Integrative Energy Management in the Distribution Grid

Astrid Nieße, Martin Tröschel, Ontje Lünsdorf, Carsten Wissing, Steffen Schütte,
Stefan Scherfke, Michael Sonnenschein, Christoph Mayer

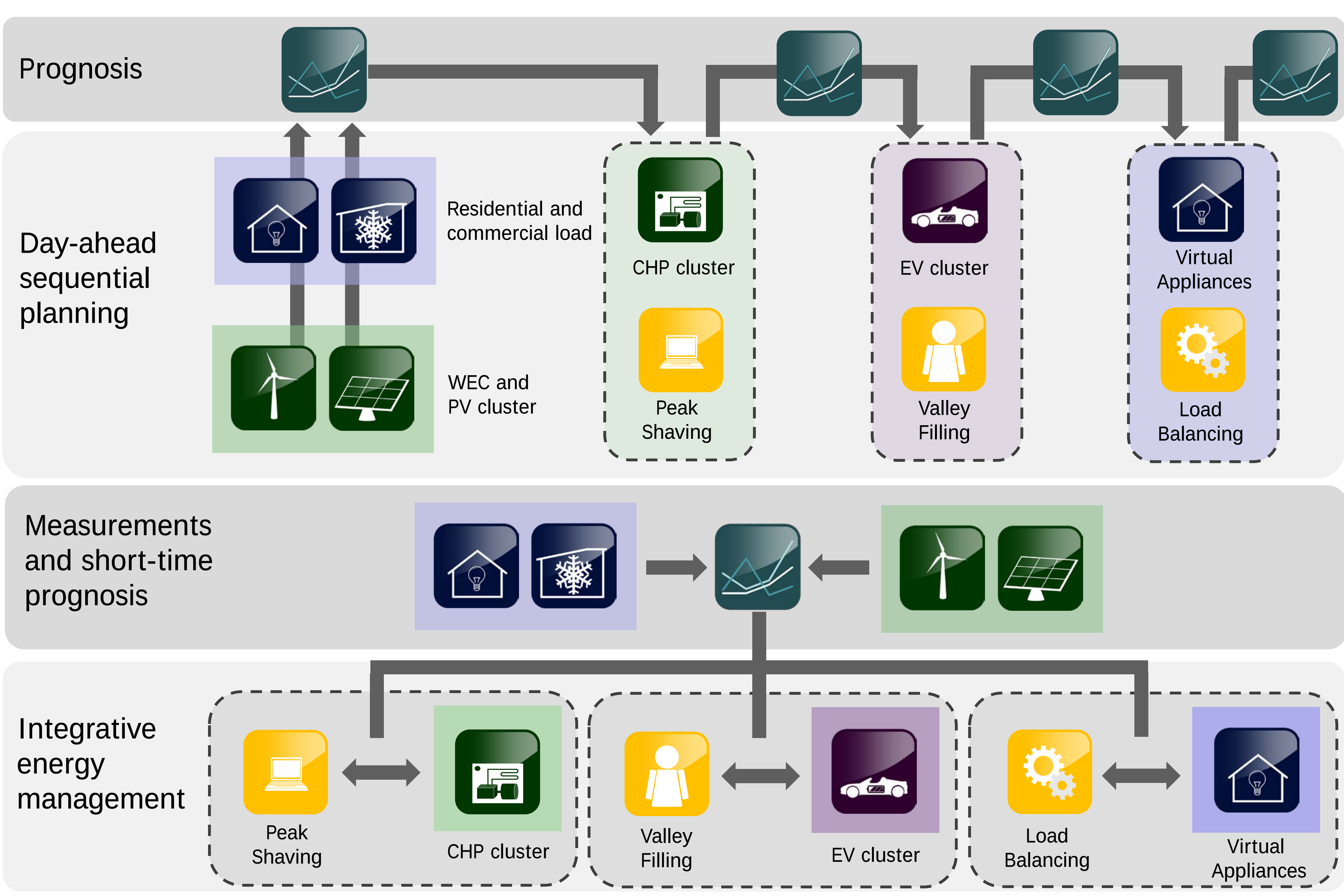
OFFIS – Institute for Information Technology
R&D Division Energy, 26121 Oldenburg
Germany

The role of ICT in the distribution grid management has long been minor compared to SCADA systems used for the management of large power plants and transmission grid operation. However, with the rising amount of distributed and especially renewable energy resources, the need for ICT systems in the distribution grid for both measurement and control becomes more obvious. One major challenge in distribution grid management is the fluctuating feed-in behavior of solar plants, wind power plants, and other electricity generation units on the low-voltage level, like micro-CHP (micro cogeneration of heat and power). Uncontrolled feed-in without any compensation at the low and medium voltage level can induce grid instability on these levels, and is expensive to compensate by large power plants on the high voltage level due to its high variability. In this poster we present the idea of an integrative energy management of controllable plants, storage systems, and controllable appliances on the low voltage level, to compensate fluctuations in the feed-in of renewable energy sources. We show the capabilities of this approach to level the residual load at the example of a windy summer day.

The Basic Idea

Integrative Energy Management

In our approach we use the inherent flexibility of active components in the low voltage grid to level the fluctuating renewable feed-in – thus balancing it locally, smoothing the residual load, and minimizing the demand for externally supplied generation. Several ICT-based solutions concerning metering, schedule generation, and control have to be coupled to take into account the components' immanent restrictions and the user requirements as well. We present results for a sequential day-ahead planning approach and the first ideas for a reactive integrative approach.



Peak Shaving
Virtual clusters of CHP units are scheduled grid oriented by a central control unit (e.g. at substation level). Reactive scheduling can be done based on effective measured values and CHP untis state information[4].

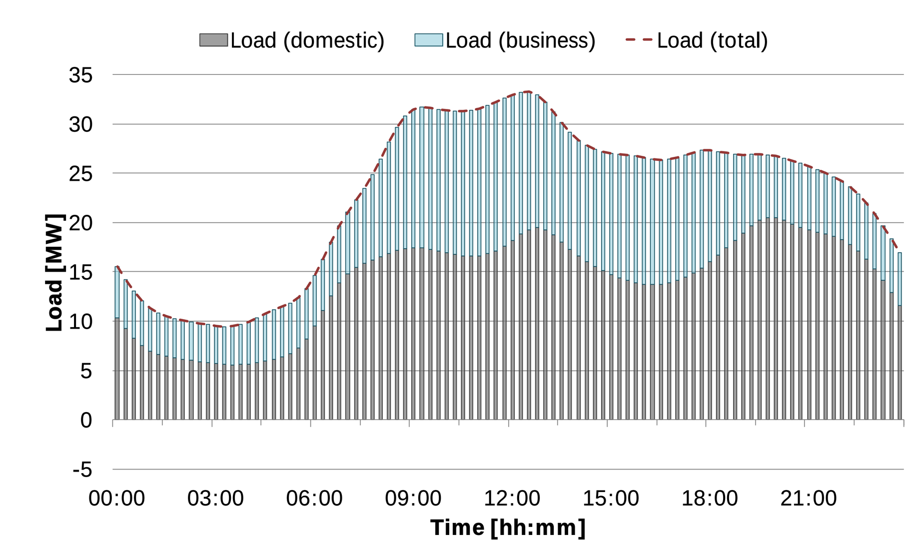
Valley Filling
Electric vehicles control their charging actions autonomously, but use actual grid load prognoses to determine the best charging slot. To reduce synchrony, charging probabilities depend on historical load profiles.

Virtual Appliances
Many appliances with similar load shift forecasts group themselves into a pool. This compensates individual stochastic effects (e.g. user interaction) and reduces communication and computation requirements.

Results for a Scenario

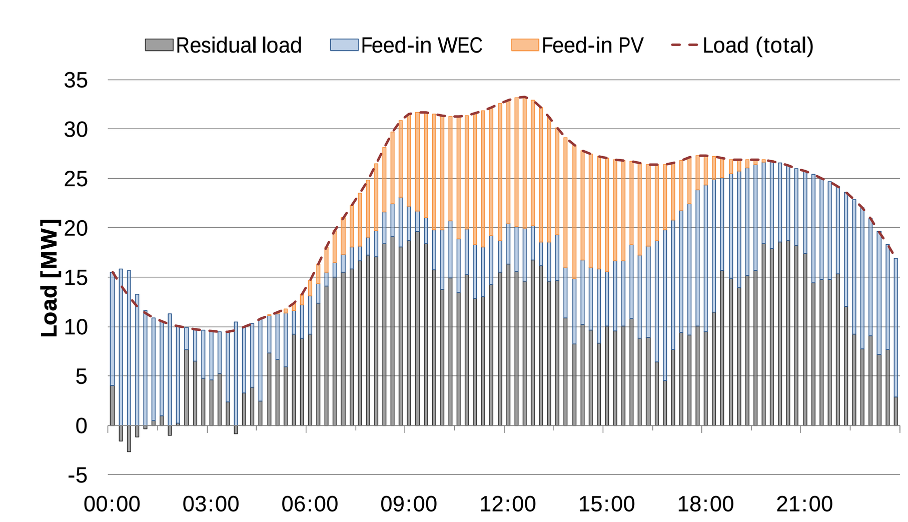
1 July 15th, 2030

We chose a given medium voltage grid comprising 40 thousand households and commercial properties. The figure depicts the typical load based on standardized load profiles for a working day in summer.



In our scenario, about 50% of the total annual electric energy consumption is supplied by wind energy converters (WEC) and photovoltaic plants (PV) located in the medium and low voltage grid

Renewable feed-in 2

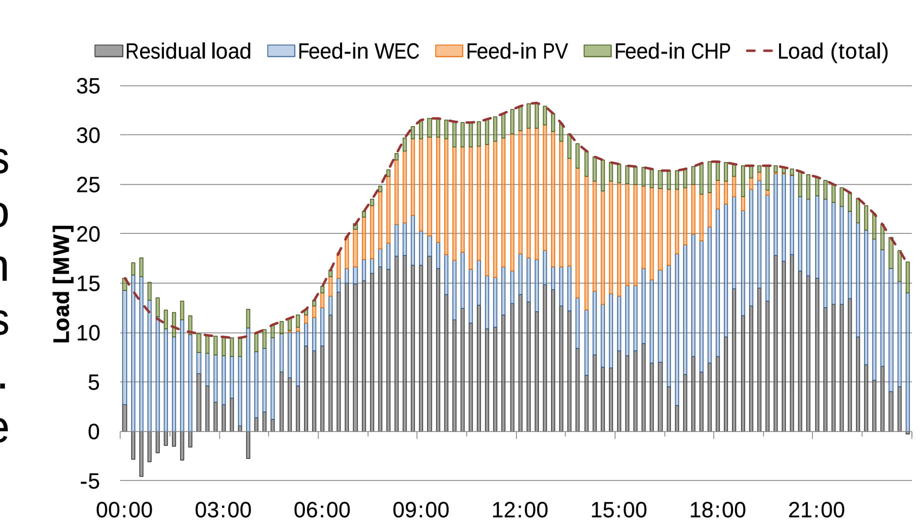


Systems based on renewable energy sources are considered "must-run", meaning their electrical feed-in behavior is neither controlled nor restricted except for reasons of grid stability.

The uncontrolled and stochastically fluctuating feed-in behavior from WEC and PV typically leads to a disturbed residual load—periods of light load and heavy load alternate in short time intervals.

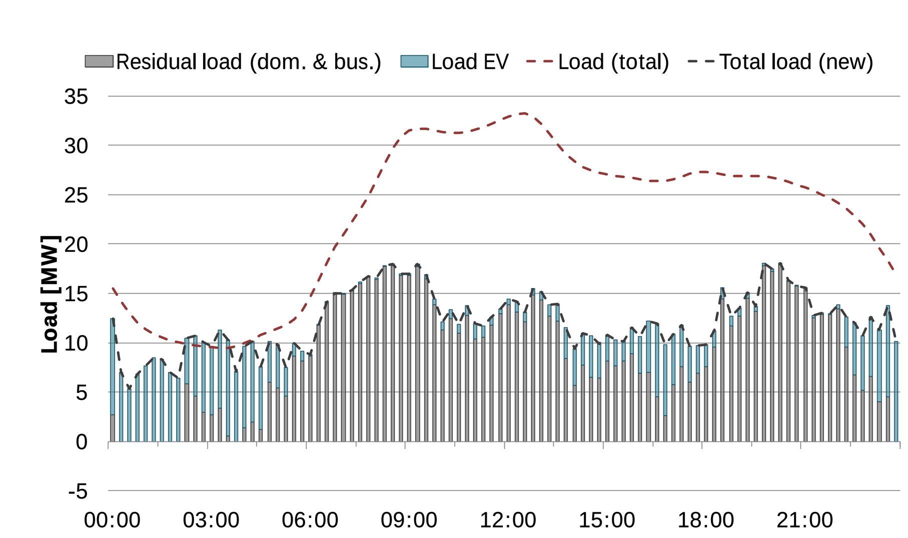
3 Peak Shaving with CHP

Using controllable CHP units with thermal storages to decouple electrical feed-in from thermal demand, peaks in the residual load (e.g. during wind calms) can be substantially reduced [1].



However, the operating times of CHP units vary significantly from season to season. In our example, about 40% of the total annual electric energy consumption is supplied by CHP plants—most of it in the winter, so only minor effects can be achieved on a summer day.

Valley Filling with EV 4

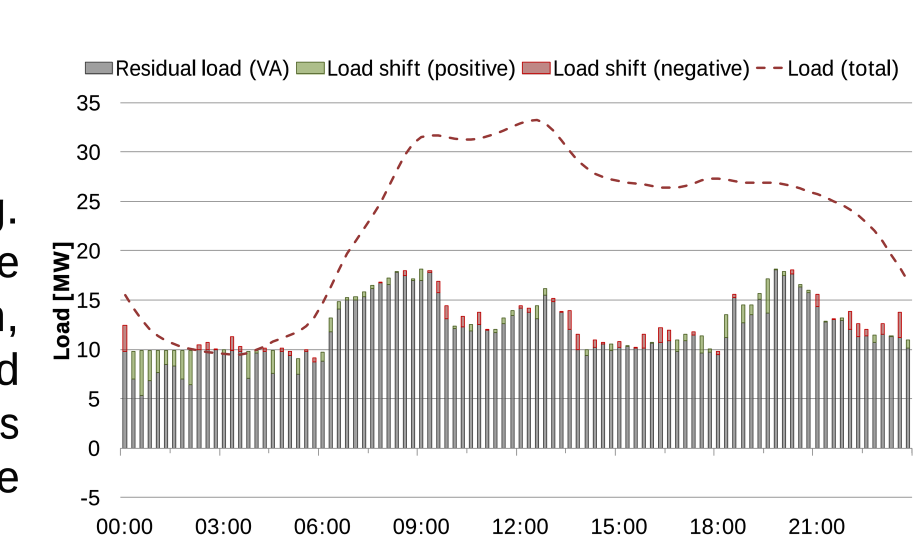


In a next step, electric vehicles (EV) are used to fill "load valleys" by controlled charging of their batteries in times of light residual load [3]. In our scenario, about 50% of the households come with an EV.

Due to their typically high charging power, the residual load can be significantly leveled. The remaining fluctuations are subject to demand side management efforts controlling rather small appliances.

5 Load Balancing with Virtual Appliances

Virtual appliances [1], e.g. from cooling devices [2], are used to shift consumption, thus leveling the residual load even further. The fluctuations of the residual load have mostly been compensated.



References

[1] O. Lünsdorf, M. Tröschel: Conjoint Generation Management and Load Adaption for an Optimized Power Grid Utilization. Proceedings of: 2010 Power & Energy General Meeting, Minneapolis (2010)
[2] M. Stadler, W. Krause, M. Sonnenschein, U. Vogel: The Adaptive Fridge - Comparing different control schemes for enhancing load shifting of electricity demand. Proceedings of: 21st Conference on Informatics for Environmental Protection – Enviroinfo Warsaw 2007 (2007)
[3] S. Scherfke, S. Schütte, C. Wissing, M. Tröschel: Simulation-based analyses of the integration of electric vehicles into the power grid. In: Proceedings of the ETG-Fachtagung Smart Cities 2010, Leipzig (2010)
[4] M. Tröschel, H.-J. Appelrath: Towards Reactive Scheduling for Large-Scale Virtual Power Plants. In: Lecture Notes in Computer Science. Multiagent System Technologies (2009)