

# Towards 100% renewables and beyond power: The possibility of wind to generate renewable fuels and materials

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DEWEC 2010  
Bremen  
18.11.10

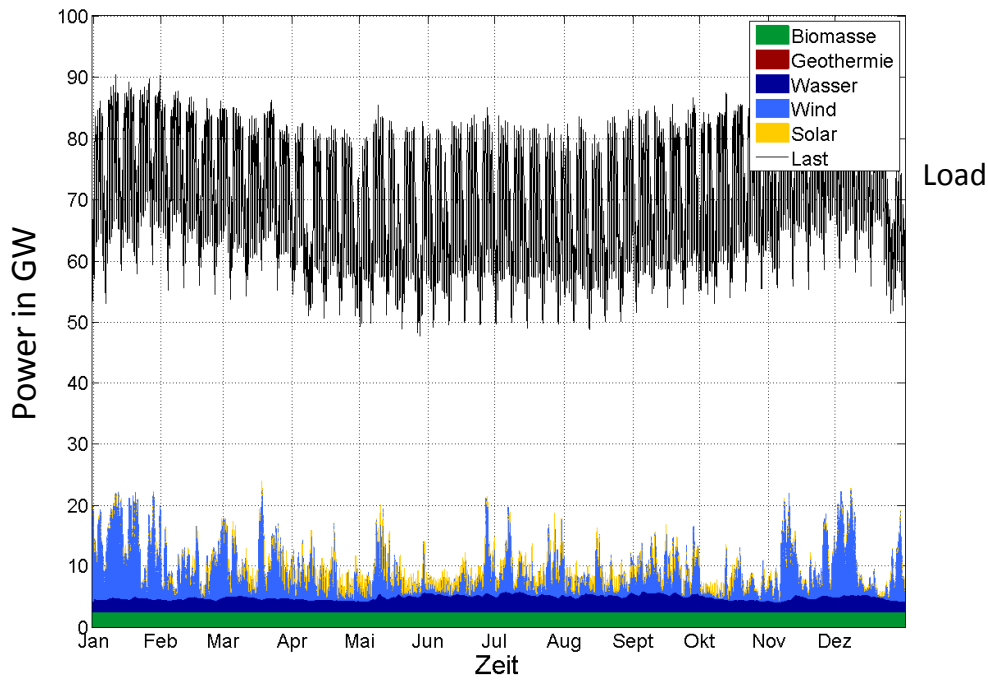


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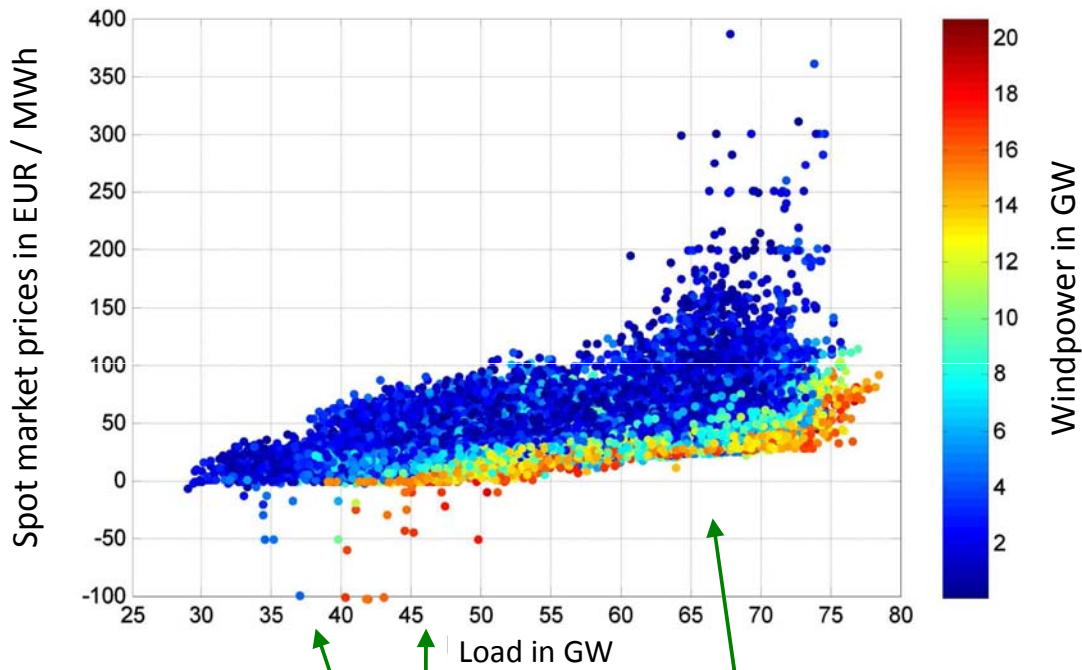
## Content

1. Wind today in Germany
2. Towards 100% RE: Balancing options
3. Storage systems
4. The UBA Scenario
5. Beyond power: Windfuels - Windgas
6. Windproducts
7. Conclusions

# RE feed-in during 2007



# Correlation Wind & Load & EEX – data for 2007 and 2008



Negative electricity prices at low load conditions with little / strong wind

Wind lowers spot market prices

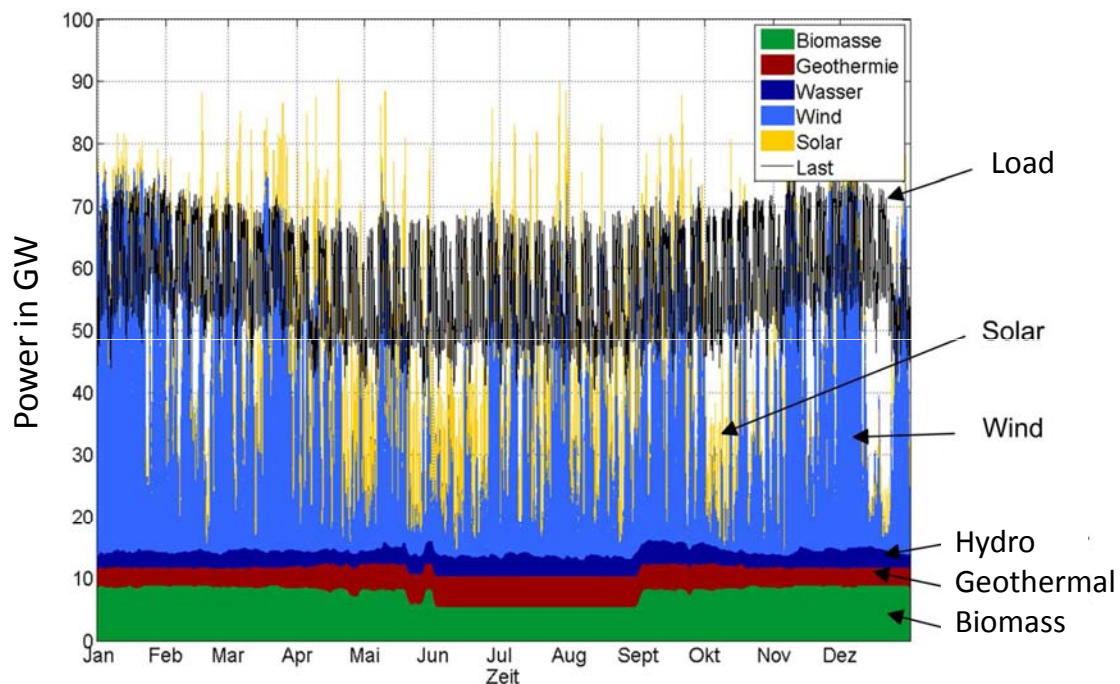
Source: Jentsch, Sterner, 2010

# Content

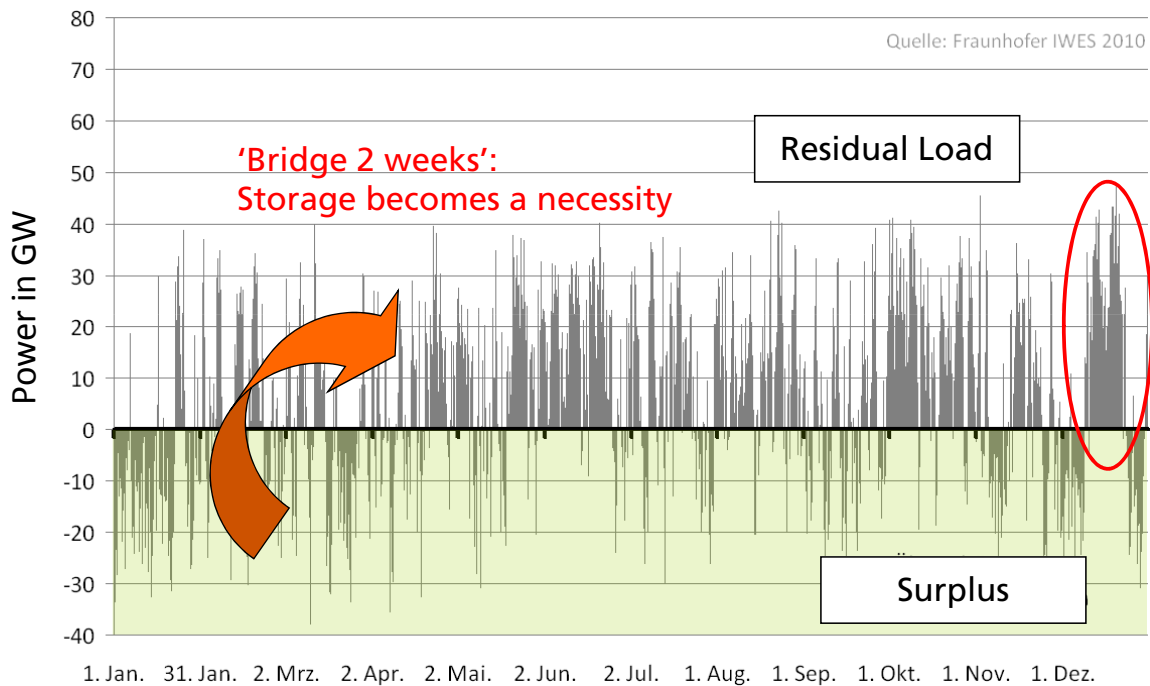
- 1. Wind today in Germany
- 2. Towards 100% RE: **Balancing options**
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## Energy scenario of BMU for 2050 (85% RES)

Situation 2050



# Major task: match surplus power with residual load



## Merit-Order of balancing options for fluctuations

	technical	economical
<ul style="list-style-type: none"> <li>■ Transport                             <ul style="list-style-type: none"> <li>■ Grid expansion</li> <li>■ European supergrid for power (and gas)</li> </ul> </li> </ul>	1	?
		Locally different
<ul style="list-style-type: none"> <li>■ Supply and Demand Side Management                             <ul style="list-style-type: none"> <li>■ Supply: Combi-plant with RE predictions, flexible gas units</li> <li>■ Demand: Electromobility, heat pumps, air conditioning, smart grids</li> </ul> </li> </ul>	2	?
<ul style="list-style-type: none"> <li>■ Storage                             <ul style="list-style-type: none"> <li>■ Short term (days): Pumped hydro power, compressed air, batteries</li> <li>■ Long term (seasonal): 1. (pumped) hydro in Skandinavia, 2. Wind / Solarpower in the gas grid as RE gas 3. as RE hydrogen</li> </ul> </li> </ul>	3	?

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## Available storage: PHS, CAES, BAT = all short term storage

### ■ Pumped Hydro:



+ efficient, available, economic

- limited capacity: 0,04 TWh

Application: PV balancing and control power

### ■ Compressed Air:



+ relevant capacities realisable (today: 0,0006 TWh<sub>el</sub>)

- expensive, efficiency, limiting heat storage

Application: daily wind balancing in North Ger.

### ■ Batteries:



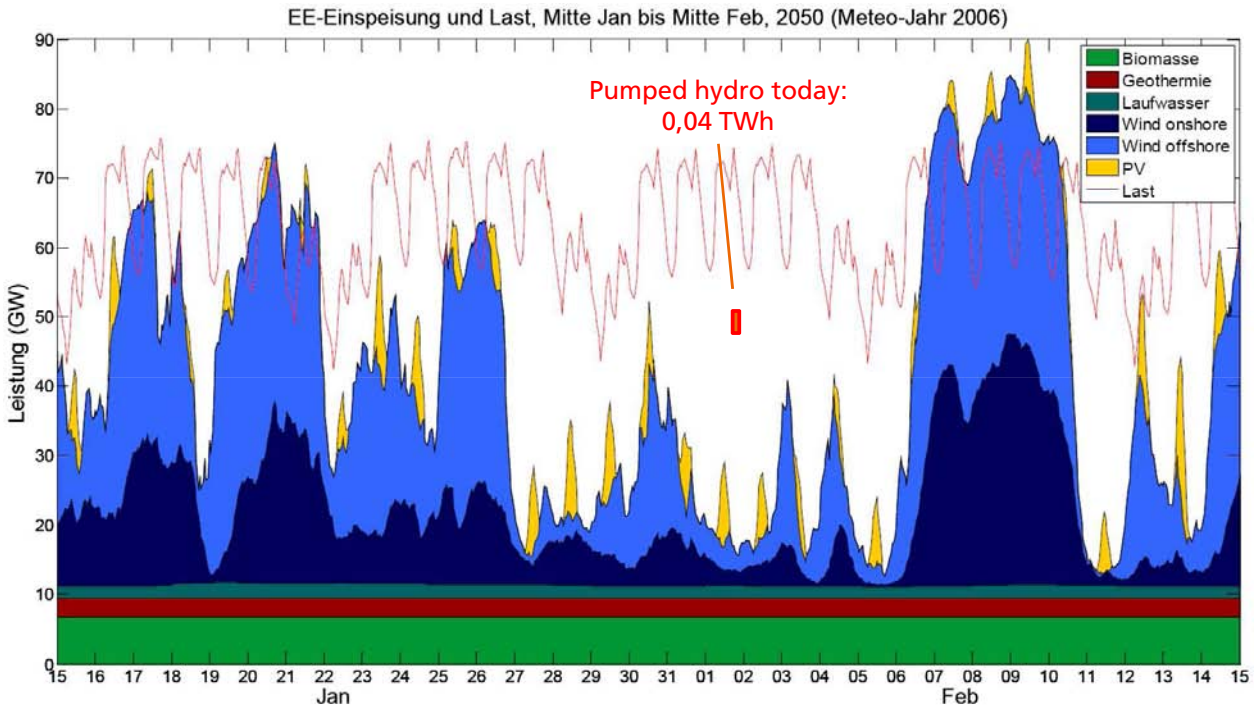
+ efficient

- expensive, time limit by electrochemics

limited capacity: 45 Mio. cars @ 10 kWh  
→ 0,45 TWh

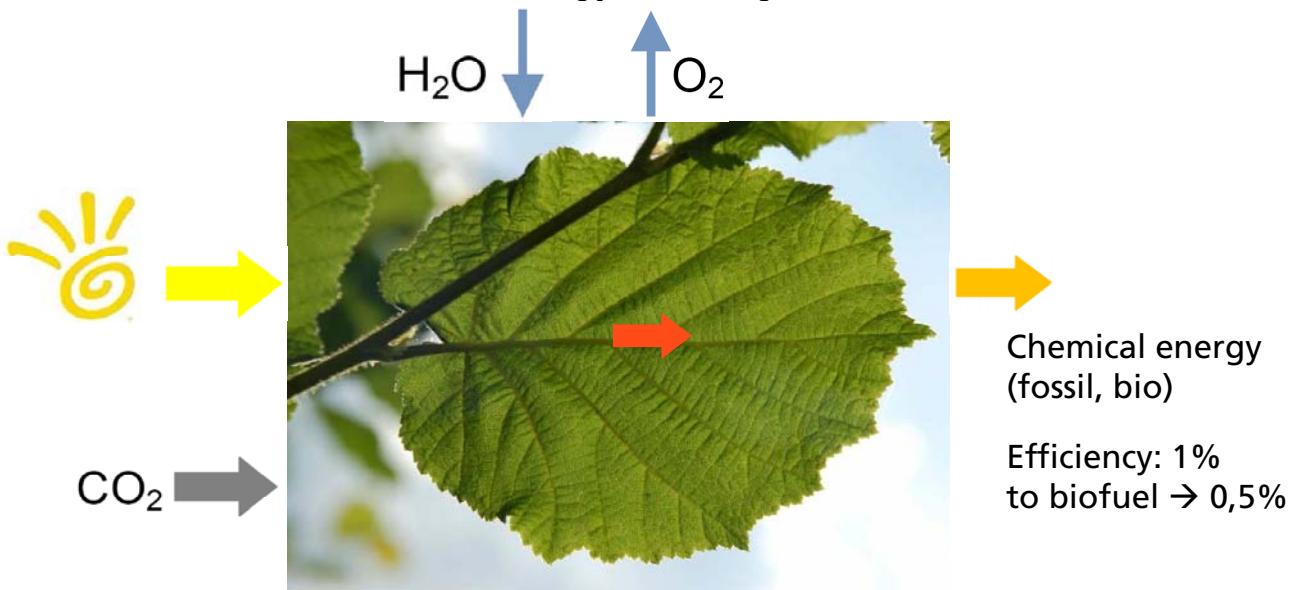
Application: black start, self supply with PV

# Storage demand: BMU lead study 2010 – 85% RE – ca. 30 TWh<sub>el</sub>

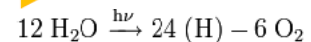


Source: Nitsch, Sterner, et al. 2010 (BMU Leitszenarien Zwischenbericht)

## How does nature store energy for long periods of time?

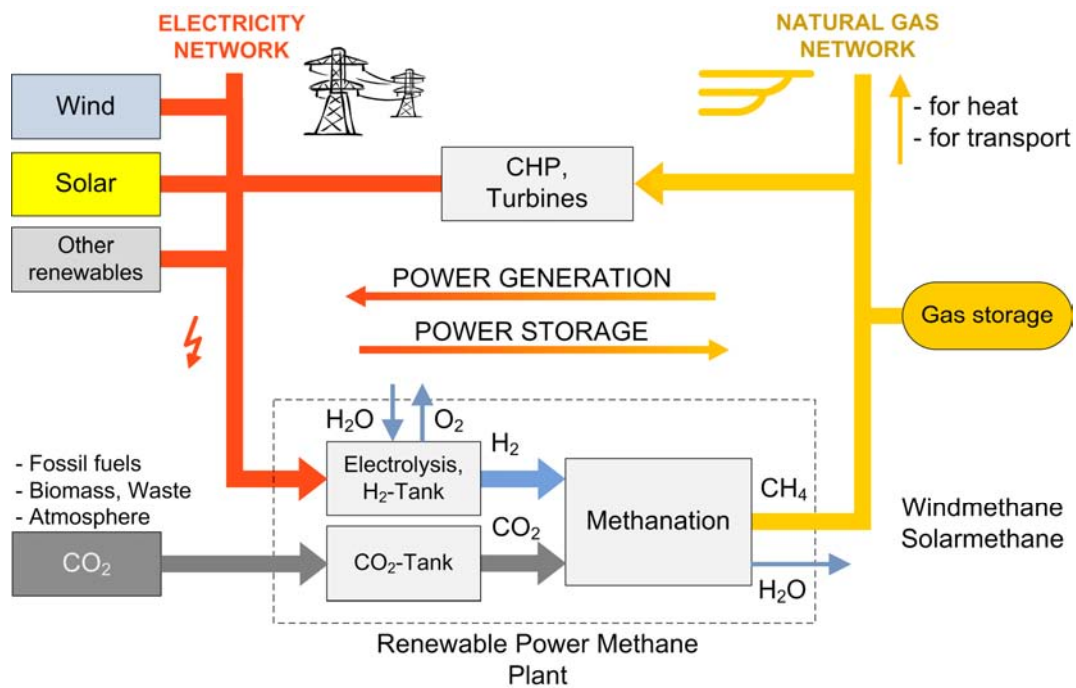


Core process: 1) splitting of water  
2) hydrogen reacts with CO<sub>2</sub>



# Renewable power to gas

## Storing wind by linking power and gas networks



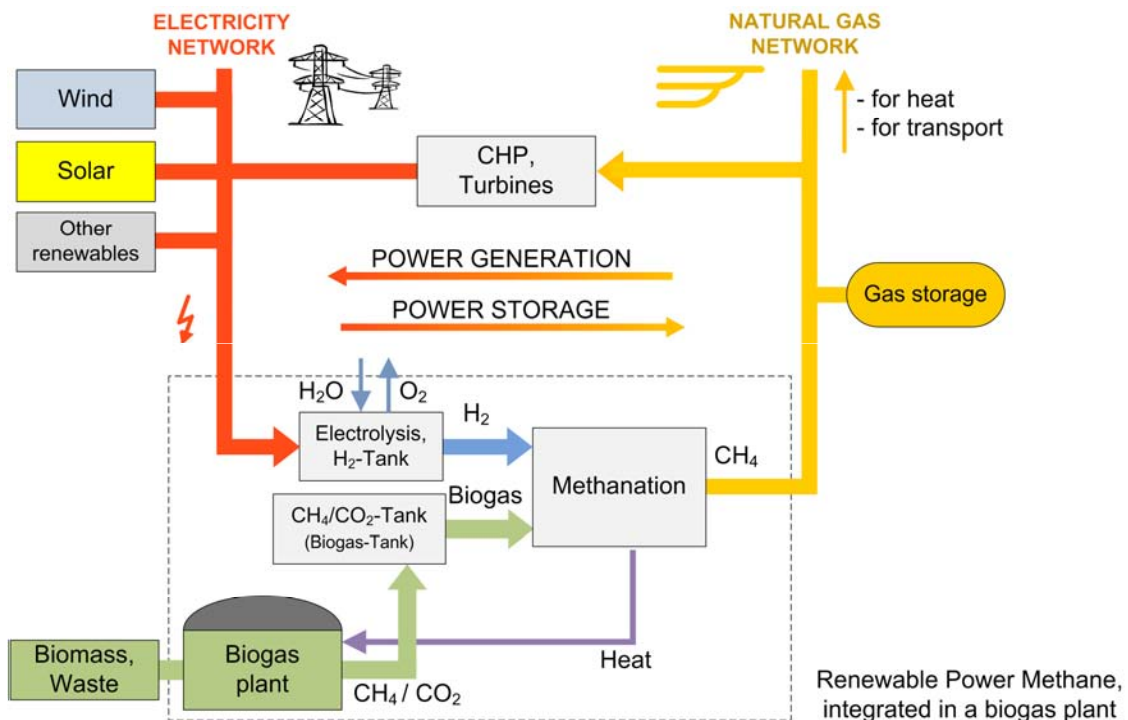
Source: Sterner, 2009; Specht et al, 2009  
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# Renewable power to gas with biogas plants

## Doubling methane output – Maximizing carbon use

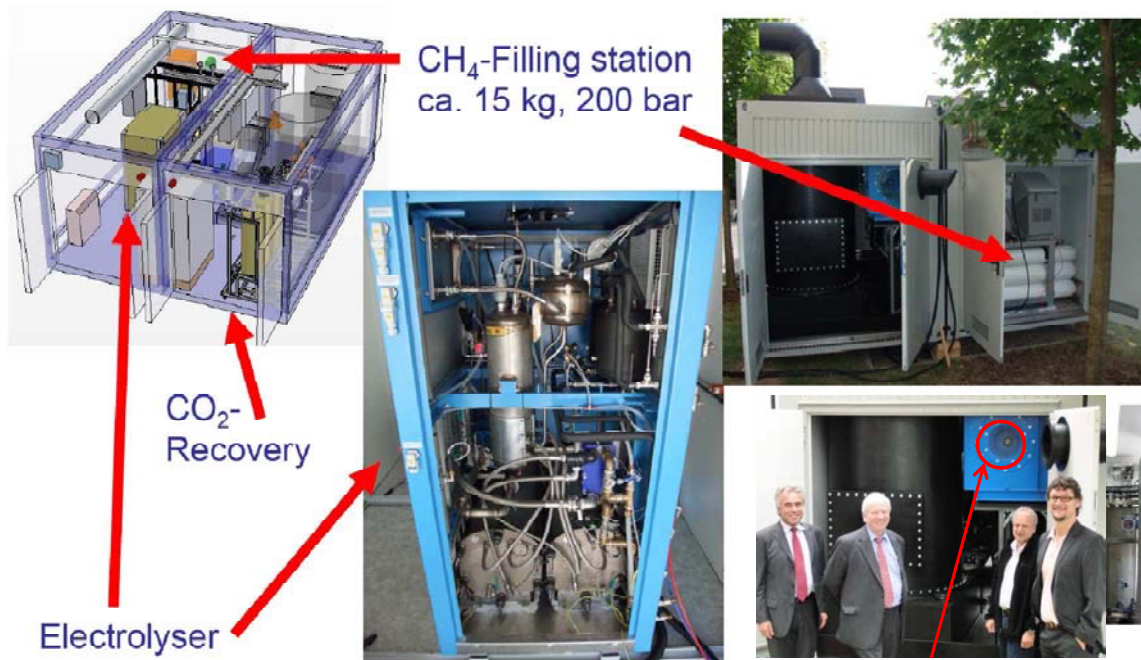


Source: Sterner, 2009; Specht et al, 2009  
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# From concept to reality – Setup 25 kW<sub>el</sub> The first pilot plant from Solar Fuel at ZSW Stuttgart



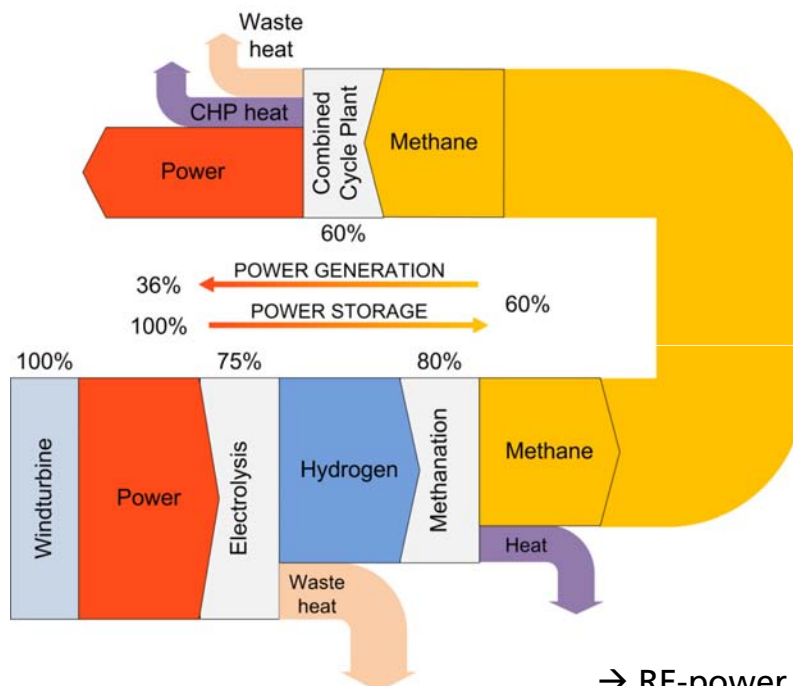
CO<sub>2</sub> Absorption Capacity = 1.5 ha Maize p.a.

Source: Waldstein, 2009  
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## Wind gas Efficiency



60-65% SNG  
(today: 40%  
due to electrolysis)

35-40% Power

50-60% CHP

Vs. 0% due to  
power cut off

Vs. More efficient but  
capacity limited storage  
alternatives

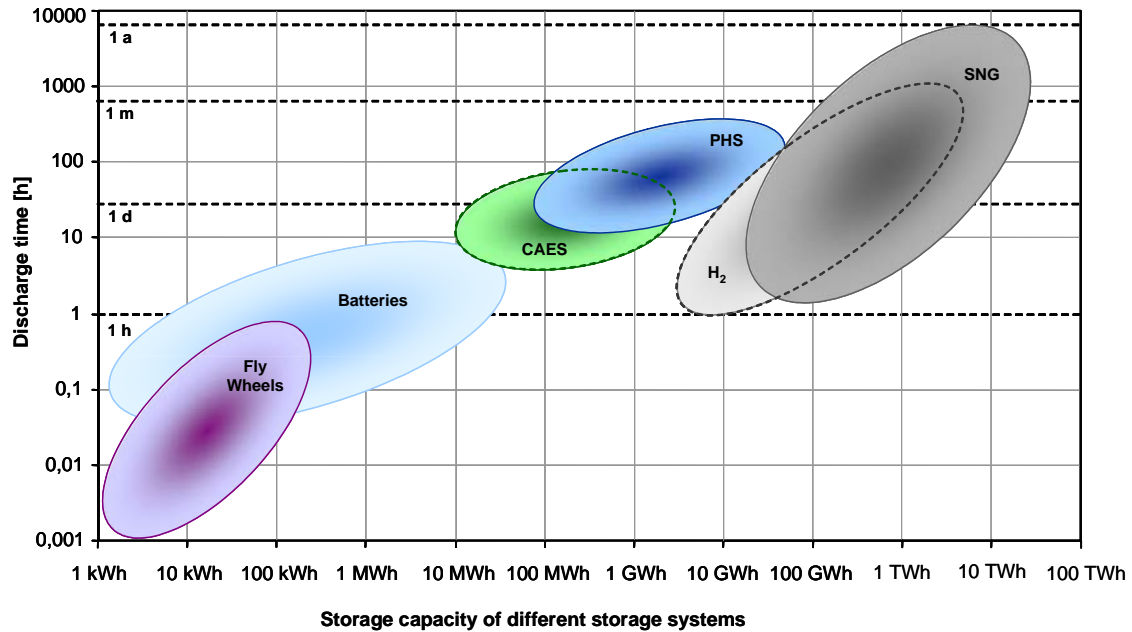
→ RE-power becomes primary energy

Source: Sterner, 2009  
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# Comparison of storage capacity and discharge time of RE-gas



Different solutions for different tasks: ancillary vs. arbitrage

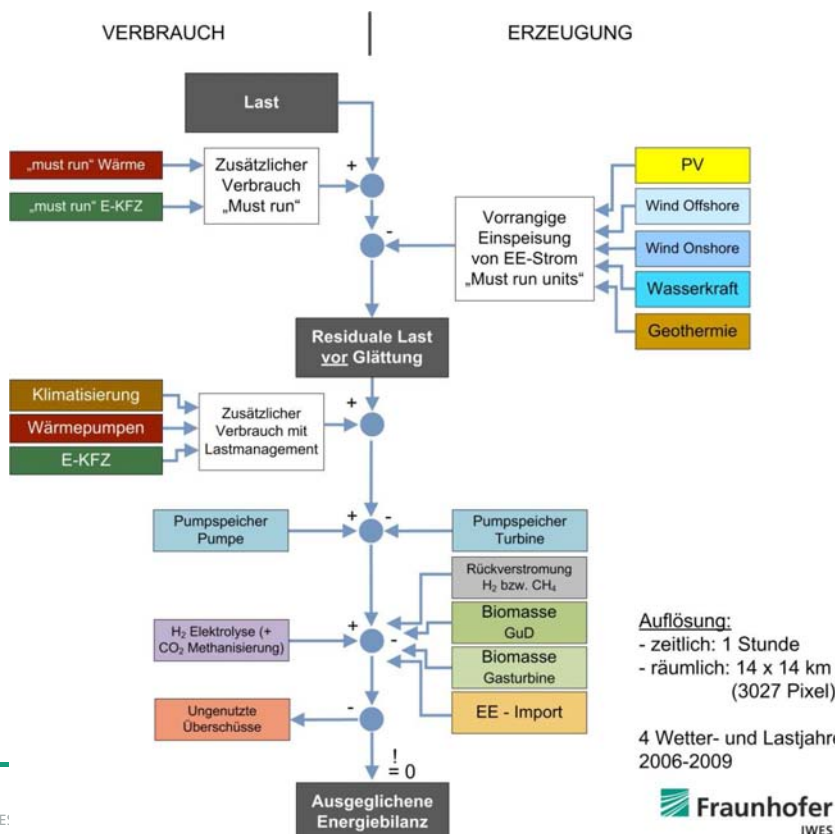
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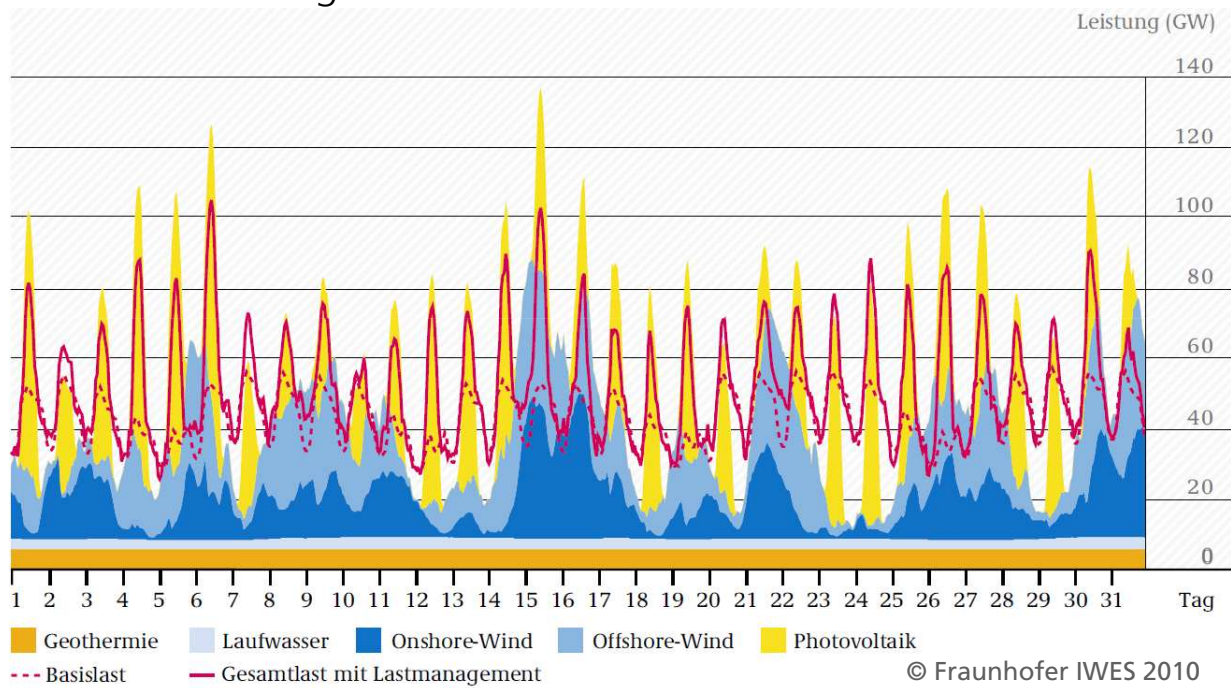
# The UBA-Szenario Energieziel 2050: 100% – Capacities in GW

	UBA 100% Regional
Wind onshore	60
Wind offshore	45
PV	120
Hydro	5,2
Geothermal	6,4
Bioenergy (Residues)	2-23 GW
RE total – internal	Ca. 240
Net Power Consumption	540 TWh
E-Mobility	ca. 50 TWh
Heat pumps	ca. 40 TWh
Pumped Hydro	ca. 5 TWh
Power Transmission losses	ca. 30 TWh

## Dynamic modelling – modell setup of SimEE



## Correlation PV and load (esp. air conditioning) meteo data August 2006

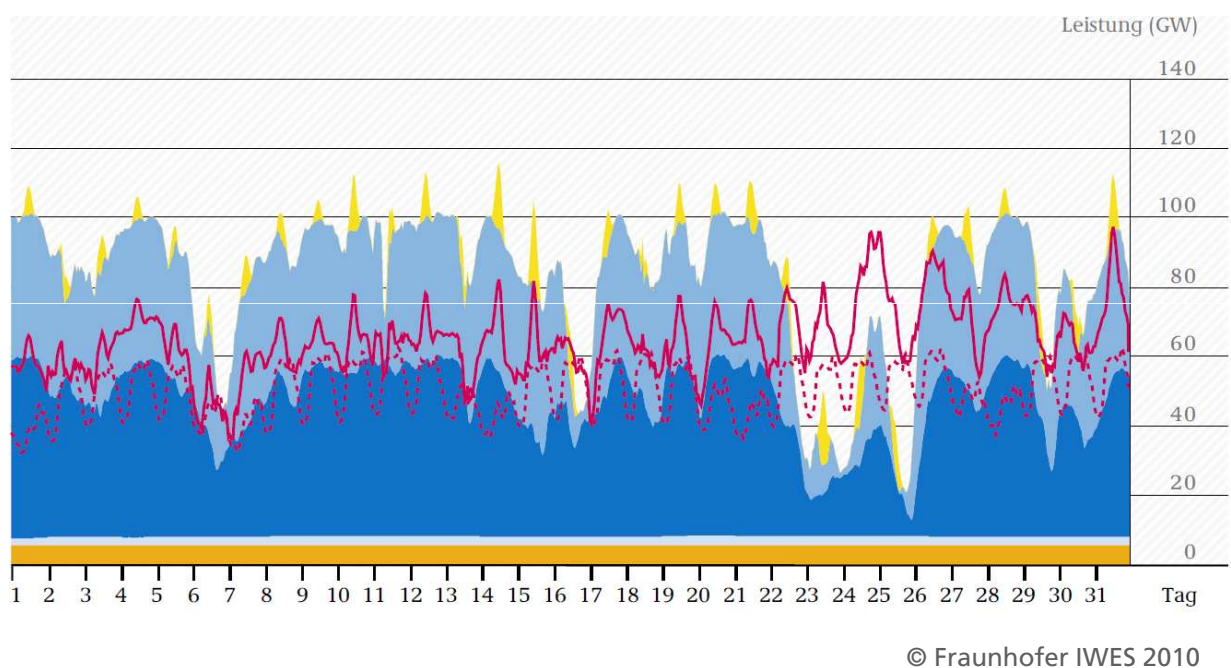


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## Wind: large surplus and large gaps meteo data Jan 2007

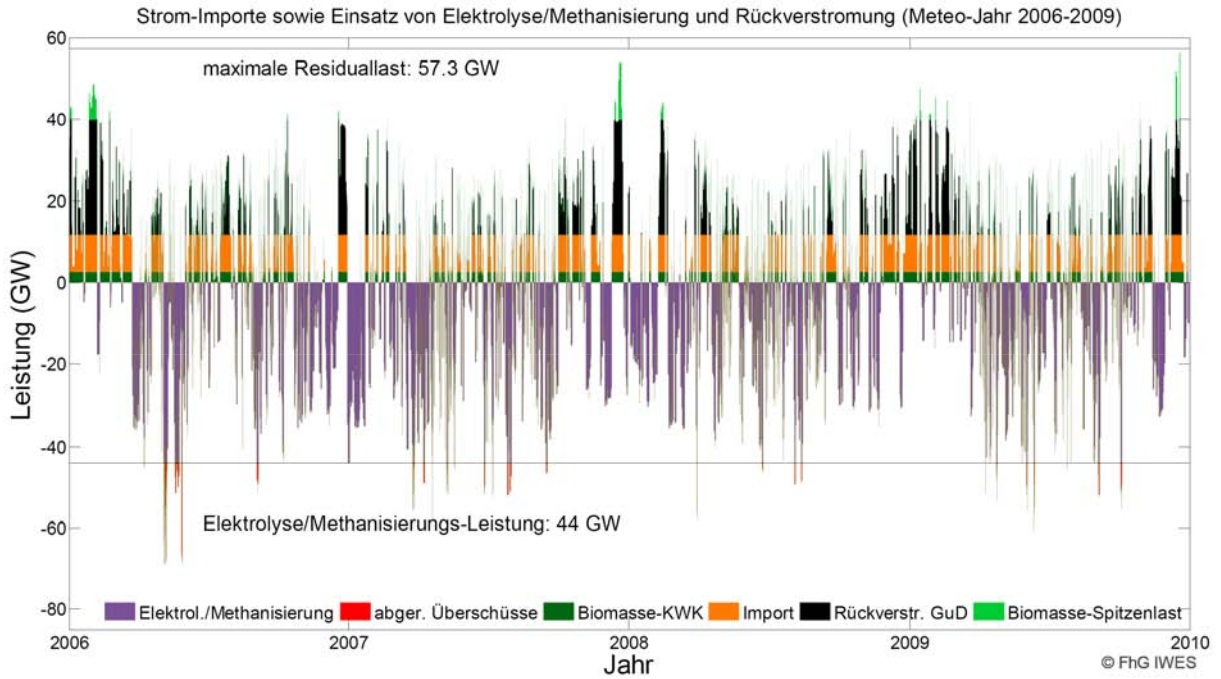


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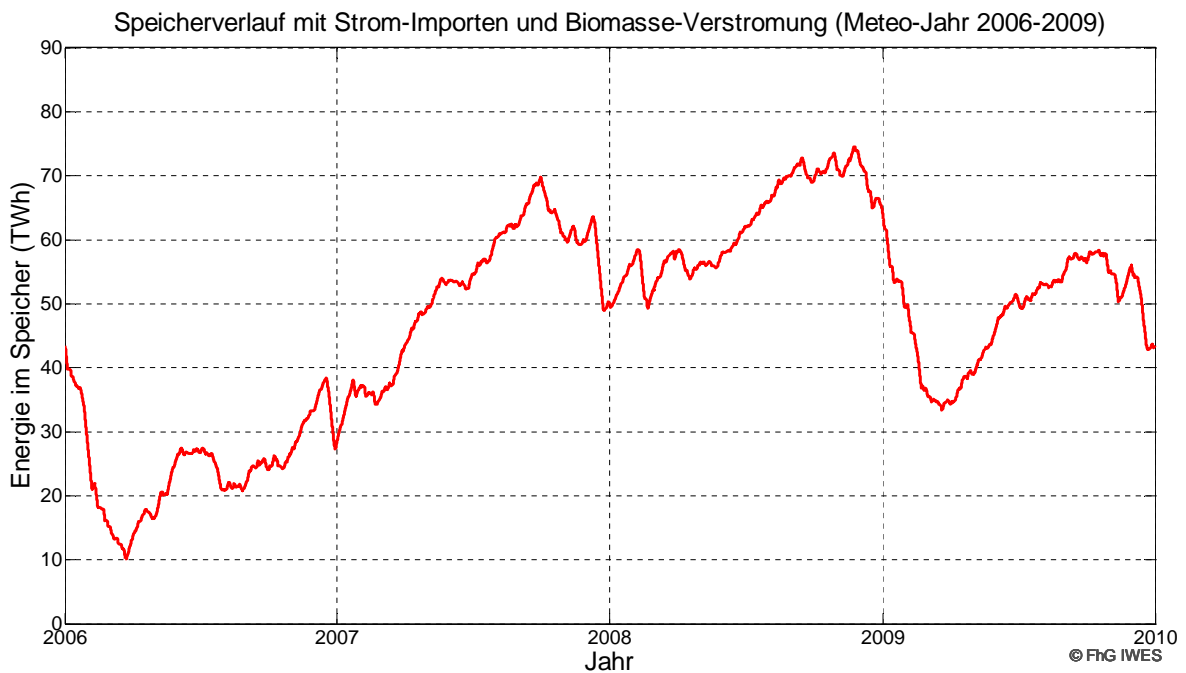
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# Handling surplus and residual load - 4 years – storage use



Source: Klaus et al, 2010

# Level of gas storage in TWh - 4 years



Source: Klaus et al, 2010

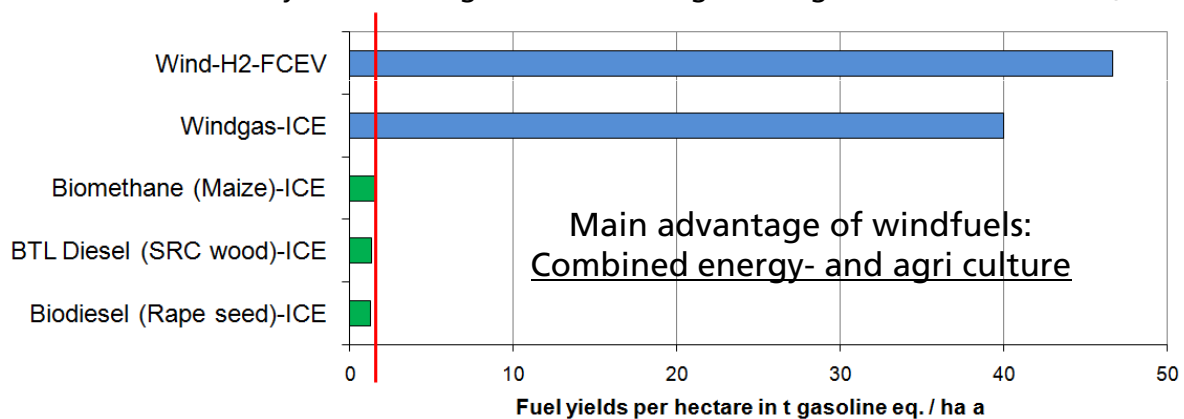
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## Windfuels gain much higher hectare yields than biofuels

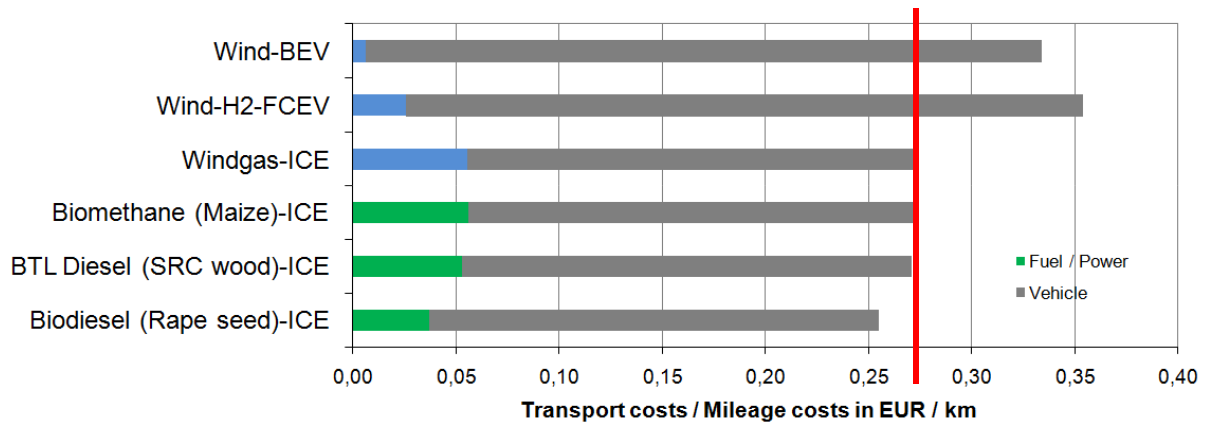
### ■ Gas yields exemplary for one hectare in Germany:

- **Maize:** 15 t<sub>Dry Mass</sub> per ha → 53 MWh<sub>th</sub> → 20 MWh<sub>th</sub> Biomethane (without by-product allocation)
- **Wind:** 0,4 MW per ha and 2000 Full load h → 800 MWh<sub>el</sub> → 480 MWh<sub>th</sub> Windgas (Special role Wind: „vertical“ energy yield – area „still available“; „hectare yields“ of single WEC 3-15x higher – e.g. 3 MW on 1 ha → 8x)



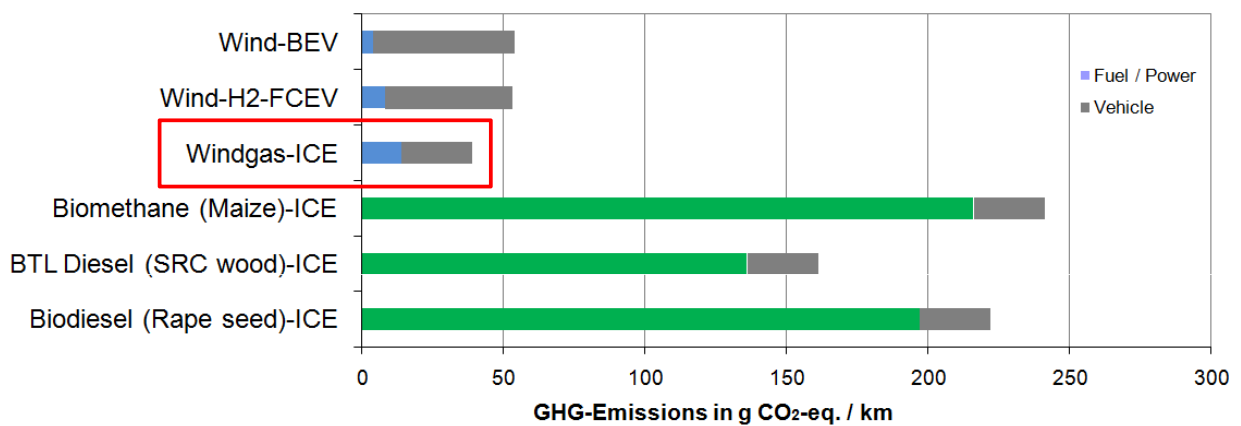
Source: IWES, LBST & ISI, EWI, DBFZ und Sterner, 2010 (FVEE Jahrestagung)

# Milage in EUR / km of windgas comparable with biofuels



Source: IWES, LBST & ISI, EWI, DBFZ und Sterner, 2010 (FVEE Jahrestagung)

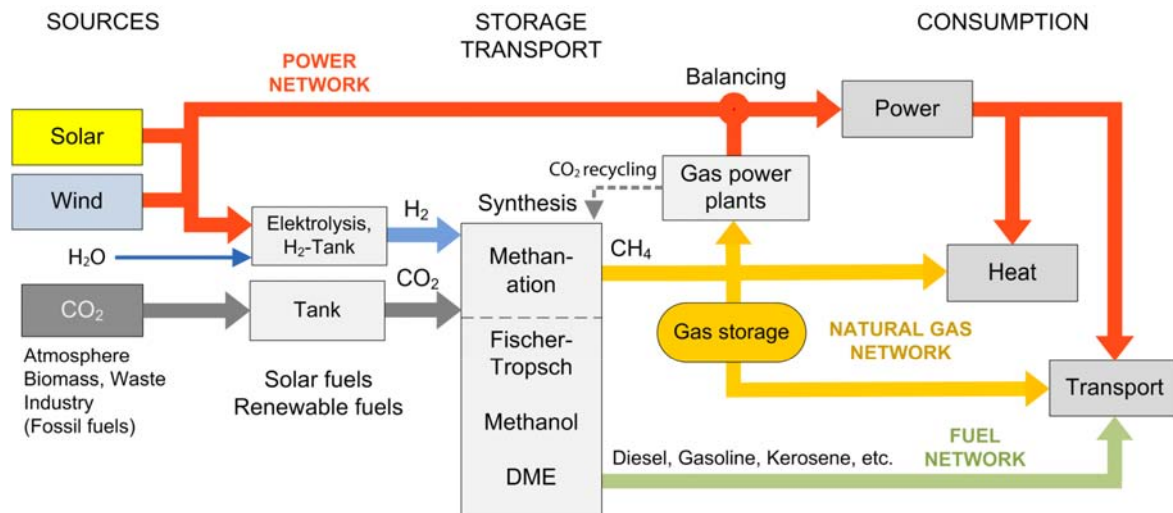
# GHG-Emissions in g CO<sub>2</sub>-äq. / km – Windgas also favorable



- a) Low carbon fuel &
  - b) Existing vehicle technology
- Windgas favourable option for renewable mobility

Source: IWES, LBST & ISI, EWI, DBFZ und Sterner, 2010 (FVEE Jahrestagung)

# Wind (- and Solar) Fuels for transportation

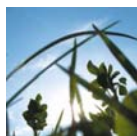


- Energy vector for Wind and Solar into transportation
- Peak oil may hit automotive soon → windfuels may become feasible

Source: Sterner, IPCC Special Report Renewable Energy 2011

# Wind as energy source for basic chemical materials

	Gases	Liquids	Materials
■ Energy source: <b>Wind</b>	→ Hydrogen	→ Diesel	→ Plastics
■ Material source: <b>Water</b>	→ Gas (Methane)	→ Kerosin	→ Synthetic materials
<b>CO<sub>2</sub></b>	→ Ethylen	→ Methanol	→ Polyethylen (PVC)
		→ Ethanol	→ ...
		→ Formic acid	
		→ ...	



Overall goal:  
overcome fossil fuel dependency of basic material industry

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## Summary

- **100% or renewable-dominant power supply will only work with**
  - Wind and other RE taking responsibility of technical supply security
  - Use of all balancing option (grid extension, supply & demand management, storage)
- **Transmission capacity of energy grids – the „Super Grid“ already exists:**
  - electricity grids: one-digit GW
  - gas network & pipelines: two-digit GW – one order of magnitude higher
  - „Gas“ from the Sahara: Pipeline between Algeria and Italy / Spain exists
  - Storage capacity: 220 TWh (110 TWh<sub>el</sub>) = ca. 5000 times current pumped hydro
- **Power (to) Gas can be the „missing link“ for storage**
  - Use of existing infrastructure (transport, storage, use) – cost savings
  - Long term energy storage without capacity limits
  - Reserve energy, balancing power for fluctuating RE from fluctuating RE
- **Power-to-Gas as energy vector for wind into transportation and materials**
  - CO<sub>2</sub>-neutral carbon-based energy carrier, High energy density, less competition on land use
  - Wind as energy source for a renewable material supply

## Sources

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Thanks a lot!