

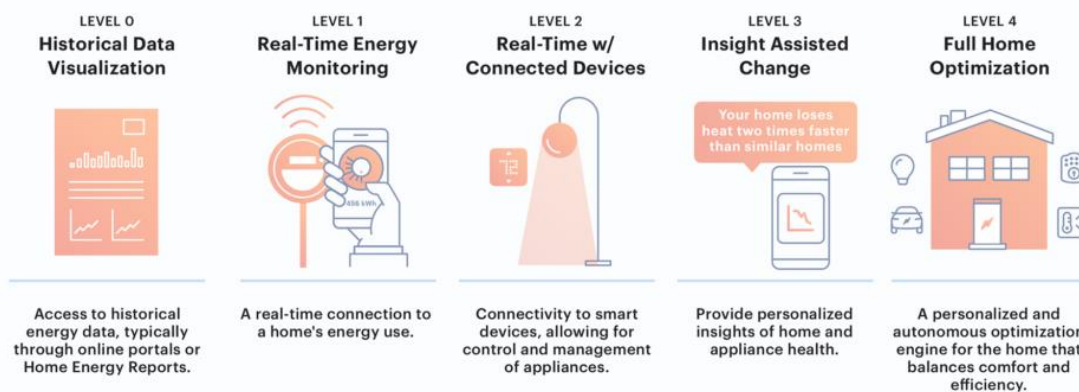
Bosch Research

Economy of Things – contributions to the community

Can energy management and trade be implemented decentrally across households?

Everyone who works in the IoT and AI environment is familiar with the six stages of autonomous driving as defined by [SAE International](#) in 2014. These range from Level Zero – no automation – to full automation at Level 5. Can this development be applied to energy management in households? The Smart Electric Power Alliance (SEPA) answered this question with a resounding “yes” in one of its [blog posts](#) last year. In the post, it defined the following levels:

4 Levels of Autonomous Home Energy Management



Source: SEPA

Thinking outside a household's own four walls

The team behind the “Economy of Things” (EOT) strategic advanced engineering project at Bosch Research is looking into the question of whether energy management in private households shouldn't be thought of much more as extending beyond one house. First of all, this is based on the fundamental idea of the EoT team that, while the Internet of Things (IoT) networks devices, they still aren't achieving their full potential for sharing economic values in the sense of an EoT. Second, the research team's work is also founded on the principles of socially fair mechanisms. Taken together, these two ideas could create energy marketplaces without any central authority. This would be an unprecedented innovation, and therefore a significant improvement on current practice in Europe. “From a technical standpoint, it is already possible to optimize energy consumption within a single household as part of a smart home. For example, the washing machine could be set only to run when it is most economical, such as when the PV system is generating excess power. Another possibility would be for the refrigerator to regulate its own power consumption based on its contents,” explains Christian Heise, deputy project director of “Economy of Things”, adding: “However, things become much more exciting when we look beyond Level 4, with households potentially able to trade the power they don't need with others in their neighborhood. A great many PV systems have been installed as a result of Germany's Renewable Energy Sources Act. The many revisions to this law mean the feed-in

tariff is no longer as attractive as it was originally, however, and will soon end for existing installations. Trading electricity locally could therefore provide households with an additional source of income, especially since reducing the numbers of these systems does not really represent an alternative in the long term.”

The challenge of data sovereignty and integrity

As soon as thoughts on optimized energy management and trade start going beyond a single household, challenges such as data sovereignty come into play as potential issues. Quite rightly, Household A has no interest in revealing its electricity consumption – or how much individual household appliances consume – and the associated excesses to its neighborhood. Personal price limits for specific energy demands are another example of information that must not be made public. The background conditions must also be considered private. For example, it is likely that a household’s energy consumption will be lower when family members A and B are at the gym every Wednesday evening. The electricity this frees up could then be traded on a decentralized market – this is even more true when the whole household is on vacation. Integrity poses another challenge. This involves clearly identifying the parties and the authenticity of the values exchanged while still safeguarding privacy and complying with data protection requirements.

Technologies and concepts must pay into the most valuable currency – trust

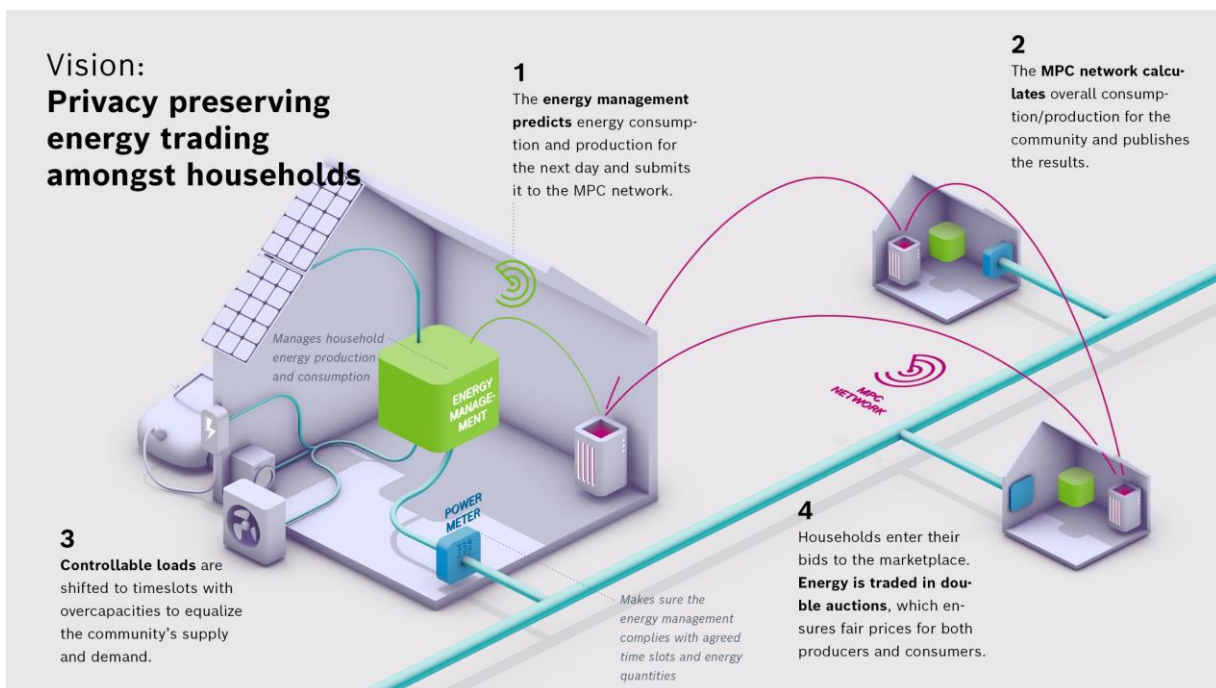
“When we are researching a decentralized energy management and trade system, we are dealing with an extremely challenging context. It affects basic supply, which is an area that requires the highest level of security. From the users’ point of view, on the other hand, trust is key,” says Jared Weinfurter, Lead Architect for Decentralized Energy Trading. “All the technologies we develop and use must therefore contribute to that trust.” Distributed ledger technologies (DLT), multi-party computation (MPC) and decentralized identity management (e.g. self-sovereign identity (SSI)) are among the technologies and concepts designed to create trust. While DLT ensures a transparent, verifiable and consensus-based transaction history, MPC is a cryptographic process that provides the associated electricity price calculation environment, safeguarding privacy and thus ensuring security and trust. SSI, for example, gives owners control over their data.

A software agent to represent the house

“Embedded into this kind of technological environment, there would be space to program an appropriate piece of agent software,” explains Lars Wegner, Senior Developer for Multiagent Systems. “This kind of agent acts as a representative of the household, so to speak. Ideally, it is intelligent enough to make predictions about how much energy the household will need and when. It knows when loads need to be moved. This might involve starting the dishwasher or interrupting the charging process of the electric car.” The agent would then also recognize whether a certain generator in the house can be switched off, or whether the better option would be to trade the unused electricity decentrally. The agent would also be able to draw electricity on behalf of the household. “Unlike a conventional marketplace, nobody has a complete overview of the market, so no agent has an advantage in terms of knowledge. All the energy agents have the same historical and current information. The agents would then have to use this information and their actual energy capacities to target optimum economy for the household.” Programming this kind of agent is a huge challenge. No exact frameworks currently exist. The mere fact that data

would have to be processed more or less in real time presents researchers with a huge task.

However, the status quo is not a satisfactory alternative for the EoT team. In a centralized energy market system such as the one currently in place, all the devices would have to send their environmental data and requests to a coordinator, and electricity providers would all also have to send their details. “This would all involve calculations, is highly complex, and requires huge computing power,” says Heise. “Distributed agent-based systems can ease the load on the critical energy infrastructure, reducing energy consumption overall. We will soon be publishing a series of demo systems relating to the necessary concepts and are therefore calling on the large energy and decentralized technology community to work collaboratively with us on a framework for decentralized energy trading.”



The team behind the “Economy of Things” (EoT) strategic advanced engineering project at Bosch Research is working on the vision of data-protected energy trading between households.

The principles of the Economy of Things as a guideline

Over the next few months, Christian Heise and his research team will systematically apply all the principles of the Economy of Things, as they have been defined at Bosch, to the plan for a decentralized energy marketplace – ideally with partners. Briefly, these principles are:

- ▶ **Openness:** The energy marketplace is always open to all participants who adhere to the principles that apply to everyone
- ▶ **Neutrality:** No single participant in the marketplace ecosystem is to dominate it
- ▶ **Transparency:** Transparent business model, organizational structures, regulations and decision-making processes
- ▶ **Sovereignty:** Keeping sovereignty over the data with the owner and equal access rights to data for all market players
- ▶ **Integrity:** Unique identification of everyone involved and authenticity of information shared
- ▶ **Coopetition:** Cross-company collaboration on developing and operating the technical system outside the individual household (open-source software); competition in developing new products and services based on this in the household itself (agent technology, intelligent hardware)

Vision of combining energy and mobility solutions

If you have been reading carefully, you will have noticed that the ideal scenario described above included the charging process for an electric vehicle. Heise aims to bring together the mechanisms involved in mobility and energy. “Our core idea is to use resources efficiently in all domains and still set up a socially fair system. For example, we feel that the electricity price should not skyrocket when there are shortages, but rather that the entire system should simultaneously be encouraged to cut consumption.”

Renningen, October 2020