	2000 – 2014	
Renewable Energies		+ 114 TWh
Export Surplus		+ 34 TWh
CO_2 Emissions		± 0
Nuclear Energy		- 72 TWh

IT FOR THE ENERGY TRANSITION

Energy is the indispensable basis for the functioning of our economy. Despite all efforts to increase efficiency, we still consume ever more fossile energy and are dependent on suppliers. Our locally available renewable energies offer independence, security of supply, and affordability in the long term.

In the project **"CEM - CROSS-ENERGY MANAGEMENT"**, we are building the IT architecture for a safe energy supply in the future. Smart coordination between the various sources of energy (such as electrical power, heating/cooling, gases, energy-intensive semi-finished products) does not only lead to optimization of system efficiency, but also helps to compensate for the fluctuation in the energy provided by sun and wind. The necessary prerequisite is an interconnected, resilient IT that flexibly integrates all stakeholders from the energy supply chains. We provide answers to questions regarding the system architecture, system security, data security, as well as openness and interoperability.

WHERE DO WE STAND TODAY? The changes in the energy industry in Germany in the past 15 years are remarkable, considering the increase in the proportion of renewable energies. However, this success is put into perspective if one takes into account that an import/export balance that was still balanced in the year 2000 today shows a strong export surplus fed from cheap fossile power plant outputs. The desired reduction of CO_2 emissions in power generation failed to materialize because, due to the no longer functioning trade with CO_2 certificates and low fuel prices, the coal-fired power plants, which are particularly harmful to the environment, are able to produce power at competitive rates, whereas modern gas-fired power plants are unable to compete.

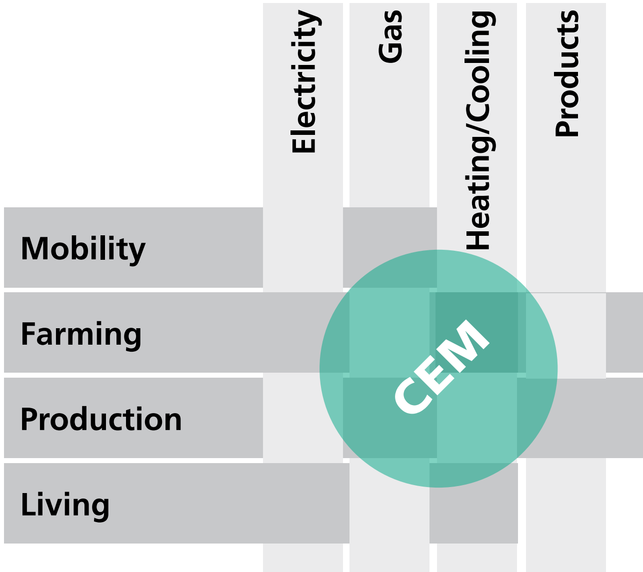
HOW WILL IT GO ON? The energy system is becoming the more decentralized the more electricity is generated from photovoltaics and wind, but also from CHP and biogas plants. Already today, several millions of volatile plants are connected to a (by historical design) centrally controlled power grid in Germany, whereas prior to the turnaround in energy policy, there were only a few thousand plants with stable generation. Are these plants interconnected via ICT? No, they are not!

WHAT DOES THIS MEAN? It is common knowledge that electric power from renewable energies is volatile depending on the time of day and the weather and that it can fluctuate very strongly in extremely short intervals (minutes). At least this can be predicted with a fair degree of accuracy. Since, however, an intentional increase in power generation is not possible, other energy sources (gas-fired power plants, hydroelectric power plants, batteries) must fill the gap, or consumption must be adjusted to the available power. According to the current state of the practice, the only feasible way to jointly reach climate and efficiency goals and achieve independence from international fuel markets appears to be the coordinated combination of the available flexibility potential of generators, storage facilities, and consumers. This requires both a suitable design of the market, which in the future must honor these flexibilities as well as the achievement of climate goals, and technical controls that are adequate for this task. ▶▶

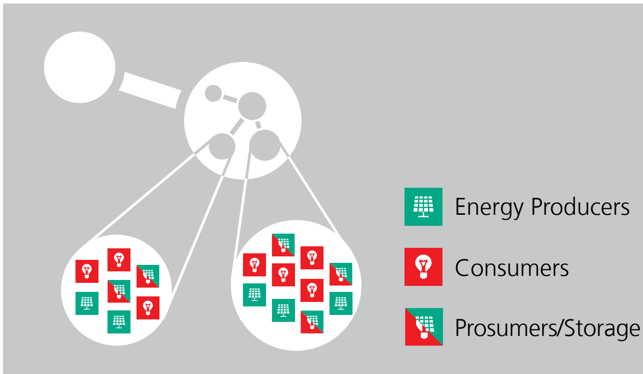
ENERGY SYSTEMS OF THE FUTURE

The systemic view of the different energy businesses in one technical system consisting of generators, storage facilities, and consumers is known under the term Cross-Energy Management (CEM). CEM means that in addition to electrical power, gas, heating, and cooling, (energy-intensive) products are also viewed in an integrated manner in terms of control technology, which allows the resulting system to respond flexibly to fluctuating energy supplies (according to availability and price) instead of assuming (as is the case now) that energy is available at a stable price all the time. How CEM systems are actually designed depends on the application area and can differ widely in terms of the technologies used: In residential areas, for example, electric heating systems (such as heating pumps) might provide flexibility; batteries of (hybrid) electric vehicles might open up new options in manufacturing plants and in farming, or district heat could be generated electrically as an alternative in the case of a surplus supply of electric power.

On the level of control technology, individual CEM systems would have to be combined into regional clusters that are integrated with the distribution grids (electricity, gas, heat) in terms of control technology. In this way, the existing distribution grids would be complemented by an additional all-inclusive, but open and extensible cellular-hierarchical ICT structure. This is still a vision!



Systemic view of the different energy businesses



The cluster structure of CEM systems

If we look at the installed ICT infrastructure of the energy industry, we must come to the sobering conclusion that to date, there is no "architecture" that could map an energy system based on renewable energies. The task of coordinating many millions of plants in a strongly decentralized, but transnational grid means that a completely new ICT network must be set up, comparable in complexity to the Internet.

THE NEW ERA IN ENERGY – A CHALLENGE FOR ICT!

The Internet was and is successful because it has some simple and robust architectural features and comes with basic standardization aimed at interoperability; however, as it is open, it does not pre-determine possible applications. In particular, the topology of the infrastructure does not determine the logical topology on the application level.

For an "Internet of Energy", these features must be transferred. And even more is necessary: The highest degree of reliability and safety, data security and data usage control, openness for all types of plants, and flexibility for mapping business processes that have not been defined yet are all essential design objectives.

In order to achieve these goals, system architects are needed who are independent of self-serving interests and who can swiftly design such an architecture, develop a prototype, and then subject it to an international standardization process. In its entirety, this is a range of tasks for a whole series of institutes of the Fraunhofer-Gesellschaft. Regarding the software system architecture and the required specific software qualitites, IESE, in particular, has already demonstrated numerous times in other application areas how to successfully implement these goals in dependable systems.

THE CONTRIBUTION OF FRAUNHOFER IESE

IESE makes very specific contributions to realizing the vision of the energy system of the future. It focuses mainly on a safe and reliable ICT system architecture (by design), on integrated, transparent data usage control, on standardization, and on openness. In various projects, the above-mentioned cellular-hierarchical system is being implemented prototypically and is the subject of ongoing research; concepts for integrated data usage control (from collection to final use) of data are being tested; and safety and security features are being defined, tested, and demonstrated.

■ Frank Bomarius, Jens Knodel