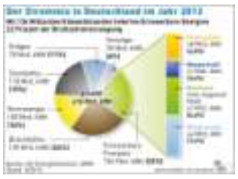
Infoblätter **Kombikraftwerk 2**

Field Test of Kombikraftwerk 2

Provision of Balancing Power from Renewable Energy Sources



In 2012, renewable energy sources already accounted for 22 percent of the total electricity generation and 23 percent of the electricity consumption – figures that continue to rise. By 2020, this figure is to reach 35 percent of the electricity consumption.

The stability of our power supply is highly dependent on the frequency in the electricity grid, which, to date, has been stabilised by drawing on balancing power from large-scale fossil and nuclear power plants and pumped-storage facilities. Due to the increasing percentage of renewable energy and the objective of building a future power supply system primarily or entirely on renewable sources, renewable energy sources must increasingly provide balancing power. In a field test with present-day wind, photovoltaics and biogas plants, the Kombikraftwerk 2 research project proved that this is possible and that in some cases, renewable energy systems can even react faster than thermal power stations.

Balancing power must be provided reliably in the electricity grid, to compensate frequency fluctuations due to an imbalance of consumption and generation, guaranteeing reliable system operation. To date, particularly thermal large-scale power stations and pumped-storage facilities offer this ancillary service. However, the German energy transition ('Energiewende') changes the system of providing balancing power, not just generating electricity. Instead of individual large-scale power stations, in future a variable system of renewable generators, storage facilities and flexible backup power stations must assume responsibility for balancing the system. In the project, wind, solar and bioenergy plants with a total capacity of roughly 80 MW were therefore connected to form a virtual power plant, to compensate fluctuations and reliably deliver electricity and balancing power.

What is balancing power?

The oscillation of alternating current in the German electricity grid

The frequency of 50 Hertz in the integrated European grid must be within a specific range (generally +/-0.2 Hertz) for the power supply system to remain stable. As long as the electricity generation and consumption are balanced, the frequency is not affected - the system then remains stable. As soon as something changes in these conditions, the frequency reacts. If additional loads are connected to the grid or less generation is available, e.g. because a power station fails, the frequency in the grid is reduced. Conversely, the frequency increases if more electricity is generated than consumed, for example because a settlement is disconnected from the grid after a major short circuit. In order to guarantee the balance of generation and consumption apparent in the frequency, balancing power is required and must be available extremely quickly.

Besides the distinction between positive balancing power to increase the frequency and negative balancing power to reduce the frequency, there are also chronological classifications. Primary balancing power must be available fastest – it must be possible to activate the offered reserve on dispatch in full within 30 seconds. This is intended to compensate initially for abrupt changes in the grid frequency. Secondary balancing power, which must be available within five minutes, must then return the frequency to its target value. Tertiary balancing power is the last link in the chain, with a

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timeframe of 15 minutes. The higher the balancing power activated for the follow-up phase, the earlier the preceding balancing power can be replaced to be available for new requests.

Balancing power from renewable energy sources

Technically, most renewable energy facilities can already provide balancing power. By contrast to conventional sources, the most important renewable energy sources sun and wind are not available constantly, but depend on the weather conditions. In addition to this, there are also controllable renewable energy sources such as bioenergy and hydroelectric power.

By connecting various renewable energy systems to form a virtual power plant, the individual strengths of wind and solar energy, biomass, geothermal energy and hydroelectric power, storage facilities and backup power stations can be combined. A renewable virtual power plant of this kind can not only generate electricity reliably, it can also generate balancing power. Another advantage of this pooling is the geographic balance – for example when wind farms from various regions are networked, there is rarely no wind everywhere. Also, weather forecasts for larger regions are more accurate.

At the same time, the forecasts to predict the generated power in wind and solar energy systems are getting better and better, so that these fluctuating energies are becoming more and more plannable, and can therefore also contribute to frequency stabilisation – with corresponding framework conditions, which would also permit short-term participation in the balancing power market (see below).

The **virtual power plant 'Kombikraftwerk'**


Altes Lager wind farm (source: Energiequelle GmbH)


Photovoltaic system on a factory roof (source: SMA Solar Technology AG)


Heilbachhof biogas plant (source: ÖKOBIT GmbH

In order to demonstrate the provision of balancing power via renewable energies practically, a virtual power plant, the so-called 'Kombikraftwerk', was formed from a variety of renewable energy systems as part of the project. The wind, solar and biogas plants involved are managed centrally from a digital control centre at Fraunhofer IWES in 3-second intervals.
The renewable virtual power plant in the research project has a total capacity of roughly 80 MW and consists of the following individual systems:

- Altes Lager wind farm operated by ENERCON GmbH, Jüterbog (Brandenburg)
  18 turbines with a total capacity of 37.2 MW
- Feldheim wind farm (Brandenburg) operated by energiequelle GmbH
  19 turbines with a total capacity of 39.2 MW
- Photovoltaics:
  12 photovoltaic systems in the Kassel region, including 9 systems on private buildings and 3 large-scale photovoltaic systems with a total capacity of almost 1 MW
- Wallerstädten biogas plant (Hesse)
  Capacity: 1.2 MW
- Mittelstrimming biogas plant (Rhineland Palatinate)
  Capacity: 0.5 MW spread over 2 CHP stations with 0.2 and 0.3 MW
- Zemmer biogas plant (Rhineland Palatinate)
  Capacity: roughly 1.4 MW - 1 CHP station with 889 kW and one satellite CHP station with 536 kW
- Heilbachhof biogas plant, Zweibrücken (Rhineland Palatinate)
  Capacity: 0.5 MW distributed to 2 CHP stations with 250 kW each

The field test

Running the target signal in the combined power station during the balancing power test

In order to be approved as a provider of balancing power, the systems which take part in the tender must prequalify. The power stations must prove that they can react to changes in capacity within the required time and to the prescribed extent. These requirements were also made of the systems in the virtual power plant in the demonstrated balancing power test as a target signal. After running the prescribed target signal, the balancing power activation is aligned based on the real grid frequency. Depending on the state of the grid frequency, the renewable energy systems provide positive or negative balancing power. Overall, the systems linked in the virtual power plant proved that they can provide balancing power securely and reliably to stabilise the grid frequency in this way for a 20-minute period.

The provision of balancing power via wind and photovoltaics systems was proven based on a new process. The wind and photovoltaic systems provide the balancing power relative to the available active power, i.e. the capacity the systems would have generated had they not been scaled down. Technically, positive balancing power is provided by throttling the systems. In this way, they can be ramped up again if needed and provide the positive balancing power offered. If negative balancing power is requested and drawn, the systems reduce their feed further (relative to the available active power). The amount of balancing power that can be provided at specific times by systems which feed electricity based on the weather conditions can already be predicted relatively precisely via forecasts. The shorter the forecasts look into the future, the better they are. Forecast errors of individual systems or farms are partially compensated by linking them in the Kombikraftwerk.

Summary and changes required in the balancing market

The field test as part of the Kombikraftwerk 2 research project shows that renewable energy sources are already technically in a position to provide balancing power.

The framework conditions of the balancing market currently prevent renewable energy sources from actually offering these abilities, and thus taking responsibility for stabilising the system. As a result, the transformation of the energy system should now also occur on the balancing market and offer options for fluctuating renewable energy sources to participate. With shorter tender announcement periods and lead times, photovoltaic systems and wind turbines, whose feed capacities can only be predicted precisely with a lead time of a few hours up to roughly one day, can participate in the balancing market. This would also allow flexible systems which convert gas from renewable sources into electricity and are operated by demand with high-efficiency cogeneration to access the market.

Also, the verification of the balancing power provision should be based on the actual "available active power" of wind turbines and photovoltaic systems. If fluctuating generators had to provide balancing power like existing providers, they would have to conform to a constant chronological roadmap. On one hand, this would have the disadvantage that the fluctuating generators would have to be scaled down to a constant level, leaving much potential energy unused. On the other, it would mean that the compensating effects between the generators and loads could not be used.

Background & contact

The three-year "Kombikraftwerk 2" research project is funded by the German Federal Ministry for the Environment. The consortium partners are: CUBE Engineering GmbH, German Weather Service, ENERCON GmbH, Fraunhofer Institute for Wind Energy and Energy System Technology, ÖKOBiT GmbH, Institute of Electric Power Systems of Leibniz University Hanover, Siemens AG, SMA Solar Technology AG, SolarWorld AG and German Renewable Energies Agency.

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