The Race to Replace: the economics of using renewables to free Europe from Russian gas

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Executive Summary

By 2028 the European Union (EU) can replace Russian natural gas for power and heat with renewables and heat pumps. Not only is this achievable and beneficial for the EU's energy security and climate action, but also a significant fraction of the investment required can be paid for from the resulting reduction in gas expenditure. Russia accounted for almost 50% of the EU's gas supply before the invasion of Ukraine.[1]

We find that the incremental investment requirement to replace Russian gas during 2023-2028 would be €512 billion, with this being about 70% more than a business-as-usual scenario. We also project that replacing Russian natural gas with green technologies will result in operational savings of €238 billion over the next 30 years, i.e., almost 50% of the incremental investment requirement.

This is critically important because the EU needs to wean itself off its dependency on natural gas, and Russian natural gas specifically. There are near term energy security concerns, given the cost-of-living crisis due to the Russian-Ukraine war, as well as the imperative of achieving net zero emissions from a climate perspective; and realising other policy objectives, including EU leadership in green technologies, and providing more jobs.

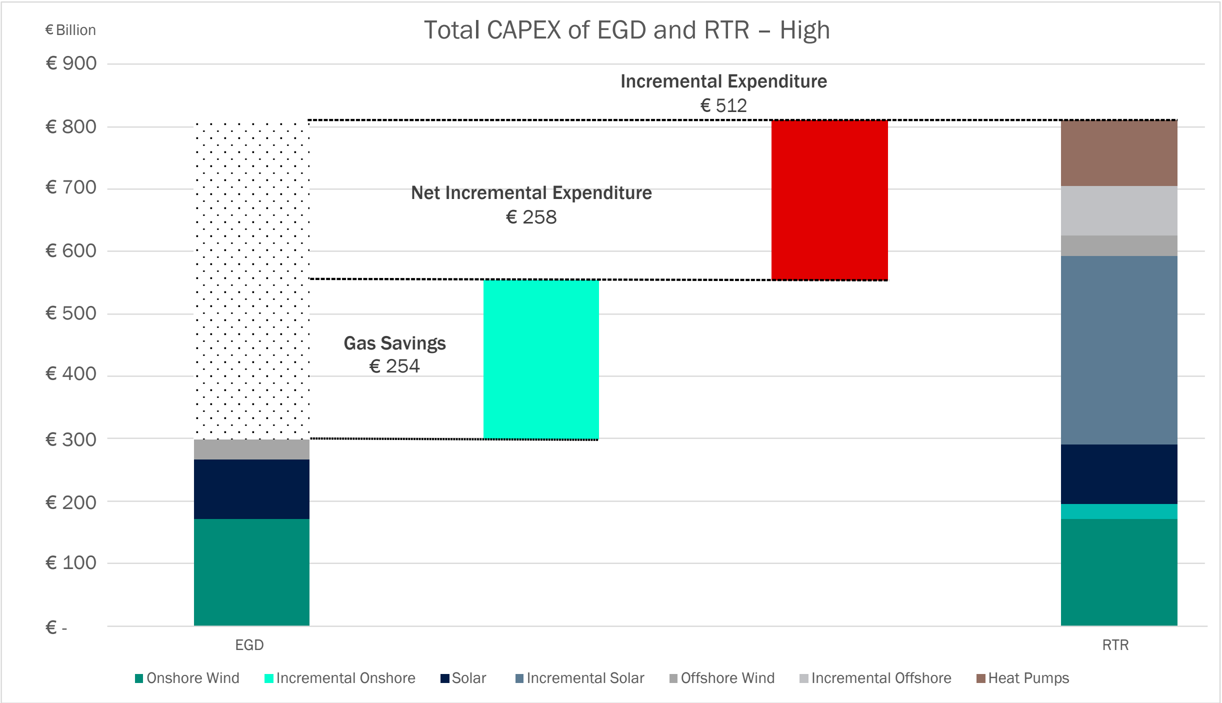
The ability of the EU to achieve this is essential for ensuring secure and affordable electricity and heating for its citizens and businesses. A clear path to phasing out natural gas in the EU with green technologies will also be essential for companies and investors because it allows for a transparent and consistent business environment with lower risk for investments. This is crucial given that lower risks would result in lower cost of capital, which in turn is key to deploying green technologies at scale.

We develop and compare a Race to Replace scenario with the pre-war business-as-usual European Green Deal. The European Green Deal was agreed by the EU in 2020 and envisions a reduction in net EU greenhouse gas emissions by at least 55% from 1990 levels by 2030 and climate neutrality by 2050. The Race to Replace scenario focuses on the replacement of natural gas supplied from Russia with green technologies as soon as possible before 2030 in a fully accommodative policy environment.

We assume that the Race to Replace starts at the end of 2023, resulting in initial impacts on the ground by 2025. Our analysis – focusing on the speed and cost of Race to Replace relative to the European Green Deal – is based on published estimates for deployment constraints, capital expenditures, and natural gas prices. The incremental investment requirements as well as fuel savings are calculated in net present value terms to 2023.

[1] See How Europe can cut natural gas imports from Russia significantly within a year (International Energy Agency, 2022d). We focus on electricity generation and heating, which represents approximately half of natural gas usage in the EU. Given that Russia supplies almost 50% of natural gas in the EU, we thus examine the implications of eliminating approximately a quarter of natural gas usage in the EU. We recognize the need to focus on other sectors as well as non-Russian natural gas as part of future work.

Our findings are as follows (see chart below).



It is entirely possible to replace Russian natural gas with green technologies by 2028.

While it is possible to replace Russian natural gas in electricity and heating by 2028 under Race to Replace, this will require a more conducive policy environment, including faster permitting for renewable electricity, diversified and secure supply chains, widespread weatherisation of facilities and a supportive subsidy and financing ecosystem.

The incremental investment requirement would be about 70% higher.

The total capital expenditure of the Race to Replace, assuming Russian natural gas is eliminated by 2028, is €811 billion, split across renewables at €706 billion and heat pumps at €105 billion. The incremental capital expenditure is €512 billion, or about 70% more than under a business-as-usual scenario, which is estimated at €299 billion.[2] Depending on reasonable capital expenditure forecasts, the incremental investment falls to €426 billion.

[2] These are our estimates for the European Green Deal.

About 50% of the incremental investments would be recovered by fuel savings.

Replacement of Russian natural gas via different measures – renovation, efficiency gains from heat pumps, and use of renewable electricity – results in savings of €254 billion, i.e., almost 50% of the incremental capital expenditure of €512 billion. That is, while the incremental capital expenditures are about 70% more, net incremental expenditures are about 15% less than the business-as-usual scenario.

Our key finding is that policymakers, by enacting and implementing plausibly ambitious policies can replace Russian gas in electricity and heating in the next five years, and simultaneously achieve the twin goals of energy security and climate mitigation in an expedited manner. Given that Russian gas accounted for approximately half of the EU's natural gas supply in 2021, this is significant given the energy security and decarbonisation challenges facing Europe today.

Further, while the incremental investment requirements are significant, a significant fraction of this (about 50%) is recovered via lifetime savings from using a lower amount of natural gas. Depending on reasonable natural gas price assumptions we estimate that this could be as high as 92%.

To get to the deployment numbers envisioned under the Race to Replace scenario, EU policymakers can focus their policy efforts in the following areas:

- First, they should provide a supportive subsidy and financing environment for green technologies, including renewables and heat pumps.
- Second, they should strengthen and enhance transmission system capacities and reduce renewable electricity deployment permit times, as proposed by REPowerEU.
- Third, they should rapidly grow the pool of a renewable workforce who have the skills and expertise to deploy renewable technologies at the required scale.
- Finally, they should also ensure sustainable and reliable supply chains that can ensure renewable production throughput achieves the levels needed for rapid deployment.

In this context, collaboration – via appropriate sharing of investments and development of innovative financial instruments – between policymakers and financiers is also going to be key.

1 Introduction

1.1 REPLACING RUSSIAN GAS

On 24 February 2022, Russia launched a full-scale invasion of Ukraine. The United States, the UK, and the European Union condemned the invasion, and imposed heavy economic sanctions on Russia. The sanctions imposed included trade embargoes, the freezing and expropriation of Russian assets located in the European Union, and other economic measures.

Russian response to the sections was to reduce the amount of natural gas supply to the European Union. On 26 April 2022, Russia's state-owned Gazprom announced it would stop delivering natural gas to Poland via the Yamal-Europe pipeline and to Bulgaria due to failure to make payments for natural gas in Rubles. By 31st of August 2022, Gazprom announced a halt of gas flows to Europe via Nord Stream 1. The reduction in natural gas supplies from Russia has posed an immediate and serious energy security risk to the European Union (EU).

To address the crisis, the EU began implementing emergency measures titled as the "REPowerEU" plan. The main goal of the REPowerEU plan is to remove the EU's reliance on Russia as a source of natural gas by 2027. This plan seeks to do so by revising several directives related to the previously passed European Green Deal, also known as the Fit for 55 package. The measures enacted under this plan would include demand reduction measures, natural gas supply diversification from new partners and with new types of infrastructure and expedited deployment of green energy technologies.

While this plan increases the deployment of renewable and green technologies, the overall focus of this plan is to simply replace natural gas from Russia with natural gas from other sources. EU has diversified its natural gas supplies from countries such as Azerbaijan and the United States. For the EU to use such natural gas sources, the EU must construct additional infrastructure that would allow the EU to import and distribute this form of natural gas to Member States.

While the EU envisions this infrastructure to be employed with future technologies such as hydrogen and green natural gas, the EU's focus on natural gas diversification versus elimination raises serious questions about EU's commitment to addressing climate change as well as its exposure to risks associated with energy security. Shouldn't the EU be focused on eliminating the share of natural gas represented by Russian imports rather than substituting them with other natural gas suppliers?

To address the crisis, the EU began implementing emergency measures titled as the "REPowerEU" plan.

1.2 GOALS OF THE STUDY

To address the existential threat of climate change and to secure Europe's energy security, this study proposes to estimate and assess the timeframe, costs, and benefits of phasing out the use of Russian natural gas in electricity and heating in the EU. In doing so, this study seeks to achieve several goals in its analysis. These are detailed below.

1.2.1 HOW QUICKLY CAN RUSSIAN GAS BE REPLACED WITH GREEN TECHNOLOGIES?

The main goal of this study is to determine what is the fastest possible way natural gas use in electrical and final energy consumption in heating can be eliminated in the European Union. It does so by determining the time when the share of natural gas supply from Russia is eliminated.

1.2.2 WHAT ARE THE ASSOCIATED INCREMENTAL INVESTMENTS?

This study will estimate the investments associated with achieving a rapid removal of natural gas usage in the EU. The investments assessed will be both the overall total investments, as valued to 2023, of various natural gas elimination scenarios as well as their incremental investments. This study will compare currently adopted EU plans for renewable and green energy deployments with scenarios representing natural gas elimination as fast as possible.

1.2.3 WHAT ARE THE POTENTIAL BENEFITS?

This study will also identify financial benefits that the EU will witness under various scenarios eliminating the use of natural gas. Financial benefits as represented by lower total and incremental operational expenditures both within individual scenarios for elimination as well as compared to current EU plan will be compared.

This study will also identify EU member states that stand to benefit from increasing the speed of green technology deployment to eliminate natural gas. These are Germany, France, Italy, and Spain. This study will provide estimates of the proportional number of green technologies applied per member state under various rapid natural gas removal plans.

1.2.4 WHAT SHOULD POLICY MAKERS DO?

Finally, this study will provide concrete steps and policy suggestions that EU and member state policymakers should adopt to achieve faster natural gas elimination. This analysis will aim to provide policymakers with clear guidance in setting industrial strategy that will successfully deploy the green technologies at scale to achieve ambitious natural gas removal scenarios.

2 Methods

2.1 COST-BENEFIT ANALYSIS

This study employs cost benefit analysis as the basis for valuing natural gas replacement. Costs and benefits are framed in financial terms; nonpecuniary costs and benefits are not included. Economic costs are accounted for through a comparison of various scenarios along with valuation employing the real cost of capital. Capital expenditure costs are accounted for including solar photovoltaic (equipment and utility-scale), onshore and offshore wind power plants, and heat pumps. The benefits are assessed through analysis of foregone costs. For example, the deployment of renewable technologies to replace electrical generation means that there are natural gas expenditure costs that are foregone.

2.2 SCENARIOS

The cost benefit analysis is performed in the context of three scenarios that describe potential green technology deployments by the EU: European Green Deal (EGD) and Race to Replace (RTR) – High variant and Low variant. The first scenario outlines current EU policy and is assumed to be business as usual. The latter two scenarios represent this study's attempt at identifying the fastest path to deploying green technologies to replace natural gas depending upon technological and policy constraints that restrict green technology deployments.

2.2.1 EUROPEAN GREEN DEAL (EGD)

This scenario assumes that the European Green Deal package passed in July 2021 acts as the main policy guidance for member states to adopt renewable technologies and phase out the use of fossil fuels. This scenario does not include potential changes due to the REPowerEU package. This is because, at the time of publication of this study, the REPowerEU package has not fully been passed by the European Union. This scenario is used to identify the current costs and benefits of the European Union's policies towards renewable energies.

2.2.2 RACE TO REPLACE

There are two variants of this scenario: Race to Replace – High and Race to Replace – Low. They vary based on assumptions regarding speed of renewable energy deployment, based on policy measures. In crafting these scenarios, the probabilities assessed relate primarily to the difficulty of overcoming the policy and industry barriers that affect energy system construction and upgrades. The Low scenario assumes the most likely outcome in light of currently announced EU policies (e.g., REPowerEU), while the high scenario extends this to what we label as an ultra-supportive policy environment.

2.2.2.1 HIGH VARIANT – FASTEST RENEWABLE DEPLOYMENT

The Race to Replace – High represents a case where EU policymakers focus on speeding up renewable energy deployment. For solar, it projects 100 GW deployment in 2025 and, though only 20 GW more than the low variant, the difference doubles by 2030. This exceeds the EU's projected manufacturing capacity, which is expected to reach 30 GW by 2025. In the very short term, this difference will need to be made up with imports, a key assumption in this analysis; however, the EU could also prioritize the development of its renewable industry through industrial strategy measures.

This variant assumes that the EU will seek to revise regulations that allow for fast tracking of renewable deployment. This includes mapping of national contributions towards renewable energy targets determined at the EU level within one year of the variant's passage, the designation of "renewable-go-to-areas," strong policy support to signal to developers and financiers that renewable projects will be deployed according to the maximum feasible and granting of key permits associated with renewable deployment as fast as possible.

It assumes that the current EU Renovation Wave, pursued by policymakers since 2001, will be scaled significantly – e.g., the EU will set a renovation rate of 3% of the housing stock per year from 2024 to 2030. Such measures would significantly reduce natural gas demand in final energy consumption for heating.

2.2.2.2 LOW VARIANT – INCREASED RENEWABLE DEPLOYMENT

The Race to Replace – Low variant represents a case where EU policymakers support the rapid deployment of renewable energy but will not address historic problems in deployment. It assumes the EU does not address undersubscription in auctions owing to their design (e.g., not recognizing logistical challenges owing to the pandemic). It assumes that EU policymakers would not undertake any additional measures to reduce natural gas demand; it assumes that the "Renovation Wave" will continue to 2030 in line with historical trends, i.e., that 1% of the building stock of the EU would be renovated per year. Most importantly however, it assumes supply chain constraints due to a lack of political co-operation between the EU and key trading partners including China and increasingly, the United States, where production of strategic technologies is expected to expand with the support of the Inflation Reduction Act.

Nevertheless, the Low variant stretches current policy frameworks. For example, as onshore wind farms in high wind-resource areas come to the end of their life, it assumes that over 20 GW of farms will be repowered with more efficient technologies tripling their electricity output (WindEurope, 2022). For permitting, it assumes a continuation of the REPowerEU policy until 2026 to ensure the full pipeline of renewables are delivered by 2030 (European Commission, 2022). It also assumes the legislation is amended to push forward projects currently stuck in red tape – over 80 GW of renewables (Ford & Ford, 2022; Simon, 2022).

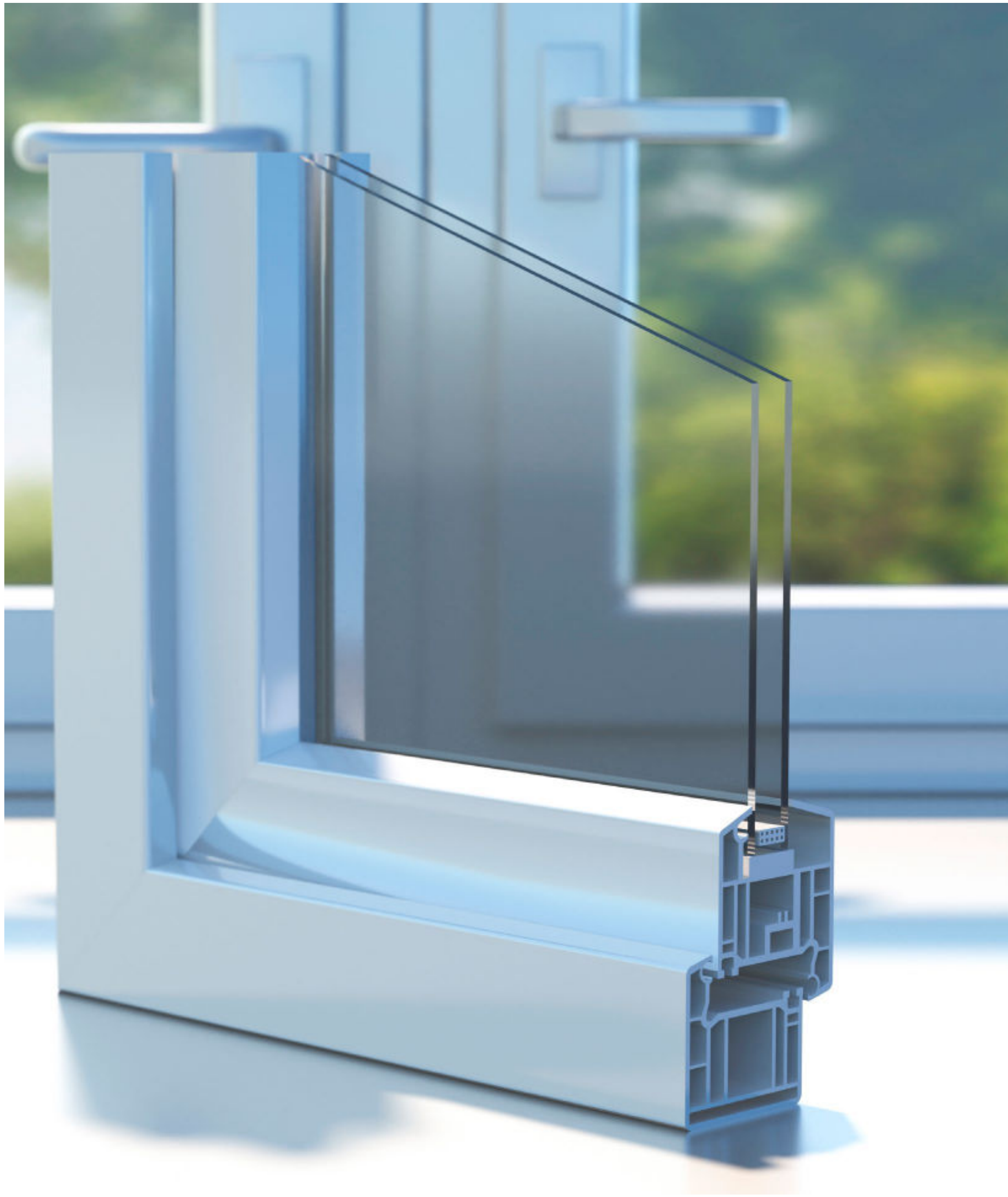
2.3 TECHNOLOGIES AND POLICIES

In this study, natural gas is to be replaced with a portfolio of green technologies, including renewable energy (solar, onshore wind, and offshore wind) for electricity and renovation as well as heat pumps for heating. We have not accounted for the potential higher need for battery storage, assuming that the additional renewable capacity is within the balancing capacity of the system.

2.3.1 HEATING TECHNOLOGIES

2.3.1.1 ENERGY EFFICIENCY RENOVATION

For the purposes of this study, energy efficiency renovation is defined as a bundle of technologies that reduce use of fossil fuels for space heating within households, commercial buildings, and public sector buildings. This includes better insulation, energy efficient windows, etc. It is assumed that building renovations will target the lowest energy efficient buildings, lowering natural gas demand by 45% (Allianz, 2022). After this, no further renovations will take place as incremental improvements to energy efficiency for the remaining buildings have been found to be uneconomical (Allianz, 2022).



2.3.1.2 HEAT PUMPS

A heat pump uses electricity for heating (Energy Savings Trust, 2023). There are many types of heat pumps including air to air, water source, and ground source. This study focuses on air source heat pumps given they represent 85% of heat pumps deployed globally (International Energy Agency, 2022a). Heat pumps are more energy efficient than their fossil fuel counterparts with a performance coefficient of 2.5 – i.e. for every watt of electricity used, they produce 2.5 watts of heating energy. On the other hand, a natural gas boiler has a performance coefficient of 0.9 (Clade, 2023). This study assumes that the deployed heat pumps will be powered by renewable electricity and are selected as the heating technology of choice by policymakers as a cost-effective means of decarbonizing space heating in the EU. Indeed, a recent study found that mainstreaming hydrogen heating would cost 2-3x more compared to scenarios that elected heat pumps, in addition to transgressing several planetary boundaries (Weidner & Guillen-Gosalbez, 2023).

2.3.2 RENEWABLE ELECTRICITY

This study makes several assumptions regarding renewable technologies, such as solar, onshore wind and offshore wind. First, it is assumed that these deployments are utility scale for wind whereas solar would include distributed generation as well. Second, the average capacity factor matches their 2020 capacity factors as estimated by the IEA and others (IRENA, 2021). Third, there is no change to the capacity factors overtime. Finally, capital expenditure and operational costs are assumed to be constant at 2020 levels. The combination of the last two assumptions is likely to result in an overestimate of incremental capital expenditure, given the continuous decline of green technology costs (Way et al., 2022).

2.3.3 SENSITIVITY ANALYSIS

To reflect the likely decline of capital costs, we conduct sensitivity analysis using forecast installation costs of commensurable green technologies (NREL, 2023).[3] In light of recently announced policy support, we assume an optimistic cost trajectory for onshore and offshore wind. We assume a moderate cost trajectory for solar to accommodate supply chains and logistical hurdles in critical raw mineral and geopolitical tensions. Overall, these forecasts see onshore wind, offshore wind, and solar capital costs declining at a geometric average of 7.35%, 2.38%, and 8.06% from 2023 to 2029, respectively.

[3] See Annual Technology Baseline 2022 for forecasts of installation costs in the United States to 2030. Though generalisability to the EU economy may be limited, initiatives such as the Inflation Reduction Act may only to translate into cost divergences in the latter half of this decade. In the meantime, cost parities are expected between continents given shared supply chain dependencies (see Country and Policy Aspects).

3 Results

To replace Russian gas in heating, the EU needs to replace 535 TWh of energy. We assume that this replacement starts in 2024, pending approval by the EU in 2023.

3.1 TIMELINES FOR REPLACEMENT OF RUSSIAN GAS

This section identifies the potential timelines for the elimination of Russian gas for use in electricity and heating for buildings in the EU27. It begins with an analysis of renewable deployments under the European Green Deal, which provides an illustration of "business as usual" deployments of renewables in the EU27. It then identifies the renewable deployments under the Race to Replace scenario in both the high and low variants.

3.1.1 EUROPEAN GREEN DEAL

By the time the Race to Replace Scenario High variant replaces Russian gas in 2028, the European Green Deal deploys a total of 801 GW of renewable electricity (Figure 1). By 2029, when Russian gas is replaced under the low variant, the European Green Deal deploys 854 GW of renewable electricity.

3.1.2 RACE TO REPLACE – HIGH

Reductions in heating demand through renovation allow for a quicker replacement than heat pumps alone. The increase in the renovation rate of the EU's building stock from 1% to 3% per year between 2024 and 2028 would lead to a renovation of roughly 40 million buildings and decrease the heating demand by roughly 73 TWh. These savings are almost 60% of the natural gas saved through demand reduction measures undertaken at the beginning of the Russia-Ukraine war.

This scenario assumes a 15-20% year on year increase in the heat pump market in the EU, following trends in 2021-22. It projects that heat pumps would cover the share of Russian gas used in heating by 2027. This is one year before the replacement of Russian gas in electricity, i.e., 2028. It envisions a significant expansion of EU renewable deployment projections under the European Green Deal, by roughly 650 TWh more renewable energy.

By the time the Race to Replace – High replaces Russian gas in 2028, it deploys 1303 GW of renewable electricity (Figure 2). This is close to renewable electricity deployed by the European Green Deal by 2035.

FIG 1. PROJECTED RENEWABLE DEPLOYMENT BY TECHNOLOGY AND TOTAL

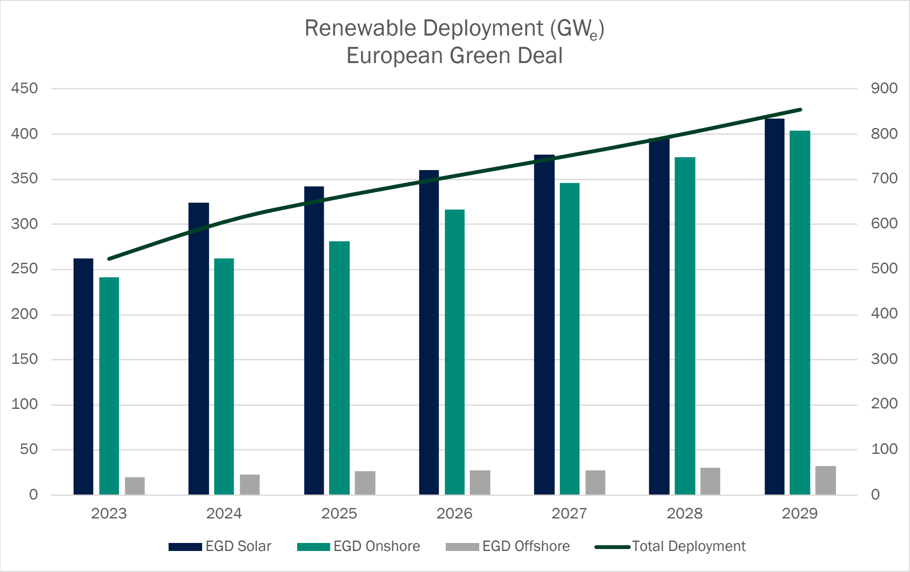


FIG 2. PROJECTED RENEWABLE DEPLOYMENT BY TECHNOLOGY AND TOTAL

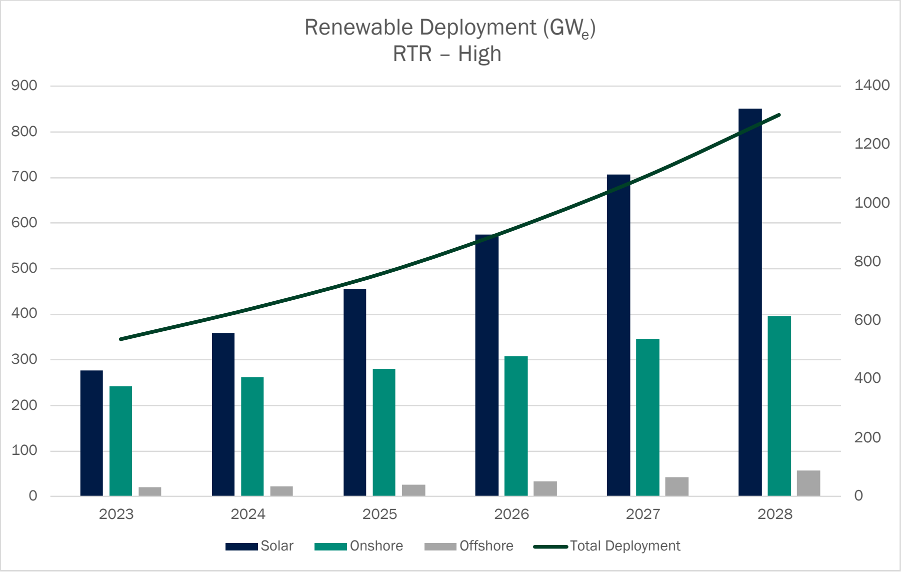
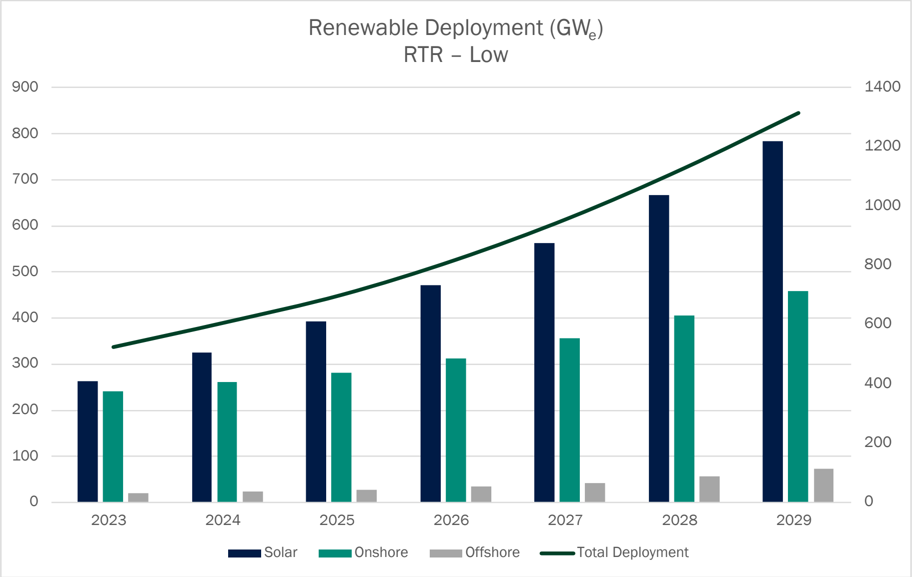


FIG 3. PROJECTED RENEWABLE DEPLOYMENT BY TECHNOLOGY AND TOTAL



3.1.3 RACE TO REPLACE – LOW

In this scenario, it is assumed that current renovation of the building stock as well as heat pump deployment in the EU27 follows current projections. It assumes that the EU will achieve its target 1% renovation of the building stock per year until 2030, which results in heating demand being lowered by 37 TWh by 2030. It also assumes that the heat pump market grows at a compound annual growth rate of 8%.

This scenario projects that the heat pumps will be able to fully replace Russian gas in heating by 2028. When replacement of Russian gas in both heating and electricity occurs in 2029, it predicts that 33 million heat pumps will be deployed. It envisions a significant expansion of EU renewable deployment projections under the European Green Deal, by roughly 900 TWh more renewable energy.

By the time the Race to Replace Scenario – Low variant replaces Russian gas in 2029, it deploys 1315 GW of renewable electricity (Figure 3). This is also close to renewable electricity deployed by the European Green Deal by 2035.

3.2 CAPITAL EXPENDITURE: ABSOLUTE AND INCREMENTAL

This section presents the absolute as well as relative capital expenditure under the three scenarios, under the timelines presented above for Russian gas replacement. We focus on the capital expenditures for renewable energy and heat pumps.[4] Capital expenditures – annual as well as cumulative – are expressed in present value terms to 2023. A real discount rate of 4% is also assumed throughout the process.[5]

3.2.1 RENEWABLE ELECTRICTY

The total capital expenditure of renewables in the European Green Deal, assuming Russian natural gas is eliminated by 2028, is €299 billion, with the annual average at €60 billion (Figure 4). The total capital expenditure of renewables in the European Green Deal, assuming Russian natural gas is eliminated by 2029, is €353 billion, with the annual average at €59 billion. Annual expenditure ranges between €50 billion in 2025 to as much as €85 billion in 2024. Capital expenditure increases under the low variant due to the additional year required to replace gas for both space heating and electricity generation.

The total capital expenditure of renewables in the Race to Replace – High, assuming Russian natural gas is eliminated by 2028, is €706 billion, with an average annual expenditure of €141 billion (Figure 5). Annual expenditure ranges between €100 billion in 2024 to €195 billion in 2028.

The total capital expenditure of renewables in the Race to Replace – Low, assuming Russian natural gas is eliminated by 2029, is €778 billion, with an average annual expenditure of €130 billion (Figure 6). Annual expenditure ranges between €85 billion in 2024 to €177 billion in 2029.

[4] We do not account for the capital expenditure for renovation. This may result in under-estimation of the incremental capital expenditure – for example, around 10% in the Low variant.
[5] This in line with the European Commission Impact Assessment recommendations. We also find that our results are insensitive to discount rates.

FIG 4. RENEWABLE CAPEX UNDER THE EUROPEAN GREEN DEAL WITHIN THE TIMELINES TAKEN TO REPLACE RUSSIAN GAS UNDER THE RACE TO REPLACE SCENARIO

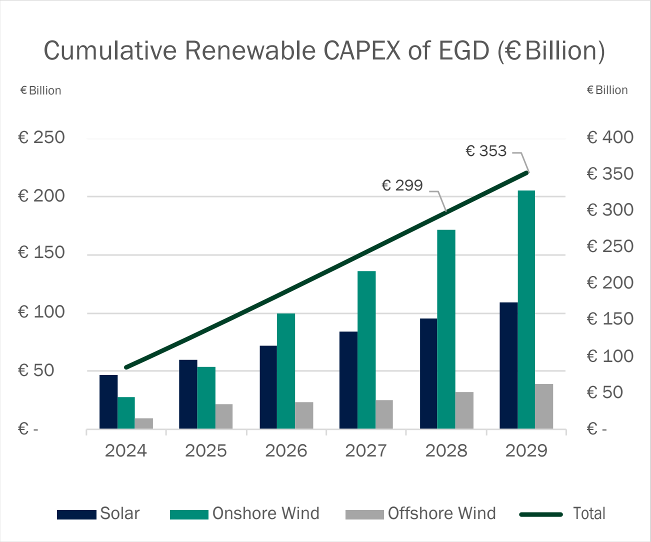


FIG 5. RENEWABLE CAPEX UNDER RTR – HIGH BY TECHNOLOGY AND TOTAL

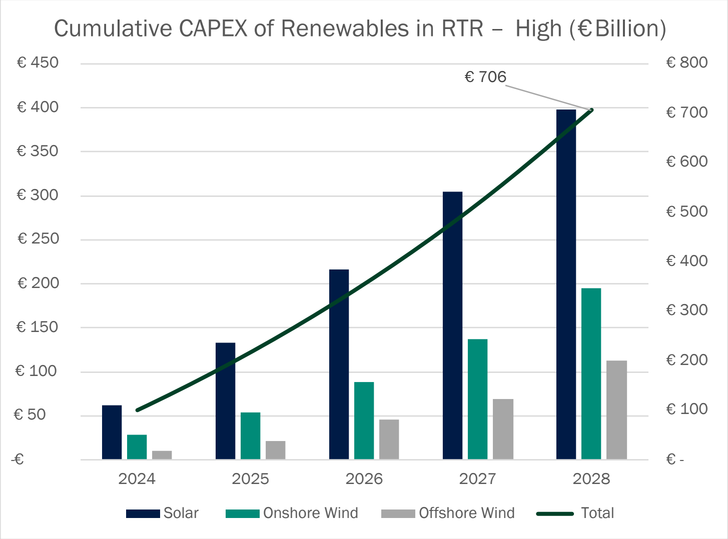
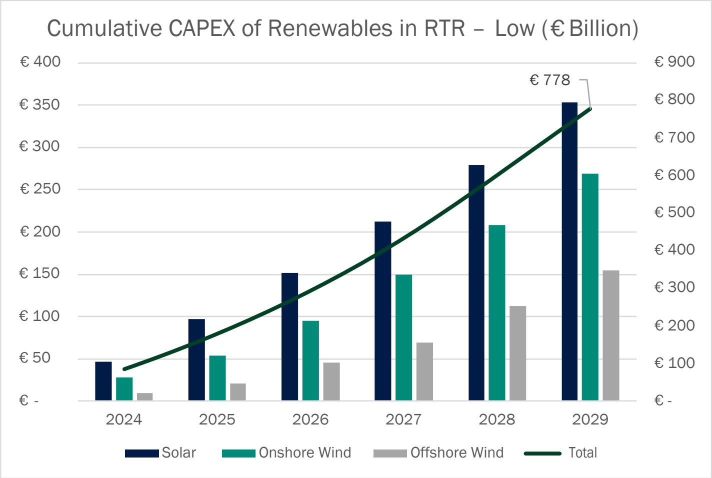


FIG 6. RENEWABLE CAPEX UNDER RTR – LOW BY TECHNOLOGY AND TOTAL



3.2.2 HEAT PUMPS

The total capital expenditure of heat pumps in the Race to Replace – High, assuming Russian natural gas is eliminated by 2028, is €105 billion, with an average annual expenditure of €21 billion (Figure 7). Annual expenditure on heat pumps ranges between €17.8 billion in 2024 and €23.4 billion in 2028.

The total capital expenditure of heat pumps in the Race to Replace – Low, assuming Russian natural gas is eliminated by 2029, is €110 billion, with an average annual expenditure of €18.4 billion (Figure 8). Annual expenditure ranges between €16.7 billion in 2024 to €20.1 billion in 2029.

FIG 7. HEAT PUMP CAPEX UNDER THE RTR – HIGH SCENARIO

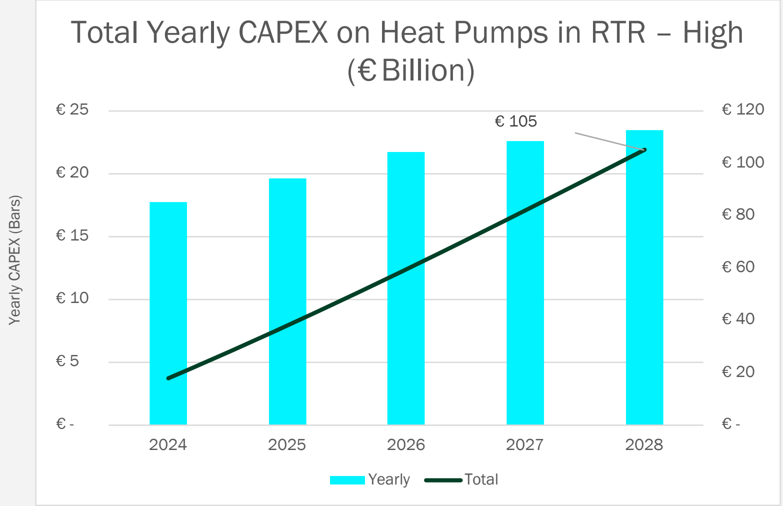
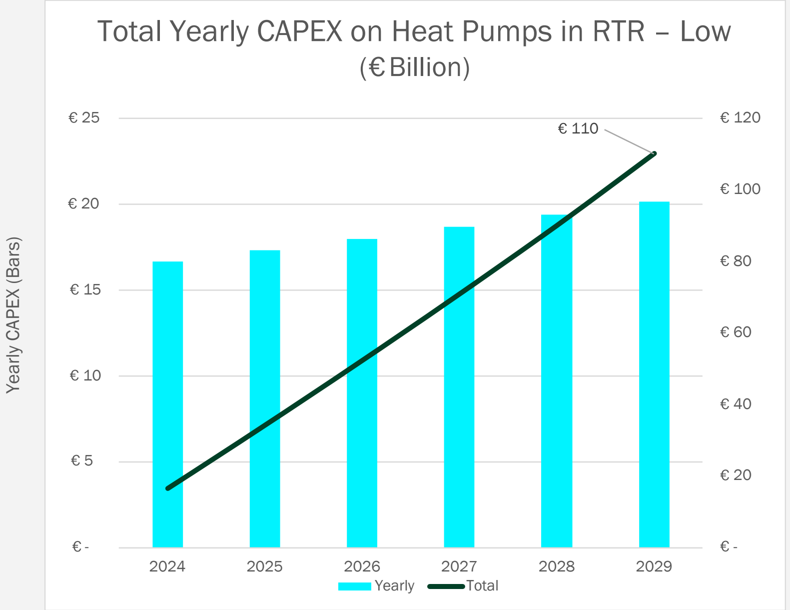


FIG 8. HEAT PUMP CAPEX UNDER THE RTR – LOW SCENARIO



3.3 CAPITAL RECOVERY DUE TO GAS SAVINGS

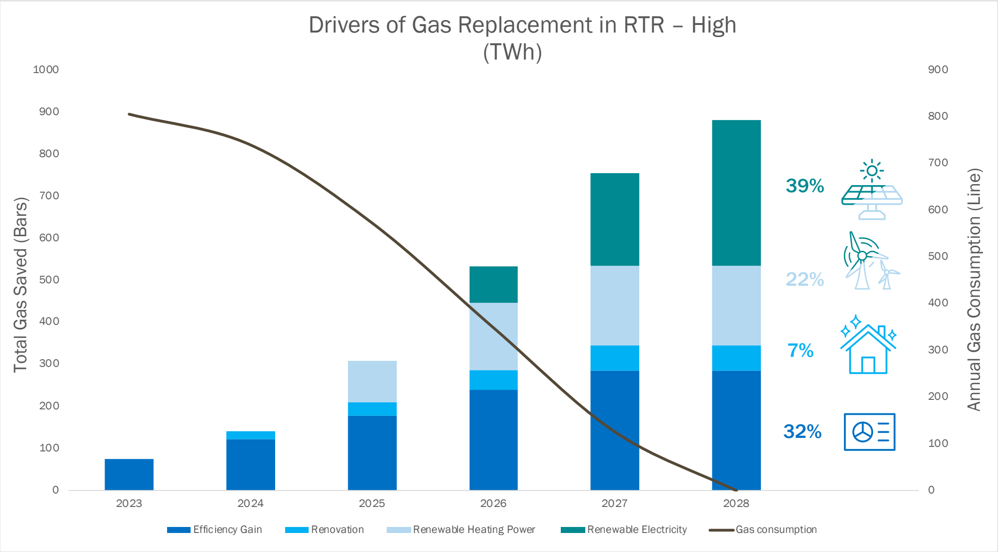
This section examines how the incremental investment requirements under Race to Replace can be recovered via forgone expenditure on natural gas. Given that the incremental operational expenditures of green technologies are negligible in comparison with the incremental capital expenditures, the savings on natural gas can be significant. This study uses natural gas prices as projected previously in the REPowerEU communication (EU Commission, 2022). In each year, the incremental energy replaced by the Race to Replace in both electricity and heating is converted back into natural gas units and is used as the basis to identify yearly gas savings. We calculate these savings over the lifetime of the incremental renewable electricity and heat pump deployment.

3.3.1 RACE TO REPLACE – HIGH

Under the RTR-High variant, Figure 9 depicts the replacement of Russian natural gas via various components, including renovation, efficiency gains, use of renewable electricity at the input of heat pumps, and use of renewable electricity for usage beyond heat pumps. The savings from elimination of natural gas usage are €254 billion, i.e., 50% of the incremental capital expenditure of €512 billion.

The economic efficiency of gas savings varies across components. Demand-side efficiency gains, which represent the lower input energy requirements of heat pumps compared to gas boilers, bear the greatest economic efficiency. For every billion euros spent on heat pumps, the EU can save approximately 2.72 TWh of gas, much higher compared to renewable electricity (0.76 TWh) and renovation (0.29 TWh).

FIG 9. DISAGGREGATING ANNUAL GAS SAVINGS BY DRIVER UNDER THE RTR – HIGH VARIANT SCENARIO

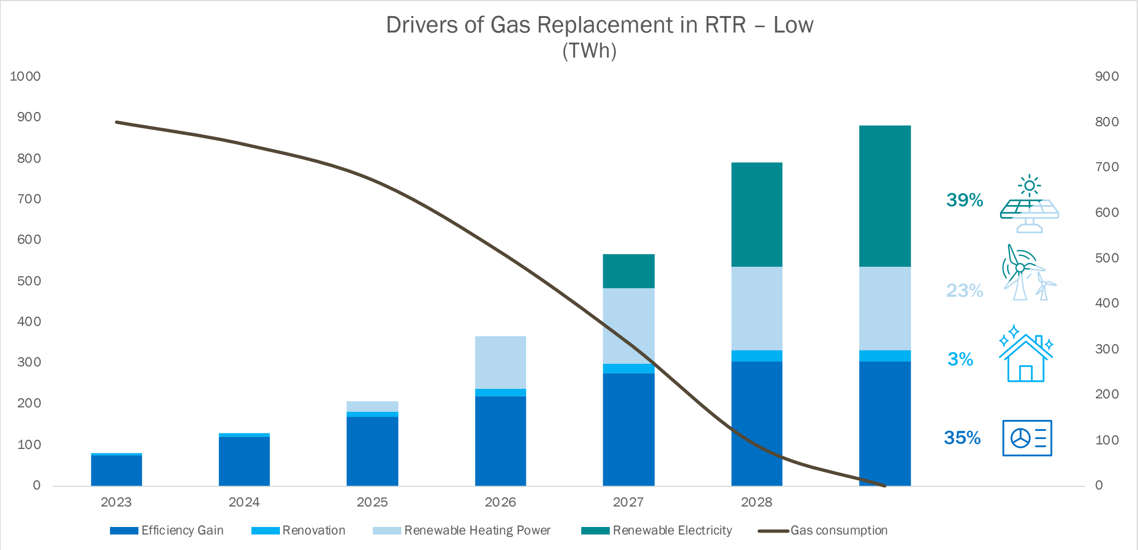


3.3.2 RACE TO REPLACE – LOW

Under the RTR-Low variant, Figure 10 depicts the replacement of Russian natural gas under various components, including renovation, efficiency gains, use of renewable electricity at the input of heat pumps, and use of renewable electricity for usage beyond heat pumps. The savings from elimination of natural gas usage are €267 billion, i.e., 47% of the incremental capital expenditure of €534 billion.

Economic efficiency trends in the low variant mirror that of the high variant, with heat pumps saving roughly 2.76 TWh per billion euros spent, followed by renewables (0.71 TWh) and renovation (0.29 TWh). Economic efficiency drops across interventions because of an additional year of capital expenditure on renewable supply side technologies to replace Russian gas.

FIG 10. DISAGGREGATING ANNUAL GAS SAVINGS BY DRIVER UNDER THE RTR – LOW VARIANT SCENARIO



3.4 SCENARIO COMPARISON

The total capital expenditure of the RTR (High) scenario, assuming Russian natural gas is eliminated by 2028, is €811 billion, split across renewables at €706 billion and heat pumps at €105 billion (Figure 11). This equates to an incremental expenditure of €512 billion, 71% higher than the corresponding spend in the EGD, i.e., €299 billion. Solar PV accounts for 59% (i.e., €302 billion) of the incremental capital expenditure, with offshore wind following at 16% (i.e., €81 billion), onshore wind at 5% (i.e., €24 billion), and heat pumps at 21% (i.e., €105 billion). However, once operational gas savings of €254 billion are accounted for, the net incremental cost is reduced to €258 billion, at 86% of the cost of the EGD.

The total capital expenditure of the RTR (Low) scenario, assuming Russian natural gas is eliminated by 2029, is €888 billion, split across renewables at €778 billion and heat pumps at €110 billion (Figure 12). This equates to an incremental expenditure of €534 billion, 151% higher than the corresponding spend in the EGD, i.e., €353 billion. Solar PV accounts for 46% (i.e., €244 billion) of the incremental capital expenditure, with offshore wind following at 22% (i.e., €116 billion), onshore wind at 12% (i.e., €64 billion), and heat pumps at 21% (i.e., €110 billion). However, once operational gas savings of €267 billion are accounted for, the net incremental capital expenditure is reduced to €266 billion, 75% of the cost of the EGD.

FIG 11. TOTAL EXPENDITURE UNDER RTR – HIGH AND EGD BROKEN DOWN BY GREEN TECHNOLOGY. THE MIDDLE OF THE GRAPH SHOWS THE OPERATIONAL GAS SAVINGS FROM RTR AND THUS THE NET INCREMENTAL EXPENDITURE TO EGD

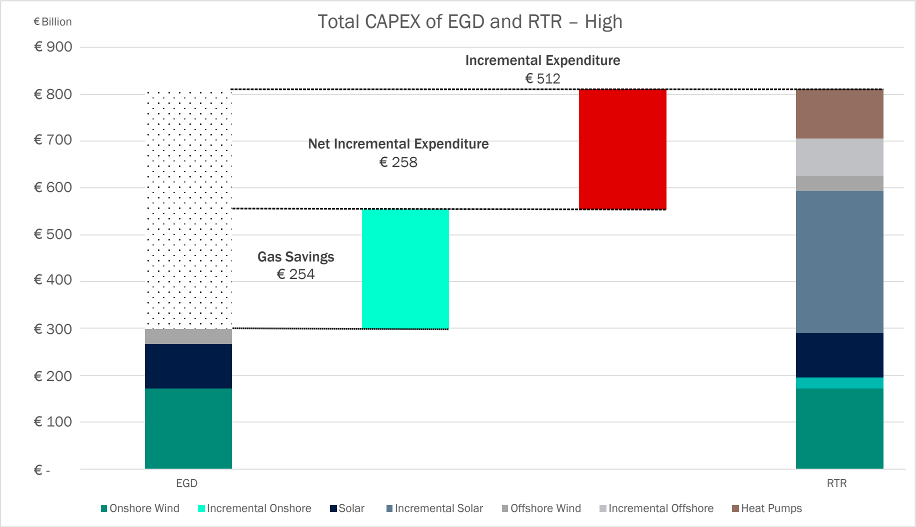
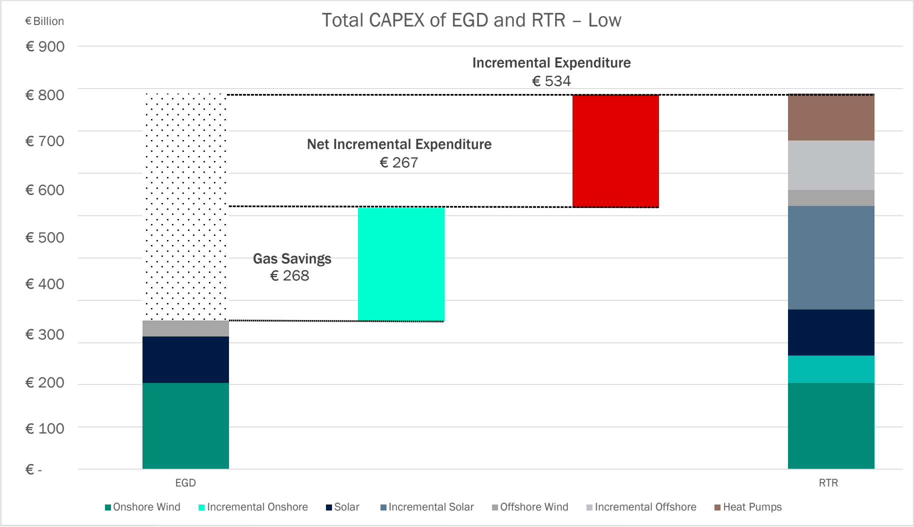


FIG 12. TOTAL EXPENDITURE UNDER RTR – LOW AND EGD BROKEN DOWN BY GREEN TECHNOLOGY. THE MIDDLE OF THE GRAPH SHOWS THE OPERATIONAL GAS SAVINGS FROM RTR AND THUS THE NET INCREMENTAL EXPENDITURE TO EGD



4 Country and Policy Aspects

4.1 COUNTRY ASPECTS

This study considered Germany, France, Italy, and Spain to determine what would be the appropriate approach for these countries to rapidly replace natural gas along a similar pathway described in this study. [6]

4.1.1 GERMANY

Of these countries, Germany has the greatest dependency on Russian gas. As of 2022, it had no regasification units to import liquified natural gas and was nearing completion of the Nord Stream 2 pipeline to double Russian Gas Imports. Since the war commenced in February 2022, both Nord Stream pipelines have been out of operation and Germany has diversified to other sources, including Norway, Netherlands, and Azerbaijan (Eckert & Kaeckenhoff, 2022). However, Germany imported over 57% of its gas from Russia before the war, with just under half of all gas used for household and commercial heating. By 2027 Germany is projected to replace Russian gas in electricity, but this replacement in heating only occurs by 2030. Thus, Germany needs to deploy heat pumps more aggressively. Though Germany is densely populated, the nation only uses 7% of its land area available for renewable energy projects and needs to exploit about 24% of its potential wind resources in the North Sea in the RTR High variant.[7] Given a greater proportion of onshore wind farms in the low scenario, land area and potential wind resources rises to 8% and 33% in the low variant, respectively.

4.1.2 FRANCE

France puts 52% of its gas towards commercial and household heating yet imports a moderate 30% of its gas from Russia. Most of its gas is sourced from European neighbours such as the Netherlands and Norway as well as Algeria and Nigeria. France is expected to replace Russian gas for heating by 2026 despite its lower onshore renewable deployment rates compared to Germany. However, due to a growing heat pump stock requiring more renewable electricity, Russian gas is replaced by renewable electricity after 2030. Considering the relatively low exploitation of its viable land, France would stand to gain by phasing out Russian gas faster by utilising its renewable electricity resources more aggressively. In both the low and high variant of RTR, France utilises 4% of available land area for renewable deployment and 1% of potential wind resources in the North Sea.

[6] The UK has not been included for a few reasons: (1) As of the 1 January 2023, the UK banned all imports of Russian Gas, which previously accounted for 4%, (2) the UK sources 40% of its gas from the North Sea fields which alleviates energy security concerns. [7] Land Area and Exclusive Economic Zone available for green technologies obtained from estimates in Enevoldson et al. 2019 and Caglyan et al. 2019.

4.1.3 ITALY

Italy follows Germany in her reliance on Russian Gas, accounting for over 52% of total gross consumption prior to the war. On the other hand, Italy diverts a smaller proportion to heating (41%) in favour of electricity (16%). Combined with its leading market for heat pumps in the EU, Italy expects to replace gas in heating by 2028. Italy has the greatest potential wind resources in the Southern Mediterranean, a fortune it intends to exploit. Even still, Russian gas for electricity is expected to be phased out by 2030 yet could be phased out earlier in 2028 if the nation scales its currently moderate ambitions for onshore wind. In both the low and high variant of RTR, Italy exploits 2% of available land area for renewable deployment and 1% of potential wind resources in the Mediterranean Sea.

4.1.4 SPAIN

Spain expects to be one of the first EU members to phase out Russian Gas for heating (2023) followed by electricity being fully replaced by renewables in 2027. Despite its low exploitation of sun and onshore wind resources, Spain could phase out Russian gas without offshore wind. This is owing to its low dependence on Russian gas accounting for 10.97% and warmer climate that has led to a structurally lower demand for heating compared to northern EU member states. In both the low and high variant of RTR, Spain utilises 1% of available land area for renewable deployment and 1% of potential wind resources in the Atlantic and Mediterranean Sea.

4.2 POLICY ASPECTS

Our report finds that it may be possible for the EU to electrify its heating systems and completely phase out Russian gas by as early as 2028. Achieving this objective will require a significant effort from the EU. To make this a reality, we have triangulated scenarios from leading sources and are postulating that the Race to Replace scenario is feasible so long as policy makers adopt a combination of policy packages, discussed below.

The package (acronym "FAST") entails:

- Finance – Funding supply-side policies that boost deployment of green technologies and demand-side measures that enable rapid household adoption.
- Ability – Skills to realise policy vision, particularly for distributed solar.
- Supply – Supply chains must be secure, both domestically and abroad through favourable trade relations.
- Transmission – Networks must be upgraded to accommodate a surge in renewable energy.

4.2.1 FINANCE

The crucial element is that funds – both public and private – are available to achieve large-scale deployment of renewables and heat pumps. Policy makers need to be clear that targeted policy support would be made available to investors. For each technology, the following policy measures would allow for rapid deployment.

A lack of ambitious planned procurement for utility-scale solar and wind within member states need to be addressed to create the necessary pipeline of projects. A solution could include extending current schemes, providing a schedule of planned auctions, allocating greater volumes, and improving auction design (International Energy Agency, 2022b). Beyond auctions, the primary constraint of permitting challenges needs to be addressed, a priority under REPowerEU (EU Commission, 2022; International Energy Agency, 2022b).

Additional policy measures to deploy rooftop scale solar photovoltaic at speed should also be adopted. Examples of such measures include commitments under the European Solar Rooftops Initiative in REPowerEU that would mandate that all new public and commercial buildings have solar installed by 2026, existing public and commercial buildings by 2027, and all new residential buildings by 2029 (Santos, 2022). Remuneration for self-consumers should also increase, if not extended, from Resilience and Recovery funds deployed in the wake of the COVID-19 pandemic (International Energy Agency, 2022b).

Within the Race to Replace scenario, it is envisioned that the renovations undertaken to increase energy efficiency could simultaneously include heat pump deployment. Policy makers could provide financial assistance to consumers seeking to install heat pumps to address high upfront costs. In this context, Italy provides a best practice in the "Superbonus 110%" that funded energy refurbishment actions, including heat pumps (Calise et al., 2022).

4.2.2 ABILITY

The ability to deploy the ambitious amounts of renewable energy sources and heat pumps is vital. A recent European Investment Bank poll found that skills shortages, most acute in the digital and engineering sector, are holding back green projects (EIB, 2023). It is estimated that Europe will need 1.1 million full time workers in the solar industry to reach the target of 750 GWe, with 80% of this workforce needed for distributed PV on rooftops (SolarPower Europe, 2022). The Race to Replace scenarios will thus require a scaling of workforce trades such as electricians, engineers, and certified installers (International Energy Agency, 2022b). Importantly, the skills needed for wider electrification of buildings strongly overlaps with those needed for the installation and certification of heat pumps (SolarPower Europe, 2022).

4.2.3 SUPPLY

To secure raw materials, solar modules and components needed, Europe must lean into existing trade arrangements with key suppliers, including India, Asia Pacific, the United States, and China (International Energy Agency, 2023). For example, over 90% of mass-manufacturing capacity for many strategic clean energy technologies is currently concentrated in China and the Asia Pacific region.[8]

Cost competitiveness in a market that prioritises levelized cost of energy is vital. However, supply chain issues in the wake of the pandemic have prevented wider renewable uptake across solar and wind, as rising costs translate to lower competitiveness against fossil fuels and foreign competitors. Interim measures could include logistical support for Chinese supply chains, the source of over 70% of components found in Western wind turbines (Reed, 2022).

On the other hand, opening trade beyond Europe means the European Solar PV Industry Alliance should also be supported by government to remain competitive against global suppliers and secure its longevity. The recently released EU Green Deal Industrial Plan provides measures that tackle conflicting priorities, including legislation and trade defences to foster domestic industry while connecting the Single Market to robust supply chains (European Commission, 2023).

[8] See Energy Technology Perspectives 2023, IEA, page 96 for a breakdown of regional manufacturing capacities of mass-manufactured clean energy technologies.

4.2.4 TRANSMISSION

Underinvestment in transmission can be very costly for taxpayers (Hodgson & Mikkonen, 2023). While long lead times for grid connection offers were recently addressed by the EU Council (2022), member states need to ensure the grid infrastructure is ready for the incoming wave of renewables. The TEN-E regulation 2022, which requires all member countries collaborate with the European Commission and Transmission System Operators (TSOs), should be operationalised by 2024 (European Commission, 2023). Projects of common interest could also be used to capitalise on the comparative advantage of Member States. For example, although Germany has higher solar targets than Spain, there are economic gains to be made by concentrating solar production in Southern European nations with higher solar resources (Weidner & Guillén-Gosálbez, 2023).

Investment in storage capacity may also be needed for expanding intermittent renewable energy sources. This need is underlined by the energy mix of the Race to Replace scenario and its emphasis on solar PV, wherein electricity supply may not coincide with peak heating demand. While REPowerEU and the European Green Deal do not specify a storage strategy by 2030 (EASE, 2022), provisions for renewable storage have been made in the incoming EU Green Deal Industrial Plan (European Commission, 2023).

EU Green Deal Industrial Plan – a balancing act?

The EU Commission recently released a preliminary communication of its full EU Green Deal Industrial Plan. The plan, which sets out the EU's strategy for achieving a Net-Zero economy by 2050, has been touted as a response to the Biden administration's Inflation Reduction Act, a USD$369 billion package that includes subsidies and tax credits designed to attract green technology investors to the United States.

On one hand, the industrial plan duly acknowledges the need for open trade to import critical raw materials and technologies to close the shortfall in domestic demand and supply. To avoid the risk of running into supply chain bottlenecks that limit the growth of domestic industries, the EU will seek to diversify sourcing, which is likely to serve two purposes, (1) manage strategic dependencies and (2) improve the resilience of supply chains.

On the other hand, the plan makes provisions for state aid for key technologies such as solar PV while protecting domestic industries from distortive trade subsidies from other countries. This will involve making use of trade defence instruments. The Commission has also proposed initiatives that support consumers by, for example, introducing a unified energy label by the end of 2023 to allow fair comparison between heat pumps.

As the EU sets out to achieve its renewable targets, the line between trade partner and industrial rival is becoming increasingly blurred as economies across the globe plan ambitious industrial strategies to lead production of strategic green technologies. The EU is likely to experience a surge in manufacturing capacity due to support from policymakers and industrial partnerships such as the Europe Solar PV Alliance (SolarPower Europe, 2022). Consolidation of the EU's strong position in wind technologies is also expected with increasing investor confidence in state support (EU Commission, 2023). Nevertheless, the EU will continue to rely on its trading partners, and will demand a careful balancing act from policymakers who seek to nurture industries within EU borders and equally maintain ever important ties to supply chains abroad.

5 Conclusion

This study undertook an analysis to determine if it is possible to replace Russian gas used in electrical generation and heating with green technologies. It concludes that it is possible to do so by 2028. While incremental investments would be significant (i.e., about 70%), a large fraction (i.e., about 50%) could be recovered via natural gas savings. Furthermore, individual countries stand to benefit from plans to rapidly scale renewable and heat pump deployments.

The main uncertainty is with respect to policy, and the European Union would need to be bold and ambitious in green technology deployment. In particular, policymakers must prioritize the removal of regulatory barriers to green technology deployment as soon as possible and support the rapid uptake of efficient heating technologies. While current plans under REPowerEU and Industrial Plan suggest a path forward; this study's view is that these should be expanded upon to ensure green technology can be deployed as quickly as possible.

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