ISET

Electrical Engineering and Systems Technology

for the Use of Renewable Energies

and Decentral Energy Supply

Applications oriented Research and Development





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No limits for a full electricity supply by renewables

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1st of April 2008

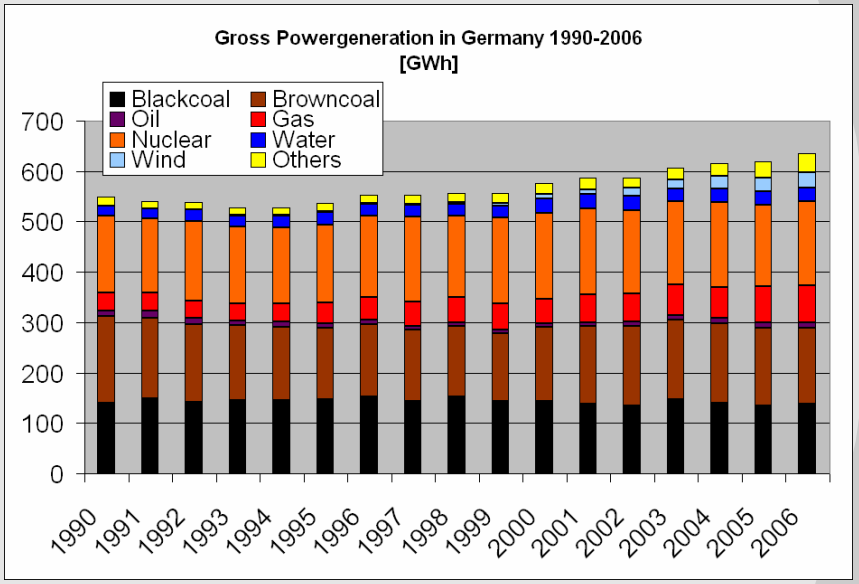
ewec 2008 BRUSSELS
Europe's premier wind energy event

Outline

- Why renewable energies?
- The 100% renewables scenario
- The virtual power plant
- Conclusion/Outlook

Why renewable energies? – The German situation

- Electrical power generation in Germany 540 TWh in 2006
- Over 60% of the fuels have to be imported
- Prices for fossile fuels rised to 150-200% related to 2000
- New gas and coal fired plants are planned – with the assumption of effective CO_2 storage



Source: Statistisches Bundesamt, EuroStat - Statistical Office of the European Communities 09.03.2008

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Why renewable energies? – The German situation

- Share of renewable energy sources about 8.5% in 2007
- Target for German share of renewable sources in 2020 is 18%
- Target for reduction of CO_2 emission related to 1990 36% until 2020
- Additional phase out of nuclear Power until 2021

Source: Statistisches Bundesamt, EuroStat - Statistical Office of the European Communities 09.03.2008

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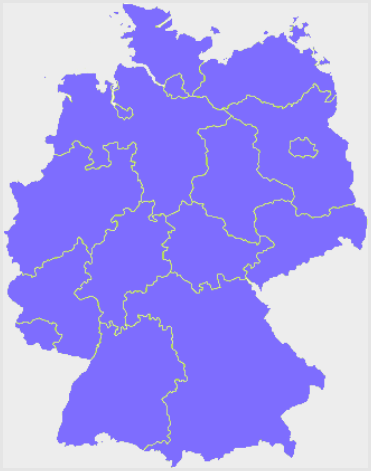

No Limits means to supply Germany with 100% renewable energy.

So we have to ask two (main) questions:

1. Potential: Is it possible to replace all conventional power generation with renewables?
2. Availability: Have renewables the ability to meet the consumption any time?

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The 100% renewables scenario – Power generation

	2006	Future… (2050)
Power generation in Germany [TWh/a]	536,1	573
Conventional powerplants	363,4	0
Wind onshore	30,5	168
Wind offshore	0	120
Biogas	18,6	100
PV	2,0	60
Hydro	21,6	25
Waste incineration, decentralized CHP	100	100

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

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The 100% renewables scenario – Energy production of renewables

Wind	Wind onshore		Wind offshore	
	2006	Future…	2006	Future…
Avg. capacity in kW	816	6000	0	6000
Number of plants	18.685	10000	0	5000
Total capacity in GW	20,62	60	0	30
Full load hours	2000	2800	0	4000
GWh/a	30500	168000	0	120000

Source: Enercon GmbH, ISET e.V. – 10th of July 2007

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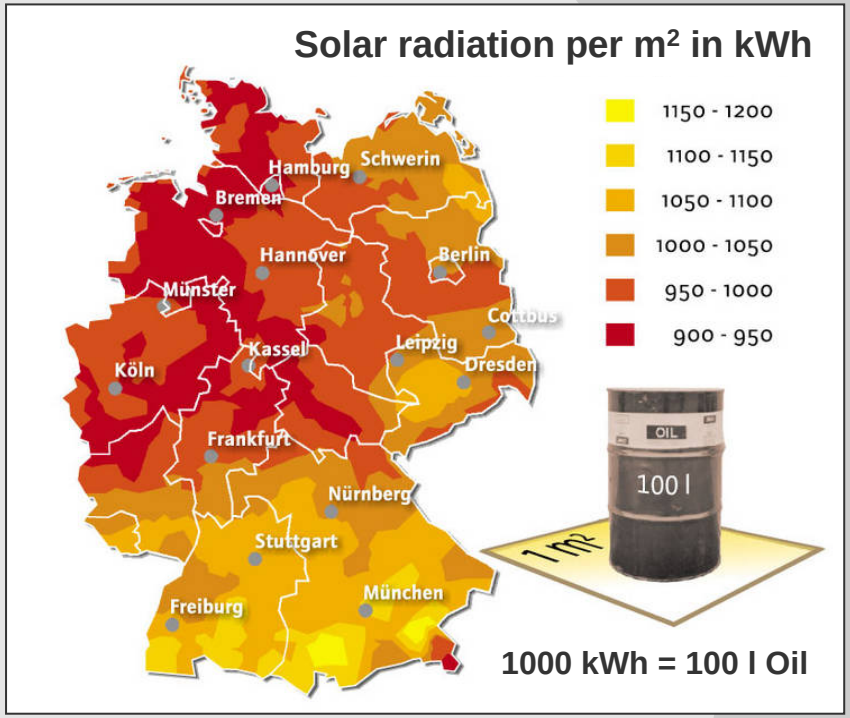
The 100% renewables scenario – Energy production of renewables

PV	2006	Future…
Rooftops in Mio. m²	3600	3600
% of Rooftops	0,58%	19,61%
Mio. m²	21	706
W / m²	120	150
Capacity in GW	2	71
Full load hours	950	850
GWh / a	2000	60000



Source: Solarworld AG, BSW Solar e.V ISET e.V. – 10th of July 2007

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The 100% renewables scenario – Energy production of renewables

Biogas	2006	Future…
Agricultural land in Mio. ha	17	17
% Agricultural land for el. power generation	5,47%	16,81%
Mio. Hektar	0,930	2,857
Mio. Ton	46,5	200
Tons of Corn / Hektar	50	70
m^3 Gas / Ton of corn	200	200
kWh / m^3	5	5
kWh_{el} / kWh / m^3	2	2,5
Gas Mio. m^3	9300	40000
GWh_{el} / a	18600	100000

Source: Schmack Biogas AG, ISET – 10th of July 2007

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The 100% renewables scenario – Installed capacities

Wind	60 GW onshore 30 GW offshore
Photovoltaic	70 GW (using 20% of the rooftops)
Biomass	40 GW CHP (using 16,8% of the agricultural area)
Storage capacities	10 GW
Import/Export	10 GW

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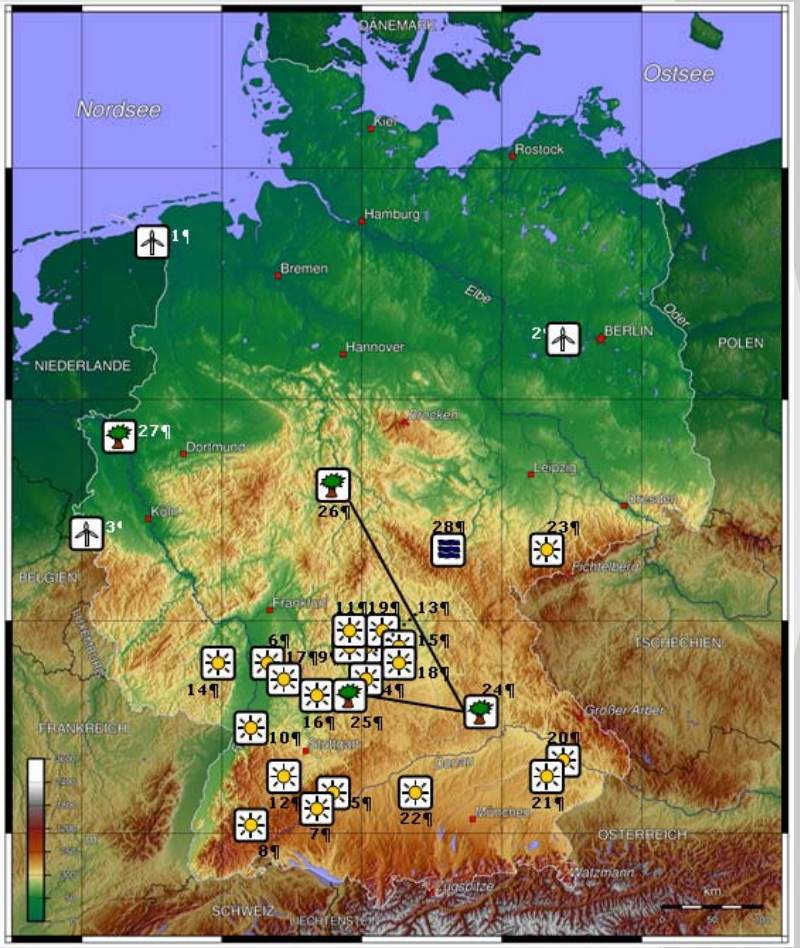
The 100% renewables scenario - The virtual power plant

- Virtual power plant - real energy.
- Consumption of Germany 2006.
- Combination of wind, pv, biogas and pumped hydro.
- Scaling 1/10000.



Wind	Solar	Biogas	Hydro	Import /Export
12,6 MW	5,5 MW	4,0 MW	1,0 MW	1,0 MW

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The virtual power plant – Interfaces

Agents

Load

Wind

Biogas

PV

Hydro

Import/Export

Calculationalgorithm

Results

Control

System is running operationally since 3rd of July 2007

Webservice **Webservice**

Powerproduction **Calculationserver** **Graphical Interface**

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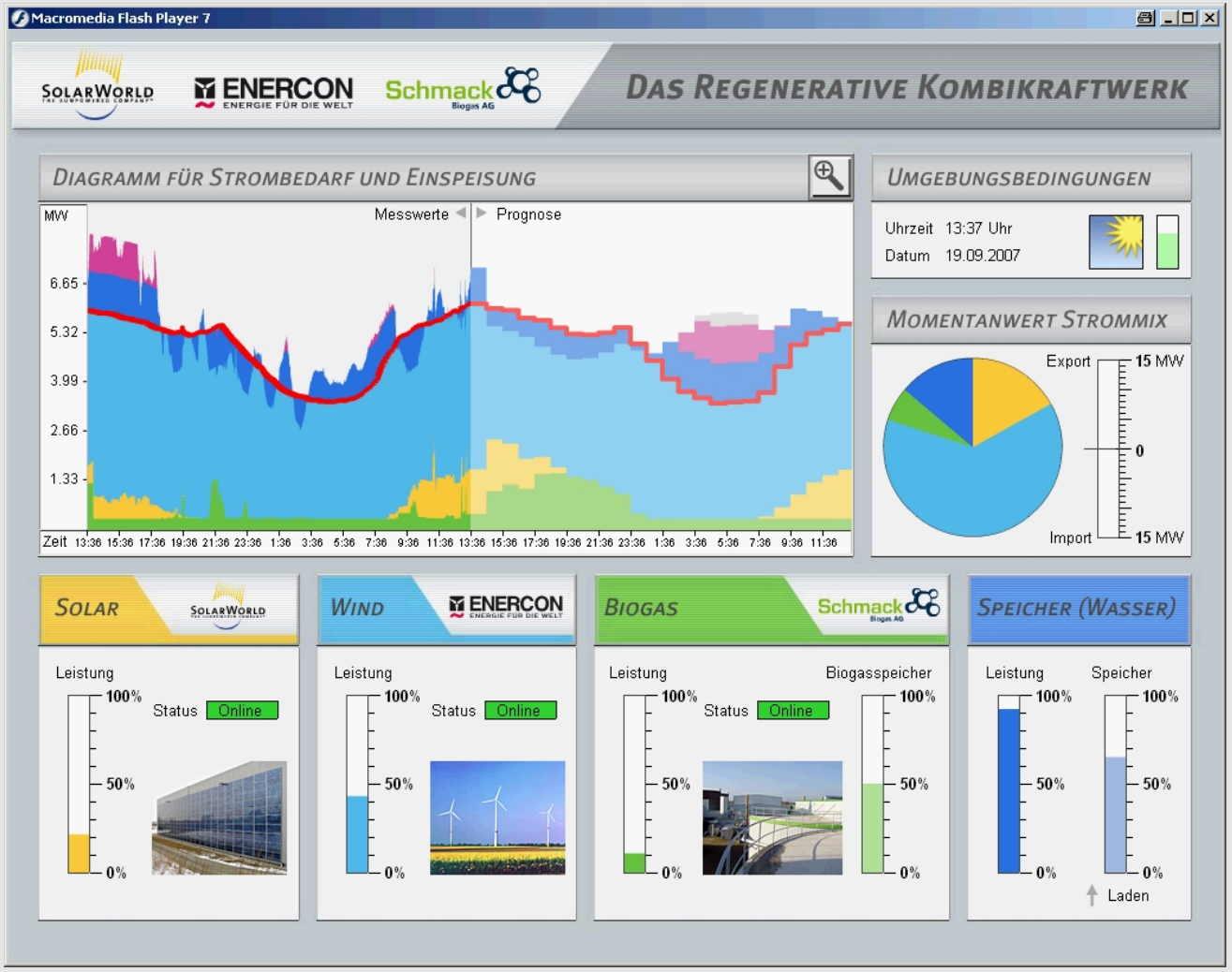
The virtual power plant – Graphical user interface



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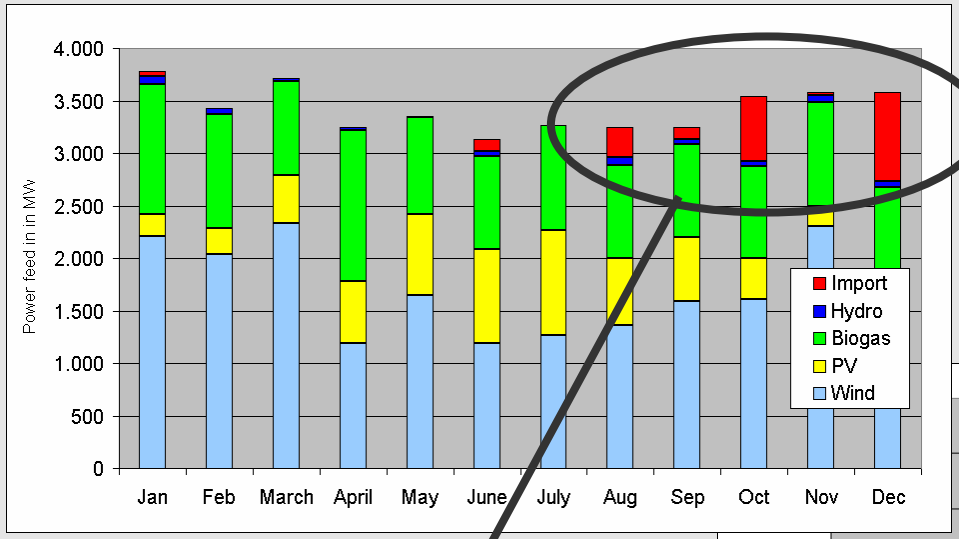
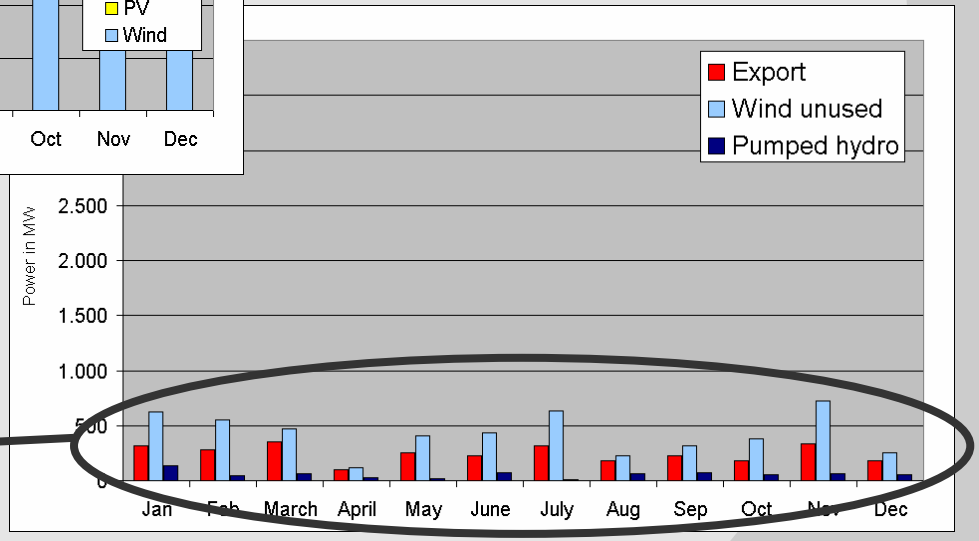
The virtual power plant - Results

Simulation with lower wind feed in – 90% related to avg. wind year



Demand	41.124 MWh
Wind	20.338 MWh
PV	6.153 MWh
Biogas	12.043 MWh
Hydro	522 MWh
Import	2.067 MWh



Higher imports during winter

Smaller portions of unused wind

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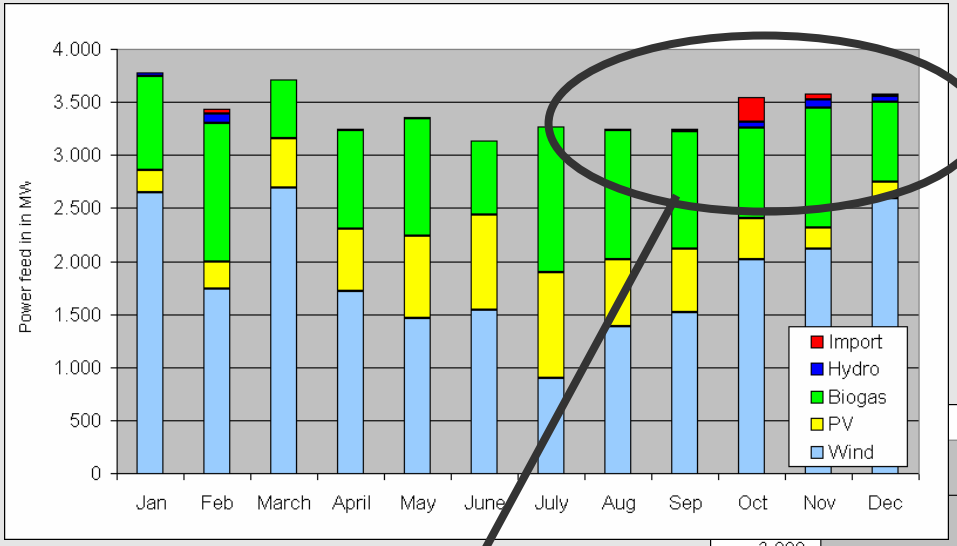
The virtual power plant - Results

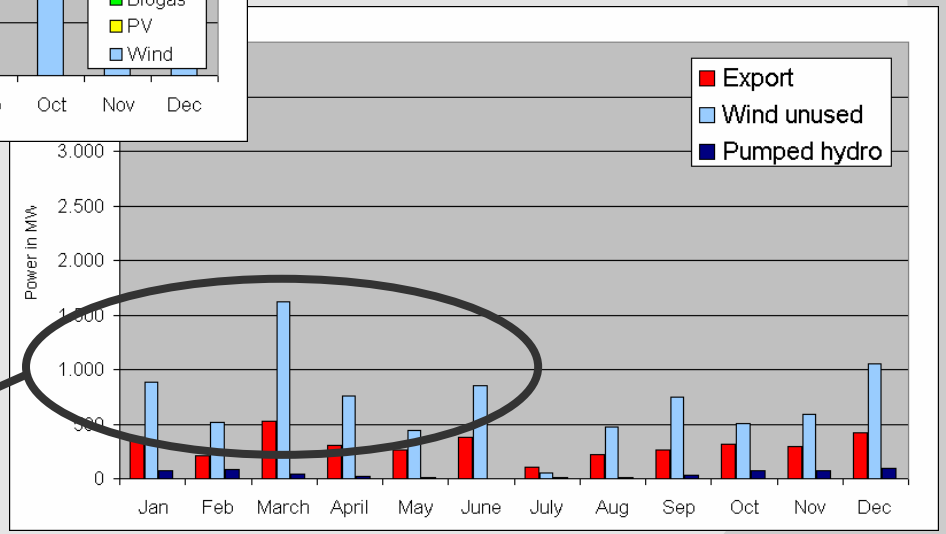
Simulation with higher wind feed in – 116% realted to avg. wind year



Demand	41.124 MWh
Wind	22.328 MWh
PV	6.153 MWh
Biogas	11.907 MWh
Hydro	385 MWh
Import	352 MWh

Low imports in total

Higher portions of unused wind



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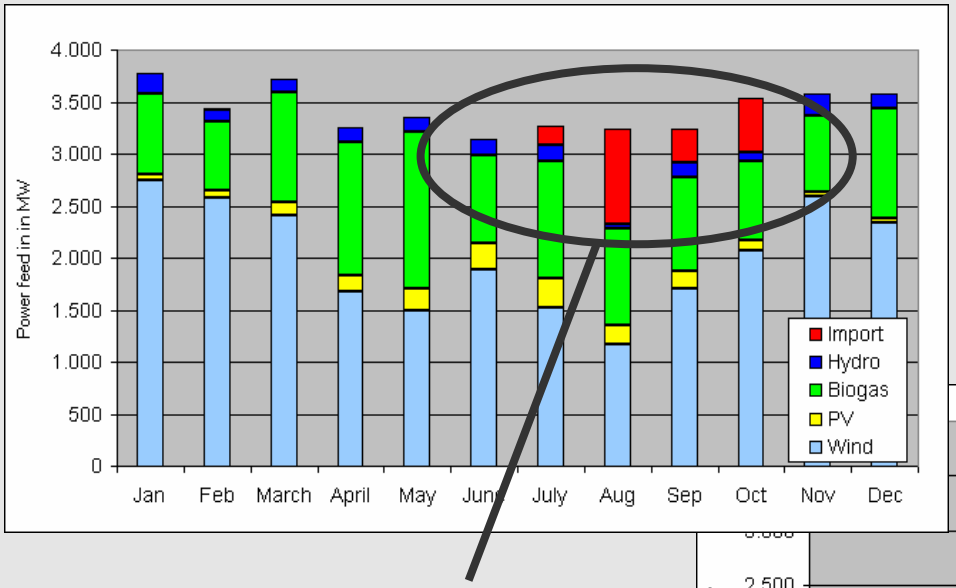
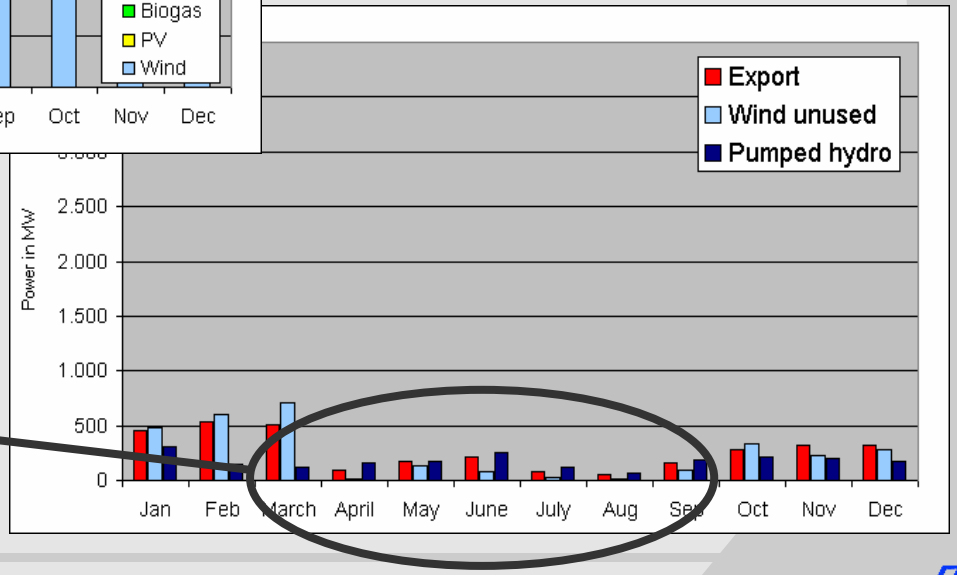
The virtual power plant - Results

Simulation with avarage wind and lower pv feed in



Demand	41.124 MWh
Wind	24.176 MWh
PV	1.682 MWh
Biogas	11.626 MWh
Hydro	1.663 MWh
Import	1.977 MWh

High imports during summer



Smaller portions of unused wind

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Conclusion/Outlook

Conclusion :

- It is possible to supply an area like Germany with renewable energy.
- Fluctuating power feed in raises the need of storage devices and cogeneration.
- Further possibilities for storing energy have to be found.
- Systems like the regnerative power plant have to balance between storage and energy imports/exports.

Outlook:

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

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Thanks for your attention!

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