INFRASTRUKTURA I EKOLOGIA TERENÓW WIEJSKICH
INFRASTRUCTURE AND ECOLOGY OF RURAL AREAS

No IV/1/2018, POLISH ACADEMY OF SCIENCES, Cracow Branch, pp. 1033-1043
Commission of Technical Rural Infrastructure

DOI: https://doi.org/10.14597/INFRAECO.2018.4.1.071

THE IMPLEMENTATION OF THE LOW-STACK EMISSION REDUCION PROGRAM IN THE MUNICIPALITY OF NOWY SĄCZ

Agnieszka Petryk, Sylwia Guzdek
Cracow University of Economics

Abstract

The article analyzed the results of air quality measurements in the city of Nowy Sącz and assessed the activities of the local government to reduce low-stack emission. Nowy Sącz is among the top European cities with the most polluted air. According to the annual mean PM10 particles levels within the Małopolska Province, Nowy Sącz belongs to the group of cities and poviats where the highest levels of this pollutant are recorded. In the case of PM2.5 particles, Nowy Sącz is the second city after Krakow in the Małopolska Province, where there is a significant exceedance, including the margin of tolerance, of the limit value of the pollutants. The background and inflow of pollutants from outside the city reaches the level of about 17 $\mu g \cdot m^{-3}$, i.e. 85% of the limit value and 50% of the total level of the pollutant in the city. The local government undertakes investments aimed at improving air quality, *inter alia*: thermo-modernization of buildings, Renewable Energy Sources installation (solar installations) in buildings, elimination of coal boilers and replacing them with gas boilers or new generation boilers.

Keywords: air quality, low-stack emission, suspended particulates, ecological policy

INTRODUCTION

The lack of social awareness in the field of air quality issues affects the everyday non-ecological attitudes of the society (National Air Protection Program until 2020). Poor air quality contributes to the creation of social costs that affect the deterioration of the quality of life. According to Dzikuć (2017), low-stack emission directly influences the level of expenses incurred by the society and enterprises. Shaping proper social behaviors and involving society in actions to improve air quality by conducting cyclical education and information activities at the national, regional and local levels (National Air Protection Program until 2020) may be a response to environmental dilemmas. Environmental protection programs that take into account the local natural specifics and socio-economic needs should be equally vital. Effective cooperation between governmental and self-governmental administration at various levels is particularly important (National Urban Policy 2023).

Currently, cities are directly at risk due to three phenomena: intensification of the urban heat island, heavy downpours causing flooding and drought conducive to water deficit in cities. Winds are also a threat that affects small towns and suburbs with dispersed development. The urban heat island is the result of excessive energy emission from various urban sources (Strategic for the adaptation. 2020). Pałasz (2016) reports that the development of the area and the location of emission sources have a significant impact on the distribution of pollutants. The location of obstacles (e.g. buildings, housing estates) in the compact buildings surrounding the higher buildings considerably worsens ventilation of the area (natural atmospheric ventilation). Open areas connected in continuous corridors play the role of the urban regeneration and air exchange system. In order for the aeration process of the city to be effective, the system must take into account the natural conditions, e.g. the dominant wind directions, the layout of river valleys. It is important that open areas that act as aeration corridors are managed in a way that is attractive to residents. This limits construction pressure and prevents degradation (National Urban Policy 2023).

In Poland, the high concentration of particulate matter (PM) in the air, caused by the original emission of particulate matter from various sources, applies especially to industrial areas and densely populated cities. According to recent research, there are around 60,000 substances considered as pollutants over industrialized areas (Bojanowska *et al.* 2015). The solid atmospheric pollutants released during the combustion of solid fuels include particulate matter (Petryk 2018). They can be divided into dropping particulates (subject to sedimentation) with a relatively large grain diameter and suspended particulates which are light, fine and very fine. Fine particulates (especially PM 2.5) are particularly hazardous to human health. These particulates are transported in a stream of pollutants

discharged from the emitter (chimney) and moved to quite considerable distances (Pałasz 2016, Malec and Borowski 2016). Heating technologies as well as sources of energy supply are often the most important emitters of urban pollution (National Urban Policy 2023). Combustion of fuels is the greatest source of anthropogenic air pollutants (Nadziakiewicz 2005, Juda-Rezler 2000). Local governments should limit the use of harmful materials in heating processes (especially solid fuels, e.g. coal) as well as expand the municipal heating network (National Urban Policy 2023).

As shown by studies carried out by the Regional Inspectorate for Environmental Protection (WIOŚ), concentrations of PM10 particles in the non-heating season (from May to September) are around 20 $\mu g \cdot m^{-3}$ and are essentially caused by linear and point emission sources. In turn, during the heating period, they exceed the limit value (50 $\mu g \cdot m^{-3}$), the level of public information (200 $\mu g \cdot m^{-3}$), and even alarm levels (300 $\mu g \cdot m^{-3}$). It can be concluded that low-stack emission, which is linear emission and high emission constituting a „base", which when increased by low-stack emission results in exceedances of permissible substances, is the factor determining the creation of air pollution. (Pilot 2017).

At present, various coal fuels are used in households. To produce heat in households, boilers of various designs, often homemade, are used, which with a greater or lesser efficiency even allow for the combustion of sludge (Pyka and Wierzchowski 2017). Burned coal with a high sulfur and, ash content of low calorific value. So-called coal sludge and household waste are also used as a fuel. A characteristic feature of low-power energy sources is emission from a large number of emitters introducing pollution into the air from low-height chimneys. The effects of the emission are very onerous, as pollution accumulates around the place of creation, most often around areas with compact housing. This is particularly troublesome especially in the so-called heating season, especially during smog episodes (Hławiczka *et al.* 2012).

Short-term (acute) and long-term (chronic) effects are among the health problems associated with exposure to fine particulate matter present in the air. Long-term effects include: an increase in the frequency of chronic respiratory symptoms, impaired lung ventilation efficiency in children and adults, and cancer (Kowalska and Zejda 2012). So far, there has been no reliable data on the share of particulate matter emission from fuel combustion processes for the heating of flats, in shaping the concentrations of this pollutant in the area of a single commune. These emissions are dispersed; therefore it is difficult to quantitatively estimate the total emission rate from this type of air emissions sources (Hławiczka *et al.* 2012).

MATERIAL, METHODS AND RESEARCH AREA

The current study evaluates pro-ecological activities in the city of Nowy Sącz in the field of air quality protection against the effects of low-stack emission. Data from the years 2016-2017 regarding the PM10 and PM2.5 and PM1 suspended particles level come from 9 measurement points installed in Nowy Sącz. The analyzed data for the period 2011-2015 regarding the values of annual mean concentrations of PM2.5 particles come from the Air Protection Program for the Małopolska Province. "*Małopolska in a healthy atmosphere*." The results of annual mean SO_2, NO_2, NO_x and PM10 concentrations for the years 2014-2017 were obtained from the Regional Inspectorate for Environmental Protection (WIOŚ).

The city of Nowy Sącz is distinguished by its considerable population (Table 1). It is the third city in the Małopolska Province in terms of population. It has a favorable geographical location in the fork of two rivers−the Dunajec and the Kamienica Nawojowska (Low-emission Economy Plan ... 2015). For residents of the poviat of Nowy Sącz, part of Limanowa and Gorlice, it is the center of public services in the field of self-government administration, health protection, education and culture (Development Strategy. 2020$^+$).

Table 1. Population in the city of Nowy Sącz and Nowosądecki poviat in the years 2013-2017

City/poviat	2013	2014	2015	2016	2017
Nowy Sącz	83943	83853	83903	83933	84041
Nowosądecki poviat	211045	211830	212894	213864	214999

Source: *Author's own elaboration based on data of the Local Data Bank (accessed in June 2018)*

Nowy Sącz, due to its location at the intersection of important transportation routes from west to east (DK28) and south to north (DK 87), is a transit city. It is an important economic center in the region, as evidenced by the number of business entities registered in 2017 in the REGON system (Table 2) in the Nowosądecki Poviat (16058) and in the city of Nowy Sącz itself (9863). The city is distinguished by a large diversification of the economic base and significant income from PIT and self-government own revenues (Development Strategy 2020$^+$). Here, large companies from various industries have their headquarters, including: Fakro, Newag, SGL Carbon Polska, KORAL Ice Cream Production Company (Low Emission Economy Plan ... 2015).

Table 2. Entities registered in the REGON system in the city of Nowy Sącz juxtaposed with the Nowosądecki Poviat and the Małopolska Province in the years 2009-2017

Administrative unit	2009	2010	2011	2012	2013	2014	2015	2016	2017
Nowy Sącz	8934	9366	9293	9454	9511	9556	9682	9750	9863
Nowosądecki Poviat	12549	13352	13621	14179	14643	15029	15426	15721	16058
Małopolska Province	314017	331363	331595	343375	351074	356785	363883	371107	380020

Source: *Author's own elaboration based on data of the Local Data Bank (accessed in June 2018)*

RESEARCH RESULTS AND DISCUSSION

Pursuant to Resolution No. XV/149/2015 of the City Council of Nowy Sącz, dated September 15, 2015, the Low-Emission Economy Plan (LEEP) for the city of Nowy Sącz was adopted and implemented. The adopted LEEP is compliant with the local policy of the city and strategic planning documents, i.e. the Nowy Sącz Development Strategy 2020^{+}, the Environmental Protection Program for the city of Nowy Sącz, the Study of Conditions and Directions of Spatial Development for the City of Nowy Sącz as well as the Plan of heat demand, electricity and gas fuels for the city. As part of the pilot system of local air quality monitoring in the years 2016-2017, 9 measurement points of PM10, PM 2.5 and PM1 suspended particles were installed in Nowy Sącz. The results of measurements, i.e. the mean-hour concentration of suspended particulates in the air, are presented on the city's website in order to make the inhabitants of the city aware of the amplitude of changes in air pollution. The obtained results of measurements indicate the main source of pollution, which is emission from household furnaces due to the fact that the highest particulate matter concentrations occur in the evening (Low-emission Economy Plan ... 2015).

According to the Air Protection Program for the Małopolska Province "*Małopolska in a healthy atmosphere*", the mean daily concentrations of PM10 particles may exceed 50 $\mu g \cdot m^{-3}$ only 35 days a year. In the zones of the Małopolska Province, at the measurement stations in 2015, the value of daily-average concentrations was exceeded for a greater number of days. In Nowy Sącz (Table 3), these concentrations were exceeded even for 100 days.

Table 3. The number of days with exceedances of 24-hour permissible concentrations of PM10 particles at the Nowy Sącz measurement station

Measurement station	**Number of days with occurrence of 24-hour PM10 particles concentrations above 50 [µg·m^{-3}], Permissible number of days (since 2005): 35**						
Nowy Sącz	2010	2011	2012	2013	2014	2015	2016
	114	126	121	102	97	118	82

Source: Author's own elaboration based on data obtained from the President of the City of Nowy Sącz in the public information mode (correspondence dated December 11, 2017)

The values of annual mean PM10 particles concentration in the years 2014-2017 at the monitoring station showed the exceeded level of PM10 particles. During the same period, exceedances of NO_x standards were recorded. The highest value of this pollutant 58 µg·m^{-3} was noted in 2015 (Table 4).

Table 4. The value of annual mean concentrations of SO_2, NO_2, NO_x and PM10 in the city of Nowy Sącz in the years 2014-2017

Year	**SO_2 [µg·m^{-3}]**	**NO_2 [µg·m^{-3}]**	**NO_x [µg·m^{-3}]**	**PM10 [µg·m^{-3}]**
	Limit value of pollutants			
	20 µg·m^{-3}	**40µg·m^{-3}**	**30 µg·m^{-3}**	**40 µg·m^{-3}**
2017	6.8	26	**49**	**42**
2016	7.9	24	**53**	**41**
2015	8.2	28	**58**	**45**
2014	7.9	22	**48**	**42**

Source: *data obtained from http://monitoring.krakow.pios.gov.pl/dane-pomiarowe/*

The PM2.5 particles concentration standard will be being tightened by 2020, when the limit value will be 20 µg·m^{-3}. The PM2.5 particles measurements carried out at the station in Nowy Sącz indicate exceedances of concentration limits in 2011-2015 (Table 5).

Emission from individual heating of buildings, adverse meteorological conditions, in particular poor airing of the city (54% of silence in a year) and the occurrence of temperature inversion that cause slow spread of local emission are the cause of exceedances of PM10 and PM2.5 particles in Nowy Sącz. Emission from local and individual boiler rooms, industrial boiler houses and large energy sources is responsible for the sanitation of the air (Low-emission Economy Plan ... 2015).

Table 5. The value of annual mean concentrations of PM2.5 particles at the air quality monitoring station in 2011-2015

Measurement station	Annual mean concentrations of PM2.5 particles Limit value (2015): 25 µg·m^{-3}, since (2020): 20 µg·m^{-3},				
	2011	2012	2013	2014	2015
Nowy Sącz	40	43	36	33	36

Source: Air Protection Program for the Małopolska Province. *Małopolska in a healthy atmosphere*. Annex No. 1 to the Resolution No. XXXII/451/17 of the Małopolska Province Assembly of January, 23 2017. Office of the Marshal of the Małopolska Province 2017 [in Polish]

The background and inflow of pollutants from outside the city reaches the level of about 17 µg·m^{-3}, i.e. 85% of the limit value and 50% of the total level of this pollutant in the city. It illustrates the required level of inter-municipal co-operation to achieve air quality improvement by reducing the level of pollution below the limit value (Low-Emission Economy Plan ... 2015).

In 2015, an inventory of individual heating systems was carried out (Table 6) in the city of Nowy Sącz. 11 521 address points were inventoried, of which up to 4 711 were heated with solid fuel.

Table 6. Inventory of individual heating systems in the city of Nowy Sącz

City	Heating with oil fuel	Electrically heated	Heated with gas	Heated with solid fuel	Heating provided by MPEC
Nowy Sącz	42	191	4362	4711	630

Source: Author's own elaboration based on data obtained from the President of the City of Nowy Sącz in the public information mode (correspondence dated December 11, 2017)

In 2017 an inventory of the number of communal buildings was carried out with an indication of the heating method (Table 7) in the area of Nowy Sącz. 75 address points were inventoried, 32 of which were connected to MPEC (Municipal Thermal Energy Enterprise), and only 2 were heated with solid fuel.

Table 7. Inventory of communal public buildings in the city of Nowy Sącz

City	Heating with oil fuel	Electrically heated	Heated with gas	Heated with solid fuel	Heating provided by MPEC
Nowy Sącz	5	1	38	2	32

Source: Author's own elaboration based on data obtained from the President of the City of Nowy Sącz in the public information mode (correspondence dated December 11, 2017)

There are two independent heating systems in Nowy Sącz (Table 8) managed by Miejskie Przedsiębiorstwo Energetyki Cieplnej Sp. z o.o. (Municipal Thermal Energy Enterprise). The systems are fed from the Milenium and Sikorski boiler houses, however, a significant part of thermal needs is met by hard coal combustion in coal-fired boilers or ceramic tiled stoves (Low-emission Economy Plan ... 2015).

Table 8. The number of connected consumers to the municipal heating network in the city of Nowy Sącz in the years 2010-2017

Year	2010	2011	2012	2013	2014	2015	2016	2017
The numer of connections	2	4	11	7	0	0	6	24

Source: Author's own elaboration based on data obtained from the President of the City of Nowy Sącz in the public information mode (correspondence dated December 11, 2017)

As part of the KAWKA program, in the years 2014-2016, natural persons were granted funding for the purchase and installation of 80 solar collectors and the purchase of 326 solar collectors was financed with the subsidy from the budget of the city of Nowy Sącz. From the aforementioned program in the years 2014-2016, 625 coal-fired boilers were eliminated and replaced with gas boilers (548 items) or with high-efficiency solid fuel boilers (28 items) or with heat pumps (5 items). In the city of Nowy Sącz as part of the Low-Stack Emission Reduction Program (PONE) in 2010-2017, residents submitted as many as 616 applications for replacement of boilers as part of the "Elimination of low-stack emission" project and 22 applications as part of the project of "Improvement of air quality for the city of Nowy Sącz – stage II for the years 2017-2019" (Table 9).

Table 9. The number of buildings subject to partial thermo-modernization in the years 2010-2017 carried out by the Investment and Renovation Department of the Nowy Sącz City Council

Year	2010	2011	2012	2013	2014	2015	2016	2017
Public buildings	10	4	2	3	7	6	2	0
Municipal buildings/ communal flats	9	10	16	10	20	44	36	15

Source: Author's own elaboration based on data obtained from the President of the city of Nowy Sącz in the public information mode (correspondence dated December 11, 2017)

Informing residents about the exceeded permissible concentrations of pollutants in the air plays a social and educational role. The project called "Improving air quality in the city of Nowy Sącz, stage II in the years 2017-2019 is currently being implemented (Table 10).

Table 10. Activities in the city of Nowy Sącz contributing to clean air

Year	Type of action	The final effect of the action
2014-2016	Application to the Provincial Fund for Environmental Protection and Water Management in Krakow (WFOŚiGW) for the implementation of the PONE (Low Emission Reduction Programme) stage I as part of *the "Low Emission Liquidation Program supporting the increase of energy efficiency and the development of dispersed renewable energy sources"* program. The aim of the project was to improve the air quality in the Nowy Sącz area by: liquidation of coal-fired boiler plants belonging to the municipality and the State Treasury, replacing the boilers for gas boilers, heat pumps, installation of solar collectors, conducting emission inventories, educational campaign.	The funding received from the WFOŚiGW– PLN 1 582 073.00. Co-financing from NFOŚiGW of the value of PLN 2 988 476.00 was also obtained.
2017-2019	Implementation of the project „Improvement of air quality in the city of Nowy Sącz – stage II"	Co-financing for replacing the heat source in residential buildings and separate flats

Source: Author's own elaboration based on data obtained from the President of the city of Nowy Sącz in the public information mode (correspondence dated December 11, 2017)

CONCLUSIONS

The research results obtained allowed to put forward the following conclusions:

- According to the annual mean PM10 particles levels within the Małopolska Province, Nowy Sącz belongs to the group of cities where the highest levels of pollution are recorded.
- Low-stack emission in Nowy Sącz is generated by individual heating systems of buildings as well as adverse meteorological conditions. The obtained results of measurements of air pollutants concentrations indicated that the main source of their emission comes from household furnaces.
- The Low-Emission Economy Plan being in force in the city of Nowy Sącz is consistent with the local policy defined in the strategic documents on the development of the city.

- The share of funds obtained by the city from the KAWKA program is systematically growing, as evidenced by the scope of subsidies granted to households for the purchase and installation of solar collectors granted in the years 2014-2016.

ACKNOWLEDGMENT

The publication and research was financed by the Ministry of Science and Higher Education of the Republic of Poland no 100/WGAP-KGR/03/2017/M/7100 Zanieczyszczenie powietrza – wpływ na jakość życia mieszkańców południowej Polski.

REFERENCES

Air Protection Program for the Małopolska Province. Małopolska in a healthy atmosphere. Annex No. 1 to the Resolution No. XXXII/451/17 of the Małopolska Province Assembly of January, 23 2017. Office of the Marshal of the Małopolska Province 2017 (in Polish).

Bojanowska, M., Muszyński, P., Paszko, T., Brodowska, MS. (2015). *Zanieczyszczenia powietrza w Polsce na tle Europy.* Towarzystwo Wydawnictw Naukowych LIBROPOLIS, Lublin

Dzikuć, M. (2017). *Ekonomiczne i społeczne czynniki ograniczenia niskiej emisji w Polsce*. Wydawnictwo Difin, Warszawa.

Hławiczka, S., Strzelecka-Jastrząb, E., Kliś Cz., Cenowski, M., Bronder, J. (2012*). Udział emisji z ogrzewania mieszkań w stężeniu pyłu w wybranych gminach południowej Polski.* Ochrona powietrza w teorii i praktyce I: 65-74.

Juda-Rezler, K. (2000). *Oddziaływanie zanieczyszczeń powietrza na środowisko*. Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa.

Kowalska, M., Zejda, EJ. (2012). *Wpływ zanieczyszczeń powietrza drobnym pyłem na stan zdrowia i jakość życia mieszkańców aglomeracji Górnośląskiej*. Ochrona powietrza w teorii i praktyce I: 157-169. Zabrze.

Low-emission Economy Plan for the city of Nowy Sącz 2015. Annex to the Resolution No. XV/ 149/2015 of the City Council of Nowy Sącz, dated: September 15, 2015.

Malec, A., Borowski, G. (2016). *Zagrożenia pyłowe oraz monitoring powietrza atmosferycznego.* Inżynieria Ekologiczna 50: 161-170.

Nadziakiewicz, J. (2005). *Źródła zanieczyszczenia powietrza i metody oczyszczania gazów z zanieczyszczeń pyłowych i gazowych.* Wyższa Szkoła Ekonomii i Administracji w Bytomiu, Bytom.

National Air Protection Program until 2020 (with a prospect until 2030). Air protection. Ministry of the Environment. Warsaw, 2015.

National Urban Policy 2023. 4.8. Environmental protection and adaptation to climate change. Document adopted by the Resolution of the Council of Ministers on October 20, 2015, Warsaw 2015.

Strategic plan for the adaptation of sectors and areas sensitive to climate change until 2020 with a perspective until 2030. Ministry of the Environment, Warsaw 2012.

Strategy for the development of Nowy Sacz 2020+. The Heart of the Sądecki Subregion. Annex No. 1 to the Resolution No. XIX/209/2015 of the City Council of Nowy Sącz dated: December 29, 2015.

Pałasz, JW. (2016). *Niska emisja ze spalania węgla i metody jej ograniczenia*. Wydawnictwo Politechniki Śląskiej. Gliwice.

Petryk, A. (2018). *Evaluation of development directions of low-carbon economy in the Nowy Targ Commune*. Infrastructure and Ecology of Rural Areas III(1): 673-685. DOI: https://doi.org/10.14597/INFRAECO.2018.3.1.046

Pilot, A. (2017). *Działania antysmogowe w województwie śląskim.* Niska emisja-jak skutecznie ją zwalczyć? Praca zbiorowa pod redakcją Mariana Turka, Główny Instytut Górnictwa, Katowice.

Pyka, I., Wierzchowski, K. (2017). *Prognoza ilościowo-jakościowa dostępności krajowego węgla kamiennego dla gospodarstw domowych.* Niska emisja – jak skutecznie ją zwalczyć? Praca zbiorowa pod redakcję Mariana Turka, Główny Instytut Górnictwa, Katowice.

http://monitoring.krakow.pios.gov.pl/dane-pomiarowe/ – accessed: 12.01.2018

Corresponding author: Eng. Agnieszka Petryk, PhD
Department of Regional Economics
Cracow University of Economics
ul. Rakowicka 27
31-510 Krakow
e-mail: agnieszka.petryk@uek.krakow.pl
Phone: 48 12 293 55 33

Sylwia Guzdek, MSc
Department of Microeconmics
Cracow University of Economics
ul. Rakowicka 27
31-510 Krakow

Received: 24.01.2018
Accepted: 28.12.2018