SECURETY OF SUPPLY

HOW TO ENSURE SECURITY OF SUPPLY IN AN ENERGY SYSTEM BASED ON RENEWABLE ENERGY SOURCES

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ENERGINET

THE ENERGY BACKBONE

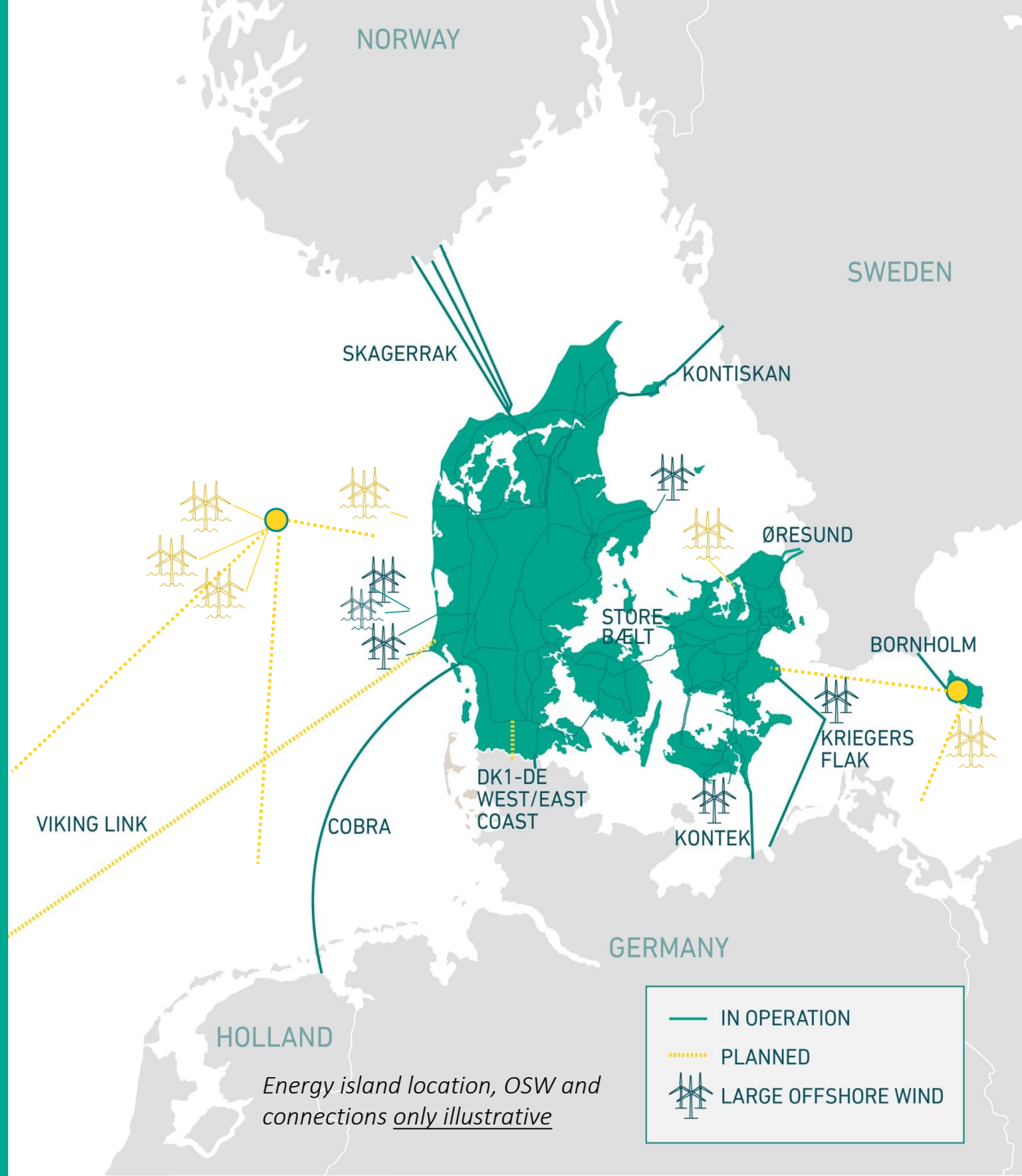
We operate and develop the transmission grids and gas pipelines in Denmark.

ENSURE BALANCE

We have the day-to-day and long-term responsibility for the overall electricity and gas system in Denmark.

WORKING FOR THE SOCIETY

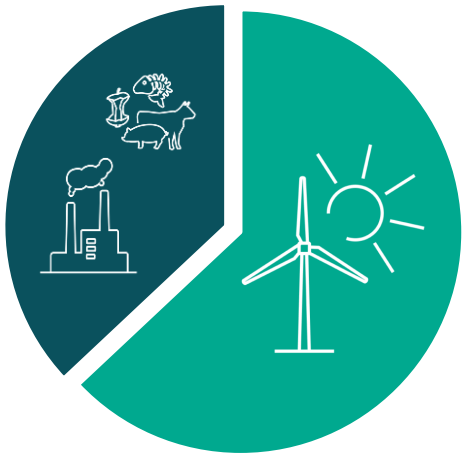
Owned by the Danish Ministry of Climate, Energy and Utilities we safeguard society's interests as we move to a 100% green energy system.



A FUTURE WITH A GREEN ELECTRICITY SECTOR

Forecasted development in Denmark's electricity mix

2022



37,4 TWh
Wind & Sun: 63 pct. of electricity consumption

2030

60,5 TWh
Wind & Sun: 86 pct. of electricity consumption

2040

83,8 TWh
Wind & Sun : 117 pct. of electricity consumption

Challenges

- Massive, local RE production
- Energy Islands

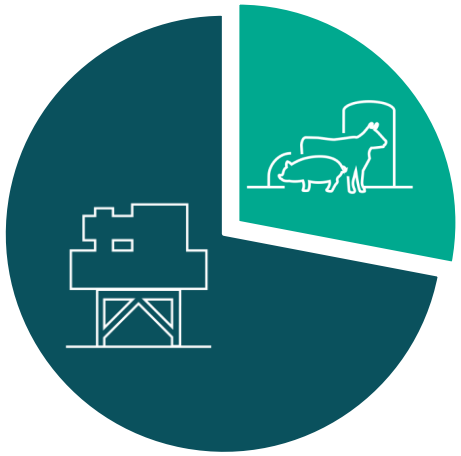
Opportunities

- Aggregators
- Energy Islands
- Offshore SO

A FUTURE WITH A GREEN GAS SECTOR

Forecasted development in Denmark's gas consumption

2022



12,3 TWh
RE: 28 pct. of domestic gas consumption

2030

16,6 TWh
RE: 75 pct. of domestic gas consumption

2040

12,3 TWh
RE: 123 pct. of domestic gas consumption

Challenges

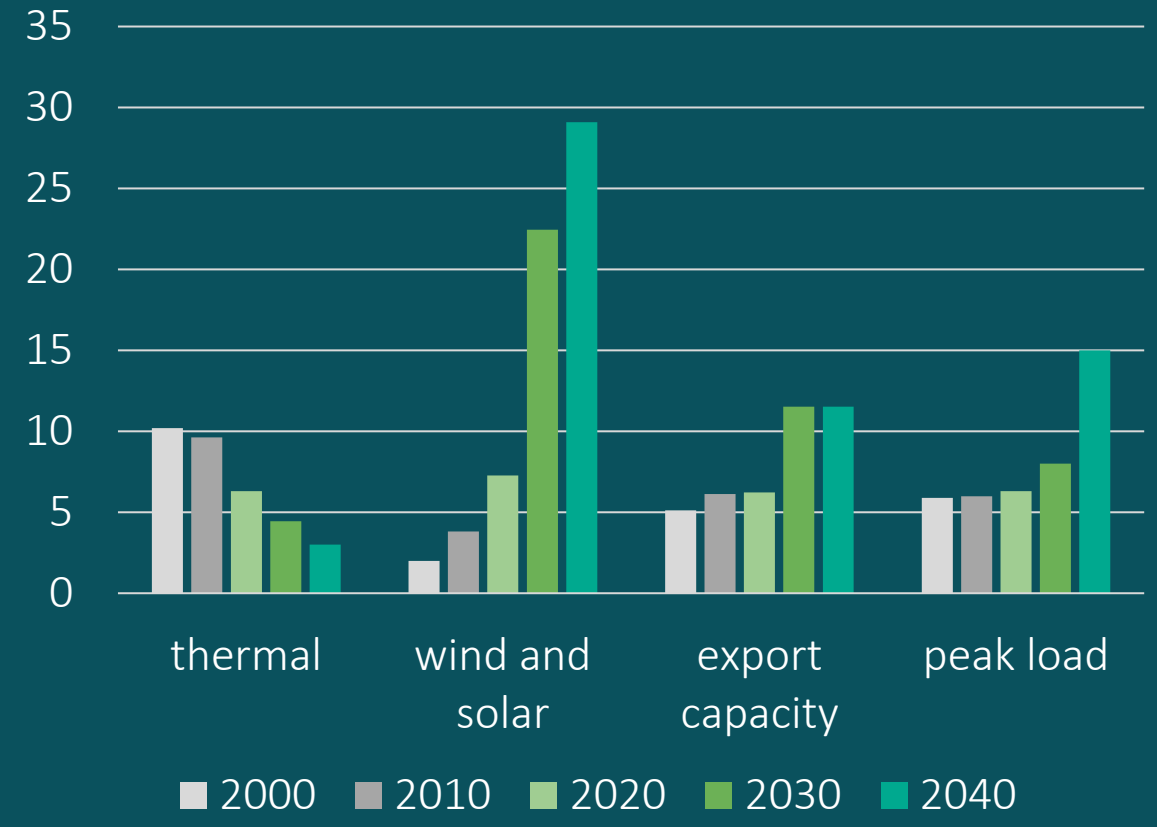
- Natural gas is not 100 pct. green
- Decreasing gas consumption
- Local surpluses of biogas

Opportunities

- Biomethane at 70 pct.
- Baltic Pipe utilize existing grid and support Polish green transition
- Heavy industry as gas consumers
- PtX and Hydrogen

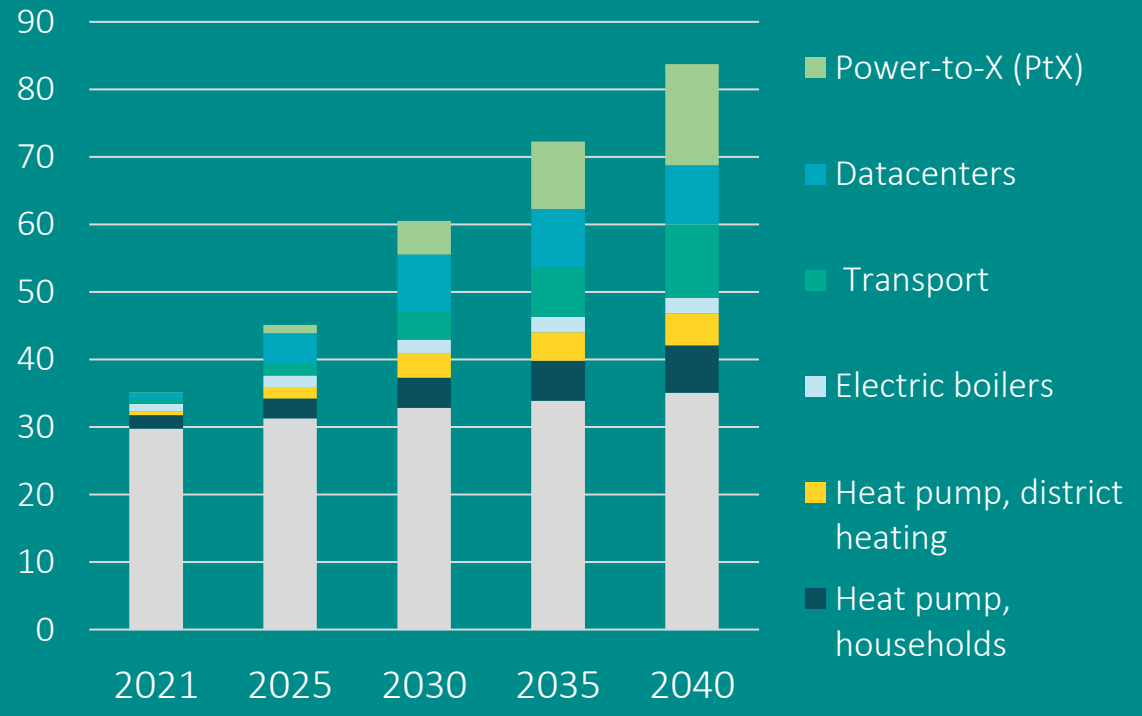
WHAT HAS BEEN ACHIEVED IN THE LAST 20 YEARS ACCELERATES TOWARD 2040

Electricity generation and peak capacity, GW



ELECTRIFICATION DRIVES THE CHANGE TO A CLIMATE NEUTRAL ENERGY SYSTEM

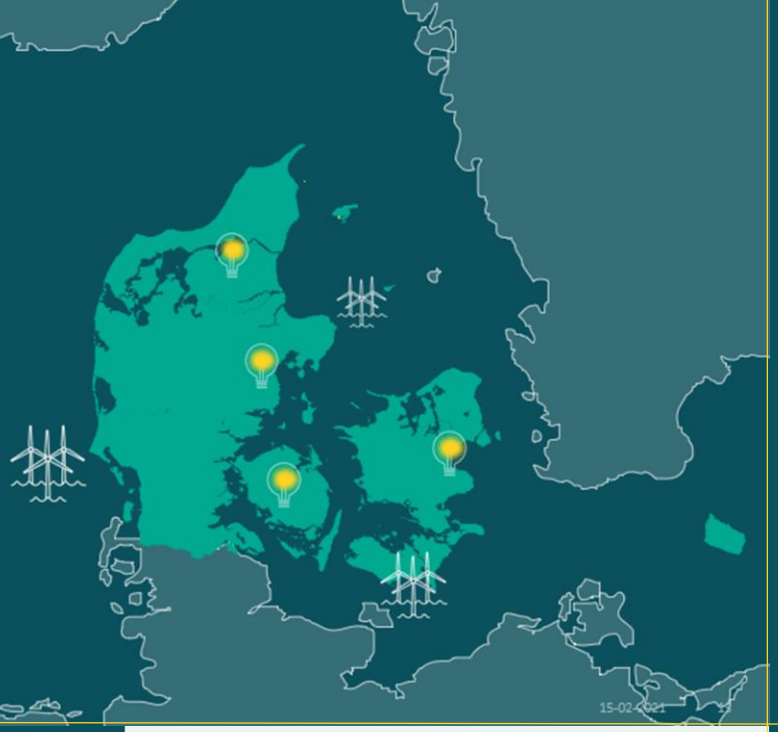
Electricity consumption, TWh



Source: Danish Energy Agency

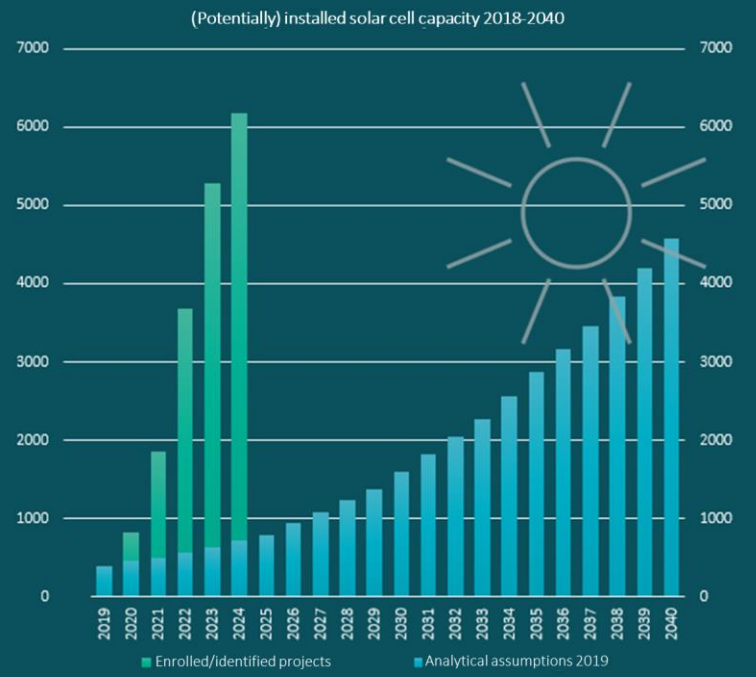
GEOGRAPHY

PRODUCTION AND CONSUMPTION
ARE GEOGRAPHICALLY SEPARATED



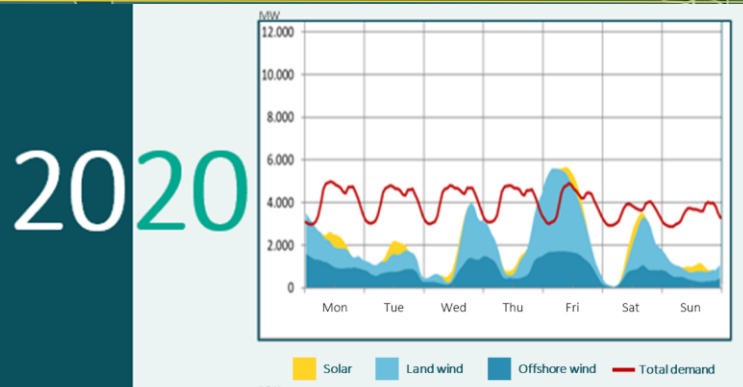
UNPREDICTABILITY

HIGH UNCERTAINTY
AND GREAT COMPLEXITY



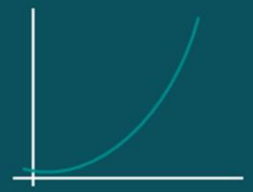
ASYNCHRONOUS

CONSUMPTION AND PRODUCTION
ARE NOT SYNCHRONIZED



SPEED

RE-EXPANSION, INCREASED
CONSUMPTION AND NEW TECHNOLOGIES



Expansion of
renewable energy sources

Increasing
electricity consumption

Emerging tecnologies

New business models

GEOGRAPHY

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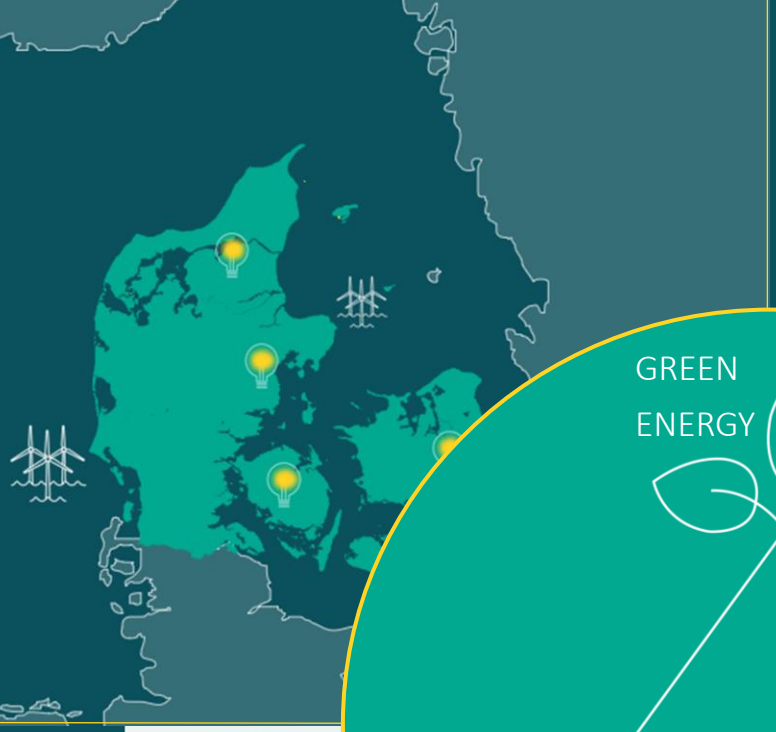

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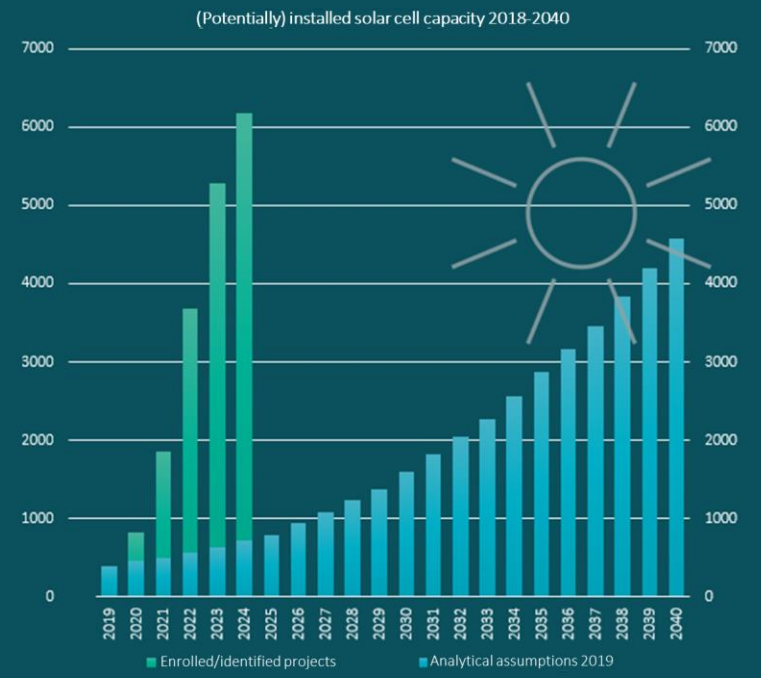
UNCERTAINTY
COMPLEXITY



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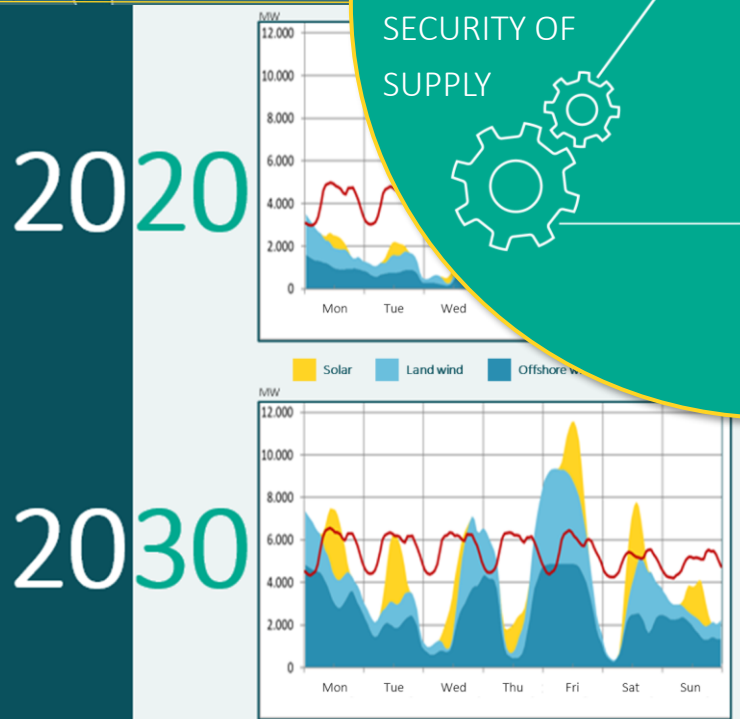

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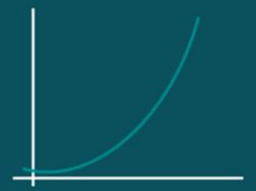
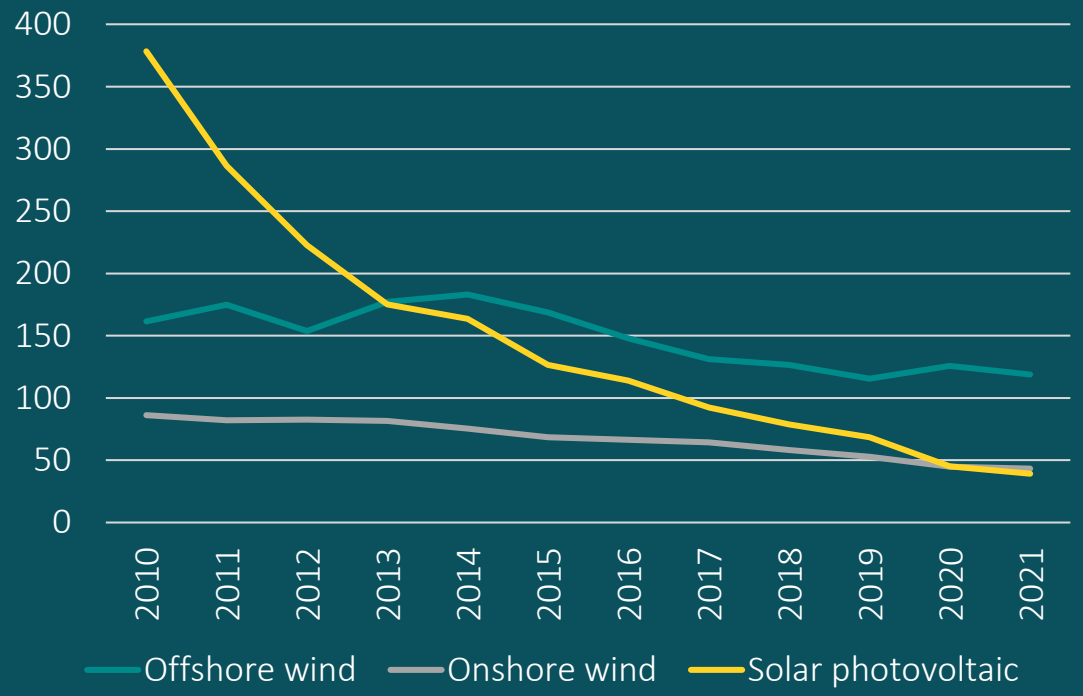
ANSION, INCREASED
OMPTION AND NEW TECHNOLOGIES



- Expansion of renewable energy sources
- Increasing electricity consumption
- Emerging tecnologies
- New business models

VOLUME TO REDUCE COSTS FOR RENEWABLE ELECTRICTY

Historic learning curve , LCOE $/MWh



Source: IRENA, 2021

‘THOR’ OFFSHORE WIND FARM

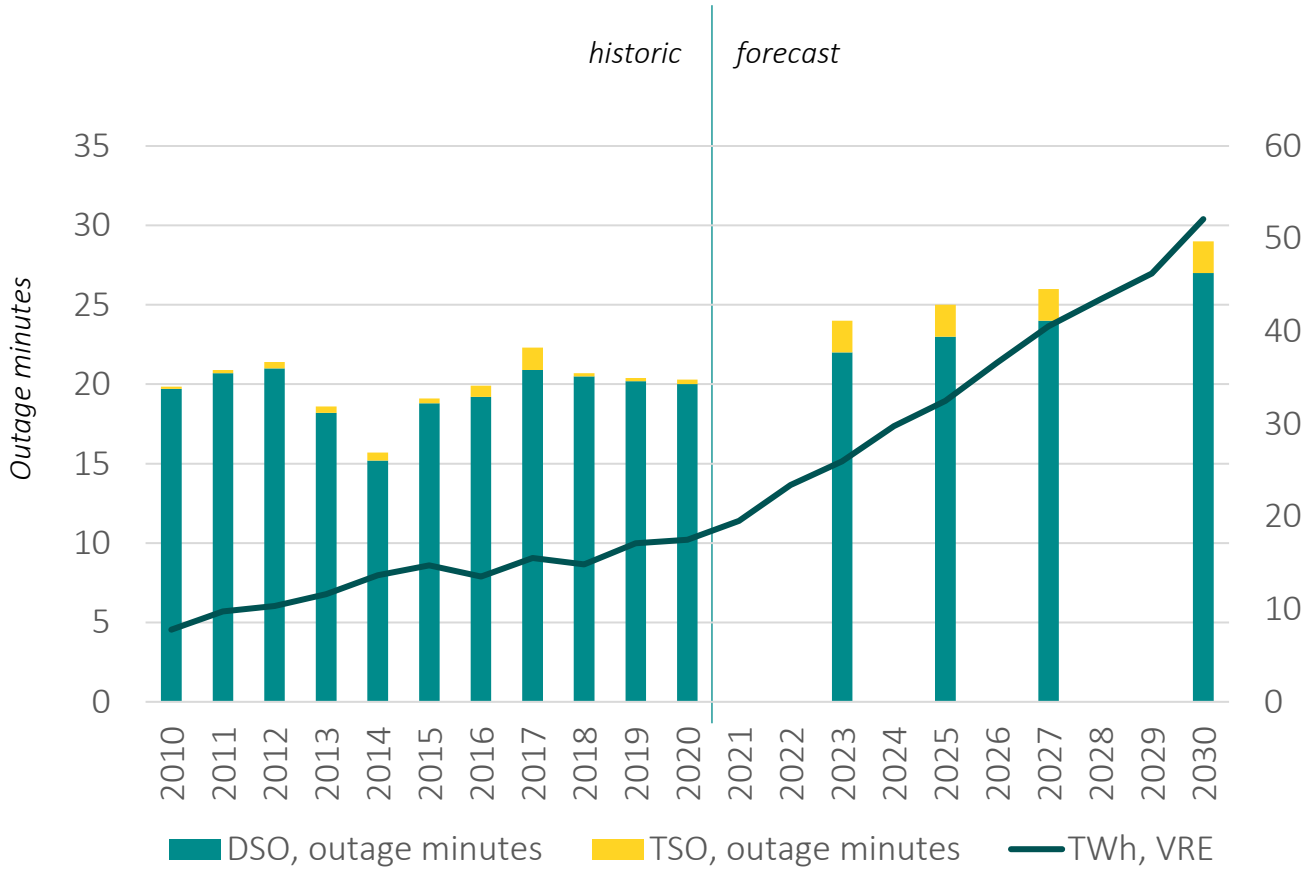
- Five out of six bidders gave the lowest **possible** bid for Thor offshore wind farm.
- The winner RWE will **subsidy free** build a 1 GW offshore wind farm
  – and **pay** the Danish state €377m during the first few years off operation.
- Thor offshore wind farm will each year produce around **4.5 TWh** subsidy free, renewable electricity
  – around **1/8** of the current Danish electricity consumption.

Location

Owners transmission grid

Energinet’s transmission grid

Historic and future development of security of supply and share of VRE



Source: Energinet security of supply report, 2021. Danish Energy Agency: Monthly energy statistics and Assumptions for Energinet, 2021

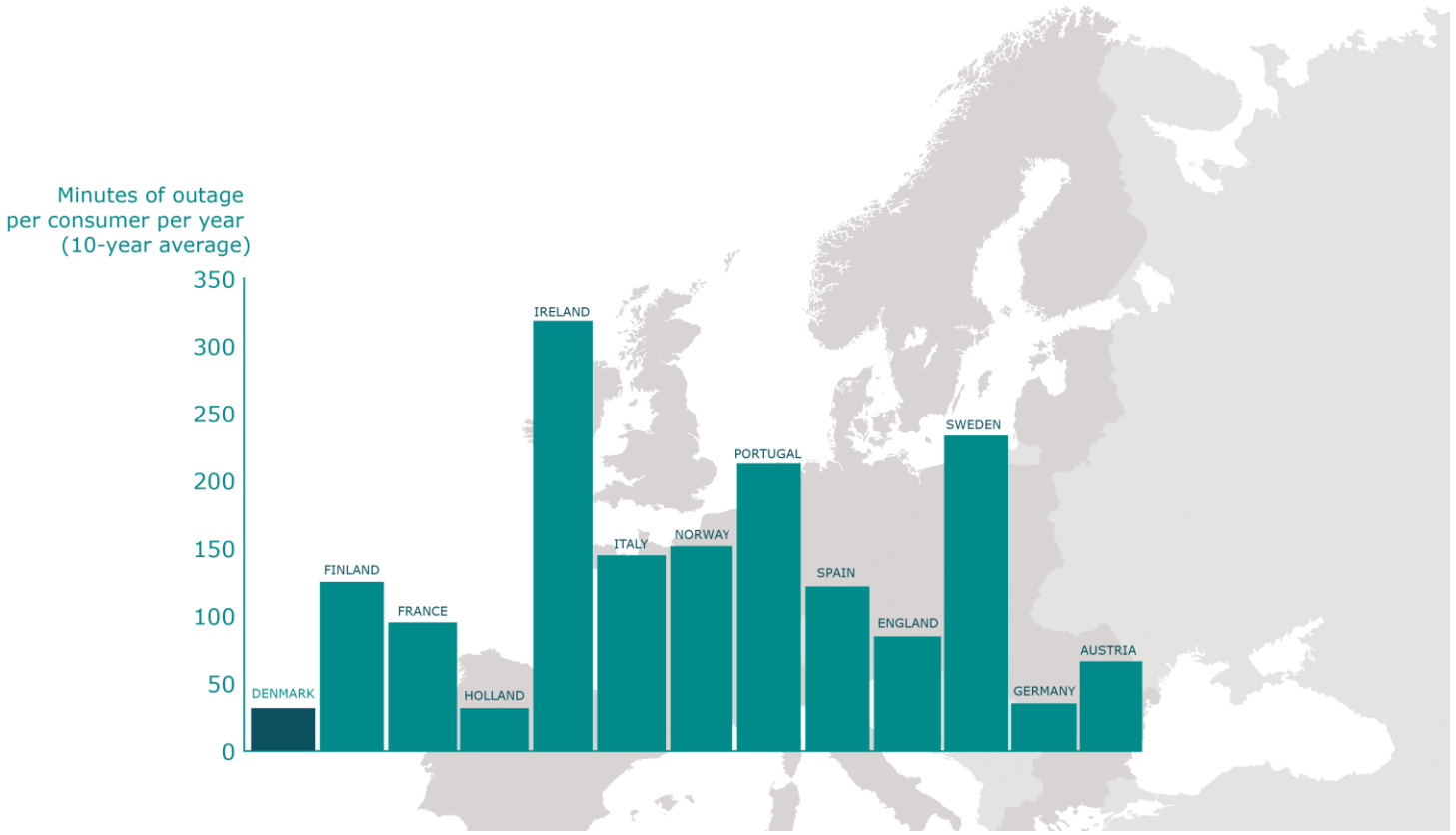
SECURITY OF SUPPLY AND VARIABLE RE

Increasing share of variable renewable energy (VRE) does **not** jeopardize security of supply

- In 2020 security of supply was 99,996%
- Forecast for 2030 is below target of 35 outage minutes (99,993%)
- Production from solar and wind is expected to increase from 17 TWh in 2020 to more than 50 TWh in 2030.

OUTAGE MINUTES IN EUROPE

- VERY HIGH SECURITY OF SUPPLY IN DENMARK IN PERIOD WITH INCREASING SHARE OF RENEWABLES – 99,996%



KEY FIGURES FOR THE ELECTRICITY SYSTEM

OUTAGE MINUTES ELECTRICITY SYSTEM TOTAL
(average number of outage minutes per electricity consumer)

2019, minutes:	20
2018, minutes:	21
2017, minutes:	22

OUTAGE MINUTES ELECTRICITY TRANSMISSION GRID
(consumption-weighted outage seconds)

2019, seconds:	13
2018, seconds:	11
2017, seconds:	92

WIND AND SOLAR ENERGY SHARE

2019, per cent:	50
2018, per cent:	44
2017, per cent:	46

COST OF ANCILLARY SERVICES

2019, million DKK:	665
2018, million DKK:	806
2017, million DKK:	626

EMERGENCY INCIDENTS

2019, number:	0
2018, number:	1
2017, number:	1

IT INCIDENTS

2019, number:	0
2018, number:	1
2017, number:	0

ALERT STATE

2019, number:	1
2018, number:	2
2017, number:	1

EMERGENCY STATE

2019, number:	0
2018, number:	0
2017, number:	0

SECURITY OF ELECTRICITY SUPPLY

SYSTEM ADEQUACY

GENERATION ADEQUACY
Ability to meet overall demand

GRID ADEQUACY
Ability to supply electricity to consumers

SYSTEM SECURITY

ROBUSTNESS
Ability to handle sudden disturbances or outages

IT SECURITY
Ability to maintain secure system operation

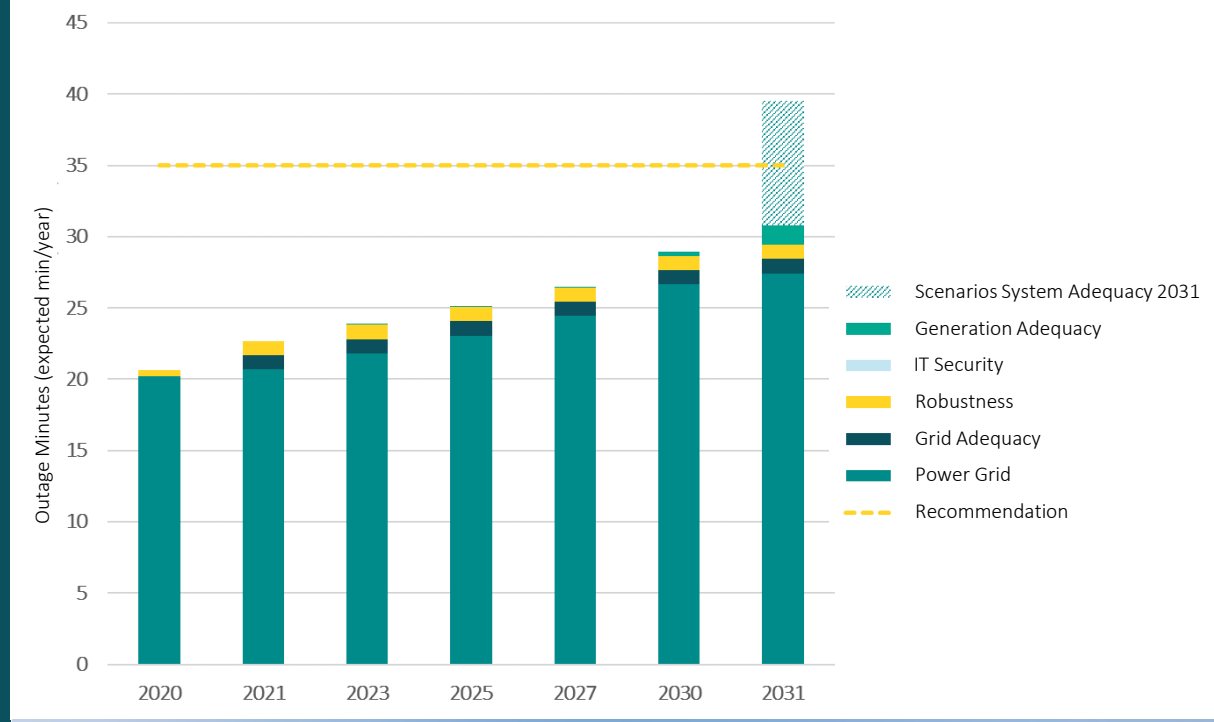
FUTURE SYSTEM ADEQUACY

NEW CHALLENGES

- Decreasing thermal capacity
- Asynchronous electricity supply and consumption
- Weather dependency
- International interdependency

NEW POSSIBILITIES

- Strong grids both cross boarder and internally
- Hybrid solutions
- Large scale demand response
- Energy storage



FUTURE SYSTEM SECURITY

NEW CHALLENGES

- Inverter-dominated power system
- Decreasing inertia
- Challenge of frequency qulity

NEW POSSIBILITIES

- Fast responding reserves
- The digital control center with real-time ”big data”
- Synchronous condencers
- HVDC technology

DEEP DIVE

NEXTGEN DIGITAL SOLUTIONS TO ENSURE SYSTEM SECURITY

DIGITAL TWIN – CAPABLE OF SIMULATING EVENTS IN AN INVERTER-DOMINATED POWER SYSTEM AT ALL TIMES SCALES

THE DIGITAL CONTROLE CENTER REQUIRES ”BIG DATA” FROM THE ELECTRICITY SYSTEM IN REAL TIME

- Real-time platform
- Situation Awareness
- Dynamic Line Rating

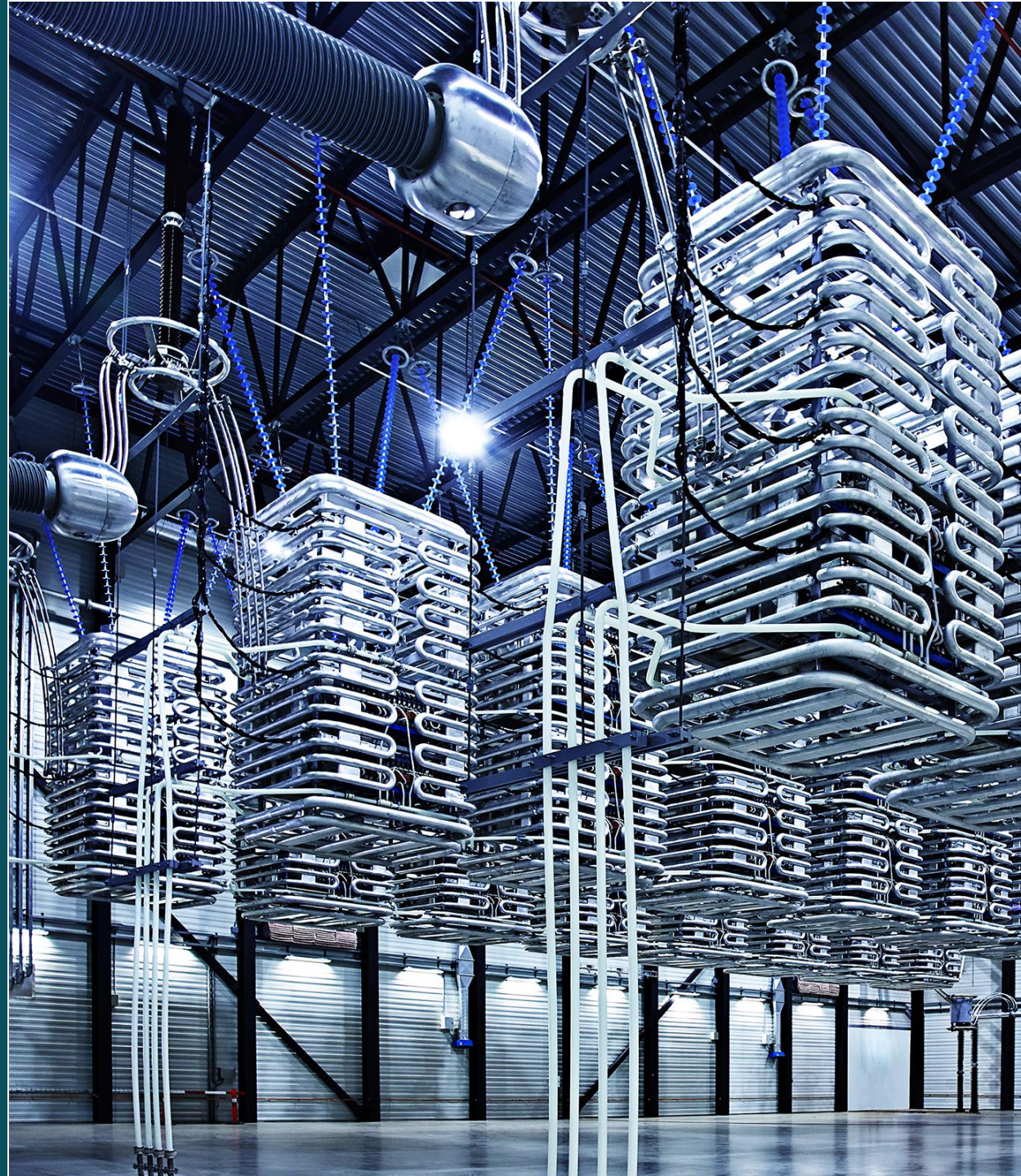
DEEP DIVE

ACTIVE TRANSMISSION COMPONENTS

ENABLING A RES-BASED INERTIA-LIKE RESPONSE THROUGH GRID-FORMING CAPABILITY

NEW USE OF CLASSICAL COMPONENTS FOR SUPPORT FOR HIGH LEVELS OF RES

ACTIVE UTILIZATION OF HVDC TECHNOLOGY FOR SYSTEM SUPPORT BETWEEN SYNCHRONOUS AREAS



DEEP DIVE

SECTOR COUPLING

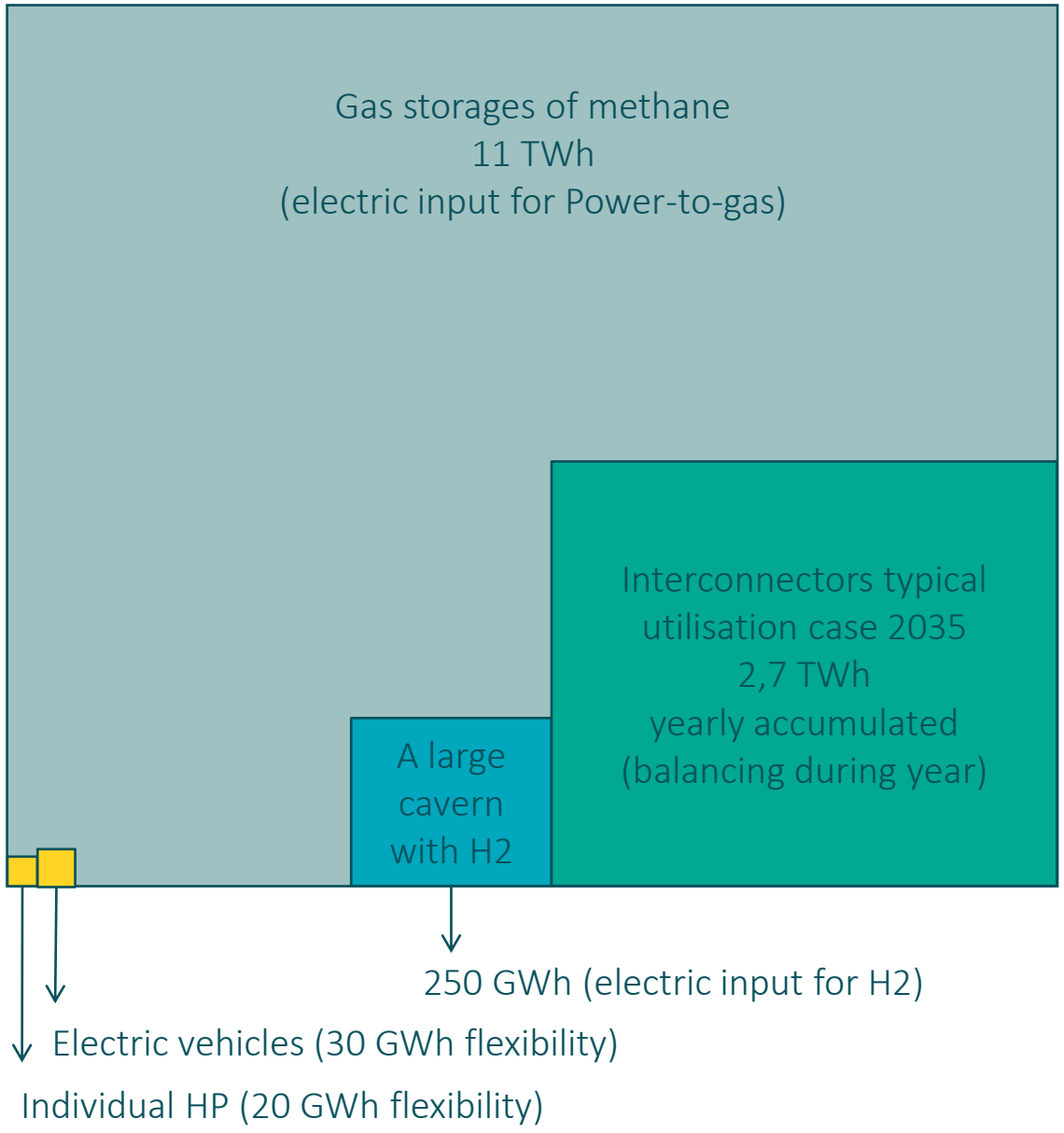
FLEXIBLE ELECTRICITY COMSUMPTION

- Through PtX, heating, transportation etc.
- New ancillary services and balancing possibilities

ENERGY STORAGE POTENTIAL

- H2 and green gasses converted to electricity

COMBINDED HEAT- AND POWERPLANTS (CHP)
ON BIOMASS WITH CCS



DEEP DIVE

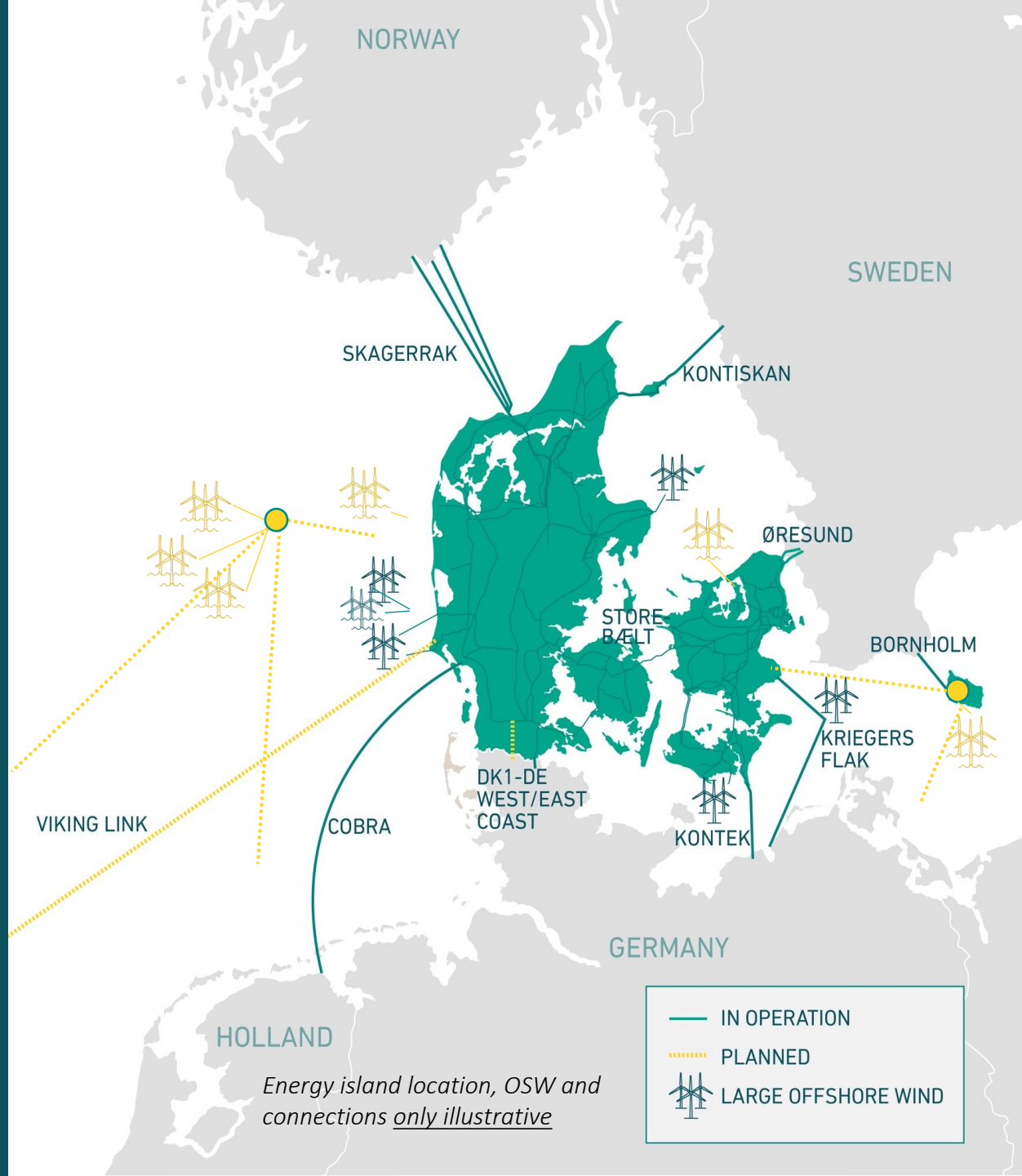
NATIONAL AND INTERNATIONAL MARKET INTEGRATION

STRONG GRID – CROSS BORDER AND INTERNALLY IN DENMARK

- Daily exchange of electricity
- Continued strong internal grid in Denmark

FLEXIBILITY FROM WHOLE SALE AND RETAIL ELECTRICITY MARKETS

- Flexibility increases security of supply
- European day ahead and intraday market incentivices
- Hourly metering of all consumers in Denmark



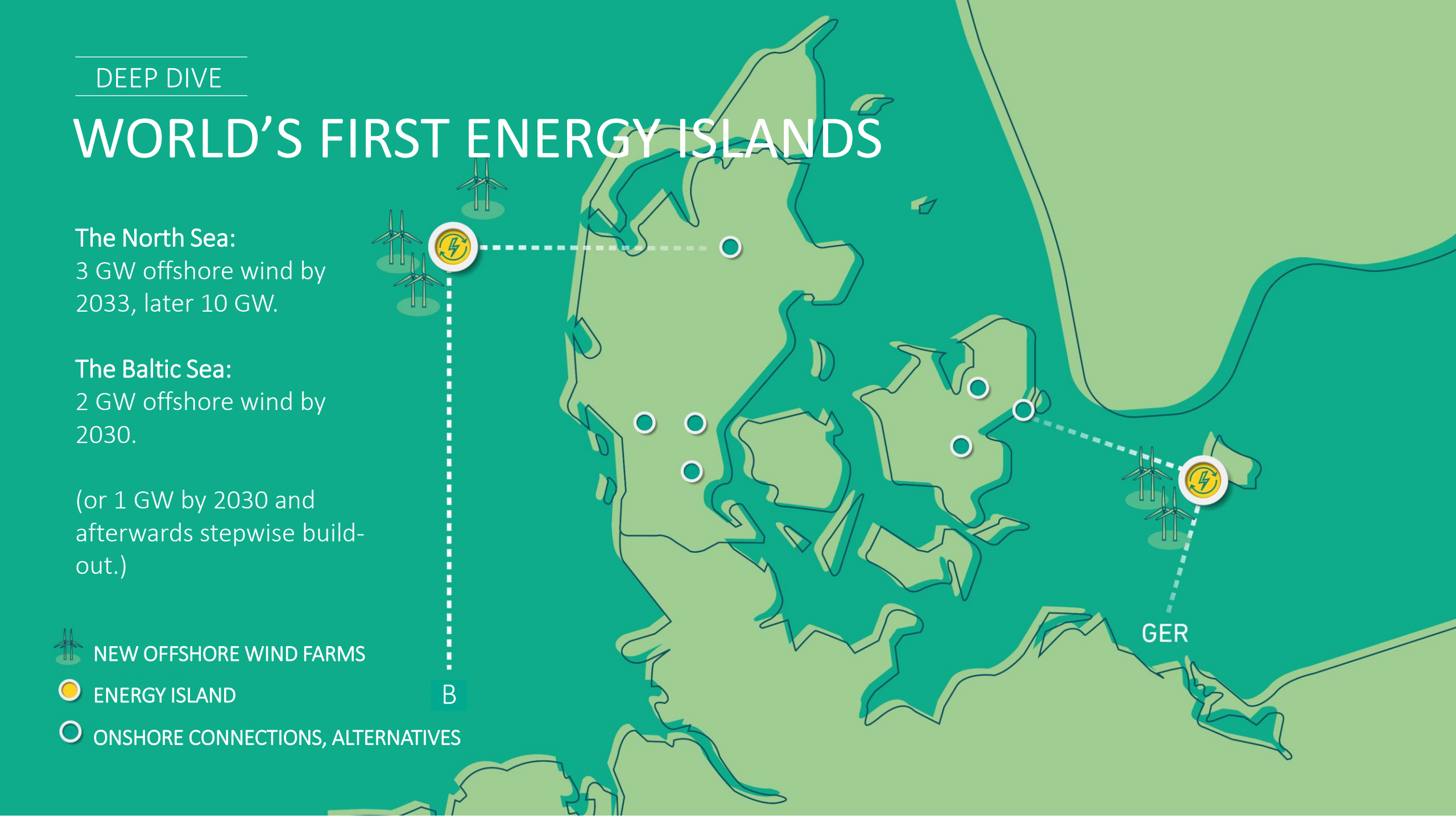
DEEP DIVE

WORLD'S FIRST ENERGY ISLANDS

The North Sea:
3 GW offshore wind by 2033, later 10 GW.

The Baltic Sea:
2 GW offshore wind by 2030.

(or 1 GW by 2030 and afterwards stepwise build-out.)



ARTIFICIAL ISLAND IN THE NORTH SEA

- 80 km from the shore of the peninsula Jutland
- 3 GW growing to 10 GW (3-10 million european households)
- EUR 28 billion, including 10 GW wind farms, electrical installations and power cables
- Public private partnership

Preliminary timeline

2021	2024	2028	2031	2033
Preliminary studies & co-ownership tender	Preparing and building the island and (IC) international connections offshore	Island ready for energy-infrastructure – offshore windfarms are being set up	Infrastructure and IC established	Wind in service

"We choose to go to the moon in this decade… Not because it's easy, but because it's hard, because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one we are unwilling to postpone, and one which we intent to win, and the others, too."
- John F. Kennedy (Sept. 12, 1962)

QUESTIONS