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*This article discusses the economic effects of a potential cut-off of the German economy from Russian energy imports. We show that the effects are likely to be substantial but manageable. In the short run, a stop of Russian energy imports would lead to a GDP decline in range between 0.5% and 3% (cf. the GDP decline in 2020 during the pandemic was 4.5%).*

*(i) In the case of an import stop, imports of oil and coal from Russia can be substituted from other countries, but the situation in the gas market is more challenging. An increase in gas imports from other countries, substitution of gas used for electricity production by coal or nuclear as well as refilling of storage facilities over the summer can only reduce the shortfall to about 30% of gas consumption or 8% of German energy consumption over the next 12 months.*

*(ii) How would the German economy cope with such a shortfall of gas deliveries? The economic effects crucially depend on substitution and reallocation of energy inputs across sectors. To quantify these effects, we use a state-of-the-art multi-sectoral open economy model following Baqaee and Farhi (2021) that accounts for elasticities of substitution and reallocation between different intermediate inputs. In a second step, we turn to a simplified model that helps us derive plausible bounds for the economic effects using observed elasticities for energy inputs. In the Baqaee-Farhi model, the output costs of a Russian import stop remain firmly below 1% of Gross Domestic Product (GDP), or between 80 and 120 Euros per German citizen per year. In a more pessimistic scenario where it proves very difficult to substitute Russian gas in the short-run outside the electricity sector, the economic costs would rise to about 2-2.5% of GDP, or about 1000 Euros per German citizen over 1 year. This comes potentially on top of a large increase in energy prices for household and industry even without a shortfall of gas deliveries. Of course the effects are more detrimental in energy intensive sectors.*

*(iii) Data from the Income and Consumption Survey (EVS) show variation in the expenditure share on energy across the income distribution. However, the distributional consequences of an increase in energy prices appear manageable. A targeted policy towards low-income households without reducing the incentives for households to save energy would be a cost effective way of ensuring a fair burden-sharing across households. It is important to maintain strong incentives for households to reduce gas usage.*

*(iv) Economic policy should aim at strategically increasing incentives to substitute and save fossil energies as soon as possible. In case that an active embargo is politically desired, it should start as soon as possible so that economic agents can use the summer period for adjustment. To reduce dependence on imported energy, it is advisable for the government to commit to elevated fossil energy prices, in particular for natural gas, for an extended period to create incentives for households and industry to adjust quickly.*

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How would the German economy cope with a sudden stop of energy imports from Russia, either triggered by a further tightening of the sanctions regime, or following a stop of energy deliveries by Russia? In this paper, we combine the latest theoretical advances in multi-sectoral open-economy macroeconomics with an in-depth look at German energy usage and empirical estimates for elasticities of substitution to estimate the short-run costs.

Section 1 looks at Germany's energy dependence from Russia and shows that in the case of an import stop, the country would face a shortfall equivalent of ~30% of gas usage net of what can be substituted in electricity production, or 8% of total energy usage. Section 2 asks how the economy would adjust to such a shock, and at what cost. We show that losses to the German economy of embargoing energy imports from Russia are highly sensitive to the degree of substitutability of gas with other inputs. We use observed elasticities of substitution in industry to derive estimates of economic costs. Unlike frequent fears voiced in the public debate, substitution and reallocation would likely keep the economic costs below 3% of GDP, provided that fiscal and monetary policies cushion potential demand-side Keynesian effects.

Section 3 discusses the distributional effects of the import stop by looking at expenditure shares of high/low income households. Section 4 draws policy implications and in particular stresses the point that economic policy should encourage the adjustment, not try to delay it. Policy measures should aim at strategically increasing incentives to substitute and save fossil energies as soon as possible. If an embargo of Russian energy becomes politically necessary, a case can be made that actions should be taken as early as possible in order to trigger adjustments in industry and households before the winter while gas demand is seasonally low over the summer.

## **1. Germany's dependence on Russian energy**

Germany imports about 60% of its energy use (World Bank 2022), with import quotas between 94% and 100% for oil, gas and hard coal (Umweltbundesamt 2022). In 2021, the value of imports of fossil fuels and electricity amounted to about 80 bn Euros, or slightly over 2% of GDP (Statistisches Bundesamt (2022b)). About half of German imports of gas and hard coal, and about one third of oil imports originate from Russia. Germany depends on Russia for about 1/3 of total energy consumption (Table 1). Total goods imports from Russia in 2021, including other products, stood at 33 billion Euros (Statistisches Bundesamt 2022a). Trade with Russia accounts for only 2.3% of total German trade.

In the German economy, gas is predominantly used in industry (36%), by households (31%), as well as trade and commerce (13%), in the case of the last two predominantly for heating purposes (BDEW 2019, 2021). The usage of gas for electricity production is comparatively small. In industry, about three quarters of the gas are used for heating and cooling, as well as for material use. About a third of industrial use goes to the chemical industry (Zukunft Gas 2022). Regarding the use of hard coal, about  $\frac{3}{5}$  went to the steel industry and  $\frac{5}{8}$  to public electricity generation in 2018 (Sandau et al. 2021). Oil was predominantly (about 75% in 2017) used in the form of gasoline and diesel fuels (Wissenschaftliche Dienste des Deutschen Bundestages 2019).

Table 1 German primary energy usage 2021

	Oil	Gas	Coal (Lignite and Hard Coal)	Nuclear	Renew- ables	Others	Total
ThW	1077	905	606	209	545	45	3387
%	31.8	26.7	17.9	6.2	16.1	1.3	100
of which Russia	34%	55% <sup>§</sup>	26%	0%	0%	0%	30%

Notes: <sup>§</sup>in 2020 – already lower in 2021 and 2022.

Source: Agora Energiewende (2022); Eckert, and Abnett (2022).

If Germany decides to embargo Russian energy imports or Russia decides to impose export restrictions in reaction to, say, an embargo on oil sales, Germany would need to compensate for the decline of Russian energy imports either through alternative supply sources, fuel shifting and economic reallocation, or demand reduction. The different channels are likely to operate differently in the short and long term. In the short run, a stop of Russian exports has to be compensated through alternative energy sources from other countries and domestic sources to meet electricity, transport, heating and industrial demand or through substituting energy-intensive production of certain products by direct imports. In the medium and long term, increased use of renewable energy use and energy efficiency improvements can contribute significantly to lowering energy demand.

To start with, substituting Russian imports of oil and coal will likely not pose a major problem. Sufficient world market capacity exists from other oil and coal exporting countries to make up the shortfall. The greater challenge is to find short-run substitutes for Russian gas. Russian gas accounts for about 15% of Germany's total energy consumption. While oil and coal can likely be shipped from other countries, the situation in the gas market is more complex. Owing to the existing pipeline network and ultimately limited terminal capacities, a short-term substitution via LNG is challenging while raising pipeline imports from other countries is also subject to limitations.

The IEA estimates that imports via pipeline to the EU from Norway, Algeria and Azerbaijan could be increased by 10 billion cubic meters (bcm) compared to 155 bcm imports from Russia in 2021, and LNG imports theoretically by 60 bmc (up from 110 bcm in 2021 (Rashad, and Binnie 2022)). The IEA considers 20 bcm additional LNG more realistic in the current market (IEA 2022). Some of this gas would have to be stored pre-winter to compensate for missing Russian gas in the cold months. Moreover, switching from comparatively cheap contract prices with Russia to world market spot prices would imply a substantial (currently five-fold) increase of the gas price.

A recent study by Bruegel (2022) comes to the conclusion that it will be possible through substitution and European cooperation to meet demand in electricity generation, transport, and heating in the EU without encountering physical shortages (McWilliams et al. 2022a, 2022b). In its 10-point-plan to reduce the European dependency on Russian gas, the IEA (2022) also lists increasing coal and nuclear power production and renewables deployment as well as a number of demand-related measures that could theoretically contribute another 33 bmc reduction of gas usage in the EU. While switching to coal or nuclear can be considered plannable options, it remains uncertain to which extent potentials from changing consumer heating habits, increasing renewables deployment and energy efficiency of buildings can be raised. Most likely at least the later two options will play a minor role in the very short run.

There are few historic examples of energy supply disruptions on the scale of a potential Russian energy import stop. Comparisons might be drawn to the shutdown of nuclear power plants in Japan following Fukushima. Nuclear power at the time generated about 30% of electricity in Japan which was almost driven to zero in a time span of one year. Estimates show that the shutdown of nuclear power plants increased electricity prices, depending on the initial energy mix of a region, between 10% and 40% (Neidell, Uchida, and Veronesi 2019). This being said, with respect to overall energy consumption, nuclear energy accounted for only 13% in 2010 and due to previous overinvestment in LNG import capacities, substitution by natural gas was not subject to physical limits (Nesheiwat, and Cross 2013).

Russian gas imports already decreased substantially in the second half of 2021 and especially in the first months of 2022. On the EU level, its import share fell from about 40% to 20-30% (McWilliams, Sgaravatti, and Zachmann 2021). Liquefied natural gas (LNG) surpassed Russian imports, although capacity for further increases of LNG imports are limited (Rashad, and Binnie 2022). During the last few months, prices for coal, oil and gas have already increased dramatically.<sup>1</sup> It remains hard to pin down to what extent gas, hard coal and oil prices will rise further in the short term and what scenarios are priced in. We take this high degree of uncertainty into account in the next section by providing different scenarios. It is clear that prices had already increased before the Ukraine war broke out due to the revitalization of the world economy when COVID restrictions were lifted, the appreciation of the US Dollar, and, in the case of oil, the reluctance of OPEC to increase extraction substantially.

Taken together, the available evidence suggests at this point in time that other gas producers will only be partially able to make up the shortfall from Russia. Substitution and reallocation will thus be crucial. To construct a plausible size for the shock to the German economy from an Russian import stop, we make the following assumptions:

- Russia's import share in German gas consumption stood at 55% in 2020, but has declined in recent months. We make cautious assumptions with respect to the potential for increases in supply via LNG in the short run. We assume that capacity increase is

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<sup>1</sup> For crude oil (Brent) from 60 USD/Bbl in March 2021 to 90 USD/Bbl in the beginning of February 2022 to 110 USD/Bbl, coal (API2) from 65 USD/metric tonne of thermal coal in March 2021 to 145 USD/tonne in the beginning of February 2022 to 345 USD/tonne and for gas (TTF Gas) from 17 Euro/MWh in March 2021 to 70 Euro/MWh in the beginning of February 2022 to 160 Euro/MWh (March 3, 2022).

limited to 5% over the next year, meaning that the German economy would have to cope with a shortfall of 50% of gas deliveries.

- Looking at gas consumption, there is consensus that gas that is currently used for electricity generation can be saved by switching to lignite or hard coal. Nuclear energy can play a role here too, but in view of existing surplus capacity in coal-based power generation, the debate seems somewhat less crucial at the moment. The resulting savings of gas currently used for electricity generation free up close to 20% of total German gas consumption.
- We are thus left with a situation where the remaining consumers of energy (households, industry, services) will have to cope with a reduction in aggregate gas supply of 30%. Households account for about  $\frac{1}{3}$  of total gas consumption and services for 15%. Gas is used mainly for heating purposes in both. The best available evidence points to elasticities of substitution in the household sector between 0.2 and 0.4 in the short-run (Aufhammer and Rubin 2018).
- Industrial use accounts for 36% of the total, of which 11% are used as a direct input into chemical production and can likely not be substituted at all. The bulk of industrial gas use is for heat and cold applications. The potential for substitution is difficult to estimate, but likely substantially higher than for direct production usage. Existing studies for the UK manufacturing industry point to considerable short-run substitutions possibilities in heat generation of up to 0.5 (Steinbuks 2012).
- In the main scenario studied here, we assume that a reduction of gas deliveries of 30% or about 8% of total German energy consumption will result from a Russian energy embargo. This will have to be borne by domestic industry, households, and services. To build-in a dose of caution, for our simplified model we will assume a low elasticity of substitution of 0.1 in these sectors. This is substantially lower than the observed elasticities in the literature. We do so to account for potential rigidities of adjustment of the household sector related to the so-called “Kaskadenmodell”.

While some part of this gap can potentially be closed by filling reserves over the summer when heating demand from households is low without hurting industrial usage, our baseline assumption is that in the short-run the Germany economy would be forced to adjust to such a shock. What would be the economic effects?

## **2. The macroeconomic effects of a stop of energy imports from Russia on the German economy**

In the following we will approximate the effects of a reduction of German gas consumption triggered by a stop of gas imports from Russia. To estimate the macroeconomic effect, we build on a state-of-the-art multi-sector macro model with production networks based on work by Baqaee and Farhi (2021). The aim is to estimate the economic costs of a stop of Russian energy imports for the German economy in the current situation. We use the multi-sector model to conduct counterfactual simulations of the macroeconomic effects of cutting energy imports from Russia. We will cross-check the results of the complex model with a simplified version relying on different assumptions about elasticities of substitution.

The details of the model are explained in the Appendix, but a few words of explanation are important. The Baqaee-Farhi model is a state-of-the-art multi-sector model with rich input-output linkages in which energy is a critical input in production. The key economic assumptions of the model relate to (i) the degree of substitutability between different intermediate inputs in the production process, in particular between the type of energy imported from Russia and other inputs, measured by various elasticities of substitution, and (ii) to the ease of reallocation of resources in the economy. Both factors influence each other. A low elasticity is less of a problem if resources can be reallocated to other parts of the economy to maintain production in the critical sector.

This elasticity of substitution is challenging to discipline empirically, especially for large changes in the economy's input mix of the type that we are concerned with. A macroeconomic analysis is therefore subject to a considerable degree of uncertainty. It seems plausible to assume, however, that the elasticity of substitution is larger in the medium- and long-run, and smaller in the very short run (see e.g. Caballero, 1994). The size of economic losses stemming from a Russian import stop therefore depends crucially on the time frame over which adjustments take place.

It is implausible, however, to assume that even in the short-run the elasticity of substitution is zero. Producers and households will switch to other inputs to some extent, change their consumption baskets, or outrightly import energy, especially gas, or products with high energy content that can be transported in bulk. This qualification is important as the difference between a very low, but non-zero, and a literally zero elasticity translates into much smaller economic losses than in the case of zero substitutability (a Leontief production function). Estimations assuming zero short-run substitution are not suited for policy analysis. .

In the estimated model, for low elasticities of substitution, the Baqaee-Farhi multi-sector model predicts modest losses of around 0.2-0.3% of German Gross National Expenditure (GNE), or around €80-120 per year per German citizen. GNE is about 94% of German GDP so that the corresponding GDP effects are somewhat smaller and remain firmly below 1%.

The key reasons why the model-implied economic losses are relatively small are the following: (i) the share of fossil energy imports (gas, oil and coal) in German production is small to begin with at about 2-2.5% of GDP, and (ii) the model predicts that, while this share rises considerably, it will not rise by an unreasonably large amount. In the model, the change in the share of energy imports in GNE summarizes in a succinct fashion the substitutability implied by model choices about elasticities and changes in the input-output structure. Beliefs about substitutability boil down to beliefs about changes in the energy import share in GNE.

While the numbers coming out of the Baqaee-Farhi model imply limited costs, we acknowledge that the uncertainty surrounding elasticities of substitution (and the corresponding change in the import share) could be large. To derive a plausible upper bound of the costs, we complement our calculations from the rich multi-sector model, with an analysis of a simpler model. We discipline these estimates with empirical elasticities found in the literature for industrial energy usage on 4-digit Standard Industrial Classification (SIC) level (Steinbuks, 2012). Similar estimates are found for short-run residential demand for natural gas (Auffhammer and Rubin, 2018) and they also lie in the middle of the estimates for short-run demand elasticities across a large set of studies (Labandeira et al., 2017). In the first exercise,

we calculate the effects of an 8% aggregate reduction in overall German energy use. In the second scenario we model a 30% reduction in gas inputs as a shock to that specific energy source.

Table 2 shows the results of the different approaches, starting with the most complex Baqaee and Farhi (2020) model. Assuming very low short-run substitution elasticities, an 8% energy adjustment to oil, gas, and coal consumption leads to a 1.4% of GDP loss, or costs of €500-700. In a last scenario where we model a more extreme 30% adjustment in gas usage, the economic losses rise to 2.2% of GDP (2.3% of GNE), equivalent to up to €1,000 per year per German citizen, i.e., an order of magnitude higher than the 0.2-0.3% or €80-120 implied by the Baqaee-Farhi model.

It is important to stress that the model we use is a real model with no further business cycle amplification. In other words, it calculates the economic response based on the assumption that monetary and fiscal policy can undo further effects from nominal rigidities in the economy. On the monetary side, a firm commitment to stable prices can soften the potential trade off between stabilising output and inflation. If one views the energy price shocks as akin to a productivity shock, then this would require the central bank to raise interest rates in order to stabilise inflation. Through dampening economic activity somewhat, this would also alleviate further the direct energy supply problem.

Given that the shock also has the potential to increase the profit share of foreign energy importers, the shock has some elements of a shock to markups, which are more difficult to deal with for the central bank as they raise a conflict between stabilising output and inflation. At the same time, fiscal policy needs and can, through insurance mechanisms (like short term work) take care of second-round demand effects. With appropriately calibrated demand-side stabilization policies, it should in principle be possible to avoid additional costs.

This being said, it is important to note that our estimations assume that such second round effects can be avoided and potential problems in the financial sector through bad loans or house price declines in specific regions and industries can be dealt with without further amplification. We also assume that central bank policy avoids a potentially costly inflation surge that unanchors inflation expectations of the public.

Table 2

	Baqaee-Farhi (2021), full model	Simplified model, 10% oil, gas, coal shock	Simplified model, 30% gas shock
GDP, %	0.2-0.3	1.3	2.2
GNE, %	0.2-0.3	1.5	2.3
Cost per citizen	€80-120	€500-700	€800-1000

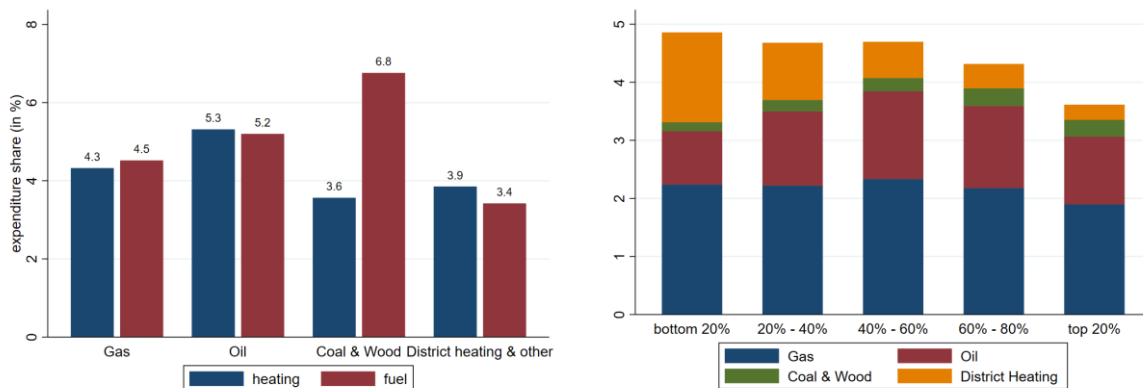


### 3. Distributional effects

Fiscal insurance elements would be particularly important if, beyond their macroeconomic consequences, increased fuel and gas prices are redistributive. If, for example, the poorest households were overly exposed to such price changes, then this might be of independent concern. To explore the distributional consequences of a rise in energy prices, we take data from the German Income and Consumption Survey (*Einkommens- und Verbrauchsstichprobe, EVS*). We focus predominantly on expenditure for heating as gas prices have risen the strongest over the last year (almost 10-fold increase). Nevertheless, price increases for oil and hard coal of course add to the overall additional burden on households, especially in the case of gasoline, diesel and electricity.

The EVS data provide representative data for the German population on their consumption and income. As the source of the German CPI consumption basket, the data provide a high granularity on the expenditure composition of households including data on expenditures on different energy sources. We rely on the latest available microdata from the Research Data Center of the German Statistical Office. For our analysis, we group households by income, type of heating, and household size. For income, we use data on net household income and group households into income quintiles.

**Figure 1: Energy expenditure shares**



(a) By heating source

(b) By income

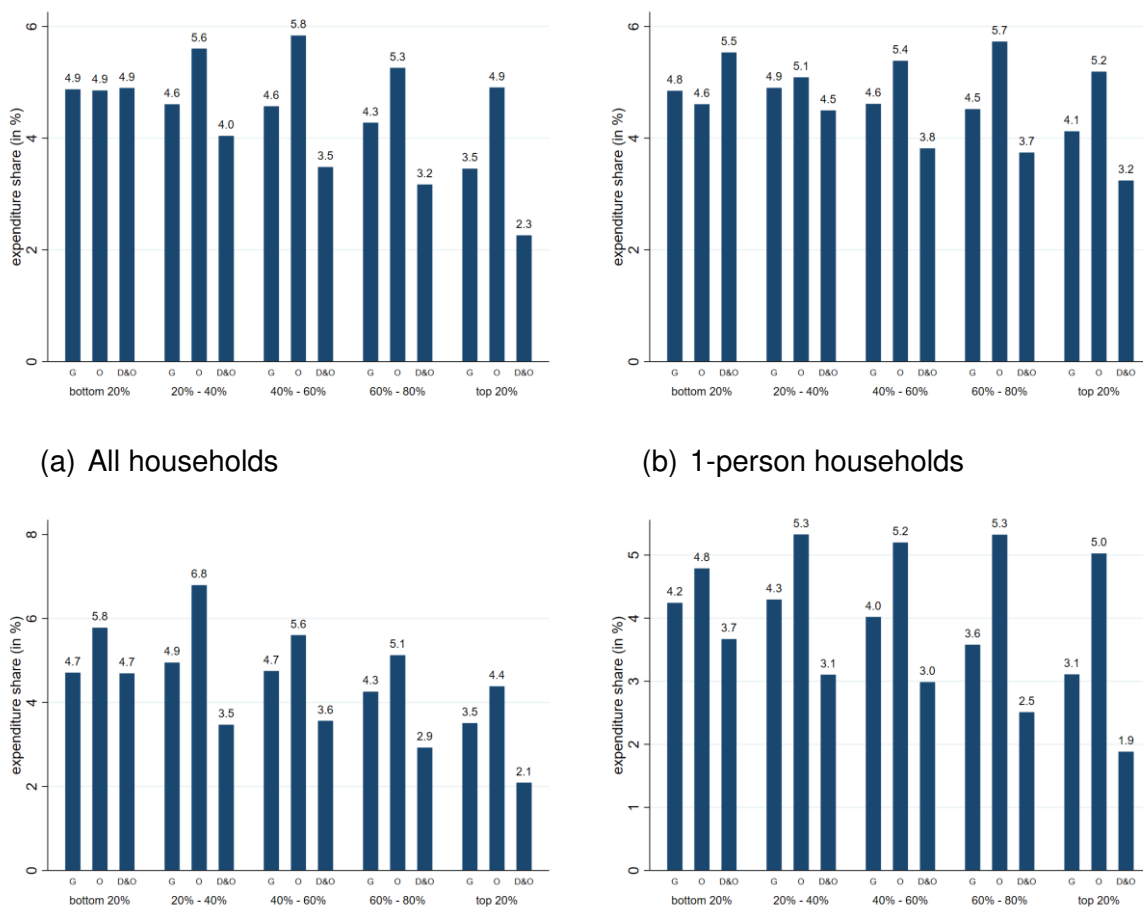
Notes: Left panel shows expenditure shares for all households by type of heating for heating (blue bars) and for fuel (red bars). Right panel shows energy expenditure shares for different heating sources along the income distribution.

Figure 1 shows the expenditure shares depending on the main source of heating (a, left panel) and by income quintiles (b, right panel) for both heating and car fuel (only left panel). We find that typically households spend between 3 and 6 percent on heating. Similar expenditure shares apply to car fuel that vary between 3.4 and 6.8 percent. If we consider only gas and oil as the two by far most important heating sources, the heating expenditures are 4 and 5 percent and car fuel varies between 3.4 and 5.3 percent as well. Gas is the most important source for heating energy and oil comes in second. One exception are the bottom 20% of the income distribution where district heating is the second most important expenditure category, see

Figure 1b. Changes in expenditure for this heating source can also arise, however, as only 17.4% are estimated to be generated from renewable energy.<sup>2</sup> What is striking is the fact that the income gradient in the expenditure share for heating is small. Potentially, differences in household size might be a confounding factor here. Therefore, Figure 2 splits up the data further and distinguishes not only along the income distribution but also along the main type of heating and household size.

The top left panel of Figure 2 first looks at all households independent of household size. We find again that expenditure shares for oil are the highest and do vary only a little along the income distribution. Costs for gas are second and decline slightly up to the fourth quintile and decline by about 1 percentage point between the fourth and the fifth quintile. District and other heating shows the lowest expenditure share throughout and also shows a strongly declining trend along the income distribution from 4.9 percent in the bottom 20% to 2.3 percent in the top 20%. Panels (b) to (d) offer a further breakdown by household size. The overall pattern is robust: there is relatively little variation in the expenditure share on heating across the income distribution. One exception are households with 3 and more members. They have lower expenditure shares in general and the decline of expenditure shares from 3.7 percent to 1.9 percent in income is the strongest.

**Figure 2: Heating expenditure shares by income, heating source, and household size**



<sup>2</sup> <https://www.bdew.de/online-magazin-zweitausend50/schwerpunkt-netze/fernwaerme-waermetetze-fuer-die-energiewende/>

(c) 2-person households

(d) 3 and more person households

*Notes: Heating expenditure shares for households along the income distribution and by source of heating. Panel (a) shows all households, panel (b) 1-person households, panel (c) 2-person households, and panel (d) households with 3 and more members. Income deciles are separately computed for each household group. Heating sources are labelled "G" for gas, "O" for oil, and "D&O" for district and other.*

Along the income distribution and depending on household size there are some differences in expenditure shares. High-income households and families have slightly lower expenditure shares. We also find that compared with oil heating, households that rely on gas heating have on average lower expenditure shares so that a stronger increase in the gas price than in the price of oil might lead to an equalisation in expenditure shares between these two largest household groups, albeit at a higher level.

High-income households can absorb expenditure shocks from rising energy prices better than low income ones as the former can reduce savings (or use accumulated wealth) to smooth out transitory cost increases. Targeted transfers to low-income households can be a cost efficient way to compensate for an unequal impact of rising energy prices along the income distribution. As inflation will be very high in 2022 and rising energy prices will further contribute to rising price levels, it seems necessary to adjust the nominal values of certain parameters of the tax and transfer system should the ECB not manage to stabilise the overall inflation rate by inducing offsetting price decreases elsewhere.

#### **4. Policy implications**

The discussion above shows that the macroeconomic effects highly depend on how much the production structure can adjust to the reduction of fossil energy imports and on how substitutable these imports from Russia are in terms of replacing them by imports from other suppliers. In the very short run, this substitutability is of course limited and depends on the final usage of these fossil resources: electricity production can adjust quickly and at relatively low costs while replacing their material use, for example, will be more difficult up to impossible. However, the overall economic costs can be affected by targeted policy measures and their timing.

First and foremost, policy measures should aim at strategically increasing incentives to substitute and save fossil energies as soon as possible even if an embargo is not imminent. Beginning to take action immediately avoids even harsher adjustments later this year or in 2023 should push come to shove. While the currently high energy prices create some adjustment incentives, existing insurance schemes (e.g., emergency rationing plans for gas to favour households, expected bail outs for affected industries), have a tendency to lull decision makers in industry and households into not fully internalising potential costs of delaying their adjustments, and instead might induce them to gamble on a no-embargo scenario with a normalisation of energy prices. This, in turn, might severely limit political options to strengthen the sanctions regime down the road.

By the same token, if an embargo of Russian energy turns into a political necessity in the short-run, a case can be made that such action has the lowest economic costs if it is taken as early as possible. The main reason is the seasonality of gas demand. A cut-off from Russian gas over the summer months could be substituted from Norwegian and other sources, keeping

industrial supply going. At the same time, such an early move would immediately trigger the substitution and reallocation dynamics that are central to reducing the economic costs. It has, however, to be taken into consideration whether it will be possible to fill up storage capacities during the summer if Russian imports are stopped now. A continuation of Russian gas imports today, might reduce uncertainty of whether this will be feasible. Otherwise, the economic costs of an embargo might be considerably higher and give additional leverage to Russia.

Absent imminent action, there is a strong case for forward guidance in energy markets for the next couple of years. Governments should commit to elevated fossil energy prices for an extended period of time even if no embargo realises. This could include, for example, some sort of “energy security levy” on natural gas. It also means that there should be a firm commitment to climate policy driven increases in energy prices. On the European level, this implies support of tightening the EU emission trading scheme as planned in the EU’s Fit for 55 Package. More importantly, however, this also makes a case for increasing German CO<sub>2</sub>-prices that are predominantly levied on mobility and heating. This would also prepare these sectors for the introduction of an EU emission trading system as intended in the EU Fit for 55 package.

Although raising high energy prices will be the political equivalent of a hot potato, only this will create the needed incentives for households and industry to take immediate action, by increasing efforts to improve energy efficiency and substitute towards renewable energy. Of course such a persistent increase in energy prices would have implications for households as well as industry. As we have seen, the costs are distributed relatively evenly across households but would still need to be addressed with respect to the poor. In case of no embargo realising, revenues from CO<sub>2</sub>-pricing and/or a “energy security levy” would create government revenues that can be used to finance such measures. Regarding industry, a blanket compensation for higher energy prices cannot be efficient. However, targeted policies can help adjustment in the short-term if the long-term outlook for an industry under lower energy use or a fuel switch is positive. This way, such policies have the potential to accelerate the transition to a carbon-neutral economy.

Another area of action concerns the energy infrastructure. Given the higher costs of adjustment in the short compared to the long run, it makes a difference if an LNG terminal is ready by autumn 2023 or 2026. Government subsidies and contracts should therefore create clear incentives here as well, providing substantially higher payments under early completion. This includes encouraging private investors to privately assume risks, like when Tesla builds a factory without all constructions being finally approved by the public authorities. This will increase costs, but it is important to view these as an insurance premium. If no embargo realises, having LNG terminals ready earlier serves little purpose, but in case of an embargo, they are of great value. This also needs to be taken into account when designing the public processes of approving.

Let us close with more on the consequences of a potential embargo on the household sector, as much of the current discussion revolves around this topic. While power shortages or cold homes are highly unlikely, rising energy prices will be felt acutely. One concrete remedy could be to rebate (artificially) increased gas, oil and electricity prices through lump-sum payments. If not only poor households are targeted, these payments could be made independent of income purely on a per capita basis. This still would have regressive effects without impeding

the incentives to reduce energy consumption. Alternatively, such a scheme could be carried out by gas or power providers who would then be compensated by the state. This would allow for the lump-sum payments to be based on actual past energy consumption. This would, however, also imply that higher income households who on average have higher absolute heating and electricity expenditures would receive more.

Other candidates for policies targeting especially poor households would be, for example, increasing the basic amount of social assistance payments (“Hartz IV Regelsatz”) or the housing allowance. Also, lowering electricity prices through a reduction of the electricity tax would help poor households most and, at the same time, incentivize the use of increasingly green electricity in mobility and heating. Furthermore, regarding adjustments of the tax system, raising the basic allowance of the personal income tax is one of the measures suggested by the German governance. Increasing Hartz IV and the basic allowance of the personal income tax both by 5% (10%) each could result in total fiscal costs of approximately 5 (10) bn Euro per year while slightly reducing inequality and poverty.<sup>3</sup> This being said, a more targeted policy towards low-income households would likely be more cost effective and hence preferred - not only from an efficiency point of view but also a redistributive one.

In case of an actual embargo and consequently rising energy prices, additional energy price increasing measures should be dropped or adjusted. Payments to households would still be necessary to avoid economic hardship, but should be decreased over time to induce necessary investments and behavioural adjustments. Given their temporary nature, these payments could in the meantime be financed through government debt.

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<sup>3</sup> See ifo microsimulation model.

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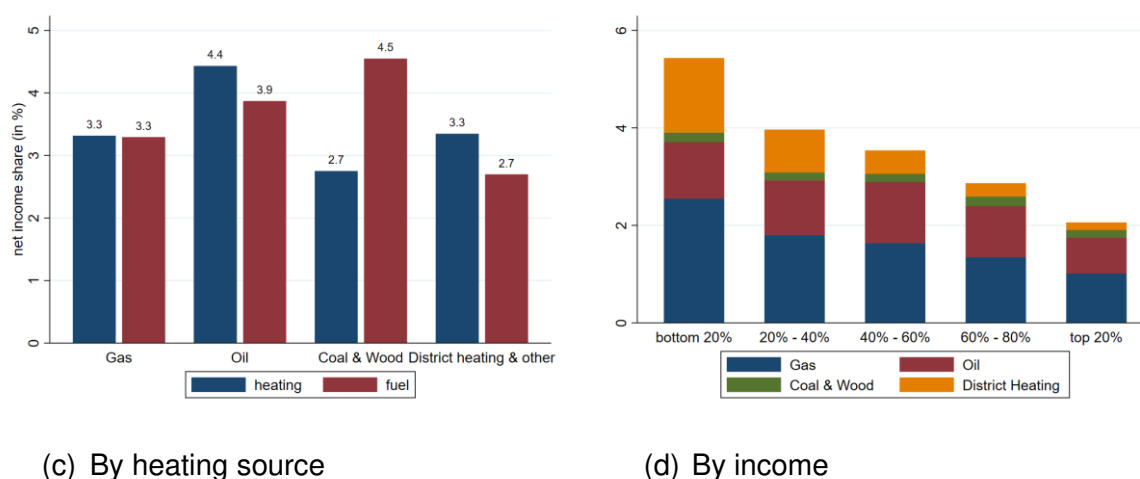
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## Appendix A

### A Energy expenditure shares of income

In the main part of the analysis, we focus on the share of energy expenditures in total household expenditures as this is directly related to purchasing power of households and welfare. If energy prices increase, households will be able to buy less goods and services with the same amount of income. An alternative is to look at the share of energy expenditures in total household income. The difference between the share in household expenditures and the share in household income is the saving rate of households. It is well known that high income households have higher saving rates (Dyner et al. 2004). Hence, we expect that the level of household expenditures as a fraction of income declines with income because income exceeds expenditures for most households while differences in expenditure shares of households increase because of different saving rates along the income distribution. Figure A presents the equivalent results to Figure 1 from the main text but as a fraction of household net income rather than household expenditures. The main difference is that now because of higher saving rates with higher incomes, the energy expenditure share as a share of income declines along the income distribution but it is also substantially lower. The typical household in Germany (median household in income group 40% - 60%) spends only between 3% and 4% of net income on energy, and gas expenditures are even below 2% of household net income.

**Figure A: Energy expenditure as share of household net income**

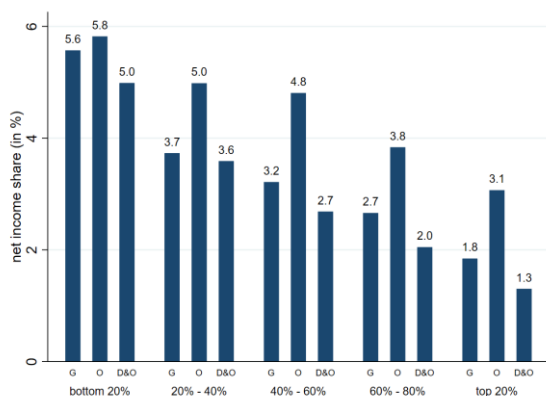


Notes: Left panel shows expenditure as a share of household net income for all households by type of heating for heating (blue bars) and for fuel (red bars). Right panel shows cost shares as a fraction of household net income for different heating sources along the income distribution.

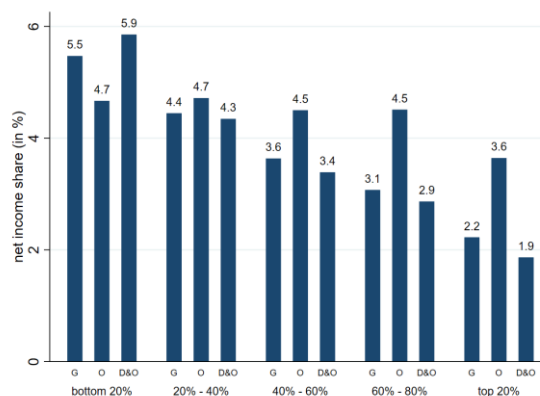
Figure B repeats the results from Figure 2 of the main text but showing heating expenditures as a share of household net income rather than total household expenditures. The same conclusions as for the comparison between Figure 1 and Figure A apply: We find shares in income to be lower and we find a noticeable decline of the expenditure shares with income.



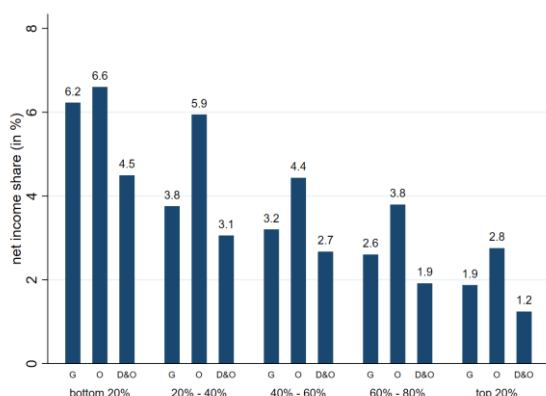
**Figure B: heating expenditures as share of household net income by income, heating source, and household size**



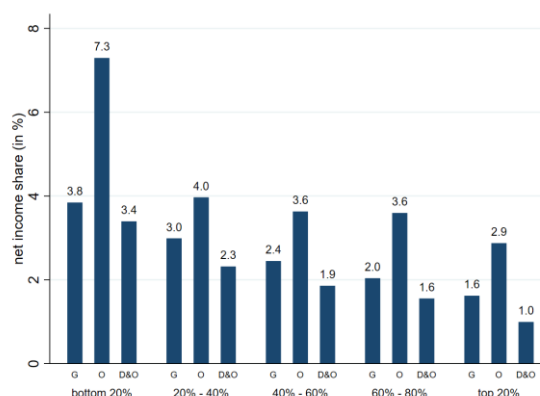
(a) All households



(b) 1-person households



(c) 2-person households



(d) 3 and more person households

Notes: Heating expenditures as shares of household net income for households along the income distribution and by source of heating. Panel (a) shows all households, panel (b) 1-person households, panel (c) 2-person households, and panel (d) households with 3 and more members. Income deciles are separately computed for each household group. Heating sources are labelled "G" for gas, "O" for oil, and "D&O" for district and other.