EU's Green Energy Transition

By the conceptual team of Global Arena Research Institute (published August 2024)

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"Working and conceptual papers" are analytical reviews of existing resources, including academic literature, think tank analyses, and inputs from formal institutions such as the World Bank, European Commission, and OECD. They are not intended to present original research but rather to build a background for developing research concepts used in data-driven analytics. Originally intended as internal working material, these papers are published when they are deemed to be of broader public interest. This paper is part of a series of "conceptual papers" produced as part of a project supported by the International Visegrad Fund and Konrad Adenauer Stiftung in Prague.

1. Introduction

The green energy transition has been defined by the EU as the transition of the economy and society towards the achievement of the climate and environmental objectives in line with the European Green Deal. The energy sector was identified as a key area to focus on since it accounts for 75% of overall EU greenhouse gas emissions. The greenhouse gas emissions need of reduction was steaming from the increasing sea levels and extreme weather events affecting various regions worldwide, and the effects of global warming.

The Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) on the Physical Science Basis, reasserted the need for the fact that climate change and environmental degradation are posing a big threat and called for urgent action. The estimate losses due to climate change has been estimated to be on average over €12 billion per year[1]. Those losses could reach an additional EUR 175 billion, which is 1.38 % of Union GDP, per year if global warming reaches 3°C above pre-industrial levels, as opposed to EUR 65 billion for 2°C and EUR 36 billion per year for 1.5°C.

1.1. Why a green energy transition

According to the World Health Organization (WHO), about 99 percent of people in the world breathe air that exceeds air quality limits and threatens their health, and more than 13 million deaths around the world each year are due to avoidable environmental causes, including air pollution. The unhealthy levels of fine particulate matter and nitrogen dioxide originate mainly from the burning of fossil fuels. In 2018, air pollution from fossil fuels caused $2.9 trillion in health and economic costs, about $8 billion a day.

Job wise, renewable energy creates jobs. Every dollar of investment in renewables creates three times more jobs than in the fossil fuel industry. The International Energy Agency (IEA)

[1] European Commission (2021), PESETA IV study 'Climate change impacts and adaptation in Europe', Joint Research Centre, Sevilla, http://ec.europa.eu/jrc/en/peseta-iv.

estimates that the transition towards net-zero emissions will lead to an overall increase in energy sector jobs: while about 5 million jobs in fossil fuel production could be lost by 2030, an estimated 14 million new jobs would be created in clean energy, resulting in a net gain of 9 million jobs In addition, energy-related industries would require a further 16 million workers, for instance to take on new roles in manufacturing of electric vehicles and hyper-efficient appliances or in innovative technologies such as hydrogen. This means that a total of more than 30 million jobs could be created in clean energy, efficiency, and low-emissions technologies by 2030.

Economically, About $7 trillion was spent on subsidising the fossil fuel industry in 2022, including through explicit subsidies, tax breaks, and health and environmental damages that were not priced into the cost of fossil fuels.

In comparison, about $4 trillion a year needs to be invested in renewable energy until 2030 – including investments in technology and infrastructure – to allow us to reach net-zero emissions by 2050. The reduction of pollution and climate impacts alone could save the world up to $4.2 trillion per year by 2030. So, green energy transition or switching to clean sources of energy, such as wind and solar, thus helps address not only climate change but also air pollution, additionally green energy transition contributes to health, economic.

1.2. What are the priorities

Key policy priorities to foster the EU energy transition can be summed in to:

First priority: To adopt transformative policies to decarbonize the transport sector

Transport is thus becoming a key obstacle to EU decarbonization. A particular focus should be placed on decarbonizing road transport because it is responsible for more than 70 percent of overall transport emissions. Decarbonizing road transport would also improve air quality in cities, which remains a fundamental challenge for better public health in Europe.

Second priority: To prepare the electricity system for a substantial increase in renewables

In the EU, most of the expansion of renewable energy generation arises from utility-scale projects. Wind is more important in Europe than solar, and for wind the average project size is increasing. The most promising developments in recent years have been the technology and cost breakthroughs related to offshore wind, which have made possible really large scale developments. Progress has been made in integrating utility-scale renewables, but it is still an unfinished journey: transmission needs to be expanded both onshore and offshore, more flexibility needs to be added and ultimately a better market design is needed.

Third priority: To strengthen the EU's comparative advantages in low carbon technologies

The Paris Agreement should accelerate the global transition to a low-carbon economy. Global investment in low-carbon technology sectors driven by investment in renewable electricity generation has increased substantially and this trend is likely to continue. The strengthening of the EU's comparative advantage in low-carbon technologies would provide future job and growth opportunities. To achieve the EU's energy and climate policy targets, a wide range of low-carbon innovation is needed in different sectors including electricity, heat and cooling, transportation (see priority 1), the built environment and energy-intensive industrial sectors including iron and steel, metals, cement, pulp and paper and chemicals. Compared to the rest of the world, the EU is highly specialised in research and innovation in renewables and energy efficiency in buildings, and has increased its specialisation in renewable fuels, bioenergy, batteries and e-mobility.

Forth priority: To foster the decarbonization of industry and building,

Industry currently produces 25 percent of Europe's GHG emissions (European Environment Agency, 2018b), and is subject to the EU emissions trading system (ETS) and thus exposed to a carbon price. This, together with the fact that industry is generally considered the most energy-efficient sector, has led to no particular policies being proposed beyond carbon trading for the decarbonization of industry. However, there are four elements that would justify a more active stance: i) Industry does not feel the full impact of the carbon price because of the protective measures devised by the EU to prevent loss of competitiveness. Many industrial sectors still receive free carbon allowances; ii) The EU would like to see growth in the manufacturing sector; iii) When it comes to full decarbonization, industry faces many more technical challenges than other sectors, in particular in relation to process emissions (that is, emissions not associated with energy use); iv) The circular economy will also induce a significant move in the EU industrial sector towards more recycling, which might be used also as a lever for decarbonization.

1.3. Strategy

Council Recommendation of 16 June 2022 on ensuring a fair transition towards climate neutrality 2022/C 243/04.

On 11 December 2019, the European Commission set out a strategy entitled 'The European Green Deal' that would guide the EU towards having a sustainable, fairer and more prosperous society that respects the planetary boundaries.

The European Climate Law established a binding Union-wide objective of climate neutrality by 2050 and a binding intermediate target of a net domestic reduction in greenhouse gas emissions of at least 55 % by 2030[2].

The 8th Environment Action Programme to 2030 aims to accelerate the green transition to a climate-neutral, sustainable, non-toxic, resource-efficient, renewable energy-based, resilient and competitive circular economy in a just, equitable and inclusive way, and to protect, restore and improve the state of the environment[3].

The European Commission formulated a 'REPowerEU Plan' in light of Russia's war of aggression against Ukraine. The plan is to phase out the Union's dependency on Russia's fossil fuels by identifying alternative gas supplies. The plan encouraged the use of solar, wind and heat pumps, as well as decarbonising industries and catalysing renewable energy projects.

WIth the fact that the green energy transition requires comprehensive policy action and substantial investment across many areas, such as climate action, energy, transport, environment, industry, research and innovation. The Commission issues the 'Fit for 55' document that includes proposals to update relevant legislation, including the EU Emissions Trading System (EU ETS)[4], the energy taxation, energy efficiency and renewable energy Directives, the CO2 emission performance standards Regulation for cars and vans, the Regulation on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry, the Directive on alternative fuels infrastructure, and the effort sharing Regulation (ESR) with respect to sectors outside the current EU ETS, namely transport and building sectors. The document also conveyed the EU's 2030 Climate Target on the way to climate neutrality.

Statistics

State of the Energy Union Report 2023.

In 2022 the EU's net greenhouse gas emissions decreased by around 3%, which is 32.5% decrease compared with 1990. With a decreased demand of more than 18% compared to the previous 5 years.

[2] Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ('European Climate Law').
[3] Decision (EU) 2022/591 of the European Parliament and of the Council of 6 April 2022 on a General Union Environment Action Programme to 2030.
[4] Proposal for a Directive of the European Parliament and of the Council amending Directive 2003/87/EC establishing a system for greenhouse gas emission allowance trading within the Union, Decision (EU) 2015/1814 concerning the establishment and operation of a market stability reserve for the Union greenhouse gas emission trading scheme and Regulation (EU) 2015/757, COM(2021) 551 final.

From the Ukraine-Russia war, the REPowerEU Plan and a series of emergency legislative measures that were employed helped in easing the pressure from the energy market and catalysed the restructuring of the EU's energy system. As a result, the EU's dependency on Russian fossil fuel decreased. The EU phased out coal imports, reduced oil imports by 90%, reduced gas imports from 115 billion cubic metres (bcm) in 2021 to around 80 bcm in 2022, and to an estimated 40-45 bcm in 2023.

With the call for renewable energy sources, 39% of electricity was generated by renewables having wind and solar power surpassing fossil fuels for the first time in May 2022. The new solar photovoltaic capacity in 2022 was recorded to be 60% more than 2021; with new onshore and offshore wind capacity recorded to be 45% higher than 2021.

Looking at the gross final energy consumption, renewable energy share was recorded at 21.8% in 2021. Observing the increasing share since 2010, the average yearly increase is about 0.67%. Therefore, a much faster growth is required for the coming years in order for the EU to reach its 2030 target of 42.5%.

Challenges and opportunities

Council Recommendation of 16 June 2022 on ensuring a fair transition towards climate neutrality 2022/C 243/04.

Complete the legal and policy framework under the European Green Deal, and shift to effective implementation of legislation, including the Fit for 55 package, in the Member States.

Boost competitiveness and industrial leadership, including through the Net-Zero Industry Act and the European Wind Power Package.

Secure reliable supplies of critical raw materials, including through agreement on the Critical Raw Materials Act .

Secure the needed investments for the clean energy transition, working with the private sector as well as the European Investment Bank and European Bank for Reconstruction and Development.

Provide affordable energy prices and ensure strong consumer protection and empowerment, by implementing a revised Electricity Market Design.

Strengthen and expand energy grids, and further integrate the energy systems.

Address skills and labour shortages relevant for the energy sector.

Address the impact of water scarcity on energy systems.

Set a firm time frame for the phase out of fossil fuel subsidies which do not address energy poverty or just transition, in line with the decarbonisation objectives of the European Green Deal.

2. Energy transition progress in Visegrád countries

2.1. Use of renewable sources as part of combined energy effort

To conform with the Paris Agreement, the European Union has set itself the target of achieving climate neutrality by 2050. This implies substantial reduction of greenhouse gas (GHG) emissions levels, through change of industries such as electricity, heat and transport considering their crucial role in GHGs emissions. As such each EU Member State agreed to achieve a certain attainable renewable energy target and all Visegrád countries have word on reaching their set mixed energy target as shown in figure 3.1[5] [6]. Initially, Visegrád countries had agreed and set the following target of share of renewable energy sources: Czech republic and Hungary 13% by 2020, while Slovakia and Poland 14% and 15%, respectively [7]. While these energy merge targets for use of renewable energy might be considered minor compared to other EU members, they constitute a progress and shows commitment of Visegrád countries[8].

Figure 3.1 shows the share of renewable energy sources in the energy mix of Visegrád countries, Austria and EU27 from 2012 to 2020. When looking at this figure, it can be observed that Slovakia had achieved 17% of renewable energy which is currently the highest share among Visegrad countries, followed by Czech, Poland and Hungary. It can also be observed that there was no augmentation of renewable energy usage in the Czech Republic for several years while in the case of Hungary, since 2012 there has been a decrease or reduction in utilisation of renewable energy.

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[5] Ulucak, R and Apergis, N (2017). Does convergence really matter for the environment? An application based on club convergence and on the ecological footprint concept for the EU countries:https://doi.org/10.1016/j.envsci.2017.11.002.

[6] Visegradgroup.eu (2021). Joint Statement of the Prime Ministers of the Visegrád Group. 9 July 2021. Ljubljana, Slovenia. [online]. https://www.visegradgroup.eu/joint-statement-of-v4-210730.

[7] Heilmann, F., Popp, R., & Ámon, A. (2020). The Political Economy of Energy in Central and Eastern Europe: Supporting the Net Zero Transition. E3G. https://www.euki.de/wpcontent/uploads/2020/02/E3G_2020_Comparative_Analysis_CEE.pdf.

[8] Gosling, T. (2022). Electric cars spell trouble for Central Europe. Politico. 20 May 2022. Retrieved from https://www.politico.eu/article/central-europe-struggle-keep-up-electric-car-race/.

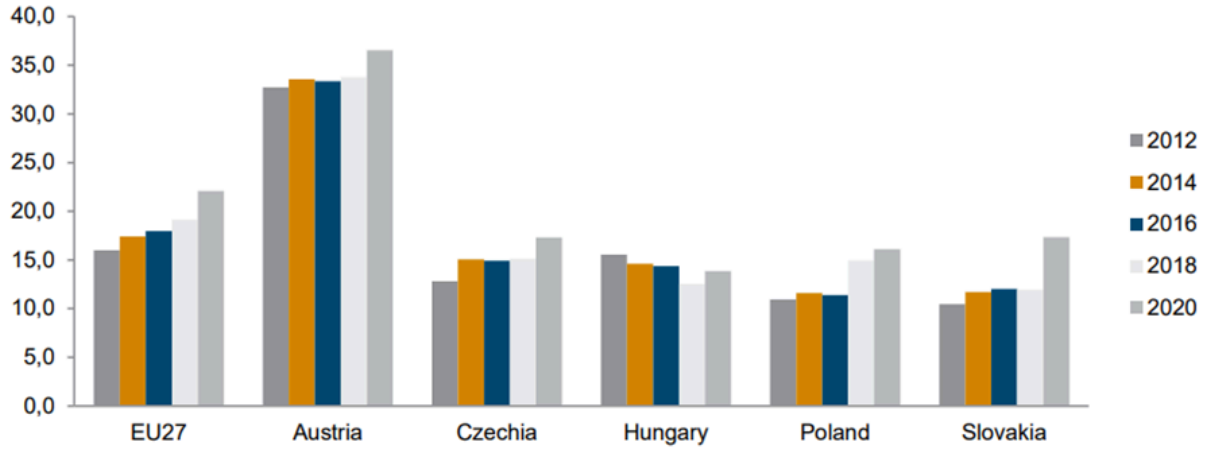

Figure 3. 1: Share of renewable energy sources in the energy mix of Visegrád countries, Austria and EU27 from 2012 to 2020 (% of gross final energy consumption).

2.2. Generation of electricity

When looking at the energy source used for electricity generation in Visegrád countries, the high share of renewable energy is utilised in generation of electricity. While Austria is not a Visegrád country, it has a close historical and economic relation with Visegrád countries and can be used as an example and best practice in relation to renewable energy utilisation as it uses over 80% of renewable energy for electricity production.

When looking at figure 3.2 it can be seen that Austria generates over 60% of its electricity through hydropower, nearly 10% using wind energy, and other renewable energy such as solar, waste and biofuel account of approximately 10% of electricity production and only about 18% of its electricity is generated using fossil fuels. When looking at figure 3.2, comparing Austrian renewable energy for electricity production to all Visegrád countries. It can be seen that Visegrád countries struggle to attain similar shares of renewable energy in their electricity mix as compared to Austria. Nonetheless, they demonstrate distinct differences in their energy utilisation compositions for electricity generation[9].

It is important to highlight that all the Visegrád countries rely largely on fossil fuels and nuclear energy, however, Poland particularly and distinctively showed that it is less ready for the green transition as it generates over 81% of its electricity using fossil fuels, with coal burning

[9] Riepl, T and Zavarská, Z (2023) Policy Notes and Reports 64: Towards a Greener Visegrád Group: Progress and Challenges in the Context of the European Green Deal.

accounting for approximately 70%. This first of all contradicts the idea of green transition and secondly Poland intends on continuing to use coal for energy generation for a prolonged future, which will contribute in further GHGs emissions.

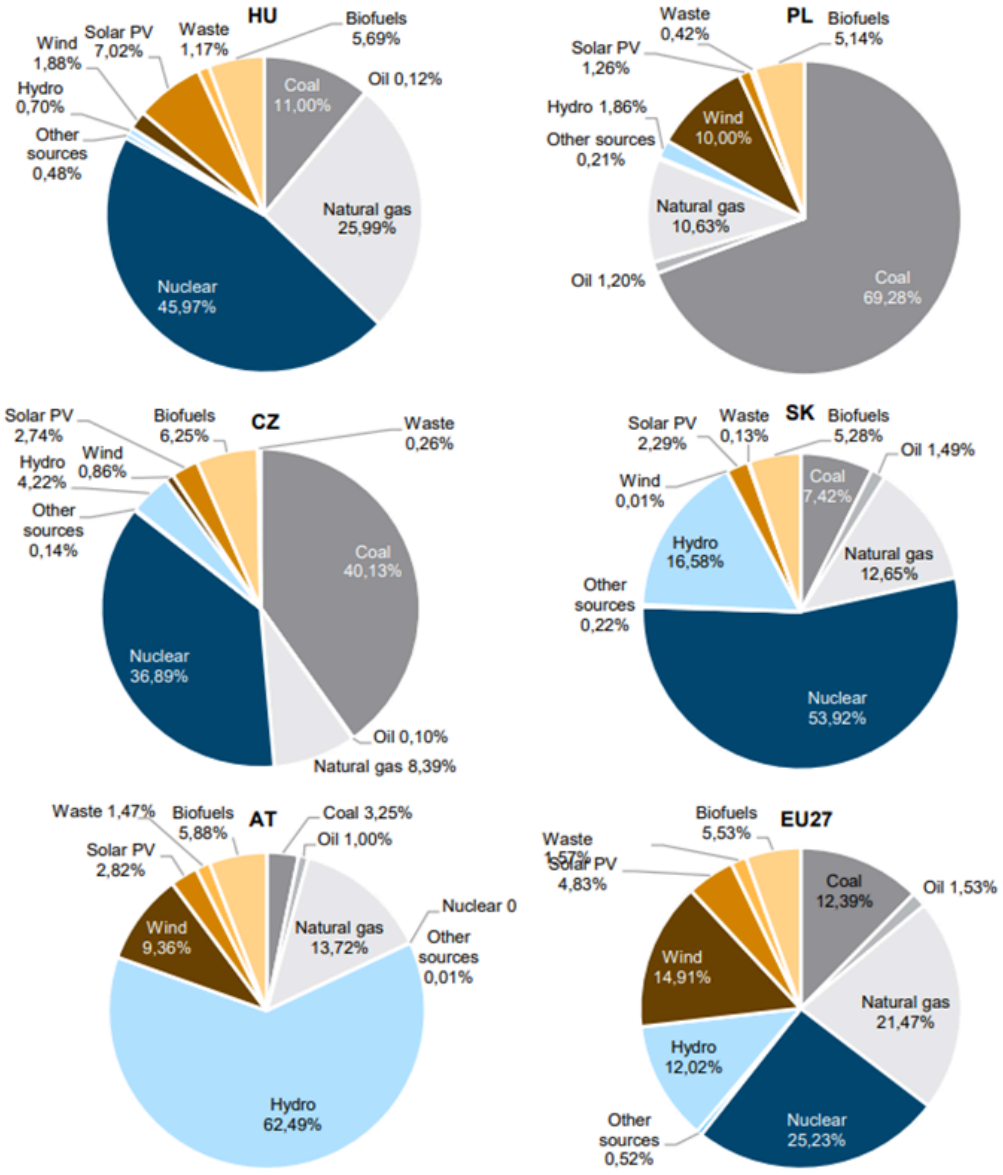

Figure 3. 2: The electricity mix in Visegrád countries, Austria and EU27, 2020.

It is also crucial to mention that Slovakia, Czech Republic and Hungary have made public their intentions and plans to switch from coal burning in the year 2023, 2023, and 2025 respectively[10].

[10] Heilmann, F., Popp, R., & Ámon, A. (2020). The Political Economy of Energy in Central and Eastern Europe: Supporting the Net Zero Transition. E3G. https://www.euki.de/wp

Among the Visegrád group Slovakia is in advance on decarbonisation of electricity production with approximately 24% of electricity being produced through renewable resources. There is additionally a notable utilisation of nuclear energy, more than half of electricity in Slovakia, furthermore, there is less coal burning for production of electricity in Slovakia as it accounts only for approximately 7%. Hungary primarily relies on nuclear energy which accounts for over 46% of electricity production, and secondly a combination of coal and natural gas constitutes approximately 37% of electricity production. Finally, the Czech Republic's electricity production is mainly dependent on nuclear energy which accounts for 37% and coal accounts for 40%.

When looking at figure 3.2 it is noticeable that the Visegrád countries decarbonisation approach and strives are founded on nuclear energy as a low cost and dependable alternative source of energy to carbon emissions reduction. This is also a result of these countries' history, as in Slovakia and Hungary almost fifty per cent of the electricity is produced using atomic energy. The Czech Republic intends to increase its nuclear energy share in the same magnitude as Slovakia and Hungary in the future. Presently, Poland has no nuclear energy, however, it has announced that it will be constructing it first nuclear power plant before 2030 [11].

2.3. Transport industry

The transport industry is one of the sectors that is fully dependent on fossil fuel, and the EU is currently struggling to sustain a green transition in this industry. Figure 3.3 (a) and (b) shows the total GHGs emission from EU and GHGs emissions from EU transport sector respectively. When looking at Figure 3.3 (a) the transport industry accounts for 24% of the total emissions of GHGs in the EU, and figure 3.3 (b) shows that the passenger's cars and LDVs account for 53% of GHs emissions. These statistics highlight that the transport industry is also among the challenging aspects of green transition[12].

When it comes to the transport industry, the efforts made by the Visegrád countries are quite like the other EU members. As shown by figure 3.4, one can notice that among the Visegrád group Hungary has the highest renewable electricity in rail transport, followed by the Czech

[11] Kochanek, E. (2021). The Energy Transition in the Visegrad Group Countries. Energies, 14(8), 2212. https://doi.org/10.3390/en14082212
[12] European Academies' Science Advisory Council. (2019). Decarbonisation of transport: options and challenges Decarbonisation of transport: options and challenges (easac.eu).

Republic, Slovakia and Poland occupying the last position. Furthermore, Hungary has an excellent compliant biofuels usage in the transportation sector with percentage surpassing Austrian usage of compliant biofuel in the transport industry. Slovakia has the highest percentage of renewable electricity usage in other transport modes compared to other Visegrád group members.

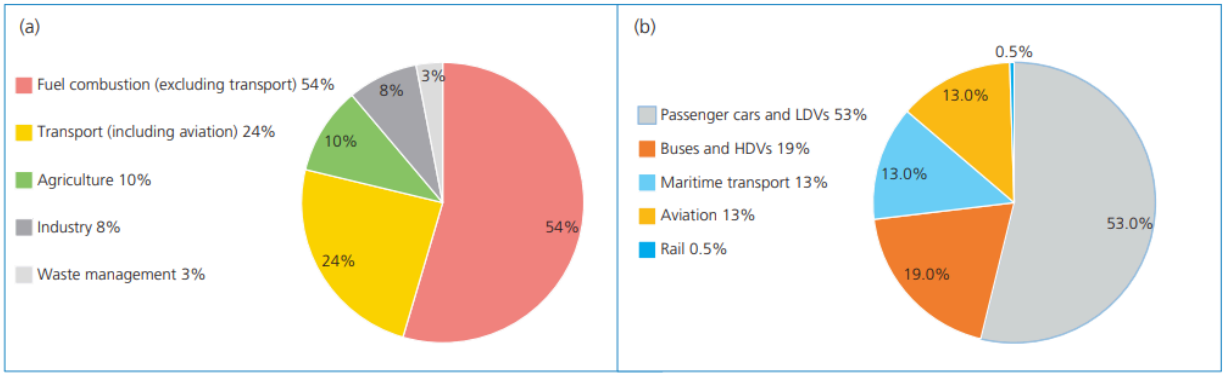

Figure 3. 3:(a) Total GHG emissions from the EU. (b) GHG emissions from the EU transport sector.

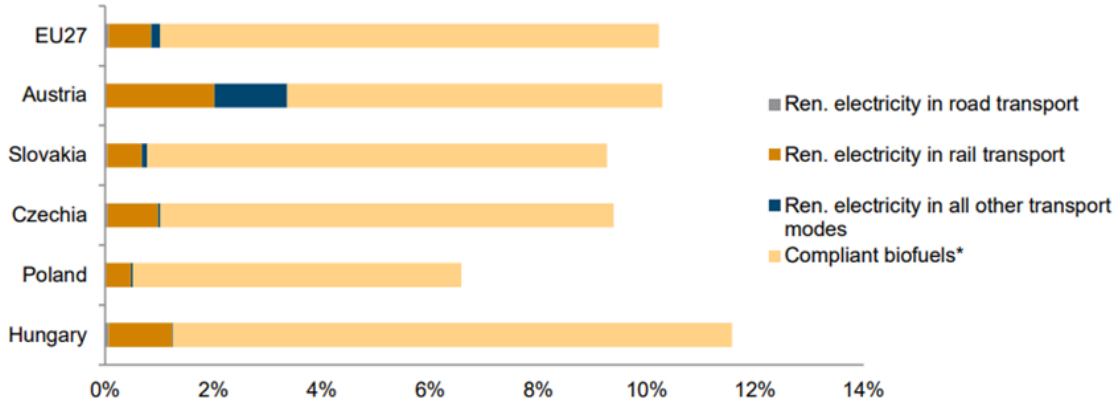

Figure 3. 4: Share of renewable energy in transportation in Visegrád countries, Austria and EU27 in 2020

It is clearly observed that compliant biofuel occupies the first place in renewable energy utilised in the transport industry for other EU members and in the Visegrád countries. However, this presents a problem of its own, firstly because in general, electric vehicles can only convert 70-80% supply energy into motion and secondly in particular compliant biofuel have very low energy efficiency ranging between 10 to 15%. This is a discouraging fact for the transport

industry and automotive producers and results in rejection of biofuel as sustainable green fuel[13]. Though, turning down compliant biofuel implies removing the biofuel data in the figure 3.4, and in such case, we obtain figure 3.5 after removal of compliant biofuel, and looking at figure 3.5 it is evident that that the transport industry is unable to achieve more than 2% in renewable energy for transportation usage which complicates the green transition ambitions.

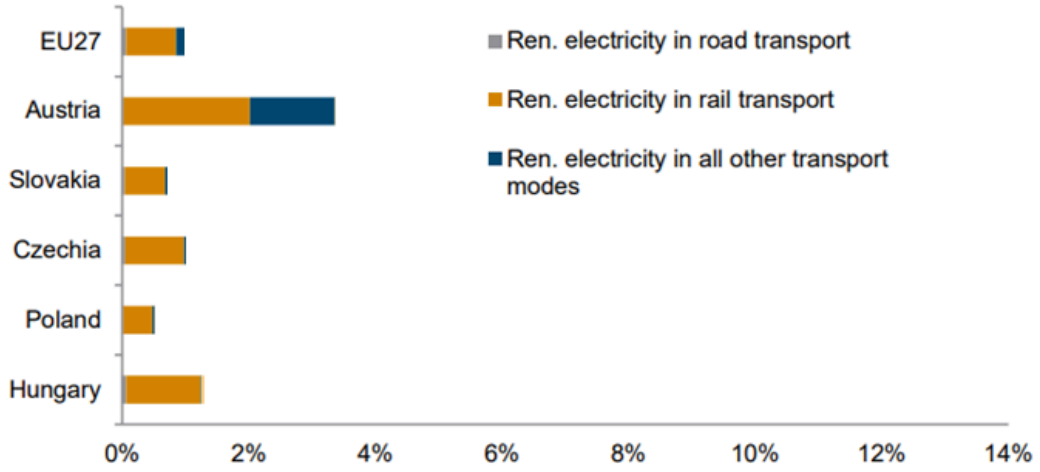

Figure 3. 5: Share of renewable energy in transportation in Visegrád countries, Austria and EU27 in 2020 without considering compliant biofuel.

3. Further observation on each Visegrád country

Kochanek, E. (2021). The energy transition in the Visegrad group countries. Energies, 14(8), 2212.

With the EU's vision of a green Europe, Visegrad countries are in for a lot of pressure given that the green transition means free of coal and other fossil fuels amongst its members. The Visegrad countries have been the main importers of Russian energy resources and recently they have been working on changing the dependency. Coal mining has also been a major pillar for the economy in driving its GDP and employment. Overall, the cost of green energy transition is higher amongst Visegrad countries compared to other EU countries.

[13] ADAC. (2022). Synthetische Kraftstoffe—Sind E-Fuels die Zukunft? https://www.adac.de/verkehr/tankenkraftstoff-antrieb/alternative-antriebe/synthetische-kraftstoffe/

Until recently, the V4 countries did not want to hear about the decarbonisation of the economy. Today, the situation has changed. Hard coal mines are being closed due to low raw material prices and strong foreign competition, and lignite mines are also being closed due to emission regulations and pollution charges. Both in the Czech Republic, Slovakia and Hungary, national strategic plans have been drawn up to help the coal regions to switch to other activities.

The Czech Republic

To start with, coal has been a significant source of energy in the Czech Republic, with a reserve of around 705 million tonnes. Primary energy supply, which was 61.8 million tonnes of coal equivalent (Mtce) in 2018, comprised: 36.2% coal (22.4 Mtce total of which an estimated 5.7 Mtce was hard coal and 16.4 Mtce was brown coal), 15.8% fossil gas (9.7 Mtce) and 21.6% oil (13.3 Mtce). The primary energy mix also includes nuclear energy with an 18.1% share in 2018 (11.2 Mtce), as well as biofuels and waste which together accounted for 10.2% (6.3 Mtce). Solar, hydro and wind power supplied the remaining 0.9% (0.6 Mtce).

The Czech Republic is aiming to significantly reduce its reliance on coal, from 41% (2015) to 21% (2040) of its energy, with all hard coal for energy expected to be imported. The decline in electricity production from coal is planned to be offset by reducing electricity exports and increasing the production of nuclear energy, which puts the Czech Republic as the fourth largest energy producer in the EU. Nuclear energy is projected to account for more than 50% of electricity production, replacing a significant portion of energy obtained from coal sources.

The current energy mix heavily relies on coal (44%) and nuclear power (34%), with renewable energy sources (RES) only making up about 12.5%. The government envisions green sources becoming the second-largest source of energy production after nuclear energy by 2040, although their share in total energy production will remain lower than in most EU countries.

Despite the focus on nuclear energy, there's a plan to reduce the installed capacity of coal-fired power plants significantly in the next decade and simultaneously develop renewable energy without compromising system stability.

Czech politicians view the use of coal as a comparative advantage for energy security, while renewable energy sources are considered a risky investment. However, there's acknowledgment that the Czech Republic can reduce coal-fired power plants' capacity and develop renewable energy with stable system operation. The RESTART programme aims to stimulate the development of mining regions, focusing on reducing pollution and supporting small and medium-sized enterprises.

The government adopted the national Recovery and Resilience Plan in May 2021 and did an analysis on the measures included in the plan. The Green Recovery Tracker report found that with investments of €7.9bn, equaling 3.7% of Czechia's GDP, can make a positive contribution to the green transition, though there are several specific shortfalls. The country's recovery plan

achieves a green spending share of 25%, below the EU's 37% benchmark. Furthermore, we find that 15% (€1.1bn) may have a positive or negative impact on the green transition depending on the implementation of the relevant measures, illustrating the importance of further scrutiny during the further planning, review and implementation of the recovery measures.

The green recovery tracker outlined some measures with an effect on the green transition.

1. Energy: New solar PV installations (€196m, very positive), modernization of district heating (€65m, likely climate effect but direction not accessible).
2. Mobility: Support for railway infrastructure (€454m, very positive) , electrification of railways (€264m, very positive), various measures to support public and private charging infrastructure
3. Industry: Research and development in enterprises (€322m, likely climate effect but direction not accessible), recycling infrastructure (€63m, likely climate effect but direction not accessible), circular solutions in private companies (€39m, positive).
4. Buildings: Energy savings in residential buildings (€393m, likely climate effect but direction not assessable), replacement of old heating sources in residential buildings (€334m, very positive), energy efficiency measures in public buildings with the target of increasing deep renovations (€295m, very positive).
5. Agriculture: Creating climate-resilient forests (€336m, positive).

Poland

Hebda, W. (2022). Energy Policy of Poland until 2040: The Challenges and Threats to Energy Security in the Next Two Decades. Politeja-Pismo Wydziału Studiów Międzynarodowych i Politycznych Uniwersytetu Jagiellońskiego, 19(79), 167-186.

Poland's main objective in the green energy transition has been decarbonization due to its high usage of coal. EPP 2040, adopted by the Council of Ministers on February 2, 2021, outlines an ambitious, responsible way of carrying out the energy transformation in Poland. It aims for a significant reduction in coal use, especially in the residential sector, and a focus on improving air quality. The policy is based on three pillars: just transition (creating new development opportunities and jobs in regions affected by the energy transition), a zero-emission energy system (building nuclear power plants, introducing wind power, and temporary use of gas fuels), and improving air quality (transforming the heating sector, transport electrification, and promoting zero-emission houses).

The challenge with Poland's transition is that the country is highly dependent on coal as its major source of electricity (estimated at 70%) and also a product of its imports. Therefore, branching out to alternative sources of energy will not only bring risk to its energy production but also have social and economic impact at the local level.

The "National Energy and Climate Plan for 2021–2030" document stated that reducing the share of coal in electricity production was one of the main objectives of Poland. Poland is to reduce energy production from coal by 56–60% by 2030 which will in turn reduce the share of coal-fired power plants. Gas will then be a very important energy source during the transition.

In light of the Ukraine-Russia war, Poland has been made more aware of the effect of heavily relying on imported energy sources. Thus, there is the need for diversification of energy sources and supply directions. Therefore, the country has ongoing projects like the Baltic Pipe to complete and the development of LNG terminals so as to reduce the dependency.

The introduction of nuclear energy is part of Poland's efforts in the green energy transition. The country has partnered with U.S. firm Westinghouse and has a planned opening in 2033. The country is also considering a public-private project with Korean firm KHNP. State oil company Orlen plans to build a Small Modular Reactor (SMR) unit by 2030, with aspirations for over 70 additional units across Poland. This initiative has faced some challenges related to technological choice, location, social approval, and the development of the necessary infrastructure.

When it comes to renewable energy development, Poland has mainly focused on solar and offshore wind energy. By 2030, Poland aims to have its total installed capacity at approximately 23-25 GW with its offshore wind development capacity at 5.9 GW.In its efforts, the challenge has been in the integration of these sources into the national grid and how to increase the capacity of wind and solar powers given the country's current technology and infrastructure.

On the other hand, solar photovoltaic (PV) has boomed from its marginal capacity in 2018 to over 16 GW by the end of 2023, which supplied 8.7% of the country's electricity. This boom in capacity created pressured the outdated electricity grid to its limit, highlighting the need for updates in legislation and grid infrastructure.

The Green Deal has brought some conflicts between Poland and the EU plus its institutions. Poland has challenged the Fit for 55 package pillars which include: the ban on combustion engine car sales by 2035; the reduction of free allowances in the ETS; increased EU forest management; and the overall increase of the EU's greenhouse gas emissions reduction target. Poland has challenged EU climate policies at the high court on many occasions and the new pro-EU coalition government is expected to improve relations with Brussels. This shift was made to potentially unlock funds for green investments like the 5 billion euro in RePowerEU pre-financing the country received in December 2023.

The new pro-EU coalition government announced that they want to phase-out coal-fuelled power by 2049. This move would help the district heating sector have a more efficient source of energy considering that Poland has the largest number of district heating customers among the EU countries. However, updating the heating sector and adoption of heat pumps is proving to be a challenge given the rise of energy costs.

Slovakia

Slovakia has been more focused on energy self-sufficiency, diversification of the energy mix and increasing electricity generation using low-carbon technologies. In terms of diversification of the energy mix, the share of fossil fuels and nuclear energy in electricity consumption has been a bit more balanced with almost 60% of the energy being nuclear. In place of coal, the country has been increasing the production of biofuels and bio-waste for energy production and heating. This move has increased the rate of energy self-sufficiency in the country.

The increase in the share of renewable energy in electricity consumption enabled the country to meet the EU's initial target (14%) which can be attributed to use of hydropower and biomass energy. Currently, around 70% of the technical hydropower potential is used in the country. In terms of exact targets, Slovakia aims to significantly increase its renewable energy capacity by 2030, with wind power at 0.5 GW, biopower at 0.8 GW, small hydropower at 1.75 GW, and solar PV at 1.2 GW.

Slovak climate policy was defined in the studies "Environmental Strategy-Greener Slovakia" and in the Low-Carbon Development Strategy of the Slovak Republic until 2030 with a View to 2050. The plan included adaptation measures for the coal region of Slovakia, called Upper Nitra, which is a very economically developed area with a high density of industrial sector. It is worth adding that this region was qualified in 2017 for a pilot EU programme supporting the transformation of coal mining regions.

The EU, in November 2022, allocated €459 million to Slovakia from the Just Transition Fund (JTF) to support the phasing out of coal extraction and coal-fired electric power generation by 2023. This included creating new job opportunities and enhancing energy efficiency in the Upper Nitra, Košice, and Banská Bystrica regions.

With the suspension of coal mining, the country started leaning on imports from Russia and Ukraine. However, in light of the Russia-Ukraine war, the country proposed several changes in its original recovery and resilience plan. Slovakia's plan includes a €446.5 million investment for renovating family houses to improve energy efficiency and around €368 million for the decarbonization of industry through energy efficiency improvements and innovative technologies. Additional investments focus on sustainable transport (€759.3 million), climate change adaptation (€150 million), and nature conservation.

Hungary

In comparison to other Visegrad countries, Hungary has the smallest potential for energy resources. About 45% of the total primary energy supply is domestic thus making it more dependent on imports. Natural gas and crude oil are the largest sources of primary energy, while nuclear power has the largest share in electricity generation.

Hungary's climate ambition does include a carbon neutrality goal for 2050 with a long-term National Clean Development strategy attached to it. With the aim of having its main (90%) electricity generation coming from low-carbon sources by 2030, part of the country's strategy involves a significant reliance on nuclear energy for electricity production and a gradual increase in renewable energy sources. Nuclear energy supplies more than half (52%) of the country's electricity production. Hungary has one Paks nuclear power plant with 4 PWR (pressurised water reactors) with a capacity of 500 MW each. Electricity that is generated at the Paks power plant provides Hungary with energy security while reducing carbon dioxide emissions. The construction of the new units is considered to be the government's priority project.

Biomass is a major driver of renewable energy growth, and geothermal resources are also notable. A "solar energy revolution" was noted by the government, with 5,600 megawatts of solar panels installed by the end of 2023. Despite this development in solar energy, wind energy has not seen significant growth due to legislative challenges. Legal conditions for the installation of wind turbines will be eased in 2024, reducing the required safety distance and abolishing the tender requirement, aiming to triple the current wind capacity by 2030.

Hungarians have done best in the implementation of EU law, as evidenced by the rapid achievement of the RES targets set for 2020. The country's energy policy also includes maintaining coal usage as part of its strategy until 2030. This approach reflects a balance between transitioning to cleaner energy forms and addressing economic and infrastructural realities.

This paper was produced by the conceptual research team of the Global Arena Research Institute (GARI) as part of the preparatory work for utilizing GARI's signature digital twin of the globalized environment. Supported by the International Visegrad Fund and the Konrad Adenauer Stiftung, GARI is at the forefront of integrating leading-edge computing technologies with socio-economic and political analysis. These internal conceptual working papers lay the foundation for our digital twin's application, offering critical insights and frameworks that enhance our understanding and foresight into global and local processes across various domains, including economy, trade, politics, defense, society, energy, and the environment.