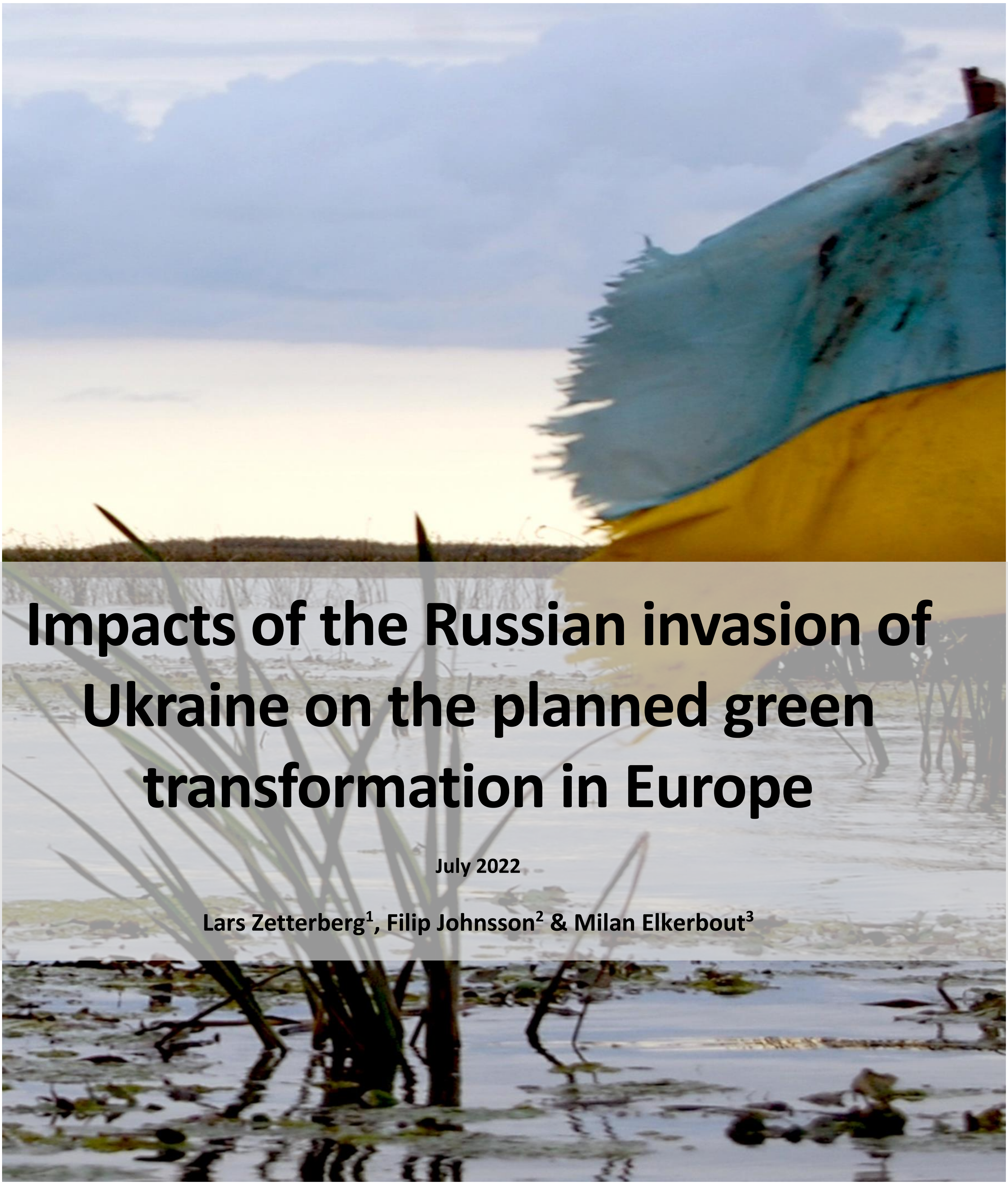

Impacts of the Russian invasion of Ukraine on the planned green transformation in Europe

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Summary

The Russian invasion of Ukraine in 2022 has altered dramatically the European security landscape. This will have ramifications for the European economy, as well as for the transformation of European economies to climate neutrality. Politicians and policymakers across the EU, and at the national level in Sweden, have expressed that this new situation should be used to accelerate the transition of energy systems to comply with climate targets and to minimize dependency on fossil fuels in general, and on fossil fuels from Russia in particular. Yet, there are indications that decisions made during the spring of 2022 have not necessarily been in line with this ambition. A possible explanation is that Europe's dependency of fossil fuels from Russia is difficult to eliminate in the short term. This paper examines the immediate and longer-term impacts on the green transition in Sweden and in the EU, focusing on the energy systems, the supply of critical minerals, and policy implications for the Green Deal and Fit-for-55 package. From our discussions on these issues, we draw the following conclusions:

Energy transition

Few technical measures can have a meaningful impact on EU fossil fuel use in the short term. Instead, the most important measure that can be taken, in our opinion, is to ensure that climate policies are not weakened, but instead strengthened so that the energy transition can be accelerated, such that the measures that can be expected to have effects in the medium and long terms will actually be implemented.

- It is unlikely that the decisions taken by EU Member States will have a substantial or immediate effect on ending the dependency on Russia for energy. Instead, there is a risk that Russian fossil fuel revenues will increase during the coming year in spite of reduced levels of imports (due to increased prices).

- Only a few options constitute a short-term response to Putin's war with respect to decreasing dependency on Russian fossil fuels. These include a reduction of the indoor temperature, acceleration of the deployment of renewable electricity in the form of wind and solar power, and increased use of biofuels (provided in the form of drop-in fuels). Even so, it will most likely take at least a few years before these options have a significant effect. Clearly, the transition to renewables should, when possible, be prioritized over resourcing fossil fuels from suppliers other than Russia.

- In the EU, replacement of heating systems and diversification of natural gas sourcing are measures that have significant potential, although these cannot be expected to have an impact until the medium term. Yet, these measures rely on a clear policy being in place, for instance a policy that provides financial support for switching from individual gas heating to electricity-based heat pump systems, possibly in combination with the expansion of district heating and various distributed energy systems such as solar PV and solar heating systems.

- For Sweden, simply lowering the indoor temperature and accelerating the deployment of renewable electricity are measures that will have impacts in the short term. A reduced indoor temperature may reallocate biofuels to sectors or regions

where there is currently an oil or gas dependency. However, this will require industrial processes to be modified to allow the use of this biomass, since it is in the form of waste from the forest industry (e.g., wood chips and sawdust). In addition, it is likely that a reduction of the indoor temperature will be difficult to apply broadly due to a lack of social acceptance.

Critical minerals

The green transition is dependent upon the availability of certain critical minerals, such as nickel, platinum, silver, cobalt, rare earth metals, lithium, neodymium, dysprosium, gallium, indium, tellurium, and silicon. There are concerns that the war will disrupt the supply chains for these metals and retard the green transition. However, although Russia is one of several important producers of critical metals, they do not dominate the world supply of any of these metals.

- Russia contributes to 11% of the global production of platinum, 9% of nickel, 5% of silver, 4% of cobalt and 1% of rare earth metals. Although in the short-term, scarcity on the margin could still lead to price volatility in the longer term, sourcing of these metals to Europe should not need to depend on Russia.
- Although Russia is not a dominant producer of metals critical for the green transition, the suppliers of many critical raw materials are highly concentrated in a few countries. For example, South Africa provides 72% of the world production of platinum, Congo is responsible for 71% of cobalt, China produces 60% of the rare earth elements, Australia produces 55% of lithium and Indonesia 37% of nickel. Therefore, in the longer term, Europe should increase efforts to secure its supply by: diversifying the countries of origin; moving the processing of minerals to Europe; considering opening new mines in Europe; increasing recycling; and improving the metal efficiency in products. The potential for substitution is large and can be manifested in different ways, for instance by: changing from one critical metal to another; substituting one technology for another (e.g., from batteries to hydrogen when possible); and switching from one service to another (e.g., from electric vehicles to public transportation).

Policy implications

The war in Ukraine provides further impetus to efforts to accelerate the energy transition and implement the Green Deal, especially in the mid-to-long term. However, the social impacts of higher energy prices may make climate action more difficult in the short term. Therefore, the distributional impacts of EU climate and energy policy matter more than ever.

- It is likely that the EU climate targets, and the Fit-for-55 package, will not be abandoned or radically changed due to the war. However, at the level of specific policies, some adjustments may be made that create more flexibility in the short term, but which may be perceived by some as a weakening of ambition.
- The proposal to raise €20 billion by selling additional allowances from the ETS Market Stability Reserve (MSR) represents a watershed moment for ETS governance. It is important and legitimate to consider the political sustainability of high carbon and energy prices, i.e., through support for the ETS and climate policy as such. Nevertheless, if the concern is related to carbon prices increasing too steeply, it would be better to pursue this objective by reforming the existing mechanism to deal

with price spikes. Likewise, raising funds for EU spending may be a legitimate aim, although this would be best done in a structural rather than *ad hoc* way.

- Given the increased salience of the social dimensions of energy prices and climate policy, the second ETS for transport and heating fuels might be less palatable for some countries. However, the Social Climate Fund, funded by the sales of allowances from the new ETS, can serve as an important tool for the same social reasons, and it should be strengthened if the new ETS will still be pursued.
- Industrial competitiveness will remain high on the EU's political agenda, especially in the face of sustained high carbon and energy prices. This will affect the ongoing negotiations on the EU ETS (free allocation) and the Carbon Border Adjustment Mechanism (CBAM). Policymakers should consider how industrial decarbonization can accelerate if electricity prices remain high.
- The CBAM (even if it remains only a legislative proposal for now) has already had a strong impact as an instrument of climate diplomacy, by making countries all over the world consider their industrial decarbonization plans. However, the actual implementation of the CBAM may be more difficult since some of the countries that are most severely affected by CBAM are also key players in the war in Ukraine.

1. Introduction

Russia's war on Ukraine has changed the European security order, which will have ramifications for the entire European economy, as well as for the transformation of European economies to climate neutrality. This paper examines the immediate and longer-term impacts on the green transition in Sweden and in the EU.

After the COVID-19 pandemic, Europe faces its second, world-altering and historic external shock in only 2 years. At the onset of the pandemic, concerns were raised about the viability of strong climate action in the face of such an immediate shock to societies and the economy – should we still pursue or prioritize climate action and the EU Green Deal at all? This was quickly followed by a successful defense of the Green Deal and commitments to ensure that the COVID-19 recovery phase would be a green one, to ensure that investments in the energy transition would not lag behind or be undermined. Several researchers and policymakers also argued that the pandemic should be seized upon as an opportunity to change course to a more-sustainable track. In the aftermath of the pandemic, one can conclude that the latter has not happened but that global CO_2 emissions are once again increasing after a drop in levels during the pandemic. It is also worth noting that the decrease in global carbon emissions during the pandemic – around 6% – corresponds approximately to the yearly reduction required if the world should comply with the Paris Agreement target of limiting warming to 1.5°C.

Yet, with the war in Ukraine, there are those who argue that we cannot afford to prioritize climate action as strongly as before. However, to a far greater extent than during the health crisis, at least some of the immediate challenges raised by Russia's aggression overlap with climate action policies. Thus, energy efficiency, use of renewables, and electrification can all help to reduce the dependency on Russian hydrocarbon imports and fossil fuel dependency in general – and many of these measures would need to be pursued anyway over the next two decades to meet the EU's climate targets.

Indirectly, the war has reordered the geopolitical landscape and will affect climate and energy policies in several ways – not all of which can yet be foreseen. Issues such as energy security and security of supply have made a comeback. The social implications of energy prices will remain high on the political agenda for as long as energy prices, in particular for heating and electricity, remain at record levels. In addition, many companies that use energy, including electricity, will reconsider their supply chains and possibly reshore manufacturing to within Europe, which may impose higher pressure on the energy supply.

Faced with Russian aggression and the fact that Russia is a totalitarian state on the EU border, several EU countries have committed to increase defense spending, most prominently Chancellor Scholz in his *Zeitenwende* speech. How exactly will this money be spent? Will it come at the expense of other policy priorities?

The war has also triggered a forceful response to impose economic and political sanctions on Russia. These sanctions will to some extent also harm the European economy. Trade with Russia (and Belarus) will be minimal if it continues to exist at all. Trade with Ukraine will be strongly affected by the war.

The most far-reaching sanctions – although they have not been implemented as of yet – will be those involving Russian energy imports. Europe imports coal, oil, and gas from Russia, which for Russia represent a large share of their economy. Coal is abundant in many countries, is inexpensive, and is not imported in great quantities. For these reasons, the European Commission has already added Russian coal to the sanctions package. Oil and gas are different. Their revenues to Russia exceed the European aid given to Ukraine by orders of magnitude. Gas, in particular, is challenging to replace in the short-term, due to infrastructure constraints. While some of the sanctions being considered involve a full boycott and suspension of energy flows, the key objective should arguably be to cut the revenues? that Russia receives from the export of fossil fuels. Thus, some analyses have argued in favor of a punitive tariff or joint purchasing agreements as alternatives to full-scale boycotts, as such measures could reduce Russia's revenues without necessarily bringing an end to all energy flows.

Voices have been raised that the crisis could have implications for the supply of critical metals and minerals needed for the climate transition. These minerals are needed for the manufacture of batteries, wind turbines, solar cells, hydrogen production units, and other low-carbon technologies. How exposed are Sweden and the EU and what can be done to reduce the risk of supply disruptions?

The crisis is likely to have an impact on EU climate policies. The European Commission has suggested increasing the cap by adding allowances to the EU ETS. This would increase coal consumption and slow the climate transition. However, we may also expect policies that speed up the introduction of renewables. An overview of the CBAM (Carbon Border Adjustment Mechanism) is likely since it will have impacts on Ukraine, Russia, and Turkey.

In light of the above background, the aim of this paper is to discuss the potential impacts on the climate transition of the Russian aggression in Ukraine, addressing the impacts for the energy supply, supply of critical minerals and components, and the financial impacts and impacts on climate policy.

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2. Energy supply

The Russian fossil fuel context

As indicated above, the Russian economy is heavily dependent upon revenues from oil and natural gas. In 2021, these revenues made up 45% of the federal budget of Russia (IEA, 2022). In 2020, 43% of natural gas imports to the EU came from Russia (Eurostat, 2022). The Russian gas is distributed through a network of pipelines collected in regional storage hubs, from which it is distributed across the continent. Italy and Germany have the highest levels of dependency of Russian gas, with the gas being used for heating and in industry. However, also other countries depend strongly on Russian gas, such as Slovakia to which Russia supplies around 35 TWh of gas, accounting for around 60% of the domestic market. In addition, industry throughout Europe uses natural gas in their processes (especially in refineries and in petrochemical industries).

Despite the above, the US, EU and UK all have announced restrictions on fossil fuel imports from Russia. Since the beginning of the invasion, Russia has (June 2022) exported fossil fuels worth €63 billion via shipments and pipelines (CREA, 2022). Of this, the EU accounts for 71% or around €44 billion. Thus, the sanctions have so far had a relatively limited effect on the Russian economy (although there have been impacts on daily life for the Russian people and for some of the wealthiest oligarchs). In fact, there are projections that Russian fossil fuel revenues will increase during the coming year (due to increased prices). On the other hand, it can be expected that the potency of the effect will increase because imports to Russia from Europe and the US have more-or-less completely stopped, which will have an intensifying effect on availability of many critical products, such as spare parts for cars, airplanes and IT equipment. The extents to which these shortages can and will be replaced by imports from Asia (China) are currently unclear.

Russia is an example of what is referred to as the “natural resource curse”, which is also known as the ‘paradox of plenty’, a phenomenon noted for poorer countries with an abundance of natural resources, such as fossil fuels. Such countries often have lower levels of economic growth, are less democratic, and have high levels of corruption (Smith and Waldner, 2021). Similarly, Friedrichs and Inderwildi (2013) have identified what they refer to as “the carbon curse”, concluding that fossil fuel-rich countries have (up to Year 2008) followed carbon-intensive development pathways (in terms of CO_2 emissions relative to GDP). Similarly, Johnsson et al. (2018) have investigated and discussed trends for the primary consumption of fossil fuels and renewables, comparing regions with large and small domestic fossil fuel reserves. They have concluded that countries with large domestic fossil fuel reserves have experienced significant increases in primary energy consumption from fossil fuels, but only a moderate or no increase in primary energy from renewables, and in particular from Non-Hydro Renewable Energy Sources (NHRES), which are assumed to represent the cornerstone of the future transformation of the global energy system.

From the above, we conclude that *from an energy transition perspective*, the world's response to Russia's invasion of Ukraine can have two outcomes. First, it may contribute to accelerating the clean transition to achieve a more-resilient energy system and a true Energy Union, as pointed out in the REPowerEU Plan (COM, 2022). Second, it could contribute to transforming Russian oil and gas into stranded assets, possibly in conjunction with the continued use of some of the fossil fuels in combination with CCS. The first potential outcome is likely to be realized at least in part. The second potential outcome is likely to be more-challenging, since Russia is likely to continue to find buyers for their oil and gas and it seems unlikely that Russia – or other countries that import Russian oil and gas – will invest in CCS in the foreseeable future. We may also see the re-sourcing of fossil fuel imports from other countries, such as from the US, Saudi Arabia and Norway. Here, we focus on the first option, since although the second option is decisive in terms of the world successfully meeting the targets in the Paris Agreement, this is a global challenge related to all countries with large reserves of coal, oil and gas, the analysis of which is outside the scope of this work (but see the discussion related to this published in Johnsson et al., 2018). However, a successful energy transition for Europe will most likely influence global supply chains, resulting in the global energy transition being accelerated. Thus, the current crisis may result in the EU becoming a frontrunner in the energy transition sooner than would otherwise have been the case. Yet, this is of course contingent upon the transition achieving social acceptance and the national and EU political leaders maintaining a reasonably stable course. In this respect, there are worrying indications of increased polarization within politics regarding the direction that the energy transition should take. Even in Sweden, which has a long-standing tradition of broad cross-party consensus around important issues, there is currently increased polarization in the energy debate, with nuclear power being placed in opposition to renewables (wind power in particular). This situation exists despite the strong agreement among researchers and industry leaders that there is no contradiction between these two sources but a great need for expansion of wind power in the near term (since this is the only electricity supply that can be expanded now) and that beyond Year 2030, nuclear power may be available at a competitive cost, perhaps in the form of Small and Modular Reactors (SMR).

REPowerEU

The REPowerEU Communication (COM, 2022) represent the official European Commission response to the energy challenges raised by the Russian invasion of Ukraine. It contains several proposals – many of which require further legislation and therefore time – that can affect the Green Deal and the Fit-for-55 legislation both directly and indirectly.

The impacts are already obvious for the top-level targets, with the Commission proposing to increase the renewables target from 40% to 45%. With regard to energy efficiency, the Commission proposes a binding target of 13% to be included in the new Energy Efficiency Directive. The REPowerEU Communication also distinguishes between such structural mid-/long-term efficiency measures and more immediate energy savings achieved through behavioral changes. While much of the displacement of Russian gas is expected to come from other natural gas supplies, the Commission also proposes a greater emphasis on biomethane, with a soft target of 35 bcm by Year 2030. Electrification is also mentioned as an important driver of reducing gas dependency. For transport, the Commission may propose new initiatives for corporate car fleets, while also suggesting that the deployment rate of heat pumps in the EU should be doubled.

In the case of hydrogen, the war in Ukraine creates additional complications. The high gas and electricity prices make both blue and green hydrogen more expensive. Nevertheless, the Commission proposes that by Year 2030 the EU will produce 10 million tonnes of renewable hydrogen domestically while importing another 10 million tonnes.

The energy transition

Energy (in particular, electricity) is an obvious element in the value chains of almost all products. Around 65% of the energy used in EU industry is derived from fossil fuels, of which 27% comes from natural gas (Honoré, 2019). For many industries that supply base materials and feedstocks, electrification is a major decarbonization option that applies direct or indirect electrification, with the latter using electrolyzers to produce hydrogen or other electrofuels, when the hydrogen is combined with a climate-neutral carbon source. Applying electrification as a decarbonizing option obviously requires carbon-free electricity. The carbon intensity of the electricity production differs significantly between EU Member States. Sweden is fortunate in already having an almost carbon-free electricity system, which means that it can focus on ensuring that the additional electricity required for the electrification program will come from carbon-free sources. Countries in which the electricity generation is partly fossil fuel-based must expand the use of carbon-free electricity to replace the existing fossil fuel-based electricity and to meet the expected expansion in electricity use. Thus, any contributions from energy efficiency and energy saving measures are important to limit the pressure on additional electricity.

In addition to electricity, heating systems in continental Europe rely to a large extent on natural gas, with the building sector being the largest gas consumer in the EU, responsible for approximately 38% of EU gas use (IEA, 2018). For example, around half of German households depend on natural gas for their heating.

As mentioned above, the REPowerEU initiative (COM 2022) aims for the EU to achieve a more-resilient energy system and to become less-dependent on Russian oil and gas. The two options of substituting gas and oil with different sources of energy and reducing overall energy consumption each contain various measures, for which the possibility for deployment differs in time. Table 1 exemplifies different measures covering these categories, with the columns indicating when it is estimated that they can be deployed at scale (short, medium and long term) and what are the opportunities and challenges associated with deployment.

The obvious challenge is to find short-term measures that at the same time will have the desired effect to reduce the financial support for Putin's war on Ukraine, while maintaining social acceptance of the measures taken. In the political sphere, there is a perceived challenge to maintaining social acceptance, although due to the urgency, sometimes without much analysis as to the basis for the immediate measures taken. As an example, the recently increased prices for gasoline and diesel – in particular the latter – have caused some governments to decide to reduce the taxes of these fuels – a measure that has been criticized by both other politicians and the research community. This is because a reduced tax is a subsidy for fossil fuels, including those coming from Russia (also bearing in mind that the share of the average household income spent on transport by car has not increased over the last decades, while the cost of public transportation has increased substantially over the same period). In addition, there are indications that oil distributors anticipate the tax reduction and raise their prices by the same amount, leading to windfall profits[1] (Montag et al., 2020). Alternatives would have been either a direct monetary subsidy (at least allowing recipients to choose how to spend the subsidy) or the drawing of a distinction between city dwellers (having access to public transport) and rural dwellers (dependent on private cars).

Energy savings, such as reduced indoor temperatures (see Table 1), can be applied directly at no or little cost. The challenge lies in gaining social acceptance for such measures. To save energy by shifting the mode of transport from private cars to public transportation is for many associated with a broader change of behavior. For energy savings to have a significant impact some type of rationing may be required. Thus, energy savings are measures that may rather be used in immediate crisis situation (from a Ukrainian perspective one can of course argue that the current situation is an immediate crisis but even so, it may be politically difficult to base actions within the EU on immediate crisis types of measures).

Energy savings may also be achieved by various extended work-from-home initiatives, reducing transportation work with fuel savings as a result. Due to the Pandemic, there was a strong increase in home working in 2020. Estimates suggest that around 40% of people employed in the EU started working from home fulltime due to the Pandemic (Eurofound, 2020) while only 5% did so before the Pandemic. Working from home is more common in Northern Europe including Sweden than in south of Europe. The IEA (2020) analyzed commuter trends and labor market data and found that if everybody around the world could work from home for one day a week, it would result in a reduction of around 1% of global oil consumption for road passenger transport per year. Although this is rather limited, there should be large differences between regions as well as between different types of professions. The residential energy use may also increase with increased home working.

Increased energy efficiency is also generally a low-cost option because it lowers the operational cost, albeit with an initial investment cost that can be high. Thus, cost efficiency occurs provided that there is a sufficiently long depreciation time of the investment. It includes improvement of industrial processes for more fuel-efficient cars and renovation of buildings. Large roll-out of efficiency measures also depend on multiple decision makers (especially in the residential sector) and may entail split incentive problems [2]. In the residential sector, the actual requirement for rate of return is often high (since one would

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[1] See https://twitter.com/COdendahl/status/1532438209254281227

[2] Split incentives can be exemplified as comparing a case where landlords pay the household's energy bill, in which case the tenants are significantly less likely to turn their thermostat down at night, with a case in which the tenants pay the energy bill, where landlords are much less likely to install building insulation (Melvin, 2018).

rather spend additional money on something that gives an immediate experience such as traveling, and it is not obvious if one will recover the investment in energy efficiency measures on a property when later selling the property). From a more philosophical point-of-view, increased efficiency will result in a net monetary gain for Society and if climate policy is too weak this resource may be spent on other carbon-intensive activities (e.g., charter flights in the case of private households or producing more-carbon-intensive products in the case of industries). Thus, there may be a significant indirect rebound effect (Sorrell and Dimitropoulos, 2008) from efficiency measures (as opposed to the direct rebound effect, which is mostly limited, e.g., lower fuel prices will only result in marginally higher levels of car driving since, after all, most driving serves a specific purpose). Avoiding the risk of an indirect rebound effect calls for a strong climate policy, underlining the importance of EU ETS 2 (see below).

As mentioned above, a change in mode from private cars to public transportation may be seen as saving energy. However, if considering the entire transportation system, a redesign of this system may be regarded as increasing its efficiency. With respect to private cars, there is an obvious high potential for increased efficiency since todays transportation system – at least in big cities – is far from efficient, with the common practice of one person in each car and the cars standing still for at least 95% of the time. However, drastically changing this situation represents a broad task related to overall city planning, new forms of car ownership (e.g., increased car sharing), and a change in the general view of the car as being partly a consumer good (e.g., status symbol). More-immediate possibilities are improved fuel standards for cars and the increased efficiency that comes with electrification. Both of these measures are ongoing, although it will take some time before they have a significant effect (related to the age structure and capital stock turnover of the car fleet).

When it comes to **fuel and technology substitutions**, there is currently much work being carried out in governmental organizations and industry. Many municipalities and cities have set their own climate targets, such as being fossil-free (or even climate-neutral) by Year 2030. The same goes for industry where, for example, vehicle manufacturers have targets for achieving climate neutrality by a certain year (e.g., Volvo Cars AB plans to be climate-neutral over the entire value chain by Year 2040, and Polestar intends to offer climate-neutral cars by Year 2030). When manufacturers at the end of the value chain, e.g., car companies, set such targets, there are impacts further up the value chain, e.g., the need for fossil-free steel, as developed in the Swedish Hybrit project [3]and for fossil-free transport of their cars (e.g., using the sail ship developed by the shipping company Wallenius Wilhelmsen[4]).

Accelerating the deployment of renewable energy is an obvious measure to substitute oil and gas and to achieve independence from imported energy, in particular when expanding electricity generation from wind and solar power. In the case of Sweden, little oil and gas is used in electricity and heat production, whereas oil is used in the transport sector and gas is mainly used in the industry sector. Yet, Swedish electricity prices are influenced by the

[3] https://www.hybritdevelopment.se/en/a-fossil-free-future/
[4] https://www.walleniuswilhelmsen.com/news/orcelle-wind-wallenius-wilhelmsens-first-full-scale-wind-powered-roro-ship

European electricity prices, which depend on the natural gas prices. This is an effect of the integrated electricity market with interconnection capacities between the EU Member States.

The diffusion of high electricity prices from continental Europe to Sweden has resulted in some politicians calling for a more-protective attitude towards limiting further investments in transmission capacity in some form of "energy nationalism", which is clearly in conflict with the EU strategy of integrated markets. It is important to remember that the actual electricity production cost in Sweden has not increased and the increased electricity prices are mainly due to the spot price market and to a lesser extent to the long-term contracts, which are more common for industry. Yet, expanding the transmission capacity will result in an upward pressure being applied to electricity prices, as long as the surrounding countries have more-expensive electricity generation. Since Sweden has generally favorable conditions for renewable electricity, having a large share of existing nuclear power and hydropower generation, it is likely that Sweden will have competitive electricity prices over the foreseeable future. This is because the transmission capacity to neighboring regions will be limited. Indeed, a certain "energy nationalism" can be defended in the sense that it will be beneficial for Sweden to use favorable electricity prices for valorizing the electricity within Sweden to produce certain products and then exporting these products rather than exporting the electricity. Such a strategy should be driven by companies taking the opportunity derived from access to carbon-free electricity at attractive prices rather than from an electricity market interference that limits import/export with the surrounding countries. From a security point-of-view, import and export between countries should be beneficial for all countries. It should also be mentioned that Sweden is both importing and exporting electricity over the year, although there is typically a yearly net export of electricity.

Expansion of renewable energy is primarily in terms of wind and solar power, with wind power dominating in the north of Europe and solar power in the south of Europe. Both these technologies are non-dispatchable, i.e., their outputs will vary in time. In addition, biomass-based systems, such as those in combined heat and power plants and advanced renewable fuel production plants, are important, especially in sectors and activities where it is difficult to replace carbon-based fuels and feedstocks (e.g., in aviation and shipping).

The challenge associated with expanding renewable electricity is not mainly a technical one but is related to making the electricity system more flexible, so as to be able to utilize wind and solar power in an efficient way and to increase social acceptability of new sitings of wind power and new transmission capacity.

Increasing the flexibility of the energy system (and in particular, the electricity system) is required both on the demand side ("Demand-side response") and on the dispatchable part of the supply side, in order to minimize curtailment of generated wind power (as well as for efficient utilization of solar power). The measures can include the shifting of electricity generation in time, the conversion of electricity to another energy carrier (hydrogen or other electrofuels), and the complementation of renewable electricity with dispatchable electricity generation (Göransson & Johnsson, 2018). There are plans for large onshore wind farms in the North Sea, and in Sweden these need to be connected by means of new transmission capacity. Moreover, in general terms, efficient integration of wind power will require expansion of the transmission grid, in order to avoid wind power becoming "locked in". Building new transmission capacity is associated with high levels of investment. An alternative could be to produce hydrogen in direct connection to the power generation (e.g., in an offshore wind farm), with subsequent transportation of the hydrogen to the end-user (e.g., an industry).

In most EU Member States, there are many more applications for wind power projects than those that receive approval (Ferris, 2022). There is growing resistance to wind power in many areas, in particular to onshore wind power. Thus, there is a strong need for a more-inclusive process when planning and permitting new sitings for wind power. The same goes for building new transmission capacity, especially when it comes to overhead lines. Both wind power and transmission line projects have, consequently, become associated with long lead times. In this context, the EU Commission has called for the speeding up of permitting processes, with each Member State identifying renewables "go-to areas" and other ways to shorten and simplify permitting. A renewables "go-to area" refers to "*a specific location, whether on land or sea, which has been designated by a Member State as particularly suitable for the installation of plants for the production of energy from renewable sources, other than biomass combustion plants*". This is in line with the recent Government of Sweden decision[5] regarding the development of offshore wind power plans ("*havsplaner"*), which will be carried out in co-operation with several key authorities.

The sustainability of biomass – including its climate benefits - is not obvious and has been the subject of significant discussions in political circles as well as in the research community. This, in spite of the fact that LULUCF [6]accounting accounts for biomass stock changes. There seems to be a division between countries that have a well-developed forest industry – such as Sweden – and those where forests are more-limited and more-associated with recreation and natural conservation. As for climate benefits, a key consideration should be that there is not a decrease in the forest carbon stock over time and that the biomass is used where the climate benefit is as high as possible (i.e., where electrification is difficult). The reader is directed to the papers of Berndes et al. (2018) and Cowie et al. (2021) for discussions of the climate benefits of biomass.

Electrification of home heating with heat pumps is a key measure to render EU Member States, such as Germany and Italy, independent of fossil gas. Sweden is fortunate in having more-or-less zero dependency on gas for heating. Instead, heating is delivered mainly in the form of district heating in urban areas and as electricity-based heating (mainly heat pumps) in the case of single-family houses and in rural areas. Only a month before the war started, it was reported that German households were increasingly switching to electric heat pumps when upgrading their heating systems (Clean Energy Wire, January 2022[7]), and that this trend will continue. With the war continuing, this trend can be expected to be accelerated

[5] https://www.regeringen.se/pressmeddelanden/2022/02/sveriges-forsta-havsplaner-mojliggor-snabbare-utbyggnad-av-havsbaserad-vindkraft/ eringen.se/pressmeddelanden/2022/02/sverigesavsplaner-mojliggor-snabbare-utbyggnad-av-havsbaserad-vindkraft/
[6] LULUCF: Land Use, Land-Use Change and Forestry
[7] https://www.cleanenergywire.org/news/prospect-decade-heat-pump-germany-excites-producers

further. A previously decided upon ban on any new fossil fuel heating installations as of Year 2025 will be brought forward in Germany by 1 year to Year 2024 due to the war (Euroactive, May 10, 2022)[8]. Nonetheless, the expansion of district heating system in urban areas has been suggested. The effect of the strong focus on heat pumps has been questioned given that at present they only contribute a few percentage points to the overall home heating demand. District heating will obviously take even longer to expand since it requires the expansion of a large, centralized infrastructure.

Nuclear power has, since the 1980s, provided a large share of the base load in several Member States, such as Germany, France, Sweden and Finland (as well as in the former EU Member State of the UK). This nuclear power capacity was mainly built up during the 1970s and 1980s, before the electricity markets were deregulated. Thus, the financial risks associated with the high up-front investments in nuclear power were assumed by the states and not by individual companies in a deregulated electricity market. The establishment of new nuclear power plants with current technology levels (Generations III and III+) is associated with long lead terms, as well as uncertainties related to the costs (which are considered high; the cost of the Olkiluoto 3 plant in Finland, which was recently put into operation after a delay of more than 10 years, is estimated at €11 billion according to TWNI, 2019). Therefore, current development of new nuclear power technologies involves SMR. Since the idea is that SMR will be partly produced in factories in several units, it is believed that the cost will be lower than that for the traditional technology. However, the cost of SMR is not yet known, and the year in which they can be expected to be commercially available is uncertain. A reasonable assumption is that SMR will be commercially available in Year 2030 at the earliest. In Sweden, the debate regarding the future of nuclear power has regained momentum. As indicated above, some of the political debate tends to be focused on wind *versus* nuclear power, while there is a rather broad consensus among experts, market actors and researchers that this is not the most pressing issue. The Russian invasion of Ukraine, together with its implications for energy security has fueled the debate on nuclear power. Wind power can be expanded immediately (since it is available at a known cost) but suffers from lack of social acceptance in many places, whereas, as mentioned above, nuclear power can possibly compete in a cost-efficient way beyond Year 2030, depending on the cost development trajectory of SMR.

As for nuclear power, it is noteworthy that Germany and France have responded very differently to the Russian-instigated war. While Germany so far seems to maintain its course towards phasing out nuclear power, President Macron seems to have more or less completely changed the French nuclear strategy; when he took office the decision was to reduce nuclear dependency to some 40%. Now, the plan is to expand nuclear power by developing "innovative small-scale nuclear reactors" by Year 2030 as part of a €30 billion plan, in addition to a €100 billion Pandemic Recovery Plan announced in Year 2020. Yet, to change course entails serious challenges. Currently, the French nuclear power industry faces several maintenance issues in relation to its ageing nuclear power reactors, partly as a result of many years without new nuclear investments. Around 50% of the 56 nuclear reactors in France are currently (May 2022) offline. Twelve of these are shut down due to corrosion

[8] https://www.euractiv.com/section/energy-environment/news/germanys-summer-package-to-focus-on-heating-sector-revamp/

inspections. This may be used as an illustration of how more generally it is challenging to make sudden course changes in developments that involve large infrastructures.

CCS and reforestation and land use change are measures that are beneficial for climate change mitigation. If implemented, these measures will help the EU and Sweden to become forerunners in the energy transition towards zero-emissions systems. Yet, these measures will have no direct effect on the dependency on Russian fossil fuels. However, we discuss these measures briefly here since they are part of an overall portfolio for the energy transition.

Carbon Capture and Storage (CCS) has been the subject of extensive research and discussion over the past 20 years or so. Yet, CCS has never reached close to commercial status. This is mainly due to its cost, since climate policies have to date induced costs that have so far been too low to trigger CCS, which typically comes at an estimated cost of at least 100 €/t CO_2. However, in Europe the emissions allowance prices within the EU ETS have increased steeply over the last years and are now (May 2022) at more than 80 €/tCO_2. Early this century, the focus of CCS was for applications in coal-fired power plants, such as the lignite-fired power plants in the eastern part of Germany. Now, the strategy seems to be to phase out the coal-fired power plants and to replace this with renewable electricity generation from wind and solar power. Instead, within the EU, CCS is primarily investigated for applications to cement production, waste-fired combined heat and power plants, and other biogenic emission sources, such as biomass-fired CHP units. In Sweden, there are plans to apply CCS to the refining and cement manufacturing sectors as well as on CHP plants. Cementa, which is the Swedish branch of Heidelberg Cement, has declared that they will apply CCS to become climate-neutral by Year 2030 (for the largest of their two cement plants in Sweden).

Applying CO_2 capture to biogenic emissions sources will, assuming sustainably grown biomass, yield negative emissions and is often termed BECCS (bioenergy CCS). BECCS has recently come into focus in Sweden because the Government of Sweden has launched a reversed auctioning system for BECCS credits. Thus, the Swedish State will pay for negative emissions at a certain level (corresponding to around €35 million). The reason is that BECCS is one of the so-called supplementary measures identified by the Swedish government. These measures are meant to be used to offset residual emissions from hard-to-abate sectors according to the Swedish climate framework and in the longer run, to contribute to net-negative emissions. A governmental inquiry (SOU, 2020) has identified BECCS as the most promising supplementary measure with the largest volume potential and has proposed targets for BECCS of up to 2 MtCO_2/year by Year 2030 and 3–10 MtCO_2/year by Year 2045. The wide range estimated for Year 2045 reflects the uncertainty regarding the need for supplementary measures in Year 2045, i.e., uncertainty related to the contributions from other greenhouse gas (GHG) reduction measures. Thanks to the reversed auctioning system, it appears that BECCS can be applied at full scale within 5 years in Sweden, with Stockholm Exergi expected to be first to operate capture in their newest combined heat and power plant “Värtan” in Stockholm. Thus, although BECCS is designed to compensate for residual emissions, it will be implemented soon and, thus, it is not yet clear for which emissions it will compensate. There is hope that voluntary markets will be developed. See Zetterberg et al. (2022) for a recent discussion on policy measures for BECCS. In the context of the response to Russia waging war on Ukraine, CCS and BECCS will not contribute to any energy independency, since these measures provide reductions of CO_2 emissions without any additional benefits. In fact, since capture requires energy, CCS and BECCS will require more fuel if maintaining the same total output.

Reforestation and land-use change have strong potentials to reduce climate impact. In addition, reforestation will most likely have positive effects on biodiversity and other environmental targets (assuming intensive mono-cultures are avoided during replantation). However, as is the case for CCS, there is no additional benefit with respect to reducing the effects of the war. In Sweden, reforestation is not that much of an issue since there is a net growth in carbon stock in the forests and an active forest management program (with replantation of clear-felled areas). There are relatively low-cost options in terms of the rewetting of drained peatland forests and covered peatlands, with a potential in the order of 10 $MtCO_2$/year. However, there are significant controversies surrounding forestry practices. Not only are the NGOs and part of the general public often in opposition to the forest industry, but also the forestry research community is to some extent divided.

From Table 1, it can be concluded that only a few options are available to mount an immediate response to Putin's war with respect to decreasing the dependency on Russian fossil fuels. These options include reducing the indoor temperature, accelerating the deployment of renewable electricity in the form of wind and solar power, and increasing the use of biofuels (provided in the form of drop-in fuels). Yet, it will most likely take at least a few years before these exert significant effects.

Table 1. *Examples of measures that can reduce fossil fuel dependency and increase self-sufficiency and reduce climate impact in the short, intermediate and long-term. The timing of the measure indicated by "X" is qualitative and represents an estimate that includes the technology, policy and social acceptance issues. The "X" is an estimate of when the measure can be expected to be implemented at the earliest, while all measures can of course be implemented any time after that.*

Measure	**Short term, in a few years**	**Medium term, in 5 to 10 years**	**Long term, beyond Year 2030**	**Challenges**	**Opportunities**
Energy savings					
Reduced indoor temperature	X			Social acceptance and many decision-makers (households) Weak incentives Split incentives	Cost-efficient and potential for "negative cost" No regret option
Reduced driving of private cars		X		Requires the establishment of better alternatives and/or change in norms; may require different	Cost-efficient for Society, positive side-effects on urban environment

				policies for urban and rural areas	
Extended work-from-home initiatives	X			Limited effect To maintain a good balance without jeopardizing health effects	Low cost Already implemented due to Pandemic
Energy efficiency					
Insulating houses		X		Weak incentives Split incentives High internal rate of return for private households	Cost-efficient No regret option
Improved CO_2 emissions performance standards for cars		X		Will take time due to turnover in capital stock (vehicles) Difficult to avoid rebound effect from increased size and power of the cars.	Cost-efficient measure
Electrification of road transport		X		Will take time due to turnover of capital stock (vehicles) Will need to be supported by building up of the charging infrastructure	Already ongoing Reduced noise
Change in mode of transportation with reduced focus on individual road transport			X	Will require significant changes in values and norms in the population Requires a broad shift in urban planning	High potential Positive side-effects, such as better air quality, and social benefits
Fuel and technology substitution					
Renewable electricity	X			Social acceptance of siting (for plants, as well as the associated transmission capacity)	High interest levels among developers and high demand for renewable energy
Electrification of transport		X		Infrastructure Heavy road transport, aviation and sea transport	Roll-out already initiated with plans to stop producing internal combustion cars by around Year 2030

Electrification of home heating with heat pumps		X		Myriad of heat pump investments by private households and property owners	Improvements to the environment and increased safety
Electrification of industry		X		Potentially too-weak policies for large-scale rollout in some industries	Roll out already initiated with momentum from value chain
Biofuels (drop-in) for transport	X			Uncertainties in relation to feedstock sustainability and policies	Low barrier for implementation
Nuclear Gen III+			X	Long lead times, high costs and weak social acceptance	Can provide base-load generation
Nuclear SMR		X[1]		Uncertainties related to time to commercialization and costs	Possibly lower cost than large-scale nuclear plants
Capturing and storing CO_2 (only for climate mitigation)					
CCS		X		Cost and no additional value, other than to reduce carbon emissions Social acceptance	Key mitigation technology for cement production
BECCS	X			Cost and no additional value, other than to reduce carbon emissions Uncertainties related to long-term policies and whether voluntary markets will develop Social acceptance if fossil emissions are not addressed seriously enough	High potential in the Nordic countries, and can offset hard-to-abate emissions

Reforestation and land-use change		X		Cost and no additional value, other than to reduce carbon emissions Competition with biomass economy	Relatively low-cost options for rewetting of drained peatland and forest-covered peatlands

X 1) There is a high level of uncertainty regarding when SMR can be expected to be commercially available and at what cost. It seems unlikely that this will occur before Year 2030 (i.e., it is not clear whether SMR should be filed under medium-term or long-term technologies

3. Critical minerals for the green transition

Which minerals are needed for the green transition?

The European economy is highly dependent upon critical metals. Between 75% and 100% of critical metals are imported to the EU (EC 2020). Many of these metals are needed for low-carbon technologies. Lithium, cobalt, and nickel are used in batteries. Platinum is used in electrolyzers and fuel cells. Nickel is also used in stainless steel, which has many applications, for instance in wind towers, and the casing and piping used for gas storage and transportation. Silver is used in solar panels and other electrical equipment. Neodymium and dysprosium are used in the permanent magnets in turbines. Gallium, indium, tellurium, and silicon are used in semiconductors in, for instance, solar cells and low-energy lighting (LED). Copper is used in electrical equipment (IEA, 2022).

The production of low-carbon technologies is expected to increase by a factor of 20 the demand for certain raw materials by Year 2030 (European Commission, 2016).

Impacts of the war and long-term supply of critical minerals

The war sent a shock wave through the global markets for critical metals. For instance, following the invasion, some observers (Pakiam, 2022, Wallace, 2022) raised concerns that Russia dominates global production of palladium. However, palladium is mainly used in catalytic converters for vehicles with combustion engines and is not primarily used in low-carbon technologies. If we look at the critical metals used for the green transition, Russia's shares of global production are 11% for platinum, 9% for nickel, 7% for silver, 4% for cobalt, and 1% for rare earth minerals (See Table 2). When it comes to known reserves, Russia contributes 6% of platinum, 8% of nickel, 8% of silver, 3% of cobalt and 18% of rare earth minerals globally (USGS 2022a-f).

Table 2. *Countries with the highest production levels and known reserves of platinum, nickel, silver, cobalt, rare earth minerals and lithium (Data from USGS 2022a-f).*

Mineral	**Main producers in Year 2021**	**Countries with largest known reserves in Year 2021**
Platinum	South Africa 72%, Russia 11%, Zimbabwe 8%	South Africa 90%, Russia 6%, Zimbabwe 2%
Nickel	Indonesia 37%, Philippines 14%, Russia 9%, New Caledonia 7%, Canada 5%	Indonesia 22%, Australia 22%, Brazil 17%, Russia 8%, Philippines 5%
Silver	Mexico 23%, China 14%, Peru 13%, Chile 7%, Australia 5%, Poland 5%, Russia 5%	Peru 23%, Australia 17%, Poland 13%, Russia 8%, China 8%, Mexico 7%, Chile 5%, USA 5%
Cobalt	Congo 71%, Russia 4%, Australia 3%	Congo 465, Australia 18%, Indonesia 8%
Rare earth minerals	China 60%, USA 15%, Burundi 9%, Australia 8%	China 37%, Vietnam 18%, Brazil 18%, Russia 18%,
Lithium	Australia 55%, Chile 26%, China 14%, Argentina 6%	Chile 42%, Australia 26%, Argentina, 10%, Zimbabwe 10%, China 7%

Although Russia is one of several important producers of critical metals, they do not dominate the world supply of any of the critical metals needed for the green transition. In the short-term, scarcity on the margin can still lead to price volatility. Following the invasion, the price of nickel almost tripled (Trading economics, 2022). However, after a 3-month period of significant volatility, the price has fallen back to a level 50% above the January price.

Although Russia might not be a dominant producer of metals critical for the green transition, the suppliers of many critical raw materials are concentrated in a few countries. For example, South Africa provides 72% of the world production of platinum, Congo 71% of cobalt, China 60% of rare earth elements, Australia 55% of lithium, and Indonesia 37% of nickel (USGS 2022a-f). Therefore, in the longer term, Europe should increase efforts to diversify the sourcing of these materials.

Månberger and Stenqvist (2018) have shown that, given a recycling rate of 80%, the known global reserves of critical metals are sufficient to support the expected demand from investments in solar power, wind power and electric motors. The exception is lithium, which is needed for batteries, where the reserves are insufficient to meet the expected demand in the scenarios that the authors have analyzed.

Increasing resilience to disruptions to the supply of critical minerals

In order to become more resilient to disruptions in supply chains of critical minerals, it is important to find new sources. Increased sourcing from the EU is also an interesting alternative. Batteries require cobalt, nickel, lithium, and platinum. In Europe, there are significant unexploited sources of these metals in Portugal (lithium), Finland (lithium, nickel, cobalt, platinum), and Sweden (cobalt) (European Commission 2020 and NMR 2021). According to the European Commission (2020), Europe is well-endowed with several battery metals but has been less successful in developing projects to source these critical raw materials. The reasons for this are multi-faceted: lack of investment in exploration and mining; diverse and lengthy national permitting procedures; and low levels of public acceptance (European Commission, 2020a).

In addition to these battery metals, significant sources of niobium have been found in Norway, Finland and Greenland. Large sources of rare earth metals have been found in Greenland, Sweden, Norway and Finland (NMR 2021).

Certain materials mined in Europe (such as lithium) currently leave Europe for processing, later returning to Europe. These gaps in EU capacities regarding extraction, processing, recycling, refining and separation (e.g., for lithium or rare earth materials) reflect a heavy dependency on supplies from other parts of the world (European Commission, 2020a).

Månberger and Johansson (2019) have shown that with current recycling rates, i.e., 40% for cobalt and 10% for lithium, the known sources of cobalt and lithium do not meet the global future needs. With a recycling level of 80%, the known sources of cobalt and lithium correspond to 96% and 59%, respectively, of the expected future demand.

There is a potential to decrease the metal intensity in green technologies. For instance, the amount of cobalt used in batteries has gone down (Castelvecci, 2021)

The most basic type of substitution is element for element. For example, aluminum can be used as a substitute for copper in many electrical applications. Another type of substitution is replacing one technology for another, for instance replacing permanent magnets in wind turbines (that require neodymium, which is critical) with electrical magnets (that do not require neodymium). Another type of substitution is to replace the services that the technology provides, for instance providing mobility through public transportation instead of through (electric) cars. This will of course require larger societal changes with downsizing of the automotive industry if it is to have an effect.

The European Battery Alliance (EBA) was launched in 2017 with the aim of making Europe a global leader in sustainable battery production and use. The alliance consists of the European Commission, EU Member States, industry, and the scientific community (European Commission, 2022). Since then, several battery factories have been established in Europe, including France, Germany, Sweden, Norway, Great Britain, Poland, Slovakia, and Hungary.

The EU Commission has adopted a circular economy plan as one of the building blocks of the EU Green Deal. The aims are to, *inter alia*, focus on the sectors that use the most resources and where the potential for circularity is high, such as electronics and ICT, batteries and vehicles, packaging, plastics, textiles, construction and buildings, food, water and nutrients (European Commission, 2020b).

In May 2022, Europe's largest electricity vehicle recycling plant (Hydrovolt) began commercial recycling operations, with an expected capacity of 12,000 tonnes of battery packs per year (around 25,000 EV batteries) (Northvolt, 2022)

It can be concluded that although Russia is one of several important producers of critical metals, it does not dominate the world supply of any of these metals. The Russian aggression has highlighted that Europe is very dependent upon critical metals for the green transition and that the supplies of many critical raw materials are highly concentrated to a few countries (other than Russia). Therefore, in the longer term, Europe should increase efforts to diversify sourcing, moving processing of minerals to Europe, considering opening new mines in Europe, increasing recycling, improving metal efficiency in products, and seeking opportunities for substitution.

4. Policy implications for the Green Deal and Fit-for-55 package[9]:

For some of the key components of the Fit-for-55 package, which are currently under negotiation in and between the European Parliament and Council, the Russian invasion inevitably will affect the perceptions and priorities of policymakers and stakeholders in the EU.

EU ETS:

The sanctions imposed on fossil imports from Russia could be addressed in two ways: 1) accelerating the deployment of renewables and increasing energy efficiency, which is addressed by the REPowerEU Plan; and 2) increasing the use of coal, oil and gas from sources other than Russia to fill the gap. This would lead to an increase of GHG emissions. At first glance, since emissions are capped under the EU ETS, the integrity of the climate policy would be assured, although we would expect that the increased use of coal would lead to higher prices for allowances. A proposal to provide the market with extra allowances currently held in the MSR could reduce this price impact, although this would undermine the integrity of the cap.

MSR: €20 billion in revenues?

One of the most notable impacts on EU climate policies would be the proposal to raise €20 billion by selling the ETS allowances currently held in the MSR [10]. Normally, under the current rules, these allowances would be invalidated after Year 2023, or would re-enter the market if the surplus falls below 400 million. The €20 billion revenue target is fixed in the legislative proposal. This means that the exact number of allowances that would be auctioned from the MSR will depend on the ETS price. If the ETS price is lower, more allowances will re-enter the market and the environmental impact will be greater. If the carbon price is higher, fewer allowances will need to be sold to reach the €20 billion sum.

The impacts of the additional supply may have some second-order effects. First, the mere announcement has already affected the ETS price, which dropped around 8% after the proposal was published [11]. This means that regular auctioning revenues for EU Member

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[9] This section is partly based on an earlier chapter by Milan Elkerbout on the implications of the Russian invasion, released as part of the CEPS Report ”A Transformational Moment: The EU’s Response to Russia’s War in Ukraine”. See: https://www.ceps.eu/ceps-publications/a-transformational-moment/

[10] https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A32019R0331

[11] https://www.nasdaq.com/articles/european-carbon-hits-3-week-low-on-auction-permit-sales-plan

States may be lower than without the proposal. Eroded credibility or price impacts from the actual sale of MSR allowances may further exacerbate the impact for regular auctions.

It also remains to be seen how much discretion the European Investment Bank (EIB), which has been tasked with the sale of the allowances, can be afforded. While the Commission suggests that the allowances should be auctioned in a way "that does not disrupt the market", there are no legal details as to how this should be ascertained.

The proposal comes at a time when there is already heightened concern about the role of speculators in the ETS (witness ESMA studying the impact of financial operators on the market). Paradoxically, however, the extra sale of €20 billion in allowances may attract speculative activity. If the price is driven up prior to the sale, fewer allowances will be auctioned to reach the sum of €20 billion. Thus, speculators would be assured of greater scarcity if they time their purchase appropriately. Conversely, EU Member States that are concerned about high ETS prices (and less so about their own revenues) could support policies that lead to lower ETS prices, knowing that this will lead to a greater supply in the future.

Finally, the additional supply from the sale of the extra MSR allowances will still interact with existing MSR provisions. Thus, notwithstanding any impacts on the ETS price and subsequently on emissions, the additional allowances may simply be added to the existing surplus, leading to the MSR removing them from auctions again[12]. However, if the MSR remains within the range where no interventions take place, the cap could be structurally inflated.

The proposed design paves the way to numerous possible complex interactions with the rest of the MSR and the ETS, making it difficult to predict its consequences when accounting for second-order effects. However, even the basic principle of using MSR allowances for *ad hoc* revenue raising (some stakeholders have called it "using the MSR as an ATM" [13]) represents a major schism with ETS governance up to now. The European Commission has long and vigorously defended the ETS as a quantity or volume-based system. Any interventions in the policy design would always target the volume of allowances, and never the carbon price. Hence, when the ETS price dropped as low as 3–5 EUR at the beginning of Phase 3 (between 2013 and 2015), backloading and the Market Stability Reserve – both instruments that adjust the ETS supply by adjusting auction volumes – were adopted as solutions, rather than mechanisms such as a price floor or auction reserve price. The justification for the MSR was that it would increase stability in the market by creating structural, albeit predictable changes to the auction supply. With the new proposal, the structural, rule-based design of the MSR would be altered. This precedent could entail negative consequences for the credibility and trust in the ETS as a whole[14], or to investors discounting the value of ETS allowances[15].

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[12] As noted by certain market analysts in discussions on the MSR proposal
[13] See, for example, this comment by Sandbag.
[14] See also the discussion in this blog post, which covers the debate from various angles: https://www.carbonreporter.com/post/ooooh-look-at-that-cookie-jar
[15] As noted by Michael Liebreich

The impacts of the extra allowance sale are difficult to predict for now, although there is a real chance that it will have adverse environmental implications while also reducing auction revenues to EU Member States. The only thing that would be achieved then is a lowering of the ETS price, while ensuring that a greater share of revenues is redistributed to the EU level, with the €20 billion going to the Recovery and Resilience Facility.

Politically, it is understandable that the increased ETS price leads to concerns, given the high levels of inflation and energy costs for households. Carbon pricing needs to be sustainable from a social-political perspective as well. A given ETS price will have a different impact depending on the relative income levels in a Member State. This makes concerns about the price – and rapidly accelerating prices – understandable. Even if the price of (fossil) energy itself is a much stronger driver of energy prices than carbon costs, perceptions matter. The fear is that perceptions of a too-high carbon price will undermine the political support for the ETS, especially in countries where energy poverty is higher on the agenda. However, this would make the "€20 billion proposal" a backdoor into a price discussion about the ETS. Once this door is opened it cannot be closed.

If there really is a concern about the sustainability of higher (relative to, for example, the period 2018–2019) carbon prices, it would be better to reform the mechanism intended to deal with carbon price surges, i.e., Article 29a, which allows for extra allowances to be auctioned if the ETS price remains above a certain level for a sustained period of time. In fact, the MSR itself could arguably be used to address concerns about price surges and drops: in addition to the already existing triggers that are based on the ETS surplus (officially, the total number of allowances in circulation), price-based triggers could be included to either withdraw or add extra volumes to the market. These price triggers could also be expressed in a dynamic way, i.e., in percentage terms.

Conversely, if the stated aim of the MSR proposal is the actual goal – to raise EU revenues – this could be pursued in a more transparent manner (even if the negotiations with Member States would be difficult) by ring-fencing a share of either total ETS auction revenues or only of allowances that re-enter the market from the MSR.

An unintended consequence of the war is that it allows us to revisit the merits of a critical choice in climate policy design: whether to target a specific carbon price (e.g., through a carbon tax) or to limit the quantities of emissions. While many major economies have yet to make such a choice, the EU has long ago decided in favor of quantities of emissions with the EU ETS, even if institutional [16] rather than environmental or economic arguments were the reason. Now, with coal-use inevitably rebounding [17] (though not the use of sanctioned Russian coal), and the relative costs of energy sources and other technologies being shaken up by sanctions and supply chain disruptions, the benefits of having a ceiling (i.e., the cap in 'cap-and-trade') for emissions are clearer than ever. Had the EU instead had a carbon tax, the very high price of gas well-exceeding the carbon price would not have constrained

[16] Specifically, a carbon tax would have required unanimity in the Council of Ministers, whereas the EU ETS was passed by a qualified majority.

[17] EU ETS data from 2021 shows power sector emissions having increased by about 4% compared to 2020

emissions in any way. Nevertheless, the MSR proposal included in the REPowerEU initiative also shows that the ETS cap is contingent on political developments, as well as specific rules, both large and small, which can ultimately affect the credibility of the system.

ETS 2:

The war could also influence the prospects for a major revision of the EU ETS planned under the Green Deal, entailing a new system for emissions trading for road transport and energy use in buildings [18]. President von der Leyen has proposed this extension together with a new fund to address the social costs of climate policy: the Social Climate Fund [19]. The two proposals are closely linked, even if proponents of the new transport and buildings ETS often dislike the social fund, and *vice versa*. Without the revenues from the allowances auctioned under the new ETS, the budget for a social fund cannot easily be found. There is, therefore, an almost paradoxical situation in which the new ETS has become even more controversial and less likely to be agreed upon, as additional costs for households are hard to swallow for some countries, but also more desirable as an EU-wide instrument to address the social impacts of high energy prices becomes more important. In that light, it is worth recalling that while energy costs for households have indeed risen precipitously, the main reason for this is the cost of energy itself, and gas in particular, rather than climate policy costs *per se* (Elkerbout, 2021).

CBAM:

Related to the EU's carbon market, the political circumstances surrounding the proposed CBAM have changed significantly due to the war, although this does not imply that the proposal will be abandoned. The CBAM is conceived as a measure to mitigate the risk of carbon leakage and indirectly, to motivate other countries to move to more-ambitious carbon pricing and climate policies. The CBAM would apply to a limited numbers of sectors, mostly the production of primary industrial goods such as steel, cement, and chemicals, and some intermediate goods, but not complex final goods such as vehicles. It is an instrument that is strongly intertwined with international trade. As such, close neighbors of the EU are likely to be the most-severely affected due to the high volumes of trade in relevant energy-intensive goods. In fact, analyses (Droege, 2021) before the war showed that Russia, Ukraine and Turkey would be the most-affected countries, in particular due to their steel and cement exports to the EU.

The problem of equal treatment under the CBAM (which in principle is desirable) of these three countries in the current geopolitical situation is obvious: trade with Russia will disappear through sanctions, trade with Ukraine cannot be disadvantaged in any way by carbon costs, while Turkey as a NATO ally may find renewed political capital in engaging with the climate diplomacy surrounding CBAM. Similarly, any future climate club [20] may need to account for (energy) security issues. While large economies such as the US, China, Japan and

[18] See question 3 on the following EC page: https://ec.europa.eu/commission/presscorner/detail/en/qanda_21_3542

[19] https://ec.europa.eu/clima/eu-action/european-green-deal/delivering-european-green-deal/social-climate-fund_en

[20] For more discussions about what a climate club might comprise, see: https://www.ceps.eu/ceps-publications/from-carbon-pricing-to-climate-clubs/

South Korea will also be affected by a CBAM, their trade with the EU in affected goods is lower than that of the three countries mentioned above, even if it is not insignificant. Nevertheless, these countries – both policymakers and companies – are (re)examining their industrial decarbonization strategies to anticipate or even mitigate the impact of CBAM, demonstrating the diplomatic impact of the Commission's CBAM proposal. In the longer term, alliances between countries pursuing ambitious industrial decarbonization may also be important in terms of dealing with countries with whom the EU is competing geopolitically. In this context, geo-economic competition with China may become particularly important.

Other aspects of the Green Deal and Fit-for-55 package:
In the longer term, the war in Ukraine and a climate and energy policy environment marked by high costs and an emphasis of security may also lead to a different dynamic between the EU Member States when the headline policy targets are set. While the EU's long-term (Year 2050) target of climate neutrality is embedded into European climate law [21] (and is not being contested), there are different pathways towards climate neutrality. Traditionally, the EU has achieved its climate and energy objectives through a mix of calibrated targets: the overall GHG emissions reductions goal is broken down into separate targets for ETS sectors (somewhat higher than the general target) and Effort-Sharing targets (somewhat lower than the general target). In addition, there are separate targets for renewables and energy efficiency, while in the future, a separate target for negative emissions is also an option.

With the war and its economic impacts focusing attention on the need to move away from (Russian) fossil fuels and to use less energy, higher levels of renewables and energy efficiency targets may be emphasized to a greater extent rather than just focusing on the overall GHG reduction target. There may be an increased emphasis on energy savings, more structural energy efficiency, and electrification as means to achieve both lower energy demands and lower emissions. The disposition towards negative emissions may also change if energy and resource constraints change the prospects for industrial decarbonization in the medium term. Between the Member States themselves, the Effort Sharing framework [22] has traditionally enabled differentiated contributions from EU Member States to the common EU emissions reductions target. However, if the energy landscape in the EU remains strongly affected by sanctions and unavailability of supply from neighboring countries (i.e., Russia and Belarus), some Member States may find themselves less willing or unable to achieve ambitious targets, thereby complicating the bargaining process between the EU Commission and EU Member States.

Beyond the EU and its neighborhood, the war in Ukraine raises questions about the multilateral processes driving international climate policy at the UNFCCC and beyond. Climate change remains one of the few policy areas where virtually every country is, nominally at least, participating in multilateral structures (the UNFCCC and the Paris Agreement). However, only the most Panglossian observers would retain any hope of successfully engaging Russia and its satellite Belarus (around 6% of global GHG emissions) on climate action. Only reduced economic output or the deployment of low-carbon

[21] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32021R1119
[22] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32018R0842

technologies that are competitive purely in economic terms (and unsanctioned) may drive emissions down in 'unwilling' countries.

5. Zooming out

Overall macro policy implications

While the energy and security policy overlaps are significant and apparent, the war affects all political and policy areas. At the macro-level, the economic impacts of high energy prices and sanctions, and the need for greater defense spending will reorder budgets and Europe's political economy.

In the EU, the war will intensify the debate regarding common borrowing and debt issuance to fund common EU policy goals. While the common borrowing system introduced by NextGenerationEU[23], as an EU-wide pandemic recovery measure, was seen by many EU Member States (especially in the frugal north-west) as a one-off, the extra spending induced by the consequences of high energy prices and other inflation may lead to more structural common EU borrowing. With the impacts of the war, whether through security implications, refugees, energy costs or supply chains, being felt differently throughout the EU, some Member States will appeal for more EU funding to contribute to their policy responses. This will increase the pressure to find EU-own resources, although the countervailing force of Member States that are not willing to increase the EU's financial resources remains strong. Nevertheless, the REPowerEU Plan suggests the sale of additional ETS allowances, so that more EU-own resources can be identified.

With regards to defense spending, two scenarios for how this might affect EU climate (mitigation) policy can be envisaged, given that some GHG emissions, both direct and embedded, can be linked to the military. Defense spending is largely funded through national budgets and remains primarily a national competence for the Member States, even if the war in Ukraine leads to intensified discussions[24] on expanding the EU's Common Security and Defense Policy[25]. Extra spending on defense at Member State level, nevertheless, entails an opportunity cost for other policy priorities. In the first scenario, military and defense are considered as being separate from the rest of the economy and are given an opt-out, or are at least are strongly deprioritized for emissions reductions. The rationale would be that security considerations – and cost-effectiveness in achieving security objectives – should dominate. In such a case, electrification or the use of climate-neutral materials would not play a role. This may lead to the EU's militaries contributing to a certain, possibly increasing share of residual emissions, which will need to be compensated through negative emissions from the 2040s onwards. Alternatively, the inevitability of increased

[23] NextGenerationEU is the EU's common economic recovery plan adopted in the wake of the first Covid pandemic phase. It is funded through joint bond sales, i.e. common debt issuance. See: https://europa.eu/next-generation-eu/index_en

[24] Witness also Denmark voting by referendum to end its opt-out from the EU CSDP: https://www.eeas.europa.eu/eeas/denmark-statement-high-representative-outcome-referendum-opt-out-defence-matters_en

[25] https://www.eeas.europa.eu/common-security-and-defence-policy-csdp_en?s=287

defense spending can also be used to support lead markets for low-carbon technologies. In particular, where electrification is not considered an option, EU Member States could contribute to a larger market for climate-neutral fuels, which will also be required to decarbonize (long-distance) aviation. Likewise, the materials used in military equipment can be gradually sourced from climate-neutral producers. While such green public procurement has been on the agendas of policymakers for a long time, (increasing) defense spending could provide a new avenue for national decision-makers.

Other issues that have tested the limits of EU governance in recent years may also be revisited and recast in light of the war. Poland, Slovakia, Hungary, Romania and other central and eastern European Member States have hosted significant (and in the case of Poland – very high) numbers of refugees from Ukraine. While their efforts are being commended, the contrast with their very different treatment of refugees from Syria, Iraq or Mali is evident. Poland and Hungary are also still embroiled in a conflict with the European Commission about the rule of law, which in the case of Poland becomes more politically difficult as the country is leading the EU response to the war. While Commission President Ursula von der Leyen still signed off on Poland's Recovery and Resilience Plan[26], this immediately caused controversy because Poland's rule-of-law issues, in particular the independence of its judiciary, remain unresolved. Therefore, some members[27] of the European Parliament wanted to censure the Commission, while Executive Vice President Timmermans took the unusual step of publicly dissenting.[28]

In the EU's neighborhood beyond Ukraine, the war creates an imminent threat to other countries that Russia regards as being within its historical sphere of influence. This has already prompted Moldova (whose Transnistria region is occupied by Russian proxies) and Georgia (already invaded by Russia in 2008) to apply for EU membership. This in turn raises expectations for the Western Balkan countries – which have long been candidate members without progressing significantly towards full membership[29]. The transformed European security situation may lead to the EU's neighborhood and accession policies being reformed more radically – with potentially different models of association or membership – as already mooted by President Macron. The external dimension of the European Green Deal should evolve as well then, with energy modernization investments and industrial transformation providing specific avenues for integration with EU governance structures.

Towards a deglobalized economy?

Judging from the EU sanctions and the discussions leading up to their imposition, it seems that imports of oil, gas, coal, and biofuels from Russia and Belarus will be phased out. Firms are taking actions to guarantee the functioning of their supply flows. These recent war-related developments come on top of a trend that has been evident for other commodities

[26] https://ec.europa.eu/commission/presscorner/detail/en/IP_22_3375
[27] https://www.europarl.europa.eu/doceo/document/B-9-2022-0320_EN.html
[28] https://www.theguardian.com/world/2022/jul/03/senior-official-criticises-eu-handling-of-poland-covid-recovery-plan
[29] https://ec.europa.eu/neighbourhood-enlargement/enlargement-policy/enhanced-eu-engagement-western-balkans_en

before the war, in that European companies are moving to repatriate the production of key commodities (European Economic and Social Committee, 2022, Consultancy.eu 2022). Factories for the manufacture of batteries and computer chips are being established across Europe.

The COVID-19 pandemic showed that the supply of medical equipment was often based on the "just-in-time" principle, a strategy that proved to be inappropriate and inadequate as the pandemic unfolded. For instance, when the demand for medical provisions increased in Sweden, the available stocks were exhausted in a few weeks. The international shortage of medical supplies led to rather aggressive actions from certain countries. For instance, France confiscated medical supplies on the way to Sweden, and Great Britain stopped exports of vaccines to the EU. To address these problems, national production of facemasks was started up in record time. Moreover, the rapid post-pandemic industrial start-up has led to a shortage of semiconductors for use in home appliances and vehicles.
Are these trends in relation to reshoring, diversifying suppliers, and building up larger stocks an indication of the start of deglobalization? Probably not. International trade and collaboration are motivated by economic considerations, such that production is located where the production cost is lowest. In addition, expertise and (natural) resources are not always available within the EU. The pandemic has shown that international collaboration is indispensable for developing vaccines. The development, production and supply of Pfizer Biontech's COVID-19 vaccine involved the efforts and collaboration of actors around the world. Perhaps we are just seeing a healthy reaction from an over-globalized world. The record time in which the vaccines were developed, tested and administered is a testament in large part to the efficient functioning of global collaboration - facilitating the rapid dissemination and sharing of information and scientific advances and monitoring the emergence of new viral variants. An argument perhaps against the notion of any trend towards 'deglobalization'?

Nevertheless, the economic benefits of globalization need to be balanced by the benefits of reshoring, so as to reduce the risks for industrial supply chains. Reshoring can also be a way to address the ethical risks in supply chains associated with, for instance, poor working and environmental conditions or violations of human rights.

The climate challenge is a global concern that can be solved only through global collaboration. International agreements on commitments and implementation of policies are needed to decrease rapidly emissions levels, as well as to create a level playing field and minimize the risk of free riders. Innovations and the development of low-carbon technologies need to be shared/traded across the global community. Some technologies require international collaboration. The Western world needs to support the developing world towards decarbonization.

6. Conclusions

We have examined the immediate and longer-term repercussions for climate policy in Sweden and in the EU, focusing on the energy transition, the availability of critical minerals for the green transition, and the policy implications for the Green Deal and Fit-for-55 package.

We conclude that only a few options constitute an immediate response to Putin's war with respect to decreasing the dependency on Russian fossil fuels: reducing the indoor temperature, accelerating the deployment of renewable electricity in the form of wind and solar power, and increasing use of biofuels (provided in the form of drop-in fuels). Yet, it will most likely take at least a few years before these measures have a significant impact.

In the EU, replacement of heating systems and diversification of natural gas sourcing are important measures, although these cannot be expected to have an impact until the medium term. However, these measures depend on a clear policy being in place, for instance, financial support for switching from individual gas heating to electricity-based heat pump systems, possibly combined with various distributed energy systems such as solar PV and solar heating systems. An alternative is to build district heating systems, although this will require high upfront investments in district heating infrastructure (production units and district heating network) if carried out in regions where such facilities are not currently available.

For Sweden, simply lowering the indoor temperature and accelerating the deployment of renewable electricity will have an impact in the short term. A reduced indoor temperature may reallocate biofuels to sectors or regions where there is currently an oil or gas dependency. Yet, this will require that industrial processes be modified so as to be able to use this biomass, since it is in the form of waste from the forest industry (e.g., wood chips and sawdust). In addition, it is likely that a reduced indoor temperature will be difficult to apply broadly due to social resistance.

In the medium term, most of the measures discussed (see Table 1) can be impactful. However, this will obviously require clear and strong policies, both at the national and EU levels.

We conclude that there are hardly any technical measures that can have a strong impact on fossil fuel use in the short term. Instead, we consider that the most-important measure is to ensure that policies are strengthened so that the energy transition can accelerate and that the measures that can be expected to have an effect in the medium and long terms will actually be implemented. This is not obvious, and if the policies are insufficiently ambitious we may see the same development as that connected to the pandemic, when many pointed to the pandemic as an opportunity to change course. However, this opportunity was not seized, and once the economy regained momentum, the levels of emissions (i.e., fossil fuel use) increased and are now on the same trajectory as before the pandemic.

The green transition is dependent upon the availability of certain critical minerals, such as nickel, platinum, silver, cobalt, rare earth metals, lithium, neodymium, dysprosium, gallium, indium, tellurium, and silicon. There are concerns that the war will disrupt the supply chains of these metals and slow the green transition. However, although Russia is one of several important producers of critical metals, it does not dominate the world supply of any of these metals. Russia contributes to 11% of global production of platinum, 9% of nickel, 5% of silver, 4% of cobalt and 1% of rare earth metals. Nevertheless, in the short-term, scarcity on the margin can still lead to price volatility. In the longer term, sourcing of critical metals to Europe should not need to depend on Russia.

In the longer term, it will be more important to secure supplies in a broader context than Russia. The supplies of many critical raw materials are highly concentrated. For example, South Africa provides 72% of the world production of platinum, Congo provides 71% of the cobalt, and China accounts for 60% of the rare earth elements. Europe should, therefore, increase efforts to diversify sourcing by moving the processing of minerals to Europe, considering the opening of new mines in Europe, increasing recycling, and improving metal efficiency in products. The potential for substitution is large and appears at different levels, for instance, exchanging one critical metal for another, substituting one technology for another (e.g., from batteries to hydrogen), or switching from one service to another (e.g., from electric vehicles to public transportation).

Are we seeing the dawn of deglobalization? The war will most likely lead to a significantly reduced dependency on Russian energy imports and increased energy security through accelerated expansion of renewables, mainly from solar and wind. We will also see actions to secure industrial supply chains and increased reshoring – bringing back production to Europe. This trend has already started with the European battery alliance and plans to deploy computer chip production in Europe. Reshoring may also be motivated by ethical concerns related to supplies from countries with poor working and environmental conditions or human rights concerns. Is this the end of globalization? Probably not. Global trade will continue because it is motivated by economic considerations and because the required competencies and resources are distributed around the world. The climate challenge is global and can only be solved through international agreements and global collaboration. Innovations and the development, and deployment of low-carbon technologies need to be shared/traded within the global community.

In addition to phasing out the dependence on Russian energy imports and reducing the revenues to Russia, the war in Ukraine provides an additional impetus to accelerate the energy transition and implement climate policies such as the Green Deal, especially in the mid-to-long term. However, the social impacts of high energy prices may make climate action more difficult in the short term. Therefore, the distributional impacts of EU climate and energy policies matter now more than ever.

The importance of distributional impacts may be manifested throughout the remaining negotiations on the Fit-for-55 policies. Areas such as the heating of buildings may receive more-intensive policy attention, due to the impact of high gas prices. The new ETS for transport and heating may be even more controversial, while new instruments (i.e., the Social Climate Fund) to compensate households for increased energy costs are more desirable than ever, especially in EU Member States that have reduced fiscal space. For industry, industrial competitiveness will remain high on the agenda in the face of increasing energy and carbon prices. This may affect the negotiations regarding measures to mitigate carbon leakage risk, such as free allocations and the CBAM. Nevertheless, the distributional impacts between industry as a whole on the one hand, and households on the other hand, may also affect the politics of the Green Deal in the future.

While the EU is unlikely to abandon its climate ambition, some policymakers may be interested in creating some ‘flexibility’ in the short term, by making adjustments to specific policy elements such as the ETS cap or free allocation, or introducing transitional periods for the CBAM. The concerns about high carbon prices – as well as finding the means to finance the energy transition – also manifest themselves through the proposal to raise funds through the sale of ETS allowances held in the Market Stability Reserve. Combined with ongoing concerns about the impact of financial speculation, this may lead to reformation of the mechanisms to manage supply and volatility in the EU’s carbon market.

7. References

Berndes, G., Goldmann, M., Johnsson, F., Lindroth, A., Wijkman, A., Abt, B., Bergh, J., Cowie, A., Kalliokoski, T., Kurz, W., Luyssaert, S., Nabuurs, G-J., Forests and the climate - Manage for maximum wood production or leave the forest as a carbon sink? KSLA, No 6, 2018, 157. ISBN 978-91-88567-22-2.

Castelvecci, D., Electric cars and batteries: how will the world produce enough? Nature 596, 336-339 (2021)

Consultany eu, https://www.consultancy.eu/news/7430/european-companies-increasingly-moving-to-reshore-asia-production, downloaded 2022-06-14

Cowie, A.L., Berndes, G., Bentsen, N.S., Brandão, M., Cherubini, F., Egnell, G., George, B., Gustavsson, L., Hanewinkel, M., Harris, Z.M., Johnsson, F., Junginger, M., Kline, K.L., Koponen, K., Koppejan, J., Kraxner, F., Lamers, P., Majer, S., Marland, E., Nabuurs, G.-J., Pelkmans, L., Sathre, R., Schaub, M., Smith, C.T., Jr., Soimakallio, S., Van Der Hilst, F., Woods, J., Ximenes, F.A., Applying a science-based systems perspective to dispel misconceptions about climate effects of forest bioenergy, (2021) GCB Bioenergy, 13 (8), pp. 1210-1231. DOI: 10.1111/gcbb.12844.

Droege, S. (2021). Ein CO2-Grenzausgleich für den Green Deal der EU: Funktionen, Fakten und Fallstricke. SWP-Studie 9, July 2021

Elkerbout, M. (2021). A tale of two prices: What higher energy costs and the ETS price mean for a just transition https://www.ceps.eu/ceps-publications/a-tale-of-two-prices/

Eurofound (2020), Living, working and COVID-19, COVID-19 series, Publications Office of the European Union, Luxembourg.

European Commission, 2016. EU Raw Materials Scoreboard 2016. https://publications.europa.eu/en/publication-detail/-/publication/1ee65e21-9ac4-11e6-868c-01aa75ed71a1/language-en

European Commission, 2018. Report on Critical Raw Materials in the Circular Economy, 2018.

European Commission, 2020a. COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS Critical Raw Materials Resilience: Charting a Path towards greater Security and Sustainability

European Commission, 2020b. COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS A new Circular Economy Action Plan For a cleaner and more competitive Europe.

European Commission, 2022. European Battery Alliance. https://ec.europa.eu/growth/industry/strategy/industrial-alliances/european-battery-alliance_en , downloaded 2022-06-14

European Economic and Social Committee, 2022. https://www.eesc.europa.eu/en/our-work/opinions-information-reports/opinions/reshoring-eu-industries-framework-reindustrialisation, , downloaded 2022-06-14

Eurostat, https://ec.europa.eu/eurostat/cache/infographs/energy/bloc-2c.html , accessed 2022.

EU ETS data from EU Transaction Log : https://ec.europa.eu/clima/ets/

Ferris, N., Data insight: The permitting problem for EU wind farms, the Energy Monitor, April 5, 2022, https://www.energymonitor.ai/policy/data-insight-the-permitting-problem-for-eu-wind-farms .

Gillingham, Kenneth, Harding, Matthew, Rapson, David, 2012. Split Incentives in Household Friedrichs, J., Inderwildi, O. R., The carbon curse: Are fuel rich countries doomed to high CO2 intensities? Energy Policy 62, 2013, pp1356–1365.

Gillingham, Kenneth, Harding, Matthew, Rapson, David, 2012. Split Incentives in Household energy consumption. Energy J. 33 (2), 37–62.

IEA, 2020. Working from home can save energy and reduce emissions. But how much?, IEA, Paris https://www.iea.org/commentaries/working-from-home-can-save-energy-and-reduce-emissions-but-how-much

IEA, 2018. World Energy Outlook 2018.

IEA, 2022. The Role of Critical Minerals in Clean Energy Transitions - World Energy Outlook Special report, March 2022.

Jesse Melvin, The split incentives energy efficiency problem: Evidence of underinvestment by landlords, Energy Policy, Volume 115, 2018, Pages 342-352, ISSN 0301-4215, https://doi.org/10.1016/j.enpol.2017.11.069 .

Anouk Honoré, Decarbonization and industrial demand for gas in Europe, OIES paper: NG 146, The Oxford institute, 2019.

Montag, F., Sagimuldina, A., Schnitzer, M., Are temporary value-added tax reductions passed on to consumers? Evidence from Germanys stimulus, accessed from https://arxiv.org/pdf/2008.08511.pdf

Månberger and Johansson 2019. The geopolitics of metals and metalloids used for the renewable energy transition, Energy Strategy reviews 26 (2018).

Månberger and Stenqvist 2018. Global metal flows in the renewable energy transition: Exploring the effects of substitutes, technological mix and development. Energy Policy 119 (2018), 226-241.

NMR 2021. Eilu, P., Bjerkgård, T., Franzson, H., Gautneb, H., Häkkinen, T., Jonsson, E., Keiding, J.K., Pokki, J., Raaness, A.,Reginiussen, H., Róbertsdóttir, B.G., Rosa, D., Sadeghi, M., Sandstad, J.S., Stendal, H., Þórhallsson, E.R. &Törmänen T. 2021. The Nordic supply potential of critical metals and minerals for a Green Energy Transition. Nordic Innovation Report. ISBN 978-82-8277-115-3 (digital publication), ISBN 978-82-8277-114-6 (printed). Online: https://www.nordicinnovation.org/2021/nordic-supply-potential-critical-metals-and-mineralsgreen-energy-transition

Northvolt, 2022. Europe's largest electric vehicle battery recycling plant begins operations. https://northvolt.com/articles/hydrovolt/ Downloaded 2022-06-14.

Pakiam, R. 2022. Wild Palladium Rally at Risk From Recession Later This Year. From Bloomberg https://www.bloomberg.com/news/articles/2022-03-14/palladium-s-russian-rally-at-risk-from-recession-later-this-year. Downloaded 15 June 2022.

Smith, Benjamin; Waldner, David (2021). Rethinking the Resource Curse. Cambridge University Press. doi:10.1017/9781108776837. ISBN 9781108776837. S2CID 233539488.

Sorrell, Steve; Dimitropoulos, John (2008). "The rebound effect: Microeconomic definitions, limitations and extensions". Ecological Economics. 65 (3): 636–649. CiteSeerX 10.1.1.486.9529. doi:10.1016/j.ecolecon.2007.08.013.

SOU 2020, Swedish Government (2020), Vägen till en klimatpositiv framtid – betänkande av Klimatpolitiska vägvalsutredningen, 2020. ISBN 978-91-38-25019-8. Norstedts Juridik, Kundservice, 106 47 Stockholm.

Trading economics, 2022. Price development of nickel 2021 and 2022 in USD/ton. https://tradingeconomics.com/commodity/nickel , downloaded 2022-06-16 .

TWNI, The World Nuclear Industry Status Report 2019, A Mycle Schneider Consulting Project.

USGS 2022a. U.S. Geological Survey, Mineral Commodity Summaries. **Platinum**, Prepared by Ruth F. Schulte (rschulte@usgs.gov), January 2022.

USGS 2022b. U.S. Geological Survey, Mineral Commodity Summaries. **Nickel**, Prepared by Michele E. McRae (mmcrae@usgs.gov), January 2022.

USGS 2022c. U.S. Geological Survey, Mineral Commodity Summaries. **Silver**, Prepared by C. Schuyler Anderson (csanderson@usgs.gov), January 2022.

USGS 2022d. U.S. Geological Survey, Mineral Commodity Summaries. **Cobalt**, Prepared by Kim B. Shedd (kshedd@usgs.gov), January 2022.

USGS 2022e. U.S. Geological Survey, Mineral Commodity Summaries. **Rare earth metals**, Prepared by Daniel J. Cordier (dcordier@usgs.gov), January 2022.

USGS 2022f. U.S. Geological Survey, Mineral Commodity Summaries. **Lithium**, Prepared by Brian W. Jaskula (bjaskula@usgs.gov), January 2022.

Wallace, J., 2022. Palladium and Platinum Prices Jump After London Market Blocks Russia-Made Precious Metals. Wall Street Journal. https://www.wsj.com/livecoverage/russia-ukraine-latest-news-2022-04-08/card/palladium-and-platinum-prices-jump-after-london-market-blocks-russia-made-precious-metals-h7Ue50Q9ShLyCi62aHJv . Downloaded 15 June 2022.

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Mistra Carbon Exit is a research programme that identifies and analyzes the technical, economic and political opportunities and challenges for Sweden to reach the target of net zero greenhouse gas emissions by 2045. We will identify pathways and policies for how Sweden and Swedish companies can become frontrunners in transforming society and industries, providing low carbon products and services while at the same time dressing market risks. This will make Sweden an important international example for other countries to follow.

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