TOO MUCH "ENERGIEWENDE"?
HOW TO HANDLE MASSIVE GROWING DECENTRALIZED ENERGY PRODUCTION

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ABSTRACT

E.DIS is a Distribution System Operator (DSO) in the north-east of Germany, running grids from 110kV HV down to 0.4kV LV. While the German Government's target leads to a Green Energy rate of 55%…60% until 2035 E.DIS reached this line already in 2009, so we are about 25 years ahead in the development. But this has not only advantages. The situation of planning and steering the grid has changed enormously and needs new ways to be gone.

Planning and running the grid under those circumstances leads to go new ways and so different measures have been taken to localize the needs, get the data and create the processes.

With the shown solutions it has been proved that a grid can be run successfully even with decentralized renewable generation three to six times higher than the maximum load.

SITUATION

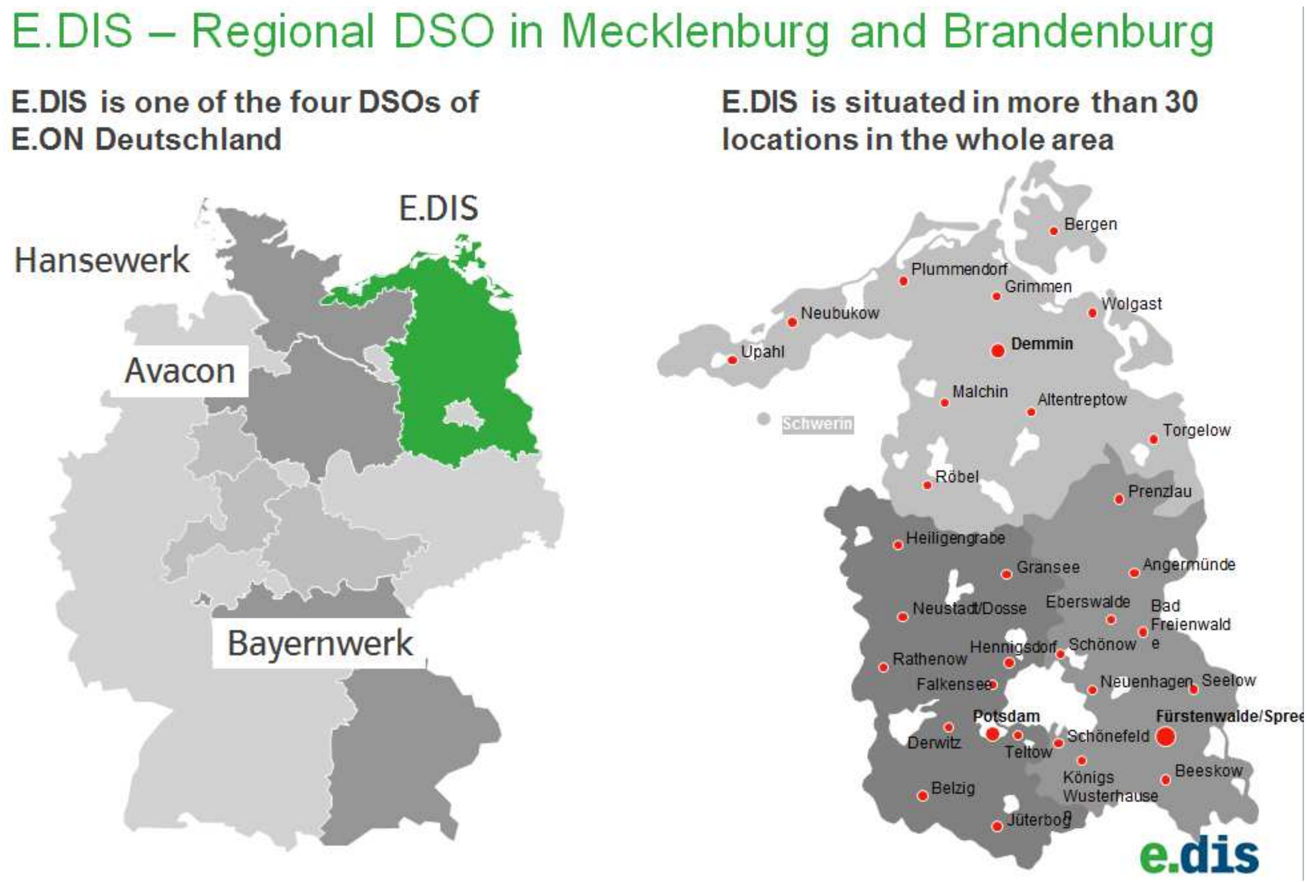

Fig.1 E.DIS area

E.DIS is one of the four DSO in the E.ON Deutschland Group. The area that is provided with energy is situated in the north-east of Germany. Traditionally this is a mostly rural region, dominated by wide areas of agriculture production; the population density is mostly less than 33 inhabitants per square km. Some lesser towns and cities (the largest city E.DIS provides with energy has a population of 35.000.

The 1.3 Mio. Customers on an area of 35.000 square kilometers are provided over a grid, formed by more than 5,000 km HV lines, 50,000 km MV and 50,000 km LV. The peak load is about 2,200 … 2,500 MW.

Mostly uninhabited areas, especially in the former GDR were often used for military purposes, here for Soviet Airfields and Military Trainings. After the fall of the German Wall those places fell abandoned. The grid was developed to fit this situation: long overhead lines with small load capacity.

The Energiewende in Germany, the decreasing of Carbon Dioxide emission meaning a total stop of nuclear energy production and the enforcement of renewable energy production gave those areas a new meaning. The Government's goal to produce more than 50% of the energy needs of Germany out of renewable sources in 2035 seamed only reachable, when the power production could rise extremely.
Renewable production needs space and wide areas were available in North-East Germany. After an explosion of wind generation the development of efficient solar generators lead to a rapidly growing number of renewable power plants.

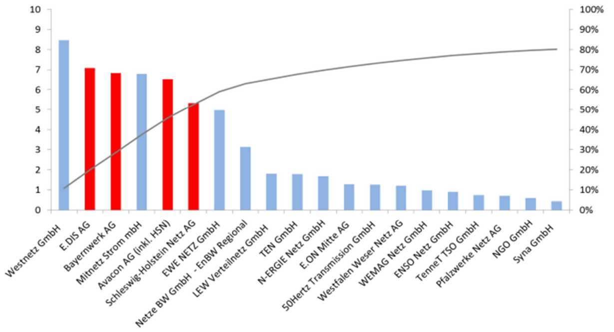

Fig.2 Installed Renewables GW and cumulated share

Only 20 units (out of more than 1000 DSOs in Germany) have to bear about 80% of all installed DER capacity.
Especially less inhabited and rural areas are the target for locating new power plants

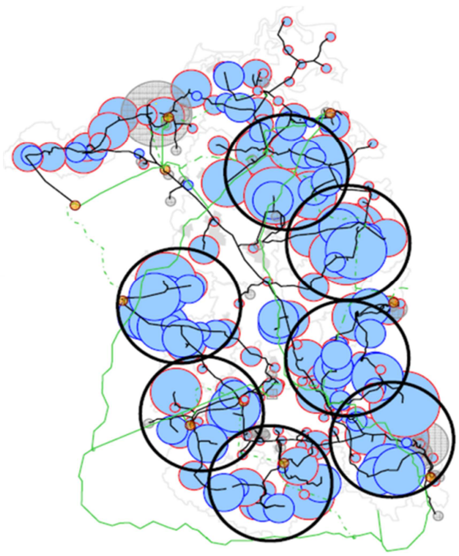
Fig.3 Renewables concentrate in Rural areas

The Governments goals have been outperformed 25 years ahead in E.DIS area. The 50% have been reached in 2007, in 2014 a nearly 100% renewable production has been reached.

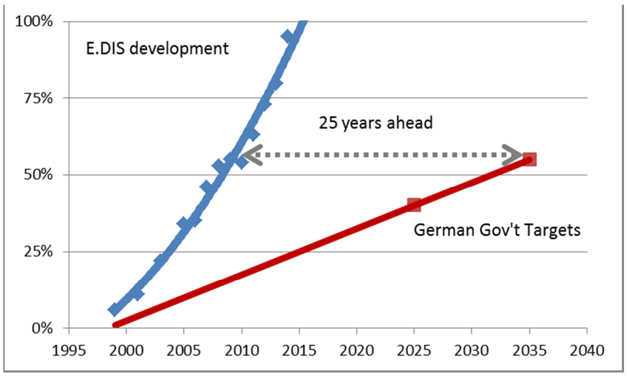

Fig.4 Renewable produced Energy: Gvt' goal and E.DIS reality

The dimension of the power plants are enourmous:
Fig. 5 shows the development of the diameter of wind turbine spinners during the last 20 years.


Fig.5 Diameter of wind turbine housing 1995, 2005 and 2014

Using former Soviet Airfields there were Solar Power Plants built until now with an installed power of 140MW each.


Fig.6 Solar Energy production in Groß Dölln ca. 140 MW

But how to connect facilities like these to the network?
The existing grid could not bear such dimensions, it was built once to provide a small number of widespread customers and not to collect Energy from large power

plants. The ressources in LV and MV networks have been fully used after a short time, the HV grid was normally not developed in rural areas.
While the maximum load is about 2300 MW the installed DER capacity is today more than 7,500 MW and another 13,000 MW are already planned and ready for being built in the next 2 or 3 years.
When this dimension of new power plants is connected to the grid we are faced with another problem, their production volatility. The infeed does not only vary from day to day but sometimes within minutes. Imagine a cloud moving over a solar field like shown, you can watch an infeed power decrease of 50 to 100 MW within a few minutes, all in one feeder and one substation. This may invert the current flow as well.
Situations like this may lead to serious system stability problems.

MEASURES

E.DIS has been faced with this situation for several years now. The grid is still working reliable and the outage number and duration is not worse than in comparable networks.
What are the measures to guarantee the system stability and the connection of customers as well as of generators according to their needs.

1. Grid extension /Grid reinforcement

Construction of new power lines, reinforcement of existing connections and substations as well as new connection points to the UHV grid

The conventional and logical way of connecting new and large participators into an existing network would lead into the building of additional lines and Substations.
Fig 7 shows the calculated need of HV-line development

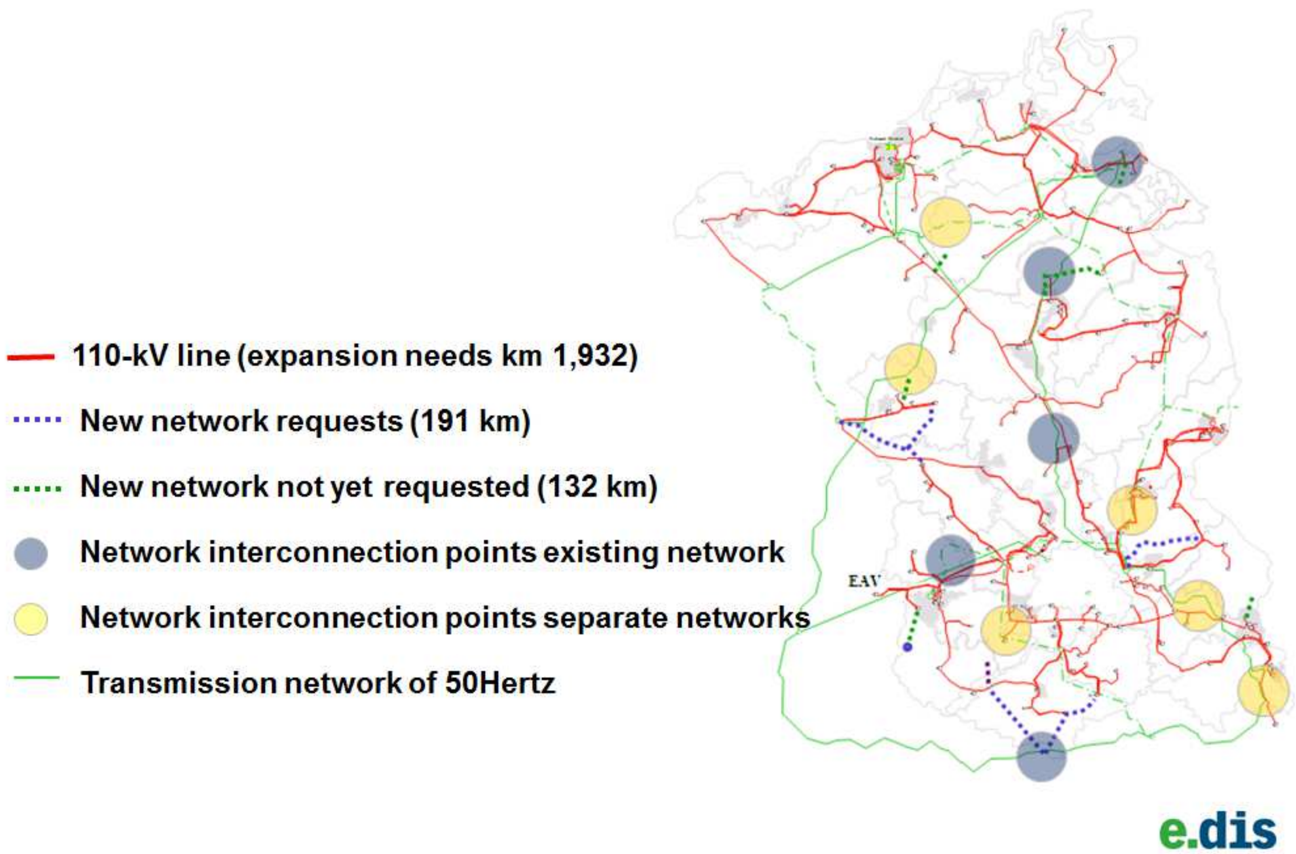

Fig.7 Needed HV grid expansion next 25 years E.DIS only

Nearly 2000km overhead lines have to be replaced by stronger ones, at least 200km lines have to be new build.
Whereas the placement of a new Solar power field needed only a few months, including 4 weeks only building time the planning of a network needs years. The official allowances alone have a timeline of more than four years, not included the negotiations and court hearings with the land owners to get permission that lead the building process up to 15 years.
Even replacements of a line on the same trail need to have nearly equal permissions.
Unfortunately only UHV connections have a chance to be enforced by law, all below has to follow the normal processes.

2. Grid planning optimization

Reduction of planning reserves

Planning a Grid is standardized in nearly all DSOs. The planning rules have been made for the development of a outfeeding network. The new situation needs an overthinking of these rules as well.

So many generators will not need an n-1 guarantee or a 2-way-connetction.

The grid planners will also cancel development reserves for load increasing during the lifetime of the line or use existing reserves to fit a new generator in.

3. Grid operation optimization

Intelligent control of reactive power

Reactive power has mostly been underestimated in its meaning for system stability. In a world of fast changes in power generation and loadflow directions, every user of the network has to take their part in stabilizing the whole grid. Using phase-shifters and steerable reactive power sources as a DSO is now taken for granted as is always has been for TNO.

There are measures to ensure that also power plants using renewable ressources are included in the steering of the reactive flow to increase the stability of the whole system.

Transmission Line Temperature Monitoring

When you control the temperature of the line directly you can make sure, that always the highest possible power flow can be guaranteed. A network of meter stations, delivering their values directly to a processor in the main control centre, help calculating the actual possible load of the line the meter is connected to.

In good situations (low outside temperature, wind chill) it was possible to increase the transmitted power up to 180% of the normal value without any risk to the asset.

Network operation (optim. on max. feed-in power)

The work in the Network Control Center has changed to fit the new situation. All subnets have been re-arranged to fit in the value of the possibly gererated power. There are a lot more of switching processes now to react on the different infeed situations (Examples of generation change within some days shown in Fig. 8).

Transformer control

There are modern transformers, which can react automatically on changes in generation, causing changes in the load flow and thus differences in the voltage.

Especially in LV networks it became necessary to steer actively instead of setting fixed values to the assets.

4. Storage

E.DIS started a pilot measure for different ways of using storages to decrease the volatility of the renewables' generation. One of the best methods seemed to be a Power-To-Gas unit. An electrolysation device produces Hydrogen from water. The Hydrogen is infeeded into the nearby gas pipeline and stored in that manner. When the power production of the renewables decreases the gas can be used in a gas-turbine to produce energy.

5. Feed-in & Grid Security Management

Switch off Renewables

All shown measures take a time to be installed and come into efficiency. Until then the network comes to the borders of its stability. As an interim solution until total renewable power can be fed in there are different safety processes installed.

So it is possible to curtail or switch off generation when the system stability is going to get lost.

The producers are given a compensation for the lost energy they could have fed in the network.

The number of such steering interventions is growing rapidly. In 2010 we found less than 10 interventions a year, the number of 2014 has been growing up to over 1,000. That means at least 2 to 3 safety reasoned steerings per day.

Network situation on 22. January 2012 – Windpower 3x larger than distribution volume

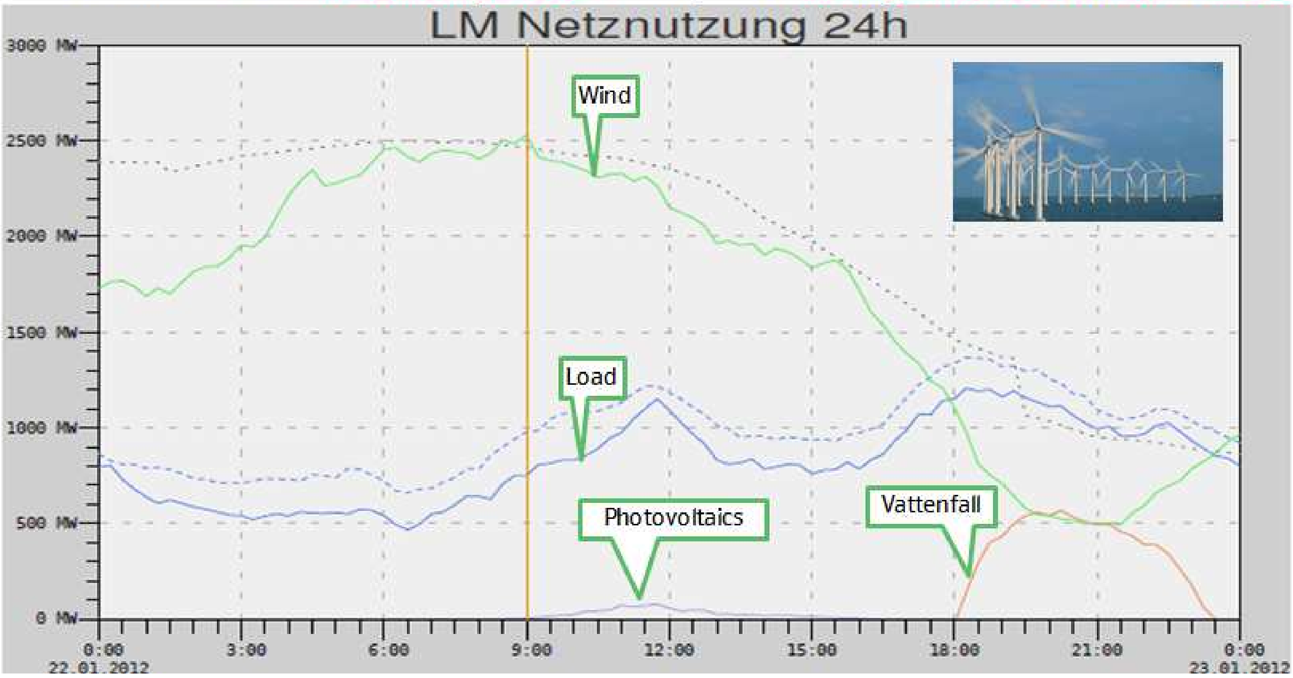

Fig.8a Day of high renewable production

Network situation on 25. January 2012– Windpower close to zero

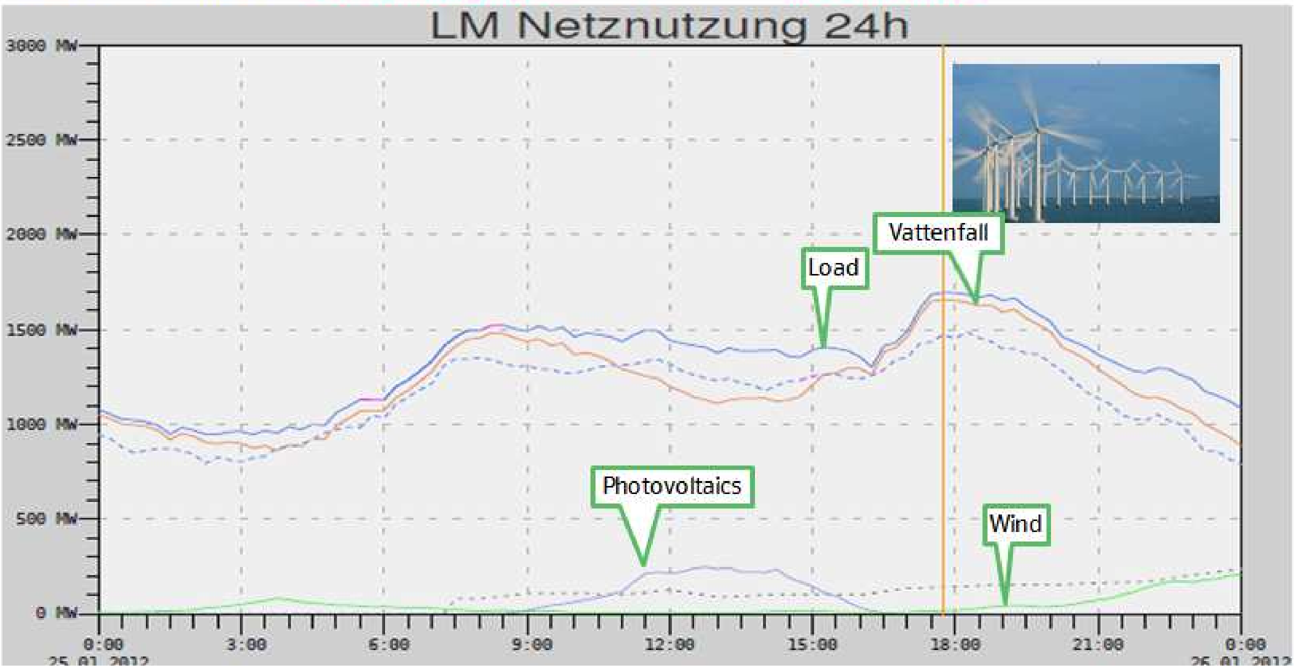

Fig.8b Day of low renewable production

CONCLUSION

E.DIS is one of the most affected DSO in Germany by renewable generation. The ideal circumstances like less inhabited areas and good conditions for DER because of the policy of the German Government lead to an energy production sometimes more than 3 times higher than the maximum need. That leads to problems, other DSO do not have or at least in a far future.

All ideas of an excessive enlargement of the network need too much time, so E.DIS took it as a chance to change a lot of processes or to try unconventional ways. The system is still stabile and a lot lessons were learned. But it has been shown that research and development can be successfully proved in reality.