ENERGINET - GREEN TRANSITION THE DANISH EXPERIENCE

March 2024

Peter Markussen, Senior Director, Energinet

VISION

GREEN ENERGY FOR A BETTER WORLD

GLOBAL PST CONSORTIUM
Founding TSO

ENERGINET

THE ENERGY BACKBONE

We operate and develop the electricity transmission grids, gas pipelines and gas storage in Denmark and is also appointed to build future hydrogen infrastructure

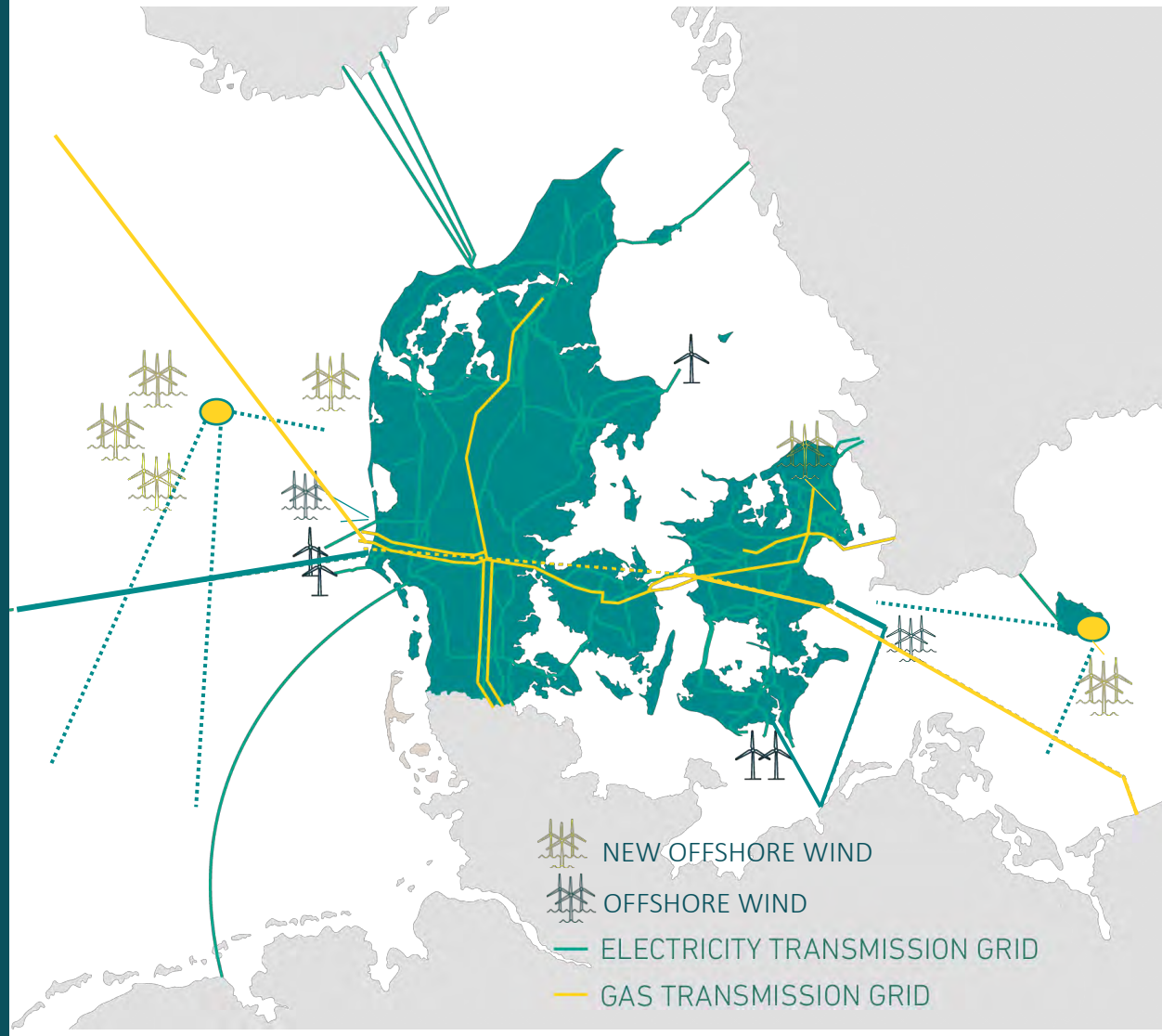
ENSURE BALANCE

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

WORKING FOR THE SOCIETY

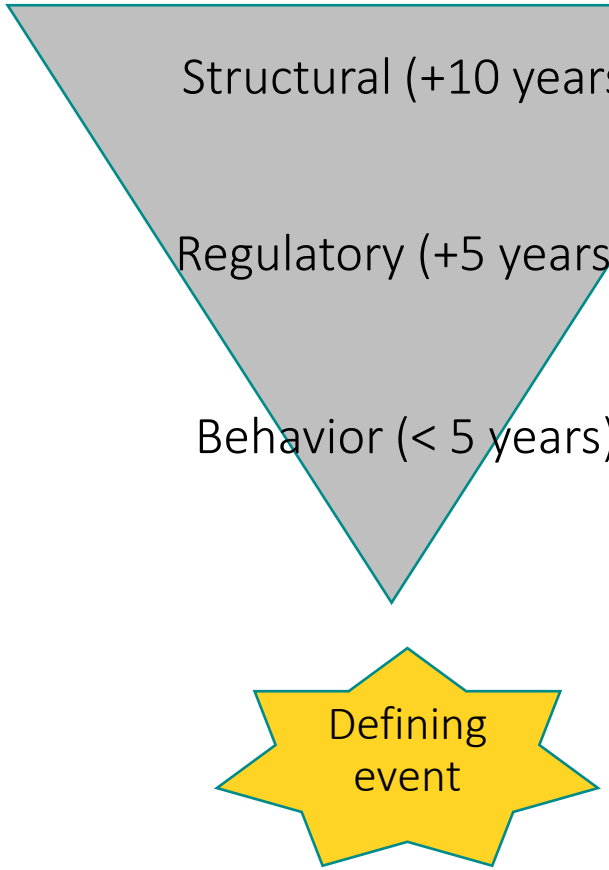
Owned by the Danish Ministry of Climate, Energy and Utilities we safeguard society's interests as we move to a 100% green energy system.

Appr. 2100 Employees



Energy island location, new OSW and connections only illustrative

THE DRIVERS FOR INCREASED CONSUMPTION FLEXIBILITY IN DENMARK

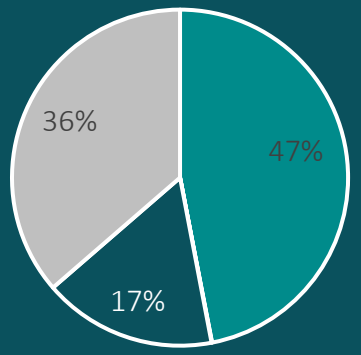


- European electricity market and unbundling (day ahead and intraday)
- Energy efficiency regulation and awareness of energy use.
- Technology development (smart meters, apps, digitalization)
- Datahub – consumer centred ownership of consumption data
- Electrification of heating and energy use in general
- Support consumer flexibility/storage as part of energy planning
- New tarif design (time dependent, location, fixed/variable)
- Adaption of ancillary services to VRE and consumption (technology neutral products)
- Large increase in active pro-sumers (roof top solar)
- Green power consumer demand – use electricity when green and price is low
- Electrical vehicles and home charging flexibility

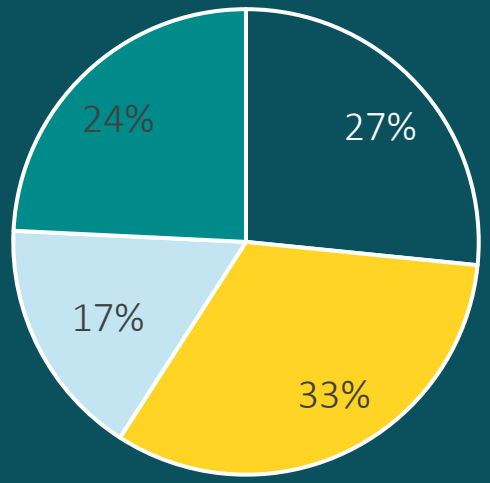
Energy crisis in 2022

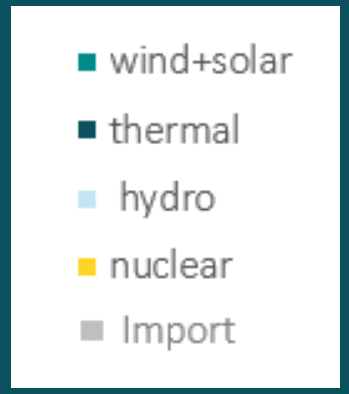
EUROPEAN ELECTRICITY PRODUCTION

Denmark, 37 TWh



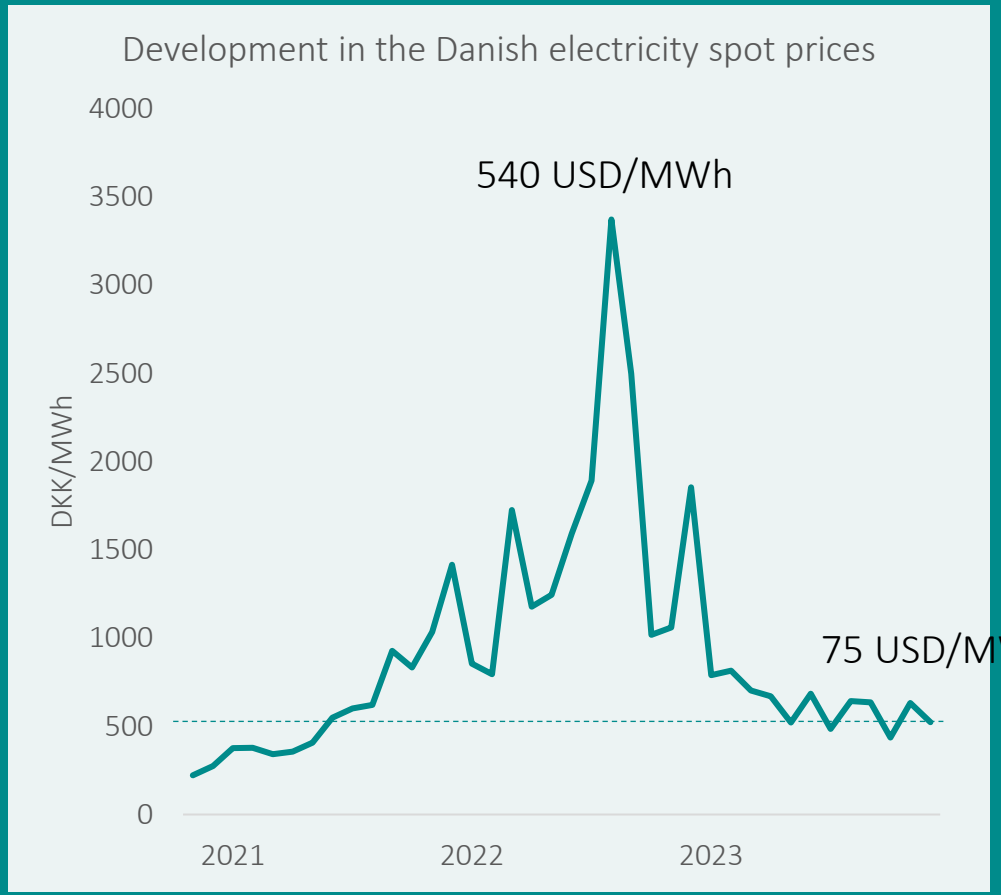
European Union, 2251 TWh





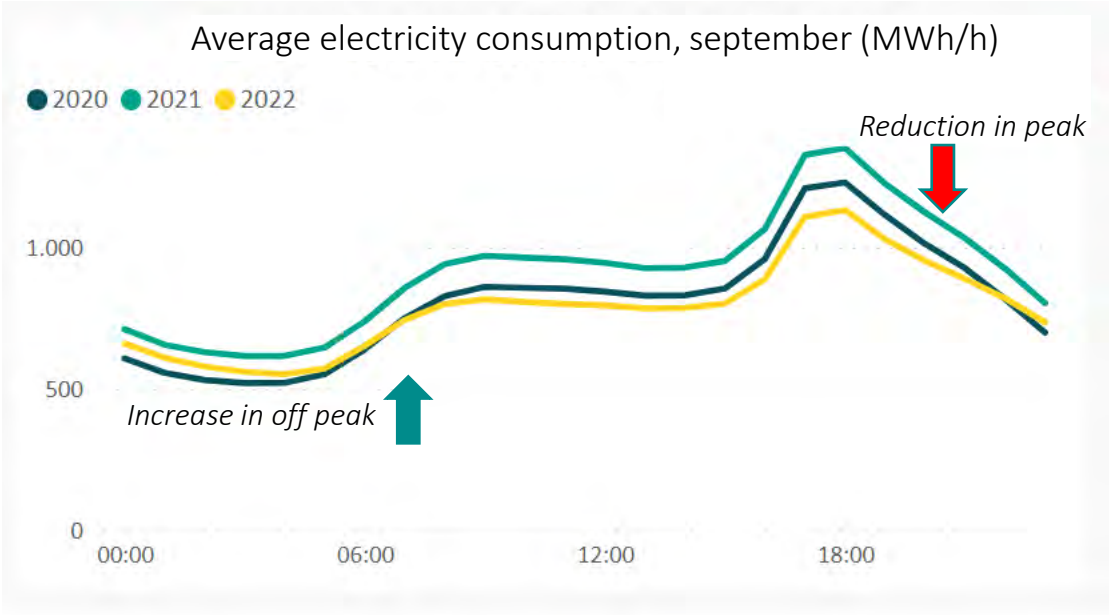
Sources: Statistics | Eurostat (europa.eu)

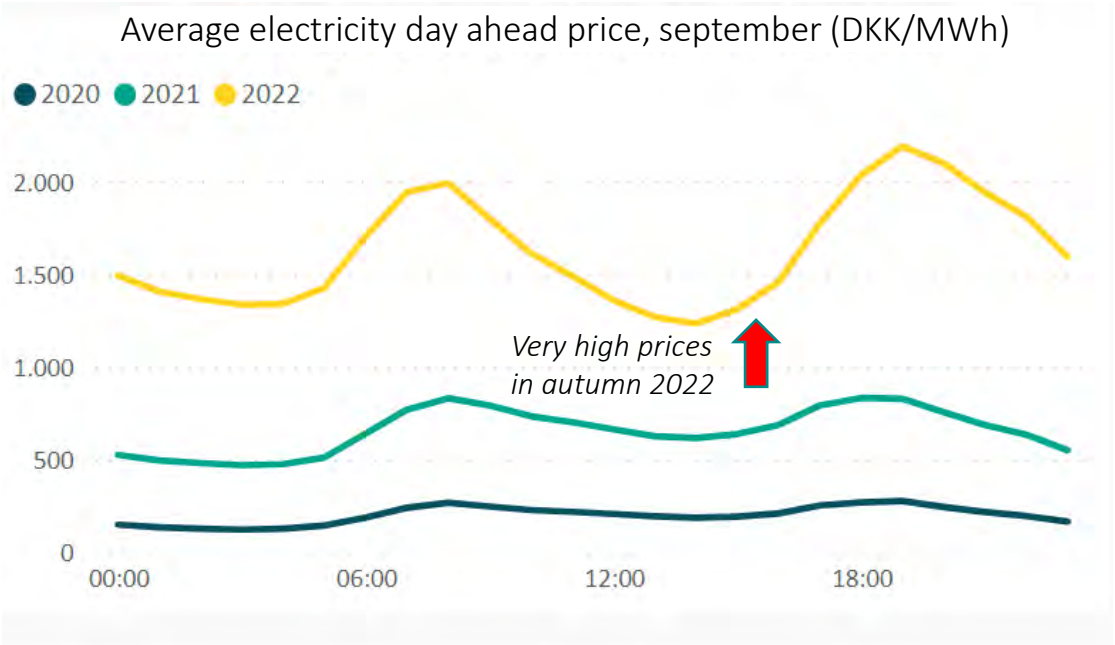
”THE PERFECT STORM”IN AUTUMN 2022



CONSUMERS ARE FLEXIBLE!

- 15% reduction in consumption in 2022 compared to 2021 (and with increasing electrification)
- Consumption moved to off peak hours with low price (night and noon)
- Flexible consumption important future tool for affordable security of supply
- Denmark: all households have smart meters with hourly measurements
- in 2022 large increase in share of consumers ”pay pr. hour”



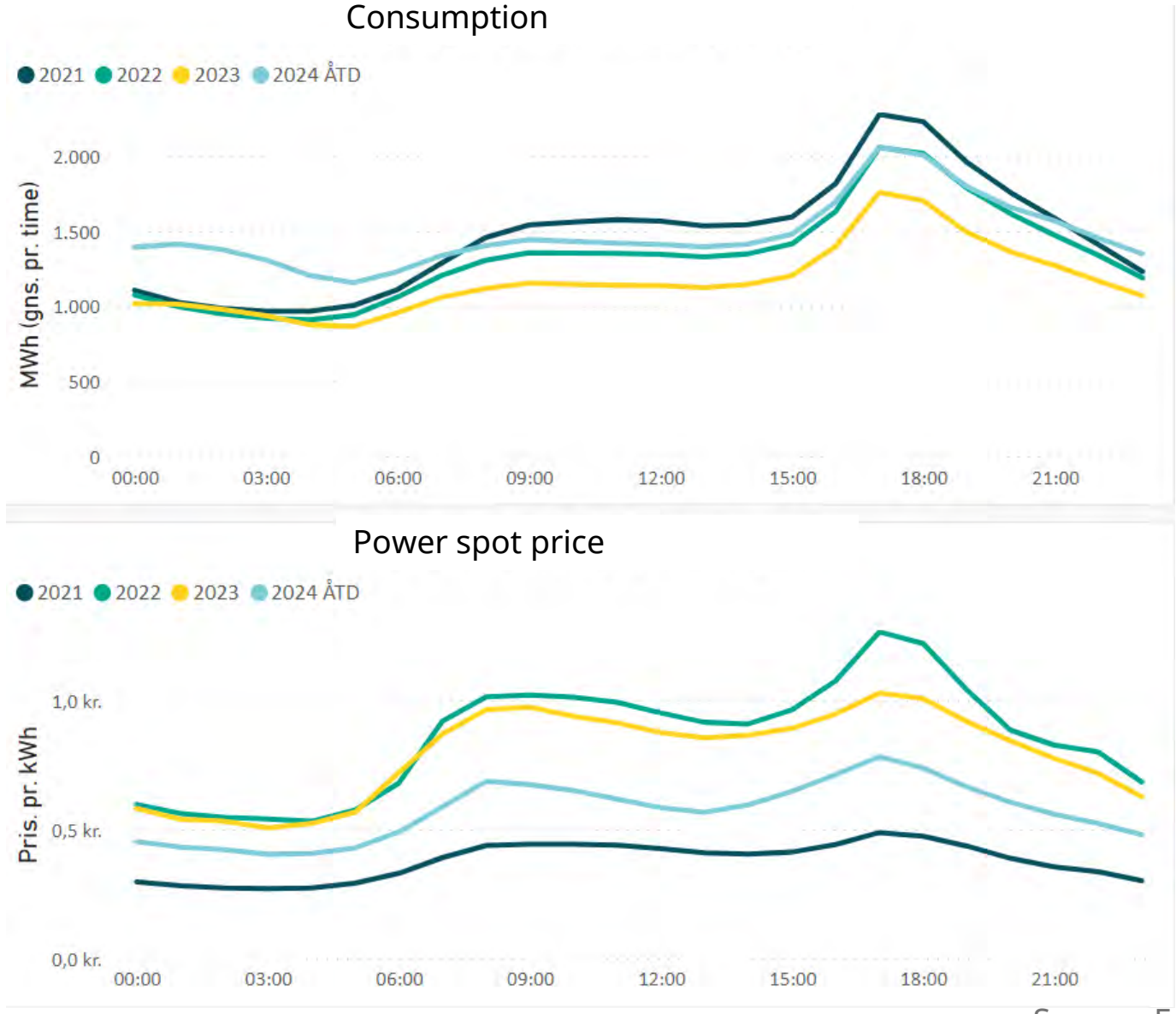


ELECTRICAL VEHICLES

…CONSUMERS ARE STILL FLEXIBLE!

- Electricity price almost back to normal in spring 2023
- Electricity consumption increased due to new EV's, heat pumps and electrification
- Very large increase in off peak consumption
- Electricity tax exemption from autumn 2022-spring 2023

Average household consumption – month of January



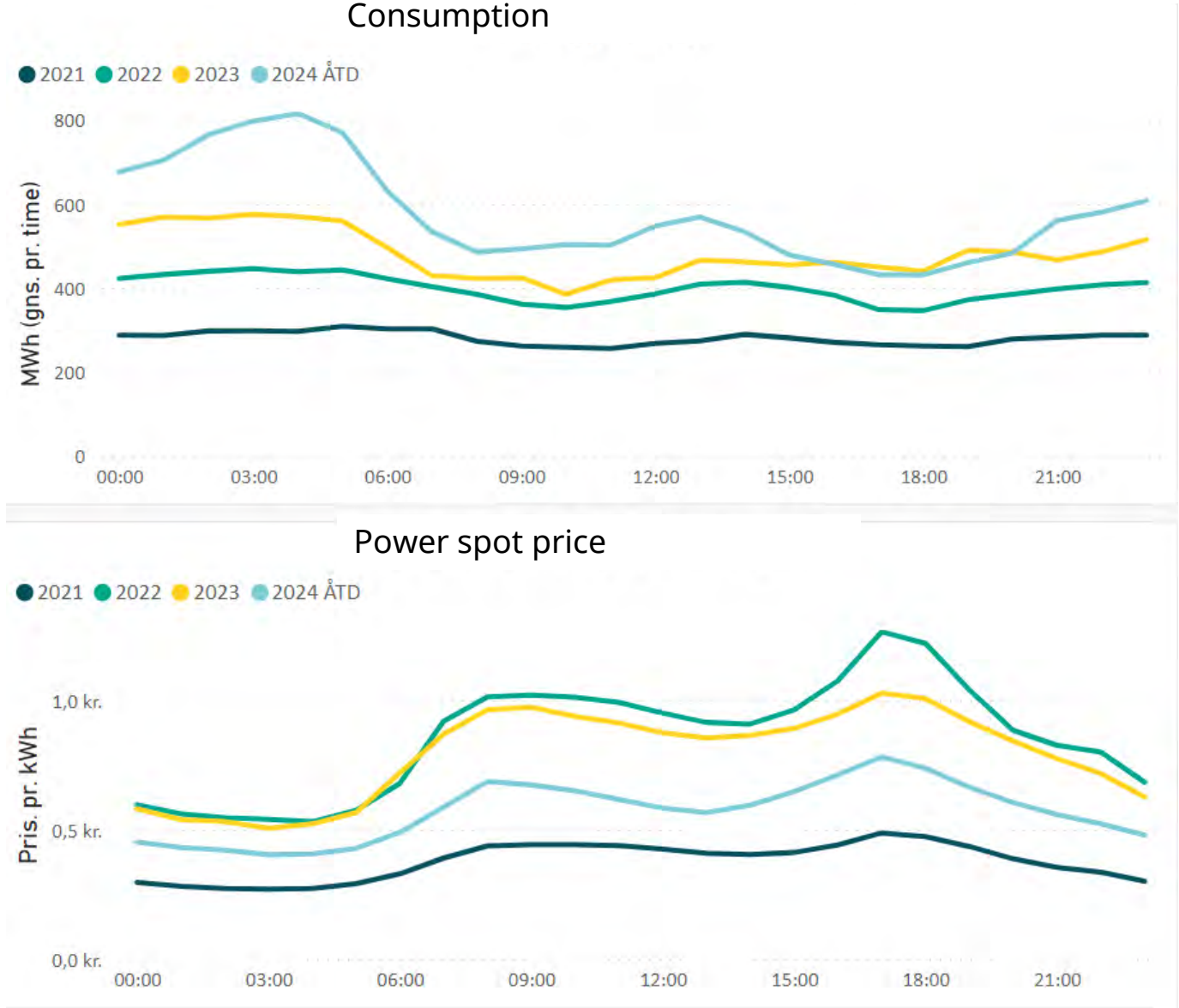
Source: Energinet

...CONSUMERS ARE STILL FLEXIBLE!

Larger effect in the utility sector.

Most likely the effect of a boost in large heat pumps and boilers in district heating networks over the last years.

Power consumption in utility sector – month of January

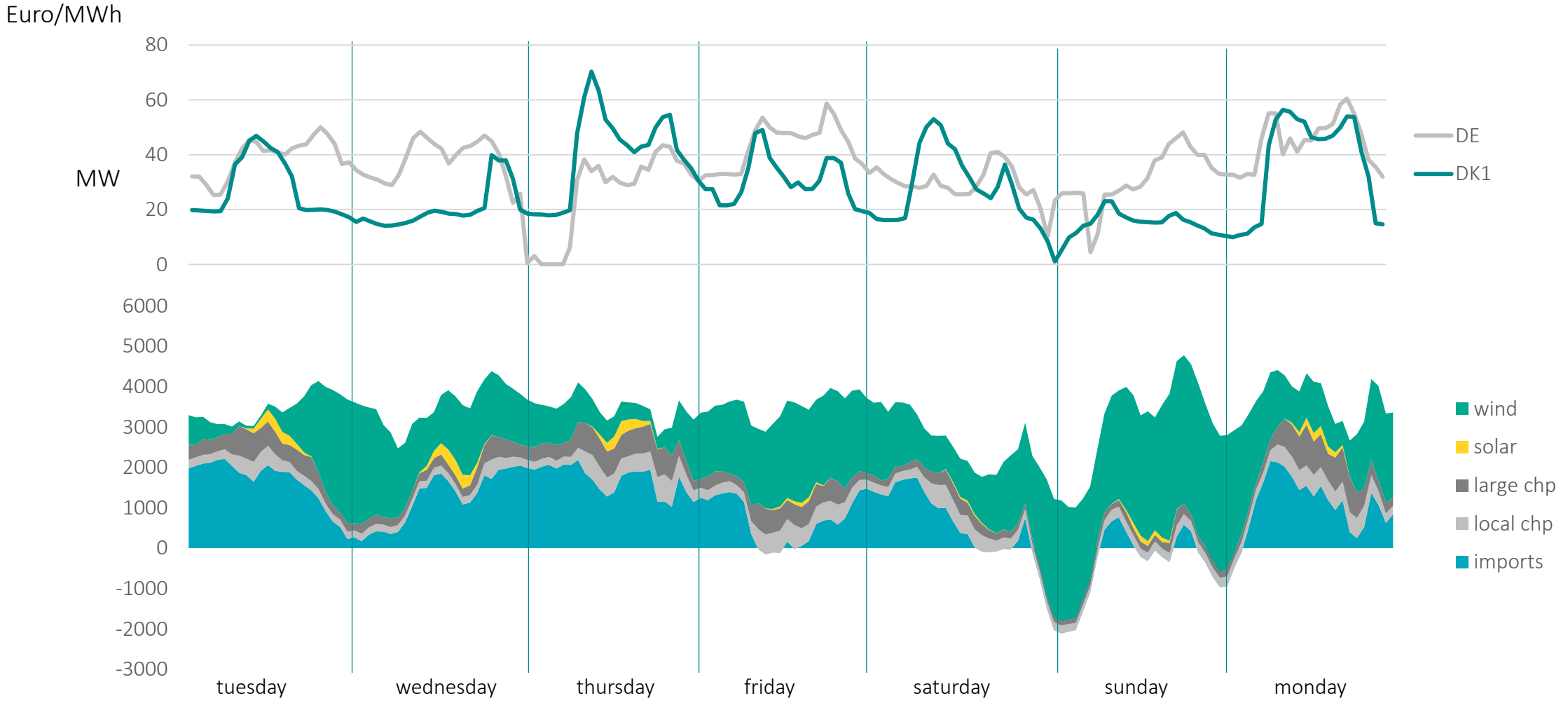


Source: Energinet

USE ELECTRICITY WHEN GREEN

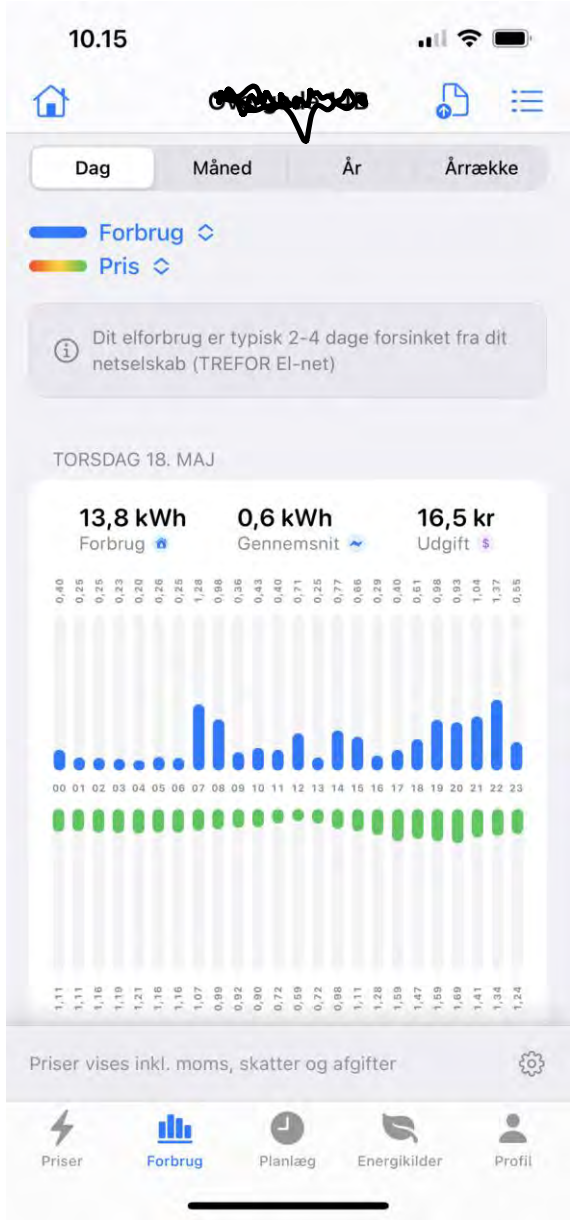
DAY AHEAD PRICE AND ELECTRICITY BALANCE WESTERN DENMARK (DK1) AND GERMANY (DE)

European electricity market and interconnectors delivers cost efficient short term balancing and increases value of renewables – no forced curtailment



IMPORTANCE OF PRICE AND CONSUMPTION INFORMATION

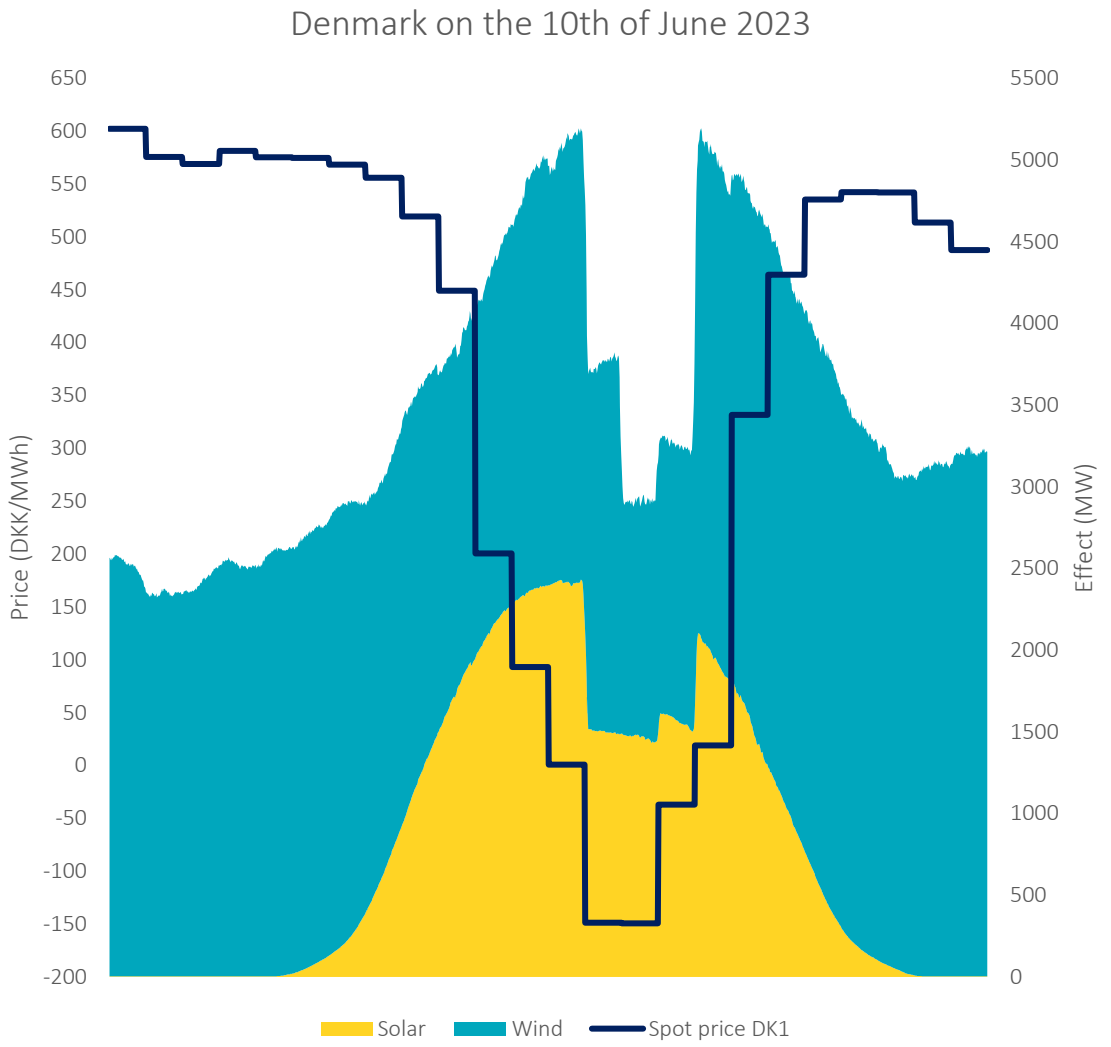
- > 70% of all Danish consumers are billed by ”time of use rates”
- Most downloaded app in Denmark in 2022 was ”Min Strøm” (My Power)
  - Daily spot prices+grid tarifs+taxes (today and tomorrow)
  - Own consumption with one day delay



ACTIVE PROSUMERS

A WEATHER DEPENDENT ENERGY SYSTEM

The effects of our electricity production being increasingly based on weather-dependent energy sources continue to be seen



Source: The year that passed 2023 in the electricity and gas systems (energinet.dk)

SETTLEMENT FOR PROSUMERS/ROOF TOP SOLAR

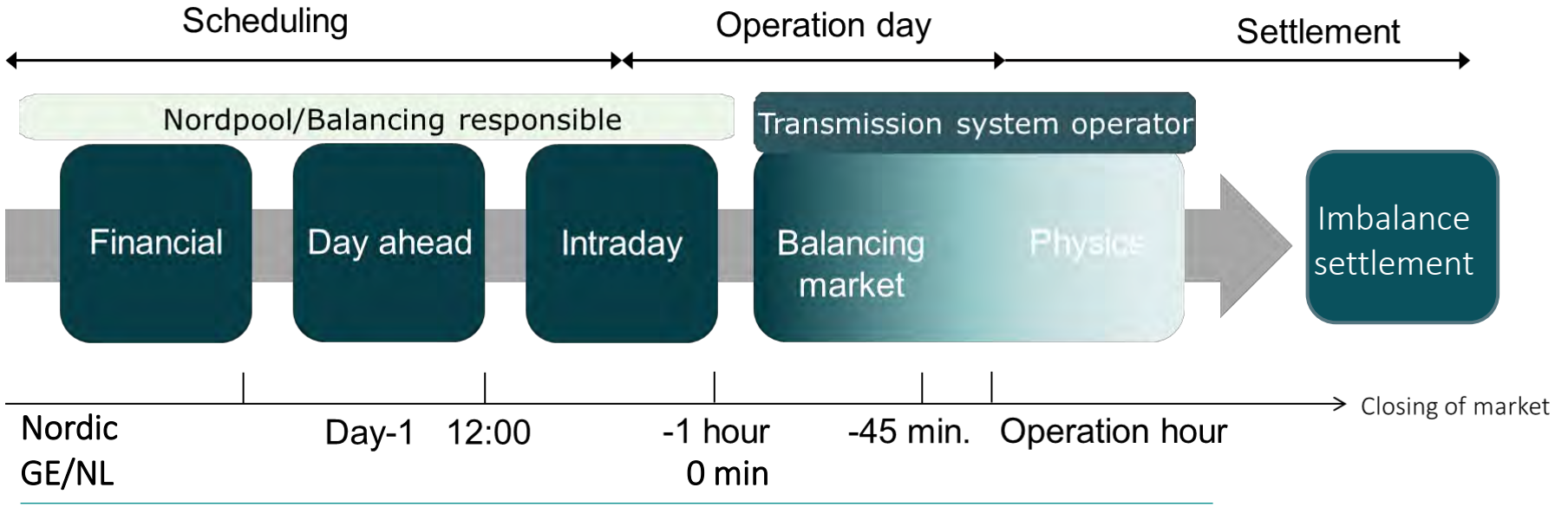
In 2019 change in settlement from annual average to hourly settlement

No longer possible to use grid as storage

Reflect actual costs/benefits for electricity system

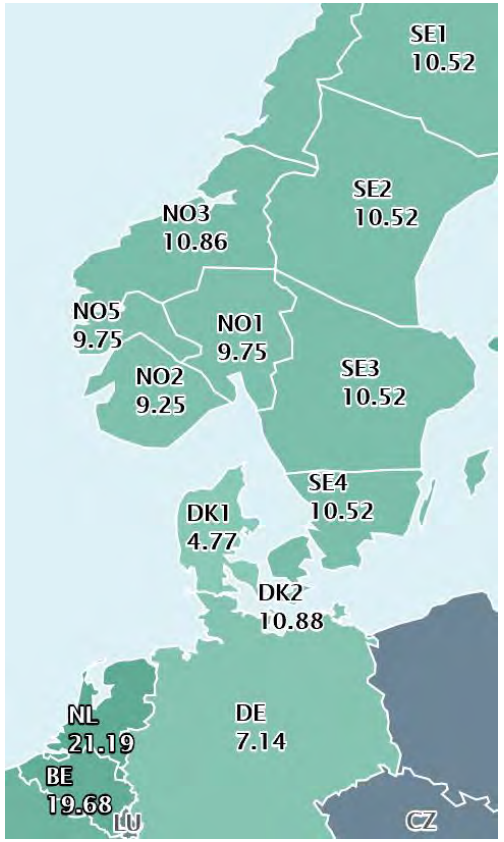
NEW ANCILLARY SERVICES

ELECTRICITY MARKETS FOR DISPATCH AND BALANCING



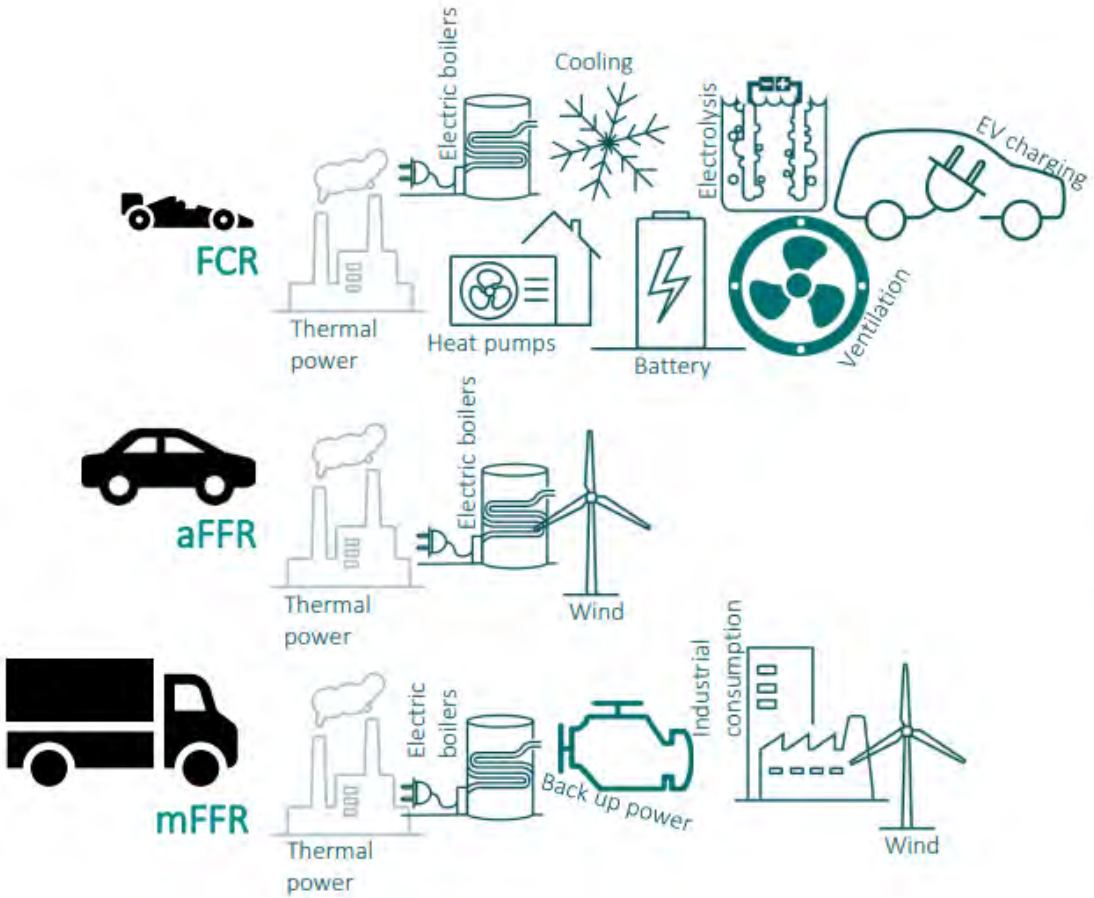
Trade in Nordic area*:	400 (500) TWh	15 TWh	2 TWh
Trade in Germany** :	250 (600) TWh	50 TWh	2 TWh
Trade in Holland*** :	100 (120) TWh	20 TWh	1 TWh

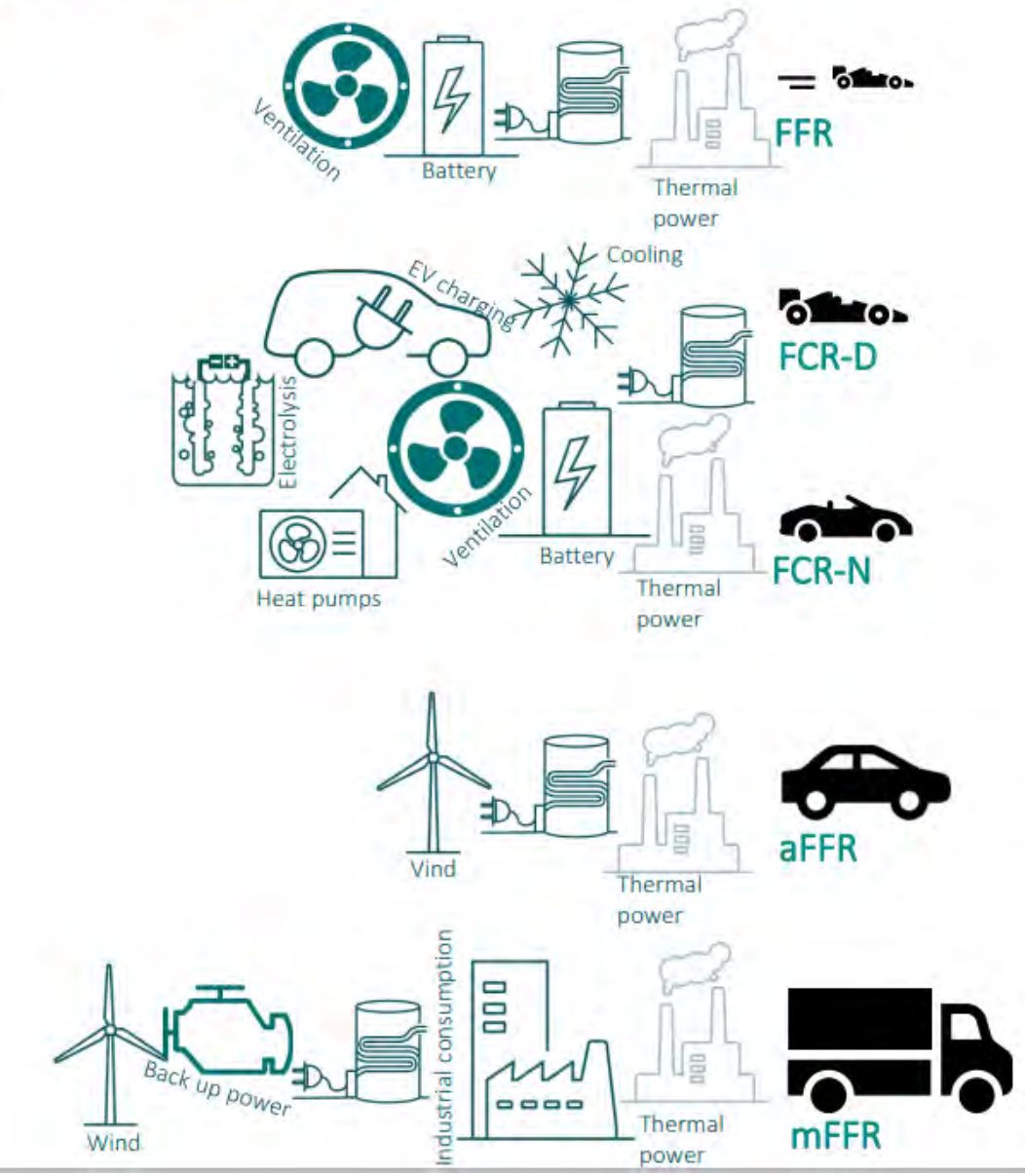
*Nordpool news, january 2020
**Bundeznetzagentur monitoring bericht, 2019
*** Tennet market review 2018



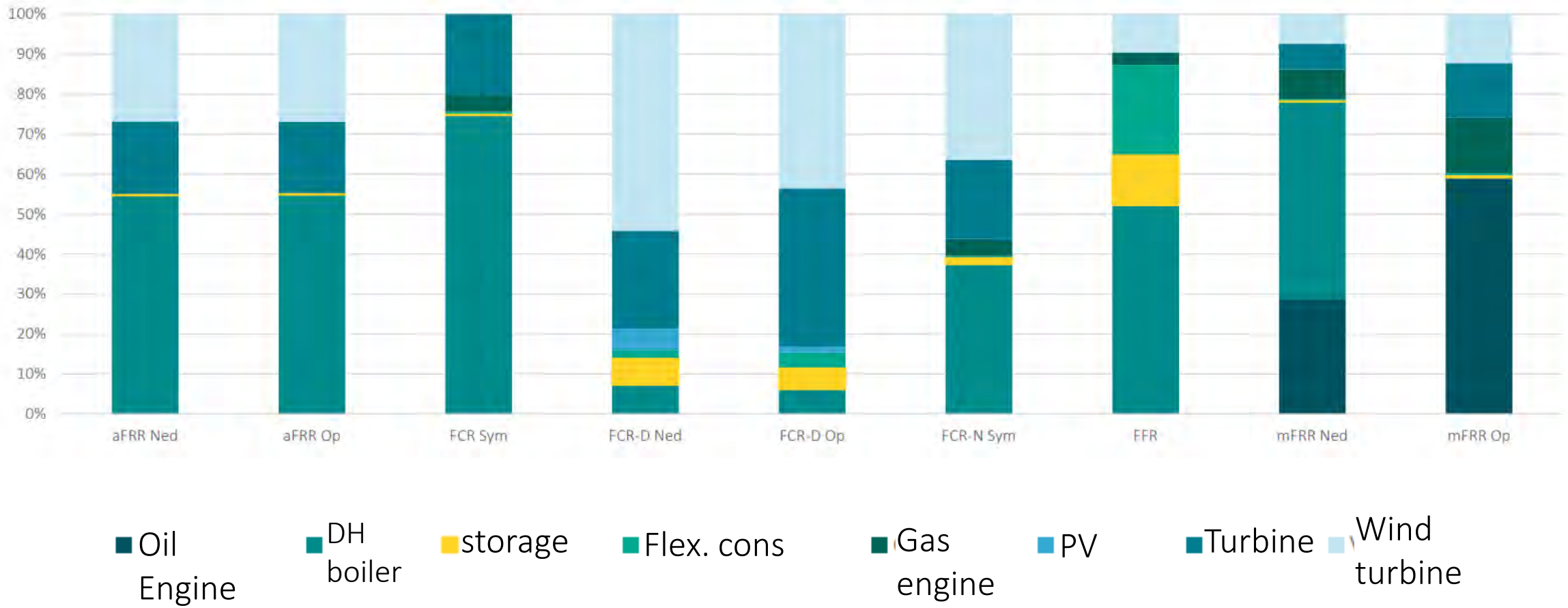
ANCILLARY SERVICE : TECHNOLOGY

The technologies that provides the different services today. Wind power is expected to provide FCR soon.





SHARE OF TECHNOLOGIES ALLOWED TO DELIVER ANCILLARY SERVICES



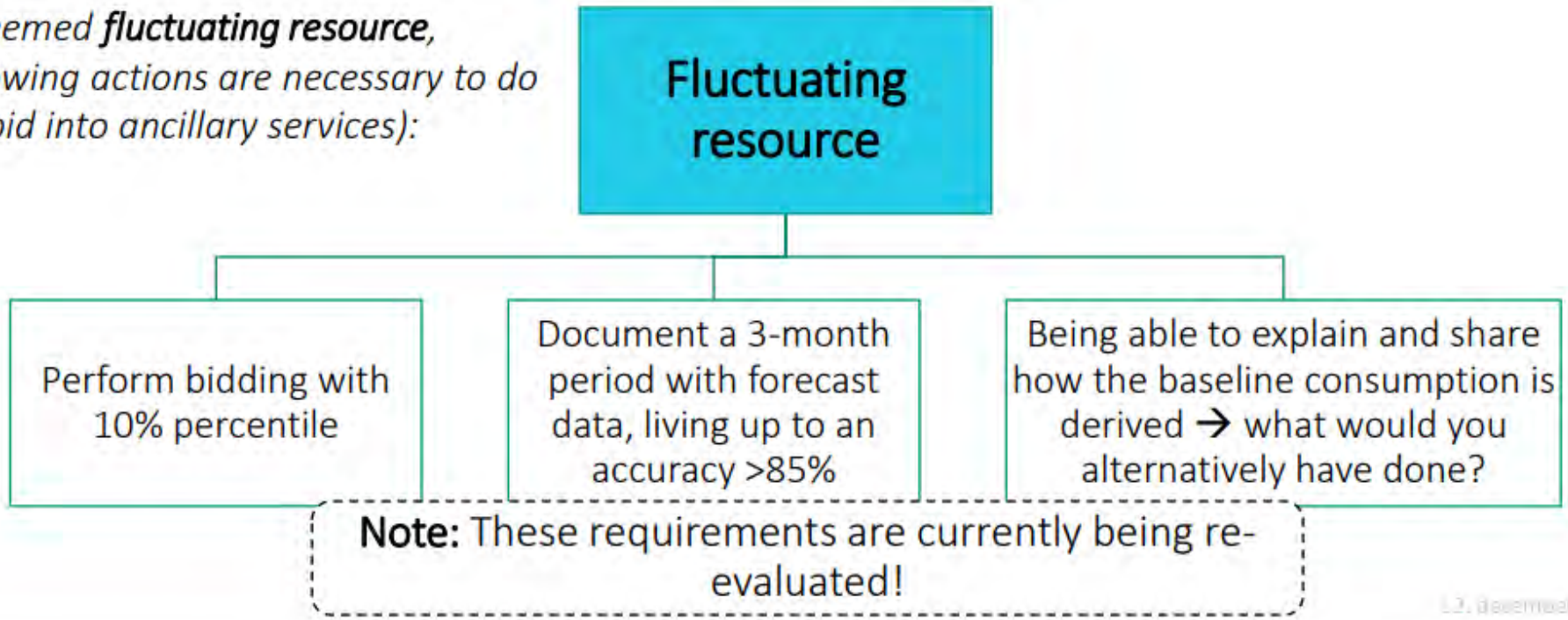
ENERGINET

CRITERIA FOR PARTICIPATING IN ANCILLARY SERVICE MARKETS WITH FLEXIBLE CONSUMPTION

The **criteria** for being classified as a **fluctuating resource** is based on a case-by-case evaluation, performed by Energinet.

A rule of thumb is that if the consumption "process" is characterized by "unpredictable" or stochastic behavior tendencies (not-centrally controlled consumption), i.e., charging of EVs or cooling a supermarket, the process will be classified as a **fluctuating resource**.

*If deemed **fluctuating resource**, following actions are necessary to do (to bid into ancillary services):*

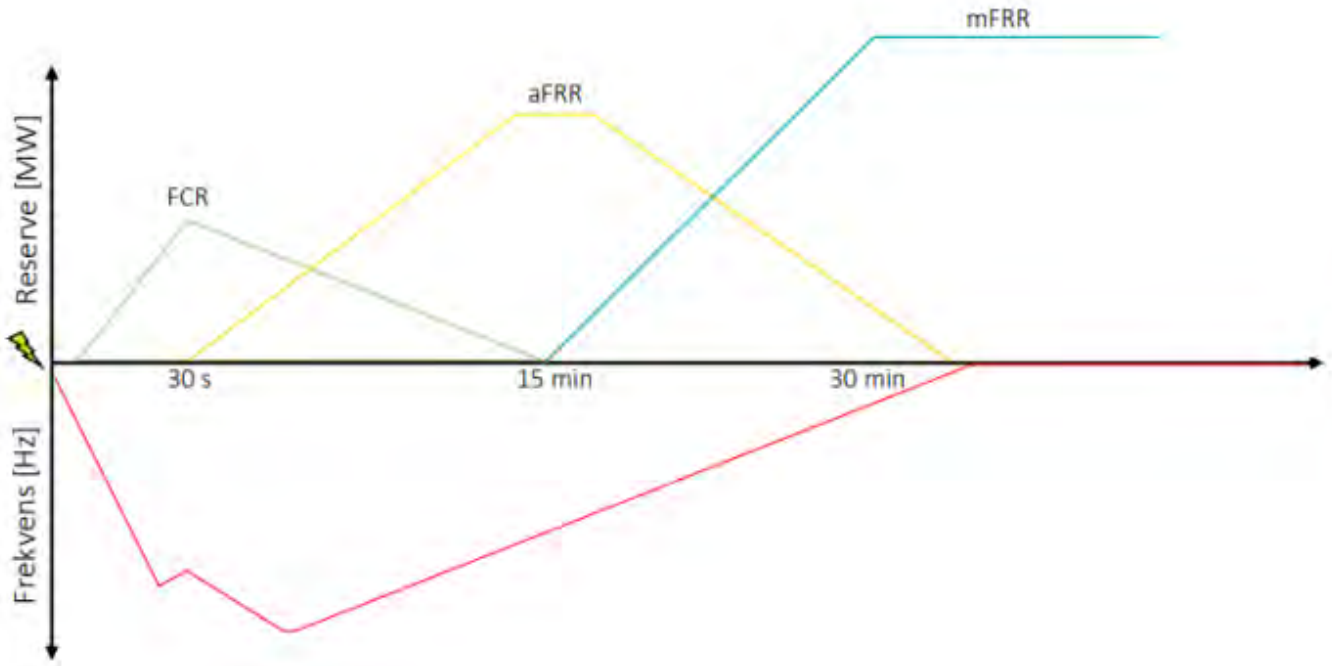


ANCILLARY SERVICE – PRODUCTS AND BALANCING FLOW

FCR (Frequency Containment Reserve)
Automatically stabilizes the frequency and stop the frequency from deviating further

aFRR (Automatic Frequency Restoration Reserve)
Helps the system to recover from larger imbalances and brings the frequency back to 50 Hz after that FCR has stabilized the frequency

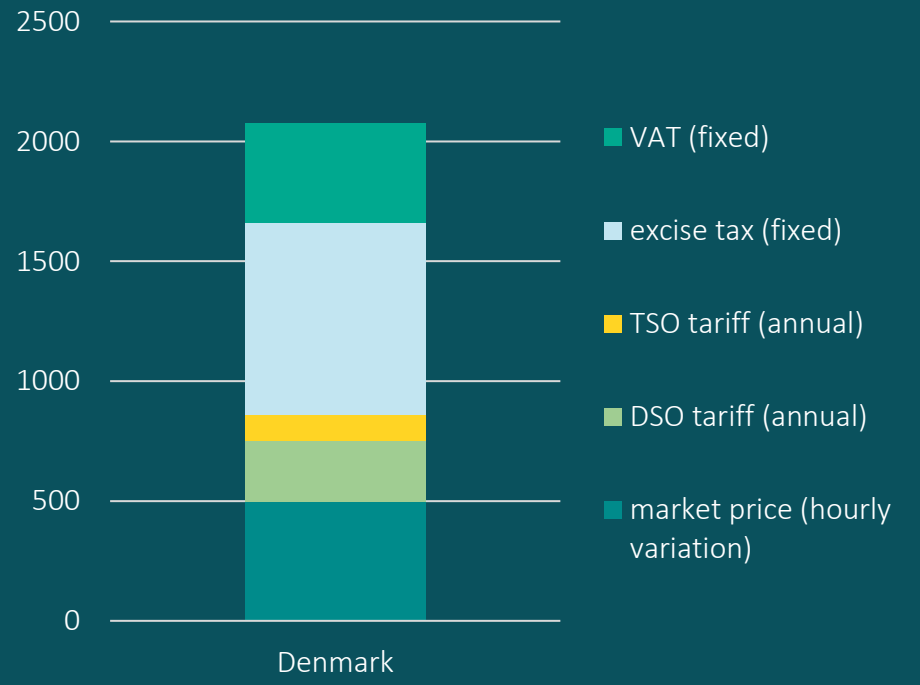
mFRR (Manual Frequency Restoration Reserve)
Helps the system to recover from very large imbalances that are not stabilized by the FCR and aFRR activations



GRID TARIFF

THE RETAIL PRICE

Household, retail price, DKK/MWh

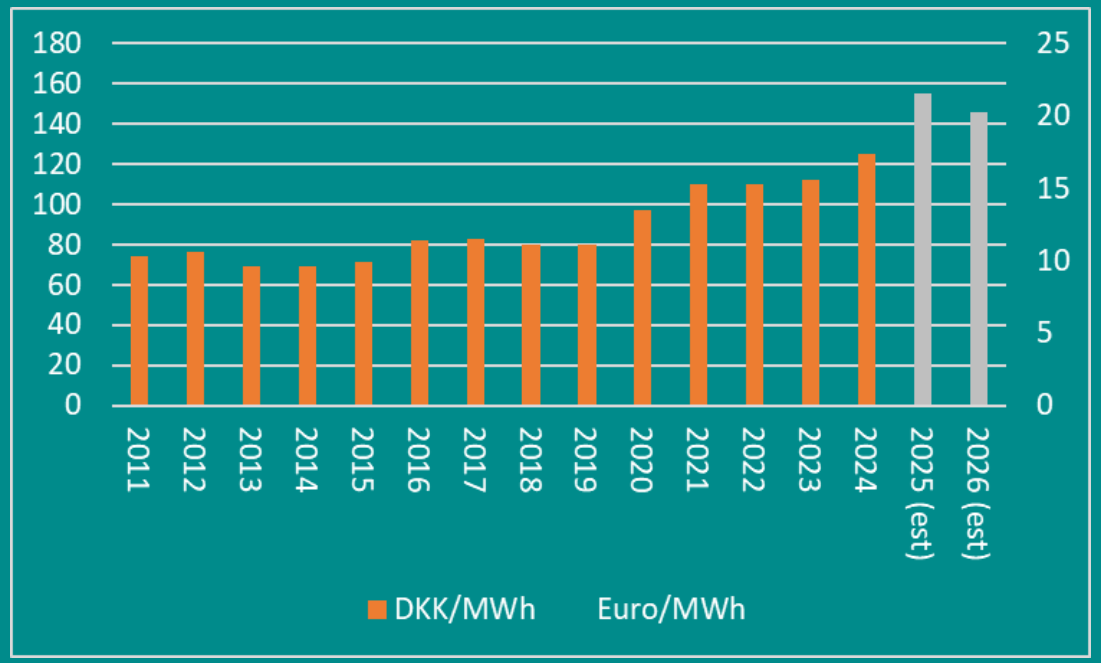


The market price can be billed on hourly or monthly average.

Excise tax is lower for industrial and large electricity consumers and set by law

THE TSO TARIFF

Energinet TSO tarif (DKK/MWh and Euro/MWh)



Tariffs are approved annually by energy regulator.

- DSO tariff based on benchmark
- TSO tariff based on actual costs and negotiated agreement

FINANCING OF GRID AND SYSTEM OPERATION

- Energinet electricity system operation and transmission grid are non-profit regulated
- Financed mainly by a electricty consumption tariff and congestion income from interconnectors.
- Tarif is appr. 16 Euro/MWh (appr. 19% of electricity market price in 2022)
- Tariff is divided in system tarif and grid tarif
- Tariff is expected to increase pr. MWh with increased grid investments and system costs.
- Grid investments are financed by bank loans and depriciated based on expected lifetime

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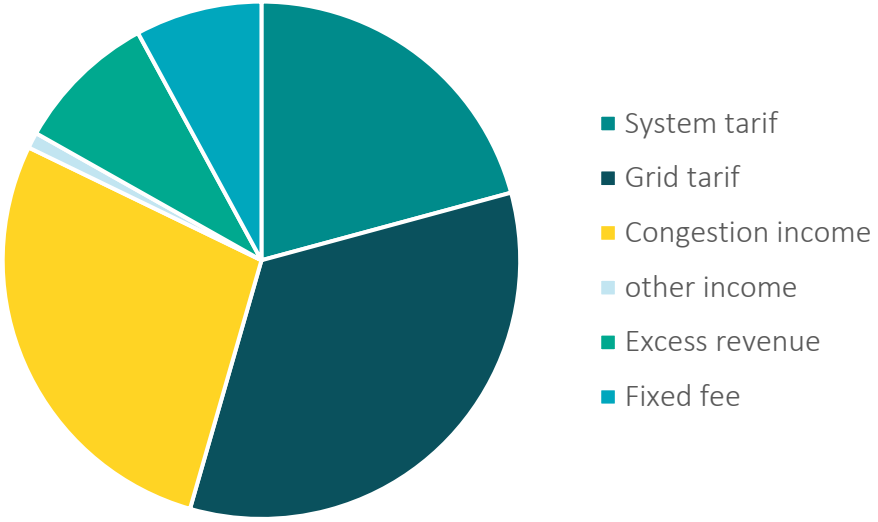
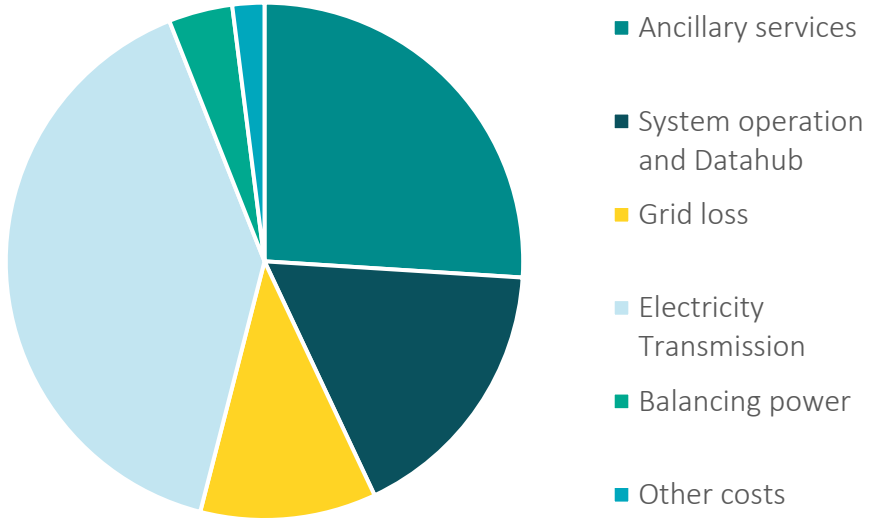
ENERGINET

Financing,
1,13 bill. Euro,
2024

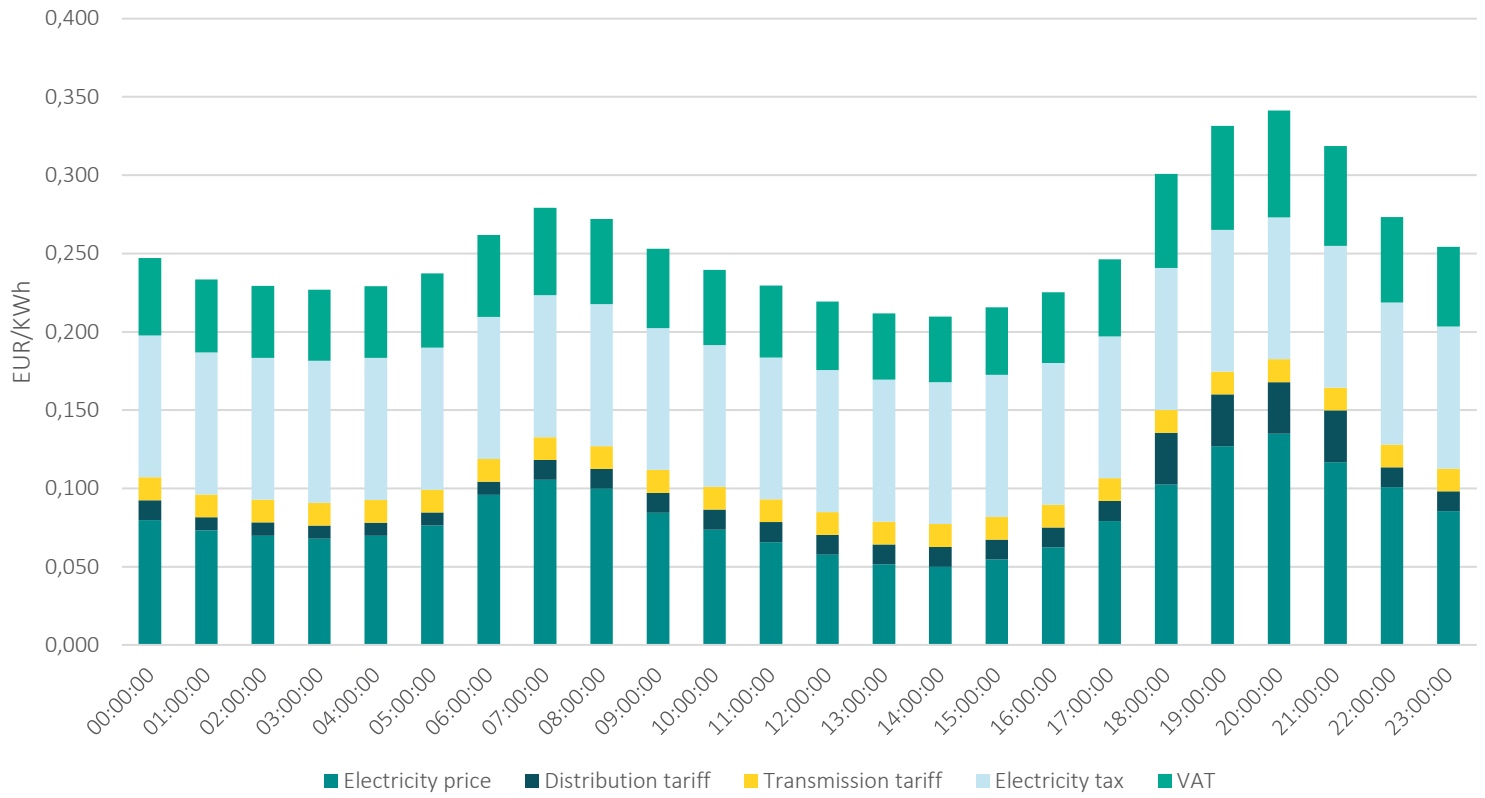


Costs,
1,13 bill. Euro,
2024



TIME DEPENDENT GRID TARIFFS AND TAXES INCREASE INCENTIVE FOR EFFICIENCY AND FLEXIBILITY

Average hourly electricity spot pricem August 2023 – with tariffs & taxes added



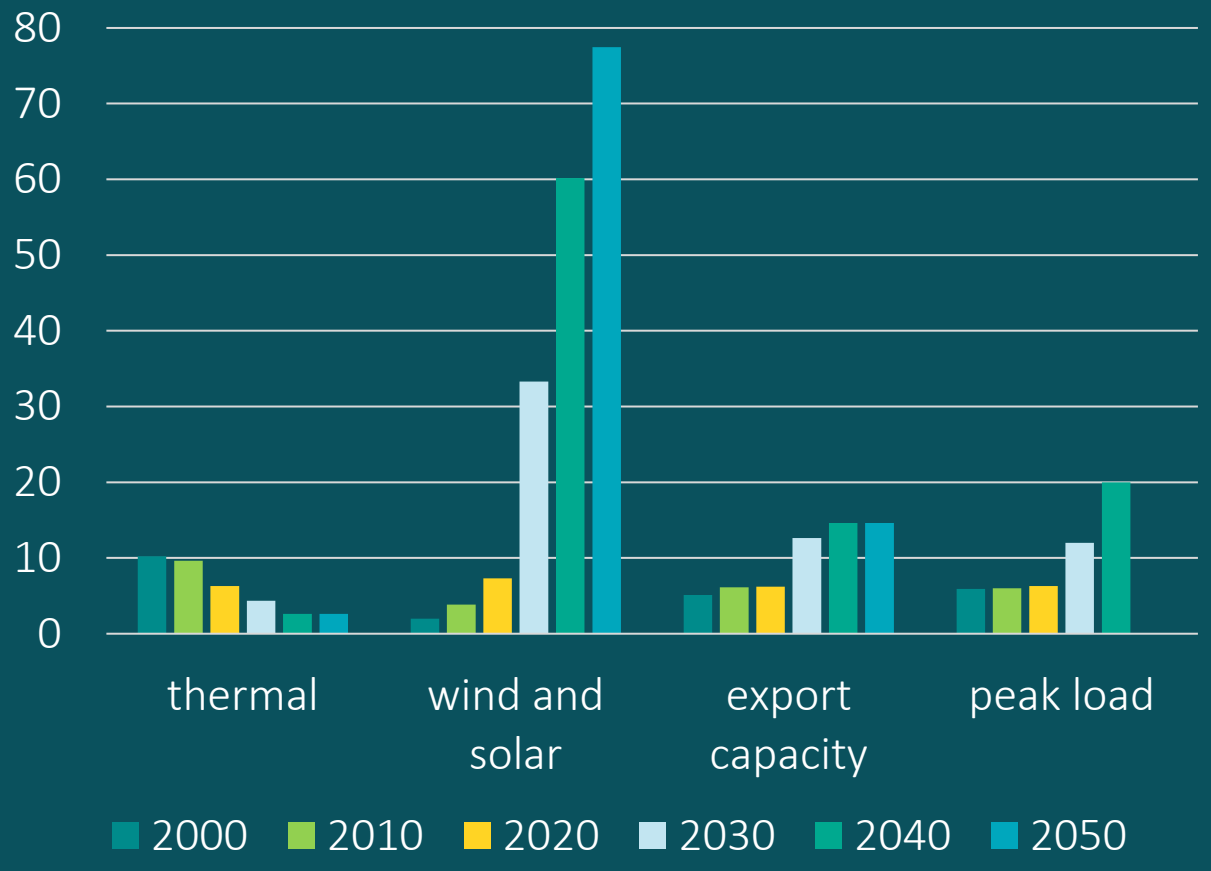
- The tax and tariffs added to the average spot price
  - From **Energinet**: the transmission tariff
    - The consumption tariff: *0.015* EUR/KWh
  - From **TREFOR**: the distribution tariff
    - Low load: *0.008* EUR/KWh
    - High load: *0.013* EUR/KWh
    - Peak load: *0.033* EUR/KWh
  - The electricity tax rate*: 0.091* EUR/KWh
  - 25% VAT on the total price

Sources: https://www.energidataservice.dk/tso-electricity/Elspotprices & https://energinet.dk/el/elmarkedet/tariffer/aktuelle-tariffer/ & https://www.trefor.dk/elnet/priser/

ENERGY PLANNING

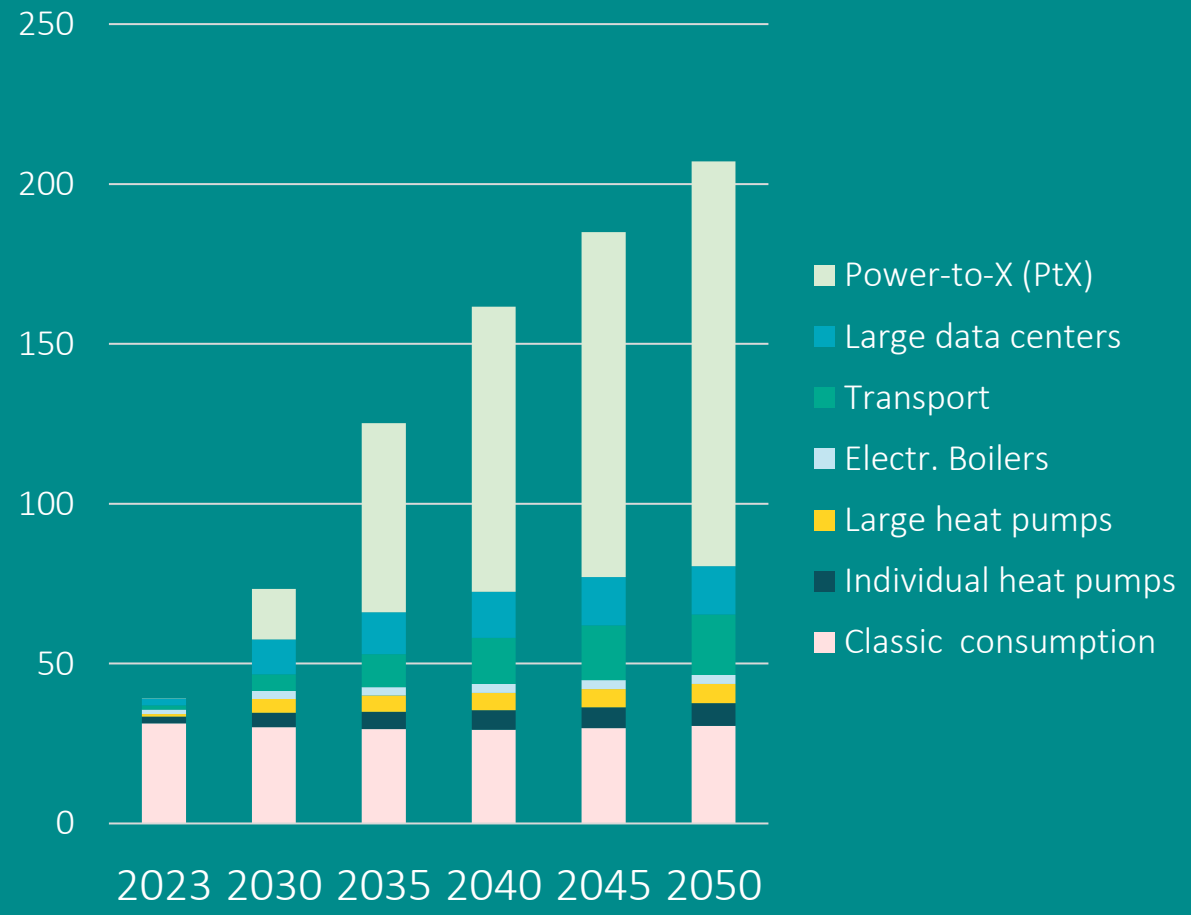
WHAT HAS BEEN ACHIEVED IN THE LAST 20 YEARS ACCELERATES TOWARD 2040

Electricity generation and peak capacity, GW



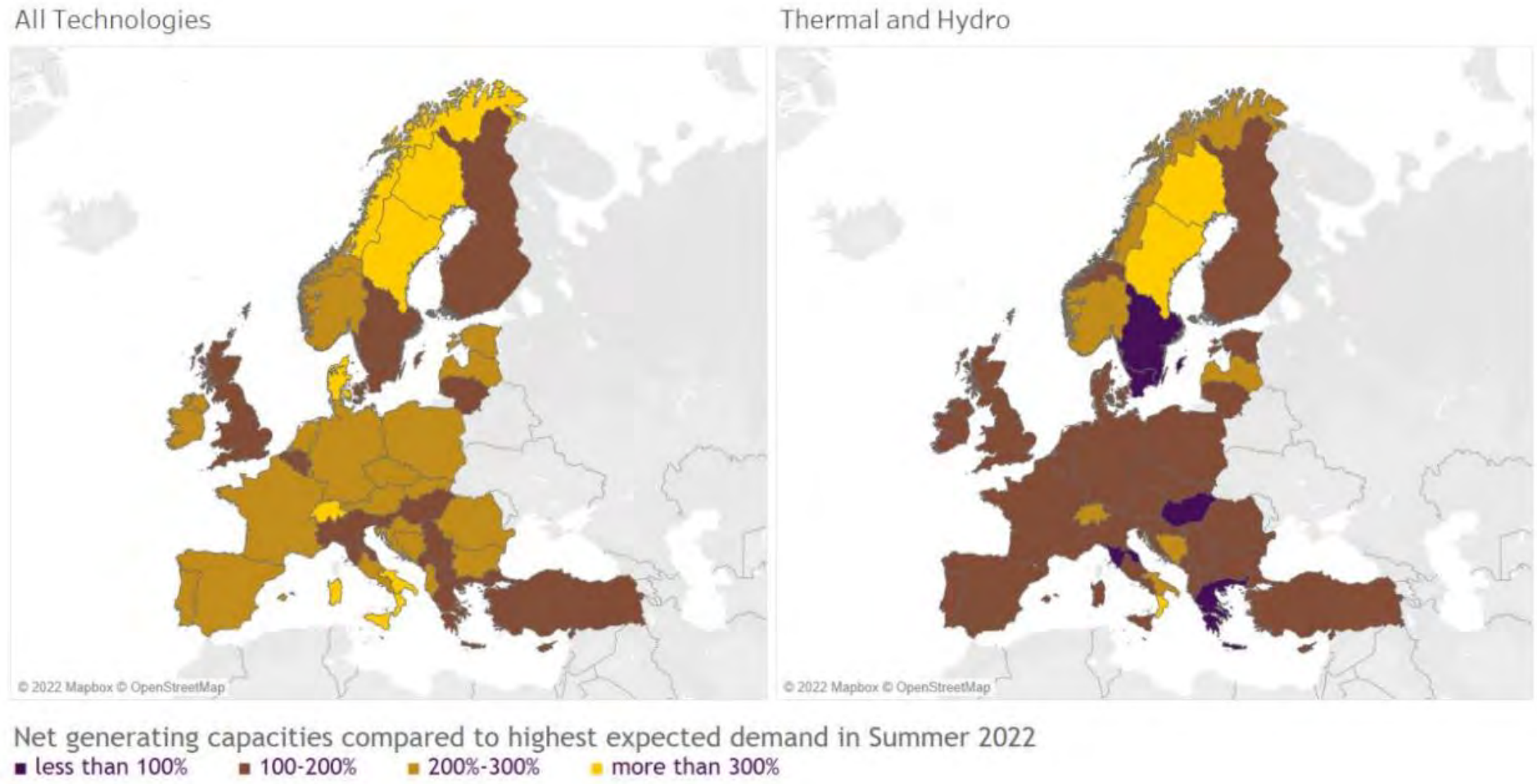
ELECTRIFICATION DRIVES THE CHANGE TO A CLIMATE NEUTRAL ENERGY SYSTEM

Electricity consumption, TWh



Source: Danish Energy Agency, Analyseforudsætninger 2023

SHORT TERM ADEQUACY FORECAST, SUMMER 2022

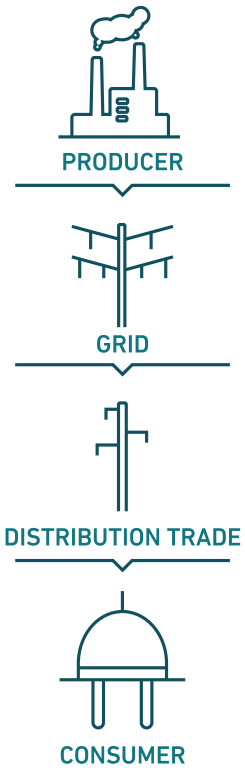


1_Summer-Outlook-Report_2022.pdf (windows.net)

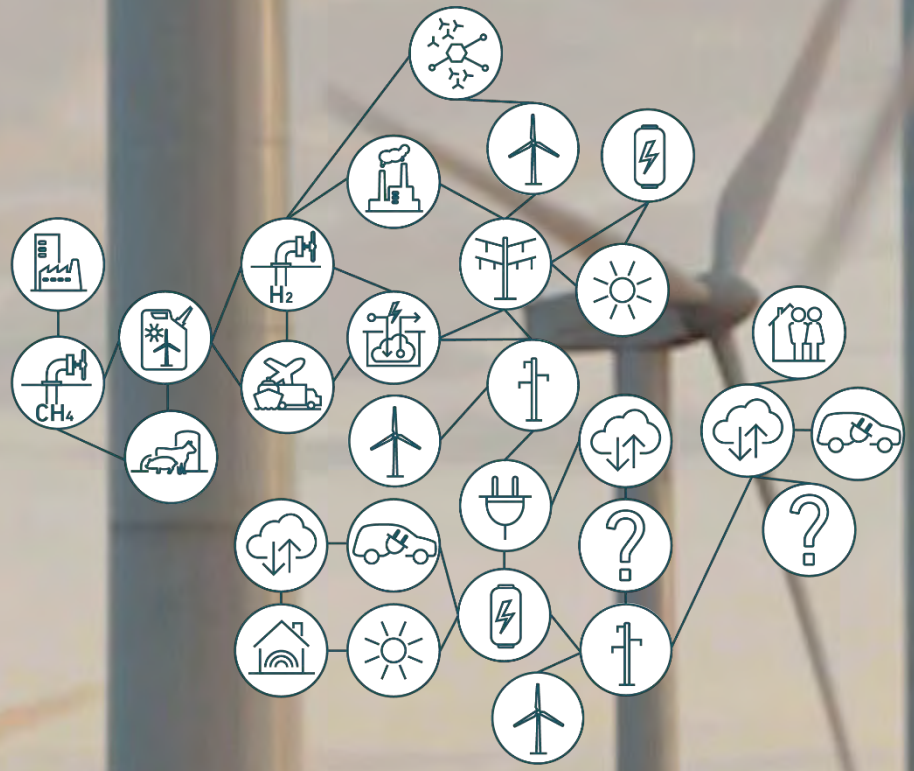
DATAHUB

DIGITALIZATION IS KEY FOR THE FUTURE INTEGRATED ENERGY SYSTEM

BEFORE



IN THE FUTURE



Electricity and gas consumers are ~~passive (inflexible)~~ active and flexible

Electricity ~~cannot~~ can easily be stored economically

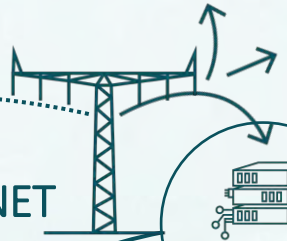
Green energy needs no subsidies to survive

Not everyone receives or wants
~~Everyone receives~~ the same product in terms of security of supply

THE DATAHUB

ENERGINET

PRODUCTION AND BALANCING



TSO ENERGINET

DATAHUB

THIRD PARTIES/ DATA SERVICE PROVIDERS

CONSOLIDATED DATA

SUBSCRIPTIONS, FEES AND TARIFFS

SUPPLIER

Bill

Meetering Point

DSO

SUBSCRIPTIONS AND FEES

TARIFFS

DATA

Free Choice of Supplyer, Energy Data Access & Third Parties Rights

CONSUMER

Real value creation throughout society!

"12,94% Drop in peak-hour electricity usage from 2021 to 2022"

IoT is coming to disrupt our well-known processes

ENERGINET

CONNECTING PHYSICS, MARKET AND DATA THROUGH DATASERVICES

Realtime production & consumption data

Planned operation and marked data

Settlement data

Electricity Infrastructure

Gas Infrastructure

Environmental declarations

ELOVERBLIK

Secure access to confidential usage information

ENERGI DATA SERVICE

Public and free API on CO2, prices, consumption and production

ENERGINET

Eloverblik

Secure access to confidential usage information

DIGITAL METERS DSOs collect data about electricity usage through connected meters.

DATAHUB Energinet processes and stores all information about Danish customers, consumption and prices.

ELOVERBLIK Authenticated API enables third-party apps to integrate usage and charge data from metering points.

ENERGINET

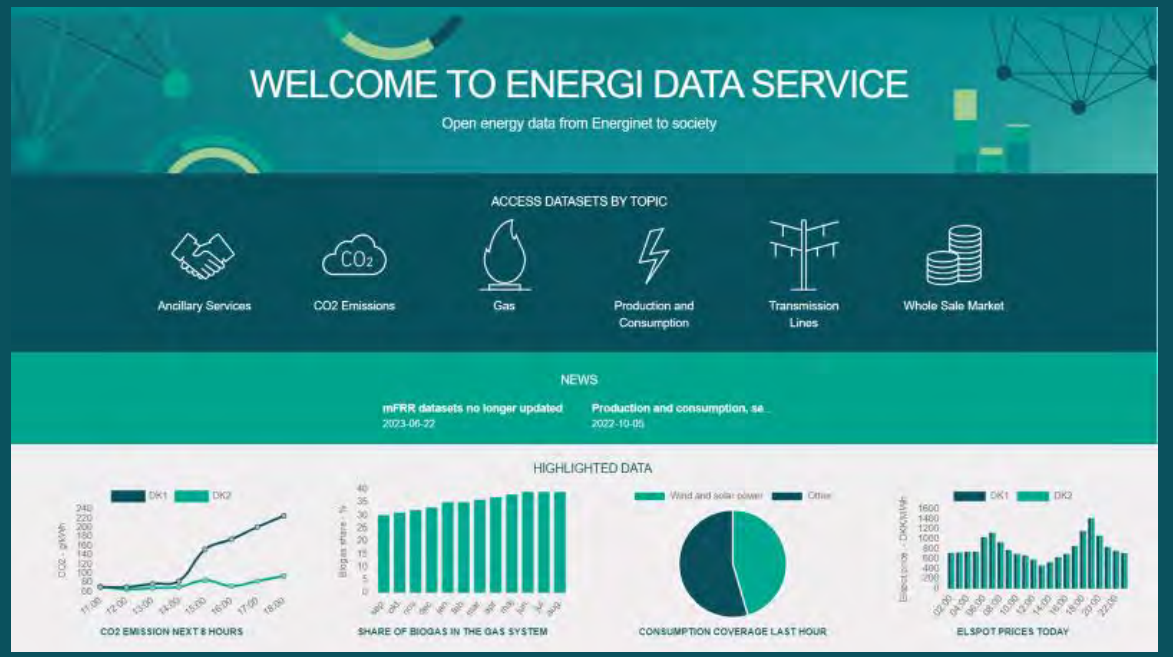
ENERGI DATA SERVICE

Energy Data Services gives public and free API access to Energy data

DPS / DDP: Internal planning system

SCADA: Grid sensors & meters.

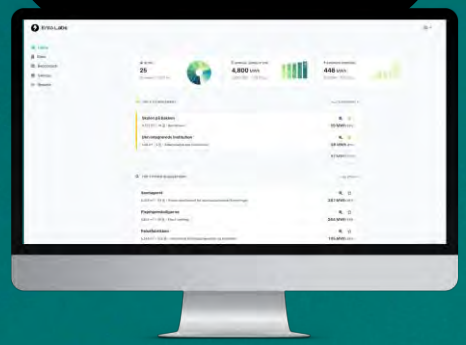
DATAHUB: DSO metering points.



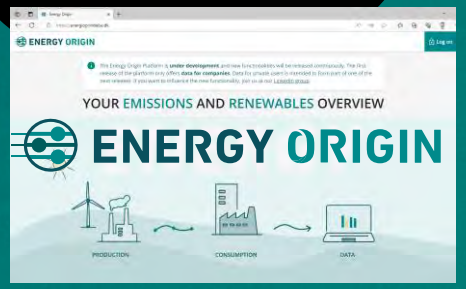
4 examples of innovation

Imagine if an app could simply let you know **when to turn on the dishwasher**

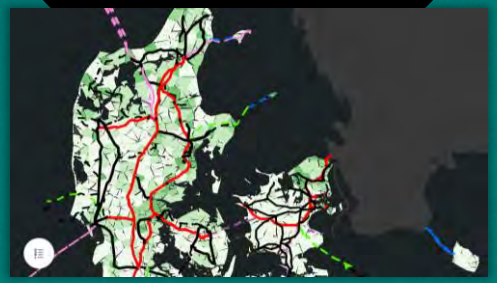
Imagine if buildings could be more **energy effefficient by use of machine learning**



Imagine if your **carbon footprint was based on data**



Imagine if you **could show available capacity in the electricity net**



ENERGY EFFICIENCY

THE DANISH ENERGY TRANSITION

MAIN TOOLS FOR GREEN TRANSITION

- Stable and holistic energy planning
- Clear mandate for TSO and transmission build out
- Flexible electricty production and interconnectors
- Market based regulation and electricity markets
- Digitalization of operation and markets

DANISH GREEN TRANSITION

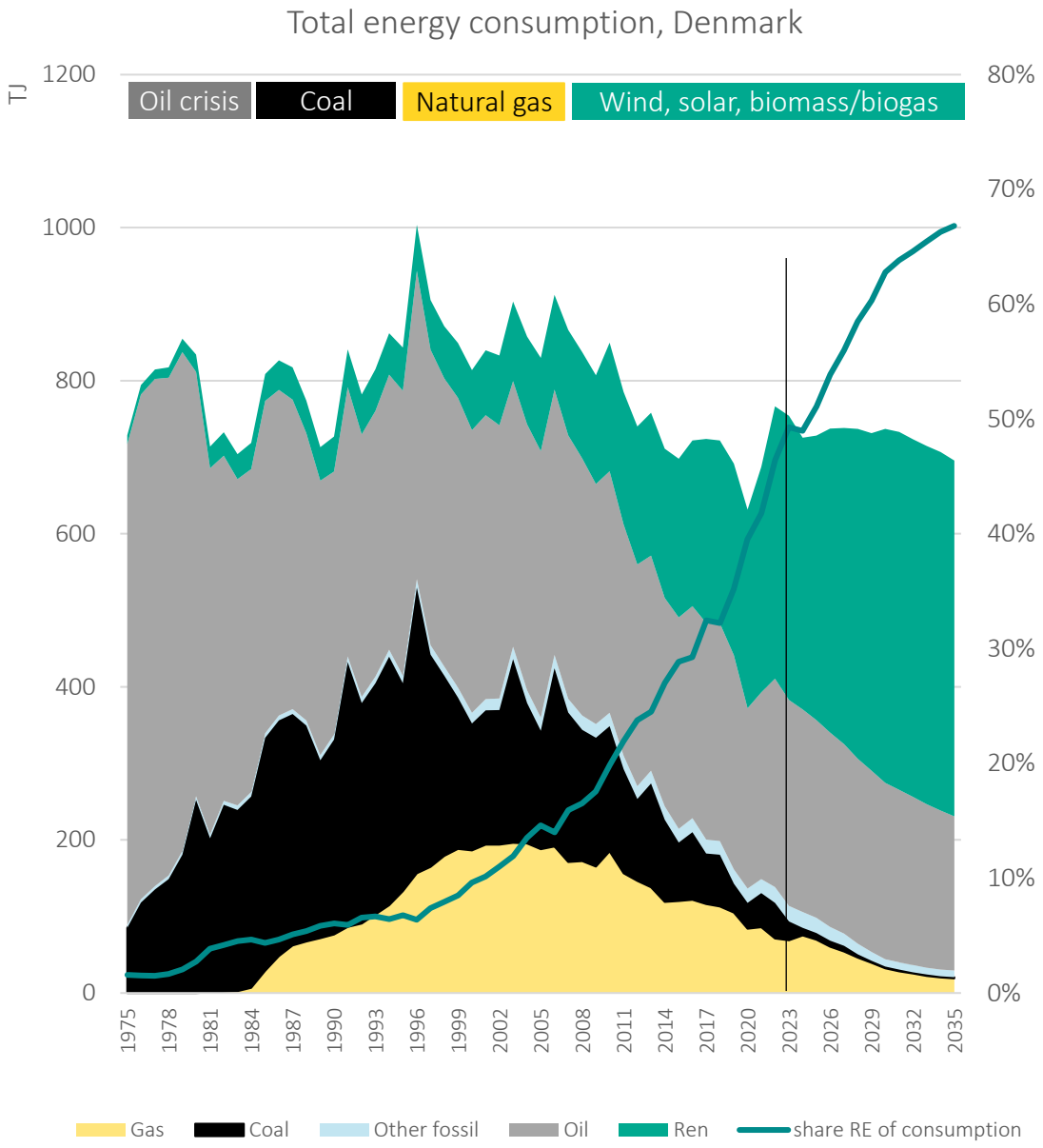
2022: 60% green VRE electricity

40% biomethane

Electricity security of supply:

99.997%

ENERGINET



TRANSMISSION PLANNING

GRID PLANNING AND CONNECTION

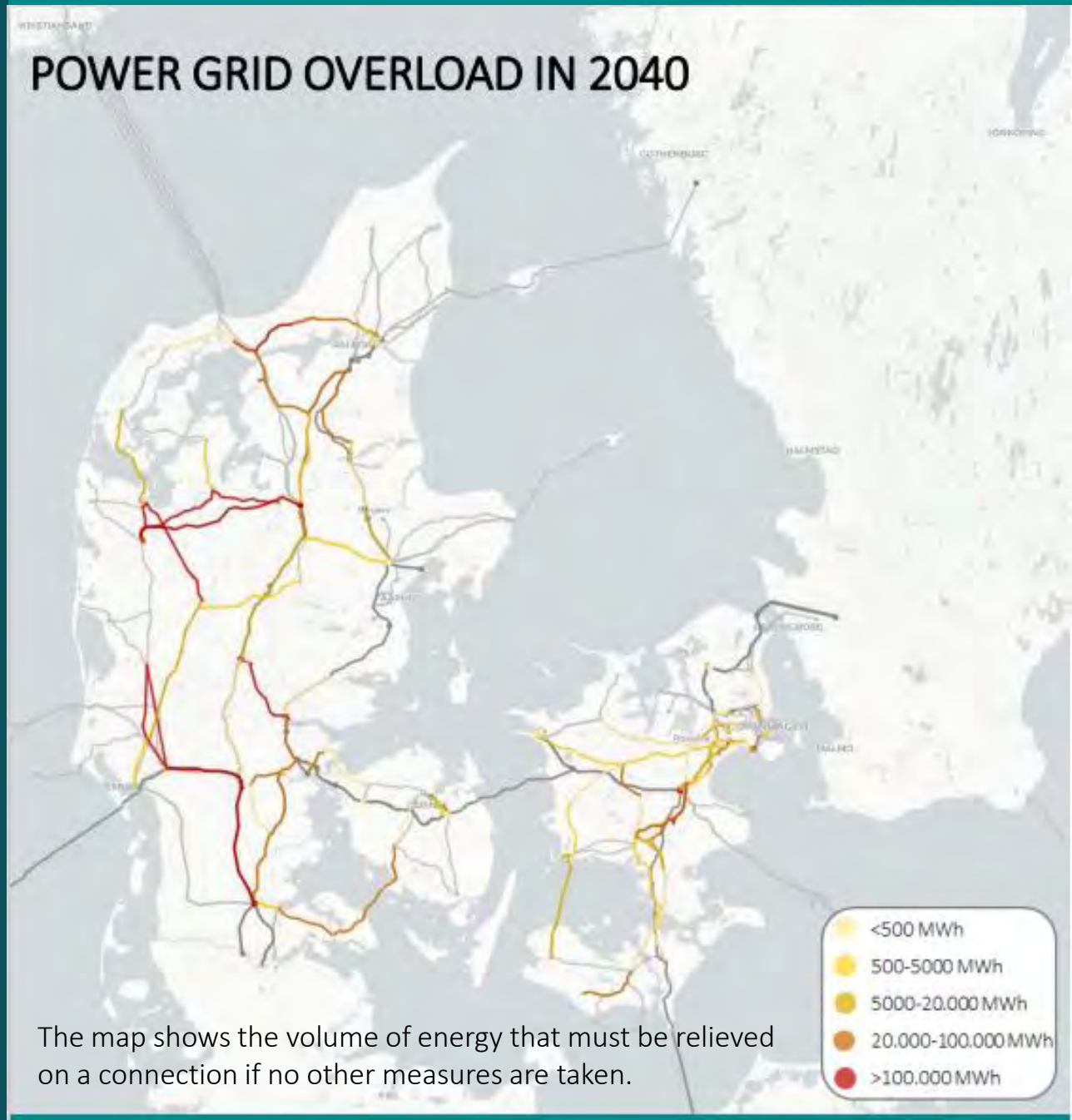
Challenge is faster build out of VRE than expected and objective to accelerate connection process and at the same time reduce transmission investments costs for affordable green transition

The electricity system needs will be solved with mix of:

- Grid investments (annual grid planning, anticipatory investments, portfolio connection, direct T-connection, temporary masts)
- Operational solutions (dynamic line rating, optimized modelling and digitalized operation)
- Market solutions (market based curtailment compensation, local markets and flexibility)
- Stakeholder dialogue (capacity map for optimal location of new generation and consumption, digitalization and transparency in connection process)
- Tariff reforms (geographical incentives, cost-oriented connection tarif, limited grid access, direct lines)

Uncertainty on expected VRE build and manage with sensitivities and anticipatory investments

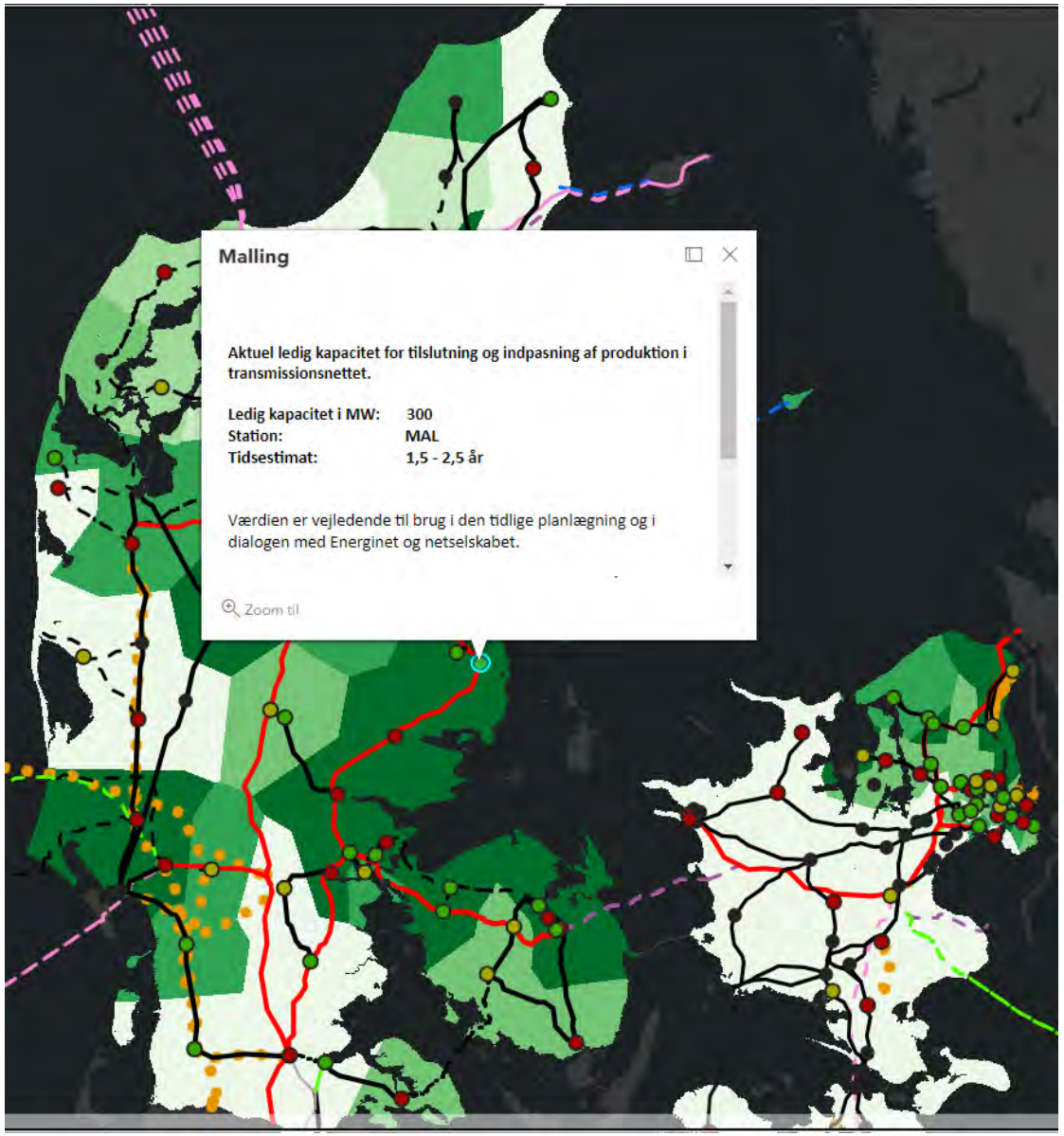
Long-term development plan for the power grid 2022 (energinet.dk)
Modernisering af tarifdesign (energinet.dk)



The map shows the volume of energy that must be relieved on a connection if no other measures are taken.

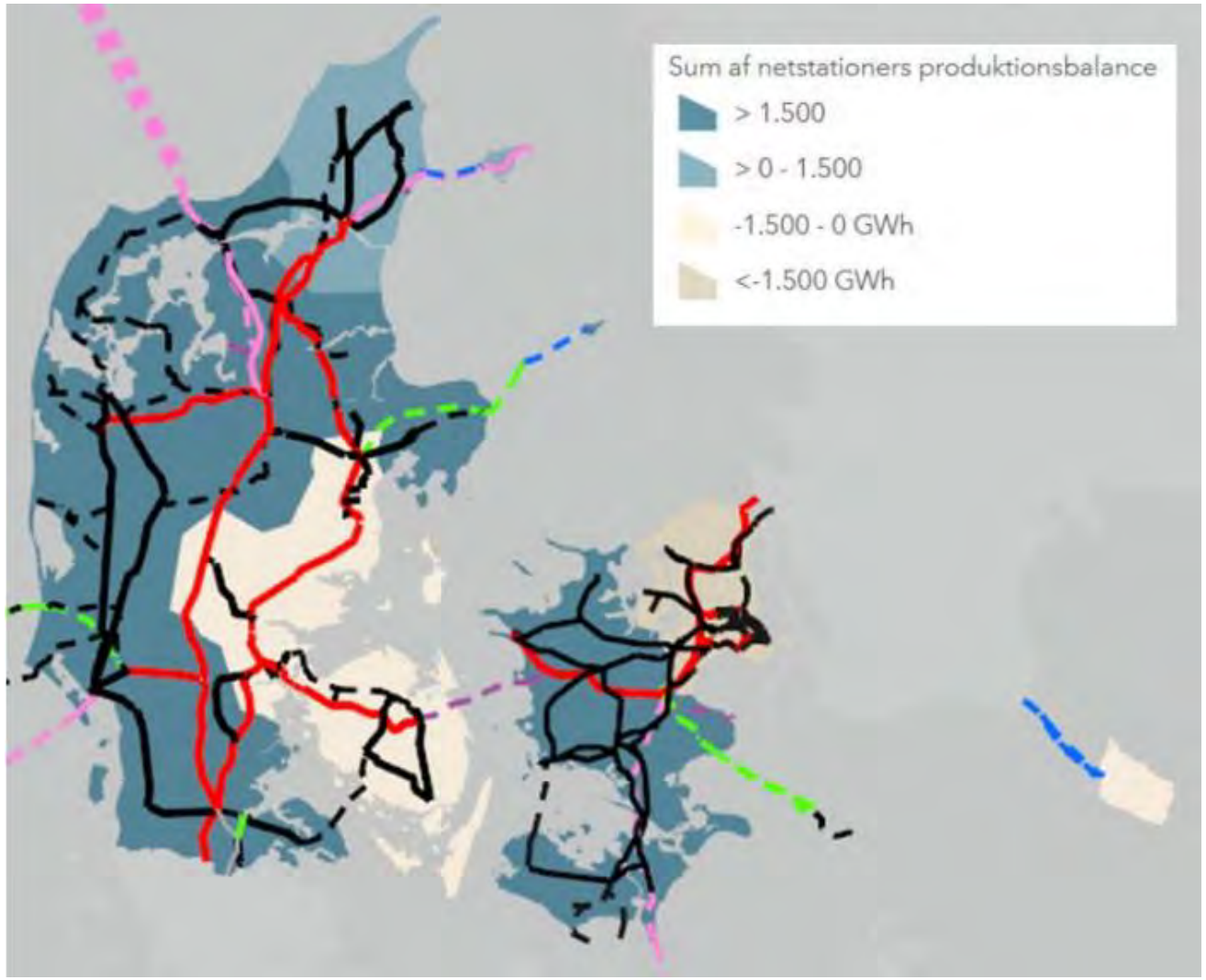
OPTIMIZING THE USE OF THE POWER GRID

- Capacity map – developing calculation methods
- Tariffs, co-location and congestion management
- Cross-sectoral planning – especially hydrogen



OPTIMIZING THE USE OF THE POWER GRID

- Capacity map – developing calculation methods
- **Tariffs, co-location and congestion management**
- Cross-sectoral planning – especially hydrogen



OPTIMIZING THE USE OF THE POWER GRID

- Capacity map – developing calculation methods
- Tariffs, co-location and congestion management
- **Cross-sectoral planning – especially hydrogen**

ELECTRICITY MARKET AND UNBUNDLING

PARALLEL DEVELOPMENTS

- TOWARDS RENEWABLE ENERGY AND OPEN MARKETS

From large coal fired to local CHP, solar and wind power

2000

From vertically integrated monopoly to competitive electricity market

Generation

Transmission

Distribution

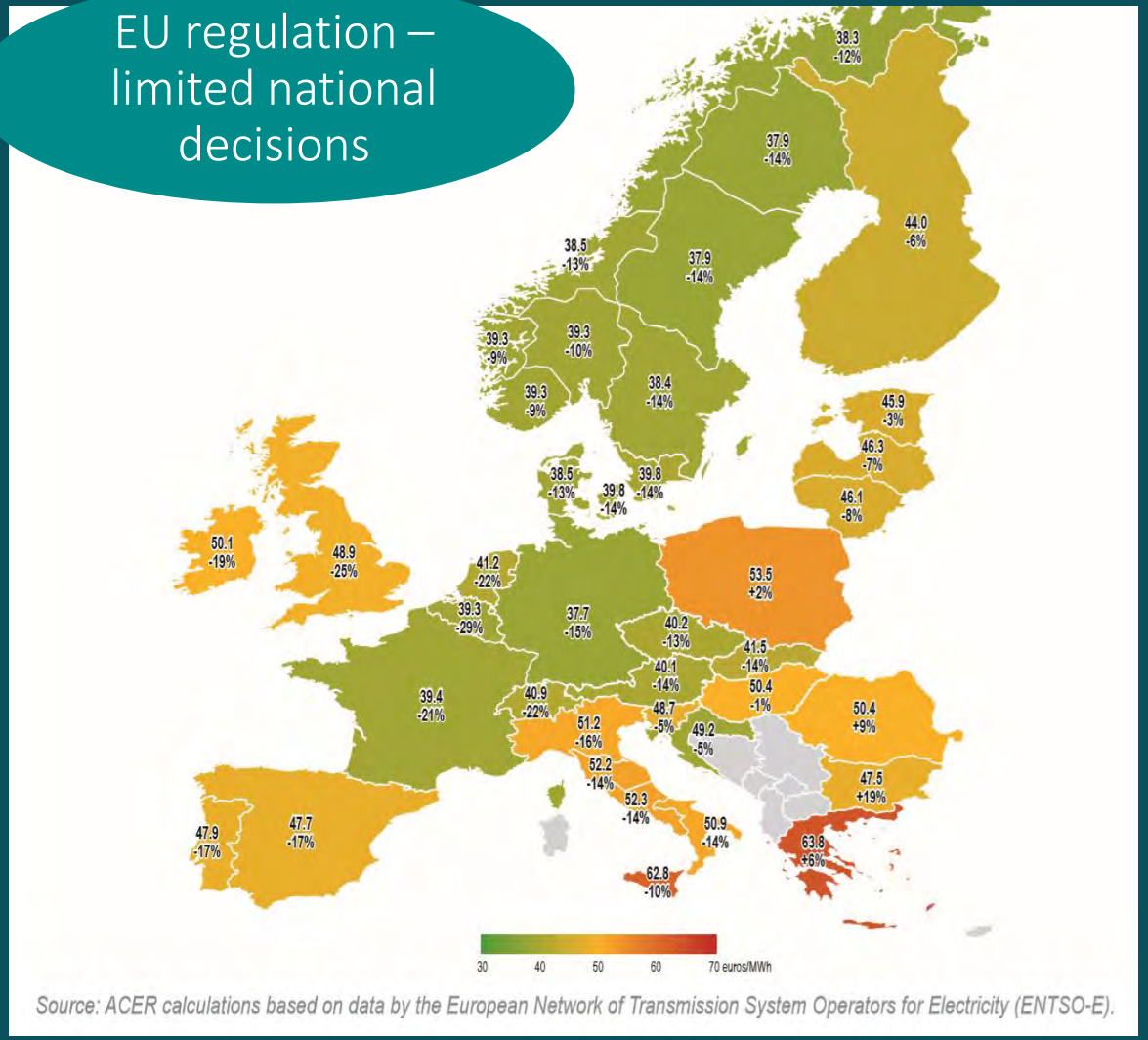
Generation | Trade | Supply

Transmission System Operator

Distribution

EUROPEAN COMMON ELECTRICITY MARKET AND OPERATION

EU regulation – limited national decisions



Source: ACER calculations based on data by the European Network of Transmission System Operators for Electricity (ENTSO-E).

EUROPEAN GRID DEVELOPMENT COORDINATION

EU coordination

National decision on grid investments