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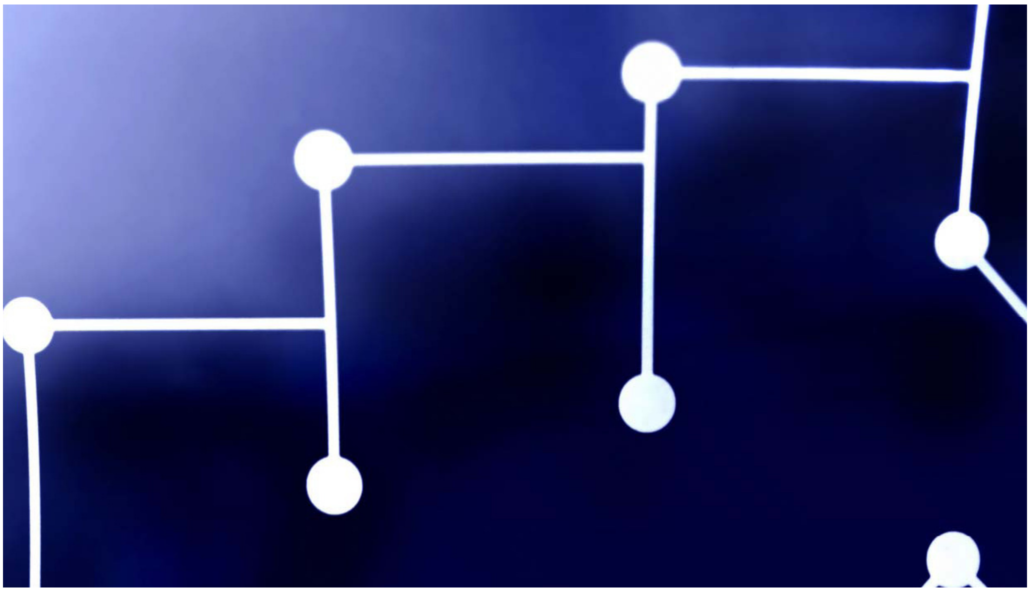

Guideline for the path to an active distribution grid

Intelligent electricity grids of the future

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Guideline for the path to an active distribution grid

Intelligent electricity grids of the future

DG DEMO NETZ KONZEPT

Andreas Lugmaier, Helfried Brunner

arsenal research

This guideline has been created in the course of the project

„Active operation of electronic distribution grids with high proportion of distributed power generation – Design of demonstration grids".

The project report is published as part of this series as Issue 13/2008.

in cooperation with the V.E.Ö.

Vienna, March 2008

Ein Projektbericht im Rahmen der Programmlinie

"Energy systems of Tomorrow-
in the framework of the Austrian Program on Technologies for Sustainable Development"

On behalf of the Austrian Federal Ministry of Transport, Innovation and Technology (BMVIT)

Preface BMVIT

One of the main objectives of the European energy policy is an intensified use of renewable energy as well as the increase of energy efficiency. Distributed electricity generation and intelligent grids are an essential part of the solution.

However, the present energy system – and hence energy supply companies – is confronted with completely new technological and organisational requirements. Fundamental system issues are again massively coming to the fore.

Austrian utilities do already have experience of many years and extensive competency in this field. Due to recent challenges new doors are opened for the domestic industry and interesting prospects for research and development emerge. It is the objective of the Federal Ministry of Transport, Innovation and Technology's research strategies to support enterprises' to innovate and to further expand strong points.

This report documents the findings of a project which is part of the program "Energy Systems of the Future" that has been started in 2003 as a perennial research and technology initiative. Thanks to the remarkable commitment and efforts of participating companies and research institutes formative and internationally accepted findings have been achieved. The quality of the projects exceeded all expectations and provides a solid basis for successful implementation strategies. A multitude of requests for international cooperations affirm this strategy which is pursued by "Energy Systems of the Future".

Christa Kranzl

State Secretary for Innovation and Technology

Federal Ministry of Transport, Innovation and Technology

Preface VEÖ

Environmental and resource problems associated with electricity supply are highly visible and are therefore discussed in many cased way too emotional and not factually enough. Distributed power generation with the aid of environmentally sound and resource-saving energy sources will definitely play an essential role in the future. This upcoming challenge has already been detected by electricity grid operators years ago; possible solutions have been discussed, and it has also been pointed at the cost-problem that the Austrian Control Agency (ECG) has to face.

The problem that grid operators are confronted in conjunction with distributed electricity producers is the striking non-synchronism between generation and use, which is especially critical in lower voltage levels. Voltage control is the major difficulty that has to be overcome by grid operators in the overall grid with self-reversing power flow programs and especially in times of increasing demands on the quality of voltage where regulation of quality is imminent.

Results which have been achieved in the course of the research project “DG DemoNet-Concept” have revealed a solution method that allows us to look optimistically into the grid future. In analogy to a formerly very often but nowadays hardly used technique of voltage regulation - the present concept is supported by the inclusion of measured data and communication intelligence. This enables a significantly more intensive use of the present grid infrastructure. Grid reserves that are mobilized in this way are of considerable size and in this extent surprising.

All project participants have to be congratulated on their findings and I would like to recommend all grid operators to read this guideline as an inspiring reading for the way to an “intelligent electricity grid”.

DI Werner Friesenecker

Head of the Committee on “Netztechnik und Versorgungssicherheit“ of the Association of Austrian Electricity Companies(VEÖ)

Preface Project Team

In order to decrease the level of import dependency of current European power supplies, the use of energy efficient technologies and renewable energy sources is highly promoted. Thus, distributedly aligned power generation is used more often today. An even stronger enhancement of this tendency is anticipated in view of political declarations of intent on the part of the European Union.

A significant advantage of distributed generation is the high level of flexibility and modularity. From a facility planer's point of view shorter planning periods and faster authorization procedures will arise for individual equipments. Due to a multitude of distributed facilities the security of supply can be guaranteed.

Distributed generation facilities feed generated electricity into regional distribution systems (both low voltage and medium voltage grids). The main problem with integrating the foreseeable augmentation of energy feed- into public distribution grids is – above all in rural areas – voltage stabilization. The grid operator has to take care that power supply voltage is within permitted marginal values at all customer hand-over points. The strategy pursued up to now is grid expansion.

In the future it will become necessary to break new grounds which are able to use expanded resources due to intelligent control and feedback control mechanisms. Such sophisticated control and feedback control mechanisms including all relevant actors of the distribution system are generally referred to as "active distribution grid operation".

This guideline points out requirements and prerequisites for planning and operating active distribution grids. This should help to be able to best possibly use expensive existing grid infrastructure also for a new form of impact due to a high number of distributed generation facilities.

Helfried Brunner

arsenal research

Andreas Lugmaier

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Project Managers DG DemoNet–Concept

Content

Why active distribution grids?

New developments in Europe's **power supply** are ongoing and will have especially large **impacts** on the electricity network:

1. EU policy and public opinions demand an **increased use of renewable energy** and combined heat and power (CHP) which should be fed in decentrally.
2. Consumers call for a higher level of **flexibility and high quality** with increasing power requirement.
3. **Cost pressure** on distribution network operators is further increasing.

The **opportunity**: Active distribution systems are a cost-efficient alternative with positive side effects.

Trends and Requirements for the Electricity Grid of the Future

Demand on increasing use of distributed energy feed-ins

In view of climate protection and imminent larger import dependency on oil and gas, the EU wants to increase the share of renewable energies in the total energy mix from currently 7% to 20% by the year 2020.[1]

The EU is therefore working on the passing of binding national directives on the share of energy from renewable sources (electricity, biomass fuel, heat, and cooling generation) in final energy consumption by the year 2020. The intention is that the share of renewable energy sources has to be increased from 23,3% in 2005 to 34% in the year 2020.[2] The EU wants to "accelerate the progress, describes the objectives as very ambitious ones and notices remarkable efforts on the part of the member states. For that

[1] Communication from the European Commission to the Council and the European Parliament on renewable energy. COM(2006) 848

[2] Proposal for a directive of the European Parliament and of the Council on the promotion of the use of renewable sources, 23.01.2008 - COM(2008) 30 final – Annex 1, page 47

purpose a credible and long-term vision of the future of renewable energies should be created..." (COM(2007) 1 - Pkt.3.5). In addition, the share of electricity in the overall energy consumption will further increase[3], and hence a new wave of distributed energy feed into distribution grids has to be anticipated. These developments are only possible when distributed power input is enabled by grid operators.

Consumers demand flexibility and high quality with increasing power requirement

In addition to the grid operators' key task - which is setting up and operating a secure grid at any point of time - operators have to guarantee a high level of quality in case of an increase of demand especially for businesses and the industry. Higher loads will eventually lead to the need for reinforcement of the grid, and grid operators will have to bear the costs thereby incurred in case the consumers will not defray these expenses. This puts grid operators under considerable pressure as costs resulting from investments that are approved are reduced by the regulation. As the graph on the following page shows, distributed generators and consumers are competing regarding voltage stabilization in case of non-simultaneity, however in the case of simultaneity due to local equalization a win-win situation can be achieved.

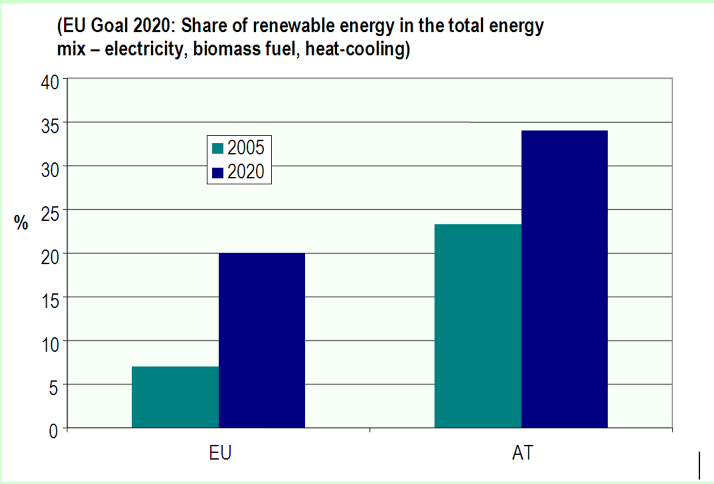
Regulators increase the pressure on grid fees

Grid operators have been confronted with reductions of approved grid costs by regulators for years. This increases the pressure that is put on grid operators, and in the case of exceedance of a certain critical point a deficit in expansion as well as a decrease of quality become a threat. A limitation of economic growth would be the result for the population. Therefore a strong motivation to find more cost-efficient solutions for grid support emerged. Active distribution systems are an attractive solution as they provide a cost-efficient alternative to grid expansion in many areas of application because existing reserves can be used.

However, active distribution systems also involve costs of operation and of investment which have to be borne by grid operators. Hence a commitment to climate protection policies on the part of regulators and the allowance of related inevitable investments is essential.

EU Goal 2020

The EU will increase the current share of renewable energy in the total energy mix from currently less than 7% to 20% by the year 2020. The EU is therefore working on the passing of binding national directives on the share of energy from renewable sources in the energy consumption by the year 2020. The intention is to increase the share of renewable energy sources from 23.3% in 2005 to 34% in 2020.



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[3] see Key World Energy Statistics 2007, International Energy Agency, page 28

Consequences in distribution grids

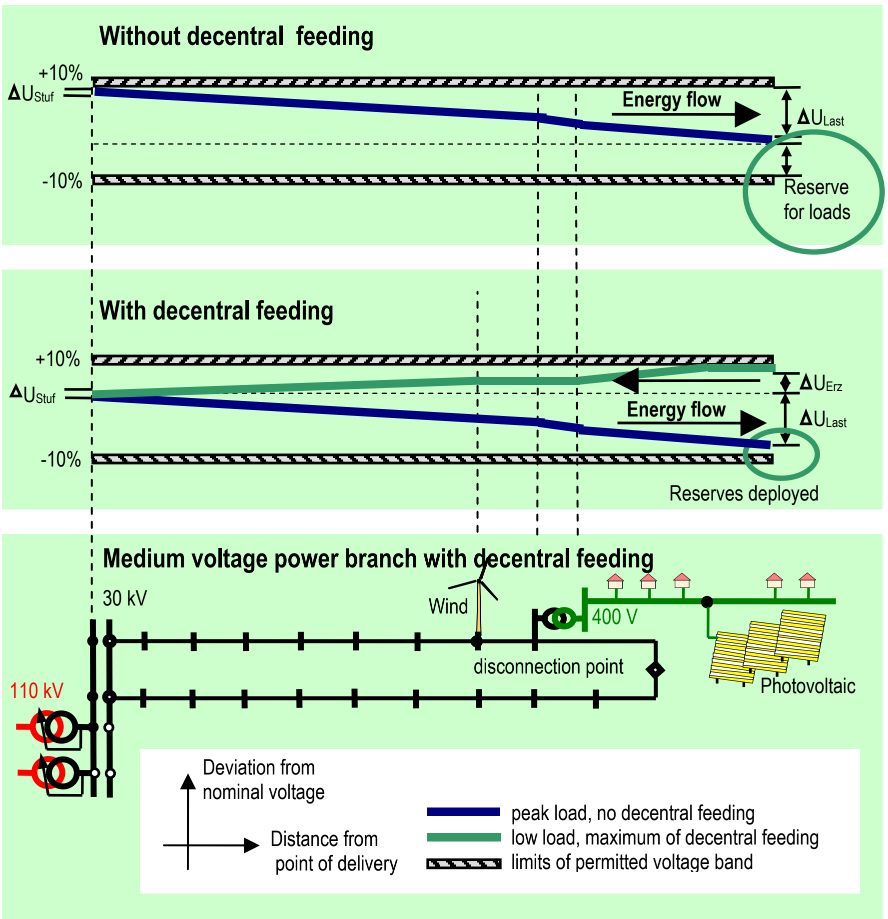
In the range of electrical grids this has led to new major challenges for grid infrastructure and hence for grid operators. Power generation from regenerative energy sources usually takes place where resources are available. Points of delivery are distributed throughout the whole grid area and are also located in remote areas near grid boarders where grids are less powerful. In Austria, so far this is typically small-scale hydropower. Due to their mostly mid-sized plant size, distributed generators feed into medium and low voltage grids. This distribution grid was designed for distribution – as the name implies – up to now and thus it was not constructed for a high increase in distributed feed-in power.

Distributed feed-in can lead to an improper local increase of power supply voltage. In order to avoid such a supply voltage increase lines concerned are typically strengthened due to common practices in grid planning. Due to thereby incurred grid access costs a number of projects are uneconomic, and thus they cannot be realized.

When complete simultaneity of consumption and generation is not given, additional distributed generators consume a substantial part of the voltage band and thus also grid reserves which would otherwise be available for the supply of more users (see figure “Voltage boost through distributed generators”). This leads to an earlier reaching of voltage band limits.

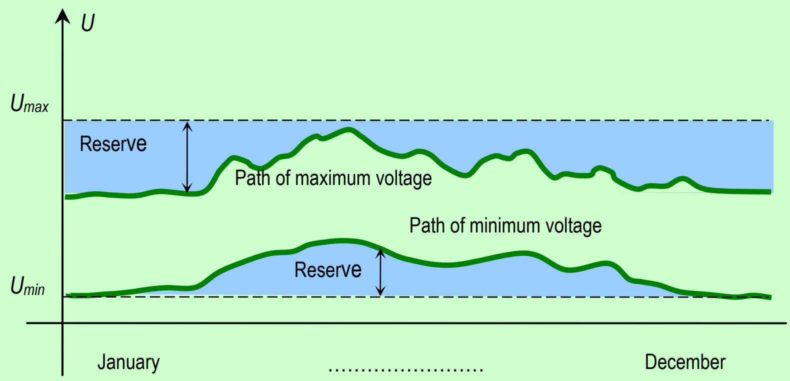
Voltage boost through distributed generators

The network has to be designed in a way that voltage lies within limitations given in EN 50160 in the whole network.
At the top the situation without decentral feeding is shown. The blue line represents the fall of voltage along the lines through consumers.
The graphic in the middle shows the voltage characteristic along the line at critical moments during full generation with lowest demand (green line) and during full load without generation (blue line).
The voltage band reserve available is strained because of the generation.
Based on this, perspective network planning and connection evaluation are accomplished.



Reserve

Transmission capacity of a line is limited through rated current (maximum permitted electricity). In expanded distribution networks an additional limitation results from voltage band limits, so lines can only be operated with a part of full load.
There is a voltage band reserve at any time which however can only be utilized with an active distribution network.
For all practical purposes the utilizable capacity can thereby be increased. In this guideline this will be referred to as **expanded reserve.**



Hence active distribution systems act on this new assumption. With regulation and control mechanisms which actively influence voltage during operation of the grid, reserves are better utilized. Therefore it is necessary to incorporate grid participants and grid components into the control mechanism.

Organizational frameworks – a challenge

The main problem is that there is lack of economically attractive answers for an intense increase of distrbuted generation. The solution which is typically currently used is a cost-intense power grid reinforcement, which only resolves the problem of voltage boost with comparably high costs.

As it is rather difficult to finance investments in grids, grid operators have to look for new ways in order to continue being able to perform their task, to play an active role in future energy policies and not being forced onto the defensive concerning politics, customers and feed-in companies.

Distributed generators are currently exempted from grid fees to a large extent[4] , however, they gain a rise in costs – depending on appearance and location – in distribution systems, that can only be partially prorated to and passed on to individual plants. Distributed generatorsare therefore given priority to over grid users, and this results for distribution system operators with high energy feed-in in a financial disadvantage in contrast to distribution system operators with low energy feed-in.

An open discussion and active participation of all grid users and grid operators is needed in order to not only find a technical solution but also to reach a fair allocation of costs , and at least to reach transparency of costs and develop new approaches.

[4] Systemnutzungstarife-Verordnung 2006, SNT-VO 2006 § 5(1), § 6(1), § 8(2)

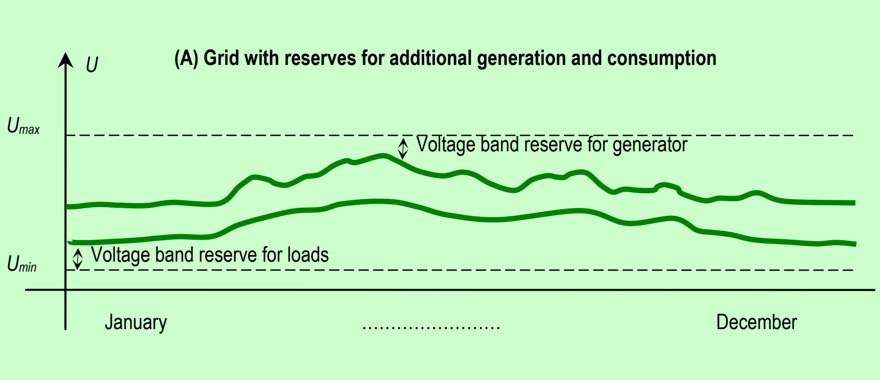
Voltage band management

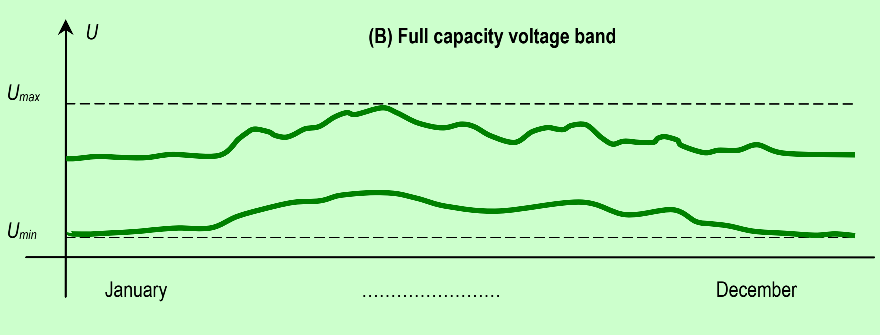
Curve progressions show the minimal and maximal voltage in a network during one year.
In (A) the state of a grid with solid reserve potential for future load and generation increases is represented. Through augmentation reserves are used up by and by (B). Without taking any measures an impermissible exceedance of upper threshold voltage would result (C).

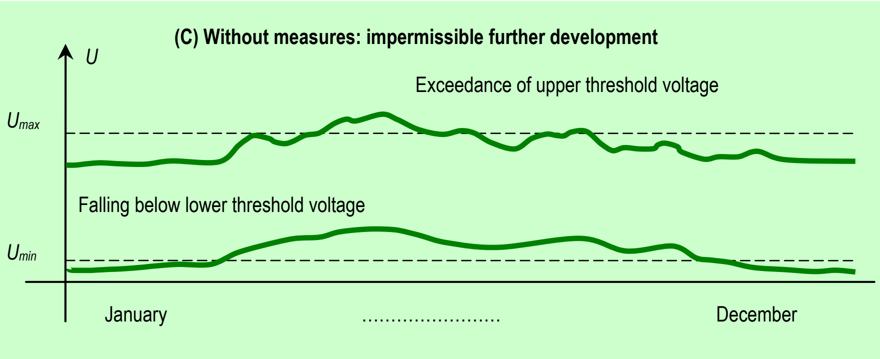
There are two possibilites:

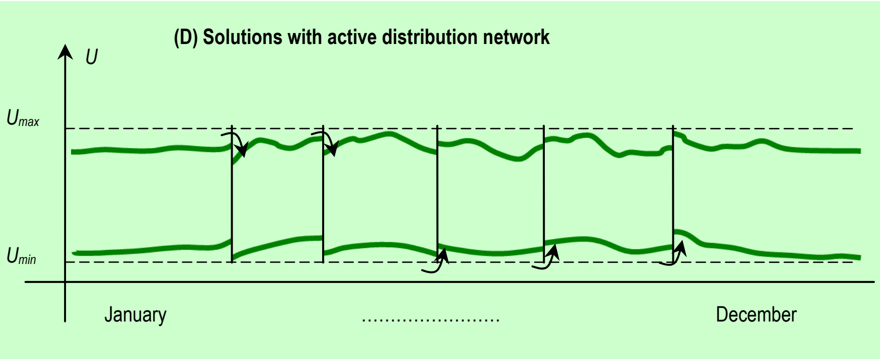
- Shifting the *overall* minimum and maximum lines in an admissible range (strengthening of lines or an active interference in voltage characteristics)
- Shifting of demand for band energy *for any time segment* (only possible with active interference in voltage characteristics, see D)

This active interference in grid operation in voltage characteristics is referred to as active distribution system operation. Possible technical solutions have been developed in the course of the project "DG DemoNet Konzept".









Benefits of active distribution grids

As investments in grids are increasingly encountering difficulties not only due to costs but also due to authorization procedures, the development of new grid logic is a promising alternative, which should enable a more cost-efficient

- intensified distributed energy feed-in (renewable energy, CHP - Combined Heat and Power)
- and an increase of energy for consumers

with least grid support by the means of so-called *active distribution grids*.

Main issues of active distribution grids		
Distribution system operators	**Owner of Distributed Generators**	**End consumer**
▸ The claim on increased distributed energy feed-in can be fulfilled with far less expansion of lines. ▸ The implementation of a new regulation concept requires substantially lower costs than the expansion of lines. ▸ Investments can be made adjusted to the need and in small steps – lower risk. ▸ With the use of existing reserves increased demand quantity (especially for commerce and industry) can be utilized[5]. ▸ Superior know-how is required for active distribution grid operations. ▸ More complex requirements for the building and maintenance are thereby arising.	As long as expanded reserve is available, the following applies: ▸ Grid access can be arranged easier and more flexible. ▸ Some generation facilities are only economically realizable due to low investment requirement at grid access. ▸ Grid access becomes more inexpensive. ▸ There is the risk for distributed generators that it may not be possible to feed-in at 100% for short periods. ▸ Approval of the feed-in company is required for the grid operator being allowed to intervene in the operation. ▸ The feed-in company's willingness is required for the delivery and sourcing of wattless power.	▸ The demand for increased use of available regional renewables can be met more easily. ▸ Voltage control at hand-over points to customer facilities occurs corresponding to limit values of relevant norms. ▸ Current costs of an active distribution grid systems and thus also user fees tend to be higher compared to conventional grid operation as distributed generators must only contribute to construction costs due to current regulations.

After exploiting all options of new grid logic, grid support has to occur only at the construction of rated current. This means that the expansion has to be effected only after a considerable period of time.

The special feature of active distribution grids is that in the above mentioned framework the regulation concepts lying behind it offer a lot of advantages to all grid partners – grid operators, distributed generators as well as consumers – in the transition period where resources are still available.

[5] An additional positive benefit of the new flexible regulation concept (phase 4: coordinated voltage regulation) in the existing grid was an approximately 10% higher potential generated load.

Investments in small steps

When evaluating new feed-in projects, grid planning is analysing through simulations whether improper voltage boost in grids is to be expected. Despite the great effort in grid modeling these calculations still show some uncertainties. The grid operator should - in case of doubt - take the safe side to prevent voltage problems.

Putting real series of measurement of voltage to critical grid nods of an active distribution system are – in contrast to calculation results – physical hard facts. This way the necessity and dimension of grid support can be calculated more exactly through grid planning.

Another essential aspect is that performance improvements always have to occur at the highest possible economic level. Thus, it is the grid distributor's task to considerer overcapacities into account so that he is able to reconnect grid users. From today's perspective extension levels for active distribution grids can be carried out in small steps. Pilot projects are intended to underline this by the means of experiences.

Chances through research

An active distribution grid is in any case a novel task and practically still pioneer work which throws up not only technical but also organizational and economic questions that have to be clarified. A number of them go beyond the scope of grid distributors, plant operators, and plant constructors.

In this situation the connecting link is research. The cooperation between scientific institutions and grid operators provides a good basis for applied research whose results are sustainably realizable. Interesting financing options exist for a lot of tasks. Both the EU and BMVIT support climate and energy funds as wells as research activities that develop new regulation strategies and business models, so that the requirements of the 21st century can be met.

Due to applied research policy in this field a solution of today's economic conflict between distributed generators and grid operations, which is becoming more and more virulent in a way that a win-win situation results for both parties involved, can be achieved. Active distribution grids can play an important role in this process.

From a grid operator‘s view an active commitment in this field of innovative approaches for the integration of high density of distributed generators means that he starts to equip for increasing challenges and thus obtains additional entrepreneurial security. Through the interaction with essential industry partners it can be focused on both the settlement and development of relevant companies can be, and new jobs in the high-tech field can be provided. Thus active distribution grids make a contribution to Austria's position as an excellent location for innovation and business as well as technology export.

This guideline was created in the course of one of these research projects and it should serve as an encouragement to continue the pursued path.

What answers does the guideline give?

Objectives of this guideline

What we want to describe and explain

The guideline presents the most important technical, economic, and organizational principals for the planning and realization of pilot projects with active distribution grid operations. The whole process of realizing an active distribution grid from the status quo to the project set-up of new technical installations is described in this guideline.

Who we want to address

This guideline addresses all persons and organizations in Austria that deal with the integration of distributed power generation into the electric distribution grid and that focus on measures for the increase of efficiency or are affected by this topic.

Especially persons who are about to plan a project for the analysis of active distribution grids with a specific case of application should be addressed.

What makes this guideline interesting and unique

The guideline does not only describe the solution procedure, the advantages of active distribution grids, it does not only point out one specific solution option but it aims at remaining open to new and even better concepts. Moreover it is based on the experience with the simulation and analysis of three special grid sections in the course of the project “DG DemoNet-Concept” and thus it provides a profound basis for further research and development in this field.

“DG DemoNet-Concept” – Reference project for this guideline

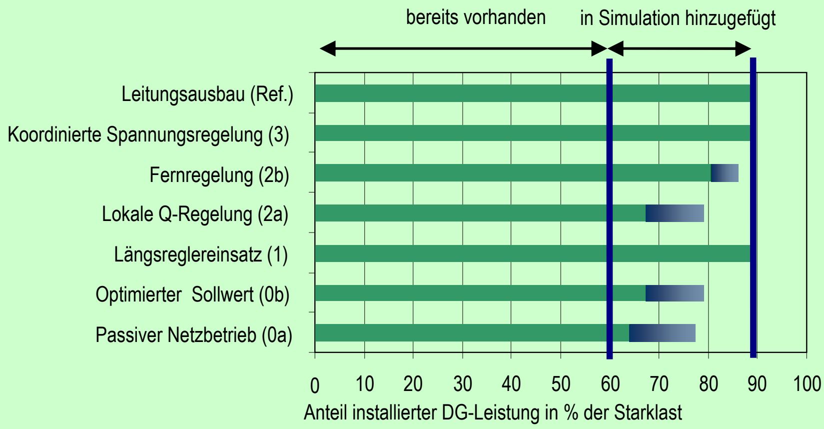
An essential barrier for the integration of a high density of distributed energy producers in rural distribution grid is the adherence to voltage band limits. Thus, the development of a number of innovative voltage regulation concepts for distribution grids was the objective of the project “DG DemoNet-Concept”. These concepts should enable a higher density of distributed energy producers without power expansion but with maintaining voltage quality. Furthermore the demonstration of concepts in several grid sections was planned. Voltage regulation concepts were evaluated on an economic and technical basis and they were confronted with a power expansion reference scenario.

By the means of this project it is exemplified how an active distribution grid operator can function as a model for future grid structures with innovative solutions. Main results of the project are:

- In the course of this project four voltage regulation concepts were developed.
- Expanded reserves are better utilized in the voltage band through regulation concepts, and resources and equipment are used more efficiently.
- The quantified potential of regulation concepts is substantial; economic and technical feasibility is given.
- The realization of the results is the aim of involved grid operators.
- Numerous details for putting the concepts into practice are yet to be determined (e.g. operations issues such as disconnection point shift and substitute power supplier).

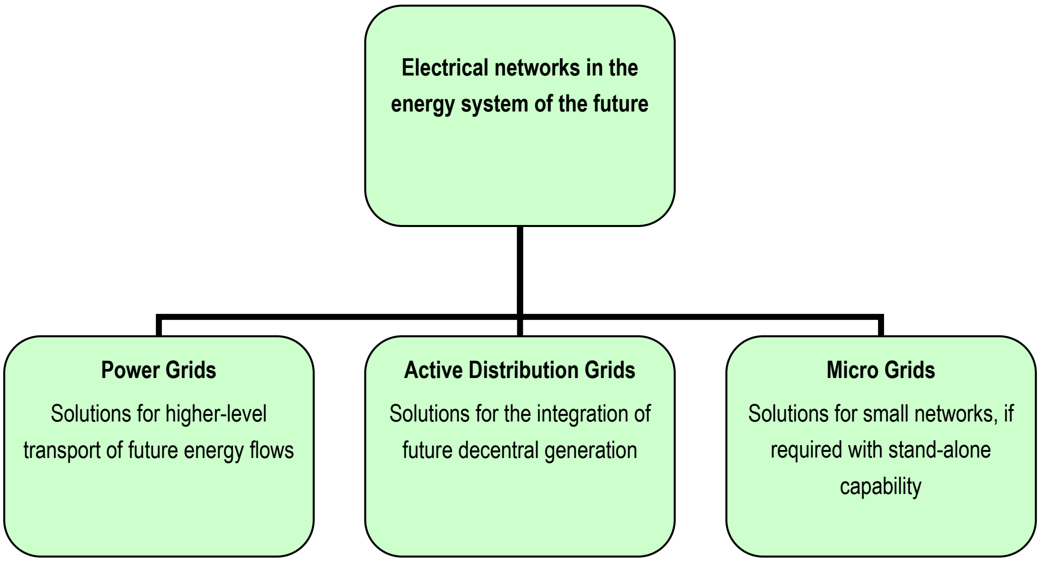
Case study: increase of DG-density in the simulations of “DG DemoNet-Concept” project

The result of the research of different solutions can be shown as in the graphic on the right. For a network section it is calculated by means of a simulation to which level the DG-share can rise for every possible variant. A certain spreading is the result of different potential asset locations.



Context of the guideline

The extensive use of renewable energy and the increasing consumption of electricity in Europe call for new solutions in all voltage levels. This guideline only focuses on active distribution grids (Smart Distribution Grids). Upcoming challenges in the Austrian and European electricity grid can only be mastered if economically and technologically measures coordinated in all ranks are taken.



Active distribution grids in general describe the approach to make best possible use of available infrastructure. In an active distribution grid controllable components, generation facilities as well as loads for better use of infrastructure are run – coordinated through a management system. Thus, an active distribution grid implies that the grid operator has the opportunity to actively involve both the generator and consumer through information and communication systems. This means that – depending on demand and supply of energy – generators alone or both generators and consumers are actively involved in the grid operation. Hence an overall stronger and more efficient use of regionally available energy resources for the generation of electricity in electricity distribution grids – by maintaining supply quality and security – is enabled.

The way to an active distribution grid

The guideline's structure adheres to classical project management. The aspects that have to be taken into consideration when planning and realizing an active distribution grid are summarized in the following table and they are subsequently commented on.

The main tasks are divided into five phases, and in each phase technical, economic as well as organizational requirements are differentiated.

This guideline which evolved from experiences with the three grid sections of the "DG DemoNet-Concept" project, should serve as a support when planning and realizing similar projects. However, the authors are aware of the limitations of this guideline and it is not intended to be exhaustive.

It is essential in all phases that participating partners and departments get informed both on schedule and efficiently and that they get involved in all development processes.

A condition precedent is that sufficient capacity of personnel is available and employees who are put in charge of the project have to work on it with strong personal commitment and pioneering spirit.

Overview of all phases in developing into an active distribution grid

	Recoding the current state	Opportunities and forecasts	Developing possible solutions	Analysis and selection	Project set-up
Technical	▪ Availability of grid data, simulation software and their compability ▪ Status of the grid (relevant grid data, grid topography and topology, …) ▪ Status of loads (location, profiles, load category, …) ▪ Status of generation (location, profiles, primary energy carriers, feed-in technology, …) ▪ Status of secondary technique (available communication equipment, power control system, …) Reliability of infrastructure (primary and secondary technique, IT)	▪ Possible increase of share of distributed generation with current grid state ▪ Adaptation potential of existing decentral generation units (controllability P and Q) ▪ Load management, ability of repositon of loads (household/industry) ▪ Effects on grid security ▪ Limitative impact of regulations and norms ▪ Technical know-out criteria for communication solutions ▪ Future tendencies of the loads and generation situation	▪ Simulation of conventional and innovative control strategies ▪ Integrate additional plants into the simulation ▪ Identification of critical points in grid sections ▪ Clarify grid operation issues (particularities: e.g. disconnection point shifts, grid safety, neutral point neutral point handling) ▪ Load management (yes/no) ▪ Impacts on grid operation	▪ Technical evaluation of possible solutions (technical effectiveness) ▪ Check for functionality and plausibility ▪ Selection of solutions possible in the grid section	▪ Work out functional specifications ▪ Schedules (retooling, communication links, stages of expansion, …)
Economic		▪ Implications on the part of the customer through short-term adaptation of loads (P) or generators (P and Q) ▪ Estimation of costs for possible solutions of grids and communication issues ▪ Estimation of benefits of storage technologies	▪ Refinement of cost data (e.g. with bid solicitation) ▪ Development of variants based on results of technical simulations, including reference case (conventional solutions)	▪ Analysis of business optimum (Comparison of variants ▪ Sensitivity analysis ▪ Testing and pointing out of possible win-win situations ▪ Ranking and recommendations	▪ Securing of financing ▪ Ongoing cost controls
Organizational	▪ collection of detailed data (grid status, equipment data,…), due to the extent and diversity of data sources often very time consuming ▪ availability of resources and professional competence	▪ determine contact person for economic and technical questions ▪ evaluation of willingness to participate on the part of plant operators and potential loads management partners ▪ environmental analysis (evaluation of critical factors of success)	▪ Analysis of contract details: loads management customers, power plant operators, property owners, public authorities,… ▪ Proposal solicitation ▪ Clarify insurance issues	▪ Coordination of documentation ▪ Prenegotiation of contract details ▪ If required: PR (information, flyers) for involved partners ▪ Gather feedback	▪ Proposal solicitation for components needed and services ▪ Prepare bidding documents ▪ Prepare contracts (conclude a preliminary contract) ▪ Comprehensible operation documentation

Record current state

Record current-state – what needs to be done

In this step all relevant data are collected from different areas and are structured. Organizational and technical interface has to be clarified.
For both the subsequent realization and going concern at least some parts of updated data is needed. Thus when designing the interfaces it is necessary to look forward so that they can be used long-term and repeatedly.

Technical	**Organizational**
▪ Availability of grid data, simulation software and their compability ▪ Status of the grid (relevant grid data, grid topography and topology, …) ▪ Status of loads (location, profiles, loads category, …) ▪ Status of generation (location, profiles, primary energy carriers, feed-in technology, …) ▪ Status of secondary technique (available communication equipment, power control system, …) ▪ Reliability of infrastructure (primary and secondary technique, IT)	▪ collection of detailed data (grid status, equipment data,…), due to the extent and diversity of data sources often very time consuming ▪ availability of resources and professional competence

The basis of a technical, economic, and organizational estimation of options for an active distribution grid operation with a high density of distributed energy generation is the availability of all data therefore needed. These data include:

- Grid data
- Generation data
- Load data
- Information about secondary technique

At the beginning of the preparations for the switch from a passive to an active distribution grid operation the above mentioned data is edited and processed in great detail. Due to the extent, the diversity, and the possible inconsistency of information this step frequently requires a lot of time. Thus, required resources and the appropriate professional competence needed for these tasks have to be made available already at the beginning of the current status analysis.

Availability of grid data, simulation software and their compatibility

It is essential that all grid data are available in the software so that research for an active distribution grid operation can be conducted in appropriate grid simulation software. In principle it is assumed that these data for medium-voltage power grids are available for a grid operator in an adequate data format for grid calculation; usually it is the format of the grid calculation program used in each particular case.

In order to reduce the amount of work it is very useful to edit and process data in a data format and structure which can be processed by the grid simulation software used in each particular case. How this data format should look like has to be clarified in the run-up to the data collection.

This is usually not applicable for low-voltage grids. In order to be able to extent the research about active distribution grids to low-voltage grids as well, they would have to be formed into grid calculations programs. Load imbalances and also the relevant detailed modelling parameters for the Zero-Lines as well as all Zero-Line components are not available. Therefore modelling results are expected to deviate substantially from the real situation. In the course of the project „DG DemoNet–Concept“ research was focused on medium-voltage grids and low-voltage grids that are subordinated to local grid stations are replicated as the sum of loads and energy feed-ins respectively.

Grid status

Grid data needed for the simulations include:

- **Main grid** (Slack-node) – short circuit power, nominal voltage, operational voltage
- **HS/MS Transformer** – nominal apparent power, nominal voltage, rated frequency, short circuit power, switching groups, tap charger (boost per level, number of levels)
- **Lines** – type of line, nominal voltage, nominal current, length of line, resistance load per unit length, reactance, capacity per unit length.
- **Geographical information -** geographical location of individual equipment and nodes. Ideally schematic illustration of the grid in the simulation environment with a map in the background. If research is conducted by grid operators with grid engineers with adequate geographical knowledge of grid sections, this issue is not that important. However, it is absolutely necessary for research to have a „picture“ of the grid.
- **Switching state -** Switching states in the grid are an essential issue for simulations of grid operation. Especially in medium-voltage grids the location of disconnection points that are open are of importance. In principle it has to be differentiated whether and to which extent the active distribution grid should also be available in the case of substitute supplies. It must be pointed out that such substitute supplies can last for several weeks, for instance in the case of large replacement investement projects.

Load status

In order to depict the co-actions of generation and loads in the simulations it is necessary that profiles of all loads in the grid are provided. For grid users of a certain size measuring data is at their disposal for a whole year (15-minutes-averages). If these data are not available it has to be worked with load profiles scaled with annual energy procurement. However, the disadvantage therewith is that especially with examinations in low-voltage grids - where only a few users are connected to individual nodal points – synthetic profiles show reality only insufficiently.

When conducting research only in medium-voltage grids it is suggested to simulate individual local area grid stations as aggregated loads. As the 15-minutes-mesured data is not recorded for smaller-sized plants it is also worked with aggregated synthetical load profiles.

The following load data are needed:

- Nominal power of loads (active and reactive components, mainly for statistical project specifications)
- Load profiles (15-minutes-averages, measured and synthetical load profiles respectively)
- cos φ of the user (if not available: ballpark estimate of cos φ in corresponding grid section)
- load types (household, commerce, agriculture, industry)
- Attribution of loads to the corresponding hubs in the grid

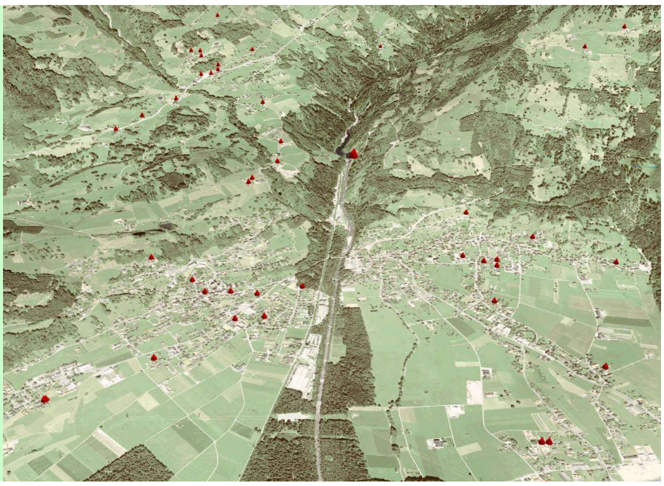
Generation status

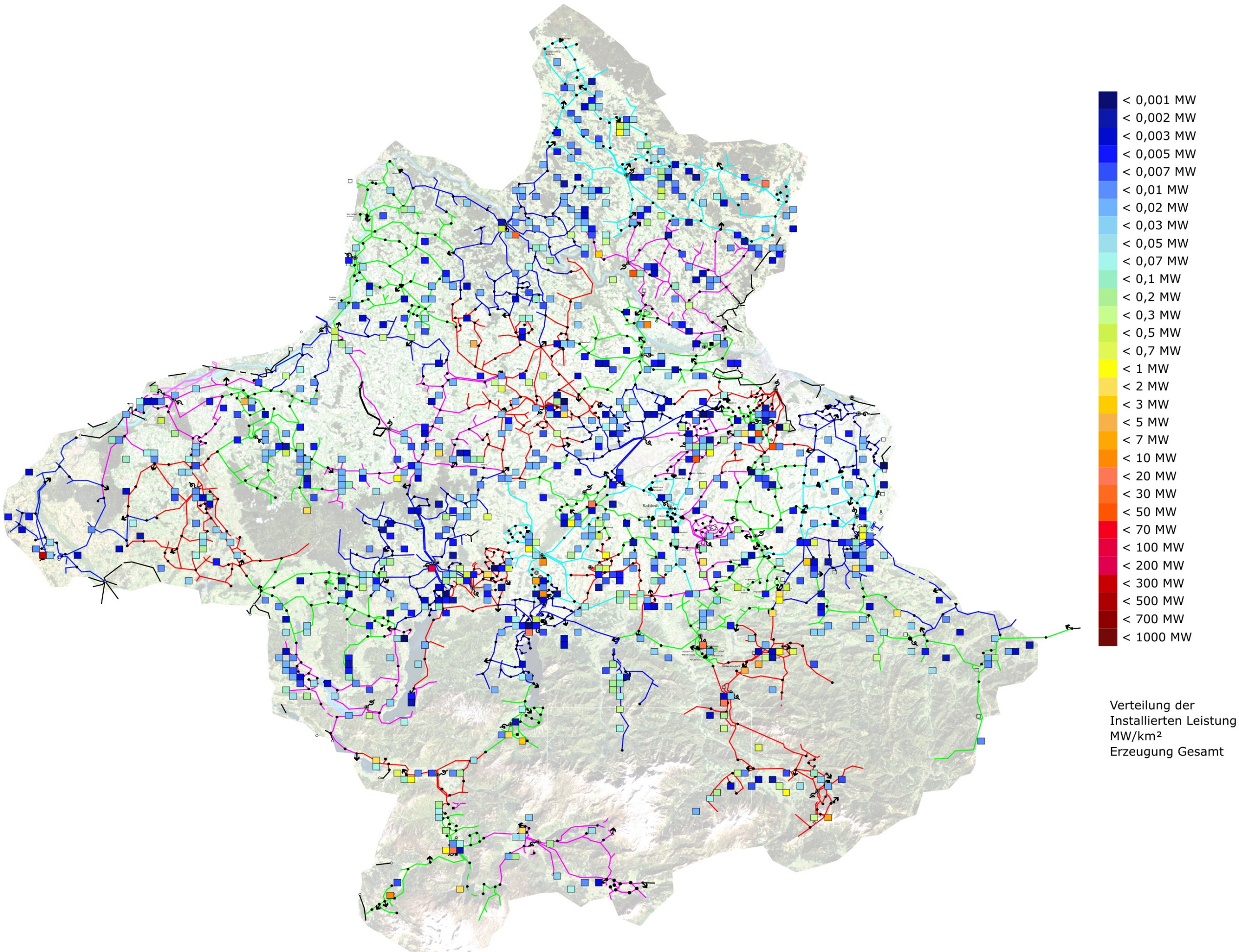
Following data are needed:

- Primary energy carrier used
- Feed-in technology (alternating-current inverter, synchronous generator, asynchronous generator,…)
- Nominal power of generation facilities (active and reactive components – current and possible operating method)
- Load profiles (15-minutes-averages, measures and synthetic load profiles respectively)
- Attribution of generators to the corresponding hubs in the grid

Data collection

Ideally all information for the relevant network section is available in form of GIS data. The illustration on the right shows an example of the graphical representation of the feed-in company in a 3D characteristic landscape. The red dots represent generation facilities of different sizes. Topological information, data for interpretation and – if applicable – measured generation profiles are usually filed in different systems which have to be merged.





Example: Distribution of installed total generation capacity per km², Energie AG OÖ Netz GmbH

In the course of the project „DG DemoNet–Konzept“ current density allocation of distributed generation (DG) in the distribution system of involved network operators was analyzed. The figure above exemplifies the results of Energie AG OÖ Netz GmbH.

1161 generation facilities, 875 MW total installed power
→708 MW in network level 3 and 4
→167 MW installed power of distributed facilities

Secondary Technique

Communication technologies play a major role in the realization and implementation of an active distribution system. The simulation of these technologies and especially the economic valuation requires knowledge of existing and future secondary techniques. This includes:

- Existing communication technologies (Radio, GPRS, fiber glass, power line carrier,…)
- Characteristics of communication technology (e.g. delay when supplying measured data)
- Existing and used grid conduction technique

Reliability of infrastructure

It has to be differentiated between primary energy supply infrastructure and secondary communication infrastructure. Medium-voltage grids are moslty (n-1) structured. This means for medium voltage that every main supply line can be supplied with another grid section. The availability usually lies at 99,99% throughout the year. Thus, although the generation facility is typically disconnected from the distribution grid only for a very short time, limitations can emerge due to the requirements of adhering to voltage bands - depending on the grid topology – in the case of replacement supply.

With secondary technique the availability is usually similarly high, but the disposability of shared public mobile telephone systems, for instance, can be below this value.

Potentials and forecasts

Potentials and forecasts – what needs to be done

On the basis of realistic development scenarios, in this step it is first evaluated how many additional plants – due to current grid reserve (up to 2% overall voltage boost, if available) – can be connected without further measures. Alternative technical solutions aiming at performance improvement require economic and organizational (including legal) framework conditions. In this stage, contact between grid operators and users should be established and first arrangements should be made.
It is advisable to set the potential of generation facilities rather high so that limits are reached and that possible solutions which are identified in the next step are probed critically.

Technical	Economic	Organizational
▪ Possible increase of share of distributed generation with current grid state ▪ Adaptation potential of existing distributed generation units (controllability P and Q) ▪ Load management, ability of reposition of loads (household/industry) ▪ Effects on grid security ▪ Limitative impact of regulations and norms ▪ Technical criteria for communication solutions ▪ Future tendencies of the loads and generation situation	▪ Implications on the part of the customer through short-term adaptation of loads (P) or generators (P and Q) ▪ Estimation of costs for possible solutions of grids and communication issues ▪ Estimation of benefits of storage technologies	▪ determine contact person for economic and technical questions ▪ evaluation of willingness to participate on the part of plant operators and potential load management partners ▪ environmental analysis (evaluation of critical factors of success)

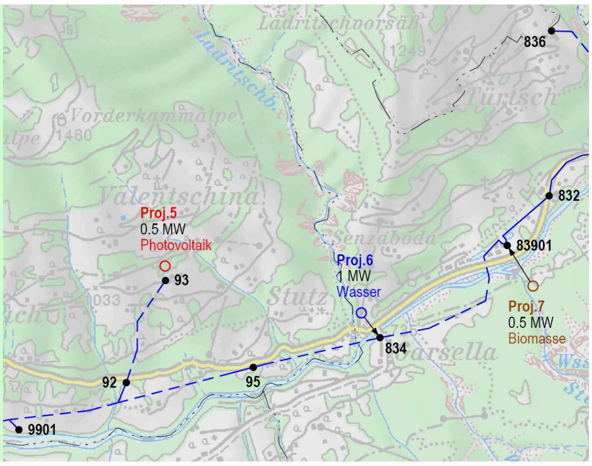
The procedural method that is described below can be used for scenario calculations. A grid operator is faced with projects over a longer period and has to make decisions at very short notice. To operationally realize these concepts the grid operator would have to conduct area-wide potential assessments for his grid and to update them regularly so that required analyses can be conducted as soon as a project starts. However, simple analysis tools that meet these requirements still have to be developed. Online power flow simulations, e.g. on the basis of a pseudo-state estimation, could thereby gain in importance.

Development of grid extension

It should be realistically assessed where potentials for additional generation units are located in the grid section. These prospective generation units are then integrated step by step into the grid during the simulation so that the expected increasing share in distributed power supply can be simulated. It is recommended to consult the scientific assessments such as the "Technology-Roadmap for Photovoltaic in Austria" (Fechner et al., 2007).

Assessment of generation development

The future generation development situation should be estimated realistically to obtain a well-founded estimate for capacity problems that could arise in the distribution network. The illustration on the right shows an example of workings done in the course of the project “DG DemoNet-Concept”. Potential expansion projects can be identified on the basis of the resource situation. In this example the location and capacity of potential photovoltaic, hydraulic power and biomass plants can be seen. However, a good knowledge of the network section concerned is necessary for these estimations.



Furthermore it should be evaluated for existing as well as for future potential plants to what extent the controllability of active power *P* and reactive power Q is given. It may be adduced as an instance that synchronous generators generally offer these possibilities, however, this functionality is in principle possible with inverters but it is currently only implemented with big central inverters.

Regulations and standards

When implementing an active distribution grid all currently available regulations, specifications, and standards have to be taken into consideration. For a grid operator the standards OVE/ONORM EN 50160 and ÖVE/ÖNORM E 1100 are compulsory in respect of voltage quality. The admissible extent of effects of a facility on the grid and of all generation facilities on the most disadvantageous node is determined through the Technical-Organizational-Rules (TOR), parts D1, D2, and D4.

Development with loads and consumers

With regard to loads, the possibilities which enable consumers to influence loads are of primary interest. Depending on the local situation, potentials for local voltage interference can be located here. Electrical heaters and hot water generators are flexible concerning their charge time and they can be operated preferably in times of high energy resources in the grid section. Also conveyor systems, pumping systems as well as other processes in which materials handling and/or processing takes place, come into question in case that sufficient flexibility is provided in the process cycle.

If appropriate loads exist it has to evaluated which effort is needed to use them for a voltage regulation system. These implications on the part of the consumer which result from the short-term adaptation of loads have to be taken into consideration.

Just as with the generation situation, an estimation of future developments has to be made for the demand side, not only with regard to influenceable loads but also to the load situation in general.

Storage technologies

With the integration of fluctuating energy carriers also the issue of storage technologies is relevant. It should be assessed to which extent their use is both technologically and ecologically reasonable.

In this regard the potentials for both pure electricity storage and for primary energy carriers should be evaluated. Here hydraulic power, biogas, and biomass have to be mentioned, where it is by all means possible to store the primary energy carrier and to transpose them to electric power at a more favorable point in time.

Communication technologies

A key element of an active grid operation is the connection of generation units in terms of communication. The availability and the development potential of corresponding infrastructures have to be detected. Communication technologies that are traditionally used in grid operation are fiber optic, radio link systems, and distribution line communication (DLC). In higher grid level, fiber optic exist mostly. Here it is to be determined how far they extend into the medium-voltage power grid and, if applicable, where expansion plans exist. Fiber optic are almost always an effective solution, which however is connected with high costs. In many cases of fiber optic expansion an additional benefit emerges. For the more cost-efficient alternatives radio link system and distribution line communication technical knock-out criteria can exist which prevent the use of these alternatives. Thus a radio link system is not suitable under all kinds of topographic terms. When a high number of disconnection points have to be bypassed in the grid line, distribution line communication only makes sense to a limited extent as the signal often has to be rejected from and then injected to the conductor by the translator.

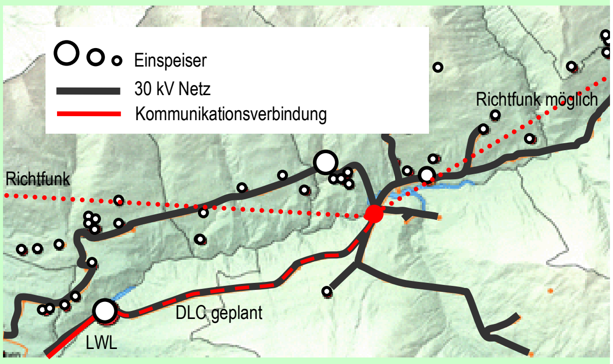
In this case an early cost estimation for possible solutions in communication technologies is suggested in the course of which it has to be taken into consideration which routes are only expanded due to the active grid operation and which routes are already intended for other reasons (e.g. expansion of the telecontrol grid, additional benefits).

Analysis of Surroundings – Assessments of critical factors for success

Besides the technical aspects mentioned above decisive potentials must not be disregarded from the

Development of communication infrastructure

In many cases part of the communication structure needed already exists. Expansion possibilities of a radio link system, for instance, can partly be very simply determined in the course of scheduled maintenance through radio measurement. The illustration on the right shows an extract of forecast for the communication infrastructure just as it was conducted in the course of the project “DG DemoNet-Concept“.



outset: the intention and attitude of participating stakeholders towards the implementation. Primary parties involved in the implementation of active distribution grids are the respective grid operator and operator of generation facilities in the concerned grid section. Furthermore local organizations and individuals can become partners if they offer flexible influenceable loads as an additional control option for line voltage. The ultimate initiative for the transition to an active grid operation in a specific grid section can only come from the grid operator. In the course of a “development evaluation” contact persons for technical and economic issues and questions have to be determined on the part of grid users, and the plant operators’ and potential load management partners’ willingness to participate has to be assessed.

Besides critical factors for success also critical interference factors have to be estimated (e.g. special legal guidelines, market regulations, etc.). When determining economic implications, applicable market regulations as well as future requirements and their development have to be taken into consideration.

Developing possible solutions

Developing possible solutions – what needs to be done		
This step focuses on grid planning. Line overload and problems with voltage level are identified, and possible solutions are calculated on the basis of the estimated developments. The possible solutions include the option of an active distribution grid operation, namely the controllability of generator plants, storages as well as loads. This phase is an iterative process. Solutions partly have to be developed with the trial-and-error method. It is essential to allow extra time for this step.		
Technical	**Economic**	**Organizational**
▪ Simulation of conventional and innovative control strategies ▪ Integrate additional plants into the simulation ▪ Identification of critical points in grid sections ▪ Clarify grid operation issues (particularities: e.g. disconnection point shifts, grid safety, neutral point handling) ▪ Load management (yes/no) ▪ Impacts on grid operation	▪ Refinement of cost data (e.g. with bid solicitation) ▪ Development of variants based on results of technical simulations, including reference case (conventional solutions)	▪ Analysis of contract details: load management customers, power plant operators, property owners, public authorities,… ▪ Proposal solicitation ▪ Clarify insurance issues

Calculate scenarios for existing forecasts

Now scenarios based on the prognoses which have been analysed in the two previous steps can be developed. *Scenarios* of future generation and load development in the grid section should in principle be distinguished from possible technical *solutions* for thereby resulting problems.

An assumption of the potential development of the shares of loads and distributed generators within a time period that has to be determined (e.g. 10 years) is considered reasonable. First is should be determined how this share is specified. The supply of installed DG power generation load on the peak load in the grid section, for instance, is a conclusive measure. Now scenarios can also be developed due to the DG-share. At the beginning an approximate classification, for instance 50%, 100%, and 150% installed rating on the peak load in the grid is appropriate.

Work out possible solutions

The intention of the analysis of variants is to bring the abundance of diverse development possibilities (problem x possible solutions) in a clearly arranged and represented form. When developing variants, the identification of characteristics which clearly distinguish themselves from each other is essential. In an iterative process differentiating factors are chosen, then the variants thereby resulting are described and analyzed in order to find out, if applicable, that another choice of variants would be more reasonable.

An approach to the choice of variants could, for instance, be the strategy for voltage regulation. Overvoltage problems – the main obstacle for the integration of additional generation units in existing medium voltage grids – can be prevented by many ways. The conventional approach to support the grid and thus to reduce impedances between grid hubs presents itself as a first reference case whose costs should be underpriced through innovative approaches to voltage control. In a further step all possible alternative approaches which are presumably able to realize voltage control in a more cost-efficient way have to be collected. Innovative technologies that have been developed in the course of the project „DG DemoNet–Concept" are described in the figure "voltage control". The use of load management for voltage control at certain grid hubs can – if applicable – be considered in the development of variants as a possible technical approach.

First simulation of the grid section

Now reasonable combinations of possible technical approaches and DG-shares can be generated. For each of these defined scenarios it has to be found out whether the respective chosen technical solutions (and combination of several measures respectively) indeed are able to guarantee voltage control. Additional not yet existing generation possibilities have to be integrated into the simulated grid. Results of preceding development estimations (where do additional DG units make sense?) can be used. The results of these simulations are answers to two essential questions:

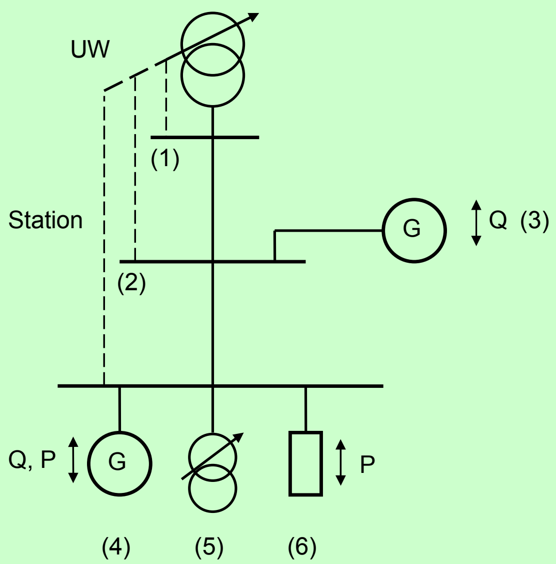
- Which technological solutions are operative up to which DG-share level?
- Which hubs in the grid are especially critical?

The identification of critical grid hubs is helpful as the number of hubs, which have to be observed during the examination, is thereby reduced. Furthermore it is decisive that the distributed voltage regulation works on the basis of the values of these critical hubs. The smaller the number of critical hubs can be kept, the more advantageous it is for the complexity of control and for the costs of communication of metering points at the critical hubs. When choosing critical points it has to be considered that - due to

Voltage control

The illustration on the right which has been developed in the course of the project „DG DemoNet-Concept" shows a catalogue of measures in the form of a circuit diagram. The illustration follows the principle „from the general idea (above) down to the detail (below)".

(1) Control with variable-step transformers due to the voltage of the transformer station
(2) Control with step transformer due to the metered values of critical hubs in the network section
(3) Local voltage regulation at critical hubs with reactive power regulation at generator plants
(4) Local voltage regulation at critical hubs with active power at generator plants
(5) Readjustment with adjustable transformators (MS/MS, MS/NS)
(6) Local voltage regulation at critical hubs with load management



disconnection point shifts in the grid operation - entirely new stress ratio can emerge which either have to be considered in the regulation concept or have to be seen as extraordinary switching status. In such a switching status the regulation of distributed generator plants is not operative.

Note: grid safety and neutral point handling have to be considered during the realization but they are not expatiated on here.

Complete variants

Due to the results of first simulations those variants where voltage control was not successful dropped out. Here it could probably come to a rearrangement of variants which would involve again new simulations. When variants are technically suitable it can be started with further refinement and implementation. Whereas up to now, emphasis was rather placed on technical aspects, now there is a focus on economic and organizations issues.

Costs have to be assessed for specified installations (with innovative approaches they may rather be secondary technological installations) in individual variants, for instance by the means of solicitations of quotations. At this point it is also recommended to start with clarifying legal and liability issues. Depending on voltage control used, contracts with operators of generation plants that will prospectively be built have to be concluded, which regulate their contribution to voltage regulation in the grid section (and their potential compensation, in case that future market regulations provide for this). This also applies to customers who can contribute to voltage control due to load management.

Moreover it has to be clarified to which extent measures or installations for the active grid operation concern third party real property and thus whether agreements with the owners are needed (e.g. installation and operation of radio data transmission stations including thereby incurred auxiliary supply requirements).

It must also be pointed out that frequency bands only offer limited data transmission capacity. The allocation of frequency bands as well as the permission for each individual radio fix is provided by the telecommunication authority. Additional frequency bands can only be assigned in the case of justified necessity as frequency bands are a scarce resource. It also has to be taken into account that these authorization procedures - which are decisive for the date of bringing into service - take up some time.

In general it is vital to ensure on an on-going basis that unbundling regulations are not violated. Thus it is definitely advised to do a legal check.

Analysis and selection

Analysis and selection – what needs to be done

In this step variants are checked for their technical suitability, costs are analyzed for the purpose of comparison, and further actions are initiated. The active distribution grid operation requires technical integration of generation facilities and if possible of consumers. After selection of the best variant the project scope can be formulated and corresponding arrangements can be made with partners. Here it is essential for success to keep operators of existing generation facilities out of economic disadvantages.

Technical	Economic	Organizational
▪ Technical evaluation of possible solutions (technical effectiveness) ▪ Check for functionality and plausibility ▪ Selection of solutions possible in the grid section	▪ Analysis of business optimum (Comparison of variants ▪ Sensitivity analysis ▪ Testing and pointing out of possible win-win situations ▪ Ranking and recommendations	▪ Coordination of documentation ▪ Prenegotiation of contract details ▪ If required: PR (information, flyers) for involved partners ▪ Gather feedback

Evaluation of possible solutions – technical and economic plausibility

As already mentioned in the section before, a portfolio results including possible solutions and variants for voltage control in the observed grid section. Strategies that seem to be technically and organizationally feasible and cost-efficient are to be defined as final variants and have to be further refined. In doing so, each solution has to be checked for functionality and plausibility with detailed simulations whereas the worst case marginal conditions have to be considered. If the refining and adaptation of the technical control concept to the special properties of the respective grid section is satisfyingly conducted, the economic evaluation can be carried out.

For economic analyses it is indispensable to identify all single expense factors such as expenses for measuring instruments needed, control units or an improvement of communication infrastructure. In doing so it has to be distinguished whether it concerns installations at facility as ownership structures have to be clarified during the project-setup phase in order to avoid later disputes.

When all cost data are recorded, a comparison to a reference case scenario (e.g. power amplification) can be drawn with the aid of present value calculations (fix costs are discounted to a base year and discounted and cumulated operating costs for maintenance and operation such as control, measure and communication facilities). The ultimate goal of analysis is to identify those variants that – dependent on the life cycle of operating resources – can be projected more cost-efficient than the reference case.

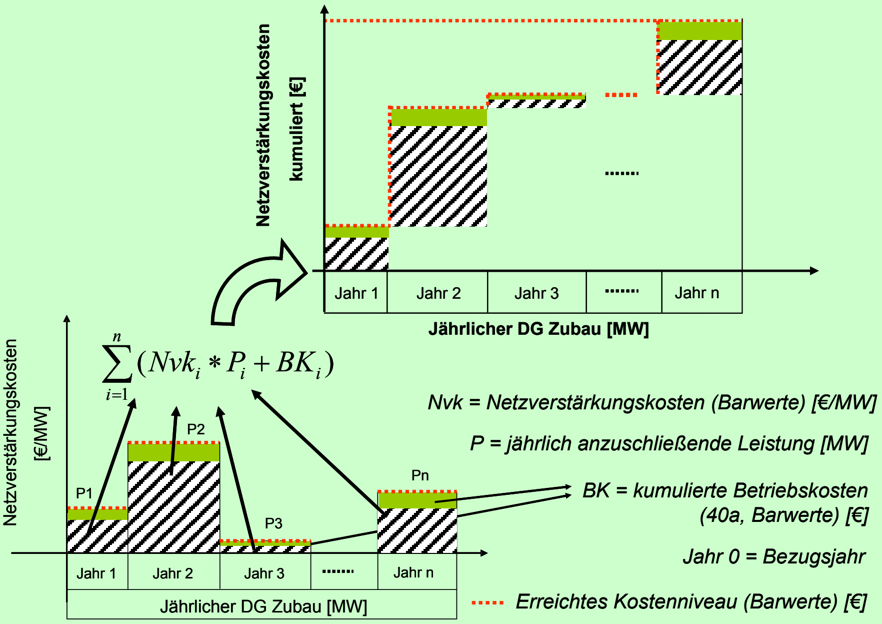
Moreover, during the economic evaluation attention should be paid to:

- The reference case is usually determined by classical grid support and grid expansion (primary technique). Economic evaluation parameters (interest rate, life cycle etc.) for all variants (incl. reference case) have to be chosen at the beginning so that comparability can be guaranteed.
- The validity of the results is corroborated by a sensitivity analysis (parameter variation), whereby critical factors as well as economic risks for a demonstration project can be identified and eliminated respectively.

Another essential aspect for successful project completion is the identification of potential win-win-win situations where advantages are aspired not only for grid operator but also for facility operator and consumers. Furthermore, incentives should be provided which make participation in an active grid management more attractive. An example for such an incentive is to enable facility operators to connect generators with higher performance if they participate in the active grid management.

Methodology of economic evaluation in „DG DemoNet–Concept“

The illustration shows the approach to evaluate resulting grid support costs by means of an example. Based on annual DG-capacity expansion (P_i), resulting grid support costs (Nvk_i) are calculated and discounted to the selected base year (in the present example to the year 0). Then this is also done for expected operating costs (e.g. communication solutions, measuring instruments) in each two-year steps and the cumulated value is calculated. The sum of annual costs equals resulting total costs (cp. illustration on the right, upper part; year 1 to year n).



Rankings ad Recommendations

Afterwards potential variants have to be compared (conventional solution vs. solution a to n) and consequently the ones should be preferred which incur least total costs. When analyzing scenarios the rules of a deregulated market have to be observed. Out of this recommendations and guidelines for the subsequent project set-up of the best approach can be deduced.

Information for involved parties

In addition to the evaluation and ranking of variants it is important to present results and solutions in a clearly arranged and comprehensible way in order to motivate project partners to participate in an active grid operation.

Project presentations and information material

Selective information for relevant target groups through workshops, information brochures, posters, and questionnaires facilitate early information for participants in the active grid operation. Sufficient transparency as well as an objective reference to advantages and disadvantages facilitate the negotiation of necessary contract aspects in the project set-up which are needed for an active grid operation.

Project set-up

Project set-up – what needs to be done **In this step the best possible solution is planned and calculated.**		
Technical	**Economic**	**Organizational**
▪ Work out functional specifications ▪ Schedules (retooling, communication links, stages of expansion, …)	▪ Securing of financing ▪ Ongoing cost control	▪ Proposal solicitation for components needed and services ▪ Prepare bidding documents ▪ Prepare contracts (conclude a preliminary contract) ▪ Comprehensible operation documentation

Upon completion of the analysis, an appropriate grid control, generation and load management concept is developed for each grid segment.

Work out specifications

Specifications are a detailed description of the design and operation of an active distribution grid with an increasing share in distributed power generation and innovative control concepts, instruments and performance criteria. This description has to be complete and comprehensible and it should be linked with technical specifications of operation and maintenance conditions. Specifications are written by the grid operator and possible vendors confirm its feasibility. Implementation works can only start after this confirmation and the completed bid invitation.

Specifications are structured as follows:

1. Objectives – Description of objective which should be reached with the overall system (grid, plants, generators etc.). It includes mandatory criteria; criteria that imperatively have to be met.

2. Detailed system description – detailed description of system requirements and conditions concerning its design and operation.

3. Detailed component description – detailed description of component requirements and conditions concerning the design and operation.

Schedules (retooling, communication links, stages of expansion, etc.)

A detailed schedule is needed for the construction of additional infrastructure (communications technology, control technology, etc.) in the grid area. This schedule requires an adaptation of all relevant components (communication links, retooling of generation and load management facilities and grid assets).

In addition, rough timing of possibly necessary stages of expansion of control strategies (expectable increase in distributed generation facilities) in the electric grid area is required.

Securing of financing

Securing of financing is devided into the following areas:

- construction
- operation
- support measures

For the financing of investments and operating costs it is necessary to arrange economic concepts with parties concerned in detail and to syncronize financial contributions to investments and to continuous operation.

Innovative and intelligent grid control strategies are currently still in the research, development and demonstration state. Both national and international research programmes are currently active in this field (Seventh EU programme “Smart Grid”, BMVIT-BMWA “Energie 2050”). Thus an assessment whether support measures are available as well as the submission of an application for support is recommended.

Solicitation of quotations for components and services needed

Requirements fixed in the specifications are used to solicit a bid from different companies for components and services needed. The solicitation of quotations enables a detailed assessment of construction and operation costs.

Ongoing cost control

If the project set-up requires a longer period it is necessary to re-examine cost aspects. Especially when the implementation is divided into several stages of expansion and therefore should be realized over a longer period of time, a new cost estimation is particularly required.

Prepare bidding documents

Requirements that are defined in the section „Work out specifications“ and used in the section „Solicitation of quotation for components and services needed“ are used as the basis for compiling of bidding documents. Bidding documents are compiled by the grid operator, generation facilities and load management aspects in accordance with operators/consumers.

Prepare contracts / Conclude a preliminary contract

Issues discussed between grid operators, plant operators, and load management customers in sections „Prenegotiation of contract details“ and „Securing of financing“ are included in the contract. As this usually is a matter of approval to a project which depends on a number of influencing factors, it typically concerns preliminary contracts that only attain effectiveness with the possibility to realize the overall project. When working on the contract the grid operator assumes the key role in the process; he ideally is supported by an independent institute and both a competent facility industry representative and a consumer representative in order to strengthen mutual trust.

Comprehensible operation documentation

For a transparent partnership between grid operators, plant operators, and load management customers a comprehensible documentation of investment and operation costs, operating status, relevant switching state, and possible disconnection or occurring events is required. This is the only way that helps providing a good basis where essential aspects can be supported and discussed between partners.

Closing words

All forecasts of the power industry in the context of ecology and resource issues show a growing importance of electricity. This involves an increasing demand for generation capacities. The intensive integration of distributed sources becomes clearly apparent. Besides the development of traditional renewable energy sources, above all roofs, facades, and other structural elements will contribute increasingly to grid-coupled electricity generation on a local basis. Furthermore, in the foreseeable future fossil resources will no longer be burnt in households and industry without combined heat and power technologies.

For basic system issues of these distribution grids new standards and optimization tools are required for grid planning, grid management, capacity planning, stability, safety strategies, supply quality as well as optimization of energy.

There is need of further research in this tension-filled area and at the same time especially here impulses from public authorities are required in order to efficiently support these foreseeable developments and opportunities of grid operators that are active in the regulated context.

Several of these topics are pre-competitive, so the initiative of public authorities plays a central role in order to initiate successful industry development in this topic. This guideline is a first essential step in marking the beginning of a needed change in distribution grids.

The aim of the project "DG DemoNet-Concept" - that is supported by BMVIT in the course of the program „Energy Systems of the Future" and in the course of which this guideline was created – is to develop a model, which sets the goal of integrating a high density of distributed generators in order to solve the problem. However, this has to be done by meeting criteria of maintaining high voltage quality and maximum economic benefits. All relevant stakeholders have been involved.

The project showed that by the help of innovative projects new and sustainable solutions for active distribution grids are possible. The guideline is a technical, economic, and organizational basis for the planning and implementation of pilot projects with active distribution grids and thus it can make a contribution to the development of new projects and innovative solutions.

It was the first time that in Austria a project team of research and distribution system operators has been put together, and the composition of the project team led to an intensive exchange between project partners about this future-oriented problem. Due to the open-mindedness and professional expertise of the projects partners this research dialog took place in an extremely constructive way.

This guideline should, however, only be the first step on a long way which will gather a special momentum due to increasing changes in the energy system.

It will be necessary on the part of authorities that are regulating the grid area to expand freedom-to-operate for research and to create active incentives for further adaptation and optimization of distribution grids.

The first success is owed to the support of the Österreichische Verband der Elektrizitätsunternehmen (VEÖ) as well as the active and stimulating participation of the members of the project advisory board; my special thank goes to all of them and all committed members of the BMVIT team (Department "Umwelt- und Energietechnologien").

Dipl.-Ing. Hubert Fechner, MSc., MAS

arsenal research

Geschäftsfeldleiter Erneuerbare Energietechnologien

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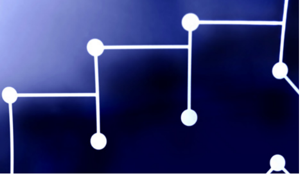

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