SMART GRIDS!
THE BASIS OF SMART GRIDS ARE "SMART" PLANNING RULES.

Karl Derler
Austria
k.derler@linzag.at

Walter Niederhuemer
Austria
w.niederhuemer@linzag.at

ABSTRACT

The goals of the European Commission force all market participants to increase energy efficiency and feed in renewable energy. A new assessment concept to increase the number of connections of distributed generators to the networks supports the intention of the European Commission. Capacity in actual electrical networks will be used by distributed generators more efficient. Necessary economical incentives have to be implemented into the liberalised market.

I. INTRODUCTION

At present the concept SMART GRIDS is the synonymous for more efficient networks, for more market and more self determination of customers. However it is not really clear what should be understood beyound SMART GRIDS. At present the situation shows different pictures depending on the position of consideration. Therefore different visions or definitions for SMART GRIDS are available. [1] [2] [3]. From our point of view we do not speak about SMART GRIDS in general, but it is necessary to distinguish between SMART Functions because different market participants are involved. This differentiation is important because in the case of roll-out of a SMART Function we have to bear in the mind the different roles of the involved participants.
The present paper presents one of the most efficient SMART Functions, the SMART network planning.

II. ENERGY POLICY OF THE EUROPEAN COMMISSION

The European Commission started before 2001 the discussion about the new energy strategy, to deliver sustainable, secure and competitive energy by publishing a green paper [4]. Therefore one of the goals of the European Commission is to increase production of energy on the basis of renewable sources by 20%. In 2009 the goals of the European Commission have been distributed detailed in the Third Energy Package [5] and the SET-Plan [6].

A. National energy strategy

The goal of the national energy policy is to transform European law into national rules. Additionally to the legal basis the Austrian government supported the establishment of the Austrian Technology Platform SMART GRIDS [2] as a promoter of the new ideas. The road-map of the Austrian Technology Platform SMART GRIDS creates the basis for research and development of the new technology. Important shareholders are working out different basic projects. An economic roll-out for the vast majority of the SMART Functions needs a telecommunication network as basic infrastructure, lacking in nearly all areas. Therefore SMART Functions without the need of a supporting infrastructure is of particular importance.

B. Goals of national enterprises

The DSOs are demanded by regulating rules to operate an economic business on the one hand and to support connection of new distributed generation on the other hand. It is very important to combine the tasks of DSOs in an economic way.
The restructuring of the existing networks into SMART GRIDS, additional to the present tasks of network operators is a challenge, but because of the know-how it should be a typical task of DSOs.
If the DSOs should act as player in the field of SMART GRIDS, it is very important that the general conditions give the essential incentives. SMART GRIDS will give an advantage to all market participants in the liberalized market. Therefore the correct distribution of the costs and benefits is very important.

III. STRATGY OF LINZ STROM NETZ GMBH

LINZ AG is a multi-utility supplier in the city of Linz and the surrounding area with electricity, natural gas, water, district heating, public traffic, telecom, waste and sewage services.
LINZ STROM Netz GmbH is the DSO for the electricity distribution network and operates additionally an extensive passive and active telecommunication network for internal and external use. Based on this background Linz AG started three years ago a SMART Metering project because only partial costs of telecom have to be considered in the business case of SMART Metering. As a result of this optimal economical situation we started the next step to implement a SMART Function by exchanging old ripple control systems by SMART switching systems for customer appliances, street lightening, .. etc.
A very important next step is to implement SMART Functions is the SMART Network planning in the low and medium voltage network.

A. Business of a regional DSO

The duty of DSOs is to connect all customers and in particular distributed generators to the network.
On the basis of the decisions of the European Commission to reinforce the support of all kinds of renewable resources the number of new distributed generators has increased in the last years. The legal task of DSOs is to optimise the job – to connect all network users – in a political economic way.
To operate the distribution networks in accordance to the market rules a DSO has to take into consideration among others, the following aspects:
- structure of the existing network
- voltage levels in the existing network
- potential and number of the new distributed generators
- power and kind of the generators
- feed in electrical energy
- costs of the connections for network customer
- costs for network investments for the DSO

An important part of the task of a DSO is to provide sufficient power quality within the permitted limits. The growing number of distributed generators can affect the power quality. So it is important to obtain the goals with low costs. Our new planning strategy allows a more efficient use of network infrastructure by fulfilling standards.

B. General conditions in the liberalized market

Our primary goal is to analyse the effects of new generators. The assumptions we have made and the results we have found had been analysed for photovoltaic generators because the density of PV-generators has increased recently and will increase also the next years. PV- plants are easily installed on the roof or wall of every building without negative intervention to nature. However the principles of our analyses may be applied to all kinds of distributed resources.
Concerning the Austrian rules for the assessment of the connection of new distributed generators - TOR D2 [7] and TOR D4 [8] - the DSO has to secure that the rise of voltage level caused by all DG in the low voltage network is less than 3% in the low voltage network in the worst case. The worst case is the basis for all calculation in accordance to TOR D2 because the DSO has to guarantee standardised power quality for all network users.

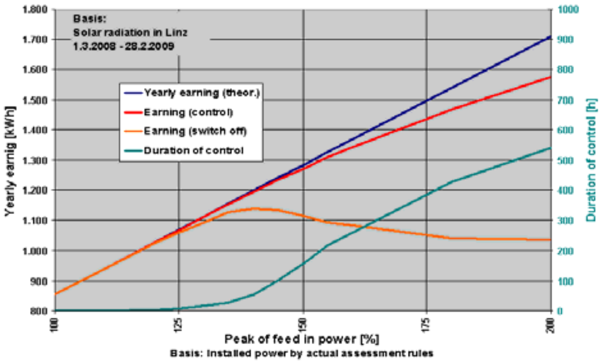
IV. THEORETICAL MODEL

On the basis of the actual rules the capacity of existing low voltage grids is quickly consumed by a few photovoltaic plants. To connect additional plants, costly investments have to be made by network users or the network operator.
To take into consideration the additional feed in electrical energy, the actual solution is not economically optimal. Therefore new connections are avoided.

The new way for the assessment of photovoltaic plants is to take into consideration the statistic behaviour of the influencing parameters as:
- the voltage level in an existing network
- the load of an existing network
- the typical feeding load of the power plant (distribution of solar radiation)
- distribution of the feeding load to the three phases

On the basis of our analyses it is possible to increase the number of connected new power plants with a defined probability of feeding and to guarantee the standardised power quality.

Additional connections of power plants would be possible if the DSO is allowed to control or switch off one or a few power producers for short time periods if real power quality deviate the standardised power quality. The lost energy near the optimal operation point is very low (picture 1).



Picture 1: Yearly earning of energy of a PV-generator and loss because of control or switch off if voltage level is too high

The analysis of the situation in real networks is associated with enormous efforts and takes a lot of money. Therefore we developed a simulation tool for calculation of the situation in the networks. The important statistical influences of loads and feedings are considered. The results of calculation have been checked on the basis of measurements in real networks.

The results of our analyses shows that the number of connected power plants and supplied energy increase significantly against the actual methods of assessment by a minimum of investment.

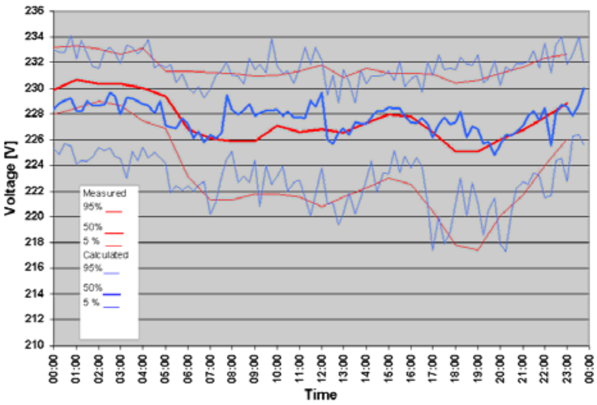
A. Technical Concept of the Model

In the new concept for the assessment of a connection to the network we take into consideration the statistical distribution (local, time, phases) of all connected loads and feedings. In a first step we calculate the present situation. The next step is to put on the expected power of the new connections and to assess the results. For new PV-generators we calculate statistical results by using Monte-Carlo-Method. For each PV-generator a maximal individual voltage change of 1,5% is allowed, automatic changes from 1-phase connection to 2- or 3-phase connection are build in.

B. Scrutiny on real networks

The scrutiny of the model has been carried out in low voltage networks and checked by comparison of the calculation to real measured values in a connection point in the network. Picture 2 shows the map of a small part of a network and picture 3 displayes the comparison of calculation and measurement. The deviation between the calculated and measured mean values as well as for the 95%- and 5% quantile is amazing low.

Picture 2: Part of a low voltage Network (one brunch)



Picture 3: Comparison of the calculation to real measured values in the low voltage Network (Connection point 24)

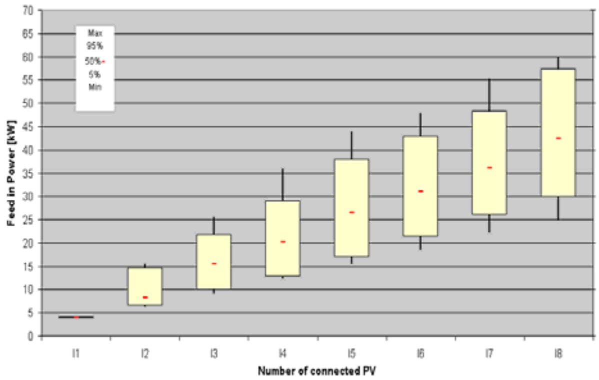
C. Results of calculations

The comparison between the actual and the new assessment model was carried out in the same low voltage network on the condition that the equal power is feed in (picture 4).

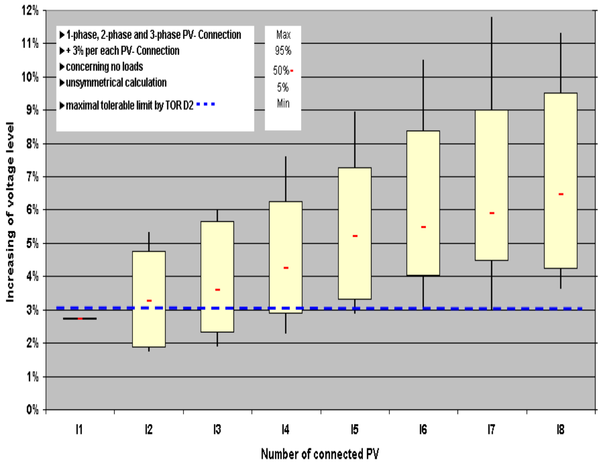
On the basis of the actual assessment model voltage rise is calculated far too high so that the DSO would not agree the planned new connections of PV-generators (picture 5).

If the new assessment model is applied, the expected voltage rise is much lower and the planned connection of PV-generators could be allowed (picture 6) so far as the feed in power of the PV-generator is controlled or switched off if voltage at the connection point is too high. Concerning the statistical conditions of the on-site and temporal distribution of feed in power, the loss of feed in power is negligible near the optimal operation point (picture 1).

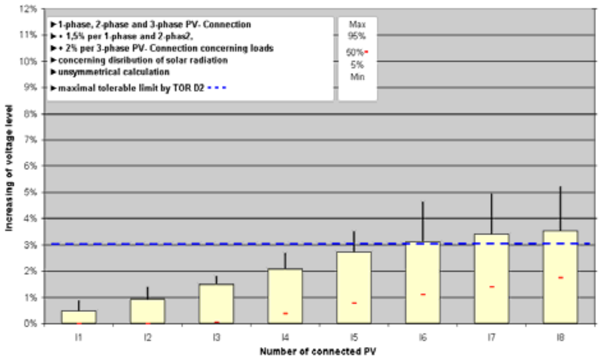
If we additionally consider the actual level of voltage in the networks (picture 7) it can be shown that additional free capacity exists in certain parts of the network depending from operating conditions in the MV network. A loss of energy will only happen in networks on the right side of the diagram.



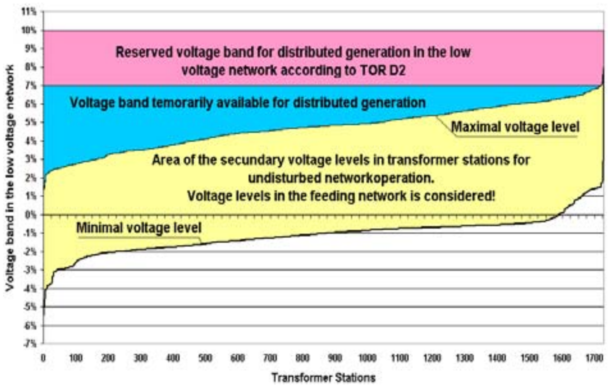
Picture 4: Distribution of the expected feed in power from PV- generators in the low voltage network.



Picture 5: Distribution of voltage levels in the low voltage network calculated within actual used assessment model (concerning only feed in by PV)



Picture 6: Distribution of voltage levels in the low voltage network calculated within proposed assessment model (concerning load of network, distribution of radiation, distribution on phases)



Picture 7: Distribution of voltage levels in low voltage networks (at normal operations condition)

V. COMPARISIONS OF RESULTS

It can be shown that on the basis of proposed assessment concept and planning tool the existing capacity of the low voltage network can be used for feed in additionally distributed power from distributed generators.

It is also possible to calculate the individual capacity required of each distributed generator and therefore to assign the costs to each individual connection of a distributed generator. It is very important to allocate incentives to market participants to bear the incremental costs of a new connection of a distributed generator.

If each generator takes the created individual costs the DSO is in the position to support the request of customer for new connections, to operate an efficient network and to provide investments if available capacity has been consumed.

VI. CONCLUSION

The new planning tool and assessment concept could be the basis for a more efficient operation of low voltage networks by increasing the feed in power of distributed generation. The necessary incentives for all market participants have to be supported by assigning the produced individual costs.

VII. REFERENCES

[1] European Technology Platform Smart Grids „Vision and Strategy for Europe's Electricity Networks of the Future", *http://ec.europa.eu/research/energy/pdf-/smartgrids_en.pdf*, 4.

[2] Technologie Platform Austria "Roadmap Smart Grids Austria", *www.smartgrids.at/smart-grids* , 7.

[3] An ERGEG Public Consultation Paper "Position Paper on Smart Grids" Ref: E09-EQS-30-04, 10 December 2009 *http://www.energy-regulators.eu/* , 11.

[4] GREEN PAPER Towards a European strategy for the security of energy supply, ISBN 92-894-0319-5
© European Communities, 2001
http://ec.europa.eu/energy/green-paper-energy-supply/

[5] DIRECTIVE 2009/72/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 13 July 2009 concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC, http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:211:0055:0093:EN:PDF

[6] Investing in the Development of Low Carbon Technologies (SET-Plan), COM(2009) 519 final http://ec.europa.eu/energy/technology/set_plan/set_plan_en.htm

[7] Technische und organisatorische Regeln für Betreiber und Benutzer von Netzen
Teil D: Besondere technische Regeln Hauptabschnitt D2: „Richtlinie zu Beurteilung von Netzrückwirkungen"
http://www.econtrol.at/portal/page/portal/medienbibliothek/strom/dokumente/pdfs/tor-d2-20060919-v2-2.pdf , 104

[8] Technische und organisatorische Regeln für Betreiber und Benutzer von Netzen
Teil D: Besondere technische Regeln Hauptabschnitt D4: „Parallelbetrieb von Erzeugungsanlagen mit Verteilernetzen"
http://www.econtrol.at/portal/page/portal/medienbibliothek/strom/dokumente/pdfs/tor-d4-20081217-v2-0.pdf