Intelligent Energy Distribution Networks through the Use of Innovative Decentralised Generation, Storage, Information and Communication Systems

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1. Structure of Electric Power Networks - Today and Tomorrow

Today, in industrialised countries the energy distribution networks are structured like shown in Fig. 1. Large centralised power plants feed into a dense distribution network. In the future, this structure will face numerous problems, because it is not flexible regarding the relocation of primary energy sources, the optimisation of energy flows and energy costs. Within a deregulated energy market, these facts lead to drawbacks with respect to market

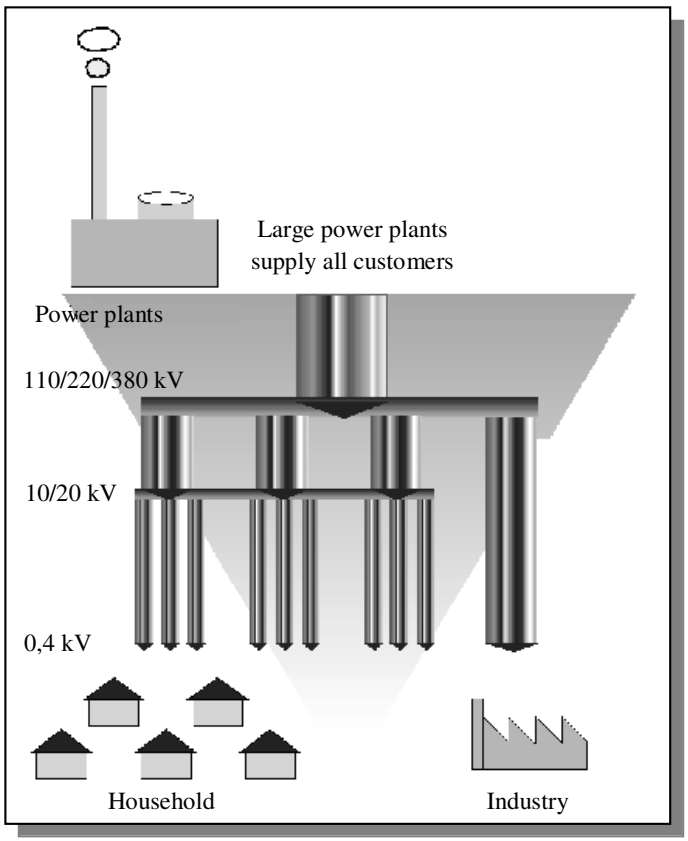

Fig. 1: Conventional supply structure

competition. In addition the acceptance of major infrastructural extensions like grid extensions, new large power plants etc. are decreasing significantly. Therefore, it will be more and more difficult to guarantee reliable and high quality power supply.

Looking at developing countries, there are no strategies for setting up dense distribution networks such as in industrialised countries.

Hence new markets for small, decentralised solutions with low investment costs including various energy storage applications are upcoming.

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The goal of the »edison« project is to combine the electricity grid and the communication systems to realise flexible, decentralised network structures (Fig. 2). This new network structure allows the integration of decentralised energy storage and converters, power quality electronics, decentralised energy management systems and high bit rate communication systems.

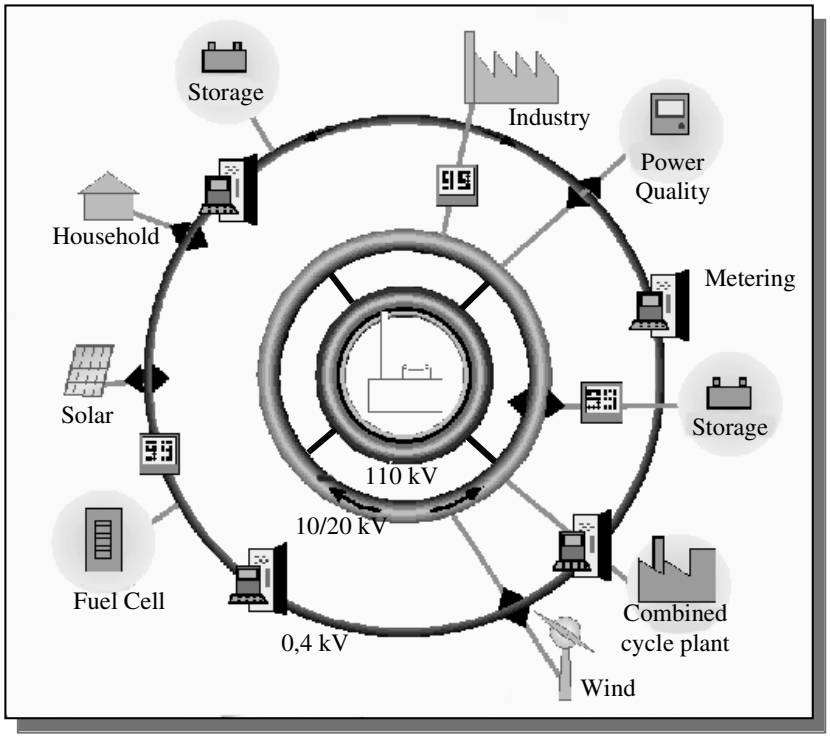

Fig. 2: Advanced supply concept

2. Goals and structure of »edison«

The goal of the »edison« project is to develop, demonstrate and evaluate modular intelligent systems that allow the construction of cost competitive energy as well as information distribution networks. To achieve this goal, 16 companies and research institutes have got a 4.5 years research contract of a value of 31.3 Mio. DM from the German Federal Ministry of Economics and Technology (BMWi). Edison started mid 1999 and will finalise in 2003.

The concepts and new technologies will be developed by five research institutes. They are working in the field of electricity distribution networks, energy storage and energy converters, renewable energy, information technology and economics.

Five small and medium enterprises as well as four large companies will realise the new hard- and software concepts. Finally, the new systems will be integrated in the networks of the local energy supplier »Stadtwerke Karlsruhe« and »Energie Baden- Württemberg« for test and demonstration.

The work of the »edison« project will be performed in eight subtasks.

In subtask 1, an analysis of existing electricity distribution networks will be performed. In this studies, the specific demand for distributed energy conversion, load management, energy storage and measures to achieve high power quality or reliability will be found out.

Subtask 2 will deal with all technical and economic aspects of energy storage and converters. First, in a study all types of energy storage and converters suitable for network integration are investigated. Models of these

components are developed to be used in other subtasks for computer simulation. Batteries, fuel cells and their peripherals are further developed and investigated.

In subtask 3, a new, decentralised energy management system (DEMS) will be developed. The goal is an optimisation of the energy flow in the grid in respect to efficiency, ecology and economy.

A powerful communication network to control the distributed net components is essential for the new grid structure. In subtask 4, suitable network structures will be developed and evaluated, also taking high bit rate power line transmission, e. g. Internet access into account.

In subtask 5, simulation programs will be developed for dynamic and static network simulation. Besides energy flow calculations, also economics will be considered.

The outcome of the previous tasks will be brought together in subtask 6, where three energy distribution areas will be equipped with the new hardware and energy management systems. Two of them will be in the city of Karlsruhe (0.4 and 20 kV), the third one will be a rural area 20 kV net. Combined heat and power systems (PEM-fuel cells, 5 kW and 250 kW), battery energy storage (some 100 kWh) and power electronics to improve power quality will be integrated in these nets.

The operation of the three demonstration projects will be monitored and evaluated comprehensively in subtask 7.

The overall goal of the project is to open new market opportunities for electricity suppliers as well as for system manufacturers. The aim of subtask 8 is to develop marketing strategies and concepts. Industrial countries as well as developing countries will be considered.

3. First Outputs

Until now there was an area in the southern part of the city of Karlsruhe with supply problems identified. These problems result in outages due to the lack of capacity. The concept for a solution is based on fuel cell and energy storage integration into the grid. At the moment it is planned to embed one fuel cell within a thermal swimming facility (ratings 200kW_{el} 300 kW_{th}) and up to five fuel cells for support within domestic households (ratings for each cell: 5kW_{el} 7 kW_{th}).

Additional support to deal with “shock loads” will be implemented by using energy storage devices with two different scopes: mobile and stationary units. The mobile units shall deal with “shock loads“ (peaks). It is intended to use units in the range of 30, 50 or 100 kW with a storage energy up to 200 kWh per day, for all-the-year use. There will be two or three container-integrated systems for mobile inset (max. 6m length, 25 t weight). The implementation of a cooling mechanism is under consideration. The process control mechanisms inside the container will enable the system to operate without additional external control, except of a schedule that is delivered to the control unit.

Furthermore some externally controlled, decoupled Power Quality devices with reactive power capabilities, implemented by using 4-quadrant-inverters, will be installed.

Additionally there will be at least one stationary unit to support weak nodes within the low-voltage grid. The ratings of the energy storage device will be within the range of 200 - 300 kW for up to 2 h. It is recommended to have up to 500 kWh per day, for all-the-year use. Due to the lack of adequate housings it is not finally decided if there will be ONE container integrated system for that purpose or if some mobile units are used to implement one stationary unit.