# Potential of Offshore Power-to-Gas to compete with Onshore Blue Hydrogen

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16th IAEE European conference
Ljubliana, 28 August 2019

Source: Mulder, Perey and Moraga (2019), Outlook for a Dutch hydrogen market: economic conditions and scenarios, CEER Policy Papers 5, March.

# Outline

1. Background, research problem and method

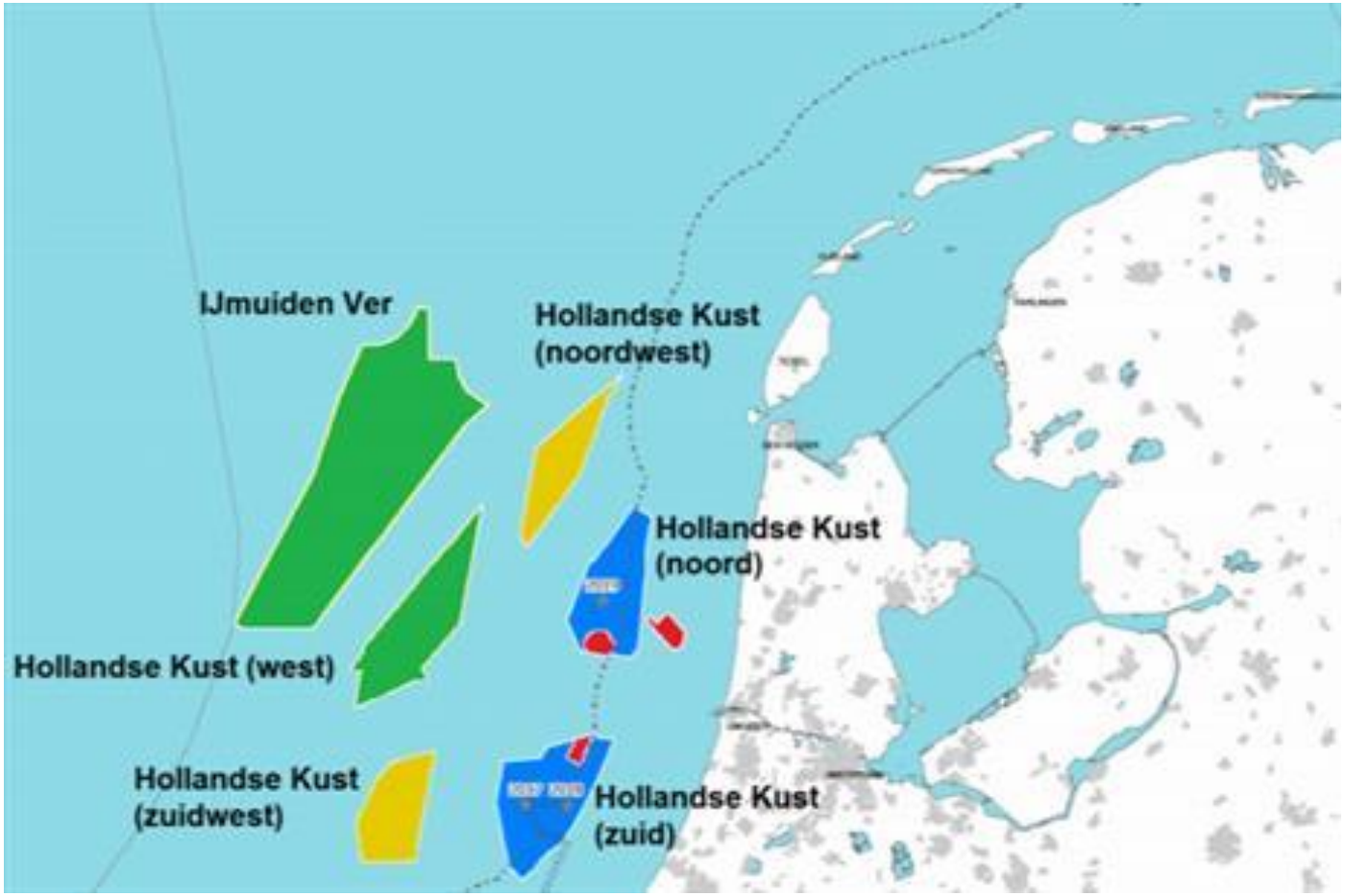
2. Factors behind the break-even prices for various types of hydrogen
    1. Electricity price
    2. Gas price
    3. $CO_2$ Price
    4. Price of green certificates

3. Economic effects of offshore hydrogen production

4. Conclusions

# Background: ambitious plans for offshore wind parks

## Increase from current 1 tot about 12 GW in 2030



Offshore wind has several benefits, but also high network costs.

Problem: how to get the power onshore in an efficient way?

Solution: sector coupling: convert electricity into hydrogen offshore (=Power-to-Gas) and use the existing offshore gas network

# Power-to gas has several potential benefits

## Providing flexibility to electricity system

- acting as storage (e.g. transferring power from oversupply to scarcity situations)
- demand response (i.e. only consuming power in case of oversupply/low prices)

## Enabling the gas sector to become green

When power is transported as hydrogen in particular the latter option is relevant
So, we focus on the competitiveness of this type of hydrogen with alternatives

# 6 types of hydrogen

| Name | Production technique | Type of energy used | Treatment of CO2 |
|---|---|---|---|
| **SMR-grey** | | | |
| **SMR-blue** | | | |
| **SMR-green** | | | |
| **electrolysis-grey** | | | |
| **electrolysis-green** | | | |
| **electrolysis-orange** | | | |

# Method:

1. Comparing the break-even prices of various types of hydrogen

Investment costs → express investments costs in fixed costs per kg. of expected production of hydrogen during life time → CAPEX

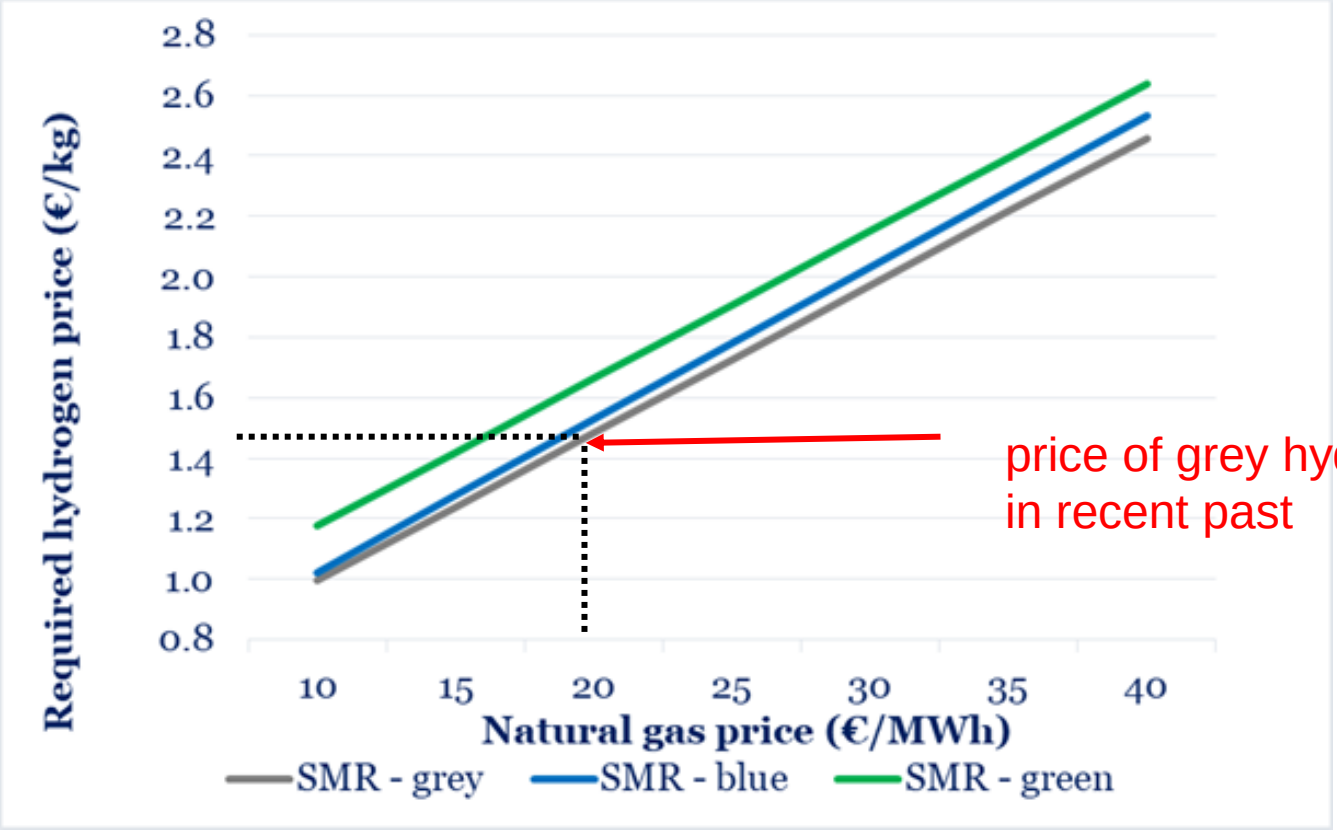
Variable costs → express variable costs per kg. of hydrogen → OPEX

CAPEX + OPEX = Break-even price of hydrogen (euro/kg.)

2. Assessing costs and benefits of offshore sector coupling

# SMR: required hydrogen price depends on prices of gas, CO2 (and green-gas certificates)

when price of gas is 20 euro/MWh and price of $CO_2$ is 15/euro, price of grey hydrogen needs to be 1.5 euro/kg, blue 1.60 euro/kg and green 1.80 euro/kg.

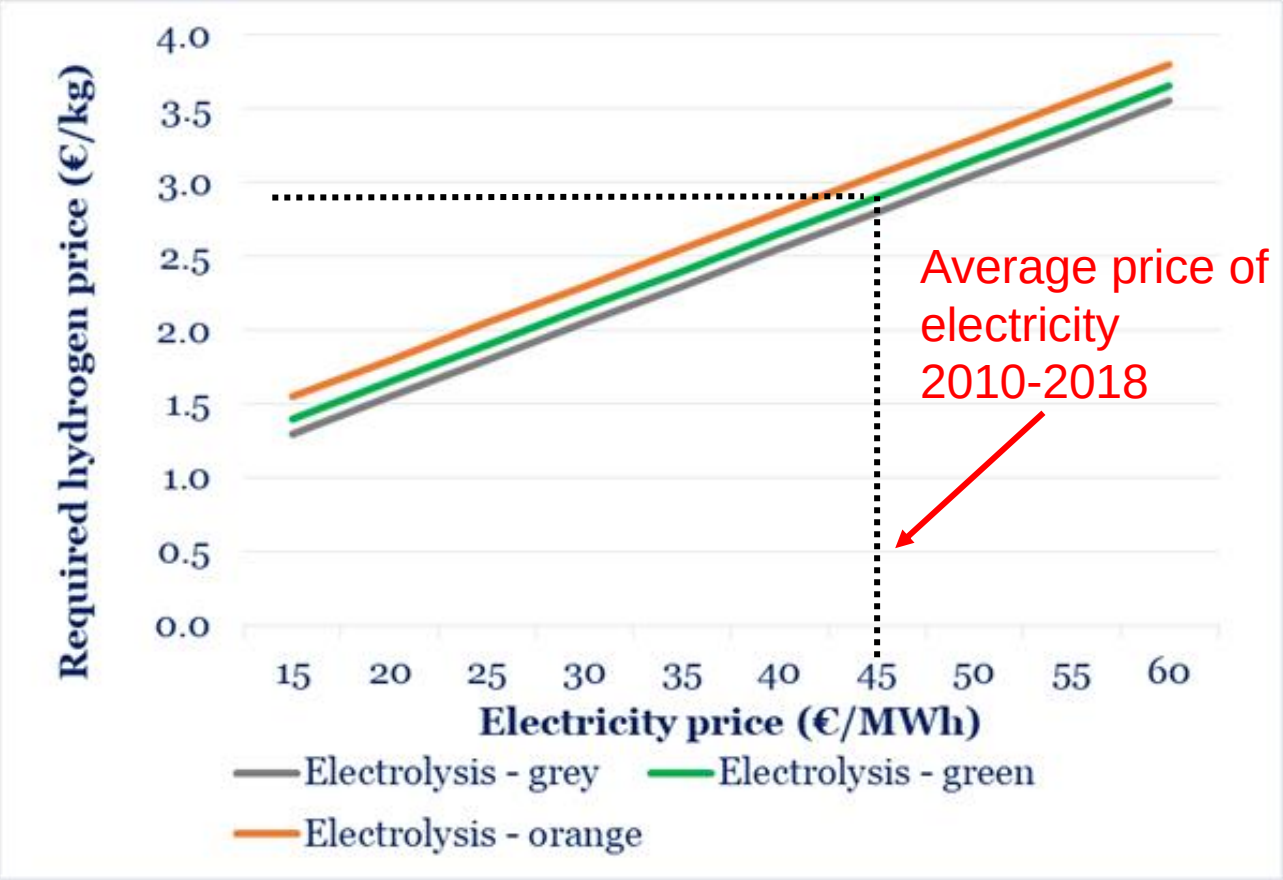


# Electrolysis: required price of hydrogen depends on prices of electricity and green certificates

when electricity price is 45 euro/MWh and $CO_2$ price is 15/euro, the price of hydrogen should be 3,0 euro/kg

*Price green certificates*

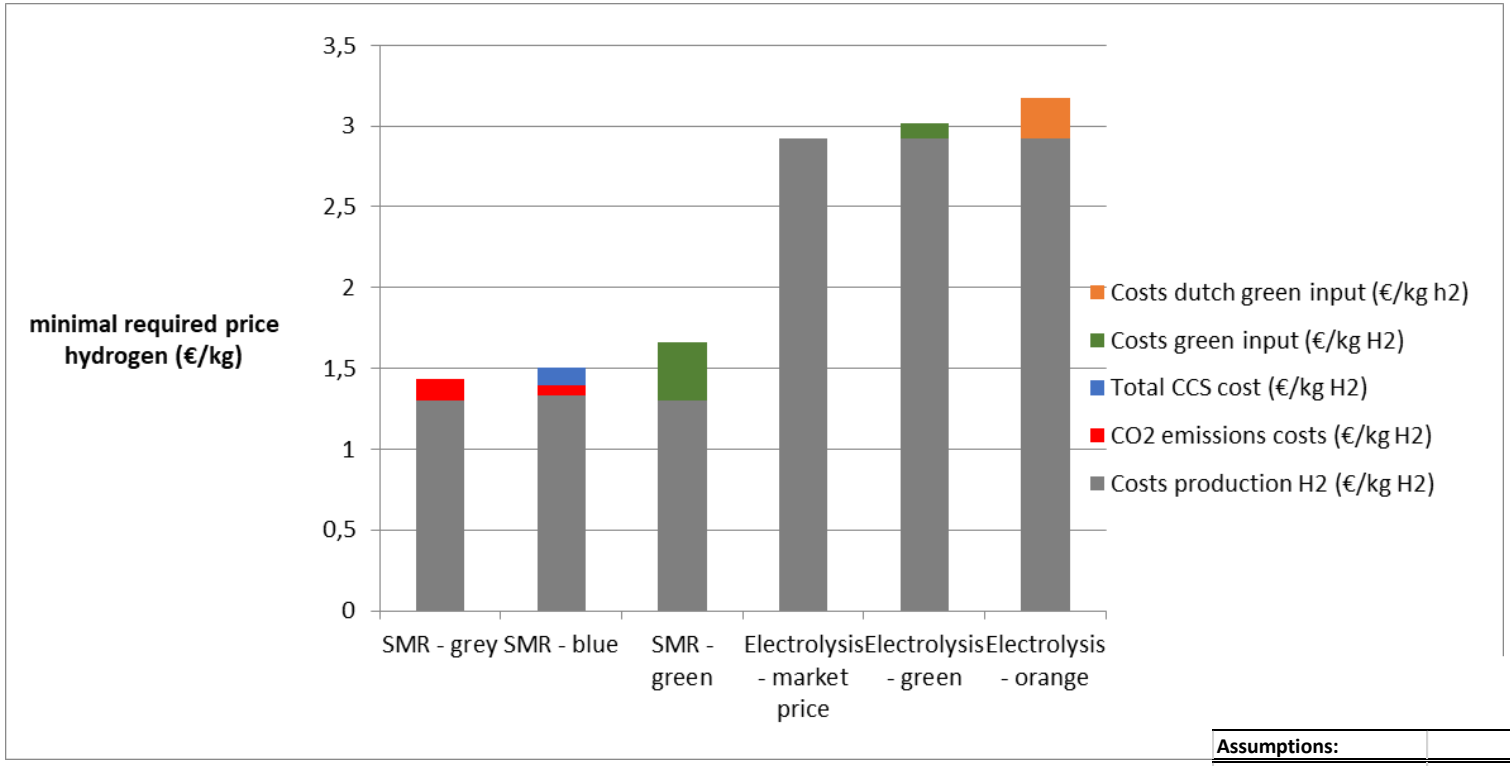
- *EU:*
  *2 euro/MWh*
- *Dutch:*
  *5 euro/MWh*



# SMR versus elektrolysis

## At current prices of gas, electricity and CO2: SMR-grey is most competitive

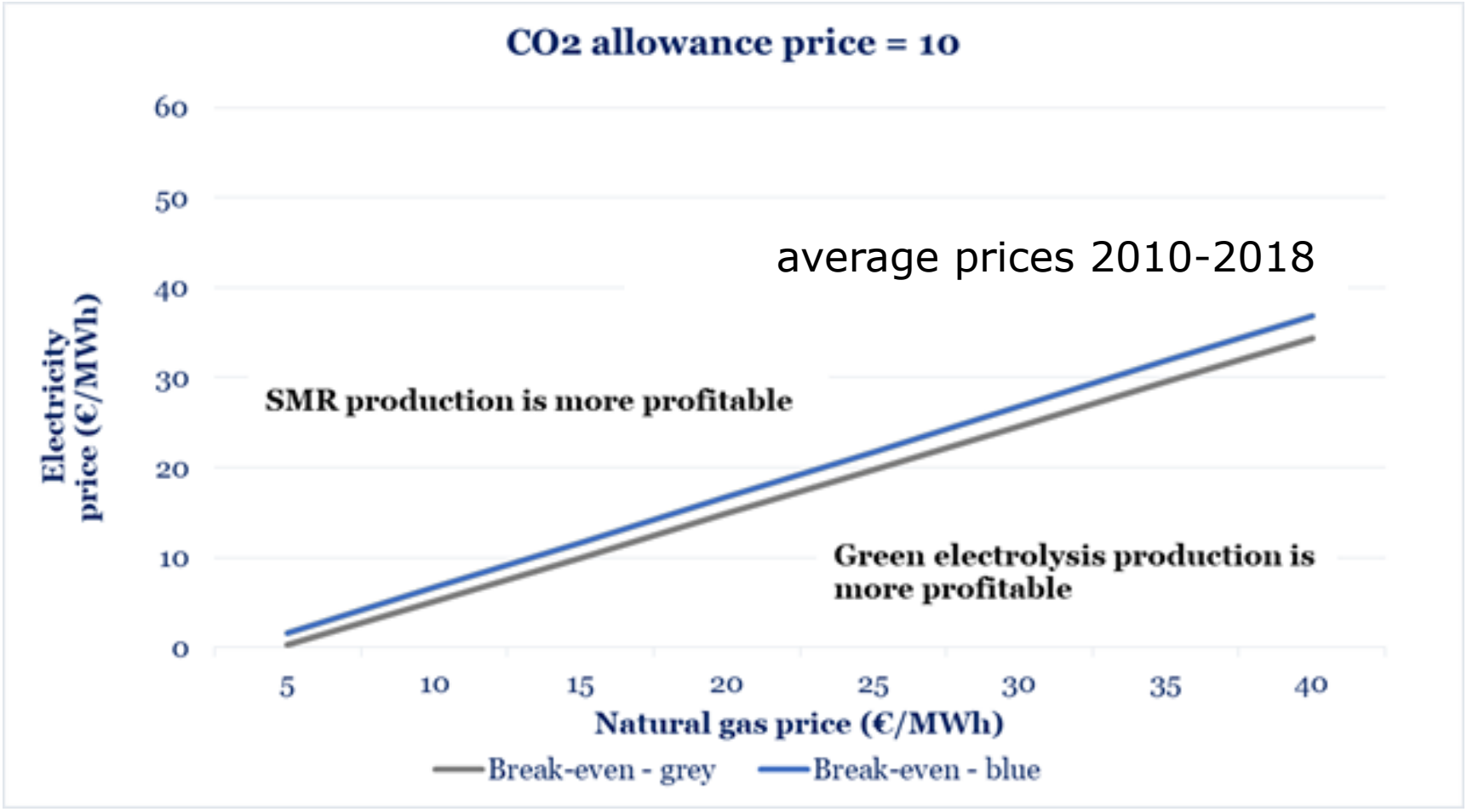
## Electrolysis orange requires hydrogen price which is 2 times as high




| Assumptions: | value | source |
|---|---|---|
| Price gas (€/MWh) | 20 | CBS |
| Price electricity (€/MWh) | 47 | Bloomberg |
| CO2 allowance price (€/ton) | 15 | |
| Premium green gas (€/MWh) | 8 | |
| Premium green electricity (€/MWh) | 2 | |
| Premium dutch green electricity (€/MWh) | 5 | |

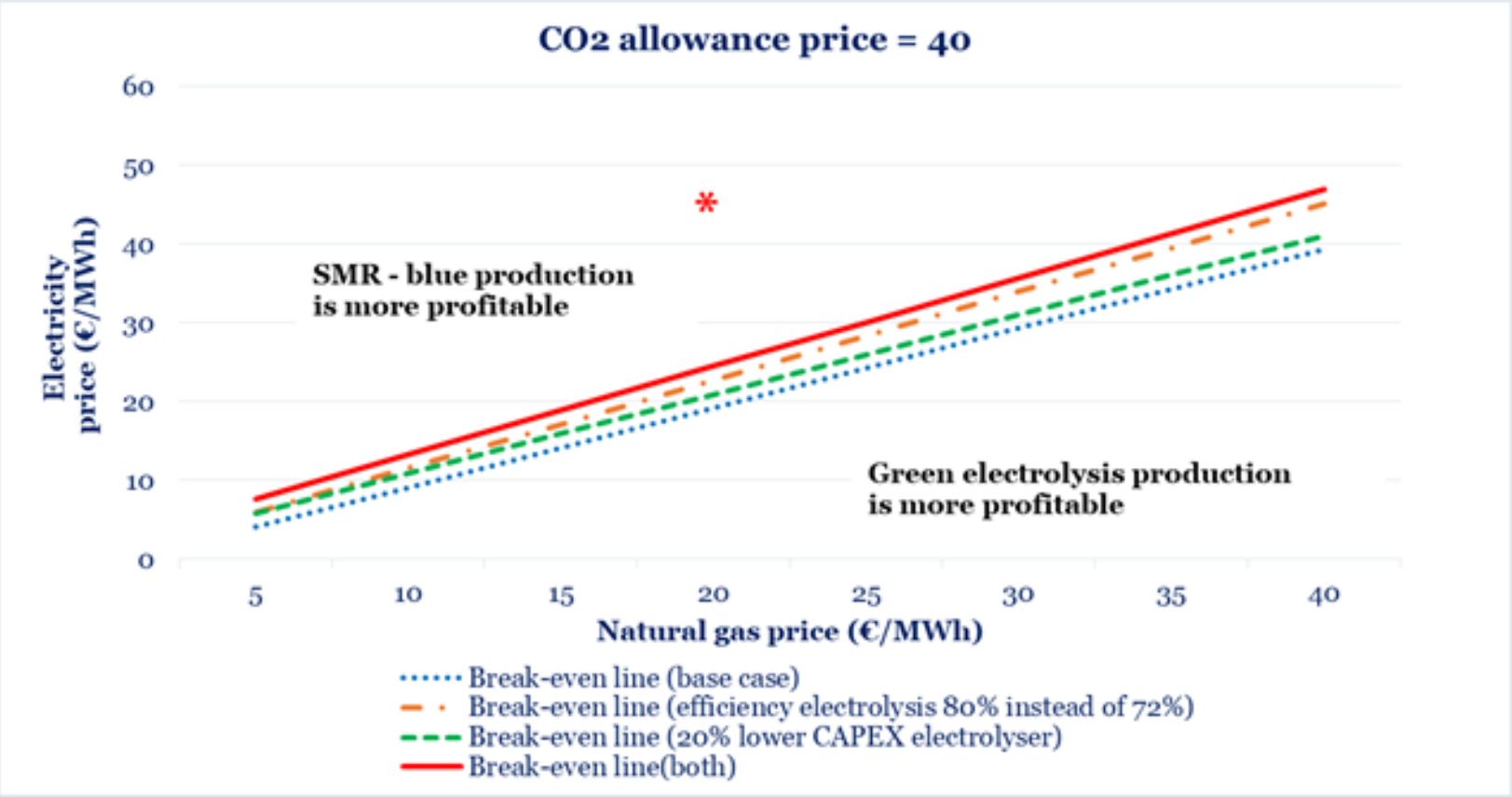
# SMR versus elektrolysis

Elektrolysis-green is only competitive compared to SMR-blue when the price of electricity is low and/or the price of gas is high



# Sensitivity analysis

if efficiency electrolysis plants is 80% instead of 72% and investment costs are 20% lower, than break-even price of electricity is 5 euro/MWh higher



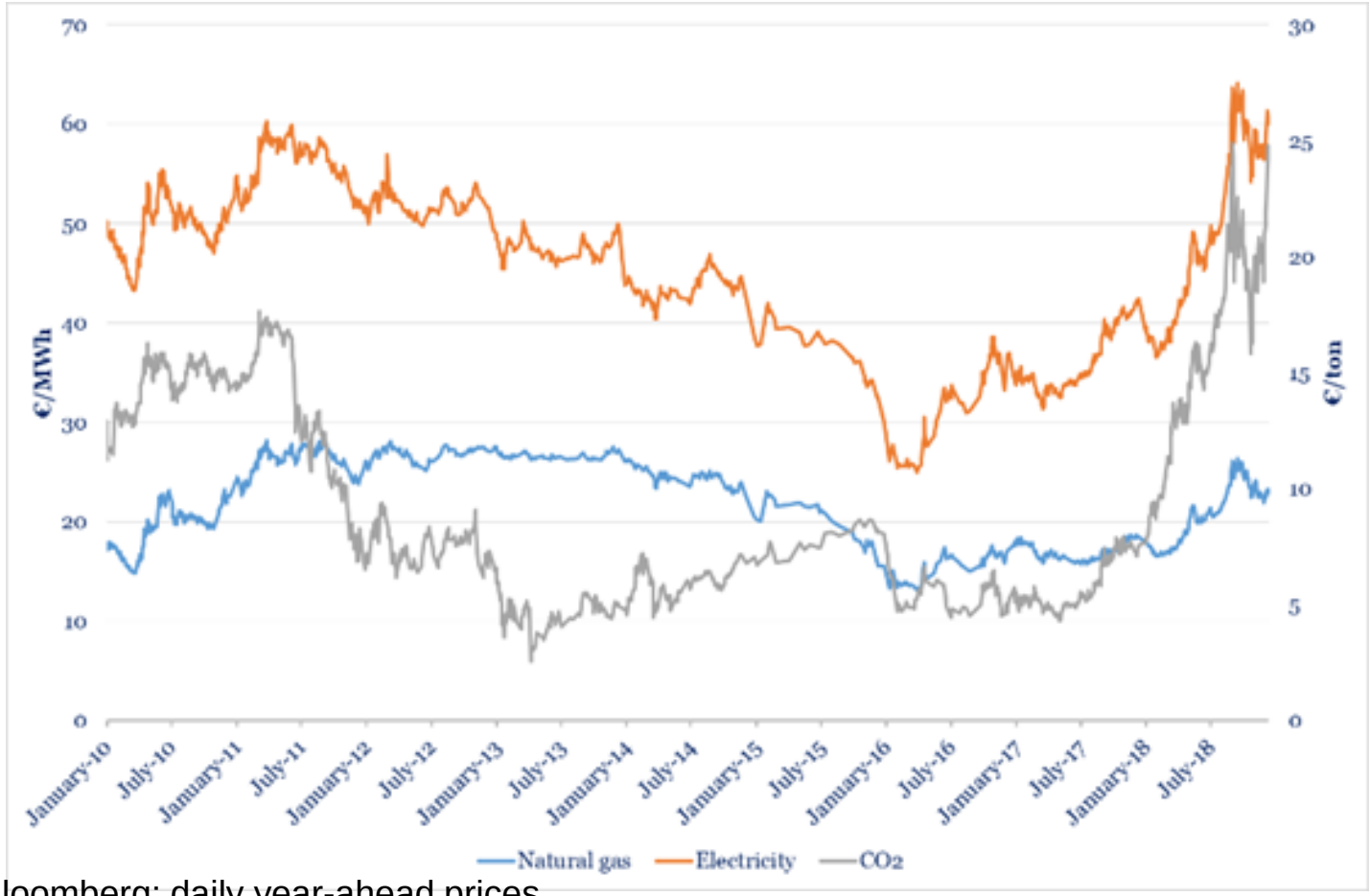
# Does it help to raise the price of $CO_2$?

- If price of $CO_2$ 30 euro/ton: SMR blue is competitive compared to SMR grey
- But: higher price of $CO_2$ makes electrolysis more expensive!


Based on:
Price of gas = 20 euro/MWh
Price of electr= 47euro/MWh

# Price of electricity is closely related to price of gas and $CO_2$

- higher price of $CO_2$ implies higher costs of gas-fired power plants
- these plants are price setting during many hours




Source: Bloomberg; daily year-ahead prices

# Economic effects of offshore sector coupling

1. Producing hydrogen directly from electricity from wind park raises the break-even price in comparison to production based on (onshore) grid connection:

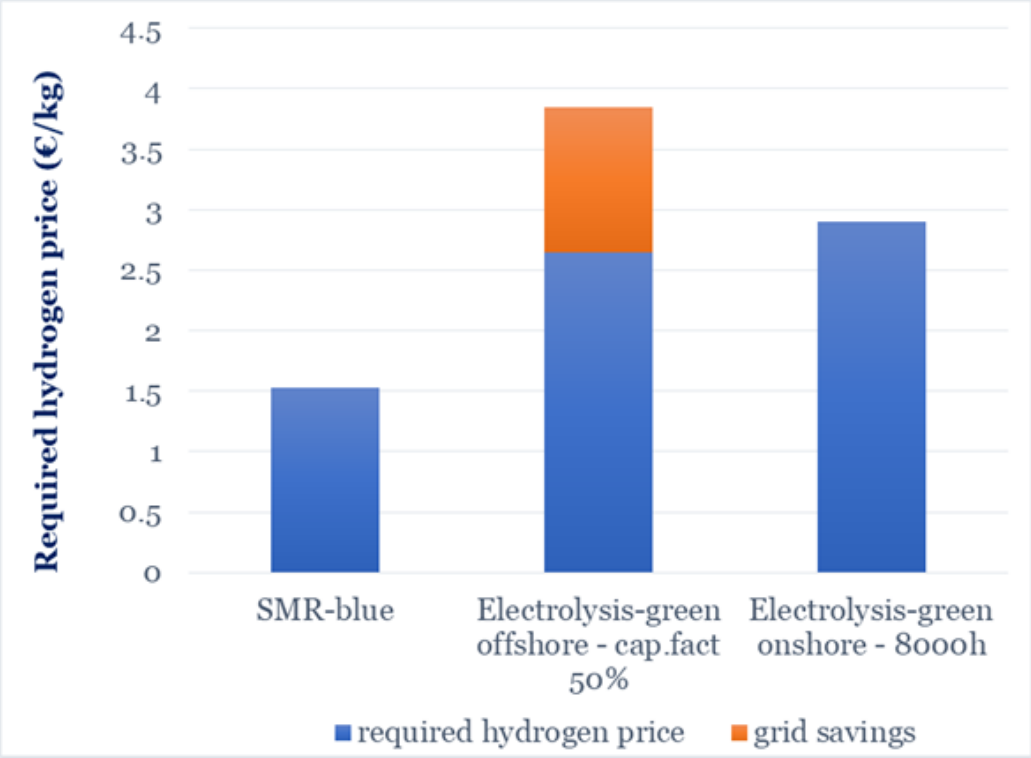
   hydrogen production becomes intermittent:
   - lower utilisation rate = higher CAPEX
   - lower technical efficiency = higher OPEX

2. If existing gas network is used instead of new electricity network, than savings on network costs

   using information on investment and operational costs of offshore grid plus capacity factor of wind production, the network costs are estimated at 20 euro/MWh

# Results

- hydrogen production directly connected to wind farm raises the break-even price
- savings on offshore electricity grid are not sufficient to make offshore hydrogen competitive compared to blue hydrogen



# Conclusions

1. Elektrolysis based on renewable electricity requires low prices of electricity, but investors in wind and solar parks require sufficiently high prices (nobody invests in ‘oversupply’)

2. Offshore elektrolysis may result in lower network costs if existing gas network can be used, but the production costs are higher (lower utilisation, lower efficiency) and electricity price needs to be sufficient to cover costs wind park

3. Blue hydrogen has much lower break-even price than offshore green hydrogen

4. This holds even stronger in case of high CO2 prices: higher prices for CO2 make electrolysis more expensive and Blue hydrogen more attractive than Grey hydrogen

5. Hence, economically, CCS is more attractive than offshore sector coupling

## References

Mulder, Perey and Moraga (2019), Outlook for a Dutch hydrogen market: economic conditions and scenarios, CEER Policy Paper 5, March

van Leeuwen, C., & Mulder, M. (2018). Power-to-gas in electricity markets dominated by renewables. Applied Energy, 232, 258-272. https://doi.org/(...)apenergy.2018.09.217

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