

# Techno-economic System Analysis of an Offshore Energy Hub and Outlook of Electrofuel Applications

*Maximilian Otto<sup>1</sup>, Christian Thommessen<sup>1,2</sup>,  
Florian Nigbur<sup>1,2</sup>, Angelika Heinzel<sup>1,3</sup>*

<sup>1</sup>University of Duisburg-Essen

<sup>2</sup>Lagom.Energy GmbH

<sup>3</sup>The hydrogen and fuel cell center ZBT GmbH



Ministry of Culture and Science  
of the German State  
of North Rhine-Westphalia



Graduate School  
for Sustainable Energy Systems  
in Neighbourhoods

UNIVERSITÄT  
DUISBURG  
ESSEN

*Open-Minded*



Powered by



6<sup>th</sup> International Conference on Smart Energy Systems  
6-7 October 2020  
#SESAAU2020



Source: SESAAU2019

Powered by

Page 2

6<sup>th</sup> International Conference on Smart Energy Systems  
6-7 October 2020  
#SESAAU2020



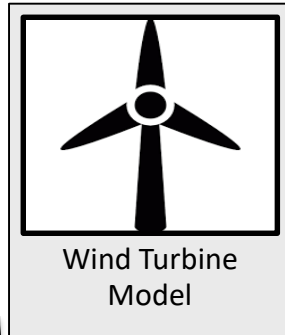
Source: North sea wind power hub (TenneT, Energinet, Gasunie und Port of Rotterdam )

Powered by

Page 3



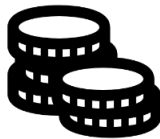
- 6 GW
- 4,000 h
- 831 km<sup>2</sup>



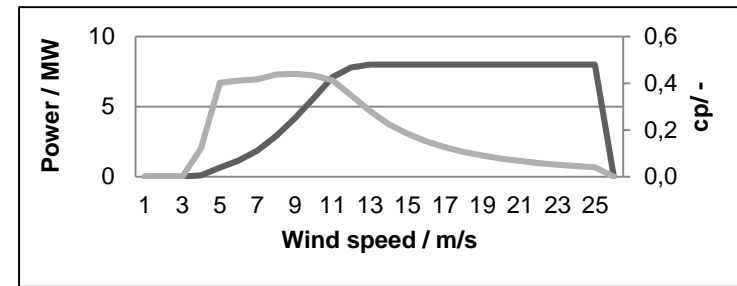
Production Quantities



Efficiencies



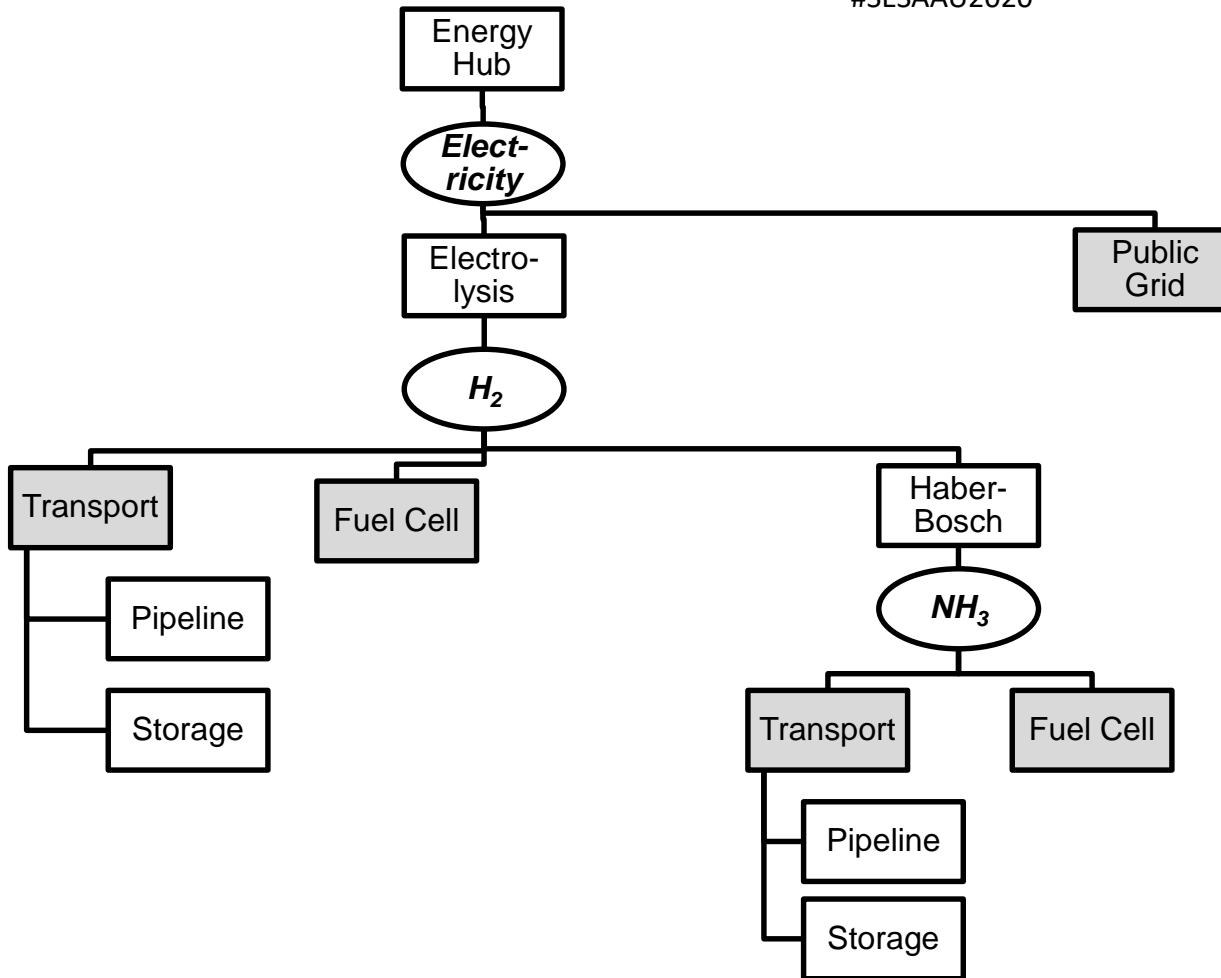
Production / Application Costs



$$LCOE = \frac{I_0 + \sum_{t=1}^n \frac{A_t}{(1+i)^t}}{\sum_{t=1}^n \frac{M_{t,el}}{(1+i)^t}}$$

Powered by

Page 4

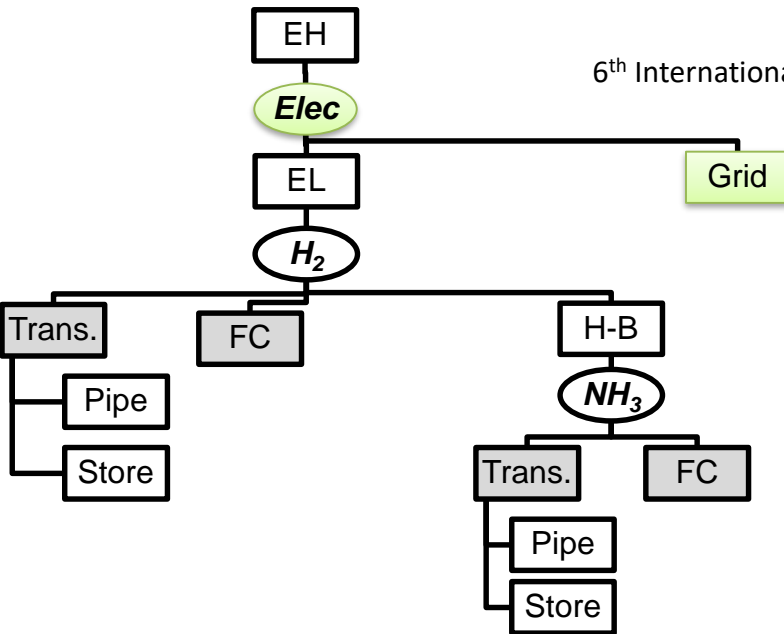


### Ammonia

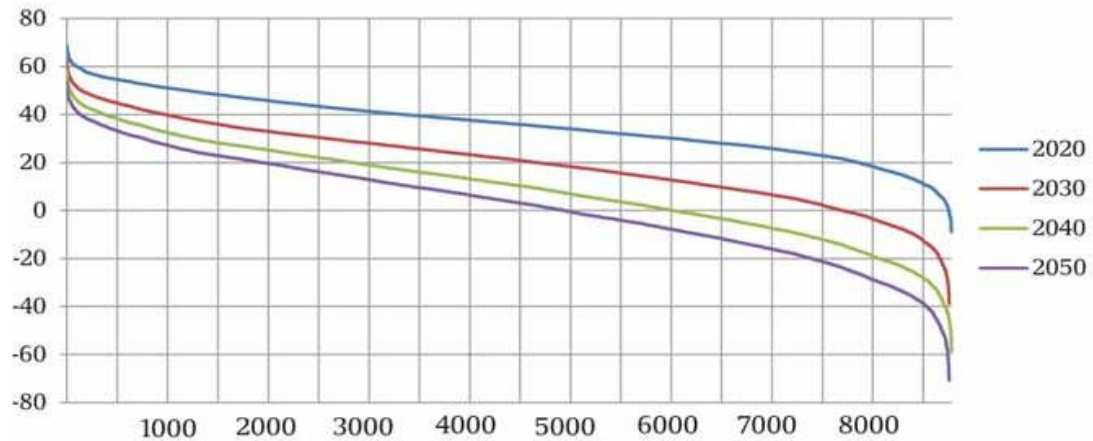
- important basic chemical (fertilizer)
- carbon free
- high energy density
- globally available
- infrastructure available
- toxic, but no persistence and bioaccumulation

Powered by

Page 5



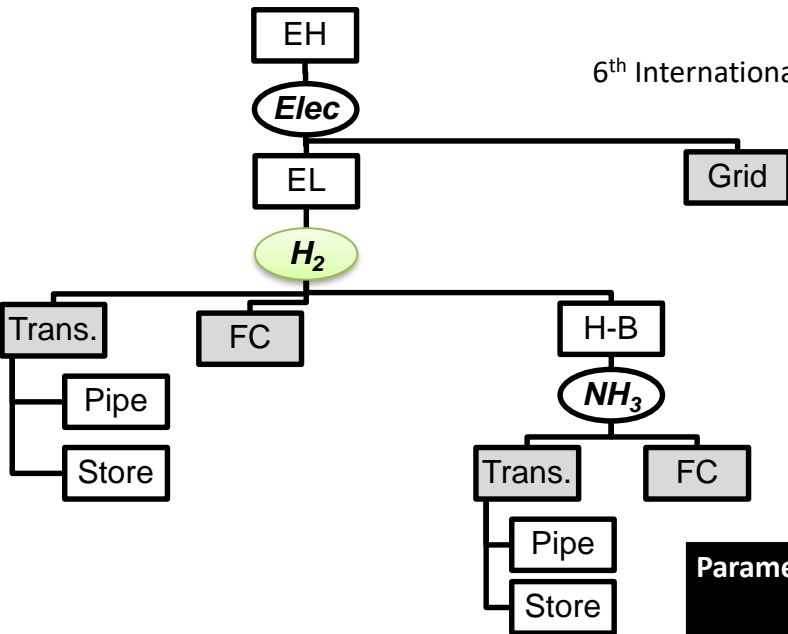
Parameter	LCOE ct/kWh	Efficiency %
Production	11.8	100.0
incl. grid transport	17.3	88.8



Source: Kohler (2012): Vernunftkraft.

Powered by

Page 6



6.5 ct/kWh

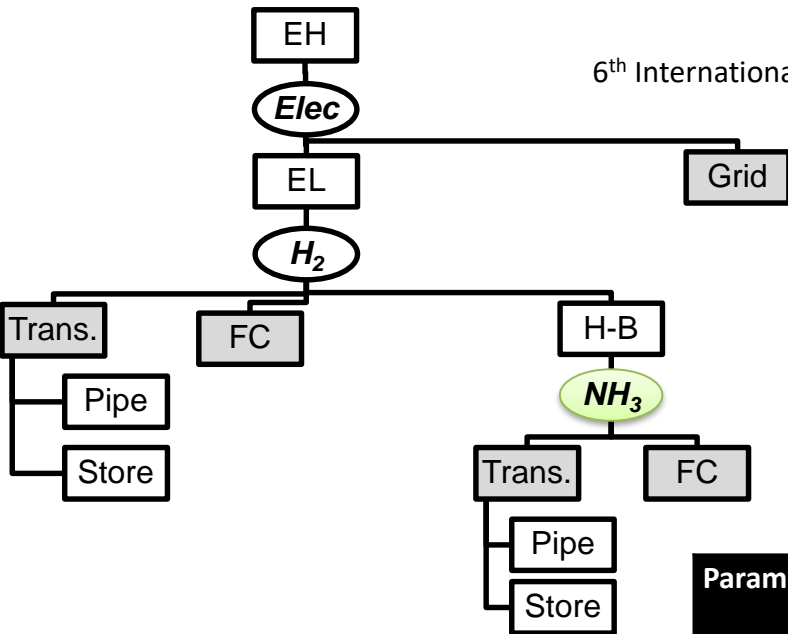
28.0 ct/kWh



Parameter	LCOE (AEL) ct/kWh	LCOE (PEM) ct/kWh	Efficiency %
Invest.	4.6	6.5	-
Production	22.8	24.7	65.0
incl. pipeline-transport	23.7	25.6	60.0
incl. storage	26.4	28.3	45.1
incl. fuel cell	51.6	54.8	24.2

Powered by

Page 7



8.7 ct/kWh



Parameter	LCOE (AEL) ct/kWh	LCOE (PEM) ct/kWh	Efficiency %
Invest.	2.3	2.3	-
Production	25.0	26.8	52.3
incl. pipeline-transport	25.1	26.9	52.0
incl. storage	25.1	26.8	52.2
incl. fuel cell	56.5	59.7	25.1

Powered by

Page 8



Parameter variation	LCOE H <sub>2</sub>	LCOE NH <sub>3</sub>
energy hub costs - 50 %	- 45 %	- 42 %
Invest. costs of electrolysis - 50 %	- 16 %	- 14 %
Efficiency of electrolysis + 75 %	- 11 %	- 10 %

Powered by

Page 9



feasibility  
flexibility  
low carbon emissions  
secure energy supply  
sustainability  
less wind energy curtailment  
ex-/import  
storage technology

energy conversion losses  
high energy production costs  
offshore space  
policy framework

Powered by

Page 10

# Thank you for your attention!

**Christian Thommessen**  
M.Sc.

**University of Duisburg-Essen**  
*Chair of Energy Technology*  
Lotharstraße 1, 47057 Duisburg  
christian.thommessen@uni-due.de  
+49 203 379 2745



Ministry of Culture and Science  
of the German State  
of North Rhine-Westphalia



Graduate School  
for Sustainable Energy Systems  
in Neighbourhoods

UNIVERSITÄT  
DUISBURG  
ESSEN

*Open-Minded*



Powered by

