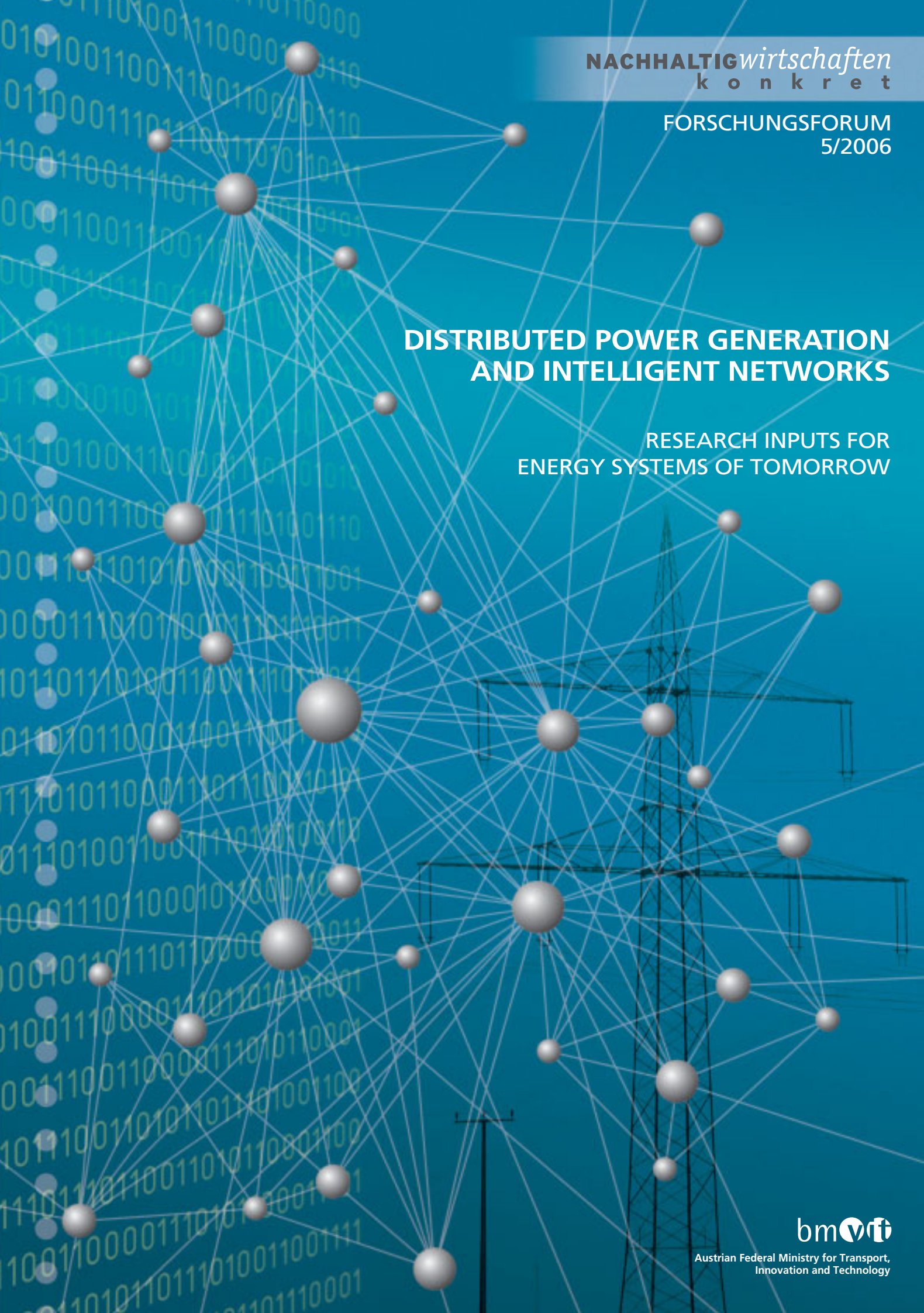

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DISTRIBUTED POWER GENERATION AND INTELLIGENT NETWORKS

RESEARCH INPUTS FOR ENERGY SYSTEMS OF TOMORROW

bmvit
Austrian Federal Ministry for Transport, Innovation and Technology

T O P I C

INTEGRATION OF DISTRIBUTED POWER GENERATION AND OPTIMIZATION OF ELECTRIC ENERGY SYSTEMS

In 1999, the Austrian Federal Ministry of Transport, Innovation and Technology (bmvit) launched the "Sustainable Development" research and technology program, which aims to effectively support approaches towards sustainability in economic activities through research. Various research and development projects as well as demonstration and diffusion measures, which give new impetus to innovation in Austria's economy have since been supported within the scope of a number of subprograms. The "Energy Systems of Tomorrow" subprogram aims to encourage innovative and trend-setting technologies and concepts in the field of renewable energy sources that are capable of safeguarding energy supply on a long-term basis.

The International Energy Agency expects that the proportion of electrical energy in the overall energy market in OECD countries will rise from 24% in 1970 to 40% in 2020. The demand for electrical energy is rising continually each year and, at the same time, experts expect a decrease of capacities and possible shortages. The economic conditions of power supply have fundamentally changed on account of the deregulation process on the European energy market and the promotion of renewable energy sources. Free access to power distribution grids offers new players access to the market. The development of new technologies makes it possible that a multitude of smaller, decentralized generation units come into existence and, at the same time, changes the structures of distribution and consumption. This offers new opportunities for the energy supply in the future: Increased use of renewable, regionally available energy sources, minimization of grid losses, optimized use of waste heat and a reduction of the consumption of fossil fuels. On the other hand, this development poses new technological and organizational challenges for the present power supply system and requires modifications of the current legal framework. What is needed is a trend-setting energy system, which ensures a safe and reliable energy supply and, at the same time, meets demanding requirements concerning environmental impact, sustainability, and cost efficiency.

The operation of grids with a high proportion of distributed generation requires innovative technologies and concepts, especially novel control and monitoring systems. The growing number of local generators raises fundamental questions concerning the whole system: capacity planning, stability, grid security strategies and, in particular, power quality. The challenge consists in the development of an efficient system that optimally integrates all existing resources in a flexible way. This refers, in particular to the use of new energy sources, but also to unused potentials in the distribution grids and on the side of consumers.

In order to make untapped potentials for optimization available it will be necessary that all actors involved in the grid have the possibility to actively participate in the management of the overall system. Such an energy system will put end users in the position to optimize their energy costs through a more flexible timing of their energy consumption. New fields of business will develop in order to provide the requisite infrastructure and information services. Amongst others, it will be necessary to collect IT-relevant data on a vast number of energy consumers, generators, and storages. Until recently, there were no cost-efficient methods to realize this task. However, the latest advances in communication and information technology offer the opportunity to integrate a large number of actors as active participants at reasonable prices.

Austria has comprehensive experience and competence in this field. In order to further develop these assets the **"Energy Systems of Tomorrow"** subprogram realized research projects, which address the technological, economic, and legal aspects of distributed power from local energy generation units and their active participation in distribution grid operation as well as information and communication technologies required for this purpose. Two of these projects will be presented below.

Project 1:
Netzqualität bei dezentraler Stromeinspeisung auf Basis erneuerbarer Energieträger
H. Brunner, R. Bründlinger, arsenal research, Vienna 2006

Project 2:
Integral Resource Optimization Network Study – IRON Study
P. Palensky, Institute of Computer Technology, Vienna University of Technology, Vienna 2005

POWER QUALITY IN DISTRIBUTED GENERATION BASED ON RENEWABLE ENERGY SOURCES

Present power grids rely basically on central supply by large power plants that operate in the high and very high voltage range. Distributed generation plants that operate at lower levels of the grid (low and medium voltage range) modify the system in so far that the formerly unidirectional energy flow from higher to lower levels of the grid and finally to the end user becomes a bi-directional flow.

This entails far-reaching changes in the Austrian power supply system: Formerly passive elements on the consumer side turn into active generators. It becomes more difficult to manage energy flows; a multitude of small generation units have to be monitored, controlled, optimized, and accounts have to be settled. Interactive and centrally controllable networks consisting of many distributed generation units and consumers may be seen as "virtual power plants". Optimization and flexible matching of demand and supply thus make the construction of additional real power plants unnecessary. In the future, virtual power plants will be of great importance because they improve the safety of supply, rely on renewable energy sources and reduce dependency on imports, reduce emissions and improve efficiency if they are used appropriately. However, this concept requires correct planning and the consideration of the overall framework necessary for distributed generation.

On account of the increasing density of distributed generation units the issue of power quality becomes more and more important. It will have to be shown that in spite of – or rather – owing to the "virtual power plants" the high power quality can be maintained or varies only within controlled areas.

The research project "Erneuerbare Energien für eine verbesserte Versorgungsqualität" aimed to develop a technologically and organizationally feasible concept for an energy system relying strongly on distributed generation. The focus of the project was on the aspect of security of supply.

A wide-range measuring program on typical sites accompanied by analytical grid simulations aimed to ascertain the impact of distributed generation on the grid. In order to demonstrate how – through the use of appropriate technologies - decentralized generation units can actively contribute to the improvement of power quality the researchers implemented a concrete concept in a second step of the project. A complementary feasibility study identified barriers and chances and assessed the technological potential for an efficient and multi-functional use of the concept.

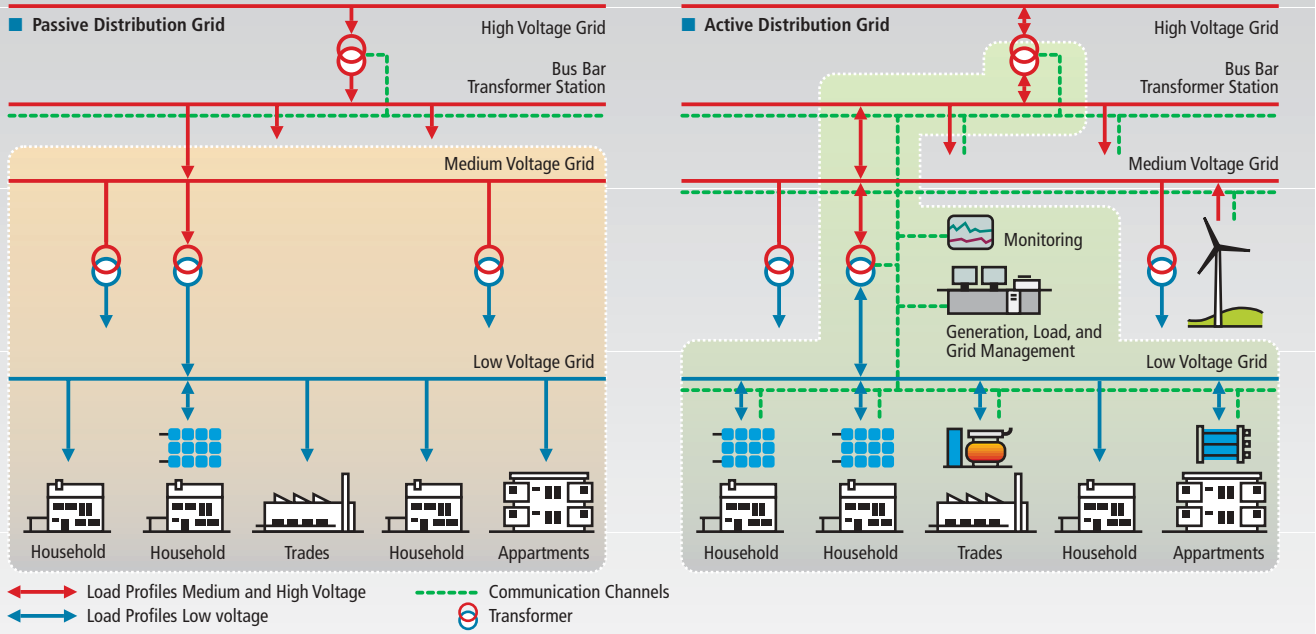
RESULTS

An analysis of the current conditions in Austria has shown that they are not an incentive for operators to actively offer access to grid services. The measuring program, which was implemented on ten sites with power from decentralized generation units in the distribution network used modern power quality analyzers to measure the most important power quality parameters. In addition to intrinsic long-term phenomena (harmonic, flicker or voltage fluctuation) the program also analyzed short-term events (voltage drops and surge voltage, interruptions etc.), which are characteristics of power and supply quality.

An analysis of the data has shown that, apart from the increase of voltage

Source: Project 1

Structural Change in Power Distribution Grids





typical of distributed generation, there was no significant negative impact on the parameters of power quality. In order to realize a high density of distributed generation units it will be necessary to develop innovative solutions that facilitate the active integration of the units in voltage control. The project has shown that appropriate technologies for the improvement of power quality are already available. The barriers for a large-scale implementation into practice reside predominantly in the current organizational and economic conditions for distributed generation.

The operators of small, decentralized generation units with often fluctuating output are still facing serious competitive disadvantages. These refer, apart from economic barriers, especially to administrative issues and high transaction costs. Grid operators are still skeptical as to the functionality and reliability of innovative concepts for the active integration of distributed generation units. It is, therefore, necessary to demonstrate their functional contribution within a broad field test in real-life grid sections and to prove their operability in practice.

DG DEMO-NETWORK

The follow-up project "DG Demo-Network" (DG = Distributed Generation) builds upon the Project "Renewable Energy for Improved Power Quality" as well as on other research projects within the "Energy Systems of Tomorrow" subprogram. The program was launched in March 2006 and is to develop the necessary framework for the practical implementation of already existing theoretical solutions for the integration of distributed generation units. The goal consists in the conception and planning of active distribution grid sections with a high proportion of distributed generation. The project includes representatives of all relevant actors within the system. The project team consists of members of enterprises and institutions such as arsenal research, Energie AG Oberösterreich, Vorarlberger Kraftwerke AG, Salzburg AG, and the Vienna University of Technology.

The objectives of the "DG Demo-Network" project include:

- Selecting grid sections in Austria, which are suitable as demonstration grids with a high proportion of distributed generation
- Documenting international demonstration projects, relevant research, and summary of existing experience of grid operators as well as analysis and assessment of this experience
- Developing model systems for active distribution grid operation, demonstrated in a multi-stage "DG-Integration" model with increasing complexity of systems
- Ascertaining which of the models are suitable for implementation in the selected grid sections in the medium and low voltage range
- Developing guidelines and a project-oriented catalog of specifications for grid sections and actors involved
- Planning of the technological, organizational, and economic implementation in the selected grid sections

The "DG Demonstration Network" highlights the impacts and requirements a further expansion of distributed generation with a minimum of additional investment entails for grid and DG operators. The planned demonstration project will thus present an approach to "best practice" and constitute a first step towards large-scale implementation of distributed generation; it also aims to mitigate existing barriers and limitations.

Demonstrating the model of active grid operation in practice, Austria will build upon its experience of long standing and further strengthen its pioneering role, in Europe, concerning know-how in the field of embedding distributed generation in existing grids and the requisite adaptation of distribution grids operation.

INTEGRAL RESOURCE OPTIMIZATION NETWORK STUDY – IRON STUDY

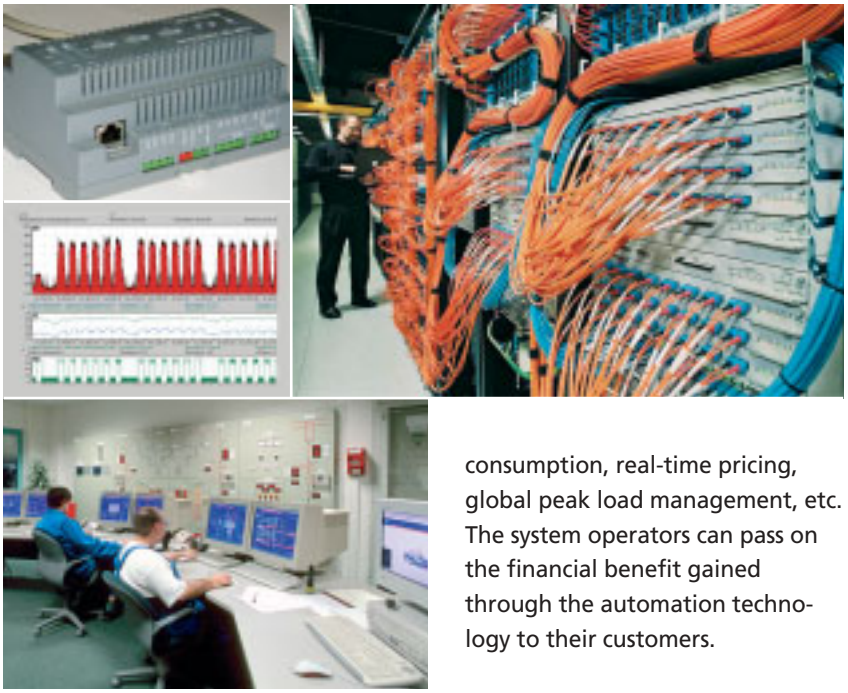
IRON (Integral Resource Optimization Network) is a fundamental study in the field of "coordination of distributed energy resources". The objective of this project consisted in paving the way for a stable, distributed automatation network for the optimization of electric energy as a resource.

Energy consumers, generators, and storages are to use a novel infrastructure that permits them to create a self-organizing network for the autonomous coordination of the use of electrical energy. In its final stage the IRON system will offer a communication technology platform that combines any number of actors in the electric network. The newly developed IT access will be deeper and more finely structured than conventional approaches. Ultimately, automation technology will work its way through to the level of end-users' appliances. Scalability and cost-efficiency are key factors in this approach.

The first phase of the IRON project served to survey the prevailing conditions and to successfully establish the topic among relevant actors by means of intense PR campaigning. "Integral Resource Optimization Network-Concept", a follow-up project is developing the various new services in order to create a communication infrastructure connecting all relevant actors in the energy network:

- Energy generators (power plants, wind power units, micro turbines, fuel cells, etc.)
- Consumers (appliances, machinery, etc.)
- (Virtual) storages (pumps, temporally flexible loads, time-lag processes such as electric heat, etc.)

The target group includes commercial buildings, single nodes (e.g. wind power stations), private homes, and small industry and trades. Large-scale energy consumers were not included,



as they usually have already developed an optimization system of their own.

Technically, the planned **IRON System** shows the following characteristics:

- Different classes of end nodes, depending on the target group (functionally and with a view to price – target cost is less than Euro 100.–), short pay-back time (2 years)
- Simple, wherever possible, automatic installation, stable, maintenance-free operation, good scalability up to a volume of 100,000 nodes
- Use of the Internet, field busses, and smart building technologies, integration of existing control systems (DMS, isolation of loads, etc.)
- Add-on services such as safety, information, or remote home features

The solutions currently available on the market do not fully meet these requirements. Therefore, new developments are needed in some areas that should build upon open standards as far as possible. Owing to its underlying concept, the IRON System is application-neutral, i.e. it may be used for a multitude of novel services: local synchronization of generation and consumption, real-time pricing, global peak load management, etc. The system operators can pass on the financial benefit gained through the automation technology to their customers.

The appliances of the end-users/customers will be equipped with an "IRON-Box", i.e. an embedded smart control device with "local intelligence". The individual modules communicate with each other and with higher-level units thus ensuring exchange of information on flexible loads and capacities (locally available transfer and storage capacities). The information thus gained forms the basis for optimization algorithms serving to coordinate the operation of the individual consumers.

The project team is developing a service portfolio, an infrastructure and marketing model as well as a preliminary study to prepare a field test. Taken together these project components constitute a concept that forms the basis for a field test, which will be realized in a follow-up project.

ECONOMIC EFFECTS OF DISTRIBUTED POWER GENERATION

■ Decentralized use of renewable resources constitutes a significant contribution to promote regional added value and is an important stimulus for regional job markets. The concept of active grid operation and the use of renewable energy sources turn the power supply sector into an open energy market. This also opens up new market potentials for innovative regional enterprises and offers attractive perspectives for skilled workers in the region.

Advanced know-how and qualification as well as the resulting leading position of Austrian companies in the field of technology (grid operators, manufacturers, consultancies, research institutions,…) contribute to securing existing highly qualified jobs. In addition, this creates opportunities to implement this know-how at an international level and to offer products and services in other countries as well in the future.

The integration of distributed generation into the system will promote the use of regional resources. It will also permit to realize local, labor-intensive projects (e.g. biomass or biogas plants as well as solar and wind power) and thus also contribute to the creation of jobs in these future-oriented areas.

Positive effects can be expected in the business sectors below:

- Research and development
- Plant designers and manufacturers (e.g. CHPs, biogas plants, Stirling engines…)
- Power electronics industry
- Manufacturers of current inverters
- Grid security technology
- Sale of plant and components
- Electrical engineers (planning, installation, and putting into operation of plants)
- Farmers (supply of primary energy sources and operation of plants, respectively)
- Entrepreneurs with projects of their own or participation in "distributed energy" projects
- Consultants (planning and consultancy)

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Project 1:
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Integral Resource Optimization Network Study – IRON Study
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Project Partners: Linz STROM GmbH, Sonnenplatz Großschönau GmbH, Envidatec GmbH, Michael Stadler

INFORMATION PUBLICATIONS

Final reports on the abovementioned studies will be published in the bmvit series "Reports on Energy and Environment Research". Project 1: (48/2006), Project 2: (42/2006)

Other projects on this topic:

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