



Electrical Engineering  
and Systems  
Technology

for the Use of  
Renewable Energies

and Decentral  
Energy Supply

Applications oriented  
Research and  
Development

Institut für Solare  
Energieversorgungstechnik  
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Universität Kassel e.V.

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# More benefit from renewable energies sources by combination with storage devices and cogeneration



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 **DEWEK 2008**  
9<sup>th</sup> German Wind Energy Conference

## Outline



### Renewable Energy production

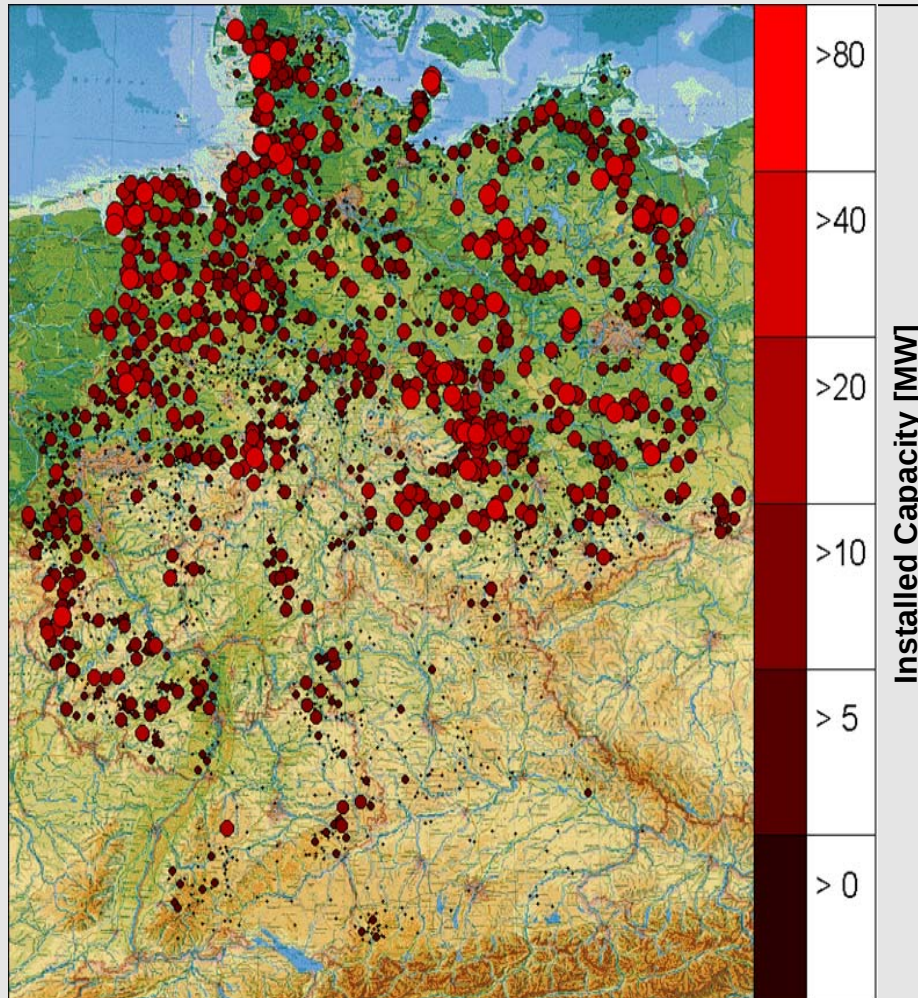
- Fluctuating renewable energy producers
- Storage capacities and constant renewable power production
- Need for local storage devices

### Combined Systems

- Combination Wind and Storage
- Wind and cogeneration by biogas

### Conclusion and Outlook

## Distribution of renewables - Wind



In 2008 over 20,000 wind turbines  
with 23.70 GW installed capacity

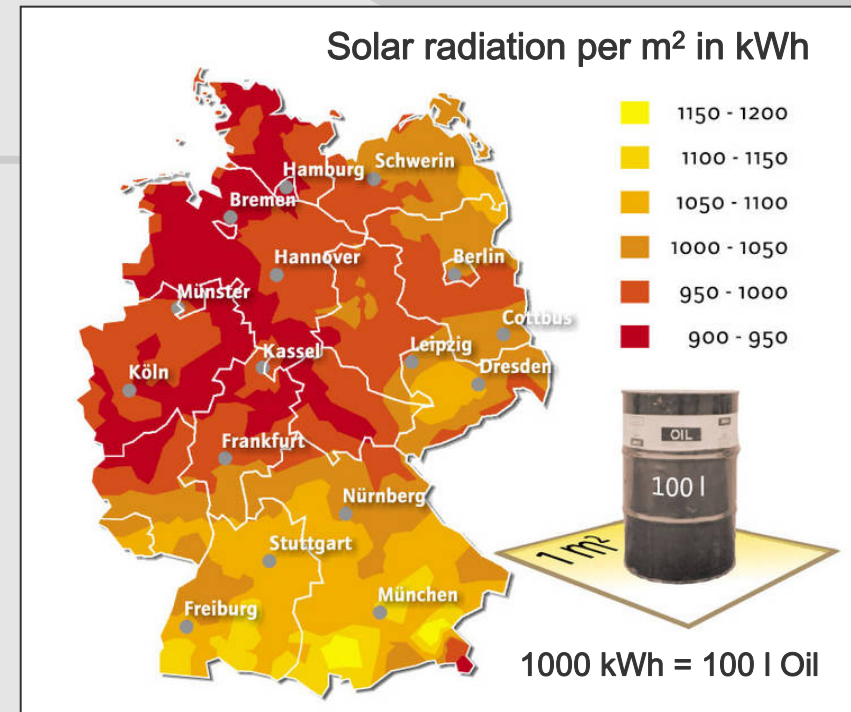
Production 2007 - 40 TWh  
-> (7% of German consumption)

## Distribution of renewables - PV

3.8 GWp installed capacity  
produced 3 TWh in 2007

|                                 |       |
|---------------------------------|-------|
| Rooftops in Mio. m <sup>2</sup> | 3,600 |
| % of Rooftops                   | 0.58% |
| Mio. m <sup>2</sup>             | 21    |
| W/m <sup>2</sup>                | 120   |
| Capacity in GWp                 | 3.8   |
| Full load hours                 | 950   |
| TWh/a                           | 3     |

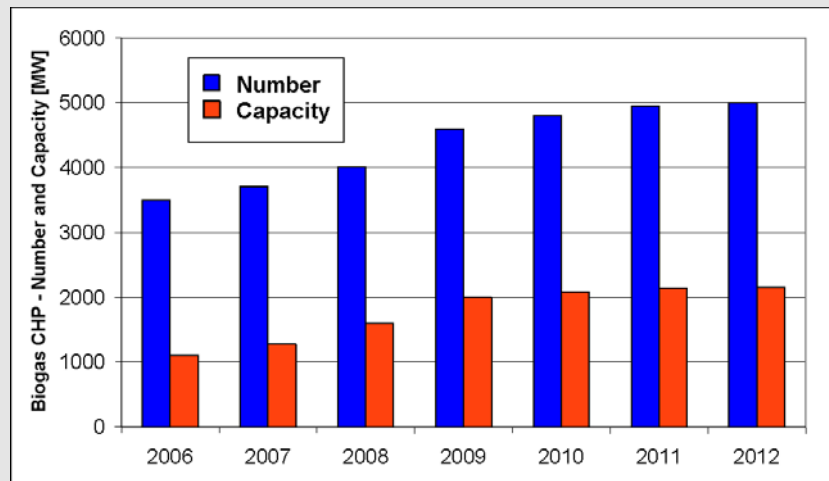
Source: Solarworld AG, BSW Solar e.V ISET e.V. – July 2007



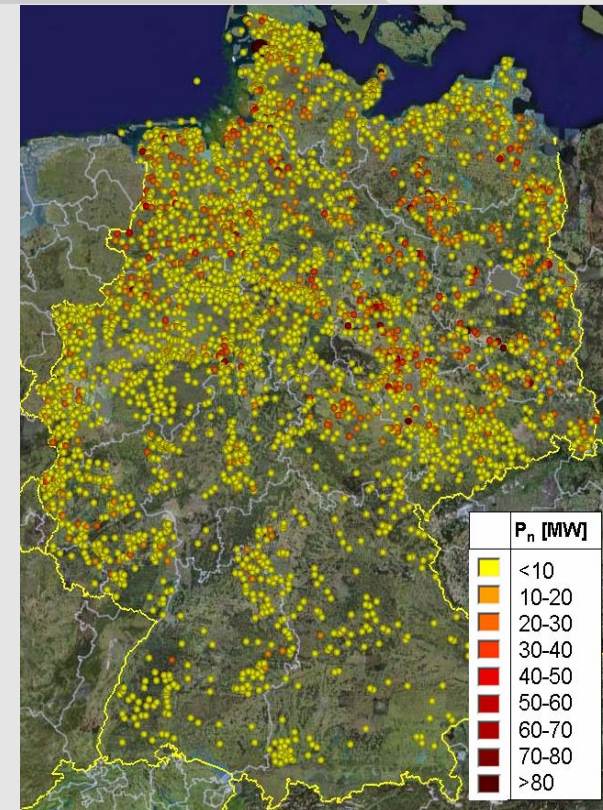
## Distribution of renewables - Biogas



3,711 Biogas fired CHP in 2007  
with 1.27 GW installed capacity  
produced 7.4 TWh



Source: Fachverband Biogas e. V., ISET e.V.

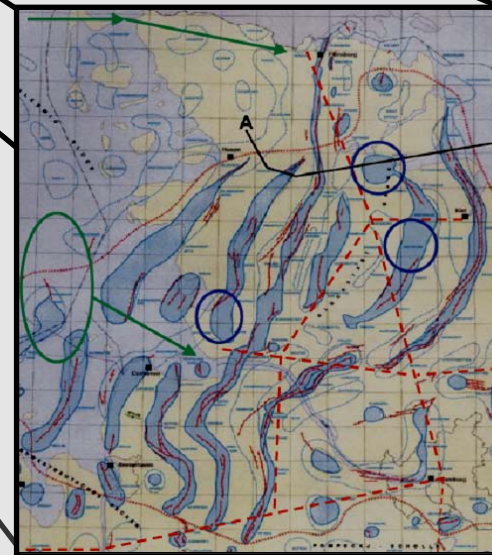
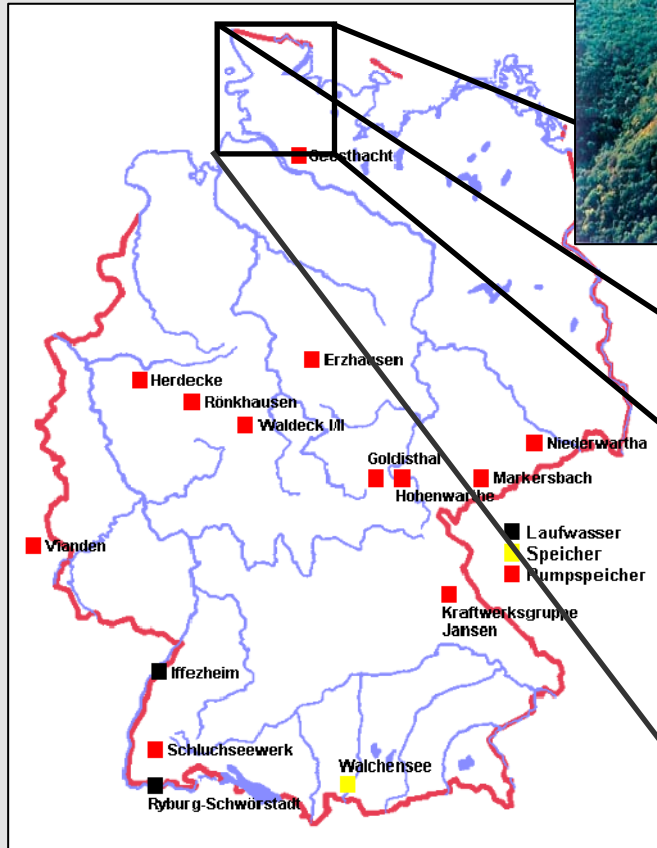


Distribution of  
biogas fired plants

## Storage facilities



Pumped hydro storage capacity 186 GWh, total peak production 6.7 GW



Adiabatic compressed air storage:  
800 up to 2,500 GWh  
(Northern Germany)

Bundesverband der Energie- und Wasserwirtschaft (BDEW), U. Ehlers - FH Flensburg 2006

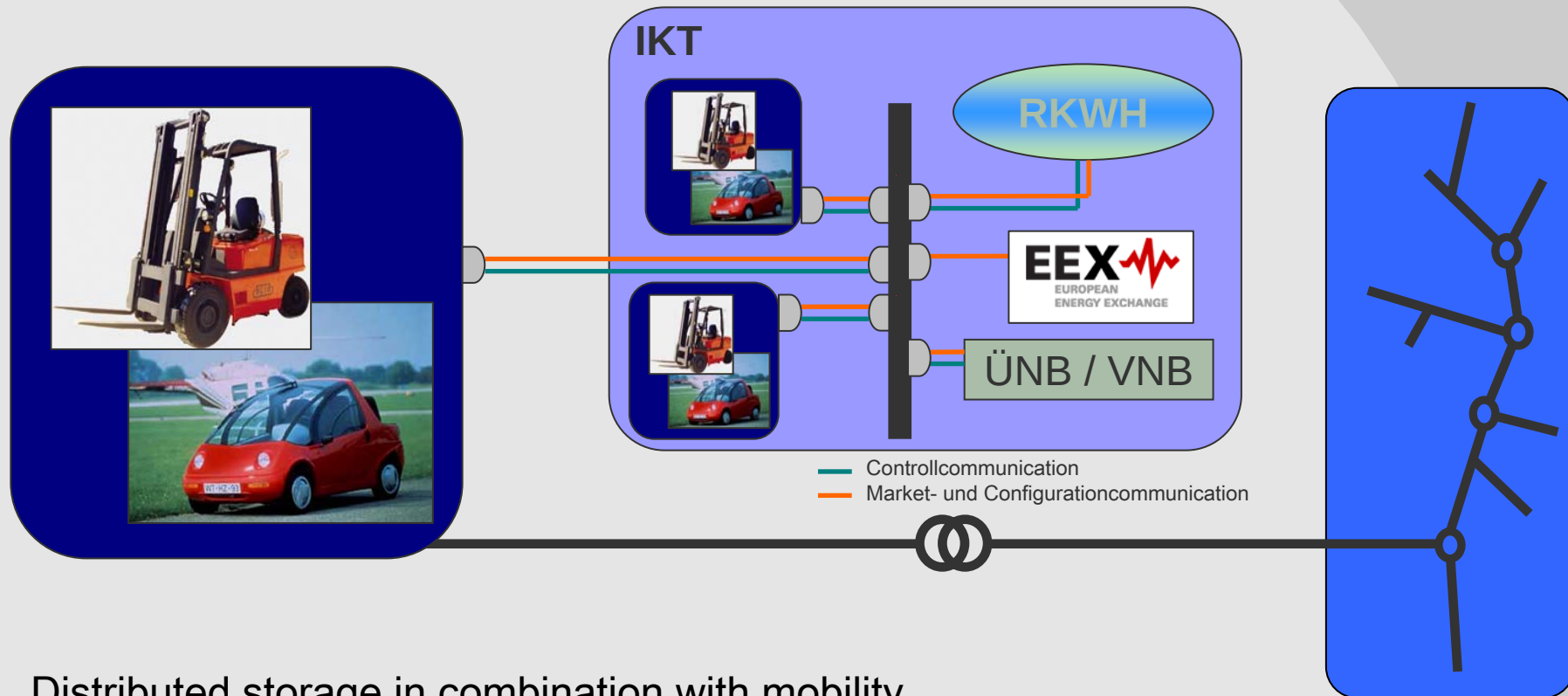
Nöther und Partner, 2008

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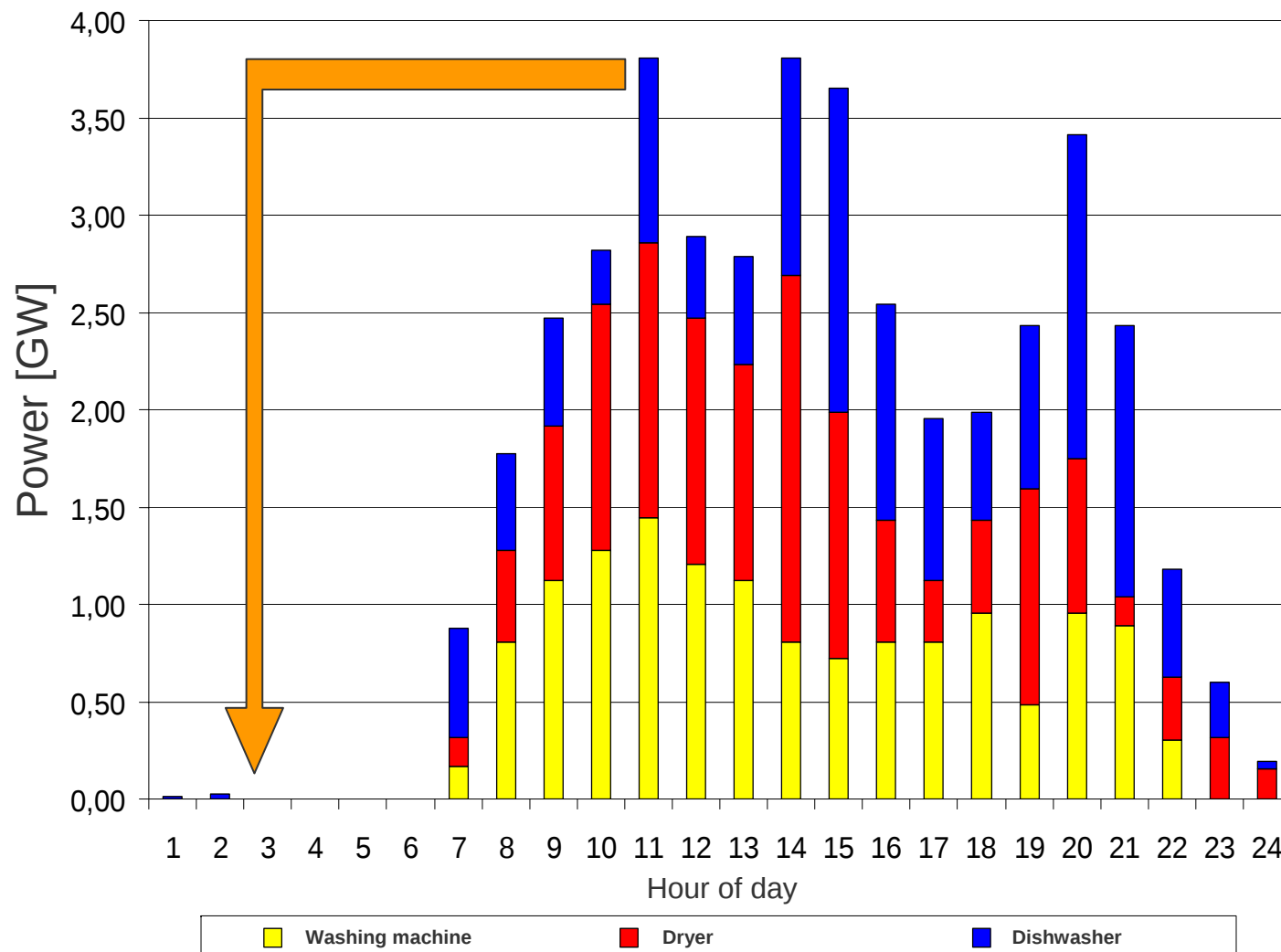
## Vehicle-to-Grid



Distributed storage in combination with mobility

45 Mio Vehicles @ 10 kW → 450 GW Controlpower

# Demandside management of private households



Source: Stadler, Dena II study, 2007

— Controllcommunication  
— Market- und Configurationcommunication

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## Power generation by renewables – Future scenario for Germany



Wind 60 GW onshore  
30 GW offshore



Photovoltaic 70 GW  
(20% of the rooftops)



Biogas 40 GW CHP  
(16.8% of the agricultural area)



Storage 20 GW peak, 370 GWh



Im-/Export 10 GW

Source: Enercon GmbH, Schrack Biogas AG, Solarworld, ISET, July 2007

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- **Need for local storage devices**

### Combined Systems

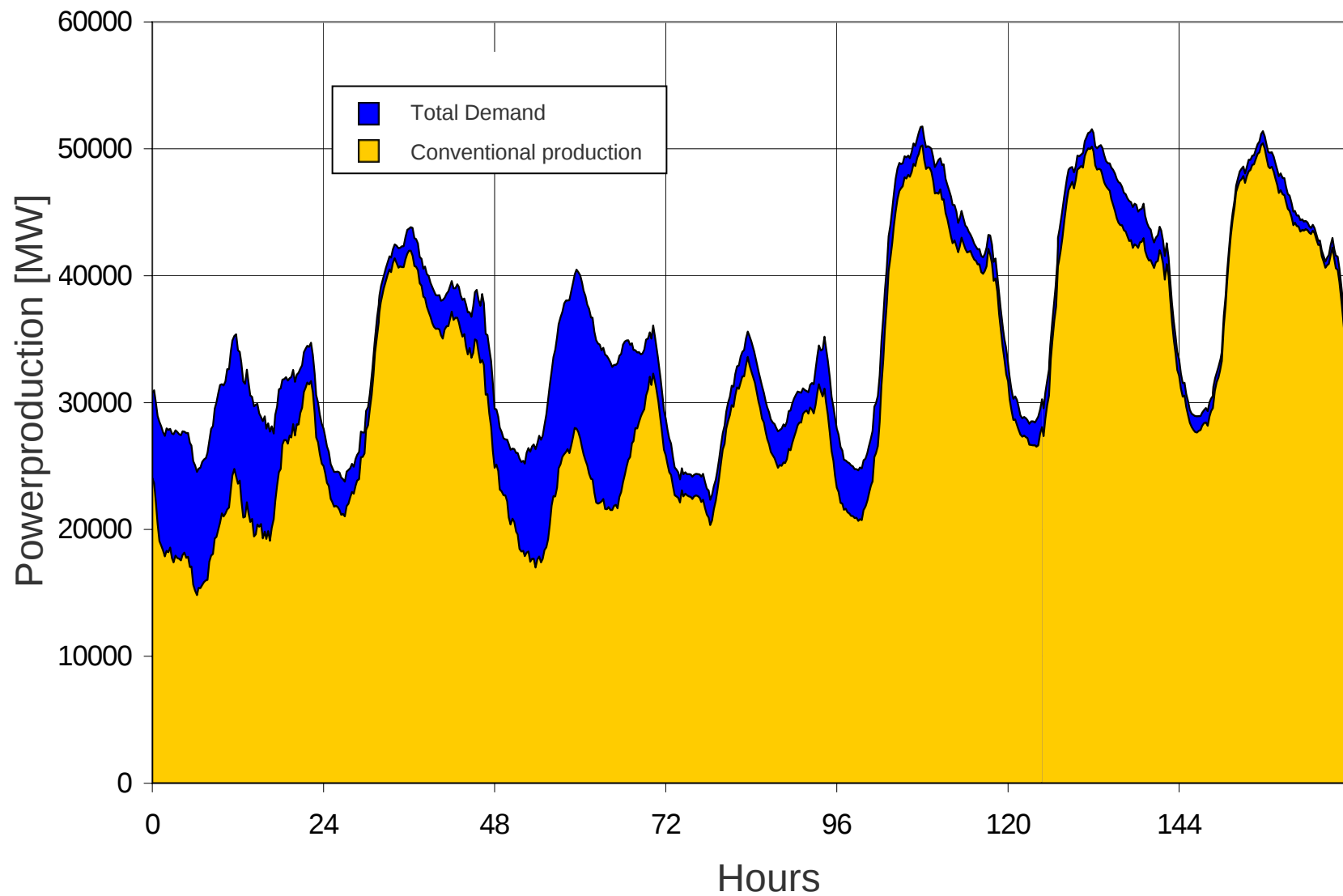
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### Conclusion and Outlook

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## Demand and wind today



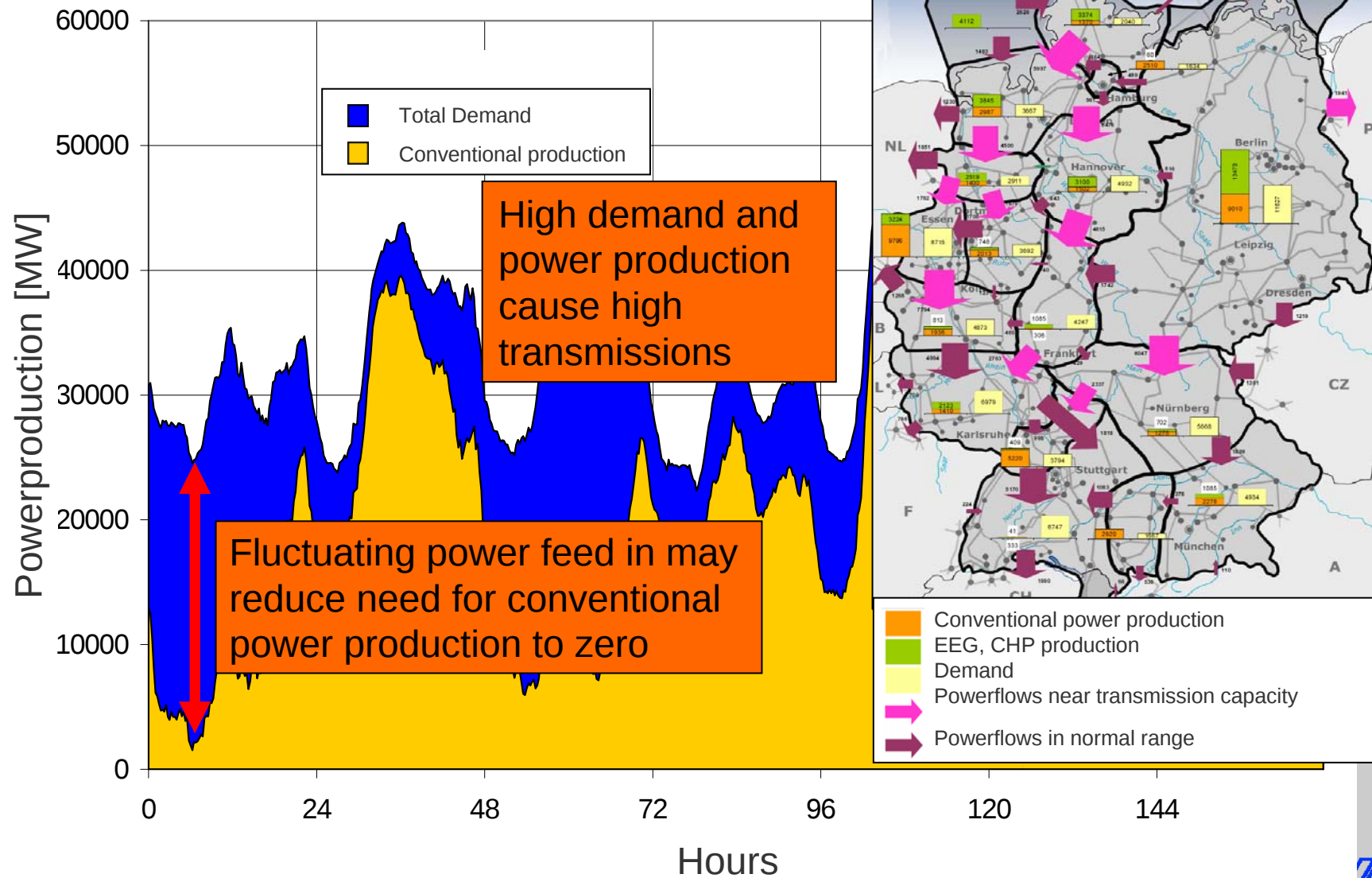
Quelle: Rohig, ISET, 2007

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## Demand and wind in future



Source: Stromtransport 2012, study German TSO

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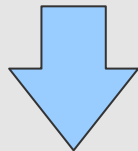
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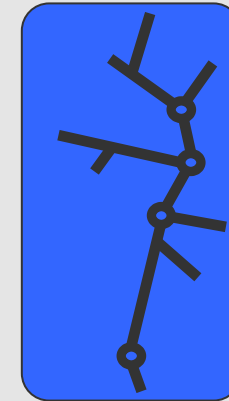
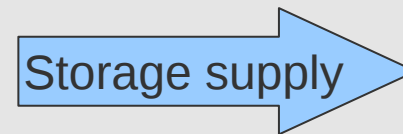
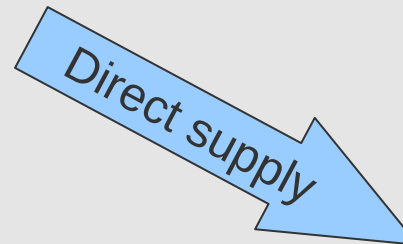
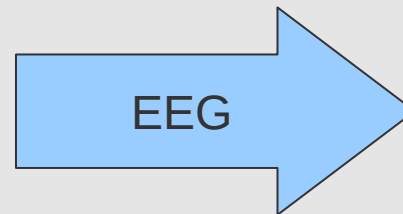


## Combination Windfarm and Pumped hydro storage

60 MW Windfarm



80 MW Storage device  
With ~700 MWh  
storage capacity

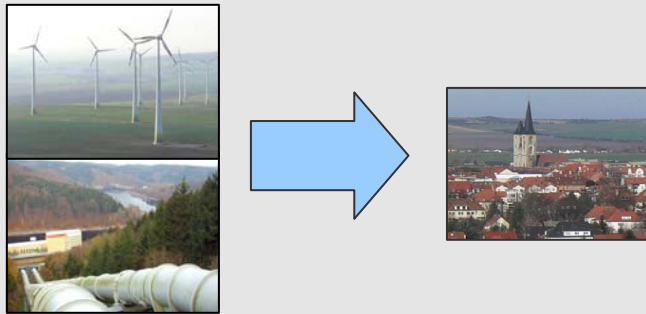


~ 6750  
households

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## Combination Windfarm and Pumped hydro storage



6750 households

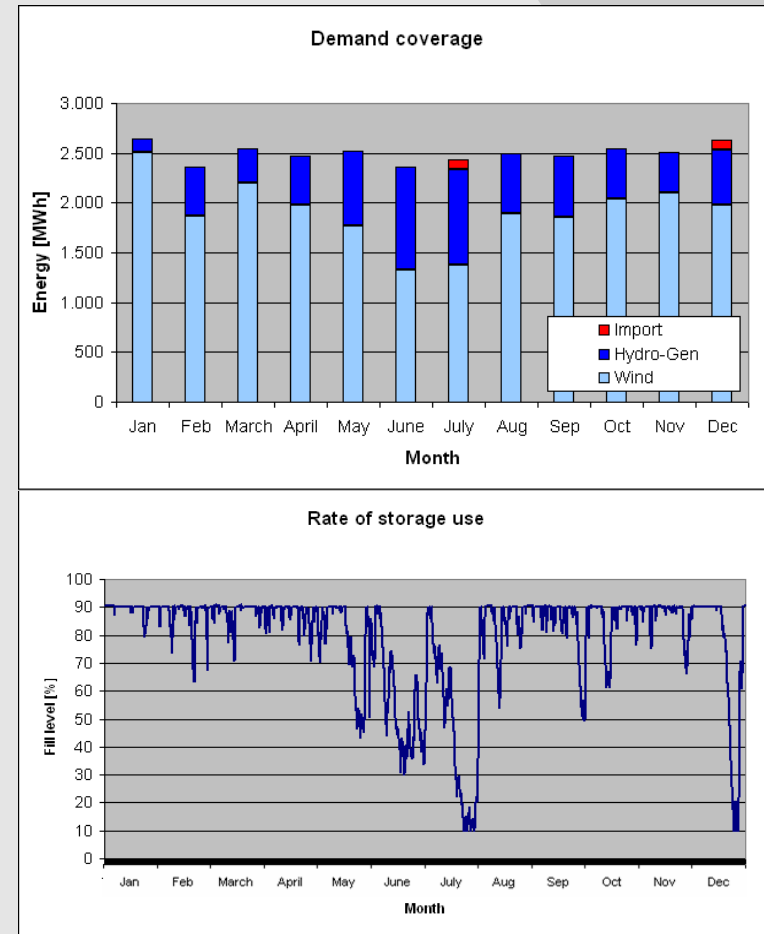
Peak load: 6.3 MW

Energy consumed 30 GWh

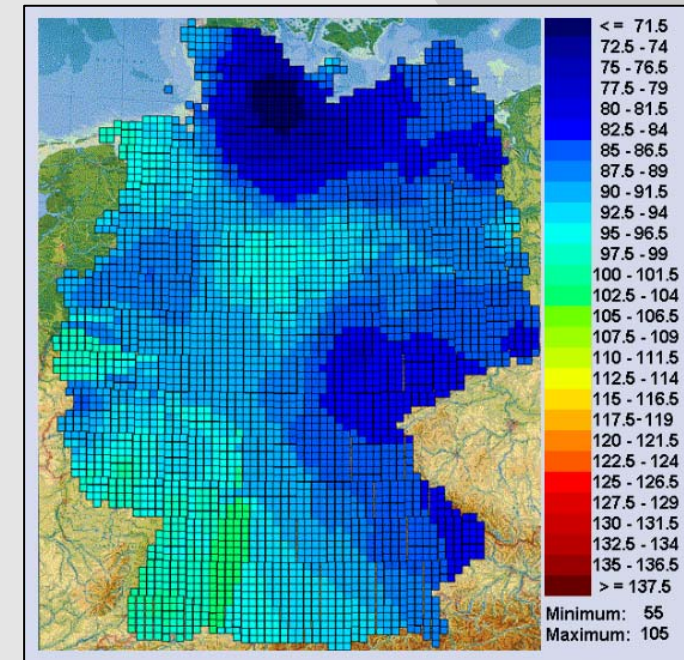
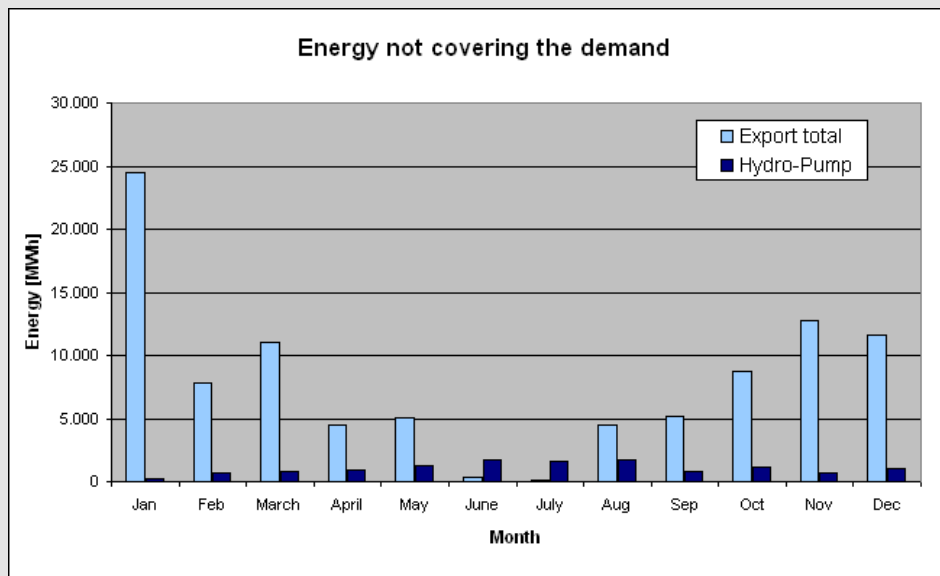
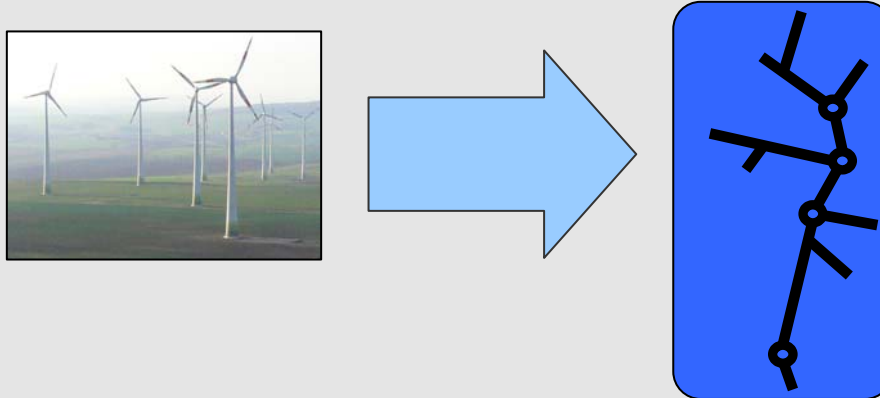
Energy supplied by windfarm 22.9 GWh

Supplied by storage device 6.88 GWh

Energyimport less than 0.22 GWh



## Combination Windfarm and Pumped hydro storage



2006, Wind 90% of av.

Windenergy fed in by  
EEG Tarif 107.7 GWh

## Combination Windfarm and Pumped hydro storage

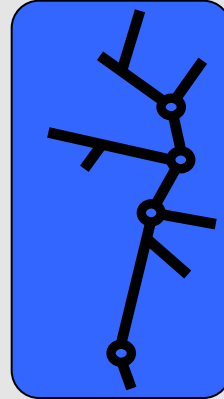
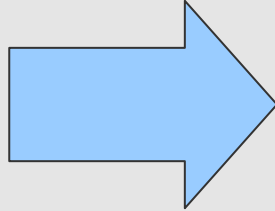


60 MW windfarm in combination with 80 MW storage device is able to secure the supply of 30 GWh demand

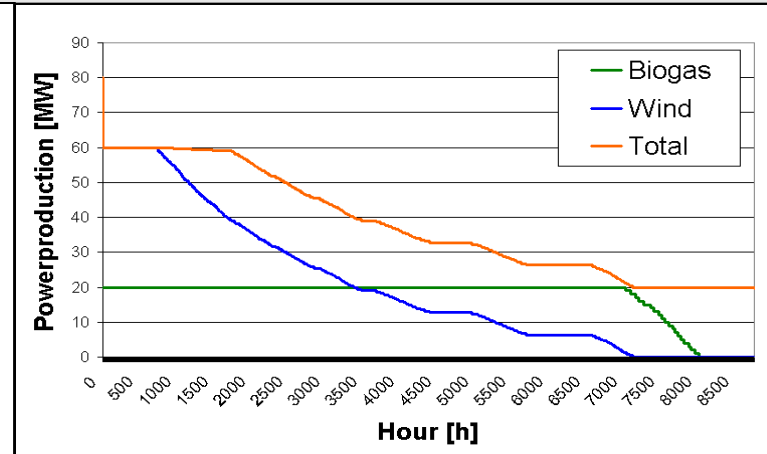
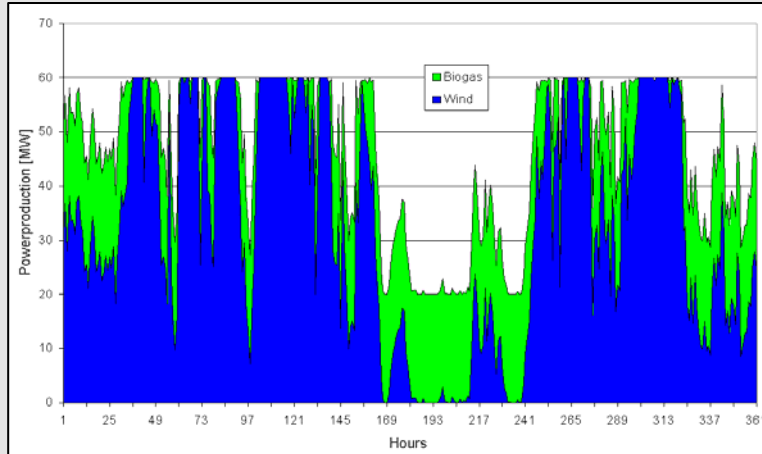
Less than 20 % of the energy produced by the windfarm covers the demand of 6750 households

The model get attractive to the windfarm controller when the feed in tarif declines to 7.6 ct/KWh

## Windfarm and Biogas cogeneration



Cogeneration by 20 MW  
Biogas plant raises combined  
capacityfactor to 45 %



Energyproduction of 80 MW Wind and 20 MW Biogas

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## Windfarm and Biogas cogeneration



To cover additional costs of biogas fired plants 2 - 2.5 ct per KWh wind power are required

20 % of the installed windpower capacity 2012 can be integrated in coordinated production

Economical attractiveness is given for windfarms with capacity factors above 28.5% (2,500 Full load hours)

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## Conclusion and outlook

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### Conclusion :

- To integrate high amounts of fluctuating power production, storage devices and cogeneration is needed
- Future systems with a high share of fluctuating power production have to balance between storage and energy transmission
- Northern Germany bears high potentials to produce and to store energy

### Outlook:

- In future smaller regions will switch to larger share of renewables
- To use energy effectively, systems of electrical power supply, heat and mobility have to be researched in context



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Thanks for your attention,  
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