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Rüdiger Bachmann
Moritz Kuhn
Benjamin Moll
Moritz Schularick
David Baqaee
Andreas Löschel
Andreas Peichl
Georg Zachmann
Christian Bayer
Ben McWilliams
Karen Pittel

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Rüdiger Bachmann, David Baqaee, Christian Bayer, Moritz Kuhn, Andreas Löschel, Ben McWilliams, Benjamin Moll, Andreas Peichl, Karen Pittel, Moritz Schularick, Georg Zachmann*

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**Abstract**

An end to gas supplies from Russia has recently become much more likely. Russian supply volumes have already been substantially reduced, and uncertainty about future supplies and the winter supply situation is high. In this study, we ask what the economic consequences would be of a complete halt to Russian gas imports at present (August 2022).

Almost five months have passed since our first study, "What if" (Bachmann et al., 2022), on the economic effects of a March 2022 Russian energy import freeze. The debate sparked by the study has sharpened the focus on the issues and assumptions that are critical to estimating the economic costs of a Russian energy import freeze. In this study, we update the results based on the situation in August 2022.[1]

(i) We estimate the necessary demand reduction that would result if Russian gas imports were halted from August 2022 and discuss economic policy strategies to achieve this adjustment. (ii) We update our estimated expected economic costs and discuss practical examples of substitution options in the industrial sector. (iii) We evaluate the federal government's economic policy, in particular its decision to increase storage levels with continued gas imports from Russia since March 2022, but to largely forego measures to reduce gas demand in power generation, industry, and residential and commercial sectors.

The key findings of the study can be summarized as follows:

In the event of a complete loss of Russian gas supplies in the next few weeks, Germany will have to reduce its gas demand by around 25% (equivalent to 210 TWh) by the end of the coming heating period (April 2023), even if the planned liquefied natural gas terminals come on stream as planned in the winter. When factoring in the savings in gas demand that can be achieved through alternative energy sources in power generation, this leaves an adjustment of about 20% of gas consumption that must be borne by industry, households, businesses, and the public sector. Such a reduction is feasible in a collective effort if measures are taken

[1] The focus of the analysis is exclusively on the effects of a halt to Russian gas imports. We had already argued in March that an end to Russian oil and coal imports could be implemented at a comparatively low cost. After some initial hesitation, policymakers have adopted this view, and decisions have now been taken to stop such imports in the future.

* Rüdiger Bachmann: University of Notre Dame; David Baqaee: University of California, Los Angeles; Christian Bayer: University of Bonn; Moritz Kuhn: University of Bonn and ECONtribute; Andreas Löschel: Ruhr-University Bochum; Ben McWilliams: Bruegel; Benjamin Moll: London School of Economics; Andreas Peichl: Ifo Institute for Economic Research, University of Munich; Karen Pittel: Ifo Institute for Economic Research, University of Munich; Moritz Schularick: Sciences Po Paris, University of Bonn and ECONtribute; Georg Zachmann: Bruegel. We are very grateful to Sven Eis for excellent research assistance.

quickly to save gas. The good news from our study is that Germany can get through the winter without Russian gas. Panic mongering is out of place.

Nevertheless, it should be clear to everyone that the Russian invasion of Ukraine has made Germany permanently poorer. The days of cheap energy are over and collective efforts are needed to make the economy crisis-proof. Reducing gas consumption is feasible, but it comes at an economic cost. In particular, there is much less time now to substitute gas in the industrial sector and power generation than in the spring. It is difficult to estimate how many companies have made the sometimes costly investments in alternatives even without the appropriate political framework. However, it has become clear that the view that gas substitution was not possible at all within six months was wrong. There are now numerous examples of substantial substitution possibilities, including in the chemical and glass production industries.[2]

The bottom line is that the economic costs of adjusting to an import freeze are likely to remain similar to those of committing to an import freeze already in the spring. This is because the gas gap is smaller than in the spring, but the remaining adjustment period is shorter. In this respect, the costs remain substantial, but manageable with appropriate economic policy measures. There is no threat of mass poverty or popular uprisings in the event of a halt to Russian gas imports. The economy will face production losses of a magnitude that Germany has already managed in the past when it had to face economic shocks. It is also important to interpret the effects of a gas import stop relative to a scenario without an import stop. For example, Germany could fall into recession even without an import freeze.

The assessment of the German government's strategy of not enforcing an early demand adjustment and continuing gas imports from Russia despite the war of aggression on Ukraine is ambivalent. Although a good 100 TWh of gas was stored from April to July, without Russian supplies the need for adjustment on the demand side remains substantial at 25% until the end of the next heating period. In a counterfactual scenario, in which Germany would have had to manage without Russian gas imports as early as from April onwards, demand would have had to be reduced by 31%, a good 6 percentage points more. Yet in return, there would have been more time to prepare the appropriate adjustments for the winter heating period. Even if the storage facilities were filled to 100% in the fall, Germany would remain dependent on Russian imports for normal winter consumption and would thus remain vulnerable to blackmail from Moscow. This is because the storage facilities only have a total capacity of below 250 TWh, which is roughly equivalent to the consumption of two winter months. In this respect, the focus on storage levels and the neglect of adaptation measures was not suitable to end Germany's dependence on Russia and its political blackmail ability completely and quickly.

While closer cooperation with European partners could have mitigated the necessary reduction in gas demand in Germany, there is still a risk that national go-it-alone efforts will undermine essential European energy solidarity. In any case, the BMWK's efforts to build LNG terminals and diversify gas supplies through imports from third countries are positive. However, this could have been done even with an import freeze or tariff solutions in March.

[2] See the examples in section 2.

## 1. Estimation of the necessary reduction of gas demand

The following analysis estimates the necessary demand reduction that would result in the event of a halt to Russian gas imports from August 2022. We build upon the work of McWilliams and Zachmann (2022) and the analyses of the Gemeinschaftsdiagnose (2022a,b,c). Our scenarios assume that a storage level of about 20% should be ensured throughout to provide enough buffer for a cold winter or other interruptions.[3] If policymakers are less risk-averse here and if it is technically feasible, lower storage levels are conceivable, which would reduce the need for adjustment on the demand side accordingly. It is also possible to adjust during the year, as forecasts become more precise, to ensure that the cost of demand reduction matches as closely as possible the value of expected storage at the end of the winter.[4]

Relative to the situation in March, the situation on the supply side is better today due to the anticipated start-up of liquefied natural gas terminals, higher storage levels, and additional imports from third countries. At the same time, relatively little has happened on the demand side to reduce gas consumption and promote the fastest possible adjustment for industry and households. In the area of electricity production, gas consumption wasn't lower than in previous years.

### 1.1 Gas supply

In the last four months, important steps have been taken to increase imports from other countries and thus become less dependent on Russian gas supplies. The share of imports from Russia has fallen significantly and was already below 40% on average between March and June.[5] The construction of floating liquefied natural gas terminals in various northern German ports is expected to be completed by next winter, giving Germany additional import capacity.

The political decision to stick to gas imports from Russia despite the Russian war of aggression on Ukraine has also made it possible to increase the filling levels of German gas storage facilities by a good 100 TWh to around 70%. It should be noted here, however, that the storage facilities only have a total capacity of just below 250 TWh, which is roughly equivalent to the consumption of two winter months.

In the event of an immediate halt to Russian gas supplies in August 2022, Germany would have to manage significantly lower supplies over the coming winter than in previous years. The gas that will be available in the coming months in the event of a loss of Russian

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[3] Our analysis differs from the Gemeinschaftsdiagnose (GD) in numerous details. The main difference is the GD's assumption that the production function of each sector is Leontief, i.e. there is no substitution. This only occurs at downstream production stages. In our simulation, we assume a low but positive elasticity of substitution of 0.1. We assume that the level of gas storage should not fall below 20% as a buffer, while in DG the storage is completely emptied. While we also consider cascading effects in our modeling, DG supplemented its supply-side modeling with a macroeconomic cycle analysis.

[4] See https://www.daswetter.com/nachrichten/vorhersage/winterprognose-wie-wird-der-winter.html.

[5] See https://www.bmwk.de/Redaktion/DE/Parlamentarische-Anfragen/2022/06/6-203.pdf?__blob=publicationFile&v=4.

supplies, results from pipeline imports from third countries, new liquefied natural gas terminals, domestic production, and stored gas.

From non-Russian sources, Germany can currently access supplies of around 52 TWh per month. Starting in December or January, the new LNG terminals will add about 8 TWh per month, based on the assumption that additional LNG volumes are procured on the world market and that Germany transfers about 30% of the additional LNG imports to other European countries, as it does with other gas imports (see McWilliams and Zachmann, 2022).

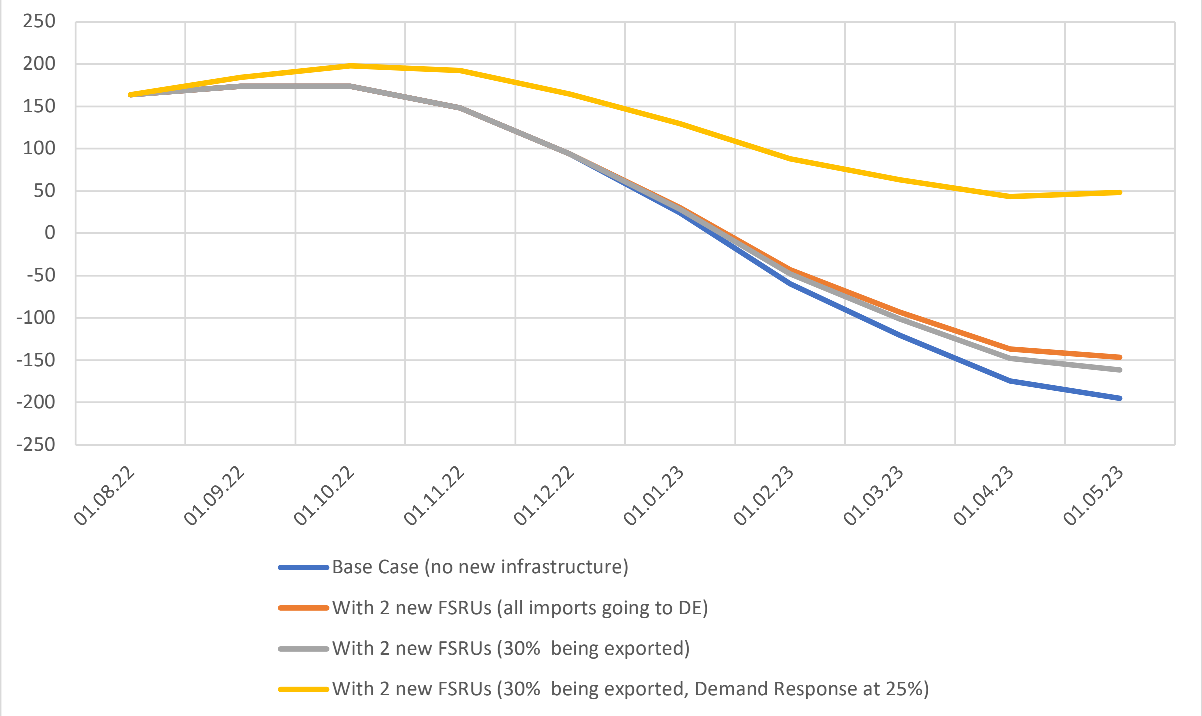
Assuming that storage levels do not fall below 20% of storage capacity, even over the heating season, e.g., to provide a buffer for a particularly harsh winter or for supply disruptions from other sources, Germany will need to reduce its gas demand by 210 TWh, or 25% relative to average demand in previous years in the August-April period (829 TWh), by the end of the coming heating season.[6][7]

Figure 1 shows the progression of storage levels in different scenarios for a) demand as in previous years and b) demand reduced by 25%. The logic is simple. Without Russian gas supplies and without demand reduction, there would be a shortfall of 210 TWh by the end of the heating season in early May to reach the assumed minimum storage level of 48 TWh. This represents 25% of the usual total demand of 829 TWh from the beginning of August to the end of April. Therefore, demand must decrease by an average of 25% over this period, about 23 TWh per month.

[6] McWilliams and Zachmann (2022) calculated a necessary demand reduction of 29% using the fundamentally identical methodology. The lower 25% in the current study is explained by the fact that we include the construction of floating LNG terminals, whereas McWilliams and Zachmann did not. BNetzA (2022) arrives at similar figures in scenario 2.1, as do Ragwitz et al. (2022).

[7] By way of comparison, in our March study we had used a simpler methodology to calculate a necessary reduction in gas consumption of around 30%, but without LNG terminals and *after factoring in the savings that can be achieved through alternative energy sources in power generation*. Thus, the two figures are not directly comparable not only because of the different methodology, but also because the figures answer different questions. As we explain in Part 3 below, the necessary savings after substitution in power generation is factored in is about 20% for a supply freeze in August (using the methodology of the current study).

**Figure 1: Evolution of German storage levels in different scenarios (TWh)**




*Notes: This figure shows the development of German storage levels in terawatt hours (TWh) for different scenarios. A distinction is made between the base scenario (blue line) and three other scenarios. The three other scenarios show the development taking into account two new floating storage and regasification units (FSRUs). The difference in the three scenarios is that in the first scenario all imports flow to Germany (orange line), in the second scenario 30% is re-exported (gray line) and in the third scenario 30% is exported and a demand reduction of 25% takes place (yellow line).*

### 1.2 Potential for reducing demand

To achieve this adjustment, there are three levers in the coming months: first, to reduce the consumption of gas in power generation; second, to reduce the consumption of gas for heating buildings; and third, to both reduce and substitute gas consumption in industry.

#### 1.2.1 Substitution of gas in electricity production

By the end of summer 2022, gas consumption for power generation was around the long-term average, despite high gas prices. Existing reserves were not fully utilized, no additional lignite-fired power plants were connected to the grid, and hard coal-fired power plants were only connected with a delay. Primarily, coal-fired power plants were only placed in reserve. On October 1, the lignite-fired power plants will be fully connected to the grid. Consideration is being given to extending the operating time of the remaining nuclear power plants that can be made operational again. Even if it is currently not clear to what extent nuclear energy is needed to maintain the security of supply, the decision on a lifetime extension must be made soon.

Realistically, replacing gas-fired power plants can only reduce gas demand by about 6-7 TWh/month, since not all gas-fired power plants can be dispensed with in winter as they are partly used for district heat generation. Natural gas will also likely continue to be needed at peak load times with low electricity production from renewables to meet electricity demand and compensate for shortages. The extent to which existing power plant capacity will be sufficient to replace gas-based captive power generation by industry remains to be seen. The experience of the last few months shows that coal-fired power plants are slowly coming onto the market and that the replacement of natural gas with coal has so far been limited due to the different functions in power generation (use of natural gas as a complement for the fluctuating feed-in of renewable energies, combined heat and power generation). In the European electricity network, however, German additional generation, for example by coal-fired power plants, could also replace gas in the electricity generation of other member states (e.g., Italy).[8]

Assuming that gas consumption for electricity generation can be reduced by about 6-7 TWh per month, this leaves a monthly adjustment requirement of 16-17 TWh on average, with peaks of up to 30 TWh in winter (relative to average consumption in previous years) that will have to be borne by households and industry.

#### 1.2.2 Savings potential for households and commerce

Heat for buildings accounts for the majority of gas consumption in the winter months (see Figure 2). Savings efforts have a particularly strong impact here. A realistically achievable savings contribution from households and businesses is around 15 percent of their consumption. For heating, this corresponds roughly to a reduction in room temperature of up to 2.5°C.[9] Additional measures such as thermal insulation can enhance the effect. Based on the average consumption of these sectors of just over 360 TWh for the period from August to April in 2019-2021, a 16% reduction in consumption corresponds to a savings contribution of 60 TWh in the heating season or about 6-7 TWh per month. To achieve this, strong pecuniary and soft non-monetary incentives are needed.[10]

A reduction in average temperature can also be achieved if fewer rooms are heated, or if certain rooms are heated only temporarily. In this context, investments that can be implemented in the short term, such as smart thermostats, the insulation of windows and doors, or the adjustment of heating systems, can reduce the comfort loss of the savings. In addition, maximum efforts to renovate buildings to make them more energy-efficient, to expand hybrid forms of heating (e.g., installation of inverter air-conditioning systems, etc.) and district heating make the adjustment less painful, but time is now running out for the coming winter to achieve substantial savings here.

In addition to private households, retail trade and the public sector are also important consumers of heating energy. Common to all these sectors is that the existing contractual structures with the utilities do not allow for an immediate pass-through of spot market prices for gas or that there is no immediate incentive to save. Appeals for thrift will therefore not suffice here either. Acting as early as possible and adjusting prices will help households and businesses to take advantage of technical margins instead of saving gas via lower room temperatures only. Organizational margins for saving heating energy must also be examined

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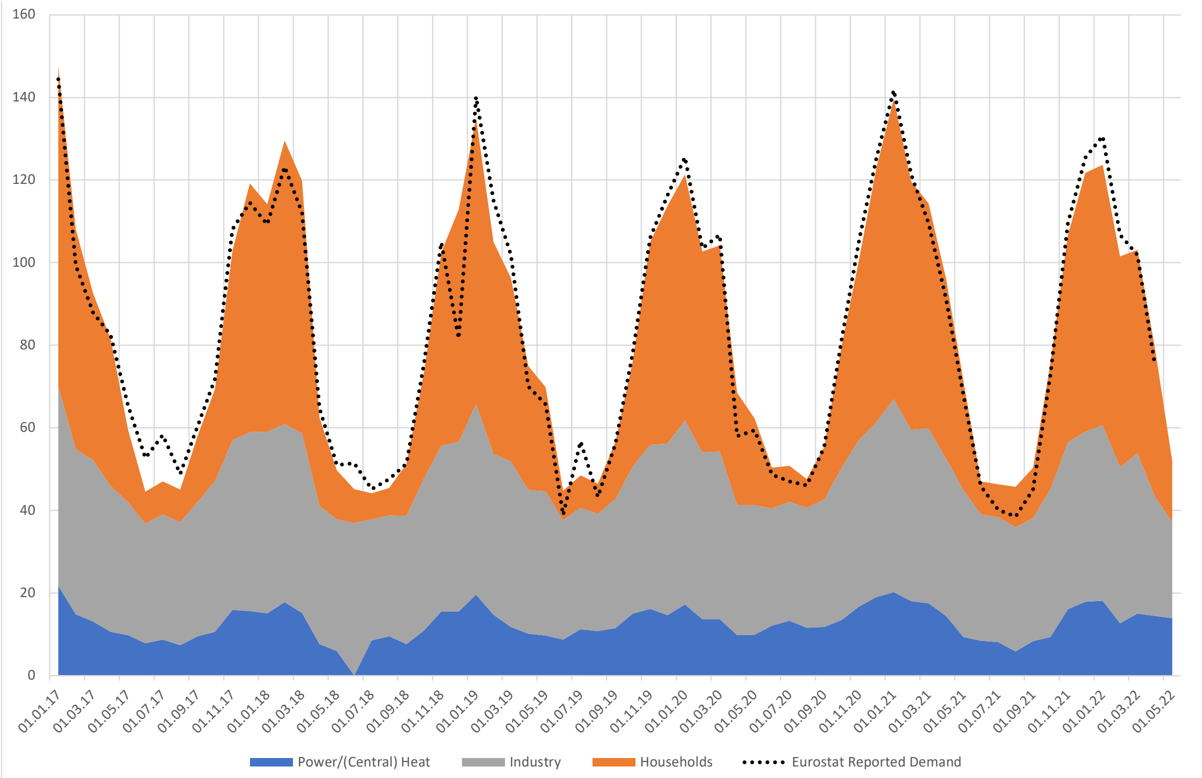
[8] https://www.bdew.de/media/documents/Brennstoffeinsatz_Erdgas_Vgl_VJ_monatlich_online_o_monatlich_Ki_08062022.pdf.

[9] https://www.umweltbundesamt.de/presse/pressemitteilungen/sparsam-durch-die-energiekrise

[10] Each degree of room temperature reduces heating energy consumption by about 6%. Households and businesses together consumed about 430 TWh of gas in 2021. Most of this is for heating and during the winter months. See Figure 2.

and, if necessary, prepared by the private sector (home office, shorter store opening hours, etc.).

**Figure 2: German natural gas demand (TWh)**




*Notes: This figure depicts German natural gas consumption in terawatt hours (TWh) from the beginning of 2017 to mid-2022. A distinction is made between natural gas consumption by electricity and district heating (blue area), consumption by industry (gray area), and consumption by households (orange area). The black dotted line reflects total natural gas consumption. Source: Eurostat and Trading Hub Europe.*

However, existing contracts of the end consumers with long-term fixed prices prevent the adjustment. The new §24 EnSiG regulates a right to adjust prices and removes this price rigidity. Its aim, however, is to relieve utilities that have run into difficulties, not to set uniform price incentives. The same applies to §26 EnSiG.

A design flaw of the law is that it does not provide compensation payments to consumers. End customers are deprived of a right to purchase at a contractually agreed price without compensation in favor of the utilities. This could make the scheme politically and potentially legally difficult to sustain. At the same time, however, a price adjustment is necessary to reduce the heating energy consumed.

In terms of economic policy, it would make sense to require a price adjustment of all gas and electricity contracts to a current tariff, which would be linked to compensation. Such compensation would have to be based on the past consumption of the property. For details of such a mechanism, see text box below.

**Compensation according to previous year's consumption**

Legislation could require utilities to provide a share of the price adjustment, e.g., 80 percent, multiplied by the previous year's consumption of the end-use customer or heated property as a credit for future bills. If the remaining term of the contract is shorter or longer, the credit would have to be adjusted accordingly. Such a credit leaves financial incentives to save gas unchanged at a high level, but end-use customers are not unilaterally burdened by the price adjustment. The kilowatt hour consumed continues to cost a lot. At the same time, it compensates partially for the disadvantage caused by the price adjustment, reduces distributional effects, and thus increases political resilience.

A numerical example helps to explain the mechanism. In this example, we assume that the original gas price in 2021 was 8 ct/kWh and that the original consumption quantity was 10,000 kWh. The gas price after the contract adjustment would be 32 ct/kWh, four times the amount.[11] A price subsidy of 80% of the price increase would raise the end-user price to 12.8 ct/kWh, thus relieving the consumer financially by €1920 if consumption remained the same. However, it strongly weakens the gas saving incentives. A limited adjustment of the end customer's contract has exactly the same effect as such a subsidy, but the burden is first on the utility company, which then has to be supported by the state in the second step, if necessary.

The proposed instrument, on the other hand, gives the consumer a credit based on the previous year's consumption in the same amount of 10,000*(4-1)*8ct/kWh*80% = €1920. The consumer then decides what to do with this credit. She can either buy an unchanged amount of gas of 10,000 kWh or she can save gas and spend the money she saves from the credit on future gas bills elsewhere. Many consumers will likely choose the second option.

Fundamentally, it is important to separate the issue of utility bailouts from the issue of price incentives for gas conservation. If necessary, a tax-transfer solution that is detached from utilities would be a legally sound option. It is important to emphasize that the proposed instrument "lets market prices work" and compensates (as opposed to a price subsidy) without destroying the savings incentives it creates and gas saving is not additionally "paid for".

**Tax-transfer solution when market price adjustments are not sufficient**

A related option would be to impose a tax on protected sector end-use customers, offset by a refund based on average property consumption between 2019 and 2021. At current wholesale gas prices, a tax rate of 20 ct per kWh seems appropriate for legacy contracts. Assuming 80 percent again, the credit would then be 16 ct per kWh. If necessary, the tax would have to be adjusted gradually depending on when the contract was signed.

Consumers who exceed the 20% savings target would thus be relieved, and consumers who do not meet it would be moderately burdened. Although this relieves the burden on utilities only indirectly via lower volumes and equilibrium price effects, it sets strong incentives to save gas.

With a well-chosen calibration of the tax levied and the rebate, such a solution would be neither a net burden for households nor a fiscal burden for the state. This measure is largely equivalent in effect to the energy-saving bonus proposed by Scheer and Südekum[12], but allows calibration via

[11] The quadrupling is chosen here because it roughly corresponds to the necessary price increase to achieve a 15% demand reduction at a demand elasticity of 10%.

[12] https://www.nina-scheer.de/2022/06/21/mit-energiesparbonus-gaspreise-daempfen-und-verfuegbarkeit-sichern/

the level of the rebate, which limits the fiscal cost. This is shown by the following formula for the net burden on a household when the compensation rate α approximates the ratio of consumption in 2022 to consumption in 2021, where τ is the tax collected:

$$NetTransfer = Credit - Tax = \alpha\tau\ Consumption_{21} - \tau\ Consumption_{22}\ .$$

We had already proposed such a mechanism in March and this proposal, partly in a slightly modified form, has found support from colleagues several times (Achim Wambach in Handelsblatt, Martin Hellwig and Gabriel Felbermayr in FAZ, most recently Jens Südekum and Nina Scheer).[13]

**Utilities and information obligations**

Both approaches relieve the utilities only indirectly. The latter would therefore, if necessary, have to be directly supported (partially nationalized) by the government, if the indirect relief is insufficient. Nor do the proposals serve to cushion the distributional consequences of higher energy prices per se – especially if they are calibrated in such a way that there is no net burden or relief on average. Distributional goals would therefore have to be addressed in parallel. In the tax-transfer mechanism above, for example, one could implement a cap on the credit as well as some minimum credit, or choose a more generous replacement rate α.

A particular challenge with any measure will be that many end-use customers do not have a direct contract with their utilities but, as renters, have only an indirect contractual relationship through their landlord. For such a measure to be effective, tenants must be made aware of what they are doing for their own wallets when they curb their consumption. Mandatory individual and public information on gas prices and potential savings is an important tool here.[14] Consideration should also be given to even more consumption-based billing of heating costs in tenancy law. A sensible legal change here could be to make it mandatory to separate fuel costs from other costs and to introduce the obligation for purely consumption-based billing for fuel costs. In addition, feedback on current gas consumption and the associated costs or savings achieved could strengthen efforts. Initial approaches to this are already in place.[15]

### 1.2.3 Consumption reduction in industry

The remaining 90 TWh (or about 10 TWh per month) will have to be saved by industry. Since industry consumes about 37 TWh of gas per month from August to April, a reduction of slightly more than 25% is necessary. If weaker incentives are applied to households, industry will have to shoulder more adjustment.

The decline in industrial gas consumption in May and June this year underscores that saving potentials do exist. Timely price signals are particularly important for industry. Incentives to do so have not been fully sufficient to date: companies will expect to continue to be supported by the state in the event of outages. This is becoming a problem, because the costs of inadequate provision are thus partly socialized.

[13] https://www.handelsblatt.com/meinung/gastbeitraege/kommentar-hohe-gaspreise-helfen-zu-sparen/28224846.html; https://www.faz.net/aktuell/wirtschaft/russisches-gas-abhaengigkeit-muss-reduziert-werden-17970427.html; https://www.nina-scheer.de/2022/06/21/mit-energiesparbonus-gaspreise-daempfen-und-verfuegbarkeit-sichern/.

[14] See also https://www.faz.net/aktuell/wirtschaft/gassparen-mit-weichen-anreizen-18214542.html on the role of soft measures in energy conservation.

[15] https://www.netze-bw.de/gastacho

A reduction in consumption will not be possible without temporary declines in production in the manufacturing sector, especially the chemical industry. The chemical industry alone contributes 13 percent of gas consumption over the year, but only about one percent of value added. It will be important to prevent the decline from spilling over to downstream sectors. These must prepare in time and, where possible, source gas-intensive products from countries that do not depend on Russian gas. New supply chains from non-EU countries must be encouraged.

The German government can, for example, promote the creation of new supply chains for basic materials by pushing for (temporarily) lower import tariffs for corresponding products. For example, certain energy-intensive precursors in the metal-producing industry can be purchased on the world market, as can ammonia and urea in the chemical industry or simple products in glass production such as beverage bottles. This then leads to a drop in production for the domestic manufacturers concerned, but avoids cascading effects on other industries and reduces gas consumption in winter.

By supporting the procurement of energy-intensive intermediate products from outside the EU, the industrial core can also be protected from further distortions and the pressure on producer prices reduced. In this context, it should already be communicated for the longer term which energy sources will be available to German industry in the future and whether the government expects imports from Russia to be largely halted in the coming years as well, so that industry can already invest in sustainable solutions today.

If these measures or a gas shortage lead to temporary production losses, it will be important to support the affected workers through appropriate measures such as short-time working. Workers in particularly gas-intensive production processes should also be supported in moving to adequate jobs that are no longer dependent on cheap natural gas.

### 1.2.4 How it can be done

The consumption reductions described in Parts 1.2.1 to 1.2.3 are sufficient to close the gas gap calculated in Part 1.1 of about 210 TWh, or 25% of typical consumption between early August and early May. Table 1 shows the calculated potential for consumption reduction. The table also shows the share of the necessary reduction in the individual sector in the period from August to April.

With savings of 60 TWh in electricity generation (6-7 TWh per month) and reductions of about 60 TWh (6-7 TWh per month) by households and small businesses plus 90 TWh (10 TWh per month) in industry, the savings target of 210 TWh can be achieved. It is important to emphasize here that these figures do not describe the consumption reductions *in each individual month*, but the average over the 9 months from August to May. In particular, for residential and commercial building heating, a large part of the required 60 TWh will have to be achieved during the heating season due to the strong seasonality of gas consumption.

Of course, it is possible that the shares of the three sectors could shift slightly. If it is possible to reduce industrial gas demand by 30% (100 TWh) because of greater substitution opportunities, then the required savings in households and in electricity production would decrease accordingly. Larger savings in households and commerce would correspondingly reduce the need for industrial demand reduction.

**Table 1: Summary of consumption reduction by sector**

| Demand reduction due to | Reduction August until April (9 months) | Reduction average per month | Relative to consumption in previous years* |
|---|---|---|---|
| **Electricity production (Part 1.2.1)** | 60 TWh | 6-7 TWh | 45% |
| **Households (Part 1.2.2)** | 60 TWh | 6-7 TWh | 16% |
| **Industry (Part 1.2.3)** | 90 TWh | 10 TWh | 26% |
| **Sum (= Savings)** | 210 TWh | 23 TWh | 25% |

* Relative to average consumption in the months of August to the end of April in 2019, 2020, 2021.

## 2. Economic consequences of the gas gap

Since March, the supply of gas has been expanded by filling up storage facilities, but important time has been lost to achieve greater reductions in consumption by households and industry. How these two opposing factors affect the vulnerability of the German economy and thus Russia's remaining threat potential is the key question we have yet to answer. We update our March estimates for the economic costs of gas reduction based on developments on the supply and demand side in recent months.

In the scenario described above, the German economy would have to manage with around 25% less gas. If gas-fired power generation is consistently reduced, this would leave a gap of around 20%, which industry as well as retail trade, small businesses and households would have to save. Compared with our study from March (in which we calculated a shock of around 30% after substitution of gas in electricity generation), the gas gap has thus become significantly smaller.

In return, the adjustment period until winter has become five months shorter. In economic terms, this means that elasticities are lower, which tends to increase economic costs. Admittedly, there is still just under half a year until the onset of winter, and we are thus still within the range of estimates for short-term elasticities on which our March paper was based. Moreover, companies have had time to put contingency plans in place and consider substitution options. So there is some evidence to suggest that our original elasticities remain realistic.

An important study by Ruhnau et al. (2022) examines the response of German industrial and residential gas demand to rising gas prices over the period January 2021 to April 2022, concluding that residential gas consumption declined by 6% and industrial gas consumption declined by 11%. For households, this was in response to an increase in average gas prices of between 50% and 140%.[16] These figures can also be used to calculate an approximate elasticity of demand for households: depending on the assumed price increase, this ranges from 0.07 to 0.15.[17] As expected, these values are very low, but not zero, i.e., when the price of gas increases, demand decreases. In our March study, we used a similar value of 0.1, based on the empirical literature.

Data on industrial gas consumption in the Netherlands also suggest that demand falls when prices rise (Centraal Bureau voor de Statistiek, 2022). For example, industrial gas consumption fell by 25% over the period from January to July 2022 (calendar week 1 to 28). Relative to the same week in the previous year, gas consumption was circa 28% lower in July 2022 and as much as 40% lower relative to May 2021.

In both Germany and the Netherlands, the reductions in industrial demand occurred without major drops in industrial production (Federal Reserve Bank of St Louis, 2022; Ruhnau et al., 2022). This is particularly noteworthy in the Netherlands because of the large reduction in gas consumption. For comparison, assuming zero substitution opportunities across industry, i.e., strong cascading effects along supply chains through Leontief production processes, industrial production should have declined one-to-one with gas consumption (see Appendix A.2 of our March study). That this did not happen is an important indirect indication that substitution opportunities must be substantial in some cases.

To sum up, there are many reasons to suggest that the costs of an import freeze on Russian gas in August 2022 will remain in the same order of magnitude as we forecast in March. Compared to March, however, the uncertainty surrounding this estimate is likely to be lower. This is partly because supply gap estimates have become more precise. On the other hand, numerous scientific studies from recent months have confirmed the magnitude of the expected effects.[18] A survey of economists working in research also comes to a similar conclusion (CFM Survey, 2022). It is also important to emphasize that the estimated effects of an import freeze should be interpreted relative to the economic development in a scenario without an import freeze. Even without an import freeze, Germany could soon fall into recession.

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[16] The average gas price paid by households has increased significantly less than the spot market price due to long-term contracts. Data from DESTATIS show an increase of about 50% and data from BDEW show an increase of about 140%. See https://twitter.com/OliverRuhnau/status/1544990379111489537?s=20&t=a8Bqx4DxqVm00BumnOlkzg

[17] The definition of elasticity is $-\Delta\log(Q)/\Delta\log(P)$ where $\Delta\log(Q)$ and $\Delta\log(P)$ are the log changes in gas demand Q and gas price P, respectively. For a 140% price increase, the elasticity is $-\Delta\log(Q)/\Delta\log(P) = -\log(0.94)/\log(2.4) = 0.07$. For a 50% price increase, it is $-\Delta\log(Q)/\Delta\log(P) = -\log(0.94)/\log(1.5) = 0.15$.

[18] See the summary of the literature through the end of April, building on Sachverständigenrat (2022) and Berger et al. (2022). See also three IMF studies (Sher et al., 2022; Pescatori et al., 2022; and Di Bella et al., 2022), Gemeinschaftsdiagnose (2022b,c), and Pieroni (2022). A post-April study by Krebs (2022) finds much higher GDP losses of up to 12%. However, the study has significant weaknesses as even the authors of a reference study, Carvalho et al. (2020), state, “Without further analysis, we would not use even this Japan- and earthquake-specific figure as a starting point for a quantitative assessment of energy disruptions in Europe.” See https://app.handelsblatt.com/politik/konjunktur/gas-krise-wie-sie-deutschland-nicht-erlebt-hat-bis-zu-halber-billion-euro-schaden-bei-energie-embargo/28316318.html.

The possibilities for substituting gas in production play a central role. It has been shown that the initially widespread view that no gas substitution at all within 6-12 months would be possible was wrong. In the meantime, there are numerous examples of substantial substitution possibilities also in the chemical industry and glass production. In the following, we report on a number of examples that show the potential for substitution:[19]

- **BASF[20]** “in Ludwigshafen can replace [with] heating oil about 15 percent of the natural gas needed for electricity and steam generation.” Gas for electricity and steam generation accounted for about half of the gas consumed in Ludwigshafen in 2021.[21] **BASF** is also substituting in ammonia production. The company has reduced the production of ammonia at its Ludwigshafen site because of high gas prices and supplemented it with purchases: “this substitution via the world market [is] relatively easy.”[22] The company can substitute some by producing ammonia in the U.S. instead of at the Ludwigshafen site.[23] This is a good example of substitution through imports, which we emphasized in our earlier study, in this case even within the same company. A study by Stiewe et al. (2022) examines German fertilizer production, for which **ammonia** is an important precursor, which in turn is produced with gas. The study concludes “that increased ammonia imports have caused domestic fertilizer production to remain remarkably stable.” Consistent with these examples, data from Oxford Economics show that chemical imports have surged in recent months.[24]
- Glass manufacturer **Wiegand Glas** will be able to “heat its furnaces with light fuel oil in the future instead of only natural gas as before.”[25]
- Car manufacturer **Mercedes-Benz** sees a reduction potential for natural gas of 50% in Germany “if regional pooling is made possible.” “For example, at the Sindelfingen site [...] the paint shop can be operated in emergency mode without gas supply.”[26]
- Car manufacturer **Audi** says it can get by with 20 percent less gas. Only about 10 percent of normal gas demand, the company says, is “the minimum amount of gas needed.”[27]
- Screw manufacturer **Würth** is in the process of converting furnaces that harden the material of screws from gas to electricity.[28] At around one million euros per furnace, the costs are manageable. One problem is that this substitution could take up to 12

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[19] See also the growing list of additional examples in this Twitter thread: https://twitter.com/ben_moll/status/1548004135294754817?s=20&t=taoNd5FJWMcHBRtYX8hliw

[20] BASF is the largest single gas consumer in Europe, with approximately 48 terawatt hours (TWh) in 2021. 37 TWh of this was attributable to its headquarters in Ludwigshafen alone, which is roughly equivalent to Switzerland's annual consumption (https://www.nzz.ch/wirtschaft/chemiekonzern-basf-das-gas-wird-teuer-doch-die-geschaefte-bluehen-noch-ld.1695326).

[21] https://www.nzz.ch/wirtschaft/chemiekonzern-basf-das-gas-wird-teuer-doch-die-geschaefte-bluehen-noch-ld.1695326

[22] https://www.nzz.ch/wirtschaft/chemiekonzern-basf-das-gas-wird-teuer-doch-die-geschaefte-bluehen-noch-ld.1695326

[23] https://www.icis.com/explore/resources/news/2022/06/28/10779322/basf-s-antwerp-us-ammonia-output-could-offset-potential-shutdown-in-germany-bank/

[24] https://twitter.com/OliverRakau/status/1546774406197874688?s=20&t=jyomoCqhWGQinPvmJHjEng

[25] https://www.zeit.de/news/2022-07/25/schnelle-genehmigung-wiegand-glas-kann-erdgas-ersetzen

[26] https://mbpassion.de/2022/07/mercedes-benz-steigert-q2-ergebnis/

[27] https://www.n-tv.de/wirtschaft/Audi-kaeme-mit-20-Prozent-weniger-Gas-aus-article23484747.html

[28] https://www.faz.net/aktuell/wirtschaft/unternehmen/wuerth-chef-warnt-teilemangel-erschwert-gassparen-18172847.html

months due to long delivery times for the necessary components. The time dependency of substitution measures was the reason that economists had called for them to begin as early as March.

- **Chemical company H&R** says it can replace about 25% of its gas consumption with coal and oil.[29]
- The brewery **Veltins** says it can continue brewing without interruption in the event of a gas supply stoppage: "We can switch from gas to fuel oil firing in the boiler house within a few hours."[30]
- **Dairies** switch from gas to emergency operation with oil.[31]
- **Steel producer Arcelor-Mittal** says the company can buy steel precursors externally and thus reduce gas consumption in production.[32] In part, **Arcelor-Mittal** buys these precursors from its plant in Canada and then imports them into Germany.[33] Similar to the **BASF** example above, this is substitution through imports even within the same company.
- **Stadtwerke München** "has postponed the conversion of a large cogeneration plant from coal to gas and will convert two heating plants from natural gas back to fuel oil."[34]

Interestingly, the models in many of the studies produced since March cannot capture this substitution behavior, as they assume zero substitutability (substitution elasticity equals zero, i.e., Leontief case). This also applies to some high-profile studies such as Gemeinschaftsdiagnose (2022a,b,c), and Deutsche Bundesbank (2022). The models in these studies are therefore also of limited use to analyze gas demand reduction through economic policy measures. Exceptions to studies that model substitution, in addition to our March study, include the IMF studies (Sher et al., 2022; Pescatori et al., 2022; and Di Bella et al., 2022) and Pieroni (2022). Nonetheless, models without direct substitution possibilities in the production function assumed for individual industries also provide useful information, as their results should be interpreted as a worst-case scenario. With substitution possibilities, the consequences of a gas supply stop would be correspondingly milder.

## 3. Evaluation of the measures taken by the federal government

The assessment of the German government's strategy of not enforcing early gas demand adjustments more consistently and sticking to gas imports from Russia despite the war of aggression on Ukraine is ambivalent. In particular, even in the best-case scenario (full storage in fall), this strategy was not suitable to make Germany's gas consumption independent of Russia in the winter. In other words, even in the best-case scenario, if Moscow had passively watched Germany fill up its storage facilities, the country would have

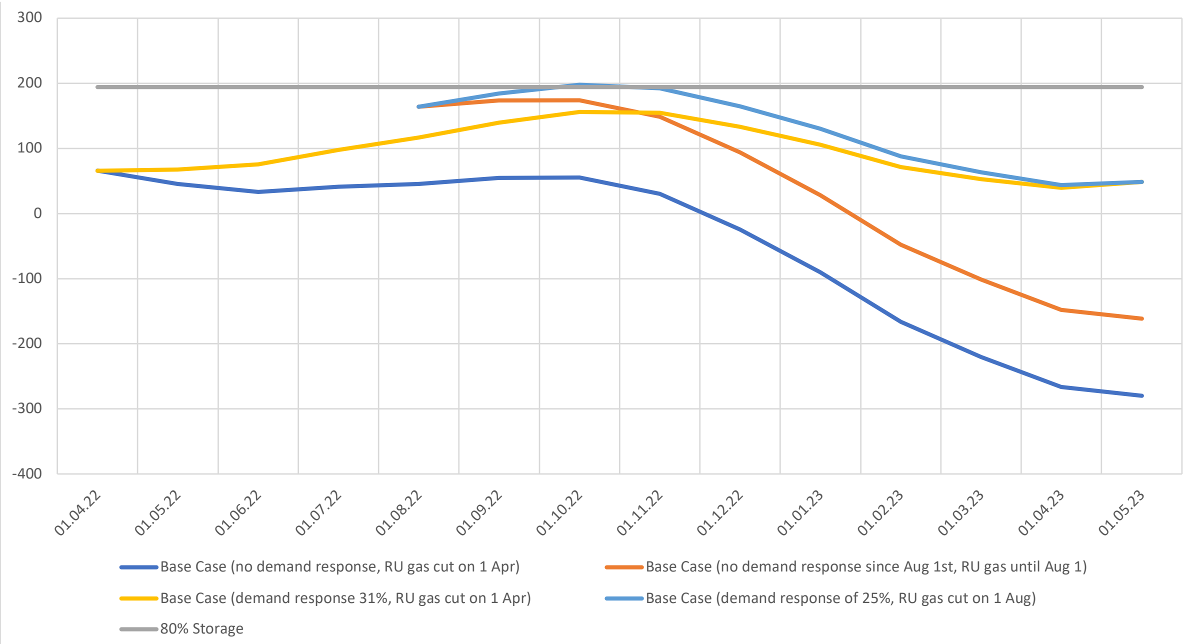
[29] https://www.ft.com/content/619946ac-94b9-4d93-bc7f-d458dfc8b39a
[30] https://www.faz.net/aktuell/wirtschaft/unternehmen/brauerei-veltins-bunkert-heizoel-und-sorgt-fuer-gas-lieferstopp-vor-18175875.html
[31] https://www.tagesschau.de/wirtschaft/unternehmen/gasknappheit-molkereien-101.html
[32] https://www.faz.net/aktuell/wirtschaft/unternehmen/wie-in-der-industrie-am-besten-gas-gespart-werden-kann-18126831.html
[33] https://www.nytimes.com/2022/07/30/business/europe-natural-gas.html
[34] https://zeitung.faz.net/fas/wirtschaft/2022-07-17/9db2c3db5df167136d04035d5f00c832/?popup=user.lf-ns

remained vulnerable to blackmail. In this respect, the policy pursued so far has not been suitable for achieving energy independence from the regime in Moscow by winter.

As we pointed out in March, this always required a parallel reduction in gas demand. Although this is repeatedly emphasized by politicians, it is not implemented with sufficient determination. In any case, the efforts to build LNG terminals and diversify gas supply through imports from third countries are positive. Nevertheless, the remaining need for adjustment on the demand side remains substantial.

How much higher would the need for adjustment have been if Germany had had to do without Russian gas imports as early as from April onwards? In Figure 3, we present a simple counterfactual scenario. The calculations show that gas demand would have had to be reduced by 31%, a good 6% more than the 25% with a supply freeze in August (of course, this difference would be somewhat smaller again with a gas freeze on May 1, perhaps an even more realistic phase-out date). An April supply freeze without gas demand reduction would have resulted in a shortfall of 328 TWh of gas by the end of the heating season, significantly more than the 210 TWh shortfall that would occur with an August supply freeze. This represents 31% of the average consumption of 1060 TWh over the 13-month period from the beginning of April to the end of the heating season the following year.

**Figure 3: German Gas Storage Evolution (TWh)**




*Notes: This figure plots the progression of gas storage levels in terawatt hours (TWh) for four different scenarios and compares them to a storage level of 80% (gray line). In the first scenario, it is assumed that there would have been a Russian gas supply freeze from April 1 and no gas demand reduction followed (dark blue line). In the second scenario, the assumption is that Russian gas will be supplied until August 1 and no gas demand reduction will follow from August 1 (orange line). The third scenario shows a gas demand reduction of 31% with a Russian gas supply freeze from April 1 (yellow line) and the last scenario shows a gas demand reduction of 25% with a Russian gas supply freeze from August 1 (light blue line).*

The difference between 25% and 31% is not insignificant. But in view of the political and social implications of a gas import freeze, which are repeatedly put forward by politicians, it is clear that difficult decisions would be necessary in both cases.

Why is the difference in the necessary gas demand reduction not higher, especially in view of the significantly higher filling level of German gas storage facilities compared to April (67% at the end of July instead of 27% at the beginning of April)? The answer is that the capacity of gas storage facilities, and therefore the importance of fill levels, is often overestimated. For example, German gas storage facilities have a capacity of just under 250 TWh. This is "only" about a quarter of the annual consumption (or the consumption of two winter months). Even with gas storage facilities filled to 100%, only part of the demand could be met and Germany would remain dependent on gas imports.

However, an adjustment strategy in the event of an immediate "cold turkey" import freeze in April would have increased incentives to initiate gas demand reductions early and thus reduce dependence on Russia. At the same time, because household consumption drops sharply after the end of the heating season (Figure 2), remaining imports from Norway and elsewhere would have been sufficient to supply industry. Thus, an immediate "cold turkey" import freeze in April would not have led to an immediate gas shortage in industry at all because of the strong seasonality of gas consumption. Industry would have had time until winter to conserve and substitute gas. In this respect, the most important difference between an import freeze in April and in August lies in the fuller storage facilities, which, however, have only slightly reduced the necessary gas demand adjustment. The price for this is shorter adjustment times. In this respect, the economic costs remain quite comparable.

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