NEW CONCEPTS FOR SMART SYSTEMS – FROM A SMART GRID VIA SMART BUILDINGS TO SMART BILLING

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ABSTRACT

With the introduction of Smart Meters new kinds of metering, communication and billing systems are available to offer new opportunities for making buildings smarter. The interoperability between metering devices of different (energy) sources (electricity, gas, heating, water), the integrated information and communication technology (ICT) and decentralized feeders are basics to realize Smart Buildings. In Smart Grids respectively in Smart Buildings a part of the own energy demand in a building is generated by decentralized feeders. In future the use of flexible tariff models, provided by the energy provider, shall be possible. In order to utilize the economical optimum for the costumer, two groups with several Smart Meters (energy procurement and energy regeneration) are applied.

Further the electrical installation in the house is split into several load groups and the electric equipment is classified according to the functionality (controllable loads for load shedding or uncontrollable loads). A bus system for load-, energy-, cost- and process-management as well as a display unit for visualization inside the house is scheduled. Special metering devices for recording the energy consumption of selected electrical equipment are useful.

In combination with intelligent Smart Meter technologies issues regarding the functionality of the new electronic equipment and issues regarding data security are important.

Due to the high demands regarding reliability and protection of essential electrical equipment in Smart Grids specific considerations in connection with the integrated earthing, equipotential bonding and lightening protection system in a Smart Building is shown.

INTRODUCTION

Targets determined in the 20-20-20 energy and climate package of the European Commission to increase energy efficiency and furthermore to reduce energy costs are the background to focus on new Smart Metering systems.

Decentralized feeders and the information and communication technology (ICT) are main parts of Smart Buildings; through these technologies buildings can turn into partly autonomous components of the Smart Grids.

Photovoltaic elements or small decentralized generators like stirling engines deliver a part of the own energy need in a building. The dc power rail can provide an innovative and economic supply of the dc equipment and shall be coupled with inverters to the ac power supply. The part of the energy, which is not consumed in the building or if it is more economic, due flexible tariff models the whole customer generation of the building can be fed into the distribution network.

Each building is equipped with a number of Smart Meters which are grouped by different requirements in dependency on the request of the building (e.g. single family home, apartment block, commerce, industry etc.).

Furthermore the electrical installation in the building can be split up into different load groups and the electrical equipment is classified according to its functionality (controllable loads for load shedding or uncontrollable loads).

Interoperability between the metering devices for electricity, gas, water and heating shall be required for a new multivalent energy concept of a Smart Building and in addition for a Smart Billing system to provide energy and cost efficiency. Inside the house a bus system for load-, energy-, cost- and process-management as well as display units for visualization and information are provided.

A measuring system to get detailed information of the connected electric appliances is plugged into the socket and delivers information like electrical power consumption to get information regarding efficiency, trends, cost, savings and waste. Data have to be transferred to a centralized collecting point and are available for subsequent treatment. Exemplarily by detailed measuring high energy consumers are identified and saving potentials can be shown [3].

The increased use of electronic equipment in Smart Buildings and also the whole Smart Grid including the necessary bidirectional information and data flow through cables or power line carrier requires special considerations regarding availability of electronic equipment on the one hand and grounding, equipotential bonding, shielding and lightning protection on the other hand [1].

In the following the concept to make buildings smarter and how they become a part of a multi-functional, innovative and sustainable Smart Grid is presented in detail.

SINGLE FAMILY HOME

To generate a part of the own energy needs of a building (e.g. single family home, apartment block) decentralized sources have to be provided. Photovoltaic elements (on the roof or installed on the facade) or small decentralized generators like stirling engines (e.g. generators based on gasification using wood as raw material in combination with heat production) supply a part of the own electricity consumption of the building – see Fig. 1. Thermal solar cells for the supply of hot water are assembled on the

facade or on the roof and contribute a part to the hot water needs of the consumers.
As can be seen in Fig. 1 decentralized sources like stirling engines, photovoltaics etc. are connected directly via inverter to the dc power rail.

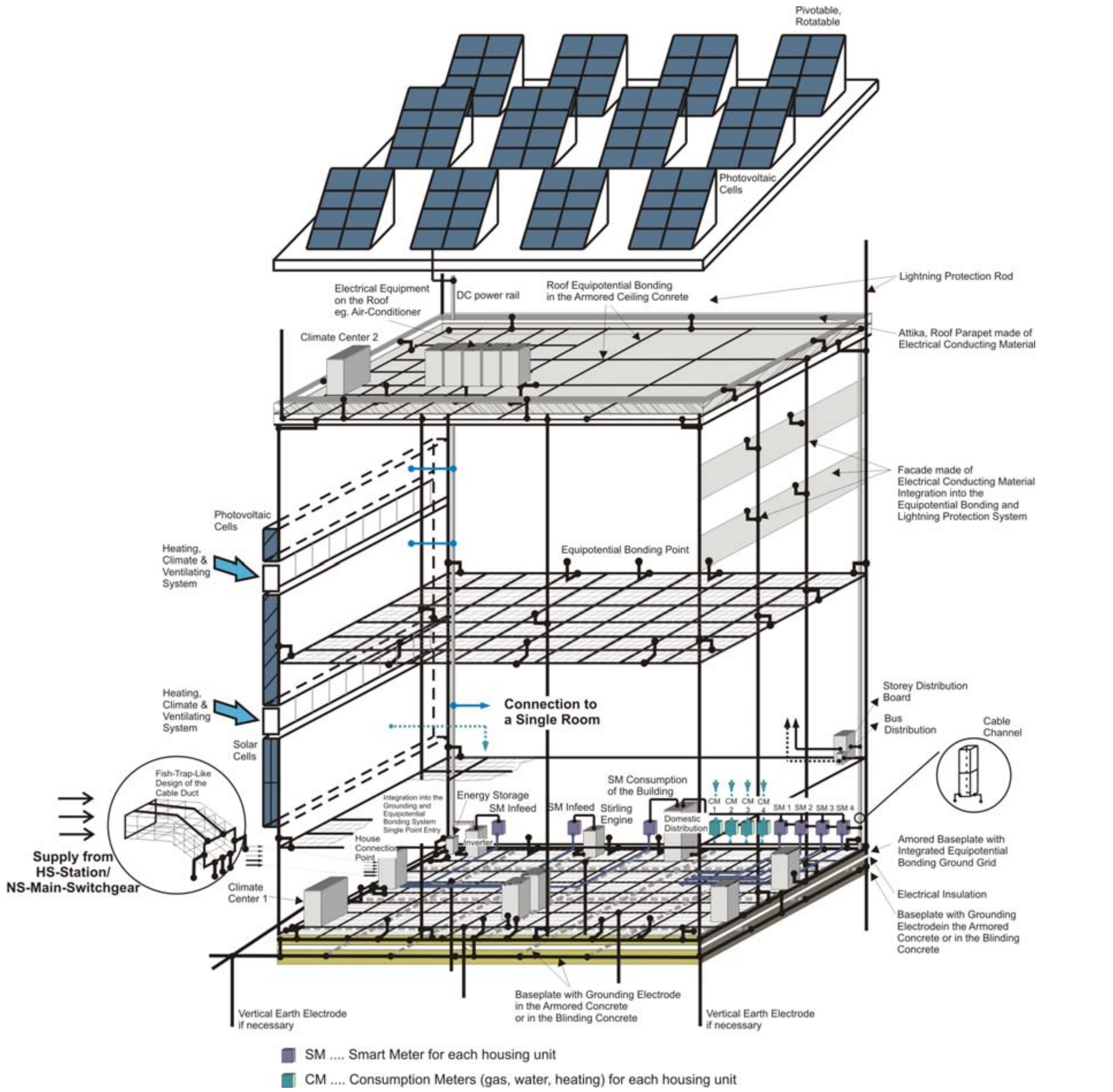

Figure 1: From the grounding via equipotential bonding to the Smart Building installation system

Electrical equipment with power supply units or exemplarily audio/video devices (AV) can be directly coupled to the dc power rail - see Fig. 2. Additional energy storage units (e.g. batteries) can easily be connected to the dc power rail.
Due to local energy supply and consumption the transmission and distribution losses are minimized.
Separate Smart Meters shall be provided for recording the consumed electrical energy and the recovered electrical energy into the main supply grid.
Commerce and industry buildings differ from the single family homes because of the different numbers of Smart Meters and of increased implementations of decentralized generators of higher power.
The interior climate (heating and cooling) and the interior air quality can be regulated with facade integrated ventilating apertures or with conventional climate systems.
Additional communication within the building is necessary to meet the high requirements of a Smart System. Furthermore load-, cost-, production-, storage-

and process-management can be implemented. Current circuits are separated into controllable and uncontrollable loads, thus allowing a controllable load and energy management and to realize new billing systems. Electrical equipment integrated in the management process can be connected with a common bus system (communication infrastructure) – see Fig. 2.

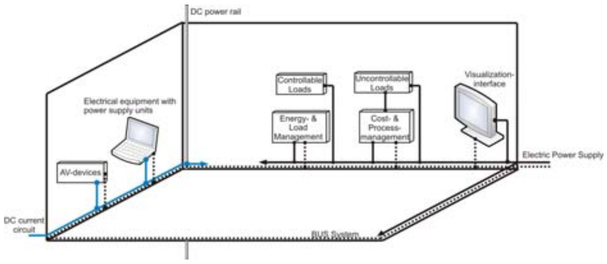

Figure 2: Zoom into a single room of a Smart Building (see Fig. 1)

Multifunctional interfaces and additional components to aggregate the data for visualization shall be available (load curves, energy consumption, efficiency, load management, switching times etc.). So with the knowledge of load-curves the user has direct access to his consumption behavior and is able to identify energy waste and saving potentials.
To improve energy efficiency a high degree of interoperability of different counting systems for electrical energy, gas, district heating and water supply is necessary. Due to the new electric and electronic equipment a new earthing, equipotential bonding, shielding and lightning protection system beginning at the transformer station and ending at the building is important [1].
In Fig. 3 the necessary use of the 5-pole system in a building (building complex) to avoid low frequency EMC is shown, problems through vagabonding currents and with transient voltages so are avoided.
The aim of the above mentioned system is a comprehensive energy and resource management inside the building which includes optimal main supply, decentralized feed in, consumption and feed in into the distribution network via single-phase and three-phase current inverters.

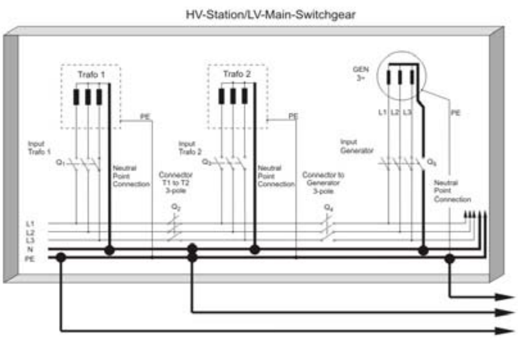

Figure 3: HV-Station/LV-Main-Switchgear

DATA SECURITY

Questions regarding the security of private data in combination with Smart Meter technologies are of great interest and should be considered in future investigations. Today no uniform standard regarding functionality of Smart Meters and data storage and transmission exists. A general international or European standard for common used Smart Meter systems is necessary. Fact is that detailed energy consumption data should not be spread to unauthorized third parties.
Existing concepts comprehend data transfer of the whole data package which is recorded by the Smart Meter.
Additionally concepts differing from existing one have to be developed. Exemplarily data which are not of interest for the grid operator shall not be transferred. Consumer's specific and detailed data (exemplarily specific in-house consumption) can be stored on the home PC and shall only be transmitted to the grid operator on request and after confirmation. Exemplarily data for subsequent processing for the energy information centre can be stored on the home PC and forwarded if required and authorized [2].

MEASURING SYSTEM "SMART PLUG"

A measuring system called "Smart Plug" which records voltage, current and phase angel shall be plugged into the socket of important end devices and delivers detailed information of the connected electric device to a centralized collecting point with selectable time steps. The centralized collection point acts as information and saving unit for all installed Smart Plugs and data are transferred to the home PC. There the collected data are consumer-friendly prepared by a special software. Exemplarily load curves or maximum values can be visualized and the consumer shall have the possibility of direct access to his or her consumption behavior.
Additionally communication between the measuring system and the Smart Meters should be possible in the future Smart Systems [3].

EARTHING, POTENTIAL EQUALIZATION AND SHIELDING

The increased use of electronic equipment like Smart Meters, modules for the load and energy management in Smart Buildings and the bidirectional energy- and information flow requires new considerations regarding, basic earthing, equipotential bonding, shielding and lightning protection. Fig. 1 shows a concept for the planning and construction of electrical installations inside a building to fulfil the requirements regarding connected supply systems including electrical energy, district heating, water, gas and telecommunication in order to avoid stray currents, undesired interference fields and inductive interferences caused by low-frequency and transient currents [1]. A concrete footing-type grounding electrode system in the foundation area (eg. base plate, granular sub-grade course, blinding concrete) is an essential part of the building. An additional potential equalization for the reduction of magnetic, inductive and resistive interferences caused by transients on each floor is essential. Grounding, potential equalization and lightning protection systems must be designed in compliance with the requirements for ICT-wires; each wire (conductor cross section, length and distances) have to be constructed to meet the requirements for a worst case consideration. In order to guarantee functionality of protection measures against hazardous shock currents / touch voltages and additionally protection measures against conductive, inductive and capacitive coupling the adjustment of earthing, potential equalizations and lighting protection in the planning period is substantial. Due to considerations of the implementation of earthing etc. at the beginning of the construction phase effectiveness can be increased and economic expense and costs can be minimized.

SUMMARY AND FUTURE ASPECTS

Communication within the building and furthermore between buildings and distribution network is necessary to meet the high requirements of a Smart Grid.

With the increased integration of Smart Meters better information about energy consumption, costs and energy efficiency is possible. Through the combination of decentralized sources, multifunctional installation concepts, consumer oriented monitoring, energy and load management measures the prospect of an energy autonomous building exists. Each building is part of a complete system – the Smart Grid - and is able to maintain supply even in case of a fault in the higher grid level (distribution network) by optimal utilization of decentralized generators implemented in the concept of a Smart Building.

A positive feature of the proposed concept is the possibility to maintain power supply in case of a fault in the main supply.

Additionally by the use of Smart Meters the end user gets direct information via displays or multimedia applications. Improved load and energy management contribute an essential part to save costs and to reduce greenhouse gases.

Future developments also include closer investigations on the commerce and industry buildings and how they differ regarding communication and installation from a single family home or from an apartment block.

Additional applications in Smart Buildings should not establish only a Smart Billing system but also a multi-functional, innovative, sustainable system, which is the part of Smart Grids using advanced metering, billing, information and communication technologies as new concepts of installations as an integral part.

In order to get an efficient use of different energy forms intelligent installations in buildings are necessary, because an efficient use of energy requires the in time use of several kinds of energy forms.

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