OXYGEN HANDLING AT INTERCONNECTION POINTS

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DENMARK AND OXYGEN

Where does oxygen come from?

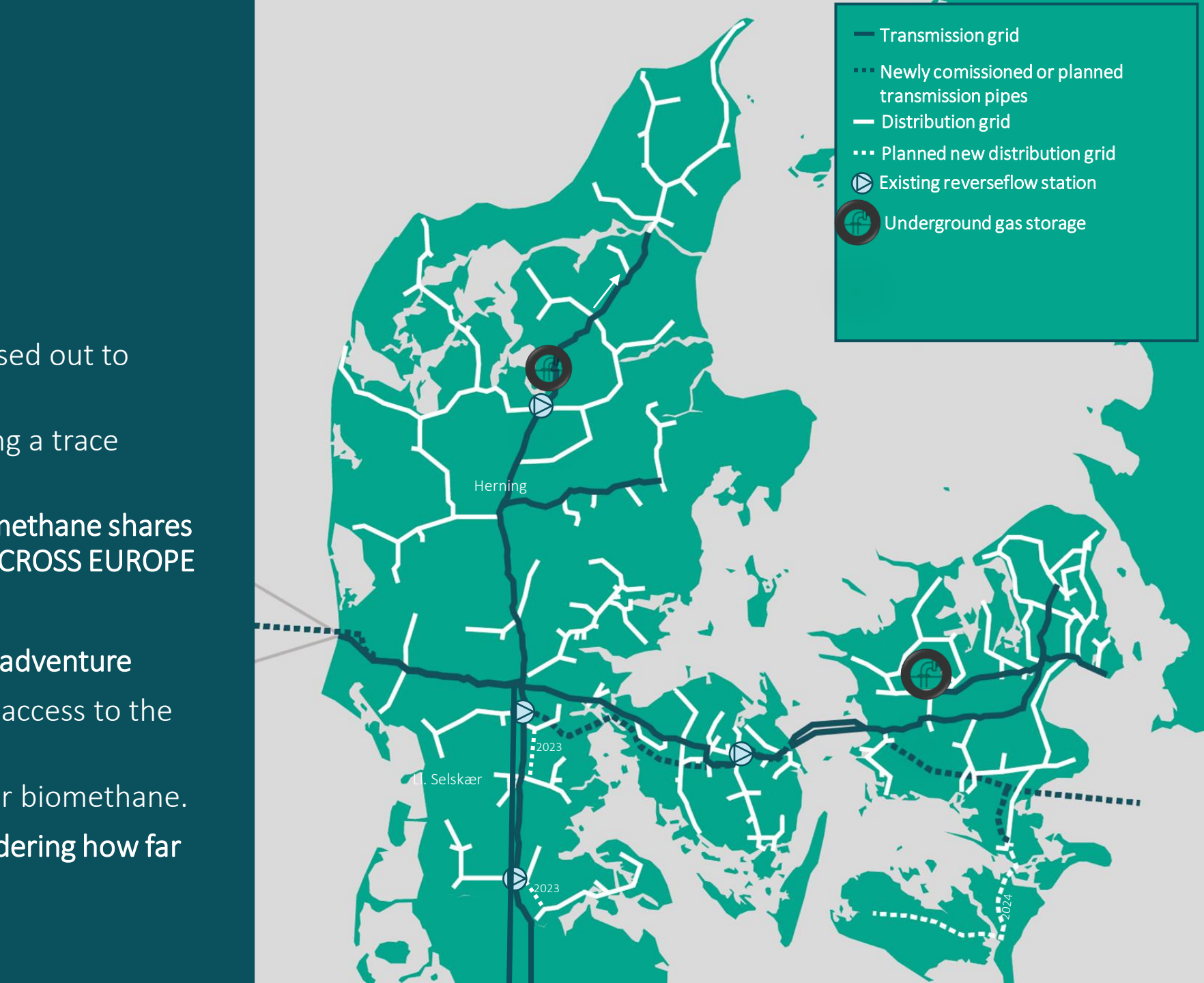
- CO2 and H2S from biogas is rinsed out to obtain the desired gas quality.
- Oxygen is usually needed leaving a trace behind in the gas stream

35 BCM target and increase in biomethane shares mean this is now a TSO issue ALL ACROSS EUROPE

Denmark set out on a biomethane adventure

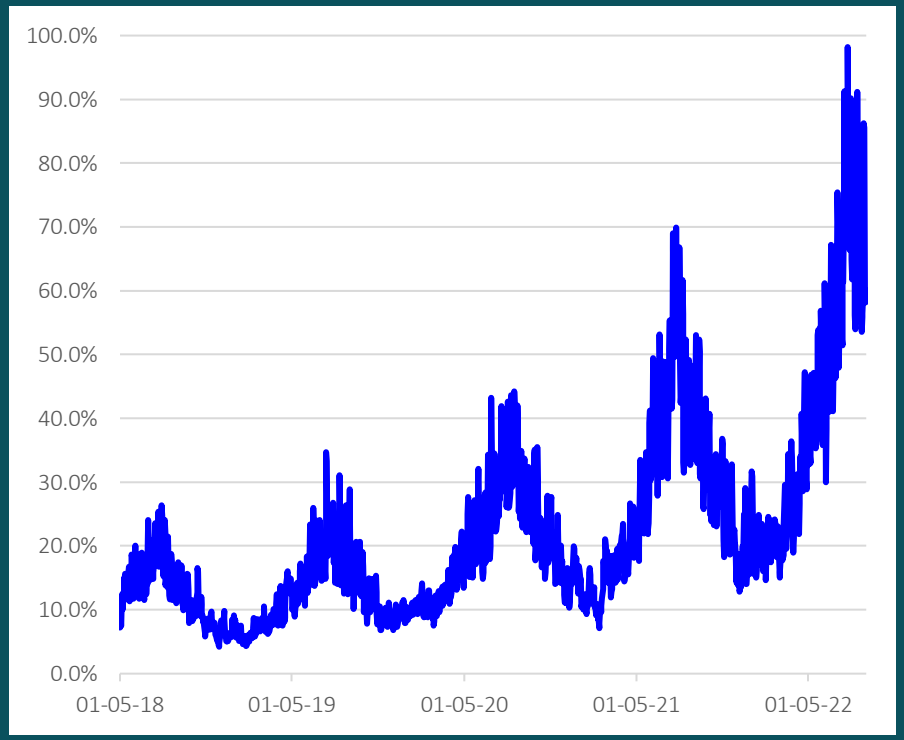
- Enable biomethane producers' access to the grid at low cost.
- Oxygen level was set to 0,5% for biomethane.

This was a risk taken without considering how far we would get!

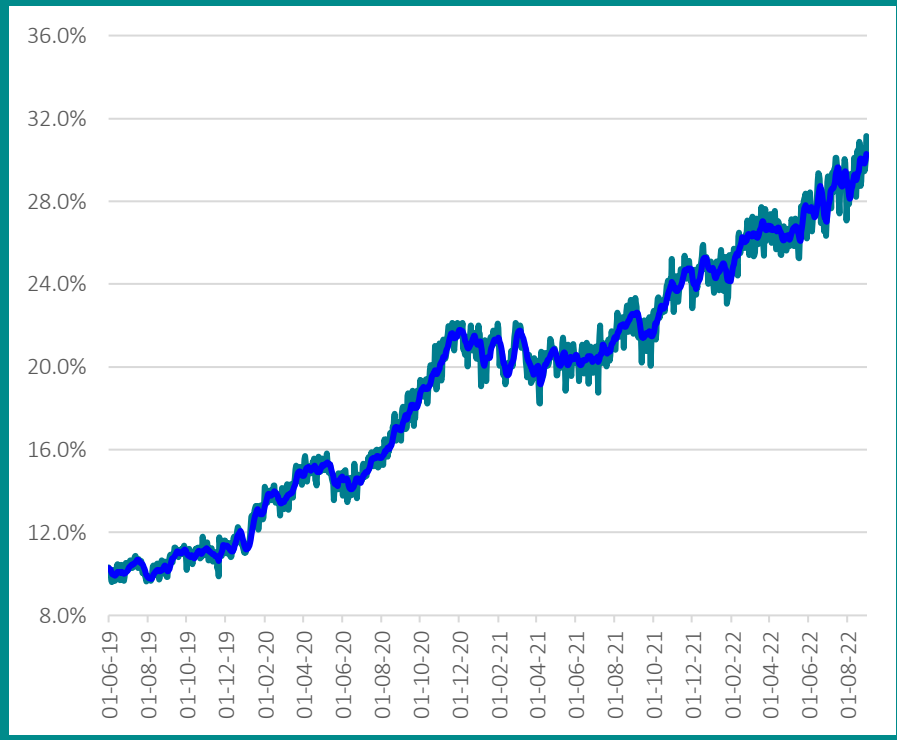


BIOMETHANE DEVELOPMENT IN DENMARK

DAILY BIOMETHANE SHARE

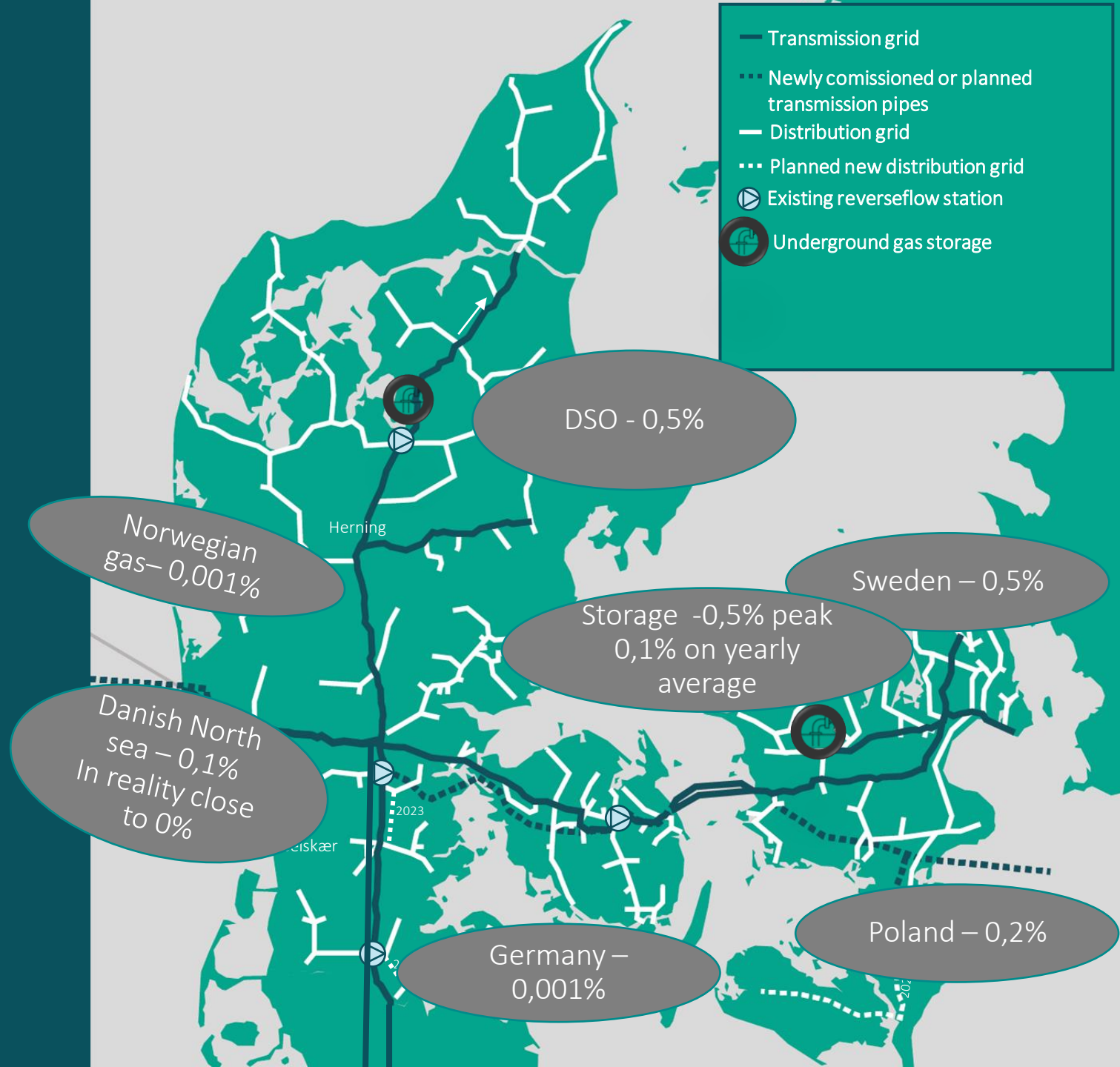


RUNNING 12 MONTHS AVERAGE



OXYGEN AT IPS

- Energinet has 6 Ips
- Entry point: Norway, North sea and Germany
- Exit points: Sweden, Poland, Germany and DSO
- Because of increase in biomethane at DSO level Denmark now has 4 reverse flow stations
- To almost all exit points we see a potential issue
- Creates paradox as we need free flow but also want green independent gas supply

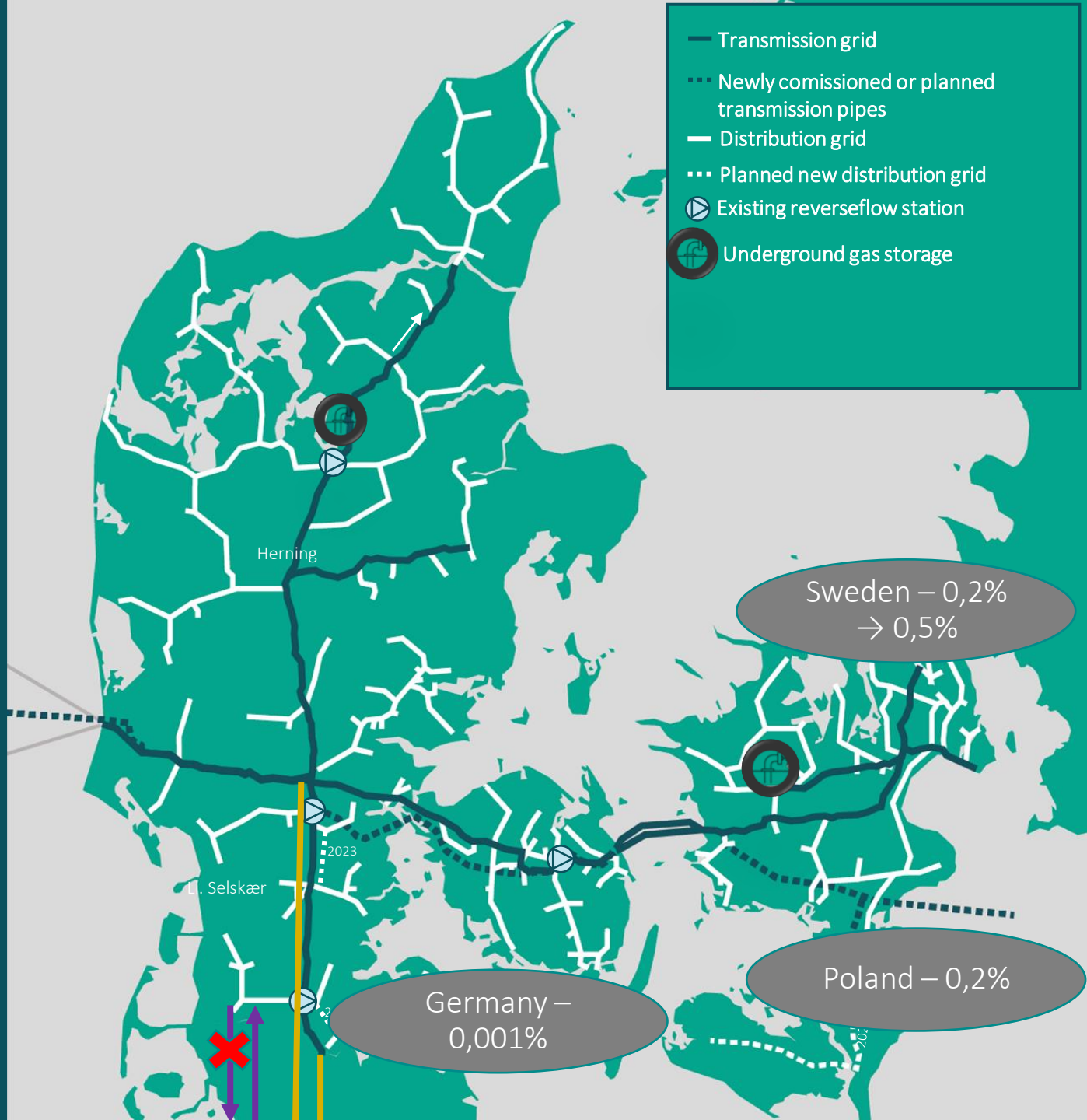


FIRST ISSUE IN 2016

- First direct biomethane plant connected to southern Jutland caused off-spec gas with oxygen towards Germany
- The result was that we had to limit capacity while a solution was found
- Infrastructure work around where all reverse flow and biomethane is connected to pipe1 which only flows north and pipe2 only flows south with north sea gas without O2

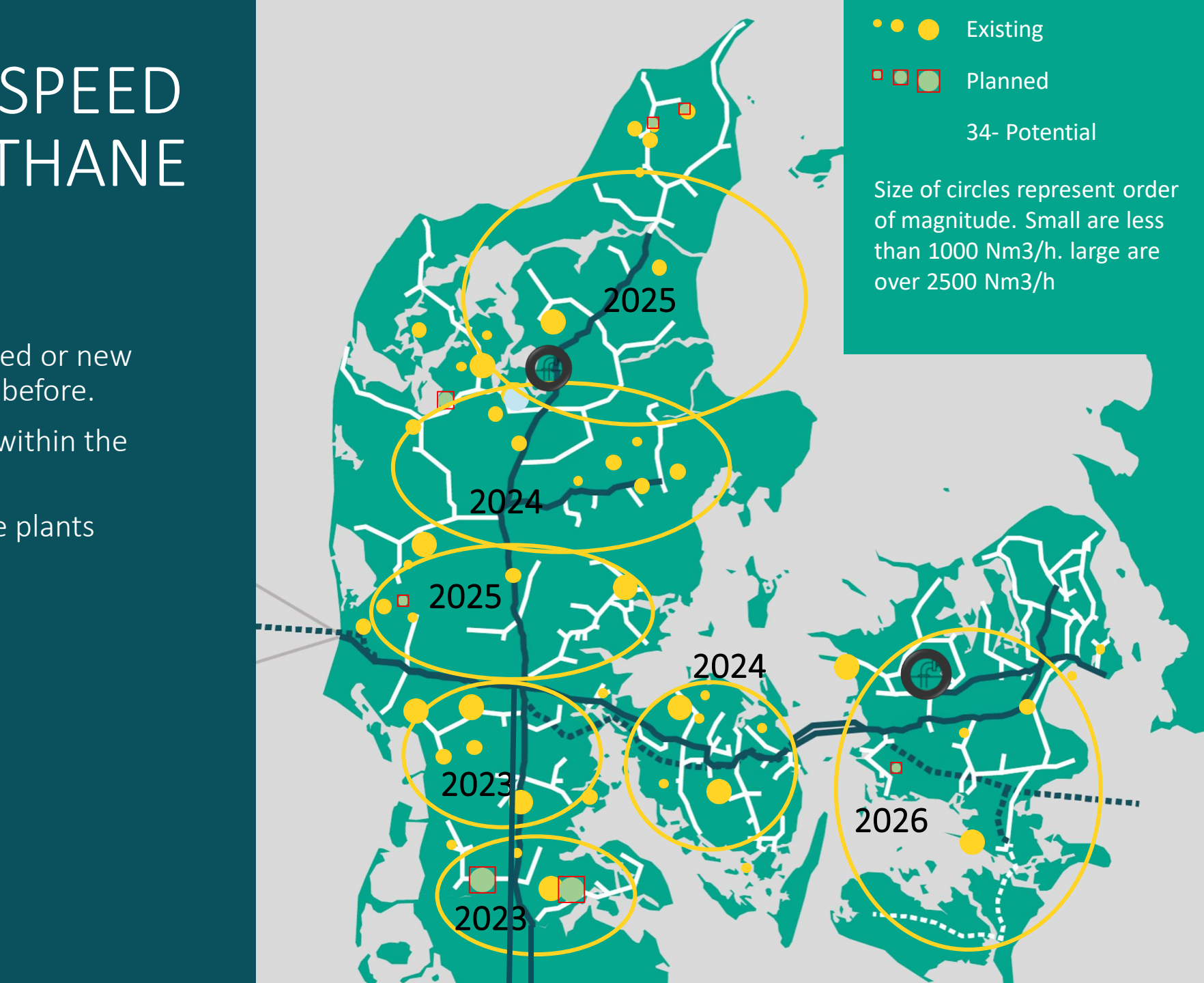
DIFFERENT SOLUTIONS FOR DIFFERENT IPS

- Germany: has a low threshold and we have done infrastructure development to accommodate this
- Poland: we have incorporated operational tools and plans in case of biomethane pocket entering the Baltic Pipe stream
- Sweden: Through dialogue and the Swedish TSOs work together with end-users Sweden has ben able to increase the oxygen acceptance level



ENERGY CRISIS SPEED UP THE BIOMETHANE DEVELOPMENT

- We are seeing a future where biomethane plants are expanded or new ones are built faster than ever before.
- Many areas will be congested within the next 4 years
- Newer plants are mainly amine plants which produces at low O2



NEW ”BIOGAS FASTTRACK ” PROJECT

- Energinet and the DSO are looking into to all options to operationally allow as much green gas as possible into the grid
- This includes
  - Combining distribution grids
  - Operate current reverse flows without redundant until they can be upgrade
  - Build new MR station to lower pressure in Transmission grid
  - 6 new reverse flows
  - All while ensuring no oxygen reaches IPs

We are in a hurry!

BIOMETHANE DEVELOPMENT IN DENMARK

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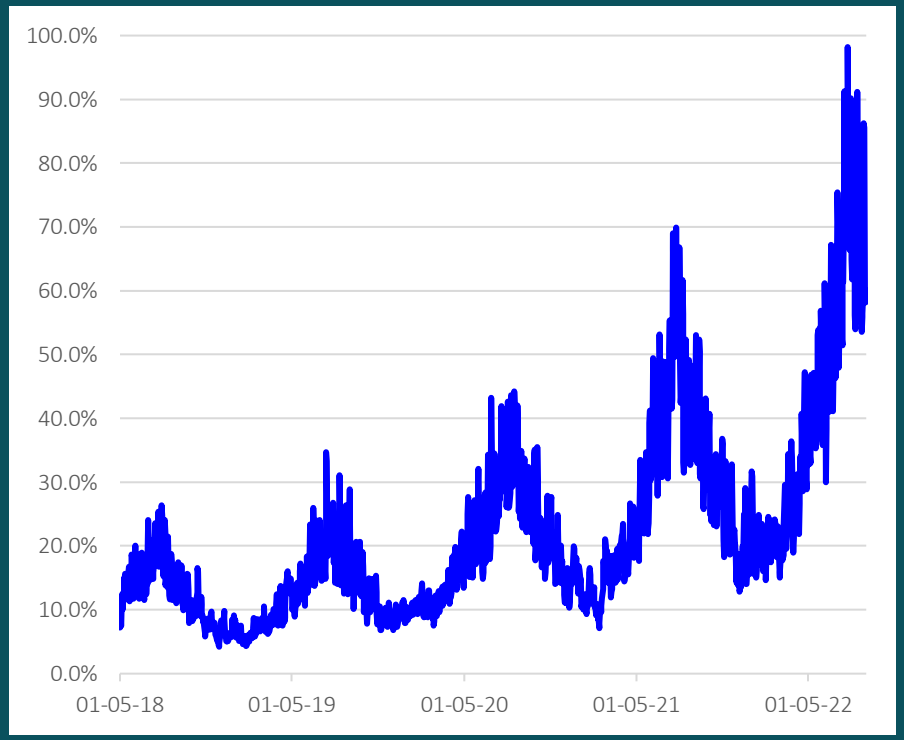

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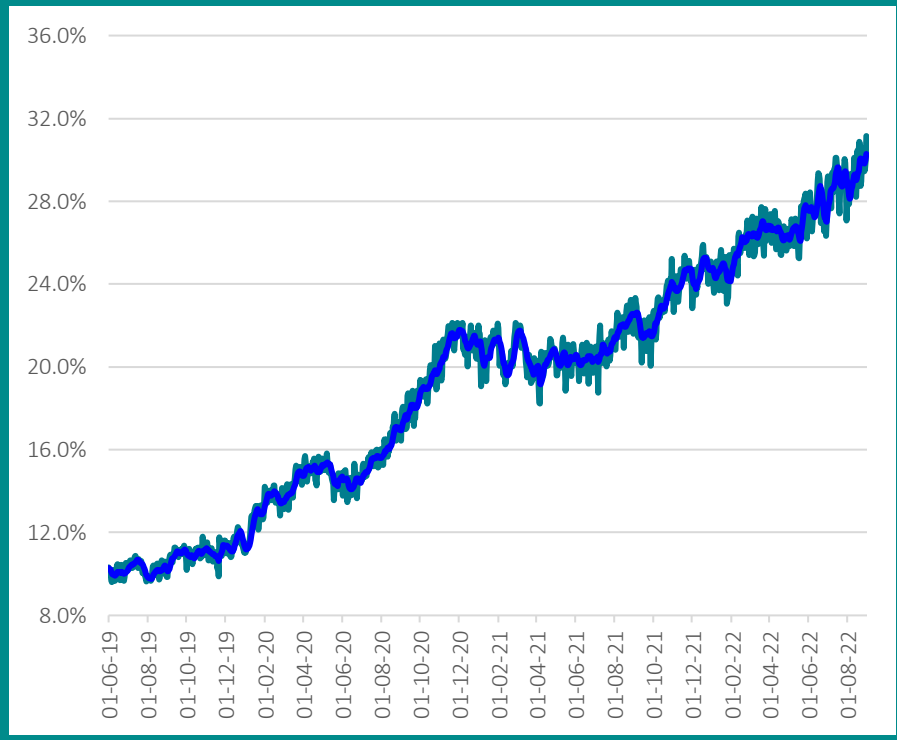
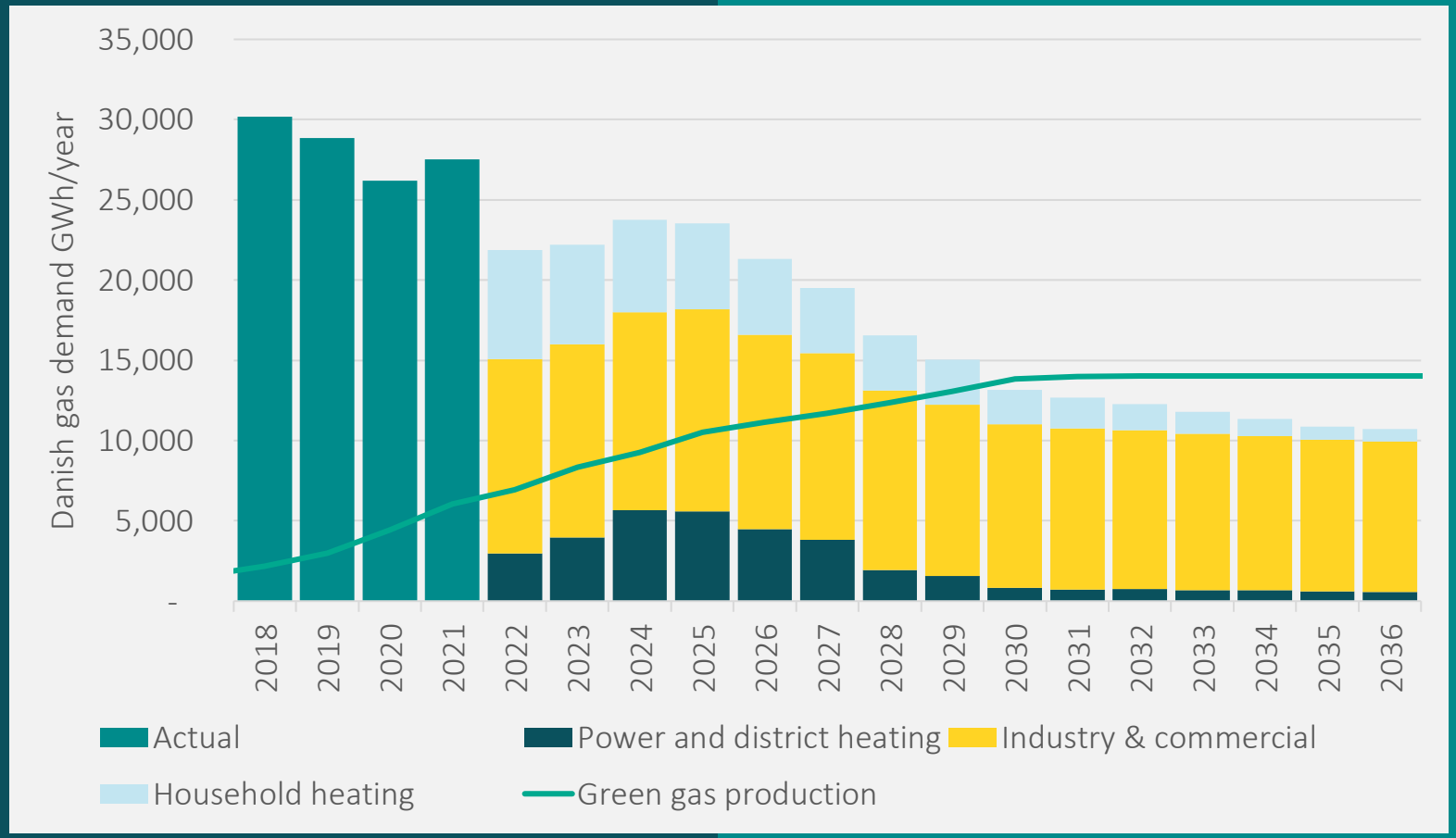


BIOMETHANE IS NOT JUST GREEN TRANSITION, BUT ALSO SECURITY OF SUPPLY

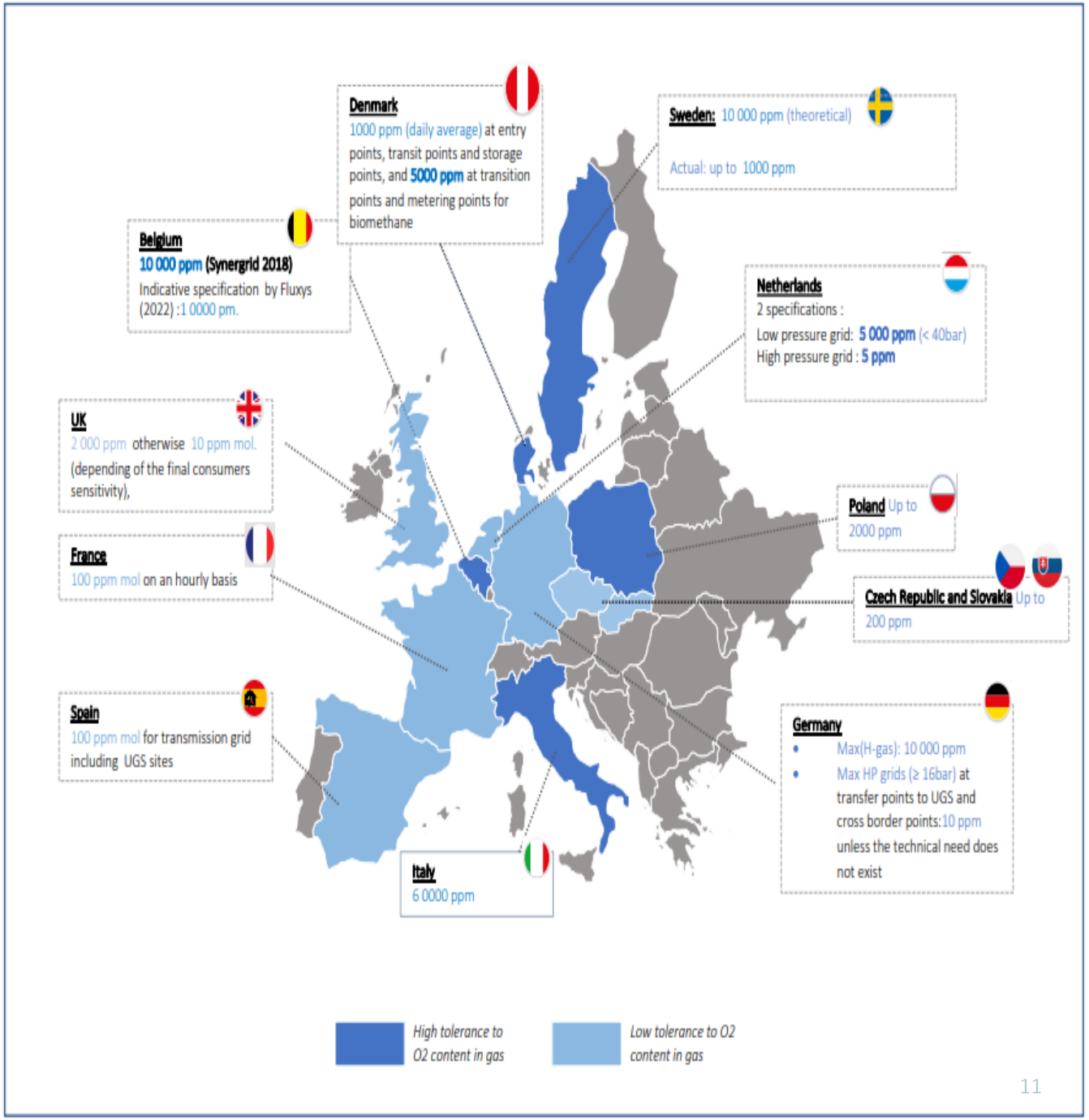
Historic and projected - demand and green gas production



EUROPEAN GAS SPECIFICATIONS VARY

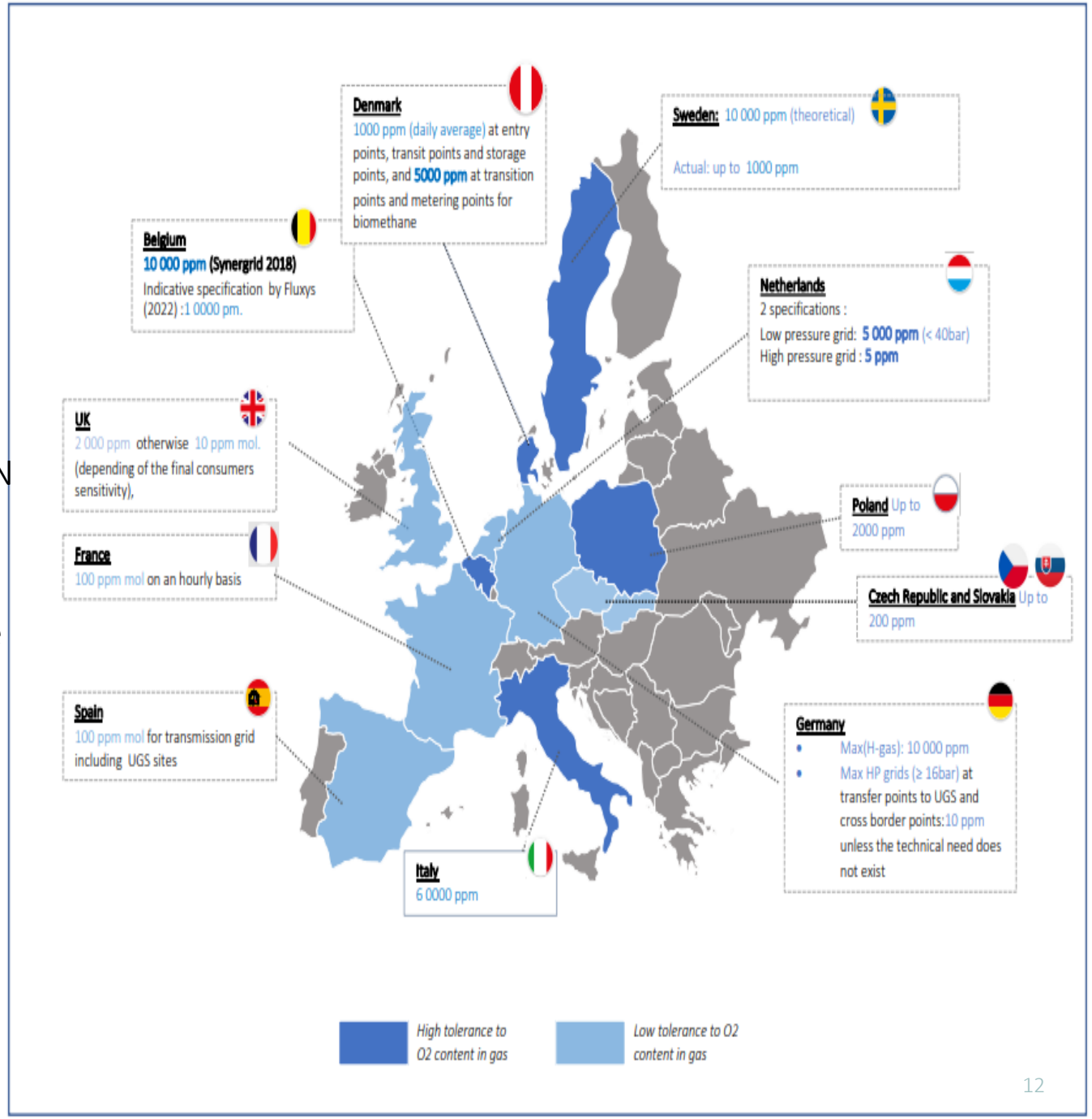
- Gas quality is decided nationally
  - Some use CEN standards
  - Others decides based on national strategy and infrastructure

- We need 35 BCM
- It becomes difficult to handle this nationally without considering IPs
- To cost optimize the European gas infrastructure it is necessary to look beyond ”arbitrary borders”



CURRENT METHOD OF DEVELOPMENT OF SPECIFICATIONS CREATES ISSUES

- The business-as-usual approach with “polluter pays” does not help green transition
- There is an issue in aligning gas quality on IPs being determined by technical standard like CEN or similar
  - Risk aversion and consensus approach
  - Advantage to very sensitive costumers on the behalf on green transition
- Who pays for avoiding oxygen in biomethane?
  - Users of the gas grid and end-users
  - Green agenda
  - Risk: it expensive to be first-mover on green transition

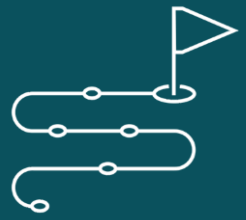


THREE STEP TO TAKE WHEN INTEGRATING BIOMETHANE

TSO's need to ask themselves three questions and go through each step to fully optimise regarding oxygen from biomethane in the European gas grid

No. 1 - Is there a reason for removing the oxygen in the first place?

DK- No we can operationally handle biomethane with high O2 content



NO. 2 - how much oxygen should be allowed in the grid?

DK – We have been able to allow up to 0,5% until now

We have reached 30% shares of biomethane before even considering this option

NO. 3 - what is the most cost-efficient removal point?

DK – We now have to look into what options are available and what is necessary