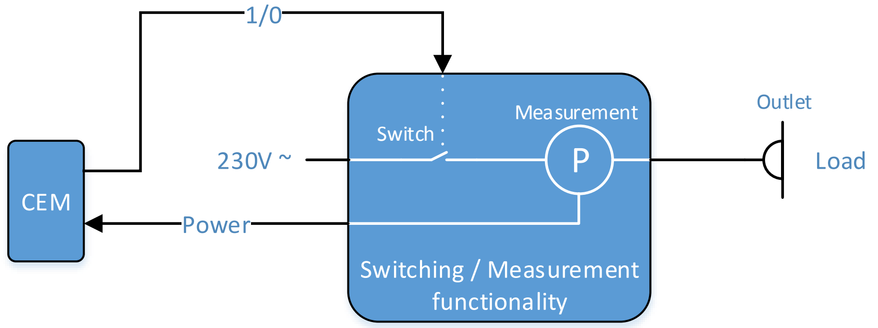

Figure 9: Centralised DSM for a switching application e.g. a load connected to an outlet

General Use Case: KNX centralised load management

A CEM controls directly a KNX application and switches the load on or off depending on a tariff event or other event.

4.3.3 Smart Metering

In terms of M/441, Smart Metering is understood as measuring with calibrated meters for billing the consumption of energy. 'Smart meters' describe newly developed utility meters, which are able to bill TOU, RTP and other tariffs. As an extension these meters contain communication systems for transmitting the measured values or billing information to a smart grid actor or utility. In terms of EN50090 Smart Metering is understood as an exact measurement of values of any kind. For this task own KNX meters are used. Those offer more degrees of freedom as they can be used also for sub metering e.g. in sub power strips. Figure 10 shows the smart grid and smart building in a simplified view as a cascaded control and is used for explaining the difference between both kinds of metering. Utility meters represent in terms of DR use cases the feedback-loop for the DR controller. KNX meters represent the feedback-loop for load management and thereby for the Prioritised Mode Control. Therefore both kinds of metering have different tasks. KNX meters can thus also be implemented in KNX end devices such as switching actuators.

Tech Talk: Closed-loop control

A closed-loop controller adapts the output (control variable) to its input (setpoint variable). Depending on the used controller a control deviation or over- and undershooting can occur. A cascaded control contains two controls. The inner control has to be faster than the outer control.

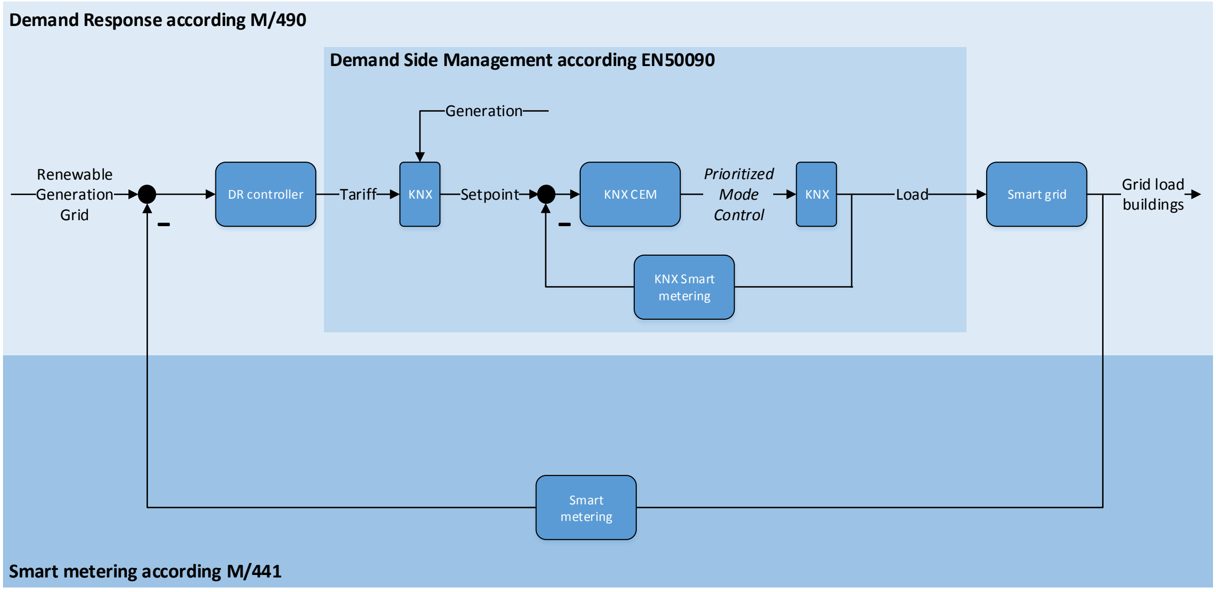

Figure 10: In a simplified view smart grid and smart building represent a cascaded control

5 Load management algorithms and control strategies

A load management is only successful if algorithms or controllers exists that implement the CEM functionality to adapt loads. KNX foresees three options:

1. Prediction based optimisation:
   This method can be used in the case that the load requires a fixed runtime (e.g. appliances) and that a setpoint is given for a longer period of time (e.g. curve).
2. Real time based optimisation:
   This method can be used for open-loop controls if no feedback on real power consumption of the load is given (open-loop control).
3. Real time control:
   This method can be used for real time load adaptions if a feedback on the real power consumption is given (closed-loop control).

5.1 Prediction based optimisation [4]

For the prediction based optimisation, the load profiles and the setpoint curve must be known. Figure 11 shows an example of a washing machine. The operation of a washing machine shall not be interrupted. Therefore, the washing machine has to run for about 1 hour. The load profile is not constant. It varies in time. As a boundary condition for optimisation the user can define a time period (time slot) after which the washing machine has to have its washing program completed.

As due to the fact that not every load in a building is suitable for a load adaption, an offset load profile can be subtracted from the setpoint curve. This offset profile represents a prediction of all loads that are not suitable for the load management, in which they thus do not participate. The result of the subtraction is a new setpoint curve, which needs to be used for optimisation. This is dispensable, if the FB Energy Manager will be used. Due to this this shall not be explained detailed in this paper.

KNX foresees for the prediction based optimisation the functional block FB Prediction Based Optimisation (PBO). This FB can be used for multiple loads in a centralised - as well in a decentralised load management, as shown in Figure 12. For detailed information please see the KNX specifications.

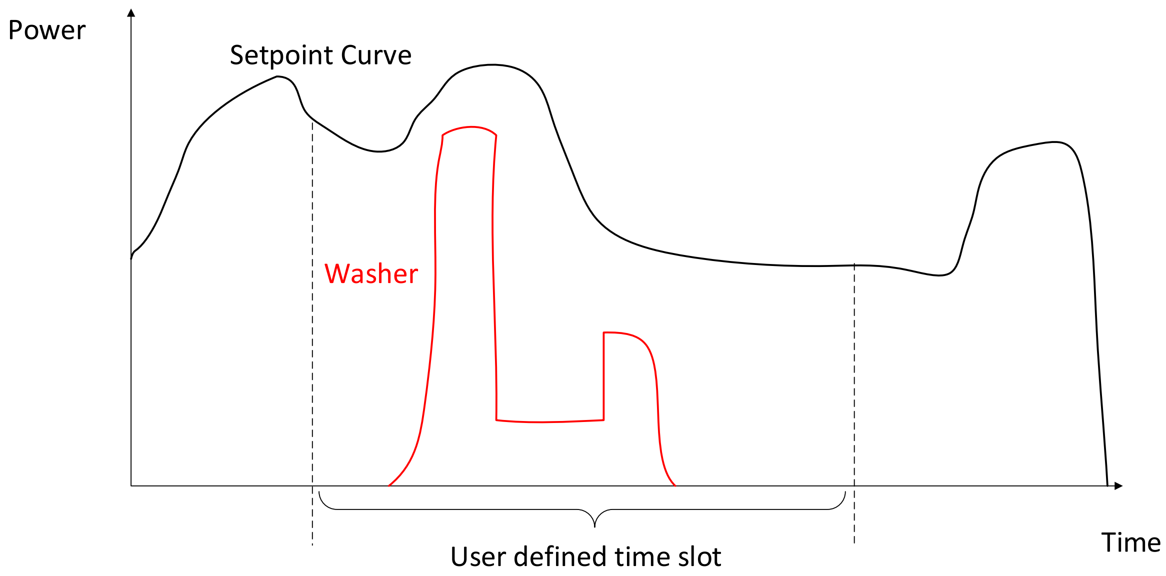

Figure 11: Prediction based optimisation of a washing machine

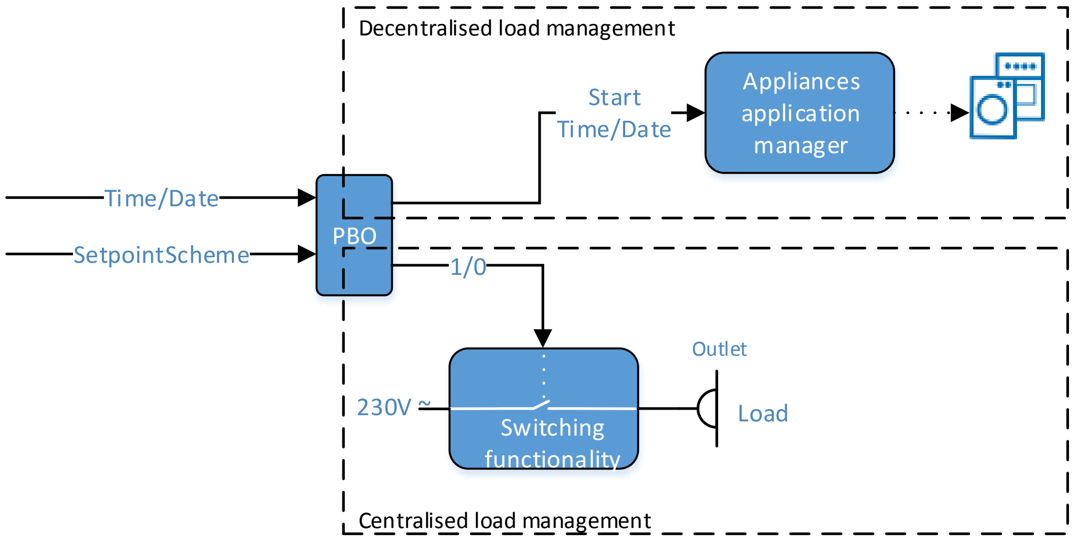

Figure 12: Centralised and decentralised load management with FB Prediction Based Optimisation for the example of a washing machine

5.2 Real time based optimisation [4]

The real time based optimisation can be used for real time load adaption and is especially suitable for loads that can be interrupted or provide different modes and thus support the Prioritised Mode Control. Since this is an optimisation, an open-loop control can be realised and a feedback with the real power consumption of the load is not necessary. In this case the load consumption of the different modes has to be known. If a feedback loop of the power consumption is available, this optimisation can be used as a 'pseudo controller'. In this case the setpoint for optimisation comes from the difference of the original setpoint and the current total load. The optimisation is done for short time periods Δt, in order to enable the real time load adaption. The FB shall internally calculate the current total load of the participating loads (via the saved load values and in dependence of its started loads or modes). This calculated load value ($P_{load,next}$) has to subtracted from the original next setpoint value and results in a new next setpoint value for the next Δt. The optimisation can also handle fluctuating setpoint values, coming e.g. from photovoltaic systems. The algorithm can calculate new setpoint values (valid for Δt) based on dynamic mean values from the past (see Figure 13 right diagram). This is an optional function that does not need to be used.

KNX foresees for the real time based optimisation the functional block FB Real Time Based Optimisation (RTBO). This FB can be used for multiple loads for a centralised load management as well for a decentralised load management as shown in Figure 14. For detailed information please see the KNX specifications.

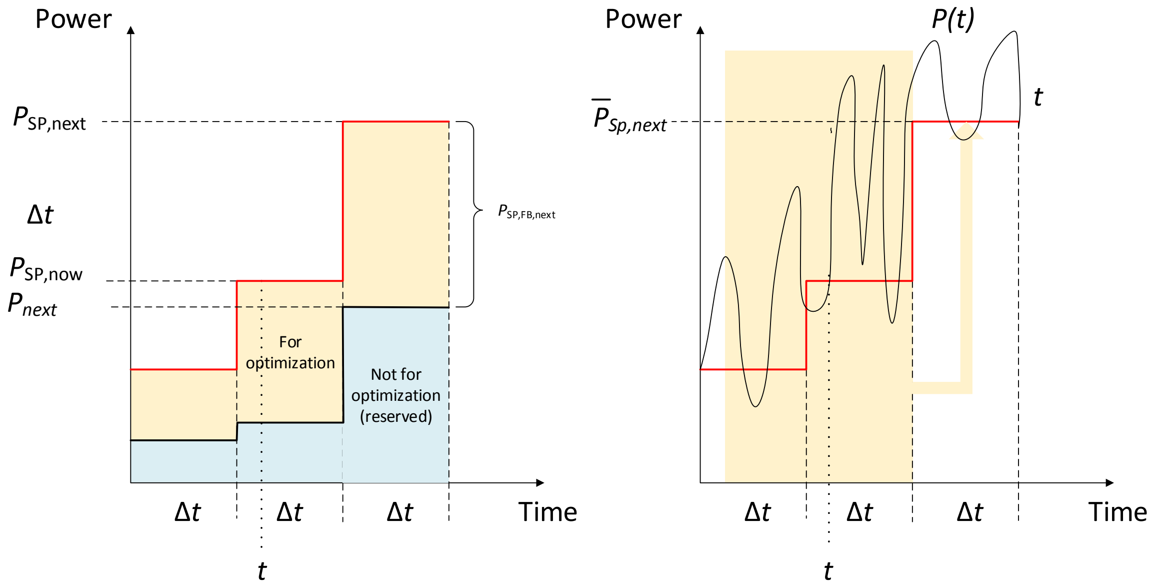

Figure 13: Optimisation for small time periods Δt (left), setpoint creation for next Δt based on dynamic mean values of the past for a photovoltaic generation (right)

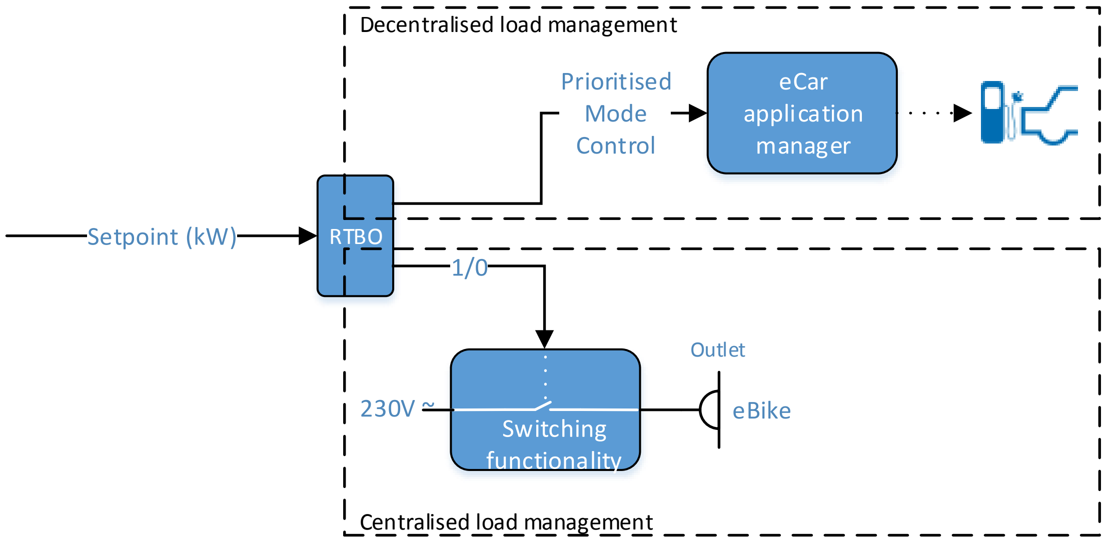

Figure 14: Centralised and decentralised load management with FB Real Time Control: an eCar with different charging modes (G2V) and a simple eBike charged on an outlet

5.3 Real time control [4]

The real time control represents a closed-loop control and uses DPT_Prioritised_Mode_Control as the actuating value (mode *m*). The controller varies the actuating value until the control deviation is minimal. The controller sees the mode threshold value (MDT) of the application manager as a limitation of the actuating value. As a result the control deviation will be minimized as much as possible, although it does not disappear. For the real time control it is necessary to get a feedback of the real consumption of the actual load. KNX Smart Metering can ensure this, if the concerning KNX application manager does not provide this information itself.

KNX foresees for the real time control the functional block FB Real Time Control (RTC). This FB can be used for a decentralised load management. For detailed information please see the KNX specifications. Figure 15 shows the control scheme as it is also used in Figure 10. An example for the real time control can be the control of an air conditioning system as explained in Figure 6.

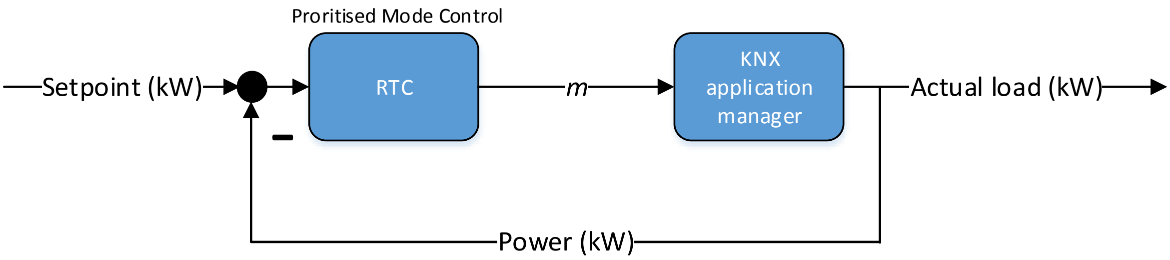

Figure 15: Closed-loop control in the context of Prioritised Mode Control

5.4 Aggregation of different controls and optimisations

For the aggregation of different controllers or optimisations, it is necessary to operate different controllers or optimisations in parallel. In this case the different setpoint values need to be created depending on the building's current power generation, the building's current load and as well the electricity multi level tariff. Fuzzy logic can be used to create these setpoints based on rules. Figure 16 shows as an example (for one rule) for the charging of an eCar through such fuzzy control. The result will be the concerning setpoint value in kW.

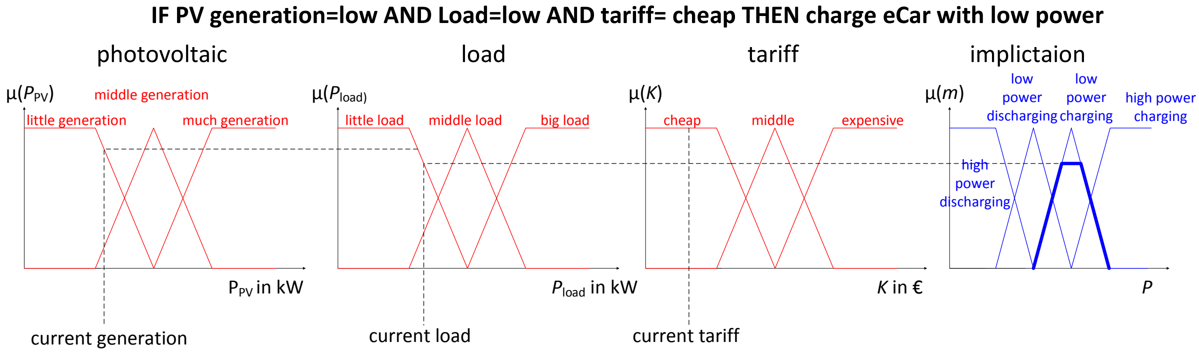

Figure 16: Fuzzyfication control of generation, load and tariff for the example of the charging of an eCar

In KNX the coordination is ensured by the FB Energy Manager (EM). Figure 17 shows the FB including the fuzzy logic scheme. This FB uses existing DPTs. The tariff input can directly come from either the tariff setpoint output of FB Tariff Handler or the tariff DPs from FB Electricity Tariff Server. This FB needs to be configured via parameters depending on the used applications (e.g. HVAC, light, etc.)

Tech Talk: Fuzzy logic

Fuzzy logic represents a method for the development of controls in automation technology. Fuzzy logic makes it possible to handle represent human behaviour or human causal knowledge by mathematical means and thus to imitate this on a computer or in a control. Fuzzy logic can be used for open-loop and closed-loop controllers.

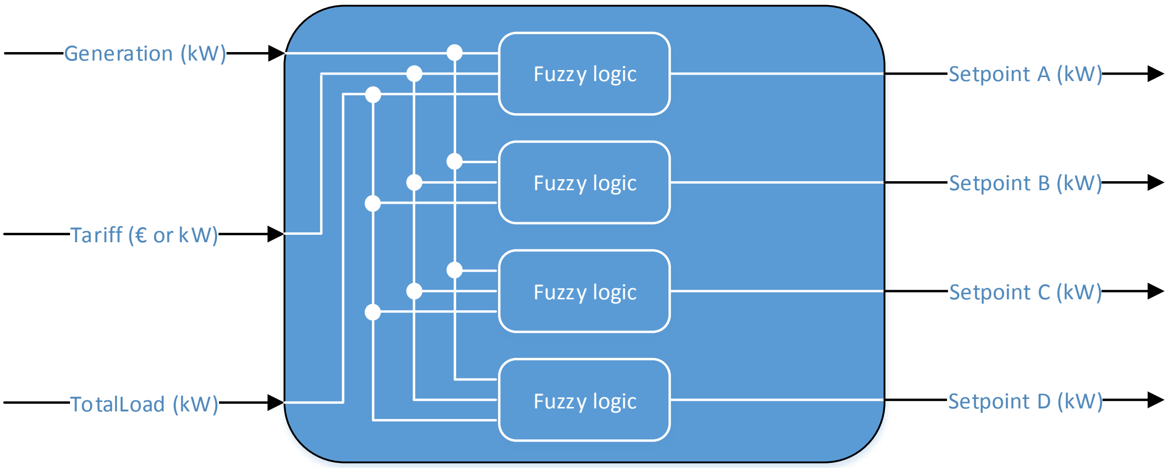

Figure 17: FB Energy Manager based on Fuzzy Control for setpoint creation

6 Providing flexibilities

All use cases described in section 7 can be combined and implemented in a total mechanism to provide flexibilities in the sense of M/490. For this, the general use cases 'KNX decentralised load management' and 'KNX centralised load management' can be used. Figure 18 shows the total scheme for providing flexibilities.

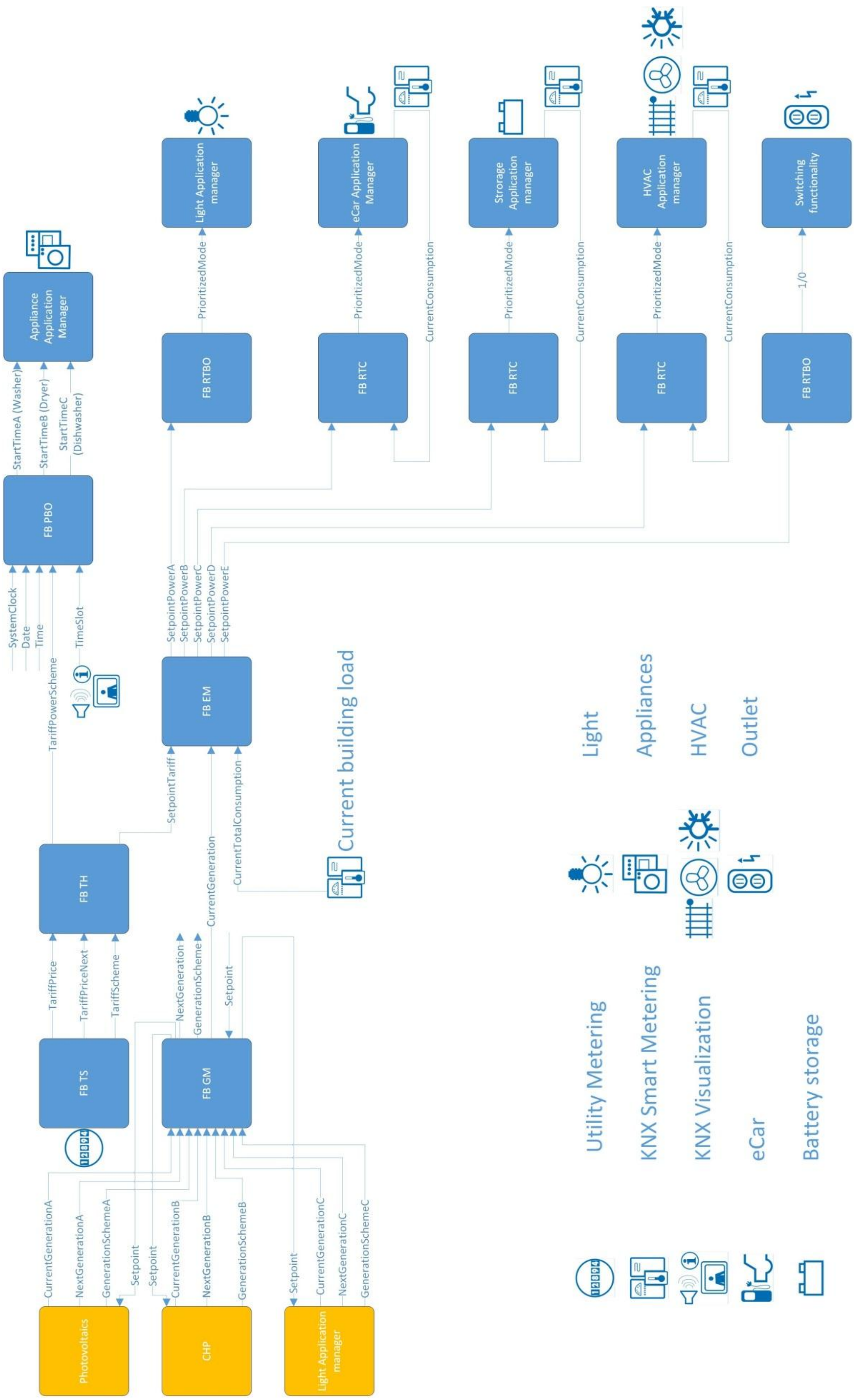

Figure 18: Overall Scheme of Demand Side Management with KNX

7 Use Cases

In the following some examples for use cases are given (based on the general use cases, described in this document and based on Figure 18). The general use cases provide help to increase or decrease the building load, which in turn helps the utilities to

- consume surplus generation from renewable energies in the grid (increasing of KNX loads)
- cope with a lack of renewable energy generation in the grid (reduction of KNX loads)
- avoid transformer overloads due to a high amount of loads e.g. simultaneous charging of eCars (KNX Demand Side Management), and
- load shedding.

Customers benefit from cost savings thanks to an optimal usage of the tariff price level by KNX.

7.1 Building use cases

In the following, examples for the general use cases are given. All of these can be combined with each other for implementing an overall KNX Demand Side Management as shown in Figure 18.

7.1.1 Load adaption with appliances to a TOU tariff

Use Case: Load adaption with appliances to a TOU tariff

The customer receives a TOU tariff from his utility and wants to start his appliances the next day between e.g. 11:00h and 15:00h (boundary condition) at the cheapest tariff time for saving energy costs. The tariff levels of the TOU tariff are known.

This use case can be implemented with FB Prediction Based Optimisation (PBO). The user defines the time slots for the running of the appliances e.g. via a KNX visualisation. The FB Prediction Based Optimisation optimizes the loads of the appliances and determines the best starting times for the next day depending on the tariffs and the given boundary conditions. The appliances can be started via an appliance application manager, which can receive either the starting time or a direct switching signal from KNX.

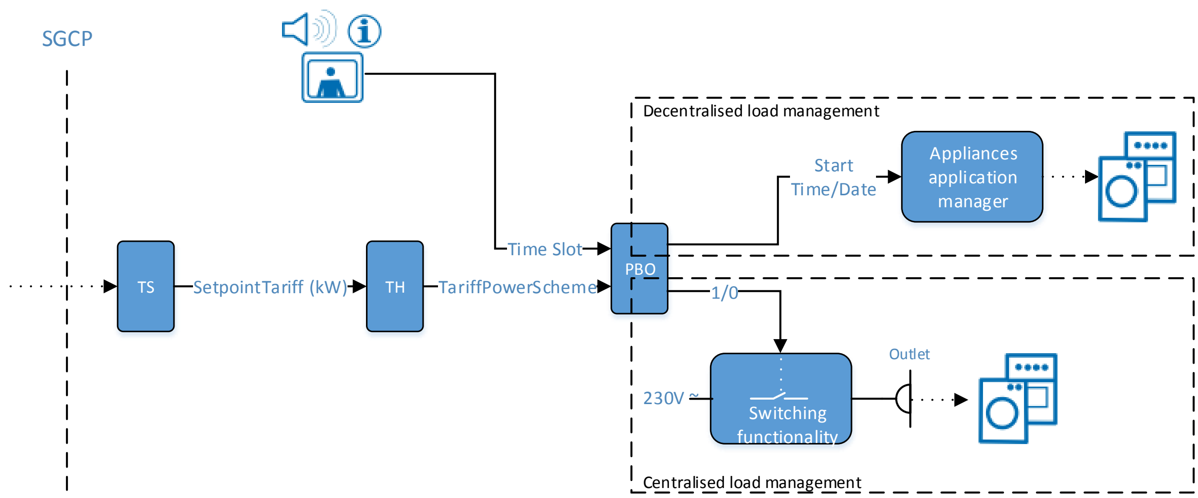

Figure 19: Load adaption with appliances to a TOU tariff through the use of FB Prediction Based Optimisation for either a decentralised or a centralised load management

7.1.2 Load shedding in commercial buildings via light scenes

Use case: Load shedding in commercial buildings via light scenes

The reduction of light can save a lot of energy. In a commercial building, light scenes shall be controlled depending on a RTP tariff and the own photovoltaic generation. To ensure this the customer has defined light scenes e.g. eco, normal, comfort. Light scene eco shall be e.g. only selected if the electricity prize is expensive and if there is no photovoltaic power generation. Light scene comfort shall be selected when tariff is cheap and in case of enough surplus power generation. In all other cases light scene normal shall be set.

This use case can be realised with FB Electricity Tariff Server, FB Tariff Handler, FB Generation Manager, FB Energy Manager and FB Real Time Based Optimisation. In this case, the real time based optimisation can be used, as the consumption of the different light scenes can be measured once and will not change. Hence, a measurement of the light power is not necessary. Of course FB Real Time Control may be used as well instead of FB Real Time Based Optimisation if the light power is effectively measured.

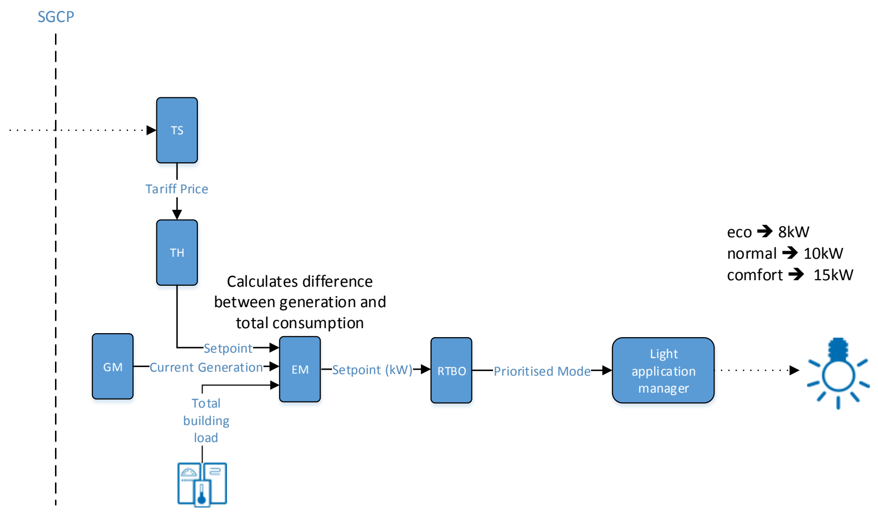

Figure 20: Load shedding via light scenes

7.1.3 Regulation of the control deviation coming from prediction based optimisations

Use case: 6.1.3 Regulation of the control deviation coming from prediction based optimisations

The efficiency of prediction based optimisations depends on the accuracy of their forecast setpoint curves. If e.g. loads are scheduled for the next day to a forecast generation profile of a renewable generator (e.g. photovoltaics), then a control deviation occurs, if the real generation does not match the prediction. This control deviation can be regulated with the real time prediction based optimisation or with the real time control.

An implementation of the real time based optimisation in line with Figure 20 automatically regulates the control deviation. The efficiency depends on the loads that participate in the real time based optimisation or real time control. In the presence of an energy storage or eCar, this regulation shows the best results.

7.2 Mobility use cases

7.2.1 Charging of an eCar with photovoltaic surplus energy (G2V)

Use Case: Charging of an eCar with photovoltaic surplus energy (G2V)

The customer wants to charge his eCar predominantly with surplus energy from the own photovoltaic system. The eCar provides different charging modes (e.g. 3A, 6A, 16A).

This use case can be implemented with FB Energy Manager and FB Real Time Control. The energy manager calculates the setpoint value by subtracting total consumption from generation. In the case of a decentralised load management the real time control adapts the eCar load (by requesting different modes) to the setpoint as best as possible. In case of a centralised load management the charging plug of the eCar can only be switched on or off.

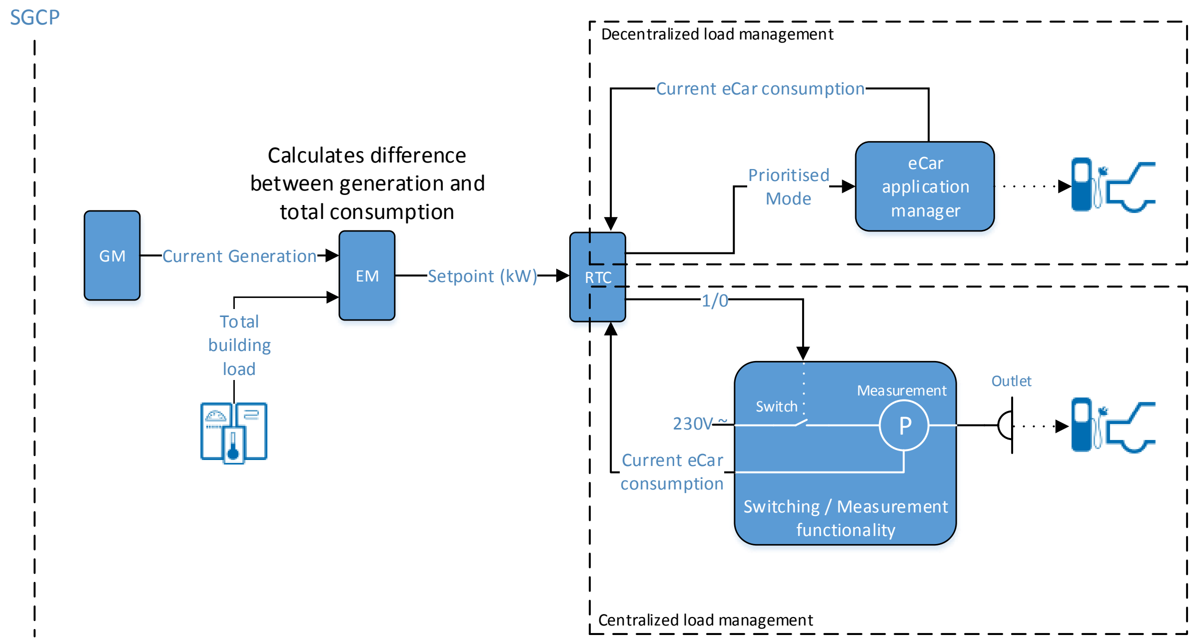

Figure 21: Charging of an eCar with photovoltaic surplus energy for a decentralised and centralised load management

7.2.2 Charging of an eBike with photovoltaic surplus energy

Use case: Charging of an eBike

The customer wants to charge his eBike predominantly with surplus energy from the own photovoltaic system. eBikes are always charged via conventional plugs.

This use case can implemented in the same way as described in 7.2.1

7.2.3 Vehicle to Grid (V2G)

Use case: Vehicle to Grid (V2G)

In case of a demand Response request for feeding back energy to the grid, the battery of an eCar may be used for this. The discharging of the battery shall be started if the tariff level becomes expensive or depending on an external signal from the utility.

This use case can be implemented with FB Electricity Tariff Server, FB Tariff Handler and FB Real Time Based Optimisation. FB Real Time Based Optimisation can be used, as the mode for discharging is known and can be directly requested. Figure 22 shows an implementation with direct load control from the Smart Grid beyond the Smart Grid Connection Point. If two Inputs for Prioritised Mode Control are used, then the one with the higher priority level will be successful.

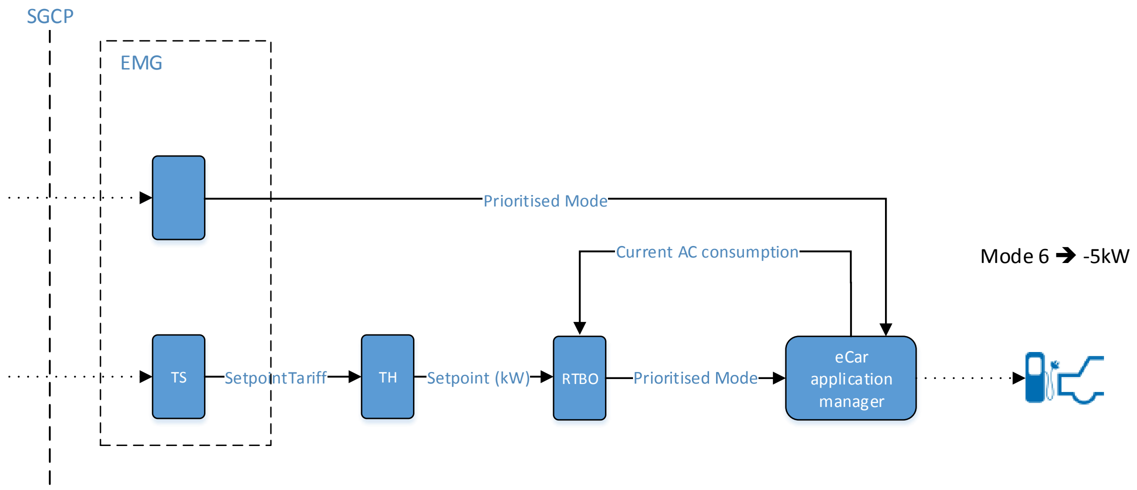

Figure 22: Vehicle to Grid (V2G)

7.2.4 Avoiding transformer overloads due to high charging loads of eCar

Use Case: Avoiding transformer overloads due to high charging loads of eCar

A high number of simultaneously charging eCars can lead to a transformer overload in the power grid. An own RTP tariff for eCars can signal that a transformer overload is imminent. With the real time control, the charging load can be decreased to avoid such transformer overload.

This use case can be implemented as in Figure 22 with the only exception that the eCar application manager needs to provide different charging modes with different charging currents.

7.3 Infrastructure use cases

7.3.1 Demand Side Management with an air conditioning system

Use case: Demand Side Management with an air conditioning (AC) system

In metropolitan cities, air conditioning systems are responsible for a large share of the energy consumption. Via Demand Response (RTP tariff) the utility wants to control the customer's air conditioning system in order to be able to briefly reduce the load at times of power grid overloads.

The utility transmits a RTP tariff, which is evaluated via FB Tariff Server and FB Tariff Handler. The resulting setpoint is used (Prioritised Mode Control) for requesting different air conditioning modes via FB Real Time Control. The HVAC application managers follow the request depending on the room temperature.

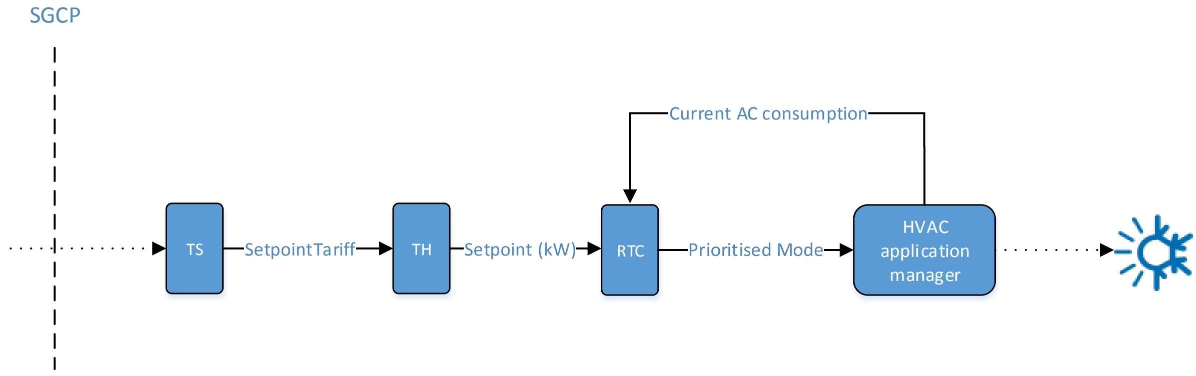

Figure 23: Demand Side Management of an air conditioning system depending on a RTP tariff

7.3.2 Water heating depending on renewable generation in the power grid

Use case: Water heating depending on renewable generation in the power grid

A separate electrical heating coil in a hot water tank shall be controlled depending on the renewable generation in the power grid (RTP tariff). By doing so, electrical energy is transformed into heat energy and stored.

This use case can be implemented with FB Tariff Server, FB Tariff Handler, FB Real Time Control via the Prioritised Mode Control. The MDT value that is used by the HVAC application manager ensures that heating process is adapted in function of the available water temperature.

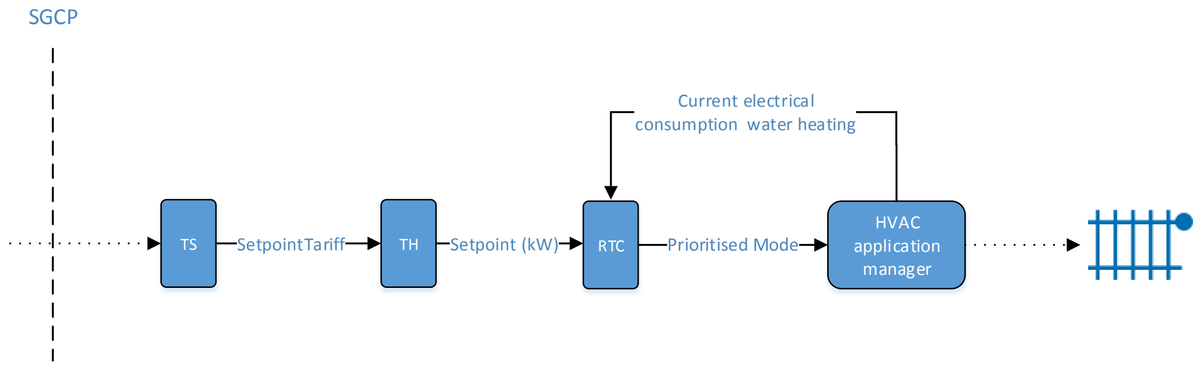

Figure 24: Operation of a separate electrical heating coil in a hot water tank depending on an RTP tariff

7.4 Energy generation use cases

7.4.1 Buffering the generation of a photovoltaic system via an energy storage

Use Case: Buffering the generation of a photovoltaic system with an energy storage

At times of surplus generation, the surplus energy shall be stored in an energy storage. At times without surplus generation, the energy can be fed back in.

This use case can be implemented with FB Generation Manager, FB Energy Manager and FB Real Time Control. The energy storage needs to provide modes for charging (positive sign) and discharging (negative sign). The real time control will automatically request the best mode and will adjust the best charging/discharging mode.

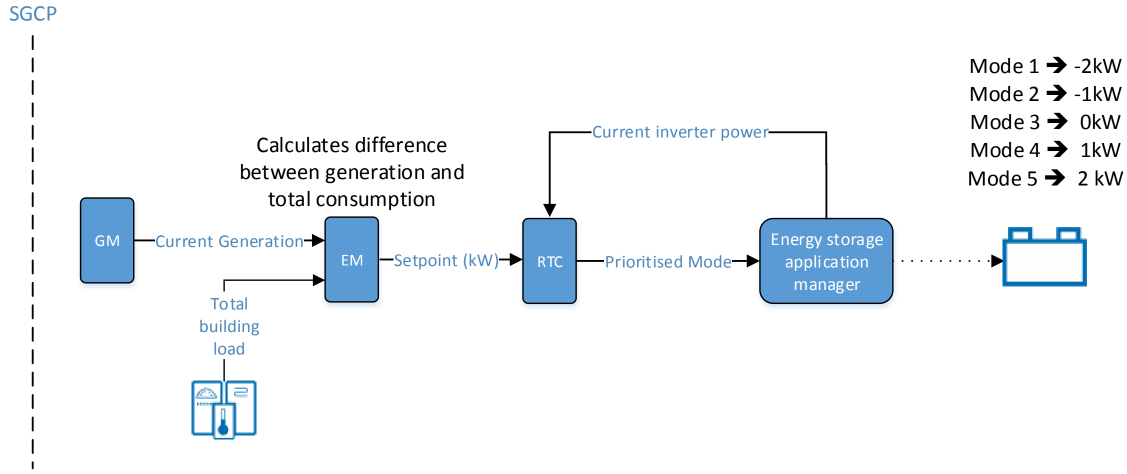

Figure 25: Buffering the generation of a photovoltaic system with an energy storage

7.4.2 Avoiding the reduction of the building's generation in the case of voltage problems in the grid

Use case: Avoiding the reduction of the building's generation in the case of voltage problems in the grid

High amounts of renewable energy (e.g. photovoltaic systems on buildings) can lead to an increase of the grid voltage. Some utilities therefore require the possibility to reduce generation. The same netto effect can be achieved with the increase of the building load instead of the reduction of the generation.

This use case can be implemented with all the other use cases leading to an increase of the load.

8 Literature

[1] CEN CENELEC ETSI, Final report of the CEN/CENELEC/ETSI Joint Working Group on Standards for Smart Grids.

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[3] DKE, Normungsroadmap E-Energy / Smart Grids 2.0, 2012.

[4] L. Steiner, Lastmanagement in Gebäuden als Beitrag zur Reduktion der Auswirkung der Volatilität erneuerbarer Energien (Entwurfsversion), Darmstadt.