RENEWABLE THERMAL COLLABORATIVE

Green Hydrogen and Power-to-X

Presented by the Renewable Thermal Collaborative

AstraZeneca · Cargill · Kaiser Permanente · Kimberly-Clark · L'Oréal USA · Mars (Tomorrow starts today) · novo nordisk · City of Philadelphia · P&G · Roche · StanleyBlack&Decker · Stonyfield Organic · Unilever · University of California

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TODAY'S SPEAKERS

Blaine Collison
Renewable Thermal Collaborative

Louise Hansen
Advisor
Energinet

Thomas Young Hwan Westring Jensen
Senior Advisor
Wind Denmark

Patrick Molloy
Rocky Mountain Institute
Senior Advisor of Industry and Heavy Transport

AGENDA

RTC Overview- Blaine Collison

Power-to-X and Hydrogen: A European Perspective- Louise Hansen

Why Green Hydrogen Matters: A Wind Perspective- Thomas Jensen

Hydrogen in Industrial Decarbonization- Patrick Molloy

THE RTC'S OBJECTIVES

1. Educate parties about the urgent need to address renewable options for thermal energy.

2. Identify market barriers to renewable thermal technologies.

3. Enable delivery of cost-competitive renewable thermal options.

4. Improve marketplace and financing for renewable thermal technologies.

5. Develop long-term vision for scaling up renewable thermal technologies.

RTC PROJECT HIGHLIGHTS

1. Renewable Thermal Buyers' Statement
2. Renewable Natural Gas/ Power-to-Gas Technology Assessment Plan
3. Biomass Accounting Guidance
4. Renewable Thermal Policy
5. Solar Thermal Technology Assessment
6. Beneficial Electrification

UPCOMING EVENTS

Register today for the first annual Renewable Thermal Collaborative Virtual Summit, taking place on November 9 & 10, 2020.

Look out for new webinars and blogs every month!

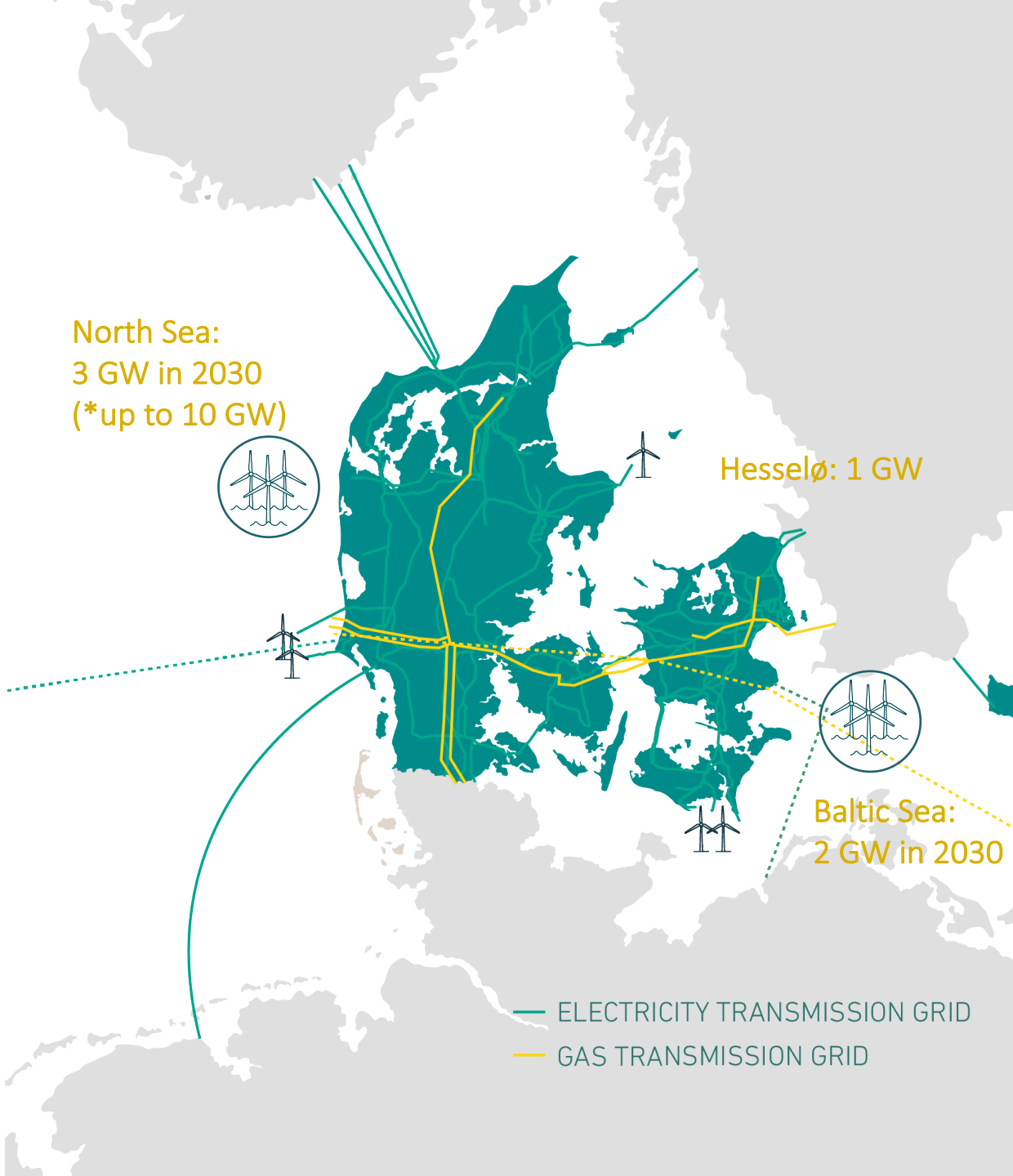
POWER-TO-X AND HYDROGEN

A European perspective

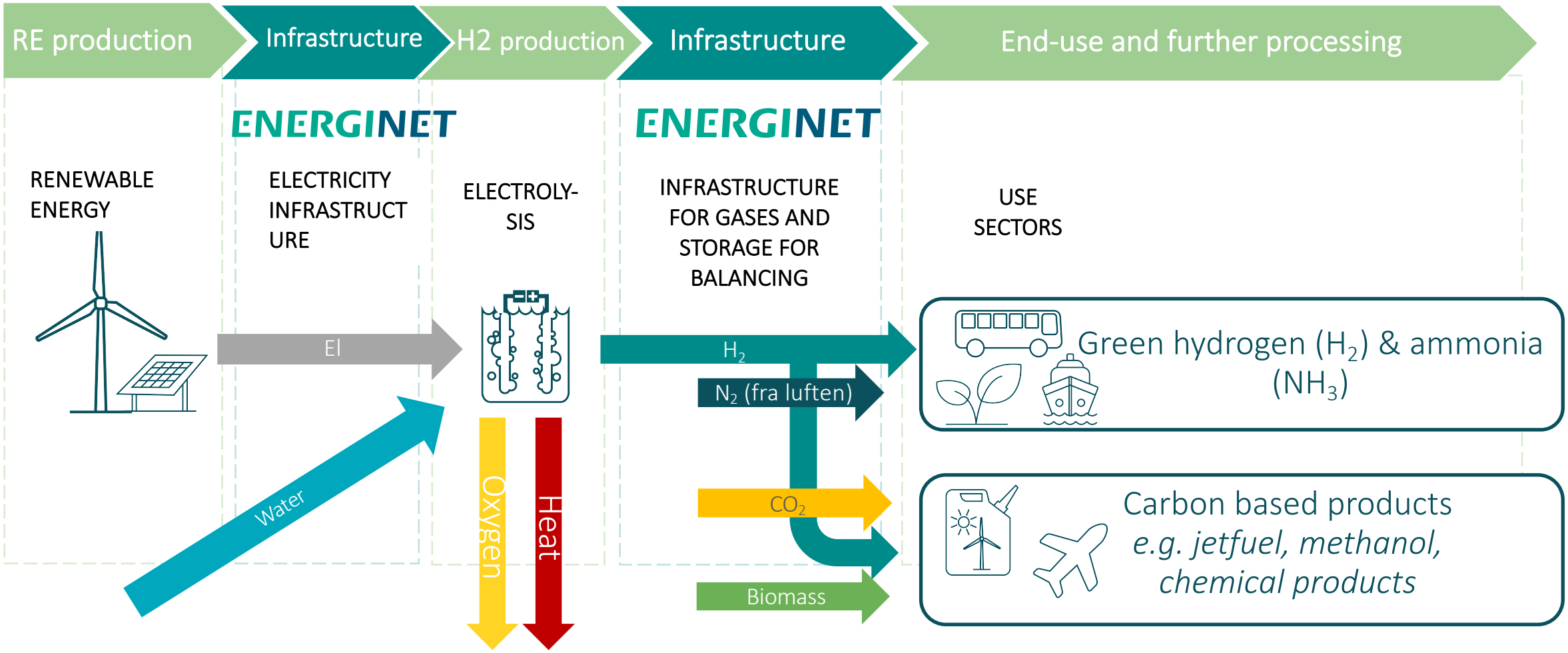
Louise Hansen – lah@energinet.dk
Advisor, Gas System Innovation - Energinet

OFFSHORE WIND DRIVES PTX

- 70 % binding climate reduction target in 2030
- 6 GW offshore wind in 2030
  - End use sectors: Exports of green power, data centres and Power-to-X
- The Netherlands wil fund 100 MW hydrogen factory in Denmark
- Market signals: ~3 GW in 2030



THE PTX VALUE CHAIN



BALANCING THE GRID WITH PTX

Wind and solar in DK i 2019 (ca.)

Onshore	4.325 MW
Offshore and coastal	1.700 MW
PV	1.025 MW
Total	**7.050 MW**

Wind and solar in DK i 2030

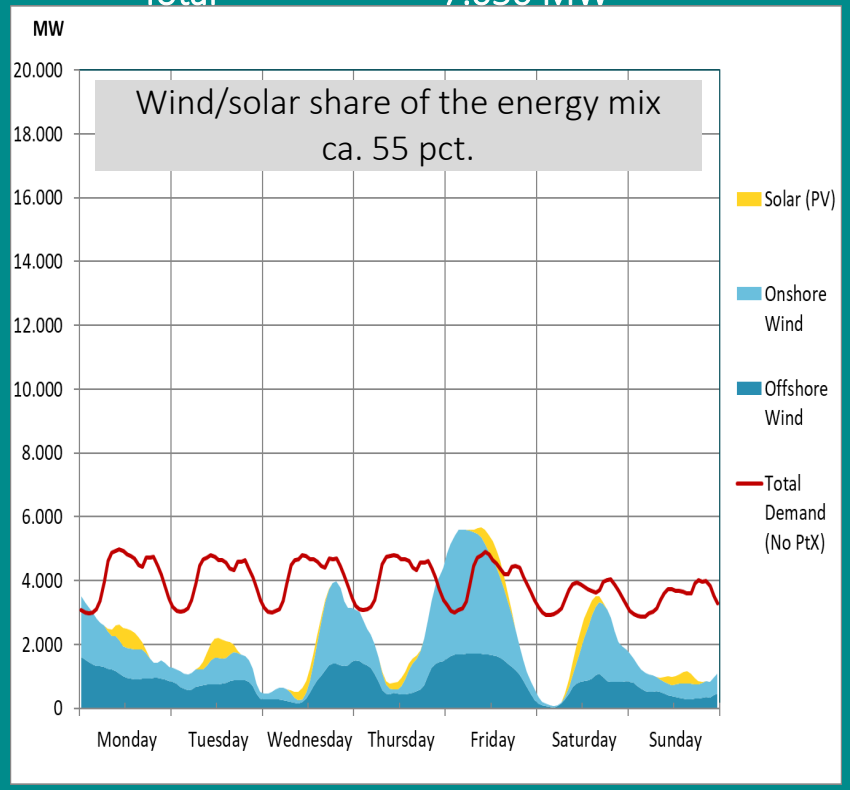
Jf. AF2019

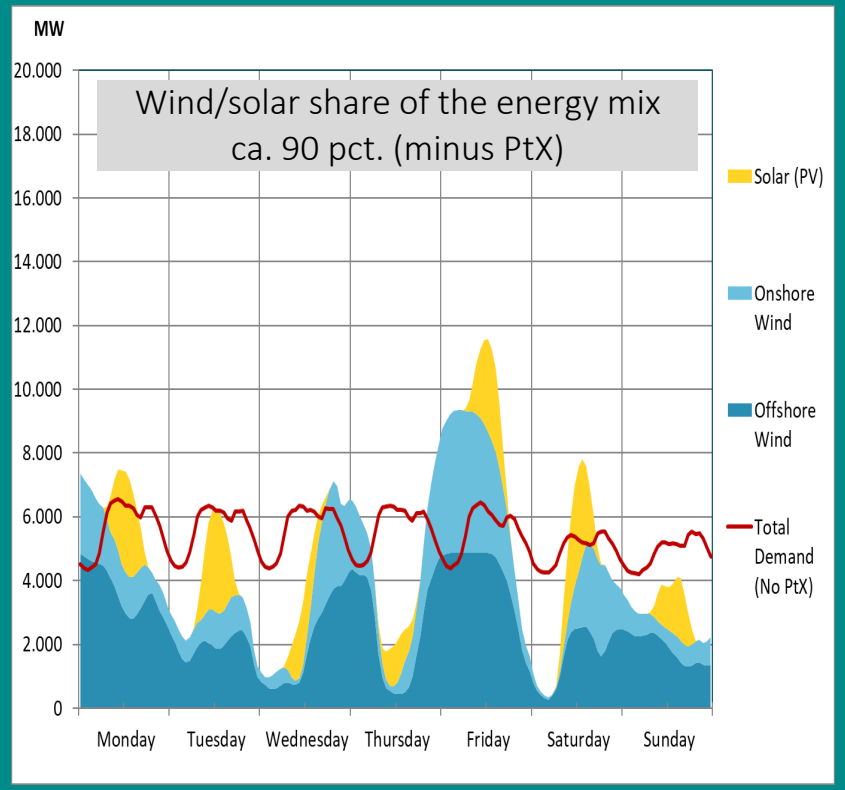
Ohshore	4.600 MW
Offshore and coastal	4.900 MW
PV	4.900 MW
Total	**14.400 MW**

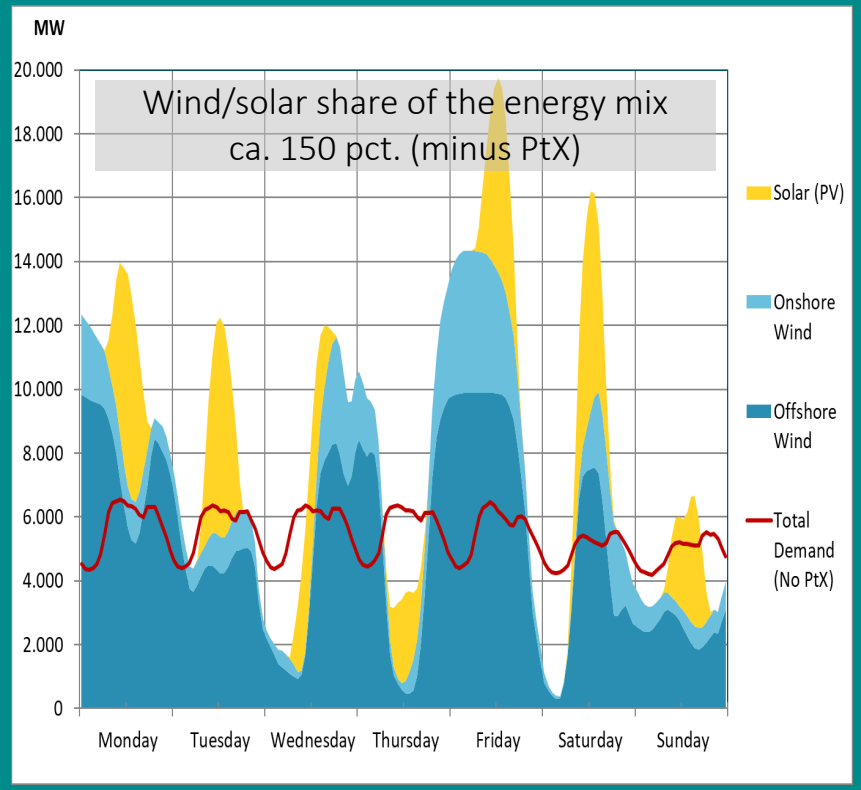
Wind and solar in DK in 2030 (+10 GW)

Jf. AF2019 + 5 GW offshore and 5 GW solar

Onshore	4.600 MW
Offshore and coastal	9.900 MW
PV	9.900 MW
Total	**24.400 MW**





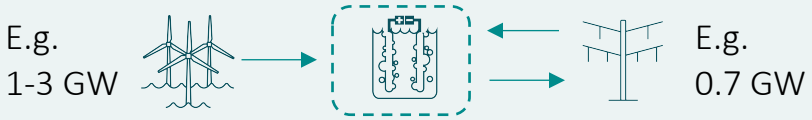


PLANNING LARGE SCALE PTX

How do we exploit the full potential?

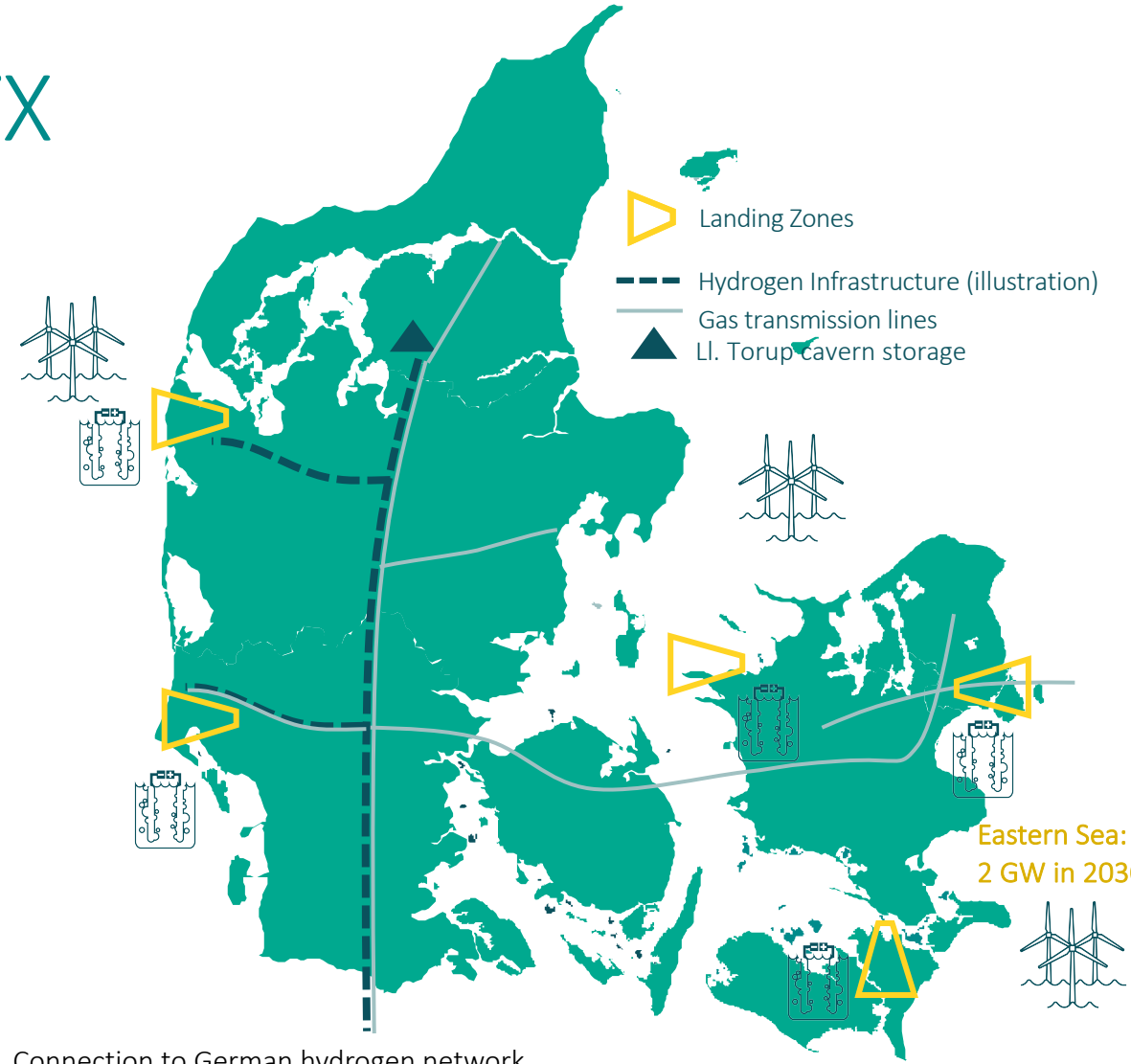
LANDING ZONES

- A ”buffer- and conversion zone” between large scale feed in of RE and the common AC-power grid



H2 INFRASTRUCTURE

- Make it possible to efficiently decouple hydrogen production (electrolysis) and hydrogen consumption in time (storage) and geography (pipes).

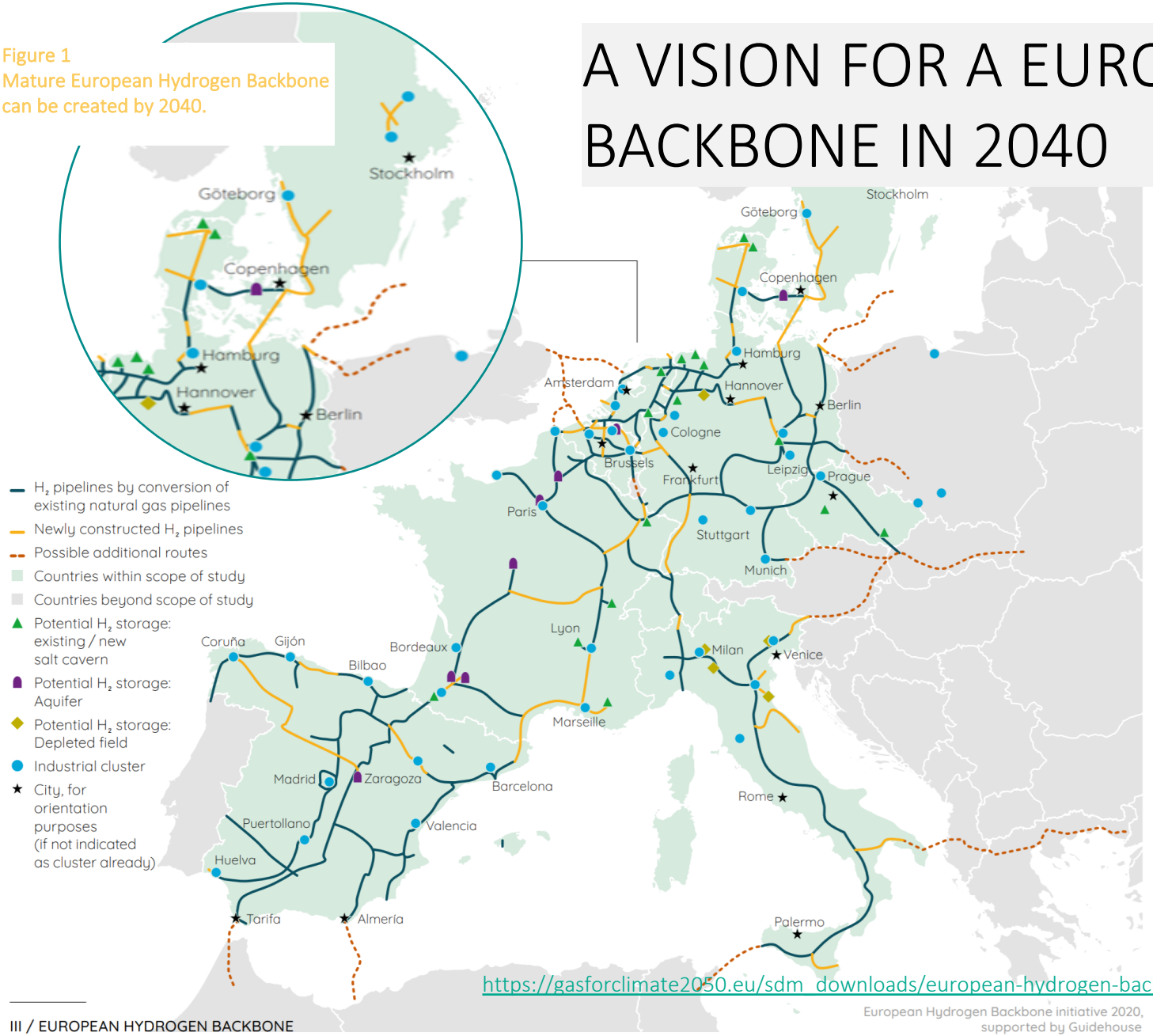


EUROPEAN COMMISSION ANNOUNCES HYDROGEN STRATEGY (JULY 2020)

Commissioner of Energy Kadri Simson speaks at a press conference in Brussels on 8 July 2020. Source: Euractiv

A VISION FOR A EUROPEAN HYDROGEN BACKBONE IN 2040

Figure 1
Mature European Hydrogen Backbone can be created by 2040.



1. Identifying RES hotspots

2. Connecting industrial clusters with an infrastructure backbone that runs thru Europe

3. Retrofitting existing gas infrastructure

https://gasforclimate2050.eu/sdm_downloads/european-hydrogen-backbone/

European Hydrogen Backbone initiative 2020, supported by Guidehouse

THANK YOU FOR YOUR TIME

lah@energinet.dk

Why green hydrogen matters

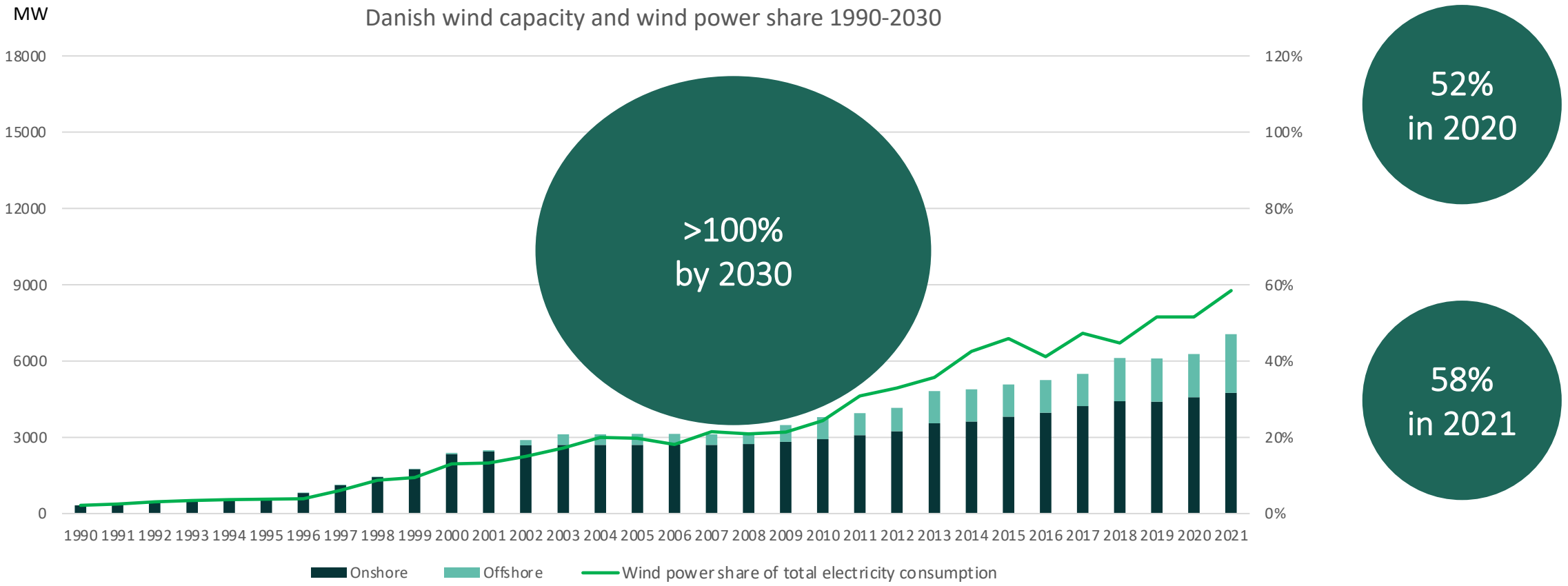
- From a wind perspective

Thomas Hwan Jensen, Senior Advisor, tyj@winddenmark.dk

27.10.2020

wind denmark

World record in share of wind in electricity consumption



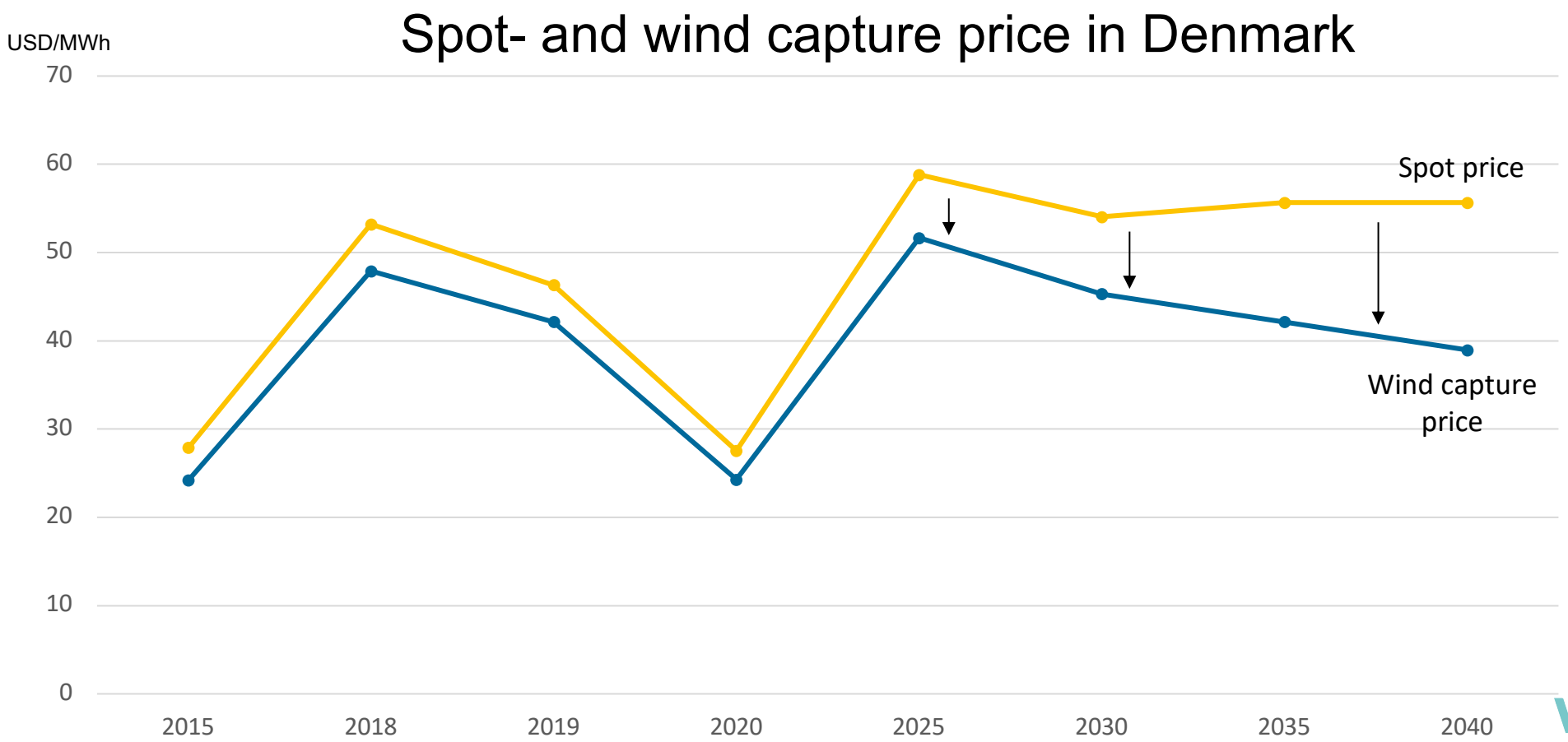
wind denmark

Source: Wind Denmark based on historical data and analysis conditions 2020

New Climate Agreement includes 6GW offshore wind and two energy islands

wind denmark

Bulk renewable energy will result in a downward pressure on the settlement price unless…



Source: Wind Denmark based on historical market data and analysis conditions 2020

…sector integration happens as it is instrumental to accelerate the realisation of merchant renewable energy projects

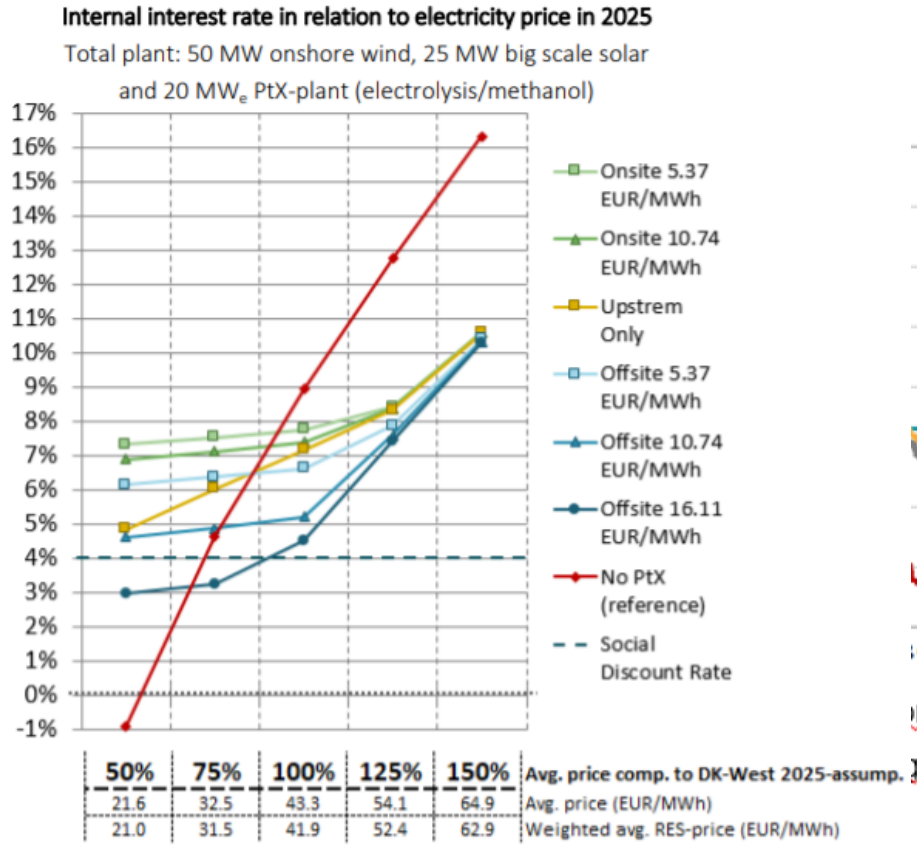
Hedging potential

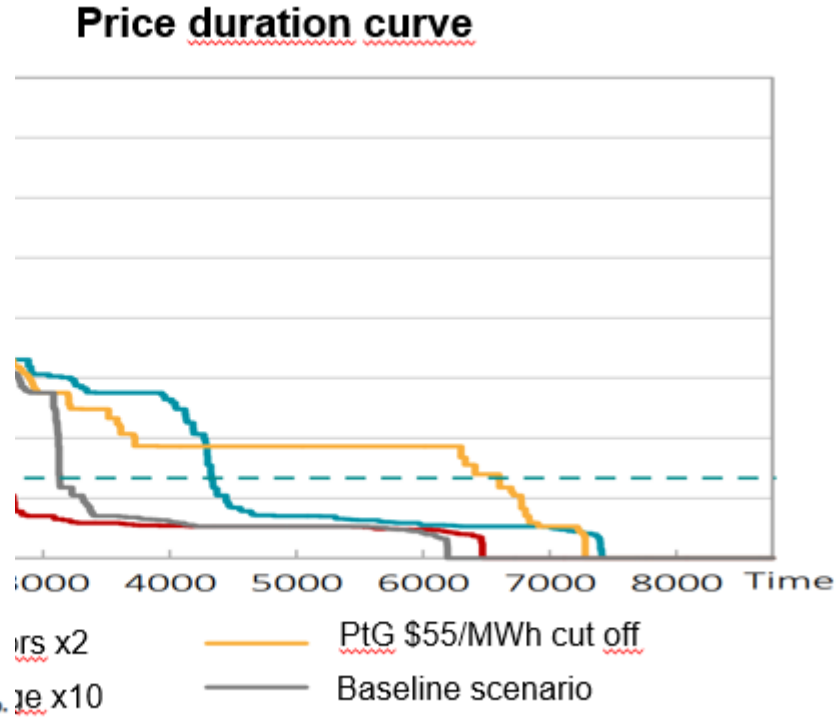
Direct electrification

Hard to decarbonise sectors

LCFS Weekly Snapshot	
Transfer Type	
Average Price [3] ($/MT)	
Price Range ($/MT)	$
Total Volume (MT)	
Total Value ($)	

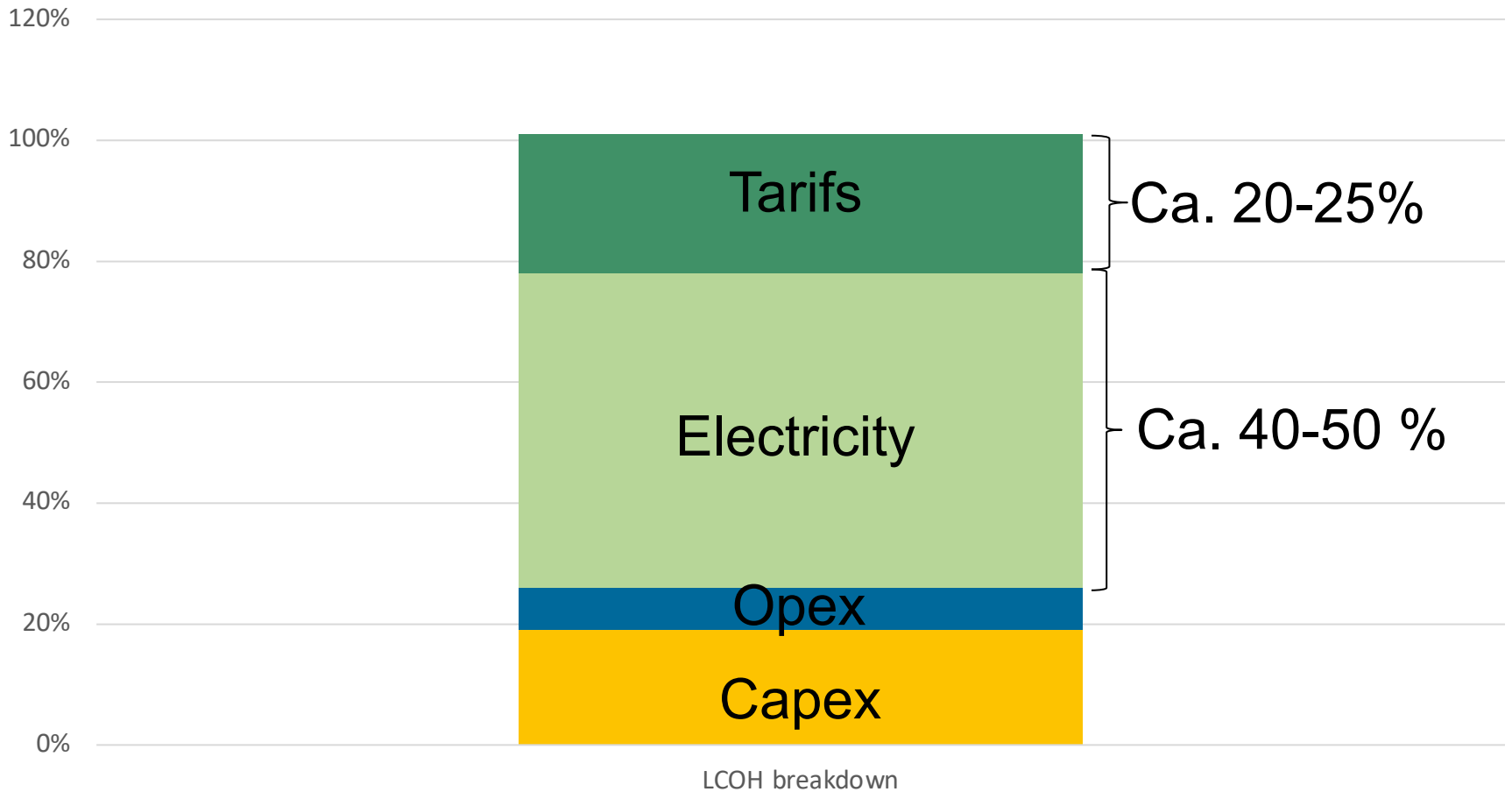
/ includes transfers that were completed in th





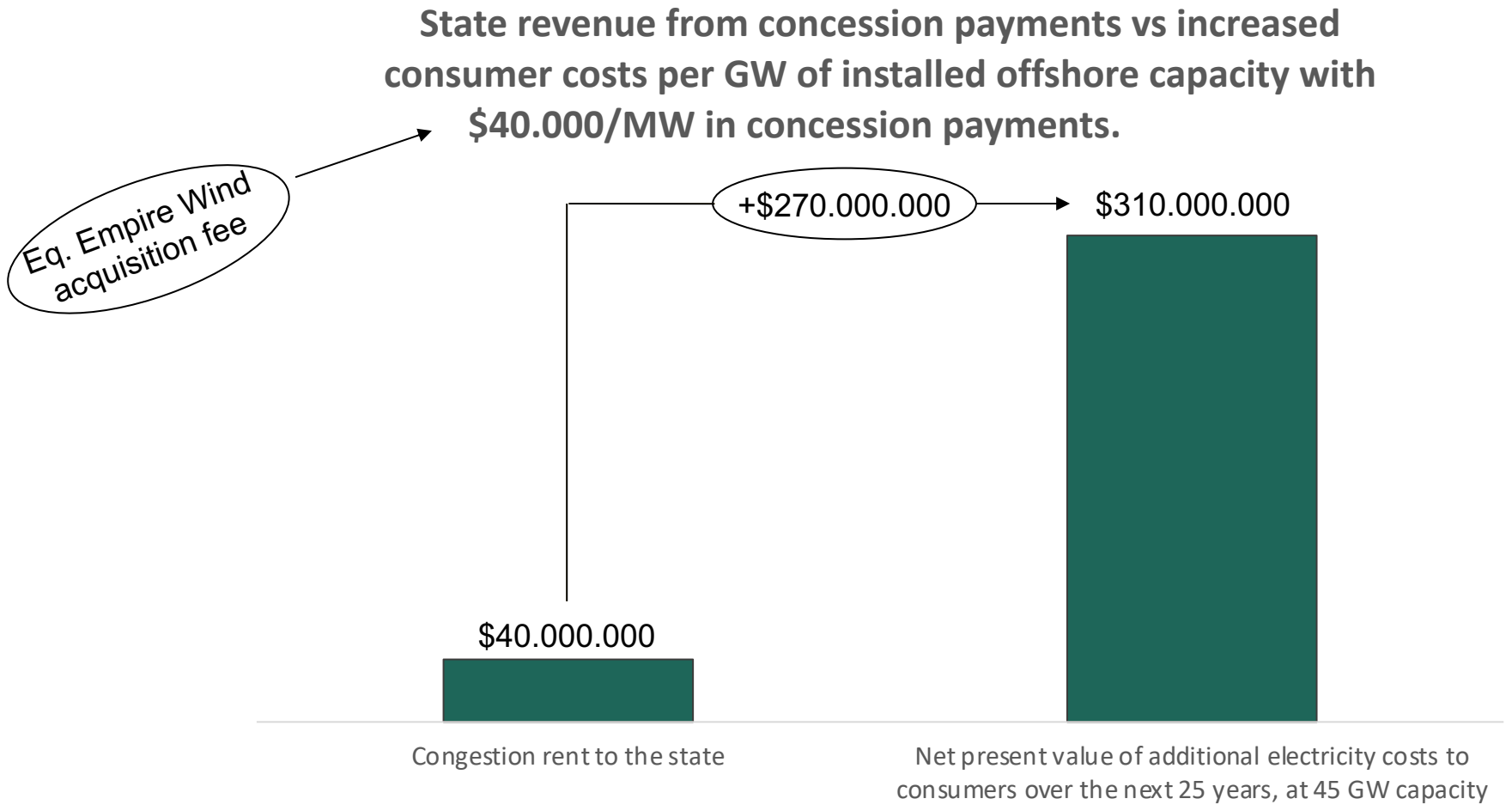
Source: Wind Denmark based on LCFS average LCF price; Energinet PtX in Denmark before 2030 & System Perspective 2035

Cost breakdown of hydrogen



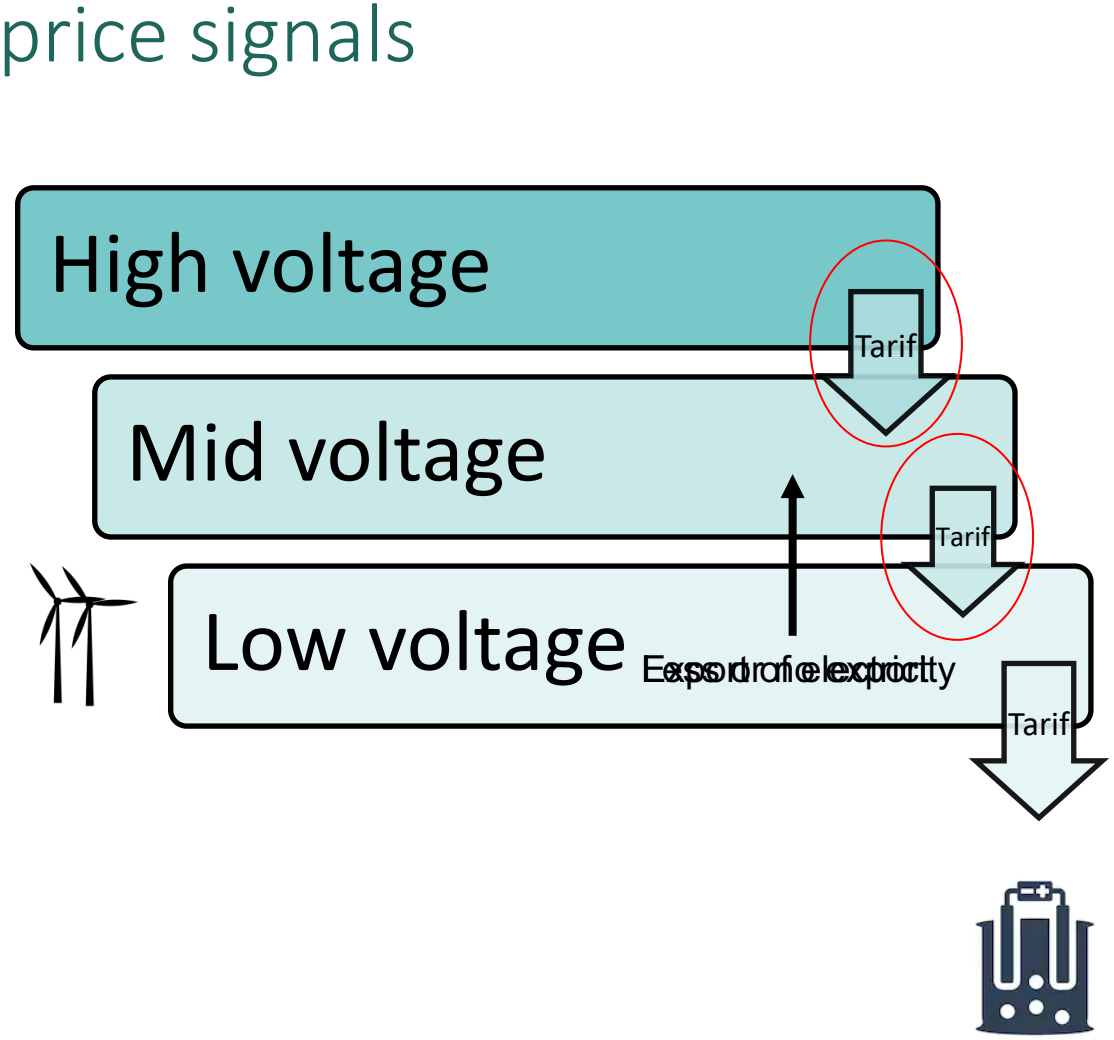
Source: Wind Denmark estimation

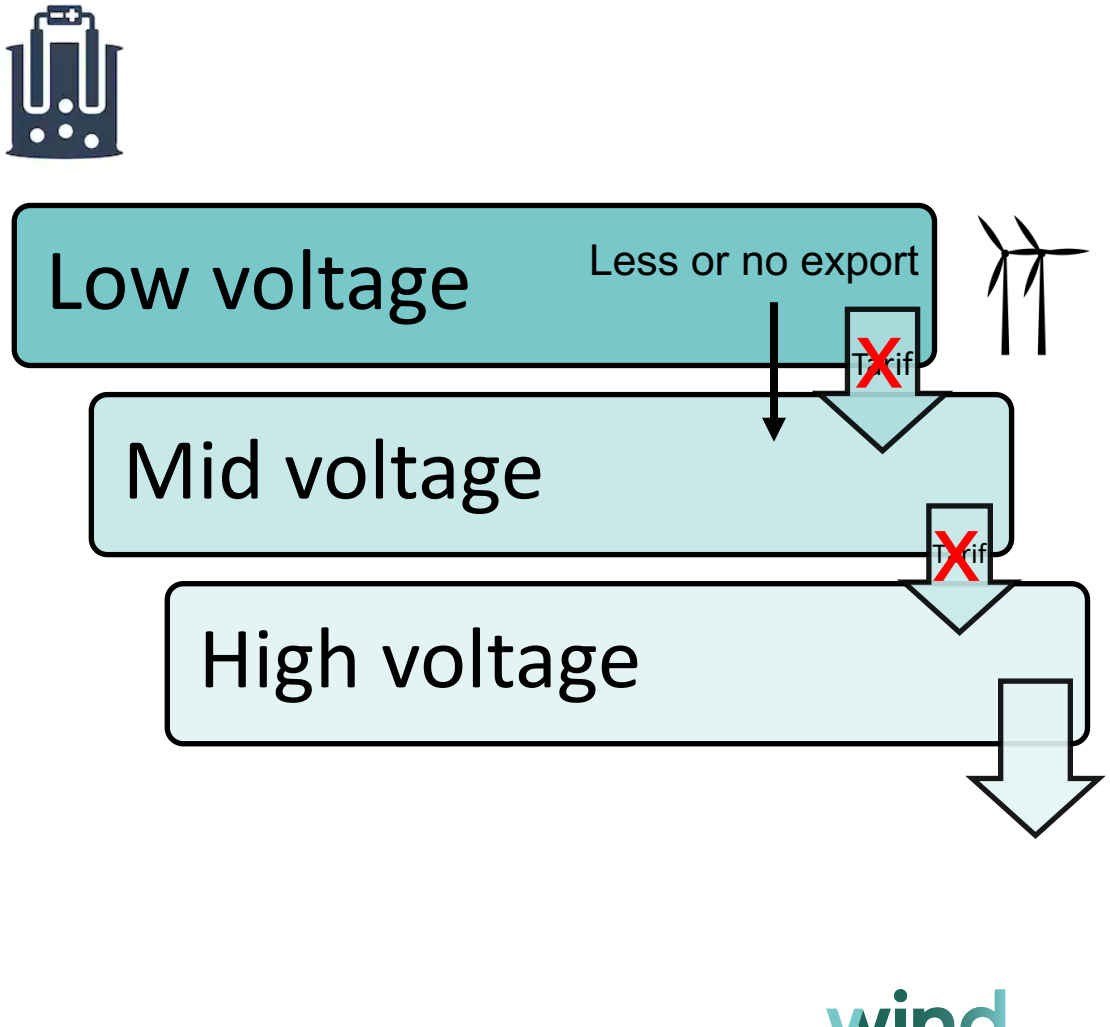
Acquisition fees will increase consumer cost, thus also hydrogen



Source: Wind Denmark from a yet to be published analysis based on the projected electricity consumption in Denmark by 2050

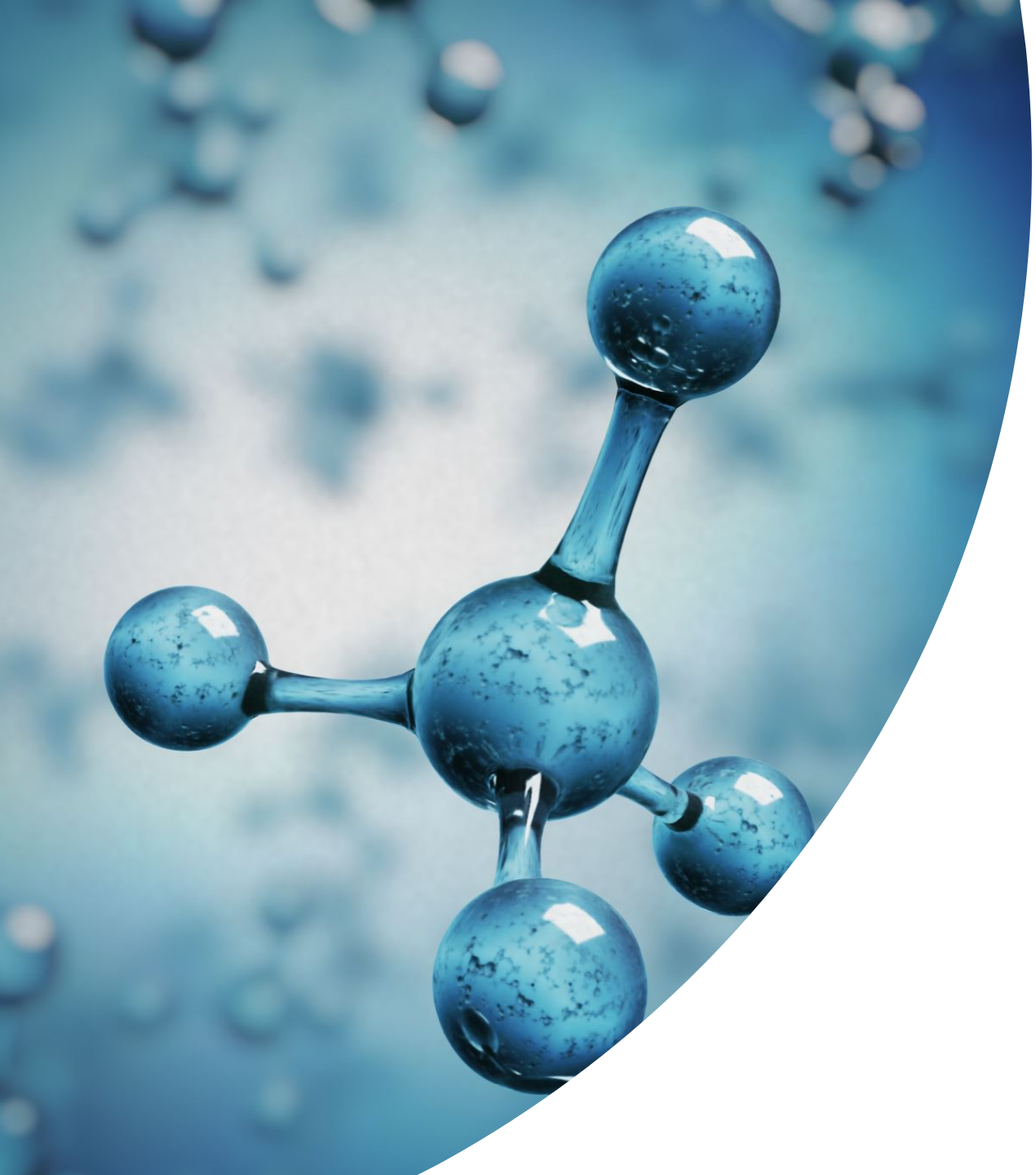
Tariffs needs to be cost reflective in order to provide the correct price signals





Thank you for your attention!

wind denmark



HYDROGEN IN INDUSTRIAL DECARBONIZATION

Patrick Molloy

Industry and Heavy Transport Program

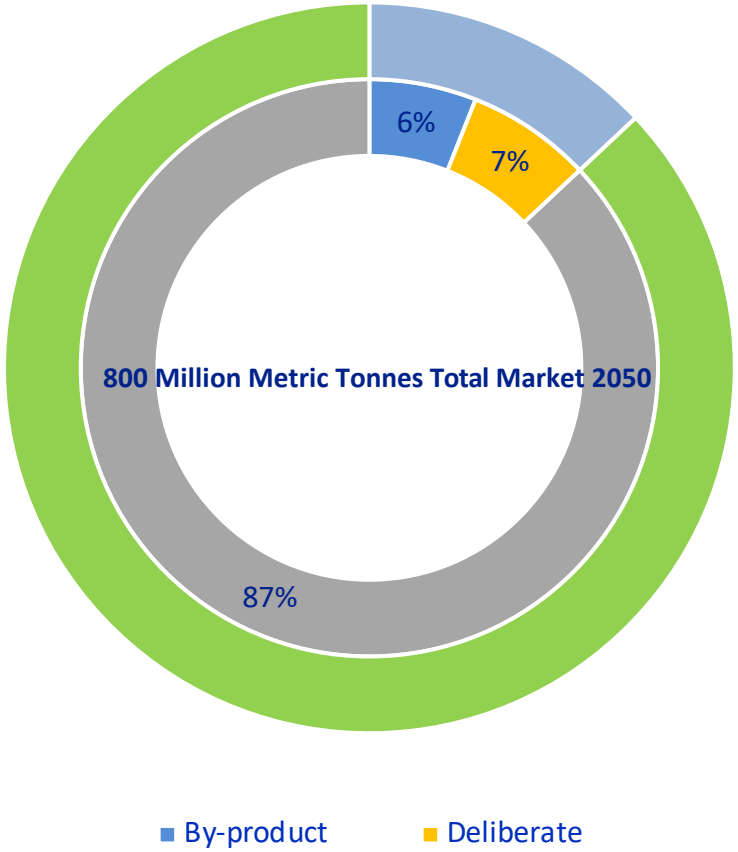
SO WHY RENEWABLE HYDROGEN PRODUCTION?

- Estimated 2% of global CO2 emissions come from current hydrogen production (~830 million tonnes CO2)
  - –Equivalent to the CO2 emissions of Indonesia and the United Kingdom combined

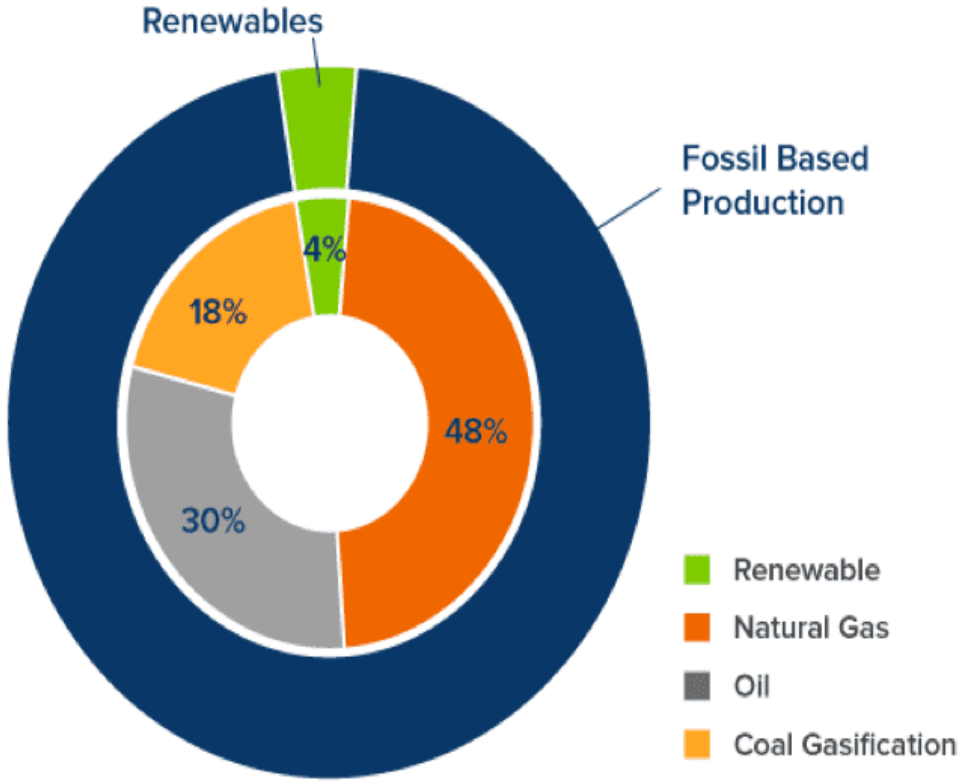
- All major decarbonization studies and reports including, ETC's Mission Possible, Shell's Sky Scenario, IEA 2 degree Scenario, project a massive increase in the amount of hydrogen required and in new industrial applications

CURRENT VS EXPECT FUTURE PRODUCTION REQUIRED

The 2050 Hydrogen Market



Hydrogen Production as % of Total Metric Tonnes



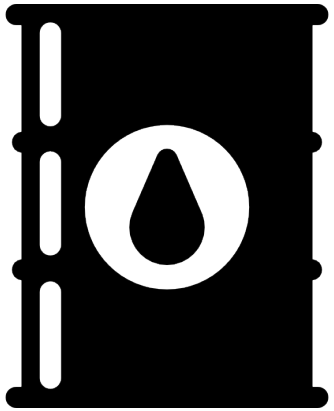
RMI: `https://rmi.org/the-truth-about-hydrogen/, ETC Mission Possible, Estimated Market and IRENA Deliberate and By-product production

SO HOW HAVE/DO WE CONSUME ENERGY?

AND WHERE DOES HYDROGEN FIT IN?

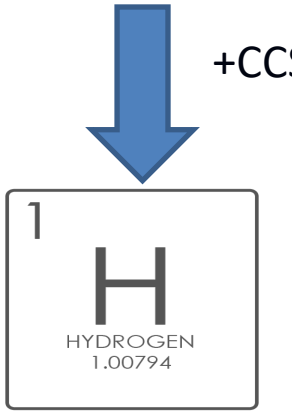
Long chain carbon molecules

Mixed chain carbon molecules



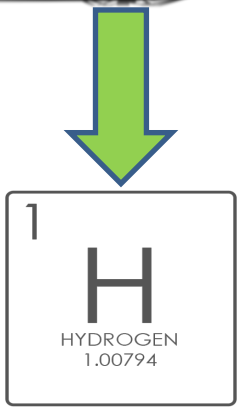
A single carbon molecule

+CCS



Low carbon production

Zero carbon electrons

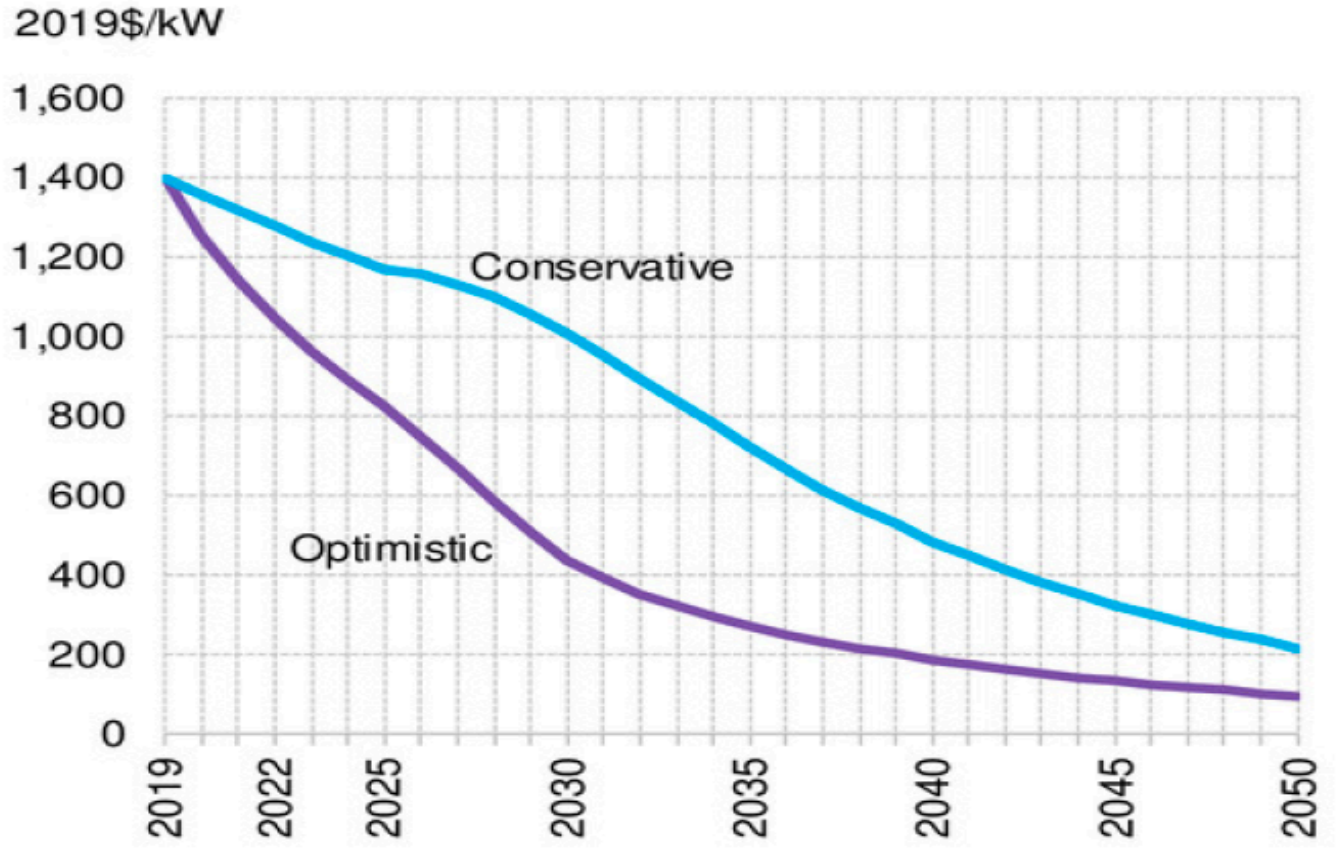


Zero carbon production

COST AND QUEST

BNEF REPORTS AN OPTIMISTIC FUTURE

- Estimates that Electrolysis costs will fall substantially
  - –Specifically CAPEX declines
  - –Increasing availability of the renewable energy
- The implications of these declines are:
  - –Range of $1.4-2.9/kg by 2030
  - –Range of $0.8-1/kg by 2050



Source: BloombergNEF.

BNEF: Hydrogen: The Economics of Production From Renewables

WHAT PROJECTS AND WHAT SIZES ARE WE SEEING?

Australia backs desert project to export green hydrogen to Asia

Canberra shifts focus from fossil fuels to supporting world's biggest solar and wind farm

Meridiam buys 60% in PV-plus-hydrogen project in French Guiana

Air Liquide selects Hydrogenics for 20MW electrolyzer for hydrogen production; largest PEM electrolyzer in world

26 February 2019

Air Liquide will build in Canada the largest PEM (Proton-Exchange Membrane) electrolyzer in the world with a 20 megawatts (MW) capacity for the production of low-carbon hydrogen (the facility will use hydropower).

ITM Power begins construction on world's largest hydrogen refinery in Germany

By **DANIEL BRIGHTMORE** · Jun 30, 2019, 6:48PM

BP, Nouryon and Port of Rotterdam partner on green hydrogen study; 250 MW electrolyzer

29 April 2019

Hyperdrive

China's Hydrogen Vehicle Dream Chased With $17 Billion of Funding

Bloomberg News

June 27, 2019, 5:00 PM EDT *Updated on June 28, 2019, 12:00 AM EDT*

BEIS has also announced £350m of new funding alongside the grants – £100 million for a competition to boost hydrogen production and £250m for a new Clean Steel Fund

Pilbara green hydrogen project grows to 15GW wind and solar

Giles Parkinson 12 July 2019 0 Comments Share

WHAT PROJECTS IN THE US?

NextEra Energy to Build Its First Green Hydrogen Plant in Florida

Largest U.S. renewables generator "really excited" about green hydrogen, reveals plans for $65 million pilot plant for Florida Power & Light.

Combined Cycle, Emissions, Energy Storage, Gas

Entergy, Mitsubishi Power partnering on decarbonizing power fleet via hydrogen, energy storage

Rod Walton, Clarion Energy Content Directors 9.28.20

Microsoft tests hydrogen fuel cells for backup power at datacenters

July 27, 2020 | John Roach

ZeroAvia Completes Test Flight Of Hydrogen Fuel Cell Powered Passenger Airplane

September 28th, 2020 by Steve Hanley

The Hyperion XP-1 Has Landed! First Look At The Futuristic Hydrogen-Powered Electric Supercar

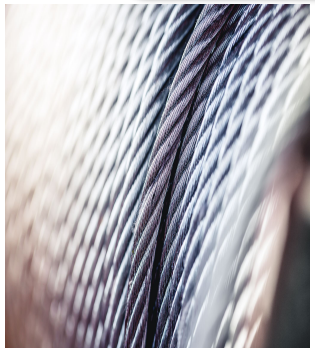
August 12th, 2020 by Kyle Field

BUSINESS / CORPORATE

Toyota adds to hydrogen bet with North American fuel cell truck

USES FOR HYDROGEN FOR INDUSTRIAL USERS

Feedstock



- Substitution in steel manufacturing
- Decarbonization of ammonia feedstock

Backup Power

- Longer duration storage and capacity match load requirements directly
- PEM faster ramping
- Alkaline typically larger but slower ramp

Combined Heat Power

- Solid Oxide Fuel Cell, operates at ~750° - 1000°C exhaust temperature ~300 Celsius (567.68 F and 570.75 K)
- PEM, Operates at ~65° - 85°C
- Alkaline, ~90° - 260°C Celsius operating temperature

VALUE OF USING H2 SYSTEMS IN INDUSTRY

- Opportunity to decarbonize some of the most substantial industrial challenges
- Opportunity to provide callable generation resources
- Zero carbon resiliency systems
- Potential to integrate CHP systems


THANK YOU

RENEWABLE THERMAL COLLABORATIVE

QUESTIONS?

ENTER YOUR QUESTIONS IN THE BOX AT THE BOTTOM OF YOUR SCREEN

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Presented by the Renewable Thermal Collaborative

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