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Smart grids for rural conditions and e-mobility - Applying power routers, batteries and virtual power plants

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SUMMARY

Significant reductions of greenhouse gas emission by use of renewable energy sources belong to the common targets of the European Union. Smart grids address intelligent use and integration of conventional and renewable generation in combination with controllable loads and storages. Two special aspects have also to be considered for smart grids in future: rural conditions and electric vehicles. Both, the increasing share of renewable energy sources and a rising demand for charging power by electrical vehicles lead to new challenges of network stability (congestion, voltage deviation), especially in rural distribution grids. This paper describes two lighthouse projects in Europe ("Well2Wheel" and "Smart Rural Grid") dealing with these topics. The link between these projects is the implementation of the same virtual power plant technology and the approach of cellular grid cells. Starting with an approach for the average energy balance in 15 minutes intervals in several grid cells in the first project, the second project even allows the islanded operation of such cells as a microgrid. The integration of renewable energy sources into distribution grids primary takes place in rural areas. The lighthouse project "Smart Rural Grid", which is founded by the European Union, demonstrates possibilities to use the existing distribution system operator infrastructure more effectively by applying an optimised and scheduled operation of the assets and using intelligent distribution power routers, called IDPR. IDPR are active power electronic devices operating at low voltage in distribution grids aiming to reduce losses due to unbalanced loads and enabling active voltage and reactive power control. This allows a higher penetration of renewable energy sources in existing grids without investing in new lines and transformers. Integrated in a virtual power plant and combined with batteries, the IDPR also allows a temporary islanded mode of grid cells.

Both projects show the potential of avoiding or postponing investments in new primary infrastructure like cables, transformers and lines by using a forward-looking operation which controls generators, loads and batteries (mobile and stationary) by using new grid assets like power routers.

While primary driven by physical restrictions as voltage-band violations and energy balance, these cells also define and allow local smart markets. In consequence the distribution system operators could avoid direct control access by giving an incentive to the asset owners by local price signals according to the grid situation and forecasted congestions.

KEYWORDS

Virtual power plant, electric vehicle, power router, variable tariff, charge control, cellular grid cells, local markets

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1. INTRODUCTION

The European power system is characterised by a continuously increasing number of distributed energy sources (DER) in low and medium voltage levels. As a consequence the resulting power flows are not as they were assumed during the primary planning and installation phase of the grids years or even decades ago. Especially renewable energy sources (RES) are installed in low-voltage networks, which were once build as a distribution grid to transport electrical energy from the medium-voltage level to the consumers. Since the consumers nowadays also may feed in power in the networks, they become prosumers, defining new scenarios for operation and planning of the distribution grids. In addition, a new group of loads, the electric vehicles (EVs), have occurred in the recent past. For low-voltage networks these new consumers have a high energy and power demand. In the future, a rising penetration of EVs is expected which lead to additional challenges for the distribution system operators (DSOs) in times of a high demand for charging power. Challenges are the avoidance of network congestion (rated current of grid equipment) and voltage-band violations. The problem of voltage maintenance might especially occur in areas with a high share of DER in the lower voltage levels, where the voltage deviations are already often close to the limits of the technical standards.
While dispersed generation as well as the charging demand of EVs stresses the distribution grids and network operators, their combination can be a key to the solution. Since the locally generated energy could be used locally by the EVs in the grid cell, this might help to avoid intensive power flows to and from the overlay networks. This leads to the cellular approach, where in terms of energy balance and voltage stability topological and geographical areas for controlling and balancing of all assets are defined.
An extension of this approach is the additional control of frequency inside a cell independently from an overlay network, leading to a cell as a microgrid. This defines an actual distribution grid as a patchwork of interconnected microgrids. As an example, in case of a failure in one cell, the other cells may continue to work connected while the fault area will be restored as an islanded microgrid and then reconnected to the others.

2. CHALLENGES AND POTENTIALS OF ELECTRIC VEHICLES

In the research project "Well2Wheel" the effects of a high penetration of EVs are analysed and practical solutions for an optimised integration are developed. The project started in May 2013 and is completed in April 2016. It is realised in Germany in the supply area of the utility ENTEGA in the region around Darmstadt. For demonstration of a cellular approach the supply area is divided into five regional grid cells (fig. 1, left).

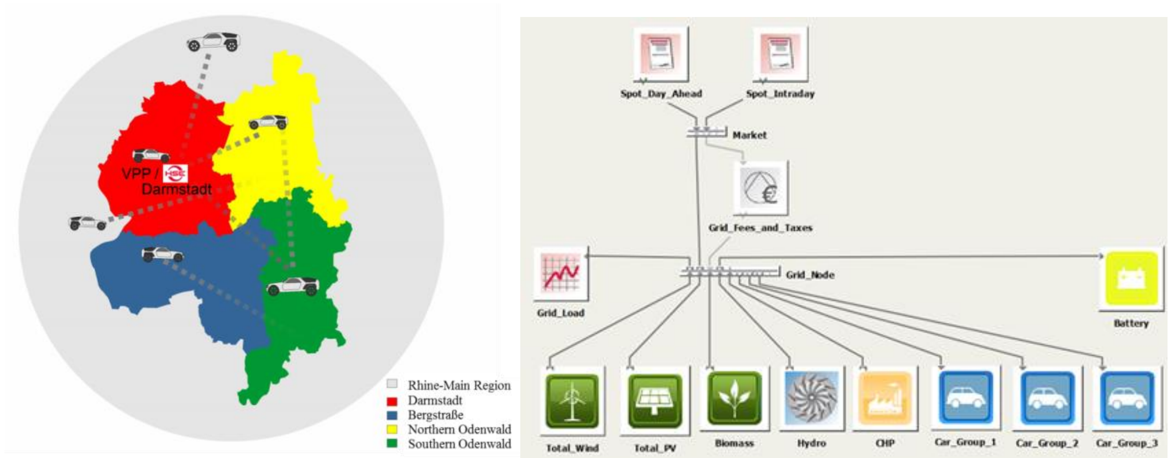

Figure 1: Supply area and regional grid cells in "Well2Wheel" (left) and VPP model (right)

In the first place, coincidence of numerous simultaneous fast charging processes represents a new challenge for network operators, especially in rural areas where the grids were not designed to provide

high power levels. Static voltage deviations at the end of the lines exceeding the limits of the technical standards or overload of grid equipment close to the transformer are one of the results, if no control of charging processes of EVs is available. Therefore a virtual power plant (VPP) continuously calculates traffic light tariffs which are depending on different business cases and considering the current load situation. Figure 1 (right) shows the simplified grid, markets, stationary batteries and generation and load assets taking into account by the VPP. The traffic light tariffs are representative for variable electricity tariffs in future and are used to implement smart charging strategies for EVs in a grid cell. Green traffic light intervals signal a regional surplus of feed-in by RES or dispersed generation in general. In red time intervals charging power for EVs should be reduced because of high residual load or limited network capacities.
Hardware solutions like an adequate ICT-infrastructure and smart charging stations have been developed which allow a direct control of charging processes by the VPP. Beside 50 EVs, the VPPs pool and control also flexible loads (air condition, electrical heating, etc.), generation units and energy storages for the adjustment of generation and demand.
The evaluation of real driving data of EVs in "Well2Wheel" has shown that there exist numerous time slots during the course of the day in which an excessive number of charging processes could be shifted to avoid congestion without any influence on user behaviour. This could be done by using automatic control systems for charging stations that receive optimised charging times from a VPP or the local DSO. For the evaluation of user behaviour, special communication boxes were installed within the project in 17 EVs, which back up all relevant driving data like driving distances, charging times, state-of-charge and charged energy. Figure 2 shows the driving data of two EVs with different fields of application over the period of almost one year. Whereas the privately used vehicle (fig. 2, left) shows in average the highest demand for charging power in the evening hours after arriving at home from work, the commercially used vehicle (fig. 2, right) has its main time for being charged during the normal working time and not in the evening hours. It can also be seen that there exist high potentials for the shift of charging processes in the case of network congestion. Especially commercially used vehicles are connected to a charging station almost the whole day.

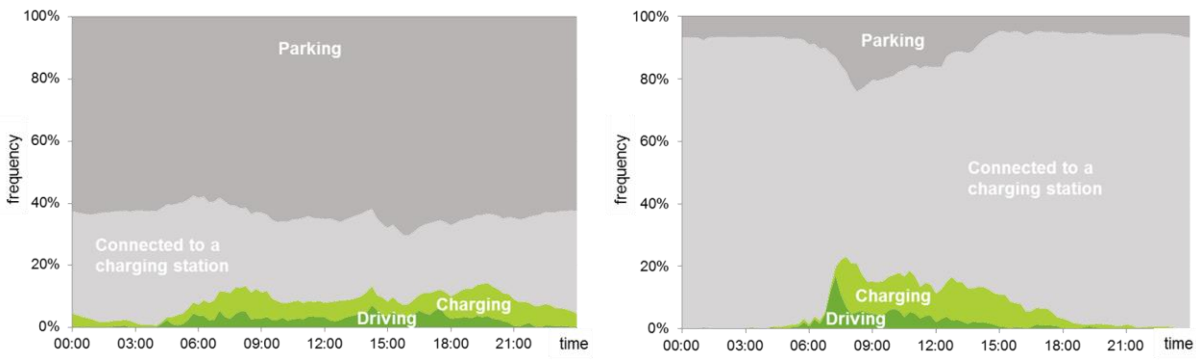

Figure 2: Driving data of EVs in "Well2Wheel" [1]: private use (left) and commercial use (right)

The quantitative analysis of the effects of EVs on electrical power systems is done by the help of power system simulations in two real network areas with different characteristics (one residential and one industrial area). These networks are located in the supply area of ENTEGA close to Darmstadt.

2.1 Load profiles

For the charging of the EVs a typical charging power of 11 kW (3-phase, 16 A) is assumed. In figure 3 the standardised load profile of a privately used and a commercially used vehicle is shown. For the calculation, it is expected that the vehicles are directly plugged in a charging station and recharged after being parked.
Figure 3 (left) shows that the average peak demand of a private household owning an EV more than doubles, compared to the established standard load profile of households H0 [2]. The standard charging profile E0 of an EV with exclusively private use is based on the assumption of an average car driving distance in Germany of 42 km on a working day and an energy consumption of 20 kWh per 100 km. For the determination of a standardised load profile of EVs with commercial use, the driving

and arrival times of [3] are used. In average, commercially used EVs are driven longer distances per day and therefore need more energy for recharging. The maximum peaks occur in the morning and at midday when the vehicles are parked for lunch (fig. 3 right). Since some of the commercial vehicles are also privately used, the average demand for charging power reduces in the evening, because it is often no possible to charge the vehicle at home. The maximum demand for charging power of commercially used vehicles coincides with the same time of the peak load of a typical industry G0 [2].

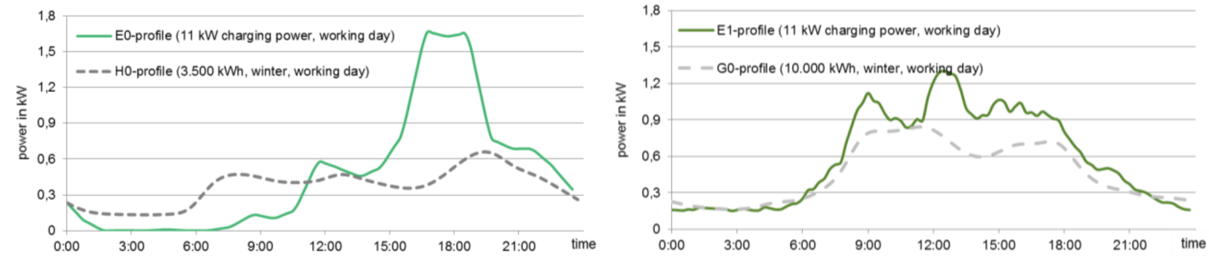

Figure 3: Comparison of standard load profile of households H0 and of privately used EV E0 (left) and comparison of standard load profile of industries G0 and of commercially used EV E1 (right)

2.2. Residential area

The analysed low-voltage network of the residential area shows a suburban character (fig. 4 left). Almost all of the 88 buildings in the area are single-family houses. For the simulations randomly distributed smart meter data is used to represent the consumption of the households. Since even in the time of annual peak load the transformer has only a maximum utilisation rate of 40%, around 60 EVs can be integrated in this residential area without causing any congestion of grid equipment (fig. 4, right). Thereby it has to be considered that the simultaneity factor of charging processes decreases by an increasing number of EVs, when the typical driving and arrival frequencies of car users are taken into account.

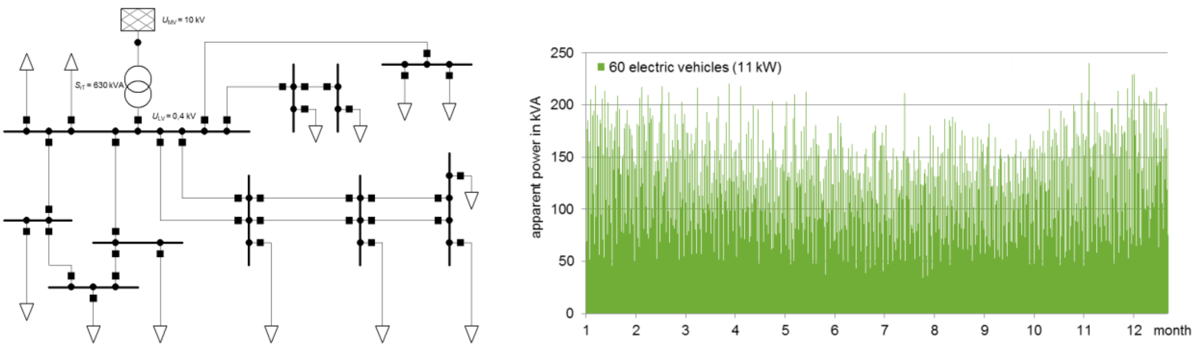

Figure 4: Simplified model of a low-voltage network in a residential area [4] (left) and annual load profile at the transformer with 60 electric vehicles [1] (right)

A more critical point is the effect on voltage deviation caused by fast charging processes. Even in this relatively sustainable low-voltage network, the simulations pointed out that already 10 randomly distributed EVs can cause voltage deviations exceeding the permitted limits of the technical standard EN 50160 [5]. This was primarily the case in times of a high base load caused by households and several charging processes of EVs close to the end of the feeders at the same time. By implementing simple charging strategies like a shift of charging processes in times with low consumption of the households or a general limitation of charging power during the peak hours, these problems can be avoided. This is possible in practice by the help of the modified controllable charging stations in "Well2Wheel", which allow a shift of charging processes by the DSO or tariff signals by the VPP [6].

2.3. Industrial area

For industrial and commercial areas two low-voltage networks, each with a 630-kVA transformer, were analysed (fig. 5). In times of annual peak load the transformers have utilisation rates of around 40% respectively 80%. In the industrial area A 17 companies are supplied by the secondary substation, in area B 30 companies are connected. The energy consumption of the companies is represented by the standard load profiles for industrial and commercial consumer loads G0 to G6 [2]. The assignment of the profiles is done by classifying to sectors. The penetration of EVs in the networks is based on the share of fleet vehicles of [7]. The use of electric trucks is neglected. Finally, 15 electric cars and 8 electric transporters were integrated in area A (area B: 14 cars, 8 transporters). The vehicles are charged at the point of common coupling of each individual company. To simulate worst-case scenarios, driving profiles with relatively high driving distances were chosen from the data of [3].

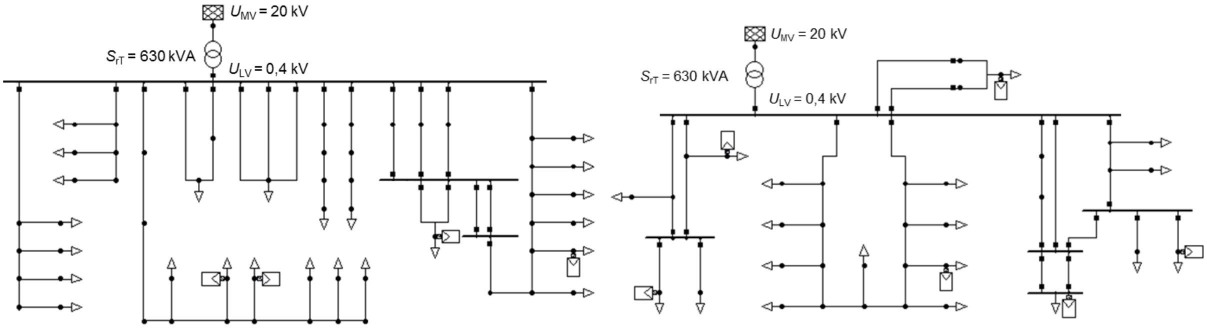

Figure 5: Low-voltage networks with industrial and commercial character (left: area A, right: area B)

The simulation results with real driving data show that the charging of 22 (area A) respectively 23 (area B) EVs lead to a maximum simultaneous demand for charging power of 90 to 100 kVA. This peak demand for charging power coincides with times of a high power demand of the industry. However, even if the power transformer comes close to its limit in one of the networks, no congestion of grid equipment occurred in the simulated worst-case scenarios. What could be also seen is that on days with high solar radiation, the load profiles of the companies and the demand for charging power of EVs go well together with the generation of PV-systems in these industrial areas.

A more challenging issue in these networks is again the problem of voltage maintenance. In all cases, the technical standard of EN 50160 was fulfilled, but at the most critical nodes of the networks, a maximum voltage deviation of more than 8% occurred in times of high demand for charging power. One possible solution in the industrial areas would be a central parking place for all EVs with direct connection to the secondary substation. Another possibility is a limitation of the maximum charging power dependent on the time of day.

The overlay medium-voltage network of the two industrial areas has got an open ring structure with a maximum length of line of 1,3 km. Almost all of the twelve low-voltage networks, which are connected to the medium-voltage network, show an industrial or commercial characteristic. For this medium-voltage network the power system simulations figured out that neither congestion nor the effected maximum voltage deviation by EVs will become a problem in the future. Because of the lower simultaneity of the accumulated charging processes in this voltage level, even a high penetration of EVs in the connected low-voltage networks does not bring the analysed medium-voltage network at its limits. Therefore, it can be concluded that in the case of a rising penetration of e-mobility, the effect on the low-voltage networks has to be observed at first.

2.4. Results

The power system simulations showed that a high penetration of EVs is totally changing the present load profiles of consumers, which have been used by the DSOs so far for network planning. This is especially the case in residential areas where the power demand for simultaneous fast charging processes greatly exceeds the average consumption of households. Regarding low-voltage network in the suburban area, congestion of grid equipment is not the main problem for the DSO, even if many EVs are integrated in the networks. Voltage maintenance is a much more critical issue. Already a

small number of simultaneous charging processes at the end of a feeder caused voltage-band violations. This is representative for weak low-voltage networks with long feeders, e.g. in rural areas.
For the industrial and commercial areas the simulations figured out that due to the high capacities and big cable cross sections, probably no charge control will be necessary in the future to avoid congestion. Assuming a penetration of EVs equivalent to the present penetration of conventional company vehicles, the peak load increased by around 20% of the transformer capacity in the analysed industrial areas. Critical voltages did not occur, but high voltage deviations along the lines in times of a high demand for charging power greatly reduce the available capacity for the connection of new industries in a network. Therefore, the installation of parking areas close to the secondary substation should be considered.
Another possibility to avoid these violations is by the help of local markets [10, 11]. This is done by generating a tariff signal for the EVs and thus indirectly control the charging behaviour. The price depends on the actual forecast for RES generation, residual load and charging demand in the local grid cell. If no physical restriction is forecasted the wholesale market (spot, intraday) comes into place and defines the price signal for the EVs.
The demonstration and pilot phase of the project “Well2Wheel” showed that the spread between the lowest and highest price for charging must be noticeable to the end customer. By only forwarding wholesale market prices (energy only) this spread is relatively small compared to the total end-customer tariff. Thus the additional local market has to multiply this effect either by applying a bonus or malus as a local market or by special grid fees, depending on the forecasted network situation.

3. SMART AND RURAL MICROGRIDS WITH POWER ROUTERS

The EU founded lighthouse project “Smart Rural Grid” aims a novel system architecture for rural smart grids and has been deployed in a part of the EyPESA distribution network. EyPESA is a DSO placed in Catalonia, Spain, having a network of over 1.100 km, servicing around 56.000 customers. Its grid consists of two substations connect to the transmission network at 220 kV with the sub-transmission network at 40 kV which are almost fully automated and distributes power to lower level distribution networks at 20 kV, 5 kV or 3 kV through around 800 secondary substation. Finally, EyPESA distributes energy to its clients in the low voltage networks, almost with no automation. The major particularity of the grid is that about 50% of the networks belong to rural environment where over two thirds of customers are domestic and services. The chosen pilot test network (fig. 6) is the final part of a 5 kV distribution network in a rural area, with a low population density.

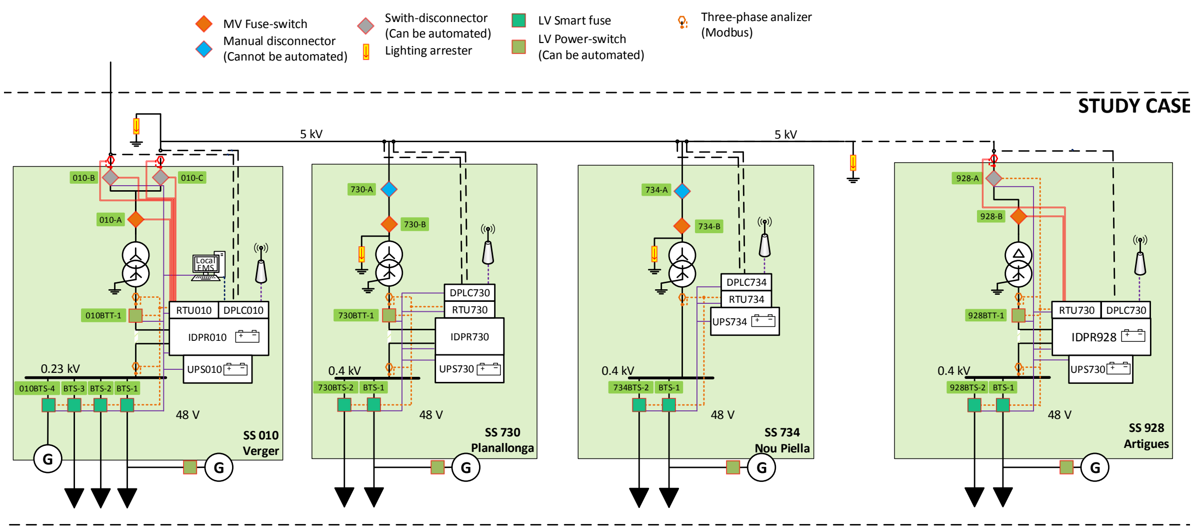

Figure 6: Distribution network selected for the Smart Rural Grid Pilot

In particular there are only 25 costumers distributed by four low level secondary substations. Moreover, the selected networks are characterized to be a non-manageable and radial grid, where safety operation is guaranteed as it is the case with traditional networks through manual switch-disconnectors and fuses. The medium voltage lines cross valleys and mountains, thus difficult to access for failure location and more exposed to adverse weather conditions.

A result of rural environment is, that electrical customers are suffering a weaker grid than the urban customers resulting in a worse system average interruption duration index (SAIDI) and also, poorer power quality condition like, unbalance, harmonics and reactive power that are in traditional networks difficult to manage. As well, it is important to ensure the telecommunications coverage to get safety and robustness links among secondary substations to transfer data between devices to measure and take decisions.

The project targets the need of gaining substantial improvements in terms of efficiency, quality and network resilience by rigorously exploring the potential resulting of the convergence between energy and telecommunication networks and technologies. In fact, this rural grid has a substantial potential of improvement in efficiency, in particular in terms of continuity of supply. Moreover, it is considered that the number of DER from customers will increase in electric networks, due to reduction of costs in DER technologies and the increment of energy cost. But also with the interest to contribute to the improvement on power quality, considering that one of the profits is increasing the continuity of supply and power quality.

For that reason, five kinds of actions are carried out to transform the traditional rural distribution grid in an active rural distribution grid architecture:

- Promotion of DER in low scale and voltage level, providing ability and support to clients.
- Introduction of intelligent distribution power routers (IDPR) [8], in order to assurance the robustness, stability of network and increase the continuity of supply.
- Conversion of a unidirectional and traditional networks into a flexible and active distribution network, replacing the low voltage fuses by automated and remotely controlled power breakers, and updating the manual disconnectors to automated and remotely controlled disconnectors.
- Bring resilience capability in rural areas and improve the quality of service without build new electrical infrastructure by incorporating batteries in the IDPRs.
- Creation of a new telecoms network with the aim of guarantee the efficient integration and management of new controllable DER to manage the smart system.

The integration of DER into the distribution grids primary takes place in rural areas where resources are abundant. The “Smart Rural Grid” project demonstrates the possibilities to use the existing DSO infrastructure most effective by applying optimized and scheduled operation of the assets and the use of IDPR.

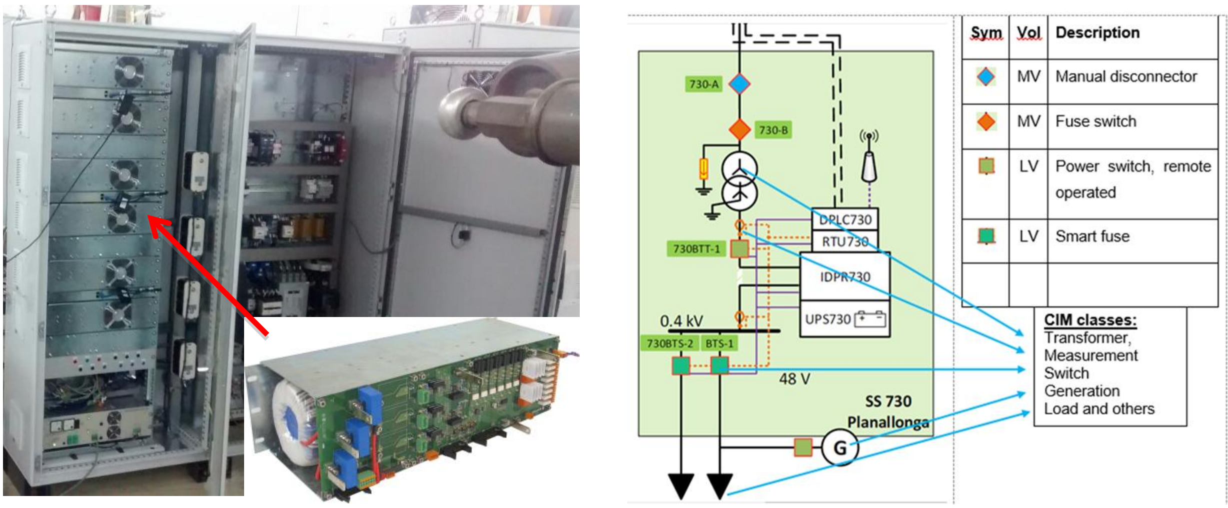

Figure 8: An intelligent distribution power router (left) and CIM classes for a substation field (right)

The IDPR (fig. 8, left) is an active power electronic device [8] operated at low voltage in rural distribution grids aiming to reduce losses and enable voltage and reactive power control. This allows a higher penetration of RES generation in existing grids without investing in new lines and transformers. Integrated in a VPP and combined with batteries the IDPR it also permits island mode of grid areas. To handle a large number of active elements and grid topology the Common Information Model (CIM) is used in the project to describe these elements and exchange data between the systems (fig. 8, right). Since the telecommunication infrastructure (fibre, 3G, etc.) is mostly poor in rural areas, in contrast to urban areas, a new PLC technology for a robust communication of the IDPR and VPP has been developed and is currently tested in the field test

Figure 9 shows the final pilot scheme with IDPRs and smart grid infrastructure installed. The batteries included in the IDPRs are a fundamental part of creating a microgrid operation, balancing the generation and demand during islanded operation [8]. When the "Smart Rural Grid" works connected to the external grid, the IDPR is able to provide active and reactive power (active power is limited by the battery capacity), balance the three-phase system and mitigate the harmonic currents. In the case the system works disconnected from an external grid (microgrid operation), one IDPR stabilizes the voltage and frequency like a slack bus [8,9], and the others provide grid support like in the grid connected mode. Each substation has installed an Uninterruptible Power Supply (UPS) that contains small batteries, which only deliver supply in case of emergency to the telecommunications network, the local control and the managed devices (Electrical Switching Elements (ESE), Electrical Measurement Units (EMU), Local Energy Management System (LEMS), Local Controller (LC) and Transformer Controllers (TC)).

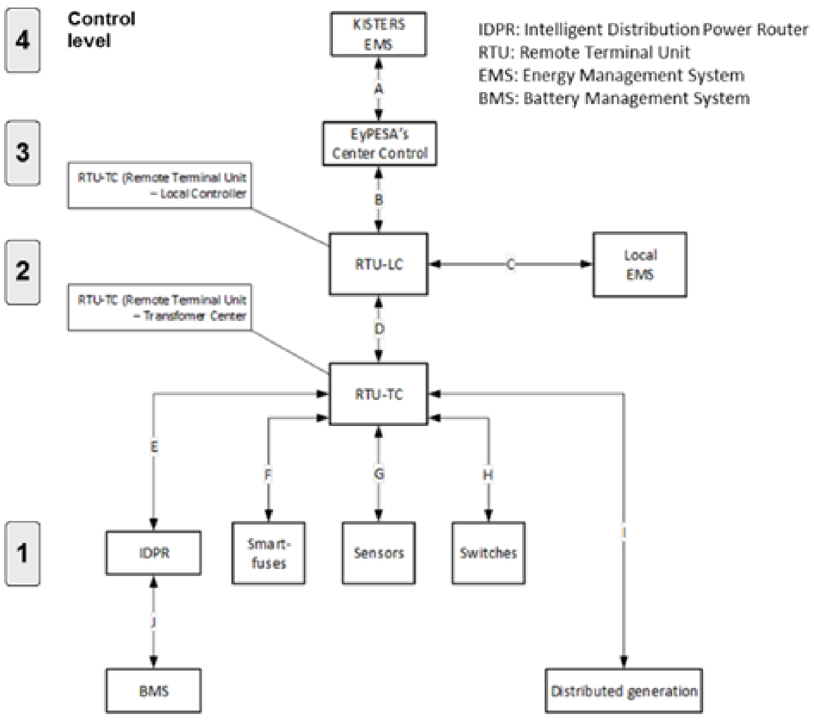

Figure 9: Overall system architecture with IDPRs, SCADA and VPP

The IDPR is a power converter device based on silicon carbide (SiC) switches and high efficiency inductances. The IDPR is built by modules, each of the power modules is **Figure** rated for 20 kW, able to be parallelized up to 10 modules. The IDPR is able to improve the power quality by balancing currents in phases in grid upstream of the coupling point, applying a reactive power reference and compensating harmonic currents. Figure 10 shows laboratory measurements of the IDPR harmonic compensation operation. The load current (green, middle) is compensated by the IDPR current (blue, bottom), resulting a sinusoidal current supplied by the grid (red, top).

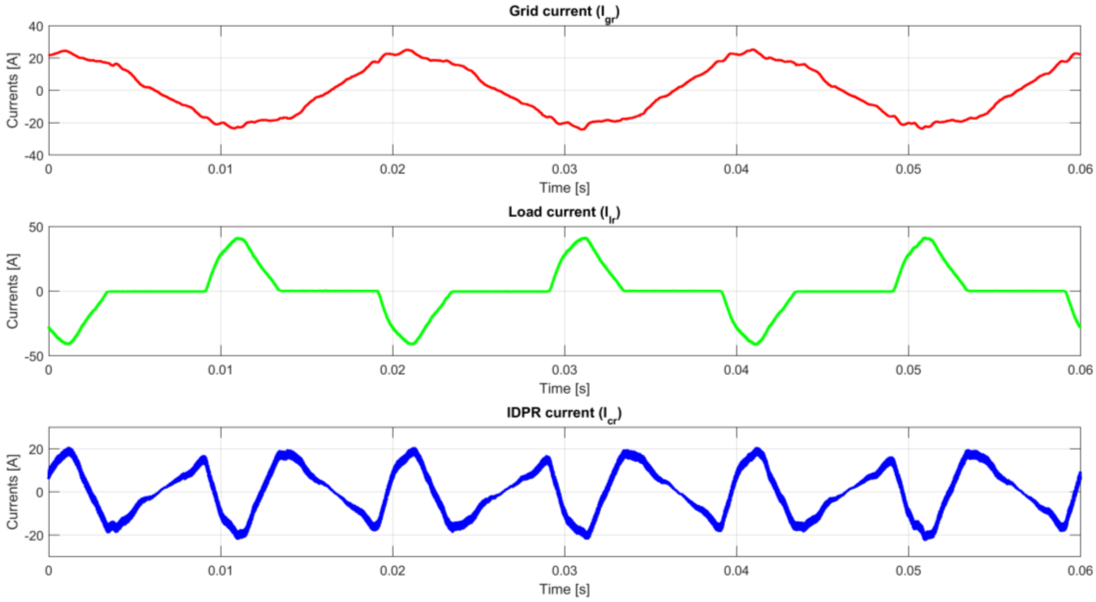

Fig. 10: Laboratory measurements of the active filter function of the IDPR

With the help of applied batteries an IDPR can also storage energy from DER during peak generation hours and supplies it to the loads. Another important feature is to give support during a supply disruption, where an IDPR is able to restore the supply of electrical power in the pilot network. Therefore, the IDPR works in two different operating modes, slave and master mode. In slave mode, the voltage and frequency in the coupling point of the IDPR is provided externally. In the project scope, the voltage and frequency reference can be provided by the overlaying grid or by another IDPR in master mode. The IDPR that operates in the slave mode is controlled as a current source delivering or consuming power, as stated by the provided setpoints, scheduled by the VPP.

In this master mode, the IDPR generates the voltage and frequency of the local grid. In the project scope, when the master IDPR starts this operation mode, the external grid is decoupled from the system set. The master mode will start from a zero voltage, e.g. after clearing a grid fault. All loads will be disconnected and only the transformers and the line are connected. Then the local grid energization is done by a voltage ramp until the grid has reached the nominal values. Consumers, DER and slave IDPRs allocated inside the same set will be progressively connected and configured in order to assure that the master IDPR is able to guarantee the system stability. For this operation mode a battery energy storage system (BESS) is necessary in order to operate the pilot network isolated from the external grid. The BESS comprises high capacity lithium-ion batteries and a control and power conditioning system which are integrated in the IDPR.

4. CONCLUSION

Both projects show the benefit of a cellular approach. Since the number of DERs and individually controllable loads like EVs constantly increases, from a control engineering perspective the overall system with a increasing growing number of controllable elements (as variables in the mathematical optimization problem) becomes too big at a certain point. While in the past this was expected for the whole European transmission system the transmission system operators (TSOs) organize individual control areas, where they are responsible for their area in terms of frequency and energy balancing on their own. In that way the cellular approach breaks down this proven method by defining much smaller areas with individual controls.

As a first step the introduction of local markets, taking into account the local generation and grid situation, results in building local market cells. This might already postpone or even avoid investments in new lines, cables and transformers by using and scheduling the existing grid capacity.

By even controlling the cells as islanded areas as microgrids and being able to reconnect them to a patchwork of cells this cellular approach finally allows the maximum installation of DER and EVs in a cell by using locally generated energy for local loads in a scheduled way without overload the already existing network capacity. To archive this goal new grid assets like IDPRs and a centralized and dispersed (in every cell) control system with forecasting, optimisation and scheduling are required.
From the market point of view grid customers, or better prosumers, with their batteries, generators and loads might also react to price signals instead of being directly controlled by the DSO. The direct control would be the ultima ratio if grid stability is at risk. To archive significant reactions of the prosumers to price signals these tariffs must have significant spreads between the highest and lowest prices or tariffs. This spreads could be generated either by local markets, in addition to the wholesale nationwide spot market, or by grid fees, depending on the forecasted network situation.

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BIBLIOGRAPHY

[1] P. Franz, J. Hanson, B. Fenn, V. Buehner, B.M. Buchholz, L.-W. Tiede "Integration of Electric Vehicles into a Virtual Power Plant: The German Research Project “Well2Wheel”" (DistribuTECH, San Diego, Feb. 2015)

[2] German Association of Energy and Water Industries "Standardlastprofile Strom" (www.bdew.de)

[3] Fraunhofer ISI "Regional Eco Mobility 2030" (www.rem2030.de)

[4] P. Franz, A. Hoffmann, J. Hanson, B. Fenn "Integration of electromobility in a distribution grid: results of the beacon project Well2Wheel" (CIRED Workshop, Rome, June 2014)

[5] EN 50160 "Voltage characteristics of electricity supplied by public distribution networks" (European Standard, Feb. 2011)

[6] P. Franz, B.M. Buchholz, V. Buehner, B. Fenn, L.-W. Tiede, J. Hanson "Energy management of private households with electric vehicles as active consumers in the German research project “Well2Wheel”" (CIRED Conference, Lyon, June 2015)

[7] Federal Ministry of Economics and Technology "Energieverbrauch des Sektors Gewerbe, Handel, Dienstleistungen in Deutschland für die Jahre 2007 bis 2010" (Report, Karlsruhe, Aug. 2011)

[8] J.-M. Rodriguez-Bernuz, E. Prieto-Araujo, F. Girbau-Llistuella, A. Sumper, R. Villafafila-Robles, J.-A. Vidal-Clos "Experimental validation of a single phase Intelligent Power Router, Sustainable Energy, Grids and Networks" (Volume 4, Pages 1-15, ISSN 2352-4677, Dec. 2015, http://dx.doi.org/10.1016/j.segan.2015.07.001)

[9] R. Abe; H. Taoka; D. McQuilkin "Digital Grid: Communicative Electrical Grids of the Future" (Smart Grid, IEEE Transactions on, vol.2, no.2, pp.399, June 2011, DOI: 10.1109/TSG. 2011.2132744)

[10] B. Fenn, A. Doss, B.M. Buchholz, V. Buehner, P. Franz. A. Hoffmann "Integration of electric-cars into an existing Virtual Power Plant - Experiences from a lighthouse project" (CIGRE Session, C6-205, Paris, Aug. 2014)

[11] V. Buehner, B.M. Buchholz, B. Fenn "The economy of Smart Grids requires Smart Markets" (VDE Congress, Stuttgart, Oct. 2012)