Smart Energy Systems ERA-Net | Spotlight

STORAGE AND CROSS ENERGY CARRIER SYNERGIES

2017 Edition: Demand response for grid-friendly quasi-autarkic energy cooperatives

This series of documents keeps experts updated on the ongoing activities and intermediate results of the ERA-Net Smart Energy Systems Knowledge Community. Spotlights concentrate on specific topics with high relevance for project participants and practitioners. In that sense, this spotlight represents a condensed version and extract from the respective ERA-Net SES Living Document "Storage and Cross Energy Carrier Synergies".

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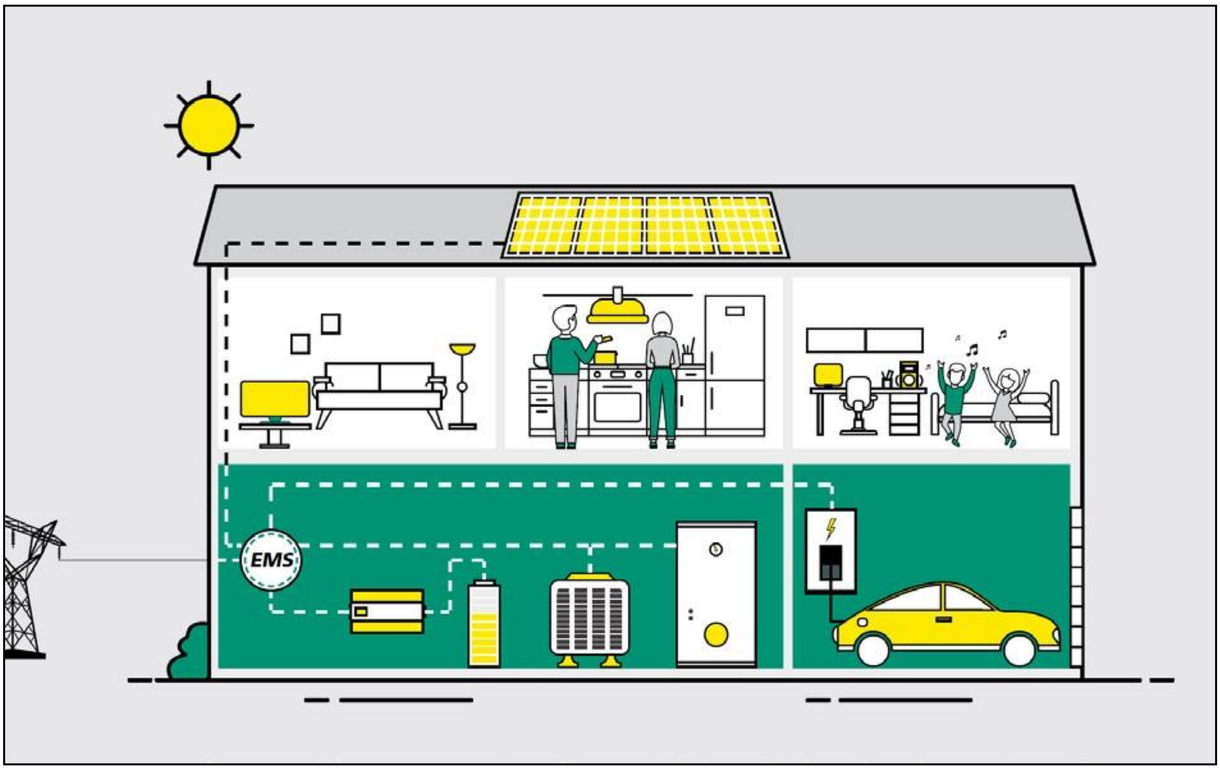
Introduction

This Spotlight comprises insights gained in the ERA-Net SES funded project Grid-Friends evolving around the topic "smart energy collectives – supporting sustainability, autonomy and cooperation with negotiations and opponent modelling". It has been composed for dissemination within the ERA-net Smart Energy Systems Knowledge Community.

The energy transition towards (fluctuating) renewable electricity generation requires more flexible demand response. This demand response is possible thanks to decreasing storage prices, flexible thermal loads, electric vehicle charging schedules etc., but it requires intelligent coordination. Since centralized solutions are intractable due to privacy concerns, limited computational scalability, and the individuals' concern to maintain decisional autonomy, this project proposes decentralized coordination in quasi-autarkic energy cooperatives, striving for operational energy balance. This German-Dutch research project develops and evaluates the coordination mechanisms and the technological platform for the energy cooperative, to achieve cost efficiency or maximum autarky by shared exploitation of storage and other flexible resources. A transnational energy market aims to further push cost efficiency when the two pilot cooperatives are more widely replicated and adopted in future scenarios.



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Summary

Intelligent energy management requires a robust platform (such as mypowergrid), on which models of user preferences and opponent behaviour can inform individual decision making.

Finding 1: Using Multiagent Learning Algorithms to Learn Behaviours in Energy Communities (Hernandez-Leal & Kaisers, 2017)

An autonomous agent can learn a model of another agent by observing its behaviour. In particular, in this project an algorithm was developed to identify friendly and adversarial behaviour, and changes between the two types of behaviour in repeated stochastic games, which are a fundamental model of multi-agent interactions.

Energy management systems are commonly used to optimize local behaviour (e.g., a household). However, in energy communities, the option of exchanging flexibility (energy) between prosumers could provide major benefits by reducing costs. Developing efficient exchanging mechanisms is an open problem due to various factors, for example the free-riders, subjects who benefit from a resource without paying for it. In this regard, the algorithm can be the basis of a sharing mechanism for energy cooperatives that can identify cooperative (friendly) behaviour. This will indirectly promote cooperation in the community, because agents are enabled to choose to cooperate with those who also cooperate back.

Finding 2: Personalized Negotiation Is a Key Element of Community Trading With Many Open Challenges

Energy community trading within Schoonschip - a residential energy community in Amsterdam Noord - can be performed by a negotiation agent that needs to make balanced and personalized trade-offs between multiple issues, such as cost, sustainability and convenience. As a simple example, a smart thermostat controlling a heat pump could provide demand response to the electricity grid if the inconvenience is offset by the grid relieve incentives. In such situations, the negotiation agent represents a user with individual and a priori unknown preferences, which are costly to elicit due to the user bother this incurs. Therefore, the agent needs to strike a balance between increasing the user model accuracy and the inconvenience caused by interacting with the user. To do so, we require a tractable metric for the *value of information* in an ensuing negotiation, which until now has not been available.

Project showcase

During the project a decision model was developed to (presented at AAMAS 2017) find the point of diminishing returns for improving the model of user preferences with costly queries. A reasoning framework was presented to derive this metric, and a myopically optimal and tractable stopping criterion for querying the user before a fixed number of negotiation rounds. The method provides an extensible basis for negotiation agents to evaluate which questions are worth posing given the marginal utility expected to arise from more accurate beliefs.

There are still many open challenges for designing personalized negotiators. During the project also a research agenda has been developed (presented at *IJCAI 2017*) that outlines a number of future challenges for automated negotiation.

Finding 3: The Energy Flow Inside the Community Can Be Optimized in a Sector Coupled Way

Based on the myPowerGrid web platform and the Amperix™ local energy management system, developed in the former myPowerGrid project (2011-2014), the goal is to optimize the energy flow inside the community in a sector coupled way: power, heat and mobility; e. g., battery storage systems, heat pumps and electric cars.

In order to identify the energy flows inside the community, a sophisticated measuring concept is required. This measuring concept can be more complex than you would have in a regular home. The more complex a measuring concept, the higher the costs. Therefore, these costs must be minimized to be competitive.

Controlling heat pumps can be done via the popular SmartGrid Ready standard. This standard has only four modes: *stop*, *default* (no change to internal heat pump control), *excess energy available*, and *maximum power*. The SmartGrid Ready communication is only unidirectional. As such there is no possibility to read feedback from the heat pump control systems and values like heat storage temperature and so on. However, with external components like an energy meter for the heat pump, temperature sensors on the water tank of the heat storage, and heat meters at the water pipes. The behaviour and status of the heat pumps can be approximated, but these components come yet again with extra costs. Sophisticated machine learning techniques to derive the internal state of the heat pump system are required. Some heat pumps have additional interfaces to communicate with a more powerful communication protocol, for example providing several temperatures and status information. Unfortunately, there is no industry standard, leading to repeated implementation effort for each vendor/model. Also, not all heat pumps come with such interfaces.

In general, controlling the charge power of an electric vehicle is possible. It is actually necessary to statically limit the charging power to the available power wire conditions of the wallbox. Some wallboxes come with a communication interface like OCPP or proprietary ones to dynamically limit the charging power and to stop and restart the charging process.

> In the past, Demand Side Management, most of the time, only considered white goods such as washing machines, dryers and dishwashers. In private households, however, there will be greater flexibilities in the future due to heat pumps and electric vehicles. By definition, these flexibilities should have open, standardized and cost-effective interfaces in order to make use of them.

Finding 4: Insights from Evohaus

Within the scope of Grid-Friends a battery storage system was installed in a pilot settlement in Cologne to increase the autarchy of the settlement. In a first step, energy out of the battery was distributed in direct response to the demand.

Right now, the project develops, together with the Fraunhofer ITWM an algorithm that discharges the battery at a lower output power based on the forecasted energy demand, aiming to increase the efficiency and life expectancy of the battery storage system by achieving the same results regarding self-sufficiency of the settlement.

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