HYDROGEN IN THE RENEWABLE ENERGY SYSTEM – VIEW FROM AN UTILITY

Oliver Weinmann, Managing Director Vattenfall Europe Innovation

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The Challenges of the Energy Transition

- **Fossil/Nuclear** to **Renewables**
- **Demand driven** to **Supply driven**
- **Centralized** to **Decentralized**
- **Analog** to **Digital**
Share of renewable Energy Feed-in in the German System

Source: ZSW nach Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat)
Next Steps Energy Transition

• First Step: Quantity
  - Market Introduction RES (low penetration, cost decrease, funding schemes)
  - Focus on electricity

• Next Step: Quantity, Quality and Energy System
  - Further increase share of renewables
  - Manage volatility and flexibility
  - Decarbonization of other energy sectors (sector coupling)
Agenda

1. Energy Transition
   - Renewables growth & cost
   - Volatile Renewable Production
   - Flexibilities & Sector Coupling
2. Conclusions
In 2016, global renewable energy capacity grew 8.7% to more than 2,006 GW

IEA: Since 2015 share of renewables in new installations > 50%
**Generation cost - Development Auctions Solar and Wind**

**PV**
- **60 EUR/MWh** (Germany 10 MW)
- **17.9 USD/MWh** (Saudi Arabia 300 MW)

**Wind**
- **49.9 EUR/MWh** (Denmark 600 MW)
- **37.8 USD/MWh** (Peru 126 MW)
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Challenges of REN Feed-in into the System

Vertical Load, Wind Energy Forecast and Wind Energy Feed-in in East Germany
(1.-30.06.2013, MW)

1. Deviation from forecast
2. Calm
3. Gradient
4. Production > Load

Quelle: 50Hertz Transmission
Cost figures Congestion Management (Germany)

Source: BDEW
Agenda

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Change from Demand to Supply Driven System

Production

Centralized and Decentralized

2015
Nuclear
Fossil

In future

2030
Wind
Solar

Flexibility options

Network Expansion
Flex. Power Plants
Demand Response
Power to X/
Sector coupling
Electricity Storage

Consumption

Commercial & Industry sector

Transport sector

Residential sector
Energy sectors and sector coupling

- Wind
- Solar
- Hydro
- Biomass

Electricity

- Gas
- Coal
- Nuclear
- Oil

- Heating/Cooling
- Industry
- Transport

- Oil
- Gas
- (Electricity)
Sector Coupling

• **Goals:**
  - Decarbonisation of mobility and heat
  - Implementation of renewable electricity (incl. surplus production) for house heating, industry, and transport.
  - Supply of flexibilities

• **Technologies:**
  - Power to Gas (Hydrogen)
  - Power to Heat

• **Main applications:**
  - Utilization of renewable electricity for heat and transport
  - Supply of ancillary services

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The role of hydrogen in the energy system

Hydrogen can play 7 roles in the energy transition

1. Enable large-scale renewables integration and power generation
2. Distribute energy across sectors and regions
3. Act as a buffer to increase system resilience
4. Help decarbonize transportation
5. Help decarbonize industrial energy use
6. Help decarbonize building heat and power
7. Serve as renewable feedstock

SOURCE: Hydrogen Council
Hydrogen as transportation fuel

- Hydrogen (power to gas) production with electrolysis can be used to balance volatile production
- Most attractive business case for H2 is transportation fuel
- Vattenfall operates the largest European H2 filling station since 2011 in Hamburg
- H2Mobility builds up refueling infrastructure for H2 vehicles – 400 filling stations until 2023
- Several European cities are interested in H2 busses for public transportation
- Hydrogen fuel cell trains are developed
- Vattenfall currently investigates hydrogen production infrastructure solutions to serve emission free transport on a commercial basis
Availability

- Availability means „ability to refuel“
- Errors in redundant systems irrelevant
Power to Gas at Refineries

- Transportation sector has legal obligations to reduce the CO2 footprint of fuels (e.g., diesel, gasoline)
- CO2 reduction today is done by addition of biofuels
- Huge amounts of hydrogen are needed in the refinery process, today produced by steam reforming of natural gas
- Replacing this hydrogen with green hydrogen (power to gas with renewables, P2G) can deliver CO2 reductions comparable to blending of biofuels
- Business case is achievable since power to gas competes to (expensive) biofuels, not with cheap hydrogen from steam reforming
- Major obstacle: permission to get CO2 reductions credited similar to biofuels not yet in place – regulation needs to be adapted
Power-to-gas – decarbonization of industry

- HYBRIT: Fossil free steel – Cooperation with LKAB and SSAB

- Renewable diesel: from forest to drop-in fuel – Cooperation with Preem
Fossil free steel with SSAB/LKAB

HYBRIT
FOSSIL-FREE STEEL

Iron ore pellets + Hydrogen = Sponge iron + Water

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HYBRIT pilot plant - the next step

- Pre-engineering and design since January
- Location Luleå & Malmberget
  - Direct reduction: ~1 ton/h DRI
  - H₂: ~600-700 Nm³/h (~3-4 MWₑ)
  - Steel (EAF): ~10 ton/batch
  - H₂ storage: TBD 2019
- Time schedule
  - Start groundwork summer 2018
  - Commissioning early 2020
  - Test campaigns 2020-2024

Total cost 2018-2024 ~150 M€
- Includes CAPEX + OPEX for whole test period
- Co-funded by Swedish Energy Agency (pending)
Fossil free diesel with Preem

Cellulose (fiber)

Lignin

Pre-treatment → Lignin oil → Refining → Diesel (HVO)

Other (energy etc)

Hydrogen

Electricity

2030: 3 Mm3/yr (30 TWh/yr)

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Conclusions

• Share of renewables will further increase
• Volatile sources like wind and solar will be the dominating power generation in the future
• Besides electricity the energy sectors heat and transport need to be decarbonized as well to fulfill the goals of the Paris COP agreement
• Main source for decarbonization of heat and transport will be renewable electricity.
• Storage and sector coupling will play a more important role in the future
• Today business cases for these systems are only possible in niche applications
• Industry is willing to invest, but for large scale roll out attractive business cases are required:
  - The regulatory and legal framework needs to be adapted to develop economical viable business cases.
  - Cost of storage and sector coupling systems need to decrease
THANK YOU

OLIVER.WEINMANN@VATTENFALL.DE

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