Defining gas price limits and gas saving targets for a large-scale gas supply interruption

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Abstract

Should deliveries of Russian gas by pipeline be interrupted for an extended period of time, then gas prices could explode to up to several hundred Euros per MWh due to scarcity of supply. This risk is already reflected in future and spot gas prices and has caused much of the current extremely high gas price levels and volatility. Any additional price increase after a potential large-scale gas supply interruption would likely trigger even more government interventions in EU's energy markets, with the objective to limit costs for households and other consumers. To avoid such ad-hoc measures, the EU Commission has proposed in the REPowerEU communication to agree already now, ahead of any potential large-scale interruption, on a coordinated European response to a large-scale gas supply interruption. We explore how the proposed measures, which include binding national gas saving targets and limits to the gas price in the case of large-scale gas supply interruptions, would impact supply and demand after an interruption. We also assess how the level of the price limit would impact the supply and demand balance after an interruption and the price formation prior to it.

Keywords: Price cap, Security of Supply, Gas saving, Consumer wellfare

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Karsten Neuhoff, 8.6.2022[1]

Should deliveries of Russian gas by pipeline be interrupted for an extended period of time, then gas prices could explode to up to several hundred Euros per MWh due to scarcity of supply. This risk is already reflected in future and spot gas prices and has caused much of the current extremely high gas price levels and volatility. Any additional price increase after a potential large-scale gas supply interruption would likely trigger even more government interventions in EU's energy markets, with the objective to limit costs for households and other consumers. To avoid such ad-hoc measures, the EU Commission has proposed in the REPowerEU communication to agree already now, ahead of any potential large-scale interruption, on a coordinated European response to a large-scale gas supply interruption. We explore how the proposed measures, which include binding national gas saving targets and limits to the gas price in the case of large-scale gas supply interruptions, would impact supply and demand after an interruption. We also assess how the level of the price limit would impact the supply and demand balance after an interruption and the price formation prior to it.

1. Introduction

On the 18th of May, 2022, the EU Commission published potential measures to prepare for "a sudden large scale or even full disruption of the supplies of Russian gas" (Section 3a, EU Commission 2022). In a conventional economic analysis, such a disruption corresponds to a shift of the supply curve. The shift would result in a new market equilibrium at the intercept with the demand curve, with a higher price level rebalancing demand and supply. As the supply interruption could be large, considering that Russian gas supplies historically constitute ca. 40% of EU's supply, the new equilibrium price could be extremely high because the demand and supply curves are inelastic in the short run, e.g. the months of a potential supply interruption.

Gas demand becomes in the short run inelastic as soon as prices exceed the price that would cause a substitution of coal or oil for gas in existing boilers and power generation plants. The limited elasticity results from overall low short-term demand elasticity due to high opportunity costs of curtailing heating or production activities reinforced by contract and tariff structures that limit price pass-through. Furthermore, if gas prices would escalate to a multiple of historic values, this would lead to heating bills amounting to a large share of household incomes (Kröger e.a. 2022), triggering the need for subsidies, which could shield consumers from cost increases and further undermine the demand response.

Similarly, gas supply to the EU is in the short run inelastic whenever prices exceed historic peaks of 30-40 Euro/MWh. Assuming sufficient Liquified Natural Gas (LNG) gasification capacity to import LNG and transmission capacity to deliver gas within the EU (Holz e.a.. 2022), all pipeline-based deliveries

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to the EU and available LNG liquefaction capacity or gas production capacity to export LNG from third countries face at this point economic incentives to operate at full capacity in a competitive setting. Additional gas production capacity or pipeline and respective LNG liquefaction capacity for shipments to the EU cannot be delivered in the short-term, e.g. less than 2 years. In the short-term, additional supply is only possible if EU buyers outcompete in the spot market the competing LNG buyers in Japan, Korea, India and China or negotiate to redirect gas from existing long-term contracts (where they offer such flexibility) of these buyers to the EU. However, in all these countries final demand is largely shielded from LNG spot prices through long-term contracts and tariff structures. Increases in LNG prices will only directly influence about 1000 TWh of gas demand in these countries. Even with increases of spot prices from 50 to 300 Euro/MWh the resulting demand reduction in other countries would free up LNG volumes at the scale of 6% of EU demand for delivery to the EU.

If price response will not suffice to clear the markets in the short run, then curtailment of gas deliveries will be applied according to the existing security of supply protocols. For example, Germany has already announced the first of three stages to gather information and set up the administration to prepare for such a situation. With households, SMEs, social services, district heating, and other demand categories protected from rationing, rationing will primarily impact industrial gas usage, which risks large economic effects along the entire value chain.

One might expect that in case of an emergency such as a disruption of Russian gas supply, EU member states would provide mutual support. Western European countries, less exposed to a supply interruption due to lower shares of Russian gas imports, could share some of their gas with Central and Eastern European countries which are traditionally more reliant on Russian gas imports. The EU energy markets should, in principle, facilitate such re-allocation of gas to countries with higher scarcity to the extent that physical transmission capacity is available or LNG cargos can be redirected. In practice, however, EU member states like Spain, Italy and Greece, are already intervening in energy markets at current gas wholesale price levels (e.g., around 100 Euro/MWh compared to historically 15-20 Euro/MWh average prices) to mitigate the impact for gas and electricity consumers. If gas and electricity price levels were to escalate much further, so would market interventions and thus the ability of markets to contribute to a re-allocation of gas across EU member states would decrease.

The EU regulation on measures to safeguard the security of gas supply (EU Parliament and Council 2017) includes a solidarity mechanism for mutual support between EU member states should markets fail to clear. However, it only encourages member states to sign bilateral agreements to provide mutual assistance rather than coordinating an EU scale response. It also does not specify the most controversial element: the price at which such assistance is to be compensated. In its recent communication, the EU Commission states that “these solidarity mechanisms are meant to be triggered in case of a national security of supply emergency. In case of further gas disruptions affecting several Member States at the same time, additional measures may be necessary.” (EU Commission 2022, p. 6).

The uncertainty about how EU demand and international available supply responds to price levels which have never been experienced before, in combination with an EU regulation of risk preparedness designed for very different circumstances, makes it difficult to anticipate what will happen after a large-scale supply interruption. Will gas markets converge to a new “equilibrium” wholesale price level for spot and future contracts, and what would be the price level? Or will markets fail to clear and what will this imply for factors such as the allocation of gas and the fulfillment of contracts? This uncertainty is amplified by unpredictability of developments in forward and future markets. They can contribute to further increase the volatility if large price increases result in defaults of counterparties or emergency sales by market participants that cannot serve escalating margin call requirements.

Gas markets have priced in these uncertainties including potentially very high prices in forward markets by adding a risk premium at the scale of the probability attributed to a supply interruption multiplied with the price increase anticipated in this situation. This is one explanation why, despite gas storage levels are within normal ranges, forward prices remain extremely high and highly sensitive to new information regarding the possibility of a supply interruption in the coming months.

These price increases on exchanges have induced huge costs to gas consumers and – due to gas-based power generation setting power prices in many hours across the EU – also electricity consumers. The main beneficiaries are gas producers as their contracts to EU clients are mostly indexed to the European exchange prices for gas with only very limited time lag (1-3 months in most EU member states, longer in Germany). However, with power prices escalating, electricity generators with non-fossil generation assets have experienced increasing profitability as well.

Given these risks for energy security after a supply interruption and the negative effects the anticipation has on current costs to EU energy consumers, the EU Commission has proposed two policy responses to prepare for a sudden large-scale or even full disruption of the supplies of Russian gas (EU Commission 2022):

- **"a reduction of gas demand even in Member States less directly impacted** so as to ensure supply for essential functions or sectors in more directly impacted Member States."
- "**an administrative price for gas to be established in parallel, such as a maximum regulated price** for natural gas delivered to European consumers and companies (EU price cap) to cover the period of a declared Union emergency. (…) such a price cap can in general be introduced in different ways and can intervene at different levels of the gas value chain."

For reducing gas demand at EU scale in the short run (during an emergency), EU member states could agree on gas saving targets for each Member State: one target to apply immediately and a more demanding target to apply in the event of a large-scale gas interruption. On this basis, national and local governments can manage non-market mechanisms to unlock gas savings among all gas consumption segments of the economy. They can build on international experience and use a portfolio of communication campaigns and savings objectives for heating of buildings. This can include defining norms or formulating requirements that may be monitored, enforced or incentivized and tenders to pay for industry to pursue gas savings, in the case of a supply interruption. Gas saving targets for each member state and their governance will ensure that governments implement programs to unlock gas reductions. Daily reporting on success of gas savings in terms of securing sufficient gas in reservoirs will help to both manage the effective implementation of programs and to encourage households and firms to save gas.

How can it be ensured in a large-scale supply interruption that the wholesale gas prices do not exceed a maximum regulated price agreed at EU level? The design of the gas market offers one specific opportunity. Gas suppliers need to nominate to a regional system operator where they insert gas into the system (entry point) and where the gas is delivered to final consumers (exit point). In the case of a security of supply emergency, gas suppliers can already now nominate more exits volumes (according to the demand of their final consumers) than they can provide gas to nominate for entry into the system. The system operator then acquires in the spot market gas to match the difference and charges the supplier for these costs. A price limit could be implemented, by mandating all system operators in the EU not to acquire gas to balance the system at prices exceeding an agreed maximum regulated price. As a result, no gas supplier would acquire gas in the wholesale market at a spot price exceeding this maximum regulated price, because it would be cheaper to nominate an imbalanced schedule. Thus, across the EU there will be at the wholesale level no demand for gas at prices exceeding the price limit and hence the price will not exceed the level of the price limit. With EU being the largest global LNG purchaser, the lack of EU demand to acquire gas at prices exceeding the price limit will imply that global LNG spot prices will not exceed this limit (if the limit is set high enough).

If system operators fail to acquire sufficient gas to balance the system at this maximum regulated price, then they would curtail demand according to the security of supply protocols. These curtailments apply to all nominated gas deliveries, irrespective of the contractual situation. Hence, the specific situation of gas market design allows for the effective implementation of a price limit while avoiding risks of gaming or circumvention.

The limit should be set high enough to allow for fuel shifting in power generation from gas to coal, fuel oil and oil in competing Asian markets, and hence be set for example at 50 Euro/MWh and increase in line with global oil prices. This level would still exceed historic wholesale gas prices spikes that reached 30-40 Euro/MWh and ensure globally full incentives to maximize gas production and liquefaction. It may be considered to further increase the price limit if necessary for fuel shifting in Europe from gas to coal power generation including carbon costs. This fuel shift could however, within Europe, also be achieved with dedicated measures in the power market like gas incineration fees, limits to running hours of gas plants, or redispatch measures. A first quantification shows that after a supply interruption households and industry save more from lower prices than they incur costs in terms of unserved load. The benefits that such a response strategy can bring after a large-scale supply interruption allow governments to credibly commit to such a response strategy already ahead of any potential large-scale supply interruption. This in turn would reduce the large risk premium currently driving EU-gas prices and thus also global LNG market prices. This would reduce costs to EU consumers and payments to gas producers – currently at the scale of 400 billion Euro annually – by a factor of 2.5.

Price limits have always been a controversial instrument among economists. However, as discussed above, in case of a supply interruption the question is not whether a price limit is necessary in the short run, but whether it will be jointly implemented by EU countries ahead of a crisis, or whether national policy makers respond ad-hoc to extremely high prices that are likely after large-scale supply interruption. Such ad-hoc action is likely to be poorly coordinated, less effective and a far costlier measure, and also prone to causing difficulties in the long run, including EU's ability to address climate goals in a consistent way.

The triggering of the price limits in the case of a supply interruption can also contribute to more competitive behavior of strategic players. Russian gas supply is pivotal for the EU market, but Russian gas suppliers are currently neither behaving competitively nor responding to EU competition law. In the current market situation, Russia, as the pivotal supplier, has strong incentives to create uncertainty and scarcity to increase prices, and keep them high so as to increase revenue. Incentives to create uncertainty could be largely reduced with a price limit to be imposed in case of a large-scale supply interruption. If the limit is set sufficiently low, then the "announcement effects" (the triggering of price limits) will not increase risk premia and hence prices and revenues, as has happened for example after the recent Russian pronouncements concerning ruble payments for gas. Instead, incentives from competitive markets would be reinstated, and the pivotal supplier (Russia) would have stronger incentives for behaving competitively, i.e. to increase production and supply to the EU in order to increase revenues (Neuhoff and Hirschhausen 2006).

In addition to the measures outlined by the EU Commission, it may also be beneficial to directly cooperate with LNG importing countries in order to insure against major supply interruptions. Currently, the largest LNG importing countries (China, Japan, Korea, and India) and the EU use the price mechanism to outcompete each other for scarce LNG in case of cold winters (China), earthquakes (Japan) or supply interruptions (EU). However, as most domestic gas demand in Asian countries is largely regulated or linked to oil-indexed LNG contracts, LNG spot prices may rise to extreme levels in such scarcity situations and still fail to produce large scale demand reductions that would help countries in need. Given the social costs and implications for industrial competitiveness, it is also unlikely that governments will abandon their policies that help to stabilize energy prices. To increase the ability of the global LNG market to respond flexibly to unexpected regional shortages, countries should bilaterally or multilaterally cooperate and agree on protocols to provide mutual support. This could involve for example the use of government programs for short-term gas savings in one country in order to reduce LNG demand and thus provide additional supply for another country in an emergency situation. The EU should seek to agree such measures where possible.

2. Determinants for elasticity of gas supply and demand

In this section, we provide evidence for the characterization of demand and supply as the basis for the discussion of the implications for market clearing after a supply interruption. Figure 1 illustrates the net-supply, e.g. pipeline gas delivery to EU and international LNG production minus LNG demand in competing markets, and EU's gas demand curves. As price increases to levels of about 50 Euro/MWh, the increase trigger fuel shift from gas to oil and coal and may incentivize maximization of capacity utilization of gas production and liquefaction. Further demand response at a higher price level can only occur through reduced energy usage, and hence is likely to impact economic activity and comfort levels. The response of gas demand to price hikes is limited as gas consumers are shielded from spot prices hikes through the tariff structure, contract provisions, and government programs intervening at high prices.

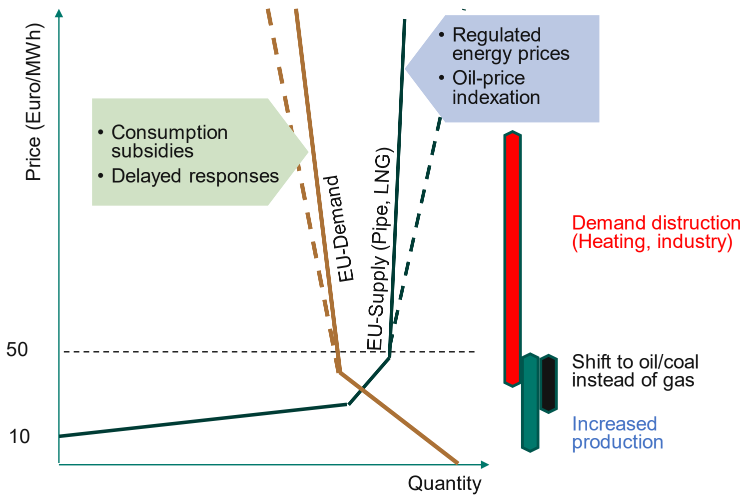

Figure 1: Factors determining gas supply and demand in the EU

EU demand response at extremely high prices is uncertain and limited

In general, natural gas demand is responsive to prices, particularly at price levels below 50 Euro/MWh. This is primarily due to the fact that different gas-fueled power generation technologies compete with different coal power generation technologies. The higher the gas price, the less gas and the more coal power generation will serve the electricity market, which leads to a reduction in demand for gas. In a "business-as-usual" environment, gas demand therefore strongly responds to gas prices. This effect is reinforced through district heating and industrial heat facilities with flexibility to use biomass, coal and gas which exhibit a similar fuel switch at the corresponding prices.

Once gas prices exceed the fuel shifting levels, further price response of gas demand will depend on demand adjustments in household heating, industrial production, and electricity consumption from both households and industry. Historic analysis shows that in the short-run, responses of demand to prices are moderate, due to potentially high costs of reducing demand, for example where gas or electricity are a necessary input to industrial processes (See table 1).

Table 1: Literature estimates of short-run gas demand elasticities.

	Region	Time	Consumer	Elasticity
Labandeira et al. 2017	Meta analysis	Since 1970s	Aggregated	-0,18
Aufhammer & Rubin 2018	USA, California	2003-2014	Households	-0,21
Steinbuks 2021	UK	1990-2007	Manufacturing	-0,2
Asche et al. 2012	Europe (12 countries)	1978-2002	Households	-0,242
Alberini et al. 2020	Ukraine	2013-2017	Households	-0,16
Andersen et al. 2011	Finland, France, Italy, UK	1978-2003	Industry	-0,06 to -0,18
Alberini et al. 2011	USA	1997-2007	Households	-0,572
Dagher 2011	USA, Colorado	1994-2006	Households	-0,091
Madlener et al. (2011)	OECD (12 countries)	1980-2008	Households	-0,24

The limited demand responsiveness is further reinforced by two more effects. First, there is a delay until price increases are passed through to consumers and there is a further delay until consumers become aware of the increased costs of their energy consumption. Second, government programs that shield household and industrial consumers from price increases with different types of subsidies lead to limited incentives for demand reduction. These subsidies may be least distortive when structured as lump-sum payments, but even lump-sum payments limit the exposure to the true costs and may thus in the short-term reduce the demand response. When such subsidies are not paid as a lump-sum but in proportion to gas consumption, the subsidies also reduce the marginal energy costs (e.g., through a gas price cap funded through government or via mechanisms by which a share of the gas costs are borne by the government). This further reduces incentives to save gas. While directly subsidizing gas prices creates inefficient incentives, distributional reasons may still encourage governments to pursue such subsidies. This is, because gas demand varies hugely among households and businesses, including also within income levels or sectors, and therefore lump-sum payments at the scale of average cost increases leave many consumers exposed while payments at the level of maximum cost increases result in high windfall profits (Kröger e.a. 2022).

Gas supply will hardly increase in the short-run, even at extremely high prices

Investments in gas exploration and production are typically large scale, complex and require specific technologies provided by highly skilled firms and staff which present a bottleneck in the realization of new projects. Given these constraints, even extremely high gas prices can at most accelerate the finalization of existing projects. Only highly modular and small-scale production of shale gas in North America can be scaled up faster, but even in that instance the ramp-up would require several months or longer. However, even if such additional gas supply in North America becomes available, it cannot quickly enter the global market, because LNG liquefaction capacity in North America is already used at levels close to full capacity and planning and construction of new terminals takes a long time (several years or more).

This also characterizes the challenges for additional LNG exports from other countries, or pipe-based supply from countries such as North-Africa or Norway to the EU. Even extremely high prices cannot deliver significant additional gas production or liquefaction capacity in the short-term (e.g. one year).

We expect existing facilities to already operate at fully capacity at very high prices, like 50 Euro/MWh that corresponds to a three-fold increase of historic price levels (Figure 2). Such high profitability already provides very strong incentives to accelerate any necessary maintenance procedures to limit downtime. Thus, in the short run global supply of natural gas can only marginally respond to price signals above the level of 50 Euros/MWh.

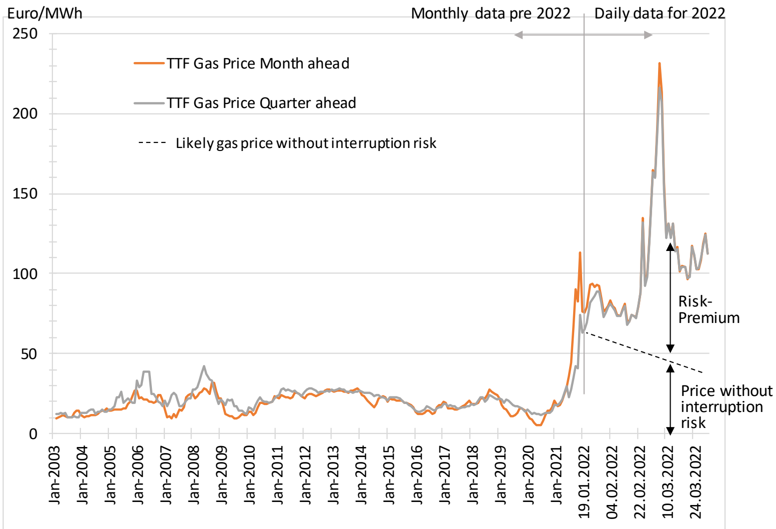

Figure 2 Historic gas price development

It is difficult to outcompete other LNG demand with extremely high prices

With global LNG supply at maximum capacity in the short run, the expectation is that increasing LNG prices due to higher willingness to pay in Europe will reduce demand in other LNG importing countries so as to increase gas available to the EU. There are historic examples for this. For example, after the Fukushima accident, Japan's demand for additional LNG was fulfilled through a redirection of shipments initially directed to the EU that were triggered by a LNG price increase to 45 Euro/MWh.

A similar development is in principle expected for the current gas shortage in Europe. The main competing LNG buyers to the EU are Japan, China, Korea and India. With increasing LNG prices, gas power generation in all of these countries will be replaced by coal and oil power generation, and consequently LNG import demand will be reduced. Very high gas prices of approximately 50 Euro/MWh will thus ensure that some LNG can be redirected to the EU (Karplus e.a. 2022).

However, a price increase above this fuel-switching price level will trigger only small additional demand reductions in Asia. The analysis by Karplus e.a. (2022) concludes that only a fraction of the demand in Asian countries will respond to extremely high price levels. Most household and industrial demand or gas and electricity is sold on regulated tariffs or tariffs linked to oil-price indexed long-term LNG imports, and will thus not be exposed to extremely high LNG spot prices.

With countries and companies largely hedged against extremely high LNG spot prices through long-term import contracts with oil-price indexation, there is also no political need for non-EU countries to expose domestic consumers to these spot prices. This is particularly true, if at the same time it is observable, that European governments attempt to shield their consumers against these extremely high prices as well.

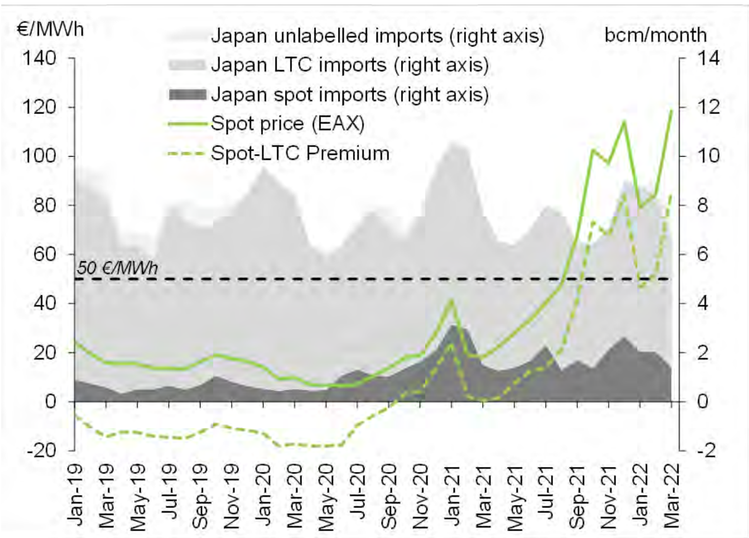

Figure 3: Japanese LNG imports did not decline in response to LNG spot prices increases end of 2021 and 2022. Source Karplus et al. (2022)

But without exposure of the final consumers to the extremely high LNG prices, they will also not respond to these prices. This can explain the trading patterns observed by Karplus et al. (2022). The extremely high LNG prices did not alter import patterns. As Figure 3 illustrates at the example of Japan, it was primarily domestic demand that was driving global LNG prices during the last years, whereas the price increases at the end of 2021 and in 2022 did not result in easily observable reductions of LNG imports.

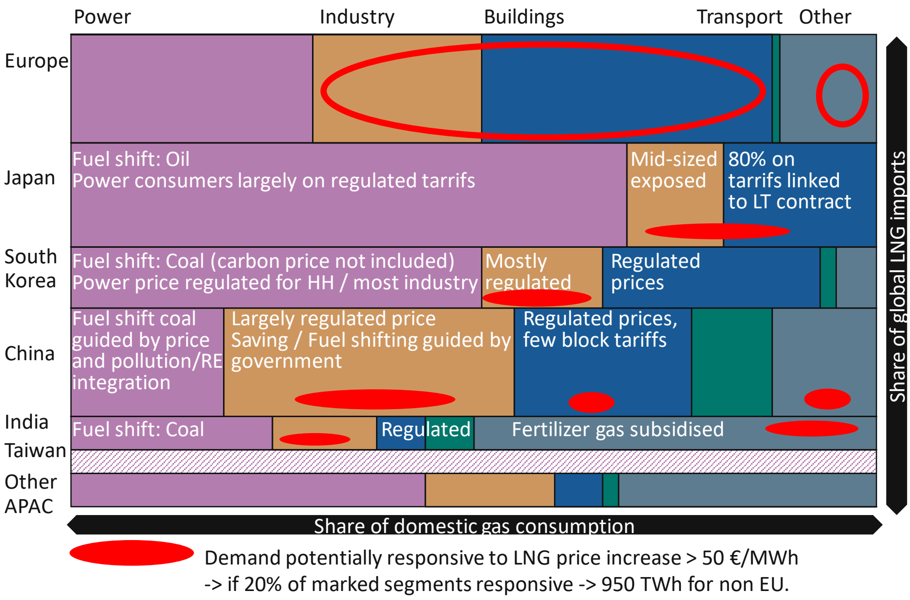

Figure 3: Global gas demand that potentially can respond to gas price increases. X-axis characterizes the share of gas use for different sectors in each country, Y-axis the share of LNG imports of the country from global supply. The red circles indicate the demand sectors that are exposed to LNG spot prices and would thus be likely to respond to price increases. (based on Karplus e.a. 2022)

Karplus e.a. (2022) identified a set of consumer segments that may well be partially or fully exposed to the LNG spot price level (Figure 3). With long-term import limiting the exposure to LNG spot prices, we assume very high LNG spot prices will not be passed on to final electricity prices and hence we do not anticipate a price-based reduction of gas demand from power generation beyond the significant reduction of electricity demand in addition to the reduction from fuel shifting. Assuming that 20% of gas demand in final demand sectors potentially exposed to global LNG spot prices, one might anticipate approximately 950 TWh of gas usage and implicitly thus also LNG demand outside of Europe to be responsive to extremely high LNG prices.

3. What could prepare the EU for a large-scale supply interruption?

To prepare for a sudden large-scale or even full disruption of the supplies of Russian gas, the EU Commission proposes two elements (EU Commission 2022):

First, the EU commission proposes that all member states should implement programs to reduce gas demand. For this, gas saving targets should be agreed at EU level for each member state to guide national and local implementation of gas saving programs.

Second, the EU commission proposes to agree on a maximum regulated price for natural gas delivered to EU consumers and companies to be applied in the case of a supply interruption.

Figure 4 depicts how these two measures would impact the supply and demand curve and the likelihood and level of a wholesale gas price clearing markets after a large-scale supply interruption. As a third element it depicts the benefits that may result if gas saving programs could also be implemented in partner countries with significant LNG imports to increase the net-supply available to the EU. As energy security cooperation, countries could thus provide mutual assistance in the case of large-scale supply interruptions.

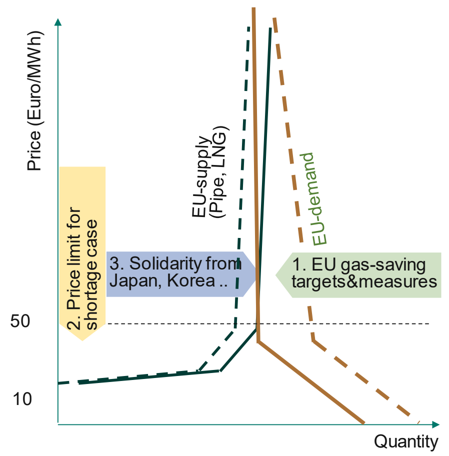

Figure 4: A combination of measures could allow EU to better cope with a large-scale supply interruption

National gas saving targets within the EU

International experience shows that there is a range of possible approaches to extreme supply shortages. At one extreme we have the highly successful example of Japan after the Fukushima accident, which managed to retain its energy system intact with a well-executed program of public campaigns and measures (Kimura and Nishio 2016) or South Africa that managed to cope exceptionally well with an extreme water shortage in 2017 and 2018 (Parks et al. 2019; Ziervogel 2019). At the other extreme, a failure to anticipate interactions and coordinate savings across gas and electricity systems contributed to the severity of the Texas power and gas supply interruptions in February 2021 (Joshua e.a. 2021).

Given the various non-market barriers to gas saving as well as large distributional implications of potentially very high prices outlined in the previous section, it seems warranted to implement government programs to realize gas savings in the current situation (Neuhoff et al., 2022). With highly inelastic short-term demand and supply it is unclear whether markets can clear given the scale of supply reduction that the interruption would entail. Thus, it needs to be clarified how gas will then be allocated between EU member states when such allocation cannot be done by the market. Agreed gas-saving targets for each member state could provide the basis for such an allocation. The 2020 renewable energy targets may serve as a successful blueprint for such targets. In the Renewable Energy Directive (Directive 2009/28/EC), the EU-scale target was broken down into binding contributions at the member state level. National governments had to provide and frequently update renewable energy action plans, and results were frequently monitored. Thus, government initiative and coordination was secured, and transparency and clear targets engaged the public.

To realize the necessary scale of gas savings, the EU Commission proposes that all member states contribute to gas savings (Commission 2022). This could be achieved, for example, with gas-saving targets defined for all member states, to be realized after a supply interruption. To prepare for potential non-market allocation of gas in security of supply (emergency) case, it may be desirable to already define such gas saving targets, albeit at a more moderate level, to be pursued prior to a supply interruption. EU-scale coordination would allow to recognize the positive externality of any national gas saving. Saving in any member state will help to reduce the price level across the EU (and possibly also for other LNG buyers), or reduce the required curtailment at EU scale.

Cooperation agreements for international gas savings and assistance

The EU is by far the biggest LNG spot buyer. Therefore, it can unilaterally implement a price limit that will cap global LNG spot prices. Taking the lead in setting a price limit involves a risk. In the case of unexpectedly high demand in Asian countries coinciding with a large-scale EU supply interruption, the Asian countries could serve their additional demand at a price of about 50 Euro/MWh. Situations that could trigger such an additional demand could, for example, be an earthquake in Japan. Current extraordinary circumstances (such as the Covid lock-down in China) are, to the contrary, likely to result in lower than anticipated economic activity and LNG demand.

The EU would therefore benefit, if it could cooperate with other countries and coordinate programs to reduce gas demand in case the security of supply incidences requires this to happen (Karplus et al. 2022). This could build on similar interests and experiences of partner countries such as Japan after the Fukushima disaster.

Cooperation with the UK should also be considered, as it remains closely integrated in the EU market. The more countries cooperate the lower the potential scale of curtailment for any country so that the incentive to join the cooperation will be larger once a sufficient number of countries have committed to it.

Countries have an incentive to join such an alliance since it reduces uncertainty in the long-run. While in the current situation the EU is particularly exposed, roles may well invert in the future. With similar challenges emerging for hydrogen imports such an alliance could also offer longer-term prospects. Hence, a security cooperation taking a longer-term perspective may be of additional value to partner countries.

Gas price limits

While gas saving targets within the EU and among other LNG importing countries may help to moderate the gas price in case of a large-scale supply interruption, significant uncertainty will remain about the precise implementation of such programs and their effect. Hence, uncertainty about the potential gas price level following a large-scale supply interruption will remain high even if such an agreement can be reached.

Furthermore, with remaining uncertainty on whether gas markets will clear across the EU, there also remains related uncertainty about how gas would be allocated across EU member states if markets fail to clear. In principle, gas could be allocated according to historic gas consumption levels minus the gas saving targets defined for each member state to the extent that physical transmission capacity and redirection of LNG imports would make this possible. In practice, however, the security of supply regulation has remained rather unspecific about any allocation using non-market allocation mechanisms so far (ENTSO-G. 2021). This is likely partially caused by the challenge to agree on a price for any transaction in such a scenario. A jointly agreed price limit could be used to determine the compensation for transactions when markets fail to clear.

To reduce these uncertainties, the EU Commission (2022) proposes to decide in advance on a price limit (maximum regulated price) to be applied in the case of large-scale supply interruption. As will be discussed in section 4, this avoids uncoordinated ad-hoc interventions after a supply interruption, and provides early clarity so as to limit market risks prior to a supply interruption

One option to implement the price limit could be through a requirement on gas system operators. Each system operator has, already now, the responsibility for a geographically defined part of the European gas transmission or distribution network. Market participants (shippers, gas suppliers, retailers …) nominate to the responsible system operator where they insert gas in the network (entry point) and where in the network it is delivered and consumed (exit point). If entry and exit nominations do not match, then gas system operators procure imbalance energy to match the difference and charge the corresponding costs to the market participants that caused the imbalance.

The price limit could be implemented by requiring the system operators not to pay a price above the price limit to procure gas to resolve imbalances. This would in turn limit the imbalance costs market participants incur if they have not acquired sufficient gas to serve their nominated demand. Market participants would not acquire gas at prices exceeding the price for imbalance energy, since it would be cheaper to pay imbalance costs instead.

Should a system operator not be able to secure sufficient gas to compensate for any imbalances, then the operator would be required to curtail demand according to the security of supply protocols. To avoid gaming between EU member states, it would be important that all (major) countries agree on the same price limit. The higher the commitment, e.g. through anchoring the limit in security of supply regulation and through complementing gas saving measures, the higher will be the credibility and impact on forward prices prior to the interruption.

4. Assessment of a limit on gas prices

The implementation of a gas price limit would be an important intervention that would affect multiple dimensions of European gas markets. Governments should hence be aware of its effects and design the instrument in a way that mitigates the risks and makes use of the advantages implied by such an instrument.

How does a price limit impact economic cost in case of a large-scale supply interruption?

Table 2 summarizes our assumptions to assess how such a price limit could impact the outcome after a large-scale supply interruption. Gas supply corresponding to 40% of EU's historic 4000 TWh annual gas demand (i.e., equal to the historic Russian gas supply) would be curtailed (McWilliams e.a. 2022).

We assume that 20% of the demand would be reduced in response to a combination of high prices and government programs (Burmeister et al. (2022) and FZ Jülich (2022) assumes 18%, BDEW (2022) 19% and Holz e.a. (2022) for optimistic scenario 18-26% gas demand reduction).

We furthermore assume that 14% of demand historically served by Russian imports could be met with additional LNG supply available at 50 Euro/MWh. Relative to IEA (2022) estimates of additional 30 bcm supply with theoretical potential of 60 bcm (approx. 7,5% and respectively 15% of demand) this is already an optimistic assumption and may imply that potentially even more gas savings may be required within the EU. Given that wholesale gas price levels have been persistently above historic price hikes (40 Euro/MWh) for more than half a year, some of additional LNG demand and demand reductions have already materialized compensating declining deliveries of Russian gas.

Table 2: Assumptions on supply-demand balance for modelling scenario

EU historic gas demand	4000 TWh
Historic Russian Gas supply (interrupted)	1600 TWh (40%)
Assumption on gas saving within EU	800 TWh (20%)
Assumption on additional gas supply at 50 Euro/MWh	560 TWh (14%)
Supply-demand gap to be filled	240 TWh (6%)

What happens to the remaining 6% of demand which is, in this scenario, not served? Let us first assume that a price increase in global LNG markets from 50 to 300 Euro/MWh would reduce the previously discussed 950 TWh of price-responsive gas demand in other LNG importing countries by a sufficient amount to meet the shortfall of EU demand. It would imply a short-term constant elasticity of supply of -0,16 slightly below the average short-term demand elasticity estimates we found in the literature (Table 1). The literature however largely estimates the demand response to final consumer prices. The demand response to wholesale prices is however lower because a 50% wholesale price increase only results in a 25% retail price increase due to additional charges and levies on retail prices.

This scenario can now be compared to an alternative scenario with an EU price limit. With the EU as biggest spot LNG buyer globally, not paying more than the price limit for gas, the global LNG spot price would most likely also decline to this limit level. Hence the anticipated demand reduction in third countries would not be incentivized, and the EU would receive less LNG at the scale of 6% of pre-crisis demand.

Figure 5 depicts the welfare costs in case the EU would not be able to deliver additional gas saving programs, but would instead have to curtail 6% of pre-crisis demand. It combines the costs to consumers for purchasing gas with the costs incurred for unserved load, assuming an extremely high value of lost load of 600 Euro/MWh that was mentioned in some conversations. Assuming a lower value of lost load increases the benefits of setting the price limit at a lower level.

The purchasing costs to consumers increase with the price limit. The costs for lost load decline with increasing price limit due to two effects. First, with higher price limits more LNG will be delivered to the EU and hence lower costs for load unserved occur. Secondly, with higher price limits the welfare loss from a unit of load declines as the gap between value of lost load and price declines. The results show that in the case of a supply interruption it is welfare enhancing for Europe to curtail some demand and pay for the remaining demand a very high price in order to avoid extremely high prices paid for all demand, even when the supply intervention is very large.

If on top of the price-based response, governments implement gas saving targets and programs domestically and in international cooperation, then the costs of unserved load will be lower than depicted in the scenarios below. Social campaigns for joint gas savings may be more successful, if customers understand that they serve to avoid extremely high prices and associated negative impacts for households and industry (Ziervogel 2019; Kimura and Nishio 2016).

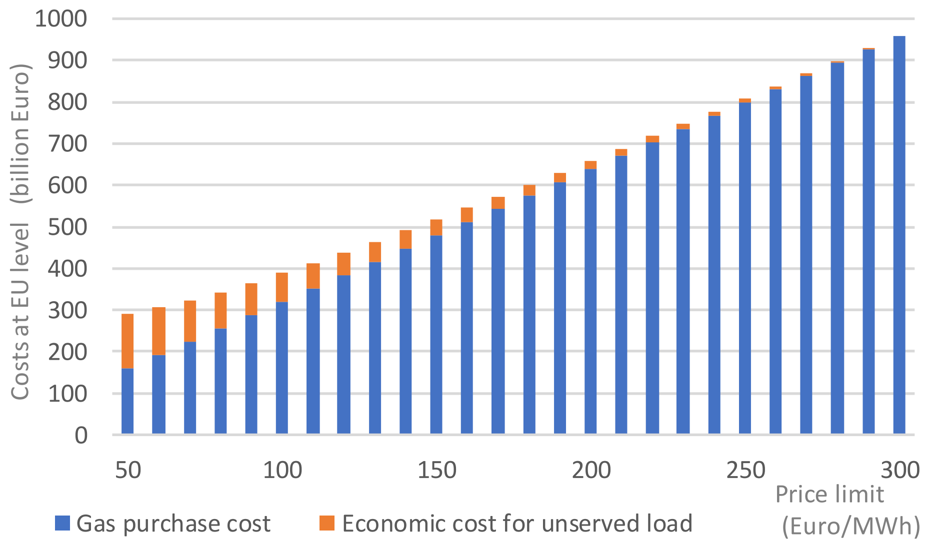

Figure 5. Costs to EU consumers after a supply interruption. Costs decline with the reduction of purchasing costs from a price limit. This result holds, even if EU fails to agree cooperation agreements with Asian buyers to jointly pursue gas saving programs and hence would have to curtail some demand. (It assumes EU demand response through government programs) [Fig. corrected July 2022]

Anticipation of gas-price limit in security of supply case already reduces costs today

In the recent months, gas supply to the EU has been high enough to refill storage sites to levels typical for this period of the year (Zachmann, Sgaravatti and McWilliams 2022) and the global supply-demand situation is no longer exceptional. Without concerns about a potential large-scale gas-supply interruption, gas prices should hence returned to levels below historic price hikes. Current gas price levels can be explained by a risk premium reflecting the expectation of a potential supply interruption and the resulting extremely high prices.

In a simplified calculation, we assume a gas price equilibrium without a risk of supply interruptions (e.g., if Russia and Ukraine would sign a peace deal tomorrow) at the level of 30 Euro/MWh. After a large-scale supply interruption, this price level is assumed to increase to 300 Euro/MWh. If market participants anticipate such an interruption with a likelihood of 25%, then risk-neutral pricing would suggest forward prices of about 100 Euro/MWh. A reduction (increase) of the anticipated likelihood of an interruption will – in this model – directly result in a reduction (increase) of gas prices both in spot and forward markets.

Figure 6 illustrates how the level of the anticipated price limit would impact the forward price if market participants have confidence in a pre-defined price limit which would kick in after a supply interruption. Interestingly enough, within a week of the publication of the EU Communication on

May 18th, forward-traded gas prices for 2022 declined by about 10 Euro/MWh. This is consistent with the assumption that expectations about the price to be seen after a supply interruption have declined.

The forward price level directly translates to spot prices, because market participants have incentives to store gas if forward prices significantly exceed spot prices. Hence the forward price also directly impacts the prices paid for spot gas and for gas imports. Assuming 1400 TWh annual imports from Russia linked to TTF prices, the credible announcement of a gas price limit for the case of a supply interruption would reduce these annual import costs from 140 billion to 56 billion Euro.

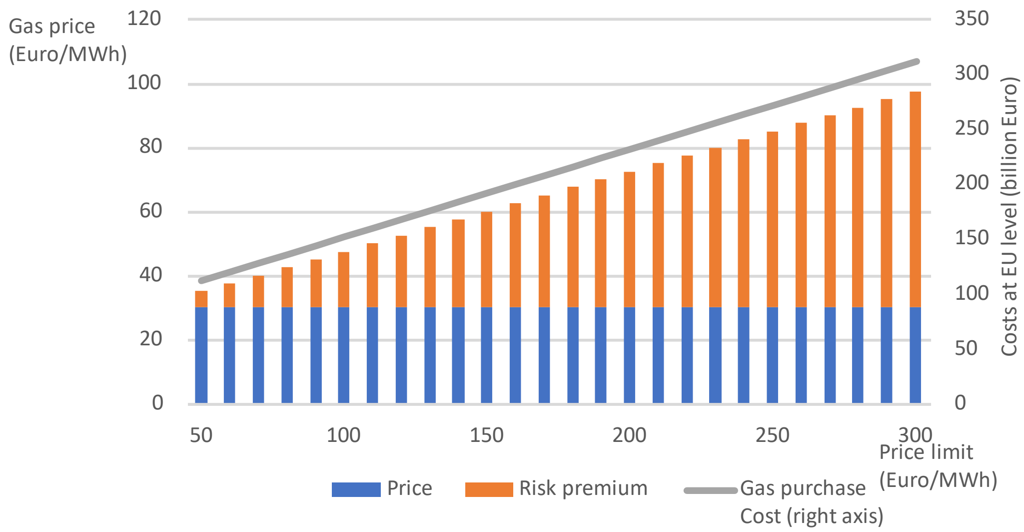

Figure 6: Prices and costs to EU consumers prior to a supply interruption. The price limit reduces the risk premium, and hence also future prices and gas purchasing costs.

As gas prices are setting the marginal power price across many hours in most EU member states, the lower gas prices will directly reduce the electricity costs for households and industry by the same order of magnitude.

The importance of gas storage requirements increases

A price limit for the security of supply case implies that future and spot prices decline. It would in principle result in higher EU demand and demand in other LNG importing countries, thus reducing the gas volumes available to fill storage. However, the ongoing energy security crisis does require refilling the storages for the next winter period. For this reason, and responding to the insufficient filling of storages during 2021, mandatory storage requirements should be agreed at the EU level for each member state (Wilson 2022). Their implementation using national regulation is even more important if a price limit is implemented. Defining additional milestones for gas storage filling levels should also be considered. To avoid that such gas storage requirements push gas prices to undesired (scarcity) levels, governments can strengthen gas saving programs already prior to a gas supply interruption.

If the announcement of a gas price limit were to reduce current spot prices from 100 Euro/MWh to 40 Euro/MWh, then non-EU gas demand competing for LNG would increase by approximately 130 TWh (assuming the same scale of price responsive demand and demand elasticity as in section 3 and assuming that price levels are above fuel shifting prices). Additional EU level measures to save 3% of gas would compensate for these reduced import volumes. This would be a benefit of defining and implementing gas saving targets already prior to an interruption.

In practice, EU level savings may not be required at such a scale, because with a gas price limit defined, the strategic producer (Russia) would face very different incentives. Currently, additional risks increase prices and revenues, and hence imply that reducing exports can actually increase revenue for Russian producers. This may be part of the motivation for Russia to cancel gas delivery contracts by stating that purchasers did not comply with the payment modalities that it required.

If, in contrast, the EU implements a price limit for the case of non-delivery of gas, and if it implements gas saving targets and measures that allow the EU to reduce gas consumption already prior to a gas interruption using non-price mechanisms, so as to avoid extreme scarcity, then the reductions of Russian exports would not result in price increases but “only” in increased gas saving efforts. In such a case, the only option for Russia to maximize revenue would be to maximize exports.

Linking gas price limit to global energy price indexes

As outlined in section 2, gas demand is very responsive to gas prices, if price changes can trigger a fuel shift from gas to coal, oil, or fuel oil, depending on the sector. Therefore, the gas price limit should be set high enough to ensure that gas power generation is the most expensive generation technology, so that these incentives remain intact.

To allow for such fuel shifts, it may therefore be warranted to index the gas price limit to an oil price index once oil prices exceed 100 Euro/barrel.

For the shift from coal to gas, a similar logic applies. At historic coal prices well below 100 Euro/ton, gas power generation was already more expensive than coal at 15 Euro/MWh gas prices. With recent price spikes of global coal prices to more than 300 Euro/ton, also the gas-coal shift point moved closer to 50 Euro/MWh. Should coal prices again escalate globally, then a coal price indexation might be necessary for coal to outcompete LNG in Korea, China and India. In this case, an indexation to global coal prices would be necessary.

Fuel shifting in EU power markets

Fuel shifting from gas to coal and fuel oil is also an option for gas savings in the EU. Due to carbon pricing on power generation and carbon emissions from coal-based power generation being about twice as high as from gas-based power generation, fuel shifting from gas to coal occurs at higher prices in the EU than in Asia. Even though Korea and China also have carbon pricing mechanisms, measures like free allocation granted to installations imply that it has limited impact for fuel choice.

This raises the question, whether a gas price limit should be also indexed to the price of EU coal delivery and EU ETS carbon price. This may not be advisable, because very high gas prices can, if coal supply is constrained, translate to high coal prices due to the previously described electricity market dynamics. Then the gas price limit would have forgone a co-benefit of avoiding escalating coal prices.

An alternative approach to ensure fuel shifting in power markets could be to explicitly constrain gas power generation. Until the 1990s incineration of gas for power generation was prohibited in the EU to ensure security of supply. Governments could re-impose limits on CCGT operation, similar to the operational limits for coal without scrubbers that were imposed by the Large Combustion Plant Directive (2001/80/EC). Thus, gas consumption for power generation would be reduced while implications for power prices would be moderate. One could also consider whether existing re-dispatch mechanisms could be used to achieve this objective – thus allowing for rapid implementation. A further approach could be a charging mechanism similar to the UK carbon price floor. An charge could be imposed on gas power generation to ensure coal runs before gas.

All three approaches differ from current proposals for gas price caps that involve government subsidies for gas power generation to reduce the power price impact of very high gas prices, in that they do not create costs to governments. The third proposal would even create revenues. They do, however, require carefully assessment for example in how they impact existing contract structures.

5. Conclusion

With gas demand and net-supply becoming highly inelastic once price levels exceed fuel shifting options, a large supply interruption creates the risk of extremely high and highly uncertain prices. It is unclear whether these prices will clear the market and facilitate an effective gas allocation across EU member states. On top of this, such prices would imply huge economic costs for households with limited budget and for industry competing in global markets. They would likely trigger policy intervention across a set of EU countries, which, if uncoordinated, may further increase uncertainty and costs.

The EU Commission therefore proposes to prepare ahead of a crisis for such an outcome by agreeing gas saving targets to be achieved by member states through dedicated measures. If the targets were implemented already now at a moderate scale this could ensure the preparation of the necessary governance and programs, facilitate learning and accelerate the refilling of gas storages. The EU Commission also proposes to define a price limit for the case of a large-scale supply interruption. This would avoid excessive. costs and pre-empt ad-hoc measures of market intervention otherwise to be anticipated. In addition, it should be considered to develop a gas security of supply cooperation with Japan, Korea – and if possible also India and China – in order to provide mutual assistance in situations of extreme shocks through government gas saving programs that release LNG for emergency assistance.

The analysis of the package provided in this paper suggests that the EU will benefit in the case of a large-scale supply interruption from each of the various effects of a price limit. In particular, while the price limit could reduce the available LNG imports by 6% compared to a scenario in which EU and global LNG prices escalate to 300 Euro/MWh, the limited gas price implies that households and consumers save more from lower prices than they incur costs in terms of unserved load. The case for a price limit is further strengthened, if international security cooperation were to make some additional LNG imports available already at the level of the price limit, e.g. through government gas saving programs implemented in Asian countries.

The benefits that such a response strategy can bring after a large-scale supply interruption allow governments to credibly commit to such a response strategy already ahead of any potential large-scale supply interruption. This in turn would reduce the large risk premium currently driving EU-gas prices and thus also global LNG market prices. This would reduce costs to EU consumers and payments to gas producers – currently at the scale of 400 billion Euro annually – by a factor of 2.5.

This risk premium currently results from the strategic non-cooperative behavior of the largest gas supplier, Russia, which benefits from creating uncertainty and partially limiting gas exports and thus escalates gas prices and its revenue. From a competition policy perspective, a price-limit for the case of a supply interruption would reduce the incentives for Russia to create uncertainty and to increase the risk premium, and thus would help to stabilize energy markets.

To ensure that fuel shifting from gas to coal and oil in Asian countries does take place even in the absence of the security cooperation, it seems warranted to increase the price limit if the oil price should increase significantly above 100 Euro/barrel. For fuel shifting in EU power markets, even higher gas price limits may be necessary due to the carbon pricing incentives associated with the EU ETS. Alternatively, it should be considered to directly limit the scale of gas power generation. This could build on historic constraints of gas usage for power generation.

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