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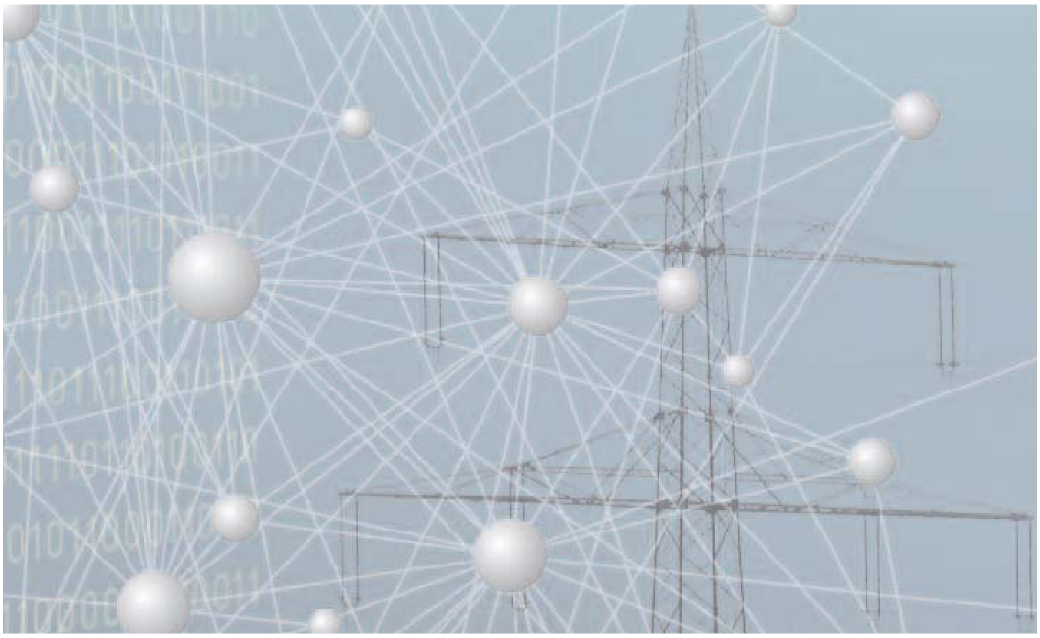

Project Synopsis Decentralised Generation and Smart Grids

Projects of the Austrian R&D Programmes 2003-2007

Berichte aus Energie- und Umweltforschung

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Project Synopsis
Decentralised Generation
and Smart Grids

Projects of the Austrian R&D Programmes 2003-2007

Vienna, May 2008

PREFACE

Improving the overall efficiency of our energy systems and their components as well as providing a sound technological basis for the increased integration of renewable energy sources is one of our major tasks those days.

The Austrian R&D- Program “Energy Systems of Tomorrow” - launched in 2003 by the Austrian Federal Ministry for Transport, Innovation and Technology (BMVIT) – aims at the development of new technologies and concepts for a flexible and efficient energy system, based on renewable energy sources. One of the focus areas is the integration of decentralised renewable energy sources into the energy grids. The trend setting outcomes of the program were picked up in the Austrian strategy finding process ENERGY 2050 (e2050) and as a result last year a number of additional projects could be started.

This publication presents the results of completed and ongoing projects within the subject area “Decentralised Generation and Smart Grids” (2003-2007) of the programme “Energy Systems of Tomorrow” as well as projects financed 2007 within the programme framework “Energy of the Future”.

The participating research institutes and companies have achieved many remarkable and internationally acknowledged results. Many of them are now working on follow-up projects in order to carry out field tests and create concepts for live demonstrations. We are pleased to see extensive cooperation and commitment among the participants which has allowed for the high quality results we have seen until today.

Building on this and on the outcomes of a broad stakeholder involvement in the Austrian strategy finding process e2050 the topic will be pursued within the subject area “Energy Systems, Grids and End-use”. I am looking forward to this challenging work in cooperation with the Austrian Industry and correspondent research networks, funding instruments and programmes as well on a national as on the European and international level.

Christa Kranzl

State Secretary Innovation and Technology

Austrian Federal Ministry for Transport, Innovation and Technology

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Introduction

Energy Systems of Tomorrow

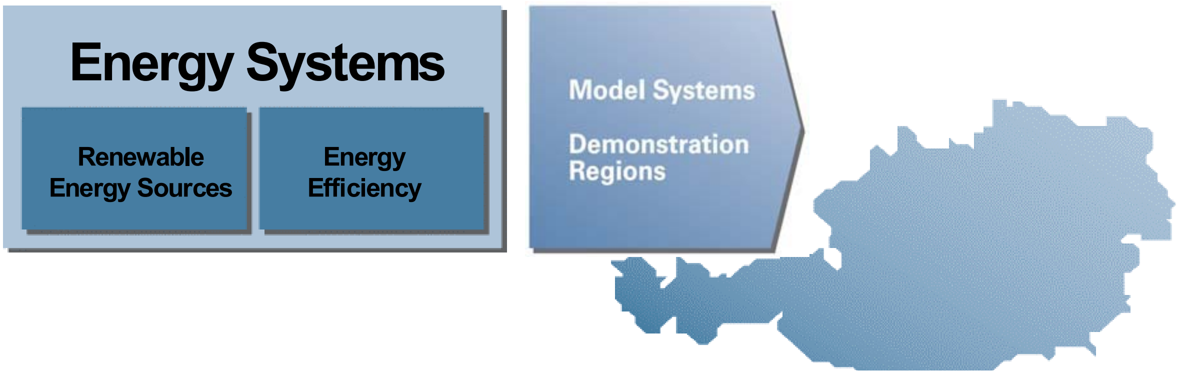
The Austrian targeted R&D Programme "Energy Systems of Tomorrow" was launched 2003. It focuses on the development of new technologies and concepts for a flexible and efficient energy system, based on renewable energy sources. Furthermore, it is an important goal to show their feasibility by realising demonstration projects.

The completed or ongoing projects presented in this publication are related to the subject area "grid-integration and management with distributed generation". The integration of distributed power generation from renewable energy sources into existing power grids gives many advantages including supply security, reduced transmission losses, and increased local economic output. Such an energy system is able to cover varying energy demands in a flexible, reliable and cost-effective way. The direct and indirect impact on the environment is thereby minimised and regional conditions are considered as best as possible.

"Energy Systems of Tomorrow" fosters research and development of new concepts and technologies as well as systems innovations and strategies. Whereas, project chains that lead from basic studies or concepts to concrete technology developments to demonstration projects are particularly valuable. In this respect, demonstration projects (e.g. model systems, model regions) shall be seen as "lighthouses of innovation" that are able to show how strategies concerning sustainability can lead to an increase in the quality of life and economic prosperity.

The programme focuses on

- energy efficiency,
- the use of renewable energy sources and
- systems innovations and strategies.



Goals of the Program

Besides the target structure developed for the Austrian Program on Technologies for Sustainable Development the following objectives play a crucial role in the programme:

- **Improvement of the over-all efficiency of energy systems and their components:** Intelligent energy systems can be created through innovations both at single components and of the total system. Those systems are able to cover varying and time-variable energy demands clearly more efficient. Moreover, questions of storage and load management as well as aspects of most efficient use of different energy products (e.g. electricity, process heat, low temperature heat…) and multifunctional energy plants also play a substantial role.

- **Provision of a technological basis for the increased integration of renewable energy sources:** The share of renewable energy sources can be noticeably increased through clever integration and improved system design. The use of renewable energy sources can create an added value for the regions and jobs can be safeguarded. Moreover a valuable contribution to the CO_2 problem will be achieved. Depending on the regional conditions and the energy demand a varying mix of solar energy, biomass, wind and waterpower can be implemented. However, this mix of renewable energy sources should be optimised according to the total system.

- **Improvement of the cooperation between science and economy and the extension of the Austrian technological strengths:** When asking questions about "Energy Systems of Tomorrow" it can be stated that an improvement of the cooperation between different protagonists from universities and research institutions and the economy is an important requirement in order to reach interdisciplinary and comprehensive solutions and technological breakthroughs. By means of cooperative projects, particularly in fields with high innovation potential, however, still with little degree of cross-linking (e.g. biogas), a professional approach and "bundling" of competences shall be supported in order to become internationally competitive. Both the know-how basis of the companies and the competence in the Austrian research area will be strengthened.

Strategy

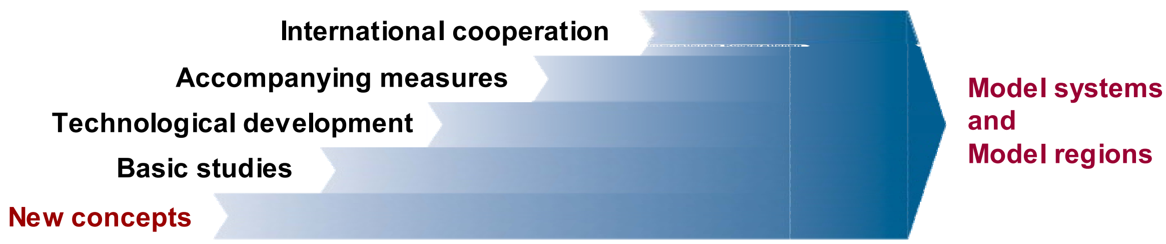
Innovations that are oriented towards sustainability can be valuable for certain areas of the Austrian economy. In order to use this potential, solutions and technologies have to be developed that are markedly superior to the already existing concepts in terms of variety, multifunctionality and high adaptability. Research projects and innovations are initiated on the following levels:

- Structural level: structural changes and changes of the system, systems performance, general conditions.

- Socio-economic level: changes in the user behaviour subject to knowledge, attitude and lifestyle, costs.

- Technological level: developments in key areas in consideration of the total chain of primary energy sources to the energy service.

The program is structured through calls for proposals which are carried out in regular intervals. Basic research studies, cooperative concepts and projects in which technologies are developed shall be initiated and financed. These projects will result in the development of demonstration projects such as model systems.



Besides the calls for proposals, accompanying measures are carried out. These measures shall support the formation of cooperative project consortia, the cooperation among the existing projects and the implementation of the project results. The intention of the competition "Energy Regions of Tomorrow" was to identify successful and innovative regions. These regions were seen as important partners for the program to develop technologies and model systems.

1st Call for proposals

In 2003 the subprogram “Energy Systems of Tomorrow” started with its first call for proposals. The design of the first call was thematically broader and had its main focus on basic studies and concepts. To some extent it already included concrete links for technological developments. The first call for proposals was structured into the following subject areas:

- Questions concerning the energy system, integration of renewable energy sources
- Innovative production and service systems
- Specific demand for technology development with special focus on system integration
- Strategic accompanying projects
- International cooperation (IEA participation)

However, due to intensive consulting done by the umbrella management, a number of demanding and high quality projects were submitted and could be started in 2004. Furthermore, it is worth mentioning that the high share of project cooperation was very pleasing (on average 4 partners per project) as well as the high share of projects in cooperation with enterprises (65% of the launched projects).

2nd Call for proposals

In 2005 the 2nd call was launched and had four deadlines until 2007. This call for tenders was structured into the following subject areas:

- Concepts for initiating and preparing model systems
- Grid-integration and management with distributed generation (renewables)
- Innovative production and service systems
- Specific demand for technology development
- Strategic accompanying projects

Strategy Finding: e2050

The trend-setting outcomes from Energy Systems of Tomorrow were picked up in the Austrian strategy finding process ENERGY 2050 (e2050). Having been started in 2004, e2050 is aiming at the creation of a long term vision for Austria´s Energy Future, involving the relevant Austrian stakeholders on a broad level. The process is initiated by the Austrian Federal Ministry for Transport, Innovation and Technology and has the concerns to gather a common view of the situation, develop and evaluate long-term options, establish R&D programmes and priorities and deduce innovation strategies. This shall be achieved through conferences, workshops, hearings, enquiries, survey reports, strategic research projects, and strategic cooperation on an European and international level.

Until 2007 seven thematic expert networks identified six technological and one strategic focal point and worked out key questions along this main issues.

Focal Areas

Energy systems and grids

Biofuels production (biobased industry)

Energy use in industry

Energy use in buildings

Demand side issues and appliances

Advanced combustion and conversion

energy and development of society
(Knowledge for Policy Making)

As a first result 2007 the call “Energy of Tomorrow” was launched, covering all seven focal points. The projects of this call were financed in cooperation with the Austrian Federal Ministry for Economics and Labour and the Austrian Climate and Energy Fund.

Projects

Project Overview

Title	Project status	published	Page
Virtual Power Plants and DSM	finished	44/2006	19
Fair market conditions for virtual power plants	finished	45/2006	23
Virtual power plants for self-sustaining regions	finished	58/2006	29
Virtual Green Power Plant	on-going		31
Wind-integration and load-management	finished	46/2006	33
Integral Resource Optimization Network Study	finished	42/2006	37
Integral Resource Optimization Network Concept			
Integration Through Cooperation	finished	47/2006	41
Energy Regions: Influencing socio-technical change by promoting technical visions in regional discourses and actor networks			43
DG-Grid: Enhancement of sustainable electricity supply through improvements of the regulatory framework of the distribution network for DG			45
Distributed Generation and Renewables – Power Quality	finished	48/2006	47
Active operation of electrical distribution networks with a high share of distributed power generation – Conceptual design of demonstration networks	on-going		51
Long time scenarios for economically optimal integration of micro-CHP into the Austrian energy system			53
Manual to realise initiatives for energy regions of tomorrow to compass the goals of the programm “Energy Systems of Tomorrow”		30/2007	55
Thermoelectric Generator for the Generation of Green Electricity in Biomass Fuelled Plants			56
Voltage stabilization by central reactive power control of biogas power plants - concept for a demonstration project			58
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Integral services	finished		71
SUPOSS – Sustainable Power Supply for Supermarkets and Surroundings	on-going	02/2006	74
Energy centres: Electric peak load balancing in food store chains- Strategies for energy efficiency improvement			79
Conception of innovative business models for active net integration of de-central consumers and production plants			81
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Incentive Net	on-going		85
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Efficient biogas processing with membran technique			107

Virtual Power Plants and DSM

(Original Project Title: Dezentral nachhaltige Energieversorgung als virtuelles Kraftwerk unter Nutzung von Demand Side Management)

Synopsis: For the cost efficient and lasting energy supply from ecological sources, wind, photovoltaic and biomass have to be integrated in existing grids. New methods for DSM and virtual power stations are investigated, to improve the control behaviour.

Due to the increased promotion of electricity from renewable energy sources in the EU-directive 2001/77/EC renewable power generation technologies have been forced powerfully. In Austria the regenerative electricity should cover electricity consumption up to 4 % until 2008. Therefore wind energy plants will contribute a main part with an installed capacity up to 1.700 MW.

In this study the effects of wind power production on the Austrian power system are analyzed.

Wind power production is characterized by stochastic generation trait and so it can be predicted with limited accuracy. Standard deviations of wind power forecast errors are about 10 % to 20 % of installed wind generation (state of the art). Therefore additional balancing energy of about 20 % of the yearly wind energy generation must be available.

In Austria the main wind potentials are focused in a small region (Burgenland and Lower-Austria) and so wind power generation can lead to a high grid loading.

The analysis of the Austrian high voltage grid shows, that high wind power generation can only be integrated if the grid will be strengthened.

The aim of this project is to dissipate balance energy caused by wind farms locally. For this purpose Demand Side Management (DSM) is a precondition and useable domestic loads are researched.

Relevant applications of households for DSM are:

- cooling and freezing
- washing, drying and dish washing
- space heating and hot water heating.

Other applications like cooking, illuminating, consumer electronics and so on can not be used for DSM because the loss of convenience is too high and so consumers would not really accept load shifting in these tasks.

The resulting load curves of the relevant applications are shown in figure 1.1 to figure 1.3. These loads determine the theoretical DSM potential in the APG-balance zone and in Austrian wind region respectively.

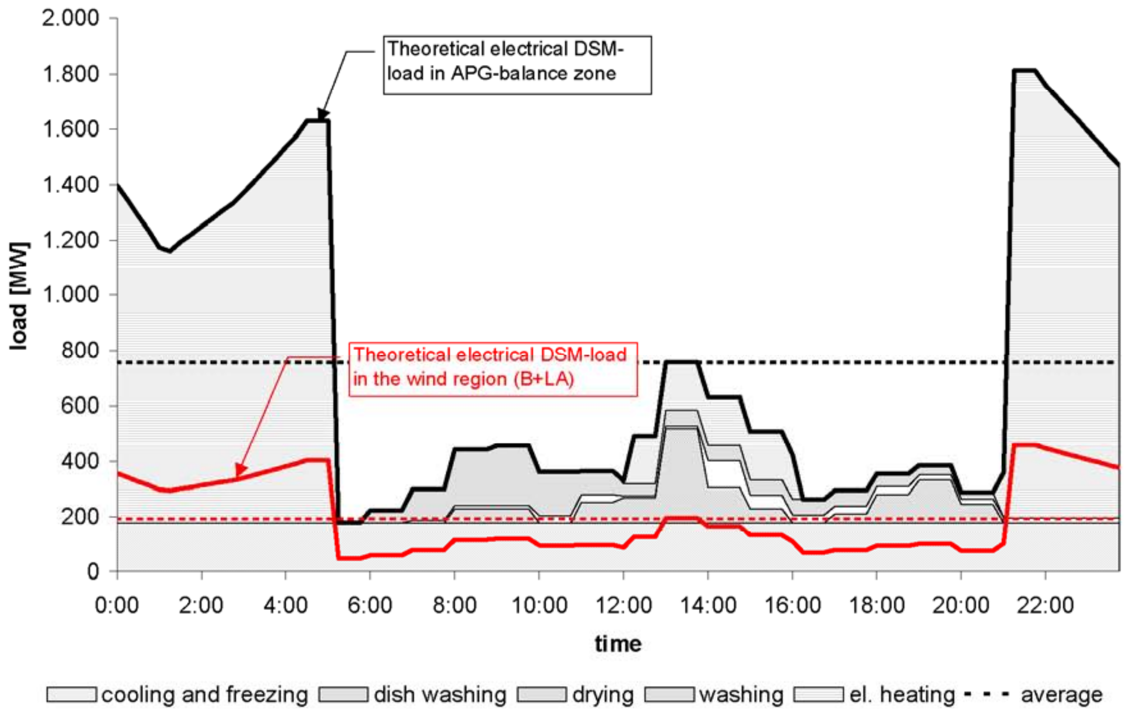


Figure 1: Theoretical DSM-Potential of relevant applications (including space and hot water heating) in households on a winter day

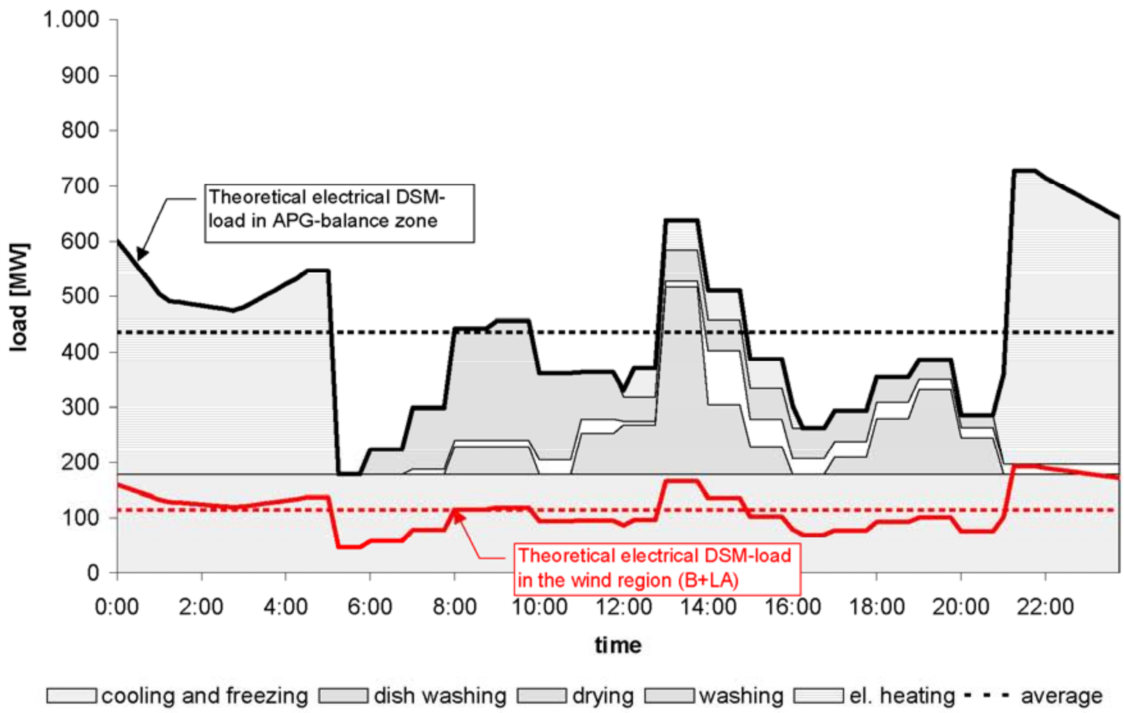


Figure 2: Theoretical DSM-Potential of relevant applications (including space and hot water heating) in households on a spring or autumn day

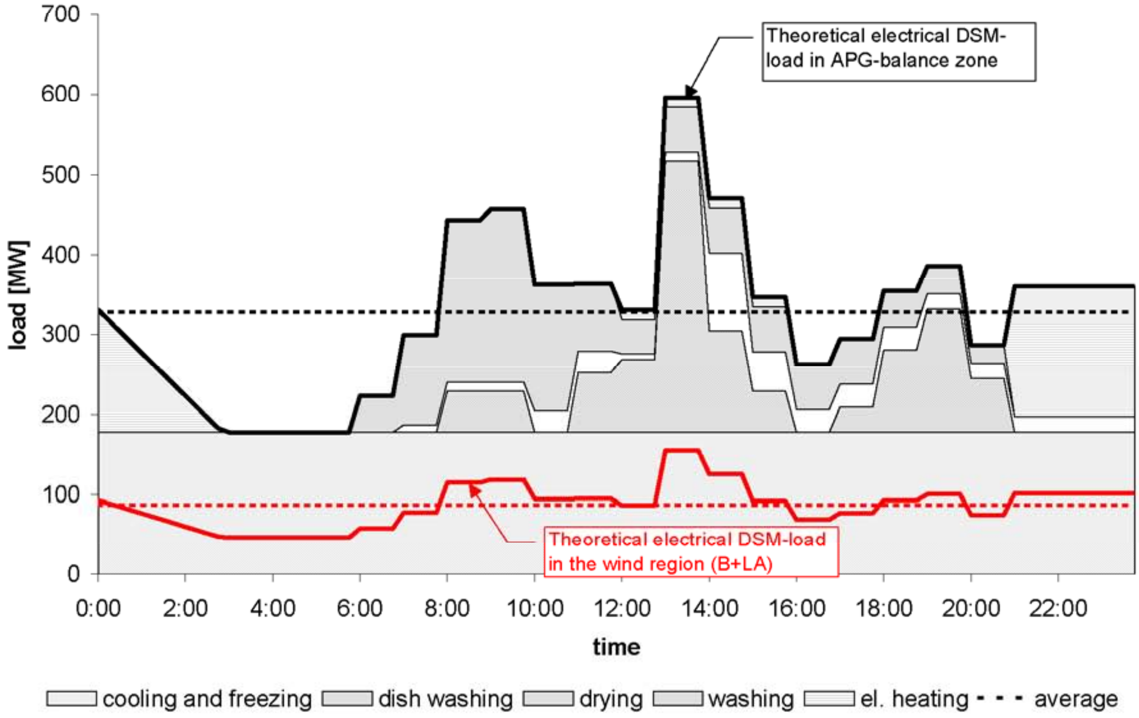


Figure 3: Theoretical DSM-Potential of relevant applications (including space and hot water heating) in households on a summer day

The main results and conclusions of these analyses are:

- The theoretical DSM potential of electrical applications in households is characterized by large daily and seasonal variations. In the APG balance zone it is on average about 757 MW on a winter day, 358 MW on a summer day and 436 MW on a day in transitional period.
- Non-heating applications like washing machines, drying machines, refrigerators and freezers make a small theoretical DSM-potential. The main part within this group give refrigerators and freezers, which cause a base load of 178 MW.
- Heating applications dominate the theoretical DSM potential. This can be seen in the fundamental seasonal variations of the DSM load.
- In the Austrian wind region (Lower Austria and Burgenland) the average of the theoretical DSM potential of electrical applications in households is 193 MW on winter days, 87 MW on summer days and 114 MW on days in transitional period. Without heating applications it is on average 80 MW per day.

The technical and economical implementations depend on the technical complexity and costs of the control equipment. There must be also financial incentives for the customers to stimulate the acceptance of DSM. The valuation also depends on prices for balancing energy.

The conclusions of the analyses have shown, that heating applications are the main parts of DSM-potential. The storage abilities of buildings and heat reservoirs suit for load shifting without having any loss of convenience. This potential can be increased by using bivalent (fuel/electric) heating systems i.g. the substitution potential of fossil heating energy (domestic fuel) will result a in a bigger potential for reducing wind related balance energy via DSM.

In the APG balance zone (and Austrian wind region respectively) the theoretical DSM potential of thermal applications in households averages 32 MW (10 MW) on winter days, 3,9 MW (1,1 MW) on summer days and 11 MW (3,3 MW) on days in transitional period per % substituted fossil energy.

So the fluctuations of wind can be balanced locally and this works like a virtual oil spring because of using regenerative wind energy instead of fossil heating energy. Therefore fuels and CO_2-emissions (in households and in balancing power plants) can be saved.

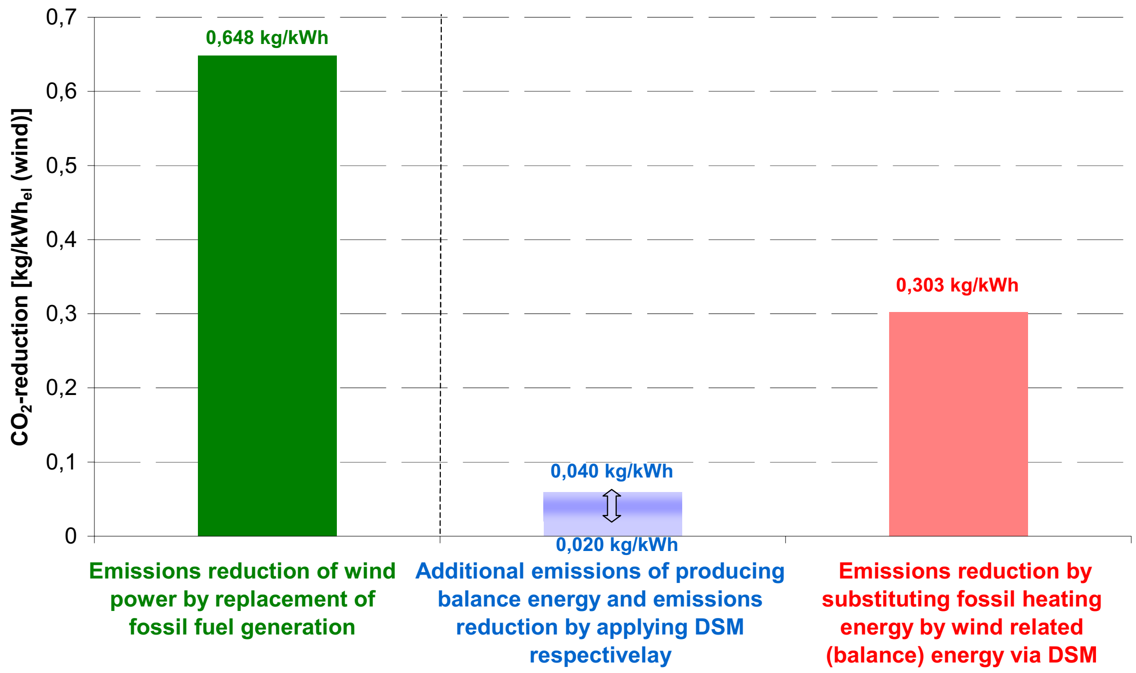


Figure 4: CO_2-reductions related to wind and DSM

The results show, that wind related CO_2-reductions are mainly determined by the replacement of conventional thermal electricity production. Additional CO_2-emissions causes by producing balance energy are very small because of the big contingent of pumped storage power plants in Austria. So there are moderate emission reductions by applying DSM.

High CO_2-emission reductions can be effectuated by substituting fossil heating energy by wind related balance energy via DSM. Therefore the use of bivalent heating systems can increase the climate efficiency of wind power plants.

Another effect of using bivalent heating systems can be used if the Austrian high voltage network will be completed adequately: Shut downs of wind power plant as a result of bottlenecks can be avoided by using wind energy locally in the wind region. This will also decrease CO_2-emissions in domestic fuel at least.

Contact:: Günther Brauner
TU Wien, Institut für Elektrische Anlagen und Energiewirtschaft
E-Mail: g.brauner@tuwien.ac.at

Fair market conditions for virtual power plants

(Original Project Title: Faire Wettbewerbsbedingungen für "Virtuelle Kraftwerke")

Synopsis: Analysis of technical, economical and regulatory conditions to get fair terms under competition in the liberalised market for virtual power plants on renewable energy basis.

The objective of this project is to analyse the general technical, regulatory and economical conditions for “Virtual Power Plants” (VPP) based on renewable energy sources. In this case a VPP is defined as an interactive, centrally controlled network of decentralised generation units with varying shares of different technologies used to meet the overall demand. Thereby communication and control systems allow to monitor and to control the operation of generation units as well as selected appliances on the demand side in order to maximise the revenue of the operating company. For the optimisation of the operation of a VPP data on relevant generation unit parameters, fuel cost, cost and potentials of storage options and responsive loads, etc. is needed in order to be able to compare cost of control options with expected cost of imbalances. In this way a VPP due to its high degree of flexibility allows to integrate intermittent generation technologies like wind power more efficiently and therefore provides an added value compared to the conventional operation that imposes high cost for imbalances and has furthermore negative effects on system stability.

The major motivation for this project is to lower competitive disadvantages for small market players operating distributed generation units based on renewable energy sources compared to incumbents characterised by large scale generation. In this context the liberalisation of the Austrian power market according to EC directive 96/92/EC in general provides a suitable framework for a non discriminatory market entry. However economical as well as administrative barriers still exist and impose hurdles in form of high transaction cost especially for small market actors.

In order to be able to address to core questions of this project it is necessary to define the term “Virtual Power Plant” with respect to the existing Austrian market framework. Furthermore international experiences with distributed generation in general and VPP in particular are analysed with respect to the framework of the Austrian market model. Finally diverse generation portfolios including intermittent generation from wind power are analysed with respect to their imbalance cost.

The major result of the project is a basic concept for VPP based on renewable energy sources including a detailed specification sheet with respect to requirements for communication and information technologies which provides the basis for the concrete design of such a system.

The main methodology developed and applied within this project is an economic model of a VPP based on MS Excel that allows to determine imbalance cost for a set of defined technical and regulatory framework conditions. Most relevant input parameters are time series of generation, demand, sale and purchase contracts and imbalance clearing prices. The model allows to evaluate different generation portfolios with respect to their need of imbalance power and corresponding cost.

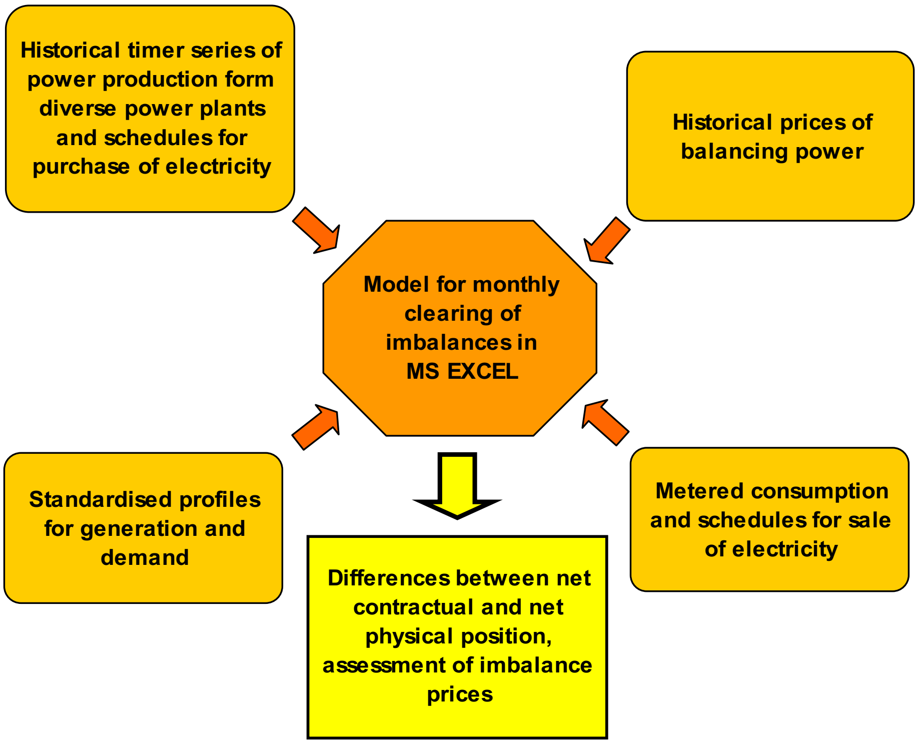


Figure 0.1: Schematic illustration of the economic VPP model

To determine volumes of imbalance energy and corresponding cost for a certain month, time series of generation and demand for units considered in the analysed portfolio are imported into an MS Excel sheet. Based on this data imbalances are calculated for every quarter of an hour and absolute values are summed up giving the value of net imbalances. Finally based on historical or assumed data on imbalance prices corresponding imbalance cost are allocated. In a first step the objective is to minimise cost for imbalances as indicated in formula! 0.1

Formula 0.1

$$\min_t K_{AE} = \min \sum_t \left(\left(\sum_i E_{i,t} - \sum_j V_{j,t} \right) * ICP_t \right)$$

K_{AE}:	Total cost of imbalances [€]
$E_{i,t}$:	Production / purchase of power in period t (of power plant i / according to contract i) [MWh]
$V_{j,t}$:	Demand / sale of power in period t (of consumer i, consumer group j / according to sales contract j) [MWh]
ICP_t	Imbalance clearing price in period t [€/MWh]

When setting up the economic model of the VPP its role as a balance responsible player within the balancing zone of *Verbund APG* was taken into account as it defines the economical framework conditions.

In Austria at present the major part of electricity generation from renewable energy sources (RES-E) is aggregated by one single balancing responsible player for "green electricity" for each balancing zone, the so called *Ökobilanzgruppe*. RES-E generators selling their power to the *Ökobilanzgruppe* are paid a guaranteed feed-in tariff over a period of 13 years which imposes minimal risk for the investment as even the risk for imbalances is carried by the balance responsible player that finally socialises the corresponding cost among all consumers. Therefore a RES-E generator hasn't any incentives to control power output of his generation units in order to support balancing the system.

For the small share of RES-E generation that is sold on the power market high cost and risks due to imbalances especially for intermittent generation like wind power are identified. For now there a only few small market actors like the project partner *oekostrom AG* which are selling "green electricity" on the market but due to the given supporting period which is limited to 13 years, the amount of generation from RES-E that has to be marketed conventionally is going to increase steadily. Therefore within the next years the value of intermittent generation will heavily depend on the general conditions given by market design and rules and innovative approaches are needed to provide an economically efficient integration.

Analysis carried out within this project show, that an increasing share of intermittent wind generation in the generation portfolio imposes considerable imbalances as fluctuations increase whilst the load curve for residential and commercial customers is given. In this respect it is important to note, that the correlation of the power output from different wind farms decreases if the spatial distribution of wind sites considered becomes higher. As for generation from Photovoltaic (PV) standardised profiles are used according to the market rules implemented in Austria, this technology shows a high correlation with the load profiles considered.

The value of "green electricity" in general and intermittent wind power in special is considerably influenced by the specific market design. The international comparison of market designs with focus on balancing markets shows, that the integration of wind power can be supported if there is an organised intra-day market available that allows adjusting schedules until few hours before physical delivery. Furthermore, if markets cover an extended geographical region, smoothing effects can lower the overall imbalances given that transmission capacities are available.

Labelling of electricity is identified as to be an important marketing instrument for retailers of "green electricity". However at present its impact is limited as there is no central database implemented for the management of proofs of origins in Europe that would avoid misuse of the labelling system.

Detailed analysis of historical imbalance clearing prices in Austria shows, that market rules considerably influence the competitiveness of VPP as balancing responsible players (with a high amount of net imbalances due to intermittent generation). The change of the Austrian market rules within the duration of the project allowed comparing the correlation between system imbalances and imbalance prices for two different price models (see Figure 0.2).

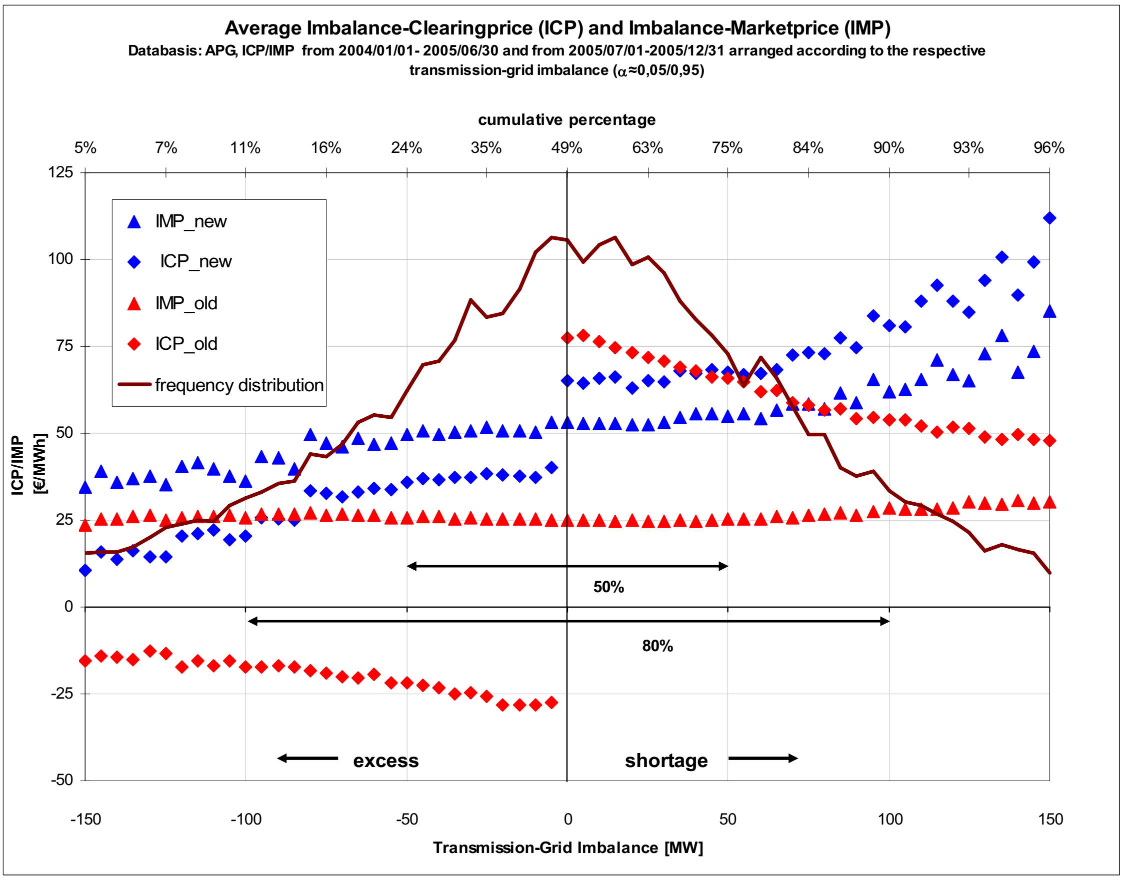
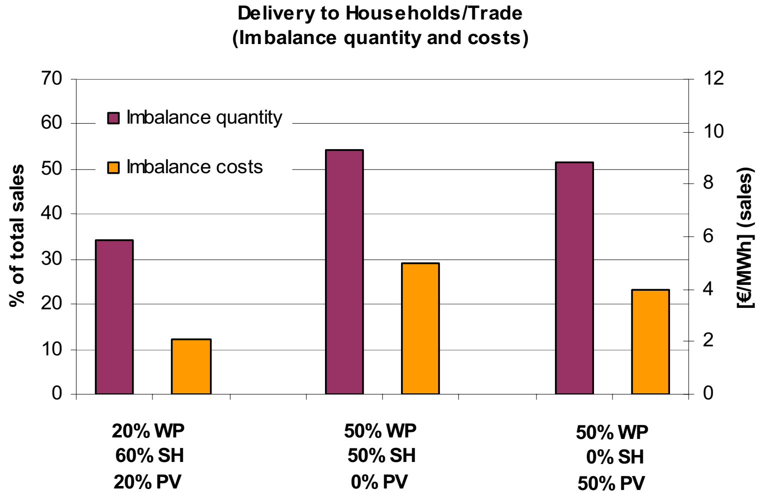
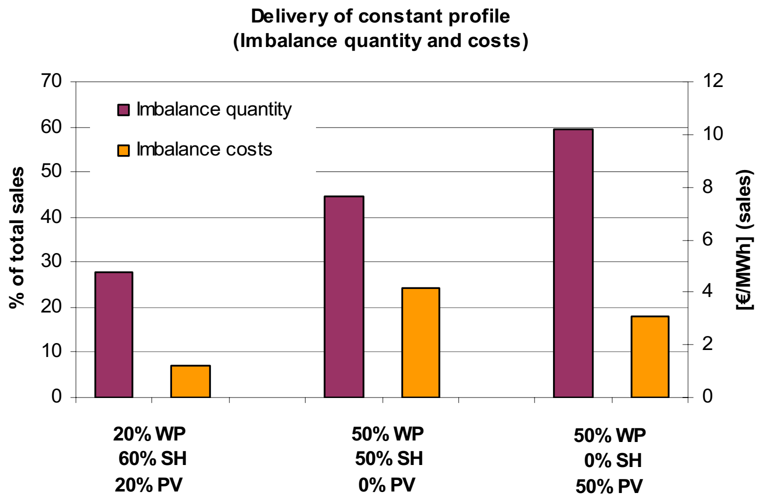


Figure 0.2. Comparison of market prices and clearing prices for imbalances for two different price models currently and historically implemented in Austria. Source: APCS (www.apcs.at), 2004.

Portfolio analysis carried out with the economic VPP model underlines the results from correlation analysis of wind power outputs. Overall imbalances as well as corresponding cost increase with a growing share of wind power. As both, the net imbalance of the balancing responsible player and the net imbalance of the balancing zone are influenced by the wind power forecast error to a high extent, imbalance clearing prices tend to be higher for such market actors. An increasing share of small-hydro generation instead influences imbalance cost positively. An outline of the model results is given in the following figure.



Load	Imbalance	
	% of sales	[€/MWh]
20% WP; 60% SH; 20% PV	**35**	**2,20**
50% WP; 50% SH; 0% PV	**54**	**5,10**
50% WP; 0% SH; 50% PV	**49**	**3,93**



Band	Imbalance	
	% of sales	[€/MWh]
20% WP; 60% SH; 20% PV	**28**	**1,23**
50% WP; 50% SH; 0% PV	**45**	**4,15**
50% WP; 0% SH; 50% PV	**59**	**3,12**

Figure 0.3: Quantity and cost of imbalance in three scenarios for the generation portfolio and two sales-scenarios using historic time series for generation, consumption and prices (Data basis: 20 months) Source: EEG, oekostrom AG.
WP: windpower, SH: Small Hydro, PV: photovoltaic

Several needs with respect to communication and information technologies for the implementation of a VPP based on renewable energy sources within the liberalised Austrian power market are described in the technical specification sheet worked out within this project. This description gives the basis for the concrete design of a VPP incl. a functional specification, a cost projection and a detailed schedule for implementation in the course of the follow-up project.

Contact: Peter Palensky
TU Wien – Institut für Computertechnik
E-Mail: palensky@ict.tuwien.ac.at

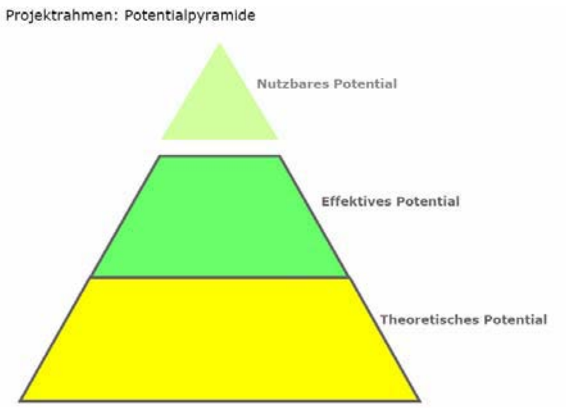
Virtual power plants for self-sustaining regions

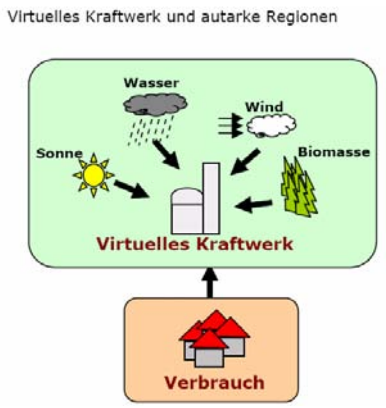
(Original Project Title: Virtuelle Kraftwerke für autarke Regionen)

Synopsis: Geographic methods for the combination of renewable energy sources to create "virtual power plants" and development of self-sustaining regions in terms of energy-balance and the Kyoto target.

Austria's national energy supply is primarily organised on a trans-regional level. A large amount of hydroelectric power contributes to a comparatively positive situation regarding renewable energy sources. Even so, meeting the legally binding emission target of the Kyoto Protocol will be difficult due to a rising energy demand and an energy production that remains dominated by fossil fuels. Renewable energy sources are primarily used to meet demand on a local level, as their large-scale exploitation is limited by economic and technical constraints as well as by resource availability.

The purpose of this project is to develop a mainly regional organised energy supply system with a high degree of internal energy self-sustenance. The highly variable production potential of renewable energy sources should potentially be compensated within one region.

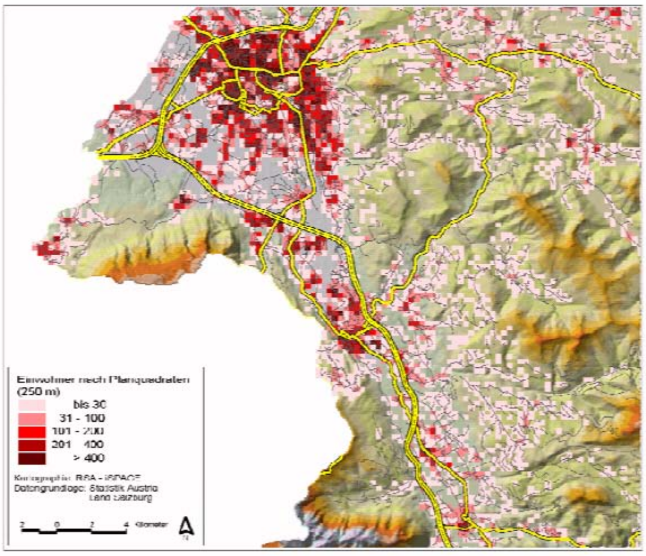




The present project adopted a clearly defined catalogue of objectives, which was accomplished within a specified test region:

- Definition and description of the test region Salzburg / Berchtesgaden (watershed of the rivers Salzach and Saalach) and assessment of the current situation
- Development of GIS-based strategies and methods for a geographically based, highly resolved estimation of the theoretical energy potential of biomass, hydro power, solar power and wind power
- Comparison of these theoretical potentials to the effectively available energy potentials of renewable sources, considering social, ecological and technical constraints
- Development of spatial indicators to delineate areas that meet the condition of internal self-sustenance by combining virtual power plants and the energy consumption structure in the test region
- Development of transferable models based on the results in the test region and conceptual preparation of the results to offer a strategic decision support tool

Verbrauchsstrukturen in Salzburg (z.B. Einwohner)



The opportunity to create energy self-sustaining regions based on the optimal combination of different renewable energy potentials into virtual power plants and their correlation with the relative energy demand structure offers a distinctive perspective for decision makers.

The present project results underline the value and structural advantage of organising a balanced, multi-source energy supply on a regional scale, focusing on renewable energy sources. Through the complementary geographic perspective they provide a valuable concept and decision support tool to promote policies and influence relevant legislative, regulatory and institutional frameworks for achieving the commitment to the Kyoto Protocol.

Contact: Manfred Mittlböck
Research Studios Austria ARC Seiberdrsdorf research GmbH
E-Mail:Manfred.mittlböck@researchstudio.at

Virtual Green Power Plant

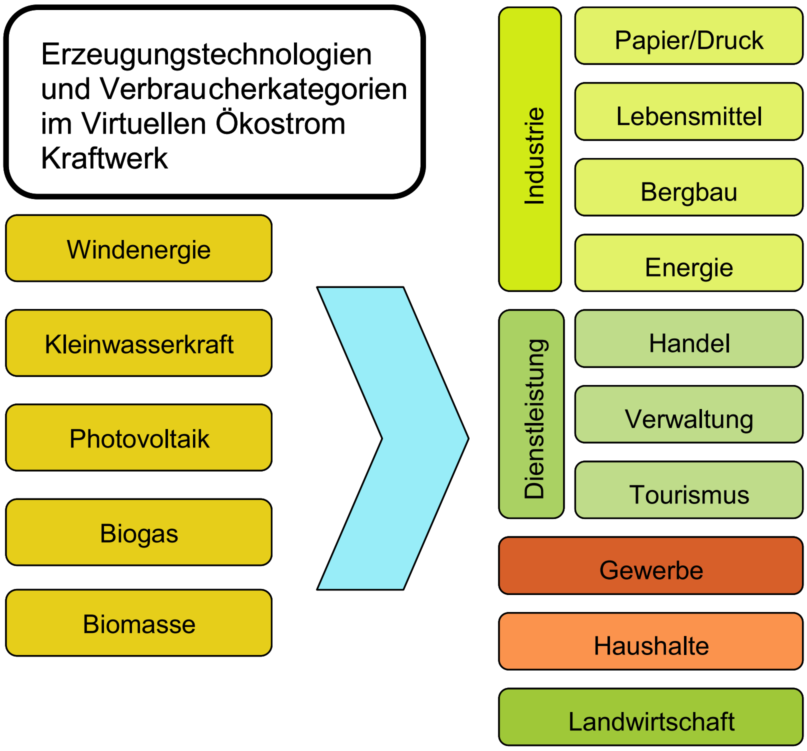
(Original Project Title: Virtuelles Ökostrom-Kraftwerk)

Synopsis: Preparation and initiation of the implementation of a Virtual Green Power Plant based on renewable energy sources at the Program Responsible Party of oekostrom AG – The conception of a power utility within the Austrian power market.

Core Objectives of the proposed project

The core objective of this project is to enhance the competitiveness of (grid-integrated), distributed power generation from renewable energy sources (RES-E) under current market rules in Austria. This objective will be achieved by an optimised and coordinated operation of power plants and loads within the model-system of a Virtual Green Power Plant.

The implicit objective is to integrate RES-E into the existing supply system more efficiently (i.e. rising the ecological as well as economical utilisation) taking into account their specific characteristics (e.g. intermittency of wind power, etc.).



Contents of the project

The core content of the proposed project is to initialise the demonstration of an innovative model system for power supply (from RES-E) – compatible with the existing regulation of the Austrian market – by the partners in this project: oekostrom AG, SIEMENS AG and SPAR Österreichische Warenhandels AG. In the course of the project this model system is developed in detail in order to utilise RES-E with volatile characteristics (wind, small hydro and photovoltaic), in a physically and cost-efficient way – and to mutually establish a balance with the load.

Working program

The results of the fundamental studies “Equitable competitive conditions for Virtual Power Plants” and “Wind integration supported by Demand Response” will be used as valuable inputs for the design of an overall balancing group as a Virtual Power Plant.

After the identification of relevant technical parameters of RES-E technologies (small hydro, wind, biomass, photovoltaic) and appliances of customers in different sectors (trade, industry, authorities, households and agriculture) the modular software DEMS (Decentralized Energy Management System) of SIEMENS PSE is utilised to model the Virtual Power Plant and simulate real-time operation of distributed power plants and loads. Necessary input data contains time series of production forecasts and actual power production as well as consumption and prices for balancing energy. Furthermore, data on demand response potentials, marginal costs of power production and costs for starting units and storing energy has to be procured.

Within the simulation runs, the operation of the Virtual Green Power Plant is optimised for different compositions of generation portfolios and consumer-structures as well as potentials for demand response and therefore the decisive factors for the cost-efficient operation of the overall balancing group are detected. In addition the results from conducted simulation runs are used to prepare requirement specifications and budget the costs for the technical implementation of the Virtual Power Plant for at least two different design options.

Finally the results of the project are disseminated in the course of public events and presentations of recommendations for action addressing potential operators of Virtual Power Plants.

Major results

The major result of this research project is a detailed Action Plan for the implementation of a Virtual Power Plant within the company and the balancing group of oekostrom AG. This Action Plan comprises a schedule for implementation as well as cost projections for necessary technical installations and organisational adjustments. Cost projections are thereby prepared according to the elaborated requirement specifications as a result of the economic evaluation of the optimised operation of the Virtual Power Plant in different implementation scenarios.

From this action plan business strategies and recommendations for potential operators of Virtual Power Plants are derived.

The consortium is planning to technically realise the concept of the Virtual Green Power Plant in the course of the 3rd Call of EDZ..

Contact: DI Carlo Obersteiner, DI Lukas Weißensteiner
TU-Wien, Institut für Elektrische Anlagen und Energiewirtschaft (EEG)
E-Mail: obersteiner@eeg.tuwien.ac.at

Wind-integration and load-management

(Original Project Title: Modellierung von Kraftwerksbetrieb und Regelenergiebedarf bei verstärkter Einspeisung von Windenergie in verschiedene Energiesysteme unter Berücksichtigung des Last-managements)

Synopsis: Simulation of optimal strategies for wind-integration into the Austrian and German energy system taking into consideration potentials for load-management in order to maximise the resulting CO_2-saving effect

As the amount of wind generation on an electricity network increases, the impacts on power system operation become evident and lead to extra costs and reductions of CO_2-emissions. Based on the existing literature it is not clear, to which extent these effects are influenced by the configuration of the power system and whether measures on the demand side allow more efficient integration of this renewable energy source. Answering these questions may help to compare wind power with other conventional as well as renewable energy technologies in a consistent manner and allows to evaluate approaches for an optimised integration of wind energy in power systems with different characteristics.

Several effects of wind power production on power system operation are analysed for predominantly thermal (Germany) and a hydro-thermal system (Austria) and corresponding costs and CO_2-reductions are allocated. Furthermore potentials for demand response are determined for different consumption sectors and technical as well as economical aspects of using power demands to provide reserves are investigated. Extra costs and net-CO_2-reductions related to wind power are determined by running simulations with a power system model developed within this project. Basic data for the simulation include hourly time series of wind power and demand as well as capacities, technical and economic parameters of the conventional power plants until 2020.

Main results and conclusions of this study are:

According to the BAU-scenario wind capacity continuously increases in Austria and Germany until 2020 (see table below). The annual wind power production rises up to 2760 GWh in Austria which is equal to 3.9 % of the annual total consumption. In Germany the annual production from wind power increases up to around 100 000 GWh for the year 2020 or 18.1 % respectively.

Table 1: Assumptions for the development of wind capacity and wind power production for Austria and Germany until 2020.

Baseline-scenario		**2000**	**2005**	**2010**	**2015**	**2020**
AT	Wind capacity in MW	77	654	1.162	1.209	1.494
	Wind power production in GWh/yr	129	1.226	2.138	2.232	2.760
	Full load hours in h/yr	1.675	1.875	1.840	1.846	1.847
DE	Wind capacity in MW	6.039	17.000	23.100	29.400	39.000
	Wind power production in GWh/yr	10.668	29.850	43.915	65.484	98.987
	Full load hours in h/yr	1.767	1.756	1.901	2.227	2.538

The main objective for promoting energy from renewable sources is to reduce CO_2-emissions. Wind power is replacing production from power plants that operate with fossil fuels, which leads to lower overall emissions of the energy system. The amount of the corresponding reduction is influenced by the wind power production as well as the shares of the production of different technologies that are replaced.

According to the baseline-scenario specific CO_2-reductions of wind power in Austria decline from 0.75 tCO_2/MWh(wind) in 2005 to 0.48 tCO_2/MWh(wind) in 2020. Because of the higher share of replaced production from coal plants the corresponding numbers for Germany are around 15 % higher. The results show, that the specific reduction of CO_2-emissions declines with higher wind penetrations, because production from power plants with lower emissions is gradually replaced.

Wind power, as an intermittent energy source that can be predicted to a limited extent. Current standard deviations of the wind power forecast errors in Austria are around 13.5 % and in Germany around 6.5 % of installed wind capacity. In Germany the fluctuations of wind power production are lower due to higher spatial distribution and better wind forecast tools based on meteorological approaches are used. The uncertainty of wind power leads to additional requirements for minute reserves and to higher amounts of balancing power.

Costs allocated to additional reserve requirements and balancing power (balancing costs) occur in form of opportunity costs und due to lower efficiencies of thermal power plants when operating part loaded. Specific balancing costs increase with higher wind penetration levels. In the baseline-scenario specific balancing costs rise up to 1.8 €/MWh(wind) in Austria and 3.5 €/MWh(wind) in Germany for the year 2020. The most important parameters that are influencing these costs are the quality of wind power forecasts and the configuration of the power system. Lower forecast errors may lead to a decrease of the costs in the range of 30 % until 2020. Because of increasing congestions on the on the network that lead to a lower availability of flexible production costs may rise up to 15 %.

Annual extra costs and CO_2-reductions related to wind power are summarised in the following tables. Please note, that there are effects on the operation of the existing power plants considered too.

Table 2: Development of additional annual system operation costs related to wind power in Austria and Germany until 2020 according to the baseline-scenario.

	Baseline-scenario	**2000**	**2005**	**2010**	**2015**	**2020**
AT	Reserves and balancing power cost in Mio.€/yr	0,0	1,2	2,6	2,6	3,6
	Power plant operation cost in Mio.€/yr	0,1	0,6	1,1	1,1	1,4
	Total system operation cost in Mio€/yr	0,1	1,8	3,7	3,8	5,0
DE	Reserves and balancing power cost in Mio.€/yr	11,2	70,9	115,9	173,2	281,9
	Power plant operation cost in Mio.€/yr	5,3	14,9	22,0	32,7	49,5
	Total system operation cost in Mio€/yr	16,5	85,8	137,9	205,9	331,4

Table 3: Development of annual CO_2-reductions related to wind power w/o consideration of additional system related emissions for Austria and Germany until 2020.

	Baseline-scenario	**2000**	**2005**	**2010**	**2015**	**2020**
AT	CO2-reduction in MtCO2/yr	0,10	0,91	1,26	1,27	1,32
	CO2-reduction incl. Power Plant operation	0,10	0,86	1,19	1,21	1,28
	CO2-reduction incl. PP operation & reserves	0,10	0,86	1,19	1,21	1,27
DE	CO2-reduction in MtCO2/yr	9,35	25,73	31,84	45,51	66,22
	CO2-reduction incl. Power Plant operation	8,78	23,73	29,99	42,50	61,37
	CO2-reduction incl. PP operation & reserves	8,77	23,61	29,82	42,30	61,07

The results show, that costs for additional balancing costs are dominant for the current wind penetration level and becoming even more relevant with higher penetration. Wind related CO_2-reductions are mainly determined by the replacement of fossil fuel production and effects on system operation lower this potential in the range form 4 % (Austria) to 8 % (Germany) in the year 2020.

Fairly new approach to encourage the integration of wind power is to use demand response to balance intermittent production. The main motivation for this approach is not to reduce CO_2-emissions, but to provide system security and financial benefits for utilities.

Appliances have to show specific characteristics to be suitable for providing power reserves. Table 4 gives an overview on the most important responsive appliances and their classification.

Table 4: Overview on responsive loads in different sectors.

Sector	**Appliance**	**Categorie**		
		Storage	Flexible	Discetionary
Housholds	Cooling/Freezing	**X**		
	Washing		**X**	
	Drying		**X**	
	Dish washing		**X**	
	Lightning			**X**
Commercial sector	Cooling	**X**		
	Ventilation		**X**	
Public sector	Cooling	**X**		
	Ventilation		**X**	
Industry	Cooling	**X**		
	Ventilation		**X**	

Potentials for demand response are primarily determined by the aggregated consumption of flexible appliances and are therefore depending on daytime and season. The technical potential is furthermore reduced by the aggregated availability that is in the range of 80 %. Technical constraints (like e.g. temperature limits of cooling appliances) limit the potential of demand response as the duration of the activation increases. The comparison of technical potentials off flexible loads in households with current and future requirements for minute reserves in Austria show, that the consumption is able contribute to system balancing to a high extent (see figure 1).

Based on the existing empirical data it is not possible to determine the realisable potential of reserves from consumption. Future trends that provide incentives for the activation of demand response are decreasing conventional power capacities and increasing shares of wind power in the system.

The Norwegian case shows, that power reserves from demand response can provide system security especially during peak load events even better than power plants can do. Using loads as power reserves may therefore be an adequate measure to react on the varying contribution of wind power to the system security. In contrast to the installation of new power plants, flexible loads are already available.

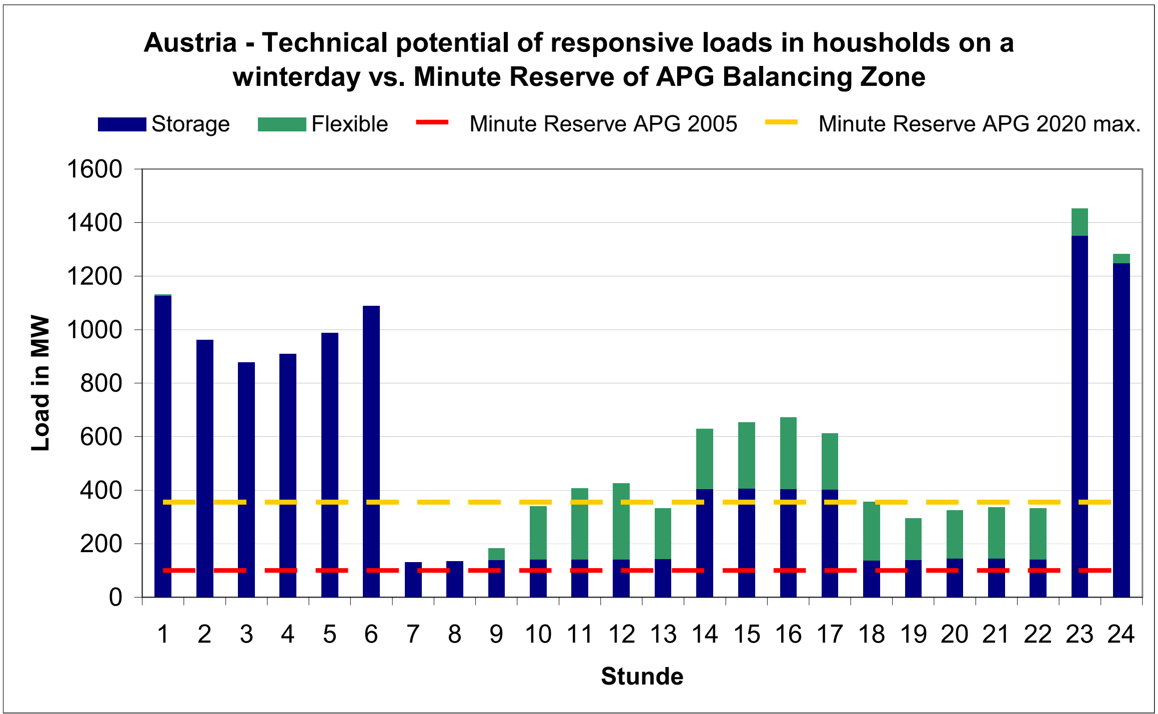


Figure 1: Comparison of the technical potential of responsive loads in households on a winterday with current and future requirements for minute reserve of the APG Balanzing Zone. Assumptions: Wind power development according to BEST-scenario, wind forecast error = 13.5 % (RMSPE).

The work conducted has shown that on the short to medium term better wind power forecasts may ensure a more effective integration of wind power. The comparison of the Austrian and German system shows, that the shares of different power technologies are considerably influencing additional wind related system costs. If the system becomes less flexible because of congestions or a decreasing share of flexible units, wind related costs are rising slightly. Activating demand response is an adequate measure to react on the limited contribution from wind power to system security especially when conventional capacities decline. For balancing groups with an increasing share of wind power, demand response may be an option to limit costs for balancing services in the future. The current allocation of grid related costs to wind power operators is not considering the fundamental principle of unbundling. This leads to discrimination concerning the access to the existing grid in Austria. In Germany the allocation from grid connection costs to wind power producer is the major barrier for the coordinated extension of the existing coastal grid, which is of importance for the future wind power development offshore.

Additional research is needed to identify how current market designs have to be adapted to react on the increasing share of intermittent production from wind power in Europe. One further interesting question is whether integrating demand response to optimise production and consumption can raise dividends for utilities under current conditions.

Contact: Hans Auer
TU-Wien, Institut für Elektrische Anlagen und Energiewirtschaft
E-Mail: auer@eeg.tuwien.ac.at

Integral Resource Optimization Network Study

(Original Project Title: Integral Resource Optimization Network Study)

Synopsis: A robust and distributed control network for optimizing the resource "electrical energy". Consumers, producers and storages organize themselves and their usage of electrical energy in order to exploit previously unused optimization potential.

Motivation and Goals

According to a Study of the International Energy Agency electricity's share of the total energy market in OECD countries is expected to grow from 24 % in 1970 to 40 % in 2020. The demand for electricity is growing continuously from year to year. At the same time, available capacity is reduced (because of companies' cost reduction policies in liberalized markets and expiring life time cycles), shortages are lurking.

To operate grids with a high level of distributed generation, new technologies and concepts are necessary, especially new control- and management systems. All available energy resources, traditional elements from the supply side as well as new potentials from the demand side or the distribution grid, shall be used in a flexible way to create the most efficient system possible. An appropriate flow of information is needed to seamlessly weave together the potentials of the individual resources. This is the long-term goal of the iron project: the development of a highly distributed communication infrastructure to exploit so far unused optimization potentials of the resource "electrical energy" – and to take the first steps towards its implementation.

At the moment, some participants of the electricity system are only very badly or not at all integrated. Those are:

- „Intelligent" consumers. Some appliances know in advance, at least partly, how much energy they will consume in the near future and can make a prognosis about it, e.g. washing machines.
- "Virtual" energy storages. These are flexible loads or consumers which can store energy for some time based on inert processes, e.g. heating or cooling devices.

Distributed generators. Examples are wind power stations, fuel cells, micro turbines, etc.

The new infrastructure increases the density and the quality of information available within the energy system and the possibilities to communicate this information. On the generation side, using control technologies to ensure a reliable and efficient energy supply is state-of-the-art. On the consumers' side, there is usually no or only a very primitive infrastructure to optimize demand. Often, there are no incentives for the customers to reduce their loads in times when energy supply is short, because they do not get a reward for this. They always have to pay the same fixed price (tariff).

State-of-the-art

This is sometimes different for big industries, but also smaller ones. Depending on their contract, they will be equipped with load profile meters which make it possible to account for the shape of consumption (the load peaks) as well as the accumulated load. The established solution for this are "maximum demand monitors". They try to limit the demand within the measurement intervals by using a simple estimation extrapolating the current consumption trend up to 15 minutes into the future (Figure 1).

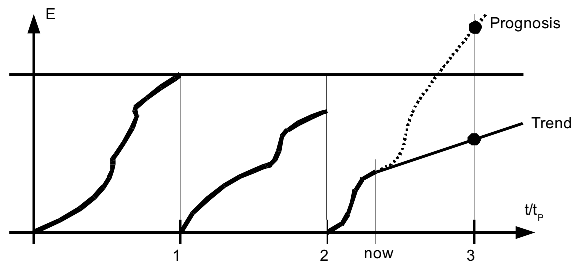


Figure1: Current maximum demand monitors are estimating future consumption by calculating a simple trend instead of a prognosis.

This is of course a very primitive method to influence or to flatten loads. Using more information, a much better prognosis – which could be very different from the trend – can be calculated. Moreover, several maximum demand monitors located at various branches of a company or at different customers' private homes could be networked to create a common load profile for a firm or a geographical region, but this is not state-of-the-art.

Programs and systems enabling customers to dynamically manage their loads in fast reaction to current market and system conditions are called demand response or demand side management systems. Although such systems have been discussed for quite a long, they have not managed to succeed on the market up to now. This is due to the insufficient degree of automation of existing solutions. DR programs are mainly used in the USA. One of the few concepts used in Europe can be found in Ireland since the early 90s („Short Duration Interruptible Tariff").

Economic requirements for the new system

To get a detailed view of the current problems and trends of the (Austrian) power market several participants (customers of variable size, utility managers, energy suppliers, etc.) have been interviewed about their opinions concerning market tendencies in general and the IRON system in particular. Lurking problems have been discussed as well as short- and medium-term solutions for the energy system of the future.

A continuous increase in demand (more than the economic growth) and a reduction of available capacities is expected by all experts. Without taking counter measures, shortages in supply are unavoidable.

Efficient measures for shortage and emergency management are very important. So far, only the generation side and the grid are included into solutions, but not the demand side. Having to cope with increased levels of renewables and distributed generation, the management of the grid should become more flexible and active. The IRON system could make a valuable contribution to this goal, for example by introducing an infrastructure to automatically and locally match demand and supply. This would reduce the amount of reserve energy which is needed to compensate for stochastic suppliers like wind power stations.

Some suppliers are expecting relatively stable prices while others consider significantly higher price levels possible, especially when reaching the point where the life time of more and more existing utilities expires. Current prices correspond to short-term marginal costs which leave very little spare money for investments. For consumers, the relatively low and inflexible prices provide no incentive to think about their consumption behavior. There is very little experience with demand response systems in Austria. Time-variable prices for flexible loads are mainly offered for big industries. Private homes are considered to be too small, although, put together, their influence of the load is significant. Ubiquitous demand side management systems like the IRON system have to be very simply installable (plug & work), unobtrusive and automated. As the expected savings per customer are relatively small, the optimization infrastructure has to be very low-cost, too.

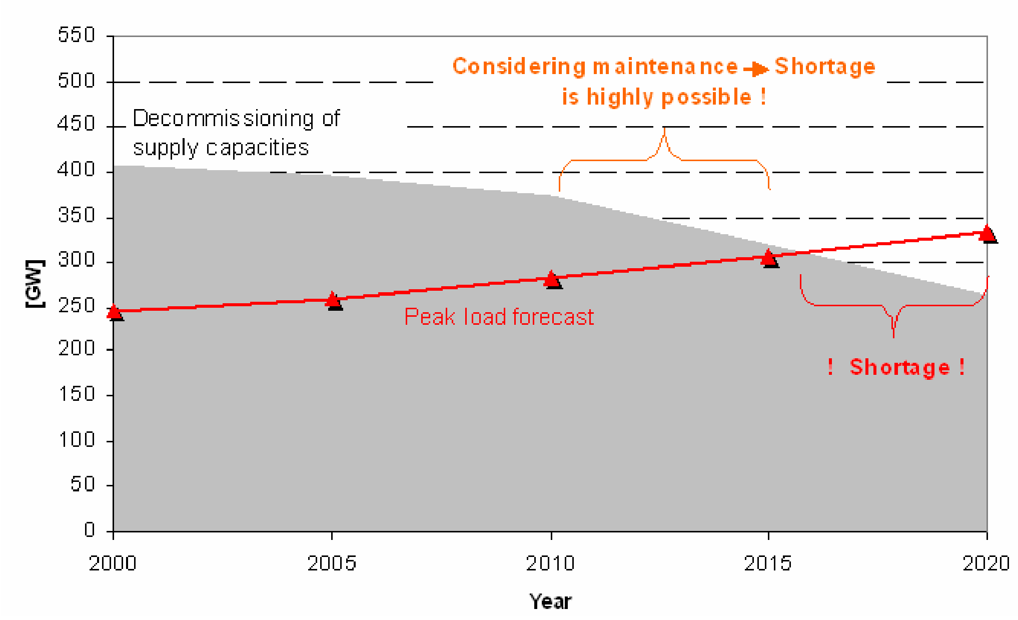


Figure 2: Decommissioning of capacities and peak load forecast for the central European Energy market (Austria, Germany, Switzerland, Italy, Slovenia, Hungary, Slovakia, Czech Republic, Poland, and France).

However, there are not only costs, but also lots of benefits which can be achieved with the IRON System:

- Significantly more information and communication
- Automated load management down to the end users' appliances, peak load reduction
- Making use of demand side potentials for shortage and emergency management of the distribution grid, improved remote monitoring and diagnostics, new real-time markets, e-business systems and (ancillary) services
- Support of distributed resources – local demand/supply matching, higher levels of decentralized generation, increased use of combined heat and power (CHP) systems
- Increased capacity factors for utilities and the grid – higher productivity of existing structures, avoidance of investments in unprofitable new power stations, reduced capital costs
- A more efficient, clean, sustainable, diverse and therefore secure energy supply

Part of the benefits of the intended automation infrastructure originate in the fact that it creates an elastic demand curve. With elastic demand curves the customers have the possibility to react to price signals – and thus shortages in supply. This leads to a better balance of demand and supply which results in a more efficient system. This is getting more and more important concerning the lurking capacity shortages (Figure 2) and their unpleasant influence on electricity prices (especially for peak load times).

Technical Concept

The basic tasks the new automation and optimization infrastructure will have to fulfill are:

- to acquire local data with embedded control modules (load data, supply data, grid status, weather conditions, etc.),
- to communicate relevant control information,
- to couple the new system to already existing control systems (interfaces to DSM systems, interruptible loads, grid management systems, etc.), and

- to provide algorithms and management tools (for optimization, cooperation, billing, etc.)

There are several technical requirements for the new IT infrastructure which are connected with IT-security, safety, robustness, scalability, flexibility, self-adaptation, fault tolerance, and network management. Concerning the fields of application for the IRON system, the following parties have been identified:

- small industries,
- big buildings,
- private homes,
- single-site stations (wind power stations, etc.).

The above mentioned entities represent the highest level of nodes in the IRON network (Figure 3). Within these nodes (e.g. within a building) additional networks will be used to reach the sub-nodes (e.g. appliances) for communication purposes. Thus, the IRON network consists of a global and a local communication infrastructure (Figure 4).

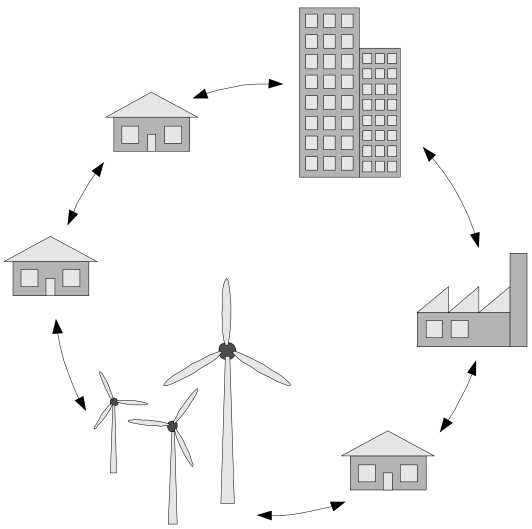


Figure 3: Types of nodes in the IRON system connected through global communication.

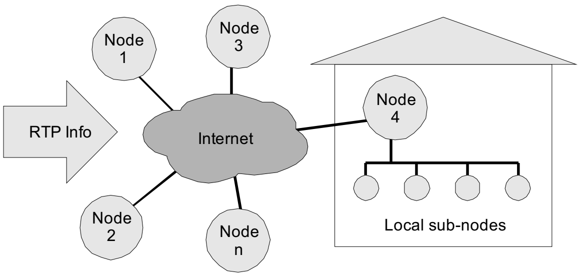


Figure 4: Distribution of price signals to sub-nodes.

For global communication the internet will be used. Other communication channels would be possible, but would, in general, lead to higher additional costs. The local network within the building or the plant, thus the communication infrastructure between the IRON nodes and sub-nodes like appliances or counters, is different for the various types of nodes (fields of application like small businesses or private homes).

Scenarios for putting the system on the market

The study analyzes three scenarios concerning the question by which party the intended system should be initiated and operated:

- A private company which takes care for the installation, operation, maintenance and administration of the technical infrastructure and acts as an energy supplier with time-variable tariffs or prices.
- (Distribution) grid operators which use the load shedding mechanisms of the new infrastructure to actively manage the grid and to provide new services to their customers.
- The system will be embedded in national energy economic strategies (e.g. creation of a dedicated economic structure similar to the Austrian “Ökobilanzgruppe”.)

Contact: Peter Palensky
TU Wien – Institut für Computertechnik
E-Mail: palensky@ict.tuwien.ac.at

Integration Through Cooperation

(Original Project Title: Integration durch Kooperation – Das Zusammenspiel von Anlagen- und Netzbetreiber als Erfolgsfaktor für die Integration dezentraler Stromerzeugung)

Synopsis: Cooperation between power producers and network operators as a crucial factor for a successful integration of decentralised generation

Background:

Key priority of the European as well as the Austrian energy policy is to increase the share of electricity from renewable sources (RES) and from combined heat and power generation (CHP). As the share of electricity generation from these distributed sources (DG) rises, they can no longer be treated as a simple add-on, while the system as a whole remains unchanged. Distributed generators rather have to get fully integrated as essential parts into networks and markets.

For their successful integration, it is crucial that the independent power producers (IPP) interact constructively with the operators of the respective networks. Distribution system operators (DSO) can with their activities and attitudes crucially affect the economic feasibility of distributed generators, since they have to provide access to the network on the basis of certain conditions and are responsible for the structural development and appropriate operation of the networks.

Project aims:

The aim of the project ‚InteKoop' was to assess which forms and conditions of interaction can foster the integration of higher shares of distributed generation into the Austrian electricity grid. A survey of international experiences and discussions brought to light a number of instruments, which have been developed elsewhere to ease the integration of distributed sources by better coordination. Especially in the UK, distributed generation is recognised explicitly in the regulation of networks (use of system UoS charges,). Certain designs of support schemes (e.g. for RES and CHP) can foster cooperation between DSO and DG-operator too.

Methods:

On the basis of diverse international examples, interviews with individuals from all relevant stakeholder groups have been conducted. These interviews covered possibilities and barriers for increased co-operation (between DSO and IPP) in order to make the integration of DG in Austria more efficient. From these stakeholder perspectives hypothesis have been derived and discussed in two stakeholder workshops. The results have been elaborated into recommendations for all relevant actor groups. Furthermore possibilities for the improvement of the legal framework of DG integration and the procedures of network regulation are pointed out with regard to a more consistent system of incentives.

Scope:

We explored the possibilities for co-operation of DSO and IPP on two levels: Firstly we looked for strategies allowing the actors to mutually benefit from co-operation within the given legal framework. These possibilities turned out to be very limited. The scope for action is heavily determined by the legal framework and the procedures of network regulation (UoS Charges). Despite this fact, in all fields considered some 'soft measures' and forms of co-operation could be identified, which could allow actors to ease the integration of higher shares of DG and reduce costs *within* the given framework. These measures predominantly concern improved communication on technical and market related issues and planning.

Conclusions:

Further decentralisation of the Austrian electricity system is only possible without major disturbances if besides the IPPs, the DSOs too develop a motivation to increase the share of

DG in their networks. A precondition therefore is that DG is intelligently and explicitly recognised in the regulation of UoS charges. Since any simple methodology of incentive regulation of networks tends to produce incentives against DG, tempting DSO to restrict the share of DG in their networks, it is necessary to design the regulatory scheme in such a way that these negative incentives get neutralised. On top of that, additional positive incentives should be considered to 'activate' the DSO to support DG integration.

For the development and testing of appropriate procedures of network regulation, an 'innovation zone' should be created. In such a pilot network area technical solutions of DG integration should be analysed in their interaction with newly developed and exemplarily implemented institutions and legal framework conditions.

The results of this project clearly indicate that the legal framework and the specific procedures of network regulation are key to any increase of DG. Without efforts in this field DG-policy is unlikely to succeed even if major technological breakthroughs occurred soon, be it cheap distributed control networks or very low cost electricity storage.

This has important implications for the priorities of further research. The testing and demonstration of new technical solutions will not be replicable in real world contexts and large-scale deployment will not be feasible as long as the legal and organisational prerequisites are not adequately dealt with.

Contact: Philipp Späth M.A.
IFZ Interuniversitäres Forschungszentrum für Technik, Arbeit und Kultur
E-Mail: spaeth@ifz.tugraz.at

Energy Regions: Influencing socio-technical change by promoting technical visions in regional discourses and actor networks

(Original Project Title: LeitER)

Synopsis:

In four Austrian regions, calling themselves ‘energy regions’, the processes leading to the formulation of common visions or ‘leitbilder’ with regard to more sustainable energy systems were analysed and the impact such ‚leitbilder’ and connected actor networks can have on the regional scale was assessed. Adapted communication and network strategies for the individual initiatives were developed and transferable elements of such strategies as well as general preconditions and requirements were identified.

Problem & Motivation:

Where a co-ordination of different actors is necessary, but not feasible through direct control or market mechanism, “leitbilder” or “guiding principles” are frequently as an instrument of governance: For the strategic orientation of companies, for urban and regional planning and in the regional realisation of goals for sustainability (LA21).

Also in the field of (sustainable) technology development a strong focus has recently been put on the function of guiding principles. In calls of the programme “Energy Systems of the Future” one can find several terms which have the potential to serve as such guiding principles. Some of them already have a coordinating function (energy autonomy, polygeneration, distributed generation, virtual power stations etc.).

To achieve the aims of the programme (to facilitate the development of sustainable energy systems) it would be helpful, if specific ‘leitbilder’ could coordinate the actions of a broad range of actors in technology development and implementation. For distributed energy technologies the implementation at the regional level is of particular importance.

Aim:

The aim of the project is to examine the potential of the regional application of ‘leitbilder’ on the way towards sustainable energy systems in an exemplary learning process involving selected ‘energy regions’. The analysis of the case studies and of relevant success factors served as a basis for the development of improved communication and network strategies for the individual ‘Energy Regions’, and provided a source for considerations on transferable elements, crucial preconditions and guidelines for such processes.

Guiding questions:

- (How) can ‘leitbilder’ coordinate concrete decisions and impact on technical change on a regional level?

- What are crucial preconditions for the success of Energy Regions?

- Which structures of actor networks are - under what circumstances - most successful?

- Which communication strategies are - under what circumstances - most effective?

- How can provincial governments and R&D programmes support the development of ‘leitbilder’ and their use for the governance of technological development (towards sustainability)?

Approach:

In selected regions an exemplary learning process was initiated, reflected and documented. The main actors of the energy regions exchanged their perceptions about the history of the individual 'leitbild' processes and their impact upon technical change. They were supported by experts on regional development and communication strategies as well as by social scientists from a variety of fields.

Finally, the possibilities for replication in other regions were assessed and conclusions with regard to the options for relevant R&D programmes were derived.

Results:

Actors of regional development are provided with inspirations for the design of regional 'leitbild' processes and respective communication and networking strategies.

A contribution was made to regional studies and technology studies by adding an empirical study of certain types of 'leitbild' processes combined with the development of related actor networks and an assessment of their impact on technical change.

Persons in charge for sustainable energy research or for energy policy and regional planning are provided with insights concerning their possibilities to facilitate the development of sustainable energy systems by the support of certain 'leitbild' and networking processes.

Contact: Philipp Späth M.A.
IFZ Interuniversitäres Forschungszentrum für Technik, Arbeit und Kultur
E-Mail: spaeth@ifz.tugraz.at

DG-Grid: Enhancement of sustainable electricity supply through improvements of the regulatory framework of the distribution network for DG

Content:
This project analysed the grid system issues relevant for increasing shares of distributed generation (DG), especially electricity from renewable sources an cogeneration. The focus was on problems with the interaction of electricity grid operators with independent power producers - and on potential for improved cooperation due to respective regulation.

The four phases of the project:

1. Reviewed the current regulation of the grids in EU MS concluding on what need to be done in improving the grid regulation in MS the short-term to remove barriers for RES and CHP deployment.

2. Analysed the consequences of network innovations in the long term on the developments of grid system regulation with large electricity volumes supplied by RES and CHP and if a large share of power generating capacity is connected to the distribution grid.

3. Assessed influence of current / and the recommended changes in network regulation etc. for the functioning of grids and grid operations. Developed grid business models for economic viable grid operation with large shares of DG.

4. Developed guidelines for network planning, regulation and to enhance integration of DG in the short term including the opportunity for new innovative changes in networks. Stakeholders group monitored results.

Lead Partner: ECN, Netherlands

Further Information and Reports:

http://www.dg-grid.org

Contact: Philipp Späth M.A.
IFZ Interuniversitäres Forschungszentrum für Technik, Arbeit und Kultur
E-Mail: spaeth@ifz.tugraz.at

Distributed Generation and Renewables – Power Quality

(Original Project Title: Verbesserung der Versorgungsqualität in Netzen mit dezentraler Stromeinspeisung aus erneuerbaren Energieträgern)

Synopsis: The EE+PQ project will demonstrate how the integration of power electronics equipment in Distributed Generation (DG) units can actively improve the stability and quality of supply of electric power distribution networks in order to increase the penetration of DG and Renewable Energy Sources.

Motivation

The increased integration of ecological power generation based on renewable resources like wind, sun, biomass or water leads to fundamental changes in Austria's power supply system: the former central structures are now being converted to a distributed system where unidirectional power flows are now reversed under the influence of small distributed generation units feeding in at low voltage levels of the network.

With increasing share of distributed generation elementary issues, like capacity planning, stability, protection strategies and mainly the quality of supply (Power Quality – PQ) come to the fore again. In particular the power quality takes focus of interests due to increasing sensibility of customers and the fear that quality and reliability of electricity supply will be jeopardised by a higher share of distributed generation. The issue of reliability will become an increasing barrier for the planned ambitious design of an ecological electricity generation and therefore jeopardise the achievement of important environmental and energy policy targets.

Approach

To reach the project targets the work was divided into three main steps:

Step 1 – Evaluation of the state of the art

This step included theoretical investigations, surveys and measurements. On the basis of the know-how of the project partners, the current framework for distributed generation was analyzed and strategies and concepts were developed. Within the scope of a measurement campaign accompanied by analytic network simulations the power quality at representative sites was investigated.

Step 2 – Empirical analysis

Through case studies an analysis of the power quality and security of supply has been carried out thanks to the following tools:

- Network analysis
- Simulation
- Analytical monitoring

Formulation of scenarios for optimization.

Step 3 – Demonstration of the feasibility

Based on the previous results, obstacles and opportunities for the improvement of power quality through distributed generation were identified. The technical potentials for an efficient and multifunctional use of distributed generation for power quality improvement were estimated

Results

The framework analyses for distributed generation showed that the rules are not transparent and not harmonised and they provide poor incentives for distributed generation.

The Measurement Campaign

The measurement campaign at sites with distributed generation showed that apart from the voltage rise effect there is generally no significant influence of the distributed generation units on the parameters of Power Quality. The measurements have been made with a modern Power Quality Analyser and analysed by specially developed software. An accompanying evaluation and validity check completed the measurements.

The measurements included both steady state PQ-phenomena (like harmonics, flicker or voltage fluctuations) and short time events (voltage dips, - swells, interruptions…), which are characteristic for the voltage quality, and their results are presented below.

- Some events including voltage dips and interruptions were recorded during the measurements at the different sites. These events were caused by faults and switching events in the network and not due to the distributed generation units.
- Mostly there was no direct connection between the level of voltage fluctuation and fluctuation of the power generation. The voltage fluctuations are predominantly caused by load changes in the network.
- Generally the harmonic level of the voltage at the investigated sites was small and no significant influence of the distributed generation units on the harmonics level was observed. Through the measurements it was possible to show that state of the art inverters and converters in distributed generation units have no negative influence on the harmonic level of the voltage.
- In general the impact of the distributed generation units on the flicker level was small.
- Also at site with unbalanced power injection no significant increase of unbalance of the voltage was observed.

From the measurements we conclude that it is necessary to actively integrate the units with innovative solution or to increase the short circuit power at the point of common coupling in a conservative way by network reinforcement. With the current framework in Austria the operator of the unit has to pay for the network reinforcement, which at many sites is not possible due to economic reasons.

<u>Concept for Enhancement of Power Quality and Simulations</u>

The simulations of distributed generation units pointed out that there is an unacceptable voltage rise at high penetration levels. As a counter measure the active filter MARS (Mains Active Restoring System) developed from the project partner VA Tech Elin EBG Elektronik was integrated into the simulation. It was possible to reduce voltage rise effect at the point of common coupling.

The practical use of the MARS was demonstrated by a case study at Tauernwindpark Oberzeiring. Due to the specific dimensioning of the unit for filtering interharmonics and to the small impact of the wind park on the parameters of power quality no significant contribution of the MARS to an improvement of the other parameter of power quality was observed.

<u>Feasibility Study</u>

Within the project it was illustrated that technologies for improvement of power quality are available and that they are working. Due to the current organisational and economic framework these technologies still do not play any relevant role concerning the delivery of ancillary services.

From the feasibility study “Obstacles and opportunities for active delivery of ancillary services by distributed generation based on renewable energy resources” following issues can be pointed out:

- The discussions with experts showed that the main potential for a contribution to ancillary services for distributed generation units is the supply of reactive power and accordingly voltage control. The availability and reliability of distributed generation units was pointed out as a critical technical challenge and thus as a barrier for a wide acceptance.

- With the increasing integration of distributed generation in European distribution networks incentives for ancillary services provision by distributed generation were developed in a few countries. One example is the supply of reactive power and the compensation of voltage dips in Spain.
- For the technical framework the improvement of power electronics will be crucial. Power electronics will offer new possibilities and enhanced flexibility. There will be an improvement in term of reliability, efficiency, modularity and also in the costs of devices. The coordination between units that deliver ancillary services is important, thus developments in the area of communication technologies will also be crucial.
- The costs for integrated units for enhancement of power quality will strongly depend on the trend of costs for power electronics. A decrease of about 50% of the price for power electronics is expected until 2010 from inverter manufacturers.
- Stand alone units for the enhancement of power quality have not found a broad market yet, but there is a clear potential for the integration of additional functions such as power quality improvement into distributed generators. A confirmation of this is that some inverter manufacturers force developments in this way.
- Within the European framework for distributed generation the delivery of ancillary services by distributed generation is partially possible. Due to unclear rules and requirements it is difficult to implement.
- The most important condition for an active role of distributed generation in ancillary services provision is the availability of an adequate organisational and economic framework.

Conclusions

The active integration of distributed generation units could contribute to the improvement of power quality. In addition to the necessary framework which is currently missing, the confidence of network operators in this concept of integrated distributed generation providing ancillary services is lacking. Therefore it is necessary to address this lack of confidence and demonstrate the feasibility within a broad implementation of such concepts in real networks.

Contact: Helfried Brunner
Österreichisches Forschungs- und Prüfzentrum Arsenal Ges.m.b.H
E-Mail: helfried.brunner@arsenal.ac.at

Active operation of electrical distribution networks with a high share of distributed power generation – Conceptual design of demonstration networks

(Original Project Title: Aktiver Betrieb von elektrischen Verteilnetzen mit hohem Anteil dezentraler Stromerzeugung – Konzeption von Demonstrationsnetzen)

Synopsis: Conceptual design, scheduling and project planning of distribution network branches with active operation and a high share of distributed generation units. Preparations of all requirements for the implementation of innovative demonstration networks with consideration of all relevant players.

Project Description

Due to actual energy related framework conditions within the EC (Directives) the penetration of Distributed Generation (DG) increases continuously and it can be expected that this increase will even grow in the future.

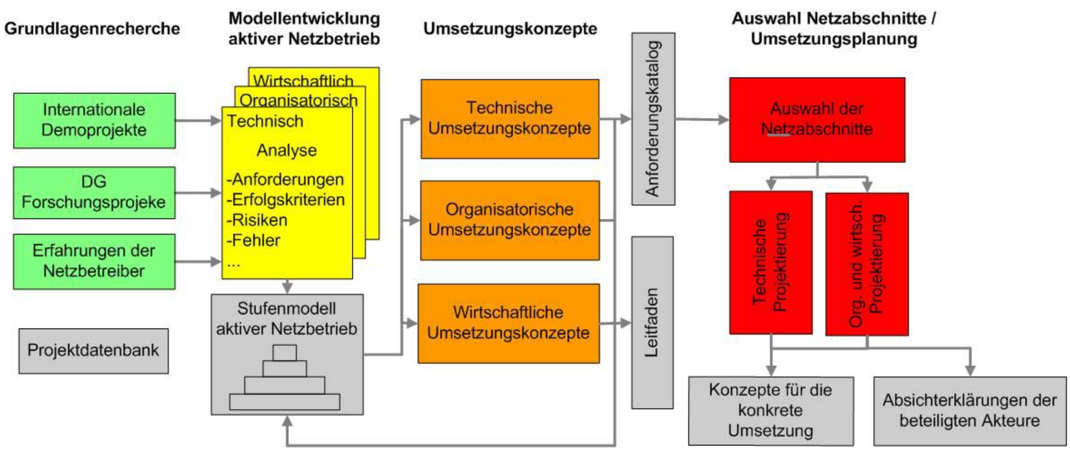
As a result of the increasing density of distributed electricity generation, basic questions related to the bidirectional power flow as e. g. reliability aspects (power quality and continuity of electricity supply), stability aspects, network capacity, network-, energy- and load management are massively arising.

The actual strategy to see the electricity production as a negative load and the resulting „fit & forget“ philosophy is not a sustainable and applicable solution for the future. Under such conditions, a significant rise of the share of DG would only be possible with a very cost intensive extension of network capacity. On the other hand research on active integration of DG in distribution networks is ongoing already for a while, but mainly stays at the point of theoretical aspects.

Objectives

Therefore the main goals of this “DG DemoNetz – Konzept” project are:

- to choose representative parts of networks in Austria (e.g.: typical Austrian network topology and demand and supply structure) for practical realisation of demonstration networks with a high penetration of DG and
- to analyse within these low and/or medium voltage network parts, the possibilities for implementing different model systems (Pyramid model “DG Integration”) and project the technical, organisational and economical realisation.



Results

At the end of the project, following results will be available in detail:

- Comprehensive documentation of international demonstration projects and relevant theoretical research projects within a database. A summary of existing practical experiences with distribution network hosting a large amount of DG will be prepared, and potential innovative ideas for future integration of high share of DG thoughtfully analysed.
- Summary of the analysed and evaluated projects of the database and of the existing practical experiences of the distribution network operators. Out of these results, model systems for the active network operation will be derived and presented within a pyramid model "DG-Integration", which presents a rise of complexity of the system
- Technical, organisational and economical realisation concepts for the implementation. Summary of the major parts of the realisation concepts in an overall guide (of potential interest for all relevant Austrian DG related actors) and a project specific list of requirements for related parts of networks and actors.
- Ranking of parts of distribution networks, which could be relevant and considered for a implementation of the model systems. Selected parts of distribution networks, which are considered for the realisation of the demonstration project will be analysed and classified.
- Technical, organisational and economical realisation concepts for the chosen parts of distribution network
- Letter of intent from for the implementation and realisation relevant players and finance partners

Conclusion

Through the DG DemoNetz – Konzept project, requirements and effects on network and generator operator to achieve the integration of a significant amount of DG into the grid with the least additional investment costs will be made available. The realisation of the demonstration project will therefore be a "best practice" example and a first step for the implementation of high density of integrated DG and reduce existing barriers.

The practical demonstration and analysis of an active network operation, with a high share of DG density, will allow Austria to become one of the European leader in questions of the integration of DG in existing distribution networks and the resulting necessary adaptation of distribution networks. Therefore a leadership in DG technology aspects for Austrian companies and related national net productivity will be strengthened.

Contact: Dipl.Ing. Helfried Brunner
arsenal research
E-Mail: helfried.brunner@arsenal.ac.at

Long time scenarios for economically optimal integration of micro-CHP into the Austrian energy system

(Original Project Title: Langfristige Szenarien der gesamtwirtschaftlich optimalen Integration von Mikro-KWK-Anlagen in das österreichische Energiesystem)

The combined optimal supply of heat (in the future also for cooling) and electricity has gained high relevance under the aspect of most efficient and extensive decentralised use of both fossil (e.g. gas) and renewable (e.g. biomass) energy sources. The increasing future demand for energy services, particularly for electricity, will be partly met by capacities, which have to be installed newly. In order to meet these future demand at present a broad spectrum of new small scale technologies (below approx. 50 kWel) like Micro-CHP is analysed and tested practically for the coupled production of heat (possibly also for cooling purposes) and electricity. Increased energy efficiency measures, the optimal plant design (economically, energetically and ecologically) and market potentials of several technologies are thereby key evaluation criterions. However, if a strategic adjustment of ongoing energy developments towards a sustainable system is evaluated, the question arises, which technology lines in a dynamic short to long-term perspective are ecologically reasonable and economically realisable and have the chance to achieve significant market penetrations or increased priorities.

The central questions of this project therefore can be defined as follows:

- Which “Micro-CHP” technologies in Austria have the future potential to serve the needs for electricity and heat supply?

- How can these technologies be integrated into existing systems, causing the lowest overall economic costs, in order to achieve ecological and energetic optimas?

In order to answer these questions, the development of scenarios showing which Micro-CHP technologies can be established in the Austrian market until 2050 under different economic, ecological and energetic developments (demand development, efficiency measures, storage options, system integration etc.) is foreseen in order to reach a critical mass or a relevant potential, respectively. Based on that, a technology ranking will be performed with respect to the robustness on the variation of several scenario parameters (e.g. electrical efficiency, investment interest rate, average life time etc.). Additionally, the dynamic analysis considers emerging changes like decreasing heat demand per m² and increasing electricity or cooling requirements. As reference scenario a centralised power system with different electricity price scenarios will be used.

For the fulfilment of these targets within the project the following work steps are intended:

- Definition and evaluation of selected Micro CHP technologies

- Options for heat/electricity storage and grid integration

- Evaluation of the optimal plant size

- Development of reference and sustainability scenarios in order to analyse the relevance of Micro CHP solutions

  up to 2050

- Recommendations for the practical implementation of several Micro-CHP technologies (Action Plan),

  conclusions, discussion and dissemination

- Project management

The foreseen methodology is based on an analysis of CHP technologies, system integration options and overall cost, which results in the development of a Micro-CHP system data base (WP1 & WP2). Subsequently, it is evaluated how several technologies are to be dimensioned, in order to reach an energetic, economic as well as ecological optimum

(WP3). Work Package 4 compiles reference and future scenarios as well as technology rankings which together with all evaluated parameters (WP1 - WP4) are synthesised in WP5 (market situation, dynamic supply and demand development, efficiency developments etc.). In Work Package 6 recommendations for the practical implementation of several Micro-CHP technologies are derived (Action Plan) and conclusions are drawn including a discussion process and dissemination activities. WP7 covers all co-ordination, communication and management activities.

The most substantial results of this project are:

1. Knowledge on the long term relevance of several Micro-CHP technologies as well as the according and optimal bandwidths for the corresponding power ranges;

2. Scenarios showing this relevance quantitatively with respect to important constraints like energy price and building efficiency developments (those scenarios represent in which extent several technology lines can penetrate the market, and what their economic, energetic as well as ecological total balance looks like) and the comparison to a reference scenario (centralised power system with different electricity price scenarios);

3. Specific evaluations regarding the robustness and the relevance of different technology developments.

Overall, recommendations for the future priority setting of technology research and development in Austria are derived.

Contact: ao. Univ. Prof. Dr. Reinhard Haas
TU Wien
E-Mail: haas@eeg.tuwien.ac.at

Manual to realise initiatives for energy regions of tomorrow to compass the goals of the programm “Energy Systems of Tomorrow”

(Original Project Title: Handlungsleitfaden „Gelingensfaktoren zur Energieregion der Zukunft“

Compilation of the manual to realise initiatives for energy regions of tomorrow; integrating the experiences generated in the winner projects, outcomes of representative energy-projects and the know-how of scientific works; distribution by multiplicators, realiziation of distribution activities.

The results in the guideline „Energieregionen der Zukunft“ are a collection of experiences from different activities along the way to future energy regions in Austria. There are in Austria numerous implementation examples with exemplary energy solutions. It spans from successful implementation of innovative energy systems and single measures in the regional context, the implementation of visions to networked local and regional initiatives.

The program line “Energiesysteme der Zukunft” has established a contest where the best works are summarized in a brochure. We have interviewed members from these and other projects from economy, politics, administration regarding the way towards the energy region

In order to guarantee the success of the approach it is recommended to consider the problem from different angles. The requirements for the development of the energy regions of the future are examined. The anaylsis of these requirements leads to a solid base for a successful approach. We go ahead in a self assured way being aware that there may be some risks. Therefore within the brochure both sides of the medal are scrutinized. Our attitude and disposition influence the way of doing and finally the success of the approach. By changing negative attitudes of the participants and the awareness of the key factors it is possible to overcome hurdles on the way.

Contact: Dr. Kurt Schauer
Wallner&Schauer GmbH
E-Mail: schauer@zukunftsberater.at

Thermoelectric Generator for the Generation of Green Electricity in Biomass Fuelled Plants

(Original Project Title: Thermoelektrischer Generator zur Ökostromerzeugung bei biomassegefeuerten Energieanlagen)

Synopsis

In biomas fired heating plants or combined heat and power plants, heat is produced at a high temperature leavel, but used only to supply low temperature district heating systems. By utilicing the thermoelectrical effect this temperature difference can be used to generate additional electricity.

Abstract

Even if renewable energy is used, a high yield of high graded energy should be aimed. The operation of biomass fuelled district heating grids is a quite dissatisfying situation, as the high exergetic potential of the biomass is hardly utilised. With the Help of thermoelectric generators this potential should be used for the production of electricity.

So additional 7% (related to the conducted heat) of electricity can be produced.

Furthermore the utilisation of up to now useless waste heat could be possible.

So biomass fuelled district heating plants could become CHP plants by integrating thermoelectric generators. The electrical efficiency of state of the art CHP plants could be raised.

The goal of the project was the development and optimisation of standardised, fitted to the application at biomass plants, thermoelectric generators.

Furthermore the electrical efficiency should be raised by the application of new material combinations, recently under development.

Exactly evaluated efficiencies, practical tests and the evaluation of different variants of process integration were important milestones. A test rig was operated at the Biomass Power Plant Güssing.

With the results of these tests the economic feasibility of a possible pilot plant was calculated. Unfortunately all tested variants turned out to be far from being feasible.

Therefore a completely new design of thermoelectric generator, derived from conventional plate heat exchangers was developed and some prototypes were built.

By that the production costs for serial production could be reduced from initial 16,- €/kW to 9,- €/kW. Aggravating factors were the prices for semi conductors and non-ferrous metals, which rose strongly during the duration of the project.

The integration of the TEG´s into the biomass CHP plant was optimised as well. By that the economic situation was improved considerably but a break even has not been reached. At the moment there are hardly any chances of implementation of the results at bigger plants.

The initially promising application area of small temperature gradients turned out to be inefficient due to low electrical efficiencies and high investments.

By the application of future developments in the area of high temperatures TEG´s could be applied at higher temperatures. Especially for TEG´s, which are directly coupled into the gas streams, a high theoretical potential for high efficiencies exist. The fact, that in that area already well proven technologies like the steam turbine or the ORC exist, must not be unmentioned.

Contact: DI Christian Aichernig
REPOTEC GmbH
c.aichernig@repotec.at

Voltage stabilization by central reactive power control of biogas power plants - concept for a demonstration project

(Original Project Title: Stabilisierung des Stromnetzes mit Hilfe eines Verbundes von Biogasanlagen)

Goals:

Electrical energy from biogas plants usually is fed into the public grid. Due to the fact, that biogas plants normally have a gas storage with at least a 1-day capacity of biogas, they are suitable to adapt the energy fed into the grid to the current requests respecting both:

- Active power (adaption to the load curve of the grid)

- Voltage resp. reactive power (by controlling the field current of the generator)

Up to now, at the best the first possibility has been used only. Requests of grid control and grid stability have not been considered. The aim of the project therefore is the development of a concept to prepare and to initiate a model system for connecting a certain number of biogas plants in the region of Southern Styria to a "virtual power plant" (see Fig. 1) with the possibility to improve grid stability via reactive power control of the individual biogas plants.

Consortium:

Project co-ordinator: Joanneum Research (Graz, A)

Partners: SNG-STEWEAG-STEEG (Graz), Bio Energie Ratschendorf, Ökostrom Mureck GmbH, Bioenergie Lukas Pfeiler – Tscherner (Grünau), NEGH Biostrom KEG (Paldau), Kohlroser Biogas GmbH (Oberrakitsch), Biokraft Hartberg Energieproduktions GmbH (Hartberg), additional operaters of biogas plants in informal co-operation.

Boundary conditions:

- Currently 26 biogas plants operating

- Total electrical power 8.9 MWel

- 11 different grid operators involved

- Biggest grid operator: SNG-STEWEAG-STEEG

* 11 biogas plants feeding into the grid of SNG

* total power 3.7 MWel

Results:

- A „virtual biogas power plant" can only be realized in the same middle voltage grid section. In the investigated region 6 biogas plants are feeding in the same middle voltage grid section:

* 3 biogas plants with together 0.8 MWel (total grid section power 10.8 MW)

* 3 biogas plants with together 1.3 MWel (total grid section power also some 10 MW)

- Reactive power compensation is only possible in high voltage grid sections.

* E.g. Transformer station Zwaring: Reactive power request in the range of ± 200 MVAr

* For comparison: The total power output from biogas plants to be expected in the whole state of Styria could reach some 45 MWel, that means a maximum reactive power of some ±20 MVAr)

- 2 technically suitable options for realization of a „virtual biogas power plant" have been identified and investigated in detail. The possible contribution to active and reactive power compensation is in the range of 1 %. Possibilities for practical realization are currently discussed with the biogas plant operators and the grid operators.

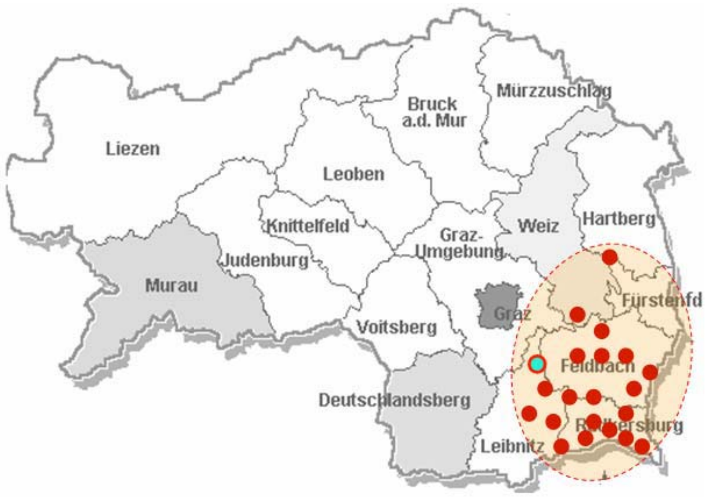


Fig. 1: Biogas plants in the region of Southern Styria

Contact: Dr. Reinhard Padinger
Joanneum Research Forschungsgesellschaft mbH
E-Mail: reinhard.padinger@joanneum.at

Innovative Concepts for Pumped Storage in Liberalized Grids

(Original Project Title: Innovative Pumpspeicherkonzepte in liberalisierten Netzen)

In liberalized grids the requirements for pumped storage equipment rise dramatically. The development of a controllable pump turbine to help stabilize the grid is one of the possible solutions to this problem.

Summary

Background

By the end of the year 2020 the energy supply of the EU shall be 20 % renewable. Wind power and photovoltaic power is said to have the biggest potential. Due to the nondispatchable wind and solar energy the energy storage becomes more and more important. The most economic way to store electrical energy is by means of pumped storage.

In liberalized grids the requirements for pumped storage equipment rise dramatically because it becomes more and more common to provide large quantities of balancing energy. Due to this reason the thermic and mechanic load on generators and turbines rises.

Contents and Goals

The development of a new thermic resistant insulation, better cooling methods and bearings within this project is an answer to above mentioned requests by the conventional motor-generators. Through the further development of the generators with variable speed the maximum efficiency of the energy conversion can be raised also in the pumping mode. A new design for pump-turbines follows the same goal on the hydraulic side. With the development of a new turbo generator for the application in compressed air systems we touch a technique with a promising future with high risks.

Methodology

The hydraulic development is done in two steps: The basic development is done in the hydraulic test laboratory of VA TECH HYDRO in Linz. The further development and tests of a first commercial operation is done in a second step in a demonstration plant.

Expected results

The success on the highly competitive market of the pumped storage equipment is determined by the technical solution as well as the price. In this project we want to develop concepts that are superior in both the technical subtlety and the price.

Contact: Dr. Heinz Panholzer
VA TECH HYDRO GmbH
E-Mail: Heinz.Panholzer@vatech-hydro.at

Improvement of the power quality in distributed generation networks

(Original Project Title: Netzqualität bei dezentraler Stromeinspeisung auf Basis erneuerbarer Energieträger)

Synopsis: The EE+PQ project will demonstrate how the integration of power electronics equipment in Distributed Generation (DG) units can actively improve the stability and quality of supply of electric power distribution networks in order to increase the penetration of DG and Renewable Energy Sources.

Motivation

The increased integration of ecological power generation based on renewable resources like wind, sun, biomass or water leads to fundamental changes in Austria's power supply system: the former central structures are now being converted to a distributed system where unidirectional power flows are now reversed under the influence of small distributed generation units feeding in at low voltage levels of the network.

With increasing share of distributed generation elementary issues, like capacity planning, stability, protection strategies and mainly the quality of supply (Power Quality – PQ) come to the fore again. In particular the power quality takes focus of interests due to increasing sensibility of customers and the fear that quality and reliability of electricity supply will be jeopardised by a higher share of distributed generation. The issue of reliability will become an increasing barrier for the planned ambitious design of an ecological electricity generation and therefore jeopardise the achievement of important environmental and energy policy targets.

Approach

To reach the project targets the work was divided into three main steps:

Step 1 – Evaluation of the state of the art

This step included theoretical investigations, surveys and measurements. On the basis of the know-how of the project partners, the current framework for distributed generation was analyzed and strategies and concepts were developed. Within the scope of a measurement campaign accompanied by analytic network simulations the power quality at representative sites was investigated.

Step 2 – Empirical analysis

Through case studies an analysis of the power quality and security of supply has been carried out thanks to the following tools:

- Network analysis
- Simulation
- Analytical monitoring
- Formulation of scenarios for optimization.

Step 3 – Demonstration of the feasibility

Based on the previous results, obstacles and opportunities for the improvement of power quality through distributed generation were identified. The technical potentials for an efficient and multifunctional use of distributed generation for power quality improvement were estimated

Results

The framework analyses for distributed generation showed that the rules are not transparent and not harmonised and they provide poor incentives for distributed generation.

The Measurement Campaign

The measurement campaign at sites with distributed generation showed that apart from the voltage rise effect there is generally no significant influence of the distributed generation units on the parameters of Power Quality. The measurements have been made with a modern Power Quality Analyser and analysed by specially developed software. An accompanying evaluation and validity check completed the measurements.

The measurements included both steady state PQ-phenomena (like harmonics, flicker or voltage fluctuations) and short time events (voltage dips, - swells, interruptions…), which are characteristic for the voltage quality, and their results are presented below.

Some events including voltage dips and interruptions were recorded during the measurements at the different sites. These events were caused by faults and switching events in the network and not due to the distributed generation units.

Mostly there was no direct connection between the level of voltage fluctuation and fluctuation of the power generation. The voltage fluctuations are predominantly caused by load changes in the network.

Generally the harmonic level of the voltage at the investigated sites was small and no significant influence of the distributed generation units on the harmonics level was observed. Through the measurements it was possible to show that state of the art inverters and converters in distributed generation units have no negative influence on the harmonic level of the voltage.

In general the impact of the distributed generation units on the flicker level was small.

Also at site with unbalanced power injection no significant increase of unbalance of the voltage was observed.

From the measurements we conclude that it is necessary to actively integrate the units with innovative solution or to increase the short circuit power at the point of common coupling in a conservative way by network reinforcement. With the current framework in Austria the operator of the unit has to pay for the network reinforcement, which at many sites is not possible due to economic reasons.

Concept for Enhancement of Power Quality and Simulations

The simulations of distributed generation units pointed out that there is an unacceptable voltage rise at high penetration levels. As a counter measure the active filter MARS (Mains Active Restoring System) developed from the project partner VA Tech Elin EBG Elektronik was integrated into the simulation. It was possible to reduce voltage rise effect at the point of common coupling.

The practical use of the MARS was demonstrated by a case study at Tauernwindpark Oberzeiring. Due to the specific dimensioning of the unit for filtering interharmonics and to the small impact of the wind park on the parameters of power quality no significant contribution of the MARS to an improvement of the other parameter of power quality was observed.

Feasibility Study

Within the project it was illustrated that technologies for improvement of power quality are available and that they are working. Due to the current organisational and economic framework these technologies still do not play any relevant role concerning the delivery of ancillary services.

From the feasibility study “Obstacles and opportunities for active delivery of ancillary services by distributed generation based on renewable energy resources” following issues can be pointed out:

The discussions with experts showed that the main potential for a contribution to ancillary services for distributed generation units is the supply of reactive power and accordingly voltage control. The availability and reliability of distributed generation units was pointed out as a critical technical challenge and thus as a barrier for a wide acceptance.

With the increasing integration of distributed generation in European distribution networks incentives for ancillary services provision by distributed generation were developed in a few countries. One example is the supply of reactive power and the compensation of voltage dips in Spain.

For the technical framework the improvement of power electronics will be crucial. Power electronics will offer new possibilities and enhanced flexibility. There will be an improvement in term of reliability, efficiency, modularity and also in the costs of devices. The coordination between units that deliver ancillary services is important, thus developments in the area of communication technologies will also be crucial.

The costs for integrated units for enhancement of power quality will strongly depend on the trend of costs for power electronics. A decrease of about 50% of the price for power electronics is expected until 2010 from inverter manufacturers.

Stand alone units for the enhancement of power quality have not found a broad market yet, but there is a clear potential for the integration of additional functions such as power quality improvement into distributed generators. A confirmation of this is that some inverter manufacturers force developments in this way.

Within the European framework for distributed generation the delivery of ancillary services by distributed generation is partially possible. Due to unclear rules and requirements it is difficult to implement.

The most important condition for an active role of distributed generation in ancillary services provision is the availability of an adequate organisational and economic framework.

Conclusions

The active integration of distributed generation units could contribute to the improvement of power quality. In addition to the necessary framework which is currently missing, the confidence of network operators in this concept of integrated distributed generation providing ancillary services is lacking. Therefore it is necessary to address this lack of confidence and demonstrate the feasibility within a broad implementation of such concepts in real networks.

Contact: DI Roland Bründlinger
arsenal research
E-Mail: roland.bruendlinger@arsenal.ac.at

BIOVISION – Visions for a multifunctional energy supply with MFC in Austria

(Original Project Title: BIO-VISION - Nahversorgung mit Kälte, Wärme, Strom und anderen Leistungen unter Nutzung von stationären Brennstoffzellensystemen)

ABSTRACT

In a systematic approach appropriate model regions have to be determined for a demonstration of a 250 kWel molten carbonate fuel cell (MCFC) powered by renewable fuels. A comparison of available qualities of the liquid and gaseous fuels with the requirements of the fuel cell focused an optimal usage of biogas. Analyses of user profiles of several branches led to a ranking according technical, ecological and social criteria.

Hospitals/hotels, breweries and diaries seem to be the most appropriate branches. An economical modelling of 6 locations within the selected branches led to a comparison according the specific boundary conditions of selected locations in Austria. Positive internal rates of return (IRR) can be shown for diaries and breweries with an internal production of biogas out of production wastes and waste water.

INTRODUCTION

The main concern of the project BioVision is the usage of alternative fuels produced of renewables for a 250 kWel HotModule MCFC (molten carbonate fuel cell). Overall aim of this application oriented project is the formulation of a concept in order to realise a future demonstration plant in Austria.

Therewith the basic principle is a sustainable, efficient energy supply by optimising a closed material circuit and usage of intermediates. With the aim of decentralization the raw materials should be produced and used "in the area – for the area".

For that purpose user profiles of branches for the potential operators of a HotModule were developed for a pre-selection of most appropriate locations. Secondly the qualities of feasible and available renewable fuels were compared with the requirements of the fuel cell. The third aim was to establish a computer assisted economy-model for analysing the economical feasibility of the selected branches using detailed descriptions of the expected costs and benefits.

METHODS

Quality and availability of renewable fuels: Literature research and chemical analyses with suggestions of cleaning requirements. User profiles and model regions: Based on statistics and databases of specific energy demands of several branches most appropriate model regions were defined and compared. Multifunctional teams carried out so called Gemba-Visits to describe 6 possible locations.

Economics: Starting with a specific description of the expected costs and benefits (capital costs, operation costs, receipts of the products of the MCFC and the respective tariffs) a comparative economical calculation is carried out using internal rate of return and capitalized value methods. For this purpose an excel-based model was developed.

RESULTS

Quality and availability of renewable fuels for the MCFC: A wide range of gaseous and liquid renewable fuels has been listed. A screening of all possible gaseous and liquid biofuels showed different availabilities in the regions of Austria and limited the potential enduser locations. The qualities of available fuels was analysed and compared with the requirements of the MCFC. A summary is shown in figure 1.

The investigation turned out to lay the focus on bioethanol, biogas and biodiesel, where the quality of the fuel fits best. Reformer tests by CFC Solutions showed good results for biogas, but a need of adaptation using bioethanol. Reforming biodiesel has to be redesigned fundamentally using other catalysts and systems. So the usage of biogas was found to be feasible for a full scale operation.

Fuel	Impurity	Conc.	Unit	Requirement MCFC	Unit	Cleaning method (in German language)
Biogas	H_2S	300 - 3000	[mg/Nm³]	2	[mg/Nm³]	Aktivkohle Eisen(hydr)oxide biolog. Entschwefelung Membranverfahren Aminwäsche Selexolverfahren Druckwasserwäsche
	Moisture	100	[%]	No water drops		Druckwechseladsorption Selexolverfahren Membranverfahren Gaskühler/Kondensation Glycol
Sewage gas	H_2S	225 - 2100	[mg/Nm³]	2	[mg/Nm³]	Aktivkohle Eisen(hydr)oxide biolog. Entschwefelung Membranverfahren Aminwäsche Selexolverfahren Druckwasserwäsche
	Moisture	100	[%]	No water drops		Druckwechseladsorption Selexolverfahren Membranverfahren Gaskühler/Kondensation Glycol
Biodiesel	S_{ges}	92	[ppmV]	15	[mg/Nm³]	Hydrodesulfurisation Flüssig-Flüssig-Extraktion
	Na + K	10 - 48	[ppmV]	je 100	[ppbV]	Ionentauscher Elektrolyse
Diesel	S_{ges}	106	[mg/Nm³]	15	[mg/Nm³]	Hydrodesulfurisation
	Aromate	28	[Vol %]	50	[ppmV]	
Bioethanol	S_{ges}	20,6 bzw. 4,1	[mg/m³]	15	[mg/Nm³]	Tests bei BASF
	Chloride	23	[ppmV]	50	[ppbV]	Ionentauscher Elektrolyse
Methanol	Kalium	100	[ppbV]	507	[ppbV]	
	Chloride	50	[ppbV]	452	[ppbV]	

Figure 1: Comparison of fuel quality and MCFC requirements (source Profactor and CFC Solutions 2007)

User profiles and model regions in Austria: The branches and their statistical data were evaluated on behalf of criteria adapted to the characteristics of the MCFC system. There are four groups of criteria: technical, ecological, economical and social criteria. Selected lead-parameters for the evaluation are shown in figure 2. The regarded branches are evaluated with max. 2 points per criterium. The economical calculation and ranking was done on basis of this profile. The most appropriate branches are so far hospitals, breweries, diaries, ethanol plants and hotels.

System \ Criteria	Size of market	Turn over	Own raw material	Heat demand	el. Power demand	Cooling demand	Continuos demand	Total	Total
Hospitals	high	high	medium	high	high	medium	high	high	12
Glashouses	high	low	medium	high	medium	medium	low	medium	7
Hotels	medium	medium	medium	high	high	medium	high	high	10
Agr.biogas plants	medium	low	high	medium	medium	low	medium	medium	6
Sewage plants	low	high	high	medium	medium	low	high	medium	8
Ethanol plants	low	medium	high	high	high	medium	high	high	10
Breweries	low	high	medium	high	high	high	high	high	11
Diaries	low	high	medium	high	high	high	medium	high	10

Figure 2: Summary of model systems evaluation (source: STUDIA 2007)

The developed calculation model describes the boundary conditions of the selected branches, where hotels and hospitals are very similar, so in the following only hospitals are mentioned. Ethanol is actually not suitable as fuel for the MCFC and the price is relative high, so this branch is not taken into account for the economic evaluation. So there were selected 6 model systems, which represent 6 locations. Each of them was analysed with a Gemba visit and modelled according the specific conditions. The results are summarised in figure 3.

		Usage of products			Economic parameter			
Model system	Fuel	Power	Heat	Other	IRR (in %)	CV (R=0%) (in Euro)	CV (R=4%) (in Euro)	CV (R=10%) (in Euro)
MS1 (Diary)	Biogas internal produced	Injection tariff	HT-Heat	none	+1,8	+254.000	-250.000	-688.000
MS2 (Diary)	Biogas internal produced	Injection tariff	Cold	none	+2,8	+414.000	-140.000	-623.000
MS3 (Brewery)	Sewage gas (connection line)	Injection tariff	Cold	none	+3,4	+519.000	-73.000	-590.000
MS4 (Brewery)	Virtual Biogas supply	Injection tariff	Cold	none	-7,7	-960.000	-1.181.000	-1.362.000
MS5 (Hospital)	Virtual Biogas supply	Injection tariff	HT-Heat	USV	-6,6	-825.000	-1.067.000	-1.268.000
MS6 (Hospital)	Virtual Biogas supply	Injection tariff	Cold	none	-7,2	-860.000	-1.081.000	-1.262.000

Abbreviations: MS: Model systems, HT: High temperature, LT: Low temperature, IRR: Internal rate of return, CV: Capitalised value, R: rate

Figure 3: Summary of economical evaluation (source: EEG 2007)

Positive IRRs are calculated for diaries and breweries. At the investigated locations a local fuel production supplies the MCFC with biogas, which is digested in biogas plants or sewage plants connected to the enterprises. Therefore the specific fuel costs can be kept low, which seems to be a decisive factor for the economical feasibility.

CONCLUSIONS

The investigated model regions for diaries and breweries in Austria seem to be the most appropriate locations for a demonstration plant of biogas-MCFC energy system, which is intended to realise in a follow up project.

ACKNOWLEDGMENTS

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Contact: Johann Bergmair
Profactor GmbH
E-Mail: johann.bergmair@profactor.at

Energy park Micheldorf-Hirt

(Original Project Title: Energiepark Micheldorf-Hirt)

Synopsis:

Zusammenschluss der Energieversorgung der Region Micheldorf in einem Betreibermodell und Bereitstellung der Energie durch erneuerbare Ressourcen.

Co-operative merging of the energy supply for the region of Micheldorf within an operating scheme and supply of energy produced through renewable resources.

Abstract

The project NAWE (sustainable, self-sufficient, economic energy park) wants to establish the energy supplies in the region Micheldorf-Hirt in a sustainable way. The region is located in the center of Carinthia. It covers an area of 17 km² and has 1 150 inhabitants. In this area there are: Brauerei Hirt GmbH (brewery), Säge Hirt GmbH (sawmill), Bistum Gurk (big administration complex) , Vitalhotel Agathenhof (Spa Hotel), Gewerbepark Pauer (Industrial park), Kaminbau Pilgram, Kraftwerkservice GmbH, Stromberger & Kollmann Maschinenbau & Automatisierung (metal manufacturing company), Vince Nat Malerei (painting), Gemeinde Micheldorf, Gemeindeamt von Micheldorf (community buildings), etc. In the past there were isolated activities in the region to supply individual companies by renewable energy sources without a systematic approach and without coordination.

NAWE is a new systemic approach to optimize the energy supply for a whole region in a holistic way by involving the community, the companies and external specialists. The participative approach, the system analysis and the expert knowledge guarantees the optimal solution considering ecological, social and economic criteria. The process involved all stakeholders, the criteria or the identification of the solution were transparent. Therefore the stakeholders are convinced of the quality of the solution and they are ready to implement proposed variant. The concept is based on an analysis of individual energy consumers, their potential for energy savings and heat integration and the interaction of the other elements of the system.

In the beginning of the analysis the demand for electrical energy and heat in the region was analyzed in detail. Therefore measurements were done in the companies and the community buildings and survey was done to collect data on energy consumption of the private buildings. Potentials for the optimization and savings were identified and presented to the companies and the communities.

NAWE aims at an optimum overall energy and resource efficiency of the energy supply of the model system of Micheldorf-Hirt. The important innovative aspect of NAWE is:

the combination of a variety of technologies to use regenerative energy sources,

by cascading energy as efficient as possible

by using industrial waste heat

by using organic waste

by synchronizing the operation of production plants

Based on these data asset of variants for a combination of energy supply units were elaborated. The main focus was, to use regional available resources in an economical and ecological way. Currently the hydro-power-stations are up-grated and their power is expanded. For the future it is planned to connect the regional hydro-power-stations to the companies.

There are four variants of heat production for the region. A fifth option exists especially for the brewery. These could also be integrated in the other four ways. This complex approach requires an additional detailed study of the control system of the brewery.

The following options were developed:

biomass heating plant

biomass heating plant with ORC for electricity generation

biomass heating plant with ORC and integration of the heating of the brewery

biomass heating plant with ORC, integration of the brewery (heating and cooling)

And the option, which can be combined with the others:

Replacement of the steam boiler in the brewery

Other renewable energy resources were excluded because they are not cost-effective and practicable.

The business plans for the options show, that all options are economically realizable. The decision, which option will be realized, can only be made in a follow up project. In this project the integration of the wood fired steam boiler with the control system of the brewery and the district heating system must be investigated.

The decision has been taken by the partners "Brauerei Hirt", "Bistum Gurk" and "Säge Hirt" to involve into the energy park. The support of the community "Micheldorf" for the implementation of the project and the district heating system has been assured. The following steps will be carried out consequently:

Establishment of the operating company in the form of a limited company

Integration of the raw material suppliers into the operating company

Calculation of a binding heating price

Conclusion of the contracts for the heating supply

Detailed planning of the heat plant and the district heating network

Application for possible subsidies

Contact: Markus Möller
STENUM GmbH
E-Mail: mmoeller@stenum.at

Energy-self-sufficient city of Güssing

(Original Project Title: Modelle zur Erreichung der Energieautarkie im Bezirk Güssing)

Synopsis

Based on the results of the concept „energy-self-sufficient district Güssing“, in this project feasibility studies for a self- sufficient energy-system in the district Güssing using renewable energy carrier coming from the region will be elaborated. Thereby, the second step towards implementation will be done.

Summary

Starting position for this project is the already existing and implemented model „Energy-self-sufficient city of Güssing“. For some years the city of Güssing provides itself with heat, power and fuels from local renewable resources. Since this model has been very successful it shall now be extended to the whole district. For that purpose a concept is developed (in the course of the first call). In that project it was already found out, that the supply rate in the district Güssing with energy from renewable energy carriers amounts to 71,73% in the area of heat, to 33,73% in the area of power and to 46,67% in the area of fuels. Thus, per year 18 m Euros of added value remain in the district Güssing.

The aim of this project is now, to investigate the feasibility and concrete implementation possibilities at concrete sites, based on the communities that were identified as potential sites in the first project, and thereby make a further step towards the realization of the energy-self-sufficient district Güssing. General aims of the project are energy-self-sufficiency of the district, use of renewable resources and thereby regional value added and creation and safeguard of jobs, as well as an increase of the publicity of the region as energy-model-system. These general aims can only be realized by the actual implementation of energy-self-sufficiency (in the third and last step).

In order to identify implementation possibilities for the energy-self-sufficiency in the district Güssing, concrete sites, in the communities that were - according to resources and energy demand - discovered as potential sites in the first project, are defined. After this, decisions for concrete technologies are made for each site, based on possibly applicable technologies that were filtered out – according to existing resources and energy demands - in the first project. In a next step the concept for logistics, that already exists on the level of the district from the first project, will be broken down to each of the concrete sites in respect of resources as well as of consumption. In order to ensure an economic operation of the plants required for energy-self-sufficiency, profitability analyses are carried out for each site and possibilities for financing are investigated. Thereby existing as well as basic conditions to be expected in the area of renewable energy will be considered. Considering the experience gained by the implementation of the model “energy-self-sufficient city of Güssing”, optimal structures for the erection and operation will be determined for each site.

In principal, in the project timetable the work packages are scheduled in the order described above – with some overlapping, but will be carried out in an iterative process, so that the results of one work package can still influence respectively change the results of the other work packages.

As results of this project, concrete sites for plants, with which energy-self-sufficiency in the district Güssing can be realized, are expected. Further more, after the completion of the project, for each site a technology will

have been selected, with which energy-self-sufficiency can be realized as efficient as possible. The concepts for logistics will have been adapted to the concrete sites regarding resources as well as consumption. From an economic site of view, profitability analyses for each plant / site, as well as knowledge of possible promotions for each plant / site and basic conditions that are existing respectively to be expected will be results of the project. According to this, preliminary talks with potential investors will have taken place. For each plant, that is required for the realization of the energy-self-sufficiency in the district Güssing, structures for the erection and operation will have been determined.

The overall result of the project is the feasibility of energy-self-sufficiency at concrete sites in the district Güssing. In turn, this overall result is the basis for the actual realization of the “energy-self-sufficient district” and the implementation of concrete (demonstration) plants, in the course of the third and last step. Subsequently the superior aim / the vision energy-model-system district Güssing will be reached!

By the realization of energy-self-sufficiency and the use of local resources independence from energy imports, regional value added and the creation of jobs, as well as high name recognition as energy-model-system can be expected as results f the project!

Contact: Mag.a Christiane Brunner
Europäisches Zentrum für Erneuerbare Energie Güssing GmbH
E-Mail: c.brunner@eee-info.net

Integral services

(Original Project Title: Integrale Dienstleistungen - Konzept zur Marktentwicklung von Energiedienstleistungen als integraler Bestandteil der Verteilung und/oder des Verkaufs netzgebundener Energie zu Erhöhung der Endenergieeffizienz)

In the framework of the study on hand, a concept was devised for the market development of energy services as an integral part of the distribution and/or sale of on-grid energy in Austria for more energy end-use efficiency.

The study on hand is based on Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on energy end-use efficiency and energy services and repealing Council Directive 93/76/EEC.

The definition of integrated energy services in the Directive was applied to the definition in the study:

An energy service is invariably an inseparable combination of energy delivery and a service or in-kind benefit directly leading to energy efficiency improvement and/or primary energy savings.

The concept aimed at the following objectives:

_ furnishing relevant information for suppliers of on-grid services to tap into the market for “integrated energy services” (an overview of existing and potential integrated energy services, framework conditions for implementation)

_ the development of a strategy to provide energy efficiency services in an energy supply company

_ the preparation of a project demonstrating the provision of integrated energy services

_ the discussion of the impact which the implementation of the proposed directive on energy end-use efficiency and energy services will have

_ a description of the market opportunities available to suppliers of energy from renewable resources and traditional energy suppliers.

The target group for the concept on hand are primarily Austrian on-grid energy suppliers, but also public authorities, contracting companies, manufacturers of energy-efficient technologies and consumer associations.

Results:

Based on literature research and personal interviews, the current range of integrated energy services available in Austria was identified and examples in EU member states were studied.

In Austria as well as in other EU member states and Switzerland on-grid energy suppliers mainly offer installation contracting, and in rare cases they also provide energy-efficiency contracting. There are partnerships for energy services involving energy service providers or installers but also energy suppliers which are able to offer energy services largely without cooperation partners.

However, in all the cases found in our research, energy services are a niche product offered by on-grid energy suppliers.

The main target groups for integrated energy services are trade and industry as well as communities. Energy services have not gained a foothold in households as yet; only few examples involving this group of energy-service customers were identified in research.

Further potential integrated energy services were discussed and described subsequently.

Moreover, light was shed on the numerous benefits and opportunities (customer retention, competitiveness, reduced dependency on world market prices etc.) which open up to on-grid energy suppliers if they offer energy services, as well as on the obstacles (lack of customer acceptance, lack of experience in the energy supply company, project risks, major capital requirements). Suppliers of energy from renewable resources may become more competitive although prices of renewables tend to be higher because such higher prices do not come to bear to the same extent as in energy delivery alone if a package also includes the delivery of energy, the implementation of measures and the provision of services.

Experiences of on-grid energy suppliers with the services offered were surveyed by

means of interviews and in a target-group workshop. It was striking that energy suppliers assessed the opportunities and obstacles due to / for offering integrated energy services differed widely, depending on their business strategy (low-cost provider, quality provider).

The study also dealt with the current legislative framework to be considered by the on-grid energy supply companies when providing energy services. It was found that a number of relevant provisions to be applied in specific cases in essence depend on

_ the type of energy resource

_ the type of integrated energy service

_ the size of the energy supplier (cf. the issue of unbundling)

_ the province ("Land") in which the service is provided

_ the customer group (end-user, business operation)

_ the status of ownership rights to the property where the service is provided (tenancy rights, etc).

The entry into contracts covering both energy services and energy delivery is possible in the current legislative framework.

However, the important thing is that energy supply companies which sell energy, technology and services have to adhere to all the provisions to be conformed with when energy is delivered alone. In this context, special mention should be made of the legislative provisions of the Electricity Sector and Organisation Act ELWOG (publication of the general tariff, mix of suppliers, labelling rules etc.) and the Gas Sector Act GWG.

This is the reason why legal experts recommend that energy deliveries and services be stated separately in the contract and the invoices.

Other laws which may have a bearing on the rendering of integrated energy services include:

_ the Act on Freehold Flats(WEG)

_ the Tenancy Act (MRG)

_ the Act on Social Housing (WGG)

_ the Act on Heating Cost Accounting (HeizKG)

_ the Act on Construction Rights (BauRG)

_ the Industrial Code (GewO)

_ the Act on Green Electricity

_ the Banking Act (BWG)

_ the Act on Prices 1992 (PreisG)

_ The Consumer Protection Act (KSchG)

_ various regulations of the provinces ("Laender")

Furthermore, the market volume for integrated energy services was estimated on the basis of the indicative energy savings target of 9% stated in the Directive for the ninth year of application of the Directive. In Austria, annual savings of 7,184 GWh can be assumed if the indicative target is reached in the ninth year of application of the Directive. Based on marketrelevant energy prices, a decline in receipts of 429 mill. euro per year would have to be compensated for by integrated energy services.

A strategy for the market launch and implementation of integrated energy services was devised for the energy supply company involved in the project, oekostrom AG. As a result, the company plans to add two integrated energy services to its product portfolio in 2007. These are the services "Reduced standby consumption" and "Rental of energyefficient household appliances". Both are to be marketed in households, a customer segment hitherto hardly tapped into in the context of energy services.

A Guide for Interested Energy Supply Companies was compiled on the basis of the results of the study.

Contact: Ing. Claudia Rosmanith
EEC Energy and Environmental Consulting GmbH
E-Mail: claudia.rosmanith@eecaustria.at

SUPOSS – Sustainable Power Supply for Supermarkets and Surroundings

The vision of a sustainable power supply for supermarkets and other local consumers of electricity, heat and cooling energy (e.g. private households, industrial consumers) is the fundamental idea of SUPOSS. This vision should be put into practice in three steps (STEP 1: Technical and commercial feasibility – STEP 2: Components development & system integration – STEP 3: Pilot projects).

STEP 1 is now completed. In cooperation with SPAR Warenhandels AG the participating project partners carried out an extensive feasibility study. The aim of the study was manyfold – to identify already existing energy systems on the basis of biomass or solar energy that meet the commercial and technical requirements of supermarkets and their local environment, to identify needs for further research and development and finally to make transparent existing commercial and legal barriers that have to be overcome, to make progress towards a sustainable power supply for supermarkets.

An in-depth energy analysis was carried out for seven supermarkets of different sizes (3 Spar Markets, 3 Eurospar Markets, 1 Interspar Market). At the same time relevant data had been collected in the local environment of these markets and based on this data the heat demand of potential local consumers was estimated.

The characteristics of energy supply systems of existing supermarkets are:

100% electricity from power station

100% cooling energy from electrical compressor cooling machines

Almost 100% heating energy from fossile fuels (gas, oil), sometimes from district heating

Detailled energy studies were done to identify energy performance parameters, other relevant technical data (heating temperatures, technical data for heat storage and transport, energy management, …) and curves with energy demands (heating, cooling, electricity). In addition SANKEY diagrams were made to show energy flows. All these date was needed to develop technical concepts for SUPOSS. The following table shows a summary of performance indicators for heating, cooling and air conditioning that are needed for different market sizes.

Type of market	Spar Super-markt	Eurospar	Inter-spar
Heating perform-ance	44 - 55 kW	108 - 160 kW	575 kW
Cooling perform-ance for tempera-tures above 0°C	32 - 35 kW	59 - 81 kW	140 kW
Cooling perform-ance for tempera-tures below 0°C	13 - 15 kW	23 - 36 kW	39 kW
Cooling perform-ance for air condi-tioning	ca. 25 kW	ca. 80 kW	ca. 160 kW

The local surroundings of the above mentioned markets were also examined. The next table shows the estimated heating demands of local energy consumers.

	Status of local development	Ratio Privat / Commercial		Building density		Heat demand (Factor)		Heat demand
		privat	com.	privat	com.	privat	com.	[kWh/a]
Vasoldsberg	Start	100%	-	low	-	15 x	-	300.000
St. Marein	Start	25 %	75 %	low	high	8 x	1 x	210.000
Fernitz	Start	50 %	50 %	low	high	15 x	2 x	400.000
Gleisdorf	Start	50 %	50 %	high	high	20 x	5 x	650.000
Fohnsdorf	Completed	50 %	50 %	high	high	20 x	4 x	600.000
Deutschlands-berg	Completed	50 %	50 %	high	high	15 x	8 x	750.000
Wiener-strasse	Completed	75 %	25 %	high	high	25 x	2 x	600.000

As a part of the study a wide-ranging analysis of the state-of-the-art for solid biomass energy conversion technologies and for solar technologies was carried out to identify the relevant technologies for sustainable power suplly for supermarkets. The results of this examination are summarized in the subsequent table.

End energy	Spar Supermarkt	Eurospar	Interspar
Combined heat and power generation		Solid Biomass based CHP with Stirling motor	
	Solid Biomass based CHP with Linear piston generator		

<table>
<tr><td rowspan="3">Cooling > 0°C
Cooling < 0°C</td><td></td><td rowspan="2">NH_3 / H_2O absorption cooling</td></tr>
<tr><td></td></tr>
<tr><td colspan="2">Compressor cooling machines with CO_2 free Kältemittel</td></tr>
<tr><td>Air conditioning</td><td>Desiccant-Cooling</td><td>Closed adsorption cooling</td></tr>
<tr><td>Heating and cooling</td><td colspan="2">Earth collectors
Air collectors
Earth coupled heat pumps</td></tr>
<tr><td>Power generation</td><td colspan="2">Photovoltaics</td></tr>
</table>

On the foundation of these findings many technical concepts were developed in a next step. A more detailed economic and technical evaluation was made for the most promising solutions.

Solid biomass based Combined Heat-Power (CHP) systems were identified as highly attractive and consequently examined for all supermarket sizes.

For the biggest market size Interspar Biomass based CHP systems using stirling machines were examined in more detail. Also possibilities to combine CHP systems with different thermal driven cooling technologies were analysed. The conclusions of the calculations were that biomass based CHP systems or biomass based district heat systems could be commercially successful operated if there is a high demand for district heat in the local environment of Interspar markets. A combination of thermal driven cooling technologies with these concepts is not possible at the moment due to technical and economic parameters.

Another Biomass based CHP technology – a linear piston machine by Button Energy which is currently in its demonstration phase - was examined for the smaller market sizes Spar and Eurospar. This linear piston machine can be fired with chipped wood and pellets. A pay-back-period of 7 to 13 years (depending on market size and technical concept) was calculated for the higher investment costs compared to oil or gas heating systems.

A lot of different solar energy based concepts were designed and analysed as earth coupled heat pumps for solar heating and cooling, air and earth collectors for pre-heating and cooling, flat plate collectors for water heating, photovoltaics, DEC-cooling.

Earth coupled heat pumps for heating and cooling could be operated economically successful if there are good ground conditions (such a system is already in operation at a Spar market). Low tech applications as air or earth collectors for preheating and cooling in combination with modifications of the building (as low temperature heating systems, better insulation, etc.) are also economically attractive due to the fact that the installation of other cooling devices could be avoided.

The study also showed a technological field – thermal driven cooling – where extensive further research and development is needed. For deep temperature cooling there is only NH_3 – H_2O absorption available. Markets like Spar and Eurospar markets need small deep temperature cooling devices that are not on the market in the moment. For air conditioning several thermal driven technologies like LiBr absorption, adsorption fluid adsorption and absorption technologies and steam jet technologies are currently under development.

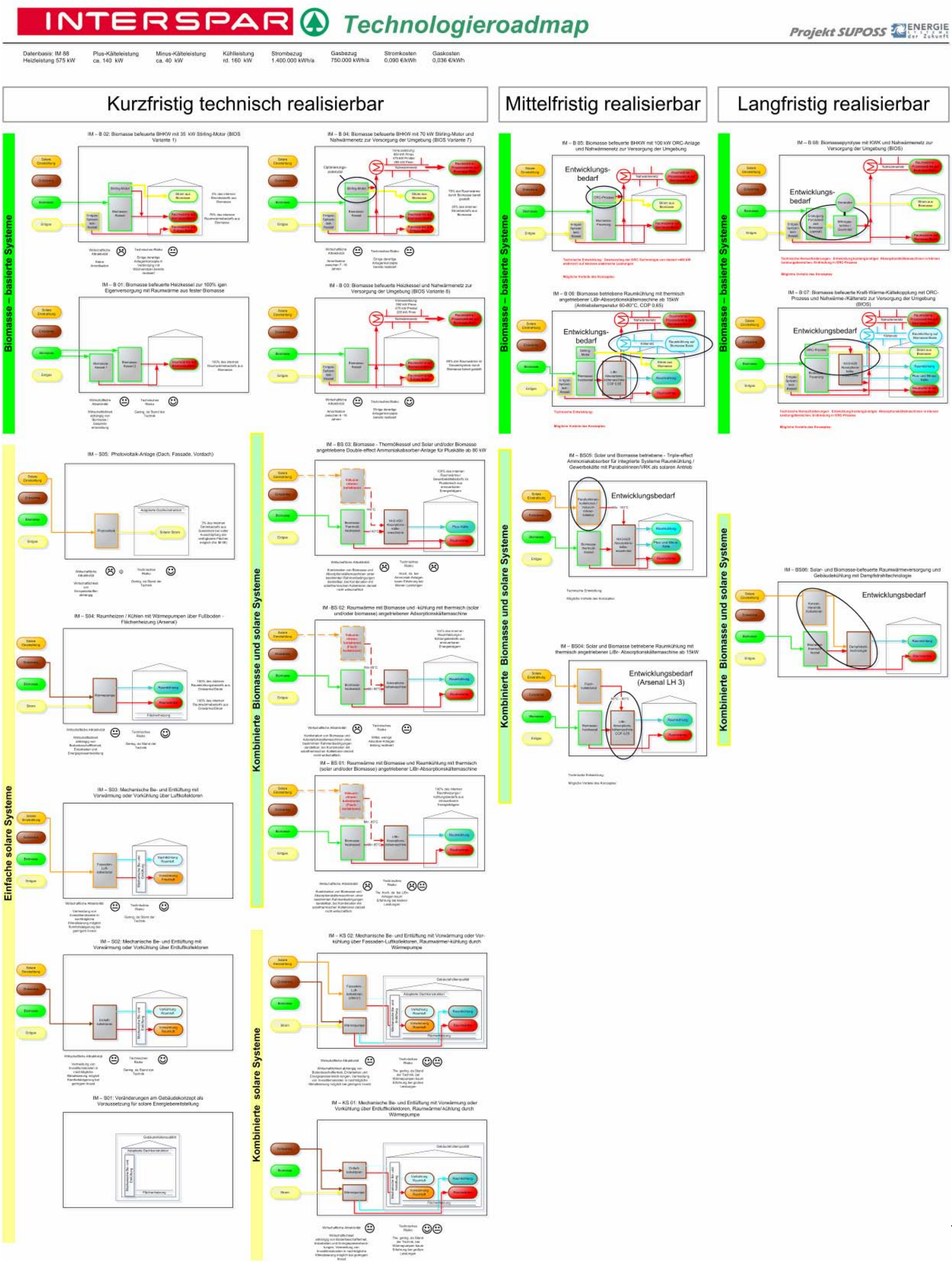
At the time beeing all these technologies are far away from beeing economically competitive. Further progress has to be made to raise Coefficient of Perfomance and decrease costs.

For a further step forward towards sustainable power supply systems in the context of

SUPOSS such thermal driven cooling devices would also have a positive impact for the above mentioned biomass based CHP or district heating systems. R&D activities heading in this direction are strongly recommended.

Based on the developed concepts technology roadmaps were created for each market size.

These roadmaps show basic technical concepts that contribute to sustainability. They are placed along a timeline that gives an indication when they will be available. This information will give value to those people involved in developing and planning future sustainable energy systems for supermarkets and their surroundings.



With the help of the roadmaps important areas for further research and development could be identified. For these research fields a couple of project specifications were elaborated.

To meet the requirements of a sustainable energy supply for supermarkets there is a need to start developments for the following technologies:

Solid biomass based Stirling motor

Organic Rankine Cycle (ORC) process

Solid biomass based linear piston generator

Desiccant cooling

Absorption heat pump

LiBr cooling technology

Parabolic trough collector

In addition to the technical development needs suggestions were elaborated in cooperation with SPAR how to prepare pilot projects. Three main directions for preparing demonstration systems were recognized.

Generating simulation models of supermarkets and analysing correlation between different building construction standards (insulation, materials,…) and different energy supply systems

Conducting a detailed feasibility study for a biomass based CHP system with district heating for a new Interspar market

Planning of a fully energy independent market (Spar, Eurospar) as a demonstration project. SPAR is already starting to talk about such a market together with a strong technology partner who is willing and able to work as a general condractor. The findings of the present study will give them a solid base.

A short market potential analysis was also done. Currently estimated 200 to 250 projects per anno (erection of new markets, refurbishments) are carried out in the food trade sector in Austria where sustainable power supply systems can be introduced.

It can be summarized that STEP 1 of SUPOSS gives a solid foundation for the next steps to transform the vision of a sustainable energy supply for supermarkets and their surroundings into reality.

Contact: DI Dr. Manfred Peritsch
IMG Innovation-Management-Group GmbH
E-Mail: m.peritsch@innovationsmanagement.at

Energy centres: Electric peak load balancing in food store chains- Strategies for energy efficiency improvement

(Original Project Title: Energiezentren: Elektrischer Spitzenlastausgleich in Lebensmittelketten - Strategien zur Verbesserung der Energieeffizienz)

Supermarkets have substantial energy expenditures to ensure the cooling chain of food products and to keep the quality criteria, so they have a strong obligation to the customer. Under these basic conditions, a concept will be developed which optimises the synchronisation of power supply and demand. With this, the integration of renewable energy sources will be facilitated and new scopes for customers and suppliers will arise. This symbiosis is the key to a long-term economy of the concept and the example for other, comparable enterprises. With a region wide realisation of the concept, the peak load demand could be reduced by 3 – 10%, depending on the design and dimensioning of the systems.

The project analyses detailed the potentials of peak load shifting and –reduction in supermarkets in detail. The focus is set on the refrigeration technologies due to its need of 50 – 60 % of the total electricity demand. Existing compressor technologies will be used, but will be extended with a novel control strategy and probably with latent cooling storages.

Such thermo-electrical systems could operate in future as a kind of huge "battery storage" in existing power systems. The use of cooling energy as integrated storage system has potentials to improve the integration of intermitted renewable energy sources such as wind energy or photovoltaic. In the course of the project the impact of the extended implementation of such "battery storages" on the balance energy will be investigated in detail.

A further goal is – beside the internal load homogenisation with storage systems and load management – also the saving of primary and secondary energy by means of optimisation of cooling equipment (e.g. insulation of cooling chambers and –lines, insulation and/or re-design of display refrigerators, etc.) to improve the total energy efficiency.

The investigations and simulations rely on a defined "reference refrigerated warehouse" of MPREIS.

For doing so, the first step is to classify different load groups of supermarkets. Criteria for the classification are among others the size of the markets, the energy consumption, the technical equipment etc. The impact will be determined with performance indicators, allowing to transfer results of the investigations to other comparable supermarkets.

Particular attention will be paid to motivate consumers by financial incentives to actively participate in and to contribute to the high performance operation of the grid. A real-price model will be developed for the "reference refrigerated warehouse" and adapted towards the foreseen demonstration object.

Furthermore a tariff model will be developed, intended to serve as an example for the countrywide implementation in future.

The project strategy includes a warranty plan for ensuring the reliability and performance of the technology and for the satisfaction of the future users.

Contact: Monika Becker
ATB/TBB
E-Mail: office@atb-becker.com

Conception of innovative business models for active net integration of de-central consumers and production plants

(Original Project Title: Konzeption innovativer Geschäftsmodelle zur aktiven Netzintegration dezentraler Verbraucher- und Erzeugeranlagen)

Synopsis

Concept economically and technically feasible business models for distribution grid operators, generators as well as end users which have potential chances to be used in the long term until 2050 (building up from the key years 2015 and 2020) in the active distribution grid operation in Austria; Indicate the optimal grid integration possibilities at lowest social cost and provide efficient energy services close to consumers' needs.

Summary

The upcoming structural change of the Austrian energy system towards distributed generation will significantly increase the requirements on the distribution network operation. Necessary efficiency increases can be – among others - achieved by a more network-oriented system integration of producers and consumers. This way to an optimized system requires however the new conception of suitable business models, which specify the rules (contracts, payments, licenses) for an active grid operation including all participants (grid operators, producers and consumers). In order to find a strategic positioning towards a more decentralized production the question arises, which solutions for the grid operators, the generators and for consumers are technically expedient and economically realisable in the long-term and have chances to be tested in demonstration regions.

The core questions of this project are therefore:

- Which technical grid operation solutions have the potential to enable a tight co-operation between distribution network operators, producers and consumers in the future?

- How can innovative business models be arranged, in order to enable an energy-efficient active grid operation achieving minimal cost for society?

On the basis of the results of foreseen business model workshops the project compiles different solution paths representing dynamically which business models are suitable for different grid operation solutions in order to find an application in Austria until 2050 taking into account different macroeconomic as well as technological developments (production, demand, storage, grid tariffs, Demand Response; etc.). Additionally an emerging change of parameters - declining grid usage, rising domestic production, rising prices for fossil fuels, etc. - is considered in the dynamic analysis. As comparative reference model, a central grid structure with different grid extension ratios is used.

The most substantial results of this project are:

1. Scenarios for the long-term organization of the distribution grid as well as corresponding optimal solutions for its active control;

2. Business models and associated development scenarios which represent their relevance for Austria quantitatively. Taking into account important boundary conditions (e.g. price development, market rules, etc.) it is examined, how the several business models perform in different scenarios and

when (building up from the key years 2015 and 2020), as well as in which extent they can be meaningfully implemented.

3. Evaluation and ranking of the business models regarding to their robustness, relevance and feasibility.

Overall, recommendations for the future priority-setting in the design of distribution grid-referred market and framework conditions are derived for Austria.

Contact: DI Wolfgang Prüggler
TU Wien, Institut für Elektrische Anlagen und Energiewirtschaft
E-Mail: prueggler@eeg.tuwien.ac.at

Concept of the Sim Tech laboratory for real time simulation of electrical netwroks and components

(Original Project Title: Konzeption des Sim Tech Labors zur Echtzeitsimulation von elektrischen Netzen und Komponenten)

Synopsis

This project aims to work out a concept of a research laboratory for integration of distributed energy resources in electricity grids. This laboratory is intended to be the Austrian contribution to the European Network of Excellence (EU Laboratory for Distributed Energy Resources). Using real-time simulation of electrical grids and grid components, this laboratory will enable deep analysis of new technologies for future energy systems.

Summary

The share of distributed generators (DG) in the electricity system has been growing continuously over the last years. Given the current technology developments and the strong encouragements for using renewable energy resources, this development will continue. With the rising density of DG, design questions for future energy systems in regard to capacity, stability, safety and availability have to be revisited.

By setting up a national laboratory for experimental real-time simulation of electricity grids and their components (SimTech laboratory), Austria will act towards the cutting edge of innovative grid technologies and become a strong carrier of know how in the area of cost-effective integration of distributed energy resources in existing electricity grids. By this project, the national research and development competences in the area of ecologic and distributed energy supply will strongly be promoted and Austria's position in this future market will be strengthened.

This project aims to develop a concept for the research and simulation laboratory SimTech, which enables to examine the advantages, impacts, as well as current and future challenges of a large number of interacting DG units in the grid.

On one hand the results of examinations in this laboratory shall be applicable to more complex problem areas, and on the other hand the simulation results shall reveal more precise predictions for future applications. Hardware tests can immediately be compared and validated against simulation results. In order to achieve this, the partners of the "SimTech Concept" project will deal essentially with the following questions:

What is required to enable the laboratory infrastructure to give comprehensive answers to current research questions for the distribution grid operation?

How must a laboratory infrastructure (SimTech laboratory) be designed and structured in order to answer current and future requirements of potential customers in the area of grid operation with a high share of DG?

The results of the "SimTech Concept" project will be:

detailed requirements analysis serving as basis for planning and implementation of the SimTech laboratory

concept for close coupling of simulation and real hardware (hardware-in-the-loop)

concept for a system configuration enabling parallel operation of smaller CHP units in large numbers

the structure of a complex integrated development environment for grid simulation

The implementation of the SimTech laboratory will allow the grid operators to gain comprehensive answers on system questions in regard to safety functions, grid management, security of supply and quality of supply. Plant supplier and operators profit from more precise component behaviour descriptions and better support of component developments. Regulatory authorities and legislators are supported in the decision finding for innovative tariff models and funding frameworks.

Contact: DI Christoph Mayr
arsenal research
E-Mail: christoph.mayr@arsenal.ac.at

Incentive Net

Synopsis

Conception and application of an economic model for the identification of long-term incentives for investments into electricity grids by grid operators with regard to three possible future scenarios of the grid infrastructure development (Super Grids, Smart Grids, No Grids); Derivation of new regulatory measures and recommendations for all stakeholders (regulator, transmission and distribution grid operator).

Abstract

In the future the prevailing capacity bottlenecks in transmission and distribution grids will further increase - among other reasons - due to the steadily growing electricity consumption. Additionally, grid restructuring measures will become necessary because of the more and more decentralised utilisation of renewable energy sources. At present, sufficient incentives for grid operators to invest in the extension and the preservation of the grid infrastructure does – because of the implemented regulatory framework - in many countries no longer exist. Subsequently, the threat of underinvestment within the grids increases and the security of supply (nationally and in selected European countries) is restrained or even decreases. Hence, the long-term elimination of these problems is indispensable.

The central question of this dissertation therefore is:

Which regulatory incentive mechanism has to be applied according to several grid infrastructure scenarios in order to achieve the necessary measures (nationally and in selected European countries) for the long-term elimination of the missing investment activity for the transmission and distribution grids?

The investment needs, in turn, are dependent on the respective scenario of the future grid structure and the technological options regarding the grid infrastructure design. Thereby, three different scenarios are analysed (compare figure 1):

Super Grids (basically transmission grids)

Smart Grids (mixture of a decentralised grid structure and transmission grids as backup)

No Grids (only isolated applications)

The essential results of the dissertation are:

Economic factors for investments in the grid

Technological framework conditions

Identification of regulatory shortcomings (national and in selected European countries) regarding incentive mechanisms for investments

Investment needs (national and in selected European countries) for the three possible grid infrastructure scenarios

Economic model for the illustration and simulation of dynamic factors for the creation of investment incentives

Deviation of new regulatory measures and recommendations for all stakeholders

The perspective of this dissertation will primarily consider the economical point of view of the gird operators, i.e. the impact of the time of investment on the operating profit or the operational aims is considered and translated into influencing factors for grid investments.

Univ.-Prof. Dr. Franz Wirl (Institute for Business Administration, University of Vienna) is the main tutor of this dissertation and above

all supports the dissertation project with regard to the scientific methods and analytical approach. Dipl.-Ing. Dr. Hans Auer (Energy Economics Group, Vienna University of Technology) undertakes especially the project-overlapping supervision and steers the co-operation with related DG-projects of the EEG. arsenal research - Österreichisches Forschungs- und Prüfzentrum Arsenal Ges.m.b.H. - is 40% financing partner, supports the dissertation in form and content and contributes to the extensive linking-up of the project by its international project work in the subject area „Distributed Generation".

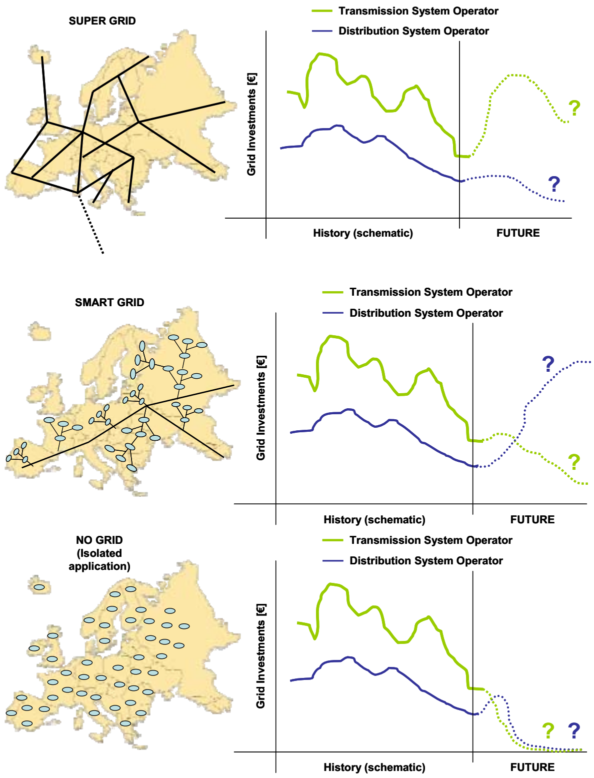


Abb. 1: Three different grid structure scenarios. Own depiction.

Contact: Mag.a (FH) Natalie Glück
arsenal research
E-Mail: natalie.glueck@arsenal.ac.at

ADRES – Autonomous Decentralized Regenerative Energy System

Synopsis

The integrated concept ADRES shall point out the future of energy supply using intelligent, regenerative and efficient energy systems (Autonomous Decentralized Regenerative Energy Systems – ADRES). Via combination of regenerative energy sources, intelligent grid management and highest efficiency in the entire energy chain, especially in innovative end use appliances, a regional low emission fully supply of all energy services (heat, electricity and local mobility) will be possible.

Purpose

Today the energy supply is faced to huge challenges. On the one hand Europe becomes more and more dependent on imports of fossil energy sources. On long term basis the delivery safety relating to price stability is not sure, caused through market power and the shortage of the resources itself. On the other hand the energy consumption considering the yearly growth between 2 and 3% results in environmental and climatic effects. Especially in Austria the problem results in a divergence of the decrease target and the actually CO2 emissions (Kyoto: 2012: -13%, 2006: +23%).

Caused by this, all energy services (electricity, heat and mobility) have to be available at low emission in the future. The development of autonomous, regenerative energy regions, in which the local supply (wind, solar thermal, biomass, photovoltaic, water) meets the requirement, requires highest efficiency and is of central importance. This can also clarify the question how much energy is needed for a full supply without a noticeable comfort loss. Connected to ADRES, industry and craft business as well as new energy services including regional value creation and employment effects are expected.

The overall and interdisciplinary solution is in the spotlight of the research project "ADRES - Autonomous Decentralized Regenerative Energy System".

Approach

The intelligent appliances will have the autonomous and individual ability to change their demand on distributed indicators for power deficits or surplus, without falling below their emergency supply. The efficient demand will be adapted to the stochastic supply at any time by an intelligent balance and control algorithm. Connected to this blackout situations may be prevented and the expenses for energy storage or backup systems can be minimised.

Methods

- Dynamic modelling of appliances and future load profiles
- Balancing of energy demand and supply
- Optimization of regenerative generation
- Dynamic simulation of control algorithm

Results and Conclusions

The visionary research project ADRES should include the energy demand of buildings, electricity and mobility in close up range of an autonomous residential area. From this, planning criteria for energy – active – settlements in the future can be derived.

The results of this project can also be used as guidelines for energy efficiency in decentralized or centralized systems.

Contact: Uinv. Prof. Günther Brauner
TU Wien
E-Mail: adres@ea.tuwien.ac.a

Micro-CHP grid

(Original Project Title: Analyse des technischen Potentials von Klein-BHKW zur Unterstützung des Verteilnetzbetriebes)

The project Micro-CHP-Grid analyses the technical potential of Micro-CHP plant arrangements for providing grid services and identifies the effect of increasing Micro-CHP shares on distribution grid investments for a case study up to 2050. The implementation of a Micro-CHP management system and the interconnection of selected Micro-CHP plants provides the basis for a potential future application of a Micro-CHP grid.

Combined Heat and Power (CHP) plants may play an important role for the transition of the existing power system towards more sustainability. Medium and large-scale CHP can only be realised within areas with sufficient population density. These potentials are already utilised to a wide extent. However, so called Micro-CHP plants work independently from any heating grid infrastructure and are therefore the key for a large-scale diffusion of this promising technology even in regions which don’t allow for a supply with heating grids for technical, economical or even societal reasons.

The project Micro-CHP-Grid analyses optimal strategies for integrating Micro-CHP plants into heating systems of buildings as well as the local (distribution grid) and global (power market) power system in order to support the market diffusion of this technology in a short to long-term perspective. Therefore the economical as well as ecological efficiency of feasible operation modes are identified and technical potentials of Micro-CHP plant arrangements for providing grid services and reducing grid investments are determined. The analyses are based on real data of six Micro-CHP plants which are installed and operated for the purpose of this project.

Central results of the project include guidelines for an economically as well as ecologically efficient operation of Micro-CHP plants under various framework conditions and the profound assessment of the technical potential of Micro-CHP plant arrangements for supporting the distribution grid through active power control. Furthermore the potential of Micro-CHP plant arrangements for reducing grid investments is illustrated within scenarios up to 2050 for a section of an existing distribution grid.

The implementation of a management system and the interconnection of selected Micro-CHP plants by means of communication technology provides the basis for a potential future application of a Micro-CHP grid. The successful demonstration of the operation of Micro-CHP test devices and the dissemination of project results further increases the acceptance for Micro-CHP within the society and with decision makers.

Therefore the project significantly supports the diffusion of this promising technology in a short as well as long-term perspective.

Contact: DI Carlo Obersteiner
TU Wien – Institut für Elektrische Anlagen und Energiewirtschaft, Energy Economics Group
E-Mail: obersteiner@eeg.tuwien.ac.at

Towards a sustainable energy future: Socio-technical scenarios and transformation pathways for Austria´s energy system

(Original Project Title: Nachhaltige Energie der Zukunft - Soziotechnische Zukunftsbilder und Transformationspfade für das österreichische Energiesystem)

Synopsis

The aim of this project is to develop different visions of the future of the Austrian energy system. The socio-technical scenarios are generated in a participatory process involving different groups of stakeholders. A back-casting process then is carried out to identify system innovations and policy strategies to support energy system transition guided by goals such as sustainability, security of supply and the competitiveness of the Austrian economy. The scenarios will focus on strategic action fields such as the design of the grid infrastructure or the interface between agricultural and energy systems.

Summary

The programme “Energy of Tomorrow” aims at a long-term transformation of the Austrian energy system. Such transitions require complex processes of social learning involving a multitude of actors and levels, such as the firm level, social networks and broader social contexts. The system innovations required for profound change processes involve the reconfiguration of technologies, institutions (e.g. regulation; informal norms such as professional cultures or cognitive paradigms), social practices (e.g. use patterns, lifestyles), cultural values, and the relations, interests and strategies of various actors. The active political and social shaping of such transformations depends on the development of shared

visions about possible ‘futures’ of the energy system as well as the continuous adaptation of strategies and action to move the energy system into desired directions.

The suggested project aims at a systematic and interactive engagement with socio-technical visions of potential energy futures and intends to support strategy development at the level of politics, programme management and firms involved in the scenario development process. The project thereby builds on the preceding strategy development process e2050 and complements quantitatively oriented energy scenario models.

The main project steps are:

- Development of framework scenarios to describe different potential socio-economic contexts and other external influences shaping the further development of the energy system.
- Participative generation of consistent and plausible socio-technical visions of future energy systems taking place in two workshops with different stakeholder representatives.
- Multi-criteria-assessment of the sustainability of different visions and identification of specific socio-economic constellations (‘hot spots’) which are regarded central for the further transformation path of the energy system (e.g. design of the grid infrastructure or interface between agricultural and energy systems).
- Organisation of three expert-panels to support the analysis of system innovations related to these hot spots.
- The development of socio-technical visions of energy futures and the analysis of policy options in fields of strategic importance for the further transformation of the energy system shall contribute to the identification of potential barriers and opportunities

for change processes and to the design of transformation pathways towards aims such as sustainability, security of supply or economic competitiveness of the national industry.

Contact: Harald Rohracher
Interuniversitäres Forschungszentrum für Technik, Arbeit und Kultur
E-Mail: rohracher@ifz.tugraz.at

A contribution to active distribution network operation through innovative voltage control

(Original Project Title: Beitrag zum aktiven Verteilnetzbetrieb durch innovative Spannungsregelung)

Synopsis

Enhancement of voltage control strategies for rural distribution networks, allowing the integration of a high share of distributed generation while maintaining the quality of supply. Energy producers and consumers are actively integrated into distribution network operation and the economical frameworks of all players are considered.

Summary

In order to reach the environmental and economical objectives such as those fixed by the Kyoto Protocol, the electricity generation from renewable energy resources will gain an increasing importance. While it is already well-known that the energy supply structure is facing some major changes, the fact that accompanying changes in the planning and operation of the network are needed is still not widely acknowledged. Without adequate innovations in the network operation, the efficient integration of a large number of distributed generators will not be possible.

The hosting capacity of rural networks (most of the Austrian territory having the highest renewable energy potential are rural areas) is mainly limited by the voltage rise effect resulting from the power injection.

The objective of the BAVIS project is to further develop a set of voltage control concepts. These concepts will make use of network assets such as On Load Tap Changers as well as network users. Depending on the acuteness of the voltage problem and on the network properties, different concepts for voltage control are proposed.

These voltage control concepts will allow distribution network operators to make a more efficient use of the available voltage band (for consumers as well as for generators) and thus a better use of the existing infrastructure.

Thanks to the innovative voltage control concepts, expensive and very long network reinforcement will be delayed or ideally replaced. Through the use of the developed voltage control concepts, the following benefits will be achieved:

- Direct saving of investments
- Better use of existing network assets
- Avoidance of the binding risk associated with long term investment

Through the more efficient use of the infrastructure, the connection of a high penetration of distributed generation will be made possible. As shown by previous investigations, a significant increase of the connectable generation capacity can be expected.

Last but not least, simplified methods for planning an active distribution network and for assessing the connection of network users will be developed. This way, distribution network operators will have at their disposal adequate methods allowing assessing with a limited effort the adequacy of the proposed control methods for particular areas.

Contact: Dipl.Ing. Helfried Brunner
arsenal research
E-Mail:helfried.brunner@arsenal.ac.at

Further enhancement of biogas production in Vorarlberg and its use over the natural gas grid

(Original Project Title: Weiterentwickllung der landwirtschafltichen Biogaserzeugung in Vorarlberg mit Einspeisung ins Gasnetz)

The central goal of this project is to enhance the production and use of biogas in Vorarlberg. There are 27 existing biogas plants, which middle size is below the Austrian average. Future possibilities are the feeding into the natural gas grid and direct use for vehicles. To enable such new utilisation paths, it is necessary to further develop the gas production structures. The project also supports existing biogas plants by offering them a new utilisation strategy after the end of their subsidised electricity generation (with no full use of heat energy). The new strategy will combine old and new plants to reach a critical size for the common upgrading of fermentation gas and tries to connect them by a microgrid.

The following work packages will be implemented:

AP 1 Coordination

AP 2 Substrate quantities and availability

AP 3 Structural development and demand situation

AP 4 Technique and substrate logistics

AP 5 Economic feasibility

AP 6 Initiation and knowledge transfer

AP 7 Reporting

Based on a careful analysis of the availability of fermentation substrates (quantity, quality, location), different development scenarios will described. Those scenarios can include the enhancement of existing plants or the construction of new plants. Increasing the production capacities in a certain region is a precondition to enable the upgrading of fermentation gas (Milestone 1).

A draft blueprint will be technically formulated and its economic feasibility examined. Additionally an appropriate substrate logistics will be suggested to ensure optimal supply and distribution of the end product. Based on this detailed planning phase the best solution will be recommended (Milestone 2).

Discussions with stakeholders will be held and additional considerations on the embedding of the scenarios in the regional framework reflected. The results will be summarized in the final report as follows:

- Overview and description of the available substrates, their origin, quality and prize

- Data on possibilities and limits for the increased use of arable land and meadows for the production of biomass

- Feasibility of an increased biogas production including locations and cluster plans for the common upgrading of biogas in Vorarlberg

- Technical blueprint of the most realistic scenarios in some variations

- Economic feasibility of the described scenarios

- Discussion of an improved substrate logistics for the optimisation of the chosen plant location

- Key figures on financial outcome or need for subsidies as basis for investment decisions

- Proposals for new operators for biogas plants and for the central biogas upgrading plant

The project started at the beginning of 2008 and take one year.

Contact: Dr. Richard Dietrich
NLE - Resource Management and Rural Development
E-Mail: office@nle.at

Establishment of a local biogas grids in Güssing-Technical and economic concept for the realization

(Original Project Title: Aufbau eines lokalen Biogasnetzes in Güssing - Technisches und wirtschaftliches Konzept zur Realisierung)

The energy supply of the city Güssing has already changed over to renewable resources. This model system is based on decentralized energy supply and is to be extended to the whole district of Güssing. By a mix of different technologies the energy supply shall be carried out as efficient as possible and it shall be adapted to the local conditions. Previous studies within this programme have already shown that biogas plants are very suitable for the local energy supply in a rural region, since there are agricultural products available. However, the studies also showed that the efficiency and the profitability of biogas plants is very limited if heat consumption at the site is not given. Therefore, the application of biogas plants and thereby the energy supply based on renewable resources is especially limited in rural, sparsely populated regions.

Hence, the aim of this project is to find possibilities in order to use the biogas technology in a more efficient also in rural regions. Due to the feed-in of biogas in a local gas grid, the biogas plants become more independent from factors as heat consumption and transport - that are crucial especially in peripheral regions – and the efficiency and profitability of biogas plants could be increased.

In the course of the concept on hand new alternatives for peripheral regions shall be developed, in order to be able to integrate local resources in the energy system. Thereby, the added value can be achieved in the region. The practicability of a local biogas grid is investigated from a technical, economical and judicial point of view. Additionally, a comparison of biogas grids and district heating grids will be carried out.

The investigation of a local biogas grid is carried out within four work packages: Besides the work package project management and public relations – which lasts for the whole project time of 18 months – in the first months of the project the technical feasibility of a local biogas grid is investigated. This analysis is done under the consideration of technical components, possible sections, quality requirements regarding biogas, availability and requirements regarding end-user units. In a further work package the profitability of a biogas grid is studied in the second third of the project. The profitability of a biogas grid in Güssing is investigated in general and will also be compared with the profitability of common district heating grids. Towards the end of the project judicial and socio-economical factors will be analysed as well.

At the end of the project essential components, section and quality requirements as well as requirements regarding end-user units for local biogas grids can be considered as results on hand. Conclusions regarding profitability of biogas grids as well as a comparison with the profitability of district heating grids will also be available. Relevant guidelines and future developments, possible structures for the operation and synergetic effects will also be results of the project. At last a concrete example for a local biogas grid in Güssing for the extension of the existing energy system will be a result of the project.

A local biogas grid in Güssing would not only result in advantages regarding the supply of peripheral regions. The provision of energy infrastructure is crucial for the settlement of companies. But the extension of the local district heating grid often involves high costs and energy losses. Thus, by a local biogas grid the site development of new companies could be carried out comparatively cheap and efficient.

Moreover, by the use of agricultural resources in biogas plants jobs in the area of agriculture could be safeguarded which would also result in a contribution to the creation of added value in the region and the conservation of landscape.

Contact: DI Dr. Richard Zweiler
RENET Kompetenzknoten Güssing
E-Mail: r.zweiler@renet-info.net

Smart gas grids – Intelligent gas networks of the future

(Original Project Title: Intelligente Gasnetze der Zukunft - Smart Gas Grids)

"SMART ENERGY NETWORKS" is one of the research topics of the FP 7 Cooperation Work Programme [KOM 2007] of the European Union. This topic includes electricity as well as gas networks.

Due to the relevance of this research area, "Energy Systems and Networks" is also one of the main topics in the new national research programme "Energy of the Future".

Regarding smart electricity networks, several research projects have already been started on a national level (e.g. DG-Demo-Net, IRON-Study/Concept). In contrast, no Austrian research institution or industry stakeholder has yet taken up on the "smart grids" concept on the level of the gas networks.

Therefore, the main objectives of this fundamental study are

to create a shared vision of a "Smart Gas Grid";

to identify and analyse the possibilities for implementing smart grid elements in the existing gas distribution networks;

to transfer the knowledge from other networks or markets (e.g. electricity networks, financial markets) to the gas distribution networks.

The following deliverables will be available after finishing the project:

a "Vision and Strategy Paper" for a "Smart Gas Grid";

a theoretical fundament for such an intelligent gas network ;

a compilation of different options for deploying singular smart grid elements in the existing gas networks;

a draft for a "Strategic Research Agenda".

Furthermore, recommendations for follow-up actions will be drawn up and the following additional objectives should be achieved:

to mobilise the relevant stakeholders of the Austrian gas industry;

to establish a platform for the exchange of know-how with European stakeholders (industry associations, research institutions, regulators);

to identify possibilities for lighthouse - and catalyst projects in the "Smart Gas Grids"-context, together with the involved stakeholders of the Austrian gas industry.

The most relevant Austrian stakeholders, including some of the biggest gas distribution network operators, have committed themselves to this research project.

Contact: Robert Hinterberger
Energy Research Austria
E-Mail: robert.hinterberger@energyinvest.at

Biogas - Feeding-in and system integration in existing gas grids

(Original Project Title: BIOGas - Einspeisung und Systemintegration in bestehende Gasnetze)

In Austria biogas is used especially in combined heat and power (CHP) generation applications. Therefore a continuous and rather constant heat demand at the plant's location must be available to enable an economical plant operation. Thus biogas production and its use are restricted to a rather small number of locations. On the other hand biogas will play a major role in a future energy system based on renewable sources. Biogas supply to public gas grids results in a broader use of this regenerative energy source with a high utilization factor, even without the demand for heat supply.

In this study, the infeed of biogas into public gas grids is analyzed by looking at system integration. A sustainable energy supply can only be guaranteed when both substrate for biogas production and deposit of fermented substrate are available in the region. On the other hand, local gas demand which leads to load characteristics of the gas grid has to be high enough to absorb the produced biogas.

In order to deal with these relations, a system approach is established in this study (see Figure 2).

The system border comprises the region, for which biogas infeed is investigated. Inside this border substrate additional auxiliary material and energy are supplied. Besides that, utilisation or deposit of fermented substrate is done inside this border, too. The biogas plant, gas cleaning and conditioning devices, infeed equipment and the public gas grid are represented as different elements of the system. These elements are interconnected. The thus gained structure fixes the transfer-function from the substrate input to the output of cleaned and conditioned biogas which is supplied to the gas grid.

In this study technical and operational data has been collected and analyzed for the different components and plant technologies.

Load characteristics of 2 typical public gas grids of grid level 3 (with an operation pressure < 6 bar]) are analyzed. The gas grid of a small village in a rural area as well as the gas grid of a district town show a dramatic decrease of the gas demand during summer. The amount of gas distributed in the grids reduces to one tenth of the medium winter gas demand (see Figure 1).

Besides that, prediction of gas demand using standard load profiles is strongly affected by errors (up to 50 [%]) during these low-load-periods.

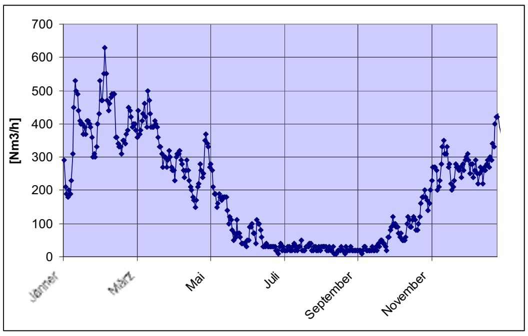


Figure 1 Load characteristics of gas demand (hourly basis) of a public gas grid of a district capital in Styria [STGW 2004]

The infeed of an, over the year, constant amount of biogas into a public gas grid depends on the minimum amount of gas in the grid. Taking this into consideration, biogas infeed to high pressure gas grids (grid level 2), which are characterized by higher amounts of transported and distributed gas, is strongly recommended.

In addition to these operational conditions, aspects regarding technical security of biogas infeed are documented in this study, too.

For the major components, available technical and operational data are documented. A method for the calculation of biogas output and quality depending on substrate input is presented. In addition to technological data, specific costs are documented for gas cleaning and conditioning technologies. Emissions which occur during operation of biogas plants, gas cleaning and conditioning and infeed into gas grids are analyzed, too.

Bearing in mind economic operation, logistics of substrate and fermented substrate are evaluated. In this context, specific costs for transport could be documented.

A method for technical and economic assessment of biogas infeed in public gas grids based on key figures is developed making use of the system approach described above. By the use of these key figures, regional and local boundary conditions can be integrated into the assessment process.

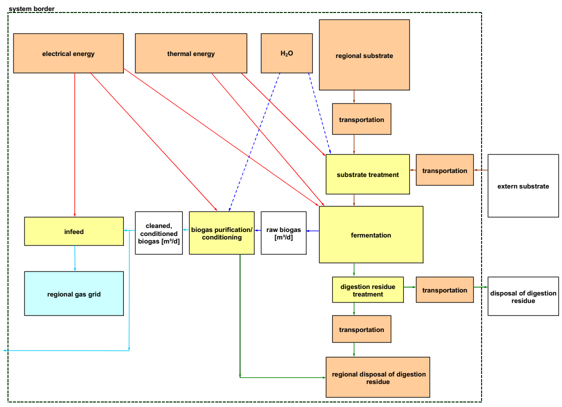


Figure 2 System approach – key figures

The key figures are structured in 3 different groups:

Key figures related to the regional and local boundary conditions

Key figures for technology qualification

Key figures for assessment purpose

Typical values for these key figures are presented as far as data in appropriate quality is available.

Key figures related to the regional and local boundary conditions mainly provide data on substrate availabilities, deposit capacities, load characteristics of the gas gird, boundary conditions regarding transport, specific costs and availabilities of auxilary material and energy, which are needed for plant operation.

Key figures for technology qualification are formulated to represent technical and economic characteristics of the biogas plant, substrate pre-treatment, gas cleaning and conditioning and infeed into the gas grid.

Key figures for assessment purpose provide information on technical and economic feasibility of biogas infeed.

Cover ratios are defined which compare each demand with the appropriate supply. Cover ratios are formulated for substrate and fermented substrate. The cover ratio of the gas grid provides information on whether the amount of cleaned and conditioned biogas and the infeed capacity (= minimum amount of infeedable biogas) of the gas grid are congruent. Figure 3 shows the relations between load characteristics of the gas grid, amount of biogas, that can be supplied to the grid and the biogas production of the plant.

Concerning quality specifications for infeed-gas this method is characterized by a high level of flexibility, because the amount of biogas that can be supplied to the public gas grid is calculated based on the desired quality of the resulting gas mixture of biogas and natural gas in combination with the load characteristics of the gas grid. Typical quality requirements for the mixed gas can be the gross calorific value etc.

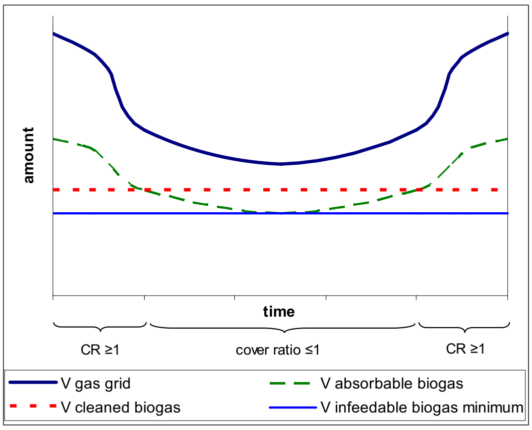


Figure 3 Load characteristics of gas grid, infeed-capacity, amount of biogas produced (schematic drawing)

For economic assessment key figures are defined which evaluate revenues and costs. Marginal costs for the installation of small CHP-units or boilers for covering the energy demand of the biogas plant are calculated, too.

Quality and risks of chosen technology, substrates and plant location are evaluated by key figures with an approach of qualitative analysis.

Recommendations for further R & D activities:

Analysis of the effect of substrate change during operation of the biogas plant. Thus variable load characteristics can be accommodated by changing biogas production.

The availability of data concerning technology and operation of biogas production plants and cleaning and conditioning equipment is rather poor. For that reason standardized biogas plants and efficient monitoring of existing plants should be implemented. Furthermore generally accepted technical rules should be elaborated.

Contact: Dipl. Ing. Dr. Matthias Theißing
FH Joanneum Gesellschaft mbH / Infrastrukturwirtschaft
E-Mail: matthias.theissing@fh-joanneum.at

Biogas microgrids

(Original Project Title: Gasversorgung mittels lokaler Biogas-Mikronetze)

Initial situation

Aim of this project is it to examine the economic and technical feasibility of biogas micro grids. A biogas micro grid is a small-scale local power supply, where several consumers are supplied with locally produced biogas via a low pressure gas grid. The biogas is delivered by one or more agricultural (or commercial) biogas producers, which are also connected to the micro grid.

In a biogas micro grid, cleaned but not methane-enriched biogas at low pressure is delivered to the consumers. Thus, the chemical composition of biogas is different to those of natural gas. Fermentation gas has significant lower methane content (depending on methane enrichment between 50 and 90 percent).

The utilization of biogas in a micro grid has some important advantages: compared to conventional generation of electricity, a micro grid has a higher energetic total efficiency, because there is no loss of energy due to unused waste heat. In comparison to the biogas net feed-in into existing gas grids, it is expected, that the economy of fermentation gas micro grids is much better.

Matters and objectives

The study is structured into 12 working packages.

AP1: Build-up and structure of biogas micro grids:

Different prototypic micro grid structures have been developed, which are the basis for further analyses.

AP2: Load management, production and load profiles:

Selected production and load profiles have been analyzed. A simulation tool demonstrates the combination of load and production.

AP3: Load management: technical equipment:

In this working package it should be examined which form of load management is practicable and cost-efficient.

AP4: Measurement and AP5: Net and pipe construction:

The technical options of biogas measurement and the typical cost of net and pipe construction have been researched.

AP6: Effects of gas quality on burning:

The effects of gas quality on commercially available gas burner have been analyzed.

AP7: Innovative usages of biogas:

Alternative applications concerning the utilization of biogas have been described.

AP8: Gas admixture:

The economical and ecological aspects of gas and liquid natural gas admixture should be characterized.

AP9: Cost structure, Cost effectiveness and AP10: Regulatory framework:

The economy of different micro grid structures and the current regulatory frameworks should be demonstrated.

AP11: Location development:

On the basis of one concrete example the optimal micro grid structure should be developed and its economy should be audited.

AP12: Project management and quality control:

AP12 contains the general management, the quality control, the organization of workshops and the creation of the reports.

Results

The main results of the study are:

1) Information on the economy and technical feasibility of biogas micro grids as a function of the substantial system parameters (grid structure, etc.)

2) Information on the height of necessary subsidies

3) Presentation of available technologies and their costs in particular load management, grid

installation, measuring techniques, burners, etc.

4) Information on the current legal situation in Austria

5) Practical experience from a site development of a micro grid

6) Presentation of the specific need in technology development

The project "gas supply by local mircro grids" has started in February 2007 and will presumably end in June 2008.

Contact: DI Dr. Dieter Hornbachner
HEI Hornbachner Energie Innovation
E-Mail: dieter.hornbachner@hei.at

Transfer of technology and know-how for the initiation of biogas net feed-in pilot projects

(Original Project Title: Technologie- und Know-how-Transfer zur Initiierung von Pilotprojekten im Bereich Biogas-Netzeinspeisung)

Initial situation

Biogas is used in Austria almost exclusively for generation of electricity in CHP plants (combined heat power). The energetic efficiency of this process is usually small, since the heat developing apart from the electricity in most cases cannot be used due to missing customers. Thus, two thirds of the energy contained in the fermentation gas is wasted.

Another, energetically much more efficient way in using biogas, is the feed-in of the gas into the public natural gas grid. The biogas is transported by the gas grid to the consumer. In contrast to natural gas, the combustion of biogas does not increase the carbon dioxide concentration in the atmosphere and thus does not reinforce the men-made greenhouse effect.

Before biogas may be fed into the gas grid, it must fulfil certain quality requirements. These quality requirements are fulfilled by an upgrading process of the biogas. One step of this upgrading process is the cleaning of the gas the other one is the increase of the methane (CH4) concentration, by methane enrichment.

Matters and objectives

The investigations done within this study showed, that present quality requirements for gas feed-in are due to historical reasons oriented at the quality of natural gas. The specialities of biogas, in particular the lower energy content of fermentation gas, are not taken into account.

The costs of biogas feed-in and the existing process technologies were analysed in detail. A substantial cost factor for the overall production costs of biogas are the production costs for the raw fermentation gas. It is shown, that the costs substantially vary depending on the source of biogas (substrate).

Results

As the study shows, the specific costs also strongly depend on the size of the plant. Larger plants lead to significant lower production costs of raw biogas.

For cleaning and upgrading of biogas numerous technologies were examined: Despite large technological concepts the costs of all procedures are very similar. Methane enrichment also cleans the biogas, therefore in most cases no additional cleaning costs have to be taken into account.

The costs for connecting the plant to the grid again vary strongly and depend on the distance between plant and grid as well as on the operating pressure within the relevant gas grid. In the cost considerations it was assumed that upgrading and Propane or Liquefied Petroleum Gas (LPG) admixture are necessary. This kind of biogas is therefore called "exchange gas", because it can replace natural gas completely. To avoid expensive upgrading, also cleaned (but not methane enriched) biogas can be fed in to the grid as so-called "admixture gas" This “admixture gas” has the natural methane content of raw biogas, which is approximately 60%.

A very special economically attractive marketing opportunity of biogas is the construction of direct lines. In this way, for instance, enterprises close to the fermentation gas facility could be delivered in direct way without using the public gas grid. Also the establishment of local fermentation gas grids (islands) is an attractive marketing opportunity.

Despite some small market niches with high price levels, cost-covering for biogas feed in is usually only realistic with attractive feed-in tariffs, similar to those for electricity from renewables in the Austrian eco current law (“Ökostromgesetz”).

The results of the study have shown that the feed-in of biogas to the public gas grid is technically feasible without undermining the safe operation of grid consumer devices. The framework is optimised for natural gas and disadvantageous for biogas. This results in high costs for biogas feed-in. By optimising the framework for natural gas and fermentation gas, the costs (and subsidies) for biogas feed-in can be significantly be reduced.

This project has started in February 2004 and was finished in January 2005.

Contact: Diana Köbrunner
HEI Hornbachner Energie Innovation
E-Mail: diana.koebrunner@hei.at

Legal, economical and technical preconditions for the feed-in of biogas into the Austrian natural gas grid

(Original Project Title: Rechtliche, wirtschaftliche und technische Voraussetzungen für die Biogas-Netzeinspeisung in Österreich)

Target group communication of the technical possibilities of biogas net feed-in. Information preparation and reduction in planning complexity. Support and networking of potential future plant operators. Establishing a service office as contact point.

Initial situation

In previous scientific projects the theoretical basis for biogas net feed-in has already been accomplished. As a result of many factors of influence and often difficult basic conditions planning of plants for biogas feed-in is a very complex procedure

Matters and objectives

Goal of this project was to initiate pilot-projects of biogas net feed-in. This should be achieved by a knowledge and technology transfer to those persons and institutions, which are able to plan, build and operate plants for biogas net feed-in in the future.

The transfer of technology and know-how should be achieved by a mixture of several, co-ordinated measures:

Support of plant planning by optimal information preparation regarding technical, judicial and economic conditions.

Reduction of complexity through exactly structured planning processes,

Description of national and international projects.

Web based planning tool for easy and quick cost estimation

Public work in order to spread the knowledge and to increase acceptance.

Establishing of a "service office°

Results

Information platform

Since 30.07.2006 a comprehensive internet-information platform concerning biogas net feed-in (www.biogas-netzeinspeisung.at) is online. The information platform is orientated on the steps of a project-conception and explains the technical, legal and economical aspects of the planning of a biogas net feed-in plant. Interested persons get informed with the assistance of checklists, examples of plants, a list of suppliers, a bibliography and a glossary. The integrated planning tool is online since 14.10.2006. The planning tool permits a first cost calculation of a net feed-in plant either in the express mode or in the expert mode.

Target group communication

The public presence and so the publicity and the interest in the subject of biogas net feed-in has been clearly increased by the activities of the target group communication. The offering of the information platform has been introduced and established in the target group. Four information events have been visited by a total of 220 persons. Altogether this technology and know-how-transfer project is a successful example of how effective technology-transfer can lead to increase activities of the target groups and therefore to and advanced distribution of technology.

Service office

From October 2006 to April 2008 the service office has been contacted over 100 times. The networking respectively the establishing of contact happened both between university facilities and companies.

Pilot-projects

The current pilot-projects in Austria have been opened to a diversified professional public through the description of the projects on the information platform. Besides the plant in Pucking/OÖ. two plants of biogas net feed-in are at the moment operating

Bruck an der Leitha/NÖ: cleaning of methane gas with membranes

Utzenaich/OÖ.: bio-refinery and methane gas feed-in

One plant in Wals/Sbg in cooperation with Salzburg AG is in the planning stage. The realisation of a large project as it exists for example in Plienig near Munich, is therefore not yet planed in Austria.

The technology transfer project has started in February 2006 and was finished in April 2007.

Contact: Diana Köbrunner
HEI Hornbachner Energie Innovation
E-Mail: diana.koebrunner@hei.at

Efficient biogas processing with membran technique

(Original Project Title: Effiziente Biogasaufbereitung mit Membrantechnik)

Biogas produced from grass or energy crops is a gas mixture containing methane (50-75%), carbon dioxide (23-48%), hydrogen (up to approx. 2%) and traces of hydrogen sulphide and ammonia. Biogas, when produced is saturated with water. Biogas can be used for several purposes: direct energetic usage (combustion), combined heat and power generation (gas engines, gas turbines), compression and usage as fuel, and the usage as a natural gas substitute after upgrading and compression.

For the usage as a natural gas substitute it is important to develop an efficient and robust technology to remove carbon dioxide, humidity and traces of ammonia and hydrogen sulphide for the specific requirements in rural areas.

Current technologies have certain disadvantages: using water absorption, for instance, it is difficult to reach the required methane concentration according to the Austrian gas quality directive G31 for the direct usage as a natural gas substitute. Investment costs are usually high and the specific energy consumption as well as the consumption of other resources (e.g. cooling water or fresh water for water scrubbers) are rather high.

It was the main goal of this project to develop a modern and efficient method based on membrane separation technology and to test the technology in combination with a biogas fermentation for the digestion of energy crops. An innovative process design required only one compressor; additionally, the methane losses could be reduced down to below 2%.

For this purpose a mobile pilot plant unit was designed, built and transported to an agricultural biogas production facility using energy crops as fermentation feed source. During the demonstration phase of the project a small bypass raw biogas stream of up to 1 m^3/h was upgraded to meet the requirements of the Austrian natural gas quality directive ÖVGW G31. The product gas quality was analyzed and confirmed by an independent laboratory. The results achieved are the basis for a future full-scale design of a biogas upgrading facility. Although the membrane lifetime cannot be estimated from the runs so far, only a small performance decline of the membrane modules was observed.

Another goal of the project involved the screening of new gas analysis techniques for the online monitoring of the product gas. A new technology based on a photoacoustic signal generation was tested by constructing a suitable prototype for the measurement of carbon dioxide. The results are promising and they may be the basis for further development.

Safety measures for the scale up of the technology and suitable control techniques were investigated and recommendations were given for the fully automated plant operation. A concept was developed for the quick shutdown of the upgrading facility.

Finally, a simulation tool was developed to model and scale up the investigated technology. The simulation model considers all the individual unit operations (compression, condensation, gas permeation, adsorption) and will be the basis for a future scale-up.

Contact: Dr. Michael Harasek
TU Wien, Institut für Verfahrenstechnik
michael.harasek@tuwien.ac.at