



Smart Energy

Introduction

Sustainable energy production and consumption are critical components in dealing with climate change, CO2 emissions and exhaustion of natural resources. The load on the energy network is increasingly unpredictable. That's why in particular the power network needs to be upgraded to a smart grid: our energy system turns into a smart energy system. Smart energy systems support controlled charging of electric cars, deploys smart grids with local, domestic energy production, energy delivery and usage. This converts the electricity network into a high tech system which relies heavily on information and networking technology.

Domain challenges

These challenges are based on interviews and a careful analysis of existing roadmaps.

Domain challenge	Description
<i>"Supplying the market with sufficient energy without building energy plants"</i>	Home automation to reduce energy-waste.
	Create Smart Grids to more accurately predict periods with high or low demands.
	Influencing user behavior: much of the demand is still user-induced
<i>Creating an infrastructure for electric cars</i>	With sufficient charging stations capable of supplying the required energy
<i>Delivering clean or pure power</i>	Maintaining the "quality" of energy production and distribution.
<i>Storage of energy</i>	It is often cheaper to produce energy than to store energy.
Delivering richer services to clients	Energy is a commodity, utilities may exploit the 'smart meter' to deliver added value services

Extrapolation: These challenges are likely to become more prominent in relation to the increasing energy demands and requirements for sustainability.

Boundary conditions to solutions:

- Use of "proven technology": Extensive roll out of new technologies in experimental settings is needed before a national smart grid is realized.
- Long time horizon: energy grids have an economic Return of Investment (RoI) of tens of years.

Trends and Solution direction: Smart Grids

Smart Grids represent the cutting edge of energy efficient technologies, applied in energy production, distribution and householder use. Smart grids are modernized electricity grids that interact with information technology and communications infrastructure to provide greater transparency on energy use to consumers, and to improve the efficiency of energy supply. Smart grids support the integration of renewable and distributed energy sources into the grid, like solar, wind and co-generation plants. Smart grids promise to be more reliable, with fewer and shorter blackouts. They allow electric vehicles to be charged when demand on the network is low, and their combined battery storage can be used to support the network when demand is high. Consumers need no longer be passive receivers of power, but instead can take responsibility of their energy use and make meaningful decisions that will benefit both the environment and their hip pockets. From the perspective of commercial energy producers the most important aspect is peak-shaving: shifting energy consumption to periods with less energy demand. This can be done by providing incentives to consumers, or by remotely controlling household appliances. Many of these changes will help lower peak electricity demand and reduce the need for electricity companies to build extra power plants simply to cope with daily peaks in consumer demand."

Key elements of this vision are:

- Production of green ('renewable') energy. This can be done by commercial energy producers, but also by individual companies or households (solar cells, wind-mills).
- Support for electric cars & chargers. This leads to new local power demands on one side, and significant electricity storage on the other side.
- Smart Metering Infrastructure (SMI) and in-house controls, to provide insight in energy usage for inhabitants.
- Advanced tariff differentiation, to provide incentives to increase or reduce current power consumption.
- Information exchange in the energy supply chain, in order to predict energy usage and control energy production.
- Communities may support local trading of energy

- Local E&G/W&C projects: specific solutions not related to the main power grid (especially local Warmth & Cooling solutions)

Scenario Smart Energy 2020

The energy market is highly diversified. Many sources of electricity are used in combination (traditional sources like gas and coal, wind, water power, decentralized solar power, decentralized small energy plants). The supply mix and demand mix is fully automated, based on rules defined by users and energy suppliers. In other words, based on weather predictions, demand predictions and user rules decentralized systems decide whether it will load electric cars, adapt lighting on high roads, or adapt energy production in gas power plants. Energy companies are competing on price and intelligent customer services, like fully automated control of household equipment based on energy supply and prices and user preferences. The supporting ICT infrastructure in the home consists of fine-grained communication networks, which exchange (aggregated and/or anonymous) information with the energy company and various third party service providers via the Internet. Users become more aware of the variety of possibilities for utility services including home-specific solutions for electricity production and saving, heating and cooling, cooking and water management. Energy-consumption can be remotely managed and controlled through web-interfaces, on the desktop, touchpad or mobile. Support for energy equipment is managed by the energy company, using a supply base of local professional heating service companies.

Use case scenario: Somewhere in the not so far away future...

I get up early this morning: today we have to decorate the living room since it's my daughter's birthday! It's mid-winter and cold outside, but luckily the heating remembers this special day from last year. It's already warm in my bedroom and in the living room, while the other bedrooms will still be cold. Nice system. My only concern is all the personal data that my energy company seems to collect. They give nice privacy guarantees, but lately it was in the news that an energy company, not mine, had kept the data after the client had moved to a competitor, sending birthday cards to his wife reminding her of the nice time they had when still a client. And I still do not get why apparently it is beneficial that my microwave is web-enabled. Anyway, my invoice was lower again, particularly since cloth washing is done on last-minute low-cost hours. Just filling the machine in the evening and the wash is clean in the morning. Oh god, I still have to get it from the machine.....

Smart Energy Challenge

The Smart Energy challenge is meant to stimulate to make research challenges explicit for the Smart Energy domain, but also to provide focus and scope.

1. Development of a smart grid communication-infrastructure, connecting house holds, grid providers and electricity providers.
2. Provide a plug-and-play smart meter that can be obtained in a DIY-store.
3. Develop in-home (or in-company) communication and controls for local energy management

Research questions

Smart grids:

- Should the electricity grid manager(s) play a role in the home-to-grid(s)-to-producer smart grid communication?
- How can a smart grid deal with all parties involved in its operation?
- If users make different types of agreements with energy providers on the terms of the contract (time of delivery, service levels), how can the electricity grid manager guarantee sufficient capacity?
- How can we model and simulate Smart Grid Systems? Which modeling techniques exist for energy provision, in which the ICT system is incorporated? How could we use perfect knowledge on the system?
- Should the smart meter only register energy consumption and production, or also control appliances?
- Is energy supply sufficient for electrical transport? Can we manage scarcity?
- How can the interests of stakeholders be represented by intelligent agents, so that they can jointly negotiate their mutual interests?
- How do you communicate energy use to users in a comprehensive, yet attractive, fashion?

Communication technology:

- Which communication technologies are needed for the smart grid? Does fiber technology offer real advantages? Is the use of the power grid itself an option? Do we need one infrastructure, or several ones?
- How can ICT facilitate the efficient use of energy transport capacity? Is it possible to determine optimal loading of (connected) parked electrical cars?
- Which information do we want to communicate? Which part of the information is time-critical?
- How can we transport sets of data with different reliability levels within the same communication system?

Can fault-tolerant systems contribute?

- How can the life span of an energy system (long) and a communication infrastructure (short) be aligned?
- How can in-house information be transported with a sufficient degree of reliability, without new wiring? Is the electricity network appropriate for this purpose, even if this would also be used for other purposes? Could it be wireless?
- What is the transition trajectory from the present state to a communication system for a smart grid? Is there a standardization trajectory?

Conditions for implementation:

- Business models: How can a supplier of communication services generate revenues and profits by transporting small quantities of data with high levels of reliability?
- Privacy: How can we guarantee user privacy in a smart grid?

Proposed Actions and Opportunities

Actions

- A national Smart Grid research & innovation program like in Australia
- Construction of a (prototype) Smart Grid infrastructure test-bed.

Opportunities

- Climate KIC in the EIT. www.climate-kic.org
- NWO's Smart Energy Systems program: www.nwo.nl/ses

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