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Energy Clusters as a New Urban Symbiosis Concept for Increasing Renewable Energy Production—A Case Study of Zakopane City

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Abstract: One of the priority lines of action in Poland is to increase energy production from renewable energy sources (RESs). Based on the “Poland’s national energy and climate plan for the years 2021–2030”, Poland aims to achieve 21%–23% of RES share in gross final energy consumption by 2030. While coal is still the most important source of energy, new technological and organisational solutions for increasing RESs are being tested and implemented. Therefore, the creation of energy clusters based on the idea of urban and industrial symbiosis was first proposed by the Ministry of Energy in 2016. To date, there are 66 clusters in different regions in Poland, but only a few of them are active and innovative. One of them is located in the city of Zakopane, a mountain resort, which attracts about 3 million tourists annually and has developed the wide-ranging use of geothermal sources for energy supply and recreation. The paper aims to analyse the impact of the creation of energy clusters on the city’s development, including economic, social, and environmental aspects. The “willingness to pay” (WTP) method was used to calculate the impact of air pollution on Zakopane and to compare it with the Polish average to estimate the significance of the transformation to RESs in this tourist city. The results from the studies are as follows: health cost per capita in Zakopane is between 252.07 and 921.30 euro. The investigations presented can be the basis for recommendations in strategic documents in the field of regional development and environmental protection, especially on the use and promotion of urban symbiosis for increasing use of RESs.

Keywords: energy cluster; urban symbiosis; willingness to pay; air pollution

1. Introduction

It has been observed that the rate of urbanisation has been increasing in recent years—in the 1950s, 30% of the population lived in urban areas; in the 2010s, the rate reached 55%, and according to forecasts it may be as high as 68% in the 2050s [1]. Due to ongoing change, cities are focusing their strategies on their environmental and social performance, including, e.g., climate change and energy scarcity [2,3]. Different projects designed to achieve environmental goals are underway, for example the assessment and accounting of the urban ecological footprint, effective treatment and management of municipal wastes, ecologically sustainable urban areas, planning and development of an eco-city [4]. However, there is still evidence of positive interdependence between the development of fragmented urban areas and the concentration of air pollutants [5,6]. The most common health impact of air pollutions is heart disease and stroke, which causes premature death [7]. On a global scale, air pollution is responsible for 20% of the deaths caused by cardiopulmonary disease in the world [8]. One of the leading global risks is particulate matter (PM_{2.5}), which leads to 6%–7% of annual

deaths around the world [9]—in Europe alone, the concentration of this particulate matter (PM) is responsible for 428,000 premature deaths [10]. Lelieveld et al. (2015) have estimated that pollution such as PM_{2.5} and O₃ contributed to a global mortality of 3.3 million in 2010 [11].

According to the World Health Organization (WHO), 36 of the 50 most polluted cities in the European Union are located in Poland [12]. This issue is connected with particulate matter (PM), which not only cause environmental damage but also is a key factor leading to cardiovascular diseases and lung cancer [13]. At the local level, different types of strategies are being implemented, such as low carbon planning, the eco-city, or the rules of clean production. However, this is still not enough. One of the solutions for decreasing air pollution in economic, social, and environmental areas is the development of renewable energy sources (RESs). In the long-term perspective, this is a global priority on a local and national level. On the local level, the development of RESs is supported by different programmes such as tax incentives, legal restrictions, and national support funds [14,15]. A unique idea of developing energy clusters based on idea of urban symbiosis to increase RESs was introduced in Poland in 2016 by the Act of 22 June 2016 on Renewable Energy Sources (RES Act, 2016). An energy cluster is defined as “a civil law agreement, which may include natural persons, legal persons, scientific units, research institutes or local government units, and which pertains to the generation and balancing of demand, distribution or turnover of energy from renewable sources, or other sources or fuels, within a distribution network with a rated voltage of less than 110 kV” [16]. The main goal of the activity of these entities is energy security based on local resources, which influences the achievement of the sustainable goals of a global economy at the national level. There are also other objectives that are perceived as key factors in the energy clusters’ activities, such as environmental protection, effective use of local resources, (including wasted or underutilised ones) supporting well-balanced urbanisation, and balancing the use of distributed energy generation with conventional energy.

The development of the clusters usually has a common point with urban and industrial symbiosis, which aims to use the potential synergy effects on the geographical localisation of the companies [17,18]. Moreover, urban symbiosis focuses on the possibility of cooperation in urban areas or between industry and urban functions [19]. One of the primary goals of the development of urban symbiosis is to close the loop of material and energy flows within a given urban area [20]. The research shows that implementation of the urban symbiosis has a positive impact on among others: carbon emission reduction [21,22], improvement in waste management [23], and the development of eco-town programmes [24]. Often the countries that are developing, develop or have already developed the national agenda for industrial symbiosis (i.e., Green Industrial Symbiosis in Denmark)-supported clustering such as Kalundborg and Kwinana [25,26]. The EU plans to foster circular industrial collaboration among SMEs on cluster collaboration [27]. In practice, urban symbiosis is often referring to the use of waste from urban areas as a raw material or source of energy [28].

In Poland, one of the ideas of urban symbiosis focus is the concept of energy clusters. Such a solution has been supported by three institutions, the Ministry of Energy, the National Fund for Environmental Protection and Water Management, and the Ministry of Investment and Development [29]. So far, 66 clusters have been selected to provide the transition from conventional centralised energy generation and fossil fuel usage towards a renewables-based decentralised energy system and to contribute to business competitiveness, reduced resource demand and environmental impact, and to sustainable societal developments. Such an idea should be assessed in three dimensions (environmental, economic, and social) using a life cycle perspective [30], taking into account not only technological but also economic and social acceptance using, i.e., multi-objective model to optimise the mix of renewable energy [31]. The development of an energy cluster can bring additional social and environmental benefits, which can be estimated using the willingness to pay (WTP) method. WTP method was used, e.g., for smart home energy products and information services [32]; to calculate green electricity in Japan [33], wind energy in Canada [34], expenditure for research and development of solar energy in China [35]; to reduce CO₂ emission [36], and as a determinant of tourists’ intention to pay a premium for accommodation in a hotel with renewable energy sources [37]; nevertheless, the research on WTP

that supports clean air transition by using urban symbiosis for promoting RESs in tourist resorts has not been identified.

The aim of this paper is to estimate WTP for the most attractive mountain resort in Poland, i.e., Zakopane, where an energy cluster has been developed, and to compare it with the WTP for Poland which was investigated on the publication of the “External health costs of air pollution emission from the municipal and housing sector”. Based on the results of an analysis, the advantages of developing the idea of local industrial symbiosis based on energy clusters can be estimated, and those should be a critical factor in RES increase in Zakopane.

2. Materials and Methods

In 2010, in countries that are part of the WHO European Region alone, the overall annual economic cost of health impacts and mortality from air pollution was estimated to be US\$ 1.575 trillion [38]. In the case of air pollution, the WTP method can be used for example: as a tool for assessing how much an entity could pay to improve air quality [39], as a source of information on the costs of air quality improvement that shows a positive influence on our health [40], to eliminate the risk of death [38].

To estimate the cost of air quality improvement in Zakopane and to compare it to the rest of Poland, the methodology based on the publication of the “External health costs of air pollution emission from the municipal and housing sector” [41] was applied. The algorithm for the calculation of the external cost for the city of Zakopane is presented in Figure 1.

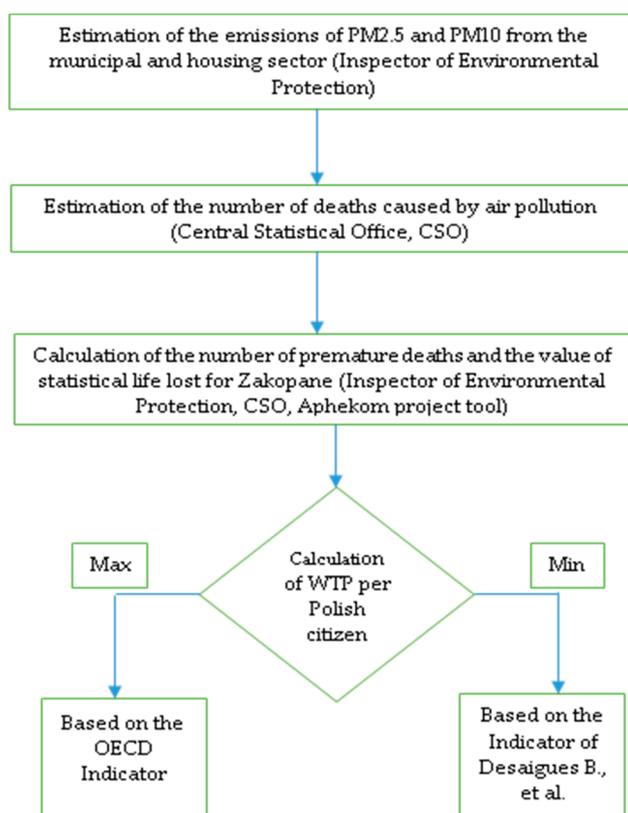


Figure 1. The algorithm for the calculation of willingness to pay (WTP) for the city of Zakopane. Source: based on the Report [41].

The first step in the analysis was to estimate the level of air pollution based on the data from the Inspector of Environmental Protection in order to demonstrate the scale of the problem. The number of deaths caused by air pollution was taken from Central Statistical Office data (based on the recommendation introduced by the WHO, the analysis only includes deaths among people over

the age of 30) [38,41]. Then the number of premature deaths caused by PM_{2.5} and PM₁₀ emitted by the municipal-utility sector was analysed. For these calculations, the tool based on Health Impact Assessment (HIA) practices proposed in the Aphekom project (Improving knowledge and communication for decision-making on air pollution and health in Europe) [42] was used. The following data relating to the levels in Zakopane were analysed: emissions of PM_{2.5} and PM₁₀, deaths caused by pollution, population numbers.

The tool enables the calculation of the number of premature deaths in Zakopane and the preparation of an estimate of the gain in life expectancy. The calculation used the concentration–response function, which estimates the “percentage change in health outcome per unit change in pollutant levels” [43].

Then, maximum and minimum WTPs per Polish citizen, according to [41] were calculated based on the following publications:

- “Economic valuation of air pollution mortality”, “A 9-country contingent valuation survey of the value of a life year (VOLY)” [44],
- “Organisation for Economic Co-operation and Development (OECD)” [45].

The minimum WTP for the average Polish citizen is €25,000, i.e., the value of lost statistical life, and for the maximum WTP, the indicator of lost statistical life is €1.57 million [41]. These values were applied for the calculation of the total WTP value in Zakopane city (multiplying by the number of premature deaths). It also allows one to calculate the potential benefit associated with decreasing pollution through the use of RESs after implementing an energy cluster policy.

3. Case Study—Zakopane

The tourism sector significantly influences the development of the Polish economy; it accounted for 5%–6% of Gross Domestic Product (GDP) in Poland [46]. Moreover, in 2016 Poland recorded its largest-ever number of foreign tourists: i.e., 18.3 million persons [47], primarily in Kraków and Zakopane [48].

Zakopane is a mountain resort with high-quality tourist attractions, in which there are 269 accommodation facilities [49] in an area of 84 km² and with 27,305 inhabitants. Particularly popular and well-known tourist features include Tatra National Park—3 million tourists, The Shrine of Our Lady of Fatima in Krzeptowki—2 million travellers, the Tatra Museum in Zakopane—147,728 tourists [50]. Although Zakopane is one of the most popular tourist destinations in Poland, due to its location and the emission of dust and gas pollution, it is also one of the most polluted cities in the country. Zakopane is located in a valley, where there is often an air inversion layer that holds all dirt close to the ground causing smog. In the EU, it is ranked in 19th place in terms of PM₁₀ pollution and 11th place in terms of PM_{2.5} [51]. A high concentration of PM in the air results from, among other sources, emissions from municipal sources, transport, the combustion of fuels in district heating and ineffective coal combustion systems in heating stoves and coal-fired boilers [52].

So far, Zakopane city has been implementing different actions and projects for environmental protection, including:

- A low-interest rate loan programme “JAWOR” for installing heating systems for individuals,
- financial support from National Fund of Environmental Protection and Water Management for thermo-modernization of the building and replacement or purchase and installation of low-emission heat sources.

Zakopane city implemented a programme for a low-carbon economy (also covering The Low Emissions Reduction Programme [53] and the Urban Mobility Plan for the Zakopane area [54]), in which the main goals for 2020 are as follows:

- reduction of carbon dioxide emissions by 14,022.84 Mg/year, i.e., 3.87%,
- reduction of energy consumption by 2020 by 18,982.65 MWh/year,

- an increase in the share of renewable energy in total consumption of 0.16% per annum (excluding the heating network) and by 0.5% (including the heating network).

The aim is to reduce pollution by increasing the energy production from RESs with the support of the government. In Zakopane, the total share of RESs is much higher than the Polish average. It amounts to 16.45% due to the use of geothermal energy, which accounts for about 80% of renewable energy in the RES consumption [53]. The distributor and producer of heat from this resource is Geotermia Podhalańska S.A., which provides approx. 35% of the heat demand in Zakopane (in 2015, the sale of heat from geothermal energy was 356.15 TJ and that from natural gas was 37.34 TJ) [55]. Geotermia Podhalańska S.A. is the first installation in Poland since 2005 to start using geothermal resources, contributing directly to the reduction in the SO₂ concentration by about 68% after the project was put into operation, lowering the suspended particulate matter concentration (PM₁₀), and reducing CO₂ emissions [56]. The company's activity covers not only heating but also air conditioning, tourism, recreation, and balneology. The Regional Operational Programme for the Małopolska Region project on "Construction of heating networks and connections in the commune of the city of Zakopane and the communes of Poronin, Biały Dunajec and Szaflary in order to increase the use of RESs and reduce the emission of pollutants into the air" includes work planned in Zakopane on the construction of a heating network, a new pumping station, and connections to existing and new facilities [57].

Based on the small share of other RESs, some initiatives are being taken at the local level to promote projects on solar energy, hydropower, and energy from biomass, among others. Data analysis shows high solar radiation (1467 h/year), understood as time, given in hours per year, during which sunlight is directly reaching the Earth's surface, [58] indicating the possible development of photovoltaic energy in the area of five hydroelectric power stations in Kuźnice, Olcza, Zakopane-Ustup, Zakopane-Jaszczurówka [53]. This is in line with the idea of an energy cluster, therefore, there are two certificated clusters, that have been created in Zakopane and provided organisational changes and new investment, which are in line with urban symbiosis, i.e.,:

- Klaster Zielone Podhale comprises 32 units which aim to improve peoples' quality of life and promote the sustainable development of a tourist region through increasing the production of energy from RESs, mainly geothermal and solar. Members of the cluster are local administrations, heat and energy producers, large energy consumers, and a scientific organisation, i.e., AGH University of Science and Technology. The geothermal water is used not only for heating (about 90% of hotels in Zakopane are already connected to the heating network), but there are few aqua parks, which are providing additional touristic attractiveness in the region. Cluster partners applied for different environmental programmes for research, new drillings, and setting of new infrastructure [59]. Moreover, the cluster partners plan to a build Tatra solar power plant, which aims to obtain an energy surplus of 2962 MWh/year [60].
- Klaster Serce Podhala aims to increase the use of geothermal resources by initialling a joint initiative of the Szaflary commune and the existing Geotermia Podhalańska S.A.

The cluster influences not only on Zakopane but the whole Tatra Powiat, which includes Zakopane and rural communes: Biały Dunajec, Bukowina Tatrzańska, Kościelisko, Poronin. The main aim of the creation of an energy cluster is to reduce air pollution, develop local energy sources, increase efficiency, and ensure safe energy sources. As the cluster is managed by the local community, the price of heat and energy could be lower for cluster members, which can be a stimulus for regional development. Moreover, the energy cluster policy in Poland proposes more benefits for members of energy clusters and local communities by:

- Decreasing the investment risk due to balancing the supply and demand side,
- Creation of a synergy effect for all stakeholders to ensure a stable source of energy with a reasonable price,
- Decreasing the impact on the environment due to the limiting of emissions, management of waste, etc.

- Development and effective use of a dispersed source of energy,
- Promoting innovative solutions and closer cooperation between science and business,
- Raising local awareness of the environmental aspects due to better education and the promotion of environmentally friendly investment.

4. Results

To estimate the advantages of developing the idea of energy clusters and the increase in the use of RESs in Zakopane, a calculation of external costs using WTP was conducted and compared to the calculation of WTP in each step for Poland, which was investigated by Adamkiewicz [41]. According to the methodology presented, first, the sources of pollution and the number of deaths caused by air pollution were analysed. In Poland, the municipal and housing sector has a significant role in the levels of concentration of air pollution [61–63]. Based on data from the Report [41], the municipal and housing sector is responsible for 41% of PM_{2.5} emissions in urban areas. An analysis of PM in Poland (urban areas), which was investigated in the Report [41] and in Zakopane, was taken into account in the estimation of premature deaths and the statistical value of a life (Table 1).

Table 1. Concentration of PM_{2.5} in the air.

		2011	2013	2015	2016
PM _{2.5} [$\mu\text{g}/\text{m}^3$]	Poland	27.1	28.4	26.0	24.5
	Zakopane	28.0	25.3	21.4	23.7

Source: Inspector of Environmental Protection, [41].

Based on the data presented in Table 1, it can be concluded that, in the analysis period, the concentration of PM_{2.5} in the air in Zakopane is decreasing, whereas, in Poland, the PM_{2.5} in the air in 2013 was higher than that in 2011 [41]. The indirect reasons for the decrease of concentration of air pollutions in Zakopane are among others: subsidies for replacement of coal boilers from European Funds [64] and investments related to geothermal sources of energy [65]. In addition to that, the national programmes such as “Clean Air” or “Stop Smog” (also in Zakopane), which mainly focused on the reduction of air pollutions, were introduced. Low-efficiency heating devices for solid fuels are mostly causing the concentration of PM in the municipal and housing sector in Zakopane as well as in other polluted cities in Poland.

Due to lower PM_{2.5} concentrations, the number of deaths caused by air pollution in Zakopane calculated by the Central Statistical Office (CSO) was one death for every eighty-nine people (1/89), whereas in Poland it was 1/70. The main causes of death in Zakopane were cardiovascular diseases (44.7%), cancer (22%), and respiratory diseases (7%) [66].

The next step was to calculate the number of deaths for Zakopane and compare it with that in the rest of Poland (summarise urban and extra-urban areas), which were investigated in the Report [41]. According to the WHO recommendations, this should take into account the adult population (age 30+ years) to estimate the long-term health impact caused by PM_{2.5} (Table 2).

The research carried out by the United Nations Economic Commission for Europe (UNECE) shows that the negative impact on life expectancy due to the density of PM_{2.5} for the average citizen of Poland accounts for 6–12 months, and for an inhabitant of Zakopane for more than 12 months [67]. In Zakopane, one of the factors related to premature deaths is air pollution generated by municipal and housing sector through the use of the low-quality coal and obsolete coal furnaces. Therefore, due to the Air Protection Program adopted by the Malopolska in 2013, Zakopane by the end of 2015 was obliged to eliminate 496 coal-fired furnaces and by 2023, the remaining 2230 furnaces [68].

Table 2. Population and deaths in Poland and Zakopane covered by the analysis of the impact on mortality.

	Poland							
	2011		2013		2015		2016	
	Population	Death	Population	Death	Population	Death	Population	Death
30–34	3,141,270	2968	3,235,198	2768	3,245,474	2758	3,217,351	2863
35–39	2,864,320	4249	3,004,273	3987	3,102,846	4000	3,113,212	4004
40–44	2,410,696	5924	2,546,248	5629	2,730,562	5522	2,831,770	5595
45–49	2,411,463	9761	2,333,568	8642	2,334,025	8196	2,370,674	8159
50–54	2,848,818	19,296	2,599,288	16,491	2,408,302	14,228	2,351,408	13,420
55–59	2,916,642	28,768	2,936,830	28,306	2,837,050	26,411	2,737,882	24,994
60–64	2,471,547	34,263	2,620,151	36,965	2,726,536	37,359	2,751,811	36,760
65–69	1,459,742	28,257	1,789,658	33,861	2,161,758	40,485	2,272,891	42,721
70–74	1,328,316	38,447	1,252,454	36,068	1,208,233	33,970	1,299,760	33,870
75–79	1,146,666	51,386	1,147,354	50,372	1,139,332	48,511	1,118,914	45,852
80–84	834,494	61,785	859,378	63,589	862,711	62,104	869,321	58,783
85+	555,797	82,497	623,764	93,508	704,384	105,083	742,519	105,018
Total	24,389,771	375,501	24,948,164	387,312	25,461,213	394,921	25,677,513	388,009
% death		1.54		1.55		1.55		1.51

	Zakopane							
	2011		2013		2015		2016	
	Population	Death	Population	Death	Population	Death	Population	Death
30–34	2091	2	2164	2	2162	-	2175	3
35–39	1865	2	1963	1	2036	1	2040	3
40–44	1686	3	1729	1	1821	7	1844	2
45–49	1860	9	1702	7	1683	3	1673	3
50–54	2054	15	1983	16	1837	13	1809	15
55–59	2245	25	2192	23	2058	20	1979	15
60–64	1834	29	1996	20	2117	25	2111	23
65–69	1193	15	1361	17	1584	22	1696	27
70–74	1119	28	1097	29	1047	31	1062	26
75–79	1049	38	1021	34	999	36	968	37
80–84	760	48	794	58	792	46	798	55
85+	541	68	610	79	697	102	733	93
Total	18,297	287	18,612	292	18,833	308	18,888	304
% death		1.57		1.57		1.63		1.61

Source: Central Statistical Office, [41].

According to the algorithm presented, it is estimated that there were 15–16 premature deaths caused by PM from the municipal and housing sector in Zakopane in the period analysed (Table 3) and compared to 19,000–22,000 in Poland based on the Report [41]. For Poland, Adamkiewicz [41] used methodology based on the health risks of air pollution—HRAPIE project and for Zakopane, the Aphekom project—both approaches are based on concentration–response functions [43].

Table 3. Premature deaths in Poland and Zakopane caused by emissions from the municipal and housing sector.

	2011	2013	2015	2016
The number of premature deaths in Poland	22,398	19,460	19,741	18,990
Value of lost statistical life in Poland	495,235	423,386	421,749	439,980
The number of premature deaths in Zakopane	15	15	16	16
Value of lost statistical life in Zakopane	284.5	279.5	289.8	329.4

Source: own studies, [41].

The number of premature deaths and value of lost statistical life in Zakopane was calculated using an Excel tool. In the light of the recommendations of the Aphekom project, the long-term impacts of PM_{2.5} were taken into account based on two scenarios [43]:

- Scenario 1, where the PM_{2.5} yearly mean is decreased to 5 µg/m³. In that case, $\Delta x = 5 \mu\text{g}/\text{m}^3$, RR per 10 µg/m³ = 1.06 [1.02–1.11], $\beta = 0.0058269$ [13],
- Scenario 2, where the PM_{2.5} yearly mean is decreased to 10 µg/m³. In that case, $\Delta x = ([\text{PM}_{2.5}] \text{ mean } 10 \mu\text{g}/\text{m}^3)$. $\Delta x = 0$ if $[\text{PM}_{2.5}] \text{ mean} < 10$, RR per 10 µg/m³ = 1.12 [1.08–1.15] $\beta = 0.0056664$ [69],

(Δx is the decrease in the concentration defined by the scenario, β is the concentration–response functions, relative risk ratio (RR) per 10 µg/m³ = $\exp(10 * \beta)$).

Premature deaths in Zakopane consist of 0.07%–0.08% of the total premature deaths in Poland (Table 3) and years of life lost (YLL) consists of from 13% to 17% of the total YLL in Poland. Due to the analysis of data in Table 3, comparing 2011 and 2016, it can be deduced that in Poland the total number of premature deaths and YLL decreased [41], while the increase in Zakopane has been noted. In EU-28, the number of premature deaths has decreased by 10%. The same trend was observed in the case of YLL, where a decrease of 8% was noticed throughout the same period [70,71].

In the next step of the analysis, results were calculated according to the algorithm presented (VOLY, [35]) and the maximum values (OECD, [36]) of WTP (Table 4) for Zakopane and compared with the results from Poland, which were provide in the Report [41]. The calculation of WTP took into account the whole population of Poland and Zakopane.

Table 4. External health cost per inhabitant by the WTP approach for Poland and for Zakopane [euro].

		2011	2013	2015	2016
Desaigues and Potential Years of Life Lost	Poland	321.26	275.37	274.34	286.20
OECD premature death		912.46	793.65	806.34	775.75
Desaigues and Potential Years of Life Lost	Zakopane	255.12	252.07	264.01	301.59
OECD premature death		844.72	849.54	919.98	921.30

OECD: Organisation for Economic Co-operation and Development; Source: own studies, Central Statistical Office of Poland, [41].

The amount of health cost per capita in Zakopane was between 252.07 and 921.30 euro, whereas in Poland it was between 274.34 and 912.46 euro in 2011–2016 [41] (Table 4). During the analysed period, the average citizen of Zakopane was willing to pay more for fresh air than the average citizen of Poland (Table 4). This proves that the inhabitants of Zakopane suffer because of the high concentration of PM in the air, which is related to, among other factors, the municipal and housing sector. Based on the geographical location of the city, during the winter, the London type of smog occurs in Zakopane. The maximum concentration of benzopyrene in the air was 900% of the norm, what among others has a negative impact on the health of the habitats of Zakopane [72]. Each year the number of days surpassing the limit of dust concentration in the air has passed 67. This is the equivalent of 2139 cigarettes smoked by each inhabitant of Zakopane annually [73]. The situation has majorly raised the awareness of the citizens of Zakopane throughout the last years. The process of replacing 700 old boilers with ecological heat sources is currently ongoing in Zakopane [74].

However, the health cost of pollution is relatively high in comparison to that in some other studies where the use of the WTP method was applied for examining issues related to polluted air. In China, for example, the mean value of WTP for mitigating smog is 206.15 euro per year, which is 1% of income [75], in the United States, the air improvement is worth about \$40 [76]. In Mexico, it costs 2000 dollars for a one-unit reduction in particulate matter emissions per year [77]. Compared to the results of WTP for Zakopane and the research in the Report [41], it may be concluded that citizens of Poland and Zakopane are willing to pay more for the reduction of air pollution. The difference between the WTP results in different countries are caused by, among others: awareness of the local community, effective implementation of clean air policy, and various shares of sources of pollution emissions.

Therefore, the topic will be extended in the discussion on the level of pollution, the health cost, and the role of the cluster, which may have a positive impact on the health and quality of people's lives in Zakopane.

5. Discussion

Our study undertook a comparison of the WTP approach for estimating the health cost for the municipal utility sector for results from Zakopane and compare it to the results presented by Adamkiewicz [41]. In 2016, there is a difference between the health cost per capita in Zakopane, which was 921.3 euro, and in Poland where the "maximum" cost was 775.75 euro [41] (Table 4). It can also be observed in the number of premature deaths between 2011 and 2016, which in Zakopane accounted for between 15 and 16 people, compared to the whole of Poland where the range was between 19,000 and 22,000 people [41]. Ligus (2018) [78], using a contingent valuation survey, demonstrated that the WTP for clean air for a Polish citizen was 59.48 EUR. On the basis of the above-mentioned research, it may be observed that Polish citizens can pay six times less in the best option for clean air.

Statistics show that almost 60% of premature deaths in Europe between 1990 and 2015 were caused by PM_{2.5} emissions European Environment Agency (EEA). Based on the EEA data, particulate matter in Europe continues to cause the premature death of more than 400,000 Europeans annually (in 2014, 1700 premature deaths were caused by PM₁₀ and 46,020 by PM_{2.5}) [79]. In 2015, Poland was ranked in third place in the EU-28 in numbers of premature deaths (there were 38,006 premature deaths annually) as well as third place in years of life lost (YLL) (1403 YLL per 100,000 inhabitants) (EEA) [80]. Similar results are confirmed in the literature on the subject, for example, Tainio et al. (2013) estimated that 39,800 premature deaths were caused by PM_{2.5} pollution in the year 2000 in Poland [81].

There are a few reasons, among others, which result in these outcomes:

- The data obtained for the analyses of PM₁₀ and PM_{2.5} were taken from one monitoring station in Zakopane operated by the Chief Inspectorate of Environmental Protection. The analysis would be more comprehensive if it were possible to receive data from different monitoring stations.
- Following the results of the WHO [82] and the Report [41], the analysis took the number of deaths of people over the age of thirty into account, excluding all other deaths. In 2016, newborns, children, and teenagers represented more than 32% of the total population of Zakopane [66].
- The data only took the inhabitants of Zakopane into account although the city is one of the most heavily visited tourist destinations in Poland. The Tatra National Park alone, for example, was visited by 3 million tourists in 2016. Therefore, the study should be extended to cover the tourists visiting Zakopane.

On the other hand, at the local level, one should also take into consideration the fact that the WTP for health cost might be lower due to, among other reasons, creation of urban and industrial symbiosis for increasing RES production. In the long-term perspective, we are able to observe that the clusters are an effective method of collaboration between representatives from different sectors.

Zakopane already has a broad scope of application of geothermal energy in place. The current state-of-play is related to the direct and indirect actions of the energy cluster in Tatra Poviát. Geothermal energy consumption is estimated at around 35% of total heat consumption [65]. Nevertheless, the potential of possible development seems to be yet unreached. The projects from European funds are stimulating the further development of solutions connected with geothermal resources, R&D, and infrastructure for the local energy sector. The examples of such projects are the following:

- construction of heating networks and connections with a full length of approx. 4.5 km for 150 individual customers [83]; approx. 6.21 km for 123 individual customers [57];
- increase of the efficiency of primary energy use and reducing the energy consumption of Geotermia Podhalańska S. A. by increasing the production of energy from renewable sources [84];
- modernisation of the infrastructure and systems related to geothermal resources [85].

Actions taken in the field of effective use of geothermal raw materials are associated with urban symbiosis. Although there is still a struggle with gathering the pieces of information that could be easily interpreted to promote solutions related to urban symbiosis. Support for the concept of urban symbiosis can influence the founding of a tourism–energy nexus. To summarise the possibilities of implementing urban symbiosis by energy clusters, a SWOT stands for Strengths, Weaknesses, Opportunities, and Threats SWOT analysis was carried out (Table 5).

Table 5. Assessment of possibilities of introduction urban symbiosis by energy clusters to increase the use of renewable energy.

Strength	Opportunities
S1: Zakopane region is rich in geothermal resources	O1: Raise the awareness of the local communities
S2: Zakopane is a mountain resort most frequently visited	O2: Development of eco-tourism in the resort of Zakopane
S3: Above-average WTP results for Zakopane	O3: Create jobs through energy cluster and urban symbiosis
S4: Transparent data available online (PM _{2.5} and PM ₁₀ concentration)	O4: Improve air quality due to elimination of pollutions
Weakness	Threat
W1: Lack of comprehensive understanding of the environmental problem i.e., waste management sector	T1: Lack of policy and national plan which will support the clustering and urban symbiosis
W2: High investment cost in the infrastructure and research and development in case of geothermal resources	T2: Lack of policy dedicated to the energy cluster activities
W3: Lack of effective mechanism management of knowledge in the cluster	T3: There is only one monitoring station located in Zakopane

Moreover, the role of the regional networks is highlighted in the sustainable transition of energy systems. Access to resources and the level of consumption and production are some of the most important factors that influence security in the region [86]. Therefore, the energy cluster initiative has a really important role in balancing demand for energy from renewable sources, which influences the sustainable development of the region [87].

From the global perspective, the concept of the clean air is in line with sustainable development goals such as: SDG 3 (good health and well-being), SDG target 7.2 on access to clean energy in the housing, SDG target 11.6 on air quality in cities [88]. In order to reach the goals, tools such as life cycle thinking are needed to support the decision-making process that will be in line with the environmental, social, and economic aspects [89].

6. Conclusions

Poland has not implemented any national plans for industrial or urban symbiosis. With the development of the circular economy and obligation towards the EU to increase RESs, new local solutions promoting urban symbiosis have been introduced. Closed-loop initiatives such as energy clusters aim to share infrastructure and resources to enhance their collective efficiency. This increases their chances of success when applying for financial support from national and EU funds and enables them to collaborate on developing new RESs. It was particularly crucial that for the touristic area as in Poland more transparent data were available due to on-line air monitoring of PM_{2.5} and PM₁₀ in Polish cities, for example from the Zakopane Main Inspector of Environmental Protection [90]. Zakopane is one of the most well-known mountain resorts in Poland.

The WTP method confirmed that for inhabitants of Zakopane, clean air regulation could be more important compared to the rest of Poland. The research indicates that the funding for the energy cluster was well allocated. Various publications indicate that WTP for RESs depends on many factors such as social status, income, age, environmental awareness, and types of RES. In this study, the WTP method was used to assess the acceptance of RES policy and to identify the priorities for energy clusters in Poland. The scope of this study is limited; therefore, it is necessary to develop a more comprehensive analysis of the effectiveness of implementing the WTP approach for all 66 clusters in Poland. The introduction of assessment of urban symbiosis based on WTP method could have a positive impact on the reduction of air pollution.

Most countries face huge challenges in terms of developing RESs by 2020 and 2030. One of the goals is to decrease the level of air pollution. The role of local cooperation and networks is highlighted in the sustainable transition of the energy system. In Zakopane, energy production from RES is higher than the average for Poland. The city has access to geothermal resources, but it also uses solar panels and hydroelectric power stations, thanks to the initiatives of other clusters such as the Zielone Podhale Energy Cluster.

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