Supplementary Tables

Supplementary Table 1: Overview of surveys among German households on saving energy in response to the current crisis

Survey	Summary
Bitkom[1]	Method: Interviews via telephone during March 2022 with 1,003 respondents, asking the following questions related to reductions in natural gas consumption: 1. Has your personal approach to the issues of electricity and energy consumption in your household changed against the background of the Russian war of aggression on Ukraine, i.e., do you, for example, consciously use less electricity, consciously heat less, or have switched to green electricity? 2. Which of the following applications or measures to save electricity and energy do you use considering the Russian war of aggression on Ukraine? Among others, the investigated measures included saving hot water, e.g., through showing instead of taking a bath; use public transport instead of individual cars, reduce space heating) Responses: 1. Significant changes were reported by 16% and small changes were reported by 32% of the respondents. Meanwhile, 47% of the respondents reported no changes. 2. Of those that consciously use less energy, 40% reported to reduce warm water and 22% report to reduce space heating.
YouGov[2]	Method: Online survey conducted from 14 to 31 March 2022 across ten European countries with about 12,000 respondents (2,111 in Germany), asking the following question related to reductions in natural gas consumption: 1. In which concrete ways, if any, has the increase in prices for electricity, gas, and heating affected you so far? Among others, the options from which respondents could choose included “I use less heating” and “I changed my habits to save energy”. Responses: 1. Both items (“I use less heating” and “I changed my habits to save energy”) were selected by 31% of the respondents (across all countries; individual results for Germany are not available).
Tado[3]	Method: 2,500 customers of tado°, a company offering intelligent heating thermostats, asking the following two questions: 1. Has your heating and energy consumption changed since the start of the war in Ukraine? 2. If so, why are you saving more energy now? Responses: 1. 55% of the respondents reported to save more energy. 2. The reported reasons were saving money (55%), reducing dependency on Russian gas (27%), and protecting the environment (18%).

Supplementary Table 2: Main specification OLS regression results for the following model specifications: small consumers (left), large consumers (center), power sector (right).

*The unit of crisis response dummies is (TWh/month) and the 95% confidence intervals are reported in brackets. The significance levels are reported as *** for 0.001 ** for 0.01, and * for 0.05.*

		Small consumers	**Industrial consumers**	**Power sector**
	Adjusted R^2	0.999	0.986	0.756
Crisis response dummies	Sep 2021	0.606*** [0.307, 0.904]	-1.438*** [-1.9, -0.975]	-2.641** [-4.151, -1.131]
	Oct 2021	-1.176* [-2.293, -0.059]	-2.32*** [-3.112, -1.529]	-3.78*** [-5.225, -2.336]
	Nov 2021	-0.761*** [-1.078, -0.445]	-0.847 [-1.798, 0.103]	-1.037* [-2.067, -0.007]
	Dec 2021	-0.259 [-0.873, 0.356]	-1.571*** [-2.251, -0.891]	0.316 [-1.616, 2.247]
	Jan 2022	0.05 [-0.379, 0.479]	-2.164*** [-2.74, -1.587]	-2.179* [-3.996, -0.363]
	Feb 2022	-0.039 [-1.169, 1.09]	-1.863*** [-2.661, -1.065]	-4.278*** [-6.372, -2.183]
	Mar 2022	-4.904*** [-5.791, -4.017]	-2.417*** [-3.346, -1.489]	-0.747 [-2.726, 1.231]
	Apr 2022	-2.078*** [-3.216, -0.94]	-2.785*** [-4.334, -1.235]	-1.817* [-3.567, -0.068]
	May 2022	-2.093*** [-3.059, -1.126]	-2.997*** [-4.281, -1.713]	-2.039** [-3.381, -0.696]
	Jun 2022	-1.186*** [-1.579, -0.793]	-3.315*** [-4.268, -2.362]	-3.215*** [-4.897, -1.532]
	Jul 2022	-1.356*** [-1.72, -0.993]	-5.248*** [-6.034, -4.463]	-4.539*** [-6.778, -2.301]
	Aug 2022	-1.349*** [-1.661, -1.038]	-6.801*** [-7.38, -6.223]	-3.338* [-6.058, -0.617]
	Sep 2022	-4.799*** [-5.283, -4.315]	-7.644*** [-8.429, -6.858]	-4.662*** [-6.44, -2.884]
	Oct 2022	-5.779*** [-6.82, -4.738]	-9.873*** [-10.626, -9.12]	-4.353*** [-6.012, -2.693]
	Nov 2022	-9.231*** [-9.558, -8.903]	-10.123*** [-11.114, -9.132]	-5.875*** [-7.285, -4.465]
	Dec 2022	-7.895*** [-8.594, -7.197]	-10.629*** [-11.535, -9.722]	-1.454 [-3.725, 0.817]
Simulated heating profiles		0.88*** [0.841, 0.919]	0.236*** [0.194, 0.279]	-
Linear time trend		0.025*** [0.015, 0.035]	0.005 [-0.012, 0.021]	0.039* [0.006, 0.072]
Month		Dummies	Dummies	Dummies

Supplementary Notes

Supplementary Note 1: Measurement error

The available price data are prone to measurement error. Regarding small gas consumers, those living in multi-family houses are often informed about price changes only with a substantial lag. The price index used in this study—although very useful because of its monthly resolution—is not based on a representative household survey that would reflect these lags, but on average residential prices derived from a supplier survey. Regarding industrial consumers, it is unclear to which extent they can resell their contracted gas volumes at the spot market, which would imply that they were exposed to spot prices instead of industrial purchase prices.

Potential measurement errors are aggravated by the fact that, during our period of observation, the German government has supported the industry during the crisis with an *Energy Cost Mitigation Program* (*Energiekostendämpfungsprogramm*). The program was proposed by the German government in April 2022, confirmed by the EU in July 2022, and applies retroactively to the period from February 2022 onwards. Under certain qualifications, it compensates industry for 30–70% of the energy cost increase, thereby reducing effective natural gas prices below the observed price index. However, the program has been criticized for its ineffectiveness[4]. For instance, by end of October 2022 only 4 billion € of the available 70 billion € have been approved[5].

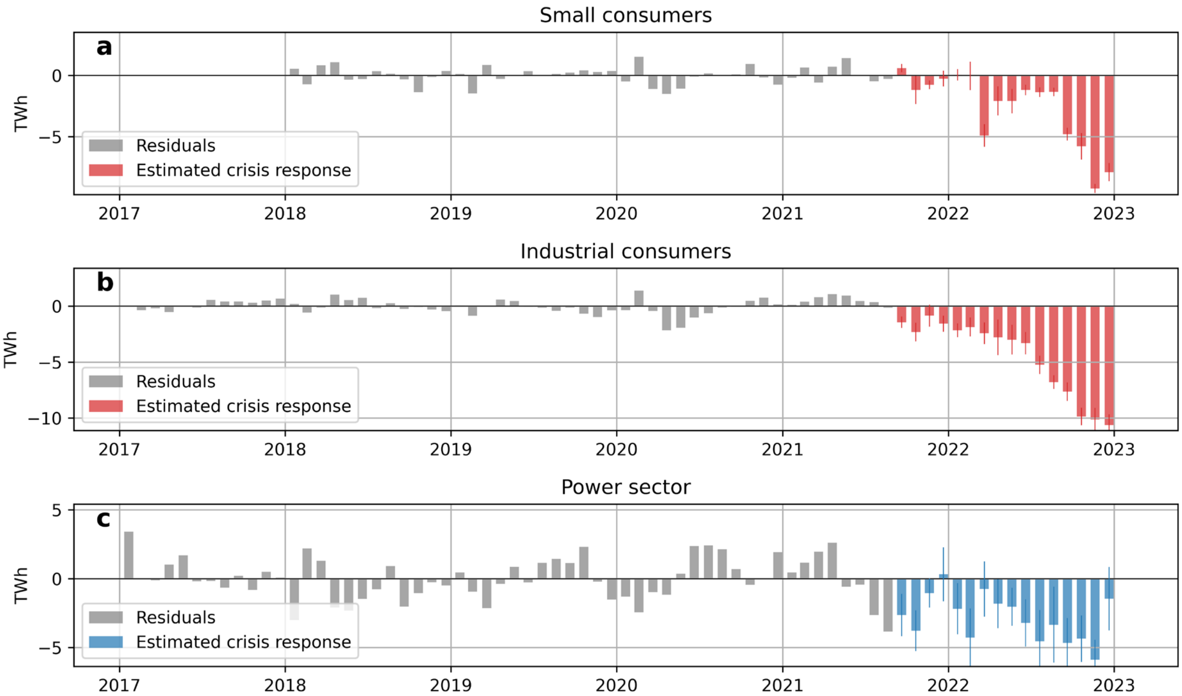
Measurement errors may induce a downward bias on price elasticities—as a general rule[6] and in particular if measured price changes are higher than effective price changes.

Supplementary Note 2: Analysis of residuals

Supplementary Figure 1 contrasts our estimated crisis responses (displayed in red and blue) with our pre-crisis model residuals (displayed in grey). The estimated crisis responses capture the differences between consumption as observed and consumption as expected by our models fitted on pre-crisis observations, while the model residuals capture unexplained changes in consumption prior to the crisis. Note that the model residuals are, because of our model specification, zero during the crisis period, as all observed changes are absorbed by the monthly crisis response variables.

For small and industrial consumers, the size of the estimated crisis response dwarfs the pre-crisis residuals. Even during the COVID-19 lockdown starting in March 2020, extraordinary gas savings are much smaller than those observed during the second half of 2022. For the power sector, residuals and crisis effect are more similar in amplitude, which reflects the smaller explanatory power of our model for this sector (see Supplementary Table 2).

We employ the White test to determine whether heteroscedasticity is present in our model residuals. The test indicates that heteroscedasticity is not an issue in our models for small and industrial consumers but indeed in the power sector model. To account for that, we compute heteroscedasticity and autocorrelation consistent (HAC) standard errors.



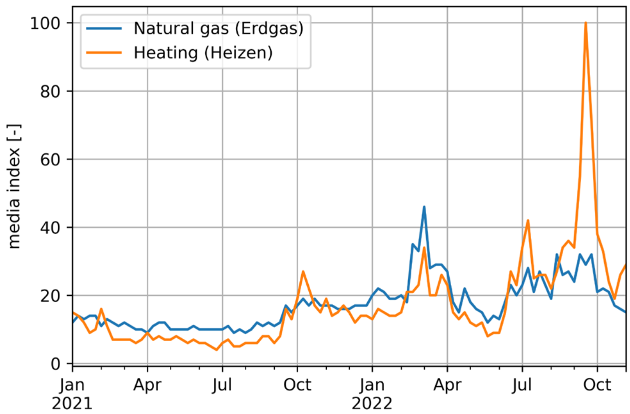
Supplementary Figure 1: Estimated crisis response and pre-crisis residuals

Residuals are the monthly difference between observed and fitted values (consumption data for small consumers is available only from 2018 onwards). For the crisis months, these residuals are zero because our crisis variables entirely explain the residual difference that cannot be explained by our independent variables. For small and industrial consumers, we control for temperature and economic activity. The bars indicate the monthly point estimates and the vertical lines the corresponding 5-95% confidence intervals.

Supplementary Note 3: Salience of energy topics

Consumer attention and engagement with energy topics can moderate and complement the effect of energy prices on consumption reductions. For instance, the literature has shown that price elasticities increase with the salience of price changes[7–9]. Price changes may be more salient to consumers when the magnitude of the change is sufficiently high, as during the current crisis. In fact, during our period of investigation, the public attention for energy topics in Germany has increased significantly and nonlinearly. This is exemplarily evidenced by the trends in online search queries for "natural gas" and "heating", displayed in Supplementary Figure 2. The number of queries surged after Russia's invasion of Ukraine in the end of February 2022 and then during the beginning of the heating seasons in September 2022.

Moreover, the literature shows that the provision of targeted information, social advertisements, education and social comparison can be used to effectively impact consumption behavior[11,12]. An example for this during our period of investigation is a campaign called *Energy Shift* (*Energiewechsel*) launched by the German Federal Ministry of Economy and Climate Protection in June 2022.



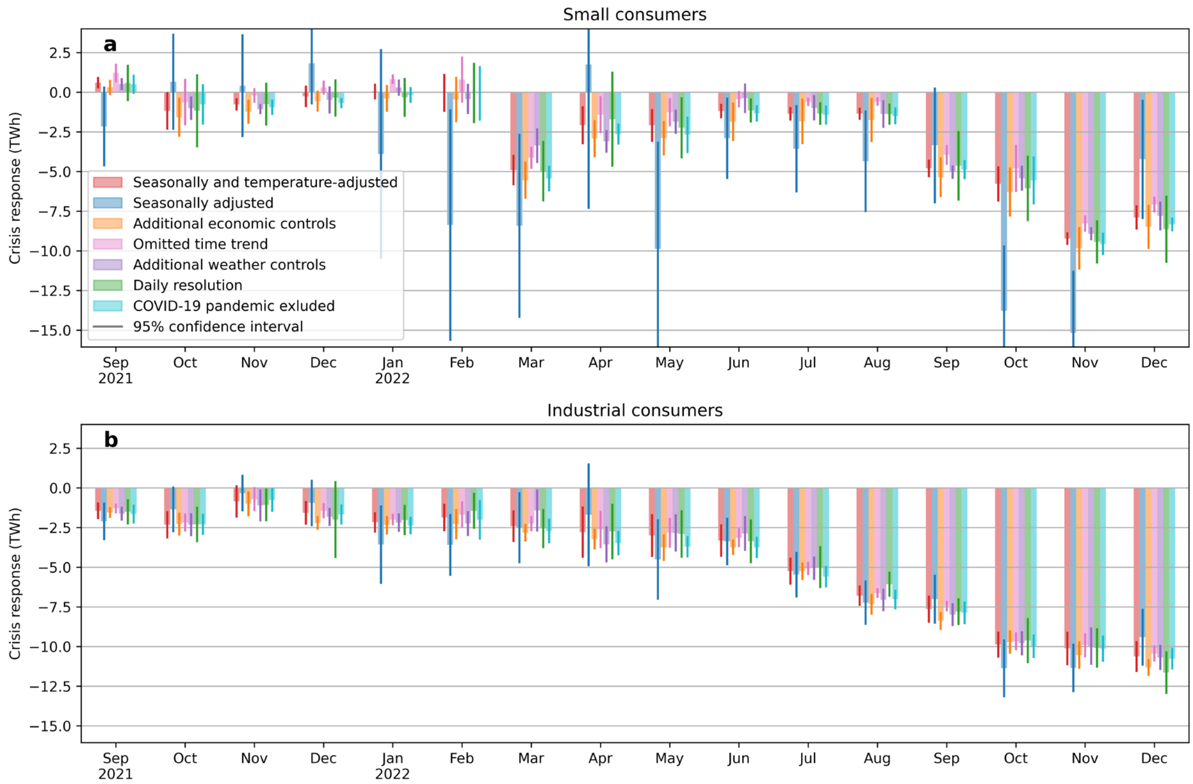
Supplementary Figure 2: Salience of energy topics throughout the crisis
The graph shows a strong increase in Germans researching natural gas (German: "Erdgas") and heating (German: "Heizen"). A prominent spike is visible in after the beginning of the Russian invasion of Ukraine in late February 2022. The data was downloaded from Google Trends[10].

Supplementary Note 4: Sensitivity analyses

To analyze the robustness of our results to changes in model specifications, we conducted additional sensitivity runs for small and industrial consumers (Supplementary Figure 3).

As a first sensitivity analysis, we omitted the simulated heating profiles to illustrate the benefits of controlling for temperature. Without temperature adjustment, the estimated crisis response for small consumers varies substantially and is subject to high uncertainty, as indicated by the large error bars. As a result, estimates are often insignificant. Only when accounting for temperature can we identify a more consistent and less uncertain crisis response. For the response of industrial gas consumers, model estimates change less when not controlling for temperature as the temperature dependency is smaller. However, our main model can better explain the monthly variations in gas consumption, and the confidence intervals of the estimated crisis responses become narrower.

We also run a sensitivity analysis with additional controls for economic activity and real hourly wages. While economic activity wages may positively affect natural gas consumption, their exogeneity during the crisis is questionable. For industrial consumers, we use the inflation-adjusted production index for the manufacturing sector as a covariate. For small consumers, around 30% of total consumption stems from small commercial businesses such as bakeries, supermarkets, or hotels[13]. We control for their economic activity through inflation-adjusted sales indices for the retail and hospitality sectors. We additionally include real wages. All indices are retrieved from the German Statistical Office DESTATIS[14], and the latest available datapoint was December 2022.



Supplementary Figure 3: Sensitivity analyses

Coefficients of the monthly crisis dummies for our main model are shown as red bars. Sensitivities depart from the main specification by omitting the simulated heating profiles (blue), controlling for economic activity and real income (yellow), omitting the linear time trend (pink), additionally controlling for solar radiation and ambient temperature (purple), or estimating the main specification using a daily resolution of our time series (green). Finally, we excluded the first year of the COVID-19 pandemic (March 2020 to February 2021) from our sample. The vertical lines on these bars indicate the estimates' 5-95% confidence intervals.

When also controlling for economic activity and income, we find insignificant effects of hospitality and retail sector activity as well as of real income on small consumers' gas consumption. The effect of manufacturing production on industrial gas consumption is, as expected, positive and significant. In many crisis months, controlling for economic activity slightly increases the estimated crisis response of industrial consumers. This implies that manufacturing activity was higher than usual, and gas consumption has been lower than usual, nevertheless. Hence, as a response to the crisis, gas consumption was disproportionally reduced compared to economic activity in manufacturing. Put differently, industrial consumption reduction was not caused by a general economic downturn in the manufacturing sector but rather by a specific crisis response, such as switching fuels or substituting domestic production of energy-intensive products with imports. One illustrative example of this is the case of German ammonia production. As we have shown in an earlier analysis, the decline in German ammonia production was largely compensated by an increase in imports, allowing downstream fertilizer production in Germany to remain fairly stable[15].

Omitting the time trend from our model reduces the size of the crisis effect for small consumers. As the trend term captures a positive and significant trend in residential and commercial consumption prior to the crisis, fitted baseline consumption during the crisis is higher when this time trend is included in the model. This increases the difference between observed and baseline consumption and thus the estimated crisis effect. A specification that does not allow for a time trend in consumption is therefore prone to omitted-variable bias and was not considered for our main model (see *Supplementary Note 5: Unit root tests* for related statistical tests).

In another sensitivity analysis, we included population-weighted ambient temperature as well as population-weighted solar radiation as additional independent variables in our model. This is to test for potential temperature effects that are not well captured by the simulated heating profiles as well as the potential of solar radiation to reduce heating demand. While the estimated effect of both variables is significant, the inclusion of these variables does not alter the estimated crisis response. For simplicity, we decided not to include them in our main model.

We also estimated our main model specification using our data in their original, daily resolution. In this specification, we include fixed effects for the day of the week and exclude holidays, days between holidays and weekends, and the period between Christmas and New Year from our dataset because German companies are often closed on these days. We find that this hardly changes our estimates.

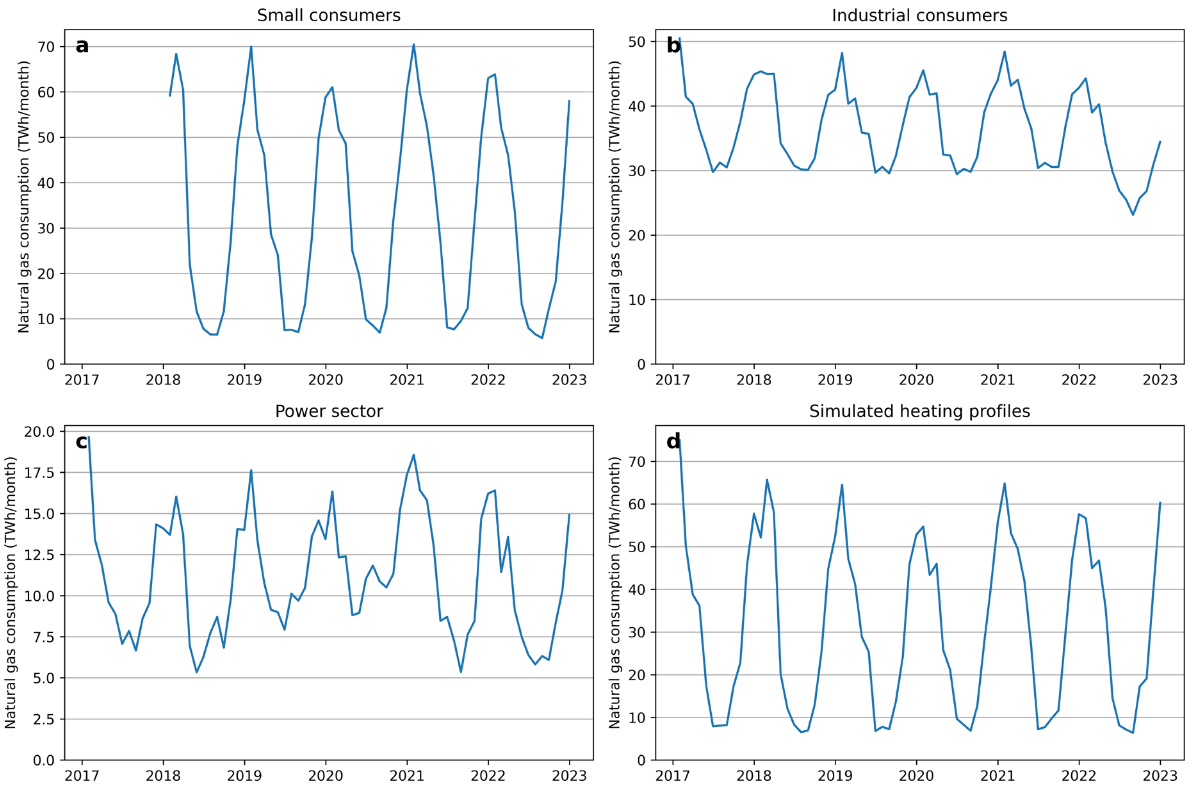
Finally, excluding the first year of the COVID-19 pandemic (March 2020 to February 2021) from our sample does not systematically alter our estimates of the energy crisis effect.

Supplementary Note 5: Unit root tests

We investigate potential unit roots of our time series using the Augmented Dickey-Fuller (ADF) test and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests. Supplementary Figure 4 clearly shows that all series used in our main specification as independent and dependent variables exhibit pronounced seasonality because of their temperature dependency. Since both the ADF and KPSS tests are tailored to detect non-seasonal unit roots, testing the original series might conceal an underlying stochastic trend.

We hence regress all four variables shown in Supplementary Figure 4 on monthly fixed effects to account for seasonality. The ADF and KPSS tests are performed on the resulting residuals. The ADF test (including a trend in the test regression) concludes that the residuals of small consumers, power sector consumers, and the simulated heating profiles are stationary after controlling for seasonality. For the seasonally adjusted industry residuals, the ADF test cannot reject the null hypothesis of a unit root.

Similarly, the KPSS test rejects the null hypothesis of (trend) stationarity only for industry residuals. This supports the notion of a persistent shock to consumption, which makes the industry residuals over the entire sample period appear like a random walk. When the tested residuals series is restricted to the pre-crisis period, we can reject the null hypothesis of a unit root for industry residuals in both tests as well.



Supplementary Figure 4: Natural gas consumption by consumer group as well as simulated heating profiles

We display monthly sums of natural gas consumption and of simulated heating profiles. Consumption data for small consumers is available only from 2018 onwards.

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