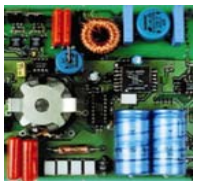
RIO 9

LAREF 2009

RIO 9 – World Climate & Energy Event, Rio de Janeiro, 17.03.-19.03.2009




Integration of Renewable Energies in existing energy infrastructure

The Combined RES Power Plant

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

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Development of Institute

Institut für Solare Energieversorgungstechnik
Verein an der Universität Kassel e. V.

founded in 1988 as „associate institute“ of the University of Kassel
since 1995 second location in Hanau

Fraunhofer Center für Windenergie und Meerestechnik
in Bremerhaven

founded in 2006 as a joint research institution of the two Fraunhofer Institutes IFAM and LBF
to concentrate their competences in the field of wind energy

In 2009 ISET and Fraunhofer CWMT will become the new
Fraunhofer Institute for Wind Energy and Energy Systems Technology,
Fraunhofer IWES

Institute Profile

Wind energy

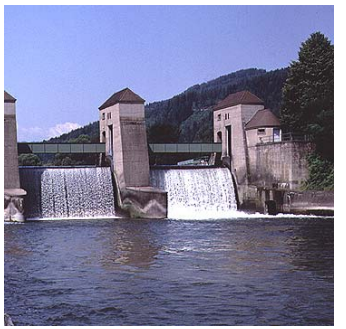
Photovoltaics

Bio energy

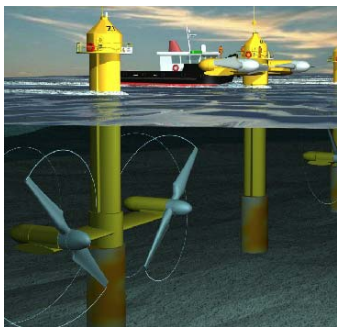
Applications-oriented research in wind energy and in energy systems technology for the use of renewable energies

- wind energy turbines & components
- on- & offshore wind energy
- maritime environmental conditions
- decentralised energy conversion & storage
- energy management & grid operation
- energy supply structures and systems analysis

Electricity grids



Hydro power



Marine energies

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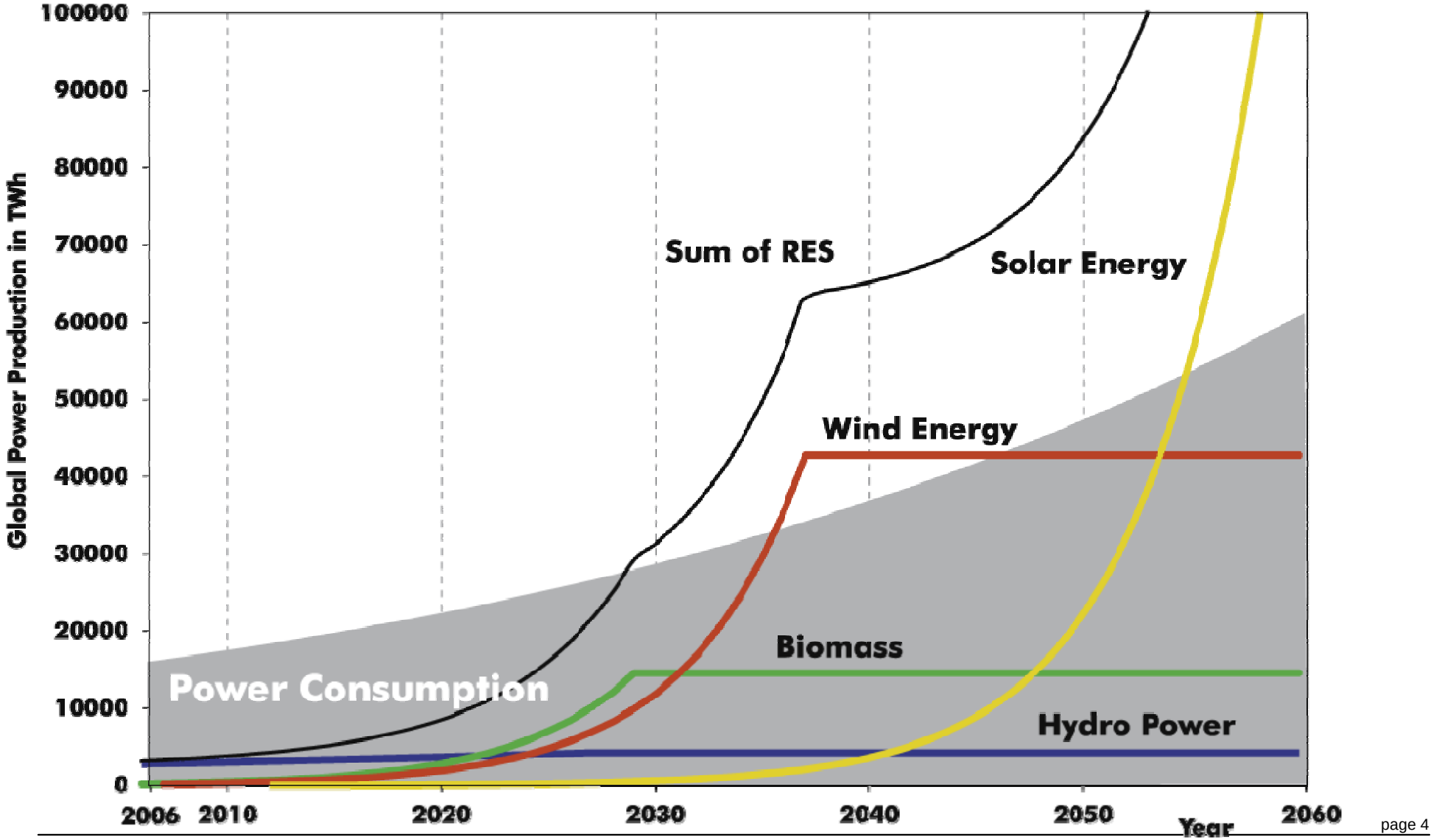
Potential for Development of Renewable Energy Resources



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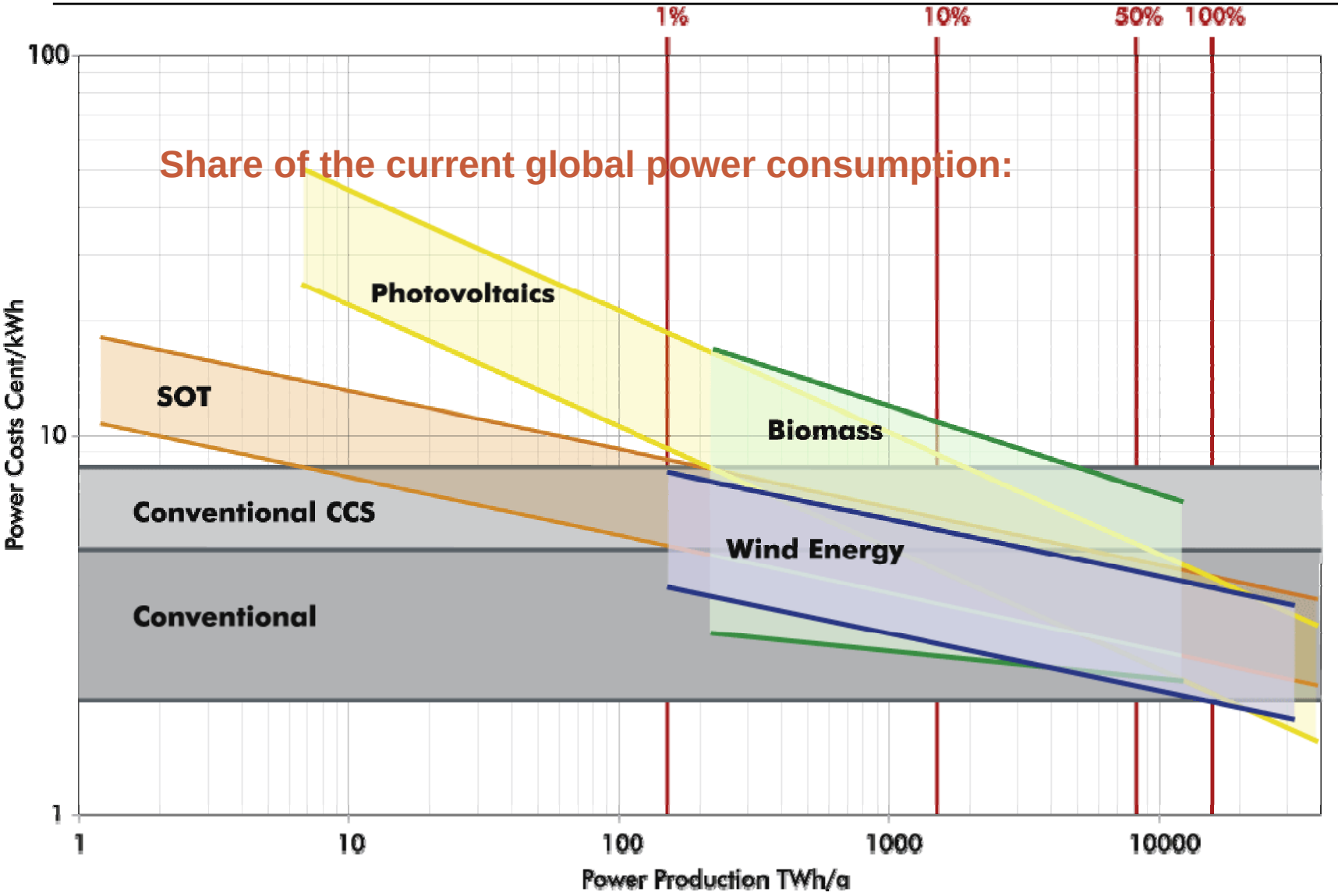
Potential for Development of Power Costs from Renewables



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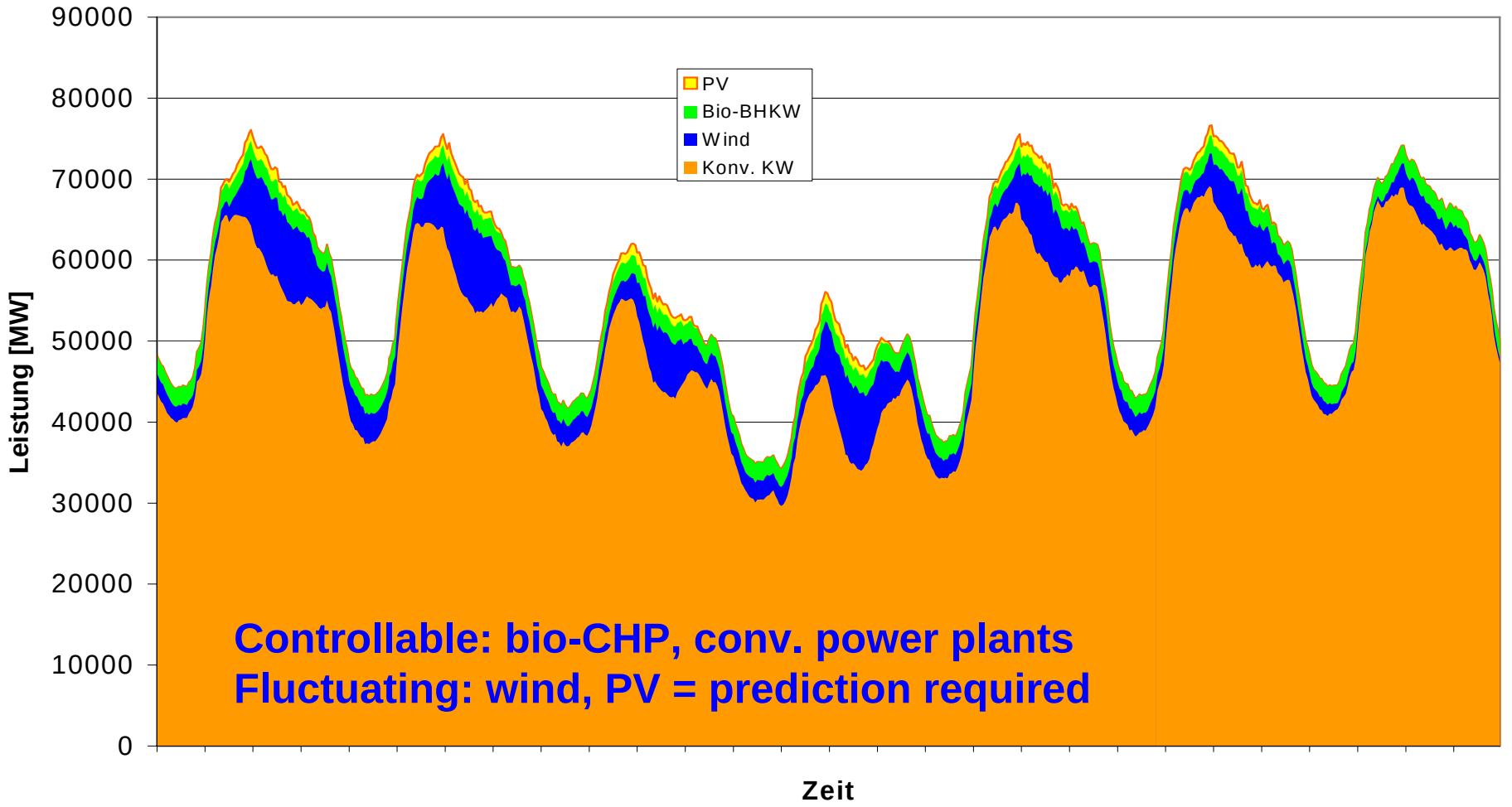
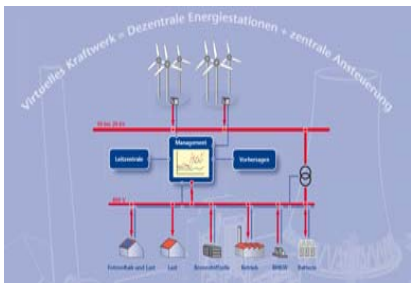
Interaction of RES



Introduction

Scale	Generation	Storage	Demand
Large Scale 	**Wind, Hydro** 	**Hydro** 	**Industry** 
Small Scale 	**Wind, PV, Bio** 	**V2G, DSM** 	**Household, EV** 

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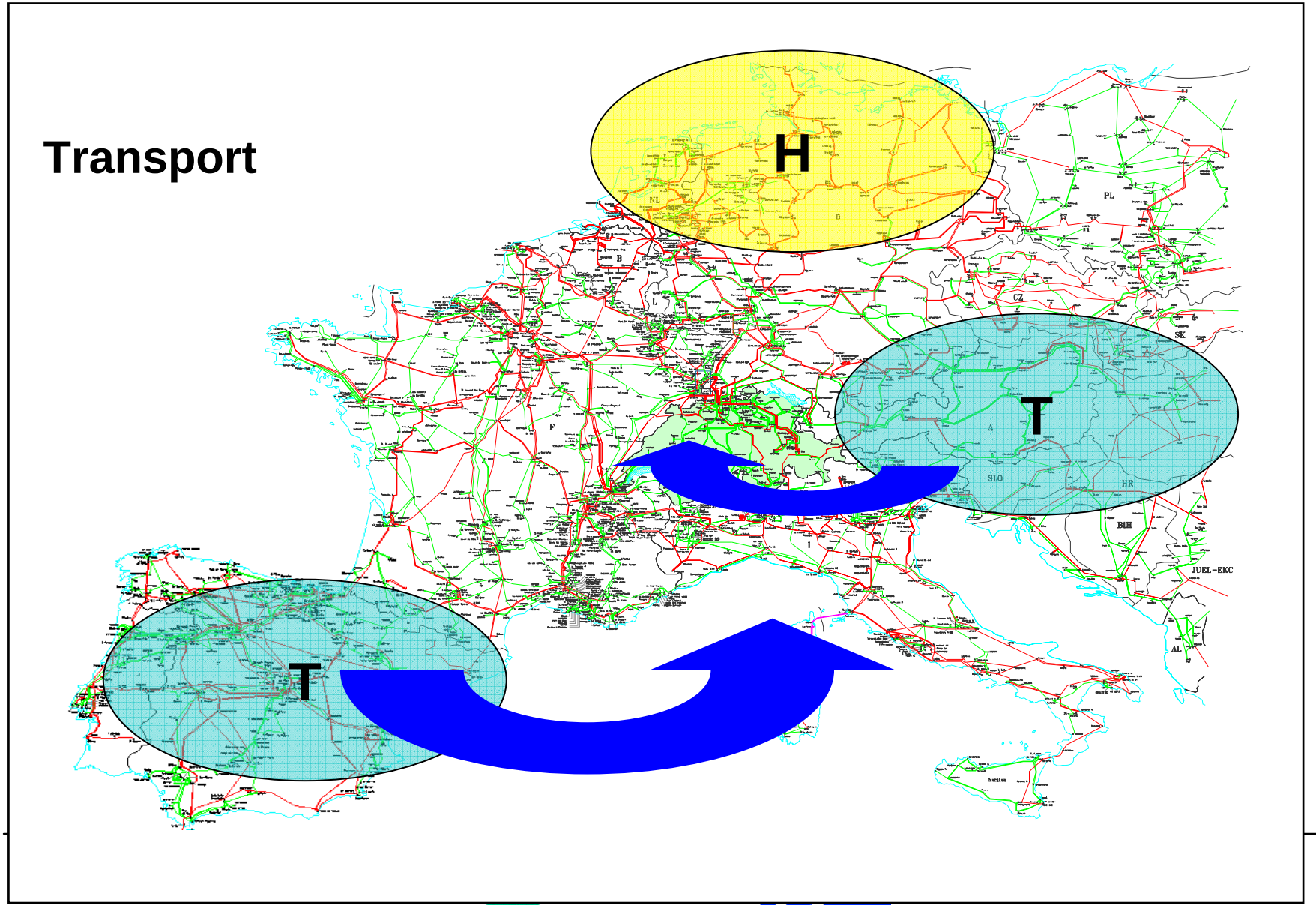
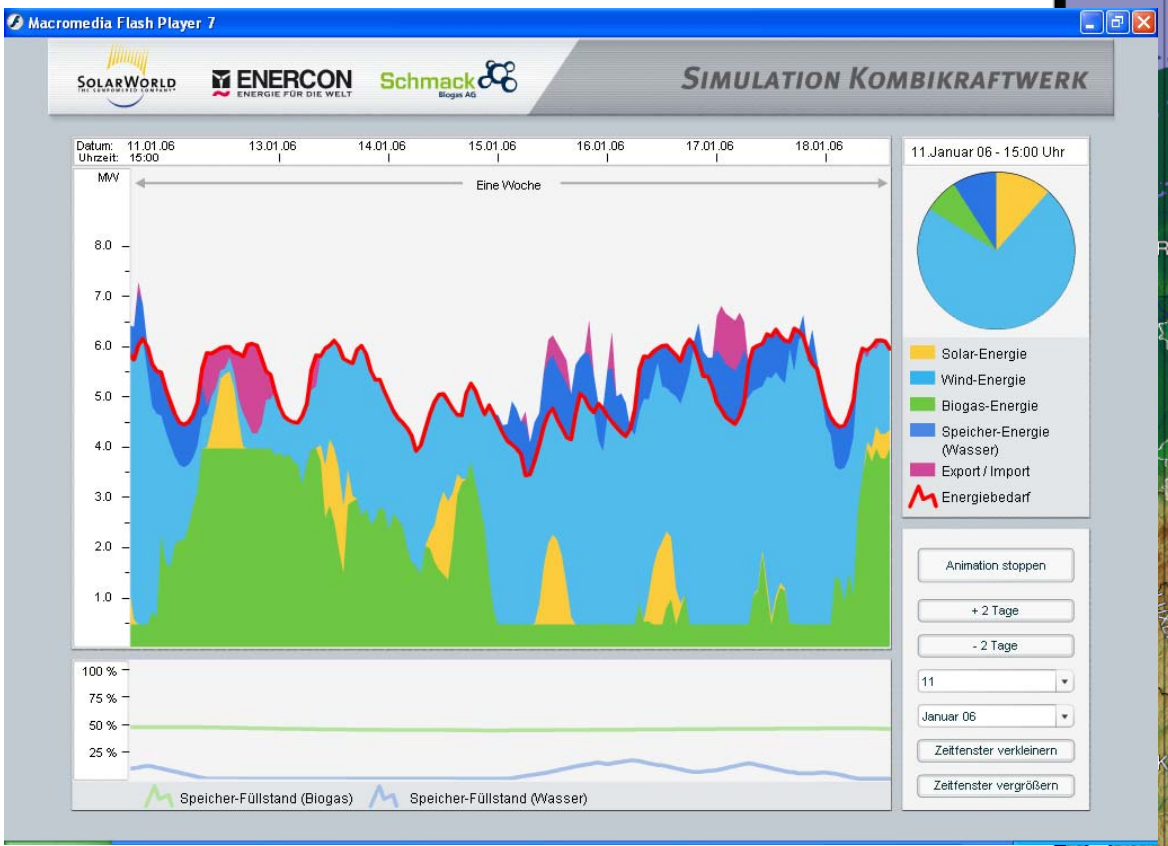
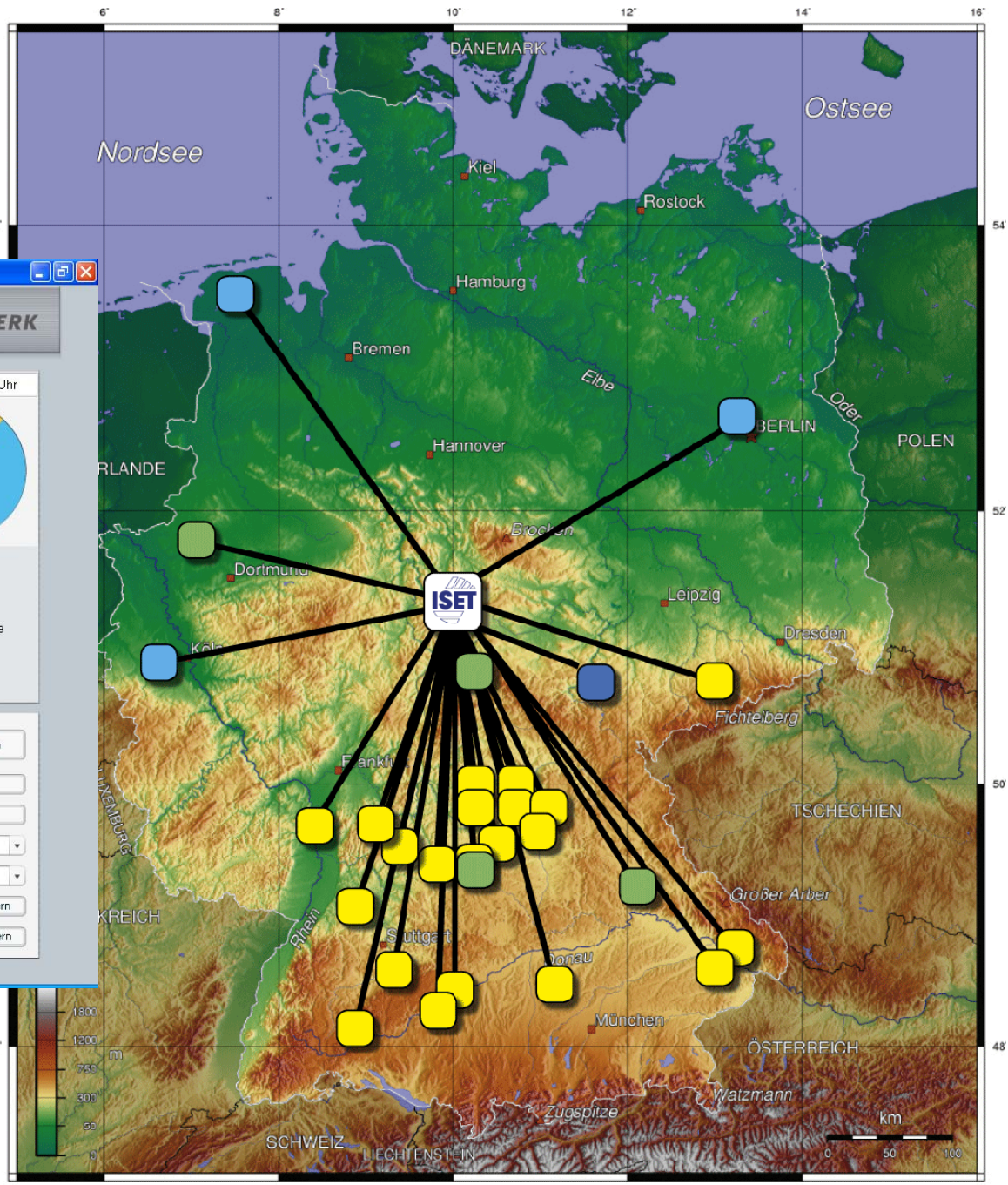
Interaction of RES



The Combined RES Power Plant

100% Electricity from Wind, PV, Biogas und Water





ISET Oliver Führer 09.01.2009

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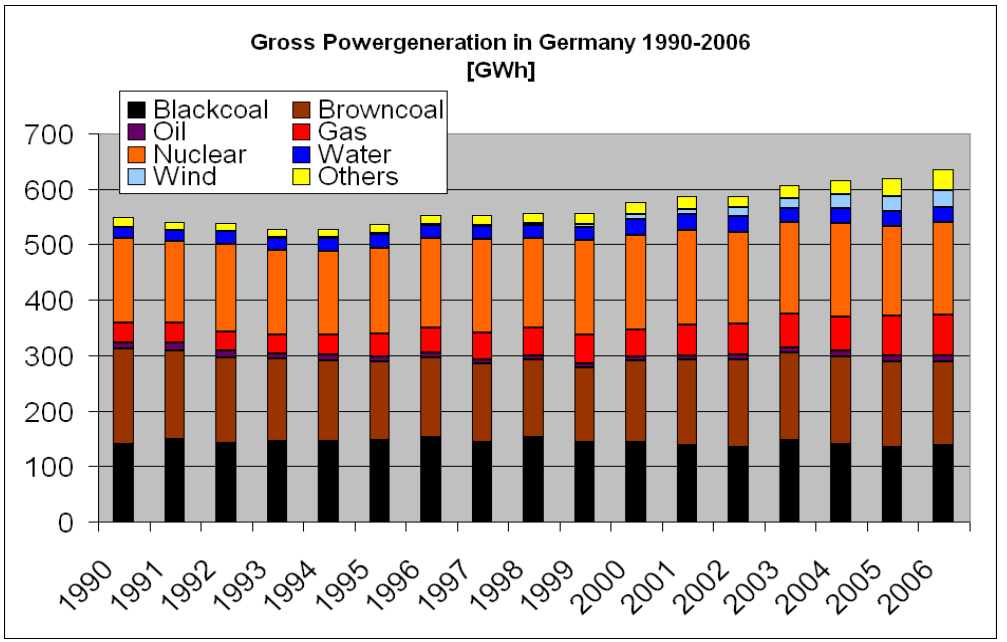
Why renewable energies? – The German situation

- 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

Why renewable energies? – The German situation

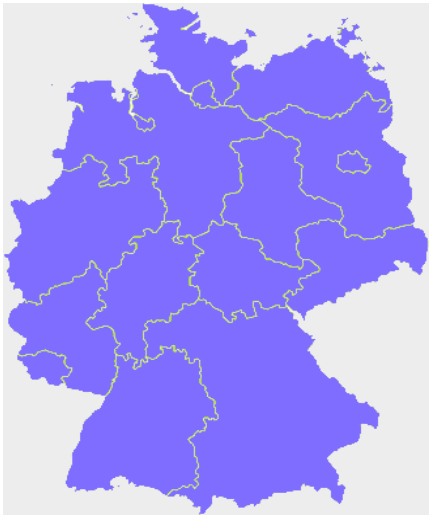
- Share of renewable energy sources about 14.2 % in 2007

- Target for German share of renewable sources in 2020 is 30%

- Additional phase out of nuclear Power until 2021

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

No limits for a full electricity supply by renewables



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




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?**

The 100% renewables scenario – Power generation

	2006	Future… (2050)
Power generation in Germany [TWh/a]	536,1	573
Conventional Power Plants	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

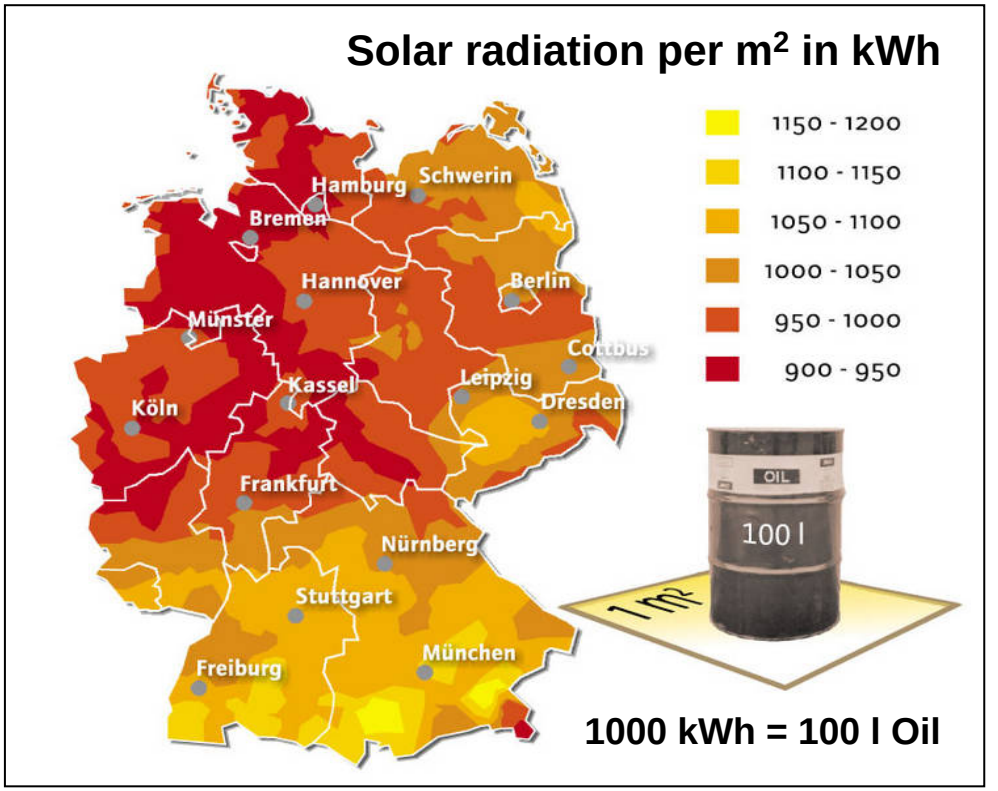
The 100% renewables scenario – Energy production of renewables

Wind	Wind onshore		Wind offshore	
	2006	Future…	2006	Future…
Avg. capacity in kW	**816**	**6.000**	**0**	**6.000**
Number of plants	**18.685**	**10.000**	**0**	**5.000**
Total capacity in GW	**20,62**	**60**	**0**	**30**
Full load hours	**2.000**	**2.800**	**0**	**4.000**
GWh/a	**30.500**	**168.000**	**0**	**120.000**

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

The 100% renewables scenario – Energy production of renewables

PV	2006	Future…
Rooftops in Mio. m^2	**3.600**	**3.600**
% of Rooftops	**0,58%**	**19,61%**
Mio. m^2	**21**	**706**
W/m^2	**120**	**150**
Capacity in GW	**2**	**71**
Full load hours	**950**	**850**
GWh/a	**2.000**	**60.000**



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

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	**9.300**	**40.000**
GWh_{el}/a	**18.600**	**100.000**

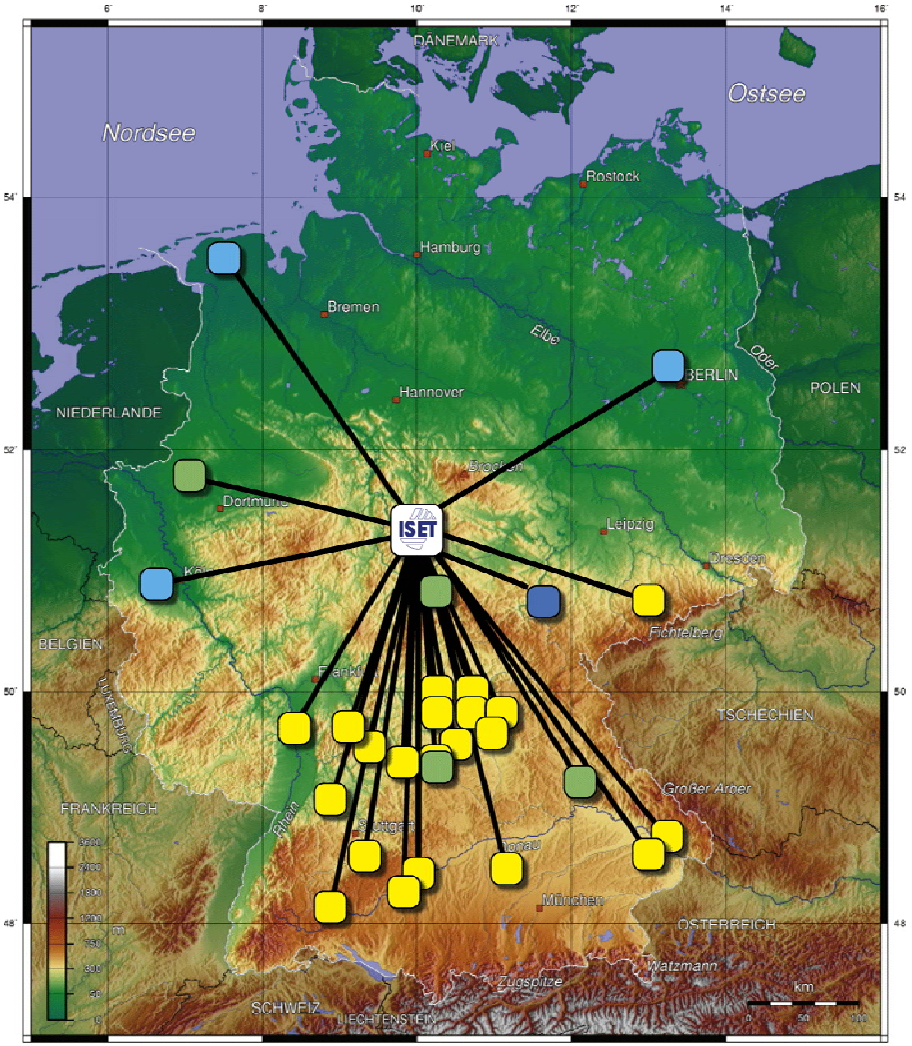
Source: Schmack Biogas AG, ISET – 10th of July 2007

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

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.
- Scale 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

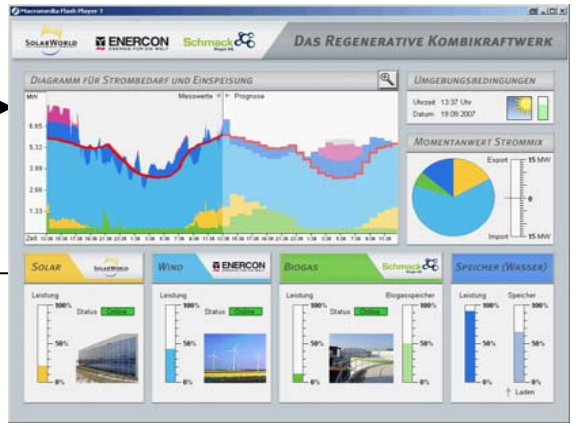
Hydro

Import/Export

Calculationalgorithm

Results

Control



System was running operationally from July 2007 – Feb 2008

Webservice

Webservice

Power Production

Calculation Server

Graphical Interface

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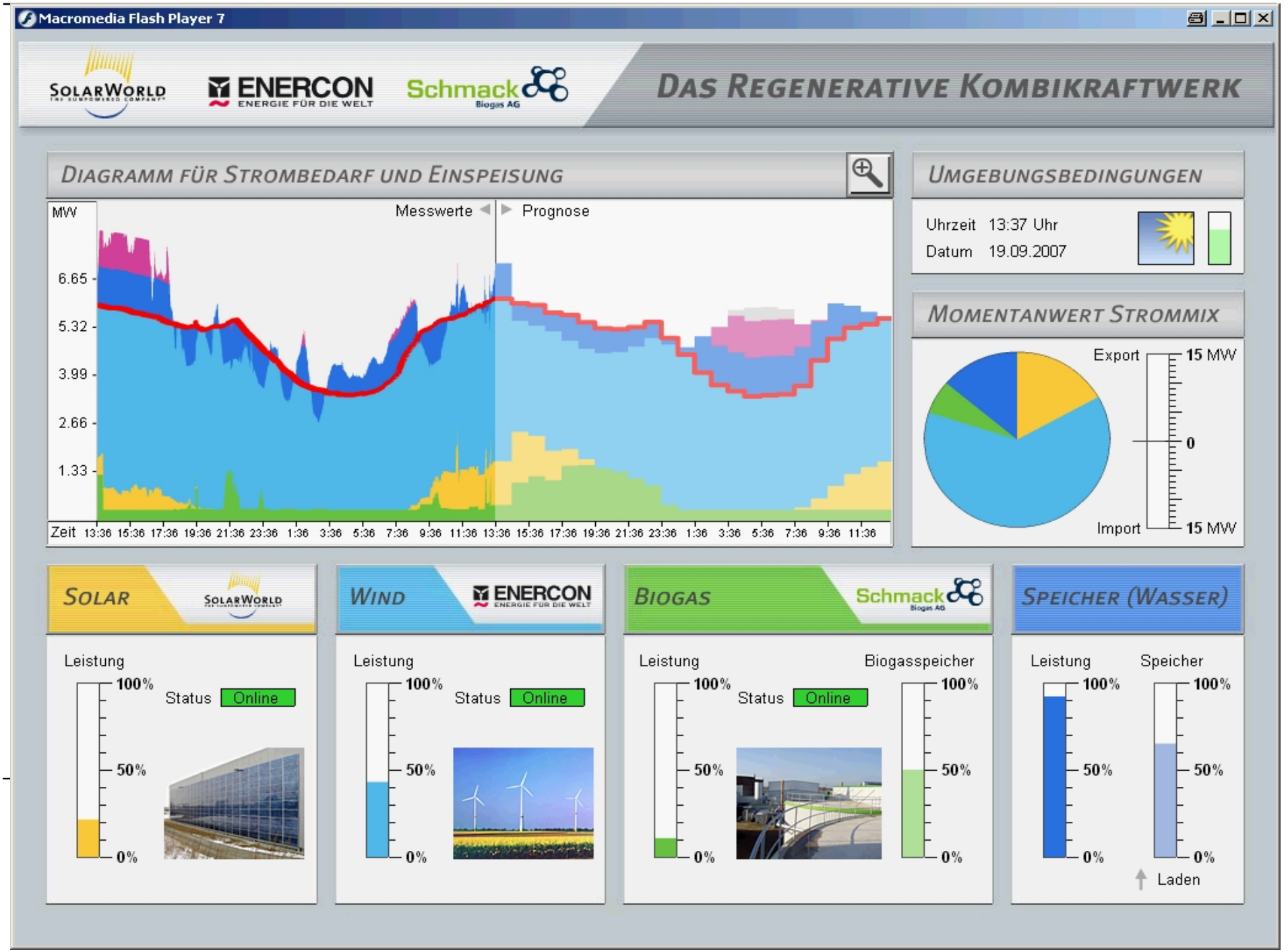
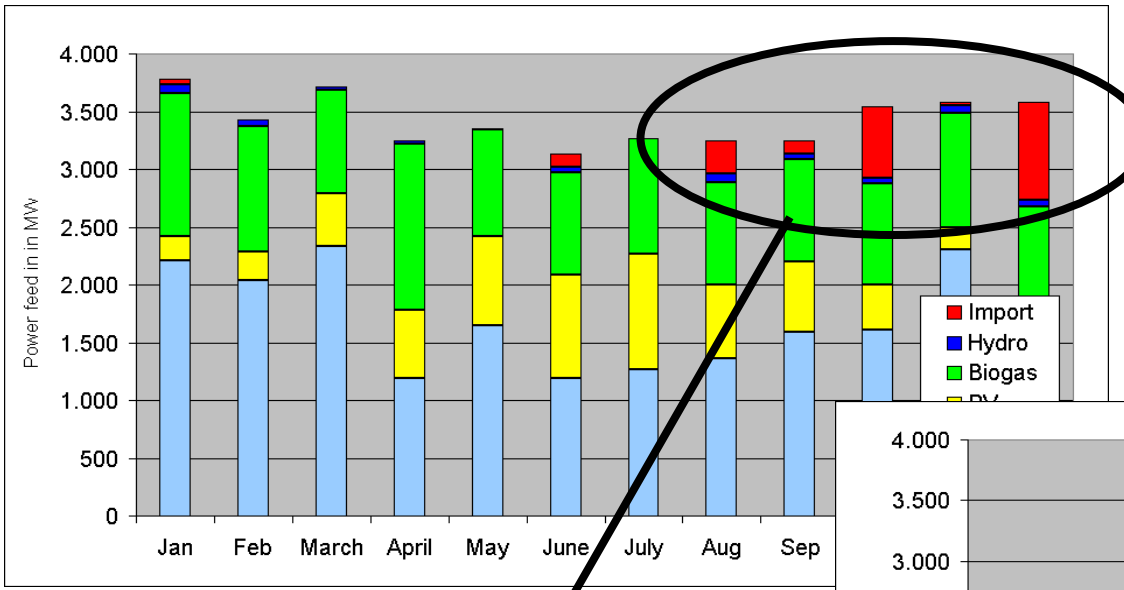
The virtual power plant – Graphical user interface

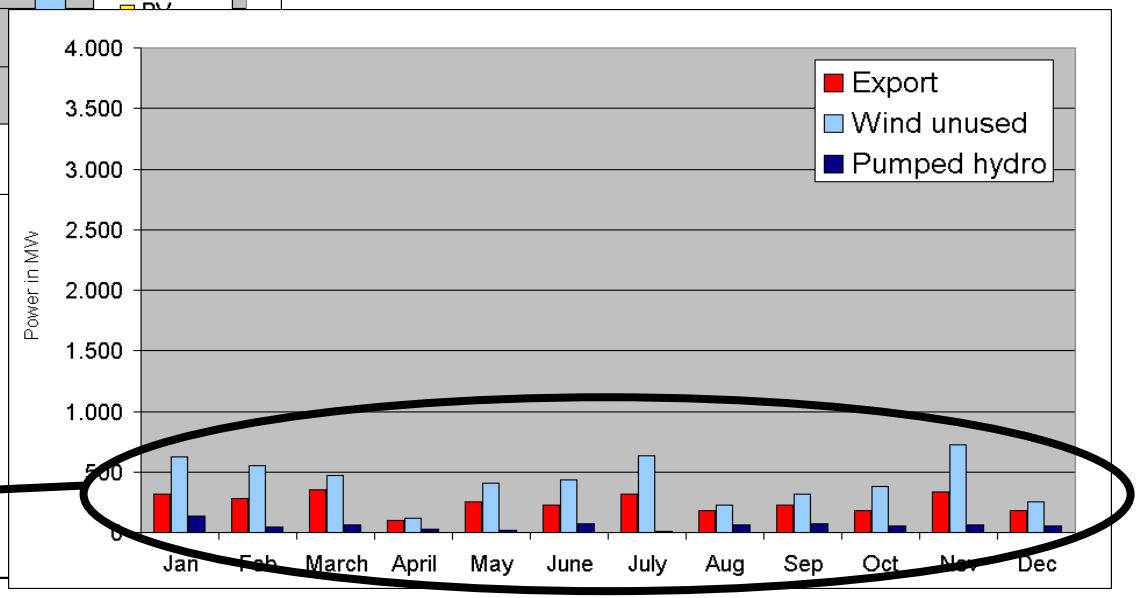


The virtual power plant - Results

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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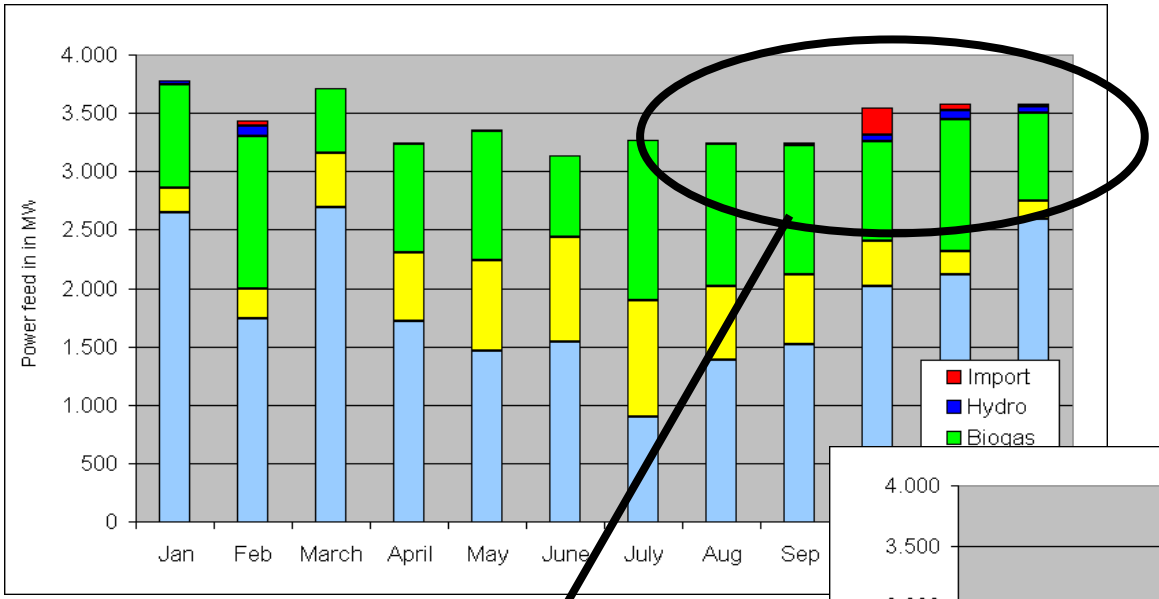
The virtual power plant - Results

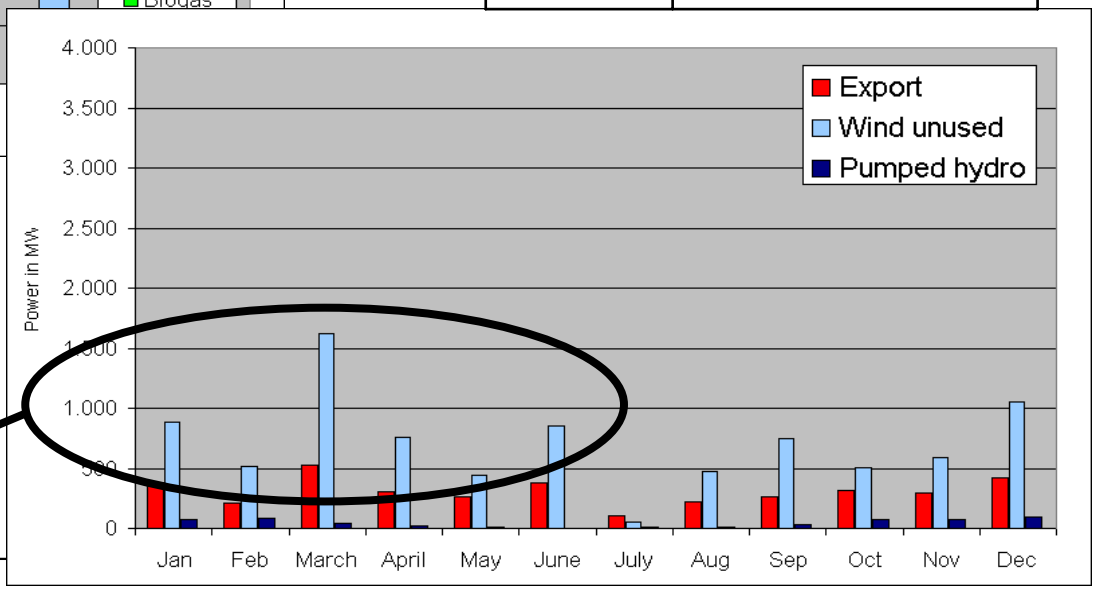
Simulation with higher wind feed in – 116% related to avg. wind year



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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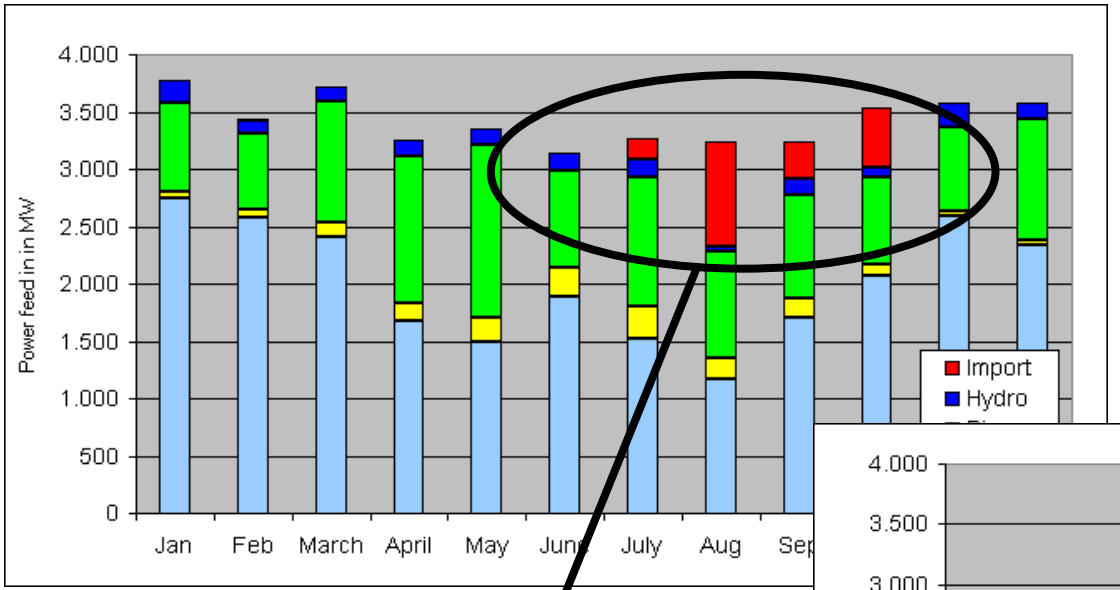
The virtual power plant - Results

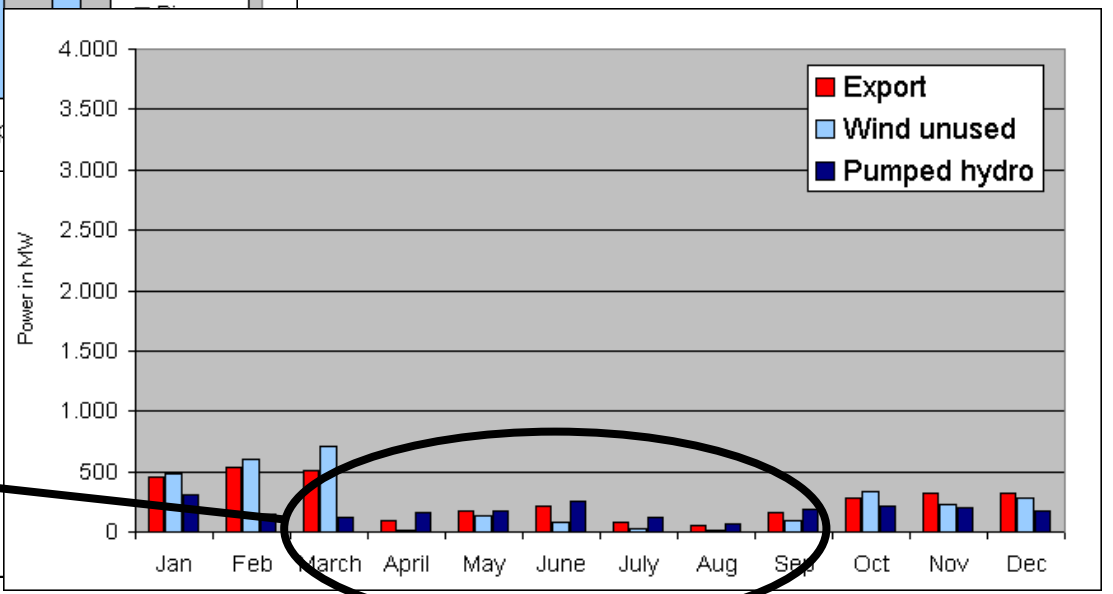
Simulation with avarage wind and lower pv feed in



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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