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THE LABOUR DEMAND EFFECTS OF RESIDENTIAL BUILDING RETROFITS IN POLAND[•]

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Abstract

This paper analyses the potential direct impact of intensifying residential energy retrofitting on the Polish labour market. We distinguish eight building classes, for which we quantify the labour intensity of improvements to building insulation and heating systems. We account for work performed by low-, medium- and high-skilled workers. We define the baseline scenario of maintaining the current rate of retrofitting and three scenarios of its acceleration (up to two times) and increased comprehensiveness. We estimate the resulting additional labour demand and changes to the unemployment rate at the country and NUTS2 region level. Our results show that the most ambitious scenario of increased energy retrofitting would see the creation of approx. 100,000 additional jobs nationwide per year, with the majority of this added demand concerning low-skilled persons. This effect is predominantly caused by energy retrofits to single-family buildings. The effect of building insulation retrofits on the labour demand is 3-4 times greater than the effect of heating and hot water system upgrades.

Keywords: residential energy retrofitting, energy efficiency, green jobs

JEL: Q52, L74

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1. Introduction

“Putting energy efficiency first” is one of the three mottos of the so-called Winter Package – a set of regulatory proposals put forward by the European Commission in 2016, outlining the most important directions of the European Union’s climate policy. The proposals currently discussed in the EU place particular emphasis on the potential to lower energy use in buildings, which account for 40% of primary energy consumption, at the same time exemplifying considerable inefficiencies (European Comission, 2016)

In Poland, the need to intervene in the housing sector results not only from many years of neglect, but takes on a new meaning in the context of policies aimed at improving air quality. Residential buildings, in particular single-family houses with local coal-based heating sources, are the main cause of air pollution in Poland. The building sector is responsible for approx. 90% of benzo(a)pyrene emissions and for approx. 45% of PM10 particulate matter emissions (KOBiZE 2018). Energy retrofitting of buildings in which the obsolete, coal heating is used, is crucial for reducing harmful emissions. However, increasing the scale of energy retrofits in such buildings will not be possible without public funds, owing to the high investment cost and the fact it often concerns relatively poor households.

The considerable cost of such policies raises the issue of potential of co-benefits that can be achieved by increasing the intensity of residential energy retrofits. Apart from contributing to meeting climate policy objectives and improving air quality, certain social benefits are also highlighted, such as reduction of energy poverty (Rutkowski et al. 2018), improved quality of life of inhabitants, and creation of new jobs (Cambridge Econometrics 2015, Tuominen et al. 2013; Cuchi & Sweatman 2012).

This study is aimed at assessing the direct impact of increased residential energy retrofits on labour demand in Poland. Current research in the field indicates that among various actions associated with climate policy objectives, improving energy efficiency is one of the more labour intensive investments, in comparison with, e.g., adoption of RES technologies, which are significantly more capital-intensive. Research also shows that energy efficiency activities are different from the other types of green jobs. First, improving the energy efficiency of buildings creates demand mostly for low- and medium-skilled labour, while other green jobs (e.g. RES) involve rather highly-skilled specialists. Second, labour demand is not only clustered in industry and tech hubs or areas whose geography favours RES installation, but is geographically dispersed. Therefore, it can have a positive impact on local labour markets in smaller urban centres (Cambridge Econometrics 2015). Both these aspects make jobs generated by residential energy retrofits particularly interesting in the context of Polish labour market. Even though the average unemployment rate in Poland has declined to a low level (6.3% in 2016), it is visibly higher among low-skilled workers (9.2%). It also varies between regions, ranging from 4.6% in Lubuskie Voivodeship to 9.9% in Podkarpackie Voivodship.

This study quantifies the potential demand for labour which could be generated by increasing the rate of residential energy retrofitting in Poland. Our research differs in important aspects from other studies of its type, both those concerning Poland (Ürge-Vorsatz et al. 2012) and conducted in other countries (Wade et al. 2000, Jeeninga et al. 1999, Sundquist 2009). First, our labour intensity data comes from databases employed in the industry itself. Second, we exploit the detailed nature of said data, refraining from approximate values employed in the majority of previous studies. We single out eight model types of residential buildings and estimate the labour inputs are estimated separately for each of them, with a bottom-up approach using individual actions that constitute a single improvement, such as insulating a roof. For each building, we select the technology of performing the given intervention. Owing to the use of such detailed data, we are able to not only precisely predict the total labour input required to complete energy retrofits, but also to analyse the labour intensity of individual interventions, in individual building types, for workers with different skills. Third, we use household survey data to estimate the current rate of retrofit measures undertaken with respect to individual types of residential buildings. We use these building-specific rates to define the baseline scenario and put forward three scenarios of its acceleration. Fourth, we combine our assessments of additional labour demand with the labour supply model, and analyse the influence of various energy retrofit scenarios on unemployment at the country and regional (NUTS 2) level, and by qualification level. This is the first such study concerning Poland.

The paper is organised as follows. The second section presents the methodology. The third section presents various scenarios concerning the rate of energy retrofitting. Results are presented in section four. They encompass, on the one hand, our estimates of the hourly labour input required for energy retrofitting of each model building, and on the other, the total effect on the labour market achieved as a result of implementing each of the proposed scenarios. The final section summarises the study and offers some policy conclusions.

2. Methodology and data

This section presents the methodology and assumptions of our study, as well as the sources of data we use. First, we divide the entire housing stock in Poland into eight building classes and estimate the number of buildings in each class. We subsequently define the model (most representative) building for each class and the most typical scope of retrofit measures for each model building. Then, we elaborate a method of estimating their labour intensity which in the next step is plugged into the labour demand model to calculate labour demand effects. These are in turn juxtaposed with the labour supply model to calculate effects on unemployment.

2.1. The structure of Polish housing stock

In order to estimate the number of jobs which can be created as a result of increasing the rate of energy retrofitting in Poland, we have to start by reducing the complexity of the extremely varied housing stock in the country. To this end, we assigned all residential buildings to eight classes (Table 1). Our point of departure here was the NAPE (2012) typology, which we then simplified and modified based on two criteria. Firstly, buildings within one class had to require similar energy retrofitting measures. Secondly, the estimation of the number of buildings in each class should possible with the use of available Central Statistical Office (GUS) data: the National Census (NSP 2011) and the Household Budget Survey (BBGD 2012, 2015) data, our two main sources of information about the housing stock in Poland.

Based on the first criterion, we grouped together single-family, semi-detached and terraced houses, assuming that the differences between the required energy retrofit measures were low. However, we divided them into those built before and after 1970, and further distinguished between them based on the heating system in place: buildings with central heating systems (own boiler room or connection to the district heating network) and buildings heated using stoves or fireplaces were classified separately. This results from the fact that buildings lacking central heating require additional energy retrofit improvements. We thus arrived at four classes of single-family buildings (Table 1).

With regard to multi-family buildings (blocks of flats, tenements, etc.), we adhered to the NAPE division into buildings with up to eight storeys and with more than eight storeys. We distinguished three classes of multi-family buildings with eight or fewer storeys: pre-war buildings, buildings erected between 1945 and 1970, and those built after 1970. In the group of high-rise buildings (more than eight storeys), we disregarded the construction period, as the vast majority of them are Large Panel System buildings from the 1970s and 1980s. We thus arrived at four classes of multi-family buildings (Table 1).

Table 1. Classes of residential buildings in Poland

Class no.	Building type	Construction period	Heating system	No. of buildings in the class	% of all buildings
1	Single-family / semi-detached / terraced	- 1970	Stove / fireplace	657 789	13%
2	Single-family / semi-detached / terraced	- 1970	Central heating	1 737 655	33%
3	Single-family / semi-detached / terraced	1971 -	Stove / fireplace	284 268	6%
4	Single-family / semi-detached / terraced	1971 -	Central heating	2 176 927	42%
	single-family TOTAL			4 856 639	93%
5	Multi-family	- 1945	-	103 914	2%
6	Multi-family	1946-1970	-	76 337	1.5%
7	Multi-family up to 8 storeys	1971-	-	153 390	3%
8	Multi-family more than 8 storeys	1971-	-	20 498	0.5%
	multi-family TOTAL			354 139	7%
	POLAND TOTAL			**5 210 778**	**100%**

Source: compiled by the authors based on NSP 2011 and BBGD 2012.

The number of buildings in each of the eight classes was estimated based on "Residential buildings according to number of dwelling units and construction period in voivodeships" prepared by GUS based on the 2011 National Census data (NSP, 2011). We make the following assumption regarding the number of dwelling units in a building:

- single-family and terraced buildings (classes 1–4) include one to five dwelling units;[1]
- multi-family buildings with up to eight storeys (classes 5–7) include six to 49 dwelling units;
- buildings with more than eight storeys (class 8) include 50 or more dwelling units.

In order to distinguish between single-family buildings heated using stoves and those with central heating (either local or from the district heating network), we use data from the 2012 Household Budget Study (BBGD).[2]

[1] Buildings with 3–5 dwelling units represent a negligible share of the entire housing stock. We assumed that the cubic capacity of such buildings was more similar to single-family than multi-family buildings.

2.2. Model buildings and retrofit measures

In the next step, a model building was defined for each building class based on the most representative features of a given class. We took into account the following features of buildings, which are key for estimating the labour intensity of the required energy retrofits:

- building technology,
- number of storeys,
- number of dwelling units in the building,
- usable floor area,
- surface area of the building envelope,
- heating method,
- method of providing domestic hot water.

A list of the basic parameters in model buildings and a detailed description of the method used to define model building is included in Appendix A1.

For each model building, we defined the most typical scope of retrofit measures that lead to considerably lower energy consumption and jointly constitute a comprehensive energy retrofit (NAPE 2012). By adopting a comprehensive approach to energy retrofitting, it is possible to achieve significant economic, social and environmental benefits, at the same time avoiding the pitfalls of fragmentary retrofitting (Staniaszek and Zaborowski, 2014). In practice, the retrofitting of buildings in Poland is rarely comprehensive, a fact that we took into account when creating energy retrofitting scenarios (section 3). For the purpose of this study, we deliberately refrained from providing the precise parameters of technologies employed, such as the density of insulation material. We assumed that these parameters would evolve over time as new building standards enter into force throughout the period studied (until 2030). Importantly, based on information obtained in qualitative interviews, we assumed that shifting to a more efficient technology (e.g., changing the insulation material density, stove class, etc.) does not have a significant impact on the labour input required to implement a given measure.

We consider the following measures aimed at improving the insulation characteristics of buildings (NAPE 2012):

Group 1: building envelope retrofits

- wall insulation,
- insulation of solid ground floor / floor over basement,
- roof insulation,
- window replacement,

Group II – system upgrades

- heating source replacement,
- heating system upgrade,
- hot water system upgrade.

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[2] We relied on BBGD data from 2012 (rather than 2011) so as to ensure coherence with the BBGD module used in the further part of our analysis: "Questionnaire on fuel and energy use in households," which is conducted every three years, most recently in 2012 and 2015.

The description of improvements to individual model buildings is provided in Table 2 (building envelope) and Table 3 (heating and domestic hot water systems) below.

Table 2. Building envelope in model buildings and corresponding retrofit measures

	solid ground floor / floor over basement	roof / flat roof	external walls	windows
model 1 & 2 existing condition	solid ground floor	unusable attic space, the ceiling stops the heat from escaping	external solid brick walls, no insulation	wooden casement windows
retrofit measures	removal of old solid ground floor, laying a new insulated one	insulating the roof with mineral wool	insulating the walls with polystyrene in the ETICS system	replacing with double-pane PVC windows
model 3 & 4 existing condition	floor over basement	unventilated flat roof, asphalt roll roofing	external brick walls, no insulation	wooden Swedish windows
retrofit measures	(insulating floor over basement with spray-polyurethane foam (SPF))	adding a layer of bitumen-laminated polystyrene boards and a new thermoplastic roofing membrane	insulating the walls with polystyrene in the ETICS system	replacing with double-pane PVC windows
model 5 existing condition	floor over basement	gable roof with unusable attic space	external solid brick walls, no insulation	wooden box-type windows (*Kastenfenster*)
retrofit measures	(insulating floor over basement with spray-polyurethane foam (SPF))	insulating the roof with mineral wool	insulating the walls with polystyrene in the ETICS system	replacing with double-pane PVC windows
model 6 existing condition	floor over basement	hip roof with unusable attic space	external brick walls, no insulation	wooden casement windows
retrofit measures	(insulating floor over basement with spray-polyurethane foam (SPF))	insulating the roof with mineral wool	insulating the walls with polystyrene in the ETICS system	replacing with double-pane PVC windows
model 7 existing condition	floor over basement	cold flat roof, precast channel slabs, asphalt roll roofing	Large Panel System building	wooden Swedish windows
retrofit measures	(insulating floor over basement with spray-polyurethane foam (SPF))	blown-in insulation	insulating the walls with polystyrene in the ETICS system	replacing with double-pane PVC windows
model 8 existing condition	floor over basement	cold flat roof, precast channel slabs, asphalt roll roofing	Large Panel System building	wooden Swedish windows
retrofit measures	(insulating floor over basement with spray-polyurethane foam (SPF))	blown-in insulation	insulating the walls with polystyrene/mineral wool in the ETICS system	replacing with double-pane PVC windows

Source: own elaboration based on Chmielewski (2017).

Table 3. Existing heating and domestic hot water systems in model buildings and corresponding upgrades

	heating source	central heating system	domestic hot water system
model 1 existing condition	coal stoves in rooms	none / coal stoves in rooms	demand water heater
upgrades	gas boiler (+ solar panels), wall-mount boiler in the bathroom	installing a central heating system *Assumptions: 5 radiators; insulated system under concrete topping*	installing a domestic hot water system (+ solar panels) *Assumptions: 2 outlets in the bathroom and 1 in the kitchen; insulated pipes*
model 2 existing condition	coal boiler	in place, cast-iron radiators	demand water heater
upgrades	gas boiler (+ solar panels)	central heating system upgrade *Assumptions: 5 radiators; insulated system under concrete topping*	installing a domestic hot water system (+ solar panels) *Assumptions: 2 outlets in the bathroom and 1 in the kitchen; insulated pipes*
model 3 existing condition	coal stoves in rooms	none / coal stoves in rooms	demand water heater
upgrades	gas boiler (+ solar panels), creating a boiler room	installing a central heating system *Assumptions: 8 radiators; 3 risers; insulated pipes*	installing a domestic hot water system (+ solar panels) *Assumptions: 1 riser; 2 outlets in each of the two bathrooms and 1 connection to the kitchen; insulated pipes*
model 4 existing condition	coal boiler	in place, cast-iron radiators	demand water heater
upgrades	gas boiler (+ solar panels)	central heating system upgrade *Assumptions: 8 radiators; 3 risers; insulated pipes*	installing a hot water heating system (+ solar panels) *Assumptions: 1 riser; 2 bathrooms with 2 outlets each and 1 connection to the kitchen; insulated pipes*
model 5 existing condition	coal stoves in rooms	none / coal stoves in rooms	demand water heater
upgrades	gas boiler (+ solar panels), creating a boiler room	installing a central heating system *Assumptions: 2 central heating risers per dwelling unit, 2 radiators per each storey connected to each riser; insulated pipes, drywall system*	installing a domestic hot water circulation system (+ solar panels) *Assumptions: 1 hot water riser per dwelling unit, 2 outlets in the bathroom and 1 in the kitchen; insulated pipes*
model 6 existing condition	coal boiler	in place, cast-iron radiators	demand water heater
upgrades	gas boiler (+ solar panels)	central heating system upgrade *Assumptions: 2 central heating pipelines per dwelling unit, 2 radiators per each storey connected to each pipeline; insulated pipes*	installing a domestic hot water circulation system (+ solar panels) *Assumptions: 1 hot water riser per dwelling unit, 2 outlets in the bathroom and 1 in the kitchen; insulated pipes*
model 7 & 8 existing condition	from the district heating network	in place, cast-iron radiators	in place, no insulation
upgrades	no upgrades / adapting to the upgraded central heating and domestic hot water systems	central heating system upgrade *Assumptions: 4 central heating pipelines and 4 panel radiators per dwelling unit, insulated pipes*	domestic hot water system upgrade; circulating system *Assumptions: 2 hot water risers per dwelling unit, 2 outlets in the bathroom and 1 in the kitchen; insulated pipes*

Source: own elaboration based on Chmielewski (2017).

For each retrofit measure in a given building, the required labour input was calculated and expressed as hours worked by low-skilled, medium-skilled and highly-skilled workers. In order to estimate the labour intensity of particular energy retrofitting measures, we relied on a study by Chmielewski (2017), which is largely based on data from the Construction Pricing Guide (KNR – *Katalog Nakładów Rzeczowych*). This is a complete list of unit costs, material and labour demands, which is used in the construction industry to draft cost estimates of construction works; the only comprehensive source of information on the labour intensity of construction works. The labour input of highly-skilled workers (auditors, energy counsellors, managers in construction companies and employees responsible for project documentation) was calculated in a slightly different manner as these inputs are not fully covered by the KNR. We again rely on Chmielewski's (2017) assessment, which takes into account such factors as formal requirements, construction work practice and the duration of construction work. Qualitative interviews with owners of construction companies, engineers and energy auditors were used as an auxiliary source of data at every stage of estimating the labour intensity.

2.3. Labour demand and supply models

The labour market model comprises the module of labour demand generated by energy retrofitting measures and the labour supply module. Labour demand is calculated by multiplying the given measure's labour intensity (discussed in the previous subsection) and the number of buildings in which this measure was applied in the given year (in individual voivodeships and in total). With regard to the number of buildings undergoing energy retrofitting, the analysed variants include the baseline scenario, which assumes that the current retrofitting rate will be maintained, and alternative scenarios, in which it is increased. The method of assessing the retrofitting rate in the baseline scenario and the manner of constructing alternative scenarios are discussed in the following section. By multiplying the labour intensity of retrofitting measures and the number of buildings undergoing retrofitting, we obtain the number of man-hours required to complete a given measure with respect to a given building class in a given voivodeship, broken down by low-, medium- and high-skilled workers. In order to arrive at labour demand expressed as the full-time equivalent (FTE), the FTE is set as 252 8-hour working days a year.

The labour supply projection is broken down by education, based on the size of the active population between 2013 and 2016 (GUS Local Data Bank – BDL data), the Central Statistical Office population projection for the 2013-2050 period (BDL data), the forecast unemployment rate (Ministry of Finance) and projected labour market participation derived from the model of Lis et al. (2015). In order to ensure correspondence between the labour demand and supply structures, the following assumptions were made: low-skilled workers are persons with primary or lower, lower secondary or vocational education; medium-skilled workers are persons with secondary education (general secondary school or vocational school) or post-secondary, non-tertiary education; and high-skilled workers are persons with tertiary education. The labour supply model is described in detail in Appendix A2.

By juxtaposing the projected labour demand and supply, it was possible to evaluate the impact of energy retrofitting measures on the unemployment rate, overall and by voivodship and qualification level. The baseline scenario of the retrofitting rate is assumed to correspond to the baseline projection of the unemployment rate. In other words, energy retrofitting measures have no impact on unemployment in the baseline scenario. In the case of alternative scenarios, absolute impact on employment (the difference between labour demand in the given scenario and the baseline scenario) corresponds to the impact on unemployment.

3. Building retrofitting scenarios

3.1. The current rate of energy retrofitting – baseline scenario

In order to define the baseline scenario – i.e., the current rate of retrofit improvements to the Polish housing stock – two pieces of information are required: first, the share of buildings that have already undergone retrofitting, and second, the annual retrofitting rate. In order to obtain the said information, we rely on data from the 2012 and 2015 BBGD module "Questionnaire on fuel and energy use in households."

According to the 2012 BBGD module, 54.1% of households declare inhabiting insulated buildings, with a further 7.3% stating that the building they live in is "partially" insulated. In practice, "partial insulation" may indicate both a relatively good and a relatively poor energy performance of the building. Therefore, we assumed that one in two partially insulated buildings would require further interventions – i.e., 50% of partially insulated buildings is assigned to the housing stock undergoing retrofitting.[3]

Available GUS data concerns only building insulation, and provides no information on the share of buildings that require heating system upgrades. Hence, we assumed that the condition of the heating system corresponds to that of the building's insulation. Consequently, on the one hand, we overestimate the required labour input by assuming the need to upgrade systems that may have already been upgraded, but on the other, we underestimate it by ignoring the need to upgrade systems in some buildings that are insulated but could require heating system upgrades. We assume that the two aforementioned effects offset each other.

According to BBGD data, in 2012 the share of insulated buildings within the distinguished eight building classes ranged from 21.5% (class 5) to 82.1% (class 8; see Table 4). Owing to the low sample size in the BBGD module on fuel use and building condition, the estimated shares were assumed to be the same in each voivodeship.[4]

To the best knowledge of the authors, no institution in Poland has comprehensive data on the rate of residential retrofitting. In particular, there is no available data that would illustrate the rate of energy retrofitting across various building types. Therefore, in order to fill this gap and estimate the annual energy retrofitting rate, we used the difference between the share of insulated buildings in the 2012 and 2015 BBGD modules, assuming that the number of buildings undergoing retrofitting increased steadily each year. We took into account both the difference between the share of entirely insulated buildings and partially insulated ones, ascribing the weight of 0.5 to the latter group. The results of our estimates range from 0.8% of class 5 buildings to 2.8% of class 2 buildings per year (Table 4). This range is are coherent with that obtained by the Ministry of Infrastructure and Construction (MIiB) which estimated that between 1.5% and 3% of the total housing stock undergoes retrofitting on an annual basis (Bertoldi 2012, as cited in: MIiB 2016). However, these results are not fully comparable – our study is limited to residential buildings, while MIiB (2016) covers all building types.

To finalise the baseline scenario, we need to specify the annual rate of heating system upgrades. Unfortunately, BBGD contains no information on the condition of heating systems in buildings. Therefore, we assumed that one in two households deciding to insulate their home also upgrades the heating system.

[3] We assumed that the need for window replacement concerns the same buildings that require building envelope insulation.

[4] We also assumed that the distribution of the number of dwelling units in multi-family buildings is the same in insulated and non-insulated buildings. This assumption – that the two distributions are independent – allowed us to use the structure of households declaring to live in insulated or non-insulated buildings as the structure of the buildings themselves.

The baseline scenario of energy retrofitting by building class is presented in Table 4. We assume a stable rate of retrofits in the given building class in all voivodships and over time.

Table 4. Share of insulated buildings (2012) and average annual retrofitting rate (2012–15) according to building type

Class no.	Building type	Construction period	Heating system	Share of insulated buildings [% of the given class]	Annual rate of insulating walls, roofs, solid ground floors or floors over basements and replacing windows [% of the initial housing stock]	Annual rate of replacing boilers, upgrading central heating and domestic hot water systems and installing solar panels [% of the initial housing stock]
1	Single-family / semi-detached / terraced	- 1970	Stove / fireplace	21.6	2.3	1.2
2	Single-family / semi-detached / terraced	- 1970	Central heating	45.6	2.8	1.4
3	Single-family / semi-detached / terraced	1971 -	Stove / fireplace	51.9	2.2	1.1
4	Single-family / semi-detached / terraced	1971 -	Central heating	62.5	1.6	0.8
	single-family TOTAL			50.3	2.2	1.1
5	Multi-family	- 1945	-	21.5	0.8	0.4
6	Multi-family	1946-1970	-	70.3	1.4	0.7
7	Multi-family up to 8 storeys	1971-	-	78.2	1.2	0.6
8	Multi-family more than 8 storeys	1971-	-	82.1	1.9	1.0
	multi-family TOTAL			60.1	1.2	0.6
	POLAND TOTAL			50.6	2.1	1.0

Source: own calculations based on 2012 and 2015 BBGD modules "Questionnaire on fuel and energy use in households."

3.2. Scenarios of increasing the rate of energy retrofitting

We formulate three alternatives to the baseline energy retrofitting scenario (Table 5). In each scenario, we assume that the retrofitting rates are constant over time and across voivodships.[5]

In the first scenario (S.1), the annual rate of envelope retrofits is the same as in the baseline scenario, but we assume that in each retrofitted building the , central heating and domestic hot water systems are also upgraded. In other words, scenario S.1 assumes that the baseline rates of heating and hot water systems' retrofit are doubled.

In the second scenario (S.2), the baseline retrofitting rate is increased twofold, both in terms of building insulation as well as heating and domestic hot water systems. For instance, if the baseline scenario projects that 1.4% of multi-family buildings erected between 1946 and 1970 (class 6) are insulated per year, with 0.7% undergoing

[5] Except for the case when, as a result of increased retrofitting rate, all buildings of the given class undergo energy retrofitting before 2030.

heating and hot water system upgrades (see Table 4), scenario S.2 assumes that this rate is increased to 2.8% and 1.4% respectively. Comprehensive energy retrofitting is performed in 50% of retrofitted buildings.

In the third, most ambitious scenario (S.3), the rate of envelope retrofits is double that in the baseline scenario (as in S.2), and all buildings undergoing retrofitting have the heating and domestic hot water systems upgraded (the rate of heating and domestic hot water systems retrofit is double that in the scenario S.2).

Table 5. Description of energy retrofitting scenarios

Scenario	Description	Retrofitting rate (rate of building envelope retrofits in the baseline scenario = 1)	
		envelope	systems
baseline	Annual rate of envelope retrofits (insulating walls, roofs, solid ground floors or floors over basements and replacing windows): between 0.8% and 2.8% of the initial stock, depending on building class (see: Table 4). Annual rate of upgrading systems (replacing boilers, upgrading central heating and domestic hot water systems) is lower by half than the envelope retrofit rate	1	0.5
S.1	Comprehensive energy retrofitting in each building	1	1
S.2	Doubling the baseline retrofitting rate	2	1
S.3	Comprehensive energy retrofitting in each building + doubling the retrofitting rate	2	2

Source: own elaboration.

4. Labour demand created by building retrofitting – results

4.1. Labour intensity of energy retrofits in residential buildings

The labour demand required to perform comprehensive retrofitting varies between building classes. Applying energy efficiency measures in single-family buildings entails the labour input of approx. 1100 to 1800 man-hours depending on the building class, whereas the relevant labour input in multi-family buildings may range from approx. 4000 man-hours in the case of a small tenement to even approx. 32,000 man-hours required to implement comprehensive energy retrofits in a 15-storey Large Panel System building (Table 6).

In all analysed building types, over 50% of the demand for labour in energy retrofitting concerns work performed by low-skilled workers. The share of medium-skilled workers amounts to 30-40% depending on the building type, while work performed by high-skilled workers amounts to 2-10%. In terms of the share in the total labour demand, the demand for high-skilled workers (auditors, managers and designers) is the lowest in the case of energy retrofits in large multi-family buildings. However, in absolute terms the workload of this group of workers related to retrofitting of large buildings is several times higher than in case of single-family buildings.[6]

[6] In the case of single-family buildings, there are no formal requirements concerning audit, supervision or project management, but we assume that all management functions have to be performed by highly-skilled workers – in practice, usually by the owner of the building company (see section 1.2).

Table 6. Labour inputs required to complete energy retrofit measures in model buildings according to worker skills

		GROUP 1 – building envelope retrofits	GROUP 2 – central heating and domestic hot water system upgrades	TOTAL
building type	worker skills	no. of man-hours	no. of man-hours	no. of man-hours
1 Single-family before 1970 no central heating	low	588	61	649
	medium	268	101	369
	high	80	30	110
	TOTAL	936	192	1128
2 Single-family before 1970 central heating in place	low	588	85	673
	medium	268	101	369
	high	80	30	110
	TOTAL	936	216	1152
3 Single-family after 1970 no central heating	low	953	78	1031
	medium	519	103	622
	high	129	34	163
	TOTAL	1601	215	1816
4 Single-family after 1970 central heating in place	low	953	71	1024
	medium	519	109	628
	high	129	34	163
	TOTAL	1601	214	1815
5 Multi-family before 1946	low	1970	249	2219
	medium	1113	658	1771
	high	141	75	216
	TOTAL	3224	982	4206
6 Multi-family 1945-1970	low	3726	505	4231
	medium	2067	825	2892
	high	162	100	262
	TOTAL	5995	1430	7385
7 Multi-family up to 8 storeys after 1970	low	3478	313	3791
	medium	1956	440	2396
	high	154	67	221
	TOTAL	5588	820	6408
8 Multi-family more than 8 storeys after 1970	low	17509	4094	21603
	medium	8310	2176	10486
	high	432	226	658
	TOTAL	26251	6496	32747

Source: compiled by the authors based on Chmielewski (2017).

Building envelope retrofits (group 1) are found to be significantly more labour intensive than heating and hot water system upgrades (group 2). The ratio of labour input required to perform building envelope retrofits to total labour input ranges from 75% in a pre-war tenement house (building 5) to almost 90% in single-family buildings erected after 1970 (buildings 3 and 4). This is predominantly due to the time-consuming nature of insulating external walls, and, to a lesser degree, replacing windows.[7] In terms of the heating and hot water system upgrades, particularly in multi-family buildings, upgrading central heating systems is found to be particularly labour intensive (replacing pipes and radiators).

The vast majority (around 90%) of work performed by low-skilled workers corresponds to envelope retrofits. The demand for work of medium-skilled workers also predominantly concerns building envelopes, but here the disproportion is not as pronounced. Particularly noteworthy in single-family buildings is the share of labour performed by medium-skilled workers required to install solar panels.

Ascribing the work of highly-skilled workers to individual categories of retrofitting measures is only relevant in partial retrofitting scenarios. In the case of comprehensive retrofitting, actions such as designing, management of works and supervising the progress of investment entail both building envelope and system upgrades.

4.2. Impact of energy retrofitting on the labour market

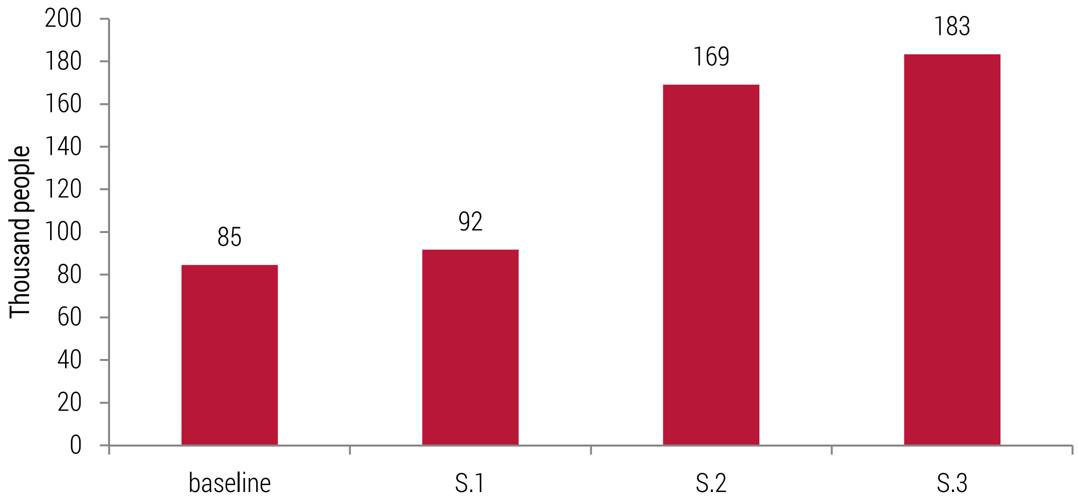
Increasing the retrofitting rate in Poland could contribute to creating an additional 100,000 jobs a year between 2017 and 2021 (Figure 1).[8] In the most ambitious S.3 scenario, the number of jobs generated by energy retrofits grows from 85,000 (baseline scenario) to 183,000 full-time positions; in the medium S.2 scenario – to 169,000, and in the least ambitious S.1 scenario – to 92,000. This means that simply doubling the rate of upgrades to central heating and domestic water systems would generate a mere 7,000 full-time jobs more nationwide. The vast majority of the additional labour demand results from increasing the number of energy efficiency activities such as insulating walls, roofs and floors as well as replacing windows.

Out of the 100,000 additional jobs in scenario S.3, almost 80% would be generated by retrofits of single-family buildings (Figure 2). This results from the fact that there are far more single-family than multi-family buildings in Poland: single-family buildings account for over 93% of the housing stock. These houses are also more likely to lack any insulation: in 2012, 50% of such buildings were not insulated, compared to less than 40% of multi-family houses (see Table 4).

[7] A detailed list of labour inputs required to complete individual energy retrofit measures is enclosed as Appendix A3.

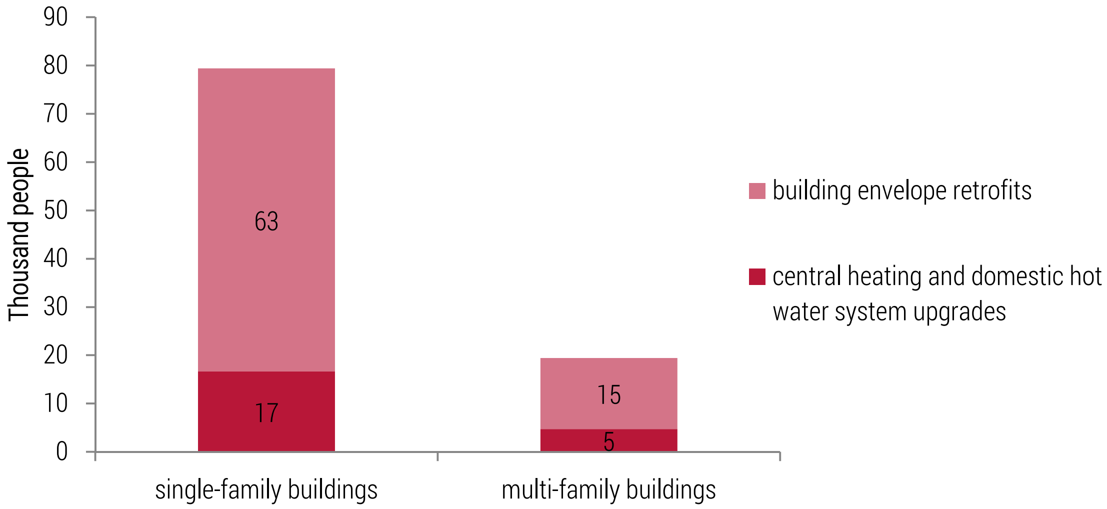
[8] The simulations were performed for the 2017-30 timeframe, but in some scenarios, the entire housing stock of certain building classes would undergo energy retrofits before 2030 (for instance, in S.3 scenario, energy retrofitting of class 8 buildings is completed as early as 2021). For this reason, we present the results for the 5-year long period (2017-2021) for which it is possible to assume that the housing stock does not run out.

Figure 1. Number of retrofitting jobs (annual average between 2017 and 2021, thousands of persons) in the selected scenarios



Source: own calculations.

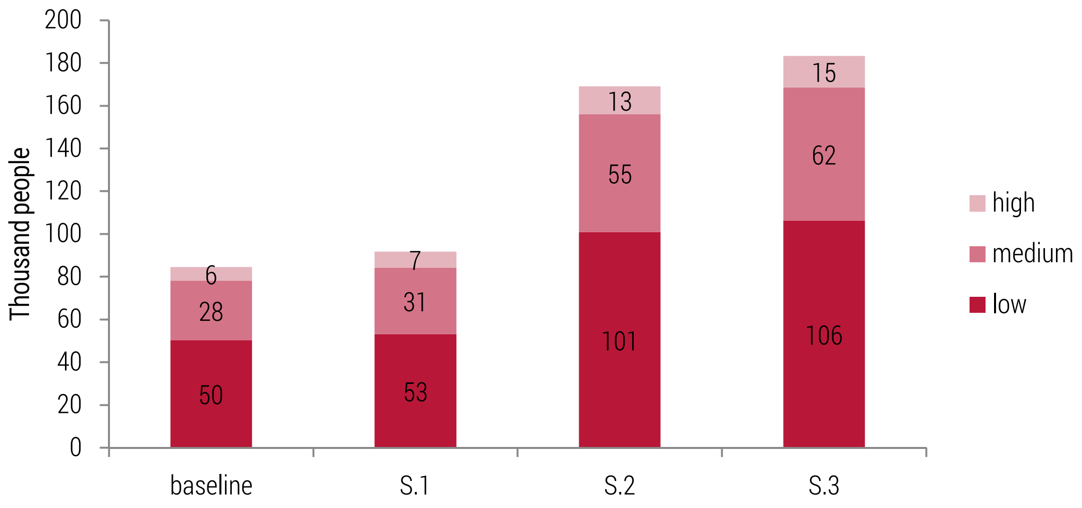
Figure 2. Sources of new jobs in the S.3 scenario



Source: own calculations.

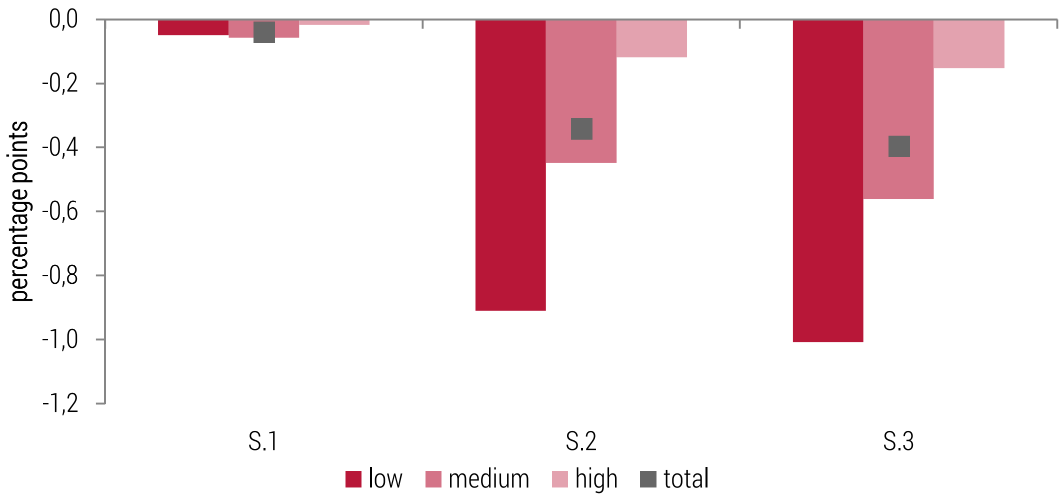
In each scenario, over 50% of additional jobs are categorised as low-skill. According to the most ambitious S.3 scenario, a total of 56,000 new jobs for low-skilled workers, 34,000 new jobs for medium-skilled workers and only 9,000 jobs for highly-skilled workers, such as managers, engineers, energy auditors, etc., would be created in Poland each year. As a result, the unemployment rate would decrease. In the most ambitious scenario S.3, the average annual decrease of the unemployment rate (for the 2017–21 timeframe) would amount to 0.4 percentage point. It would mostly benefit low-skilled workers, but the situation of medium-skilled workers would also improve significantly. In the S.3 scenario, the average annual decrease of the unemployment rate among low-skilled persons would amount to over 1.0 percentage point (Figure 4). The decrease of the unemployment rate for medium-skilled workers would amount to 0.56 percentage point, and among highly-skilled workers – to 0.15 percentage point. In the less ambitious S.2 scenario, assuming that the current rate of boiler and systems replacement and insulation measures increases twofold, the fall of the unemployment rate would amount to 0.9, 0.45 and about 0.1 percentage point for low-skilled, medium-skilled and highly-skilled workers, respectively.

Figure 3. Number of retrofitting jobs (annual average for 2017-2021), in particular scenarios, by worker qualification level (thousand)



Source: own calculations.

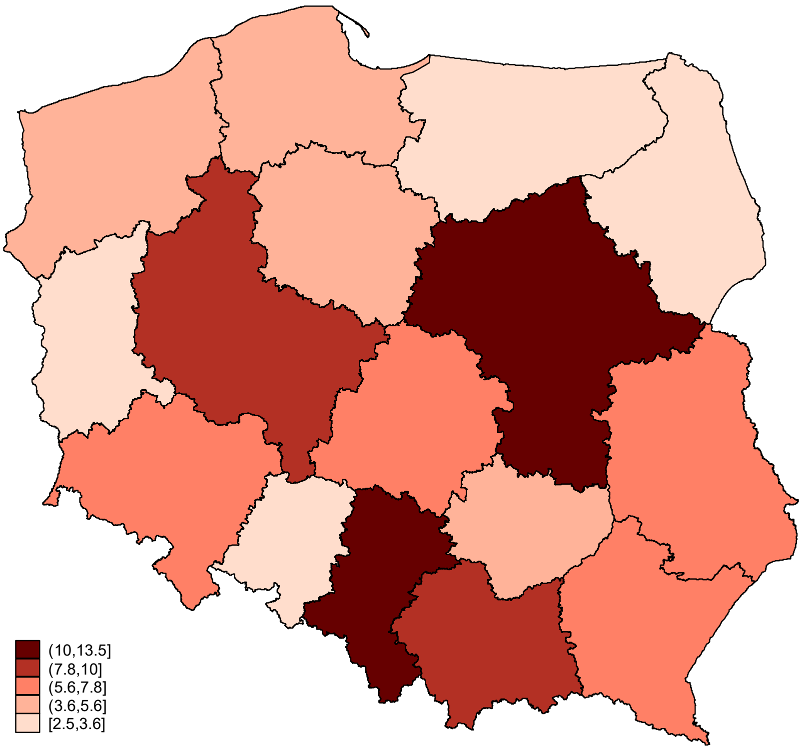
Figure 4. Change in the unemployment rate (annual average for 2017-2021) by worker qualification level (percentage points)



Source: own calculations.

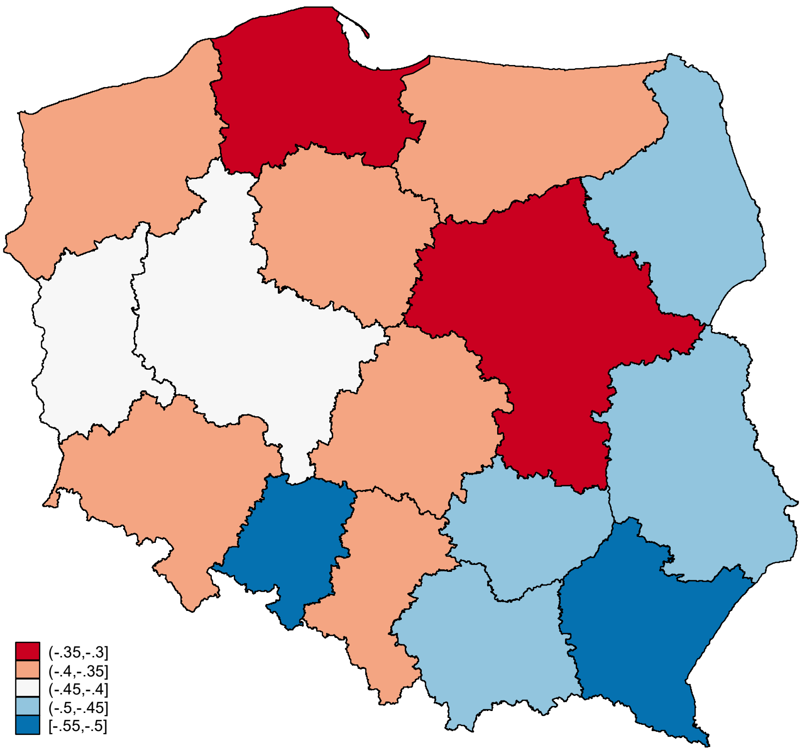
The creation of retrofitting jobs would be the highest in the most populous regions, but the impact on unemployment rate would be the strongest in the less developed voivodships with large shares of single-family homes in total housing stock. In scenario S.3, over 40% of additional jobs would be created in Mazowieckie, Śląskie, Małopolskie and Wielkopolskie Voivodships, while only 12% of additional jobs would be created in Lubuskie, Opolskie, Warmińsko-Mazurskie and Podlaskie Voivodships (Map 1). On other hand, these poorer voivodships would benefit most in terms of the reduction of unemployment rates (Map 2). In scenario S.3, in Podkarpackie and Opolskie the fall of the unemployment rate would exceed 0.5 pp., in Podlaskie and Lubelskie it would exceed 0.45 pp. This effect is driven by the high share of single-family, semi-detached or terraced houses. For instance, these houses account for 98% of all buildings in Podkarpackie and Lubelskie.

Map 1. Increase in the number of retrofitting jobs in the S.3 scenario (annual average for 2017-2021, thousand)



Source: own calculations.

Map 2. Change of the unemployment rate in S.3 scenario (annual average for 2017-2021, percentage points)



Source: own calculations.

5. Conclusions and policy implications

This study proposes and employs a methodology of assessing the impact of residential energy retrofitting on labour demand in Poland. While the main incentives behind retrofitting are lowering emissions generated by heating and improving the standard of living, job creation may be an important co-benefit. Our analysis differs from previous research on the subject in that it relies on detailed data on the labour intensity of individual measures required to perform retrofits, it outlines the baseline scenario and alternative scenarios based on historical data, and translates the resulting impact on labour demand into changes to the unemployment level. Our methodology may be used to assess the labour market impact of regulations aimed at increasing the retrofitting rate, both in terms of envelope retrofits as well as system upgrades and replacing heating sources in residential buildings in Poland.

Our study shows that investment in improving the energy efficiency of residential buildings in Poland may have a tangible beneficiary impact on the labour market. The most ambitious scenario, which assumes that the current rate of energy retrofitting is increased twofold and each building undergoes a comprehensive set of actions, would see the creation of even 100,000 additional jobs nationwide. The stock of single-family buildings would account for the greatest demand as this class of buildings represents the vast majority of the Polish housing stock, but only a minority of these buildings have been retrofitted so far.

The majority of this additional demand concerns low-skilled persons, around one third encompasses medium-skilled workers, with the demand for high-skill labour being the lowest. This result could be relevant in the context of the ever faster technological developments. Due to further automation and structural changes, the demand for low-skilled workers is going to decline in many sectors. Therefore, a policy aimed at supporting energy retrofitting may be a counteract the risk of a gradual growth of unemployment among the low-skilled workers. Similarly, our study suggests that investment in improving the energy efficiency of housing stock may have a positive impact on job creation in less developed regions – areas that are often overlooked in large investment projects of both the private and the public sector. This result further underlines that making up for the neglect in the Polish housing stock may contribute to social cohesion nationwide. Apart from granting individual inhabitants a higher quality of life and decreasing air pollution, it could also improve the situation on local labour markets.

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Appendices

Appendix A1. Methodology of defining model buildings

Our point of departure for describing the characteristics of model buildings was defining the usable floor area of each of them. According to our main assumption, the usable floor areas of model buildings were selected thus that when multiplied by the total number of buildings in the given class, we would arrive at the total usable floor area of buildings in the country – a figure included in GUS data. A similar assumption was adopted for the number of dwelling units in multi-family buildings – we assumed average values, which – when multiplied by the number of buildings – would give the total number of dwelling units as per GUS studies on the stock of multi-family buildings.

In the next step, based on the characteristics of buildings described in the NAPE (2012) and on a qualitative review of designs of actually existing buildings, the most typical building technologies, building shapes and number of storeys were selected and defined for each building class. Then, the surface area of building envelope was calculated as well as the remaining parameters comprising the bill of quantities for energy retrofitting measures (Table A1). Detailed characteristics of model buildings are available in Chmielewski (2017).

Table A1. List of the basic parameters of model buildings

	No. of dwelling units	Usable floor area	No. of storeys	Surface area of the solid ground floor / floor over basement	Roof / flat roof surface area	Façade surface area	Window surface area
	[pc.]	[m^2]	[no.]	[m^2]	[m^2]	[m^2]	[m^2]
model 1 model 2	1	75.7	1	75.7	98.4	163.5	14.2
model 3 model 4	1	136.7	2	68.4	85.4	269.9	30.0
model 5	10	503.0	5	100.6	150.9	543.2	99.6
model 6	16	820.0	4	205.0	307.5	1049.8	160.3
model 7	16	820.0	4	205.0	287.0	964.8	162.3
model 8	82	3910.0	15	260.7	443.1	3789.4	805.9

Note: In model 8 polystyrene is used up to storey 8 (2037,9 m^2), and mineral wool is used above that (1751.5 m^2).

Source: compiled by the authors based on Chmielewski (2017).

Appendix A2. Labour supply model

The predicted labour supply is broken down by education, based on the size of the working population between 2013 and 2016 (GUS Local Data Bank – BDL data), Poland's forecast total population between 2013 and 2050 (BDL data, corrected for 2014 and 2015 based on the actual population in said years), the forecast unemployment rate (Ministry of Finance) and projected labour market participation according to the model elaborated by Lisa et al. (2015).

First of all, based on data from the Lis et al. (2015) model and the forecast unemployment rate for Poland (MF), we projected the size of the working population within the 2020 time frame (noting to the available data). Then, the ratio of the working population to the total population was calculated as:

$r_i = \frac{P_i}{N_i}, for\ i = 2016{,}2017, \ldots, 2020;$ where N_i – Poland's population in year i, P_i – the number of people working in year i.

Based on the r_i percentages calculated for the 2016-20 period, r_i percentage shares for the years 2012-30 were calculated as the geometric mean of the four last periods:

$$r_i = \sqrt[4]{\prod_{j=1}^{4} r_{i-j}}, for\ i = 2021, \ldots, 2030.$$

In the next step, the size of the working population was calculated as: $P_i = N_i * r_i$ for the 2021–30 timeframe. The number of unemployed persons was calculated based on the unemployment rate and the number of workers.

Then, the ratio of the working population in the given voivodship to the total size of the working population was calculated for the 2016-20 period. The next steps were the same as in the nationwide model. The number of workers according to their level of education was also calculated in the same manner as for the whole of Poland. In this case, the values were related to the size of the population with a given education in a given voivodship. The percentage of workers according to skills in a given voivodship was calculated as a geometric mean of the four previous years.

Based on the number of employed and unemployed persons, the unemployment rate was calculated according to voivodship and level of education.

Appendix A3. Labour inputs required to complete energy retrofit measures

Table A2. Detailed list of labour inputs required to complete energy retrofit measures

		group 1 – building envelope retrofits				group 2 – upgrading the central heating and domestic hot water systems				TOTAL
building type	worker skills	insulation of external walls	insulation of flat roof / attic	window replacement	solid ground floor / floor over basement	central heating system	domestic hot water system	boiler (+boiler room)	solar panels	
1	low	388	50	41	109	34	3	12	12	637
1	medium	230	0	38	0	27	6	4	64	369
1	high	20	20	20	20	8	8	8	8	110
2	low	388	50	41	109	58	3	12	12	673
2	medium	230	0	38	0	27	6	4	64	369
2	high	20	20	20	20	8	8	8	8	110
3	low	789	59	87	18	29	3	34	12	1031
3	medium	379	46	80	14	28	7	4	64	622
3	high	32	32	32	32	9	9	9	9	163
4	low	789	59	87	18	38	3	12	18	1024
4	medium	379	46	80	14	28	7	4	70	628
4	high	32	32	32	32	9	9	9	9	163
5	low	1577	77	290	26	116	19	52	62	2219
5	medium	826	0	267	20	139	57	317	145	1771
5	high	35	35	35	35	19	19	19	19	216
6	low	3049	158	466	53	313	30	63	99	4231
6	medium	1597	0	429	41	237	89	317	182	2892
6	high	41	41	41	41	25	25	25	25	262
7	low	2802	151	472	53	217	96	0	0	3791
7	medium	1468	12	435	41	240	155	45	0	2396
7	high	39	39	39	39	17	17	17	17	221
8	low	14862	234	2345	68	3471	623	0	0	21603
8	medium	6081	19	2158	52	1241	890	45	0	10486
8	high	108	108	108	108	57	57	57	57	658

Source: Chmielewski (2017).

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