DISTRIBUTED GENERATION IN AUSTRIA

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ABSTRACT

From a regulatory perspective the approach towards a higher share of Distributed Generation (DG) has to be balanced considering national energy policy as well as maintaining the quality of electricity supply, adapted network expansion concepts and related costs. The status and potential estimation was based on collection and analysis of the existing data. The pooling of DG to e.g. virtual power plants has been evaluated by investigating the current legal and market requirements. Concerning economic and climate change aspects a comparison of mini CHPs and centralised CCGT has been modelled. The influence of DG on voltage regulation, losses and reactive power has been analysed by means of a generic network model.

INTRODUCTION

Distributed Generation (DG) could be a significant contributor to achieve energy efficiency and climate protection targets as part of the EU energy and climate package. Hence, the Austrian Regulatory Authority E-Control contracted the *Leibniz Universität Hannover, Institut für Energieversorgung und Hochspannungs-technik* and the consultancy *e3 consult, Innsbruck* to elaborate a study [1] on DG in Austria, focusing on energy economic and network issues, like status and potential of DG in Austria, requirements on DG from an energy economic perspective, pooling of DG and impact of DG on distribution and transmission networks. This paper is based on the findings of the study.

The study did not consider large wind parks, as this type of generation is seen as centralised production and was object of a separate study [2]. Small fossil fired generation was part of the analyses.

Status of DG in Austria

DG had a share of 11 TWh or 16% of the Austrian electricity generation in 2009. The major part has been delivered by small hydro power, namely 5.5 TWh. The development of the installed capacity in the years 2002 to 2010 (Fig. 1) clearly reveals the significant growth due to favourable feed-in tariffs in the first half until 2005. Further on to 2010 only minor increase took place, besides a steeper slope on PV applications in the recent year. Figure 3 shows the development differentiated for several primary energy sources.

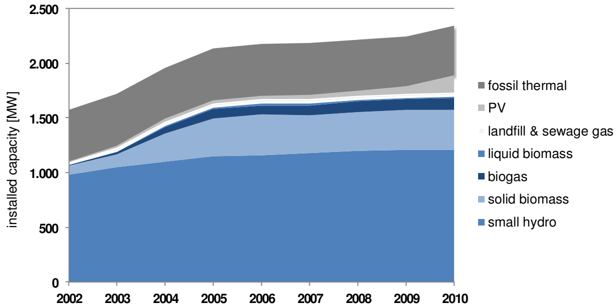

Fig. 1: Development of DG capacity in Austria

The potential for further increase of DG is sufficiently available, but deployment strongly depends on financial and political framework conditions. The Austrian energy strategy [3] identified decentralised electricity and heat production as one major column to obtain the national energy targets. DG shall contribute to an increased energy efficiency as well as a growing amount of renewables. Implicitly DG shall strengthen the security of supply due to decreasing dependence on energy imports. Hence, the recently issued new version of the green energy law (Ökostromgesetz) provides improved incentives and rising numbers of new DG applications can be expected.

ENERGY ECONOMIC ASPECTS

Small hydro is from an economic point of view still the best alternative within the range of DG technologies, but conventional centralised generation generally features higher economic benefits. But compared to overall electricity costs for the end user, DG already is an attractive option, especially small and mini CHP applications, delivering electricity and heat (Fig. 2).

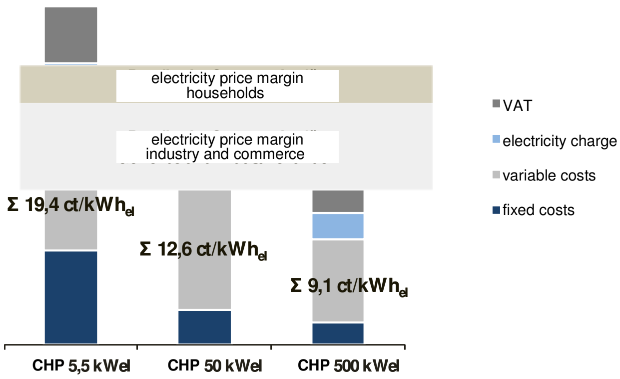

Fig. 2: Comparison of costs and price margins

The operation of micro CHP is less economically attractive and would require an adapted incentive scheme to reach a significant market penetration. Hence, from a macroeconomic perspective, the focus should be laid on small and mini CHP applications, mainly for small industry, commerce, public facilities and apartment blocks instead of micro CHP for (semi-)detached houses.

Impact on climate protection

DG based on renewables, and in some cases also on fossil fuel, can support security of supply and climate protection due to a decrease in fossil energy imports and lower specific GHG emissions. The Austrian electricity system is strongly embedded in the European network. Hence, a replacement of fossil based conventional generation due to Austrian DG will probably not take place in Austria, but in other European regions. Compared to centralised production fossil DG faces the disadvantage to negatively impact the Austrian climate change targets, because its GHG emissions are not part of the EU ETS but stress the national GHG balance. A future support regime should take this into account and e.g. link optional incentives to the GHG emissions.

Mini CHPs can save up to 30% primary energy demand for electricity supply by full thermal utilisation compared to central electricity production. The contribution of DG to the reduction of GHG emissions is generally positive, but with minor effect directly in Austria.

Pooling options for DG

For achieving a high penetration of DG within an electric system, these applications should contribute to energy economic and system operation tasks. This concerns mainly load-frequency-control and reactive power management. But DG from renewable sources can only partly substitute conventional central generation capacity. As an empirical formula run-of-river hydro power plants contribute about 40% and wind and PV plants less than 10% of their installed capacity to an overall secured capacity in the network.

Single DG applications cannot fulfil cost efficiency and energy economic requirements in an optimal manner within the overlaying network, but a bulk of DG applications could. A centrally controlled pool of DG could behave like a conventional power plant and hence, take over some network services as virtual power plant. The approach of DG pooling gets strengthened by two aspects: firstly the increasing share of DG causes an information need – and potentially requires operational measures - for the system operator to maintain the high level of system reliability. Secondly DG based on intermittent renewables with limited forecast quality requires additional flexibility in the system in future. (So far the existing share of DG led to only minor increase in balancing energy needs in Austria.) Pooled DG could provide this flexibility by contributing actively to the ancillary services market. Pilot projects have proven the general feasibility of the virtual power plant concept.

The remaining barriers are less technical than commercial and legal. Virtual power plants could increase the overall network efficiency and realise macroeconomic benefits. Therefore this pooling option for DG should be enabled. From a regulatory point of view the adequate and causer related allocation of monetary effects is crucial.

Case study on fossil DG fulfilling central supply tasks

The case study compared electricity supply from a gas-fired central CHP plant with production from a bulk of similar gas-fired mini or micro CHP applications. The model input were fuel prices and temperature profiles of the years 2008 and 2009.

Mini and micro CHP in a heat driven operation are significantly more efficient than a separated generation of electricity and heat, but the operation profile cannot be expected to resemble a conventional power plant. Yet the efficiency decreases with increased focus on power market requirements, as utilisation of the waste heat abates. Hence, a reasonable approach is to complement the CHP applications with a peak load boiler for more flexibility.

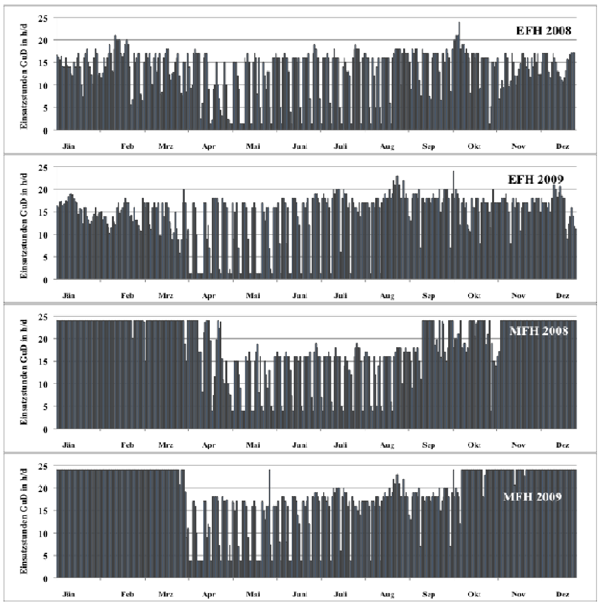

Fig. 3: Modelled operation profile 2008/2009
for detached house (EFH) and apartment block (MFH)

Considering these general relations an analysis (Fig. 3) of two CHP systems (EFH - detached house, 3 kWel; MFH – apartment block, 20 kWel) revealed that only the bigger CHP is suitable to fulfil the supply task of a CCGT plant and realise sufficient primary energy savings.

As a result this kind of DG cannot fully substitute the electricity supply from the central plant and optimise the primary energy savings at once. However, about 20,000 CHP applications of the MFH type would have to be implemented and centrally controlled to replace a typical conventional plant.

TECHNICAL ASPECTS

The growing amount of DG in the distribution network causes new challenges for the system operators. Traditionally planned networks are not capable to accommodate a significant share of DG and often touch capacity and stability limits. The analyses have been conducted by means of convolution of specific frequency distributions for DG technologies and loads.

Modelling DG's impact on networks

The restricting criterion for DG implementation is not necessarily the line capacity but the voltage margin and stability. Simulations on a model network (Fig. 4) showed exceeded voltage thresholds at low voltage level from a DG share of 50% maximum network load onwards. The MV/LV transformer stations feature a significant relative voltage spread and hence, effective remedial measures could be implemented here. DG applications could support the voltage stability with supply of reactive power. The simulation revealed a voltage dependent reactive power infeed as best approach. In this case by maintaining the voltage thresholds the additional installed DG capacity could be doubled, compared to pure active power feed-in.

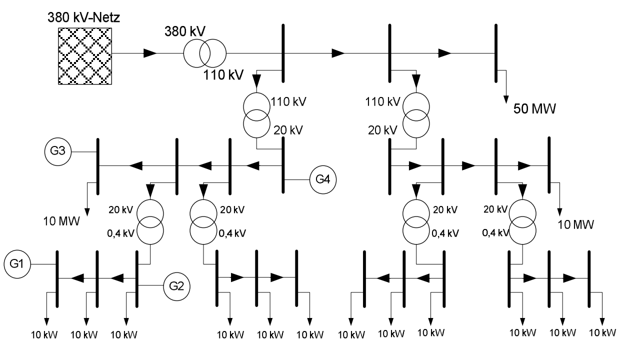

Fig. 4: Network model with embedded DG

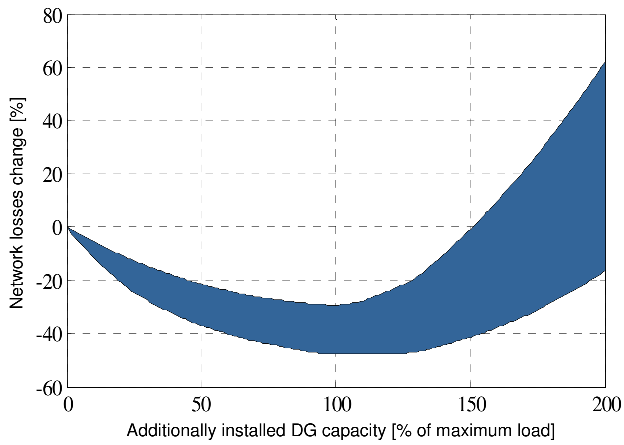

Fig. 5: Changes of network losses due to increased DG capacity based on the existing technology mix

Depending on the specific generation profile, the network topology, the position in the network and the demand situation DG could have stressing or releasing impact on the network. Assuming that the growth in DG would feature a similar technology mix as existing, Fig. 5 shows the simulation result. Generally the form of the blue area varies depending on the DG technology, and the example displays the dominance of small hydro and biomass in the actual mix. According to this simulation the optimal DG capacity for minimum network losses would be a bit above the maximum load. Considering a typical distribution network in Austria and the existing low penetration of DG a beneficial effect (e.g. reduction of losses) due to a growth in DG could be assumed on average.

The impact of DG on the transmission networks is minor in terms of losses reduction and voltage issues. But with higher penetration of DG its cumulative power could be a significant aspect under disturbed network conditions. A concurrent disconnection or at least uncontrolled behaviour of DG due to e.g. frequency variations potentially deteriorates the situation. Therefore clear minimum requirements for DG must be established. Aggregated information on the operational status of DG must become available for the system operator in order to operate the network in a safe, secure and reliable manner.

Approach on size limit for DG

The suitable network connection point for a generation plant clarifies, if the respective plant is counting for DG or conventional. The connection point is depending on the short circuit power in the overlaying network, the transformer and line parameters and the topology of the network. Hence, a plant possibly is defined differently in two networks.

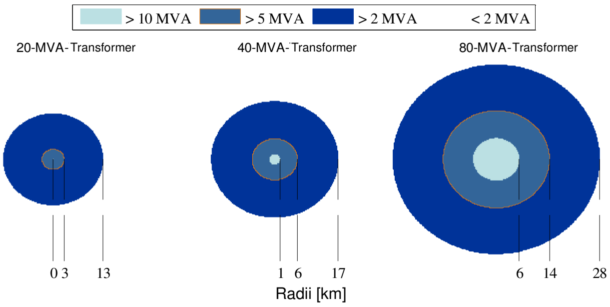

Fig. 6: Maximum electrical distance DG-Transformer (240mm² Al cable)

A more universal criterion to determine a plant as DG would be reasonable, especially in terms of non-discrimination. The approach has to be balanced between orientation on the weakest network for wider applicability and not too restrict limits for the capacity.

Based on typical network parameters Fig. 6 shows that plants smaller than 2 MVA cause no voltage problems, but do not efficiently use the potential of the network. 10 MVA would not be suitable under weak network conditions. Hence, as rule of thumb a plant size limit of 5 MVA installed power for DG seems to be reasonable.

CONCLUSIONS

The existing share of DG is low, but perspectives are promising. Considering the strategic outlook for DG in Austria the technical impact on the network in medium term is on average expected to be beneficial.

Fossil-fired DG provides best overall efficiency in case of small and mini CHP applications. Pooling concepts would be reasonable and necessary with growing DG penetration in order to contribute to system reliability and security and to participate in the market. An installed plant capacity of 5 MW seems to be adequate to classify this generation as DG. Generally DG in Austria still faces barriers more on the commercial und legal side than in technical aspects.

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