The European Energy Crisis

Prof. Dr. Lion Hirth

Hertie School

Agenda

1. **Natural gas in the global energy system**
2. The European natural gas supply
3. The 2021/22 European energy crisis
4. What can be done? (pre Feb-22)
5. An energy war? (post Feb-22)

A short history of fossil gas

“Fossil gas” or “natural gas”

- “Natural gas” is a naturally occurring hydrocarbon gas, as opposed to “town gas” distilled from coal used for cooking and lighting in the 19th and 20th century
- I prefer the term “fossil gas” as opposed to synthetic “green” gasses derived from electrolysis-based hydrogen
- Or just “gas” (not to be confused with gasoline / gas station)

In the shadow of oil

- Until the 20th century, fossil gas was usually a by-product of oil extraction
- Until the 2000s, gas prices were often oil-indexed, only since then the gas market is a separate market in its own right

Fossil gas in the global energy system

How much? 23% of global energy consumption

- Nearly doubled its share in the past 50 years, the largest increase of any fuel

What for? A variety of applications

- Around 40% of gas is used for electricity generation
- The rest is mainly used as a heat source in industry and for space heating
- About 5% each are used in transport and as a feedstock in the chemical industry

Where? America

- The United States is the largest consumer and producer of natural gas, driven by a boom in unconventional “shale” gas production since 2000
- Russia and Qatar are the largest exporters

Greenhouse gas emissions

Electricity from NG causes less than half the emissions of coal

- Coal-fired steam turbine: 0.71 t CO_2/MWh_e
- Fossil gas-fired combined cycle plant: 0.32 t CO_2/MWh_e
- This is because fossil gas is, as a fuel, 40% less carbon intensive (more H, less C) …
- … and because CC plants are 30-40% more efficient than steam turbines

Fossil gas is a mixture of hydrocarbon gas consisting primarily of methane

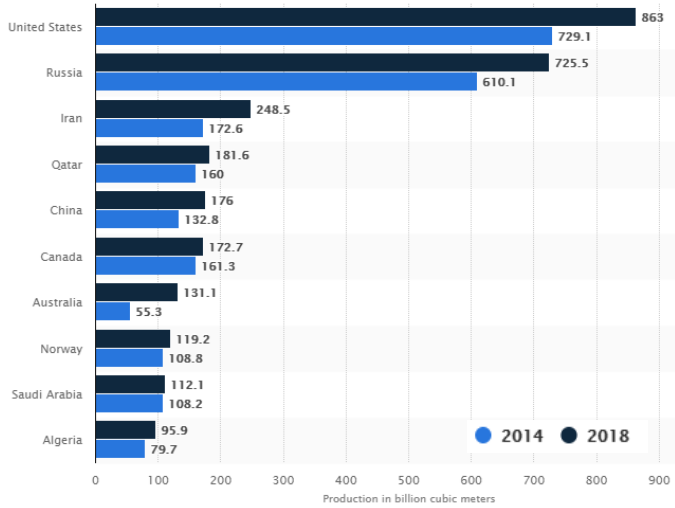
- Methane is a highly potent greenhouse gas (but has a shorter lifetime than CO_2)
- Over 100 years, it warms the Earth 28-34 times more than CO_2 (GWP_{100} AR5)
- Burning 1 t of methane yields 2.75 t CO_2 – flaring is better than releasing

Upstream (fugitive) methane emissions

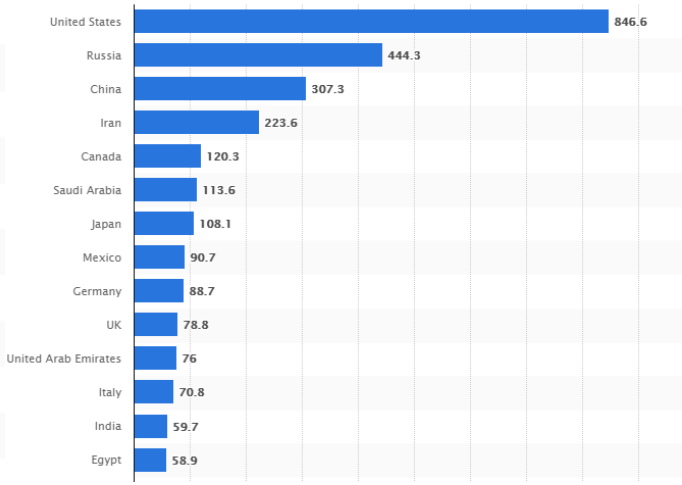
- Well construction, production, processing, compressing, pipelines, etc.
- Increases GHG footprint of fossil gas by maybe 25% (large differences)
- But also coal mining causes methane emissions

Production and consumption

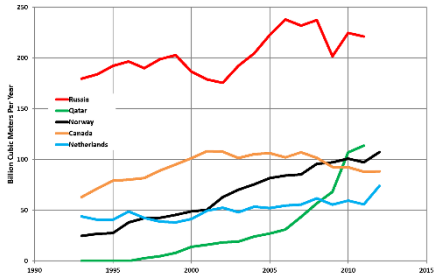
Production

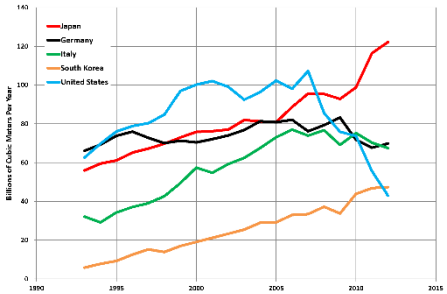


Consumption



Exporters and Importers





Gas transport

Two modes of transport

- Pipelines and LNG

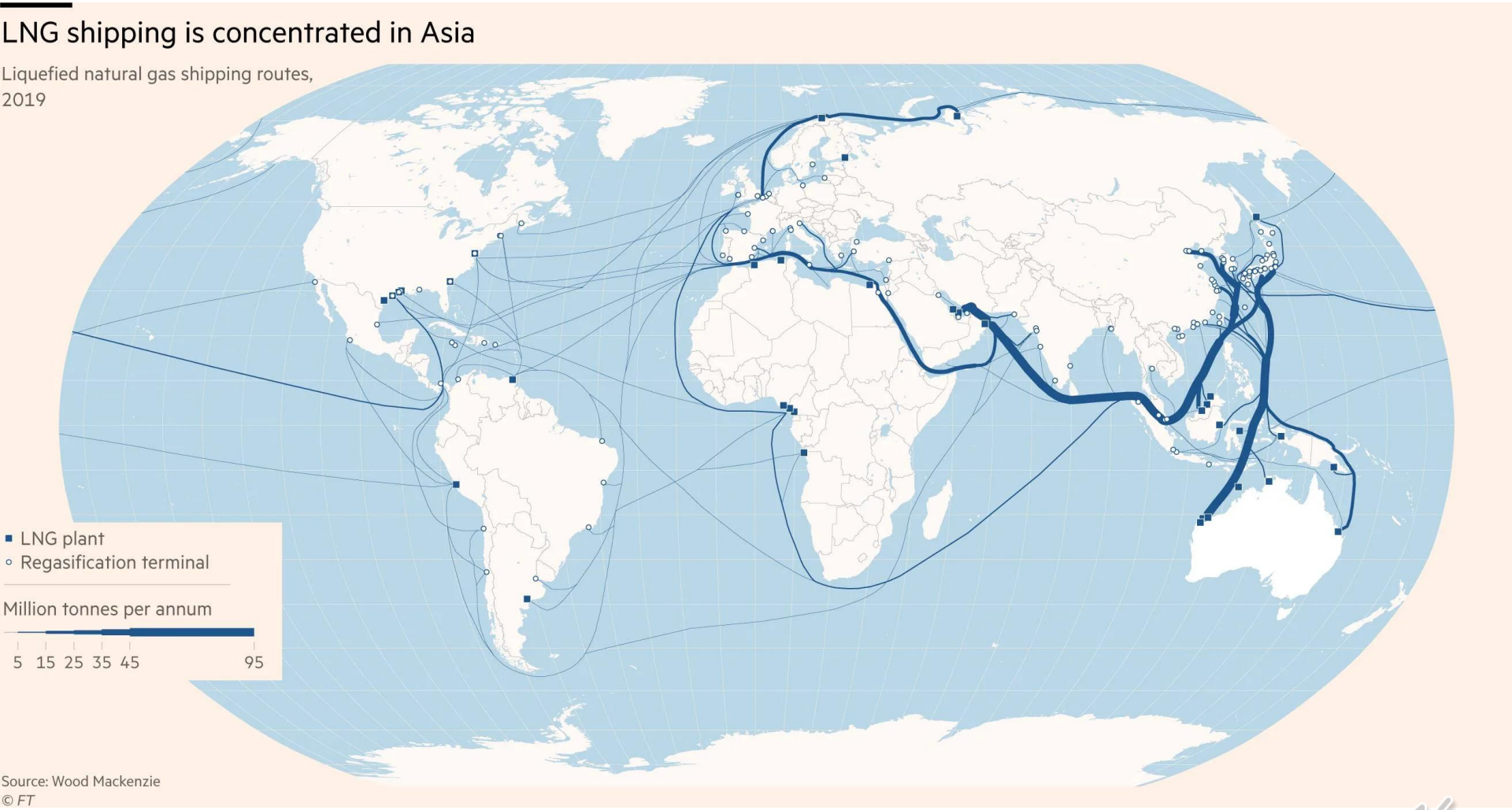
Gas pipelines

- Economic for 100s to few 1000s km
- Nord Stream 2: 1.2 m diameter, 220 bar in Russia falls to 100 bar in Germany, capacity of 540 TWh p.a.
- Compare 2 GW HVDC: 18 TWh

Liquified natural gas (LNG)

- No pipeline infrastructure needed: less investment, more flexibility
- Transport across oceans
- Liquification requires cooling to -162 °C
- This requires much more energy than pumping (up to 10% of content of gas)

Global LNG trade



Global gas hub prices

Historically: long-term contracts

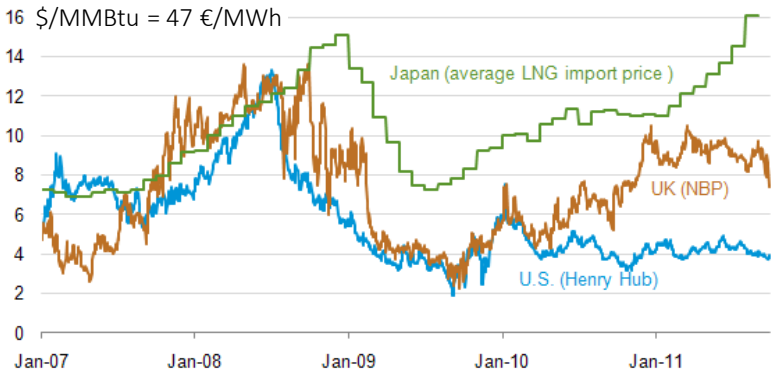
- "Take or pay" clauses, often oil-index
- Today, spot trading is benchmark price

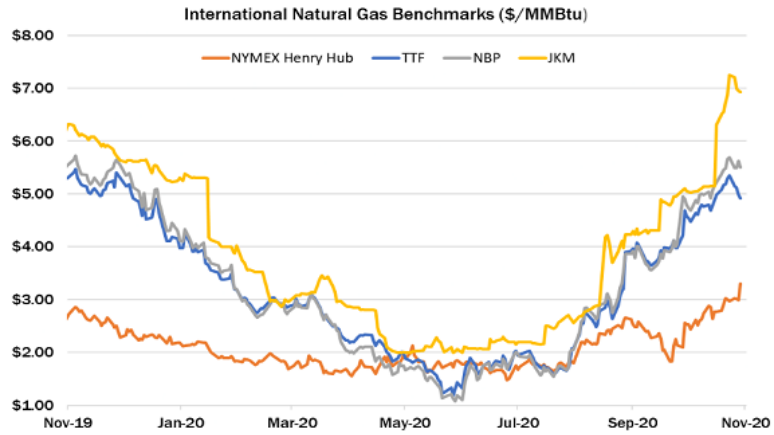
"Hub" markets: delivery a specific location

- US: Henry hub
- UK: National balancing point (NBP)
- NL: Title Transfer Facility (TTF)
- Asia: Japan/Korea Marker for LNG imports (JKM)

Three distinct global markets

- US prices low since fracking boom, Asia prices high due to LNG transport cost
- Convergence in times of abundant LNG capacity (Covid pandemic 03/20)





Seasonality and storage

Demand seasonality

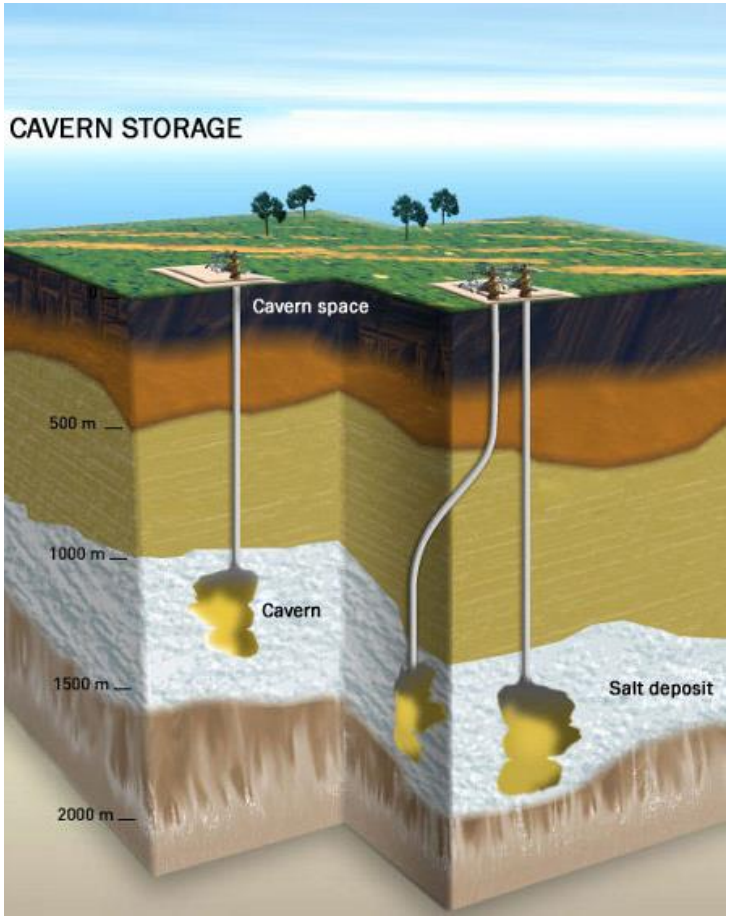
- European gas consumption has distinct seasonal patterns, because a large fraction of gas is used for heating
- Also, electricity prices tend to be higher in winter, driving up gas consumption in power plants

Short-term storage

- Pipelines serve as storage for short-term fluctuations of fossil gas demand (within-day)

Long-term storage

- Over seasons, fossil gas is stored in underground caverns
- Germany has 230 TWh of underground storage capacity, 25% of annual consumption



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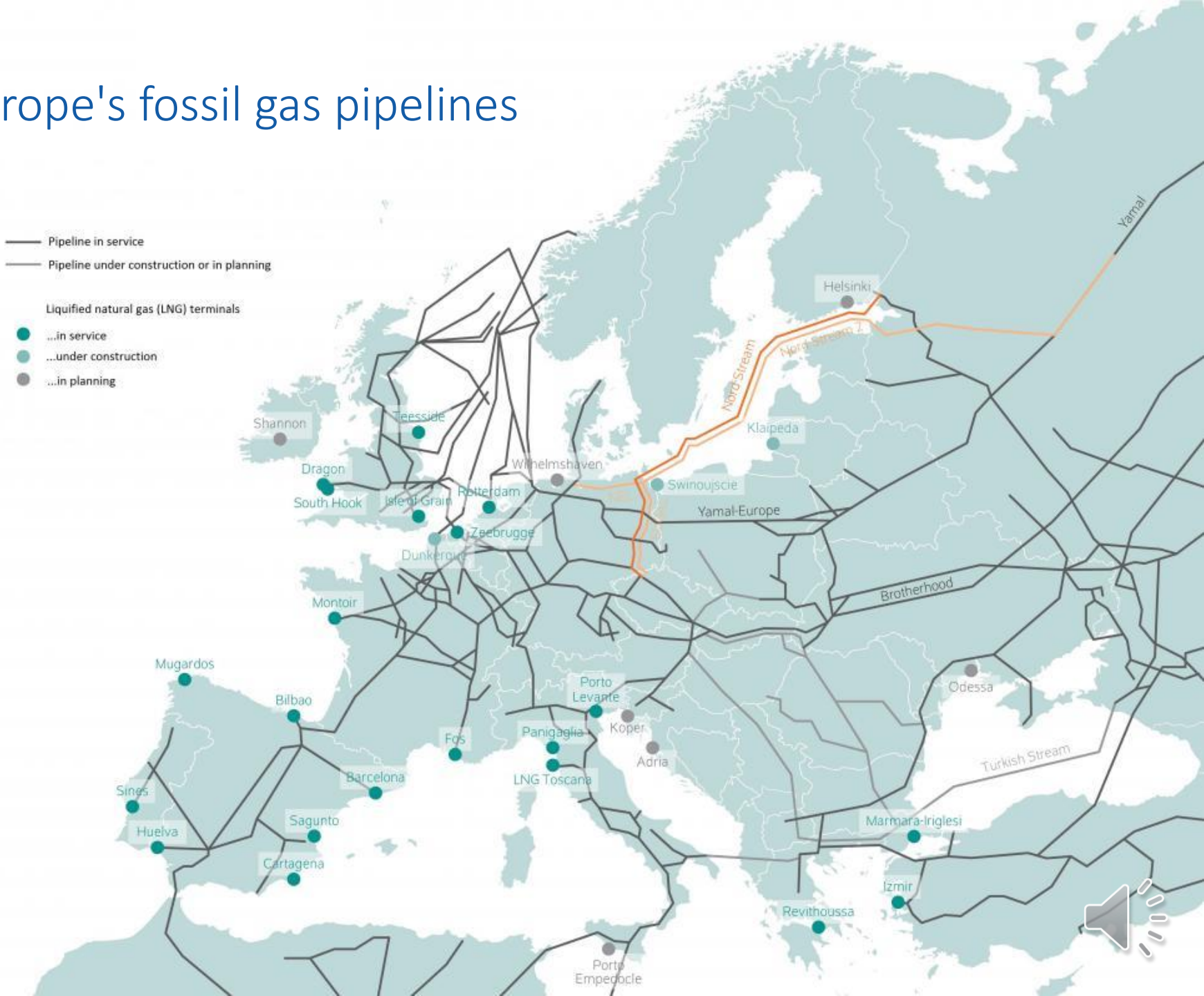
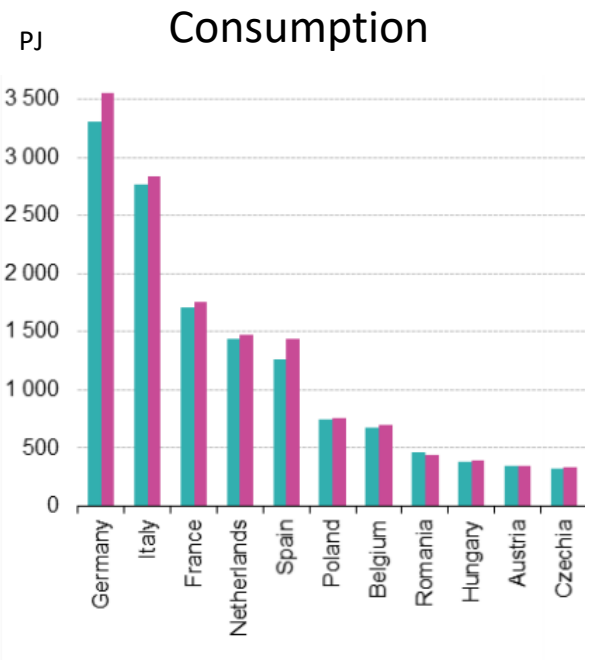
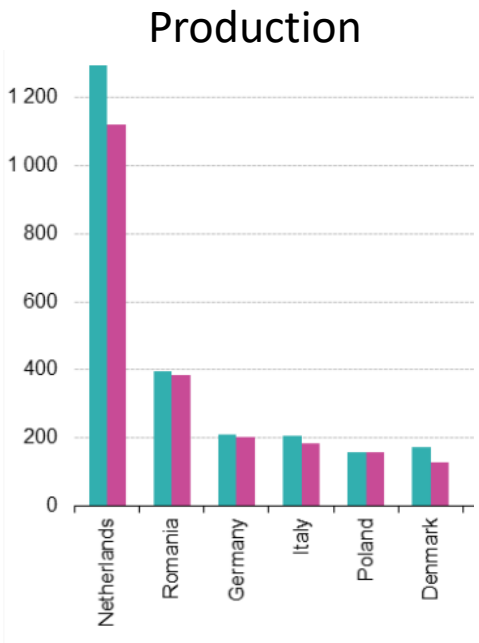
Europe's fossil gas pipelines



EU's fossil gas consumption and production

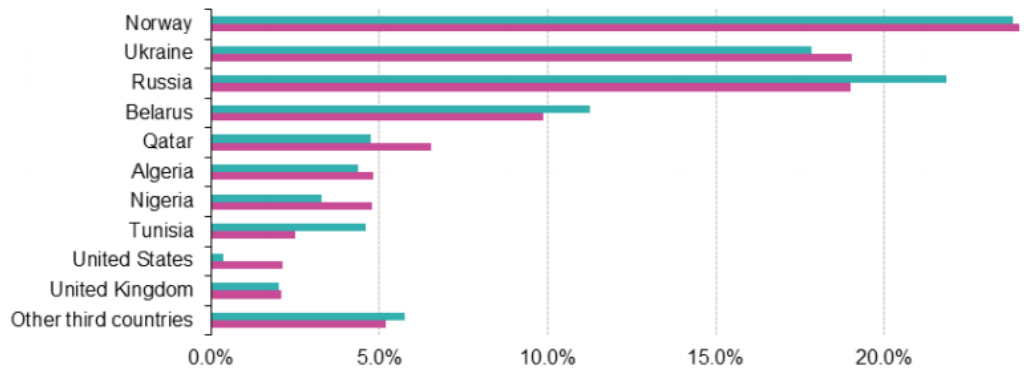


Germany's consumption of 3500 PJ corresponds to 900 TWh. Total EU consumption is about 16,000 PJ or 4500 TWh.

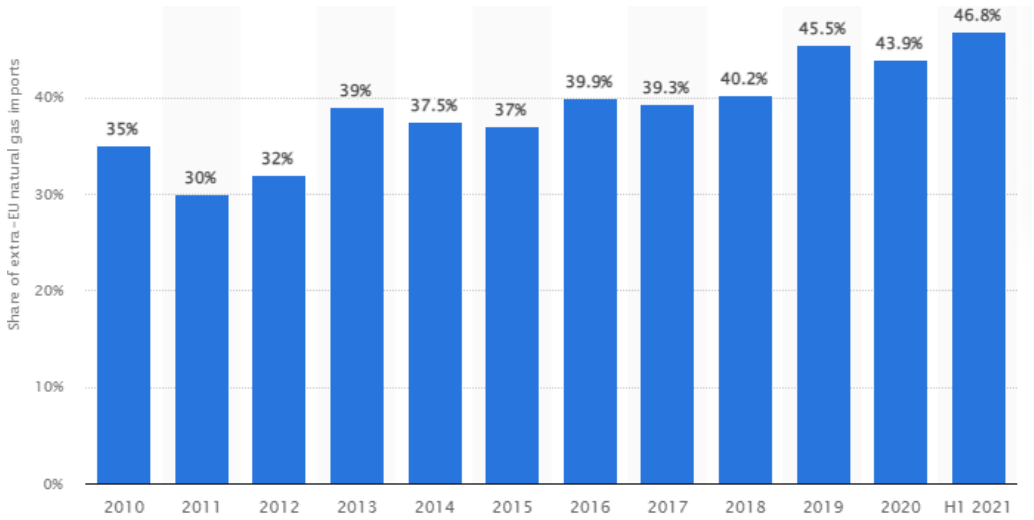


The EU produces only 1900 PJ, or 500 TWh domestically. This is about 12% of consumption

EU import sources

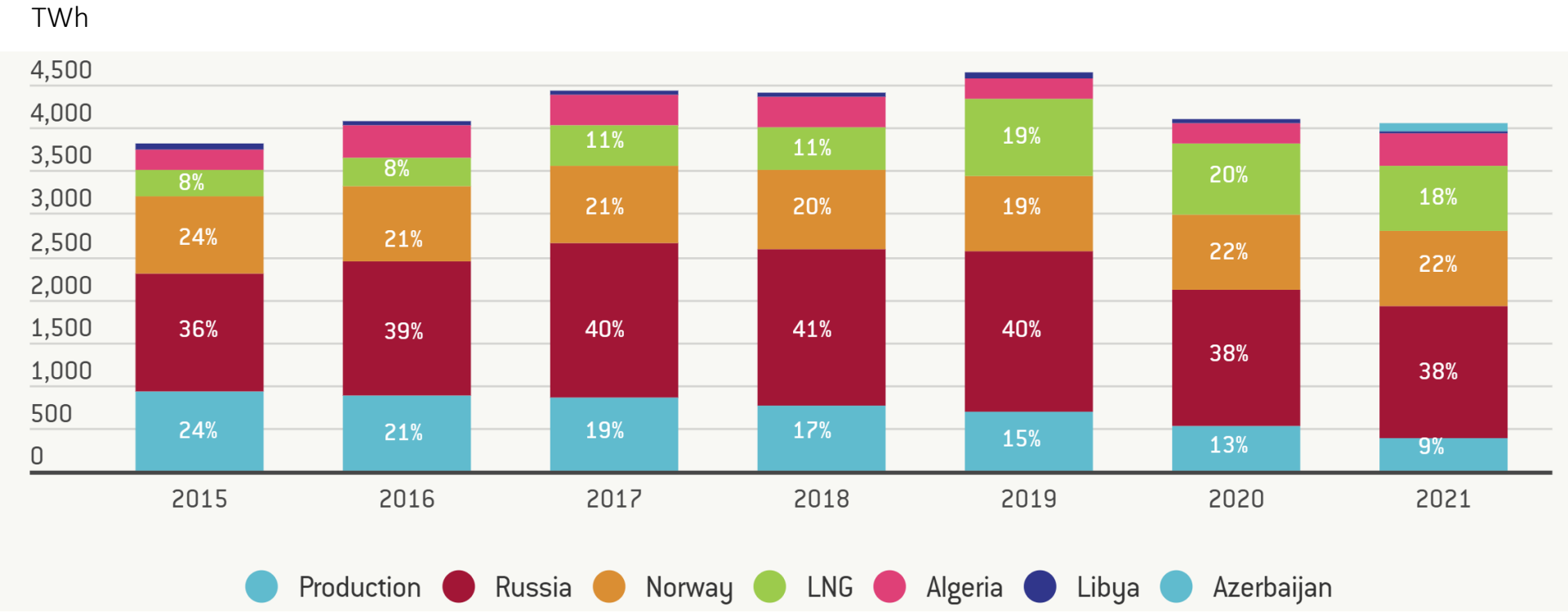


Imports from the Ukraine and Belarus are transit flows from Russia. Together, nearly half of all European imports – 40% of consumption – originates in Russia.



Russia has increased its share in EU imports from a third to roughly half during the 2010s.

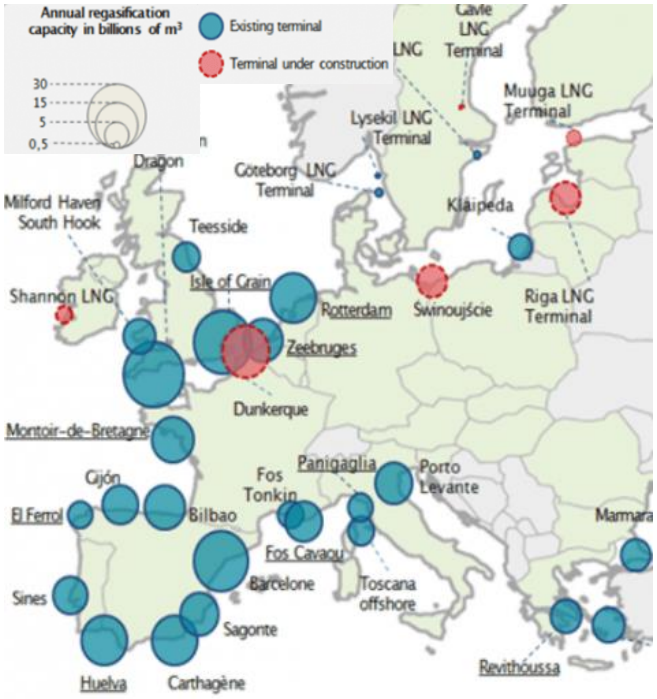
Sources of EU fossil gas



European supply options

Supply source	Capacity (TWh p.a.)
Regasification (LNG)	2400
Pipelines	6000
- Russia	3400
- Norway	1800
- Algeria, Libya	800
Total	8400
Consumption	4000

Tesio et al. (2021): Gas prices in Europe



Russa has four major export routes to Europe: Nord Stream, Yamal, Ukraine transit, and Turk Stream

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The 2021/22 European energy crisis: what's visible

Very high electricity wholesale prices

- Dec 2021: 480% increase year-on-year
- Both future and spot prices

Very high natural gas wholesale prices

- Dec 2021: 750% increase year-on-year (at current price levels, Germany's gas bill increased from EUR 15bn to 100bn)
- … and unusually low storage levels

Bankruptcies

- Energy retailers going bust
- … or terminate contracts


Stromio, Grünwelt und Gas.de 31.01.2022, 18:56 Uhr

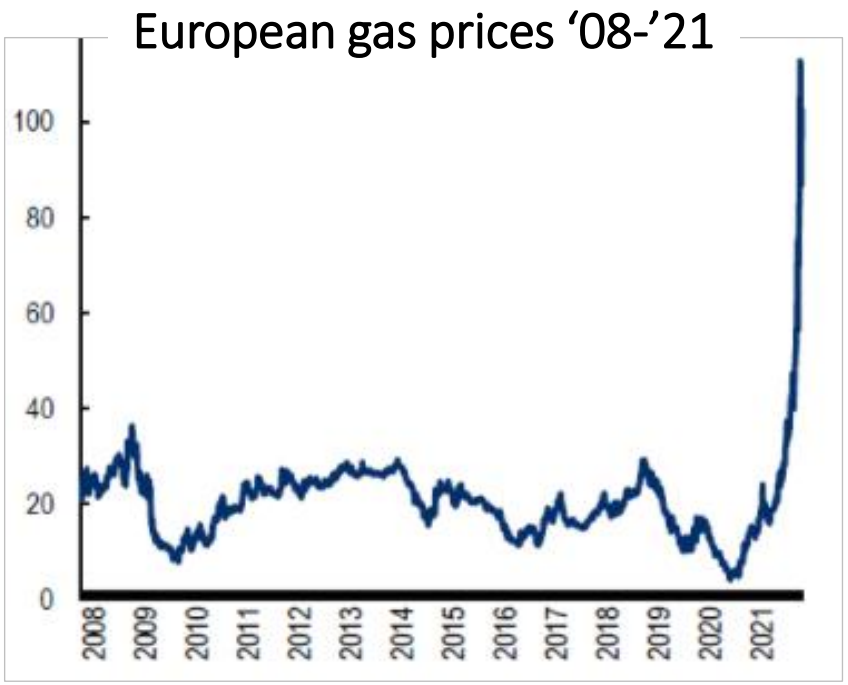
Staatsanwaltschaft prüft Ermittlungen gegen Billigstromanbieter

Drei Billiganbieter sollen Strom und Gas gewinnbringend verkauft haben, statt ihre Kunden zu beliefern. Die Kündigungen könnten ein Nachspiel haben.

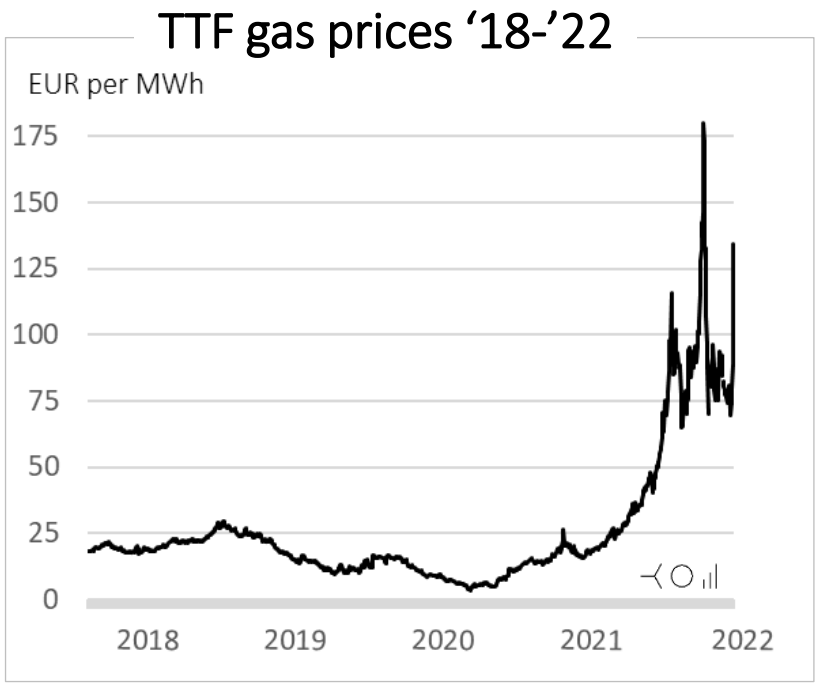
A confused (and confusing) political debate

- "We need a new model of pricing electricity"

Natural gas prices



OECD



Neon analysis. Daily front month (M+1) future prices on TTF fom Oct 2017 to end of Feb 2022 (nominal). Data source: Yahoo Finance.

Even in the 2008 commodity price boom, European fossil gas always traded at prices below 40 €/MWh.

During the first Covid year, fossil gas prices declined from 15 €/MWh pre-crisis levels to €4. In December 2021, it reached €180.

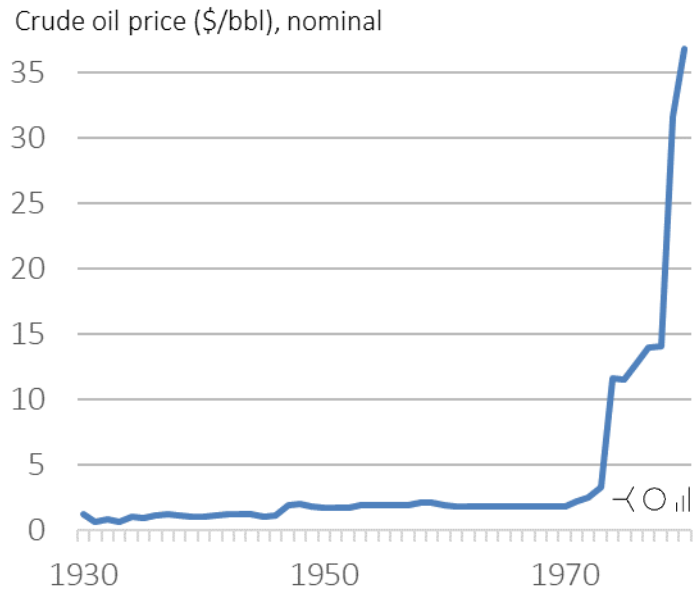
Compare to 1973 oil price shock

The first oil price shock

- 1972-74 oil prices increased five-fold from $2 to $12 per barrel (nominal)
- Germany imported 2bn barrel oil per year, meaning the bill increased by around USD 20bn
- Difference: 7% of GDP

Oil was much more important back than compared to gas has today

- Germany's annual wholesale gas bill pre-crisis was EUR 15bn, if current prices remain EUR 100bn
- Difference: 2% of GDP



Neon analysis. Crude oil prices in USD per barrel. Data source: BP.

Power prices

German power prices (front year base futures) since trading started.

At the peak of the 2008 commodity price boom, prices briefly reached 100 €/MWh.

For 13 years, power traded around 30-60 €/MWh.

In Dec 2021 prices reached 150 €/MWh, briefly peaking at 330 €/MWh (off the chart).

Since then, power trades around 130 €/MWh.

Neon analysis. Daily front year German base power future prices from 2003 to Feb 2022 in 2022 prices. Until 2018, DE-AT prices are shown, starting in 2019 DE. Data source: EEX.

Price drivers

Power prices

- Because of high prices for emission allowances, but more important because of high natural gas prices – gas-fired power plants are often price setters
- Additional factors: dry year in Nordics, outages of French nuclear plants, nuclear+coal exit in Germany
- But essentially, electricity is expensive because natural gas is expensive

Gas prices

- Higher-than-expected LNG demand in East Asia, following a strong post-Covid recovery
- Decline in domestic production, e.g. closure of Europe's largest gas field Groningen after earthquakes
- Algeria closed the Maghreb pipeline on 1 Nov 21 after tensions with Morocco
- High carbon prices drove up gas demand from the EU power sector
- Cold April 2021
- But the biggest factor is Russia …

The role of Germany's nuclear phase-out

Germany closed three nuclear power plants by end of 2021

- Totaling 4.1 GW in capacity
- Many observers pointed to this decision when explaining the energy crisis

The impact on gas demand: small

- Assuming natural gas plants are marginal producers in 50% of the year at a conversion efficiency of 60%, replacing them requires about 30 TWh of natural gas annually
- This is 3% of Germany's gas demand of around 1000 TWh p.a.

The role in the price increase: none

- This was known for many years, already priced in in future prices, so it cannot have anything to do with the 2021 increase in future prices

An evaluation

- Is this the worst time ever to take a nuclear plant offline? Yes
- Did this play a significant role in the current energy crisis? No

The role of Russia

Circumstances gave Russia much leverage in late 2021

- With EU production declining, Russia had become a more important supplier during the 2010s, now providing nearly 40% of total demand
- Short-term effects: high LNG prices, supply interruptions from Algeria, post-covid recovery, cold April 2021

What Gazprom did (and what it didn't)

- Gazprom didn't fill its storage in Europe, unlike other players
- Gazprom reduced deliveries in Q4 2021 year-on-year by a quarter, despite record-high prices (and LNG imports surging)
- Gazprom reduced deliveries through Yamal and Ukraine Transit virtually to zero

Gas storage level: the role of Gazprom

Total EU gas storage levels

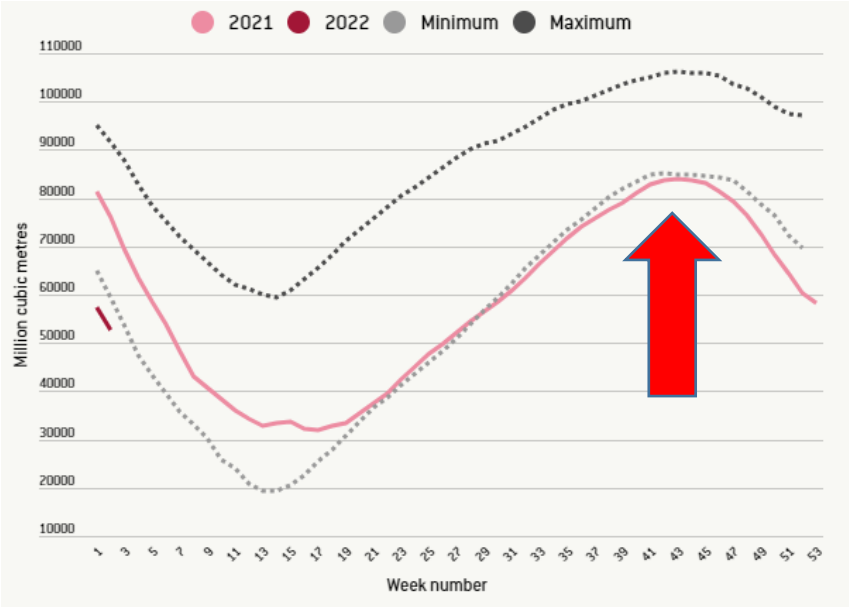
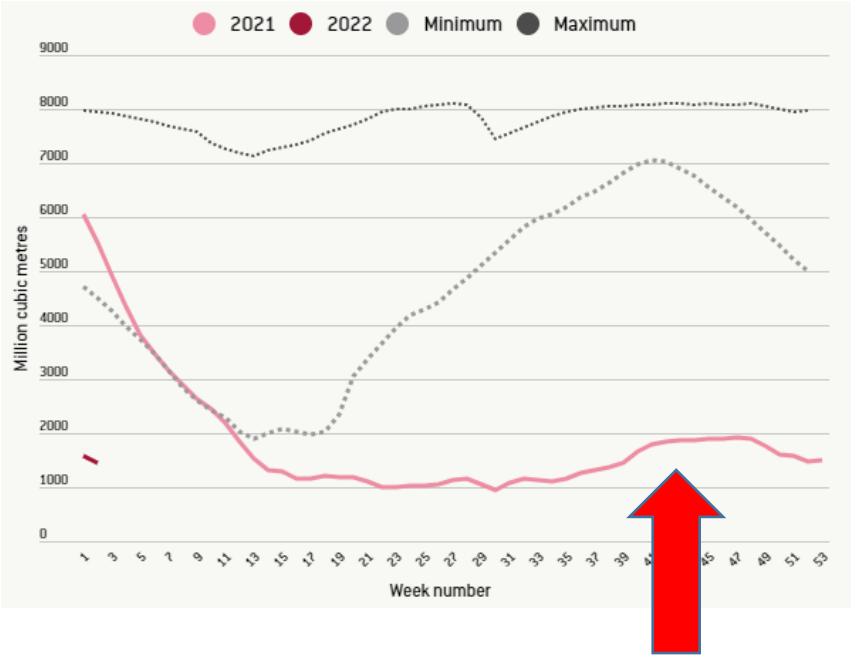


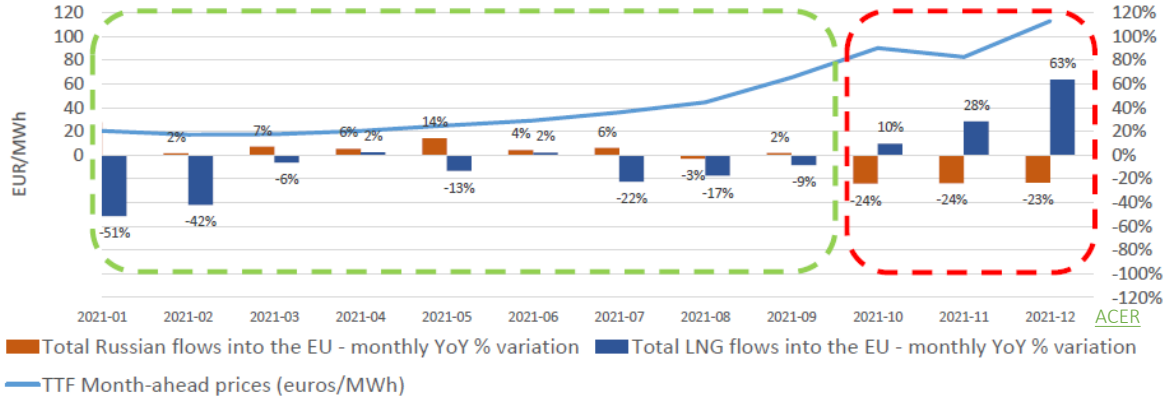
Figure Bruegel, data source AGSI

Gazprom gas storage levels



Gazprom owns the storage sites Rehden, Jemgum and a share in Katharina (DE) and Haidach (AT), totalling 60 TWh capacity. It's also involved in storage site Bergeemeer (NL). In Germany, it owns 20% of total storage capacity.

EU gas imports during 2021



During the last quarter, LNG imports to Europe increased significantly, responding to high and increasing prices. At the same time, Russian deliveries were a quarter less than the year before. Jamal and Ukraine Transit are essentially unused.

Q4 2021 vs 2019 European gas supply (EU+UK)

Consumption -49 TWh

Domestic production -24 TWh

LNG +50 TWh

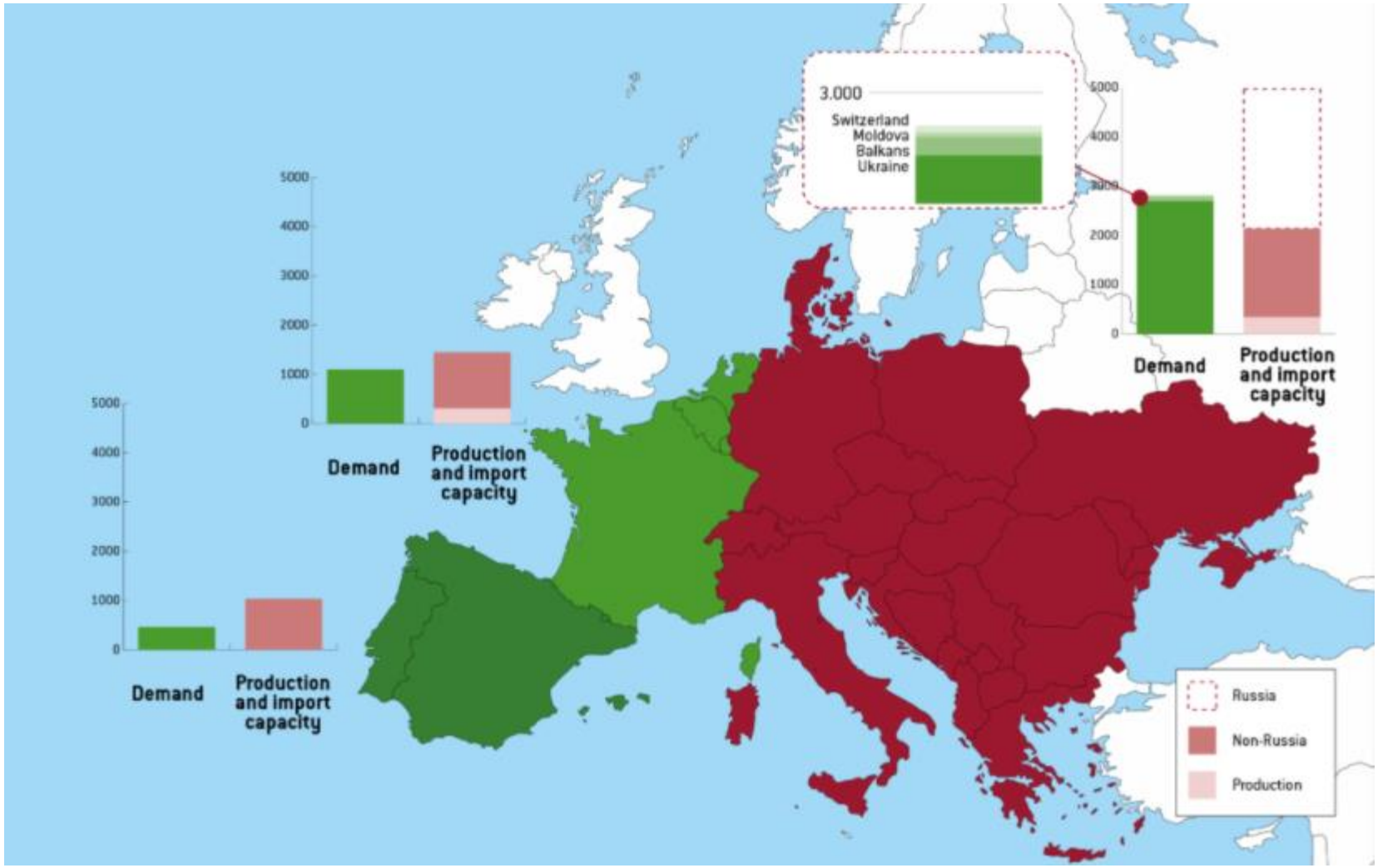
Storage withdrawal -20 TWh

Pipeline imports -54 TWh

- All except Russia +49 TWh
- Russia -102 TWh – in particular a tremendous drop on the Ukraine transit and Yamal pipelines (through Poland), but not Nord Stream and Turkish Stream

Oxford Institute for Energy Studies Quarterly Gas Review

Exposure to Russia



Gazprom strategically used selected pipelines

Nord Stream and TurkStream are used at full capacity

- No decline in flows in recent months

Yamal and Ukraine Transite run dry

- Yamal: 5% utilization in early 2022
- Ukraine Transit: 10% utilization in early 2022
- Yamal flows have declined in mid 2021, Ukraine flows much earlier
- Regular “reverse flow” on Yamal from Germany to Poland

There is no shortage of pipeline capacity

- The has not been any shortage in pipeline capacity from Russia to the EU in recent years, certainly not today
- To be very clear: Nord Stream 2 is not needed in the sense that pipeline capacity is lacking

Medium-term and long-term trends

In a net zero long-term future, fossil gas demand will disappear

- If you take Europe's climate targets seriously, the gas market will essentially disappear between the 2030s and 2040s
- It would make sense for a monopolistic supplier to become increasingly short-sighted

Fossil gas will increasingly become the fuel of last resort in the transition

- No more coal-gas-switch → much less price-elastic demand
- Electrification (and gasification) of heating → more weather-dependent demand

How can Russia's behavior be explained?

Russia's / Gazprom's behavior is clearly strategic (uncompetitive)

- Keep storages extraordinarily low during summer/fall 2021, reduce deliveries in winter 2021/22 despite record prices, under-utilizing existing pipelines
- That's a huge economic loss! Why would anyone do that?

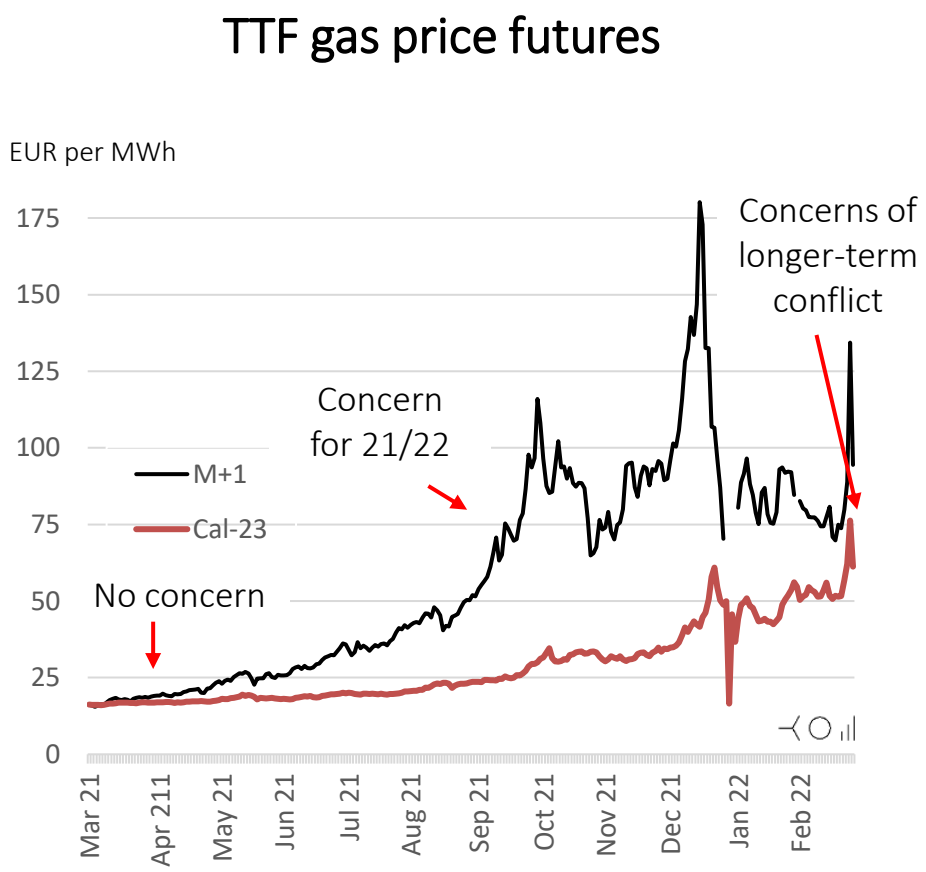
Four hypothesis that may explain this behavior

- Exercising market power when circumstances allow – drive up prices (at 100 €/MWh, Gazprom's EU revenues amount to EUR 180bn annually)
- Pressure German/EU authorities to issue permits for Nord Stream 2 pipeline
- Push European market actors back into long-term contracts
- Flanking the ongoing war in Ukraine / building leverage against Western Europe

These hypothesis are not exclusive

- Like often in politics, it might well be that different actors have different objectives that neatly align in the same action

Predicting war with energy price futures



Short term, there are two major price drivers: temperatures and the risk of escalating conflict

Longer term, it is essentially the risk of Russian supply interruptions that is driving prices

We can use gas prices as an indicator for the risk of (energy) war

Short-term gas prices have fallen back to September levels, even after the Russian assault on Ukraine

Longer-term prices (delivery 2023) have reached an all-time high

Imagine a carbon price …

Fossil gas prices increased about 100 €/MWh

- Fossil gas was priced at 15 €/MWh during 2009-20
- In the winter 2021/22 it traded well above 100 €/MWh

A price increase of 100 €/MWh corresponds to a carbon price of 400 €/t

- Since fossil gas has a carbon intensity of around 250 kg per MWh

Imagine a carbon price of 400 €/t being introduced within a year

- Most policy makers and advisors would tell you that's outright impossible

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(Why) are high energy prices problematic?

Should we care at all?

- Prices of goods go up and down – should public policy care?

From a climate policy perspective, the "energy crisis" is welcome

- A strong economic push for renewable energy and energy efficiency – the strongest incentive for decarbonization and transformation one can think off
- Pricy fossil fuels are the single most important mechanism to tackle climate change

What is (potentially) problematic about the current situation

- Geopolitical leverage for Putin and the danger of war in Ukraine
- Increasing cost for energy for people and firms
- Insolvencies of energy firms, both retailers and wholesale market parties
- Political/public pushback against liberalized energy markets and free price formation
- Political/public pushback against carbon pricing and the energy transition because of "green inflation"

Is there a role for public policy?

Power markets

- Is there a need to reform wholesale electricity markets?

Gas markets

- Is there a need to intervene in wholesale fossil gas markets?

Retail suppliers

- Is there a need to amend energy retail markets?

Compensation

- Should (certain) energy consumers be compensated or protected from high prices?

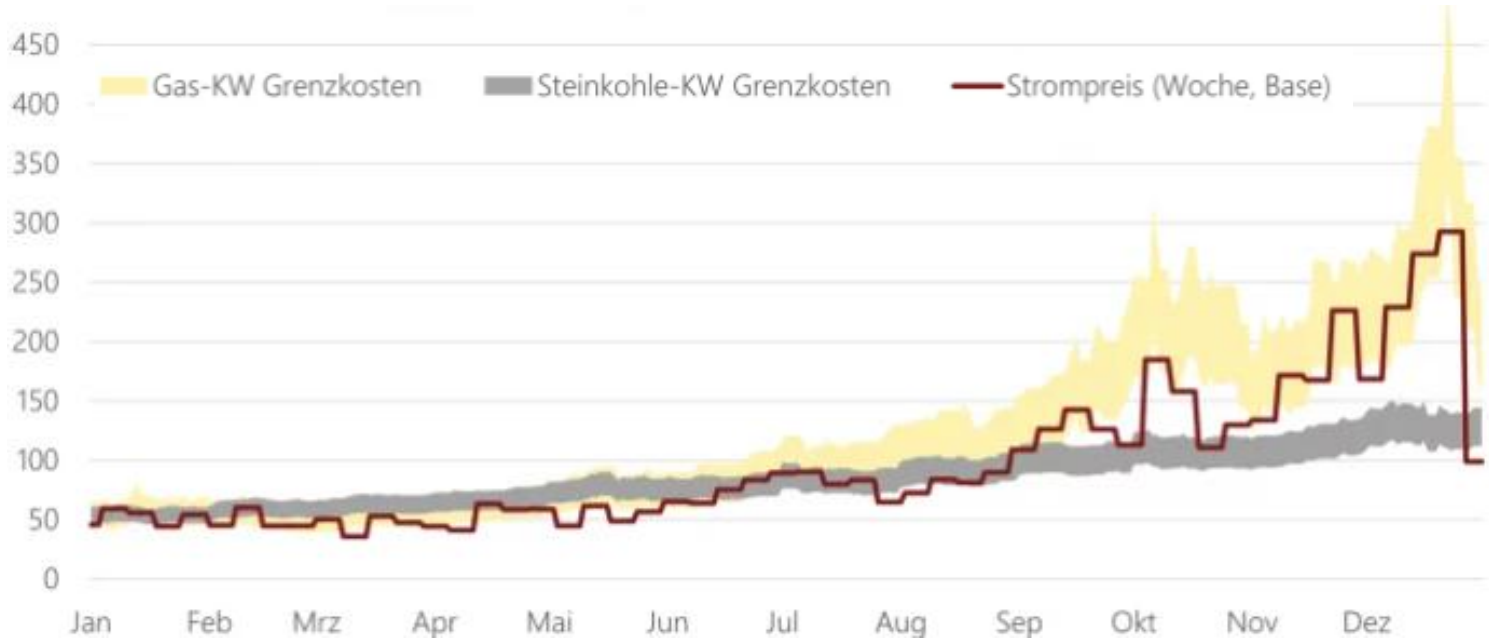
Energy sanctions in war time

- Can Russia or Europe use gas as an economic weapon on the Ukraine conflict?

Is there something wrong with electricity markets?

Are wholesale electricity markets broken?

- I haven't seen anything that looks like a flaw in power markets
- In fact, market behavior and prices can be very well explained
- Observed prices can be well explained by high prices for gas and carbon (and some additional smaller factors)



Electricity markets: reform requirements and proposals

Electricity wholesale markets work perfectly fine during the crisis

- No reason to intervene in any way

Coal and nuclear exit

- It would have been sensible to let coal and nuclear plants running for a couple of more months
- But I am aware that this is politically virtually impossible

Support schemes

- High prices are a reminder that German one-sided CfDs imply an asymmetric distribution of upside risk and a windfall for renewable generators, which isn't great
- Except for offshore wind, I expect market-based investments to dominate anyway, so this is maybe no major issue

Is there something wrong with fossil gas marktes?

There is one player with massive market power in Europe: Gazprom

- Around 40% market share in the EU, much more in individual countries, and rising
- Owner of significant gas storage capacity

Market power is likely to become more severe in the 2020s

- Reduced substitution in power generation with coal/nuclear being phased out
- Reduced domestic natural gas production

Gazprom might become more short-sighted

- The EU net-zero strategy implies gas demand will decline dramatically after 2030
- Shorter time horizon means more incentive to drive up prices

Russia is a political suppliers

- Gas supply might be reduced (now or later) not only for commercial reasons but also to blackmail Europe

Unlike the power market, the gas market is in big trouble

Gas markets: What can be done?

Energy efficiency, heat pumps, RE investments to reduce gas demand

- No-regret options, but slow

Get the two planned regasification terminals built

- Stade and Brunsbüttel, together around 20% of German gas demand
- But scheduled only for 2026 (now: 2024?)

Regulate gas storages

- Minimum storage regulation or ownership unbundling
- A pretty strong interference with gas markets
- Limited leverage: gas storage hold 25% of annual demand

Gas markets: What can be done? (cont'd)

Get Nord Stream 2 online and engage in long-term contracts with Gazprom

- Gazprom has always delivered on its contractual obligation
- This might be the strategy with quickest short-term relief …
- … but also the one that increases dependence further

There is a clear trade-off with climate policy

- Sad truth is: much of that additional natural gas storage infrastructure creates carbon lock-in and will end up as stranded assets

There are no good short-term options

- We maneuvered ourselves in a complicated situation

Retail markets and the default supplier model

Adverse selection and moral hazards

- Retail suppliers may hedge to little and then accept insolvency in high-price episodes
- Retail suppliers may even terminate contracts with customers and sell volumes back to the wholesale market

Default suppliers (*Grundversorger*)

- Stranded customers end up with the default suppliers, who is unhedged and needs to accept new customers amid high prices

Protecting consumers

Reduce distributional impact

- Fuel price subsidies, payments, support programs, etc.

Problems

- Costly (fossil gas: EUR 100bn)
- Fuel subsidies kill incentives to invest in efficiency, heat pumps, renewables
- Any compensation increases an incentive to gamble in the future (“too big to fail”)

Building an infrastructure to protect consumers

- Data on affected households (income, fuel)
- To allow targeted intervention (e.g. payments to low-income households that spend more than X% of income on heating)

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Two questions

Energy sanctions

- Can and should Europe stop/reduce buying fuel from Russia to sanction the assault of Ukraine?
- And reverse: Can Europe do without Russian fuel supply?

How dependent is Europe on Russian energy?

Economically speaking, Russia-EU oil exports dwarf gas exports

- But oil can be easily sourced from world markets, because it is easily transported by ship and EU import capacity is large
- This is even more true for coal (which is also economically much smaller)

With natural gas, diversification is much more difficult on short term

- This is true for both sides – EU as an importer but also Russia as an exporter

The bottlenecks for EU LNG imports

- Re-gasification capacity: 60% of EU demand
- LNG supply: liquification capacity constraint, about 70% in long-term contracts (EA)
- Intra-EU pipeline capacity: Spain has many LNG terminals, but little pipeline capacity to rest of EU

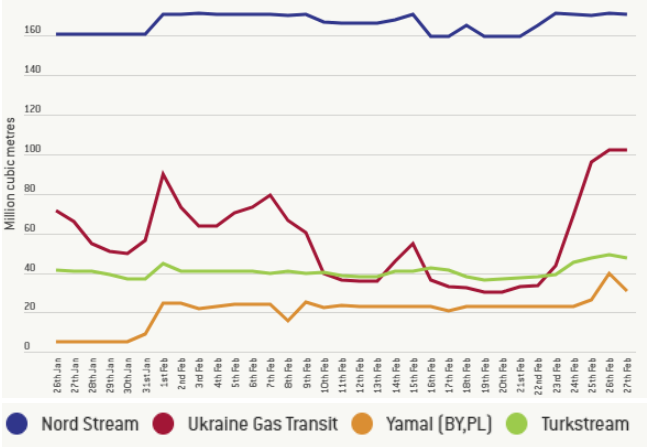
Watching natural gas storage is important

- But that misses the main problem: the overall import demand

Russian gas deliveries since the assault: up

Russia had built significant leverage

- Letting storage run dry
- Reducing deliveries
- Halting spot market sales
- Using only selected pipelines



Since February 22nd, deliveries have actually *increased*

- Maybe most surprisingly in particular across Ukraine Transit
- But also flows on other pipelines have picked up

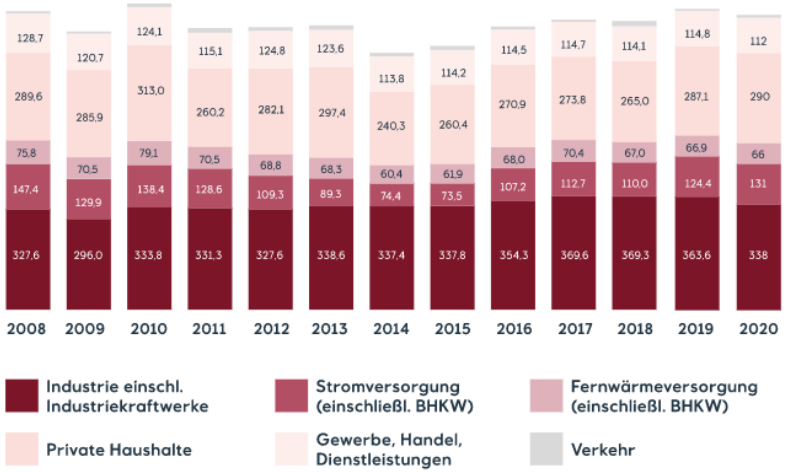
In my view, this is maybe the starkest signal of Russia trying to de-escalate

- Arguable amid a number strong signs of escalation

How fossil gas is used in Germany

Space heating: 450 TWh (50%)

- Includes homes and offices
- Mostly burned on site, a much smaller fraction through district heating
- Half of all homes are heated with gas



Industry: 350 TWh (35%)

- Industrial heat-and-power plants
- High-temperature process heat, e.g. in float glass production
- Feedstock to the chemical industry, e.g. for hydrogen used for fertilizer and in refineries

Electricity generation: 130 TWh (15%)

- About 15% of Germany's electricity needs stem from gas-fired plants

Can the EU do without Russian gas in the next 2 yrs?

I don't know

Supply side

- How much headroom do Norway and other pipeline suppliers have to increase deliveries within a year?
- How much re-gasification capacity can be used? What are intra-EU pipeline capacity?
- How much LNG is available?

Demand side

- Industry: ultimately a question of how much output we are willing to see forgo
- Space heating: this is extremely difficult, I cannot think of convincing policy levers
- Electricity: re-open closed nuclear and coal plants, conserve electricity, gas-to-oil switch – but electricity generation consumes just 15% of gas

Dependency from Russia: Options across time scales

Short term (this winter)

- We are out of the woods
- Thanks to a mild winter and continued Russian flows

Mid term (next winter)

- Regulate gas storage
- Bring nuclear and coal capacity back online

Longer term (mid 2020s)

- Build LNG terminals
- Reduce gas demand through efficiency, heat pump and RE investment

Our most important adjustment mechanism: prices

It is high prices that attracts supply and depresses demand

- Expect industrial gas demand to be quite price-sensitive

If we shield consumers from price spikes, they won't respond

Watering down high prices means weaking our most important adjustment mech

- Replacing marginal with average pricing
- Subsidize energy prices / consumption
- Pendlerpauschale
- Compensation is important, but lump-sum is much preferred

Communicating high retail prices

- I think it is important for policy to develop a clear, consistent communication strategy about very high gas prices next winter

The European Energy Crisis

Prof. Dr. Lion Hirth

Hertie School

European import capacity

Supply source	TWh per year	GWh per day	Million m^3 per week	Million m^3 per day
Regasification (LNG)	2,400	6,600	4.700	700
Pipelines	6,000	16,000	11,900	1,700
- Russia	3,400	9,200	6,700	1,000
- Norway	1,800	4,800	3,600	500
- Algeria, Libya	800	2,300	1,600	230
Total	8,400	38,900	16,600	2,400
Consumption	4,000	14,100	7,900	1,100

Tesio et al. (2021): Gas prices in Europe