Electricity and natural gas coupling: an EU perspective

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European Commission

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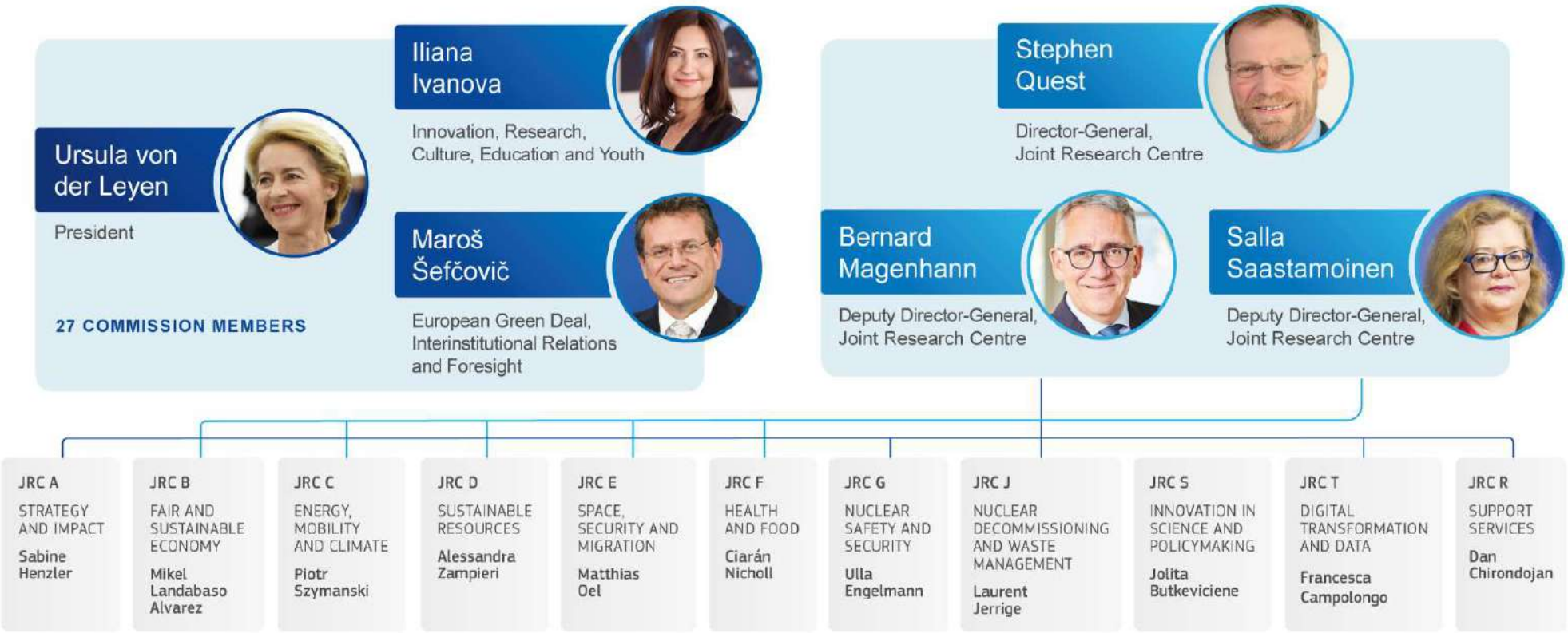
The Joint Research Centre within the Commission



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JRC sites

Headquarters in **Brussels** and research facilities located in **5 EU Countries:**

- Belgium (Geel)
- Germany (Karlsruhe)
- Italy (Ispra)
- The Netherlands (Petten)
- Spain (Seville)

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Connecting aspects of the Green Deal

50%

of our scientific work programme is devoted to the Green Deal

Transport and clean energy

Geospatial systems to assess infrastructures and land available

Biodiversity and healthy ecosystems

Knowledge Centre on Biodiversity
Global deforestation observatory

Scientific performance

- Nearly 8.000 peer-reviewed publications in Scopus
- 40-50% of articles published in the top 10 % most cited journals (KPI)
- 5-7 % among the top 1% most cited journals

Impact on policy-making

Analysis of 2.800 reports on tangible effects on policymaking 2014-2020

70% implementing, monitoring and evaluating policy
30% preparation of policy

88% report use by other Commission departments

Increasing impact on central policy-making processes e.g., better regulation, instruments (e.g. European semester) and crisis response (COVID-19)

86% JRC instrumental for shaping and implementing policies & **14%** moderate impact on policy-making

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Outline

Outline

- EU state of play on electricity and gas
- Electricity vs gas systems: key features
- Market coupling: economic efficiency
- Security of supply: a regulatory framework perspective
- Sustainability: renewable fuels
- Conclusions

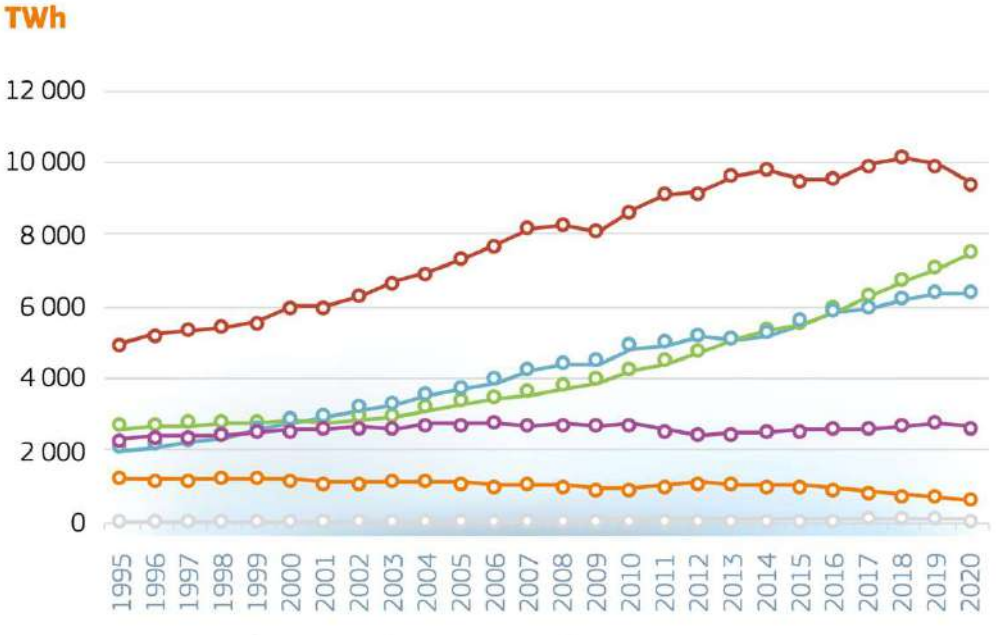
State of play

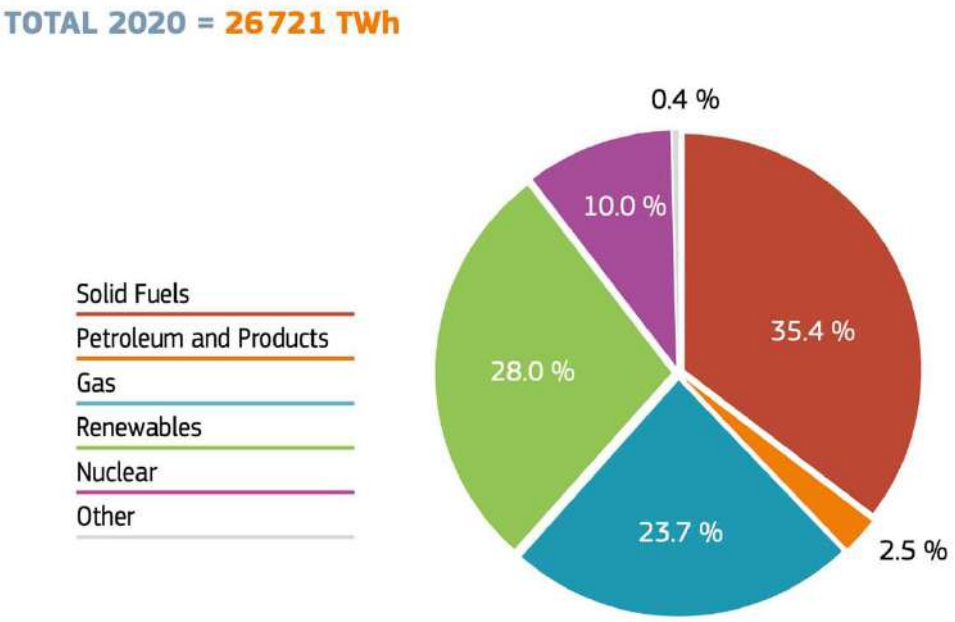
EU gas and electricity: state of play

- The **European Green Deal** stressed the importance of reducing external energy dependency in order to cut net greenhouse gas emissions by at least **55%** by **2030** (compared to 1990 levels) and become a climate-neutral energy system by **2050**.

- In the second quarter of 2022, the European Commission proposed the **REPowerEU Plan** highlighting that the clean energy transition must be accelerated to increase Europe's energy independence

World Electricity Generation by Fuel





EU energy in figures. Statistical pocketbook 2023

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CL Chile

Population ~20M

~ 80 TWh electricity generation

~ 6.5 bcm of gas consumption

EU European Union

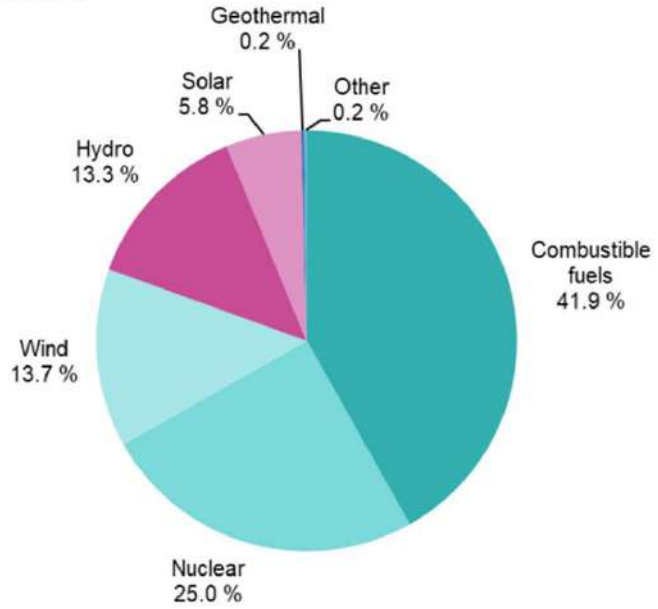
Population ~ 450M (x 22 Chile)

~2800 TWh electricity generation (x35 Chile)

~ 400 bcm of gas consumption (~4400 TWh) (x60 Chile)

Electricity mix

Net electricity generation, EU, 2021
(%, based on GWh)



Source: Eurostat (online data code: nrg_ind_peh)

eurostat

~ 20% of electricity in EU is produced using gas

CAPACIDAD TOTAL SEN - MW

RENOVABLE	**12.815**
HIDRO EMBALSE	3.395
HIDRO PASADA	3.444
BIOMASA	451
EÓLICO	2.242
SOLAR	3.238
GEOTÉRMICA	45
NO RENOVABLE	**12.937**
GAS NATURAL	4.843
CARBÓN	5.192
DERIV. DEL PETRÓLEO	2.902
TOTAL	**25.752**

Fuente: Coordinador Eléctrico Nacional

~ 20% gas capacity

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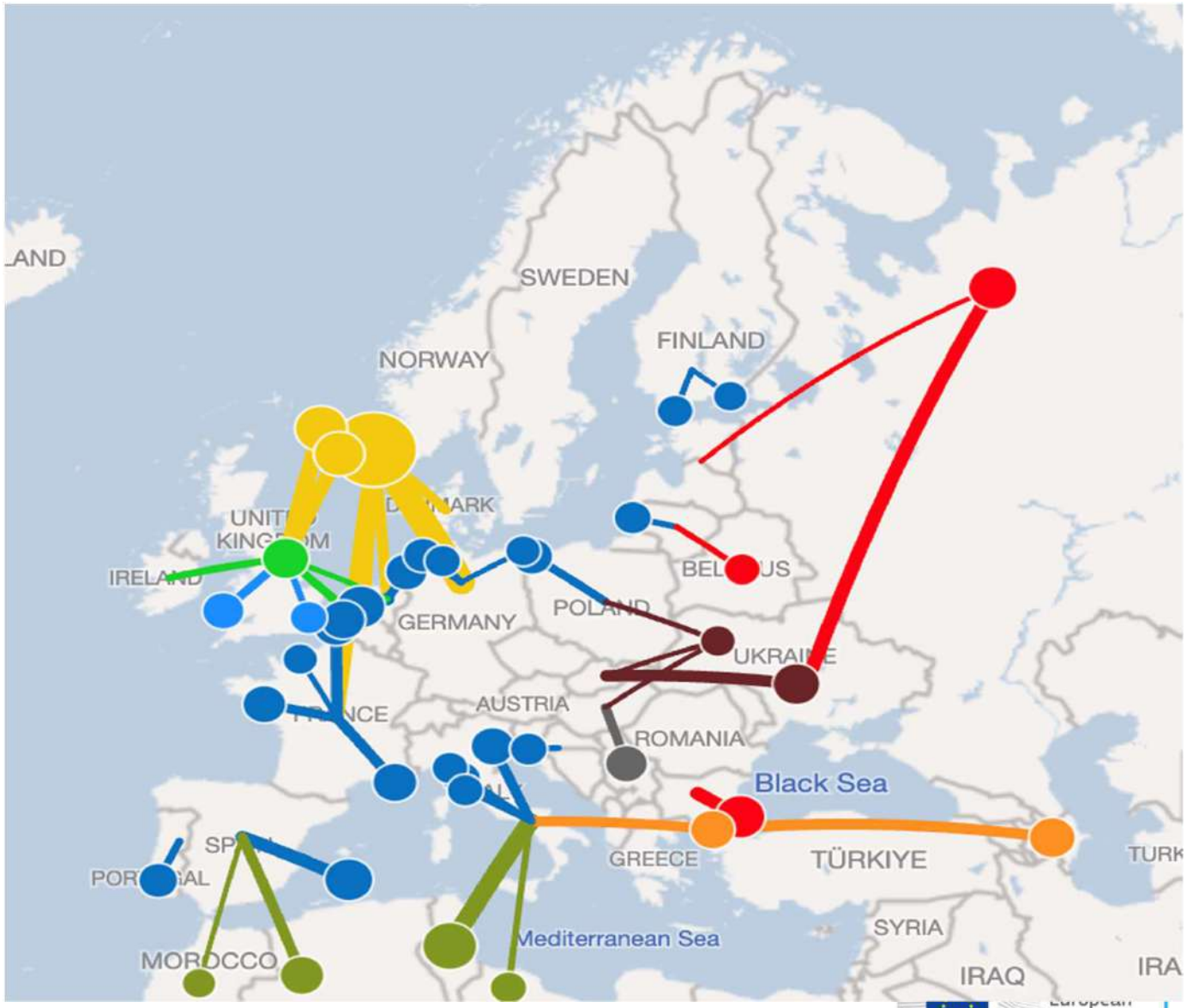
In 2023

- 41% LNG
- 30% North sea
- 12% North Africa
- 8% East (RU)
- 6% UK
- 4% Caspian

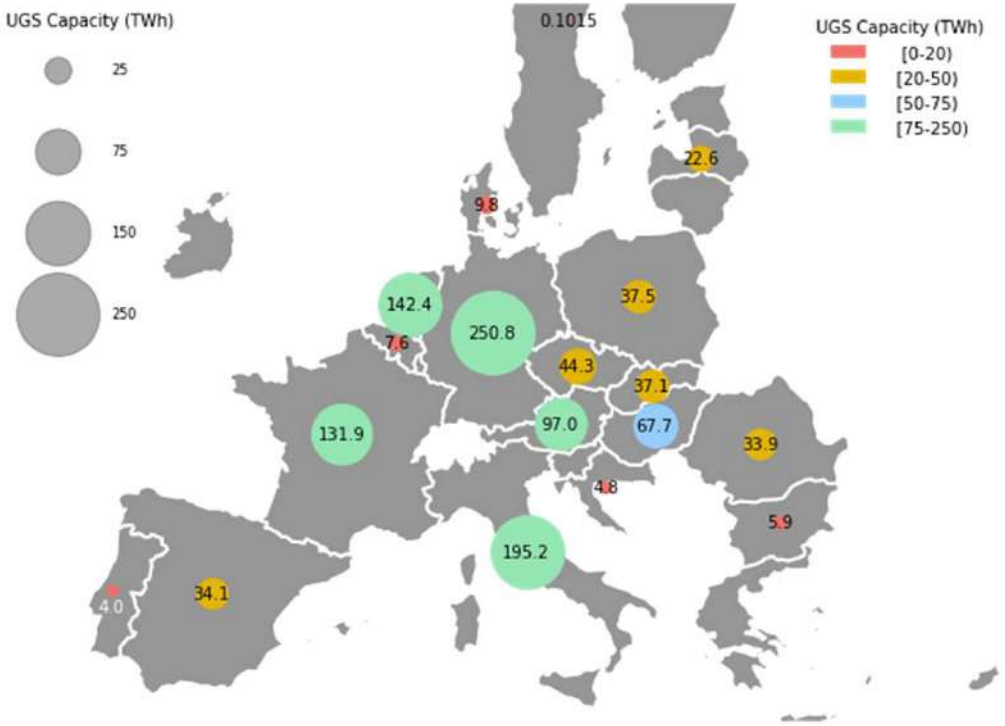


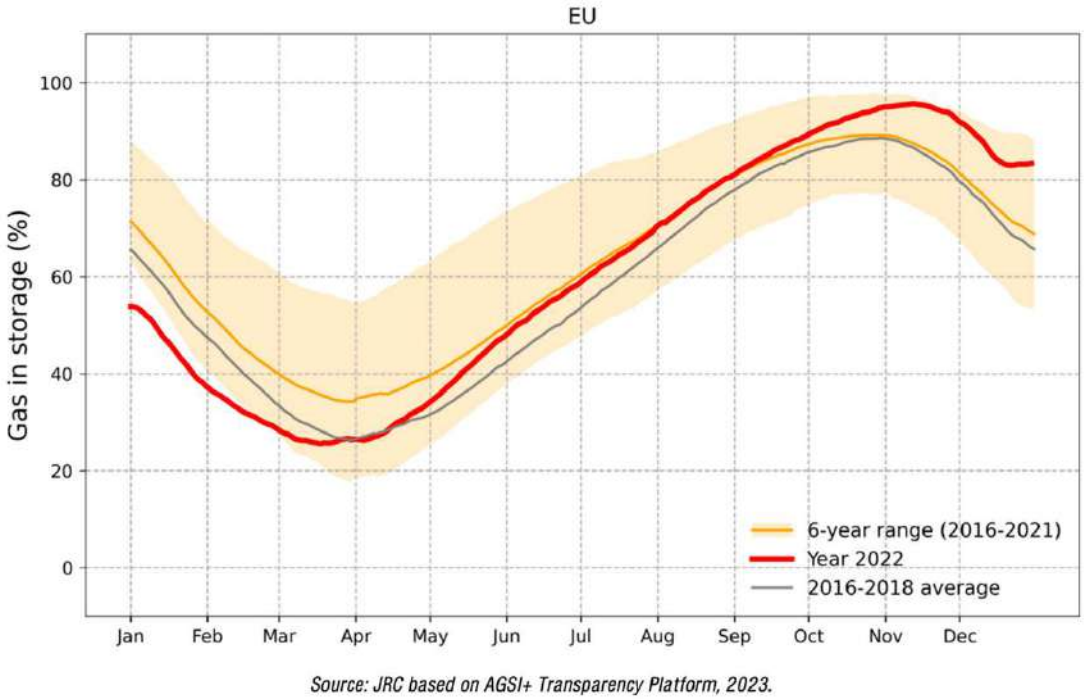
https://gasdashboard.entsog.eu/

EU gas state-of-play

- Underground gas storage (**UGS**) facilities offer large-scale, long-duration energy storage solutions that aid in **balancing supply** and **demand**, **stabilizing gas and electricity prices**, and enhancing the overall EU **energy security.**
- The EU has a storage capacity of about **1100 TWh** (~15 times annual Chilean gas demand), i.e. around 100 bcm, and 60% of this capacity corresponds to the reservoirs located in Germany, Italy, Netherlands, and France.
- The EU **UGS capacity** represents approximately **25% of annual gas** consumption, which is an indication of the importance of this source of supply in the EU.

EU gas state of play





Source: JRC based on AGSI+ Transparency Platform, 2023.

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Electricity vs Gas systems

Key features

Key facts

Gas

~m/s

~ 1-3 days of demand of energy store in the grid (linepack)

Daily resolution/hourly for taking decisions

Gas quality vary along the grid

Electricity

~speed of the electromagnetic wave

No storage

Hourly/real time for taking decisions

Homogeneity

Economic arrangements

Gas

Contracts (bilateral)

Spot

Capacity mechanism (booking/use,…)

Storage

Electricity

PPAs (bilateral)

DA

Redispatch ~ spot

Capacity mechanism

No storage

Governance

ENTSO-G

Since 2009

43 TSO association (EU+)

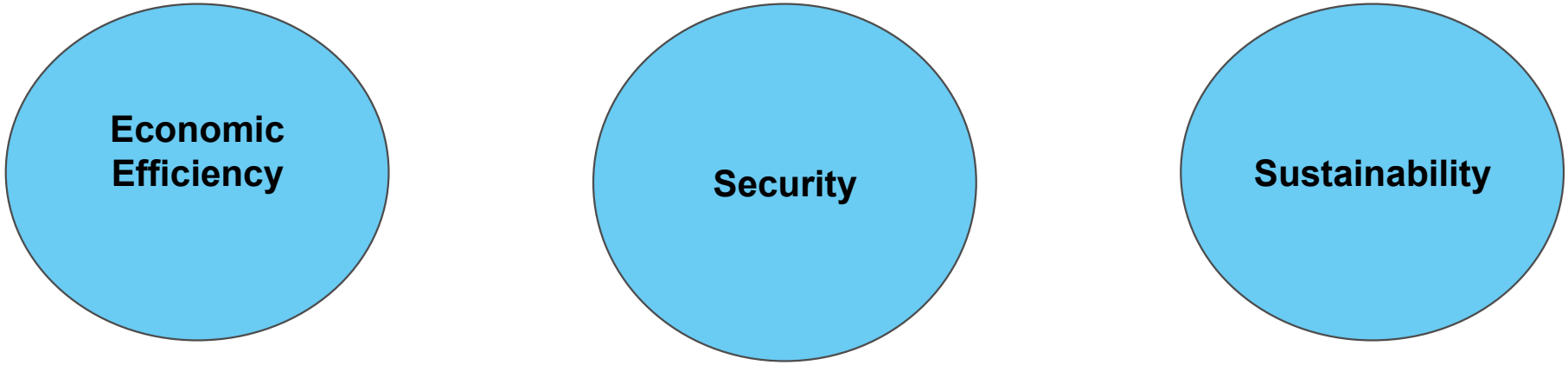
To ensure a pan-European transmission system and to meet European Union energy and climate goals

ENTSO-E

Since 2009

40 TSOs (EU+)

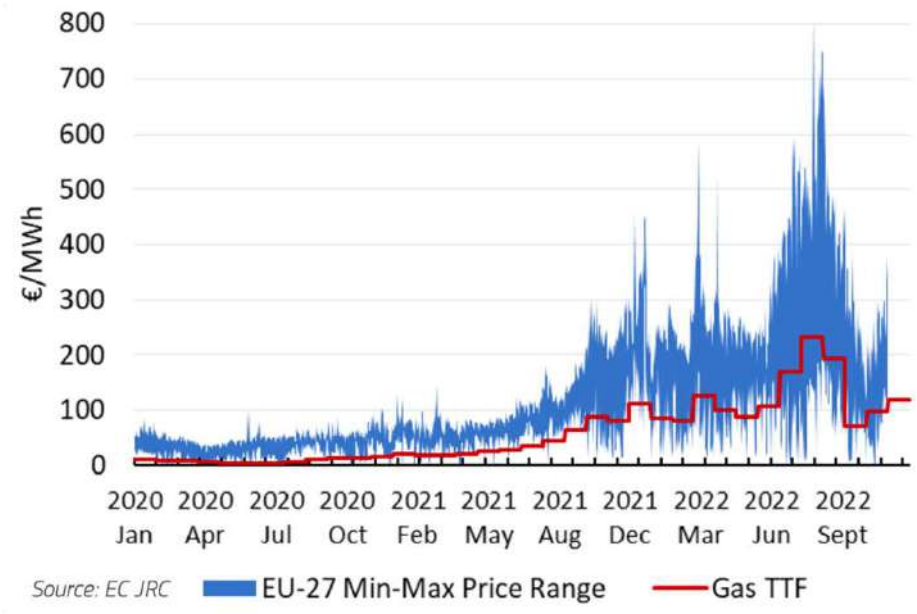
Security of the interconnected power system in all time frames at pan-European level.


Economic Efficiency
Security
Sustainability

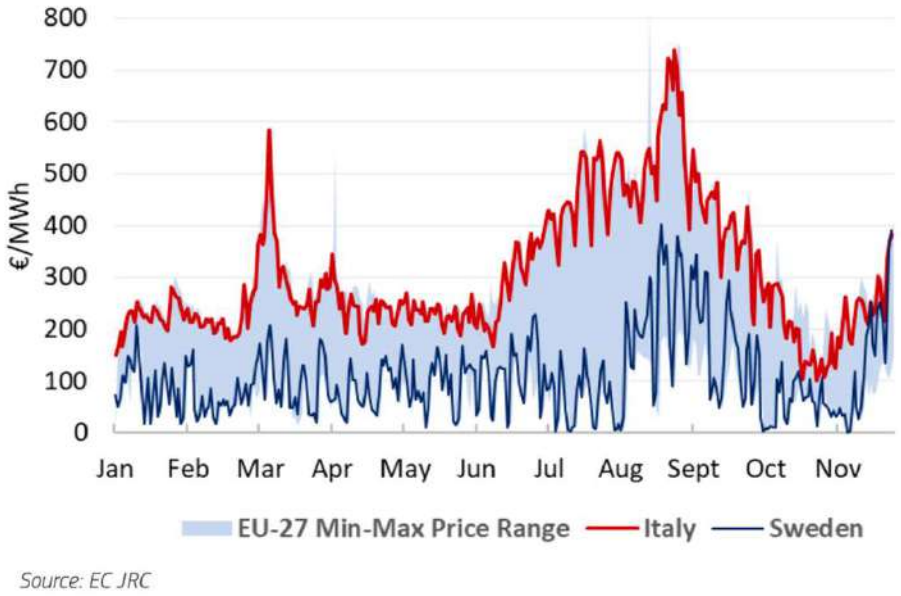
Economic efficiency

Market coupling

Historical EU daily wholesale electricity prices min-max range and monthly gas TTF evolution



Historical EU 2022 daily wholesale electricity price min-max range



Gasparella, A., Koolen, D. and Zucker, A., The Merit Order and Price-Setting Dynamics in European Electricity Markets, European Commission, Petten, 2023, JRC134300.

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Gas-Electricity

- Gas-run power plants set the price 55% of the time in **2022** while generating 19% of total EU electricity.

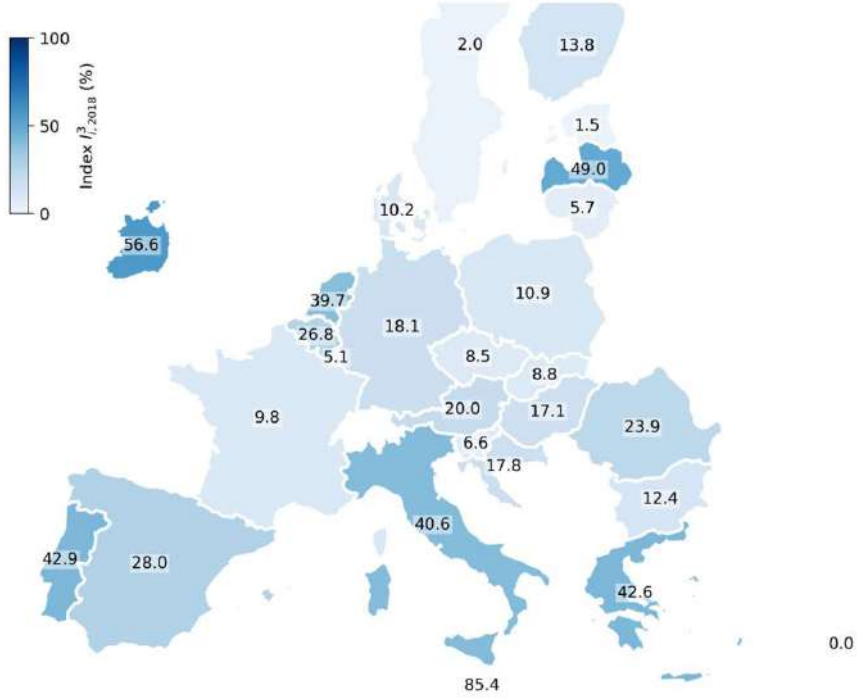
- In **2030**, the price-setting share is still close to 56%, even with generation decreasing to 11% of electricity

Gasparella, A., Koolen, D. and Zucker, A., The Merit Order and Price-Setting Dynamics in European Electricity Markets, European Commission, Petten, 2023, JRC134300.

Gas-electricity interaction toolbox

- Compound indicator based on Eurostat
- Role of gas in the production of electricity and role of electricity production in total gas demand

Example:
Indicator for the dependence of electricity on natural gas



Source: JRC, based on Eurostat (2020). Data year: 2018

Jung, D., Fernandez Blanco Carramolino, R., Yusta Loyo, J.M. and Bolado Lavin, R., Interaction gas-electricity toolbox, EUR 30935 EN, Publications Office of the European Union, Luxembourg, 2022, ISBN 978-92-76-45991-0, doi:10.2760/62982, JRC123982

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Security of supply

A regulatory framework perspective

Outlooks

ENTSO-G

Winter Outlook

Evaluates the European gas network's readiness to meet supply and demand requirements for the upcoming winter

ENTSO-E

Winter Outlook

Assess adequacy situation to prevent and mitigate risks to security of supply during the winter period

Evolution of EU policies on energy security

First Gas Directive
98/30/EC

Second Gas Directive
2003/55/EC
Third Energy Package
(Directive 73/2009; Regulations 713 and 715/2009)

The 1990s | The 2000s | The 2010s | The 2020s

Completion of the **internal gas market** and creation of an **internal competition** (unbundling)

Shifting role of **security of supply** from MSs to EU
Creation of regulators (ACER)

Source: Sesini et al. (2022)

Early 2009 crisis

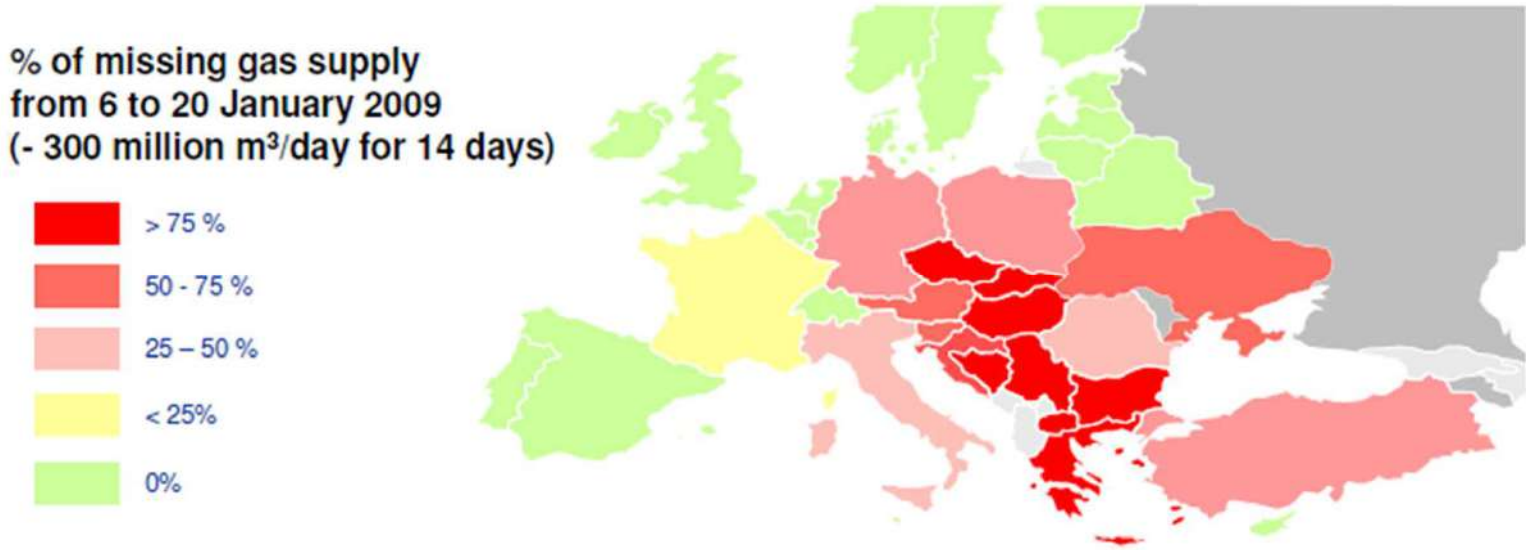
Start on 01-01-2009. Stop supply to Ukraine (UA) only (gas transit continues)

02-01-2009 – 06-01-2009. Increase of cuts of gas (mutual accusations GAZPROM - NAFTOGAZ)

07-01-2009. Full interruption of flows

07-01-2009 – 19-01-2009. Negotiations

20-01-2009. Deliveries resumed



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Lessons learnt from 2009 crisis

Council Directive 2004/67/EC proved to be **ineffective** to deal with this big gas crisis (largest ever gas crisis in the EU)

The Atlantic Basin was full of LNG vessels

There was a lot of gas in storage

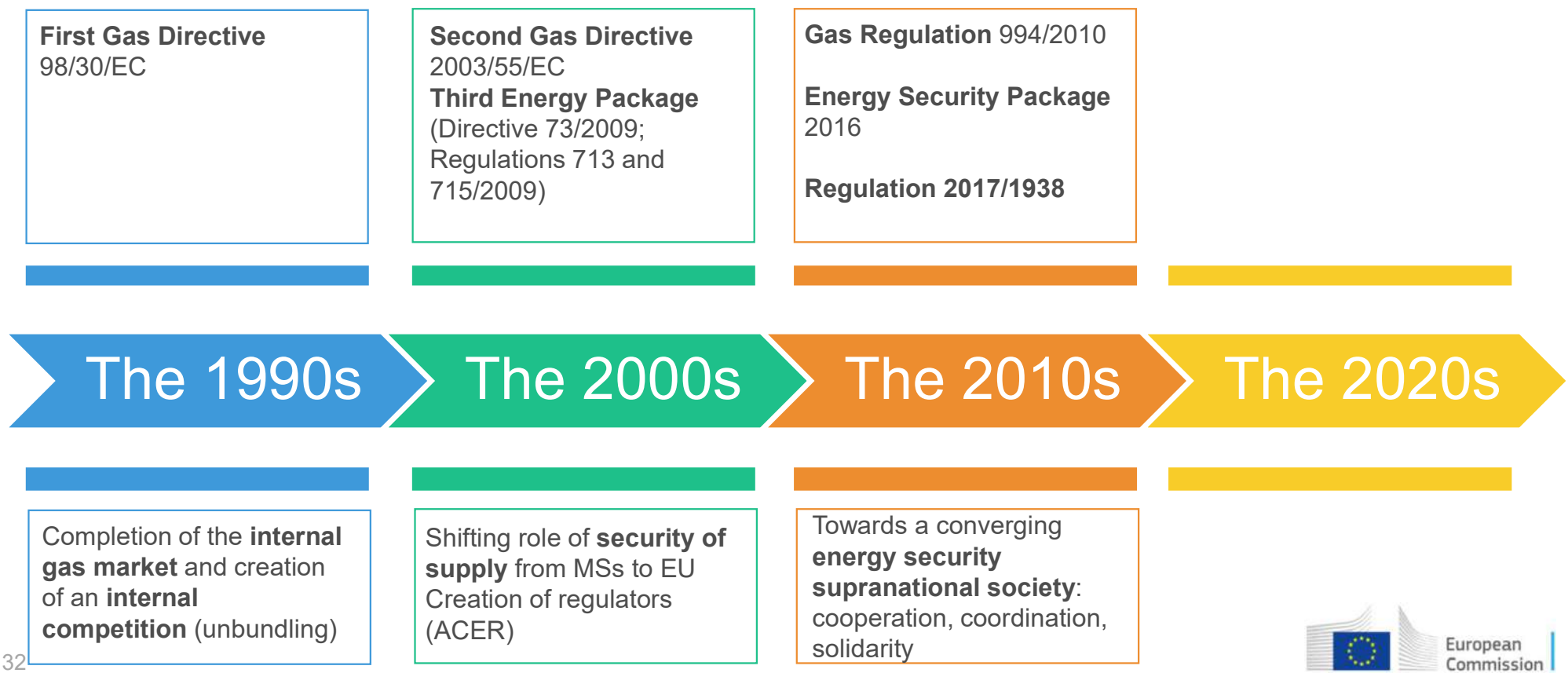
It was just extremely difficult move it eastwards

Need of real coordinated effort

Good news:

In little more than 1½ year a Regulation (EU) 994/2010 was enacted, later replaced by Regulation (EU) 2017/1938

Evolution of EU policies on energy security



Source: Sesini et al. (2022)

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Regulation (EU) 2017/1938

- Infrastructure standard (N-1)
- Supply standard (3 cases)
- Protected customers
- Bidirectional flows
- Critical gas power plants
- …
- Common and National Risk Assessments
- Preventive and Emergency Plans

Evolution of EU policies on energy security

The 1990s	The 2000s	The 2010s	The 2020s
First Gas Directive 98/30/EC	**Second Gas Directive** 2003/55/EC **Third Energy Package** (Directive 73/2009; Regulations 713 and 715/2009)	**Gas Regulation** 994/2010 **Energy Security Package** 2016 **Regulation 2017/1938**	**Regulation 2022/1032** **Regulation 2022/1369** **Regulation 2022/2576** **Regulation 2022/2578** **Hydrogen and decarbonised gas market package**
Completion of the **internal gas market** and creation of an **internal competition** (unbundling)	Shifting role of **security of supply** from MSs to EU Creation of regulators (ACER)	Towards a converging **energy security supranational society**: cooperation, coordination, solidarity	**Enhancement** of specific security and solidarity measures Rules for new **low-carbon gases**

Source: Sesini et al. (2022)

Recent energy security policies in the EU

Regulation 2022/1032	29 June 2022	Strengthen security of gas supply from a **supply perspective**
Regulation 2022/1369	5 August 2022	**Demand-side measures** to increase security of gas supply (15% reduction over last 5-year aver.)
Regulation 2022/2576	19 Dec. 2022	Improving **coordination** of gas purchases, reliable price benchmarks and cross-border gas exchanges
Regulation 2022/2578	22 Dec. 2022	**Market Correction Mechanism** to limit extreme gas prices
Hydrogen and decarbonised gas market package	15 Dec. 2021	**Amending some provisions on security of gas supply** (EU-wide Risk Assessment, extension to low-carbon gases and hydrogen) -> Still proposal

Regulatory framework – Critical gas volumes

- Regulation (EU) No 2022/2576 on enhancing solidarity

❑ Article 2 defines critical gas volume (CGV)

> '***critical gas volume for electricity security of supply***' means the maximum gas consumption needed in the power sector to ensure adequacy in a worst-case scenario simulated in the winter adequacy assessment.

❑ Article 23 extends solidarity protection to CGV for electricity security of supply

❑ Annex I provides tables for maximum CGV per Member State:

- (a) for the winter months (individually) December 2022 to March 2023 and,
- (b) one monthly value for April 2023 to December 2023

Critical gas volume – Methodology (ENTSOE)

Definition

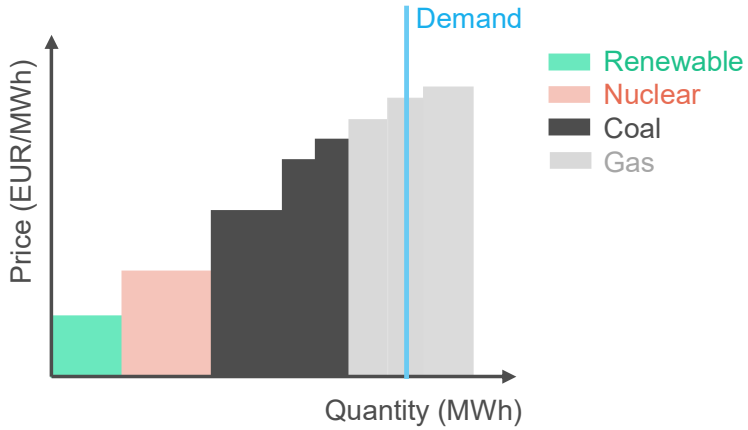
- Lowest volumes of gas absolutely needed for electricity generation using all market resources in the most adverse combination of climate conditions and outages

Key elements

- Gas is considered as the last profitable resource in the merit order
- Must-run gas-fired units are the exception

Consequences

- Gas is most likely the price setter always in the market
- Electricity adequacy is ensured even in the most adverse scenarios



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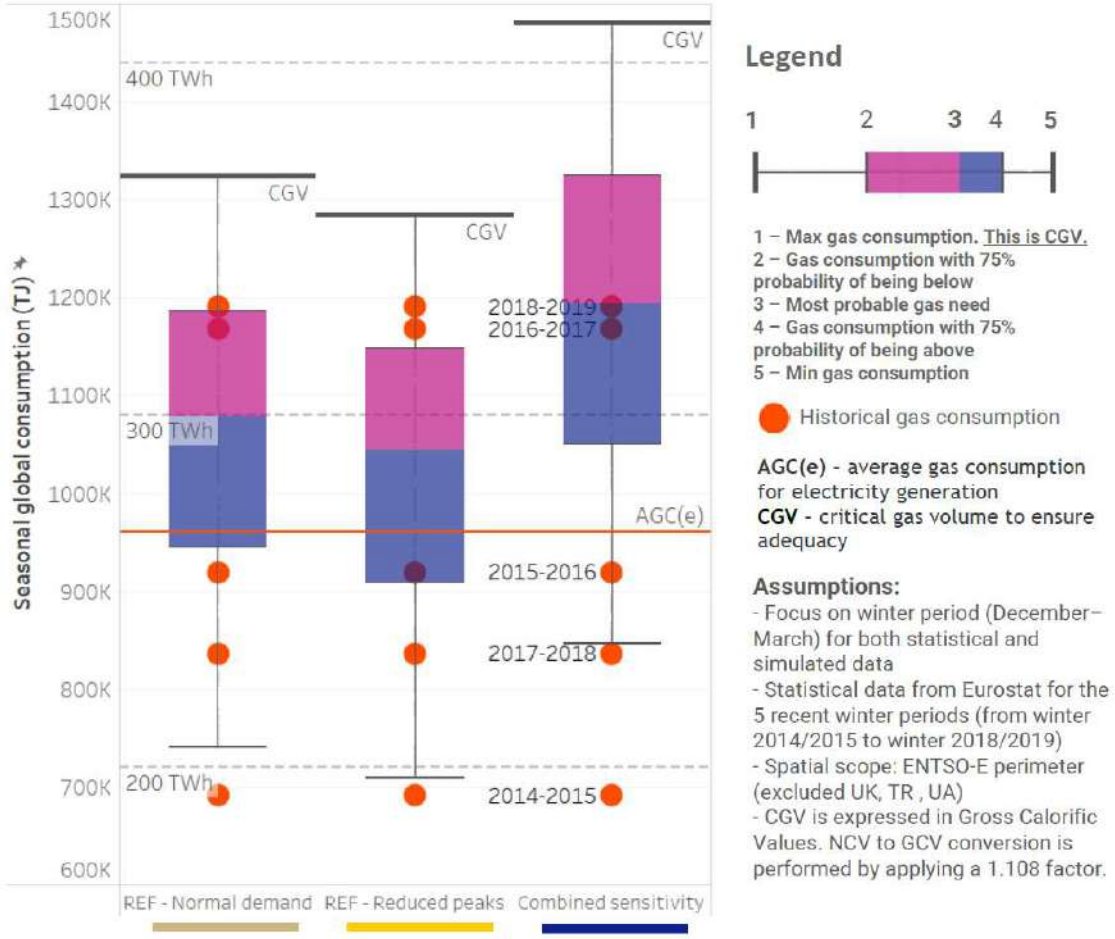
Critical gas volume in the EU – ENTSOE



Legend

1 2 3 4 5

1 – Max gas consumption. This is CGV.
2 – Gas consumption with 75% probability of being below
3 – Most probable gas need
4 – Gas consumption with 75% probability of being above
5 – Min gas consumption

Historical gas consumption

AGC(e) - average gas consumption for electricity generation
CGV - critical gas volume to ensure adequacy

Assumptions:
- Focus on winter period (December–March) for both statistical and simulated data
- Statistical data from Eurostat for the 5 recent winter periods (from winter 2014/2015 to winter 2018/2019)
- Spatial scope: ENTSO-E perimeter (excluded UK, TR , UA)
- CGV is expressed in Gross Calorific Values. NCV to GCV conversion is performed by applying a 1.108 factor.

Source: ENTSOE Winter Outlook 2022-2023

Scenarios

- *REF – Normal demand*: Best estimates for the analysed winter
- *REF – Reduced peaks*: Identical to first one but demand reduction by 5% at peak hours
- *Combined sensitivity*: Limitation of fossil fuel-based generation + prolonged unavailability of nuclear plants

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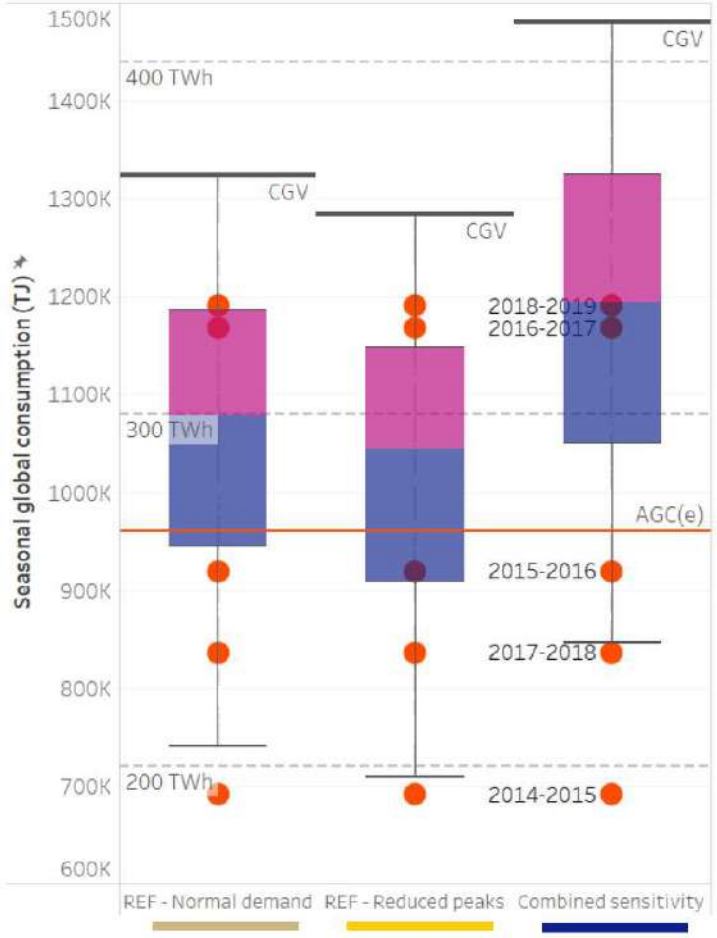
Critical gas volume in the EU – ENTSOE



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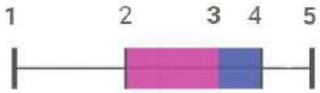

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Source: ENTSOE Winter Outlook 2022-2023

Remarks

- The CGV for winter 2022/2023 exceeds historical records
- CGV could represent one third of the working gas volume of the EU gas storages
- Lowering demand helps mitigate the gas dependence of the power system and therefore mitigate adequacy risks (not shown in this presentation)

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Sustainability

Renewable fuels

Sustainability

- Natural gas been a good alternative to decarbonize electricity mix by replacing coal. Gas-fired power plants are “controllable”, thus very similar to coal-based power plants.
- RepowerEU (2022) considers by 2030 to produce 10Mt H2 in EU and import another 10Mt. Actual H2 consumption is around 7Mt in the EU.
- Since 2023, natural gas projects are not anymore part of PCI. H2 projects can be considered for becoming a PCI.

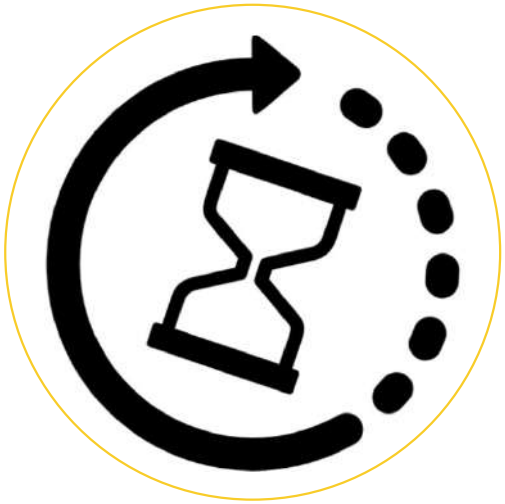
Strategy on hydrogen

- EU strategy for energy system integration on 8 July 2020.
- **2021 → Hydrogen and decarbonised gas market package (ENTSO-H?)**
- By 2022, all of its 20 action points were implemented and delivered.
- In 2023 initiates the European Hydrogen Bank
- …
- In 2023 **EU finalised its own definition of renewable hydrogen** and its derivatives

Three pillars for renewable H2

Additionality

The electricity needed for H2 production is generated exclusively from renewable sources



Hourly matching

The electricity generated during a specific hour by renewable resources dedicated to H2 production.

Geographic correlation

The electricity must be generated in close proximity to the H2 facility.

When is H2 considered fully renewable?

Off-grid operation	Grid-connected operation		
Direct connection of H2/NH3 generation and electricity generation installation / production within the same installation. No grid connection / proof of no use of grid electricity for production.	**>90% rule** Bidding zone >90% RE share Specifically identified share determines the number of annual operating hours	**Low-carbon bidding zone** < 18g CO2/MJ RE-PPA needed Hourly Matching Geographical correlation	**General grid electricity** RE-PPA needed Additionality Hourly Matching Geographical correlation

Conclusions

Conclusions

- Electricity and natural gas, though typically regulated separately, both exhibit important interdependencies.
- In the EU, natural gas is responsible for setting electricity prices in more than 50% of hours, even though its production is around 20%.
- Natural gas plays a key role as long-term storage, enhancing security in the EU and contributing to the smoothing of prices.

Conclusions

- Recent regulations have shown a tendency to "protect" customers and gas-fired power plants (GFPP) under extreme scenarios, leading to further improvements in the security of supply.
- Ambitious (non-binding) targets on renewable H2.
- The EU's hydrogen strategy envisions the possible creation of an ENTSO for Hydrogen (ENTSO-H).

Thank you

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