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Energy transition for whom? Examining the distribution of green subsidy schemes in Poland.

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1. Why you should read this research

Among EU countries, Poland is one of those for which the energy transition is likely to be the most difficult, albeit potentially the most beneficial. Shifting away from historical dependence on coal can bring not only economic but also environmental and health benefits. Yet, in the context of high inequality in Poland, it is unclear whether these benefits will be distributed equally.

This work's main contribution is that – to the author's knowledge – it is the first one to examine spatial and socio-economic distribution of two national green subsidy schemes, central to Poland's energy transition: "Clean Air" and "My Electricity" programmes. The analysis exploits extensive, and mostly previously unpublished, data on subsidy contracts signed within the framework of these two programmes at the municipal and county level. This comprehensive, comparative analysis provides rich insights for the domestic policymaking, for example by identifying 32 regional hotspots in need of urgent policy intervention.

Secondly, this study is also the first one to approach such an evaluation from an environmental justice, energy justice and just transition perspective, to assess whether the programmes mitigate or exacerbate inequality. This is achieved by introducing three original indices which reveal which regions of Poland are particularly at risk of being left behind in the energy transition. Moreover, the socio-economic and demographic disparities are studied to better understand the drivers of take-up of the two programmes. As such, it constitutes an example of how policy analysis can be conducted through these three lenses.

Thirdly, the findings presented here may have wider relevance, beyond Poland's domestic context as this work contributes to the growing body of literature on the distribution of green subsidies, proving some of the existing research, while nuancing perspective in other areas. Existing literature warns that the green subsidies often flow primarily to the wealthy. This study finds out that this is largely determined by the programmes' design. It argues that the "Clean Air" programme exhibits more equitable outcomes thanks to its dedicated support for low-income households. Tying the amount of subsidy to income can thus ensure the progressive distribution of the funds. The design of income thresholds is paramount though, as they can inadvertently exclude households in need of support if constructed improperly.

However, without consideration for income differences, seemingly universal subsidies may in fact disproportionately serve wealthier households, exacerbating inequality. Indeed, the study finds that participation in "My Electricity" – whose design seems to favour more affluent households with its flat level of support and a lack of an income cap – is more prevalent in suburban, generally more affluent areas.

The study concludes that green subsidy schemes targeted at households do not necessarily exacerbate inequalities provided they are designed appropriately. Finally, it provides actionable policy recommendations on how to reform both programmes' to ensure their equitable distribution.

2. Introduction

The year 2025 marks the tenth anniversary of the adoption of the Paris Agreement – a historical, legally binding international agreement on climate change. Signed by 196 parties, the Agreement aims to limit the increase in global average temperature to 1.5°C above pre-industrial levels (UNFCCC, no date). Achieving this goal requires a 45% reduction in global net CO_2 emissions by 2030 and reaching net-zero by 2050 (IPCC, 2022). Meeting these targets will require unprecedented economic and societal transformations. The shift away from fossil fuels will entail large-scale investments in renewable energy deployment, electrification of transport and industry, and the modernisation of energy infrastructure. These will have to be incurred not only by states and businesses but also households.

If carried out without proper recognition of regional and socio-economic conditions, energy transition risks creating a new type of environmental inequality whereby the affluent can take advantage of its benefits and the disadvantaged are left behind. State subsidies play a key role in this regard as depending on their design they can mitigate or exacerbate such inequalities by facilitating or hampering access to green technologies to certain groups. This is why, for the energy transition to be truly just and sustainable, its distributional and spatial impacts must be properly analysed and addressed.

This study seeks to understand who benefits from the “Clean Air” and “My Electricity” green subsidy schemes in Poland. By studying their spatial and socio-economic distribution it aims to identify regions and groups taking advantage of them as well as those who are lagging behind. Next, it tries to understand the barriers to participation in the programmes. Poland is a particularly interesting case due to its reliance on coal for electricity and heat production and relatively high, in the European Union, level of economic inequality. These factors make it especially prone to experiencing environmental inequalities as the result of the energy transition.

In the last 35 years Poland’s post-communist transformation has brought rapid economic growth – heralded by Piątkowski (2013) as “Poland’s Golden Age” – but at the cost of deepening inequality, with Poland now exhibiting one of the highest levels of income inequality in Europe (Bukowski and Novokmet, 2021). Bukowski et al. (2023) report that in 2023 the top 1% captured 13.4% of total income in Poland, followed by the top 10% earning 37.4%. In contrast, the middle 40% captured 41.1% and the bottom 50% only 21.5%. Moreover, they find that the Polish tax system is regressive, exacerbating the problem. As the country is now embarking on another major transition, it is key that this time its benefits are shared more equally across income groups.

The “Clean Air” programme (*Czyste Powietrze*) is a national subsidy scheme introduced in September 2018 by the Law and Justice government. It is the largest policy targeted at households supporting replacement of inefficient and polluting heating sources as well as energy efficiency investments to date in Poland, with the total budget for the years 2018-2029 amounting to 103 billion PLN (24.81 billion EUR), of which 63.3 billion PLN are allocated for grants and 39.7 billion PLN for preferential loans (Ministry of Environment, 2018). The goal of the programme is to support replacement of 3 million heating sources. As a large share of Polish households relies on solid fuels for heating, the programme is likely to have significant, positive impacts on air quality.

In 2019, the same government launched Poland's first ever programme to subsidise residential photovoltaic micro-installations – "My Electricity" (*Mój Prąd*). Its main objective was to increase energy production from solar power, confronting the challenge of decarbonisation of the Polish energy mix. Over the past six years, the programme has been one of the key contributors for the photovoltaic boom in Poland.

Both programmes are subsidy schemes targeted at owners or co-owners of single-family houses and aim to increase energy efficiency as well as take-up of clean energy sources. However, their design differs with the "Clean Air" programme offering varying amounts of the subsidy depending on households' income and excluding those with annual incomes exceeding 135 000 PLN, and "My Electricity" open to everybody regardless of income but not accounting for greater needs of households.

The hypotheses studied in this paper are as follows:

1. The take-up of "Clean Air" and "My Electricity" programmes varies across regions and socio-economic groups.
2. These patterns can be partly explained by differences in programme:
   a. The presence of an income cap and the progressive allocation of subsidy in the "Clean Air" is associated with higher take-up rates in more disadvantaged regions;
   b. Lack of an income cap, flat level of support and the requirement to cover at least 50% of the investment in the "My Electricity" is associated with higher take-up rates in more urbanised and affluent regions.
3. Regions that underperform in programme participation tend to face housing and economic disadvantage.

The study covers almost 300 000 "Clean Air" subsidy contracts from nine voivodeships signed in the years 2018-2024 and over 500 000 "My Electricity" subsidy contracts from all 16 voivodeships signed in the years 2019-2024.

The study finds that indeed the two programmes target different groups and regions. The „Clean Air" programme appears to be reaching more disadvantaged regions. Its prevalence is higher in rural municipalities with the worst air pollution levels prior to the programme implementation. Low-income households were also identified as the main beneficiaries of the programme, capturing the majority of the funding. On the other hand, participation in "My Electricity" is more widespread in suburban counties as well as counties with more modern housing stock. However, its take-up is not so clearly determined by socio-economic and housing related variables. This may be due to the county-level aggregation which conceals important within-county variation. Furthermore, and contrary to the "Clean Air", the disparities in take-up rates across the regions are much more pronounced, pointing to the higher barriers to participation.

The findings from the three indices presented in Chapter 5.3.4 reveal clear regional disparities in terms of both counties' engagement in the two programmes, the level of their needs and the mismatch between the two. Indeed, regions that underperform in terms of programme take-up tend to be more disadvantaged. Notably, Eastern Poland emerges as region most at the risk of being left behind, comprising most counties classified as in need of urgent policy intervention.

Finally, this study includes recommendations for reforming the programmes to better reflect the economic reality of the Polish people, allow more low-income households to receive additional support as well as strengthen administrative capacity of institutions in charge of programmes' implementation.

3. Interdisciplinary state of knowledge

3.1. Theoretical framework

This study is a contribution to the growing body of research on just transition, drawing on notions from environmental justice and energy justice literature – interdisciplinary fields of research integrating insights from economics, sociology and environmental and climate sciences.

Environmental justice examines how, depending on their socio-economic characteristics, different groups of people experience their environment and participate in environmental decision-making (OECD, 2024). Evidence from around the world points out that it is often disadvantaged groups and communities that experience worse environmental quality, bear the higher burden of environmental policies and face obstacles to participate in environmental decision-making (Mohai, Pellow and Roberts, 2009; Banzhaf, Ma and Timmins, 2019; OECD, 2024). With no one precise definition it is perhaps best characterised by its three pillars: distributive, recognitional and procedural justice (Schlosberg, 2004; OECD, 2024). The distributive aspect takes into account both the distribution of material environmental hazards and amenities across space and groups but also the distribution of costs and benefits associated with environmental policies. Recognitional justice highlights the importance of acknowledging diverse identities and inherent vulnerabilities of certain groups and communities. Finally, procedural justice points to unequal access to environmental information and decision-making processes due to insufficient resources and/or lack of recognition (Schlosberg, 2004; OECD, 2024). This study is primarily rooted in the distributive justice pillar.

While environmental justice emerged primarily as a field examining spatial and socio-economic disparities in terms of exposure to pollution, it has since expanded to cover a variety of topics, such as access to environmental amenities, inequalities in environmental health or uneven adaptive capacities (OECD, 2024). All these topics are relevant for this study, as it examines regional disparities in take-up of green subsidy schemes, investigating how the benefits of the energy transition are distributed spatially and across socio-economic groups – this in turn is often the reflection of households' adaptive capacities. The health dimension is relevant here as well, as the "Clean Air" programme targets solid fuel-based heating sources – a leading cause of air pollution in Poland. Therefore, programme's take-up can have significant health effects for the beneficiaries and their immediate neighbourhood.

Energy justice has emerged in recent years as a subset of environmental and climate justice literature (Jenkins, 2018)[1]. It examines justice implications of energy policy as well as its production and consumption. It asks who gets to enjoy the benefits and who bears the burden of energy systems (Jenkins *et al.*, 2016). Such a lens helps to identify the current injustices and provide a normative framework for reforming energy systems. These questions are particularly important in the context of the energy transition. As pointed out by Carley and Konisky (2020) notions explored by the environmental justice literature are relevant in the context of the energy transition as well. Disproportionate burden in this context could be understood as negative externalities of renewable energy (such as "shadow flicker" from wind turbines) or negative economic effects of coal industry closures for surrounding communities. Such burdens might also include rising costs of energy, which exacerbate energy insecurity of vulnerable households, more likely to live in energy inefficient buildings in need of modernisation. The authors also note the disparities in access to energy transition opportunities. Access to new jobs in the renewable energy industry as well as to low-carbon technologies – electric vehicles, PV panels, smart meters – are often unequally distributed across the society, with the latter primarily benefitting higher-income households (Carley and Konisky, 2020). This issue will be further explored in Chapter 3.2.

While these concepts offer valuable theoretical insights and help better understand the underlying inequalities and dynamics of environmental and energy issues, the concept of just transition helps to synthetise them and apply in a more policy-oriented way. Although the term itself was coined back in the 1980s by the workers unions, the concept of just transition has gained prominence in the recent decade, having been featured in the Paris Agreement and by the International Labour Organisation (ILO) (International Labour Organisation, 2015; UNFCCC, 2015; OECD, 2024). Lacking a universal definition, it generally refers to the need to reconcile climate and decarbonisation goals with social protection of those impacted by them, with special consideration for fossil-reliant regions and industries, prioritising the creation of new, decent jobs (Newell and Mulvaney, 2013; International Labour Organisation, 2015; UNFCCC, 2015; Leal Filho and Pons-Giralt, 2024). Some also point that by ensuring justice in terms of climate, environment and energy, just transition will result in reduction in inequality (Heffron and McCauley, 2018). Importantly, ILO points out that the just transition must contribute to the eradication of poverty (International Labour Organisation, 2015).

In the context of this study, just transition is understood as the equitable and inclusive process of adapting the Polish housing stock to the green economy, by increasing energy efficiency of

[1] Climate justice, although a prominent stream of literature, has not been featured in this study as it highlights slightly different problems, such as unequal historical responsibility for greenhouse gas emissions and unequal distribution of climate harms such as extreme weather evens and rising temperatures. It points to a more international perspective, placing the disparity between Global North and Global South at the centre and explores these issues against the backdrop of inequalities stemming from colonialism. It also highlights the issue of intergenerational justice, i.e. how present generations can help or burden future ones by engaging or not in climate policies. See: Schlosberg and Collins (2014).

residential buildings, replacing old and polluting fossil fuel-based heating sources as well as accessing renewable energy such as PV micro-installations.

By synthesising concepts from these different strands of literature, this research acknowledges that the transition to a green economy, unless properly managed, poses risks to vulnerable and disadvantaged groups. For a just transition to be truly just, specific vulnerabilities and diverse characteristics of various socio-economic groups and regions must be taken into account, as well as social and economic effects that shifting away from fossil fuels will have on them.

3.2. Empirical evidence on the unequal distribution of environmental policies

Complementary to the theoretical framework, this study draws from existing empirical evidence on economic and environmental inequality, and particularly on the unequal distribution of green subsidies for households.

Rising income and wealth inequality is one of the key considerations for this study, as it limits governments' capacity to finance investments needed to transition to a green economy. Although in the last four decades global inequality between countries decreased, within-country inequality rose significantly (Chancel and Piketty, 2021). This period has been marked by the rise of the global middle-class in the developing countries, stagnation of incomes of the middle-class in the developed countries as well as an enormous wealth accumulation at the very top, with the top 1% capturing 23% of total world growth between 1980-2020 (Chancel and Piketty, 2021).

This important rise in inequality has been accompanied by gradual reduction in progressivity of taxation. Across most advanced economies top statutory PIT rates and combined statutory CIT rates have decreased since 2000 while average VAT rates have increased (OECD, 2023c). Reintroducing progressive income and inheritance taxation alongside effective wealth taxation could help curb these extreme levels of inequality (Piketty, Saez and Zucman, 2023). In the absence of such policies, governments deprive themselves of important resources, shifting the financial burden of the transition to those at the bottom and in the middle of the income distribution.

Against this backdrop, there is a risk that public policies that fail to account for these rising disparities may inadvertently exacerbate them. A growing body of research demonstrates that environmental and climate policies can have important distributional consequences. Fullerton (2011) points to six key types of distributional effect of environmental policies[2]. From the perspective of this study, the key ones are: higher prices of carbon-intensive products, distribution of the benefits from improvements in environmental quality as well as capitalisation of these effects into housing prices.

[2] These are: "higher prices of carbon-intensive products, changes in relative returns to factors like labor, capital, and resources, allocation of scarcity rents from a restricted number of permits, distribution of the benefits from improvements in environmental quality, temporary effects during the transition, and capitalization of all those effects into prices of land, corporate stock, or house values" (Fullerton, 2011).

First, if low-income households continue to rely on fossil fuel-based energy for transportation, electricity and heating, they will bear the higher prices as prices of carbon-intensive goods are likely to increase. Thus, making low-carbon alternatives accessible for them is paramount. However, existing research points out that green subsidies often disproportionately benefit higher-income households (Vona, 2021; Vaishnav, 2023). Examples from the US (Vaishnav, Horner and Azevedo, 2017) and Lithuania (Lekavičius *et al.*, 2020) point out that subsidies for the installation of residential PV flow disproportionately to more affluent communities and/or residents. Borenstein and Davis (2016) reach a similar conclusion with regard to the US clean energy tax credits, whose benefits were primarily captured by the top quintile. Apart from subsidies directed at households, deployment of renewable energy is often encouraged by a dedicated levy of electricity consumption. Research from Germany notes that this measure, while aimed at increasing the share of renewable energy, disproportionately burdens the low-income households (Priesmann *et al.*, 2022). Similar conclusions are reached by Sheldon (2022) in the case of the US federal tax credit for the purchase of electric vehicles.

Secondly, in the Polish case where residential heating is still largely based on solid fuels, transition to low-carbon sources has direct impact on air quality – therefore, if low-income households are excluded from the process, they will not reap these additional environmental benefits. Moreover, the literature on green gentrification suggests that following an improvement in environmental quality, e.g. reduction of air pollution, a neighbourhood is likely to become more expensive, pushing out lower income residents as a result (Anguelovski *et al.*, 2022).

Thirdly, as the subsidies analysed in this study are directed as homeowners, they risk appreciating the value of the properties, potentially to the detriment of renters. Indeed, there is evidence that home prices increase with improvement in energy efficiency (Aydin, Brounen and Kok, 2020). Moreover, evidence from Netherlands shows that subsidies for home renovation, if not accompanied by appropriate taxation can indeed increase inequality between homeowners and renters (Fernández, Haffner and Elsinga, 2024). Even in the absence of subsidies, high-income households and homeowners are more likely to invest in energy efficiency and renewable energy solutions compared to lower-income households and renters (Ameli and Brandt, 2014).

Environmental and climate policies are generally regressive on income, potentially burdening low-income households the most (Vona, 2021). Therefore, they need to be accompanied by appropriate compensation policies to mitigate potential trade-offs between equity and efficiency. This is also key from the perspective of acceptability of environmental policies and their political economy (Vona, 2021). Although subsidies are generally preferred by the citizens over taxation (Vona, 2021; OECD, 2023b), there is evidence that non-adopters punish political parties who introduced solar PV subsidies which benefitted only a small group (De Groote, Gautier and Verboven, 2024). Therefore, equitable distribution of these benefits across the population could help to avoid a political backlash and increase support for transition policies.

3.3. Existing research on the “Clean Air” and “My Electricity” programmes

Given their relative magnitude and novelty in the Polish energy policy landscape, the “Clean Air” and “My Electricity” programmes have attracted researchers’ attention in recent years. Their imperfect design has also prompted calls for a reform from public institutions as well as think tanks.

Several reports raised concerns over the slow pace of the implementation of the programme and its less than satisfactory results (Sakson-Boulet, 2021; Supreme Audit Office, 2021; Wrona, 2021). An evaluation of the programme by the Supreme Audit Office in 2021 revealed that if the current (as of 2021) pace of implementation were to continue, it would mean a delay of four years from the target date of programme completion in 2029 (Supreme Audit Office, 2021). This was due to several factors, starting with the lack of clarity regarding the very ownership of the project within the public administration and unclear management arrangement resulting in a lack of clearly delineated roles and responsibilities of several public entities.

The question of resource allocation was also brought up by the (Supreme Audit Office, 2021). Firstly, in the light of the programme’s budget and timeline (103 billion PLN to be distributed between 2018-2029), unprecedented for the National and Regional Funds, inadequate human resources were provided at regional level in charge of the implementation, resulting in prolonged periods for processing applications and delays in disbursing funds. This may have disincentivised households from participating in the programme. Secondly, the financing for the whole duration of the programme was not secured, with the budget lacking clear funding sources. Uncertainty around the future of the programme’s funding might have also contributed to households’ hesitation. Finally, a lack of a centralised IT system at the National Fund for Environmental Protection and Water Management resulted in difficulties in gathering and processing data necessary for evaluating the programme’s results.

Criticism was also targeted towards the design of the programme. Instrat Foundation pointed to the problem of rigid income thresholds which decrease the attractiveness of the programme for the potential applicants as well as create administrative burden for Regional Funds which devote significant resources to verify each applicant’s eligibility (Hetmański, Iwanowski and Szwarc, 2020). Sakson-Boulet (2020) also suggested making income thresholds more realistic to broaden the pool of potential beneficiaries. A similar critique was shared by the Supreme Audit Office which noted that apart from linking the intensity of aid to the income thresholds, no targeted measures were provided for disadvantaged households that could increase their availability (Supreme Audit Office, 2021). As for the scope of available investments, researchers also noted the controversial initial decision to allow support for exchanging old coal boilers to – although more efficient – new, coal boilers (Księżopolski *et al.*, 2020). Although this was later changed in one of the many iterations of the programme, as pointed out by Matczak et al. (2023) the approval of gas installations poses a risk that Poland might shift its dependency from one fossil fuel to another.

Several articles have also examined the "My Electricity" programme implementation and its results. Cader, Olczak and Koneczna (2021) have examined regional divergence in terms of the programme take-up. They find that the installed PV capacity is positively correlated with the population of a voivodeship as well as GDP and HDI (Cader, Olczak and Koneczna, 2021). However, the authors concentrate on per capita and per household indicators, disregarding regional differences in housing characteristics, and thus, potential eligibility of households living in flats vs. single-family detached houses. Olczak et al. (2021) estimate the effects of the programme on GHG emissions and conclude that, assuming PV energy replaces energy produced from coal combustion, the programme will save 35 million tons of CO_2 over 30 years. Others considered the programme's impacts on health and found that even its partial implementation would significantly reduce air pollution and help avoid from 2 868 to 3 008 premature deaths caused by high levels of PM 2.5 concentrations annually (Jagiełło *et al.*, 2022). Finally, Zdonek et al. (2022) find that the programme is well regarded by the Polish population and that the respondents consider economic benefits (lower electricity bills, subsidies, tax relief) as the most important for them, followed by environmental benefits. For ⅓ of survey respondents, the "My Electricity" programme was the key determinant of investing in a PV installation (Zdonek *et al.*, 2022). The positive impact of the "My Electricity" programme on the PV adoption in Poland was also noted by Igliński et al. (2023). Finally, the 2022 change to the programme design, which introduced the shift from the net-metering to net-billing system, was found to increase the demand for residential energy storage, as net-billing promotes increased self-consumption (Kuźmiński *et al.*, 2023).

The works produced to date, largely exploratory in nature, relied on fragmented datasets and do not provide satisfactory explanations for the determinants of the programme take-up and its regional divergence. Moreover, as opposed to this work, these studies are limited to the voivodeship level, which prevents a more detailed analysis of particular counties, crucial for understanding the distribution of the subsidies[3]. They also tend to overlook a number of potential factors relevant to the take-up of the two programmes, such as the economic development (GDP, median income, unemployment rate), socio-demographic factors (post-working age population, education, welfare) and building characteristics (buildings age, heating structure).

4. Data, sources and methodology

One of this thesis' key contributions is its use of data on the two flagship Polish environmental policies: the "Clean Air" and "My Electricity" programmes. These schemes, although crucial in the Polish environmental policies, have not been thoroughly studied to date. To the author's knowledge this is the first study to examine the two together; moreover it is the first one to consider their design and outcomes through an environmental justice, energy justice and just transition lenses.

[3] Voivodeship (*województwo*) is the largest administrative unit in Poland, followed by county (*powiat*) and municipality (*gmina*).

As most of the data used in this study has not been made public by the responsible institutions, requests were sent to all 16 Regional Funds for Environmental Protection in charge of distributing the “Clean Air” programme subsidies as well as the National Fund for Environmental Protection and Water Management responsible for the “My Electricity” programme. In the end, for the “Clean Air” programme individual datasets were obtained from nine Regional Funds for Environmental Protection. The National Fund for Environmental Protection and Water Management shared data on the “My Electricity” programme for all 16 voivodeships. Due to different formats of the datasets, the data was next cleaned and harmonised. Data sources and the process of data cleaning are described in more detail in the Annex 1.

Supplementary air quality, socio-economic and housing-related data were sourced from Central Statistical Office of Poland, Chief Inspectorate for Environmental Protection and the Central Registry of Building Emissions.

This extensive dataset is analysed with the use of quantitative methods. First, descriptive statistics for the distribution of the “Clean Air” programme are presented. The sample includes data on 266 574 applications and 292 718 contracts signed during the period from Q3 2018 to Q3 2024 for the amount of over 9.55 billion PLN. It comprises 1 288 municipalities from 203 counties across nine voivodeships. Moreover, the data is disaggregated by level of funding, i.e. the intensity of subsidy granted dependent on applicants’ income. Three categories of financing are available: *basic*, *increased* and *highest*, with the *highest* directed to the least well-off households. However, due to data protection concerns, data on individual applicants and their incomes were not available. The analysis is thus conducted at the municipal level.

Next, linear regression models are estimated to determine which communes are more likely to apply for each of the three levels of financing. The analysis of the January 2023 reform of income thresholds follows. As not all Regional Funds for Environmental Protection provided sufficiently detailed data, this analysis is carried out on a smaller sample, comprising five voivodeships. As the reform was implemented simultaneously nation-wide, this exploratory analysis is based on a t-test, rather than more advanced difference-in-differences design.

The chapter is concluded with the analysis of the programme’s link to reduction in average annual concentration of PM10, PM2.5 and benzopyrenes (BaP). As before, since difference-in-differences approach could not be employed in this case, two types of regression models are estimated. They aim to test the relationship between programme take-up and reductions in the three pollutants concentrations after the introduction of the programme. The air pollution data was sourced from the official website of the Chief Inspectorate for Environmental Protection in Poland. As the programme was introduced in autumn of 2018 (and thus the first renovations were carried out in 2019) the period analysed is 2014-2023 with 2018 as the cutoff point.

Next, data on the “My Electricity” programme is analysed. The dataset obtained from the National Fund for Environmental Protection and Water Management covers 522 463 applications and 500 514 contracts signed during the five out of six editions of the programme in all 16 voivodeships in Poland, for the amount of 2 780 194 676 PLN. As in the case of “Clean Air”, data on individual applicants and their incomes was not available. Moreover, although data provided was disaggregated by municipalities, due to their inconsistent, often manual recording, it was necessary to aggregate them to the county level due to the difficulties in identifying some of them precisely. This has led to losing some of the analysis' granularity.

The Chapter 5.3.3. focuses on the comparative analysis of the two programmes. Due to data limitations and to ensure comparability, the analysis is carried out on county level. The key indicator of interest in this chapter is the take-up of each programme, measured as the number of contracts signed for "Clean Air" and "My Electricity" respectively, divided by the number of single-family houses in a county. This indicator ensures that only eligible households are taken into account, which is not quite reflected in per capita indicators. First, descriptive statistics are presented. Next, relationship between the take-up rates and a range of socio-economic and housing variables is suggested with the use of a correlation matrix. Finally, it is explored more in-depth with the use of regression analysis.

Often, one of the key methodological features of environmental justice research is its spatial perspective. In this study this is reflected in Chapter 5.3.4 which maps the county engagement in the two subsidy schemes. The "High/Low Take-up Index" classifies counties into four categories depending on whether they are above or below the median take-up for the two programme:

- *Leaders* (above the median for both "Clean Air" and "My Electricity"),
- *Laggers* (below the median for both "Clean Air" and "My Electricity"),
- *Prioritise heating* (above the median for "Clean Air" and below for "My Electricity") and
- *Prioritise RES* (above the median for "My Electricity" and below for "Clean Air").

The level of county-level vulnerability towards the energy transition is also mapped through the "Green Need Index". Drawing inspiration from the Indices of Multiple Disadvantage, used in environmental justice research, a composite index was constructed including variables reflecting economic disadvantage (e.g. median income, unemployment rate, share of population relying on welfare) as well as housing disadvantage (e.g. share of houses heated with coal in 2018, share of dwellings built pre-2003).

Next, this study looks at whether the level of green need is complemented by matching engagement in the two subsidy schemes studied. To this end, a third index, the Green Gap Index is constructed for each county by subtracting its standardised Green Need score from standardised Activity score, which measures the level of engagement in the two programmes.

Finally, with the use of Green Need and Green Gap indices, priority counties in need of urgent intervention are identified. To account for both high level of green need and low activity in the programmes despite these needs, counties that rank in fourth quartiles for both indices are classified as "high priority".

With the use of these methods, this study helps identify regional winners and losers of the energy transition in Poland. Although it does not account for many others effect of the energy transition, most notably employment effects, it explores the issue of buildings modernisation, residential heating – crucial in the context of air pollution in Poland – and access to green technologies.

5. Analysis

This chapter analyses two green subsidy programmes – "Clean Air" and "My Electricity". It begins with the "Clean Air" programme, analysing its structure, outcomes and distributional impacts. It then examines the impact of the 2023 reform of the programme's design on its availability to low-income households as well as its overall relationship with air pollution. Next, the evaluation of "My Electricity" is carried out. The chapter examines its distribution across county types and voivodeships as well as the impact of the programme's reform on participation. A comparative analysis of the two programmes follows, highlighting which regions and groups are their main beneficiaries. Finally, the findings are mapped with the use of three indices illustrating regional disparities in subsidies take-up and pointing out areas that are in need of more targeted support in the energy transition process.

5.1. The "Clean Air" programme

5.1.1. Why was the Clean Air programme needed?

For decades, Poland has been facing some of the highest levels of air pollution in the EU. In 2018, the World Health Organisation found that out of 50 most polluted European cities, 36 were located in Poland (World Bank, 2019). Although notable progress has been made in recent years, the country still ranked last out of all EU member states in terms of annual mean PM 2.5 concentrations in 2022 (European Environment Agency, 2024). This high level of pollution translates into severe health consequences with between 36 500 and 46 500 premature deaths attributed to air pollution every year (European Environment Agency, 2024; Clean Air Fund, 2025). Moreover, this problem is exacerbated by mountainous topography in southern regions, where smog settles in valleys, especially during the heating season (World Bank, 2019).

While Poland's mining sector, concentrated primarily in Silesia, might instinctively be held accountable, the primary contributor to exorbitant levels of particulate matter is the residential sector, and more precisely, household heating. According to the National Centre for Emissions Management (KOBiZE), household use of solid fuels-based furnaces accounts for around 80% of all particulate matter and 90% of benzopyrenes (Polish Smog Alert, 2025). As of 2022, nearly half of respondents surveyed by the Centre for Public Opinion Research heated their homes with coal, including 77% of the rural population and 43% of those living in small towns up to 20 000 inhabitants (CBOS, 2022). According to another survey by the Polish Economic Institute, in the years 2022-2023, 25% of the Polish households still occasionally relied on low-quality fuels for heating such as fine coal, wood or biomass, with 7% of those living in single-family houses admitting to sometimes burning rubbish. The majority of these households are primarily located in the countryside or small towns and often lack access to central heating and gas network and live in houses which are not properly insulated (Polish Economic Institute, 2024). The Central Statistical Office estimates that energy poverty measured as double the median energy expenditure might be touching 18.8% of all Polish households (Central Statistical Office, 2024). These households are more likely to be living in poorly insulated houses and may lack sufficient capital to invest in thermal modernisation and clean energy sources (Forum Energii, 2025b).

Moreover, a large share of the building stock in Poland is relatively old and does not comply with modern energy efficiency standards. Over 64% of all dwellings date back to pre-1989, (the end of the communist era). This number increases to 77% when looking at dwellings built before 2003, just before Poland joined the EU[4]. The government points out that almost 70% of all buildings in the country does not meet energy efficiency standards and will soon require modernisation – this is the case mainly for hospitals and old single-family houses which use solid fuels for heating (Ministry of Development and Technology, 2022). As inefficient and poorly insulated houses require more energy for keeping adequate temperature, this translates into higher spending on fuels with stark economic and health consequences for their inhabitants.

With its accession to the EU in 2004, Poland committed to stricter air quality and building standards. The country already adopted two key directives for the protection and monitoring of air quality – Directives 2004/107/EC and 2008/50/WE – which define the acceptable concentrations of certain pollutants and mandate their monitoring (European Parliament, 2024b). Moreover, Poland will soon be obliged to comply with new standards. The Ambient Air Quality Directive (AAQD) passed in 2024 as part of the European Green Deal aims to update the European air quality standards set 20 years ago and bring them closer to new recommendations published by the World Health Organisation in 2021 (European Parliament, 2024a). Poland, which has been struggling to meet existing standards, will face an even greater challenge with the entry into force of the AAQD Directive. Similar challenges await the country in the context of the Energy Performance of Buildings Directive, another part of the European Green Deal package, introduced in 2024 (European Commission, 2024). The directive provides for the gradual renovation of the buildings with low energy performance across the EU and the introduction of new zero-emission standards. This effort is set to contribute to the EU target of reducing GHG emissions in the building sector by at least 60% by 2030 and decarbonising it completely by 2050.

Against this backdrop, the "Clean Air" programme plays a critical role in addressing environmental, economic and health concerns by replacing old, inefficient and polluting heating sources, along with improving energy efficiency of the Polish housing stock. Given the heightened ambitions at the EU level and Poland's new legal obligations, accelerating and supporting these processes will be of paramount importance. As of October 2024, an estimated 2 million of such furnaces were still operating in Poland, highlighting the continuing need for targeted policy support (Polish Smog Alert, 2024).

[4] Calculations based on data from the Central Statistical Office.

5.1.2. The design and implementation of the scheme

Participation in the programme is available only to owners or co-owners of a single-family house. Persons whose annual income exceeds 135 000 PLN are not eligible to the programme. The amount of subsidy available to beneficiaries is progressive such that the lower the income, the higher the subsidy. Three levels of financing are available since 2022:

- *Basic*: subsidy covers maximum 55% of the eligible renovation costs and is available for persons whose annual income does not exceed 135 000 PLN,
- *Increased*: subsidy covers maximum 80% of the eligible renovation costs and is available for households where monthly income does not exceed 1 894 PLN per person in a multi-persons household and 2 651 PLN in a single-person household,
- *Highest*: subsidy covers maximum 100% of the eligible renovation costs and is available for households where monthly income does not exceed 1 090 PLN per person in a multi-persons household and 1 526 PLN in a single-person household (NFOŚIGW, 2024)[5].

To contextualise these thresholds, at the time the above thresholds were in force, in July 2024 the national minimum wage was set at 3 261.53 PLN net, meaning that a single person, earning a minimum wage did not qualify neither for the *increased* nor the *highest* level of financing (TVN 24, 2024). Furthermore, a single parent household with the same income would only qualify for the *increased* level of support. It is clear then, that the thresholds did not realistically reflect the economic situation of Poles and were not intended to accurately respond to the demand for support by classifying some of the most vulnerable earners as ineligible for additional aid.

The programme has undergone multiple reforms to, for example, adjust the income thresholds, review the eligibility criteria as well as modify the types of renovations eligible. The key changes included the introduction of the *highest* level of financing in January 2022 as well as the reform of the income thresholds in January 2023. The detailed description of the types of beneficiaries and renovations eligible is provided in the Annex 2. Moreover, the thresholds have been increased again as of March 2025. The study, however, covers applications and contracts submitted under old conditions (until Q3 2024).

5.1.3. Descriptive analysis

This section presents an analysis of the “Clean Air” programme outcomes at the municipal level – the smallest administrative unit in Poland – using detailed data obtained from the Regional Funds for Environmental Protection. It begins by exploring how three types of municipalities – urban, urban-rural and rural – benefit differently from the programme. Moreover, it examines the distribution of the subsidies across three funding levels – *basic, increased* and *highest* – with the most economically deprived households qualifying for the *highest* level.

[5] The thresholds relate to net income.

After cleaning the data, the final dataset used in this analysis comprises 1 288 municipalities from 203 counties across nine voivodeships. These include 121 urban, 389 urban-rural and 743 rural municipalities. Additionally, it is important to note that the programme is available to owners of single-family houses. Since the majority of single-family houses is located outside of urban municipalities, these municipalities are naturally expected to have lower programme take-up. However, precise data indicating the exact number of eligible houses is only available at the county level (*powiat*). To address this limitation, an analysis of take-up rates is conducted in Chapter 5.3, which provides comparative county-level analysis of the "Clean Air" and "My Electricity" programmes.

5.1.3.1. Rural areas are the greatest beneficiaries of the "Clean Air" programme

The analysis reveals clear disparities in participation in the programme across municipality types. Rural municipalities submitted the highest number of applications (150 886) and signed the most contracts (140 560), outpacing urban-rural and urban municipalities. Since they are more numerous, less populated and tend to have larger households than urban municipalities, both per capita and per household values for the above-mentioned indicators were calculated to provide a more comprehensive perspective[6]. Even after controlling for population size, rural municipalities maintained the highest participation rates, with 0.038 applications per capita and 0.14 applications per household – more than double the rates observed in urban areas (0.017 and 0.05 respectively). Urban-rural municipalities follow rural municipalities with 0.029 per capita and 0.097 per household applications. This pattern remains the same when looking at the number of contracts signed.

Table 1. Number of applications and contracts by municipality type

Type of commune	**Urban**	**Urban-rural**	**Rural**
Sum of applications[7]	52 571	115 688	150 886
# of applications per capita	0.017	0.029	0.038
# of applications per household	0.05	0.097	0.14
Sum of contracts	44 603	107 555	140 560
# of contracts per capita	0.014	0.024	0.031
# of contracts per household	0.039	0.081	0.11

The final allocation of funding mirrored these trends, with rural municipalities receiving 52% of the total funding within the sample – 4.96 billion PLN (1.17 billion EUR). Combined with

[6] Households in rural areas are more likely to have more children and/or to be multigenerational, comprising grandparents living in the same house. Source (Central Statistical Office, 2023).
[7] Łódzkie voivodeship did not provide data on the total number of applications. Therefore, this number relates only to the eight remaining voivodeships.

urban-rural municipalities, this share increases to 87.3%. In relative terms, rural municipalities were also favoured, with average per capita and per household subsidies of 1 167.3 PLN and 4 298.3 PLN respectively – substantially higher than in urban-rural (793.4 PLN and 2 731.4 PLN) and urban municipalities (378.8 PLN and 1 106.3 PLN).

Table 2. Value of subsidy granted by municipality type

Type of commune	Urban	Urban-rural	Rural
Total value of subsidy granted (PLN)	1 209 124 460	3 366 402 909	4 975 320 922
Average amount of subsidy per municipality (PLN)	9 992 764	8 653 992	6 696 260
Average amount of per capita subsidy (PLN)	378.8	793.4	1 167.3
Average amount of per household subsidy (PLN)	1 106.3	2 731.4	4 298.3
Average value of a contract	26 242.5	31 612	36 655.4

The average rate of rejection or resignation, computed as the percentage difference between the total number of applications submitted and contracts signed, was highest in rural municipalities (22.9%), although urban municipalities followed closely behind (21.9%). Regional disparities were more pronounced, with the rates of rejection or resignation ranging from 13.4% in Opolskie voivodeship to 25.5% in Lubelskie voivodeship.

These results reveal a clear pattern of rural municipalities being the primary beneficiaries of the "Clean Air" programme. This is a natural consequence of the programme's objective of supporting areas with higher share of single-family housing as opposed to multi-family housing, predominant in urban centres. This might also reflect the greater demand for investments covered by the programme in rural municipalities due to older and less energy efficient housing stock as well as a greater share of households relying on solid fuels for heating. Moreover, income might also play a role, with more economically disadvantaged households in need of public support located in rural areas. These correlations are further explored in Chapter 5.3.

However, the relatively high rejection or resignation rates should concern policymakers, as they reflect potential administrative barriers or difficulties faced by households in filling the applications properly. Moreover, the regional divergence in this regard suggests disparities in administrative capacities of the Regional Funds for Environmental Protection. Further support should be offered to these local entities so that they can better support potential beneficiaries in filling the applications, translating into more efficient implementation of the programme.

5.1.3.2. Funds from the "Clean Air" programme flowed primarily to low-income households

Due to the design of the programme and the presence of the three funding levels (*basic*, *increased* or *highest*) it was possible to determine the distribution of the programme across income groups. However, as very granular data on the incomes of individual applicants was not available, the analysis looks at the distribution across funding levels instead.

Table 3. Number of applications and contracts by funding level

Funding level	**Basic**	**Increased**	**Highest**
Sum of applications[8]	157 897	60 470	67 215
Sum of contracts	160 109	58 326	54 861
Share of each funding level	0.59	0.21	0.20

Most applications (157 897) were submitted and the most contracts (160 109) were signed for the *basic* level of financing, directed to the relatively better-off households in the sample. This indicated either higher participation of middle-income households and/or potential barriers for lower-income households in qualifying for *increased* and *highest* levels of support due to stringent and ill-adapted income thresholds. Moreover, it is important to note that the programme is not open to persons whose annual income exceeds 135 000 PLN, suggesting that households who qualify for the basic level are rather middle-class than truly affluent ones.

However, despite the fact that the majority of contracts (59%) were signed for the *basic* level of funding, a significant majority of all the funds spent were allocated for less numerous *increased* and *highest* contracts, aimed explicitly at low-income households. Specifically, the *highest* category alone accounted for almost half of total funding (46%), rising to 67.7% when combined with the *increased* category. Moreover, the average value of a subsidy was calculated as well and demonstrates the progressive nature of the programme's design, with subsidies ranging from 19 733 PLN at the *basic* level to 80 378 PLN at the *highest* level.

Table 4. Subsidy granted by funding level

Funding level	**Basic**	**Increased**	**Highest**
Total value of subsidy granted (PLN)	3 088 844 727	2 068 745 351	4 412 875 156
Average value of a contract (PLN)	19 733	35 793	80 378

This analysis emphasises a key feature of the "Clean Air" programme's design – the progressive allocation of subsidies, supporting economically disadvantaged households. The *increased* and *highest* funding categories received the majority of the total funding, demonstrating that the programme does indeed benefit primarily low-income households. Nevertheless, the prevailing number of contracts signed for the *basic* level relative to the other two categories might suggest that the design of income thresholds restricts access to additional support to a larger number of low-income households. For example, the *basic* category covers both middle-income

[8] Łódzkie voivodeship did not provide data on the total number of applications. Therefore, this number relates only to the eight remaining voivodeships.

households with average monthly net income of up to 11 250 PLN as well as minimum wage earners with income of 3 261.53 PLN. However, the programme does not recognise different needs of such households[9].

5.1.3.3. Share of contracts for different funding levels differs across types of municipalities

Finally, valuable insights are gained when looking at the contracts distribution by the funding level and municipality type. It is clear that depending on the type of municipality, the share of each funding level varies. Urban municipalities predominantly relied on the *basic* level (62.8% of contracts), indicating that fewer households in these areas qualified for additional support. Conversely, rural municipalities have the highest share of contracts for the *increased* (21.5%) and *highest* (24%) levels, reflecting economic disadvantage faced by households in these areas. Rural areas are also the ones where the share of the *highest* category exceeds the *increased* category, suggesting that the larger number of most deprived households resides there.

Table 5. Share of contracts for each funding level by municipality type[10]

	Basic	**Increased**	**Highest**
Urban	62.8%	18.1%	13.4%
Urban-rural	56.2%	19.2%	18.2%
Rural	47.1%	21.5%	24%

Moreover, the value of subsidies granted also varies across municipality types and funding levels with an average subsidy granted ranging from 18 296 PLN for the *basic* level in an urban municipality to 82 240 PLN for the *highest* level in a rural municipality. This is in line with the previous finding, demonstrating the progressive allocation of subsidies.

Table 6. Average subsidy granted by municipality type and funding level

	Basic	**Increased**	**Highest**
Urban	18 296	32 852	72 464
Urban-rural	19 461	35 250	79 658
Rural	20 148	36 643	82 240

The observed correlation emphasises clear socio-economic differences across municipality types in Poland. The greater share of contracts for *increased* and *highest* categories in rural municipalities reflects the higher concentration of economically disadvantaged households in

[9] See Chapter 6 for relevant policy recommendation.
[10] The values do not sum up exactly to 100% due to the presence of "Unknown" category.

these areas. In fact, given the rigid design of the income thresholds, it also sheds light on the extent of poverty in rural Poland as to qualify for the *highest* category, households need to rely on extremely low incomes. At the same time, the predominance of the *basic* category in urban-rural and urban municipalities might suggest lower demand for additional support due to better economic situation but also conceal the scale of actual needs.

5.1.4. Regression analysis

To further examine how the distribution of funding levels, mirroring the level of economic disadvantage of households, relates to a range of socio-economic variables as well as municipality types, a multiple linear regression model was estimated separately for three categories of funding:

$$Share\ of\ funding\ level_m = \beta_0 + \beta_1 Median\ income_m + \beta_2 Population_m + \beta_3 Education_m + \beta_5\ Elderly_m + \beta_6\ Welfare_m + \beta_7\ Unemployed_m + \beta_8\ TypeRural_m + \beta_9\ TypeUrbanRural_m + \varepsilon_c$$

where:

- Share of funding level $_m$ denotes the number of contracts signed in a municipality *m* for a given funding level divided by the total sum of contracts signed in *m*,
- Median income $_m$ is the gross median monthly income in municipality *m*,
- Population $_m$ is the total population of municipality *m*,
- Education$_m$, Elderly$_m$, Welfare$_m$ and Unemployed$_m$ are the shares of population respectively, with higher education, above 65 years old, relying on welfare and registered as unemployed in a municipality *m*,
- TypeRural $_m$ is a binary variable taking value 1 in municipality *m* is rural and 0 otherwise,
- TypeUrbanRural $_m$ is a binary variable taking value 1 in municipality *m* is urban-rural and 0 otherwise. TypeUrban is the baseline.

Table 7. Regression output – Share of each funding level and socio-economic characteristics

	`Share of contracts granted highest funding` (1)	`Share of contracts granted increased funding` (2)	`Share of contracts granted basic funding` (3)
Median_income	-0.0001***	-0.0001***	0.0002***
	(0.00001)	(0.00000)	(0.00001)
Population	0.00000	-0.00000*	-0.00000
	(0.00000)	(0.00000)	(0.00000)
Education	0.320***	0.175***	-1.184***
	(0.075)	(0.046)	(0.107)
Elderly	0.284***	-0.206***	-0.634***
	(0.089)	(0.054)	(0.127)
Welfare	0.735***	0.050	-0.460***
	(0.097)	(0.059)	(0.138)
Unemployed	0.298***	-0.177***	-0.772***
	(0.092)	(0.056)	(0.132)
TypeRural	0.104***	0.006	-0.185***
	(0.011)	(0.006)	(0.015)
TypeUrban-rural	0.045***	-0.010*	-0.089***
	(0.010)	(0.006)	(0.015)
Constant	0.521***	0.709***	-0.265***
	(0.048)	(0.029)	(0.068)
N	1,311	1,311	1,311
R^2	0.326	0.281	0.407
Adjusted R^2	0.322	0.277	0.403
Residual Std. Error (df = 1302)	0.097	0.059	0.138
F Statistic (df = 8; 1302)	78.892***	63.760***	111.739***

Notes: ***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

The outcomes of the regression analysis reveal a clear pattern – more disadvantaged municipalities are more likely to have a higher share of contracts signed for *increased*, and especially *highest* levels of financing.

As expected, economic disadvantage plays an important role, as the eligibility for different levels of funding is linked to income. The share of households relying on welfare support is positively associated with the *highest* level of funding, although is not statistically significant in the case of the *increased* level. This confirms that due to the thresholds design, the *highest* level of support reaches only the most vulnerable households. Expectedly, this relationship is reversed for the *basic* category as it is addressed to the relatively most well-off group of applicants. The unemployment rate emerges as an even more crucial determinant, statistically significant in all three models. It is positively associated with the *highest* level, negative for the *increased* level and strongly negative for the *basic* level.

Demographics also turns out to be an important predictor. The more elderly residents in a municipality, the higher the share of contracts for the *highest* level, reflecting the prevalence of poverty among this group. This relationship is negative for the *increased* and *highest* levels, suggesting that younger municipalities are also better off economically.

An interesting, and somehow counterintuitive, relationship is revealed between the share of population with higher education in a municipality and the share of contracts for each funding level. The more residents with higher education, the higher the share of contracts signed for the *highest* and *increased* levels of funding. Conversely, this relationship is negative for the *basic* level of funding. One of the possible explanations is that higher education may positively impact the ability of residents to seek and take advantage of dedicated support programmes such as the "Clean Air" programme. It might also be helpful in overcoming the administrative burden of submitting the application, which, reflected in high rejection or resignation rates, can be challenging. Secondly, as in absolute terms most contracts were signed for the *basic* level of funding, this category possibly captures the most diverse population, from minimum wage earners to middle-class households. As such, the impact of higher education might not be as clear – perhaps, a good idea for further studies would be to add an interaction term, capturing the effect of higher education in e.g. urban, urban-rural and rural municipalities.

Finally, the type of municipality also plays a key role. Rural municipalities are significantly more likely to have a high share of *highest* contracts, supporting previous findings. This relationship is negative for *increased* and *basic* levels, although significantly more so for the *basic* level. Urban-rural municipalities show a similar, although less pronounced pattern.

Median income and population, although mostly statistically significant, have very small coefficients in all three models. This however does not imply that income does not play a role – it is in fact the main determinant of eligibility to the different funding levels. Rather, this effect may be concealed by the use of the median value, which does not capture the income variation within a municipality. However, more granular income data would be necessary to examine this further.

5.1.5. January 2023 reform of the income thresholds

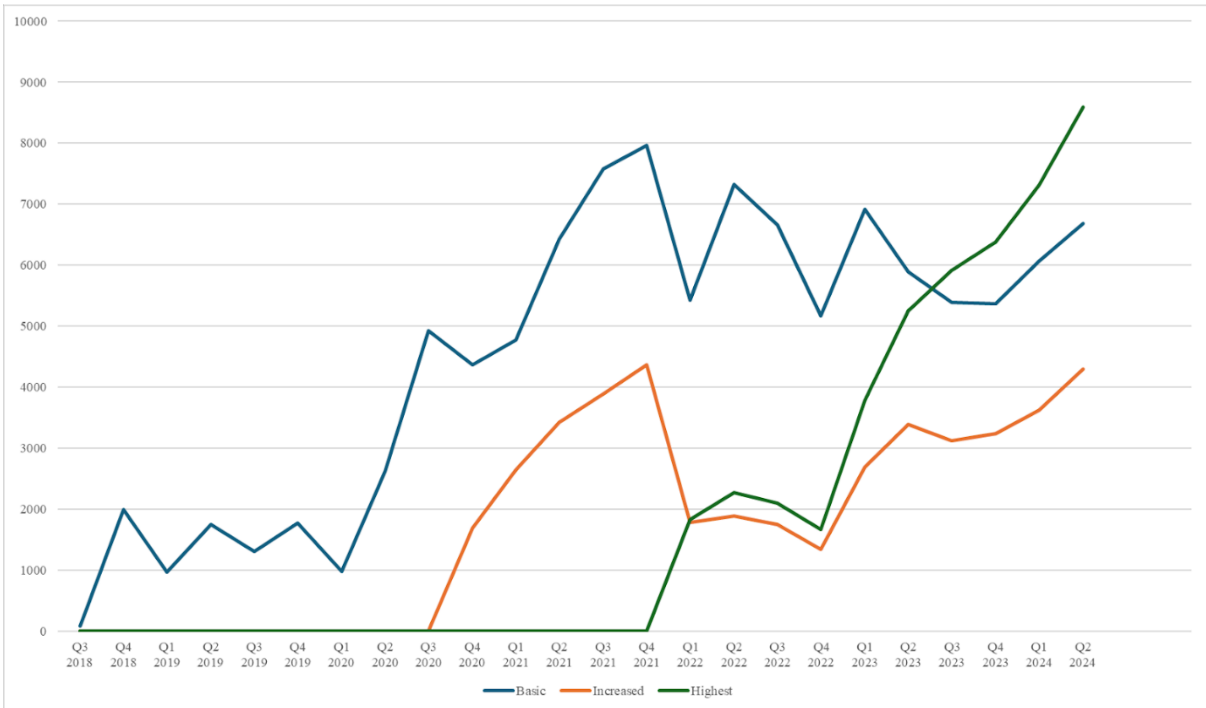
The "Clean Air" programme has undergone multiple modifications since its inception in 2018. These included for example, changes to the types of eligible renovations, the eligibility of newly built houses and, most importantly from the perspective of this work, adjustments of the income thresholds. A detailed description of these modifications is provided in the Annex 2. This section focuses on analysing the impact of one of the key changes implemented in January 2023, which increased the income thresholds by approximately 21%:

- For the *increased* level of financing, the thresholds increased:
  - from 1564 PLN to 1894 PLN per person in a multi-persons household and
  - from 2189 PLN to 2651 PLN per person in a single-person household.
- For the *highest* level of financing, the thresholds increased:
  - from 900 PLN to 1090 PLN per person in a multi-persons household and
  - from 1260 PLN to 1526 PLN per person in a single-person household.

Unfortunately, the difference-in-differences approach could not be employed in this context, as the reform was introduced simultaneously in all the regions, making it impossible to identify a proper control group. Instead, before and after comparisons are made to assess whether significant changes occurred after the implementation of the reform, while acknowledging the limitations stemming from inability to isolate causal effects.

The analysis is based on quarterly data on the number of contracts signed from Podlaskie, Opolskie, Łódzkie, Pomorskie and Lubelskie voivodeships which provided data disaggregated by quarter and level of financing. The graph below presents the evolution of the number of contracts signed for all three levels of financing[11].

Graph 1. Evolution of contracts signed by the funding level (2018-2024)



As expected, as the reform did not target beneficiaries of the *basic* level of financing, no notable changes were observed after the implementation of the reform in Q1 2023. A moderate, statistically insignificant increase is observed in the number of *increased* contracts signed following the reform, with a 9.2% increase (p-value = 0.5231). However, excluding data prior to the introduction of the *highest* category in 2022, the increase rises to 33.2%, although remains statistically insignificant (p-value = 0.06739)[12].

A notable and statistically significant increase can be observed in the case of the *highest* level of financing. While the average sum of contracts signed before the reform was only 313 per quarter per voivodeship, it rose to 825 after Q1 2023, a 163.6 % increase (p-value = 1.395e-05).

The reform of January 2023 seems to have significantly boosted participation of the low-income households eligible for the *highest* level of financing. This indicates that increasing income thresholds can considerably broaden access to the programme for households in need. The moderate increase was also observed for the *increased* level, although not statistically

[11] The data for 2024 is incomplete as at the time of reception of the data, the Regional Funds for Environmental Protection were still in the process of completing data from Q3 and Q4. As such, the graph goes up to Q2 2024.
[12] The relatively moderate effect for the *increased* category might be partly explained by its already high levels pre-2022, i.e. before the introduction of the *highest* category. In fact, before 2022 the *increased* category likely might have captured many beneficiaries who would later switch to the *highest* category. When excluding pre-2022 values from the sample, the average number of contracts before the reform drops to 355 and the percentage increase after the reform increases to 33.2%. Although still not statistically significant (as the p-value = 0.06739), this result suggests a stronger reform effect than captured initially.

significant. These findings suggest that financial accessibility remains a critical barrier to accessing programmes such as “Clean Air”. Adjusting income thresholds, and thus making more households eligible for support, can increase participation in such schemes and make them more equitable. Nevertheless, it is important to note that this analysis does not identify the causal effects of the reform and is preliminary and exploratory in its nature.

5.1.6. Air pollution analysis

This section examines the impact of the take-up of the “Clean Air” programme on the concentration of three key pollutants: PM10, PM2.5 and BaP (benzopyrenes). These three indicators were chosen due to their proven link to the use of solid fuels in residential heating (Health & Environment Alliance, 2014). The data was obtained from the Chief Inspectorate for Environmental Protection in Poland which is the official public entity in charge of conducting air pollution monitoring. The analysis is based on data for the years 2014-2023 from all monitoring stations located in the nine voivodeships for which the “Clear Air” data was available[13]. The final sample differs for each pollutant, as not all monitoring stations were installed at the same time in all municipalities. Moreover, not all stations measure the same pollutants, so the number of data points differs across three pollutants examined.

5.1.6.1. Annual mean PM10 concentrations

The sample for PM10 analysis includes 106 municipalities where air quality monitoring stations are located. In this section, programme take-up was calculated as the number of contracts signed in a municipality per household, as data on the number of single-family houses was unavailable at the municipality level. Municipalities were also divided into quartiles to allow for comparison between low- and high-participation areas.

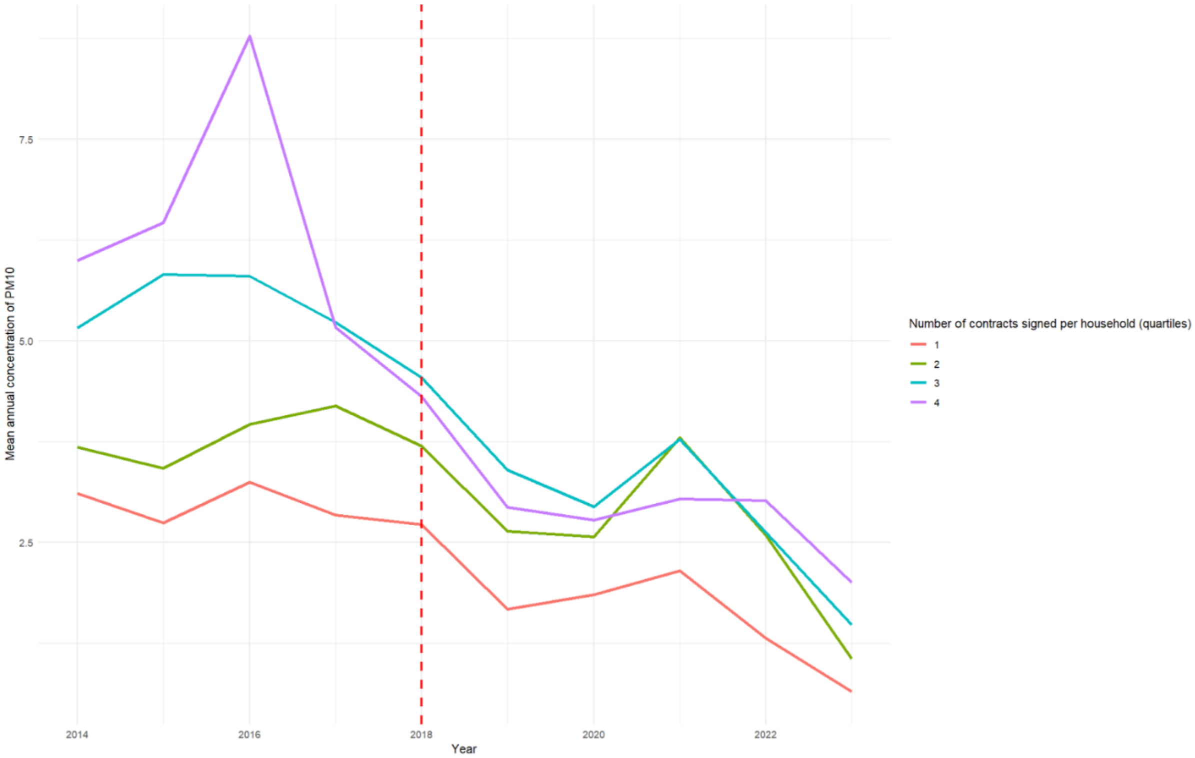
First, the evolution of annual mean PM10 concentrations was plotted, broken into participation quartiles. The analysis revealed significant variation in annual mean PM10 concentrations depending on the intensity of programme participation. Municipalities in the 3rd and 4th quartiles, i.e. those with the highest participation rates, had significantly higher levels of PM10 before the launch of the programme in 2018. This likely reflects greater reliance on solid fuels for heating, and potentially, greater awareness of the impacts on air quality, which might have motivated greater engagement with the programme.

Despite improvements, the same municipalities are still more disadvantaged today, exhibiting higher levels of PM10 compared to municipalities in lower quartiles. This might be due to structural disadvantages, for example related to the quality of housing stock or the presence of other sources of pollution, which continue to pose challenges and might require more comprehensive policy interventions.

[13] Although available, data pre-2014 was excluded due to considerably higher levels of pollution, distorting the annual concentration means before the introduction of the programme.

Finally, all quartiles experienced a general decline in PM10 concentrations over the period studied. However, as this trend predates the introduction of the programme in 2018, possibly due to other policies aiming at reduction of PM10, it is difficult to isolate its causal impact.

Graph 2. Change in mean annual PM10 concentrations



To further investigate whether higher participation in the programme is associated with larger reductions in annual mean PM10 concentrations after 2018, regression analysis was employed.

The first model investigates whether higher programme take-up, measured as the number of contracts per household, is associated with higher declines in PM10 concentrations after 2018, i.e. the introduction of the programme:

$$PM10_{\,m,y} = \beta_0 + \beta_1 Post2018_y + \beta_2 Participation_m + \beta_3\,(Post2018_y\; Contracts\; per\; household_m\,) + \varepsilon_{m,y}$$

where:

- PM10 $_{m,\,y}$ is the annual mean PM10 concentration in municipality *m* in year *y*,
- Post2018 $_{y}$ is a binary variable taking value 0 in the years 2014-2018 and 1 in the years 2019-2023,
- Contracts per household $_{m}$ is a continuous variable measuring number of contracts signed per household in a municipality *m*,
- Post 2018 $_{y}$ * Contracts per household $_{m}$ is an interaction term testing whether municipalities with higher participation experienced greater PM10 reductions after 2018.

Table 8. Regression output – Per household contracts and reduction in PM10

Per household contracts and reduction in PM10	
	Mean_PM10
Post2018	-1.192***
	(0.271)
`Contracts per household`	32.115***
	(3.516)
Post2018:`Contracts per household`	-20.597***
	(4.600)
Constant	3.051***
	(0.199)
N	627
R^2	0.275
Adjusted R^2	0.271
Residual Std. Error	2.158 (df = 623)
F Statistic	78.659*** (df = 3; 623)
Notes:	***Significant at the 1 percent level.
	**Significant at the 5 percent level.
	*Significant at the 10 percent level.

The model confirms a statistically significant and negative relationship between programme participation and mean annual PM10 concentrations after 2018. The *Post2018* coefficient indicates a general reduction in PM10 after 2018, with a 1.192 µg/m3 drop on average. The large and positive *Contracts per household* coefficient suggests that the municipalities with higher programme participation had significantly higher PM10 concentrations before 2018. Finally, the large and negative coefficient for the interaction term shows that indeed, higher intensity of participation in the programme is associated with larger reductions in PM10. Importantly, all coefficients are statistically significant at the 1 percent level.

To complement the above model, four separate regressions were tested to compare the changes in PM10 concentrations across quartiles of programme take-up. The following regression model was employed for each quartile:

$$PM10_{\,m,y} = \beta_0 + \beta_1 Post2018_y + \beta_2 Quartile_m + \beta_3 \left(Post2018_y\ Quartile_m\right) + \varepsilon_{m,y}$$

where:

- $PM10_{m,y}$ is the annual mean PM10 concentration in municipality *m* in year *y*,
- $Post2018_y$ is a binary variable taking value 0 in the years 2014-2018 and 1 in the years 2019-2023,
- $Quartile_m$ is a binary variable indicating whether municipality *m* belongs to a given take-up quartile,
- $Post\ 2018_y * Quartile_m$ is an interaction term testing whether municipalities in a given take-up quartile experienced greater PM10 reductions after 2018.

Table 9. Regression output – Reduction in PM10 by take-up quartiles[14]

Reduction in PM10 by take-up quartiles

	Mean_PM10			
	(1)	(2)	(3)	(4)
Post2018	-2.305***	-2.288***	-1.889***	-1.675***
	(0.205)	(0.214)	(0.212)	(0.207)
LowTakeUp	-2.067***			
	(0.296)			
Post2018:LowTakeUp	0.876**			
	(0.408)			
MediumLowTakeUp		-0.887***		
		(0.315)		
Post2018:MediumLowTakeUp		1.019**		
		(0.427)		
MediumHighTakeUp			1.145***	
			(0.314)	
Post2018:MediumHighTakeUp			-0.560	
			(0.424)	
HighTakeUp				2.052***
				(0.319)
Post2018:HighTakeUp				-1.643***
				(0.420)
Constant	4.995***	4.666***	4.153***	3.976***
	(0.153)	(0.159)	(0.157)	(0.152)
N	627	627	627	627
R^2	0.241	0.171	0.183	0.215
Adjusted R^2	0.238	0.167	0.179	0.211
Residual Std. Error (df = 623)	2.207	2.307	2.290	2.245
F Statistic (df = 3; 623)	66.087***	42.802***	46.515***	56.887***

Notes: ***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

These results indicate that municipalities with highest take-up rates, i.e. those which rank in the fourth quartile for the number of contracts per household experienced an additional reduction in PM10. For these municipalities, the post-2018 reduction in PM10 concentrations is significantly larger than in the other three quartiles, as evidenced by the negative and statistically significant *Post2018*HighTakeUp* coefficient. High take-up is associated with an additional 1.643 µg/m3 drop in mean annual PM10 concentration. In the case of other quartiles, the analogous interaction terms' coefficients are either statistically insignificant or are positive, suggesting that in those municipalities other factors, aside from programme participation, might have played a bigger role in reducing PM10 levels. Moreover, this may indicate that the

[14] The model was tested for all four take-up quartiles: 1st quartile (LowTakeUp), 2nd quartile (MediumTakeUp), 3rd quartile (MediumHighTakeUp), 4th quartile (HighTakeUp).

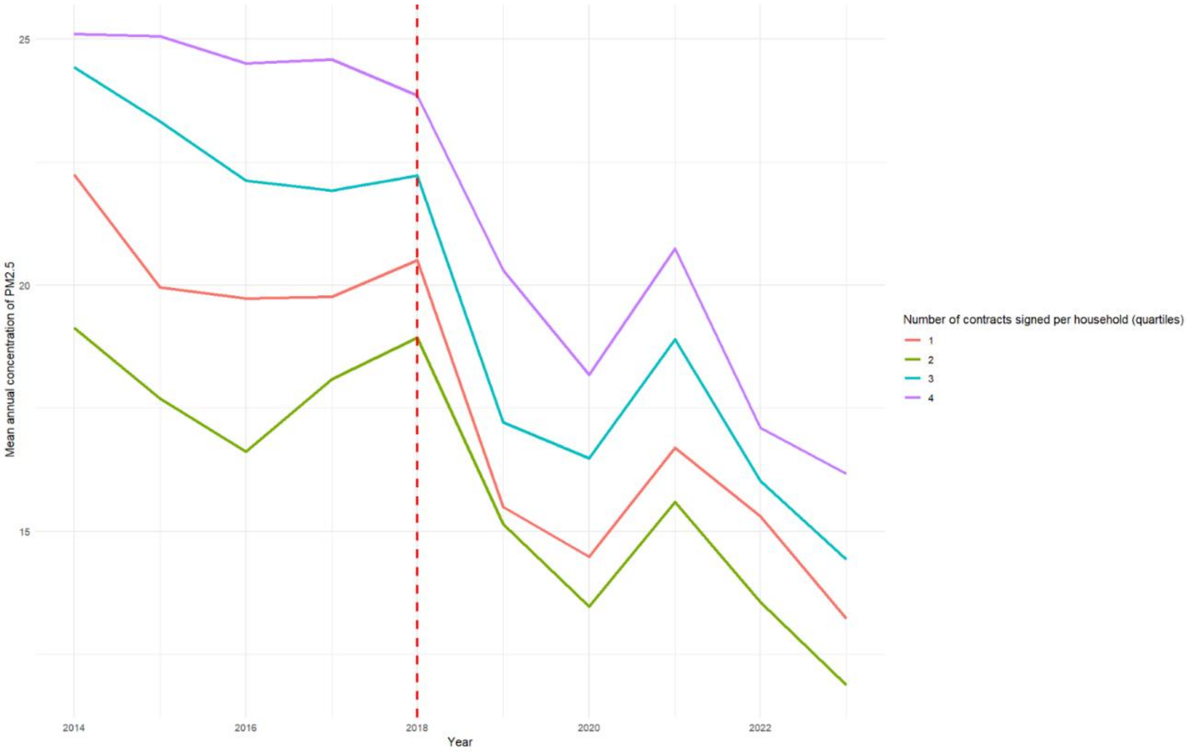
replacement of heating sources has a noticeable impact on air quality only after a certain scale of participation has been reached.

5.1.6.2. Annual mean PM2.5 concentrations

The sample for PM2.5 comprises unfortunately only 29 municipalities with available monitoring stations. As in the case of the PM10 analysis, the take-up was measured as the number of contracts signed per household, and municipalities were grouped into quartiles.

The graph below shows a similar pattern as before with municipalities in the 3rd and 4th quartile of the programme take-up started with higher levels of PM2.5 and continued to have the worst air quality throughout the 2014-2023 period. However, while in the previous case, PM10 was dropping quite constantly throughout the observation period, PM2.5 seems to have dropped more significantly after 2018, coinciding with the implementation of the programme.

Graph 3. Change in mean annual PM2.5 concentration



While these trends are encouraging, they are not sufficient to isolate the programme's impact. Therefore, analogous regression models were employed to test whether the relationship between the reduction in PM2.5 and the intensity of programme participation is statistically significant.

Table 10. Regression output – Per household contracts and reduction in PM2.5

Per household contracts and reduction in PM2.5	
	Mean_PM25
Post2018	-4.523***
	(0.614)
`Contracts per household`	80.985***
	(10.861)
Post2018:`Contracts per household`	-30.482**
	(15.101)
Constant	19.201***
	(0.432)
N	261
R^2	0.457
Adjusted R^2	0.451
Residual Std. Error	3.652 (df = 257)
F Statistic	72.244*** (df = 3; 257)
Notes:	***Significant at the 1 percent level.
	**Significant at the 5 percent level.
	*Significant at the 10 percent level.

The first model shows a statistically significant general reduction in PM2.5 concentrations after 2018 regardless of participation in the programme. However, this is not sufficient to isolate the programme's impact as other factors might have been present, such as other environmental policies or local initiatives aimed at reducing air pollution. Interestingly, this model too confirms that municipalities where more contracts per household were signed, exhibited significantly higher levels of PM2.5 in the "before" period. Finally, the coefficient for the interaction term is negative and statistically significant, meaning that municipalities with higher programme take-up experienced additional reductions in PM2.5 levels. However, the standard error is quite large and the coefficient is significant only at the 5% level compared to the others. While its negative direction is encouraging, caution is needed when interpreting the magnitude of the effect.

To better capture potential non-linear patterns, a second approach estimating separate models for each take-up quartile was used.

Table 11. Regression output – Reduction in PM2.5 by take-up quartiles

Reduction in PM2.5 by take-up quartiles

	Mean_PM25			
	(1)	(2)	(3)	(4)
Post2018	-5.316***	-5.812***	-5.055***	-5.139***
	(0.592)	(0.548)	(0.590)	(0.550)
LowTakeUp	-1.293			
	(0.813)			
Post2018:LowTakeUp	-0.074			
	(1.179)			
MediumLowTakeUp		-4.474***		
		(0.754)		
Post2018:MediumLowTakeUp		1.642		
		(1.100)		
MediumHighTakeUp			1.939**	
			(0.836)	
Post2018:MediumHighTakeUp			-1.147	
			(1.181)	
HighTakeUp				4.183***
				(0.780)
Post2018:HighTakeUp				-1.007
				(1.102)
Constant	21.734***	22.565***	20.934***	20.398***
	(0.415)	(0.385)	(0.408)	(0.381)
N	261	261	261	261
R^2	0.305	0.402	0.308	0.398
Adjusted R^2	0.297	0.395	0.300	0.391
Residual Std. Error (df = 257)	4.134	3.834	4.124	3.848
F Statistic (df = 3; 257)	37.591***	57.641***	38.153***	56.556***

Notes: ***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

While the direction of the coefficients is consistent with what was observed in the case of PM10, the interaction terms are not statistically significant. This may be due to a very small sample size comprising only 29 municipalities compared to 106 in the PM10 analysis. Nevertheless, given these initial results, further research with more comprehensive air quality data could shed light on the exact magnitude of the potential effects.

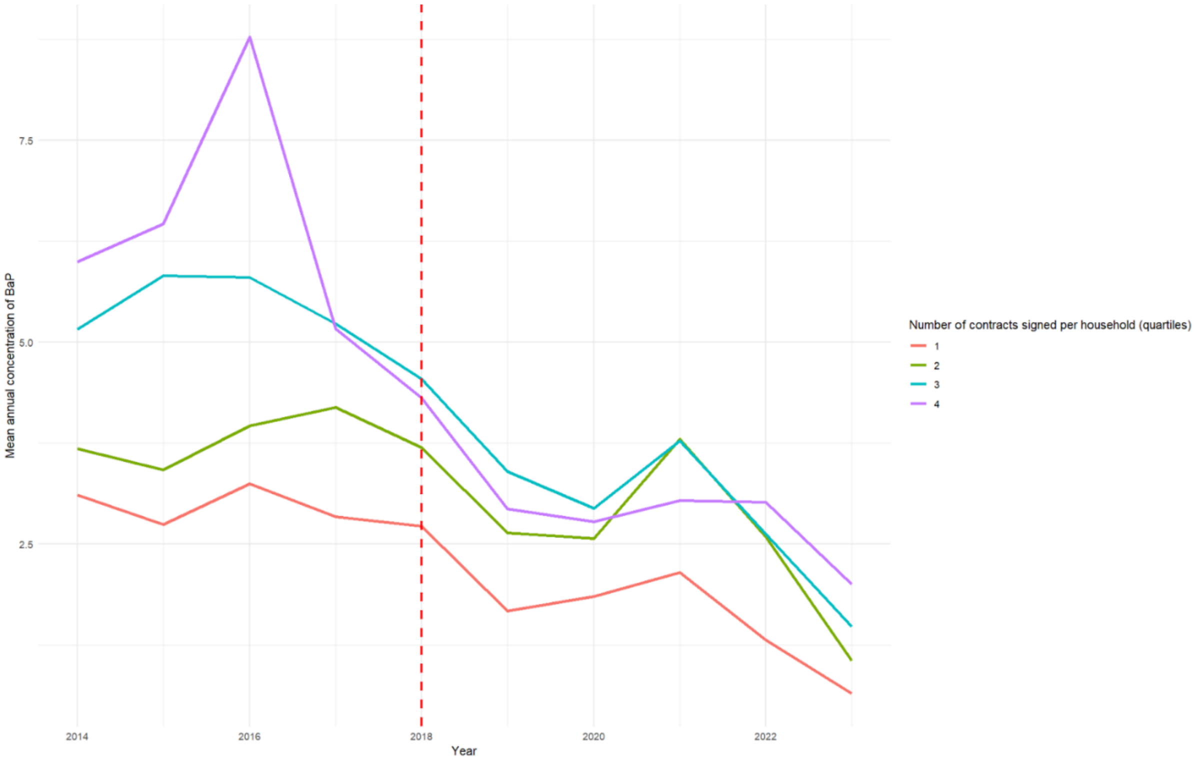
5.1.6.3. Annual mean benzopyrenes (BaP) concentrations

Finally, the reduction in the level of benzopyrenes was tested. 103 municipalities where monitoring stations are located are in the sample. The analysis was carried out exactly as in the two previous cases.

The graph shows a similar trend as in the previous cases with municipalities in the higher quartiles exhibiting higher levels of BaP concentrations prior to the inception of the programme. However, by 2023, BaP levels in these most active municipalities still remain above those in the 1st and 2nd quartiles.

Although all quartiles experienced a drop in BaP concentrations post 2018, the pace and extent of improvement varied with municipalities in the fourth quartile experiencing the sharpest drop, primarily due to improvements in Łódzkie voivodeship.

Graph 4. Change in mean annual BaP concentration



To assess the relationship between the reduction in BaP levels and participation in the "Clean Air" programme, the same regression models were employed.

Table 12. Regression output – Per household contracts and reduction in BaP

Per household contracts and reduction in BaP	
	Mean_BAP
Post2018	-1.192^{***}
	(0.271)
`Contracts per household`	32.115^{***}
	(3.516)
Post2018:`Contracts per household`	-20.597^{***}
	(4.600)
Constant	3.051^{***}
	(0.199)
N	627
R^2	0.275
Adjusted R^2	0.271
Residual Std. Error	2.158 (df = 623)
F Statistic	78.659^{***} (df = 3; 623)
Notes:	***Significant at the 1 percent level.
	**Significant at the 5 percent level.
	*Significant at the 10 percent level.

Again, the first model points to a general reduction in BaP levels post after 2018, not attributable particularly to the programme. The large and positive coefficient for the variable *Contracts per household* points as well that municipalities with higher participation had high initial BaP concentrations. Finally, the large and negative interaction term suggests that municipalities with higher participation experienced large additional reductions in BaP post 2018. Importantly, all coefficients are statistically significant at the 5% level.

Another model tested this effect across four quartiles of the programme take-up.

Table 13. Regression output – Reduction in BaP by take-up quartiles

Reduction in BaP by take-up quartiles

	Mean_BAP			
	(1)	(2)	(3)	(4)
Post2018	-2.305***	-2.288***	-1.889***	-1.675***
	(0.205)	(0.214)	(0.212)	(0.207)
LowTakeUp	-2.067***			
	(0.296)			
Post2018:LowTakeUp	0.876**			
	(0.408)			
MediumLowTakeUp		-0.887***		
		(0.315)		
Post2018:MediumLowTakeUp		1.019**		
		(0.427)		
MediumHighTakeUp			1.145***	
			(0.314)	
Post2018:MediumHighTakeUp			-0.560	
			(0.424)	
HighTakeUp				2.052***
				(0.319)
Post2018:HighTakeUp				-1.643***
				(0.420)
Constant	4.995***	4.666***	4.153***	3.976***
	(0.153)	(0.159)	(0.157)	(0.152)
N	627	627	627	627
R^2	0.241	0.171	0.183	0.215
Adjusted R^2	0.238	0.167	0.179	0.211
Residual Std. Error (df = 623)	2.207	2.307	2.290	2.245
F Statistic (df = 3; 623)	66.087***	42.802***	46.515***	56.887***

Notes: ***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

Indeed, the municipalities with the highest take-up experienced an additional reduction in BaP levels after 2018, as the coefficient for the interaction term *Post2018*HighTakeUp* is negative and statistically significant. This is not the case in the 3rd quartile (MediumHighTakeUp). In contrast, the interaction terms for the two lowest quartiles are positive, suggesting that in their case the drop in BaP was not necessarily due to engagement in the programme.

The analysis presented in this chapter presents preliminary and limited yet encouraging findings that the "Clean Air" programme seems to be associated with sharper drops in certain pollutants especially in municipalities with high take-up of the programme, measured as the number of contracts signed per household. The municipalities where participation in the "Clean Air" programme was the highest, experienced additional reductions in mean annual PM10 and BaP concentrations. In contrast, municipalities with lower programme participation and lower initial pollution levels also experienced reductions but these seem to be driven by other factors rather than engagement with the programme. This suggests that the more polluted municipalities self-sort into the programme, perhaps because of greater environmental need combined with the rising awareness of the impacts of residential solid fuels heating on air quality. Thus, the programme seems to be indeed achieving its objective by reaching municipalities in need of support. Importantly, of the three pollutants analysed, the effects were statistically significant for PM10 and BaP. Results for PM2.5, a pollutant closely linked with residential heating, were mixed, possibly due to a significantly smaller sample size.

However, the findings also point to the existence of persistent disadvantages with municipalities with higher initial levels of PM10, PM2.5 and BaP, remaining the most polluted in 2023 as well. Although notable progress has been made, this suggests that the share of houses heated with solid fuels is still relatively high in these areas or there are other factors at play, such as the presence of polluting industries. As pointed out by the environmental justice literature presented in Chapter 3, areas with high levels of pollution also tend to face multiple disadvantages, pointing to the existence of broader, structural problems.

Finally, the findings indicate that achieving measurable results necessitates sufficient scale, especially in municipalities that might be struggling with multiple sources of pollution. Although municipalities in all quartiles of programme participation achieved reductions across all three pollutants examined, the additional effects of programme participation were present only in municipalities with the highest take-up[15]. This suggests that to generate improvements in air quality, a certain share of residents needs to engage in the replacement of polluting heating sources. Fortunately, the peer effect was recently found to be quite significant in the case of the "Clean Air" programme, which might translate into higher take-up of the programme in the near future, further improving air quality (Sokołowski, Madoń and Frankowski, 2025).

Overall these findings should be interpreted with caution. This analysis remains exploratory and is limited by the lack of a control group, existence of other factors contributing to air pollution reductions, not controlled for in this study, as well as scarce air quality data. Nevertheless, the study provides encouraging initial results that the "Clean Air" programme might have contributed to the reduction in PM10 and BaP levels in municipalities with high take-up.

5.2. The "My Electricity" programme

5.2.1. Why was the "My Electricity" programme needed?

Poland has long been infamous in the EU for its strong reliance on coal. While the previous chapter explored its role in residential heating, it has also been historically the primary source of electricity generation, accounting for 73.9% of Poland's electricity mix in 2019 (Forum Energii, 2025a). However, the country's energy landscape has since undergone an enormous

[15] Importantly, these effects were only visible in the case of PM10 and BaP.

transformation, with coal's share in electricity generation dropping to 57% in 2024, mainly due to an expansion of renewable energy sources and solar power in particular (Forum Energii, 2025a). This growth was due to several factors: the introduction of the auction system in Poland, increasing prices of emission allowances, increased availability of dedicated EU funding and finally, subsidies under the "My Electricity" programme (Igliński *et al.*, 2023).

The scale and pace of this transformation has exceeded expectations. The share of solar in the electricity mix increased from just 0.4% in 2019 to 9% in 2024 – a staggering 2150% increase (Forum Energii, 2025a). This unprecedented growth has caught the government by surprise, reflected in much more conservative solar development forecasts developed previously. Most notably, the Polish Energy Policy 2040 published in 2021 has been quickly rendered obsolete, as it predicted the solar capacity to reach 10-16 GW in 2040 – it reached 12 GW already in 2022 (Ministry of Climate and Environment, 2021; Instytut Energetyki Odnawialnej, 2023).

Since its launch in 2019, "My Electricity" has played an important role in accelerating the deployment of solar power. As of December 2024, more than 1.5 million photovoltaic micro-installations with a total capacity exceeding 12 GW were connected to the national grid (Rynek Elektryczny, 2025). This represents almost 60% of the total solar installed capacity in Poland, which stood at over 21 GW at the end of 2024 (Rynek Elektryczny, 2025). With over 555 000 funding contracts signed under the "My Electricity" programme, it has thus subsidised one in three PV micro-installations in the country, testifying to its crucial role in the Polish energy transition.

5.2.2. The design and implementation of the scheme

The programme has been revised and expanded several times to adjust the subsidy amount as well as include additional types of installations. For example, at its inception in 2019, the programme granted only up to 5 000 PLN for a PV micro-installation (2-10 kW). Today, as part of the sixth edition of the programme, a beneficiary can obtain even up to 28 000 PLN for a PV micro-installation, energy storage and heat storage installations. Nevertheless, the programme's constant feature is that it can cover only up to 50% of the eligible investment costs.

Another major change occurred in April 2022, when the net-metering system was replaced with a net-billing system for all new prosumers. Following this change, investments in solar micro-installations slowed significantly as the new system, designed to promote self-consumption and to better reflect market prices, might offer less profitable conditions for selling surplus energy unless combined with an energy storage installation (Gramwzielone.pl, 2025). An overview of the programme design across editions as well as its budget is provided in the Annex 3.

The key feature that distinguishes "My Electricity" from the "Clean Air" programme lies in their affordability. "My Electricity" does not impose the income cap, meaning that the programme is available to all owners of single-family houses regardless of income. However, at the same time, no funding levels exist meaning that the amount of the subsidy granted is not reflective of the household's actual needs. Finally, "My Electricity" demands that the beneficiaries cover at least 50% of the costs, making it more burdensome for capital-constrained households. This is an important difference between the two programmes as the "Clean Air" ties the degree of funding to income, and thus makes it more inclusive to low-income households.

5.2.3. Results

This chapter presents main results for the analysis of the "My Electricity" programme. A notable advantage of the dataset used in this chapter is its nationwide coverage, allowing for a more in-depth regional comparison than in the case of the "Clean Air" programme. However, the data also has some important limitations. Due to inconsistencies in how the data was originally recorded by the National Fund for Environmental Protection and Water Management, the analysis could only be conducted at the county (*powiat*) instead of municipal (*gmina*) level, losing some of the granularity.

At the same time, such a larger-scale aggregation enabled the creation of a new, important indicator – take-up rate, calculated by comparing the number of applications or contracts to the number of single-family houses in a county, actually eligible to the programme. As the programme targets single-family houses which are less prevalent in urban areas and tend to dominate in suburban and rural areas, this indicator is more appropriate compared to the *number of contracts per household in a municipality* used in the previous chapter.

5.2.3.1. Take-up of the programme differs across county types with suburban counties being the most active

Since the original dataset did not include a classification of municipalities by type as in the case of the "Clean Air" programme (into *urban*, *urban-rural* and *rural*), a proxy variable was created to capture the differences in the degree of urbanisation and socio-economic characteristics across counties. To this aim, Poland's administrative division was exploited. The country comprises 314 counties (*powiaty*) and 66 cities with county rights (*miasta na prawach powiatu*) (Central Statistical Office, no date). These cities, which function at the same time as a city and a county, were assigned the value "1" (city).

In the second category, assigned the value "2" (suburb) are 45 "ring counties" which surround the largest cities (Kwaśny, 2023). For example, Cracow is a large city with county rights and is bordered by "Cracow county". These "ring counties" were singled out to capture the trend of suburbanisation, which has been ongoing in Poland for the past three decades, which describes the process of, mainly middle- and upper-income families, relocating from major cities to suburbs in surrounding ring counties, while continuing to commute to urban centres to work and study (Jadach-Sepioło and Legutko-Kobus, 2021). As such, ring counties tend to have higher median incomes and bigger populations compared to other counties, making them a distinct and interesting group for this analysis[16].

The remaining 269 counties, which are neither cities nor ring counties closely linked to them, were thus gathered in the third category and denoted as “3” (other). These are typically small-town or rural areas.

Table 14. Description of the sample

	1 - City	2 - Suburbs	3 - Other
Number of counties in the sample	66	45	269
Total population	12 340 005	5 181 562	20 176 727

In absolute terms, *other* counties dominate the programme, accounting for 64% of all applications, 64% of all contracts and 63% of all funds distributed. Suburbs follow, representing 24% of all three indicators.

Table 15. Applications, contracts and subsidies by county type – absolute differences

	1 - City	2 - Suburbs	3 - Other
# of applications	65 593	123 839	333 031
# of contracts	62 703	118 903	318 908
Total value of subsidy granted (PLN)	368 780 722	663 062 697	1 748 351 257

However, given that *other* counties dominate in the sample, it is more useful to look at *per capita* values. Interestingly, now the highest values are observed for the suburban counties with 0.023 contracts signed *per capita*, followed by *other* counties with 0.016. Urban counties visibly lag behind with only 0.005 contracts signed *per capita*, over four times fewer than in the suburbs and three times fewer than in the *other* counties. This is most likely due to the housing characteristics, with cities dominated by multi-family apartment buildings ineligible to the programme.

Table 16. Applications, contracts and subsidies by county type – *per capita* differences

	1 - City	2 - Suburbs	3 - Other
# of applications per capita	0.0053	0.0239	0.0165
# of contracts per capita	0.0051	0.0229	0.0158

[16] Based on the author's own calculations based on data from the Central Statistical Office: on average Cities have a median income of 6 473.89 PLN and population of 104 710; Suburbs 6 039.75 PLN and 96 166 and Other 5989.20 PLN and 66 488.

Total value of subsidy granted per capita (PLN)	29.88	127.97	86.65

However, these stark differences diminish significantly when considering a different, more appropriate indicator – average take-up. It turns out that among the eligible households, the participation in the programme was still the highest in the suburbs, but cities overtake the *other* counties, despite the findings in Table 16.

As suburbs and cities are on average wealthier compared to *other* counties this might suggest that the take-up is somehow related to income. This would be in line with the hypothesis that “My Electricity” benefits wealthier groups and regions because the amount of subsidy is not proportional to income and participation requires significant upfront investment. This is further explored in the next chapter.

Table 17. Average take-up by county type

	1 - City	2 - Suburbs	3 - Other
Average take-up - applications	0.097	0.112	0.094
Average take-up - contracts	0.092	0.107	0.090

These differences between county types were tested with ANOVA and are statistically significant at the $p\text{-value} < 0.05$ level.

Finally, the average rejection or resignation rate was calculated to see whether some types of counties are more or less effective in obtaining the subsidy. On average, cities had the highest rejection rate of 4.79%, followed by *other* counties with 4.41% and suburbs with 4.21%. However, these differences were not statistically significant.

To sum up, a nuanced picture emerges when analysing the programme’s distribution across different county types through different lenses. While in absolute terms *other* counties, presumably more small-town or rural, dominate, this is primarily due to their larger number and population. Once adjusted for population size and eligibility, it appears that suburban counties are the most active participants across the remaining indicators.

The high level of participation of the suburbs might be linked to higher on average incomes compared to the *other* counties. Higher upfront costs due to the requirement of covering at least 50% of investment costs might be important barriers for participation in the programme for less affluent households. The same reason might explain why cities slightly overtake *other* counties, when looking at average take-up rates.

At the same time, lower participation rates in *other* counties, when adjusted for population and eligibility, raises concerns about potential barriers their residents face, for example lack of sufficient capital, lower awareness or administrative barriers.

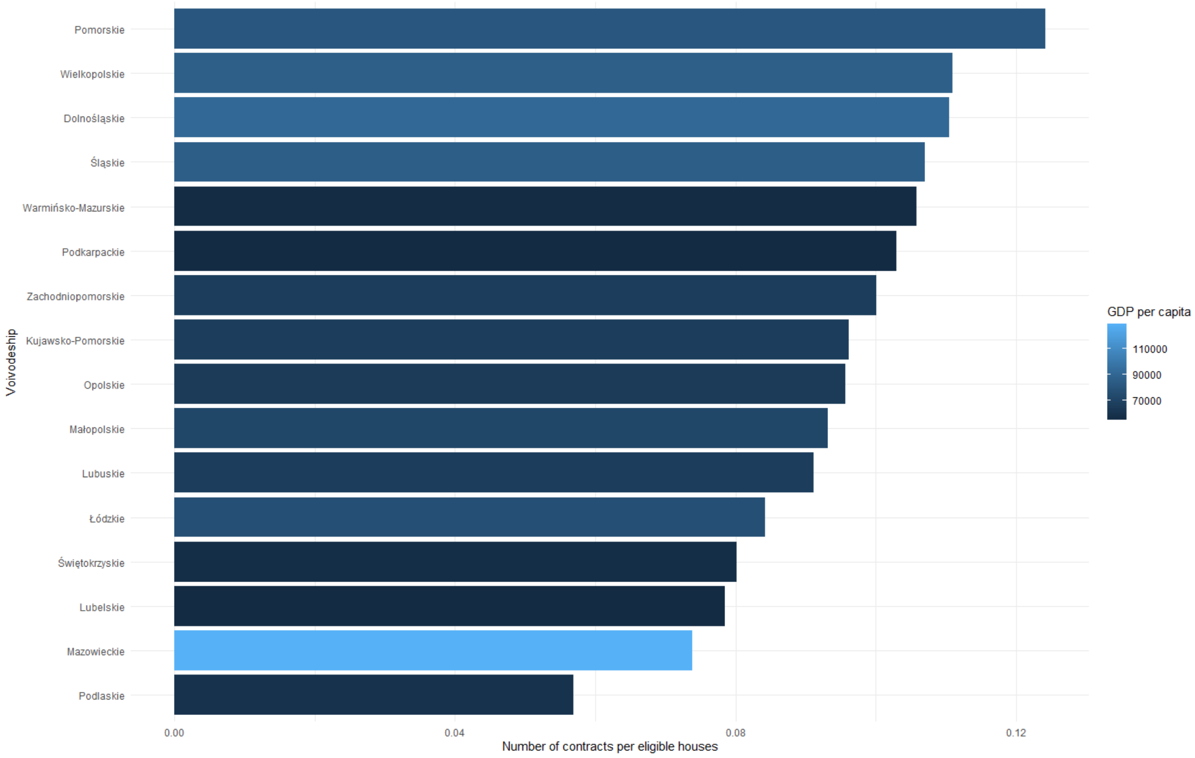
Notably, rejection or resignation rates across county types were found to be small and statistically insignificant, suggesting that most applications are approved, regardless of location. This is contrary to the "Clean Air" programme where rejection or resignation rates were significantly higher.

5.2.3.2. Important regional disparities exist in the take-up of the "My Electricity" programme

Despite the programme being universal, i.e. available for everyone owning or co-owning a single-family house regardless of income, its take-up differs significantly across the voivodeships. An average take-up ranges from little less than 0.06 in Podlaskie region to over 0.12 in Pomorskie region, a more than twofold difference.

To explore whether the level of wealth in the region might help explain these differences, GDP per capita of the region and average take-up was plotted on the graph. Indeed, top performers, with the exception of the Mazowieckie voivodeship, are among the wealthiest voivodeships in the country. The four voivodeships with the highest take-up are Pomorskie, Wielkopolskie, Dolnośląskie and Śląskie which in terms of GDP per capita rank respectively 5th, 3rd, 2nd and 4th in the country. The four poorest performers are: Świętokrzyskie (14th), Lubelskie (16th – the poorest), Mazowieckie (1st) and Podlaskie (12th) voivodeships. The poor performance of the Mazowieckie voivodeship is particularly interesting – perhaps its low average take-up rate reflects lower need for support as well as larger deployment of PV microinstallations prior to the inception of the programme. Future research could also look at Mazowieckie excluding Warsaw, which is the capital of the country and thus, skews the GDP per capita value.

Graph 5. Average take-up of the "My Electricity" programme by voivodeship



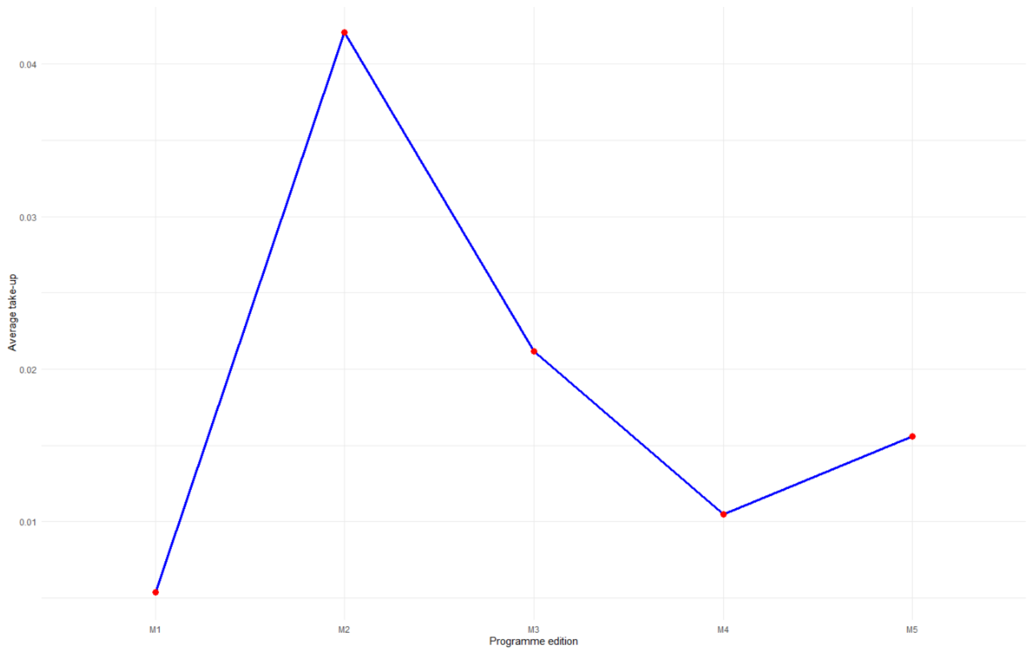
These findings highlights significant regional disparities in the take-up of the "My Electricity" programme. Although the scheme is theoretically accessible to all owners of single-family households, in practice, some regions were twice as likely to participate than others. Moreover, higher participation seems to be concentrated in wealthier regions. This confirms findings from the broader literature on the take-up of solar panels presented in Chapter 3. This would be also in line with the hypothesis that due to higher initial investments and a lack of additional support for low-income households, lower-income regions might face barriers to participation, raising concerns about equity of the programme. While universal eligibility might appear fair, lack of targeted supportive measures for regions and households in need might in fact contribute to the development of inequalities.

5.2.3.3. Reduction in subsidy and a change to net-billing system might have discouraged participation

Unlike in the case of the "Clean Air" programme where data on applications and contract dates are only available for certain voivodeships, in the case of the "My Electricity" programme, data on the edition during which contracts were concluded is available. This allowed for looking at the evolution of the take-up rate across five editions of the programme.

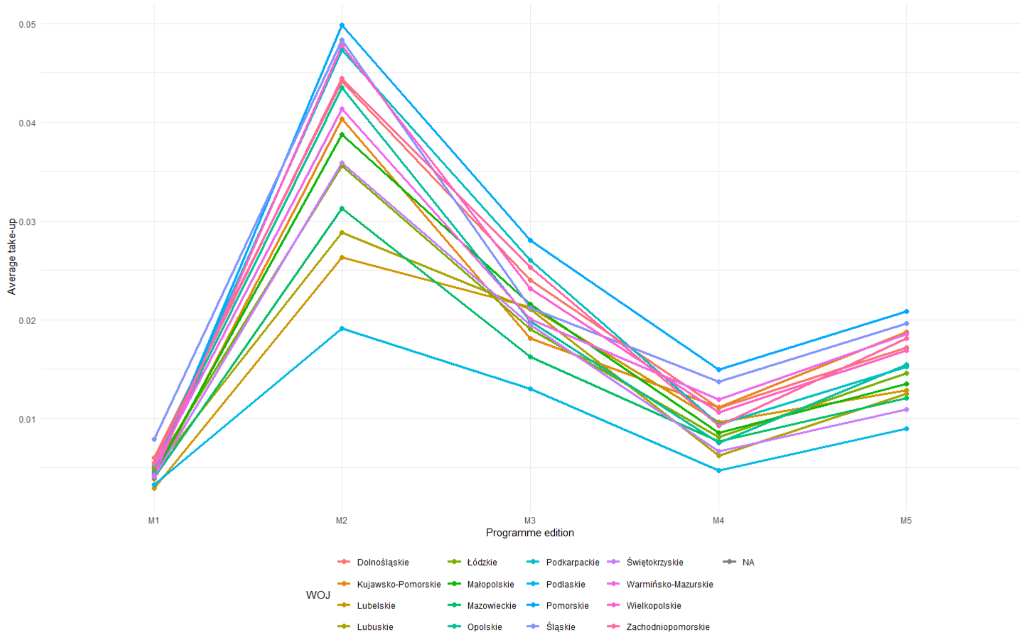
Although the programme has quickly become popular over the first two editions (spanning the period between August 2019 and December 2020), there was a significant drop in the take-up rate during the third edition and average take-up decreased even further during the fourth edition (period between July 2021 and March 2023). The drop between the second and third edition was 49.64%, and between the third and the fourth, 50.47%. Participation increased in the fifth edition, however it has not yet returned to the record levels of the third edition in 2021.

Graph 6. Evolution of the "My Electricity" take-up rate in successive editions



While the graph above shows the average take-up rate for the whole country, this pattern is consistent across all voivodeships as shown in Graph 7.

Graph 7. Evolution of the “My Electricity” take-up rate in successive editions by voivodeships



This sharp drop is likely explained by several factors. The first explanation relates to the reduction in subsidy. In the third edition, the maximum subsidy granted was decreased by 40%, from 5 000 PLN to 3 000 PLN. This might have made the participation in the programme less attractive especially given the high upfront cost of PV microinstallations. Although the fourth edition not only increased the amount of highest subsidy granted back to 5 000 PLN but also added additional subsidies for energy storage (up to PLN 7 000), heat storage (up to PLN 5 000) and EMS/HEMS systems (up to PLN 3 000), the take-up did not rebound, suggesting that other factors, beyond financial incentives, might explain this drop in participation.

The second explanation is offered by an amendment to the Renewable Energy Act of 29 October 2021. It introduced a mandatory market-based net-billing system for new prosumers from 1 April 2022, replacing previously available, more advantageous for prosumers net-metering system (Ministry of Climate and Environment, 2022). Net-billing aimed to incentivise self-consumption among concerns over grid stability, due to an unexpected surge in private investments in PV microinstallations (Benalcazar, Kalka and Kamiński, 2024). The timing of the switch coincided with the start of the fourth edition, potentially discouraging new prosumers.

Thirdly, the COVID-19 pandemic might have contributed to this drop. As households faced lockdowns, layoffs and general economic uncertainty, they might have naturally been more hesitant towards making important investments such as the installation of PV systems.

The increase observed in the fifth edition might suggest renewed interest in the programme. However, participation has not yet returned to its earlier peak, indicating a potentially lasting effect of the net-billing reform. As the programme now offers subsidies for installing energy storage, which significantly increases the profitability of a PV installation under the net-billing system, higher take-up might be observed in future editions.

5.3. Comparative analysis of the "Clean Air" and "My Electricity" programmes

This chapter presents the comparative analysis of the "Clean Air" and "My Electricity" programmes. The two were introduced in a similar time (2018 and 2019 respectively) and target owners or co-owners of single-family houses to support the country's energy transition at the household level. While they both target single-family houses, the "Clean Air" supports the replacement of polluting heating systems and increasing energy efficiency, the "My Electricity" supports deployment of PV microinstallations.

This chapter examines the spatial and socio-economic distribution of the two programmes to examine whether they serve similar or different regions and groups. To enable such a comparison, data for nine voivodeships, for which data for both programmes overlaps, was aggregated to the county level. The key indicator used in this analysis is the take-up rate, measured as the number of contracts in a county divided by the number of eligible single-family houses, as in the previous chapter.

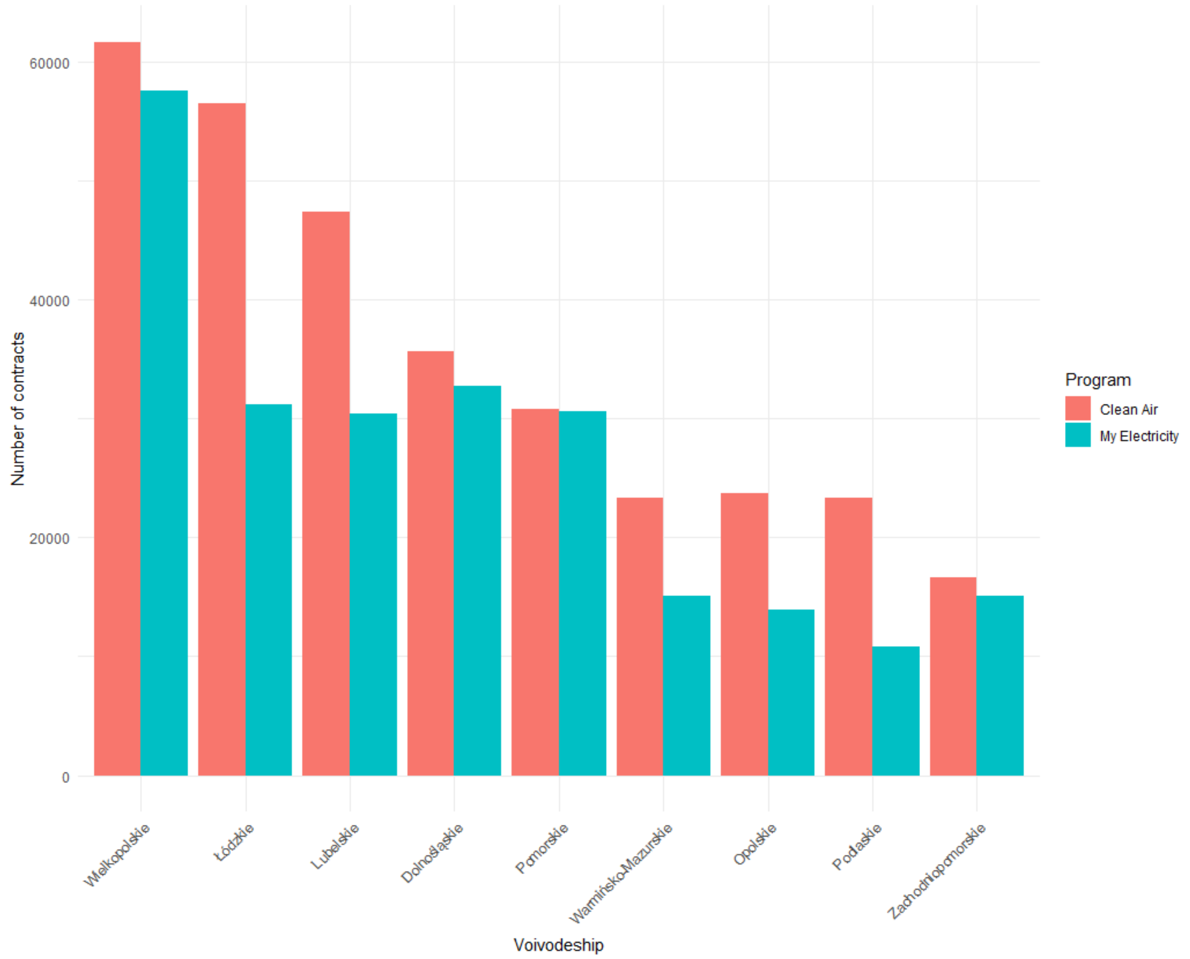
This is crucial as the two programmes differ significantly in scales and budgets. The "Clean Air" programme aims to thermally modernise 3 million houses between 2018 and 2029 and has a budget of 103 billion PLN. The "My Electricity" programme however, does not have specific numerical targets. Since 2019 it has had six editions and is continuously extended – its final budget and timeline remain unknown. To compare, to date almost 15 billion PLN of subsidies have been disbursed to beneficiaries under the "Clean Air" programme, compared to 3 billion PLN under the "My Electricity" programme. Despite this difference, the analysis does not control for the budget, given that under the latter programme the maximum subsidy per household is significantly lower and can thus reach a high number of households even with a smaller budget. Thus, the take-up indicator was chosen as the most appropriate. Finally, as data on application for the "Clean Air" programme was incomplete, the analysis only considers the number of final contracts signed within each programme.

5.3.1. Regional comparison

5.3.1.1. The distribution of the two programmes across voivodeships is unequal

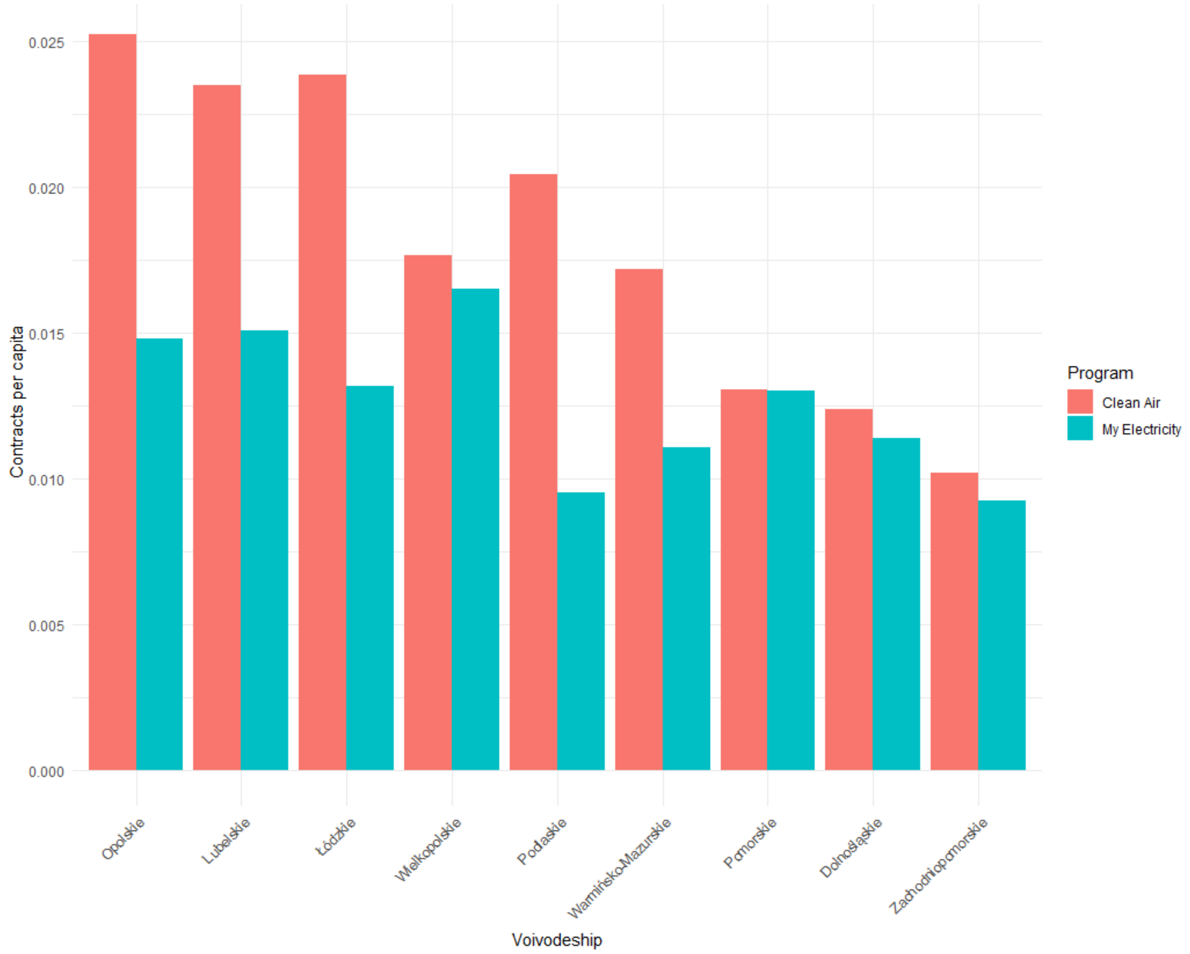
Significant regional divergence in participation can be observed in the case of both programmes. In absolute terms, Wielkopolskie voivodeship is the leader in both programmes having signed the most contracts. Łódzkie voivodeship follows closely, ranking 2nd in "Clean Air" and 3rd in "My Electricity". Podlaskie voivodeship lags behind significantly, ranking 8th in "Clean Air" and last in "My Electricity". These differences are however, mostly due to the population size.

Graph 8. Total contracts signed per voivodeship



When adjusted for population, differences remain but are less stark, ranging from 0.025 in Opolskie to 0.01 in Zachodniopomorskie for per capita “Clean Air” contracts and 0.016 in Wielkopolskie to 0.09 in Zachodniopomorskie for per capita “My Electricity” contracts. Opolskie, Łódzkie and Lubelskie perform strongly in “Clean Air” and are overtaken in “My Electricity” only by Wielkopolskie. By contrast, Dolnośląskie and Zachodniopomorskie voivodeships lag behind in terms of “Clean Air”. In “My Electricity”, Warmińsko-Mazurskie, Zachodniopomorskie and Podlaskie underperform.

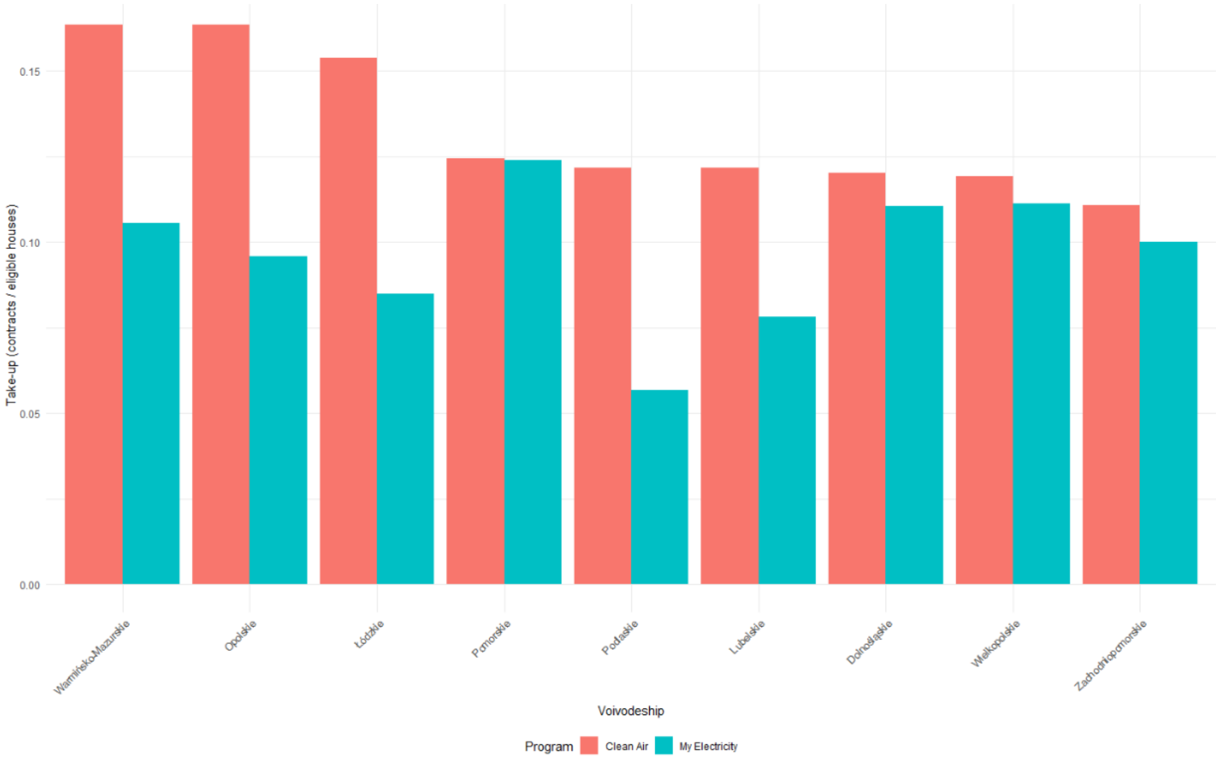
Graph 9. Contracts per capita by voivodeship



However, the take-up rate, taking into account only the eligible households, gives the most informative picture. While for “Clean Air”, the regional divergence is not that large with the values ranging from 0.16 for Warmińsko-Mazurskie to 0.11 for Zachodniopomorskie, for “My Electricity”, they range from 0.12 for Pomorskie to 0.06 for Podlaskie – a more pronounced disparity.

While some voivodeships such as Pomorskie, Dolnośląskie or Wielkopolskie take advantage of the two programmes evenly, others such as Opolskie, Łódzkie and Podlaskie focus primarily on “Clean Air” and lag behind in “My Electricity”.

Graph 10. Average take-up by voivodeship



The analysis reveals that despite both programmes being nationwide, their regional take-up is uneven, even after controlling for their population and the number of eligible single-family houses. This suggests that participation depends on various local factors, such as awareness of the programmes, administrative support in navigating the application process or access to capital. These differences might also reflect differing household priorities or energy-related needs across the regions.

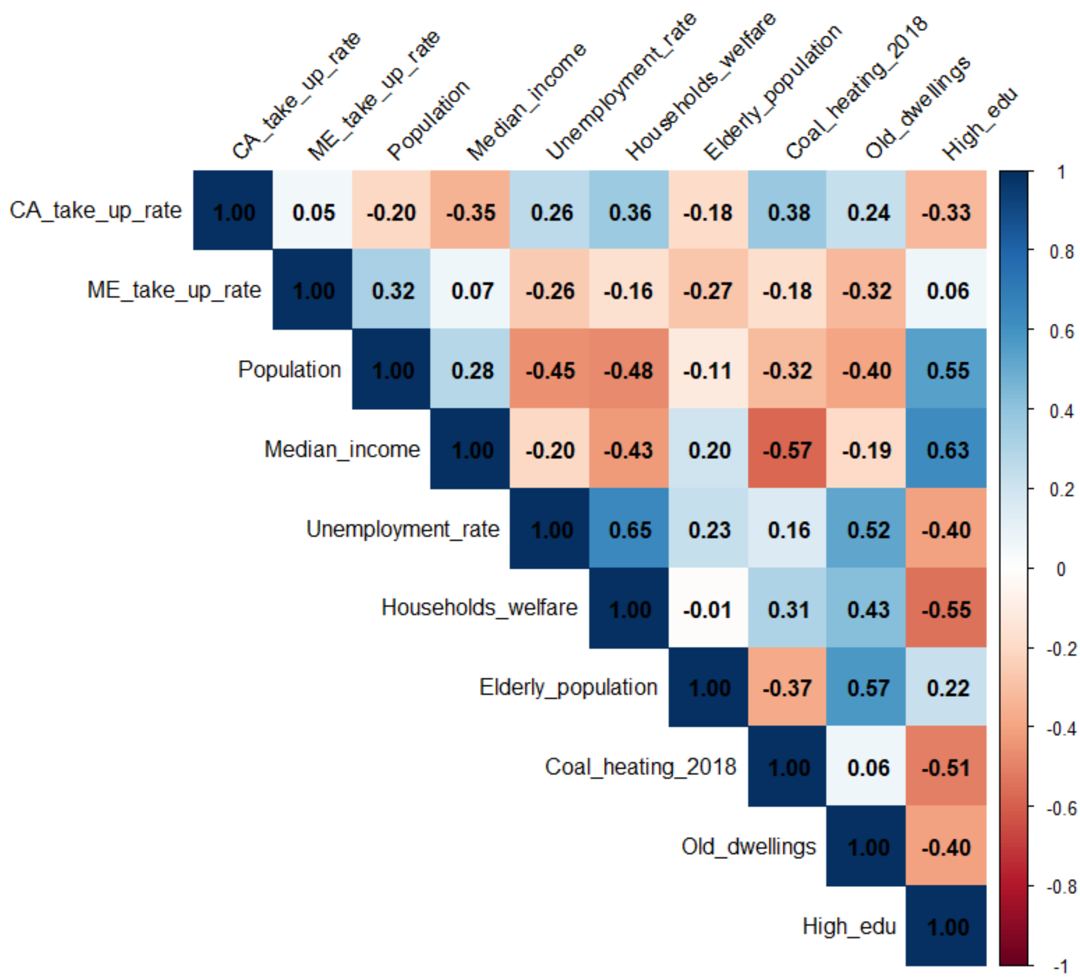
In addition, in the case of the “Clean Air” programme, the disparities in the take-up across voivodeships might be partly explained by the fact that its implementation is decentralised. The programme is being implemented by sixteen Regional Funds for Environmental Management. which might have differing financial and human resources at their disposal, translating into varied efficiency. These differences could potentially influence the degree to which households are supported throughout the application processes. However, this is not the case in the “My Electricity” programme which is centrally administered by the National Fund for Environmental Protection and Water Management. Regardless, the regional disparities in its take-up are larger than in the case of the “Clean Air” programme. This points to the existence of additional barriers, beyond simply administrative ones.

5.3.2. Correlations

5.3.2.1. Take-up rate differs across groups and regions, with “Clean Air” supporting smaller and economically disadvantaged counties

To better understand the socio-economic determinants of the take-up of the two programmes, a correlation matrix was constructed using county-level data. The variables chosen are the following: population, median income, unemployment rate, share of households receiving welfare, share of elderly population (over 65 years old), share of houses heated with coal in 2018 (at the programmes' inception), share of houses built pre-2003 and share of population with higher education.

Graph 11. Correlation matrix for the take-up rate of the "Clean Air" and "My Electricity" programmes



Firstly, the take-up rates of the "Clean Air" and "My Electricity" programmes do not seem to be correlated with each other, suggesting that the two programmes attract participants from different counties. Indeed, although they both advance Poland's energy transition they respond to different needs and target groups with different capacities. While "My Electricity" may be perceived as an opportunity to take advantage of reduced energy bills and enhance energy independence, renovations supported by the "Clean Air" are often necessary interventions to meet more basic living standards, such as keeping the house warm.

This finding is further confirmed by their contrasting relationship with the socio-economic variables. The "Clean Air" programme tends to be more popular among smaller and economically disadvantaged counties. The bigger the county, the lower the take-up rate (-0.20), which is in line with the findings from Chapter 5.1 that small-town and rural areas are the main beneficiaries of the programme. The correlations with median income and higher education are negative (-0.35 and -0.33), indicating that richer and more educated counties are less likely to participate in the programme. This may be possibly due to the programme's design, which prevents high-income households from participating and grants higher subsidies for low-income households. Moreover, the correlations with unemployment and welfare are positive (0.26 and 0.36), suggesting that counties where more households struggle economically are more actively participating. As for demographics, the correlation is quite weak but negative (-0.18), with counties with a higher share of elderly population being slightly less likely to participate in the programme. A possible explanation is the fact that, especially in rural areas, the elderly tend to live alone in houses that used to be multi-generational; thus, they might be less inclined to invest in their modernisation. Finally, housing characteristics also play a role – take-up is positively correlated with the share of old houses and houses heated with coal in a county (0.24 and 0.38) which aligns with the programme's goal of incentivising the replacement of old and inefficient solid fuel heating sources.

On the other hand, the "My Electricity" programme appears to target entirely different groups. In fact, the direction of correlations for nearly all variables is opposite to those observed in the case of the "Clean Air", with the exception of the share of elderly population. Firstly, its take-up is positively correlated with the population of the county (0.32), i.e. the larger the county, the more likely it is to participate. This is in line with findings from Chapter 5.2, where suburban and urban counties are in the lead. Although the correlations between the take-up and median income and high education are very weak (0.07 and 0.06), they are still positive, contrary to the case of the "Clean Air". Notably, again contrary to the "Clean Air" case, economically disadvantaged counties seem less likely to participate in "My Electricity" as correlations with unemployment rate and welfare are negative (-0.26 and -0.16). This is perhaps due to lower amounts of subsidy granted in the framework of the programme, and thus, the need for higher initial capital which an economically disadvantaged household might struggle to access. Similarly, counties with higher prevalence of houses heated with coal and older housing stock are less likely to participate (-0.18 and -0.32). This may be due to the fact that those counties need to prioritise urgent thermal modernisation rather than investments in modern renewable energy sources. Conversely, counties where modern houses are more prevalent may be more inclined to install PV systems to upgrade them.

To sum up, while both programmes aim to advance the energy transition in Poland, they appear to serve different regions and populations. The "Clean Air" programme seems to be of a more redistributive nature, reaching smaller and more economically disadvantaged counties with old building stock and reliant on coal for heating. In contrast, the "My Electricity" programme does not reach these counties and sees higher participation rates in larger and more urbanised counties with more modern housing stock. This is likely due to the differences in their design with "Clean Air" offering more support for low-income households and "My Electricity" offering a flat subsidy and requiring the beneficiaries to cover at least 50% of the total costs of the intervention, practically excluding capital-constrained households.

5.3.3. Regression analysis

Building on the correlation analysis presented in the previous section, a multiple linear regression analysis was performed to further examine the relationship between programme take-up rates and various housing and socio-economic variables. The model includes the same variables presented in the previous chapter with the exception of the *share of population with higher education,* excluded due to the collinearity concern[17]. The included variables are: population, median income, unemployment rate, share of households receiving welfare, share of elderly population (over 65 years old), share of houses heated with coal in 2018 (at the programmes' inception) and share of houses built pre-2003 as well as a categorical variable *type* (urban, suburban or other). Importantly, due to "My Electricity" dataset's limitations, the analysis could only be conducted on the county level. The following model was employed separately for both "Clean Air" and "My Electricity" take-up rates:

$$Programme\ takeup_c = \beta_0 + \beta_1 Median\ income_c + \beta_2 Population_c + \beta_3\ Unemployment_c + \beta_4\ Coal_c + \beta_5\ Old\ dwellings_c + \beta_6\ Elderly_c + \beta_7\ Welfare_c + \beta_8\ TypeSuburb_c + \beta_9\ TypeOther_c + \varepsilon_c$$

[17] Variance Inflation Factor for *high_edu* was 5.75 for the Clean Air model and 6.98 for the My Electricity model. This was primarily due to its high correlation with the variable *type.*

Table 18. Regression output – "Clean Air" and "My Electricity" take-up

Clean Air and My Electricity take-up

	CA_take_up_rate (1)	ME_take_up_rate (2)
Median_income	-0.00001*	-0.00001
	(0.00001)	(0.00001)
Population	-0.00000	0.00000
	(0.00000)	(0.00000)
Unemployment_rate	0.018	-0.075
	(0.101)	(0.094)
Coal_heating_2018	0.042	-0.090***
	(0.028)	(0.026)
Old_dwellings	0.166***	-0.023
	(0.050)	(0.046)
Elderly_population	-0.546***	-0.194
	(0.153)	(0.143)
Households_welfare	0.219	-0.025
	(0.169)	(0.158)
TypeSuburb	-0.006	0.041***
	(0.015)	(0.014)
TypeOther	-0.003	0.025**
	(0.011)	(0.011)
Constant	0.192***	0.233***
	(0.065)	(0.060)
N	203	203
R^2	0.363	0.143
Adjusted R^2	0.333	0.103
Residual Std. Error (df = 193)	0.035	0.032
F Statistic (df = 9; 193)	12.206***	3.583***
Notes:	***Significant at the 1 percent level.	
	**Significant at the 5 percent level.	
	*Significant at the 10 percent level.	

These results are broadly in line with what was observed in the previous section. The "Clean Air" programme indeed sees higher take-up in counties with a higher share of old dwellings, likely in need of modernisation, in line with the programme's objective. This effect is statistically significant at the 1% level. Although the *share of houses heated with coal* has a positive coefficient, it is not statistically significant. This may be due to the fact that this variable does not capture different types of solid fuels used for heating such as biomass.

Contrary to expectations, variables denoting economic disadvantage such as median income, unemployment rate and reliance on welfare, are not statistically significant although their coefficients point in the right direction. This may be attributed to the fact that the analysis is conducted at the county level, thus, within-county variation is lost. The most important predictor of the take-up of the "Clean Air" programme seems to be the share of elderly population, indicating that counties with older residents are less likely to participate in the programme, possibly due to lower digital literacy and thus lower awareness of the programme as well as financial barriers.

Take-up of the "My Electricity" programme seems to be mostly influenced by the housing characteristics, notably the share of houses heated with coal which has a negative coefficient and is statistically significant at the 1% level. While the share of old dwellings also has a negative coefficient, it is not statistically significant. As in the case of the "Clean Air", variables indicating the economic situation of a county are not statistically significant. However, the type of the county, i.e. a proxy for the degree of urbanisation, seems to be a meaningful predictor of participation, with higher take-up rates observed in suburban counties.

The explanatory power of the models varies with the "Clean Air" model explaining around 33% of the variation in its take-up and the "My Electricity" model explaining only about 10%. This suggests that other factors not captured by this study, such as local policy initiatives, information campaigns or the presence of RES-specialised companies, might better explain participation in "My Electricity".

Importantly, this analysis is conducted using data aggregated at the county level, due to data limitations encountered in the "My Electricity" dataset. This aggregation may conceal important variations between municipalities within a county. As such, while the results highlight some broader trends, they should be interpreted with caution as they do not capture local nuances. Indeed, the regression analysis for the "Clean Air" programme presented in Chapter 5.1. which was conducted at the municipal level with the use of more granular data, revealed important relationships with socio-economic variables. Future studies repeating the analysis with better quality data for "My Electricity" might yield more satisfactory results.

5.3.4. Mapping county engagement in the energy transition

This section presents three indices constructed to map the level of county engagement in Poland's energy transition. Highlighting which counties lag behind can help policymakers craft more targeted and effective support measures to ensure no community is left behind. The first index – High/Low take-up – classifies counties into four categories depending on whether they lead or lag in both programmes or prioritise one programme over another. The second index – Green Need Index – captures cumulative economic and housing disadvantages. Finally, the Green Gap Index assesses counties' performance in the two programmes relative to the level of their green need.

5.3.4.1. High/Low Take-up Index

The first index – *High/Low Take-up Index* – maps the counties according to their take-up rates of the "Clean Air" and "My Electricity" programmes. Four categories of counties were created: counties that i. lead in both programmes (*Leaders*), ii. lag behind in both programmes (*Laggers*), iii. lead in "My Electricity" but lag behind in "Clean Air" (*Prioritise RES*) and iv. lead in "Clean Air" but lag behind in "My Electricity" (*Prioritise heating*).

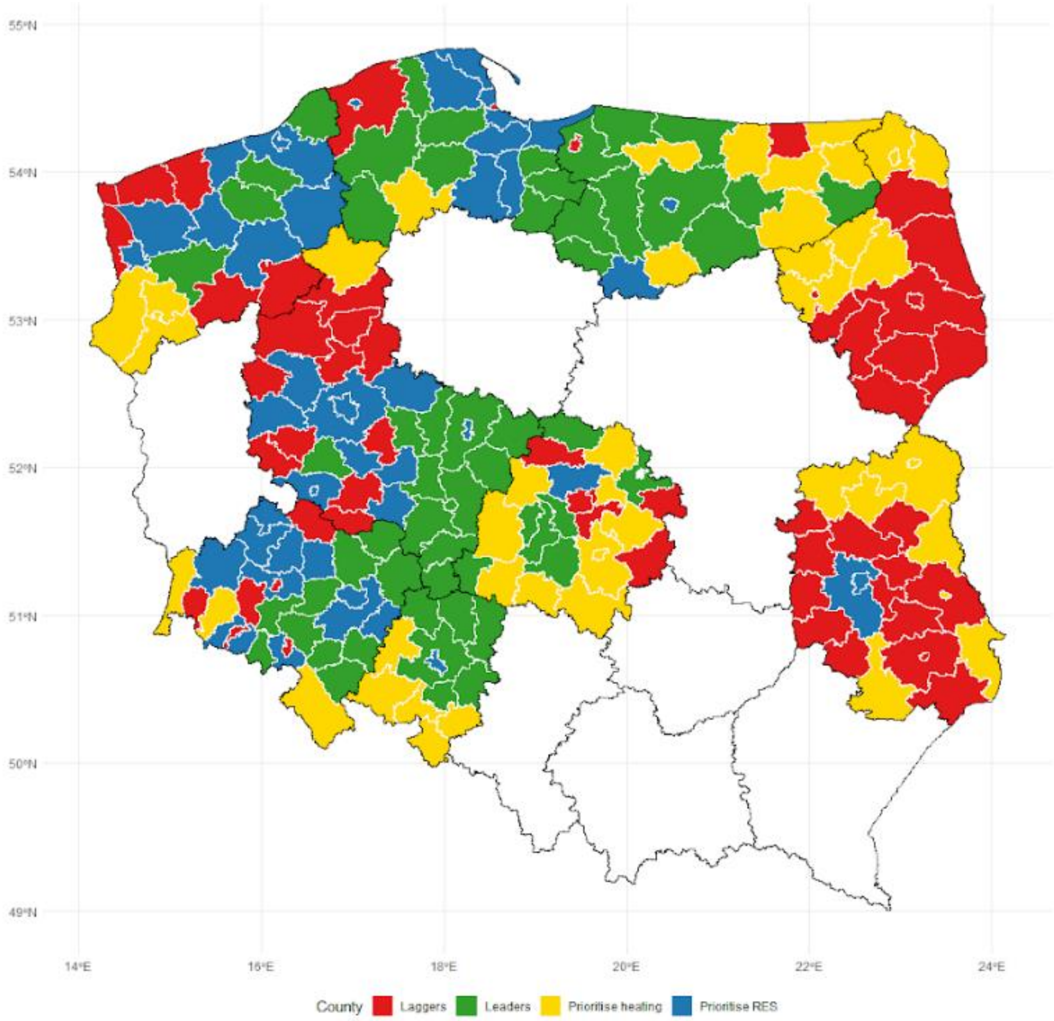
Counties were assigned to a high or low take-up group depending on whether they fall above or below the median take-up for each programme (0.13 for the “Clean Air” and 0.09 for “My Electricity”). When interpreting the map, it is important to emphasise that, as noted in the previous chapter, the two programmes tend to reach different socio-economic groups. Thus, regions where replacement of heating sources is prioritised (with higher “Clean Air” take-up), are more likely to be somehow economically disadvantaged. On the other hand, regions prioritising RES investments (with higher “My Electricity” take-up) are possibly larger and more urbanised. While for “My Electricity” the relationship between take-up rate and socio-economic variables is not that clear, disadvantaged regions are indeed more likely to participate in the “Clean Air” and thus be classified as “Prioritise heating”.

Table 19. High/Low Take-up Index classification

	High My Electricity take-up	**Low My Electricity take-up**
High Clean Air take-up	*Leaders*	*Prioritise heating*
Low Clean Air take-up	*Prioritise RES*	*Laggers*

Map 1. visualises the index on the map of Poland. In total, 203 counties from nine voivodeships were mapped, for which the data for both programmes was available.

Map 1. High/Low Take-up Index



The map shows clearly that Eastern Poland, historically rural, less developed and sparsely populated, stands out from the rest of the mapped regions with the prevalence of *Laggers* and *Prioritise heating* counties. These are Podlaskie and Lubelskie voivodeships, respectively seventh and ninth poorest voivodeships in the sample. This is in line with previous indications that economically disadvantaged regions might prioritise participation in "Clean Air" over "My Electricity" due to its design which is more favourable to low-income households. Moreover, the replacement of old and inefficient solid fuel heating systems and improving energy efficiency is likely to be more urgent there than upgrading homes with solar micro-installations. Unfortunately, there is also a high proportion of *Laggers* counties, suggesting that even the "Clean Air" programme fails to reach all counties that could benefit from it.

Two blue counties in Lubelskie voivodeship stand out as *Leaders* in "My Electricity" – these are unsurprisingly *Lublin county* and *lubelskie county*, i.e. the city of Lublin, capital of the voivodeship and the biggest city in the region as well as its suburban "ring county". This confirms what has been revealed in Chapter 5.2, that suburbs and urban counties tend to have higher take-up rates in "My Electricity".

Alarmingly, part of the Lubelskie voivodeship is a hard coal mining region where efforts to transform domestic energy use and energy efficiency should be particularly high. However, *chełmski, lubartowski, łęczyński, parczewski* and *świdnicki* counties lag behind in both programmes. The remaining "coal counties" are either prioritising heating (*włodawski* and *the city of Chełm counties*) or RES (*lubelskie county*). More efforts are needed in those counties to support households in improving their energy efficiency and access to renewable energy to offset the future potential negative impacts of phasing out coal production and the risk of energy poverty stemming from potential unemployment concerns.

Northern Poland, comprising (from the left) Zachodniopomorskie, Pomorskie and Warmińsko-Mazurskie voivodeships, presents a more diverse landscape, with significantly fewer *Laggers* counties. Of these, Zachodniopomorskie stands out with many RES-focused counties but comparably many *Laggers*. *Laggers* account for 28.5% of counties there, as opposed to 10% in Pomorskie and 9.5% in Warmińsko-Mazurskie. *Leaders*, on the other hand represent 19% in Zachodniopomorskie, 40% in Pomorskie and 47% in Warmińsko-Mazurskie. RES-focused counties dominate in Zachodniopomorskie (38%) and Pomorskie (45%) contrary to Warmińsko-Mazurskie (9.5%), where non-leaders are more oriented towards prioritising replacement of heating sources (33%). As for urban areas, they tend to either prioritise RES, as seen in the case of Lublin, or lag behind.

Moving to Western and Central Poland, Wielkopolskie voivodeship which ranked highly in the take-up of both programmes is an interesting case, where different categories of counties concentrate regionally with *Laggards* in the north, RES-dominance in the middle concentrated around the city of Poznań (voivodeship capital) and *Leaders* in the south-east, concentrated around the city of Konin. This may be due to income differences around the major cities (i.e. more capital to invest in RES and thermal modernisation). Another explanation are the regional efforts in the Eastern Wielkopolska region (around the city of Konin), which as a coal region, might exhibit greater energy transition awareness. With 30.5% *Laggers*, 33.3% *Leaders*, 2.7% *Prioritise heating* and *30.5% Prioritise RES* Wielkopolska scores well in the index but additional efforts should be made to ensure that the northern region is not left behind.

Łódzkie voivodeship, located in the middle of the country, sees the prevalence of counties prioritising the replacement of old heating sources (43%). Interestingly, similarly to the case of Wielkopolskie voivodeship, the counties that lead in both programmes are the ones relying on coal production, notably *bełchatowski county*, hosting one of the largest lignite coal mines in Europe, and its neighbouring counties (*wieruszowski, zduńskowolski, łaski, pabianicki*).

South-western Poland, comprises Dolnośląskie and Opolskie voivodeships. Dolnośląskie voivodeship fares quite well on the index with 33% *Leaders* and 36.6% *Prioritising RES*. Counties classified as *Laggards* or *Prioritising heating* are located more to the west, closer to the border with Germany, while *Leaders* and *Prioritising RES* are clustered together. Dolnośląskie is also a coal region, particularly its Wałbrzych subregion. Here, again, a similar pattern is observed, with *Leaders* counties being the ones relying on hard coal production and covered by the Territorial Just Transition Plan under the Just Transition Fund (Dolny Śląsk, 2021). These are *dzierżoniowski, kamiennogórski, świdnicki and ząbkowicki* counties.

Importantly, *wałbrzyski* and *kłodzki* counties, which are key from the coal production perspective for the region, were not classified as *Leaders* but respectively *Prioritising RES* and *Prioritising heating.*

Finally, Opolskie voivodeship is divided almost equally in half among *Leaders* (50%) and *Prioritising heating* (42%). The one county with the prevalence of "My Electricity" programme is unsurprisingly the city of Opole, the capital of the region.

Next, it was examined whether there is a relationship between a county's degree of urbanisation and its performance on the index. Firstly, in line with previous findings, urban counties tend to prioritise RES or lag behind. However, in their case, this might be due to less need for public subsidies, as households living in urban areas might have more access to capital to finance their investments or might not be eligible for the "Clean Air" programme due to the income cap. Secondly, suburban counties perform very well, with the smallest percentage of *Laggers* (21.7%). Thirdly, *other* counties rank very high, with the highest share of *Leaders* (32.7%) but also have a high proportion of *Laggers* (26.8%), possibly because it is a very diverse group of counties.

Table 20. High/Low Take-up Index by county type

Type of county	**Leaders**	**Prioritise RES**	**Prioritise heating**	**Laggers**
Urban	3.7%	44.4%	14.8%	37%
Suburban	26.1%	34.8%	17.4%	21.7%
Other	32.7%	16.3%	24.2%	26.8%

To conclude, the High/Low Take-up Index shows clear regional variations in the take-up of the two programmes supporting households in their energy transition. It demonstrates that depending on the characteristics of the region such as level of urbanisation, affluence, quality of housing stock and historic reliance on coal, they might have different needs and strategies to approach the transition. While more urban and wealthier counties tend to prioritise investments in RES under the "My Electricity" programme, therefore, upgrading their houses and reaping the benefits of accessing cheap and green energy, poorer, small-town and rural counties are more likely to benefit from the "Clean Air" programme, highlighting their need to first prioritise energy efficiency and replacement of solid fuels-based heating.

At the same time, 28% of counties remain classified as *Laggers,* highlighting the room for improvement. Importantly, the high share of *Laggers* in Eastern Poland, where historical disadvantages and reliance on coal production exacerbate the vulnerability towards the transition, should alarm Polish policymakers[18]. This implies the need for further, more targeted support for regions that despite high needs exhibit low take-up rates. This topic will be developed in the next section on the Green Need and Green Gap indices.

5.3.4.2. Green Need and Green Gap Indices

The second part of this chapter introduces the remaining two indices aimed at identifying the regional hotspots most at risk of being left behind in the energy transition and most in need of targeted support. The first of these, the Green Need Index, captures the cumulative economic and housing disadvantages. It serves as a foundation for the subsequent Green Gap Index, which assesses counties' performance in the two programmes relative to the level of the "green need" identified.

Green Need Index

The Green Need Index draws inspiration from the Indices of Multiple Deprivation, used in the environmental justice literature, where multiple domains of disadvantage are integrated into a single indicator (Pearce *et al.*, 2010; Fairburn, Maier and Braubach, 2016). Mimicking this approach, albeit in a simplified manner, the Green Need Index combines variables reflecting *housing disadvantage* (i.e. the need to modernise the housing stock) as well as *economic disadvantage* (i.e. barriers to investing).

As no official Index of Multiple Deprivation exists in Poland, several studies proposed their own methodologies. One example was proposed by (Dudek and Szczesny, 2021) who employ a fuzzy measure approach, using the prevalence-correlation method for weighting to capture the intensity of deprivation. Their analysis, based on EU-SILC data, incorporates nine indicators such as inability to keep the home adequately warm, handle unexpected expenses or pay the rent, mortgage, or utility bills. Another approach, developed by (Smętkowski, Płoszaj and Rok, 2016), focuses on spatial patterns of deprivation and constructs a synthetic local deprivation index based on a set of standardised variables across the following domains: income, labour, living conditions, education and access and services. Due to data availability as well as regional focus of this study, the latter methodology was adopted.

Following (Smętkowski, Płoszaj and Rok, 2016) framework, z-score standardisation was first used to standardise the variables. Standardised scores were then aggregated and divided by the number of variables. While variables related to some of the original domains were retained (income, unemployment rate, education), others were substituted to reflect this study's focus on housing- and energy-related deprivation. However, in light of absence of energy poverty data at the county level in Poland, proxy indicators were chosen to represent the degree of

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[18] However, with the exception of the Lubelskie voivodeship, public awareness of the need for the energy transition reflected in the high programmes' engagement appears to be quite strong in the coal regions. Because the public policy debate in Poland is mainly focused on the future of Śląskie voivodeship, where coal mining is in fact the most concentrated, there was a risk that the smaller mining regions in the Lubelskie, Łódzkie, Wielkopolskie and Dolnośląskie voivodeships would be overlooked in the transition process. Fortunately, as proven by the above results, these regions exhibit high engagement in the two programmes.

economic disadvantage of a region, thus mirroring vulnerability and potential risk of facing energy poverty.

The Green Need Index incorporates the following five variables: share of houses built pre-2003, share of houses heated with solid fuels (as of March 2025), unemployment rate, share of households receiving welfare and median income (all on county level). For stimulants, where higher values indicated greater deprivation, the standardisation was applied as below:

$$\text{For stimulant: } v_i = \frac{(x_i - \bar{x})}{\sigma_x}$$

For destimulants, such as median income, the values were inverted:

$$\text{For destimulant: } v_i = \frac{(\bar{x} - x_i)}{\sigma_x}$$

To reduce the influence of extreme values on the final outcome, all standardised scores were capped within the range of -3 to 3, also according to the methodology described in (Smętkowski, Płoszaj and Rok, 2016). The index for each county was then calculated as an arithmetic mean of a sum of standardised scores for five variables, where v_{ic} is the standardised score of a variable *i* for county *c*.

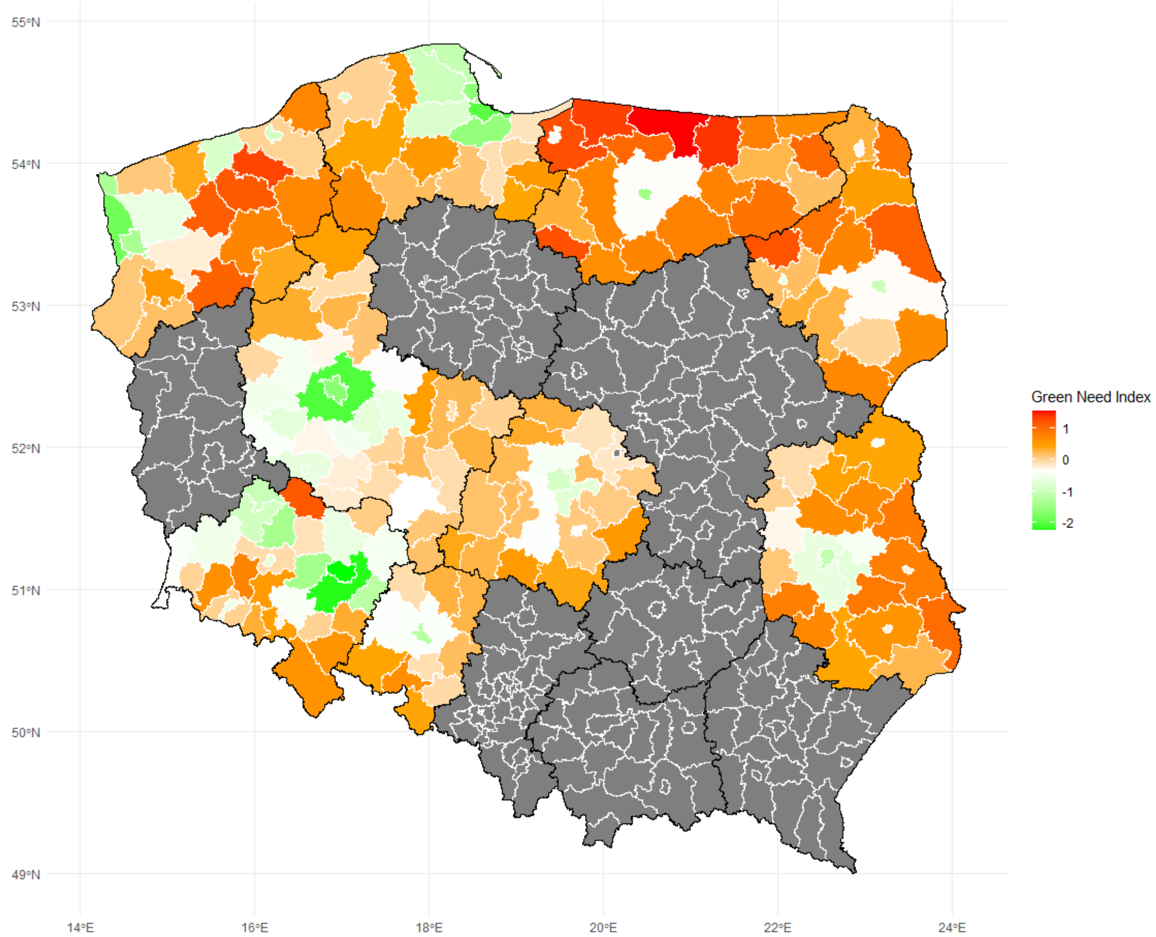
$$Green\ Need\ Index_c = \frac{\sum_{i=1}^{5} v_{i,c}}{5}$$

The resulting Green Need Index identifies counties which, given the characteristics of their housing stock, should invest in green modernisation efforts such as improving energy efficiency, thermal modernisation and replacement of heating sources. Moreover, given their economic vulnerability and thus, the risk of facing energy poverty, they could benefit disproportionately from investing in residential renewable energy sources to reduce their energy bills.

The index ranges from -2.23 to 1.54, with a median of 0.108, a mean close to 0 (0.0066) and a standard deviation of 0.74. Out of 203 counties in the sample, 115 fall above 0, indicating greater green need while the remaining 88 fall below 0 suggesting relatively better conditions.

Notably, the bottom 24 counties with the lowest index scores fall within the top income quartile, highlighting a clear relationship between economic advantage and lower levels of green need. However, this relationship weakens when looking at the top counties, suggesting that factors beyond income, such as housing characteristics, play a role in shaping local green needs.

Map 2. Green Need Index



The map illustrates the spatial distribution of counties with greater green needs, defined as areas where the housing stock is more likely to be in need of modernisation and where households are more likely to be at risk of energy poverty. These counties are marked in orange and red. They are primarily located in Eastern Poland (Podlaskie and Lubelskie voivodeships), Northern Poland (mainly Warmińsko-Mazurskie and certain parts of Zachodniopomorskie). On average, the situation is better in Central and Western Poland with some exceptions in Dolnośląskie voivodeship.

On the other hand, green colour marks regions which are more advantaged and relatively better prepared for the energy transition, i.e. they tend to have newer and more modern housing stock, use RES or a mix of RES and solid fuels for heating and have better economic situation. These include all 27 urban counties and 11 out of 23 suburban counties from the sample, suggesting that the level of urbanisation is an important determinant of the county's vulnerability to the energy transition.

Importantly, the index reflects initial conditions of a county, but it does not take into account the ongoing energy transition efforts. As such, it forms a basis for the creation of the Green Gap Index.

Green Gap Index

Building upon the Green Need Index, a second measure, the Green Gap Index, was developed to identify counties where levels of green need are not matched by corresponding level of engagement in the "Clean Air" and "My Electricity" programmes.

To construct this index, an intermediary Activity index was first created to measure counties' engagement in the two programmes. First, the programmes' take-up rates were standardised using z-score transformation. These scores were then added and divided by two to produce the final Activity Index, ensuring it remains on a comparable scale with the Green Need Index, described above:

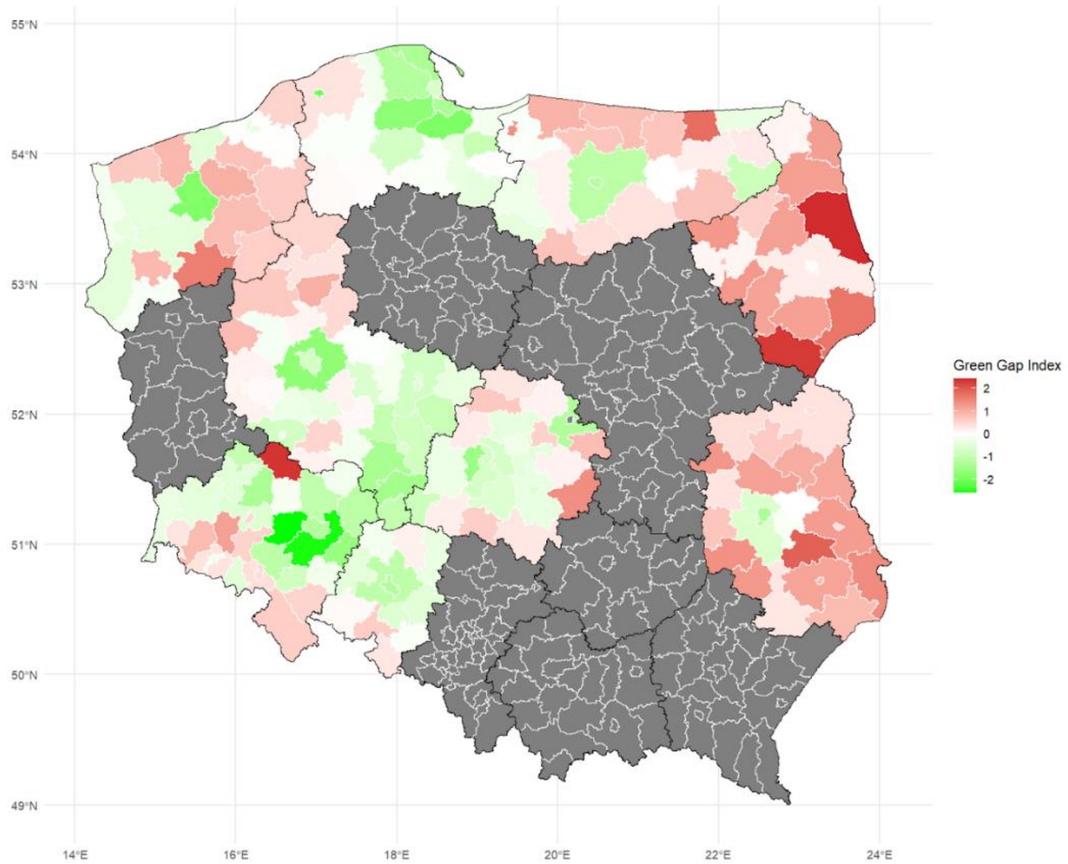
$$Activity\ Index_c = \frac{Clean\ Air\ take\ up_c + My\ Electricity\ take\ up_c}{2}$$

Finally, the Green Gap Index was calculated by subtracting the Activity Index from the Green Need Index for each county:

$$Green\ Gap_c = Green\ Need_c - Activity_c$$

This approach allows for identifying counties where high needs are not matched by their level of engagement in the two programmes. Positive values, marked in red, indicate a larger gap, i.e. counties with significant needs and low participation rates, while negative values, marked in green, point to areas where programme uptake meets or even exceeds the level of need.

Map 3. Green Gap Index



The index ranges from -2.59 to 2.40, with a median of 0.05, a mean close to 0 (0.0066) and a standard deviation of 0.89. Out of 203 counties in the sample, 106 fall above 0, while the remaining 97 fall below 0 suggesting that slightly more counties in the sample are in need of additional support.

Although the general pattern resembles that of the Green Need Index map, the Green Gap Index provides a more nuanced picture of the green disadvantage that Polish counties face, as it takes into consideration the advances already being made through participating in the two programmes covered by this study. It reveals that not all high-need counties are being left behind as their needs are already being met (although not entirely offset) by their high degree of participation in the programmes, and conversely, some counties with moderate needs are underperforming in terms of programme participation.

Just as in the case of the Green Need Index, Eastern Poland (Lubelskie and Podlaskie in the east and some parts of Warmińsko-Mazurskie in the north-east) stands out as the region that is indeed being left behind in the energy transition with its low participation rates relative to their high needs. In contrast, some regions in Central and Western Poland, particularly in Dolnośląskie and Wielkopolskie voivodeships, have a significant concentration of urban and subruban counties with negative index score, meaning that they overperform in terms of programme participation relative to their needs, which may be partly explained by stronger engagement of the local policymakers, more public awareness or higher investment capacity.

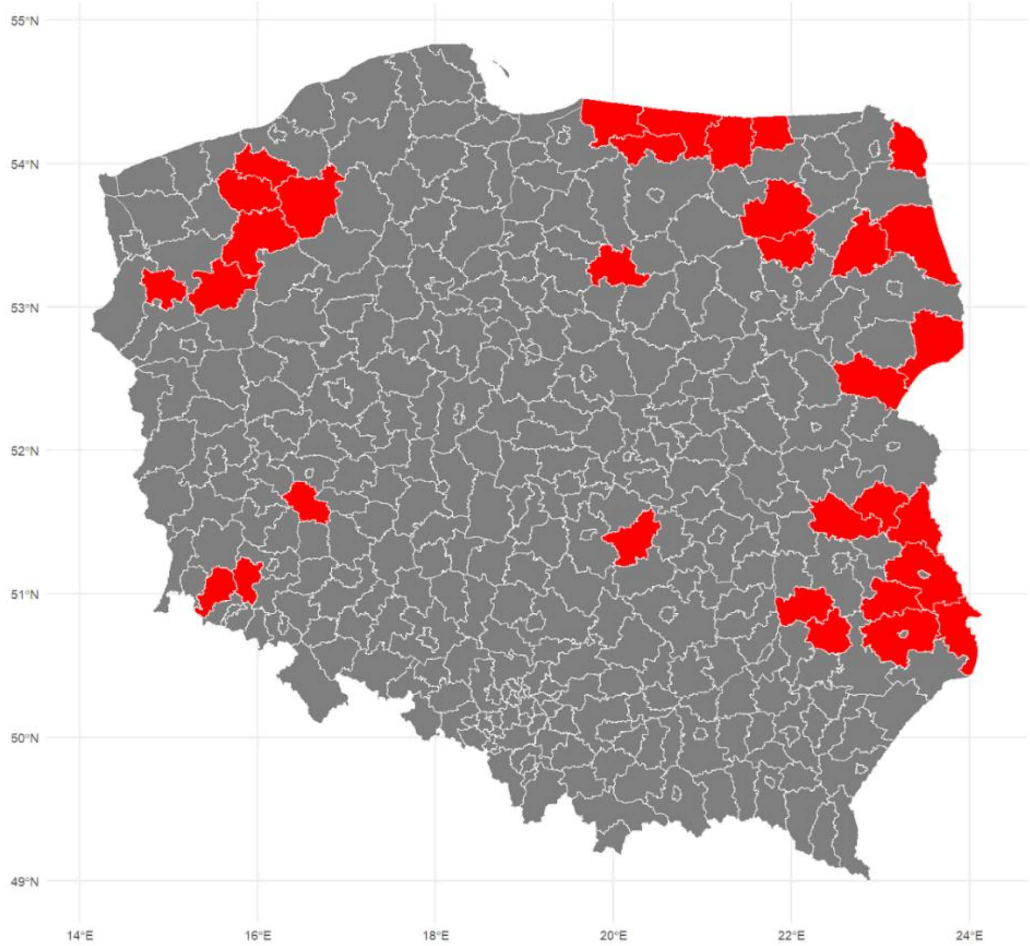
5.3.5. Priority counties in need of targeted policy intervention

Finally, areas most in need of targeted policy support were identified. To this aim, counties were divided into quartiles for both indices. The top quartile in the Green Need Index represents the 25% of counties with the most acute needs in terms of economic disadvantage (i.e. risk of energy poverty), reliance on solid fuels for heating and housing stock condition. The top quartile in the Green Gap Index represents counties with the largest mismatch between their needs and programmes participation. The counties that fall into the top quartiles of both indices were identified as priority counties for policy intervention.

This method ensures that the priority counties represent areas of both significant needs as well as those where programme participation remains disproportionately low relative to that need. While an alternative could be simply to intersect counties which rank high on the Green Need Index with those in the lowest quartile of Activity Index, such a method would neglect counties where participation is not among the lowest in absolute terms, yet significantly lags behind what would be expected given local needs. The approach used instead ensures that priority counties are selected not only on the basis of high need and low activity but also on the relative underperformance in relation to the needs.

By applying this approach, 32 priority counties were identified. Of those, 7 are located in Warmińsko-Mazurskie, 6 in Zachodniopomorskie, 9 in Lubelskie, 3 in Dolnośląskie, 6 in Podlaskie, and 1 in Łódzkie voivodeship. The full list of the priority counties is provided in the Annex 4.

Map 4. Priority counties in need of targeted policy intervention



Notably, 78% of them fall below the median income level, suggesting a link between economic disadvantage and barriers to accessing green subsidy schemes. With the exception of two suburban counties (*chełmski* and *zamojski*), the priority counties are exclusively small-town or rural.

On average, the priority counties have slightly worse indicators of economic and housing disadvantage compared to the sample average. They are characterised by an unemployment rate of 12%, compared to 7% in the whole sample. Around 9% of their population relies on welfare support relative to 6% in the whole sample. Their building stock tends to be older with 87% of houses built before 2003 compared to an average of 80% across the sample. Moreover, these areas are characterised by a high reliance on solid fuel heating, with 73% of houses using solid fuels as of March 2025 compared to 57% in the total sample.

These results confirm that the counties identified are both structurally more vulnerable towards the energy transition and underperform in the two programmes analysed. As such, they should be prioritised in targeted policy interventions, offered tailored administrative support and perhaps additional financial incentives. Crucially, as some of these are coal producing regions, they face an additional risk of the transition, related to potential job loss. Polish policymakers should thus make more efforts to ensure that the identified counties are not left behind.

5.4. Limitations

This study is subject to several important limitations both in terms of data availability as well as certain methodological choices. Thus, the results presented in Chapter 5 need to be interpreted with caution.

A major limitation of this study stems from incomplete coverage of the “Clean Air” programme. Not all Regional Funds for Environmental Protection shared their data – this is particularly unfortunate in cases such as Małopolskie and Śląskie voivodeships, infamous for their high air pollution levels and widespread coal use, especially in Śląskie. These omissions are unfortunate given the potentially significant impact of the programme in these regions. Moreover, the absence of the remaining seven voivedeships hinders the complete comparison with the “My Electricity” programme.

Among the voivodeships that did share the data, inconsistencies and gaps were present. Two branches sent incomplete datasets. For the Łódzkie voivodeship, information on the number of total applications was missing, which made it impossible to calculate the rate of rejection. In Warmińsko-Mazurskie, no distinction by funding levels was provided. Finally, not all branches provided information on the date of submission of applications, which limited the ability to analyse the effect of the January 2023 reform.

In the case of the “My Electricity” programme, although the data for all 16 voivodeships was available, the dataset suffered from lack of standardisation and manual entry. Crucially, the data did not consistently included information about the type of municipality (urban, urban-rural, rural), making it necessary to aggregate data to the county level. While this approach ensured consistency, it meant losing a lot of granularity.

Another important limitation, affecting both datasets is the lack of data on incomes of individual applicants. This made it necessary to focus on a municipality or a county as a unit of analysis, rather than individual households which would yield much more detailed results. Therefore, the regression analysis does not account for income variations within a municipality or a county, making it difficult to capture the true extent of economic and environmental inequalities. This is reflected by for example, very small coefficients for income variables. As such, although the analysis offers a valuable regional perspective, it lacks the detail that a household-level study could provide.

The air quality analysis should also be interpreted with caution and treated as exploratory. Data sourced from the Chief Inspectorate for Environmental Protection is limited to a relatively small number of monitoring stations. As a result, out of over 1 000 municipalities covered by the “Clean Air” dataset, approximately a hundred could be considered for the PM10 and BaP analysis and even fewer for the PM2.5 analysis. Moreover, for the municipalities that did have stations, the actual measurements were sometimes not available for each year in the period covered by the analysis. Finally, the analysis did not account for a range of local initiatives and other policies aimed at reducing air pollution. As such, while the findings offer interesting hypotheses for further research, the relationship between programme take-up and the reduction in pollution levels should not be interpreted as causal.

Finally, the data from the Central Registry of Building Emissions on the use of solid fuels for heating is updated continuously, and the version used in this study reflects the status as of March 21, 2025. While this provides the most current information on the use of different heating sources and could be used to estimate the degree of Green Need, using it to determine the relationship between programme take-up and socio-economic and housing-related variables would risk capturing changes that resulted after the programme's implementation, potentially introducing endogeneity problem. To mitigate this, a proxy historical variable was constructed using data on the share of houses using coal for heating from the Central Statistical Office. However, as this data is not collected annually, it was necessary to estimate the share for 2018 (before the introduction of the programmes), by assuming a linear trend between 2011 and 2021 data. This proxy is also imperfect as it focuses on coal exclusively and does not capture other types of solid fuels used for heating. As a result, it can underestimate the role which solid fuel heating can play in the programme take-up.

The above data constraints shaped several methodological choices in this study. Most notably, the lack of data on individual applicants made it impossible to employ more advanced causal inference methods. For example, regression discontinuity design could be employed in future studies to examine the differences in applicants who just barely qualified or failed to qualify for different levels of financial support. Similarly, with access to information on exact location of beneficiaries, more in-depth analyses of neighbourhood and peer effects could be conducted, as in recent work by (Sokołowski, Madoń and Frankowski, 2025). Moreover, the simultaneous and nationwide introduction of the programmes made it challenging to identifying treatment and control groups. As a result, this study does not employ a difference-in-differences approach which could estimate the actual causal impacts of, for example, impact of the "Clean Air" programme on air quality.

Given these constraints, this research could not establish clear causal effects. Instead, it should be understood as exploratory in nature. Although the insights presented here need to be interpreted with caution, they offer an encouraging foundation for future research, preferably based on more granular, ideally household-level data.

Finally, while this study focuses on potential inequalities stemming from the distribution of the two green subsidy schemes directed at homeowners, it is important to note that further research should examine the impact on renters. Publicly supported investments in energy efficiency, modernisation of heating sources and PV installations might increase the value of properties, thereby making it more difficult for younger or lower-income households to enter the real estate market. Thus, homeowners will benefit from the state subsidies twofold: by increasing their thermal comfort and reducing energy bills as well as by seeing the value of their assets appreciate. In light of the important housing crisis in Poland, but also across the OECD countries, exacerbating inequality between homeowners and renters should be mitigated by appropriate policies (OECD, 2023a; Ptak, 2024).

6. Policy recommendations

This study examined the spatial and socio-economic distribution of the two key Polish green subsidy schemes. It sought to determine whether the design of the programmes influences who they reach and where. Such large public subsidy schemes can be a great stimulus to the energy transition, but depending on their design they can exacerbate or mitigate inequalities. This research has found that the "Clean Air" reaches households mainly in the rural areas and "My Electricity" sees higher take-up in suburban counties. Moreover, while the "Clean Air" appears to benefit more low-income household in municipalities with low-quality housing stock, the take-up of "My Electricity" is not so clearly linked to socio-economic variables. While this may simply reflect the needs of households located in these areas and does not necessarily translate into unequal outcomes, several improvements could be made to ensure more equitable access to the two programmes.

1. **Reform and regularly adjust income thresholds of the "Clean Air" programme to ensure more households are eligible for targeted support**

Although the programme has been reformed several times, the income thresholds deciding the eligibility to the *increased* or *highest* level of financing have not been sufficiently increased, limiting eligibility to households living in *de facto* poverty, considering minimum wage earners as too affluent for targeted support.

The most recent reform of March 2025 is commendable in this respect, as it introduced another increase in the thresholds, although not as large as in January 2023[19]. Furthermore, with the corresponding in time increase in minimum wage, it remains true that minimum wage earners will still only qualify for the *basic* level of financing.

Thus, a new way to calculate the thresholds should be employed by tying the thresholds to for example, minimum wage and average pension in the economy. Moreover, they should be indexed for inflation to account for rising costs of living and wages. As the programme is to continue until 2029, it is possible that the thresholds introduced this year will quickly become obsolete and will again underestimate the degree of need for support and effectively exclude many households.

While the programme aimed to support modernisation of 3 million homes, 874 184 contracts have been signed as of April 7, 2025 (NFOŚIGW, 2025). Such pace of implementation is too slow to meet this target in 2029. Annually, over 270 000 contracts should be signed to meet the target, which now in the middle of programme's implementation is reached in 29%. Extending the *increased* and *highest* support for more households could thus accelerate this process, by simultaneously shielding more households from energy poverty.

The political dimension of this reform should not be neglected too. As shown in (OECD, 2023b) affordability, availability and convenience are key incentives that can green household

[19] Based on author's own calculations. The January 2023 reform increased all thresholds by 21% while the one from March 2025 by 17.9-19.3%. Source: (NFOŚIGW, 2025a).

behaviour. Extending the benefits of energy transition to more households, especially more rural and low-income is thus necessary to increase their future support for transition policies.

2. **Allow additional support for low-income households under "My Electricity" and introduce an income cap**

"My Electricity" programme should be reformed to ensure additional support conditional on income to enable investments in renewable energy to credit-constrained households. At the moment, the programme requires that the beneficiary covers at least 50% of the eligible investment costs and offers flat rate of support.

Although the programme has been reformed already several times to e.g. cover a wider range of investments (such as energy and heat storage systems) no efforts have been made to increase its availability to lower income households as in the case of the "Clean Air". As a result, although based on data available it was challenging to prove that it is not reaching lower income households, its uptake is significantly lower in Eastern Poland, which has been historically one of the most disadvantaged regions in the country.

Furthermore, policymakers should consider introducing an income cap such as in the case of the "Clean Air". At the moment, the programme offers subsidies up to 28 000 PLN for a wide range of technologies. However, in combination with the barriers faced by the lower-income households described above, the lack of an income cap risks that the programme serves primarily wealthy households who may have undertaken these investments regardless of public support.

While incentives for adopting green technologies across all income groups are needed, policymakers should consider alternative strategies to encourage high-income households to make these investments. The existing thermo-modernisation tax credit is a good example. The current programme design risks being a state-funded transfer to those households who are already best equipped to invest, thereby contributing to exacerbating inequalities in access to modern green technologies and renewable energy.

3. **Implement targeted initiatives for vulnerable regions, with Eastern Poland in particular**

This study makes it clear that some Polish regions are already ahead in the transition and some are lagging behind. The region in need of targeted support is Eastern Poland, i.e. Podlaskie and Lubelskie voivodeships and the eastern part of Warmińsko-Mazurskie voivodeship. These voivodeships exhibit the highest share of *Laggers* – counties where participation in both programmes is below the median. This engagement does not correspond to the level of their needs, reflected by the Green Need and Green Gap indices. Finally, most of the priority counties identified are located in this part of the country. This is particularly concerning in Lubelskie, as it hosts an important coal producing region, facing additional risks related to forthcoming job losses in the mining sector.

Therefore, policymakers should dedicate more efforts to first, understand structural barriers preventing households from participating in the "Clean Air" and "My Electricity" programmes in Eastern Poland. As these regions have been historically more rural, less industrialised and underdeveloped, additional support might be necessary. Moreover, dedicated outreach activities should be implemented to raise awareness of the existence of such support programmes. Next, targeted policies should be crafted together with local governments to accelerate the pace of home modernisation and deployment of renewable energy. Finally, significant funding must be allocated to this process with particular attention paid to the coal regions.

4. **Strengthen the capacity of the Regional Funds for Environmental Protection**

As proved by the high rates of rejection or resignation observed in the "Clean Air" programme – significantly higher than in the case of "My Electricity" – important administrative barriers exist for the applicants. This might be due to programme's income verification requiring submitting multiple documents or the overly complicated application forms. To address this, the Regional Funds for Environmental Protection should be allocated additional resources to be able to personally support potential beneficiaries. Such guidance could be prioritised for households qualifying for *increased* and *highest* levels of support, which might face the greatest administrative burden.

Moreover, disparities in the average rates of rejection or resignation across the voivodeships suggest that some branches support their beneficiaries more efficiently than others. These inconsistencies should be subjected to a more in-depth study. The National Fund for Environmental Protection and Water Management with the help of, for example, the Supreme Audit Office should survey the regional branches to identify the main barriers as well as potential solutions and best practices.

In addition, long application processing times identified by the Supreme Audit Offices in 2021 aggravate the situation, potentially deterring applicants and undermining the credibility of the programme. Simplifying administrative procedures and increasing human resources of the Regional Funds could help accelerate the process as well as increase trust and take-up.

5. **Look ahead and plan policies mitigating potential inequalities on the housing market**

As this study focused on programmes supporting homeowners in the energy transition, it didn't pay equal consideration to the other group – renters. Although incentivising homeowners to invest in energy efficiency and RES is paramount to accelerate the decarbonisation of the building sector, the process can inadvertently exacerbate inequalities on the housing market. Public transfers like those described in this study, while indeed supporting energy transition goals, are targeting only one group, often more affluent to begin with. The renovations covered by the "Clean Air" and "My Electricity" programmes can also increase the value of these houses. This while constitutes benefit for their owners, can be harmful for the renters through increase in rents or in prices of houses, making it more difficult to enter the market.

In the future, policymakers should take these risks into account by putting it place mitigation policies. Reforming taxation of real estate and profits from renting could be a step in the right direction provided these additional revenues are dedicated to housing policy, supporting renters and low-income households. Moreover, supporting renovations of multi-family housing as well as making it possible for these buildings to also take advantage of RES should be the next priority for the Polish policymakers. Finally, as PV microinstallations are becoming more and more popular and accessible, perhaps the focus should now shift towards incentivising the creation of energy communities that could benefit disadvantaged households, rather than private investments of individual households.

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Annex 1

Data sources

Name of the institution	Type of data	Scope of data	Source
National Fund for Environmental Protection and Water Management	"My Electricity" programme	Dataset covered: ● Number of applications and contracts disaggregated by municipality and voivodeship, signed during 6 editions of the programme during the years 2019-2024 ● All 16 voivodeships of Poland ● 504 966 funding agreements for the value of PLN 2 836 306 719	Obtained upon request on February 5, 2025. Additional data received on February 11, 2025.
Regional Fund for Environmental Protection and Water Management - Dolnośląskie	"Clean Air" programme	Dataset covered: ● Number of applications and contracts disaggregated by municipality and funding levels (basic, increased, highest) for the whole duration of the programme ● Amount of subsidy granted disaggregated by municipality and funding levels Dataset did not cover: ● Information on the type of municipality which was later added manually	Obtained upon request on November 27, 2024.
Regional Fund for Environmental Protection and Water Management - Lubelskie	"Clean Air" programme	Dataset covered: ● Number of applications and contracts disaggregated by municipality and funding levels (basic, increased, highest and "other") for the whole duration of the programme ● Amount of subsidy granted disaggregated by municipality and funding levels ● Information on the type of municipality ● Disaggregation by quarters Applications and contracts for the "other" funding category were not considered to ensure comparability with other regions.	Obtained upon request on September 24, 2024. Additional data received on March 4, 2025.

Regional Fund for Environmental Protection and Water Management - Łódzkie	"Clean Air" programme	Dataset covered: ● Number of contracts disaggregated by municipality and funding levels (basic, increased, highest and "blank") for the years 01.01.2019-30.09.2024 ● Amount of subsidy granted disaggregated by municipality and funding levels ● Information on the type of municipality ● Disaggregation by quarters Dataset did not cover: ● Number of applications Contracts for the "blank" funding category were not considered to ensure comparability with other regions.	Obtained upon request on October 16, 2024. Additional data received on March 14, 2025.
Regional Fund for Environmental Protection and Water Management - Opolskie	"Clean Air" programme	Dataset covered: ● Applications submitted in the period 19.09.2018-03.12.2024 ● Subsidy requested ● Application favourably evaluated by the Management Board (yes/no) ● Resignation (yes/no) ● Level of funding (basic, increased, highest and "blank") ● Municipality The variable "Number of contracts" was constructed by subtracting the number of rejections and rejections from the number of applications. Contracts for the "blank" funding category were not considered to ensure comparability with other regions.	Obtained upon request on December 10, 2024.
Regional Fund for Environmental Protection and Water Management - Podlaskie	"Clean Air" programme	Dataset covered: ● Number of applications and contracts disaggregated by municipality and funding levels (basic, increased, highest) for the whole duration of the programme ● Amount of subsidy granted disaggregated by municipality and funding levels ● Information on the type of municipality ● Disaggregation by quarters	Obtained upon request on February 19, 2025. Additional data received on March 13, 2025.

<table>
<tr><td>Regional Fund for Environmental Protection and Water Management - Pomorskie</td><td>“Clean Air” programme</td><td>Dataset covered:
Number of applications and contracts disaggregated by municipality and funding levels (seven groups) for the “old intake” until 14.05.2020
Amount of subsidy granted disaggregated by municipality and funding levels (seven groups) for the “old intake” until 14.05.2020
Number of applications and contracts disaggregated by municipality and funding levels (basic, increased, highest) for the “new intake”
Amount of subsidy granted disaggregated by municipality and funding levels (basic, increased, highest) for the “new intake”
Information on the type of municipality
Disaggregation by quarters
The applications and contracts from the “old” intake were rejected as they could not be matched with the rest of the dataset. They represent 22% of applications and 25% of contracts for the Pomorskie voivodeship.</td><td>Obtained upon request on September 13, 2024.

Additional data received on February 20, 2025.</td></tr>
<tr><td>Regional Fund for Environmental Protection and Water Management - Warmińsko-Mazurskie</td><td>“Clean Air” programme</td><td>Dataset covered:
Number of applications and contracts disaggregated by municipality for the whole duration of the programme
Amount of subsidy granted disaggregated by municipality
Information on the type of municipality
Number of projects completed
Dataset did not cover:
Disaggregation by funding levels (basic, increased, highest)
Disaggregation by quarters</td><td>Obtained upon request on October 23, 2024.</td></tr>
<tr><td>Regional Fund for Environmental Protection and Water Management -</td><td>“Clean Air” programme</td><td>Dataset covered:
Number of applications and contracts disaggregated by municipality and funding levels (seven groups) for the “old intake” until 2020</td><td>Obtained upon request on September 27, 2024.</td></tr>
</table>

Wielkopolskie		- Amount of subsidy granted disaggregated by municipality and funding levels (seven groups) for the “old intake” until 2020 - Number of applications and contracts disaggregated by municipality and funding levels (basic, increased, highest) for the “new intake” - Amount of subsidy granted disaggregated by municipality and funding levels (basic, increased, highest) for the “new intake” Dataset did not cover: - Information on the type of municipality which was later added manually - Disaggregation by quarters The applications and contracts from the “old” intake were rejected as they could not be matched with the rest of the dataset. They 14% of applications and 14% of contracts for the Wielkopolskie voivodeship.	
Regional Fund for Environmental Protection and Water Management - Zachodniopomorskie	“Clean Air” programme	Dataset covered: - Number of applications disaggregated by municipality and funding levels (basic, increased, highest and “blank”) for the whole duration of the programme - Number of applications favourably evaluated - Number of resignations - Amount of subsidy granted disaggregated by municipality and funding levels Dataset did not cover: - Information on the type of municipality which was later added manually The variable “Number of contracts” was constructed by subtracting the number of rejections and rejections from the number of applications. Contracts for the “blank” funding category	Obtained upon request on September 23, 2024.

		were not considered to ensure comparability with other regions.	
Central Statistical Office of Poland	Statistical data	The following variables were constructed using datasets in the brackets: ● Population - municipality, county and voivodeship (*Population status, natural and migratory movements in the first half of the year by administrative division 30.06.2023*) ● Type of the municipality (*Population status, natural and migratory movements in the first half of the year by administrative division 30.06.2023*) ● Number of households - municipality and county (*Households by number of persons, 2021*) ● Median gross monthly income - municipality and county (*Measures of wages by place of residence in May 2024. Median gross wage*) ● Unemployment rate - county (*Registered unemployed persons and unemployment rate by voivodships and powiats, December 2024*) ● Unemployment rate - municipality (*Registered unemployed persons and unemployment rate by municipalities, June 2024*) ● Share of households relying on welfare - municipality and county (*Households benefiting from community social assistance by income criterion, 2023*) ● Share of houses heated with coal - county *(Occupied dwellings by heating method and energy source, 2011 and 2021)* ● Share of population in post-working age - municipality and county (*Post-working age population, 2023*) ● Share of homes built pre-2003 - county *(Occupied residential buildings by period of construction and technical equipment, 2021*) ● Share of population with higher	Accessed online, Bank Danych Lokalnych and Produkt krajowy brutto i wartość dodana brutto w przekroju regionów w 2022 r.

		education - municipality and county (*Population aged 13 and over by level of education and sex, September 2023*) ● Number of single-family houses - county (*Occupied residential buildings by number of dwellings, 2021*) ● Voivodeship GDP per capita (*Gross domestic product and gross value added by region in 2022*)	
Chief Inspectorate for Environmental Protection	Air pollution data	Dataset "Statistics from the years 2000-2023"	Accessed online, Bank danych pomiarowych - GIOŚ.
Central Registry of Building Emissions	Heating sources data	Dataset "Structure of heat sources in single-family houses by county", accessed March 21, 2025 (updated continuously)	Accessed online, CEEB GUNB

Annex 2

Evolution of the "Clean Air" programme

Edition	**Income thresholds**	**Changes introduced and types of renovations covered**
2018-2020	Seven income thresholds existed from up to 600 PLN per month per person to over 1600 PLN per month per person. The subsidy could cover up to 90% of the eligible costs for the first group and up to 30% for the last group. The maximum eligible costs of the renovations was 53 000 PLN.	Both existing and new buildings were eligible for: • Replacement of heating sources (solid fuel boilers, oil-fired boilers, gas boilers, heat pumps, electric heating systems). The cost of dismantling old furnaces was eligible as well. • Thermal modernisation (insulation, replacement of doors and windows) • Modernisation of central heating and hot water systems • PV system (only eligible for a loan) • Mechanical ventilation

2020	Two levels of funding as well as income cap were introduced: • Basic: annual income of an applicant < 100 000 PLN. Maximum subsidy amounted to 30 000 PLN. • Increased: < 1400 PLN per person (multi-person household) or < 1960 PLN per person (single-person household). Maximum subsidy amounted to 37 000 PLN. Individuals whose income exceeded 100 000 PLN could take advantage of the thermo-modernisation tax credit in their PIT (up to 53 000 PLN).	Support was limited for only already existing buildings. The programme was extended to allow for taking on a subsidised loan. The programme was also partially integrated with “My Electricity” application for PV microinstallations to streamline the process.
2021	The threshold for the *increased* level of funding was increased to 1564 PLN per person for a multi-persons household and 2189 PLN per person for a single-person household.	It was possible to apply for additional support for the installation of a pellet boiler of a higher standard.
2022-2023	The third *highest* level of funding was introduced: • Basic: annual income of an applicant < 100 000 PLN. Maximum subsidy amounted to 30 000 PLN. The subsidy could cover between 30% and 50% of the eligible costs. • Increased: < 1564 PLN per person (multi-person household) or < 2189 PLN per person (single-person household). Maximum subsidy amounted to 37 000 PLN. The subsidy could cover between 60% and 75% of the eligible costs. • Highest: < 900 PLN per person (multi-person household) or < 1260 PLN per person (single-person household). Maximum subsidy amounted to 69 000 PLN. The subsidy could	New coal boilers were no longer eligible for support. A “prefinancing” pilot was introduced for beneficiaries qualified for *increased* and *highest* levels of support.

	cover up to 90% of the eligible costs.	
2023-2025	Income thresholds were reformed: • Basic: annual income of an applicant < 135 000 PLN. Maximum subsidy amounted to 66 000 PLN. The subsidy could cover up to 55% of the eligible costs. • Increased: < 1894 PLN per person (multi-person household) or < 2651 PLN per person (single-person household). Maximum subsidy amounted to 99 000 PLN. The subsidy could cover up to 80% of the eligible costs. • Highest: < 1090 PLN per person (multi-person household) or < 1526 PLN per person (single-person household). Maximum subsidy amounted to 135 000 PLN. The subsidy could cover up to 100% of the eligible costs.	An obligation to conduct an energy audit was introduced. An additional subsidy for this goal was allocated – up to 1 200 PLN. The renovations had to be conducted in accordance to the "ZUM list", an official list of approved green devices and materials.
March 2025	Income thresholds were reformed: • Basic: annual income of an applicant < 135 000 PLN. The subsidy could cover up to 40% of the eligible costs. • Increased: < 2250 PLN per person (multi-person household) or < 3150 PLN per person (single-person household). The subsidy could cover up to 70% of the eligible costs. • Highest: < 1300 PLN per person (multi-person household) or < 1800 PLN per person (single-person household). The subsidy	A nationwide system of "operators" (municipalities and Regional Funds for Environmental Protection) is being introduced to support the beneficiaries. The highest level of financing as well as prefinancing will only be available with the support of an operator. An energy audit will now be mandatory both before and after the renovations.

	could cover up to 100% of the eligible costs.	

Annex 3

Evolution of the "My Electricity" programme

Edition	**Characteristics**
1st edition (30.08.2019 - 20.12.2019)	Funding for projects involving the purchase and installation of: • Photovoltaic micro-installations from 2-10 kW (up to PLN 5 000) Call dedicated to prosumers under the net-metering system
2nd edition (13.01.2020 - 06.12.2020)	Funding for projects involving the purchase and installation of: • Photovoltaic micro-installations from 2-10 kW (up to PLN 5 000) Call dedicated to prosumers under the net-metering system
3rd edition (1.07.2021 - 6.10.2021)	Funding for projects involving the purchase and installation of: • Photovoltaic micro-installations from 2-10 kW (up to PLN 3 000) Call dedicated to prosumers under the net-metering system
4th edition (16.04.2022 - 17.03.2023)	Funding for projects involving the purchase and installation of: • Photovoltaic micro-installations from 2-10 kW (up to PLN 5 000) • Energy storage (up to PLN 7 000) • Heat storage (up to PLN 5 000) • EMS/HEMS systems (up to PLN 3 000) Call dedicated to prosumers under the net-billing system
4th+ edition (15.12.2022 - 17.03.2023)	Funding for projects involving the purchase and installation of: • Photovoltaic micro-installations from 2-10 kW (up to PLN 7 000) • Energy storage (up to PLN 16 000) • Heat storage (up to PLN 5 000) • EMS/HEMS systems (up to PLN 3 000) Call dedicated to prosumers under the net-billing system
5th edition (22.04.2023 - 14.12.2023)	Funding for projects involving the purchase and installation of:

	• Photovoltaic micro-installations from 2-10 kW (up to PLN 7 000) • Heat pump (up to PLN 28 500) • Energy storage (up to PLN 16 000) • Heat storage (up to PLN 5 000) • Solar collectors (up to PLN 3 500) • EMS/HEMS systems (up to PLN 3 000) Call dedicated to prosumers under the net-billing system

Annex 4

Priority counties

Voivodeship	**Counties**
Dolnośląskie	• górowski county • lwówecki county • złotoryjski county
Lubelskie	• chełmski county • hrubieszowski county • janowski county • krasnostawski county • kraśnicki county • lubartowski county • parczewski county • włodawski county • zamojski county
Łódzkie	• opoczyński county
Podlaskie	• hajnowski county • kolneński county • moniecki county • sejneński county • siemiatycki county • sokólski county
Warmińsko-Mazurskie	• bartoszycki county • braniewski county • działdowski county • kętrzyński county • lidzbarski county • piski county • węgorzewski county
Zachodniopomorskie	• białogardzki county • choszczeński county • drawski county • pyrzycki county • szczecinecki county • świdwiński county

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Energy transition for whom? Examining the distribution of green subsidy schemes in Poland.

Julia Kieloch

Abstract

Energy transition represents an opportunity to deeply reshape our economic systems to make them not only more sustainable but also more just. However, if not carefully designed, it can create new risks and divides for those who get to enjoy its fruits such as green, cheap energy and clean air and those forced to rely on polluting and increasingly expensive fossil fuels. This work examines the spatial and socio-economic distribution of two green subsidy schemes in Poland targeted at homeowners and supporting investments in energy efficiency and renewable energy. It exploits extensive, and often never published before, data on subsidy contracts signed within the framework of the "Clean Air" and "My Electricity" programmes and examines whether they contribute to or mitigate the development of inequalities. With the use of descriptive statistics, regression analyses and three original indices, this study finds that indeed, participation in the programmes differs significantly across groups and regions. It argues that this is due to the programmes' design, with "Clean Air" providing dedicated support for low-income households and "My Electricity", on the contrary. The extent of inequality in programmes' take-up is mapped, highlighting regional hotspots in need of urgent policy intervention. Finally, the study suggests how the programmes should be reformed to mitigate potential inequalities and ensure their more equitable distribution.

Key words

Energy transition, Green subsidy schemes, Environmental justice, Inequality, Environmental policy