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European Gas Technology Conference

Parallel Session I

Strategy for Gas in Europe 2030

Nov 25, 2015

OVGW
ÖSTERREICHISCHE VEREINIGUNG FÜR DAS GAS- UND WASSERFACH

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TECHNICAL ASSOCIATION OF THE EUROPEAN NATURAL GAS INDUSTRY

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Can wind and gas become a happy marriage?

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Intermittent renewables impact

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Figure 39. 2009 UK Modelled Daily Wind Power Generation in Generation Stack

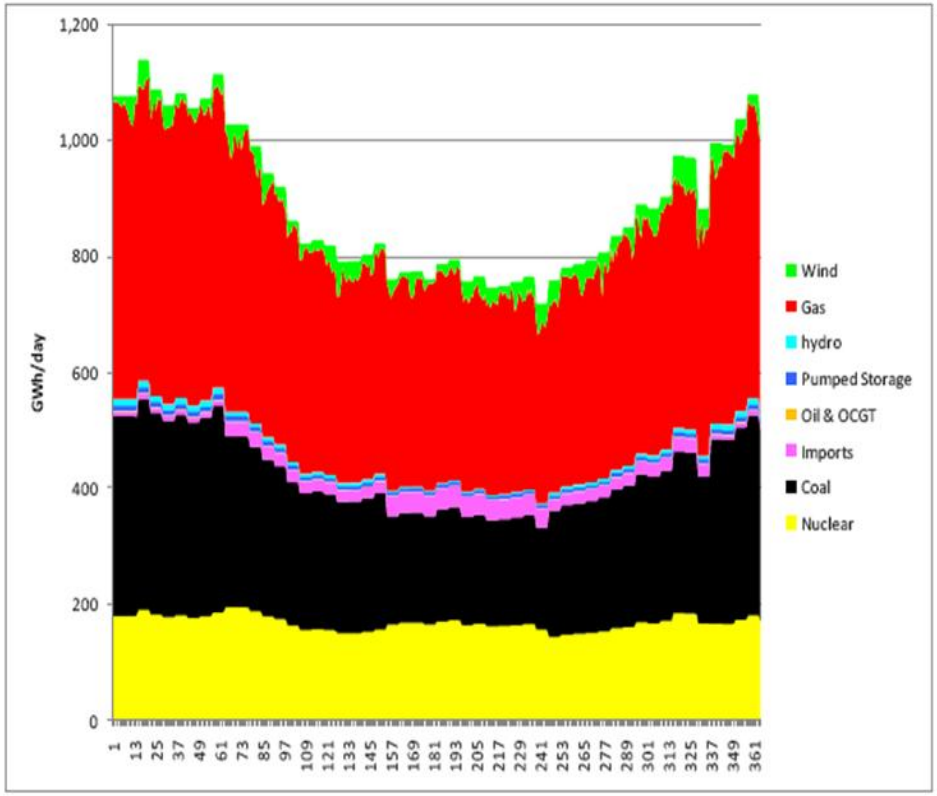
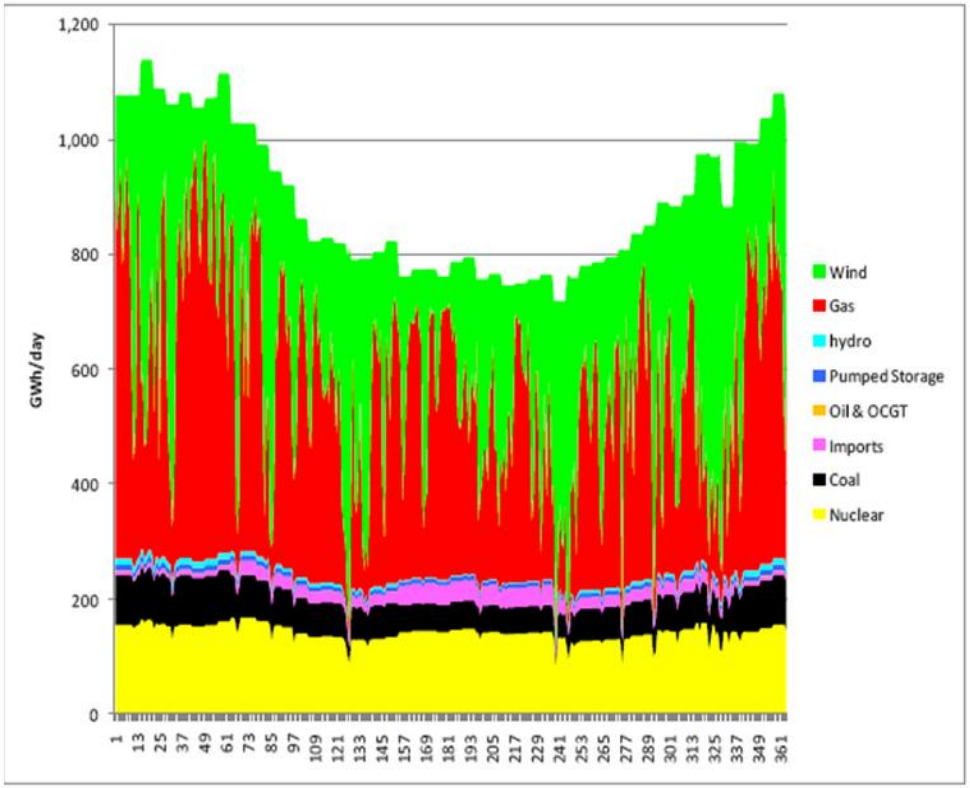


Figure 44. 2025UK Modelled Daily Wind Power Generation in Generation Stack



Source: Rogers, Oxford Inst. for Energy Studies, 2011

Introduction

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- The North Sea Area faces the crucial stage of the energy transition which is not quick fix, but needs collaboration

Renewable energy challenges	Fossil energy challenges
• Grid balancing issues due to renewable supply intermittency. • Back-up capacities. • Infrastructure capacity financing. • Lack of coordination.	• Start of costly decommissioning phase. • Removing of infrastructure. • Redefinition of the role of traditional gas suppliers as energy producers.

Basis for smart combinations:

- The combined use of existing infrastructure and storage facilities.
- Energy conversion activity.
- The ecological value of the North Sea Area region is substantial.

Smart combinations: overall perspectives

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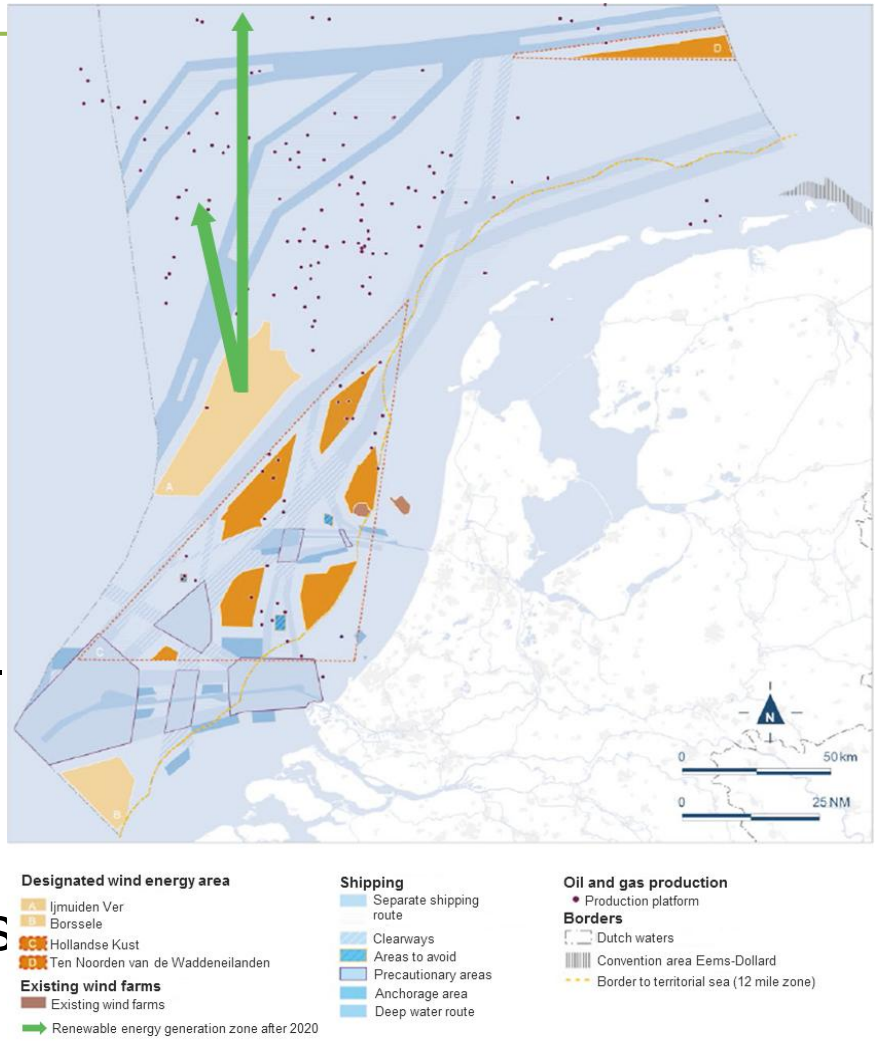
- 160 platform installations & >2,000 km of pipeline will be decommissioned.
- Reuse of these installations is allowed if installations have another legitimate purpose
- Located at centre of European industrial developed member-states
- Greater public acceptance
- Large-scale storage conditions



Smart combinations: overall perspectives

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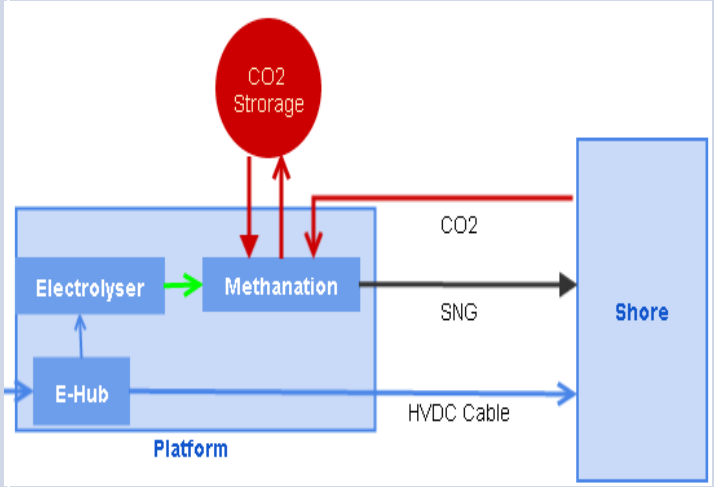
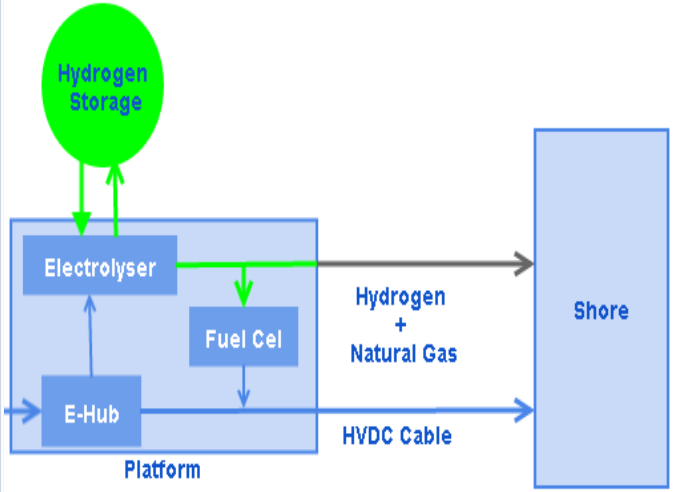
Short term	Medium term	Long term
Step 1: Small conversion pilot on an existing platform that is still operational where the technology and all needed standards and procedures are tested only. • Electricity is generated with diesel motors. Step 2: Small conversion pilot on an existing platform that otherwise would be decommissioned • Electricity is bought from wind park and an E-Hub is installed to transform AC current in DC current	start full-blown pilot farm for the production of synthetic gas. • connected to 600 MW wind park with a MVAC cable	Start large scale demonstration project with base load energy and hydrogen infeed in the gas grid. • connected to 600 MW wind park with a MVAC cable
		
	Graphical illustration of medium-term scenario	**Graphical illustration of long-term scenario**

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Some illustrative facts and figures

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- Assuming 0.5% hydrogen admixing to natural gas, 65 MW electrolyser capacity is sufficient to cover demand of 1.8 million households
- To fully stabilise 600 MW wind capacity output, a 270 MW electrolyser/fuel cell unit is required
- The foreseen Dutch Energy Agreement's offshore wind capacity can be fully stabilised with the help of about 60 platforms with 30 MW conversion capacity each

Economic and business issues (1)

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Power-to-gas-to-power

Assumptions

- Storage issues and conversion losses
- Additional investment in PEM fuel cell technology required

Results:

- Economically unfeasible

Hydrogen feedstock

Assumptions

- Yearly demand of 2.5 billion kg and assumed hydrogen price in the range of € 2- € 8
- Price depends on transport method.
- No regulations and low compression losses.

Results:

- Base case: NPV of € 51,544
- Future case: NPV of € 305,777
- Future case with SDE+ bonus: NPV of: € 1,625,926

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Economic and business issues (2)

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Hydrogen to shipping

Assumptions

- Price range of € 4.43-5.68 / kg
- Required installed capacity of electrolyser of min. 2 MW
- No regulations and low compression losses
- Additional investment offshore refuel station

Results

- Base case: NPV of € 1,492,402 (2 MW)
- Future case: NPV of € 2,032,457
- Future case with SDE+ bonus: NPV of € 15,312,219!

Economic and business issues (3)

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Hydrogen infeed

Assumptions

- Price range of € 1.06-1.95
- Regulation constrains hourly infeed

Results:

- Base case: NPV of - € 452,382 (combined with option 2)
- Future case with SDE+ bonus: NPV of € 835,673

Synthetic gas

Assumptions

- Unconstrained by regulation and lower risk of flammability
- Conversion losses apply
- Additional investment in methanation technology required

Results: Economically unfeasible

Technical issues on the platforms

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1. **Grid connection with wind farm**
2. **Possible components** – electrolysis, methanation, CCS, desalination and water treatment, hydrogen, oxygen and CO_2 storage, and gas purification – **may create spatial bottlenecks**
3. **Idem weight constraints**
4. **Corrosion and material selection issues**
5. **Safety issues**
6. **Availability of pure CO_2**

Spatial and planning issues

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Designated wind energy area	Expected installed wind farm capacity (MW)	Number of nearby platforms	Estimated conversion capacity
Holland Coast Area 1	~350 MW	7	140 – 210 MW
Holland Coast Area 2	~350 MW	4	80 – 120 MW
Holland Coast Area 3	~300 MW	6	120 – 180 MW
North Netherlands Coast	~700 MW	2	40 – 60 MW
Ijmuiden Ver	~1400 MW	1	20 – 30 MW
Future Wind Energy Area A	Not known	15	300 – 450 MW
Future Wind Energy Area B	Not known	4	80 – 120 MW

So, for 3 GW medium-term offshore wind capacity in the Netherlands, the nearby ‘maximum’ conversion capacity of about 400 – 600 MW would be capable of converting about a sixth of the generated wind energy.

Annex: main markets for hydrogen

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Usage	Demand	Price	Assumption	Source
1. Hydrogen-to-power	Variable demand	Simulated	Hourly constrained by grid line capacity, seasonality and hour. Storage issues and conversion losses.	Veijer (2014) Jansen (2015)
2. Hydrogen feedstock	Yearly demand of 2,496 million kg	€ 2-3/kg € 5-8/kg € 3.20/kg	Price depends on transport mode. No regulations and low compression losses.	Veijer (2014) Moes (2015)
3. Hydrogen infeed	Fixed demand	€ 1.06-1.95/kg	Regulations and pipeline capacity constrain hourly infeed	Jansen (2015)
4. Hydrogen to road mobility	Underdeveloped and n/a offshore.			
5. Hydrogen to shipping	Underdeveloped.	€ 4.43-5.68/kg	Required installed capacity of electrolyser of min. 2 MW. No regulations and low compression losses.	Loisel, et al. (2015); Moes (2015)
6. Synthetic gas	No fixed demand	€ 1.06-1.95/kg	Unconstrained by regulation. Lower risk of flammability. Conversion losses.	Jansen (2015)

Annex: parameters and values

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Parameters		Parameters	
K_h	1MWh	$P_{h,c}$	60.40 per MWh
K_f	375 KWh	$P_{h.g}$	37.48 per MWh
K_m	375 KWh	$P_{h.m}$	95.53 per MWh
Q_h	Determined by simulation	P_e	Simulated
Q_f	Determined by simulation	P_m	13.13/simulated
Q_m	Determined by simulation	P_o	12.75
I_h	€ 1,000,000	C	4% of investment costs
I_f	€ 375,000	D	4.5% of investment cost
I_m	€ 150,000	GD	€ 71,599
I_{rf}	€ 2,530,000	S_h	€ 1.45 per kg
I_s	€ 100,000	q_1	75%
W	€ 0.34 per MWh	q_{12}	37.5%
τ	20% < € 200,000 and 25% > € 300,000	q_{13}	60%
r	6.6% (WACC)		