Full Russian gas embargo: fallback scenarios that secure European industry by reduced heating

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Note: Working draft, version 0.08 of 01 May 2022 (Data, most recent as well as older versions at: <https://github.com/hblasum/stop-gas-imports> ). *This is currently a work of “citizen science”, driven by a need to understand the topic independently. We are very interested in review / feedback from any (also academic, professional) parties.*

**Abstract:** Concerns have been raised that a gas embargo would hurt European industry and that the potential for industry-save savings is low without harming supply chains. In order to understand our possible societal resilience, here we assume that these concerns were true and assume only a very low rate of industry savings and calculate scenarios with low industry savings, based on current Eurostat energy data available for 2019/2020, with a focus on 2019 pre-COVID-19 data. If we take as economic entity the EU plus Iceland, Liechtenstein, Norway, United Kingdom, Montenegro, North Macedonia, Albania, Bosnia and Herzegovina, Kosovo, Moldova and Ukraine, and if household / commercial / public consumption gas is saved by 40.5% (which could be entirely taken from heating), gas for electricity generation is 20% substituted, gas for industry is saved by 8%, Russian imports are substituted by 35% from other countries, then this economic entity can do without Russian gas imports.

With a substitution of gas for electricity generation of 54%, even consumer savings of 19% would suffice. Conversely, we also discuss more pessimistic scenarios. As ultimate fallback scenario, one in principle can immediately implement a gas embargo without touching industry consumption or power generation at all, and without additional imports, by a stop on heating and warm water, as the overall consumption of gas by household / commercial / public consumers is larger than the Russian gas imports.

Policy implications for the EU are to seek solidarity with non-EU gas embargo friendly countries, primarily UK, to halt any prioritization of consumers, and to prepare consumers to save on heating. For social acceptance, even if results are expected to be less than on the consumer side, industry at least should show also sincere efforts to review energy usage.

# Introduction and objective

As of 30 April 2022, the cruel war in Ukraine is being financed by Europe to the extent of more than 47 billion EUR since 24 February.[[1]](#footnote-1) As an excuse, it has been frequently argued that European industry depends on gas so much that an embargo cannot be done. We argue that an embargo is possible without almost touching industry consumption, largely by cutting private consumptions. We also give a hypothetical scenario of full embargo without any new imports and sourcing and with almost no contribution for industry, and then the cut in private consumption is very large. The objective of the write-up is not to state that such a radical industry protection is the only way to go ahead, as presumably larger savings are also possible in the industry, but to give assurance that even if it would turn out that realizable industry savings and substitution options were in fact minuscule, then a gas embargo still would not lead to any industrial breakdown.

Ethically and strategically there are strong arguments why there is an obligation for Europe to stop gas imports and why they have impact.[[2]](#footnote-2) This holds regardless whether one is in favor or against additional delivery of weapons or not: for supporters of weapons deliveries, the embargo is an additional means that should be taken; for those who object weapons deliveries, the embargo is one of the very few effective means that can be taken. Even if you disagree and do not wish an embargo our observations might be equally useful to understand the situation when Russia would could the gas exports on its side.

Numerous economic studies have already argued that, based on price elasticity, a gas embargo can be done with only moderate costs for instance to the German economy at a cost of less than 3% GDP,[[3]](#footnote-3) comparable to the financial crisis or COVID-19 economical shrinking. However, the German government seems to refuse to accept arguments based on price elasticity, worrying that in worst-case scenarios that (1) price elasticity values derived from normal situations do not carry over to a deep economic transformation and (2) core industries that are at the bottom of the value chain are especially endangered, such as for instance the chemical industry that has been relatively strong in Germany since the 19th century.

A BDEW working paper only assumes 8% savings in industry to be feasible.[[4]](#footnote-4) For the public electricity grid, there is enough capacity for power generation from coal and overall for electricity generation gas only plays a minor role, e.g. 12.6% in Germany in 2021,[[5]](#footnote-5) however gas electricity plants are used for peak load generation. The aforementioned BDEW working paper projected 54% gas savings potential for public electricity generation.[[6]](#footnote-6) For now, given that gas plants are used to balance peak loads, we consider this number high and also assume a more modest reduction for electricity generation.

In the following we show that it is possible to stop immediately Russian gas imports without little (8%) reduction in industry consumption and moderate reduction for public grid electricity generation when gas consumption in the private / commercial / public sectors (also summarized as “consumers”, as consumption is mostly used for space heating[[7]](#footnote-7)) is cut down by 40.5% (assuming a rate of substitution in electricity generation of 20%) or 19% (assuming a rate of substitution in electricity generation of 54%). Unlike many price elasticity models, mathematically our approach is very simple: it is just an addition of Eurostat publicly available numbers. We show both a European as well as a German view.

# Embargo with reduced gas import balanced by consumers

At Eurostat, the 2021 data is not yet available and the most recent year is 2020 data. However, 2019 has been intentionally selected as the year with the highest imports Europe and the EU had made from Russia ever: gas imports to the EU have been growing since the statistics are available (since 1990) and peaked in 2019, as 2020 imports were slightly lower, due to COVID-19. An additional advantage of selecting 2019 data over 2020 data is that the 2019 data is probably more finalized than then 2020 data.

## Scenario with substitution from import diversification, renewable substitution and consumer savings

Table 1 shows Russian imports, Table 2 substitution of these imports and Table 3 shows, as source of potential energy savings, current consumption for the countries that are likely to support the energy embargo against Russia (EU plus Iceland, Liechtenstein, Norway, United Kingdom, Montenegro, North Macedonia, Albania, Bosnia and Herzegovina, Kosovo, Moldova and Ukraine), **henceforth for brevity called “Europe”.**

Table : Russian gas imports into Europe in PJ (petajoule = 1015 Joule).

|  |  |  |
| --- | --- | --- |
|  | Eurostat 2019[[8]](#footnote-8) | Eurostat 2020 |
| Gas imports from Russia to Europe | 7094 PJ | 6500 PJ |

As shown in Table 2, the EU has calculated 3247 PJ for realizable short-term (2022) substitution by imports or switching to renewables[[9]](#footnote-9), which amounts to a substitution of 35.0% of Russian imports if only include direct substitution of gas, or even 45.8% of the Russian imports if we include additional renewable generation.

Table : Short-term gas substitution from imports and energy substitution

|  |  |  |
| --- | --- | --- |
| Item | Bcm | PJ (at 38.2 PJ / bcm[[10]](#footnote-10)) |
| LNG replacements | 50 | 1910 PJ |
| Pipeline import diversification (e.g. Algeria[[11]](#footnote-11)) | 10 | 382 PJ |
| Additional biomethane production | 4 | 134 PJ |
| Heat pump rollout | 2 | 57 PJ |
| SUM targeting direct gas import/consumption substitution | 65 | 2483 PJ |
| Wind and solar front loading[[12]](#footnote-12) | 20 | 764 PJ |
| SUM overall | 85 | 3247 PJ |

Table 3 summarizes gas consumption in Europe. Our main actors are households, commercial and public services (we summarize households, commercial and public services as “consumers”, electricity generation for the public grid, and industry, including non-energy use (e.g. for chemical processes). Also on-site electricity autogeneration has been fully assigned to industry.

Table : Gas consumption in Europe (derivation see Section 7)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Primary energy consumption Eurostat 2019[[13]](#footnote-13) | % | Primary energy consumption Eurostat 2020 | % |
| Households | 5627 PJ | 28 | 5578 PJ | 28 |
| Commercial and public services | 2032 PJ | 10 | 1955 PJ | 10 |
| Electricity generation (public grid) | 4622 PJ | 23 | 4550 PJ | 23 |
| Industry | 7515 PJ | 37 | 7342 PJ | 37 |
| Transport | 93 PJ | 1 | 90 PJ | 0 |
| Other | 160 PJ | 0 | 150 PJ | 1 |
| SUM | 15318 PJ |  | 14670 PJ |  |

Table 4 shows a scenario where household / commercial / public consumption gas is saved by 40.5%, gas for electricity generation is 20% substituted, gas for industry is saved by 8%. “Old” is the 2019 baseline scenario, “savings” are the savings with above-mentioned savings implemented. The balance is substitution minus Russian gas imports, where this balance is positive, the country / geographic unit can cut Russian gas without European imports; where this balance is negative, the country needs other (non-Russian) European imports (taken from the positive balance of other countries: e.g. the surplus of54 PJ of Belgium can be fed into the deficit of 43 PJ of Bulgaria). The table shows that under this strong savings scenario the inter-country gas flows are relatively small and thus should be manageable by the European gas network. From the embargo-friendly non-EU European allies, the lion’s share in contribution is UK (positive contribution 811 PJ) and Ukraine (positive contribution 284 PJ), whereas the other non-EU allies’ contributions/ needs overall are rather minor.

Table : Scenario where 35% of Russian gas imports are diversified, household / commercial / public consumption gas is saved by 40.5%, gas for electricity generation is 20% substituted, gas for industry is saved by 8%. All table value entries are in PJ.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Country | Gas imports Russia old | Import substitution | Household old | Household savings | Commercial / public old | Commercial / public savings | Electricity old | Electricity savings | Industry old | Industry savings | Substitution | Balance |
| Belgium | 150 | 53 | 151 | 61 | 88 | 36 | 148 | 30 | 318 | 25 | 204 | 54 |
| Bulgaria | 91 | 32 | 11 | 5 | 4 | 2 | 29 | 6 | 52 | 4 | 48 | -43 |
| Czechia | 364 | 128 | 103 | 42 | 55 | 22 | 48 | 10 | 119 | 9 | 210 | -154 |
| Denmark | 0 | 0 | 40 | 16 | 9 | 4 | 19 | 4 | 57 | 5 | 29 | 29 |
| Germany | 1803 | 631 | 1118 | 453 | 440 | 178 | 592 | 118 | 1365 | 109 | 1490 | -313 |
| Estonia | 19 | 7 | 8 | 3 | 3 | 1 | 0 | 0 | 6 | 0 | 12 | -8 |
| Ireland | 0 | 0 | 27 | 11 | 19 | 8 | 105 | 21 | 57 | 5 | 44 | 44 |
| Greece | 65 | 23 | 18 | 7 | 7 | 3 | 127 | 25 | 54 | 4 | 63 | -3 |
| Spain | 256 | 90 | 161 | 65 | 91 | 37 | 417 | 83 | 750 | 60 | 335 | 79 |
| France | 707 | 247 | 558 | 226 | 278 | 113 | 249 | 50 | 636 | 51 | 686 | -20 |
| Croatia | 0 | 0 | 23 | 9 | 10 | 4 | 25 | 5 | 50 | 4 | 22 | 22 |
| Italy | 1274 | 446 | 762 | 309 | 330 | 134 | 973 | 195 | 712 | 57 | 1140 | -135 |
| Cyprus | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Latvia | 51 | 18 | 13 | 5 | 5 | 2 | 26 | 5 | 6 | 1 | 31 | -20 |
| Lithuania | 46 | 16 | 11 | 4 | 3 | 1 | 6 | 1 | 67 | 5 | 28 | -18 |
| Luxembourg | 9 | 3 | 12 | 5 | 5 | 2 | 2 | 0 | 13 | 1 | 11 | 3 |
| Hungary | 689 | 241 | 152 | 62 | 49 | 20 | 73 | 15 | 112 | 9 | 346 | -342 |
| Malta | 0 | 0 | 0 | 0 | 0 | 0 | 14 | 3 | 0 | 0 | 3 | 3 |
| Netherlands | 733 | 256 | 318 | 129 | 130 | 53 | 418 | 84 | 618 | 49 | 571 | -162 |
| Austria | 0 | 0 | 75 | 30 | 17 | 7 | 86 | 17 | 179 | 14 | 69 | 69 |
| Poland | 371 | 130 | 177 | 72 | 63 | 25 | 62 | 12 | 413 | 33 | 272 | -98 |
| Portugal | 8 | 3 | 13 | 5 | 11 | 5 | 87 | 17 | 122 | 10 | 40 | 32 |
| Romania | 37 | 13 | 129 | 52 | 38 | 15 | 65 | 13 | 179 | 14 | 108 | 71 |
| Slovenia | 4 | 1 | 6 | 3 | 1 | 1 | 4 | 1 | 22 | 2 | 7 | 3 |
| Slovakia | 260 | 91 | 59 | 24 | 19 | 8 | 28 | 6 | 73 | 6 | 134 | -126 |
| Finland | 101 | 35 | 11 | 5 | 1 | 1 | 32 | 6 | 37 | 3 | 50 | -51 |
| Sweden | 0 | 0 | 1 | 0 | 5 | 2 | 5 | 1 | 34 | 3 | 6 | 6 |
| SUM EU | 7038 | 2463 | 3959 | 1603 | 1681 | 681 | 3640 | 728 | 6050 | 484 | 3496 | -1079 |
| Iceland | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Liechtenstein | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Norway | 0 | 0 | 1 | 0 | 2 | 1 | 0 | 0 | 258 | 21 | 22 | 22 |
| United Kingdom | 0 | 0 | 1116 | 452 | 305 | 124 | 836 | 167 | 851 | 68 | 811 | 811 |
| Montenegro | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| North Macedonia | 11 | 4 | 1 | 1 | 0 | 0 | 8 | 2 | 2 | 0 | 6 | -5 |
| Albania | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 |
| Bosnia and Herzegovina | 9 | 3 | 4 | 2 | 1 | 0 | 0 | 0 | 4 | 0 | 5 | -3 |
| Kosovo | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Moldova | 35 | 12 | 14 | 6 | 4 | 2 | 10 | 2 | 5 | 0 | 22 | -13 |
| Ukraine | 0 | 0 | 533 | 216 | 38 | 15 | 128 | 26 | 342 | 27 | 284 | 284 |
| SUM Europe | 7094 | 2483 | 5627 | 2279 | 2032 | 823 | 4622 | 924 | 7515 | 601 | 4627 | 16 |

## Fallback and alternative scenarios

For a scenario calculation, if we set *imports* (7094 PJ for Europe as per Table 1, 7038 PJ for the EU as per Table 6) to be the current imports of Russian gas, *imports\_substitution\_rate* to be the substitution rate of these gas imports by alternatives (as in Table 2), *electricity* (4622 PJ for Europe as per Table 3, 3640 PJ for the EU as per Table 7) to be amount of gas used for electricity generation, *electricity\_substitution\_rate* the rate for substitution of energy, *industry* the consumption of gas by industry (7515 PJ for Europe, 6050 PJ for the EU), *industry\_savings\_rate* to be the savings rate in industry, *household* to be the amount of household consumption (5627 PJ for Europe, 3959 PJ for the EU) and *commercial* the amount of commercial and public consumption (2032 PJ for Europe, 1681 PJ for the EU), then the formula to calculate the required household and commercial / public savings is:

Required\_household\_savings = (imports - (imports \* imports\_substitution\_rate + electricity \* electricity\_substitution\_rate + industry \* industry\_savings\_rate)) / (household + commercial)

Table 7 below applies this formula to calculate fallback and alterative scenarios.

Table : Fallback and alternative scenarios

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Line number | Section in this document | EU/Europe | Import substitution rate | Electricity substitution rate | Industry savings rate | Substitution amount by previous (PJ) | Still needed savings (PJ) | Savings rate |
| 1 | 2.2.1 | EU | 35.0% | 20.0% | 8.0% | 3675 | 3363 | 59.6% |
| 2 | 2.1 | Europe | 35.0% | 20.0% | 8.0% | 4009 | 3086 | 40.3% |
| 3 | 2.2.2 | EU | 35.0% | 54.0% | 8.0% | 4913 | 2125 | 37.7% |
| 4 | 2.2.2 | Europe | 35.0% | 54.0% | 8.0% | 5580 | 1514 | 19.8% |
| 5 | 2.2.2 | EU | 45.0% | 20.0% | 8.0% | 4379 | 2659 | 47.1% |
| 6 | 2.2.2 | Europe | 45.0% | 20.0% | 8.0% | 4718 | 2376 | 31.0% |
| 7 | 2.2.3 | EU | 35.0% | 0.0% | 8.0% | 2947 | 4091 | 72.5% |
| 8 | 2.2.3 | Europe | 35.0% | 0.0% | 8.0% | 3084 | 4010 | 52.4% |
| 9 | 2.2.4 | EU | 0.0% | 20.0% | 8.0% | 1212 | 5826 | 103.3% |
| 10 | 2.2.4 | Europe | 0.0% | 20.0% | 8.0% | 1526 | 5568 | 72.7% |
| 11 | 2.2.4 | EU | 0.0% | 0.0% | 8.0% | 484 | 6554 | 116.2% |
| 12 | 2.2.4 | Europe | 0.0% | 0.0% | 8.0% | 601 | 6493 | 84.8% |
| 13 | 2.2.4 | EU | 0.0% | 0.0% | 0.0% | 0 | 7038 | 124.8% |
| 14 | 2.2.4 | Europe | 0.0% | 0.0% | 0.0% | 0 | 7094 | 92.6% |

### EU-only scenarios

As shown in Table 6 and Table 7, also on EU level, almost everywhere cutting off all Russian gas imports could be entirely balanced by household and commercial and public services and a small part of electricity generation. Moreover, the pattern that household + commercial and public sector consumption + electricity generation is larger than Russian imports holds for most European countries, limiting the needs for intercountry flows.

Table : Russian gas imports into EU in PJ (petajoule = 1015 Joule).

|  |  |  |
| --- | --- | --- |
|  | Eurostat 2019[[14]](#footnote-14) | Eurostat 2020 |
| Gas imports from Russia to EU | 7038 PJ | 6443 PJ |

Table : Gas consumption in EU (derivation see Section 7).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Primary energy consumption Eurostat 2019[[15]](#footnote-15) | % | Primary energy consumption Eurostat 2020 | % |
| Households | 3959 PJ | 26 | 3913 PJ | 26 |
| Commercial and public services | 1681 PJ | 11 | 1605 PJ | 11 |
| Electricity generation (public grid) | 3640 PJ | 24 | 3531 PJ | 23 |
| Industry | 6050 PJ | 39 | 5894 PJ | 39 |
| Transport | 86 PJ | 1 | 84 PJ | 1 |
| Other | 72 PJ | 0 | 61 PJ | 0 |
| SUM | 15318 PJ | 100 | 14670 PJ | 100 |

Table 7 line number 1 shows an EU-only scenario. Here household / commercial / public consumption gas is saved by almost 60%, gas for electricity generation is 20% substituted, gas for industry is saved by 8%, this is possible when we assume gas exchange within the EU, without any additional imports on the non-EU market. However, the greatly increased savings demands also show that it would be very wise to get other non-EU partners supporting the embargo such as UK and Ukraine to support the measures.

### More optimistic scenarios with high electricity generation substitution

Table 7 lines 3 and 4 give a more optimistic scenarios with higher electricity generation substitution of 54% electricity generation substitution as per BDEW (see Section 1). This only would entail energy savings of 1514PJ (19%) to European consumers. The number of 19% is similar to a result by Cologne IWE although the Cologne calculation probably also expects 19% from industry, as it has predicted an amount to save of that has predicted a need to save 790 TWh = 2844 PJ.[[16]](#footnote-16), which is higher than our corresponding number of 1998 PJ savings in industry and households. Before the study as a whole is published it is hard to judge how treats substitution in power generation.

As another alternative (Table 7 lines 5 and 6) we have calculated a scenario with 45% import substitution (then we would have only 31% consumer energy savings demand). Whether such a high electricity generation / import substitution can be realized remains to be seen.

### Scenarios without electricity generation substitution

Table 7 lines number 7 and 8 show scenarios with an electricity generation substitution of 0% instead of 20%. As per Table 2, the growth of renewables (solar, wind, biogas) alone would account for these 20%. However, it could be argued that the growth in electricity generation would still not accommodate the need for peak electricity generation which currently largely uses natural gas. We think the 20% are still justified because at the same time electricity can be generated also from coal, oil (also short-term generation), but show the 0% electricity substitution scenario (which would push up the consumer savings rate up to 53%) for sake of completeness of the possible scenarios.

### No substitution at all scenario

Table 1 and Table 3 show that for Europe 2019 numbers (EU plus Iceland, Liechtenstein, Norway, United Kingdom, Montenegro, North Macedonia, Albania, Bosnia and Herzegovina, Kosovo, Moldova and Ukraine) the consumption by households + public and commercial of 5627 PJ + 2032 PJ = 7659 PJ alone, which is largely used for heating, is larger than Russian gas imports of 7038 PJ. That is, a gas embargo borne by households/public/commercial users (savings of 92.6%) could be done with neither touching industry use, nor imports, nor substitution in electricity generation at all, that is nothing of the substitutions expected in Table 2 would have materialized. While certainly not a popular option, it might be reassuring to know that this scenario is possible.

A no-substitution-at-all scenario would not be realizable if only the EU did it (savings larger than 100% would be needed).

Some intermediate steps to non-substitution-at-all are shown in Table 7 lines 9-13. All these are very probably overly pessimistic.

# Observations on Germany

## Overall gas consumption in Germany

Table : Gas imports from Russia to Germany

|  |  |  |
| --- | --- | --- |
|  | Eurostat 2019[[17]](#footnote-17) | Eurostat 2020 |
| Gas imports from Russia to Germany | 1803 PJ | 2045 PJ |

Table : Gas consumption in Germany.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Primary energy gas consumption Eurostat 2019[[18]](#footnote-18) | % | Primary energy gas consumption Eurostat 2020[[19]](#footnote-19) | % | For comparison: Final energy consumption BMWK 2020[[20]](#footnote-20) | % |
| Households | 1118 PJ | 32 | 1090 PJ | 31 | 914 PJ | 44 |
| Commercial and public services | 440 PJ | 13 | 463 PJ | 13 | 353 PJ | 17 |
| Electricity generation (public grid) | 592 PJ | 17 | 627 PJ | 18 | N.A. | N.A. |
| Industry (including any non-energy use and on-site electricity autogeneration) | 1365 PJ | 39 | 1317 PJ | 38 | 624 PJ | 39 |
| Transport | 7 PJ | 0 | 6 PJ | 0 | 7 PJ |  |
| Other | 0 PJ | 0 | 0 PJ | 0 | N.A. | N.A. |
| SUM | 3502 PJ |  | 3502 PJ |  |  |  |

## Gas consumption in Germany during summer 2021 as a model

Concerns have been raised that the gas network would fail under low gas pressure when the Russian gas imports are removed. However, a low gas consumption scenario, with less than 50% of normal gas consumption, is exercised every summer as can be seen Figure 1. One can clearly see that turning off heating units in summer results in correspondingly lower consumption, that is cutting consumption by more than half in comparison to the winter consumption.

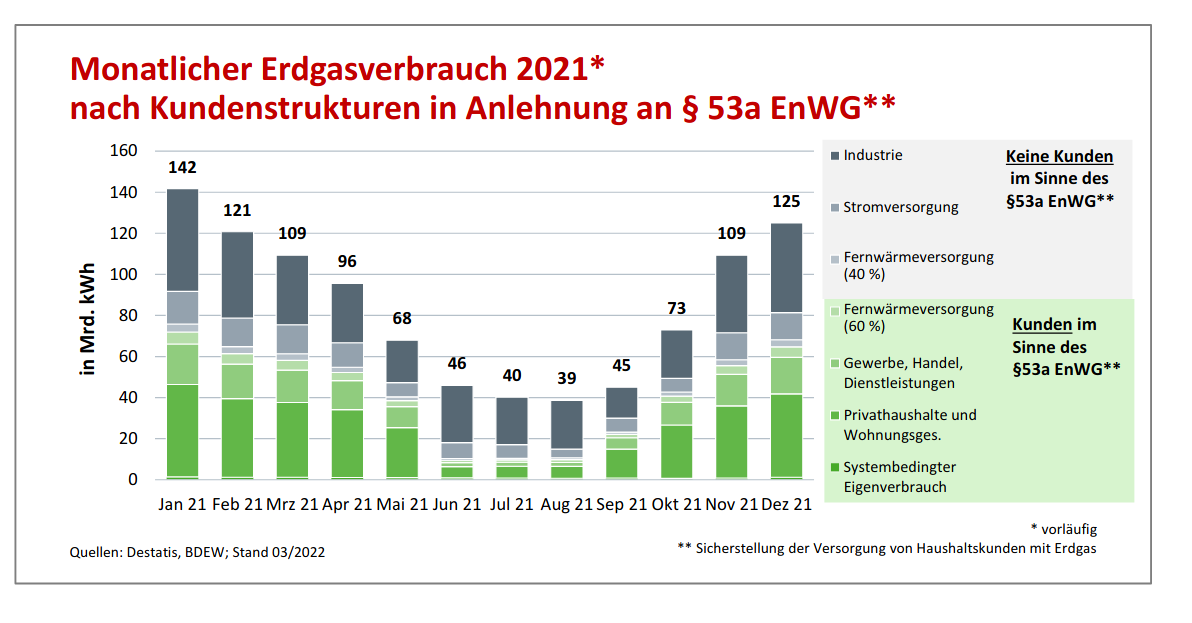


Figure 1: BDEW annual gas consumption[[21]](#footnote-21): monthly energy consumption in billion kWh in 2021, with industry (in blue) and private consumption (in green).

## Emergency economy scenario for the next winter

Note that if the German populace agrees that turning off the heating in winter would be acceptable (for instance, in the 19th century people did not have access to modern heating and dressed more warmly) if all other means fail, this would be a 100% guarantee to German industry. As space heating has no place in the value chain, cutting down heating would be a purely consumption costs and not cut any productivity.

Again let us emphasize that want to demonstrate that it is possible to secure industry in a scenario where there is no substitution at all. We are aware that in the past, public policy has secured household consumer at the expense of industry. However, in a situation of national crisis, this policy needs to be and can be reversed, by prioritizing industry over households.

However, first, as discussed before, the EU can balance this high savings number by exporting gas from other countries to Germany. We point out that instead of using purely price mechanisms, some sort of rationing might give a better feeling of social justice, which is needed in a national crisis situation. In any case, the enforcement of any strong savings is possibly best *not* left to market forces alone, e.g. a fair distribution mechanism in case of rationing gas at a modest price could be to provide gas in the distribution networks only daily at certain hours (e.g. at noon / evenings) at that price.

# Discussion

## Policy implications

The advantage of saving on heating is that heating, unlike industry, typically has an “end consumption” place in the value chain, it is pure consumption and could be avoided by e.g. insulation / warmer clothing.

The given calculations also assume that e.g. France would support Germany with gas (or energy) exports. As we have discussed, it also would be beneficial to include in the cooperation specifically the UK, which is one of the countries itself producing North Sea gas and also with a high savings potential.

For itself, the EU has already stipulated solidarity mechanisms in case of gas supply crisis.[[22]](#footnote-22) The task at hand is to (1) create European solidarity – here e.g. Germany could ask for this in turn for agreeing to energy sanctions (2) convincing public opinion for strong energy savings. For the latter, numerous polls[[23]](#footnote-23) had shown that there was already initially support for energy savings, which the governments should strengthen rather than curb.

For instance, it has to be avoided that switching en masse to electricity for heating endangers the stability of electricity networks. For instance, in the current heat wave in India, electricity outages have been related to cooling turned on by end-users.[[24]](#footnote-24) If in winter consumers who do not have access to gas heating any longer would massively turn on electricity for warm water and space heating instead, then the stability of the electricity grid would suffer, and this again could be bad for industry too. Here appeals to energy savings are needed, e.g. model roles of public ministries such as practiced during the 22 March 2011 cold wave in Tokio the electricity grid did *not* break down after the government asked for careful heating.[[25]](#footnote-25)

Putting a strong focus on maintain supplies for industry would also mean that a general prioritization of private consumers as stipulated e.g. in the current German energy law[[26]](#footnote-26) has to be removed, which could be done by legislative act. Industry demands to do this[[27]](#footnote-27) have so far been countered by German Bundesnetzagentur which has argued for fair distribution of burden,[[28]](#footnote-28) However, we would follow the argument that consumer savings, which have not been optimized very much in the past, have a much larger potential than industry savings, where we expect that the savings potential is smaller, as price pressure and savings incentive are much higher in industrial installations. However, for social acceptance, even if results are expected to be less than on the consumer side, industry at least should show also sincere efforts to review its energy usage.

## Technical feasibility of changing gas flows

Gas pipelines from Russia have been shut down e.g. for a few days regularly for system maintenance and a long shut down additionally would mean to seal the gas fields for a longer time (e.g. until the war is over), which technically can be done.[[29]](#footnote-29) It also seems to be easy to reverse the flow of gas, as has been done to provide Poland with gas via the Jamal pipeline after Russia has shut down delivery to Poland on 28 April 2022.[[30]](#footnote-30)

# Further notes on data and assumptions

Eurostat figures in general are from 2019/2020, which is the newest dataset available. Eurostat UK figures are from 2019 (for UK, the 2020 figures are not yet available). Some nuclear power plants have been shut down in Germany in 2021, which then is however overall balanced by additional renewable energy capacities. As shown in Table 10, we have ignored about 0.5% of gas consumption used for transportation (“T”) and about 0.5% gas consumption flared, which are lost in statistical discrepancies (“O”). In sum, all the aforementioned effects appear minor.

Obviously 2020 was the year when COVID-19 hit, so we have mostly focused on 2019 as baseline which of the available data with 7094 PJ of Russian gas imports rather than 6500 PJ of Russian gas imports in 2020, 2019 being the year with the highest imports from Russia ever, so we are maximally pessimistic here. Possibly it also can be observed that the trend to reduce own production and to rely more on Russian imports has continued in 2021, however this was balanced by a reduction in Q3 2021 due to higher gas prices.[[31]](#footnote-31)

As we have discussed, it also would be beneficial to include in the calculations UK and - to a lesser extent - Ukraine. As for Ukraine, energy saving is certainly not a priority for a country defending itself against an aggressor at war, but actually high gas savings compared to 2019 very likely unfortunately already have been realized by emigration and loss of lives and infrastructure during this war.

Our scenarios overall all also very conservative with asking for high consumer savings, e.g., other substitution scenarios assume that more of half of the gas consumption can be substituted from a combination of substitution by other energy sources, Norwegian, British, Libyan, Dutch and Algerian gas via pipelines and LNG imports and e.g. calculate for an overall savings of 11%[[32]](#footnote-32).

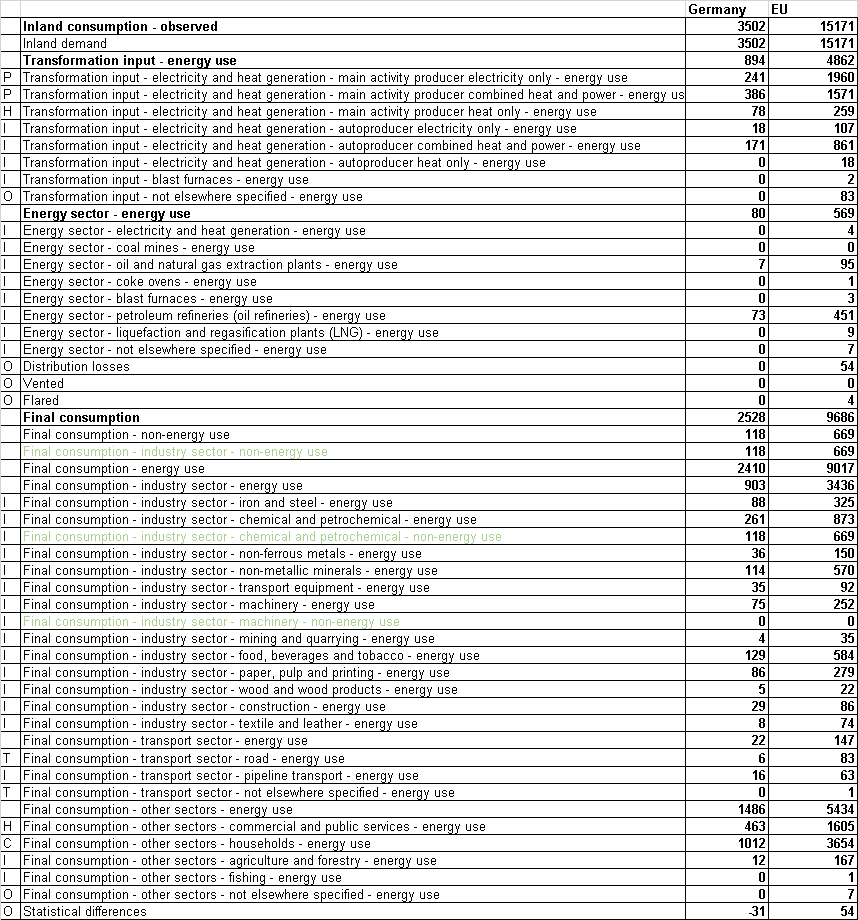
# Acknowledgment

We greatly acknowledge previous discussions and critical feedback on earlier versions of this document and/or the arguments therein.

# Appendix: Derivation of industrial use data: Germany and Europe

Table 10 shows how we have grouped the Eurostat data[[33]](#footnote-33). We did this exercise to make sure that we did not misunderstanding the Eurostat classification. Non-energy use, e.g. as input to chemical processes (overall relatively minor in the 3-4% range) is marked in green. Details on data see <https://github.com/hblasum/stop-gas-imports> .

Table 10: Assignments to “P“ power , i.e. electricity generation for the public grid, “H” households, “I” industry, “T” transport, “C” commercial / public “O” other, from Eurostat data, in PJ. Here the data is shown for 2020, which we had analysed before coding that into python program, from which also 2019 data has been processed the same way.



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