

# Russisch - Deutscher Workshop Entwicklung der Zusammenarbeit zwischen Russland und Deutschland im Bereich alternativer Energien

# Russia – Germany Cooperation in Alternative Energy

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# The German Energy Turnaround The Potential Role of Hydrogen in a Future Energy Supply System

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# Distance Gelsenkirchen – Nizhny Novgorod

Straight Line: 2.444 km, Road: 2.729 km



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**Gelsenkirchen in the Center of the industrial Heart of Germany – The Ruhr Area** 





# Universities - Important Players in the Process of Structural Change





#### Westphalian University Gelsenkirchen – Short Profile

- Founded in 1992
- More than 9000 students (incl. 1000 international)
- **Bachelor's & Master's Degree Programmes in** 
  - Engineering
  - **Computer Science**
  - **Natural Science**
  - **Business Management**
  - Law •
  - Journalism
- 12 Institutes

















# The Westphalian Energy Institute



- The **Westphalian Energy Institute** is a central research facility of the Westphalian University, which concentrates the university's energy competencies.
  - 4 Subdivisions:







# The Potential Role of Hydrogen in a Future Energy Supply System

- **1. Transformation of the energy supply system and challenges**
- 2. Hydrogen as a potential problem solver  $\rightarrow$  Power-to-Gas
- 3. Power-to-Gas Projects in Germany (Selection)
- 4. Summary



We are witnesses and actors (?) of a fundamental transformation of our energy system, both in terms of energy supply as well as the way in which we use energy!



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# **Conventional Electrical Grid**





Power Generating Capacity 1991: 126 GW (73 % Fossil; 19 % Nuclear; 7 % Water) Gross Power Production 1991: 549,9 TWh Gross Power Consumption 1991: 550,7 TWh

## The Shape of Grids to come?





Gross Power Production 2015: 647,1 TWh

Gross Power Consumption 2015: 597,7 TWh

© The Economist; ABB (2004)



In 2011 the federal government of Germany decided the decommissioning for eight nuclear power plants and the entry into The Energy Turnaround.

Core objectives are:

- Gradual phase out of nuclear power by 2022.
- Reduction of primary energy consumption in 2050 by 50% compared to 2008.
- Increase the share of renewable energy by 2050
  - $_{\circ}$  in gross energy consumption from 10.8% (2011) to 60%,
  - $_{\circ}$  in electricity generation from 20% (2011) to at least 80%.

Development of Electricity Generation Capacity in Germany 1991 – 2014 (2050)<sup>1,2</sup>





### Challenges



#### Variable Consumption Households, Industry





#### Variable Generation Wind- and Solar Power



#### 2050: 80 GW

#### 2050: 25 - 250 GW







#### Interventions by network management to ensure grid stability



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#### **Solution** !Decoupling of production and consumption!



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- 1. Transformation of Electricity into H<sub>2</sub> "on availability".
- 2. H<sub>2</sub> Storage.
- 3. Re-Electrification of H<sub>2</sub> "on demand".





Buffer capacity for some minutes / hours (Goldisthal, Thüringen) Capacity 12 Mio. m<sup>3</sup> water Power: 1060 MW (4 turbines) – turbine operation: 8 h  $\rightarrow$  8.480 MWh<sub>el</sub>



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#### **Power-to-Gas – Projects in Germany**



Quelle: DVGW 2016



### E.ON PtG-Pilot-Project "Falkenhagen",

### Hydrogen as Energy Storage – Reduction of Residual Loads





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#### Hydrogen as Energy Storage – Power to Gas (PtG)





Quelle: e.on AG

#### E.ON PtG-Pilot-Project "Falkenhagen", Electrolyzer



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Key Data: Power Input: 2 MW<sub>el</sub> H<sub>2</sub>-Production: 360 m<sup>3</sup>/h (6 ELY-Systems a' 4 Stacks with 15 m<sup>3</sup>/h) Infeed into Natural Gas Transmission Grid



### Audi e-gas Project

### PtG: Coupling of energy and mobility sector

#### PtG: Coupling of energy and mobility sector



#### Audi e-gas Project



#### PtG: Audi e-gas Plant (Werlte / Emsland)





#### Hydrogen – Clean Fuel for Vehicles







### PtG-Project "h2herten"

# Integration of Renewables in Industry and Trade by the Help of Hydrogen







Provide a ideal and Carbon neutral working environment for Hydrogen Technology Companies by utilization of local Wind power for the production of Green Electricity and Green Hydrogen.







3000 m<sup>2</sup> office space and technical areas

Today Herten Hydrogen Application Centre

### h2herten - Electricity Demand







#### **Electricity Demand – Load Profile**

### Hydrogen Technology Centre: Electricity Demand: Maximum Power:



## h2herten – Local Situation



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### **Regenerative H2-Generation & Utilization**







#### HECS → <u>Hydrogen</u> based <u>Energy</u> <u>Complementary</u> <u>System</u>

## **HECS - System Configuration**



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#### Electrolyzer 30 Nm<sup>3</sup>/h



Compressor 30 Nm<sup>3</sup>/h@50 bar



**WEC 600 kW** 



#### PEM-FC 50 kW



Battery Bank 28 kWh



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- The share of wind and solar power in energy supply will continue to grow strongly and it will lead to a much more decentralized energy system.
- Hydrogen can in addition to electricity taking the role of a secondary energy carrier with the advantage of better storability.
- The problems associated with an increasing proportion of wind- and solar-based power generators can reduced by combination with H2-energy systems and thus also their efficiency can be increased.
- Hydrogen technology has a wide range of possible applications with a high economic potential.





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