Natural gas markets

Lecture ULiège Montefiore

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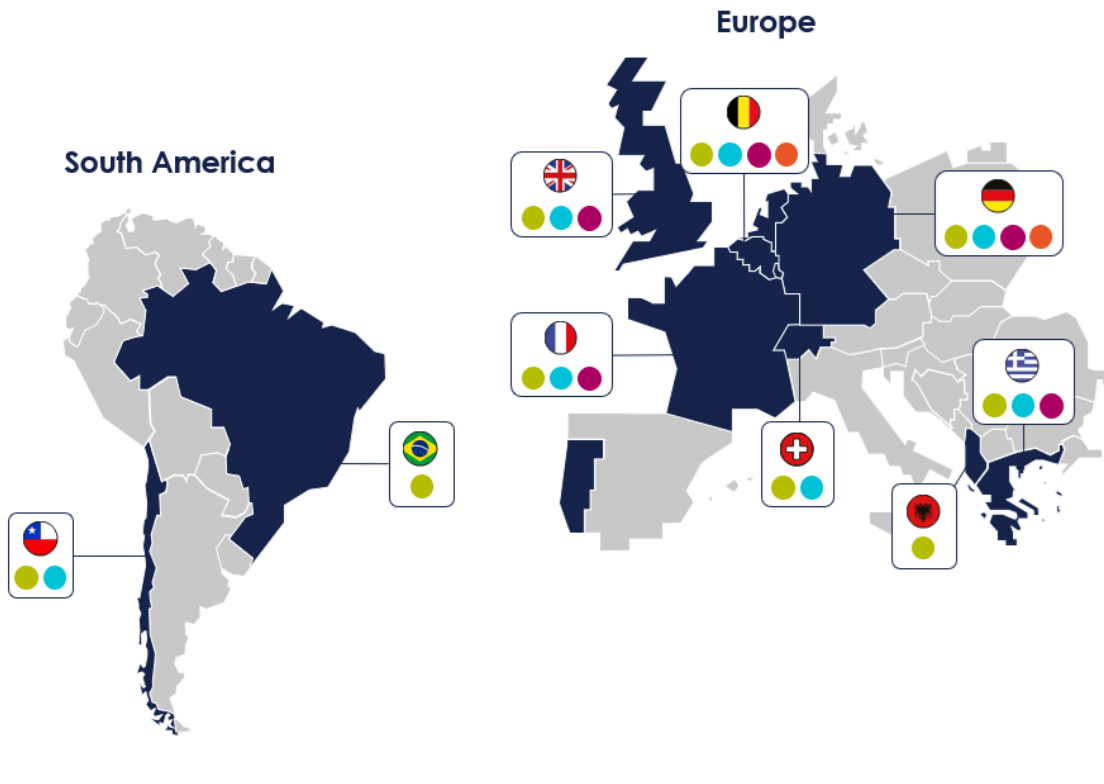


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Who is Fluxys?

4 facts about Fluxys

1. Multi-molecule infrastructure partner headquartered in Belgium
2. Strong European presence with associated companies across Europe, South America and the Middle East
3. A growing group of 1500 employees sharing respect, reliability and open-mindedness
4. Purpose-driven company committed to the energy transition with a dedicated sustainability vision



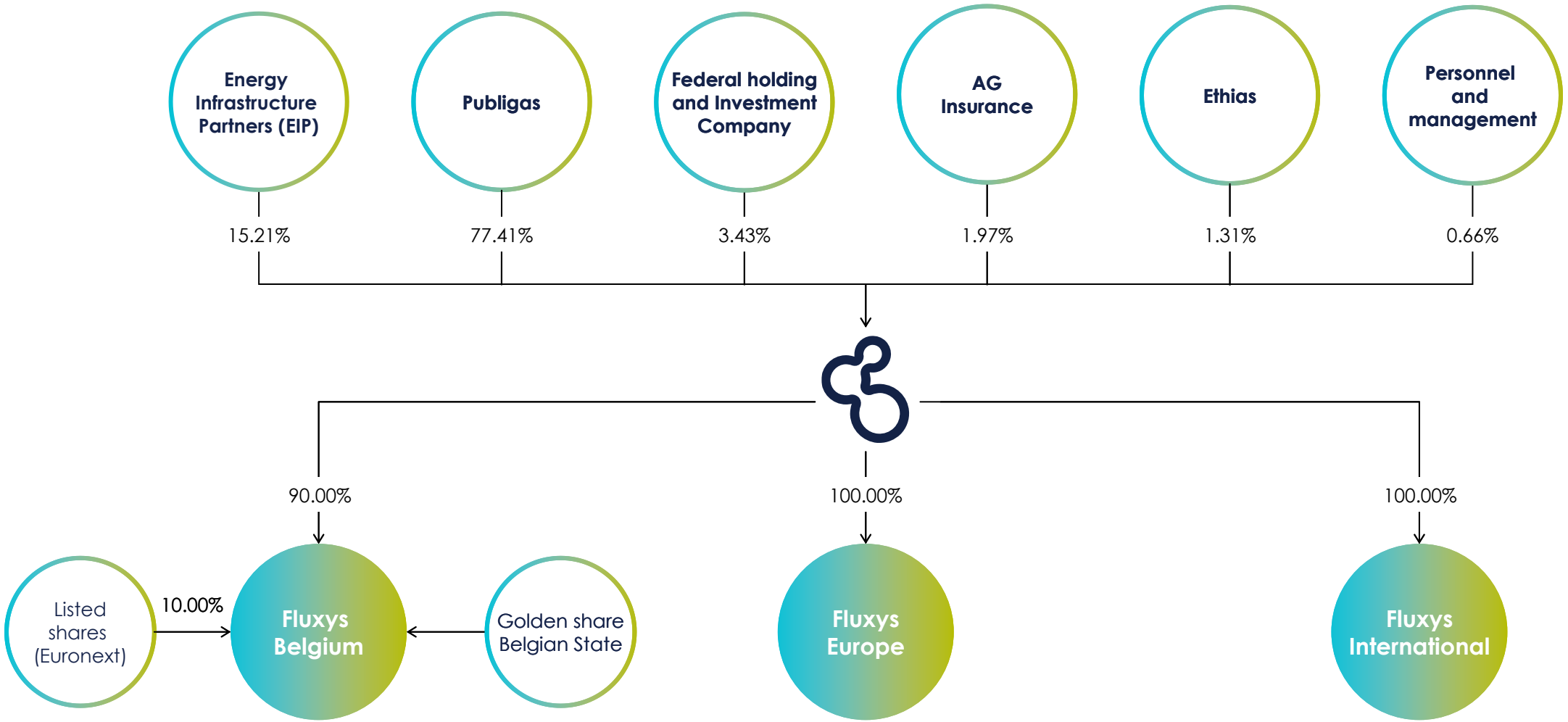
shaping together a bright energy future

CH_4 H_2 CO_2 Elec

Information only - non binding

Who is Fluxys?

Shareholding & group structure

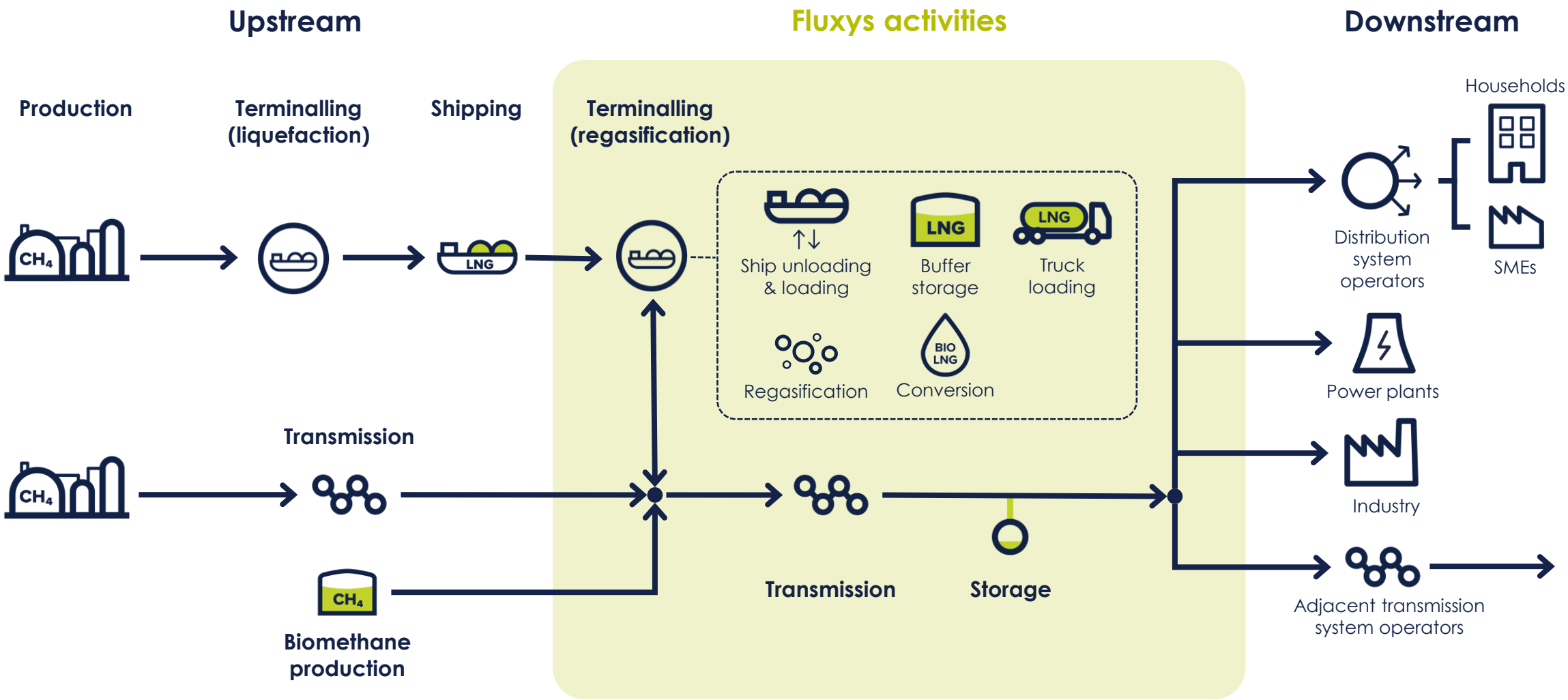


CH_4 H_2 CO_2 Elec

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Who is Fluxys?

Fluxys role for natural gas



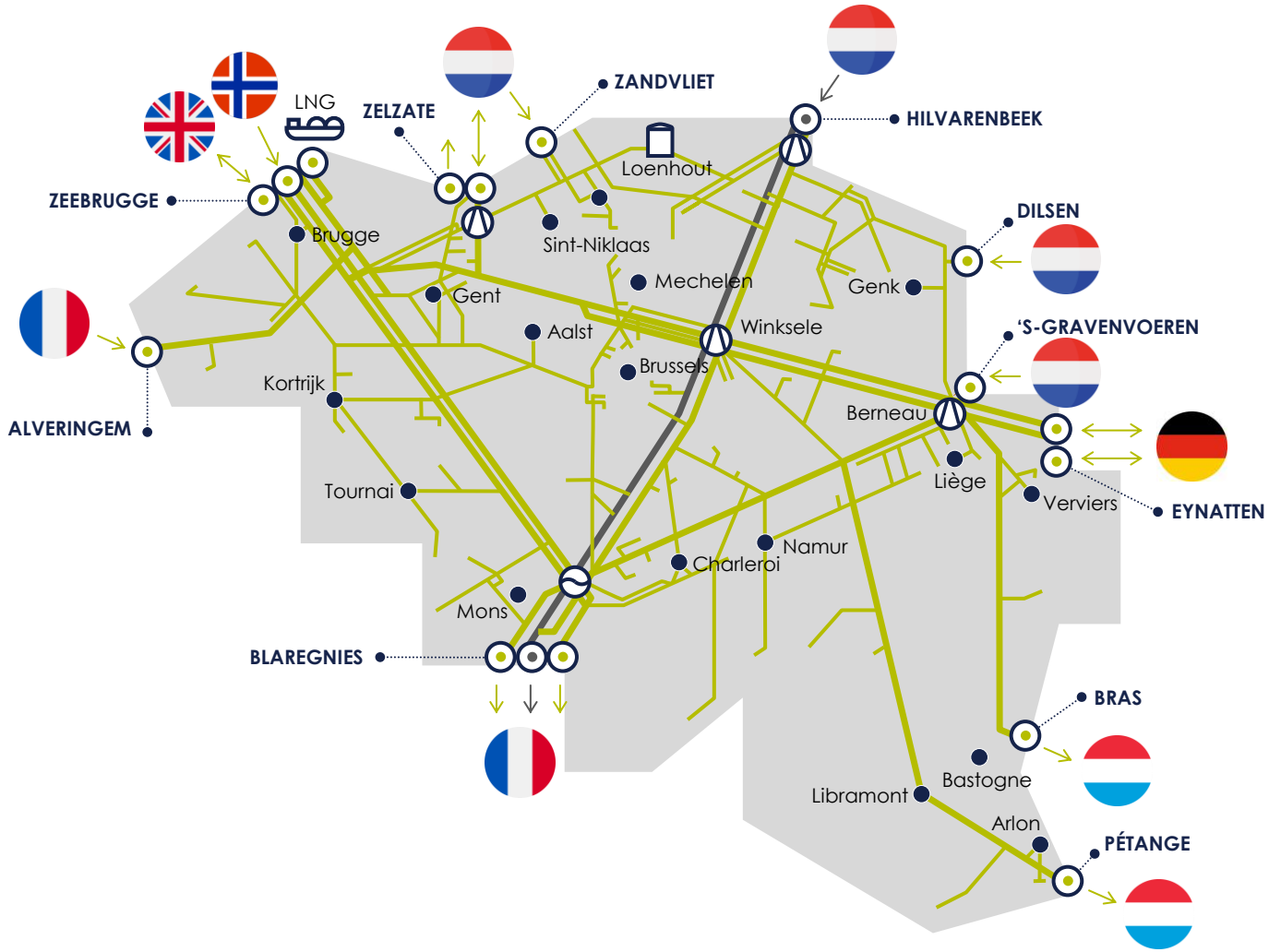
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Overview Fluxys infrastructure in Belgium

High pressure (15-80 bars) transmission infrastructure in Belgium

4,000 km pipelines in 417 municipalities

- High calorific gas (11,3 kWh/m³(n))
- Low calorific gas (9,8 kWh/m³(n))
- Physical interconnection points
- LNG terminal
- Compressor stations
- Blending stations
- Storage



Overview Fluxys infrastructure in Belgium

Fluxys role on the Belgian gas market

Total imports pipe & LNG
~1250 TWh/y entry capacity

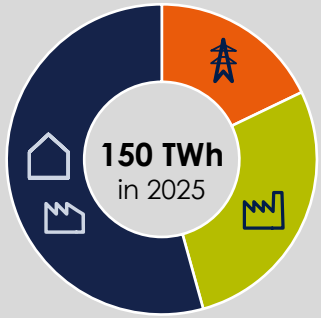
480 TWh
in 2025

Fluxys grid
4,000 km
High pressure

Total transit to surrounding countries
~850 TWh/y exit capacity

330 TWh
in 2025

Transmission for supply in Belgium



19 power stations

181 Large industrial end-users
19 Combined Heat & Power Units

Grids of Distribution System Operators
75 000 km Low pressure

450 000 SMEs

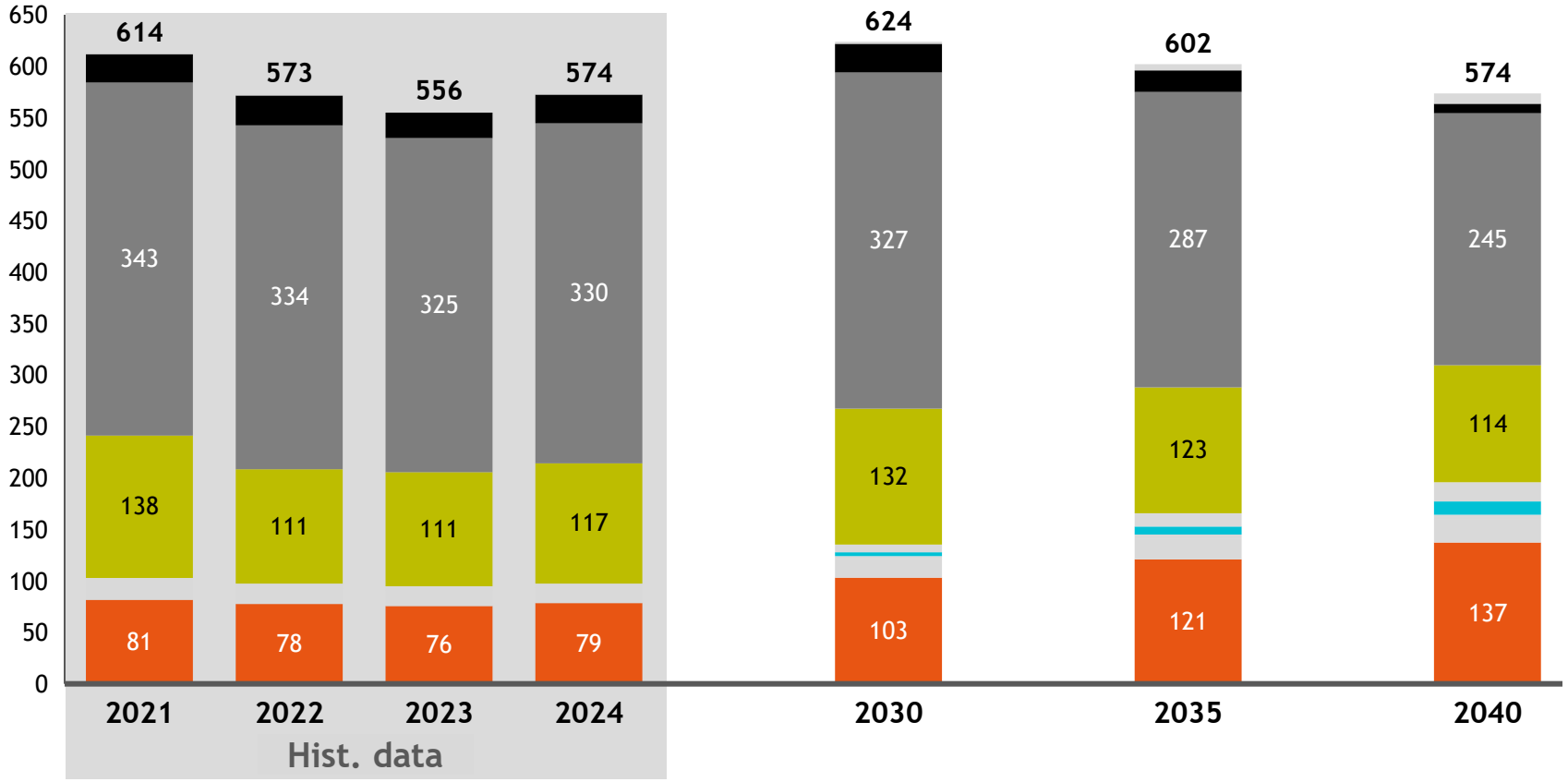
3.1 million households

The role of natural gas in Belgium

The Elia-Fluxys 'BASE' scenario, has been submitted to market consultation and validated by the Federal Minister of Energy; it is used for the electricity and H_2 NDPs

Final energy demand per carrier

(TWh_{LHV}, incl. feedstock, international aviation and international shipping)



Source: https://www.fluxys.com/en/hydrogen/empowering-you/customer-interactions/public-consultation-fluxys-elia

CH_4

H_2

Elec

Others

Oil

Coal

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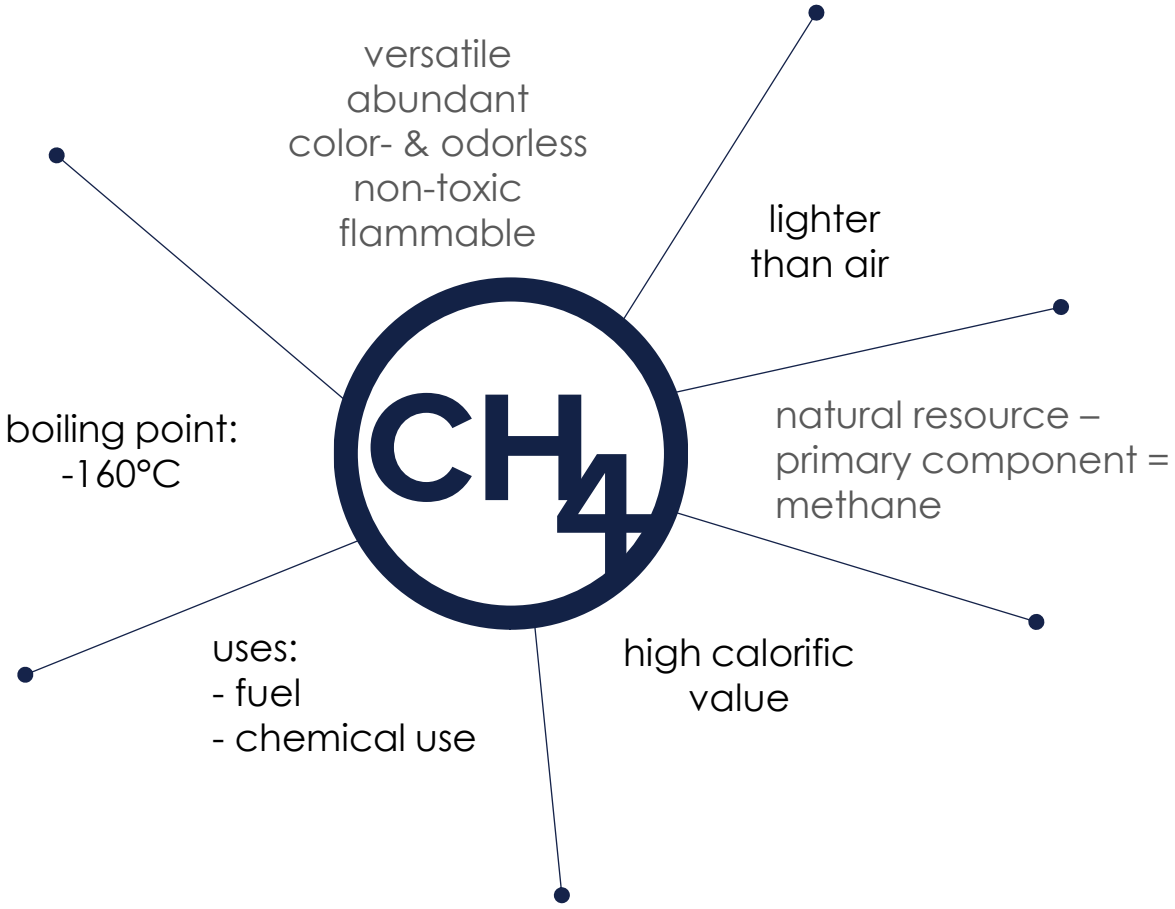
Recent events

New molecules



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What is CH_4 or natural gas ?



Average volumetric composition

Source: Fluxys metering 2017

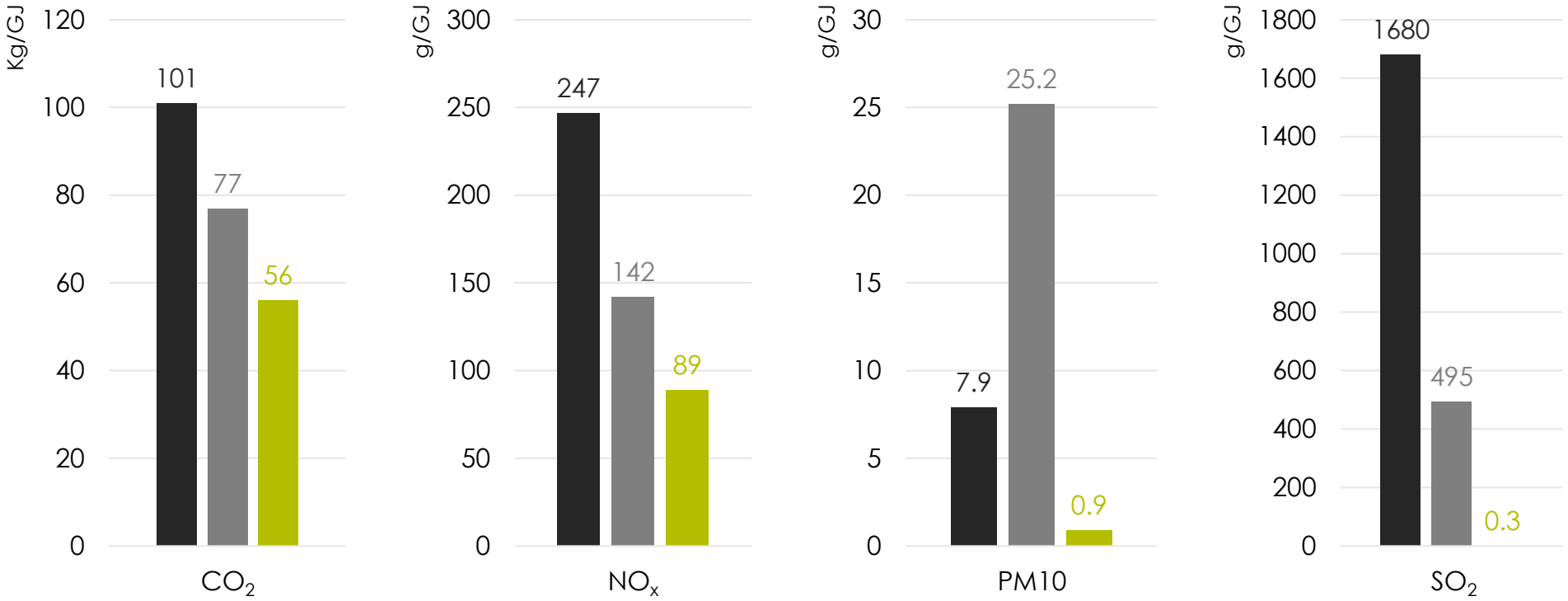
GAS COMPONENTS	GRONINGEN (NL) %	EYNATTEN 1 (DE) %	LNG %	IZTF (UK) %	ZEEPIPE (NORWAY) %
Methane (CH4)	83,903	96,263	93,100	90,642	90,748
Ethane (C2H6)	3,718	2,694	6,244	4,787	4,739
Propane (C3H8)	0,646	0,138	0,139	1,111	1,123
Butane (C4H10) (ISO and NORM)	0,228	0,068	0,026	0,338	0,425
Pentane (C5H12) (ISO and NORM)	0,056	0,008	-	0,075	0,425
Hexane and superior HC (C6+)	0,057	0,005	-	0,046	0,092
C. Dioxyde (CO2)	1,375	0,409	-	1,230	1,714
Nitrogen (N2)	9,981	0,403	0,491	1,735	1,071
Helium (He)	0,035	0,012	-	0,035	0,013
GAS CARACTERISTICS	GRONINGEN (NL) kWh/m³(n)	EYNATTEN 1 kWh/m³(n)	LNG kWh/m³(n)	IZTF (UK) kWh/m³(n)	ZEEPIPE (NORWAY) kWh/m³(n)
GCV	10,321	11,243	11,563	11,447	11,508
WOBBE	12,905	14,811	15,064	14,589	14,617

Information only - non binding

Natural gas

"Best" fossil fuel from an environmental point of view…

…but still emitting CO_2 and NO_x!



Source:
European Environment Agency - EMEP/EEA air pollutant emission inventory guidebook 2016
Public electricity and heat production - dry bottom boiler

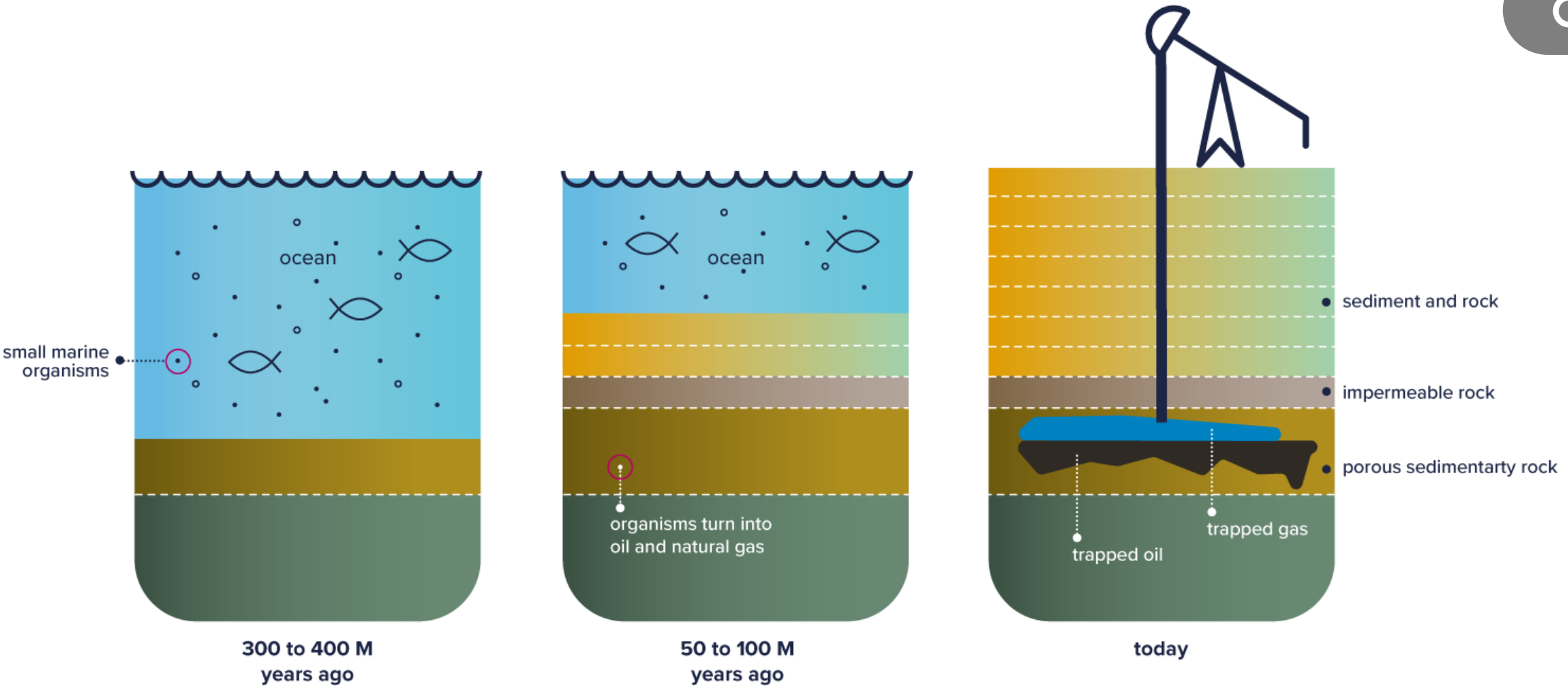
CH_4

Oil

Coal

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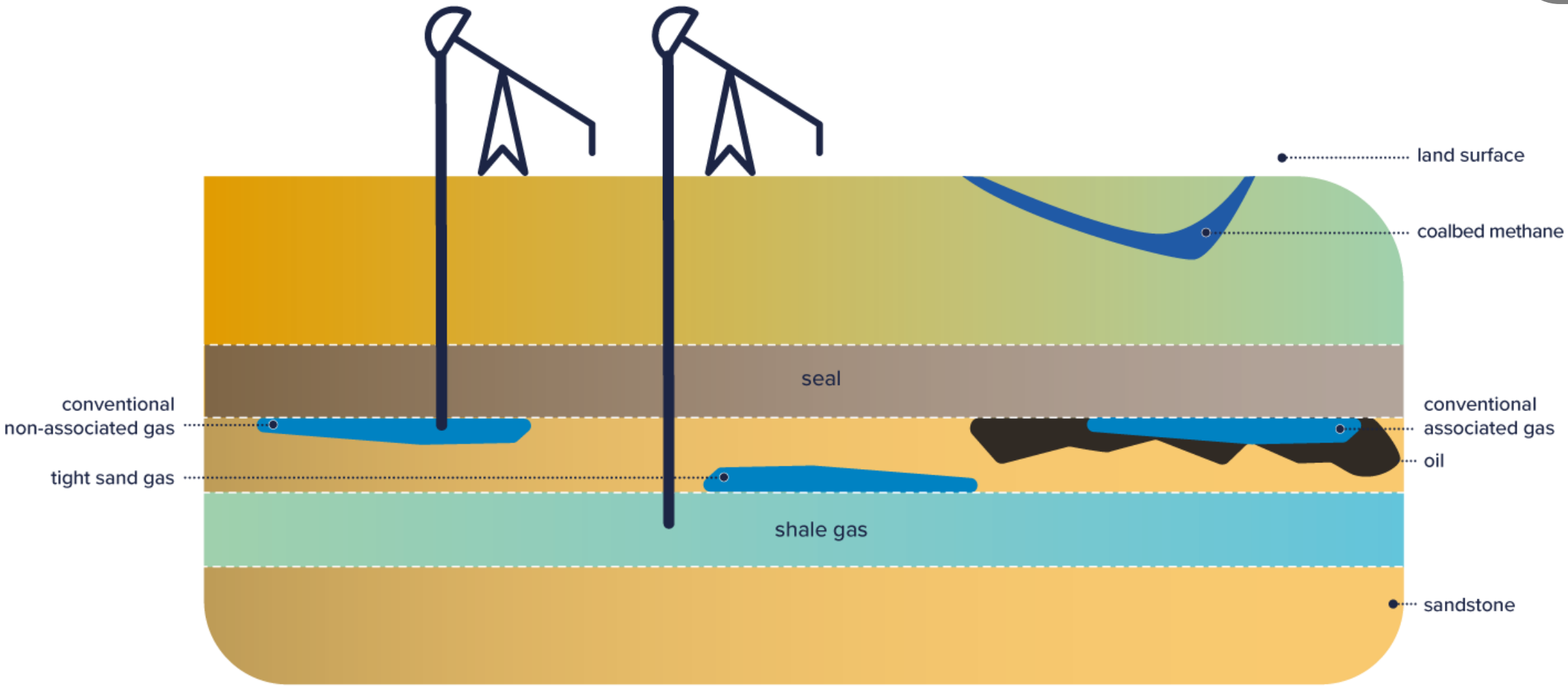
Formation of oil and natural gas



Oil and natural gas sources

CH_4

Oil

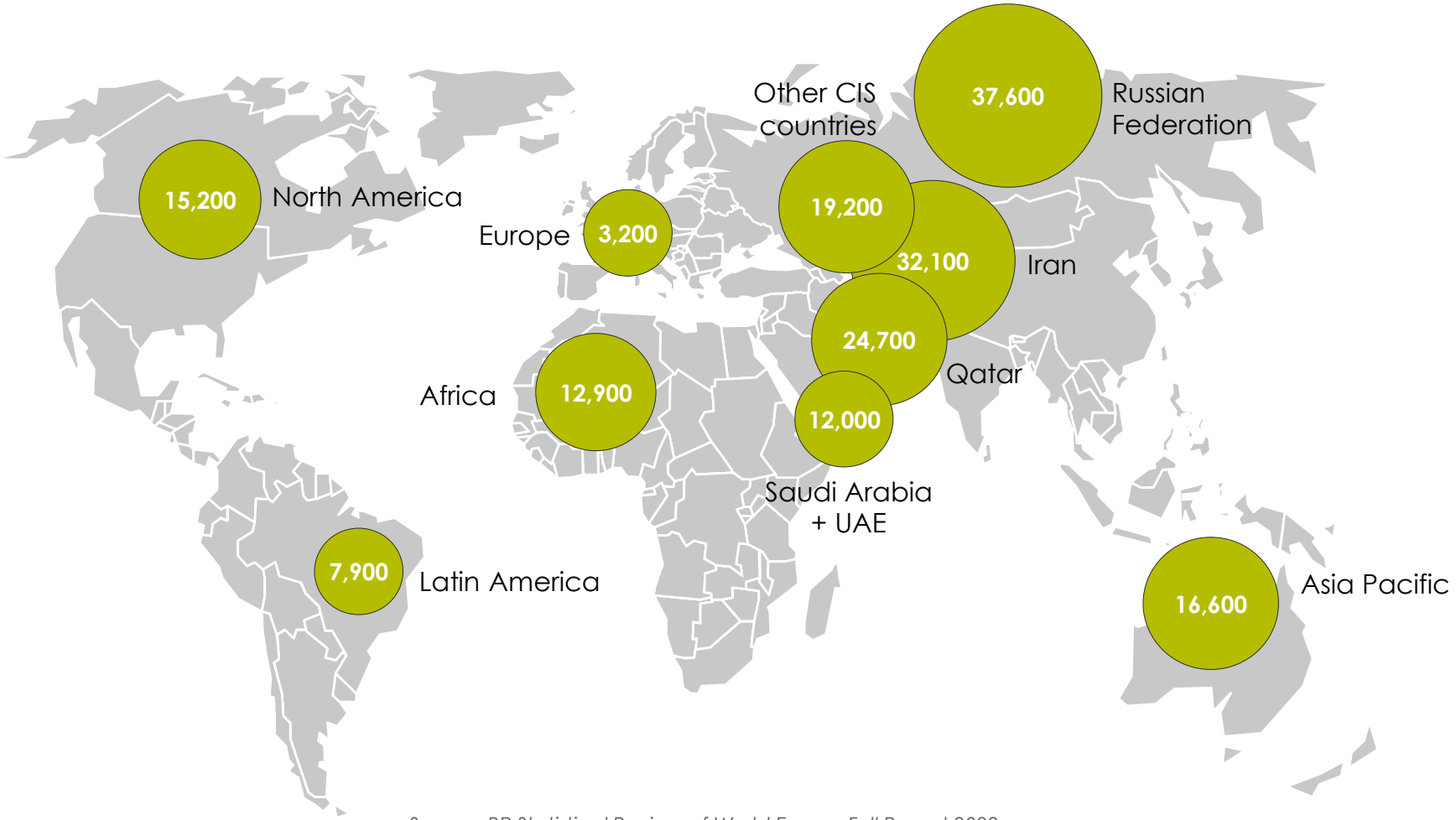


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Conv. CH_4

Conventional natural gas is abundantly available

Proven (= economically) conventional natural gas reserves (bcm)

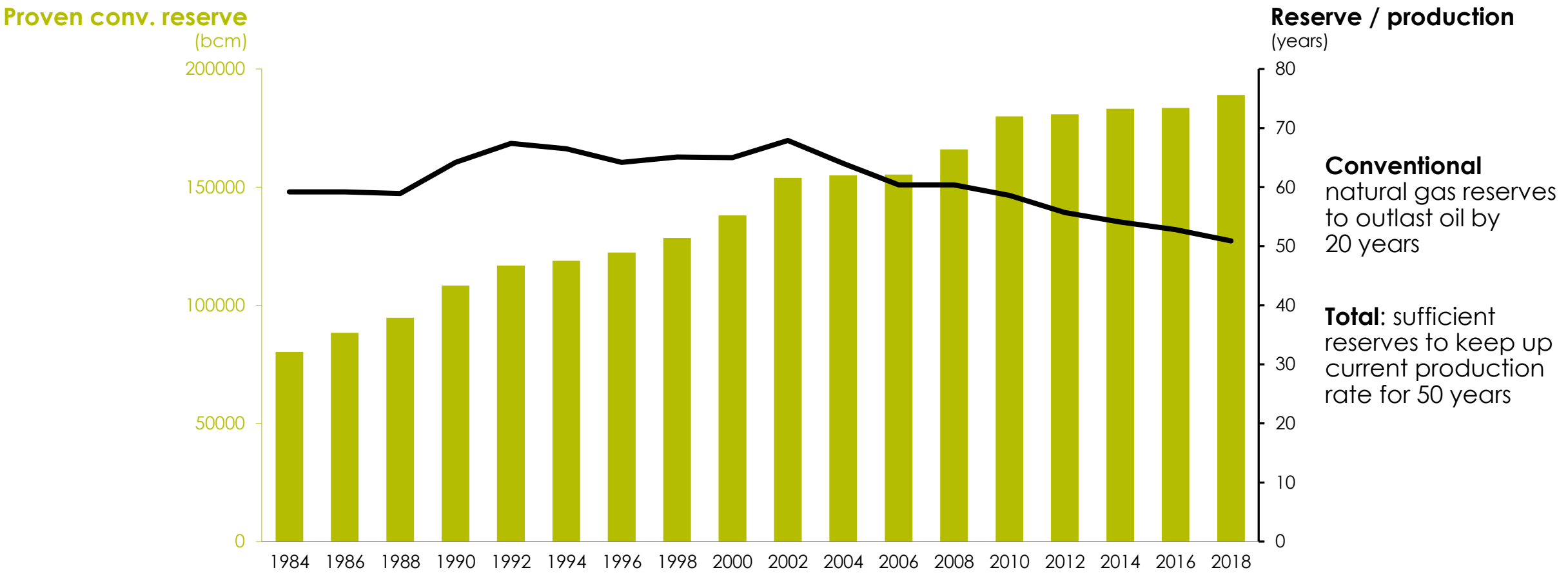


Source: BP Statistical Review of World Energy Full Report 2022

Conv. CH_4

Conventional natural gas is abundantly available

Proven (= economically) conventional natural gas reserves (bcm)



Conventional natural gas reserves to outlast oil by 20 years

Total: sufficient reserves to keep up current production rate for 50 years

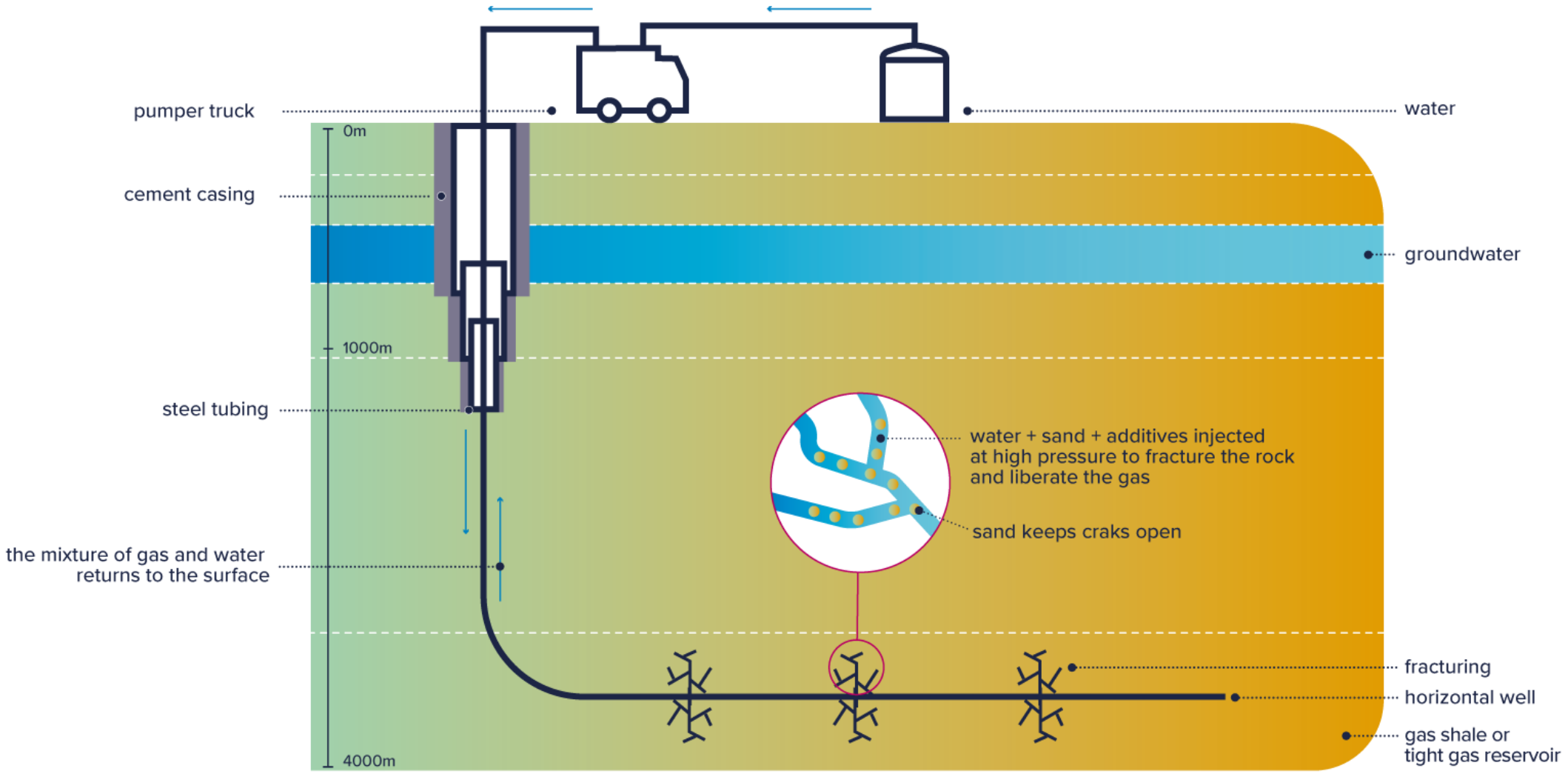
Source: BP Statistical Review of World Energy Full Report 2022

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Shale CH_4

Important source of unconventional gas: shale gas

Hydraulic fracturing

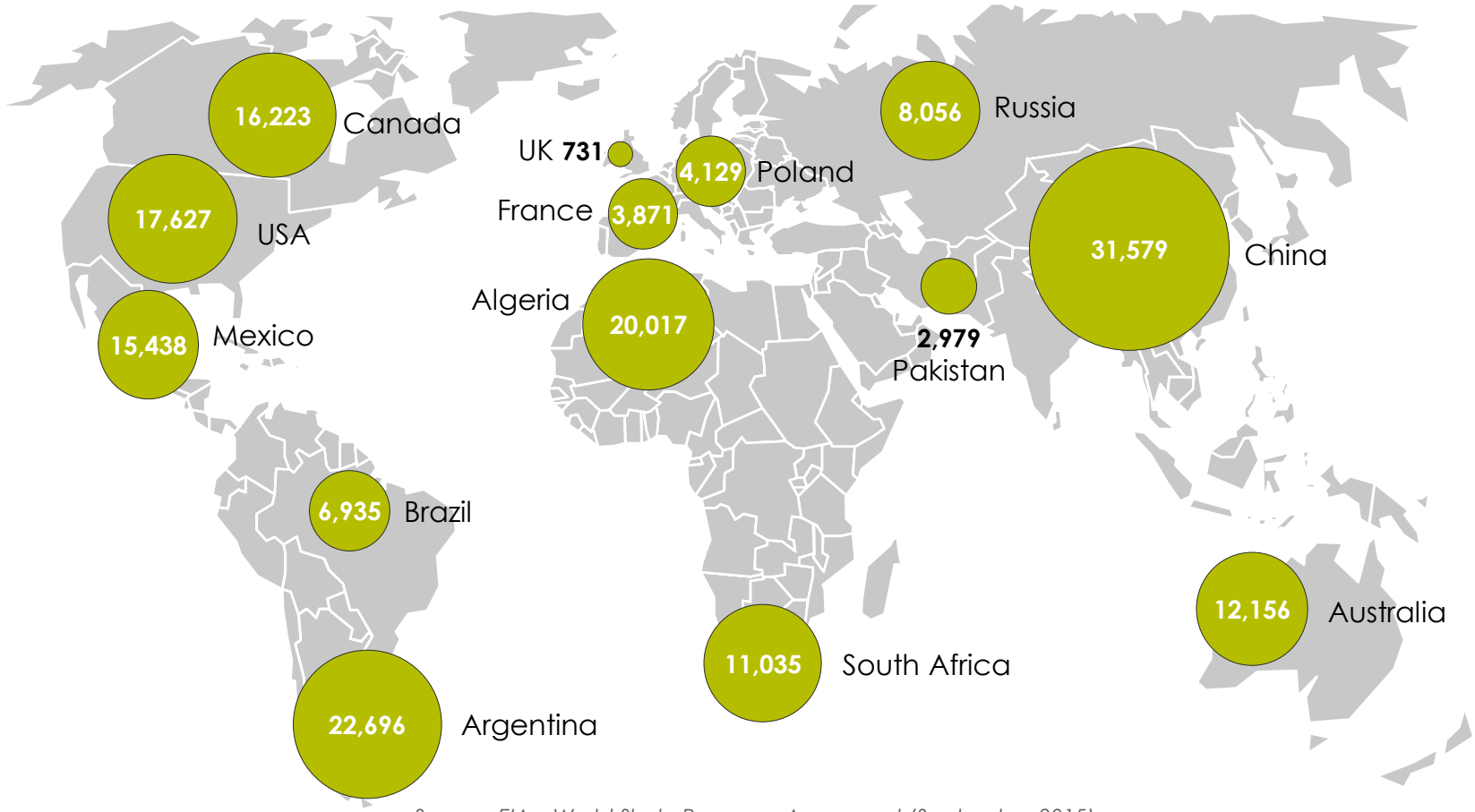


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Shale CH_4

Important source of unconventional gas: shale gas

Estimated shale gas reserves (bcm)

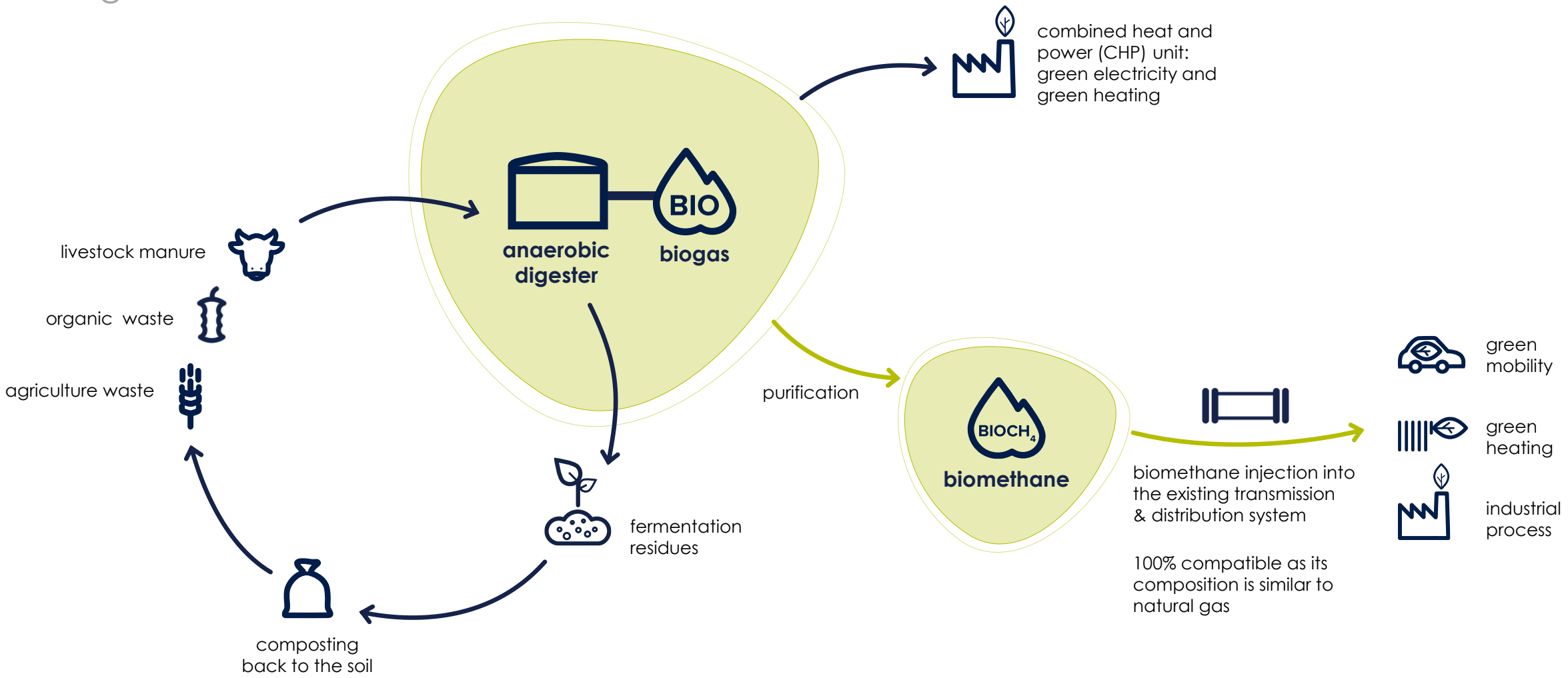


Source: EIA – World Shale Resource Assessment (September 2015)

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Natural gas can be (very) low-carbon

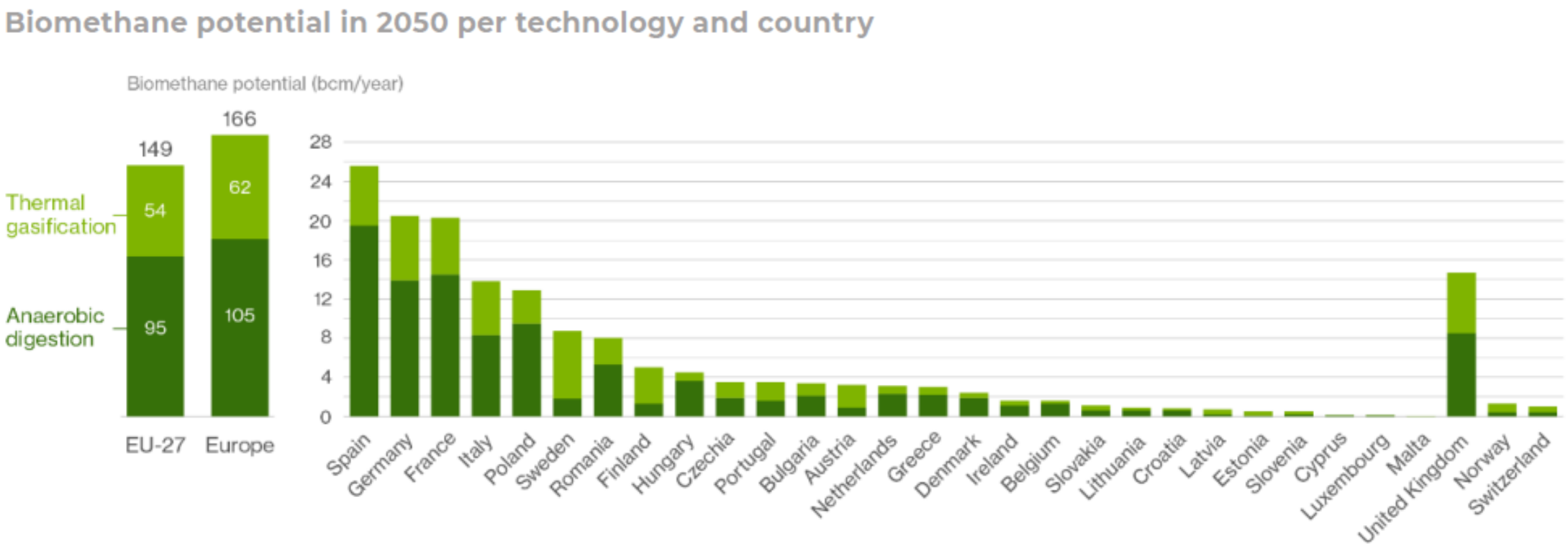
Biogas and biomethane



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Natural gas can be (very) low-carbon

Biomethane production potential in Europe

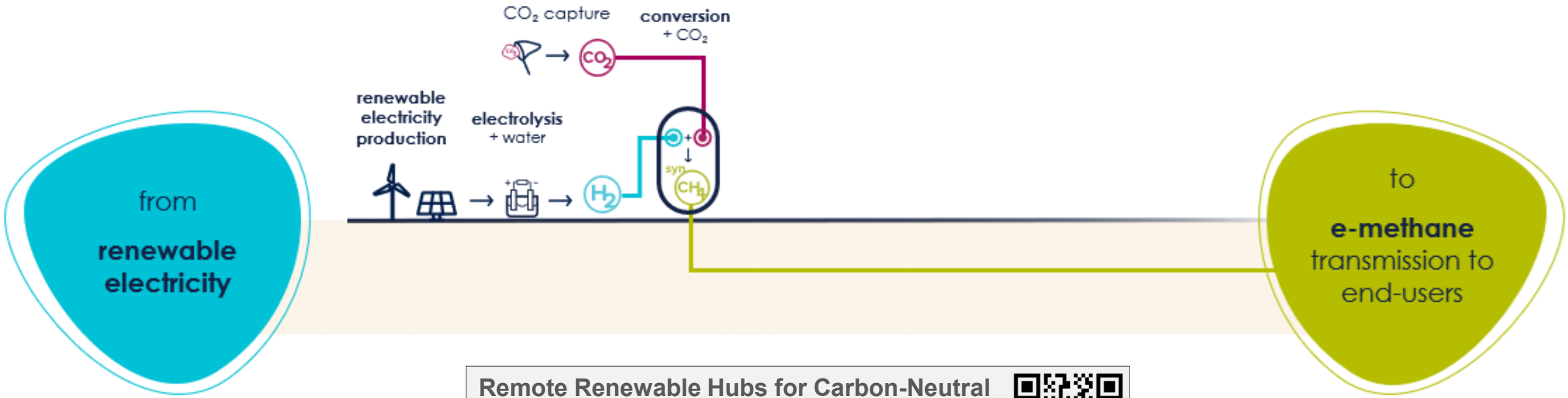


Source: Gas for Climate study, 2026
(https://www.europeanbiogas.eu/wp-content/uploads/2026/04/Biogases.-Europes-overlooked-path-to-energy-independence-1.pdf)

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Synthetic methane or e-methane

Carbon-neutral methane can be produced from green hydrogen (produced from renewable electricity) and captured CO_2



Remote Renewable Hubs for Carbon-Neutral Synthetic Fuel Production

Mathias Berger, David-Constantin Radu, Detienne Ghislain, Thierry Deschuyteneer, Aurore Richel, and Damien Ernst

2021 – in *Frontiers in Energy Research*
https://orbi.uliege.be/handle/2268/250796

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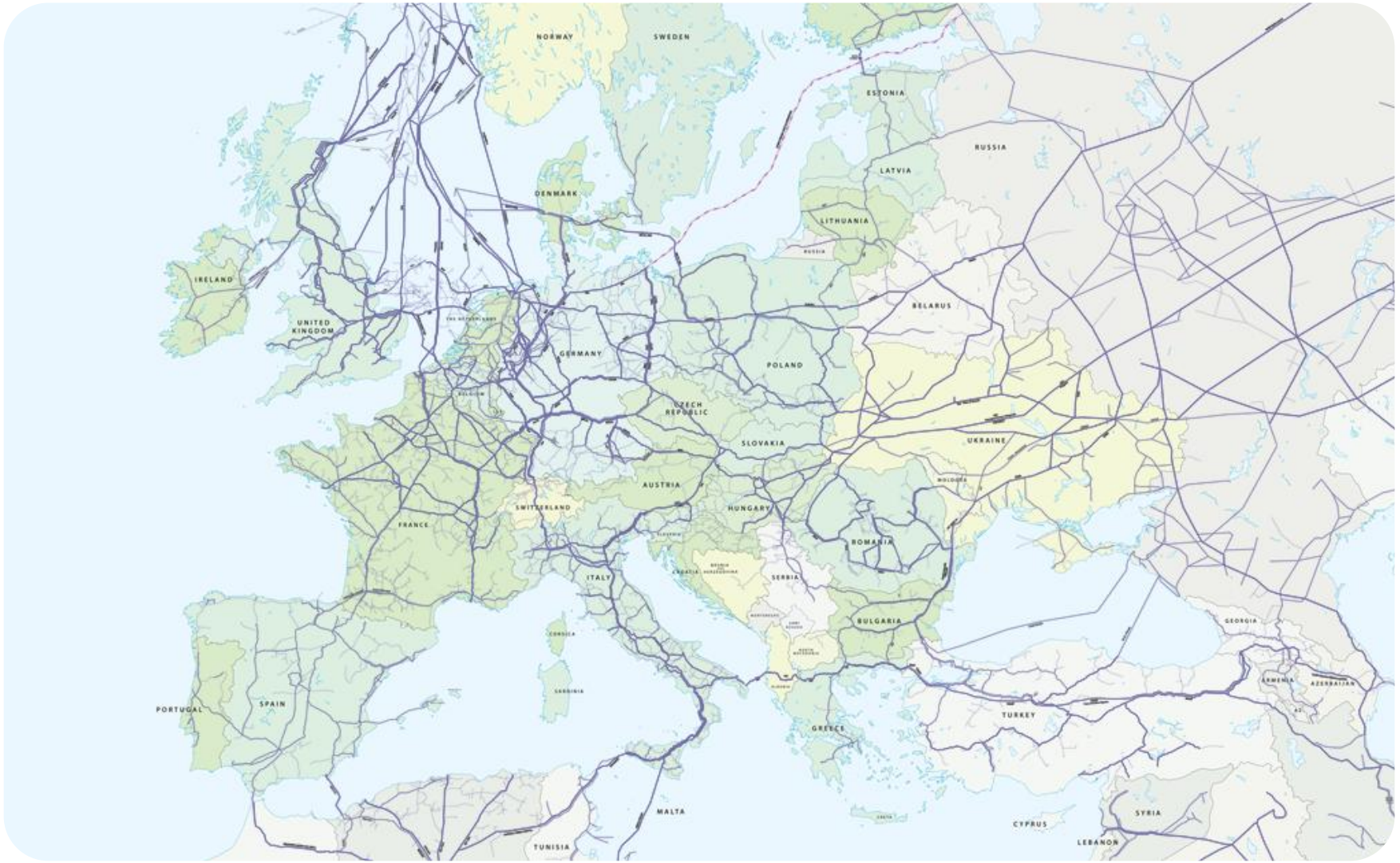
New molecules



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Gas infrastructure in Europe

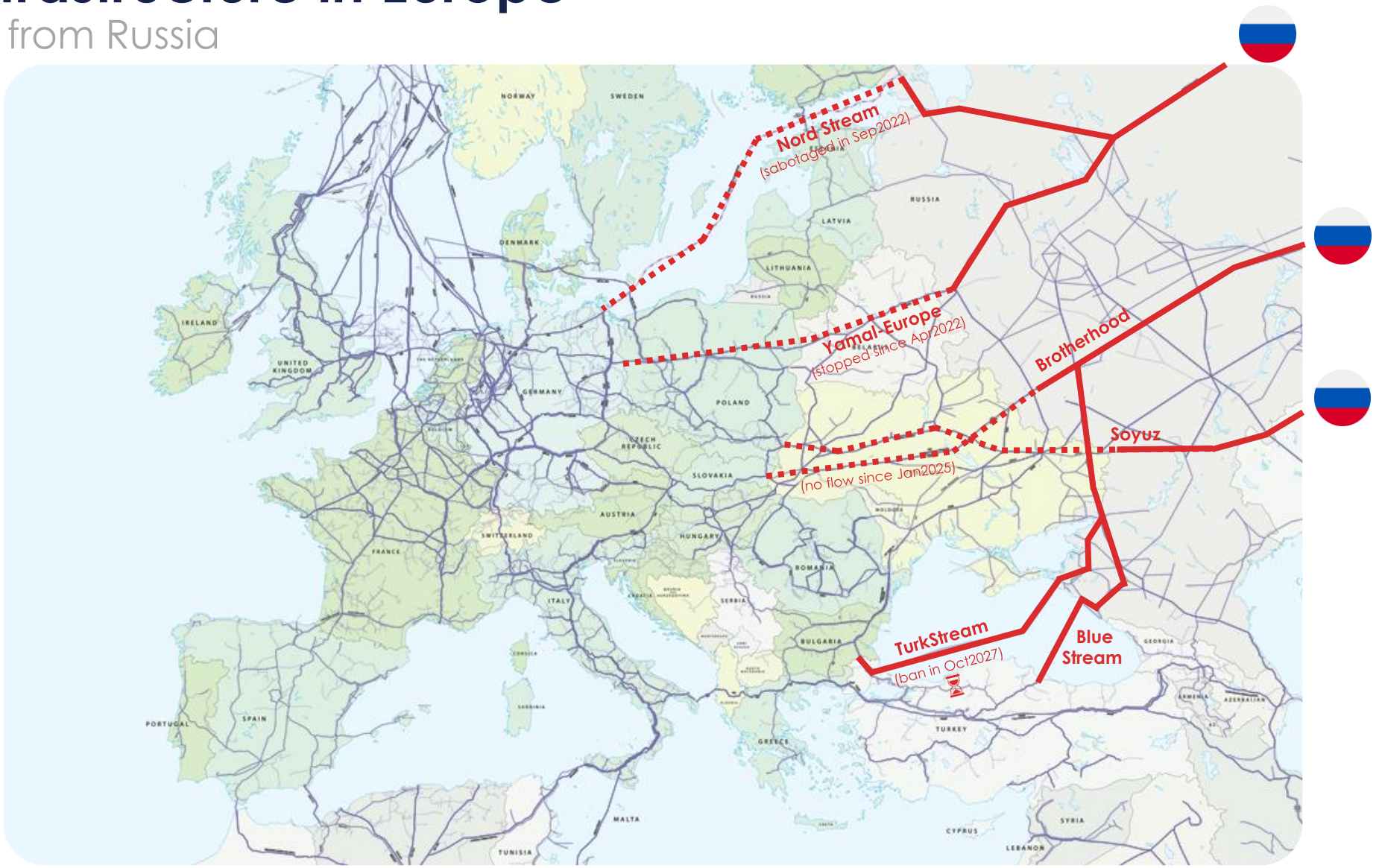
Pipelines



Source: https://www.entsog.eu/maps

Gas infrastructure in Europe

Pipelines from Russia

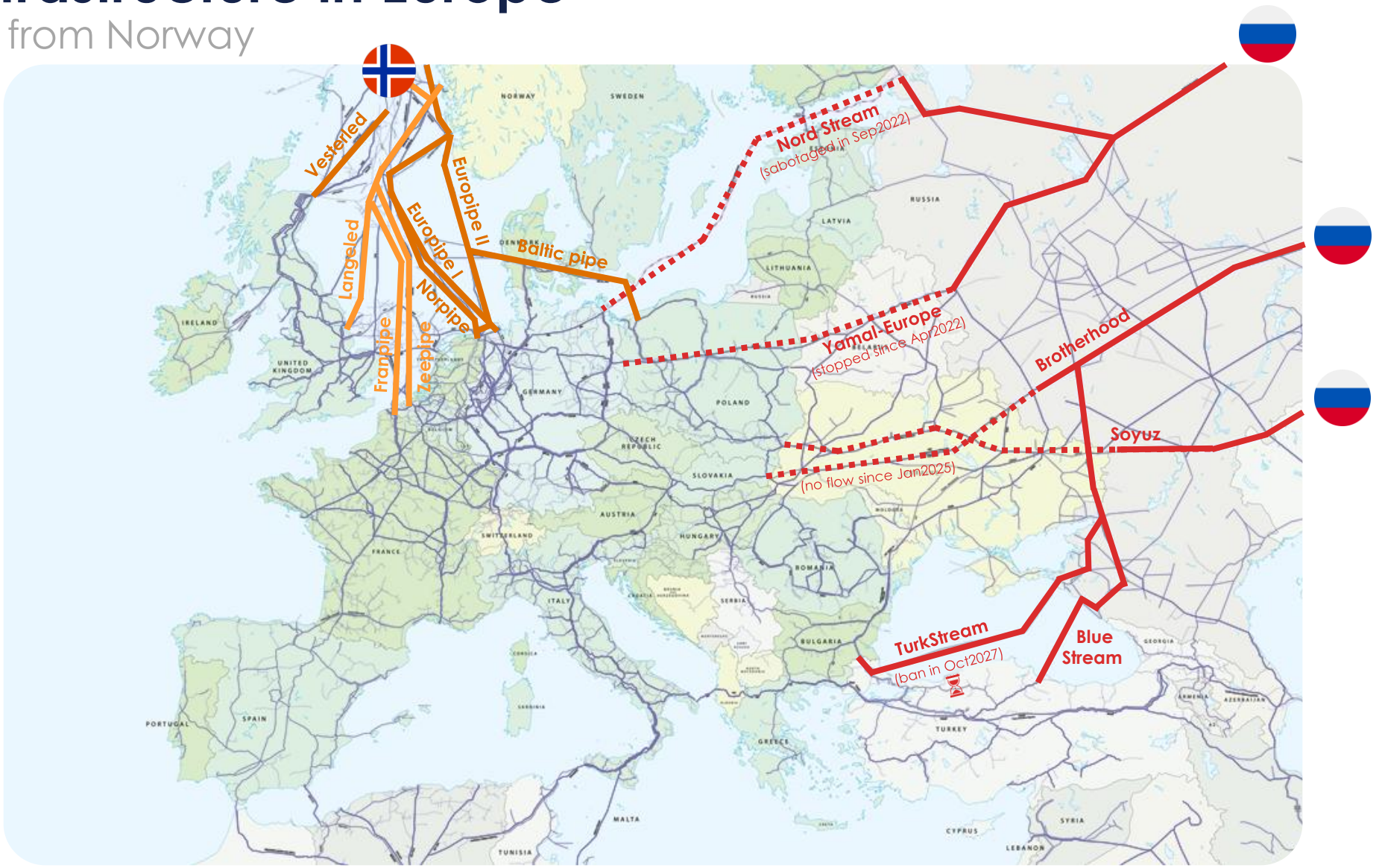


Source: https://www.entsog.eu/maps

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Gas infrastructure in Europe

Pipelines from Norway

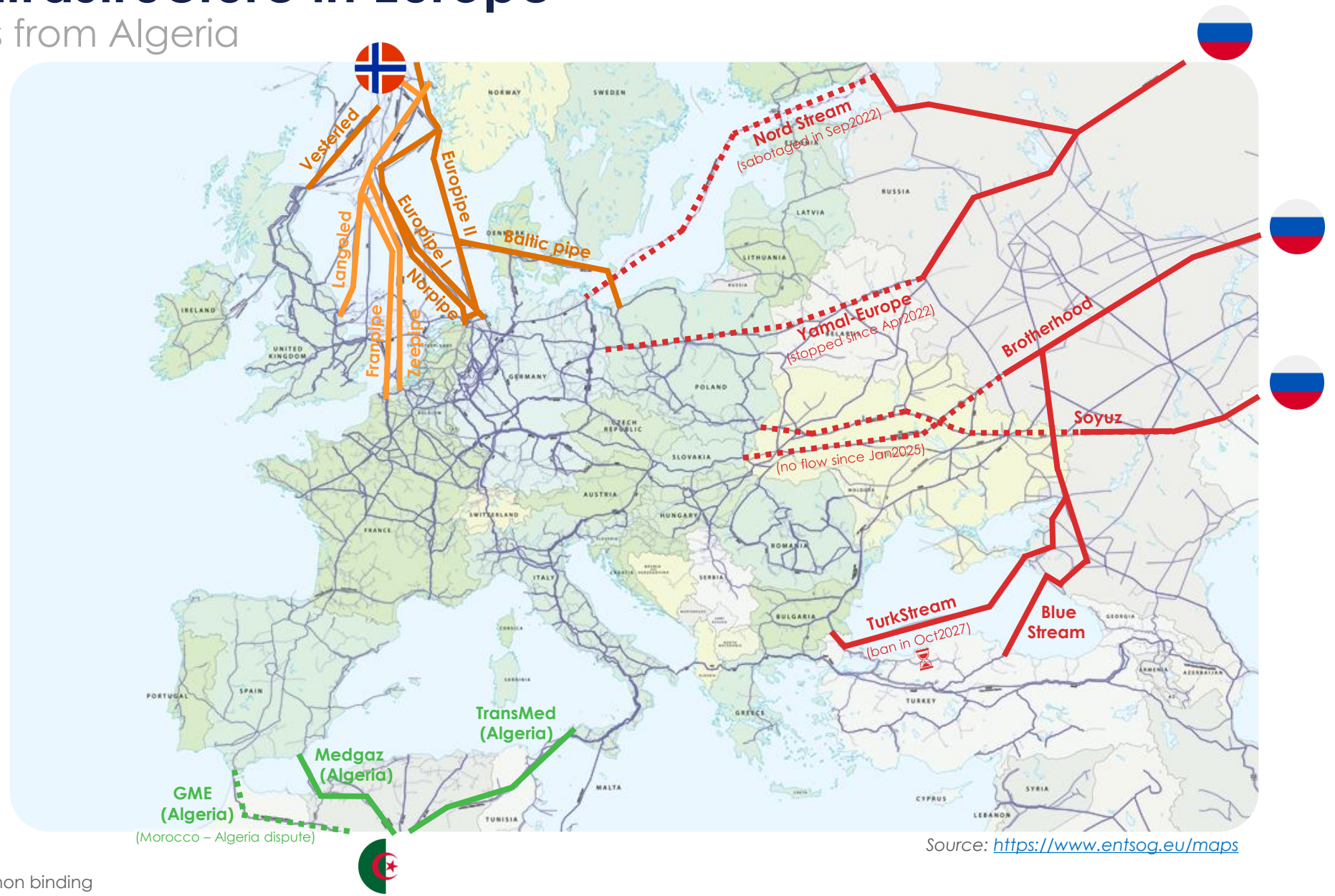


Source: https://www.entsog.eu/maps

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Gas infrastructure in Europe

Pipelines from Algeria

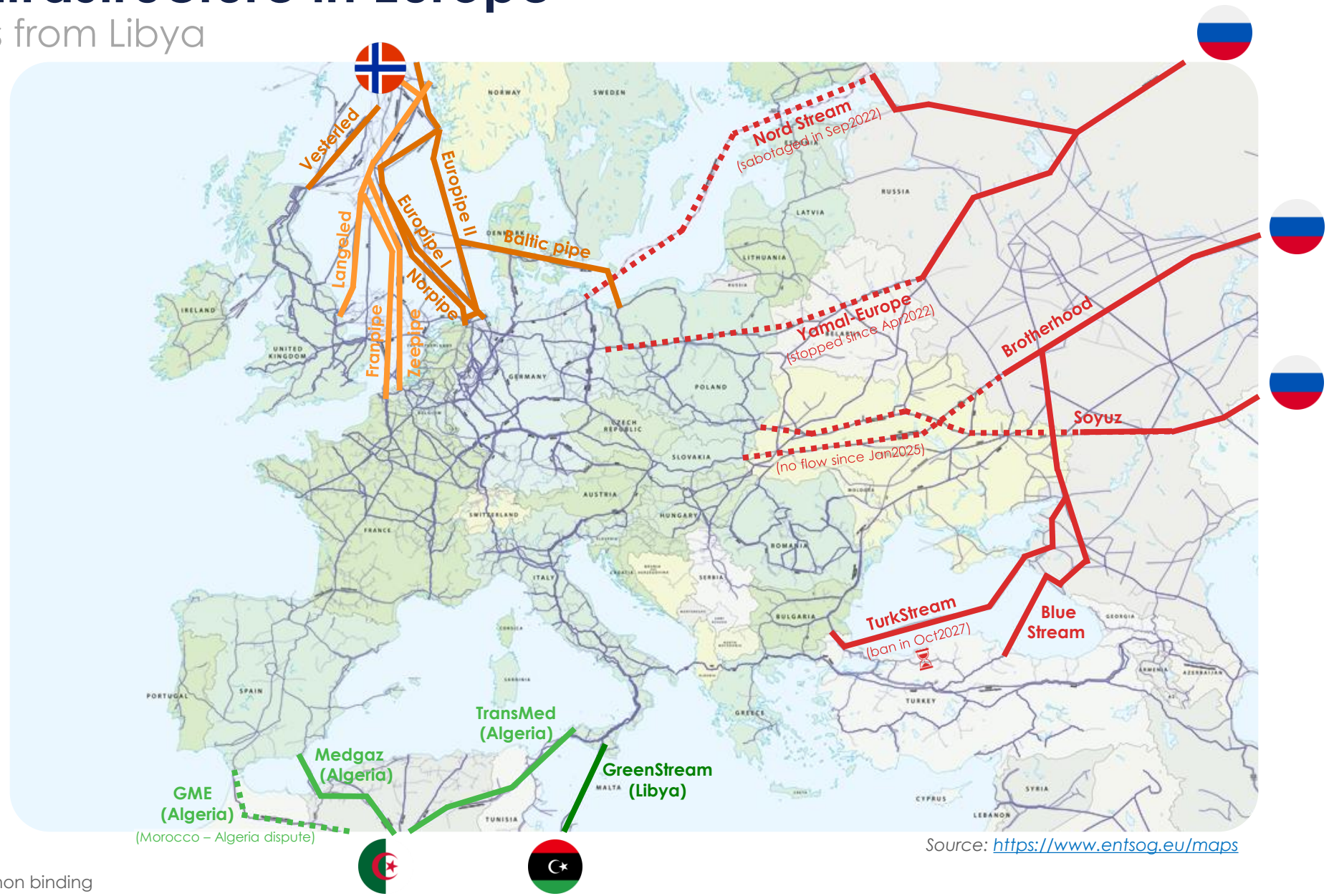


Source: https://www.entsog.eu/maps

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Gas infrastructure in Europe

Pipelines from Libya

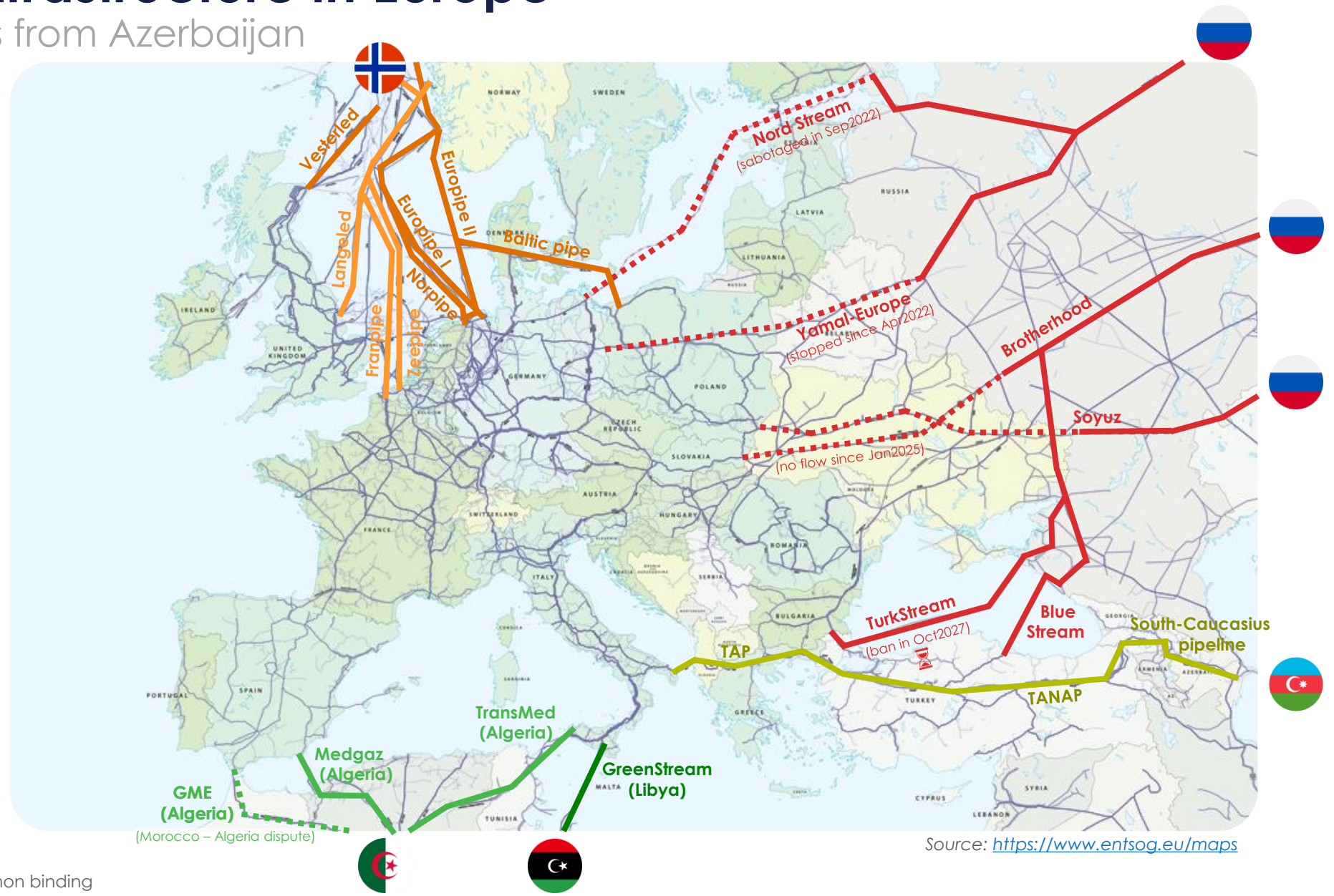


Source: https://www.entsog.eu/maps

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Gas infrastructure in Europe

Pipelines from Azerbaijan



Source: https://www.entsog.eu/maps

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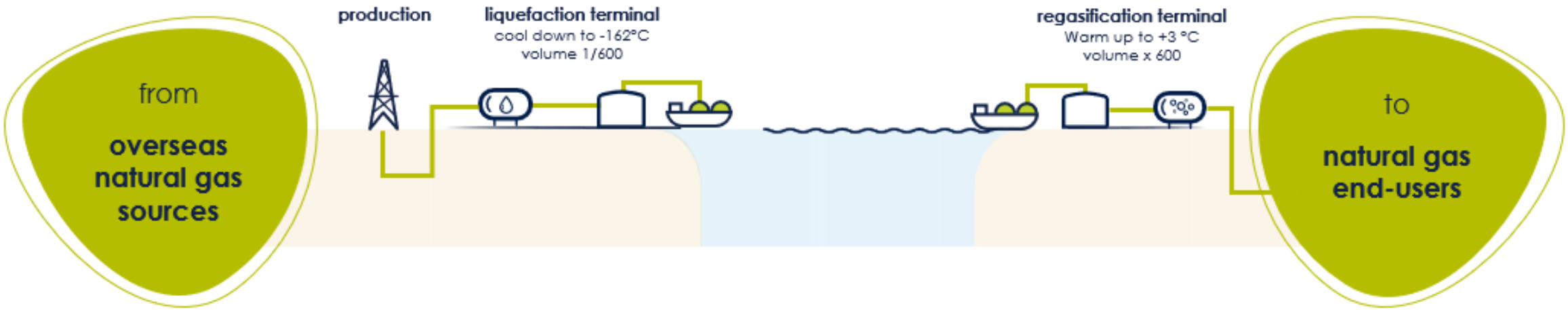


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LNG CH_4

Overseas liquefied natural gas chain (LNG)

LNG = liquefied natural gas

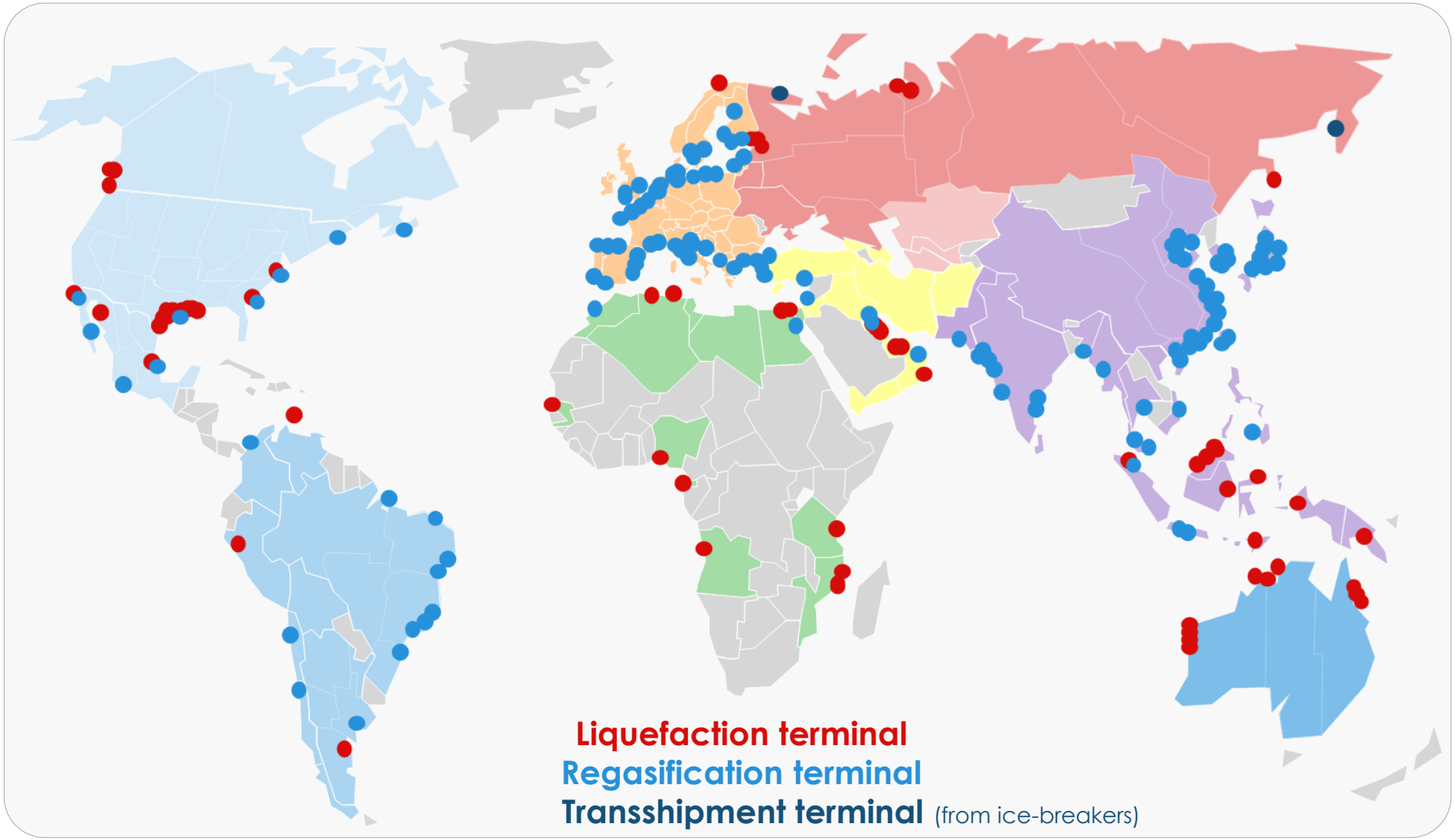


Why LNG?

- LNG offers competitive advantage over pipe gas for transmission over longer distances
- Easy diversification of sources
- Easy flexibility in destination markets
- 1 LNG tanker → ~1 TWh of energy

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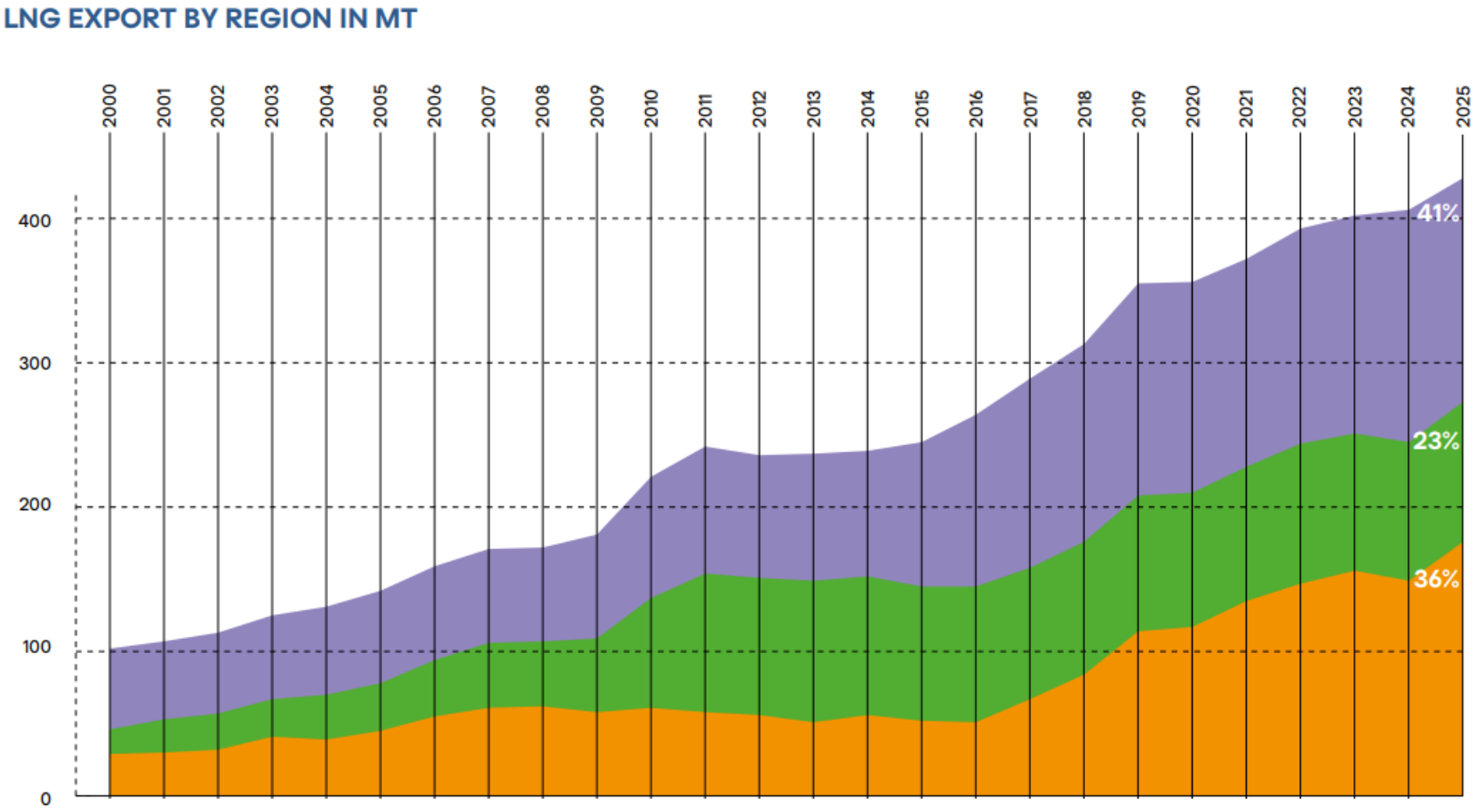
World LNG infrastructure



Sources: GIIGNL 2025 & S&P Global

World LNG production & exports

LNG CH_4



Pacific
mainly Australia

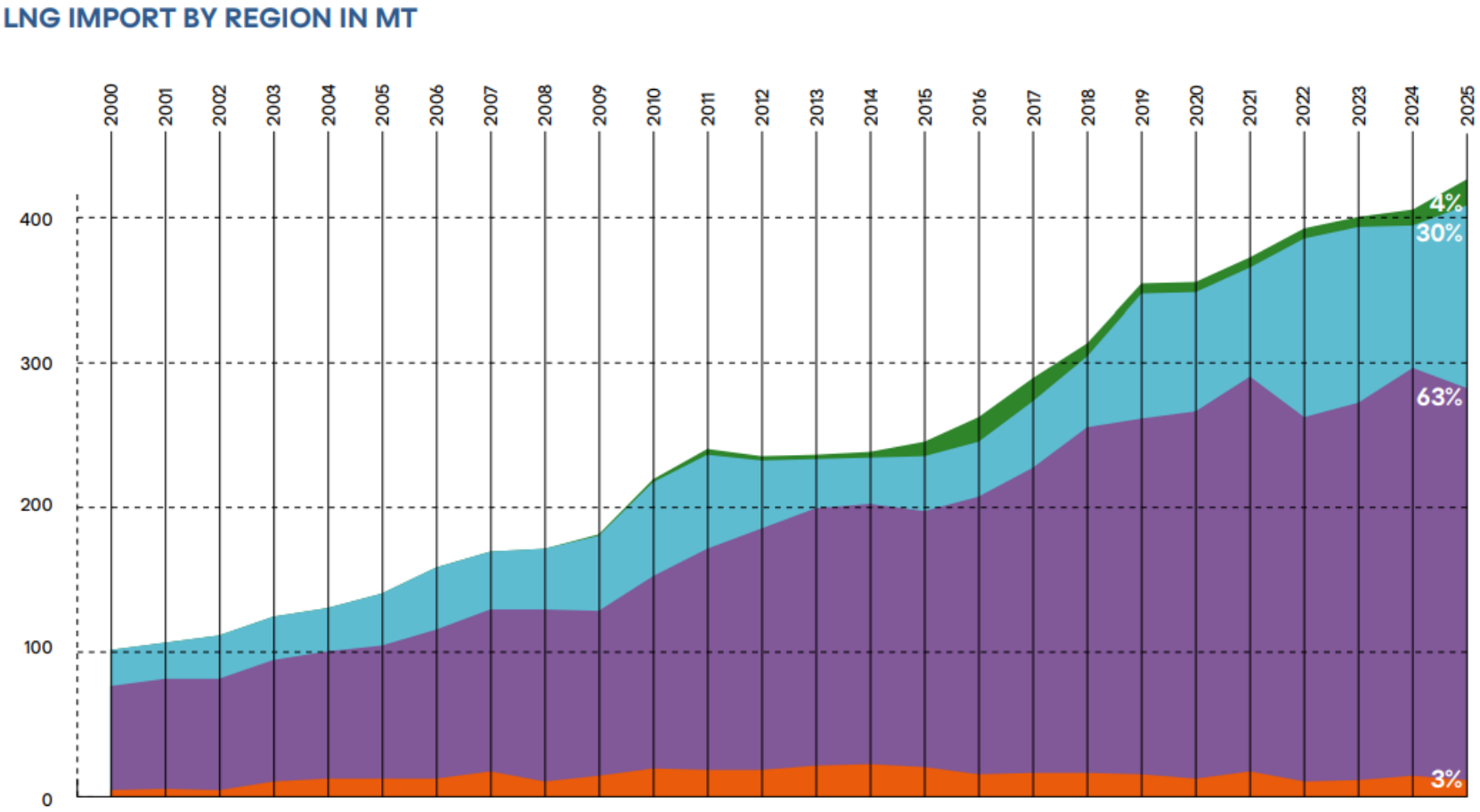
Middle East
mainly Qatar before Iran War in 2026

Atlantic
mainly US

Source: GIIGNL Annual Rport 2026
(https://www.giignl.org/annual-report)

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World LNG imports



Middle East & Africa

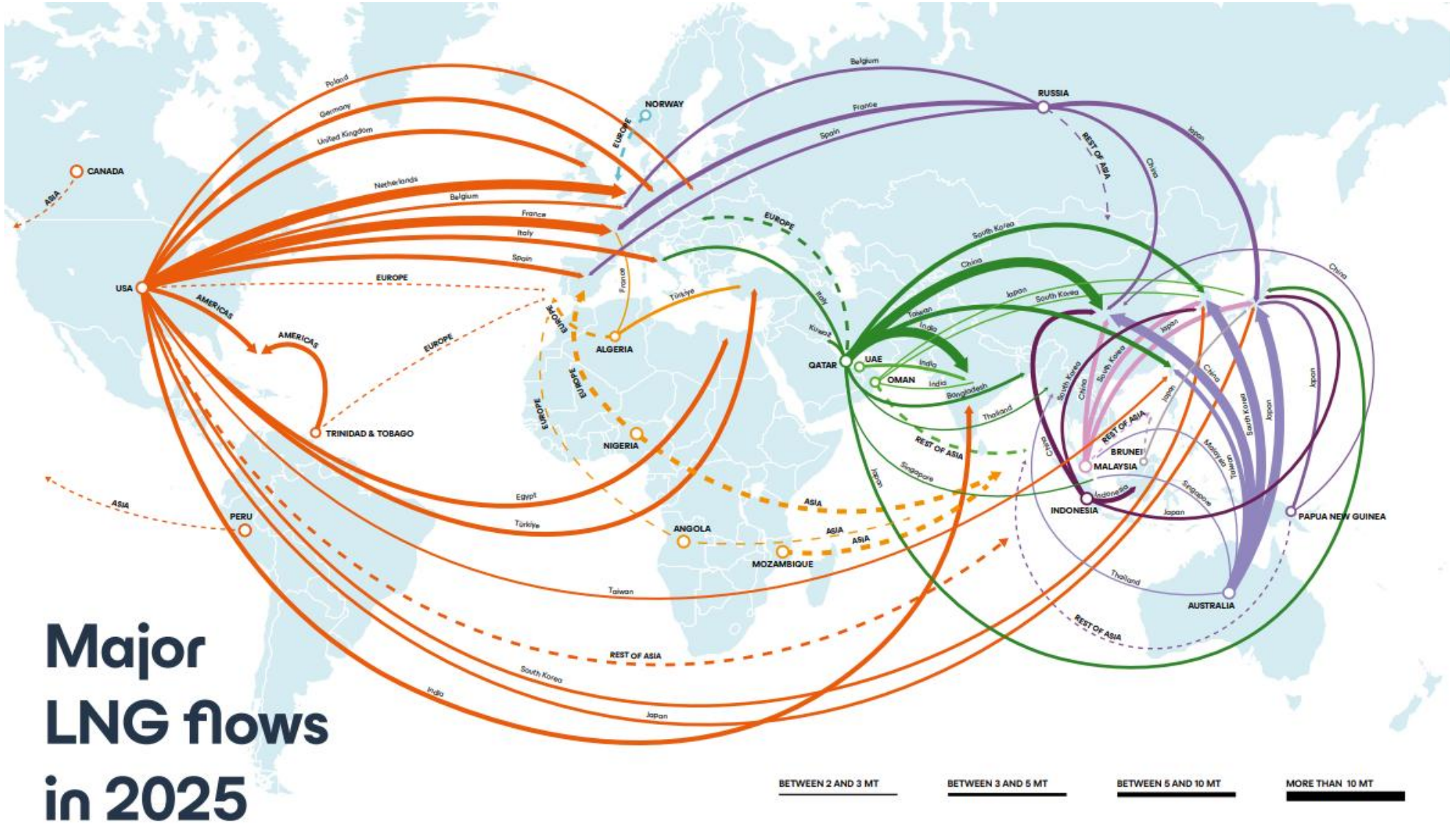
Europe

Asia

Americas

Source: GIIGNL Annual Rport 2026
(https://www.giignl.org/annual-report)

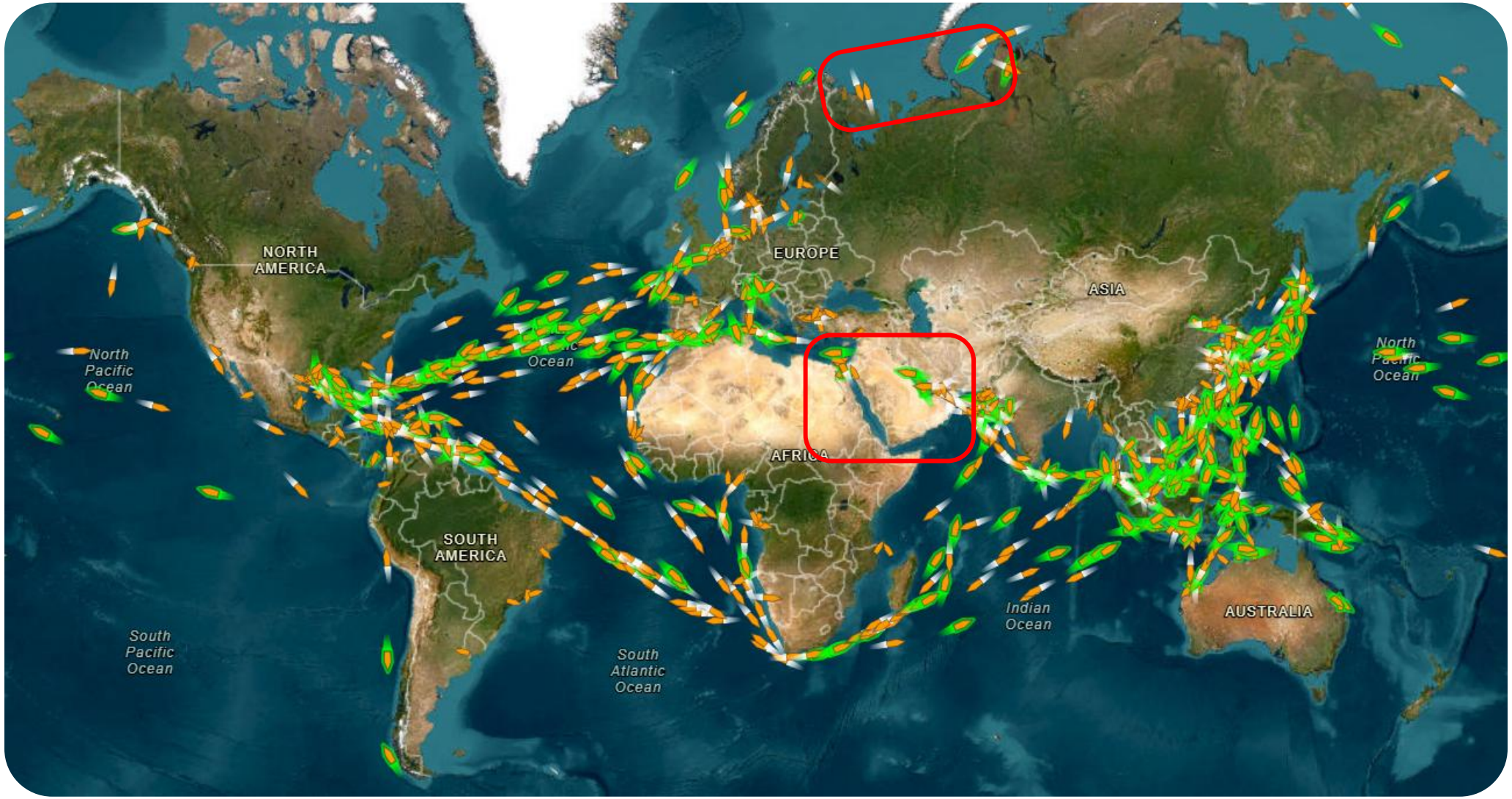
World LNG flows



Source: GIIGNL Annual Rport 2026 (https://www.giignl.org/annual-report)

LNG tankers underway

Situation on November 4th, 2026 → effect of ban on Russian LNG + Hormuz closed

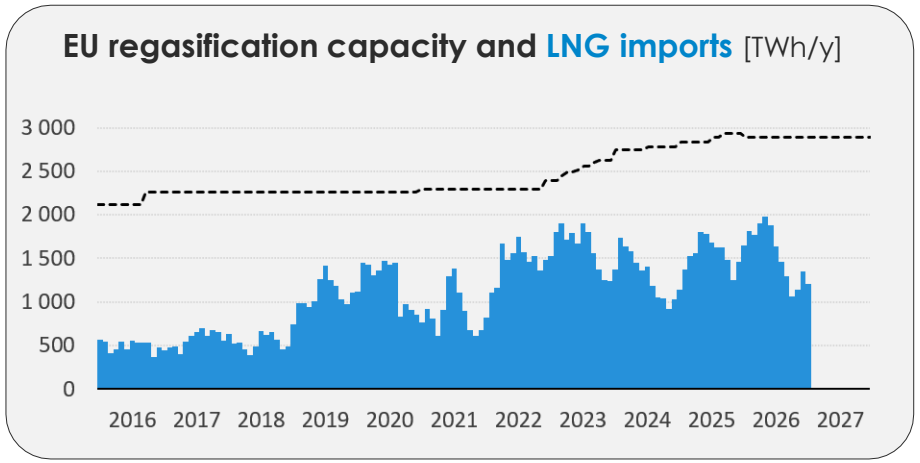


Source: S&P Global (Mint)

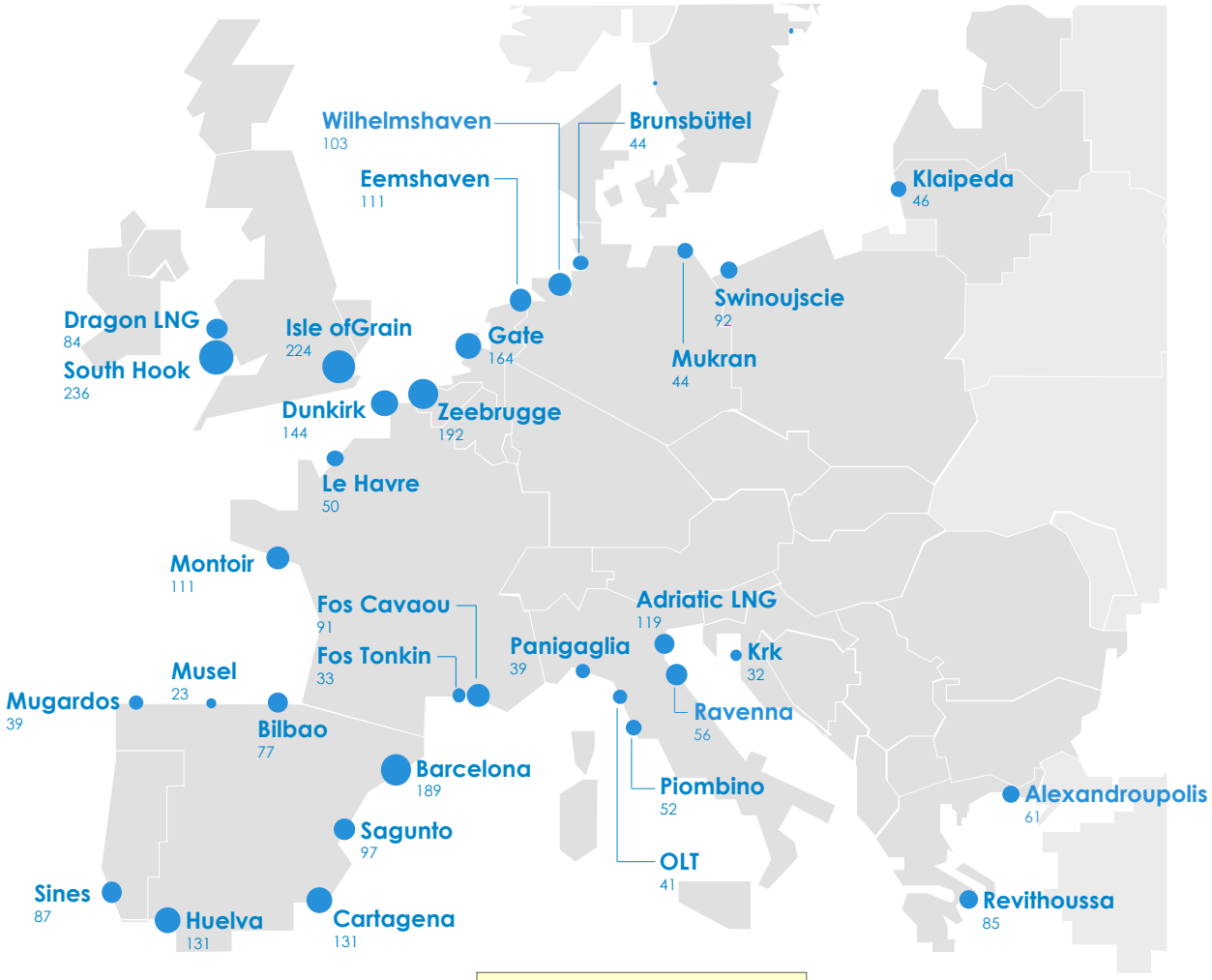
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Gas infrastructure in Europe

LNG regasification terminals



Source: all data on this page were compiled by Fluxys in October 2026 from ENTSOG, Platts, ICIS, S&P Global and https://alsi.gie.eu/



Gas infrastructure in Europe

Regasification terminal in Zeebrugge

- LNG carriers: small - standard - Q-flex - Q-max (2,000 m³ to 266,000 m³ LNG)
- Over 300 different ships docked at the terminal to this day
- 5 storage tanks - 564,000 m³ LNG = 4 standard LNG ships of 140,000 m³
- Send-out flow rate: 30.2 GWh/h or 2,500,000 m³(n)/h = 1 standard LNG ship in about 1.5 days



© Fluxys Belgium - Patrick Henderyckx

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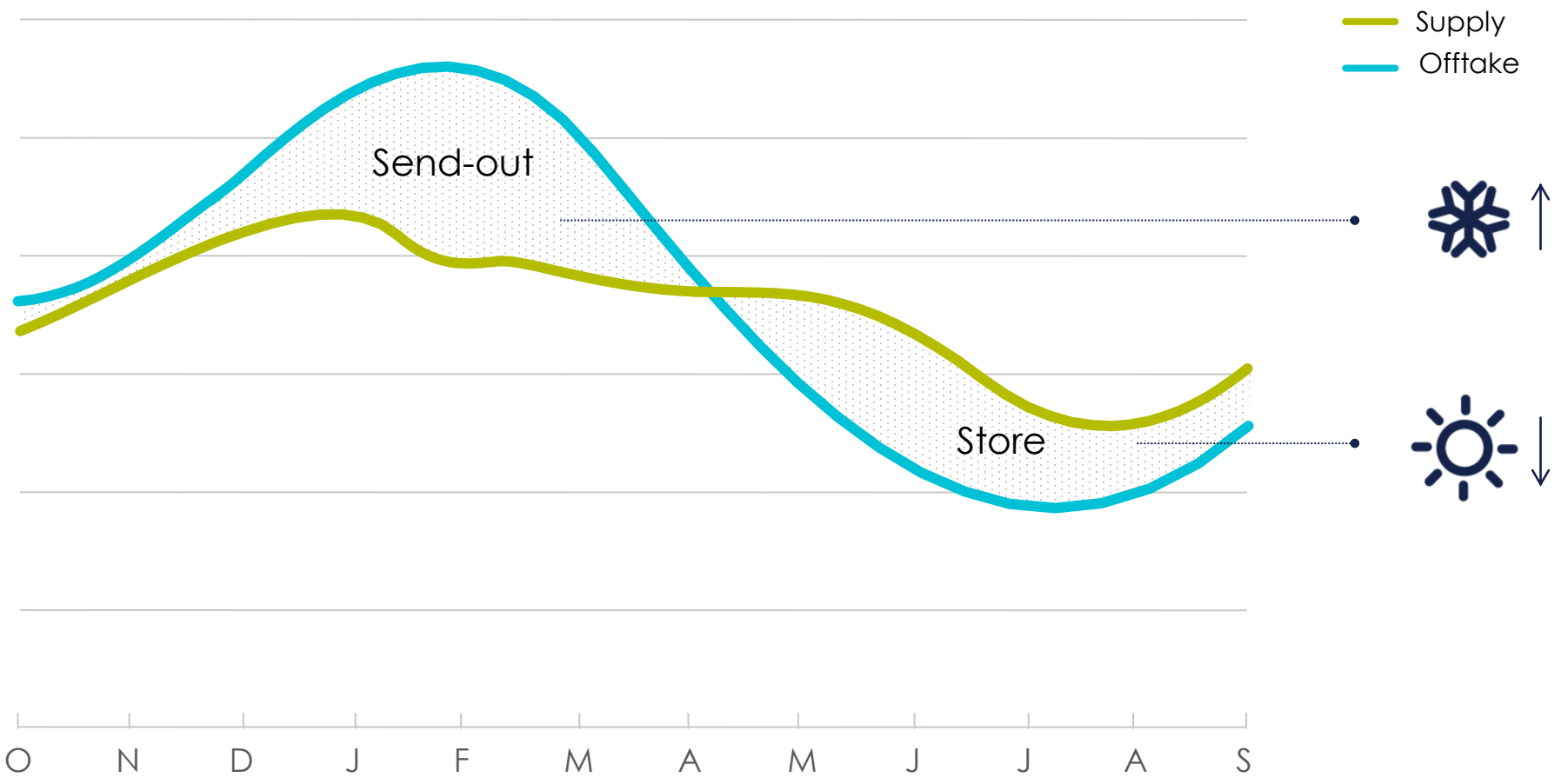
New molecules



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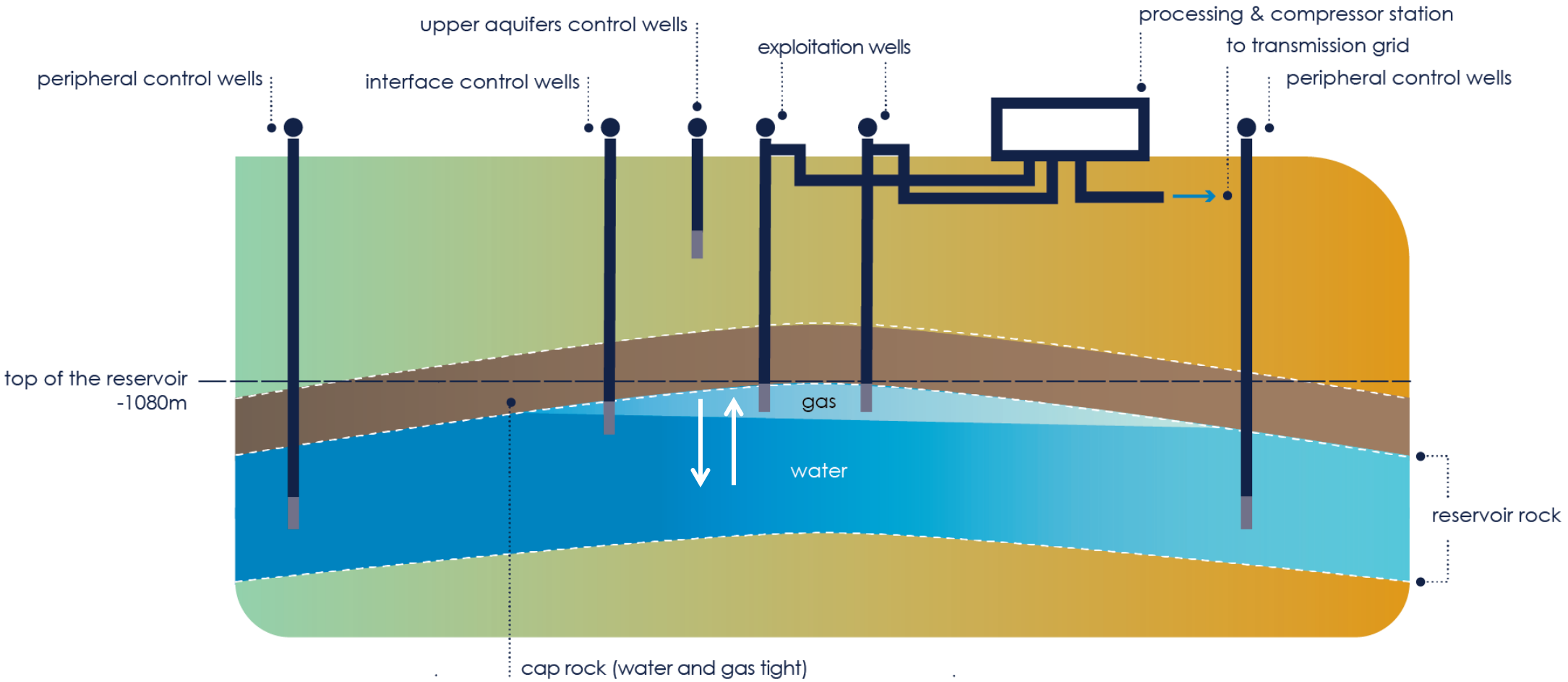
Why storage?

Because heating is seasonal, and production is cheaper (and easier!) if kept constant



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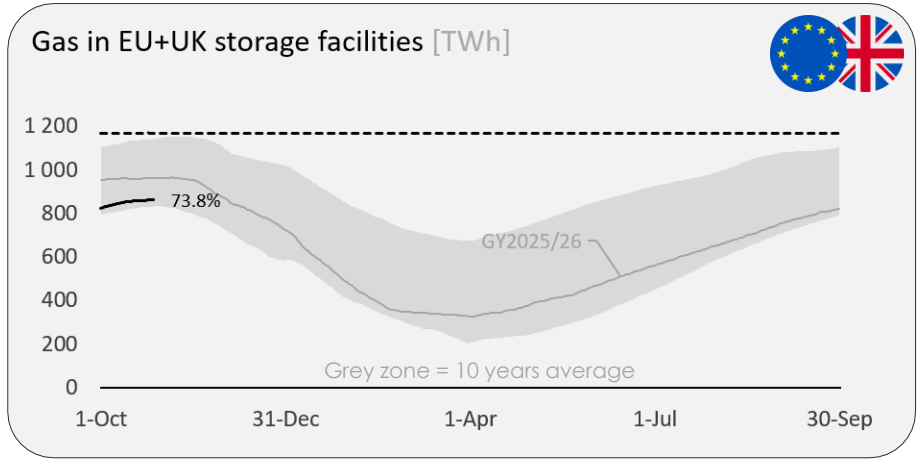
Underground storage in aquifer: how?

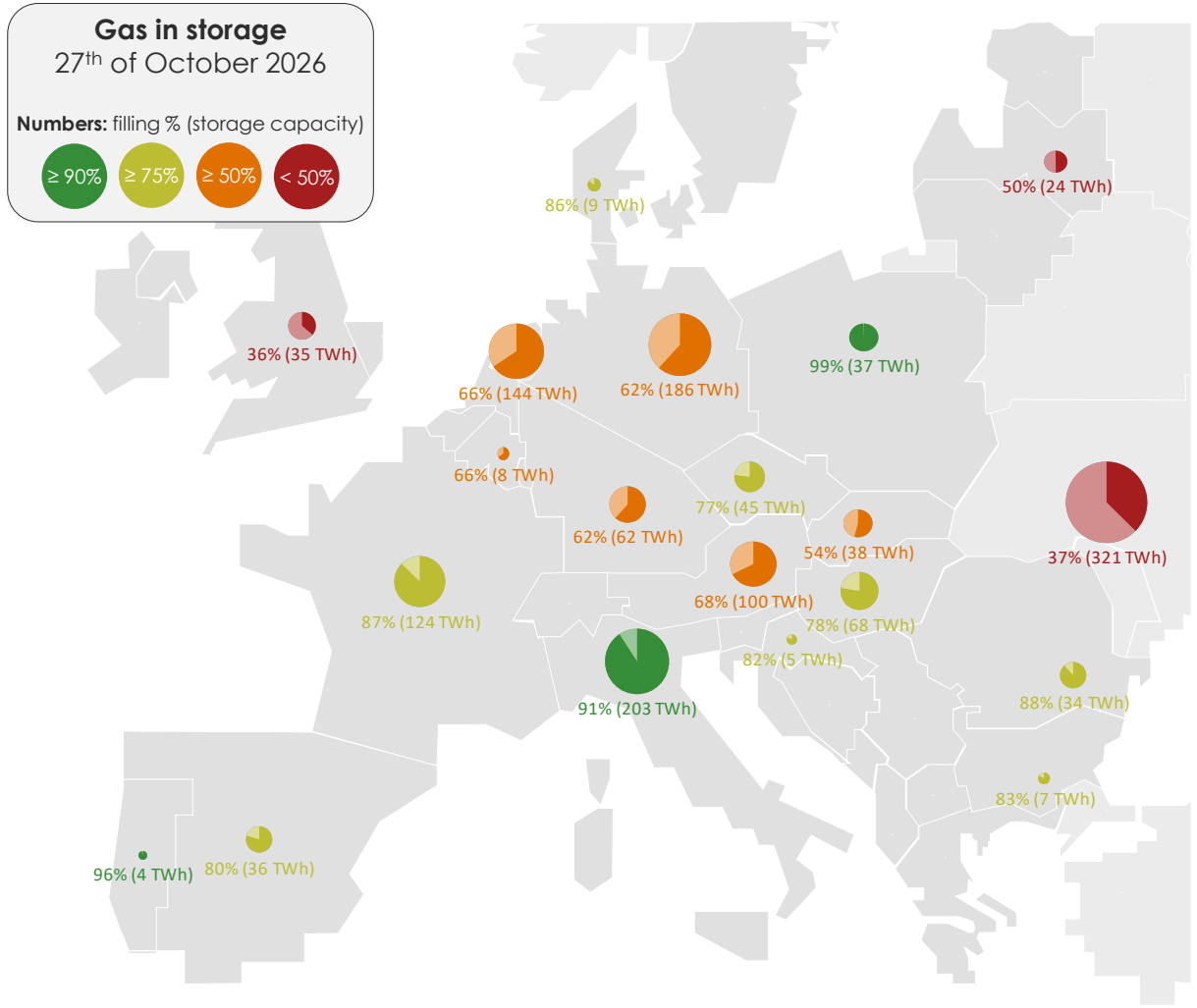


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Storage situation in Europe on October 27th

Sources: data from GIE AGSI and National Grid





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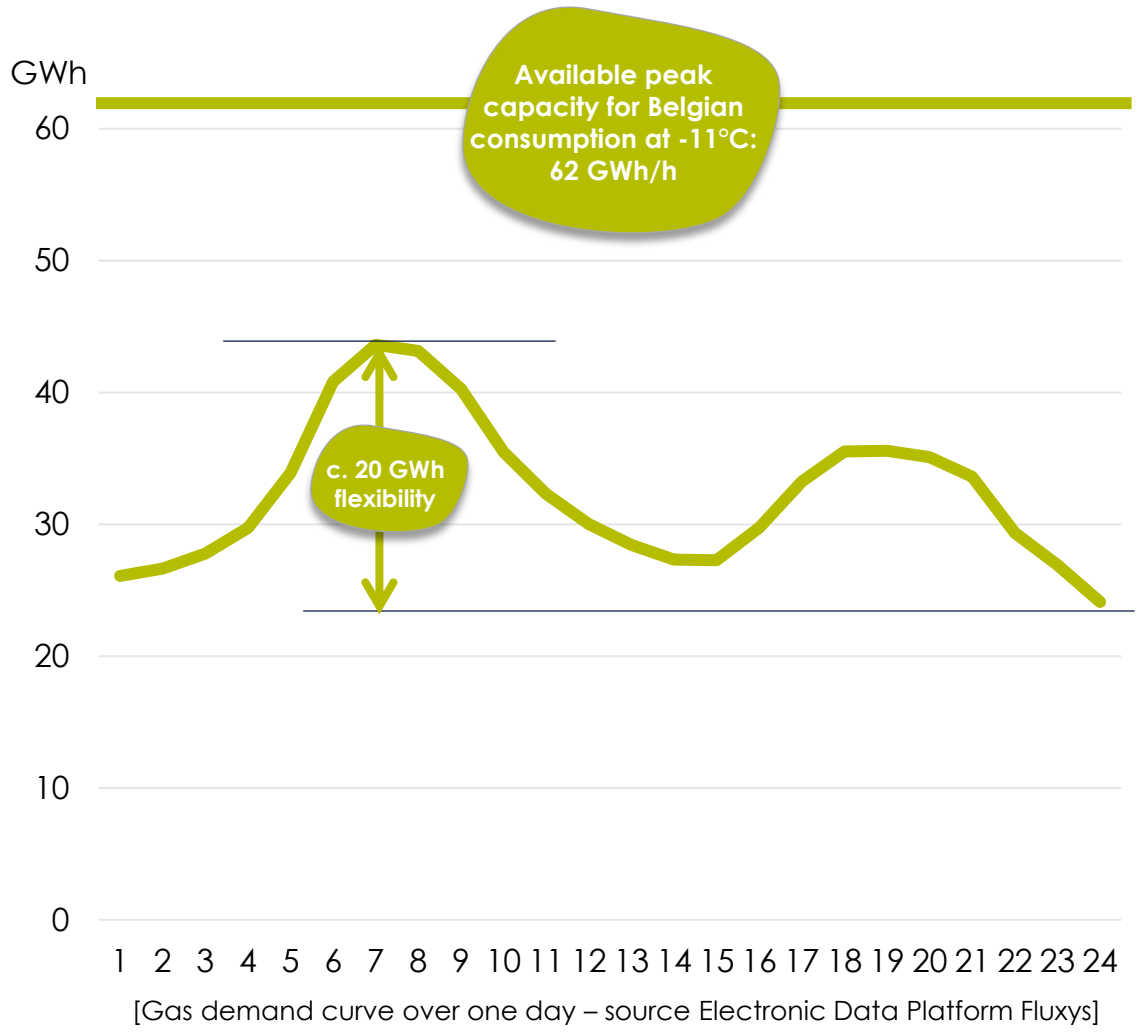
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Hourly demand profile



[Gas demand curve over one day – source Electronic Data Platform Fluxys]

- The first gas hour (GH1) starts at 6h in the morning
- Hourly demand has a morning peak starting at 8h AM and an evening peak around 19h PM
- Peak demand is typically 1,5 times night demand in winter
- Household (domestic) demand is temperature driven
- Power plants have slight decrease during night hours
- Industry has almost flat offtake

Information only - non binding

Pressure drop in pipes

Pressures drop is a non-linear function depending on gas speed, gas properties and pipe dimensions

Gas compressibility factor KPT is a function of temperature T and pressure P

$$K_P = K_{REF} - \frac{(P_{IN}-50)}{525}$$

$$K_{PT} = \frac{0.98515}{\left(1+\frac{0.98515-K_P}{0.75672\,K_P}\right)e^{-0.018584\,T}}$$

Gas density is computed from the Gas Law

$$\rho = \frac{\rho_0}{K_{PT}}\frac{T_0}{T}\frac{P_{IN}}{P_0}$$

Gas speed (m/s) is derived from gas flow (m3/h)

$$v = \left|\frac{Q}{\pi D^2/4}\right| = \left|\frac{Q_n}{\pi D^2/4}\frac{P_0}{P_{IN}}K_{PT}\right|$$

$$Re = \frac{vD}{\nu}$$

The Reynolds number is calculated from speed, pipe diameter and gas viscosity

$$\lambda = \left[0.8685\ln\left(\frac{1.964\ln(Re)-3.8215}{Re}+3.71\frac{D}{K}\right)\right]^{-2}$$

The 'lambda coefficient' (approaching the friction factor) is based on empirical formula

$$\Delta P_{rug} = \rho\frac{\lambda}{D}\frac{v^2}{2}L$$

Pressure drop due to pipe rugosity and gas speed can now be calculated

Information only - non binding

Pressure drop in pipes

Pressures drop is a non-linear function depending on gas speed, gas properties and pipe dimensions

Pressure drop due to pipe rugosity and gas speed

$$\Delta P_{rug} = \rho \frac{\lambda}{D} \frac{v^2}{2} L$$

Pressure drop due to potential energy (height of pipe)

$$\Delta P_{pot} = 9.81(h_{OUT} - h_{IN})$$

Total pressure drop:

$$P_{OUT} = P_{IN} - signe(Q_n) * \Delta P_{rug} - \Delta P_{pot}$$

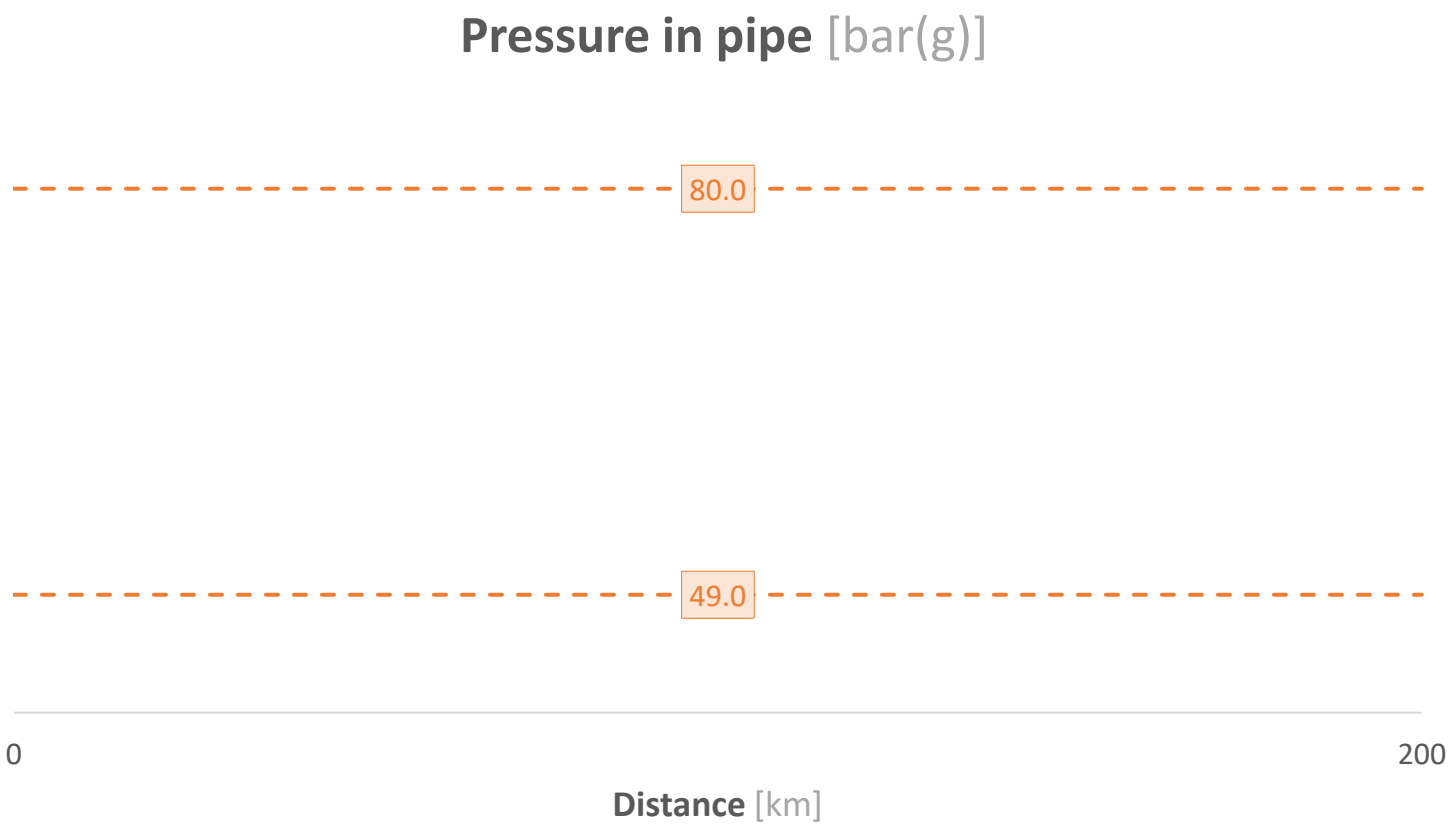
Volume of (compressed) gas in pipe:

$$Linepack_{Section} = \frac{2}{3} \frac{P_{IN}^3 - P_{OUT}^3}{P_{IN}^2 - P_{OUT}^2} \frac{273.15}{273.15+T} \frac{GCV}{K_{PT}} V$$

Information only - non binding

Pressure drop in pipes

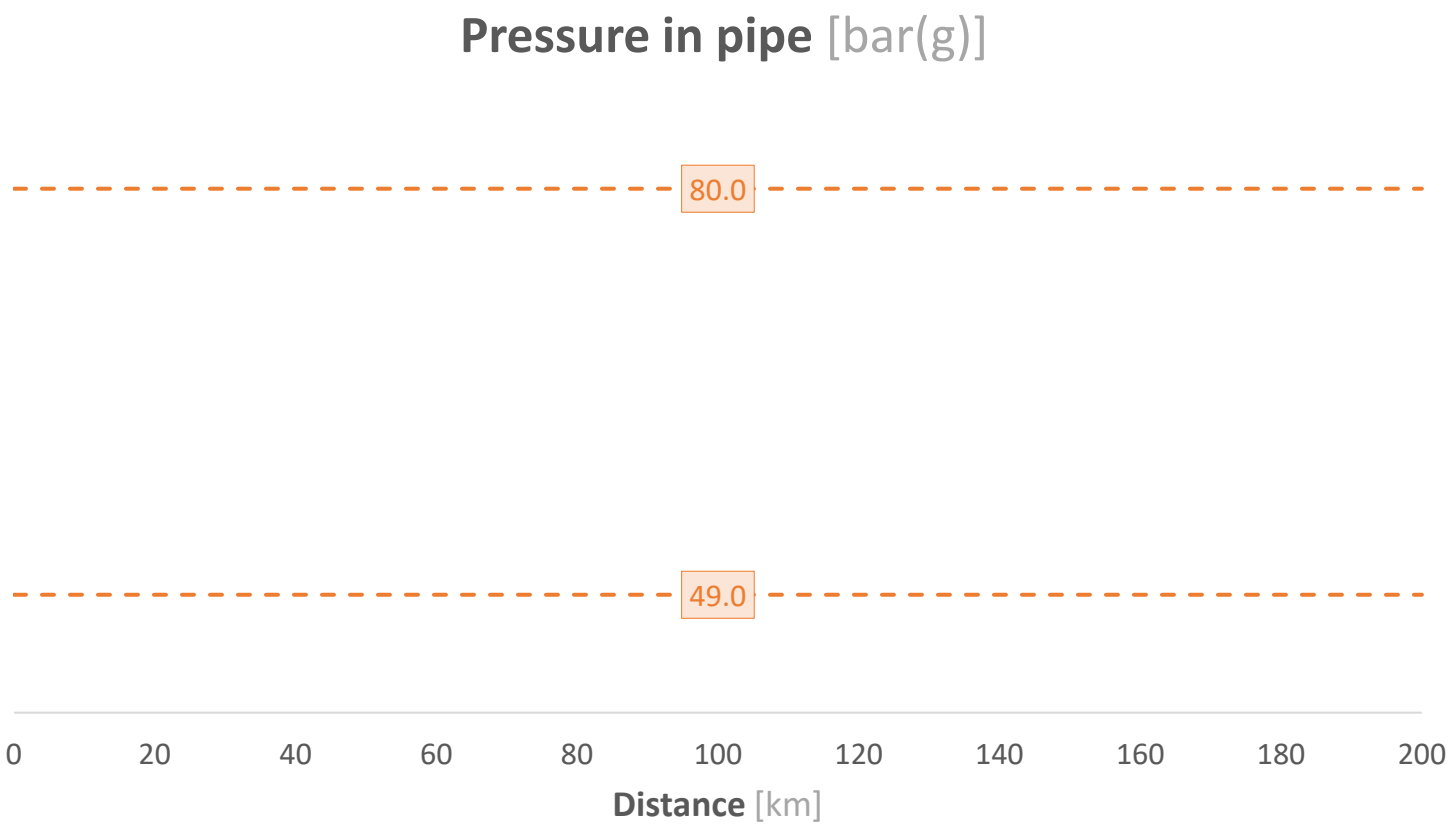
Let's take a 200km pipeline (diameter 1000mm) and represent its typical pressure limits



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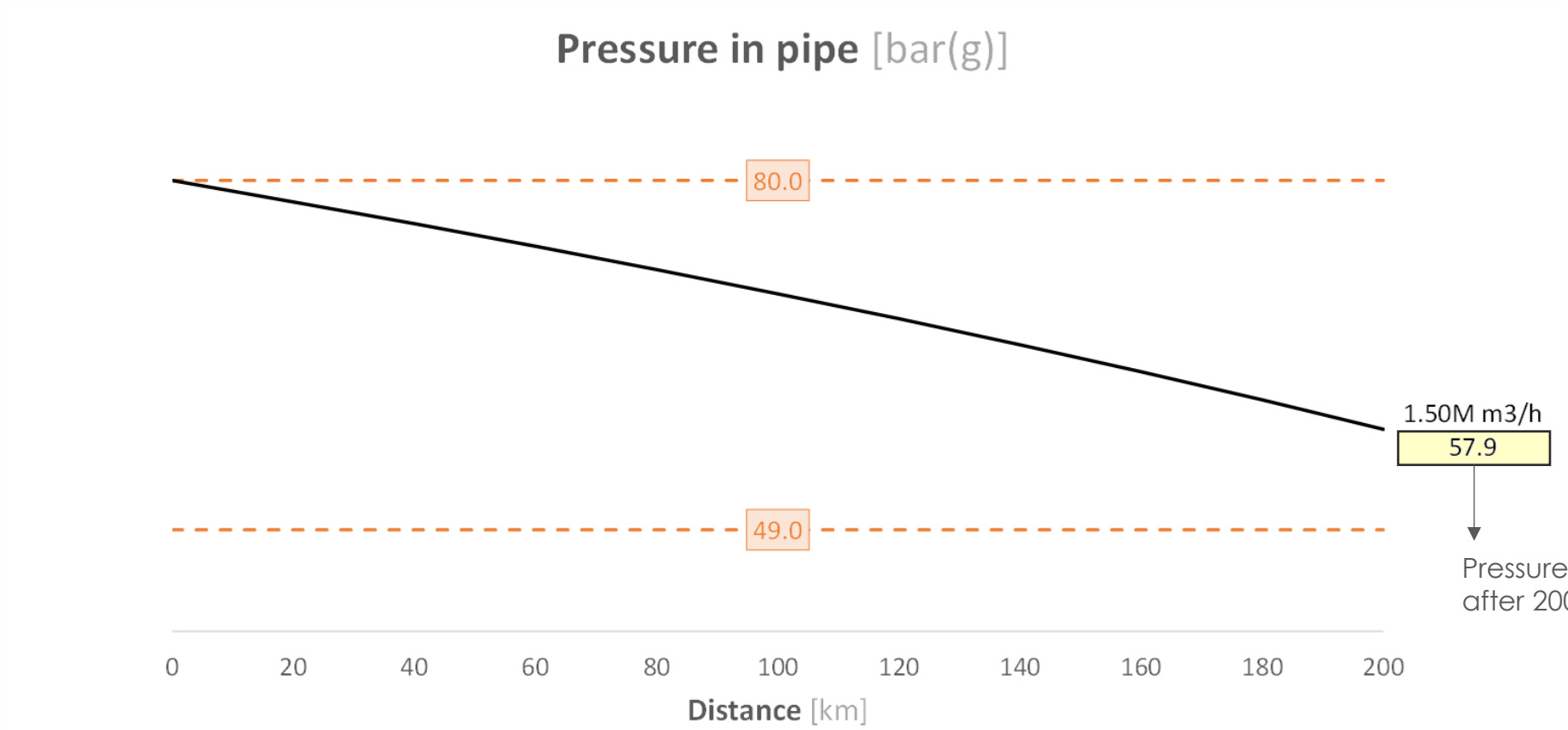
Pressure drop in pipes

For this example, pressures will be computed every 20km



Pressure drop in pipes

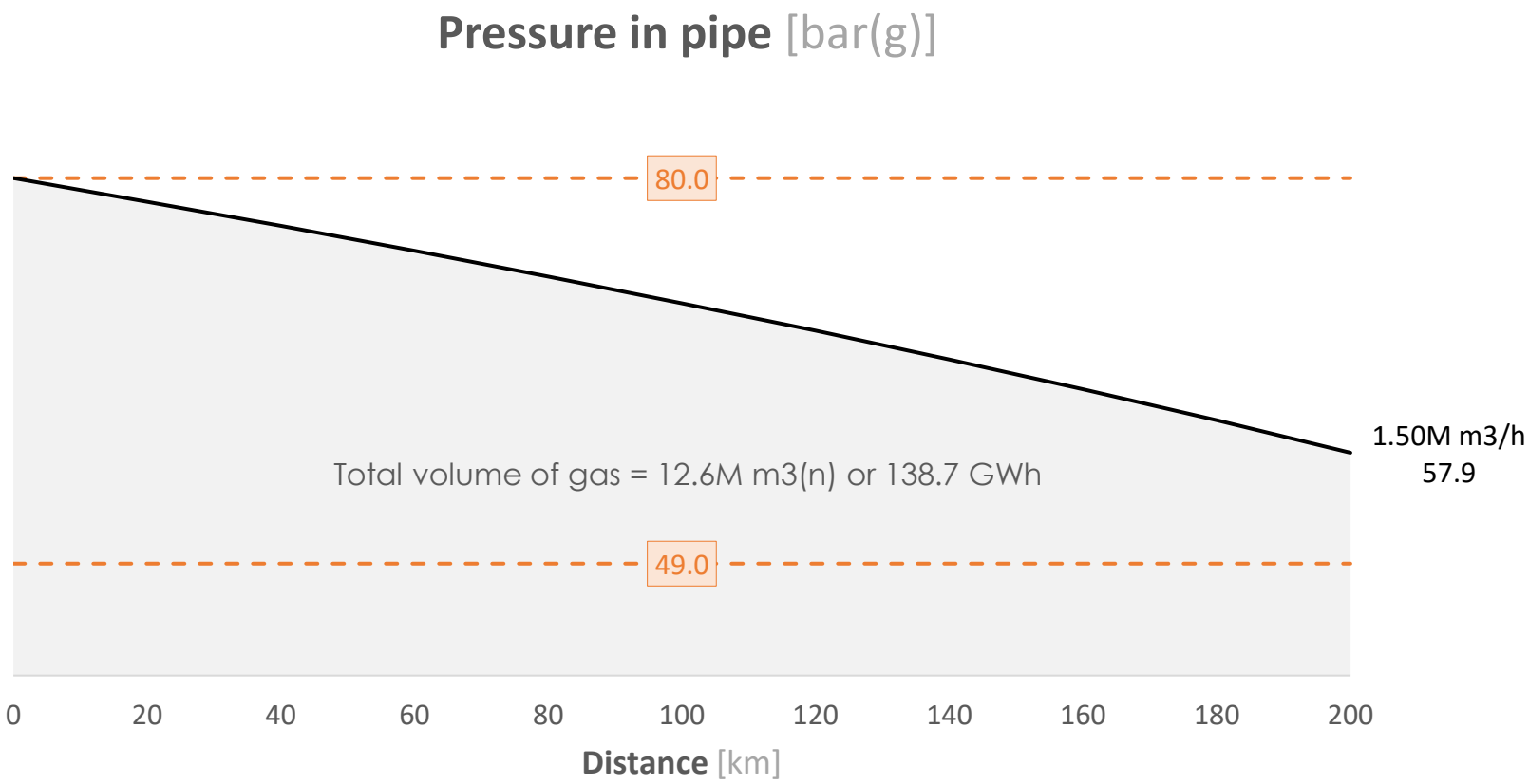
Let's assume a 1500000 m3/h flow, equivalent to ~16.6 GW or ~400 GWh/day (this is a typical value for a 40in pipeline) and let's start with a maximum entry pressure



Information only - non binding

Pressure drop in pipes

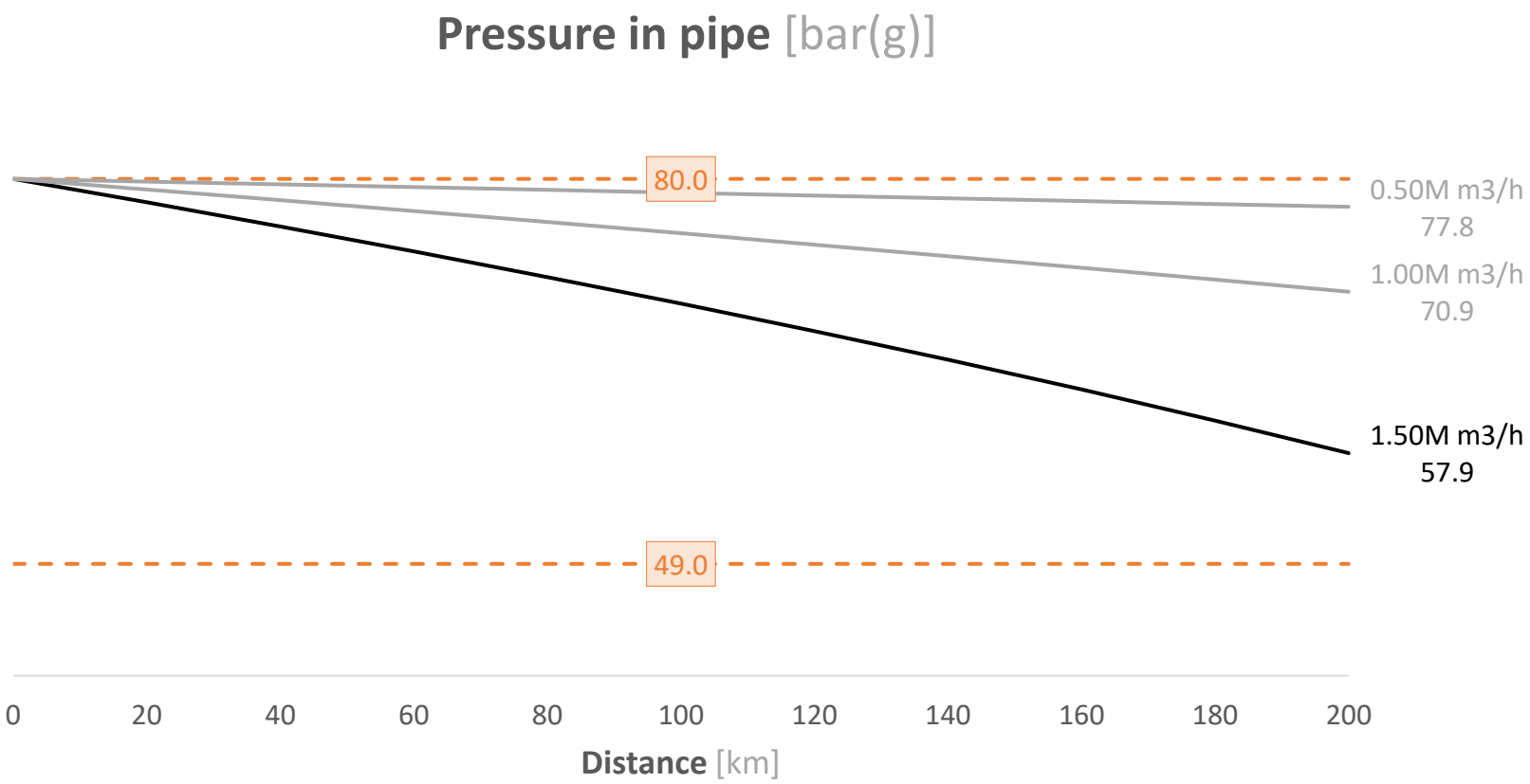
The area represents the amount of gas in pipe, derived from the Gas Law



Information only - non binding

Pressure drop in pipes

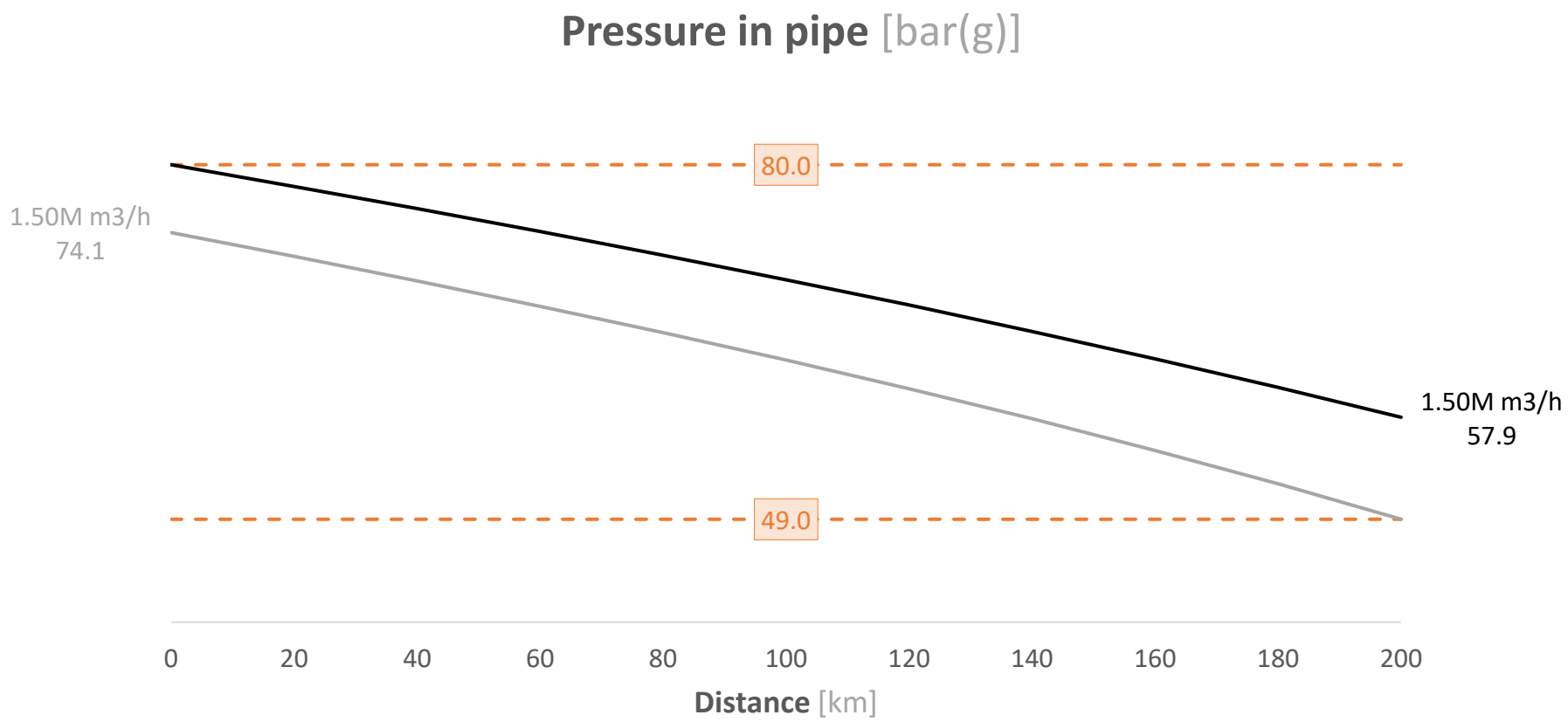
Pressure drops is significantly impacted by the gas velocity



Information only - non binding

Pressure drop in pipes

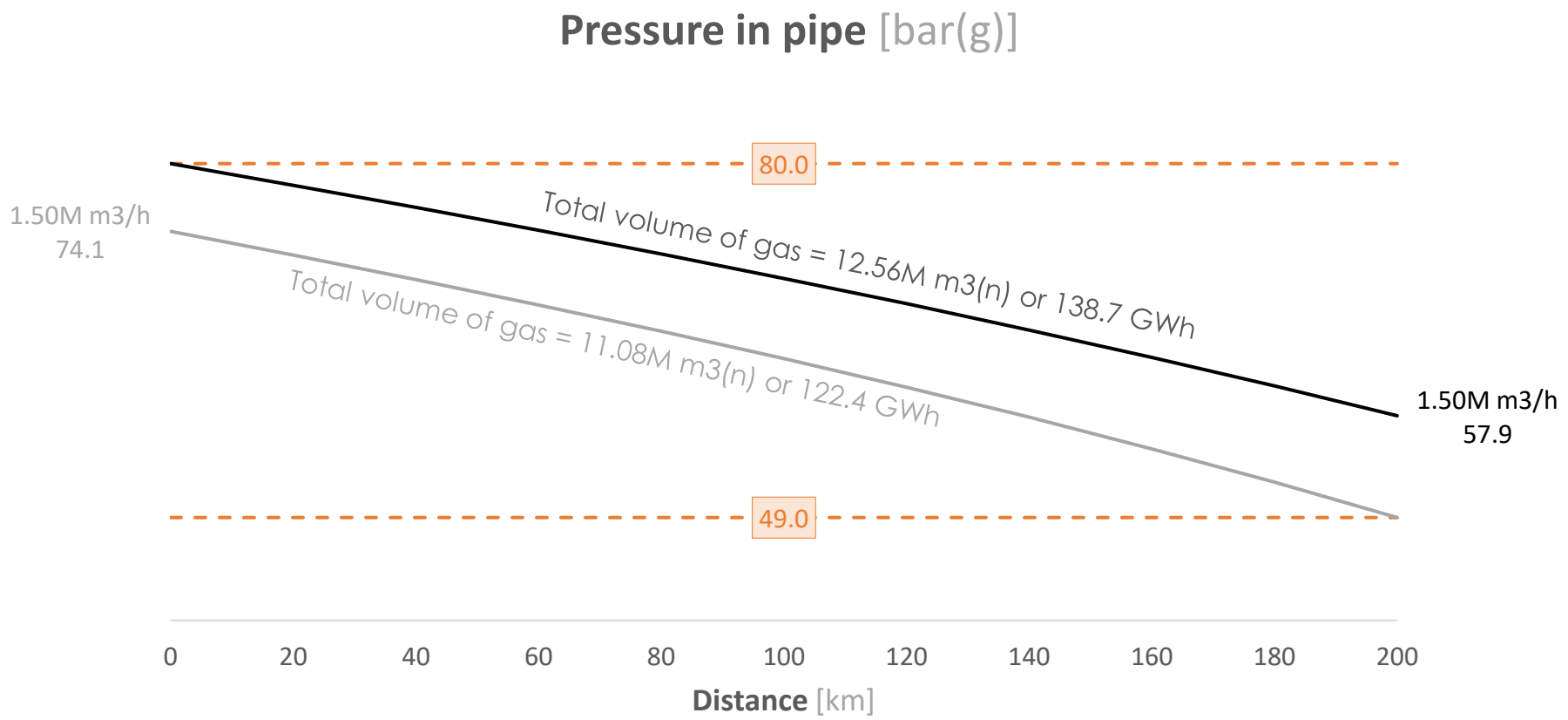
With the same gas velocity, a range of entry pressures respects pressure limits



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Pressure drop in pipes

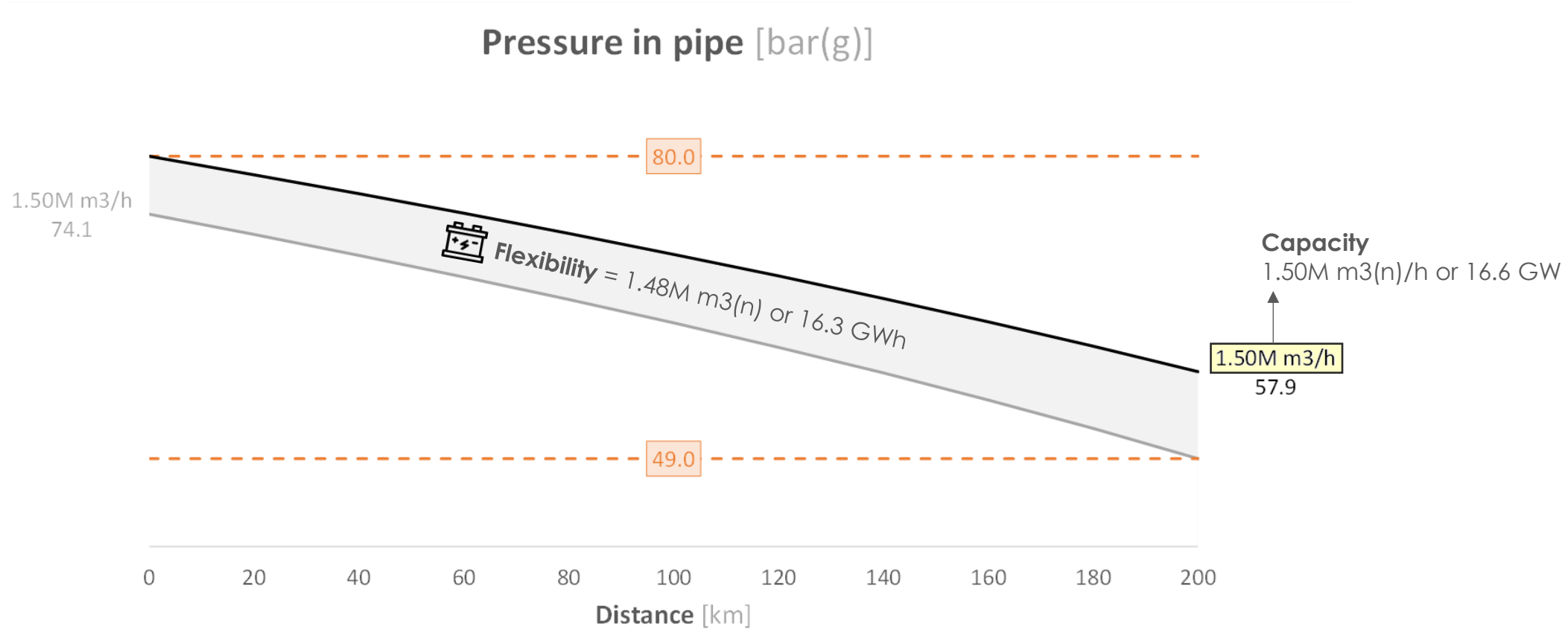
Depending on the overall pressure profile, different amounts of gas can be stored in the pipeline



Information only - non binding

Pressure drop in pipes

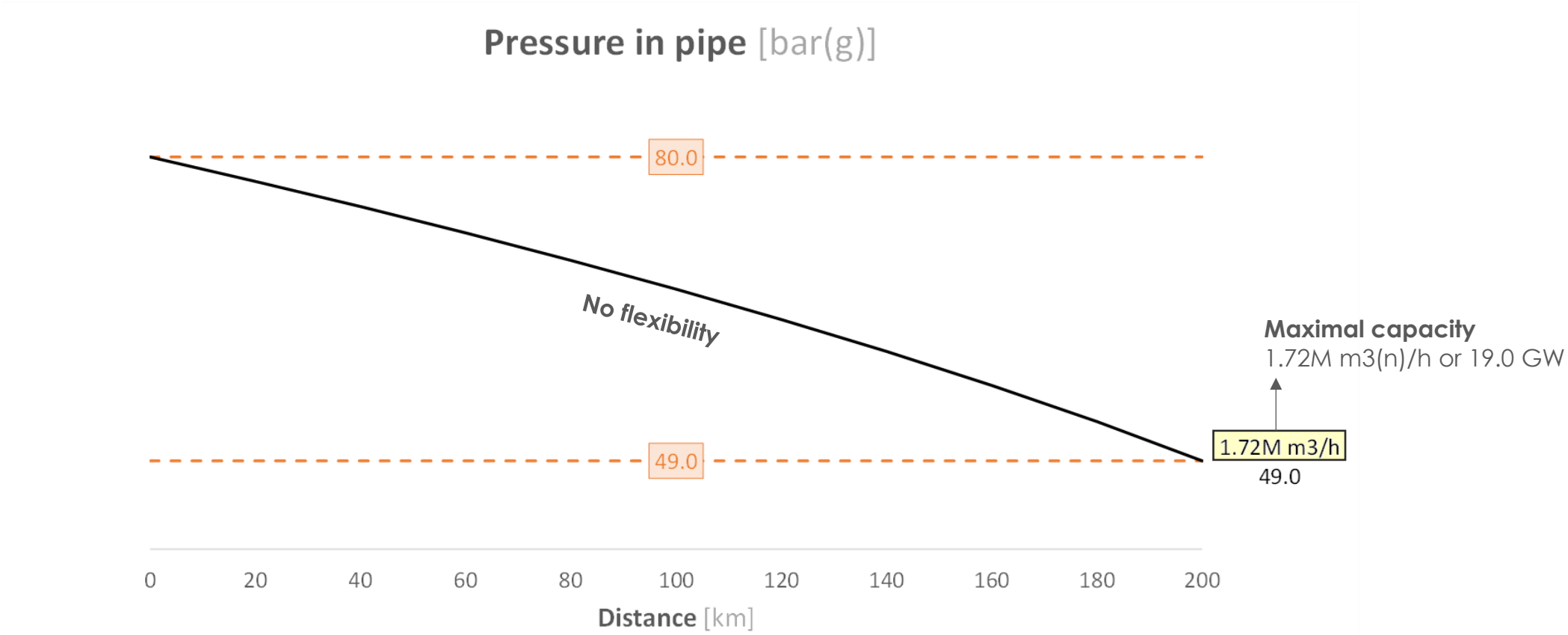
The range of gas volumes that can be stored is the flexibility of the pipe for a given flow (in this case the flexibility is typical and equal to one hour of capacity)



Information only - non binding

Pressure drop in pipes

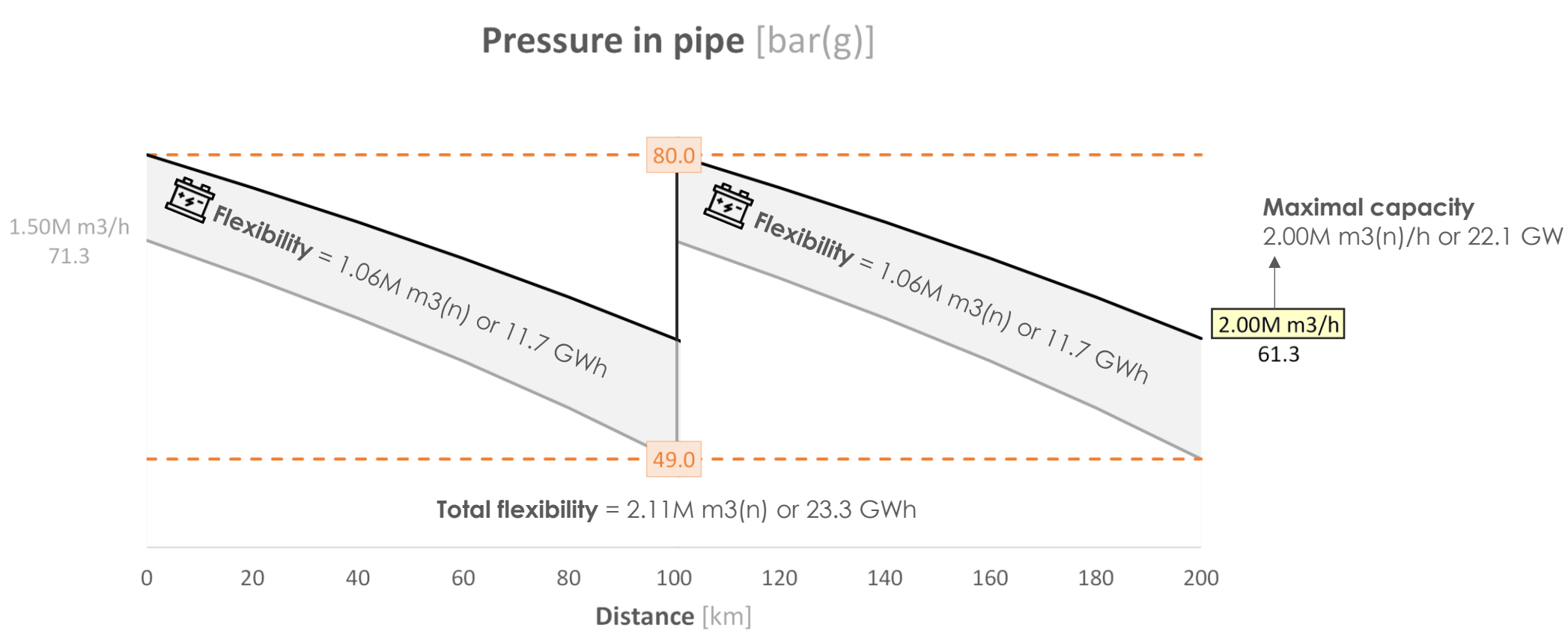
The pipe capacity can be maximized by removing any flexibility – but this will not allow to cover any demand fluctuation



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Pressure drop in pipes

Another way of increasing the pipe capacity is to build compression stations



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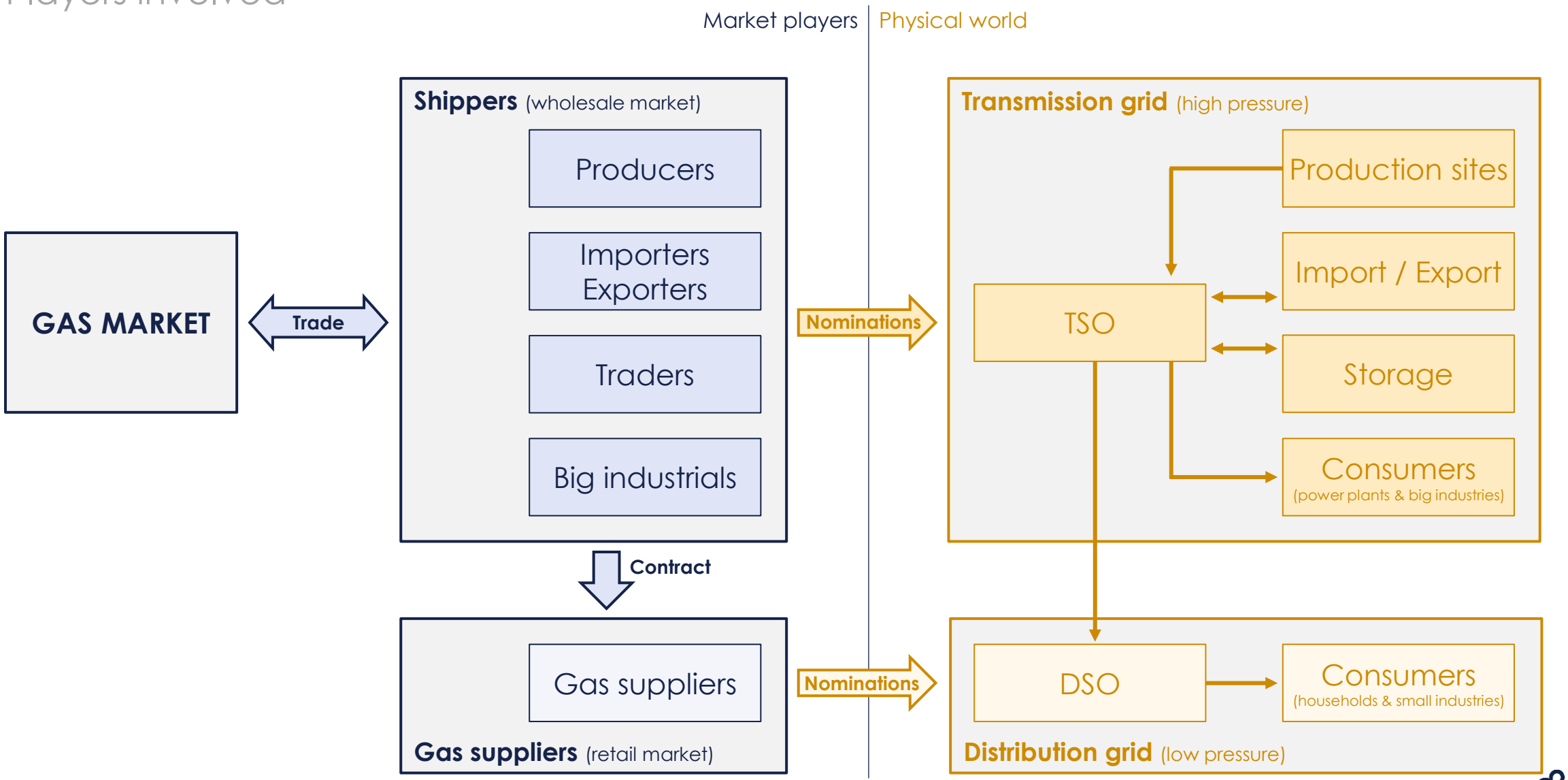
New molecules



Information only - non binding

Gas markets

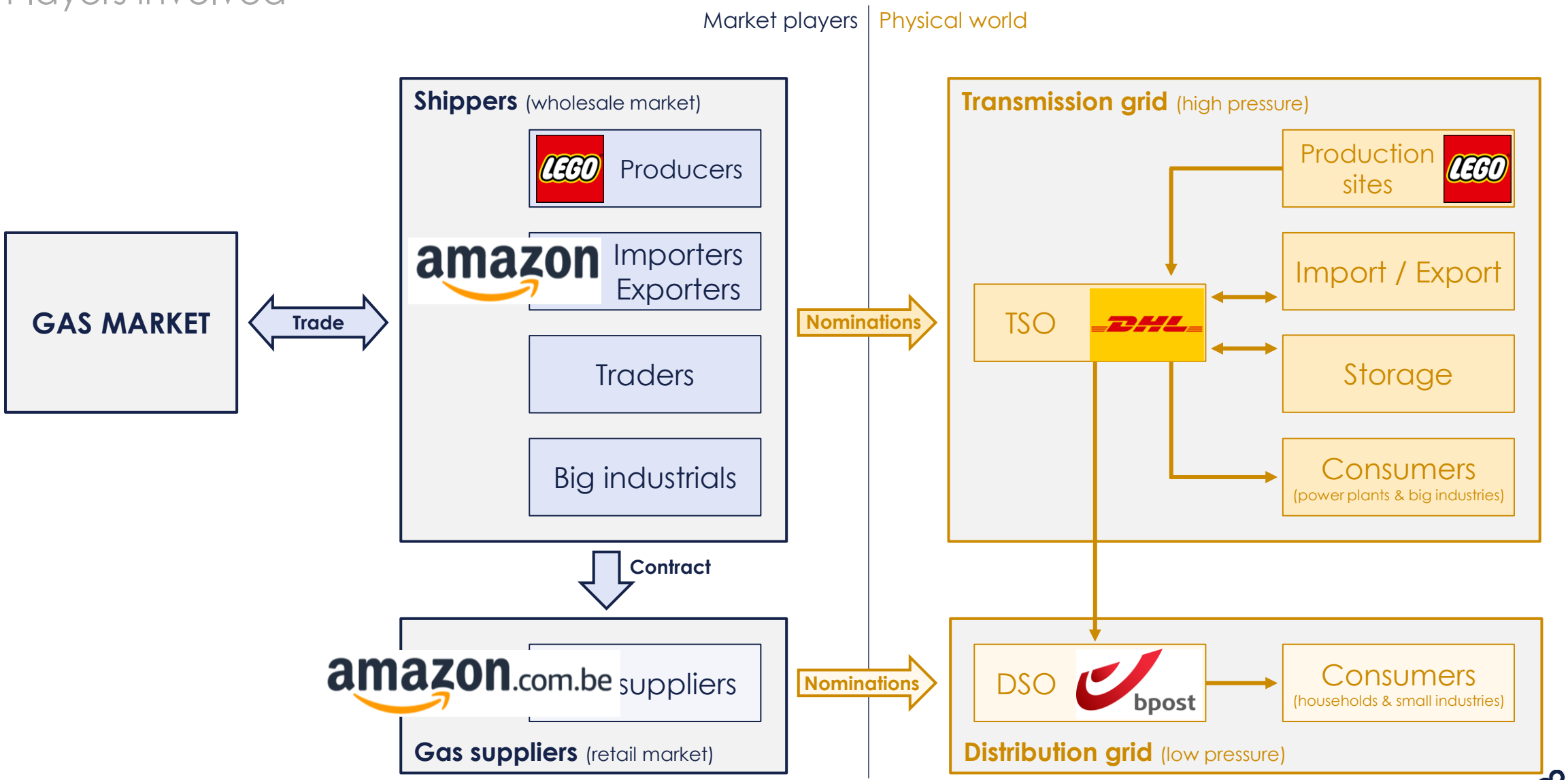
Players involved



Information only - non binding

Gas markets

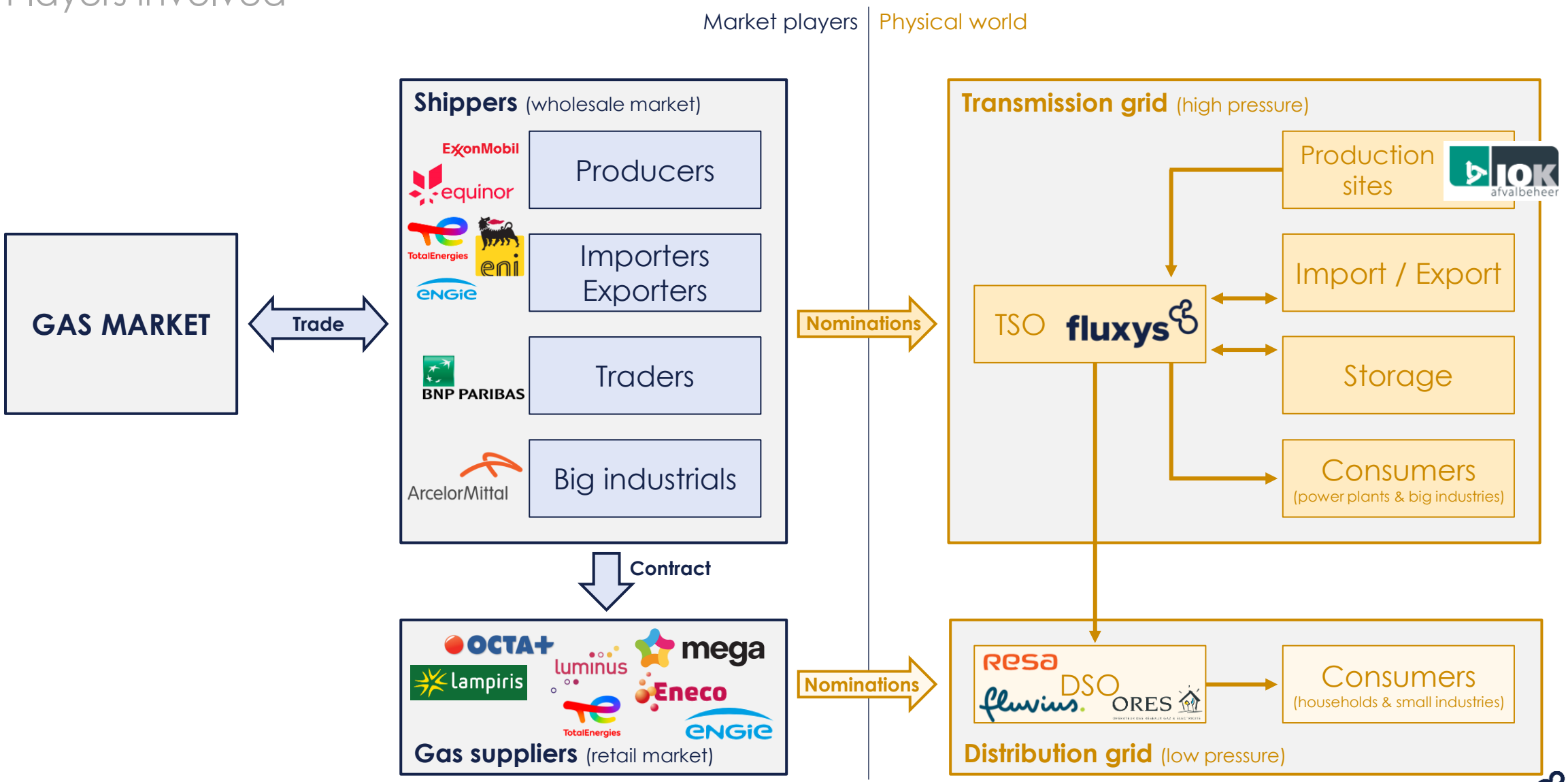
Players involved



Information only - non binding

Gas markets

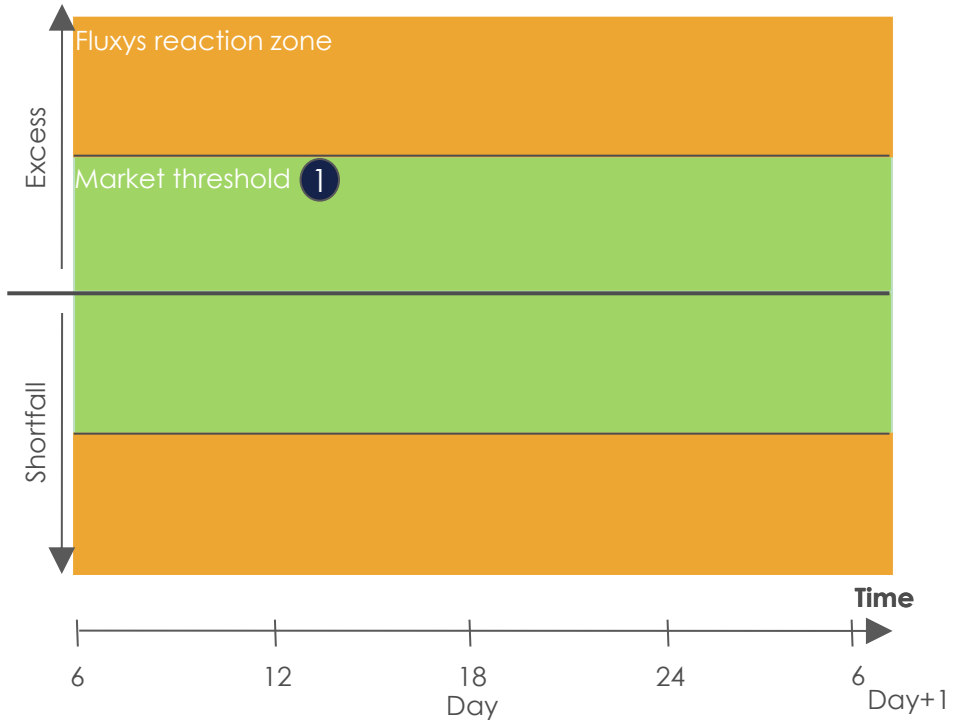
Players involved



Information only - non binding

Gas markets

The shippers are responsible for daily balancing



Daily Market Based Balancing

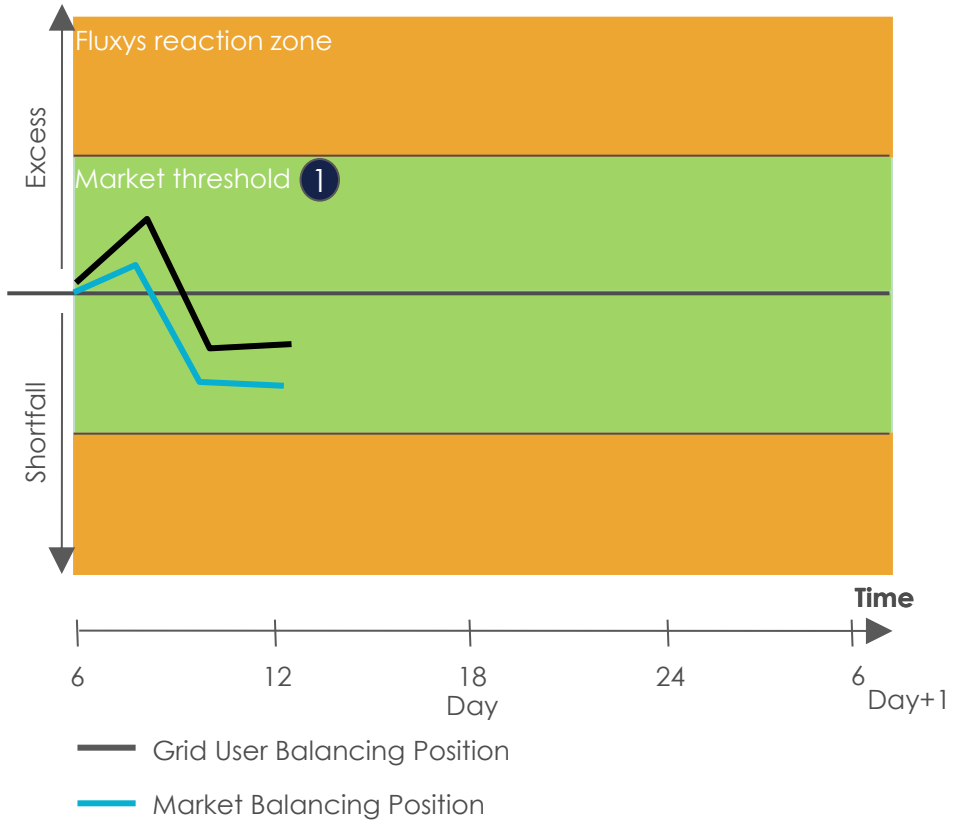
1 Thresholds to limit the aggregated market imbalances, sized to domestic market needs

The physical linepack is translated into commercial (intraday) flexibility for the market, but at the end of the gas day all gas must be balanced

Information only - non binding

Gas markets

The shippers are responsible for daily balancing



Daily Market Based Balancing

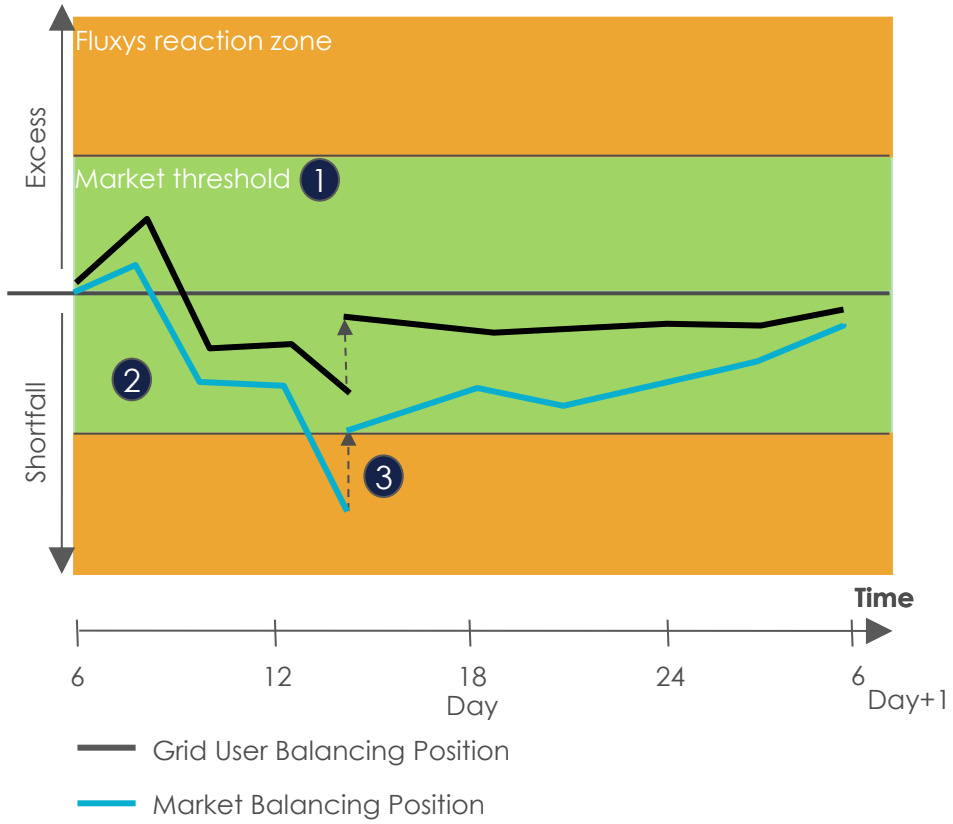
1. Thresholds to limit the aggregated market imbalances, sized to domestic market needs
2. No Fluxys Belgium action intra-day and no impact on market parties as long as market imbalance is within market threshold

The physical linepack is translated into commercial (intraday) flexibility for the market, but at the end of the gas day all gas must be balanced

Information only - non binding

Gas markets

The shippers are responsible for daily balancing



Daily Market Based Balancing

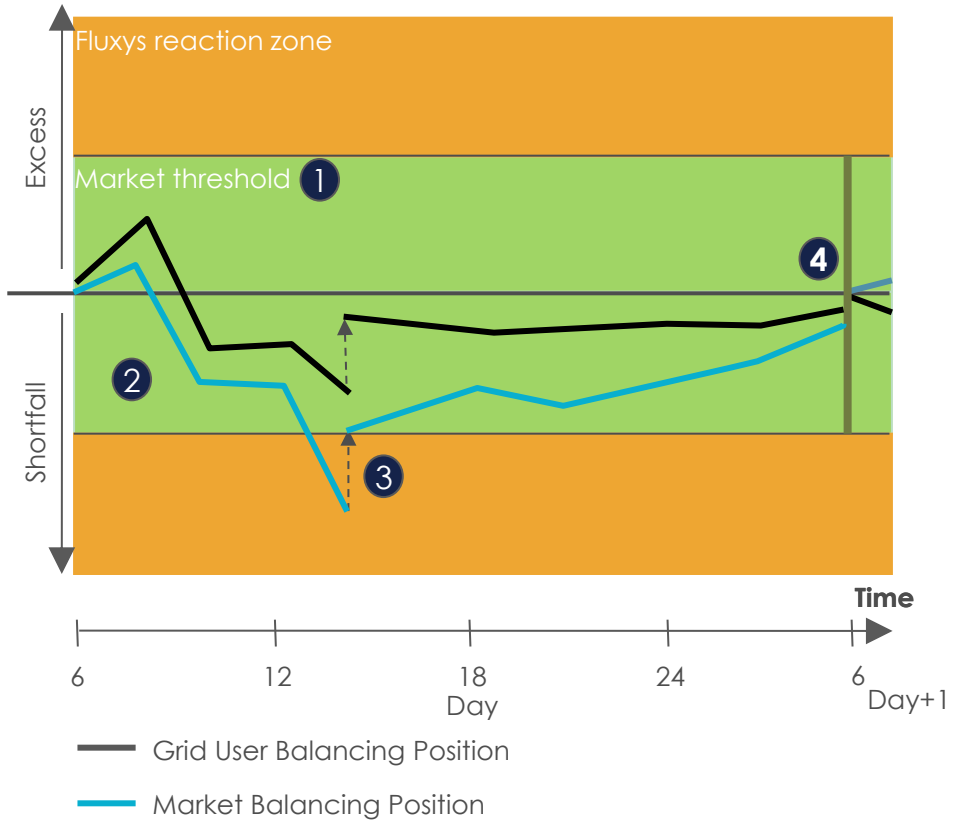
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3. Residual action initiated by Fluxys Belgium on the exchange when market position goes beyond market threshold, with cash compensation for causers

The physical linepack is translated into commercial (intraday) flexibility for the market, but at the end of the gas day all gas must be balanced

Information only - non binding

Gas markets

The shippers are responsible for daily balancing



Daily Market Based Balancing

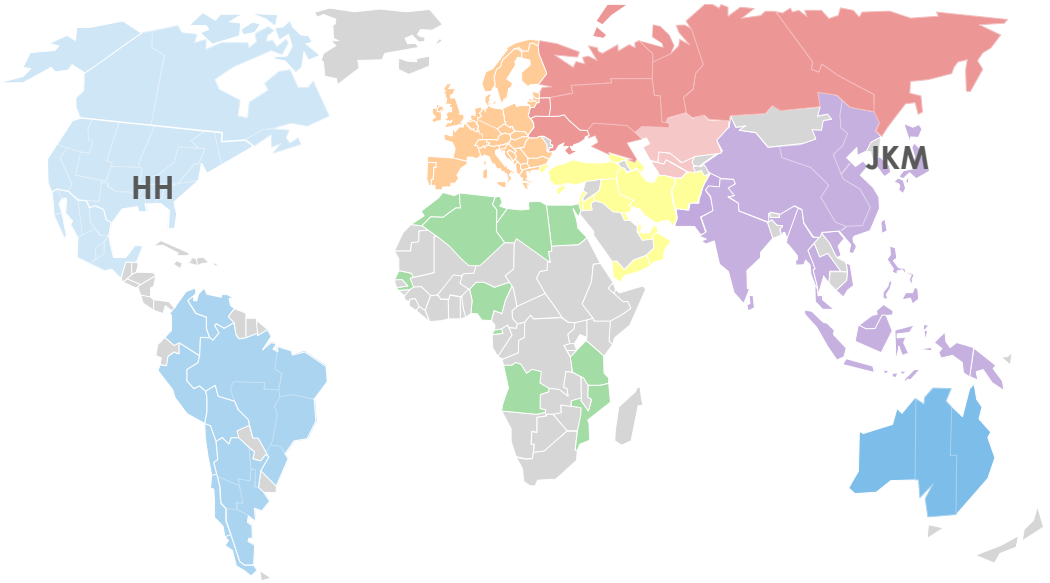
1. Thresholds to limit the aggregated market imbalances, sized to domestic market needs
2. No Fluxys Belgium action intra-day and no impact on market parties as long as market imbalance is within market threshold
3. Residual action initiated by Fluxys Belgium on the exchange when market position goes beyond market threshold, with cash compensation for causers
4. Residual end-of day imbalance settled in cash

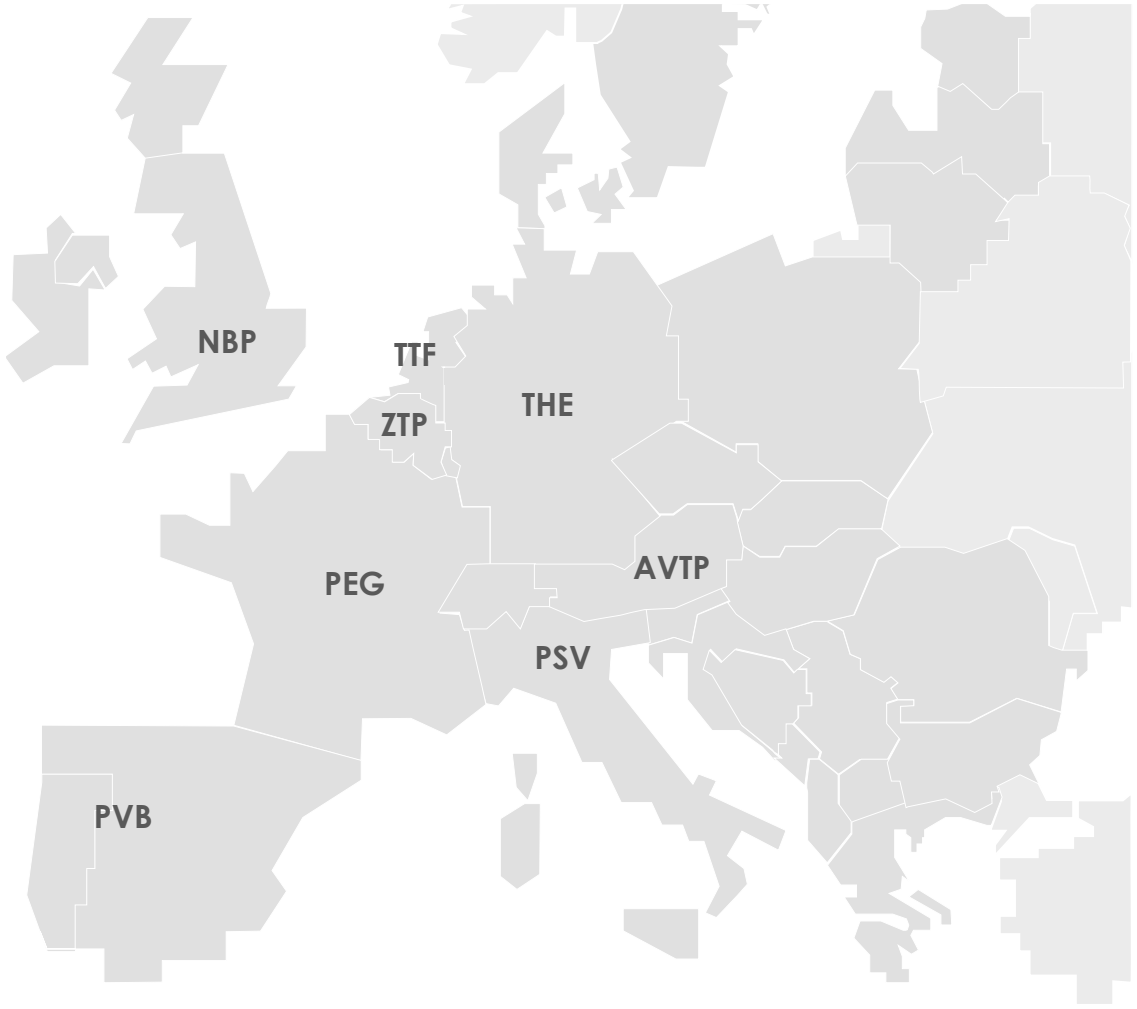
The physical linepack is translated into commercial (intraday) flexibility for the market, but at the end of the gas day all gas must be balanced

Information only - non binding

Gas markets

Major hubs and gas price indexes in the world

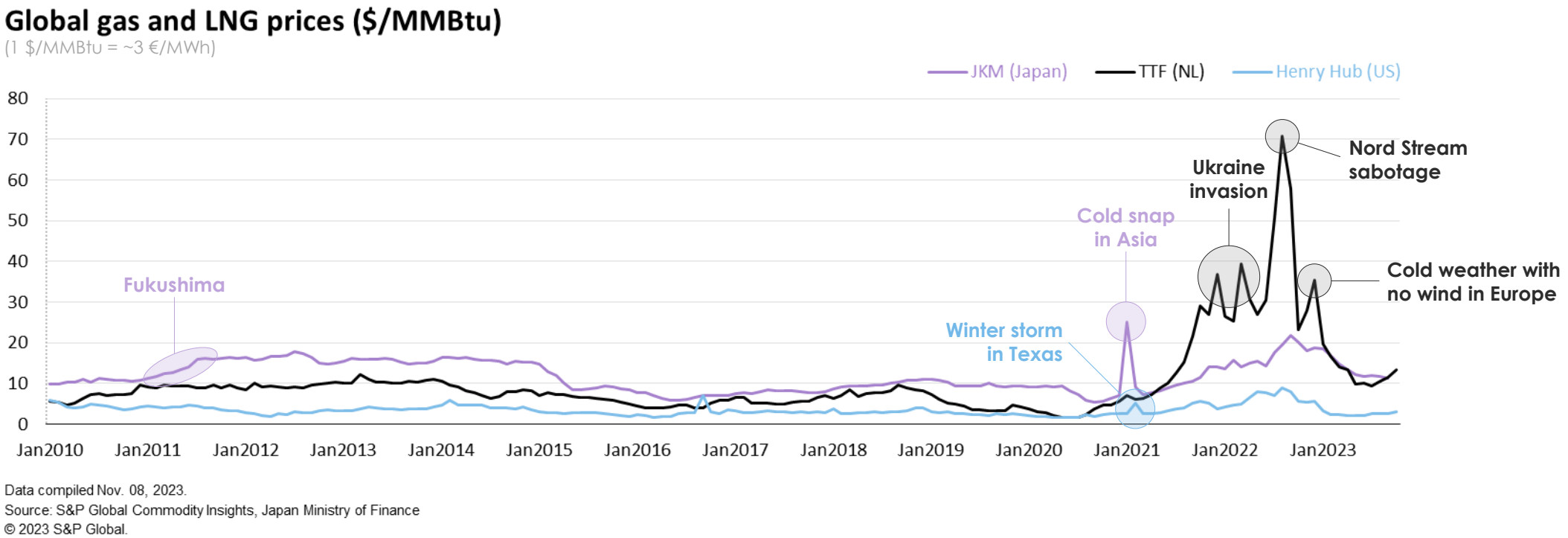




Information only - non binding

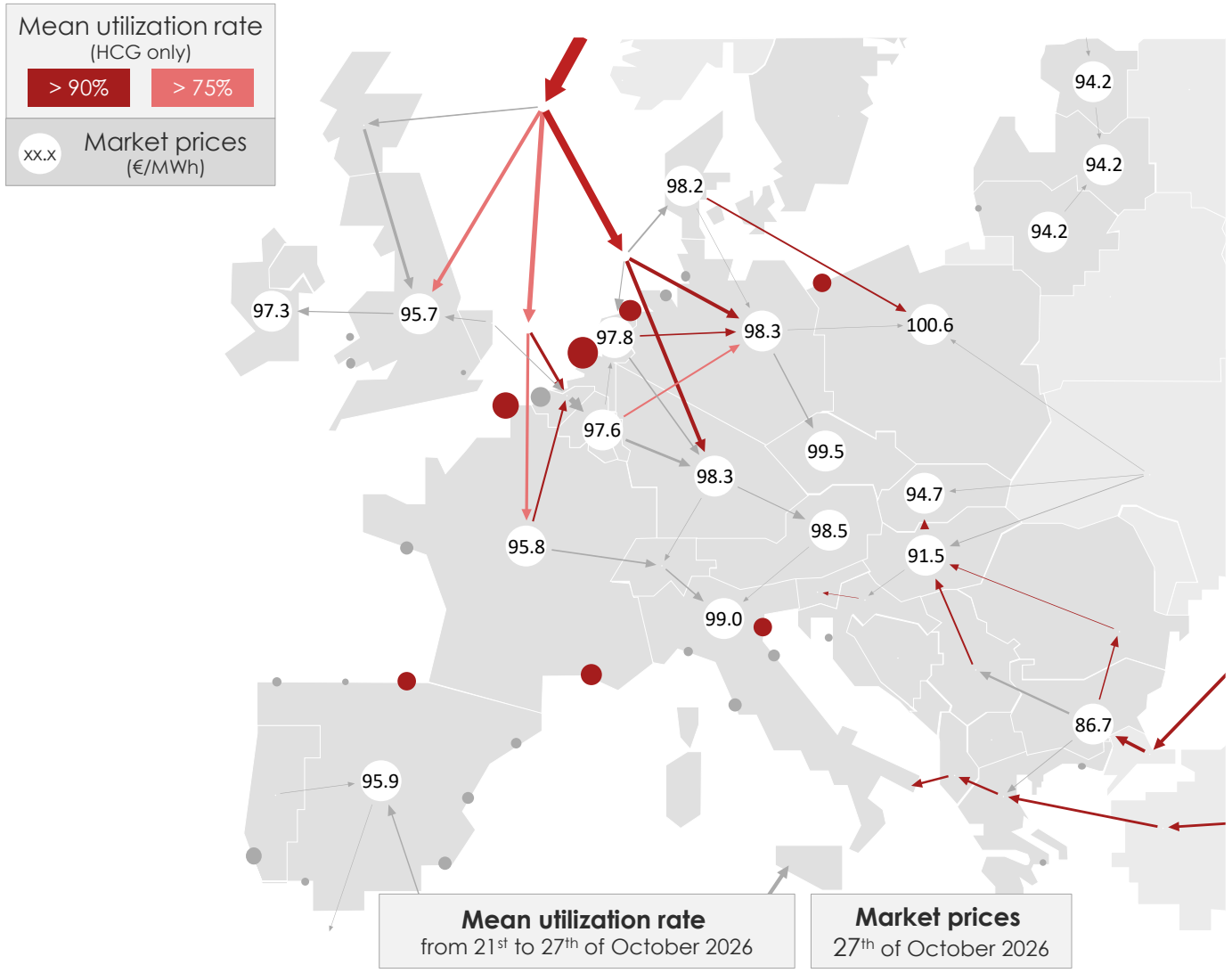
Gas markets

Major hubs and gas price indexes in the world



Data compiled Nov. 08, 2023.
Source: S&P Global Commodity Insights, Japan Ministry of Finance
© 2023 S&P Global.

Higher spread reflects congestion



Data from ENTSOG transparency platform, GIE ALSI , GIE AGSI and National Grid
Market prices from gCompass, EEX Denmark , GET Baltic, TGE Poland, IBP Ireland and Platts

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CH_4

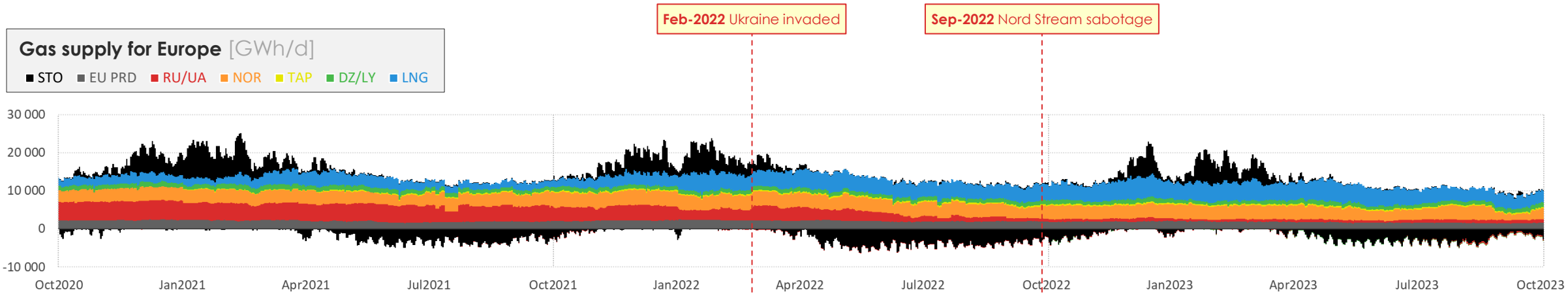
Information only - non binding

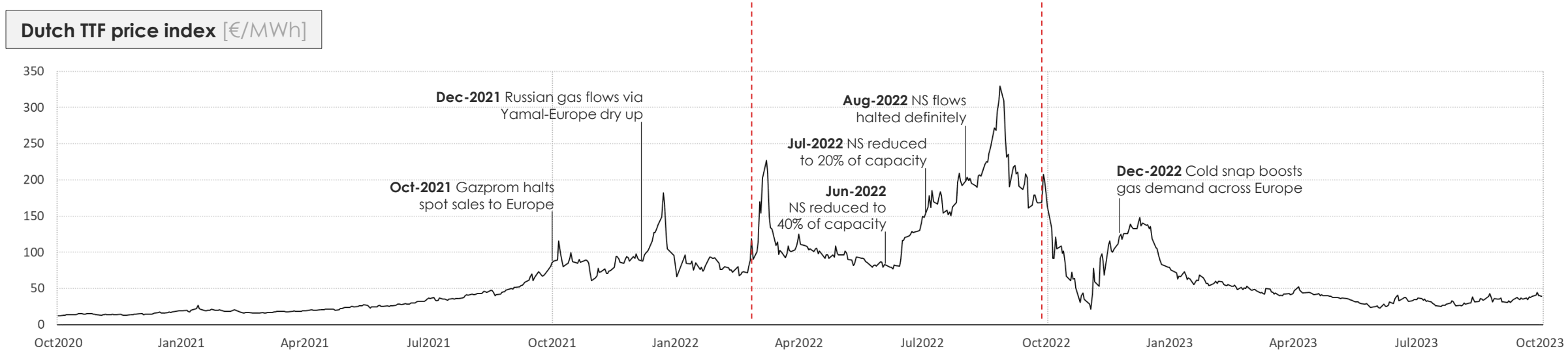
Sources: data from ENTSOG transparency platform, GIE ALSI, GIE AGSI, Platts and National Grid

CH_4

Natural gas supply for Europe

Europe = EU27 + UK + Switzerland + Balkans





Information only - non binding

Natural gas supply for Europe

Europe = EU27 + UK + Switzerland + Balkans

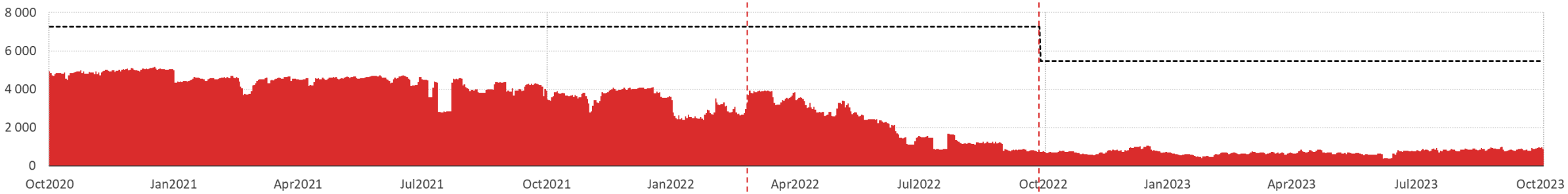
Sources: data from ENTSOG transparency platform, GIE ALSI, GIE AGSI, Platts and National Grid

CH_4

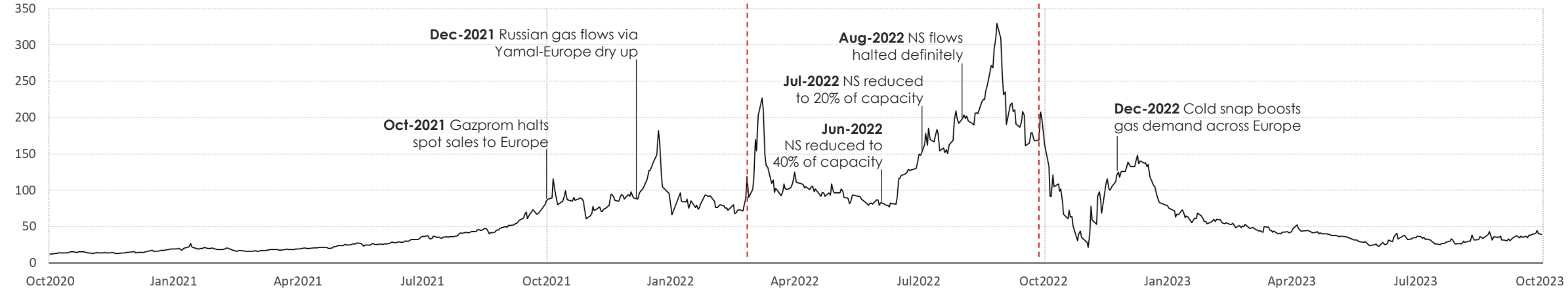
Feb-2022 Ukraine invaded

Sep-2022 Nord Stream sabotage

European import from Russia [GWh/d]



Dutch TTF price index [€/MWh]



Information only - non binding

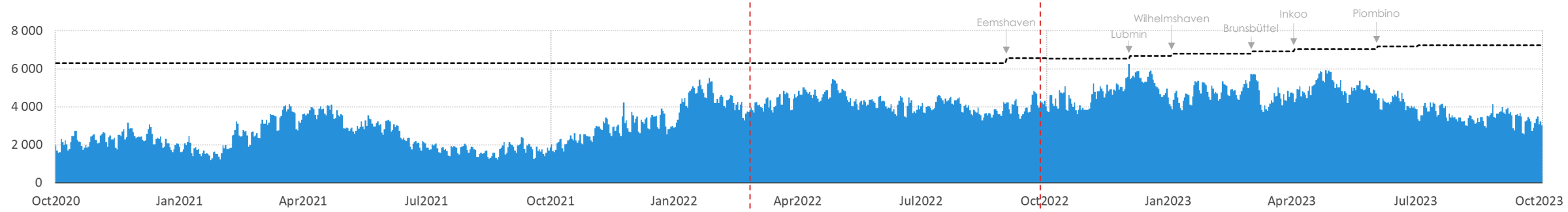
Natural gas supply for Europe

Europe = EU27 + UK + Switzerland + Balkans

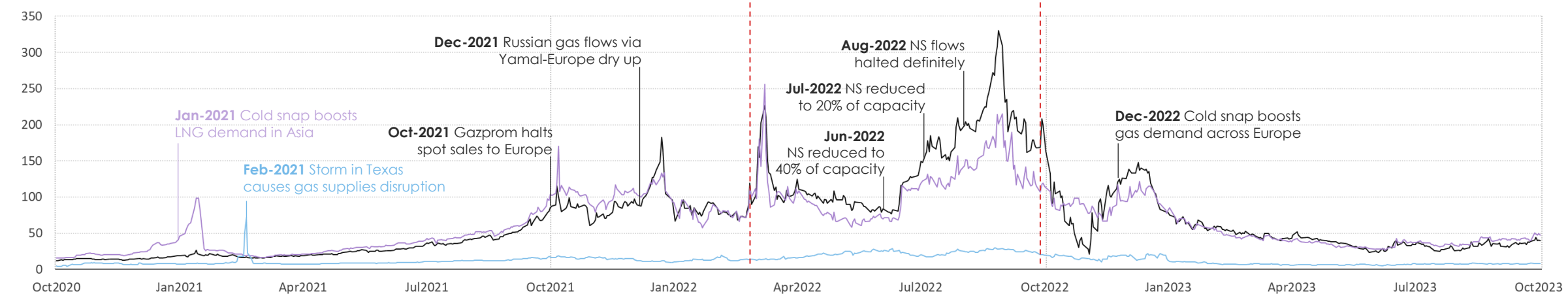
Sources: data from ENTSOG transparency platform, GIE ALSI, GIE AGSI, Platts and National Grid

CH_4

LNG imports in Europe [GWh/d]



Dutch TTF, Japan JKM and US Henry Hub price indexes [€/MWh]



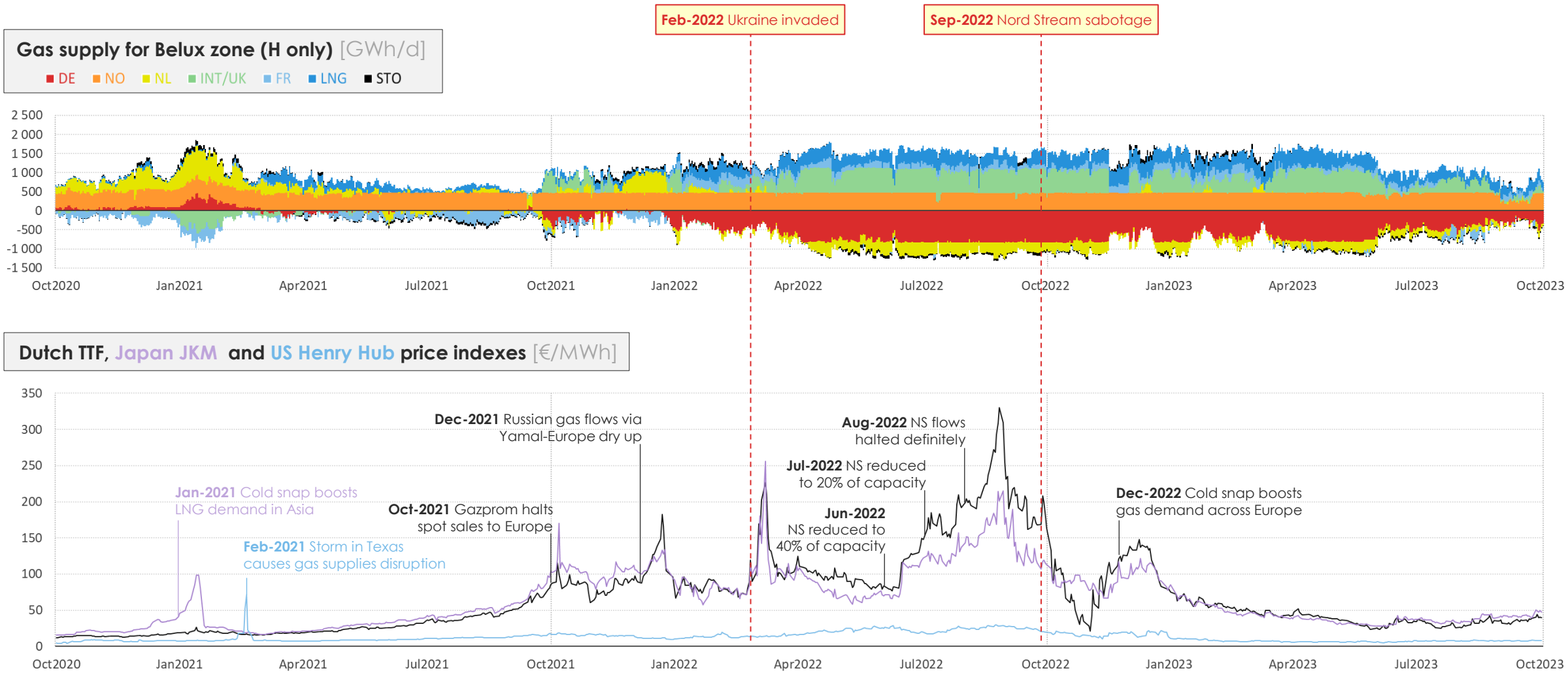
Information only - non binding

Natural gas flows in Belux zone

Net flow = entry flow – exit flow

Sources: data from ENTSOG transparency platform, GIE ALSI, GIE AGSI, Platts and National Grid

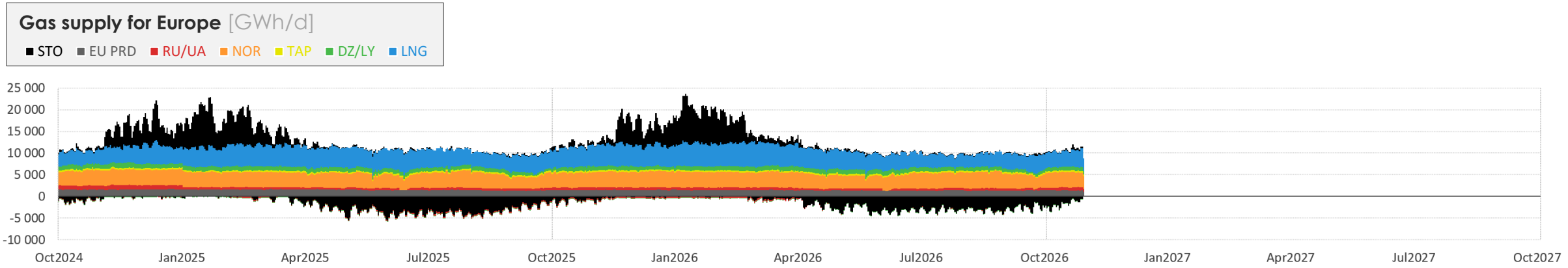
CH_4

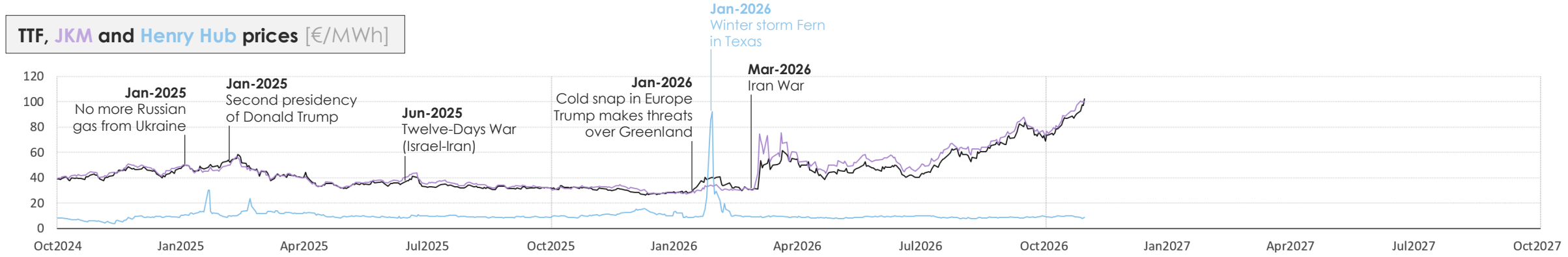


Information only - non binding


Iran
Strait of Hormuz

Natural gas supply for Europe (EU27 + UK + Switzerland + Balkans)





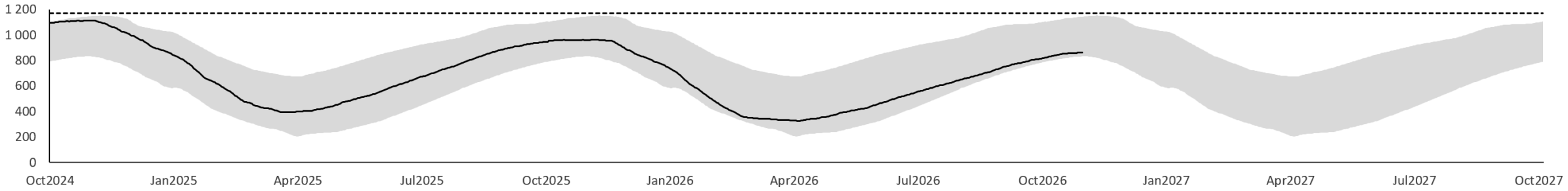
Data from ENTSOG transparency platform, GIE ALSI , GIE AGSI and National Grid

Natural gas flows in Belux zone

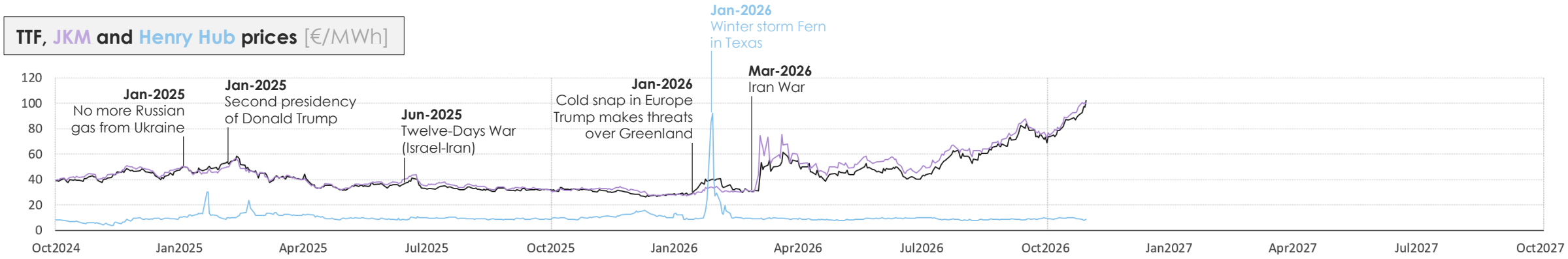
Net flow = entry flow – exit flow

Gas in European storage facilities [GWh/d]

Grey zone = 10 years average



TTF, JKM and Henry Hub prices [€/MWh]

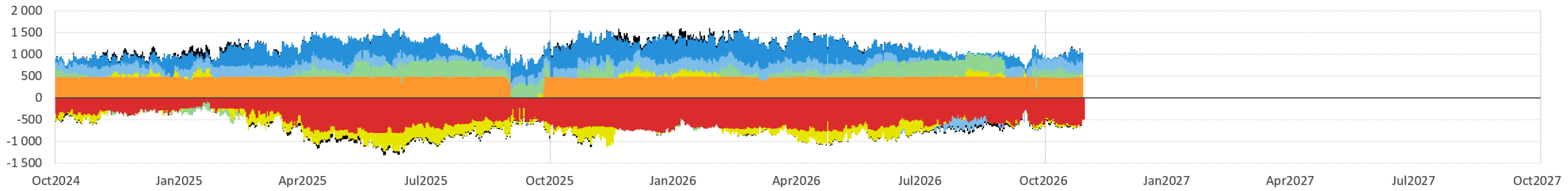


Data from ENTSOG transparency platform, GIE ALSI , GIE AGSI and National Grid

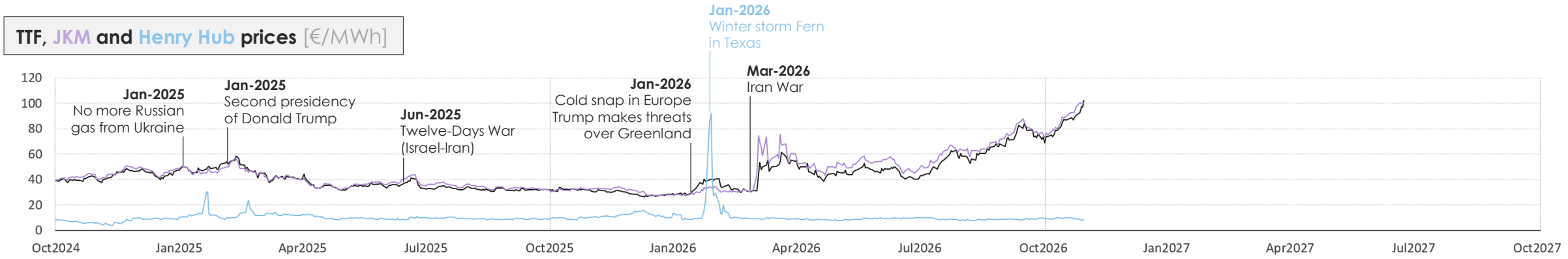
Natural gas flows in Belux zone

Net flow = entry flow – exit flow

Gas supply for Belux zone [GWh/d]



TTF, JKM and Henry Hub prices [€/MWh]



Data from ENTSOG transparency platform, GIE ALSI , GIE AGSI and National Grid

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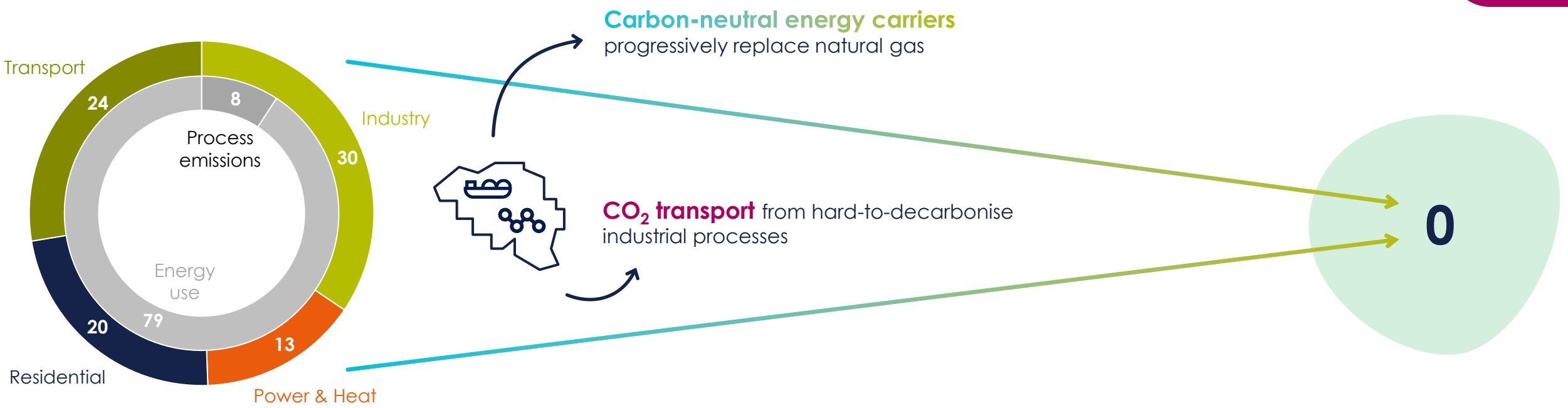
Our infrastructure as key contributor to net zero

We need a mix of solutions to achieve the net zero target

CH_4

H_2

CO_2



2024

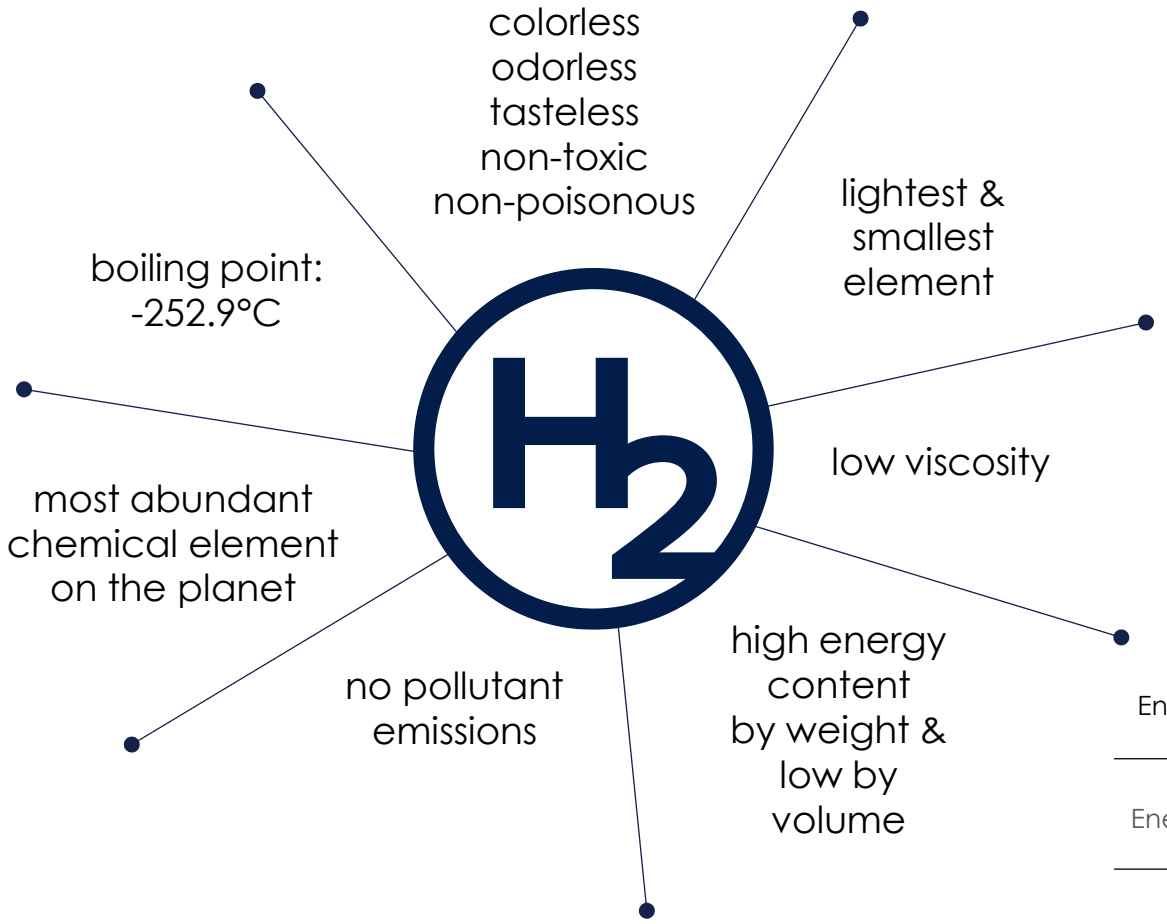
CO_2 emission
87 million tonnes/year

2050

No CO_2 emission

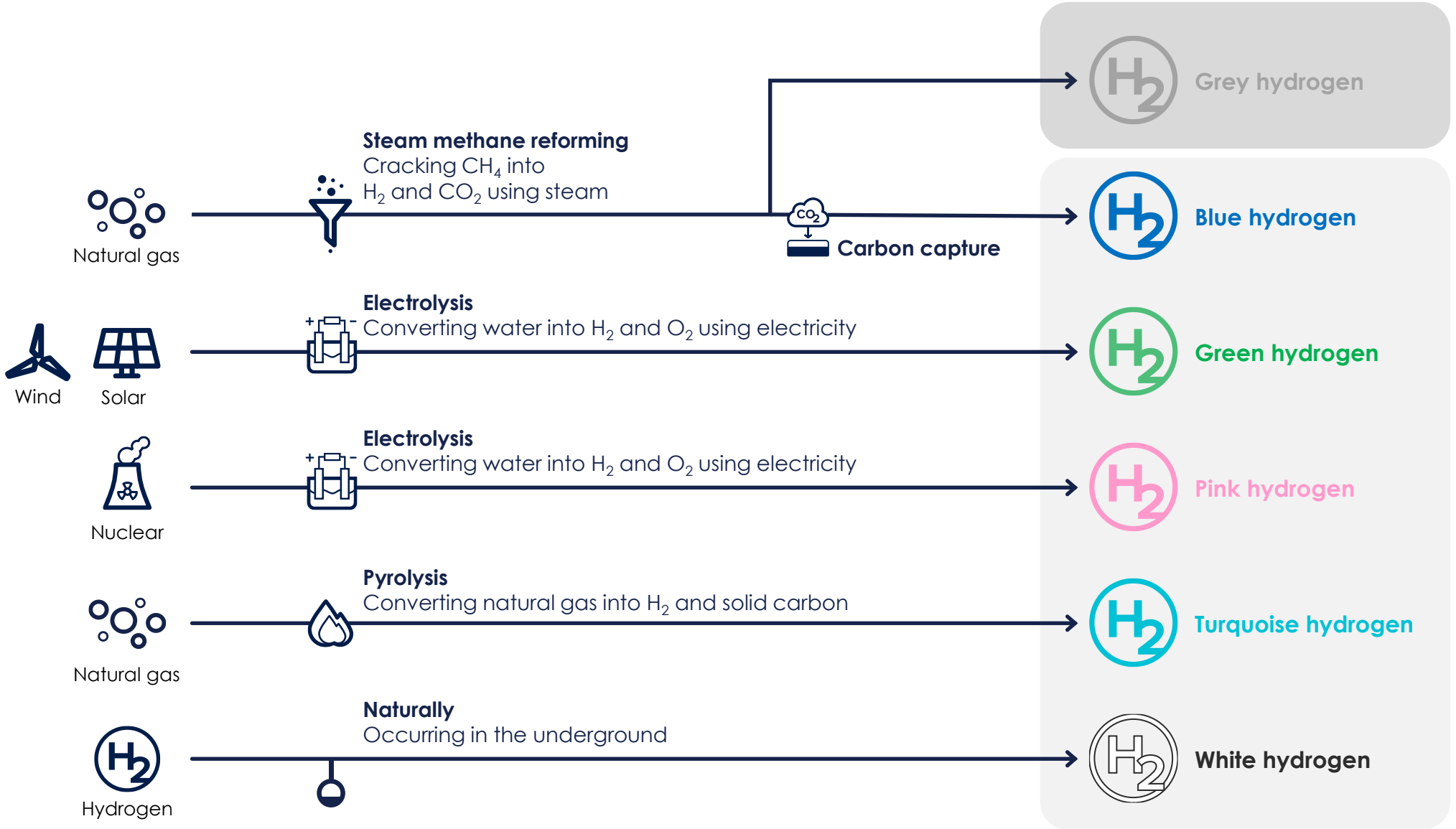
Information only - non binding

What is H_2 or hydrogen?



Energy content by weight	CH_4	X 2.5	H_2
Energy content by volume	H_2	X 3	CH_4
Volumetric density	H_2	X 8	CH_4

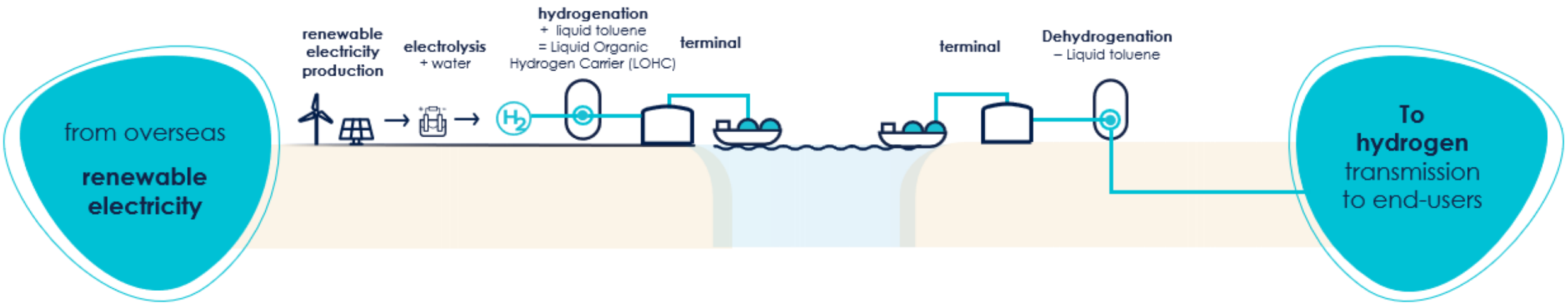
The colours of hydrogen



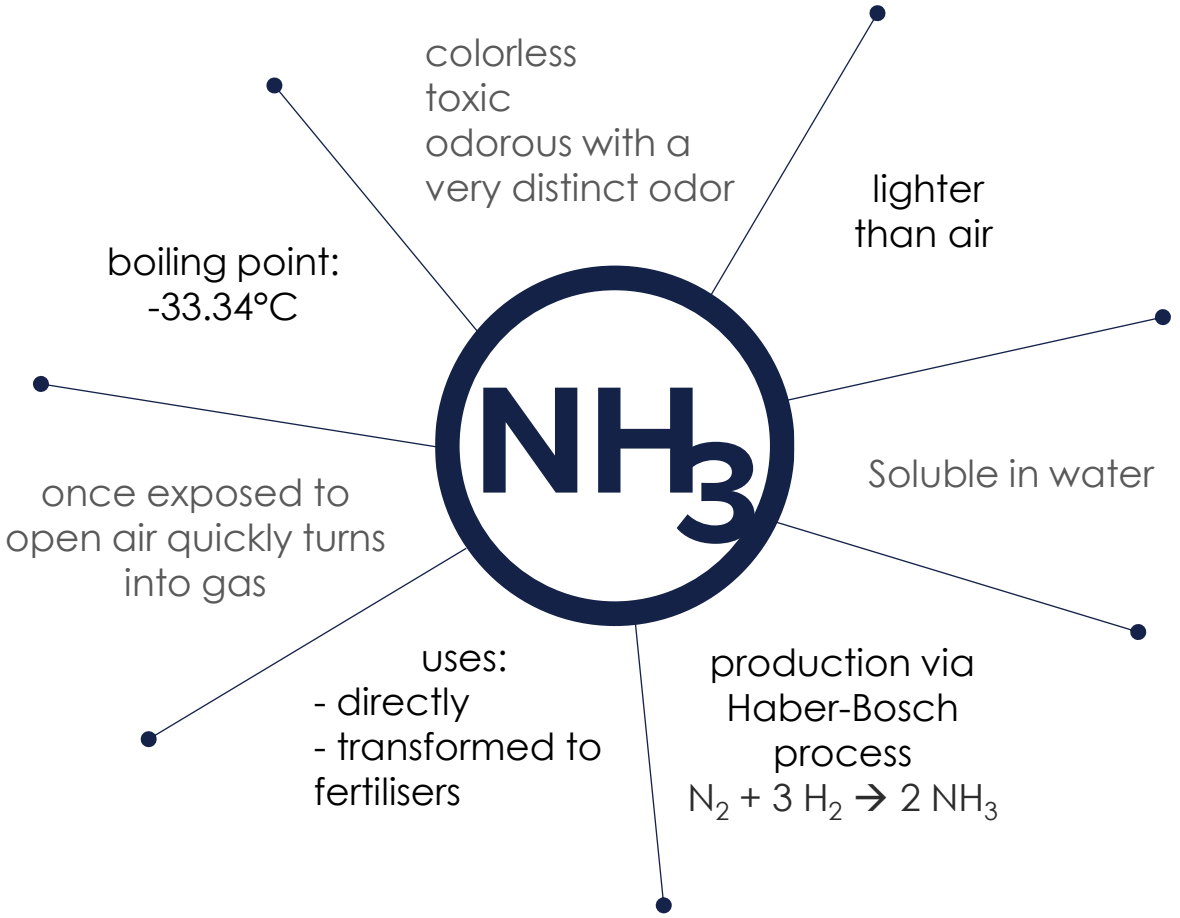
Information only - non binding

Hydrogenation

Long distance transport possible with hydrogenation



What is NH_3 or ammonia?

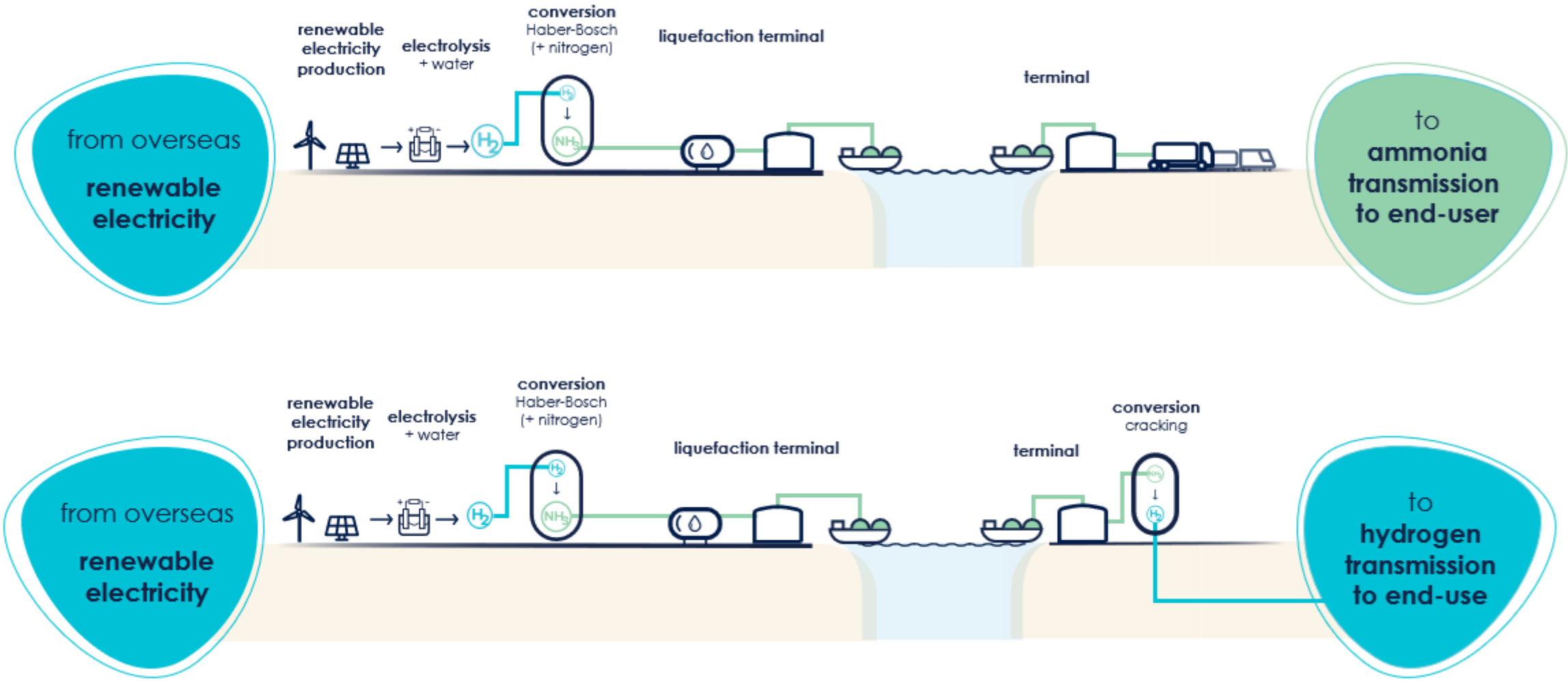


Renewable hydrogen and renewable ammonia

Long distance transport also possible thanks to ammonia

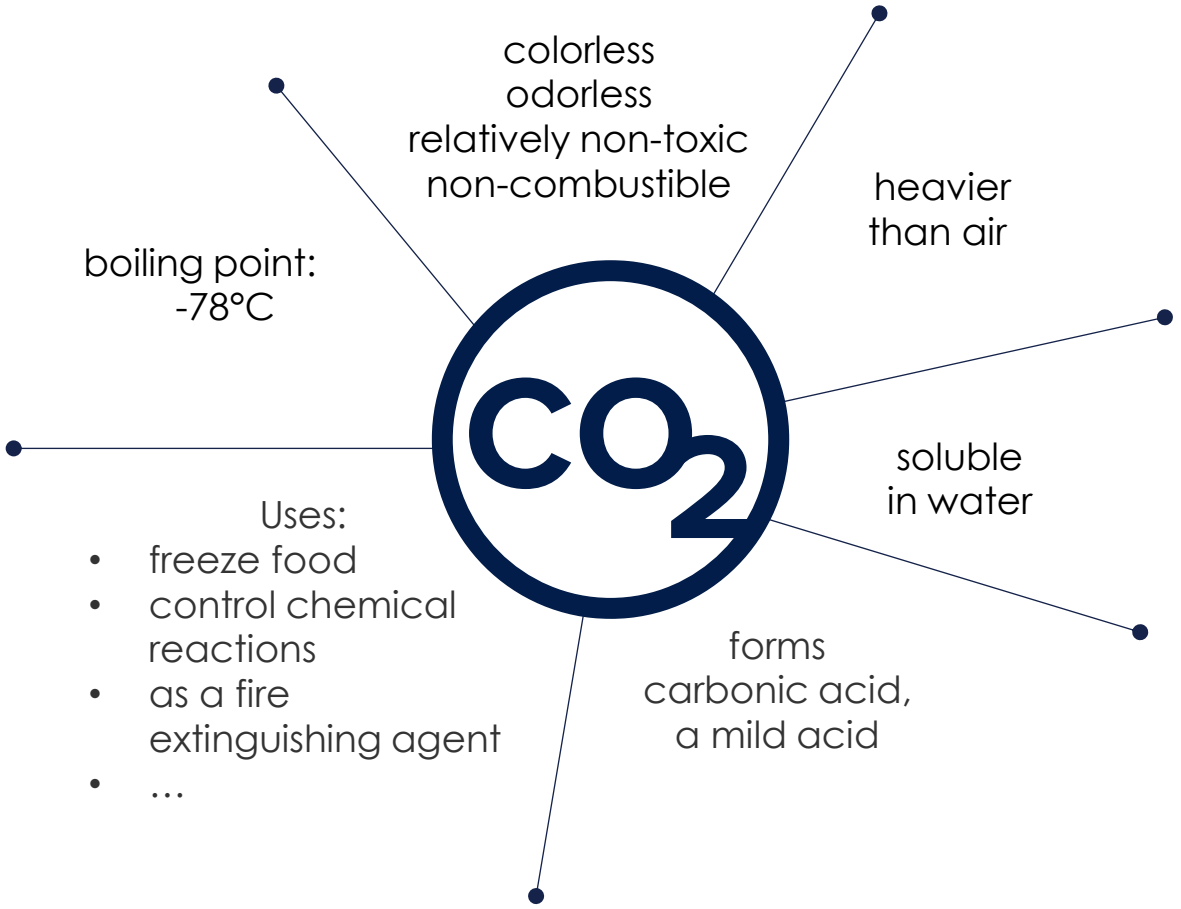
H_2

NH_3



Information only - non binding

What is CO_2 or carbon dioxide?



Information only - non binding

Carbon capture and storage/utilisation crucial for industry to decarbonise while keeping competitive





Do-or-die decarbonisation solution for **hard-to-abate industry**



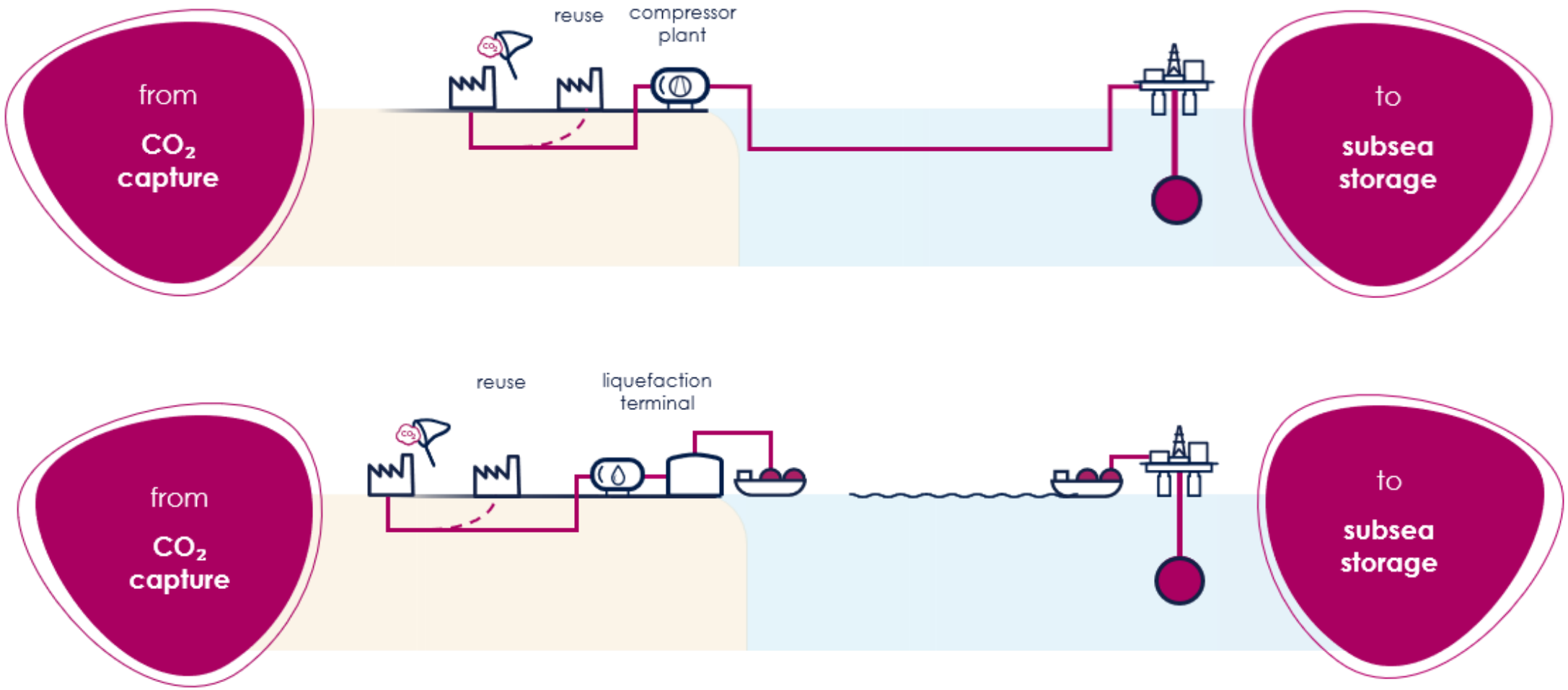
Essential for large volumes of affordable **low-carbon hydrogen**



Key for **low-carbon electricity generation** to keep the lights on

Information only - non binding

CCUS value chain



Information only - non binding

We need an integrated approach to the energy transition because the green transition holds a threefold challenge

1

a climate-neutral energy system

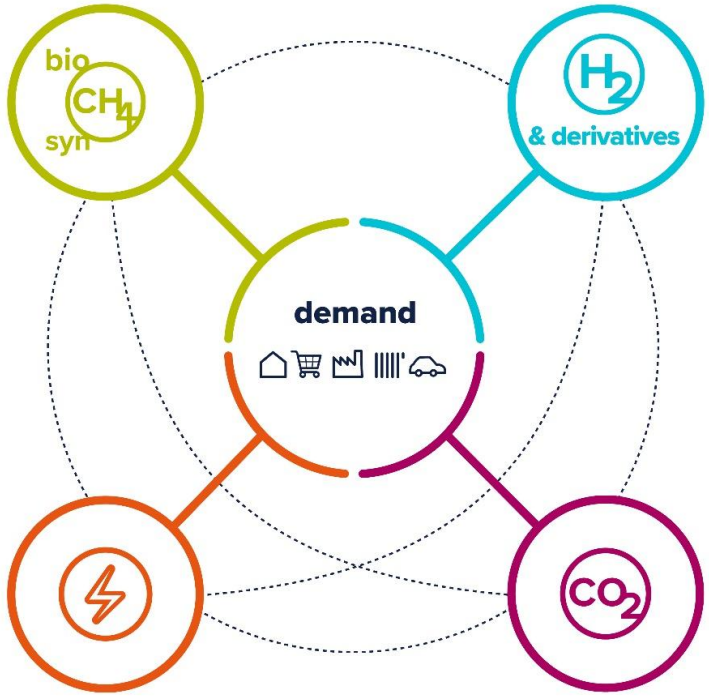
2

with energy that is always available

3

at the lowest cost

Fluxys has developed a multi-energy simulation model

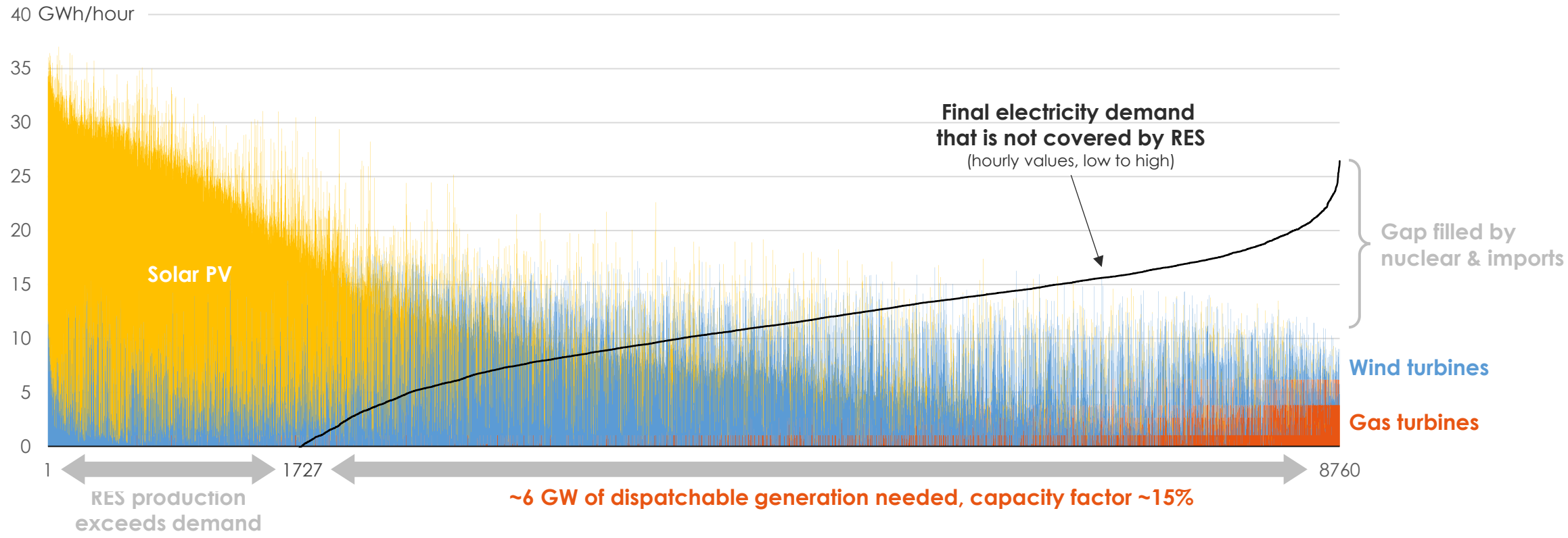


Our studies can be found on **our website**

Molecules provide flexibility

Gas turbines remain necessary, even in 2050, when renewable production is low

Electricity generation from renewable and gas turbines in 2050

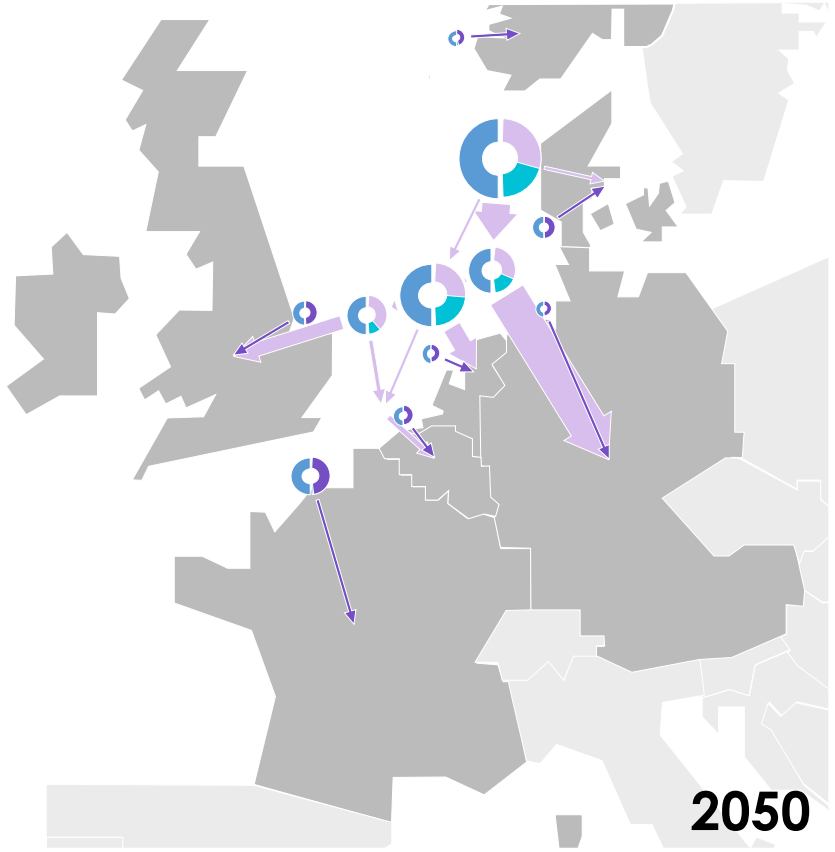


North Sea Integration Model (NSIM) optimisation results. Scenario-based insights, not forecasts.
Based on Elia-Fluxys scenarios (Belgium) and TYNDP 2026 assumptions (rest of Europe).

Molecules enable renewable integration

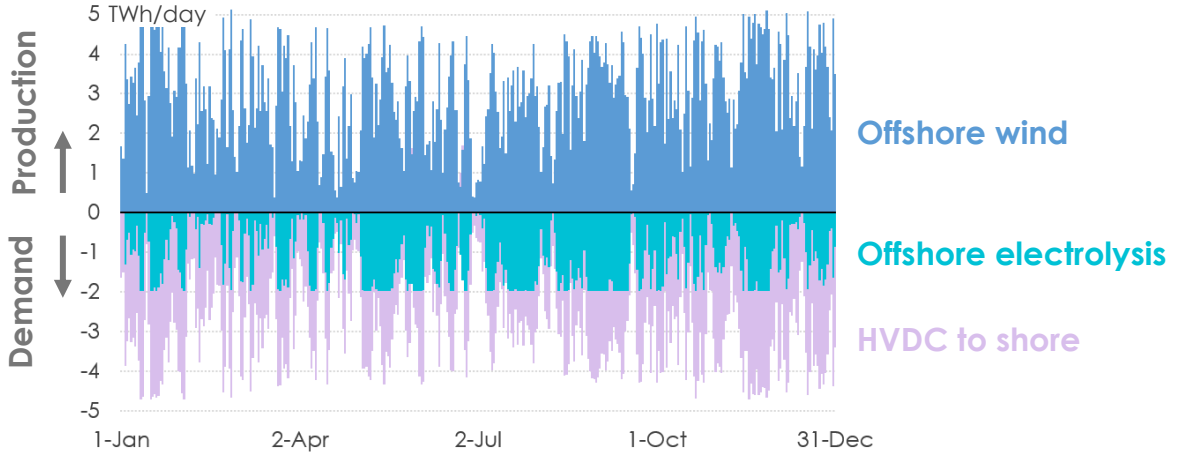
Converting part of far-offshore wind generation into hydrogen can reduce transport costs and renewable curtailment

10 Electricity balance – Offshore



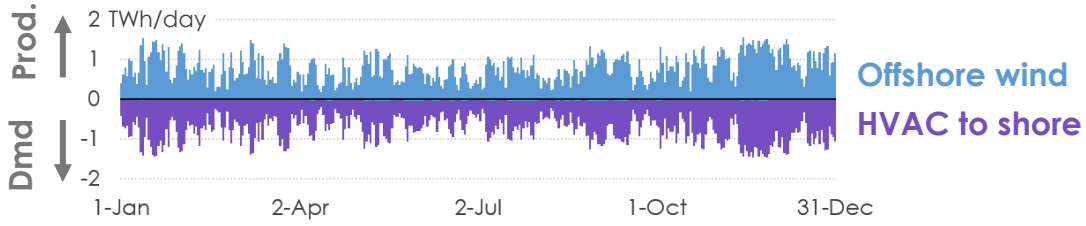
Far-offshore

> 24 nautical miles from coastline



Near-shore

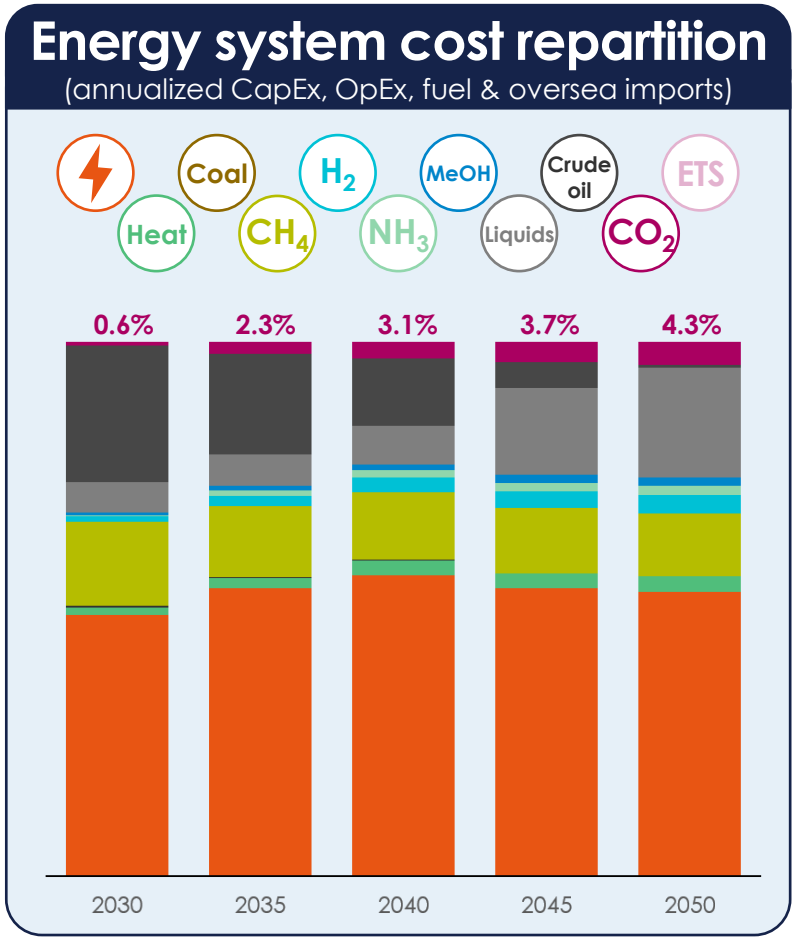
< 24 nautical miles from coastline

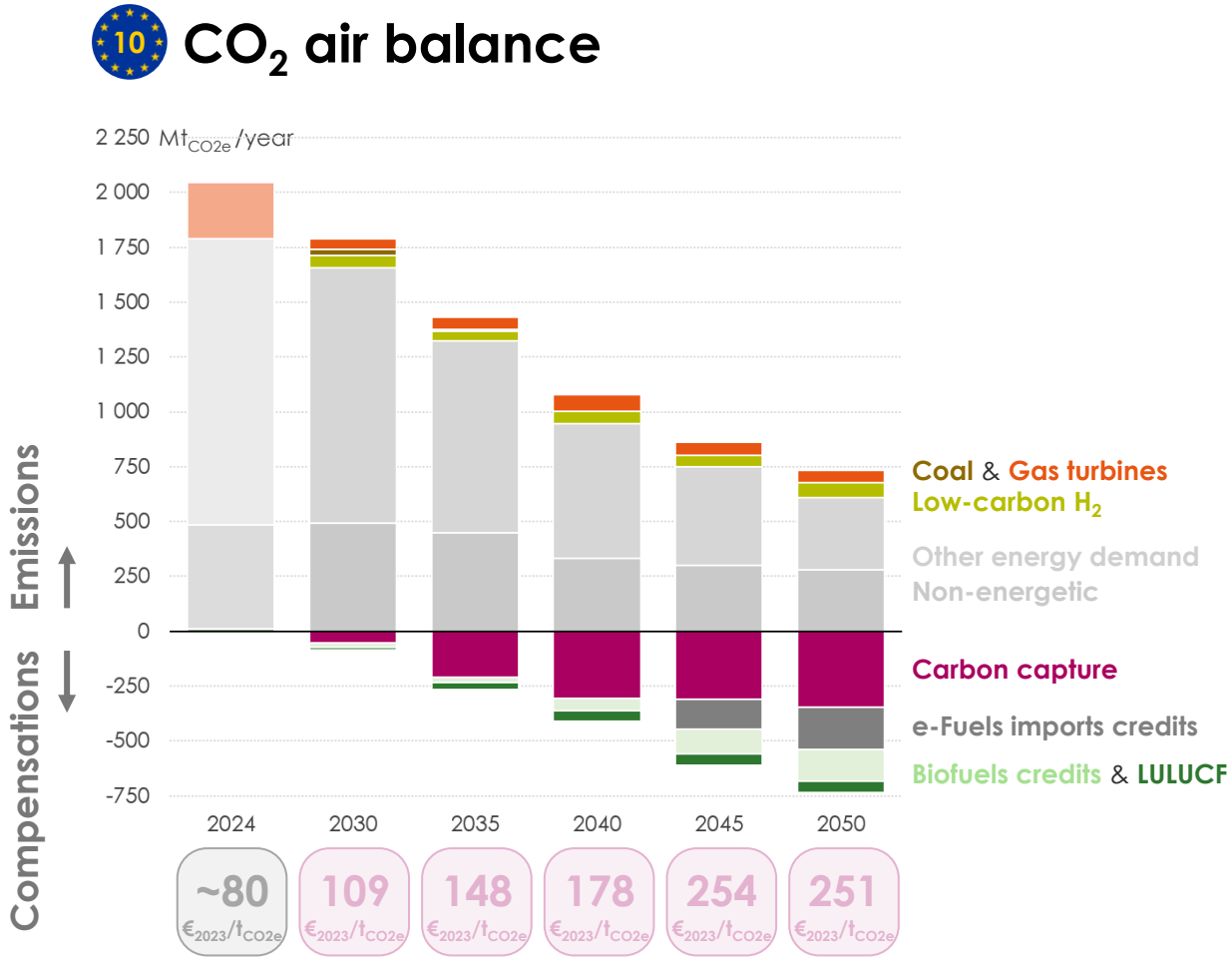


North Sea Integration Model (NSIM) optimisation results. Scenario-based insights, not forecasts.
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Molecules provide cost-effective decarbonization

Carbon capture can substantially reduce the cost of achieving net-zero





North Sea Integration Model (NSIM) optimisation results. Scenario-based insights, not forecasts.
Based on Elia-Fluxys scenarios (Belgium) and TYNDP 2026 assumptions (rest of Europe).
Costs refer to energy system only and do not include costs on demand side (insulation, industrial investments…).