ERNEUERBARE ENERGIEN

Technical summary of the Combined Power Plant

I. Portfolio and scalability

Demand curve

The Combined Power Plant meets 1/10,000th of Germany's electricity requirements. We take into account the energy released from the central power plants via the transmission networks (vertical grid load) plus the sum of all decentralised energy generators (see list, Table 1). Decentralised CHP (Combined heat and power) plants and hydropower are not replaced here – the corresponding amount of energy is disregarded. As a result, the amount to be replaced by solar, wind and biogas/biomass energy is: 411.3 TWh/a.

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Potential provided by renewable energy sources in Germany:

Renewable energy	Usable potential [TWh/a[	Remarks
Onshore wind energy	168	Full load hours: 2,800 Capacity: 6 MW Number of turbines: 10,000
Offshore wind energy	120	Full load hours: 4,000 Capacity: 6 MW Number of turbines: 5,000
Photovoltaics	60	Full load hours: 850 Capacity: 70 GW 20% of roof surfaces
Biogas	100	Yield: 14,000 m3/ha Efficiency: 2.5 kWhel/m3 17% of agricultural land
Total	448	

Energy generation and conversion portfolio

When added together, the various potentials for wind, biogas and PV each correspond to around 1/10,000th of the estimated overall potentials for these renewable energy sources. A total of 41.1 GWh is produced each year, which corresponds to the electricity demand for around 11,740 households. The incorporated storage capacity and the import/export capacity in neighbouring grids also both correspond to 1/10,000th of the actual capacities in Germany.

II. Choice of plants

In order to take advantage of equalisation effects due to different weather conditions in the German regions, wind and solar power installations were used that are as far apart as possible.

1. Wind farms

The following Enercon wind farms were selected: Pilsum on the North Sea, Nauen near Berlin and Würselen near Aachen, amounting to 12.6 MW. The selection combines locations of different quality and, thanks to the decentralised distribution, provides a certain amount of stability as would be the case with a Germany-wide provision.

2. Solar power plants

PV systems spread across Germany have been integrated in order to take advantage of equalisation effects through decentralised distribution. These have a total output of 5.5 MWp.

3. Biogas

Biogas electricity is used in the Combined Power Plant to balance out temporary fluctuations in wind and solar energy amounts. To achieve this short-term equalisation, a biogas unit with a directly connected CHP plant in Hünxe is integrated. For long-term equalisation, including several weeks of wind still, the biomethane plant in Pliening feeds biogas into the natural gas network. Corresponding to this amount of energy, a CHP plant belonging to the Stadtwerke Schwäbisch Hall municipal utility company and a micro gas turbine in Bad Hersfeld convert natural gas from the grid into electricity when it is required by the Combined Power Plant. The incorporated electrical output amounts to 4.0 MW.

4. Additional storage

If, in addition to the equalisation energy provided by biogas, there is still a difference to be made up, a reservoir is filled or emptied. Since pumped storage power plants generally consist of very large units, it is not possible for such storage to be actually regulated by the Combined Power Plant. Thus, this is the only component of the Combined Power Plant that is not actually incorporated as a power plant, but as a simulation.

As a reference, the technical features of the Goldisthal pumped storage power plant have been used and scaled down to 1.06 MW. This also corresponds to 1/10,000th of the energy storage capacity that is currently available in Germany.
For future applications, the pumped storage power plant can also be supplemented with other storage technologies (compressed air reservoirs, batteries used for electromobility, etc.).

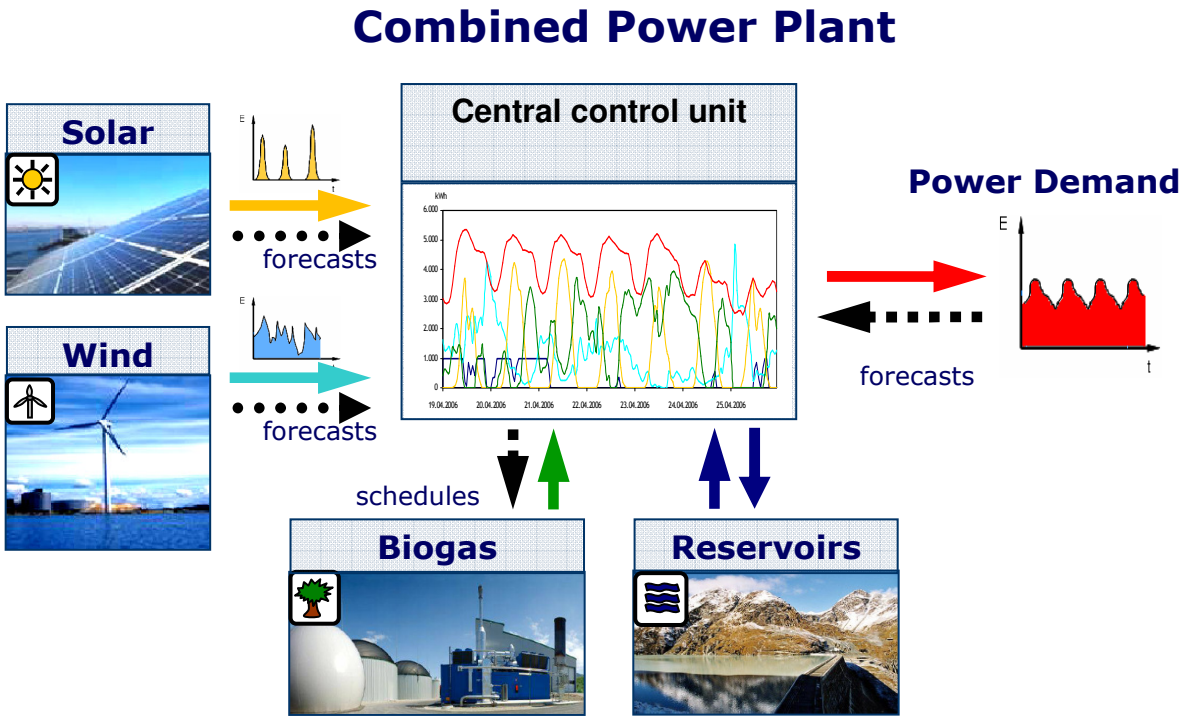
5. Import/Export

Exports and imports to and from neighbouring grids have been limited to 1 MW. This transfer rate corresponds to 1/10,000th of the output transferred by Germany to grids in neighbouring countries (10 GW).

6. Controlling wind and solar energy

In general, the Combined Power Plant is also able to throttle down wind turbines and remove solar power systems from the grid if there is so much surplus output available that the energy can not be completely transferred.

III. Function of the Central Control Unit



First step: Forecast and scheduling

The Central Control Unit (CCU) receives weather and demand forecasts and, based on these, anticipates the necessary amount of power to be produced by wind and solar plants.
To balance out the difference between the actual demand and the energy generated by wind/solar energy, it calculates and sends a schedule to the biogas electricity generators.
If there is still a surplus or shortage in meeting the demand, this is balanced out by using the pumped storage power plant and, last of all, by exporting and importing to and from neighbouring grids.

Second step: Comparison of actual data

The CCU receives feedback from all power plants on the actual current output and compares this data with the actual demand.

Differences in comparison to the forecast values are balanced out through short-term adjustments to the biogas electricity outputs, whereby the micro gas turbine and the biogas CHP plant in Hünxe make it possible to provide equalisation energy within minutes.

IV. Annex

Table 1: Calculation of the electrical energy to be replaced by renewable energy sources

	TWh
Vertical grid load	360.2
+ Wind	30.5
+ Bio-CHP	18.6
+ PV	2
Total	411.3
+ decentralised CHP 100	100
+ water 21.6	21.6
(Total	532.9)

Source: Calculations based on data from the German Environment Ministry, BMU (2007b)

Table 2: Energy generation portfolio

	Wind	Solar	Biogas	Reser-voirs	Import/Export	Total
Installed capacity [MW]	12.6	5.5	4.0	1.06	-/1.0	-
Electrical energy [GWh/a]	26.5	6.2	10.8	-0.6	0.02/1.8	41.1 (43.5)
% of Total	60.9	14.3	24.8	-	-	100.0

Table 3: Incorporated wind energy

Reference no.	Location (post code)	Plant data
1	Pilsum (26736)	6 wind turbines, each with 500 kW
2	Nauen (14641)	3 wind turbines, each with 2,000 kW
3	Würselen (52146)	2 wind turbines, each with 1,800 kW
	Total	12.6 MW

Table 4: Incorporated solar power plants

Reference no.	Location (post code)	Plant data
4	Neckarsulm (74072)	167 kW
5	Rottenacker (89616)	256 kW
6	Heddesheim (68542)	315 kW
7	Uttenweiler (88524)	118 kW
8	Donaueschingen (78166)	179 kW
9	Tauberbischofsheim (97941)	494 kW
10	Rheinstetten (76287)	170 kW
11	Würzburg (97076)	234 kW
12	Tübingen (72072)	118 kW
13	Werbach (97956)	227 kW
14	Niederkirchen (67150)	259 kW
15	Külsheim (97900)	166 kW
16	Ilshofen (74532)	400 kW
17	Kirchardt (74912)	153 kW
18	Assamstadt (97959)	151 kW
19	Tauberbischofsheim (97941)	101 kW
20	Hofkirchen (94544)	237 kW
21	Aidenbach (94501)	176 kW
22	Penzing (86929)	1,380 kW
23	Freiberg (09599)	240 kW
Total		5.5 MW

Table 5: Incorporated biogas plants and CHPs

Reference no.	Location (post code)	Plant data
24	Pliening (85652)	Gas production 1,140 kWh/h1 Fed into natural gas network (gas storage network 1,320 MWh)
25	Schwäbisch Hall (74523)	CHP 2,900 kW Gas storage: natural gas network
26	Bad Hersfeld (36251)	Gas turbine 30 kW Gas storage: natural gas network
27	Hünxe (46569)	CHP 1,046 kW Gas storage: local
	Total	4.0 MW

Table 6: Incorporated reservoir

Reference no.	Location (post code)	Plant data
28	Goldisthal (98666)	Output: 1,060 kW (actual: 1,060 MW) Storage: 80 hours (actual: 8 hours), or 84.8 MWh (actual: 8.48 GWh) Efficiency: 0.9 (turbine), 0.85 (pump)

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