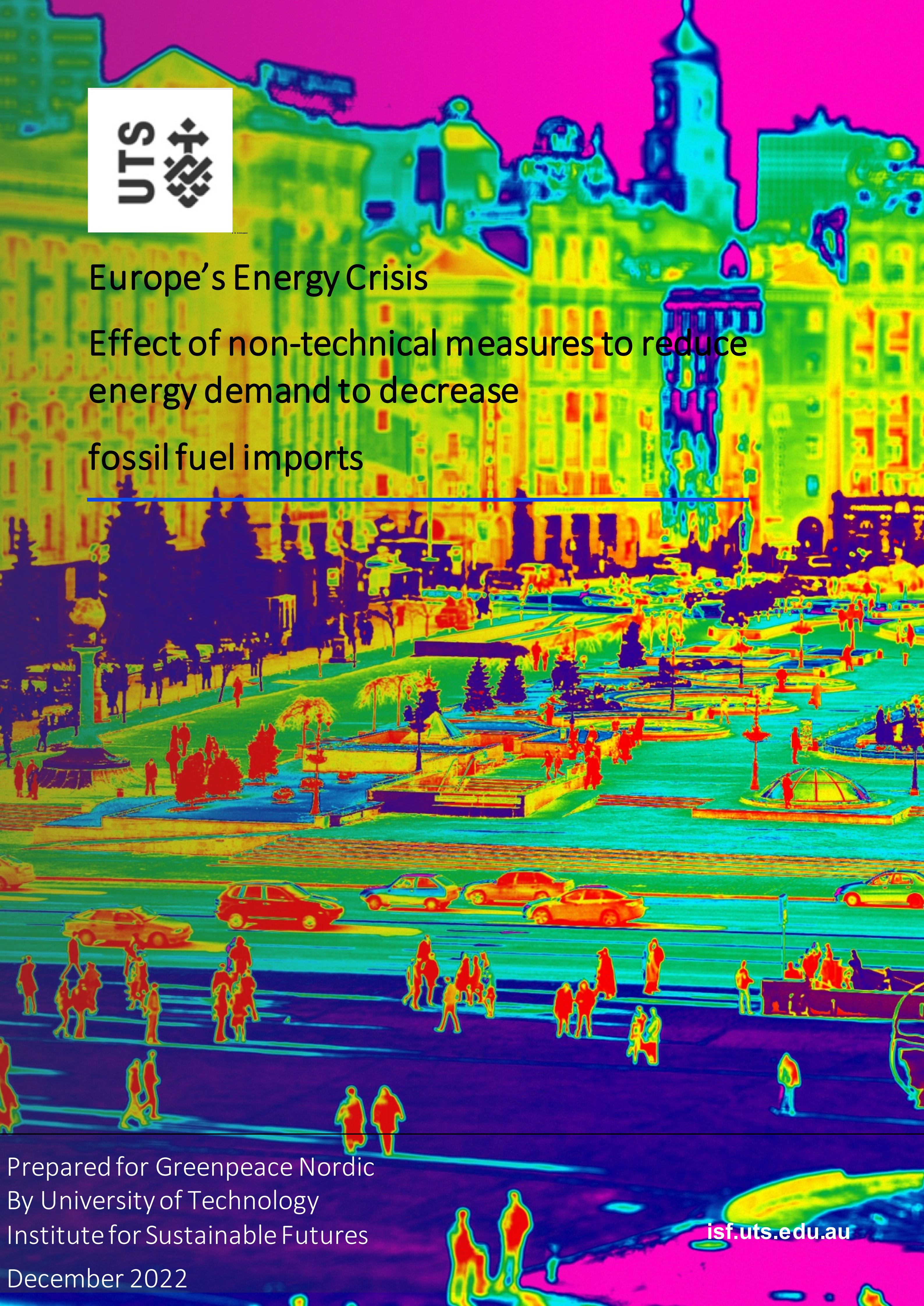

Europe's Energy Crisis

Effect of non-technical measures to reduce energy demand to decrease fossil fuel imports

Prepared for Greenpeace Nordic
By University of Technology
Institute for Sustainable Futures

December 2022

isf.uts.edu.au

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The Institute for Sustainable Futures (ISF) is an interdisciplinary research and consulting organisation at the University of Technology Sydney. ISF has been setting global benchmarks since 1997 in helping governments, organisations, businesses, and communities to achieve change to support sustainable futures.

ISF acknowledges and respects the Aboriginal and Torres Strait Islander custodians of Australia and the Gadigal people, custodians of the land upon which the UTS City Campus now stands. We continue to value the generations of knowledge that Aboriginal and Torres Strait Islander peoples embed within our university, and we pay our respect to their elders past, present and emerging.

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The Institute for Sustainable Futures (ISF) was established by the University of Technology Sydney in 1996 to work with industry, government and the community to develop sustainable futures through research and consultancy. Our mission is to create change toward sustainable futures that protect and enhance the environment, human wellbeing and social equity. We seek to adopt an inter-disciplinary approach to our work and engage our partner organisations in a collaborative process that emphasises strategic decision-making.

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This project has been conducted in cooperation with Isadora Wronski of Greenpeace Nordic, Herwig Schuster of Greenpeace Austria and has been reviewed by Greenpeace International.

CITATION

Teske, S., Feenstra, M., Niklas, S., Europe's Energy Crisis Effect of non-technical measures to reduce energy demand to decrease fossil fuel imports; prepared for the Greenpeace Nordic by The University Technology Sydney, Institute for Sustainable Futures; December 2022

ACKNOWLEDGEMENTS

The authors gratefully acknowledge data and advice contributed by November 2022.

All conclusions and any errors that remain are the authors own.

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Executive Summary

The European Union (EU-27) had a massive reliance on Russian fossil-fuel energy sources (natural gas[1], oil and coal). After the Russian invasion of Ukraine and following political tensions, the EU imposed a string of political measures. This led to Russia using partial & total cut-offs of fossil gas as a blackmail method. In the "Save gas for a safe winter' the EU came with a plan to solve shortages of Russian gas by maximum filling of the gas storage facilities, demand reduction of 15% for all member states and increasing the share of renewables as quickly as possible. As of November 2022, the EU member states have full gas storage facilities, an average fossil gas demand reduction has been achieved of 7.4% up to August and the European Winter has started mild. However, in 2023 the EU-27 will face the exact same crisis as in 2022 without the potential to fill the gas storage facilities with Russian gas. This crisis scenario identifies short-term non-technical measures to react to fossil fuel supply shortages caused by the invasion of Ukraine by Russia.

In this report we investigated the main research question: *"What is the effect of non-technical measures on the EU-27's fossil gas/oil/total energy demand?"* Here, non-technical measures require no new investment in equipment (the timespan of the crisis is simply too short for an immediate overhaul of the entire energy system).

This question is answered with the 1.5 °C energy transition pathway modelled by the One Earth Climate Model. The One Earth Climate Model has been developed by the University of Technology Sydney (UTS), Institute of Sustainable Futures (ISF) in cooperation with the German Aerospace Center (DLR) between 2017 and 2022. The OECM is an integrated energy assessment model with a detailed bottom-up examination of energy demand and supply with a high technical resolution. The base energy transition scenario for the EU-27 contains a **rapid uptake of renewable energy sources** and **no new investments in fossil-fuel energy sources.**

The effect of two different scenarios (**high industry share** vs. **medium industry share**) for demand reduction were explored expressed in achieved demand reduction for fossil gas, oil and total energy:

- Different stacking of demand reduction measures could achieve roughly the same savings. This gives the active choice to shift measures between the industrial sector and the general sector.
- **Fossil natural gas:** Residential heating & industrial process heat savings have the largest potential for achieving fossil gas reductions, with a respective -657 PJ/a and -780 PJ/a in a medium and high industry share scenario. In addition, the results present the remaining fossil gas use for electricity generation and the desirable effect of electricity saving measures across all sectors. Residential heating & industrial process heat savings result in fuel savings of 17.1 billion cubic meter (BCM and respectively 20.3 BCM[2].
- **Oil:** 10% less driving, efficient driving (reducing the max speed from 130 km/h to 110 km/h) and replacing 30% of inter-EU aviation with train travel leads to the largest oil consumption reductions compared to the other measures, with -779 PJ/a, -1323 PJ/a and -881 PJ/a. Those energy demand reductions result in annual fuel saving of 122 million barrels respectively 207 million barrels and 138 million barrels of oil. The total savings in the transport sector add up to 2,983 PJ/a or 467 million barrels of oil annually – compared to a current transport demand of around 12000 PJ/a (1880 million barrels) – about a quarter of the transport demand for fuel oil.

The analyzed non-technical measure to reduce fossil fuel demand can reduce supply bottlenecks caused by the Russian war and the resulting cuts of imported oil and gas from Russia to the European Community. However, non-technical reductions cannot overcome systemic fossil fuel demands such as high shares of fossil gas-based heating systems or the high reliance on oil for transport.

Therefore, to fill the gap left by the share of Russian imported energy, it is crucial to **increase renewable energy** in the **heating and transport sectors** up to 2030 and beyond. To achieve heating, cooling, and transport sector decarbonization,

[1] In this analysis 'fossil gas' is referred to as 'fossil gas'
[2] Based on a conversion factor of 38.53 MJ/m^3 , similar to conversions in gas data from Eurostat.

renewable heat must increase, industrial process heat systems must be electrified, or hydrogen-based systems must be implemented, and transport should be electrified. To provide rising quantities of electricity because of the increased electrification to replace (fossil) fuels and – at the same time – replace fossil fuel-based electricity generation of the current power system, a sharp increase of onshore & offshore wind and solar energy generation is required. **Solar** (roof-top and utility) and **wind** (onshore & offshore) **must double** to comply with the 1.5 °C pathway.

This report presents that the current non-technical measures can help to accelerate the transition to a 100% renewable energy supply. The above-described energy saving measures implemented in 2022 need to be maintained and extended throughout 2023 and 2024. During 2023 and 2024, additional technical measures are required to be maintained and further reduce dependence on fossil fuels. Those technical measures such as tighter efficiency standards for appliances, buildings and vehicles, energy renovations (incl. insulation of the building envelop) and increased electrification of the heating and transport sector are critical in the transition towards a fully decarbonized energy system in the EU. Furthermore, policy measures on EU and member state level are required, such as fast-tracked construction permits for on- and offshore wind parks as well as utility scale solar photovoltaic and storage technology projects.

The 'Fit for 55' of European Union represents a significant change towards an energy transition. However, the member state's specific energy demand reduction potentials are not identified yet. Each member state of the EU must develop their own energy demand reduction policies addressing both of technical and non-technical measures. To prevent short-term savings from returning to 2021 levels, long-term energy efficiency measures must be implemented. The heavy reliance on gas for space heating and industrial process heat needs to be overcome through greatly increased electrification and renewable heating technologies. The 'Fit for 55' measures of the EU fall short to transfer the short-term success of demand reduction into long-term demand reduction.

Finally, lifestyle changes especially in the mobility sector can reduce far more fossil fuel demand than the calculated 25% through a consistent mobility change that shifts away from the car and towards bicycle and pedestrian-friendly urban planning.

Contents

Introduction

EU energy crisis - What is the current challenge for Europe?

The European Union (EU-27) had a massive reliance on Russian fossil-fuel energy sources (fossil gas, oil and coal). After the Russian invasion of Ukraine and following political tensions, the EU imposed a string of political measures. This led to Russia using partial & total cut-offs of fossil gas as a blackmail method. In the "Save gas for a safe winter' the EU came with a plan to solve shortages of Russian gas by maximum filling of the gas storage facilities, recommended a gas demand reduction of 15% for all member states and increase of the renewable share as quickly as possible. As of November 2022, the EU member states have full gas storage facilities, an average fossil gas demand reduction has been achieved of 7.4% up to August and the European Winter has started mild. However, in 2023 the EU-27 will face the exact same crisis as in 2022 without the potential to fill the gas storage facilities with Russian gas.

Fossil gas demand in Europe

According to historic energy statistics, Germany, Italy, France and the Netherlands are the overall largest fossil gas users in Europe (see **Figure 1**). Typically, the largest users have a considerable industrial sector and in addition use fossil gas in heating systems and power generation.

Here, the chemical industry is responsible for the largest share of fossil gas consumption in manufacturing (see **Figure 2**).

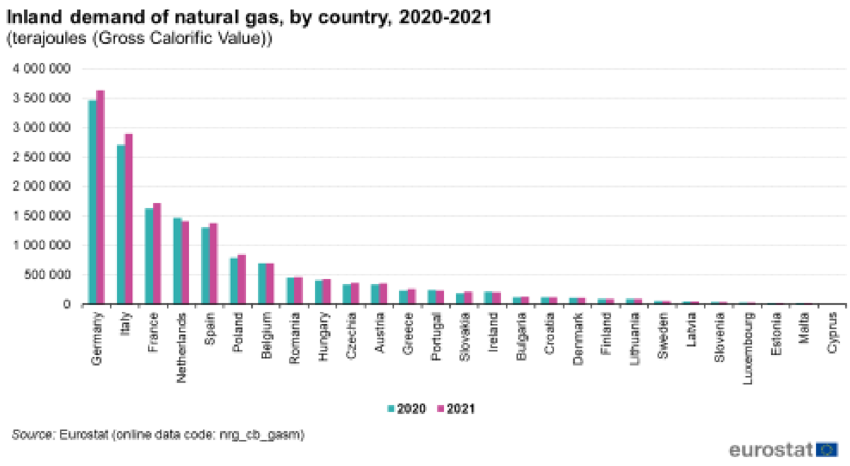

Figure 1: Fossil gas usage in Europe, Image from: (Eurostat, 2022a)

Natural gas demand in manufacturing for top 7 EU Member States
Billion cubic meters, 2019

	Chemicals	Food and beverage	Paper and printing	Refining and coke	Non-metallic mineral products	Basic metals	Other manufacturing
Germany	10.7	3.5	2.4	1.6	3.2	3.7	4.6
France	4.7	2.5	0.9	0.6	1.9	0.9	1.9
Spain	3.5	1.1	0.7	3.3	2.1	1.2	1.1
Italy	1.9	1.4	0.8	1.4	2.5	2.0	2.4
Netherlands	6.5	1.8	0.4	1.4	0.6	0.5	0.7
Poland	2.9	1.1	0.3	1.3	1.4	0.9	0.8
Belgium	2.8	1.1	0.2	1.0	0.6	0.8	0.5

Source: EuroStat and Rhodium Group estimates.

Figure 2: Split of fossil gas usage over the separate industrial sectors. Source: (Rhodium Group, 2022)

The current situation for gas storage and demand reduction

Europe is currently heading into a winter with a mild start, with full gas storage facilities. Figure 3, taken from the ENTSOG gas flow dashboard, presents the current gas storage facilities which are nearly full and above historic values.

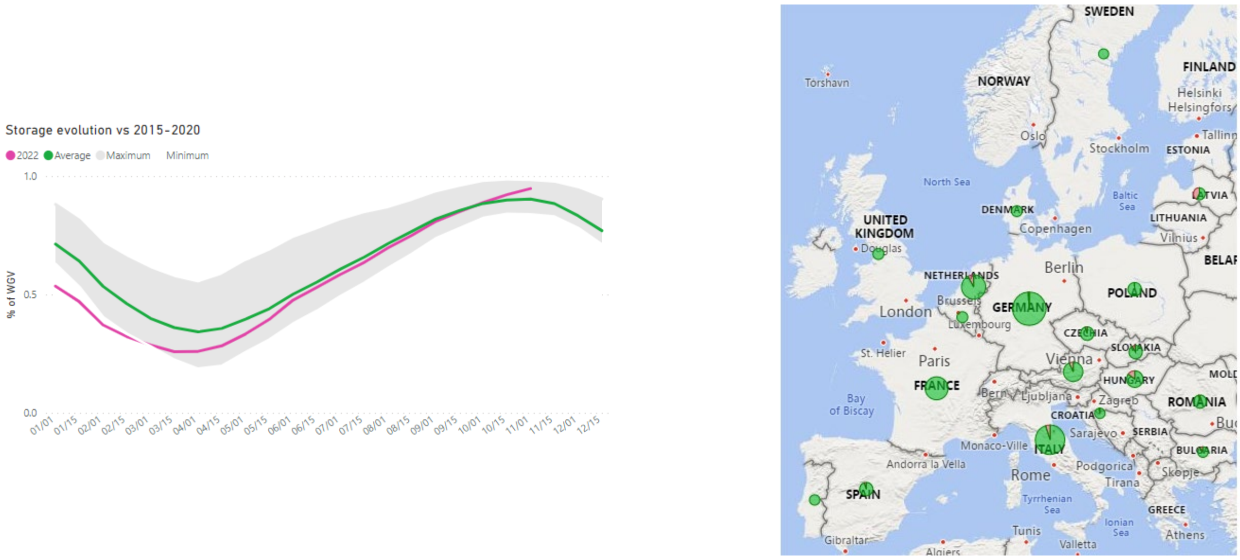

Figure 3: ENTSOG Dashboard for fossil gas storage levels, taken from: (ENTSOG, 2022)

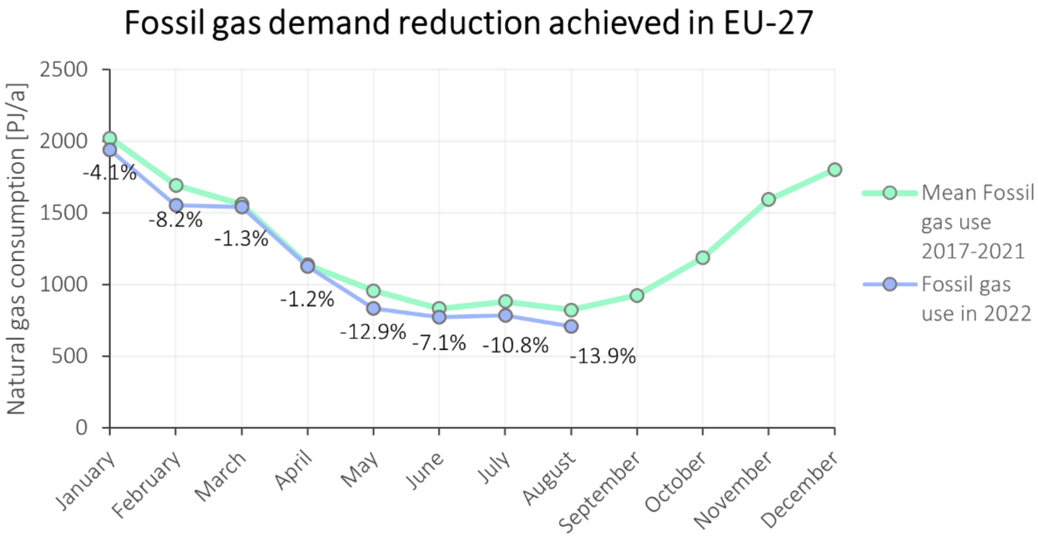

Figure 4: Demand reduction achieved in 2022 up to August, Source: (Eurostat, 2022b), NRG_CB_GAS data code

Moreover, the European member states achieved a mean 7.4% demand reduction for their fossil gas usage up to August 2022. This is so far below the set target of 15% reduction per member state. (European Commission, 2022) The EU is heading fully prepared into the winter season. However, in 2023 the EU-27 will face the exact same crisis as in 2022 without the potential to fill the gas storage facilities with Russian gas again. (IEA, 2022)

Outline of the report

The research described in this report aims to provide a ***crisis scenario*** response for the European Union (EU-27). Here, a crisis scenario is defined as a scenario with short term non-technical measures to react to fossil-fuel supply shortages from the invasion of Ukraine by Russia. The focus lies on short-term non-technical measures, because of the short-time frame that the European Union has to respond to the energy crisis (an immediate complete overhaul of the entire energy system would simply take more time). Measures are evaluated with our in-house developed One Earth Climate Model, which has a base case scenario for a 1.5°C energy transition pathway for the European Union (67% likelihood– 400 Gt CO_2 global cumulative CO_2 budget 2020-2050). In the following sections the research question, methodology, results and conclusion are presented.

Research Questions

The following question is central to the work presented in this report:

> **Main research question:** What is the effect of non-technical demand reduction measures on the EU-27's fossil gas / oil / energy demand?

Here the following boundary conditions are considered:

- Non-technical measures: No requirement for investments in new technical equipment (short-term crisis response). Non-technical demand reduction measures are methods to reduce energy that do not require new investment in new technical equipment. For example, turning down the thermostat or using less electricity in residential, public, commercial or industry environments. Non-technical measures are for short term responses and do not replace technical measures required for a full decarbonisation of the European energy system.
- Focus on fair reduction and fair distribution between industrial and residential consumer.

Methodology: The One Earth Climate Model (OECM)

To evaluate the effect of demand reduction measures, it was key to use the 1.5°C energy transition pathway for the European Union modelled in the One Earth Climate Model (OECM) as a theoretical basis. The OECM model is in-house developed at the Institute for Sustainable Futures and provides a detailed bottom-up examination of energy demand and supply up to 2050. Figure 5 presents a simplified presentation of the information flow in the model. At the input level, area/country specific information about population, GDP, historic energy statistics, industry, built environment and transport data is fed into the model. In the calculation section, the extensive data input is translated into energy demand and energy supply projections from now up to 2050. This results in detailed granular outputs for final energy demand per sector & fuel, detailed power generation and installed capacities split up by technology and CO_2 emissions per sector.

A condensed list of the key characteristics of the OECM model are:

- 1.5°C model - granular sector pathways
- 100% renewables in 2050
- Detailed bottom-up examination of demand and supply
- Net-zero emissions by 2050
- Not an overshoot scenario, meaning it does not rely of unsuccessful BECCS/CCS technologies

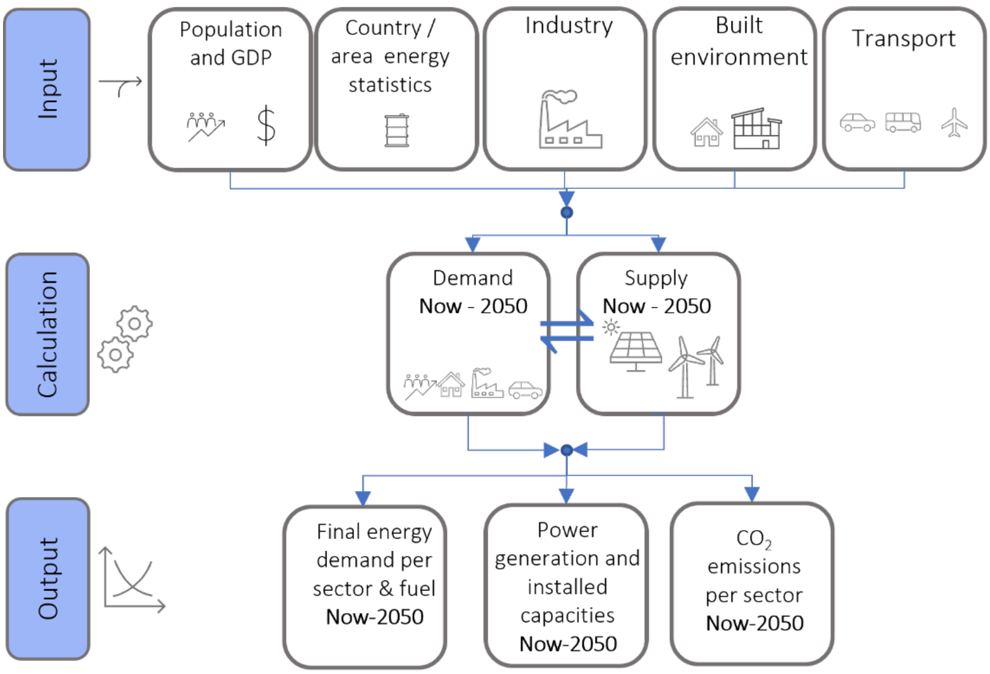

Figure 5: Information input and calculations in the OECM model.

For a more detailed description of the OECM model the reader is referred to other existing resources (Teske, 2019, 2022). Furthermore, the methodology of the OECM is published in peer-reviewed scientific literature in the following journal articles (Teske et al., 2022; Teske & Guerrero, 2022; Teske & Nagrath, 2022):

- Teske, S.; Guerrero, J. One Earth Climate Model—Integrated Energy Assessment Model to Develop Industry-Specific 1.5 °C Pathways with High Technical Resolution for the Finance Sector. Energies 2022, 15, 3289. https://doi.org/10.3390/en15093289
- Teske, S., Nagrath, K. Global sector-specific Scope 1, 2, and 3 analyses for setting net-zero targets: agriculture, forestry, and processing harvested products. SN Appl. Sci. 4, 221 (2022). https://doi.org/10.1007/s42452-022-05111-y
- Teske, S., Niklas, S., Talwar, S. et al. 1.5 °C pathways for the Global Industry Classification (GICS) sectors chemicals, aluminium, and steel. SN Appl. Sci. 4, 125 (2022). https://doi.org/10.1007/s42452-022-05004-0

The EU energy crisis in the context of climate change

The EU energy crisis must be discussed in the context of global climate change and the necessity to decarbonise the energy systems. The current measures of the European Union to reduce dependence on fossil fuel imports – especially fossil gas and oil - from Russia should therefore lead to an accelerated decarbonisation of Europe's energy supply and not simply to a change of the fossil fuel supply countries. As for fossil gas, the overall greenhouse gas emissions must be considered which includes the methane emissions caused from the extraction process and leakages during transport and storage of fossil gas besides the CO_2 emission caused by the combustion processes.

Carbon budget to achieve the Paris Climate Agreement

Time is running out. The Intergovernmental Panel on Climate Change (IPCC) released the Sixth Assessment Report (AR6) of Working Group I in August 2021, which focuses on the physical science basis of climate change (IPCC, Paola A. Arias, et al., 2021)[3].

The First Assessment Report was launched in 1990 and underlined the importance of climate change as a challenge with global consequences that required international co-operation. Thirty years later, the IPCC states unequivocally that the world is already in the middle of climate change. The UN Secretary-General António Guterres said the Working Group's report was nothing less than *'a code red for humanity. The alarm bells are deafening, and the evidence is irrefutable'*.

One of the key headline statements for policy makers is that *'from a physical science perspective, limiting human-induced global warming to a specific level requires limiting cumulative CO_2 emissions, reaching at least net zero CO_2 emissions, along with strong reductions in other greenhouse gas emissions. Strong, rapid and sustained reductions in methane CH_4 emissions would also limit the warming effect resulting from declining aerosol pollution and would improve air quality'*(IPCC, Paola A. Arias, et al., 2021; IPCC, Richard P. Allan, et al., 2021)[4]. Table 1 provides an overview of the carbon budgets and the effect on mean temperature rise. The 1.5˚C pathway developed with the One Earth Climate Model aims to limit temperature rise to +1.5˚C with a likelihood of 67% - which leads to a global carbon budget of 400 $GtCO_2$ between 2020 and 2050.

Table 1: Carbon budgets identified by the IPCC AR6

Global Warming between 1850-1900 and 2010-2019 [˚C]	Historical cumulative CO_2 emissions from 1850 to 2019 [$GtCO_2$]
1.07 (0.8-1.3; likely range)	2390 (+/- 240; likely range)

Approximate global warming relative to 1850-1900 until temperature limit [˚C] (1)	Approximate global warming relative to 2010-2019 until temperature limit [˚C]	Estimated remaining carbon budgets from the beginning of 2020 [$GtCO_2$] — Likelihood of limiting global warming to temperature limit (2)					Variations in reductions in non-CO_2 emissions (3)
		17%	33%	50%	**67%**	83%	Higher or lower in accompanying non-CO_2 emissions can increase or decrease the values on the left by 220 $GtCO_2$ or more
1.5	0.43	900	650	500	**400**	300	
1.7	0.63	1,450	1,050	850	700	550	
2	0.93	2,300	1,700	1,350	1,150	900	

Source: (IPCC, Paola A. Arias, et al., 2021)

[3] IPCC AR6, 2021; Arias P, Bellouin N, Coppola E, Jones R, Krinner G, Marotzke J, Naik V, Palmer M, Plattner GK, Rogelj J, Rojas M et al (2021) Technical Summary. In: Masson-Delmotte V, Zhai P, Pirani A, Connors SL, Péan C, Berger S, Caud N, Chen Y, Goldfarb L, Gomis MI, Huang M, Leitzell K, Lonnoy E, Matthews JBR, Maycock TK, Waterfield T, Yelekçi O, Yu R, Zhou B (Eds) Climate change 2021: the physical science basis. Contribution of working group I to the sixth assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge. https://doi.org/10.1017/9781009157896.002

[4] IPCC-AR6; SPM, 2021; Summary for policymakers. In: Climate change 2021: the physical science basis. Contribution of working group I to the sixth assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge

The One Earth Climate Model 1.5°C pathway for Europe

The analysis of non-technical measures to reduce fossil gas and oil demand for the EU27 is based on a 1.5˚C pathway for the European Union that phases out all fossil fuels by 2045 and leads to a full decarbonisation of the energy sector.

The regional OECM 1.5˚C pathways have been published in 2019 for the first time and are updated regularly. The full set of assumptions and results are publicly available (see Pregger et. al. 2019[5], Teske et.al. 2022[6] and on the website of the University of Technology Sydney).

Scenario variations: High and medium industry share

To investigate the elements of fair reduction and fair distribution, two main scenarios were evaluated. In the first scenario, the industrial sector has the highest share in demand reduction measures and in the second scenario the industry share is milder with a larger reliance on the residential, the public and the commercial sector. These scenarios demonstrate that an active choice can be made in allocation of demand reduction measures and that either scenario translates to roughly the same amount of gas savings. Results for the Demand reduction measures for the two scenarios (SC1 & SC2) are presented for fossil gas, oil and total energy.

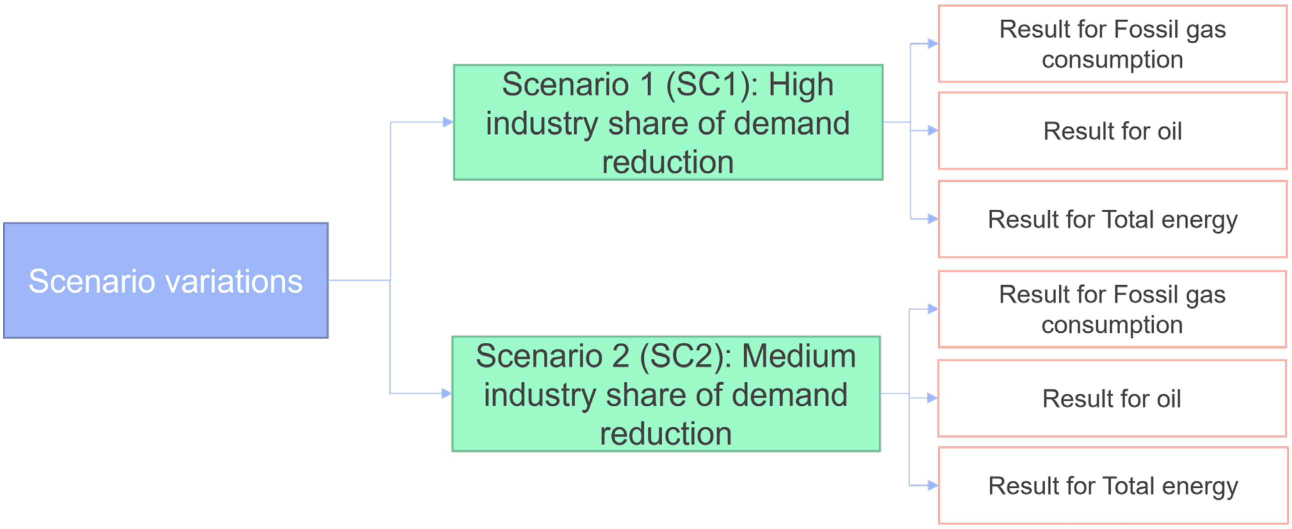

Figure 6: Two main scenarios evaluated in the OECM model: High industry share (SC1) and medium industry share (SC2)

[5] Pregger et.al. 2019, Pregger, T., Simon, S., Naegler, T., Teske, S. (2019). Main Assumptions for Energy Pathways. In: Teske, S. (eds) Achieving the Paris Climate Agreement Goals. Springer, Cham. https://doi.org/10.1007/978-3-030-05843-2_5

[6] Teske et. al. 2022; Teske, S., Niklas, S., Talwar, S. (2022). Decarbonisation Pathways for Industries. In: Teske, S. (eds) Achieving the Paris Climate Agreement Goals . Springer, Cham. https://doi.org/10.1007/978-3-030-99177-7_5

Evaluated non-technical demand reduction measures

The energy demand reduction potential for the building, industry and transport sector must be divided into two fundamentally different categories:

a. reduction potentials through behavioural changes and

b. technical reduction potentials.

Reduction potentials through behaviour changes include voluntary or mandatory reduction of the average room temperature in buildings, reduced industrial production and/or the restriction of passenger vehicle use and aviation travelling. Those measures do not change the structure of the energy system but reduce demand as a rapid response to events like the EU energy crisis in 2022.

Technical energy reduction potentials require technical changes such as the insulation of buildings, the introduction of more efficient industrial processes and more efficient vehicle technologies. The OECM includes those measures across all sectors to achieve a long-term reduction of the overall energy demand.

This analysis focusses on 'non-technical measures' to reduce the use of fossil gas and oil in the short term. The following measures are included and evaluated for fossil gas, oil and total energy use:

- Reduced heating for residential, public and commercial sectors: A 1 °C temperature reduction results in 7% less energy usage for heating. (International Energy Agency, 2022). The effect of less heating is evaluated as a 1 or a 2 °C decrease in average home temperature. For comparison, according to the IEA, the average heating temperature in the EU is 22°C.(International Energy Agency, 2022)

- Reduced heating/ electricity and fossil gas feedstock in the industrial sector: A reduced production output in the industrial sector translates to less heating, electricity and required fossil gas feedstock.

- Reduced electricity use in residential, public and commercial sectors: A range of electricity saving measures, such as less lighting in public spaces, monuments, commercial buildings can bring down overall electricity consumption. Considering that fossil gas is still used for power generation, this will have a positive impact.

For the evaluation of the oil and total energy demand reduction options, the following options were added:

- Less driving: Changing mobility needs and patterns due to COVID-19, such as working from home whenever possible, have shown that it is possible to reduce the demand for the use of private cars. In addition, the success of the 9-euro train ticket during summer 2022 in Germany demonstrated that governments can introduce effective measures that reduce individual car transport and overall CO_2 emissions. (The Guardian, 2022a).

  More efficient driving: Most countries in Europe have 130 km/h as a maximum speed on the highway. A reduction of 130 to 110 km/h reduces fuel considerably with 23 % and 17% for a reduction to 100 km/h. To account for non-constant speed driving and that not all driving is on the highway, the more conservative 17% reduction in fuel-use is taken. (Greenpeace, 2022; VCO, 2017)

- Shifting from aviation to rail: A recent analysis by OBC Transeuropa for Greenpeace about train alternatives to short-haul flights in Europe (Greenpeace, 2021) concluded that

  - 34 % of the 150 busiest flight routes in the EU can be made by train in under six hours.
  - 29 % of the 250 busiest flights in Europe (EU, Norway, Switzerland and UK) can be made by train in under six hours and
  - 27% of the 150 busiest EU flights have direct night trains alternatives in 2021

  Based on this analysis, the reduction potential for inter-EU aviation kilometres is assumed to be 30% and these kilometres are replaced by train transport.

Fossil gas demand split in the OECM model

Based on historic energy statistics, the OECM model calculates the fossil gas demand in 2023. Figure 7 presents the overall calculated demand, split up in primary energy demand and non-energy use. Here, primary energy demand represents the total energy demand of an area, including the energy sector's consumption, energy consumption of end users and all energy losses. In addition, fossil gas is used as a feedstock for the chemical industry, where it for instance is converted into fertilizers (ammonia & urea), methanol and other chemical industry processes that use fossil-fuel based hydrogen. Figure 8 presents the calculated fossil gas demand split over the separate sectors, with heat in residential, public, and commercial sectors representing the largest fraction.

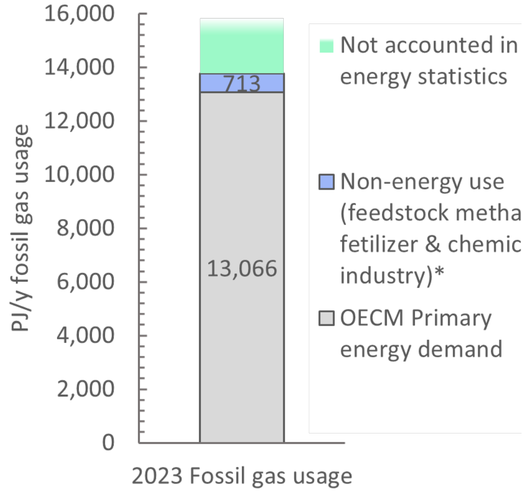

Figure 7: Fossil gas demand in 2023

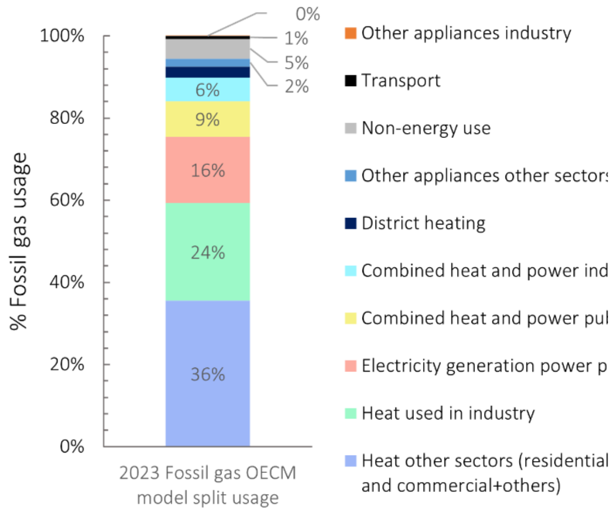

Figure 8: Fossil gas demand split as calculated by the OECM model.

How can fossil gas demand reduction be achieved in the industrial sector?

Industrial fossil gas use is responsible for roughly one third of the overall gas demand in the EU. (Rhodium Group, 2022) Considering the large share of fossil gas use in the industrial sector, the sector will take a fair share of overall fossil gas and energy demand reductions, to ensure the EU will manage gas use throughout the winter months. The key question here is how to define a fair share.

At the time of writing, the industrial sector is already reducing production in response to high energy and fossil gas prices. For the fertilizer, aluminum, zinc and steel production sector, the fuel price effect is already so pronounced that production was curtailed, because European production was no longer competitive (Bloomberg, 2022; Financial Times, 2022b; Ouest France, 2022).

This is where non-harmful and harmful demand reduction somewhat mix, but it is already observed as a natural effect to energy prices. Chemical clusters are the next line of industrial fossil gas and energy consumers. Here there can be larger negative effects of energy disruption. Chemical clusters consist of highly connected separate processes. A good example is Ludwigshafen in Germany (responsible for 4% of the fossil gas use of Germany). (Financial Times, 2022a; The Guardian, 2022b) Ludwigshafen is an interconnected cluster covering 10 km^2 with around 125 production facilities and 200 production plants and it never fully shuts down. They have indicated that if their fossil gas supply dips below 50% of their standard value, they will have to shut down the entire cluster. (Financial Times, 2022a; The Guardian, 2022b) A full shutdown would result in a ripple effect through chemical supply chains, and it would take 3-4 months to restart the complex. (The Guardian, 2022b) A soft reduction will however be possible for the industrial sector. The aluminium industry in France already reduced their production with 15% with a technical possibility up to 30% reduction.(Ouest France, 2022)

Assumptions

The non-technical energy demand reduction potential was calculated under the following assumptions:

Energy demand reduction in the transport sector:

The OECM uses a bottom-up approach to calculate the energy demand for all transport sectors. The transport service demand in passenger kilometre multiplied by the energy intensity for each vehicle, planes and marine vessels equals transport energy demand in joule. The relevant energy intensity in megajoule per person kilometre [MJ/pkm]

1. Aviation:
   a. The calculation is based on data from EU's "Transport in Figures 2022- statistical databook-p.48" for estimation. For 2019 this corresponds to 582.9 billion passenger kilometres. In the statistical overview it is reported that this number only represents inter-EU-27 transport (and not international flights).
   b. The Greenpeace report *Get on track: Train alternatives to short-haul flights in Europe* Greenpeace. (2021) concluded that 30% of the inter-EU flights could be replaced by trains for the top 250 flights in Europe. Based on this result, 30% of the inter-EU transport are shifted to the rail transport sector by increased annual passenger kilometres for railways.
2. Road transport:
   a. Reduced speed on highways from 130 km/h to 110 km/h or 100 km/a. The energy demand reduction potential is based on the results of Greenpeace. (2022). *Transport Sector Solutions* which estimated a fuel reduction of 23% and 17% respectively. In this analysis we have taken the more conservative estimation of 17% as driving behaviour might not be consistent across all European countries and is dependent on each driver as well.
   b. Less driving: It is assumed that 10% of all passenger kilometres driven in cars will either be shifted to cycling or walking or the actual travel activity will be reduced. The reduction potential of behaviour changes are individual choices and therefore difficult to implement and maintain over a longer period.

Energy demand reduction in the heating sector: The OECM uses a bottom-up approach to calculate the energy demand for space heating and based on the average heating demand per square meter building space in kilowatt-hour per square meter [kWh/m^2].

3. Space heating
   a. For the residential and commercial building sector, space heating reduction is based on behavioural changes. While in commercial and public buildings, decrease of the room temperature by 1 or 2 degrees can be implemented via top-down technical regulations, space heating reduction in residential buildings are based on individual behavior.
   b. Change of heating technology is not assumed for 2022 and 2023. The market especially for electrical heat pumps increased significantly in 2022, but the required statistical data was not available during the research period (September to November 2022).
   c. Decreased space heating temperature: The estimations are based on the research of the International Energy Agency, 2022) and reduction in percent is calculated based on the total European energy demand for space heating across all member states. A further breakdown for the 27 member states was out of scope for the analysis.
4. Industry
   a. The energy reduction potential for industrial process heat (short: industry heat) is based on the cited literature and as an average across all industry sectors. Industry specific research e.g., for specific processes in the chemical industry, was out of scope for this analysis
   b. The reduction of feedstock e.g., fossil gas, is based on the overall demand with a reduction in percent. A detailed assessment of specific industrial processes was out of scope for this analysis

Scenario Results

This section presents the effects of the separate demand reduction measures on the fossil gas, oil and total energy demand. Energy demand reduction can be approached in different ways. The approaches evaluated here are the high industry share (SC1) and a medium industry share (SC2) scenario.

Fossil gas

The result for fossil gas reduction measures is presented in Figure 9 and Figure 10. The two graphs present two different stackings of measures to achieve roughly the same overall fossil gas demand reduction. The largest fossil gas demand reductions are achieved by reduced heating in the industrial and the residential sectors. Moreover, it can be observed that reduced electricity consumption results in a fossil gas reduction because electricity generation is still partially fuelled with fossil gas. A full replacement of the 5972 PJ/a (155 BCM) fossil gas imported from Russia is not achievable with the evaluated options, which means that the short-term demand reduction measures must be combined with technical measures to reduce fossil gas consumption further.

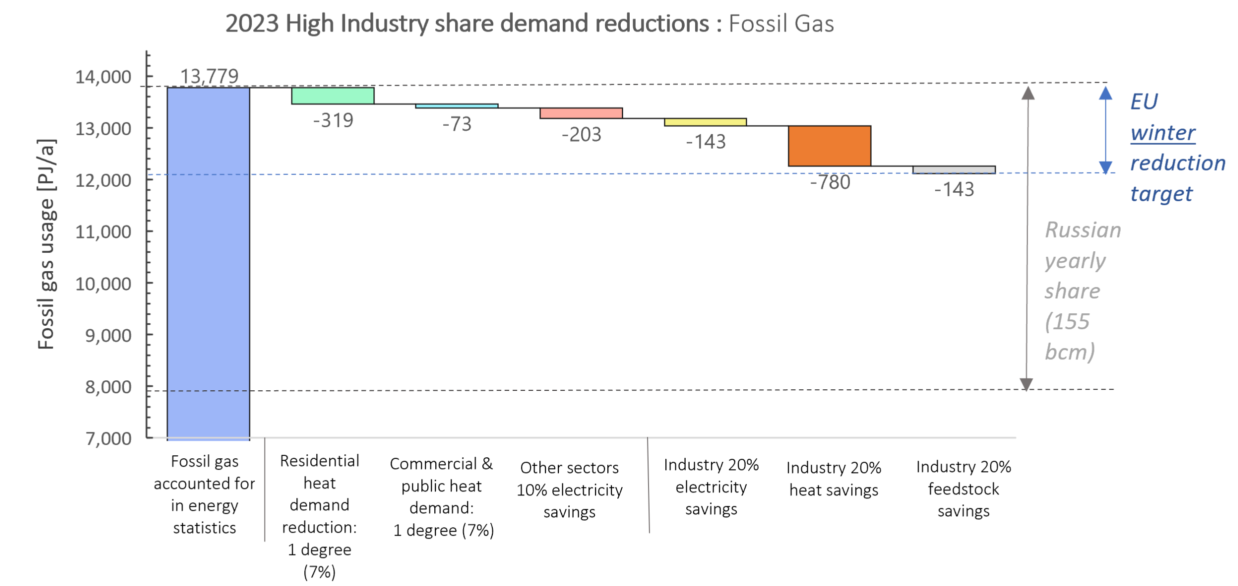

Figure 9: Effect of fossil natural gas demand reduction measures for a high industry share scenario.

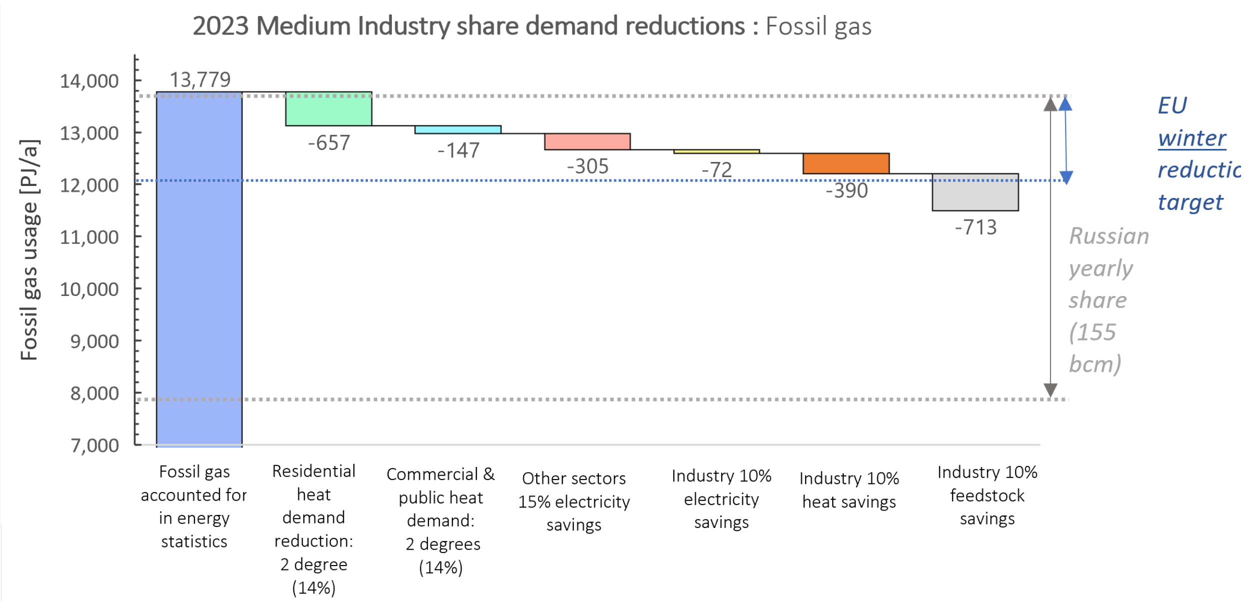

Figure 10: Effect of fossil natural gas demand reduction measures for a medium industry share scenario.

Oil

In addition to fossil gas, Russia was also a major supplier of crude oil & coal in 2021. Therefore, oil is the second energy form evaluated in this report. The effects of demand reduction measures on the EU-27's oil consumption is presented in Figure 11 and Figure 12. For oil, three demand reduction measures related to driving are evaluated with the OECM model: 10% less driving, driving more efficiently by reducing the maximum highway speed and replacing inter-EU aviation with train transport.

1. 10% less driving: Demand reduction by 779 PJ/a leading to an annual reduction of 122 million barrels of oil
2. Efficient driving (reducing the max speed from 130 km/h to 110 km/h): Demand reduction by 1323 PJ/a leading to an annual reduction of 207 million barrels of oil
3. Replacing 30% of inter-EU aviation with train travel leads to oil consumption reductions of 881 PJ/a, reducing the annual oil demand by 138 million barrels of oil.

The total savings in the transport sector add up to 2,983 PJ/a or 467 million barrels of oil annually – compared to a current demand of around 12000 PJ/a (1880 million barrel) – about a quarter of the transport demand for fuel oil.

About 2.1% of Europe's power supply is generated by oil or diesel generators, mainly by back-up generators or to supply islands that are not connected to the electricity grid. The overall oil demand for power generation in 2020 was just under 700 PJ/a or 110 million barrels of oil representing 4.5% of the EU's fuel oil demand. The use of oil for power generation for remote areas is assumed to be phased out – as a technical measure – by 2030 – and is to be replaced by solar/wind battery systems. Other measures, that are important for fossil gas consumption, have a minimum impact on reduction of oil demand as presented in the results below.

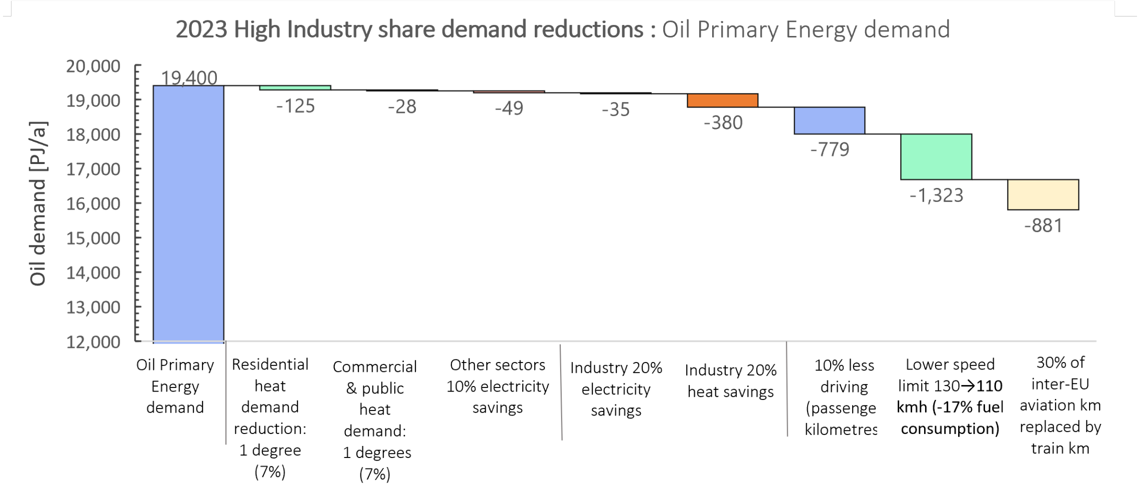

Figure 11: Effect of demand reduction measures on the oil primary energy demand for a high industry share scenario.

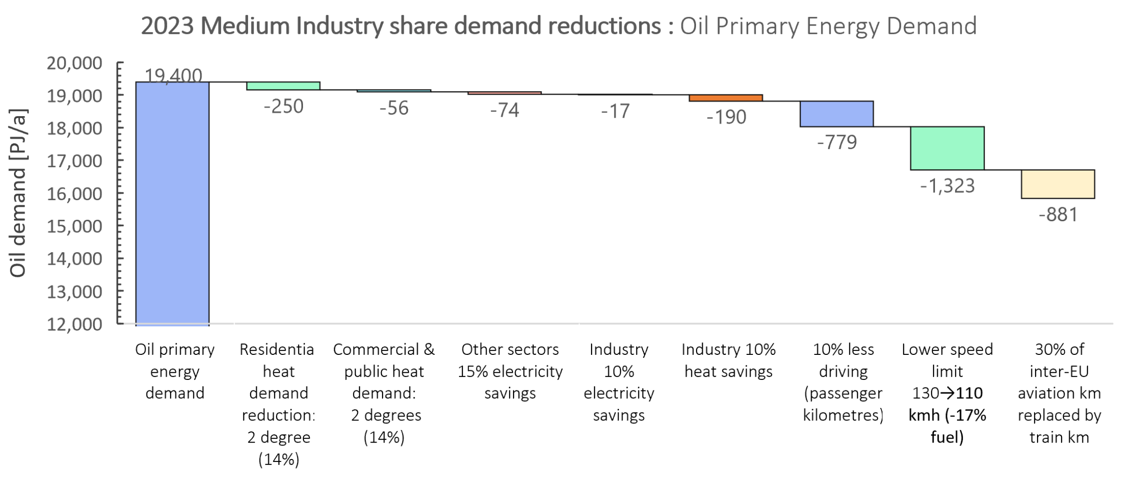

Figure 12: Effect of demand reduction measures on the oil primary energy demand for a medium industry share scenario.

Total Energy

The combined effect of all evaluated demand reduction measures is presented in Figure 13 and Figure 14.

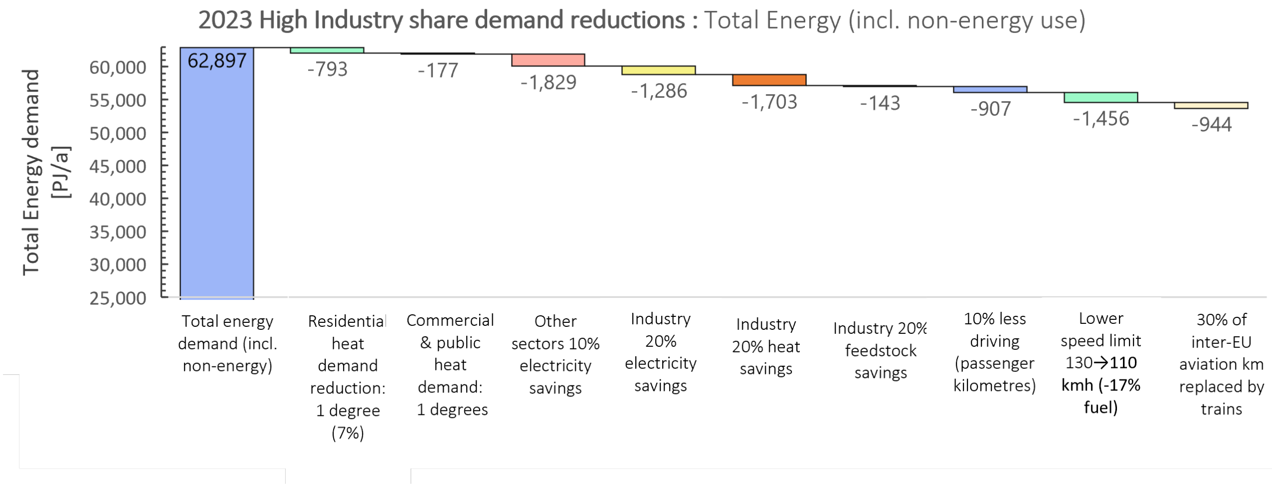

Figure 13: Effect of demand reduction measures on the total primary energy demand for a high industry share scenario

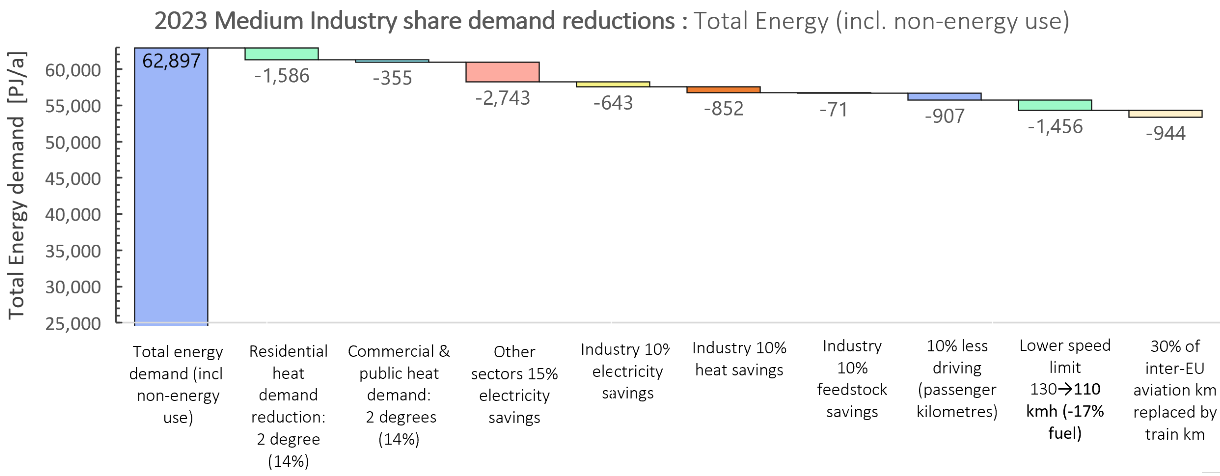

Figure 14: Effect of demand reduction measures on the total primary energy demand for a medium industry share scenario

CO_2 savings by demand reduction

In addition to improving the European energy security, the evaluated measures also decrease the yearly amount of emitted CO_2. While the One Earth Climate model is an energy transition model up to 2050, the introduced measures are temporary for 2022, 2023 and 2024. On a yearly basis, the measures result in between 350 and 450 Mt CO_2 less emitted in the EU-27 per evaluated year. This is comparable to 25 times the yearly emission of a large steel plant.

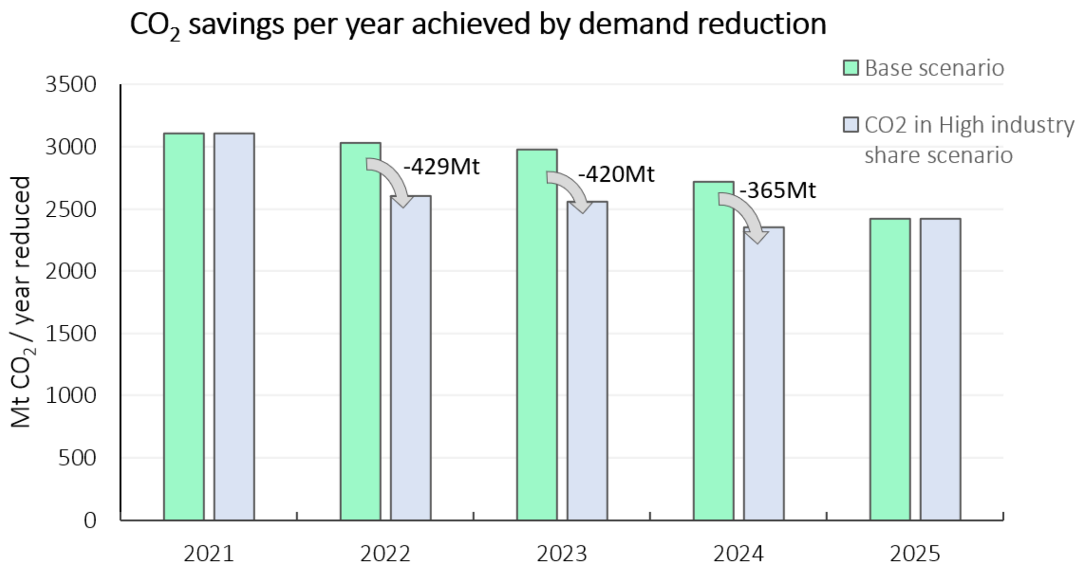

Figure 15: Achieved CO2 reduction per year by proposed demand reductions in the high industry share scenario.

Conclusion

The European Union (EU-27) had a massive reliance on Russian fossil-fuel energy sources (fossil gas, oil, and coal). After the Russian invasion of the Ukraine and following political tensions, the EU imposed a string of political measures. This led to Russia using partial & total cut-offs of fossil gas as a blackmail method. In the "Save gas for a safe winter' the EU came with a plan to solve shortages of Russian gas by maximum filling of the gas storage facilities, demand reduction of 15% for all member states and increasing the share of renewables as quickly as possible. As of November 2022, the EU member states have full gas storage facilities, an average fossil gas demand reduction has been achieved of 7.4% up to August and the European Winter has started mild. However, in 2023 the EU-27 will face the exact same crisis as in 2022 without the potential to fill the gas storage facilities with Russian gas. This crisis scenario identifies short-term non-technical measures to react to fossil fuel supply shortages caused by the invasion of Ukraine by Russia.

In this report we investigated the main research question: ***"What is the effect of non-technical measures on the EU-27's fossil gas/oil/total energy demand?"*** Here, non-technical measures require no new investment in equipment (the timespan of the crisis is simply too short for an immediate overhaul of the entire energy system).

This question is answered with the 1.5 °C energy transition pathway modelled by the One Earth Climate Model. The One Earth Climate Model is the in-house granular sector model of the Institute of Sustainable Futures, which performs detailed bottom-up examination of energy demand and supply from now up to 2050. The base energy transition scenario for the EU-27 contains a **rapid uptake of renewable energy sources** and **no new investments in fossil-fuel energy sources.**

The effect of two different scenarios (**high industry share** vs. **medium industry share**) for demand reduction were explored expressed in demand for fossil gas, oil and total energy:

- Different stacking of demand reduction measures could achieve roughly the same savings. This gives the active choice to shift measures between the industrial and the residential sector.
- **Fossil gas:** Residential heating & industrial process heat savings have the largest potential for achieving fossil gas reductions, with a respective -657 PJ (17.1 BCM) and -780 PJ (20.3 BCM) in medium and high industry share scenarios in 2023. In addition, the results present the remaining fossil gas use for electricity generation and the desirable effect of electricity saving measures across all sectors.
- **Oil:** 10% less driving, efficient driving (reducing the max speed from 130 km/h to 110 km/h) and replacing 30% of inter-EU aviation with train travel leads to the largest oil consumption reductions compared to the other measures, with -779 PJ/a (127 million barrel), -1323 PJ/a (216 million barrel) of oil and -881 PJ/a (144 million barrels of oil) in 2023.

To fill the gap left by the share of Russian imported energy, it is crucial to **increase renewable energy** in the **heating and transport sectors** up to 2030 and beyond. To achieve heat and transport decarbonization, renewable heat must increase, transport should be electrified and supplied with renewable electricity (excluding biofuels), and a sharp increase of onshore & offshore wind and solar energy generation is required.

In addition, a quick ramp-up of renewable energy generation is required to replace electricity generation with renewable sources instead of falling back into old fossil-fuel habits. **Solar** (roof-top and utility) and **wind** (onshore & offshore) **must double** to comply with the 1.5 °C pathway.

Scenario Limitations

The development of energy and emission pathways for industry sectors requires an energy model with high technical resolution. Compared with regional and national energy scenarios for all European member states, sectorial pathways for industries are based on significantly more statistical data and must be developed in close co-operation with industry partners. Therefore, the calculated non-technical measure provides an estimation of the fossil fuel saving potential and more detailed research is required which reflects the different circumstances on each of the European member states for each sector.

Furthermore, the electricity demand will increase with the electrification of process heat to replace fuels. Therefore, power utilities will play a crucial role in those industries reaching their decarbonisation targets. The decarbonisation of process heat will require changes in specific production processes and is therefore the core responsibility of the industry itself. We found that it is technically possible to decarbonise the energy supply of the analysed sectors with available technologies. However, the OECM 1.5 °C pathway is not a prognosis, but a back casting scenario that shows what must be done to achieve the carbon target.

More research is required for industrial process heat, in terms of both statistical data and the current and future energy intensities of industry-specific processes. A central database of energy intensities and energy demand for each industry sector (chemical industries, steel industry, aluminium industry etc.) would significantly enhance the level of detail available for the calculation of net-zero pathways in the future.

Data

All statistical data used in the analysis is taken from the IEA Advanced Energy Balances (IEA, 2020) and EUROSTAT (Eurostat 2022a + b)

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