Centre for Research on Settlements and Urbanism

Journal of Settlements and Spatial Planning

Journal homepage: https://jssp.reviste.ubbcluj.ro

Exploring the Process and Perceptions of Noise Conflicts Related to a Geothermal Project. A Case Study of Szeged, Hungary

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DOI: https://doi.org/10.24193/JSSP.2024.1.07

Received: 04 January 2024

Received in revised form: 12 May 2024

Accepted for publication: 25 June 2024

Available online: 30 June 2024

Keywords: geothermal energy, urban noise pollution, social conflict, environmental justice, urban development

ABSTRACT

The use of renewable energy, including geothermal energy, is essential. Hungary stands out for its remarkable geothermal potential. However, these investments often lead to noise pollution, causing social conflicts between the local population and developers. This research presents a case study of a geothermal district heating renovation project in Szeged, Hungary. The study explores public perceptions and social conflicts related to the geothermal heating renovation, focusing on noise impacts. Local media articles reflect public perspectives, while opinions of key stakeholders (politicians, service providers) offer a broader view of geothermal drilling and its noise impacts. The study examines Szeged residents' knowledge about the ongoing drilling, its benefits, and the conflicts it entails, particularly noise pollution. The empirical survey employs both quantitative and qualitative methods, including a questionnaire survey and online media analysis. Results show that the public lacks sufficient information about geothermal drilling and its noise impact, whilst online media coverage is unclear. Residents often confuse it with other developments, which neither media experts nor the project owner adequately clarify. Survey respondents provided a complex interpretation of noise impacts, mostly accepting the project but questioning why it was in their immediate neighbourhood and why drilling occurred at night. Inconsistent information emerged as a main problem, revealed through content analysis and compared with questionnaire results, highlighting a general issue of unawareness. Media analysis showed opportunities for public comment and consultation, but communication was often unsuccessful due to local residents' lack of interest. Project organizers attempted to provide information through various platforms, but local media often lacked clear information, causing confusion between past and current geothermal projects and a lack of understanding of the development's reasons and site selection criteria. Overall, there was a willingness to understand the problems associated with drilling, but this was only partially achieved due to inadequate communication.

1. INTRODUCTION

The use of renewable energy is essential in reducing greenhouse gas emissions on the European continent. The current Russian-Ukrainian war since February 2022 has further increased the role of renewables across Europe, especially in a country like Hungary, which is extremely dependent on fossil supplies from Russia. The European Union has set the objective of reducing its dependence on fossil fuels and energy imports to mitigate global climate change and ensure adequate and sustainable energy security (EC, 2022). This has put renewables on the EU policy agenda and will continue to be a major focus of scientific and political attention, both for energy transition and related investments. Europe has so far invested particularly in wind and solar energy, but some regions of the continent are already benefiting significantly from geothermal power plants (Antics and Sanner, 2007). Among the Central and Eastern European countries (CEECs), Hungary stands out as having a remarkable geothermal potential (cca. 90-100 mW/m^2), as the Carpathian Basin is an area of high heat flow on the continent (Szanyi and Kovács, 2010).

In Szeged, Hungary's third largest regional centre, 16 heating circuits of the city's district heating system have been converted to renewable energy since 2018, under the H2020 project CROWDTHERMAL (Community based development schemes for geothermal energy). Szegedi Távfűtő Kft. is the only Hungarian member of the consortium of ten partners from Scotland, Germany, the Netherlands, Spain, Belgium and Iceland, making this large-scale project the only one of its kind in the CEEC. This renewable energy technology will reduce the amount of CO_2 emitted into the city's air by thousands of tons per year, thereby significantly reducing the city's greenhouse gas emissions (Barich et al., 2021; Fernández Fuentes et al., 2022). Due to its amplitude and importance, project implementation has attracted a lot of attention for a number of reasons, as the efficiency of production means that extraction will cause short-term inconvenience to the city's population. During implementation, drilling generates increased noise pollution (Tóth and Bobok, 2010; Soltani et al., 2021) of which disruptive effects may create social conflict among population (Pellizzone et al., 2017; Benighaus and Bleicher, 2019).

This research seeks to address the awareness of the residents of Szeged city about the ongoing geothermal drilling and its benefits, as well as the conflicts that the project has generated, with a focus on noise pollution caused by drilling. Using a combination of quantitative data and qualitative findings, the study sheds light on the conflicts that arise from an intensive development in an urban environment over several months, with long-term benefits for the local residents and the residential environment. Our aim is to provide a comprehensive overview of the conflicts associated with local geothermal drilling, exploring the views of several local actors (residents, local media, politicians, service providers, etc.) on the factors affecting urban liveability.

2. ENVIRONMENTAL JUSTICE AND THE PUBLIC PERCEPTION OF GEOTHERMAL ENERGY DEVELOPMENT

Noise pollution is the result of a range of urban activities, which can be interpreted not only in isolation, but also in combination with a number of social, psychological and economic factors (Berglund and Lindvall, 1995; Simo and Cleary, 2013). Noise is a significant detriment to urban quality of life (Davies et al., 2013; de Paiva Vianna et al., 2015) can affect mental health of individuals (Onakpoya et al., 2015; Mueller et al., 2019; Obi et al., 2021), and can cause syndrome associated with both short- and long-term stress (Miller, 1978; Fields, 1991; Fields, 1993; Ohrstrom et al., 2006). In noise interactions, conflict develops between the ones who perceive noise and those who emit noise (Levy-Leboyer and Naturel, 1991). In many cases the resolution of these conflicts goes beyond the directly affected parties, raising economic, legal, social and moral questions (Casey et al. 2017; Méndez and Otero, 2018; Dreger et al. 2019; Tong and Kang, 2021). Noise conflicts related to geothermal drilling (Manzella et al. 2018) can also be placed in this broader context, raising the issue of environmental justice (Havard et al., 2011).
Environmental justice refers to the equitable treatment of all people, which is complemented by the establishment of meaningful environmental laws and other regulations and policies, where inclusion is achieved without regard to race, colour, culture, nationality, education or income status (Brulle and Pellow, 2006; EPA, 2023). This involvement is aimed at ensuring that potentially affected members of the community have adequate opportunities to participate in decisions about planned activities that affect their environment and/or health (Maantay and Maroko, 2009). This is influenced by the political-economic structures in the area under concern, which are also shaped by the current systems in place (Prugberger 2001; Ágh, 2018; Begg, 2018; Nagy, 2019). The embeddedness of environmental justice has been interpreted by a number of studies (Agyeman, 2009; Harper, 2009; Filčák and Steger, 2014; Velicu and Kaika, 2017; Filčák, 2018; Špirić, 2018; Kronenberg et al., 2020; Nagy, 2021), which have approached the issue of environmental justice from different perspectives. This research framework is relevant due to its interdisciplinary approach, which has been adopted by many environmental movements (Carson, 1962) as well as by the academic community (Málovics, 2012; Lakes, 2014; Martin et al. 2014). In the neighbouring countries

(e.g. Slovakia, Ukraine, Romania, Serbia) however, we find a rather general research on the topic, explaining the origins of the concept or the links between the concept of environmental justice and the concept of sustainable development (Krajewski, 2012; Málovics, 2012). When discussing the topic, it is often necessary to refer back to the development trajectories of the CEECs, where the surrounding countries followed different paths in terms of economic and political factors. These development paths were influenced by the inherited socialist structures, and thus the relationship to environmental injustice is rooted in these processes. For post-socialist societies, regime change promised a new way of thinking, where everyone would start with equal opportunities under the new system (Szalai, 2006). However, just as the environment in which an individual is born has a determining role in their later life, so does the position that they occupy in society at the time of regime change, thus recreating social inequalities, power relations and conflicts (Harvey, 1996; Rawls, 2001; Smith, 2003; Nagy et al., 2015). Within this framework is the narrative embedded, that for members of society, the unfairness of environmental factors is also static, predetermined by territorial and socio-economic factors.

In addition to these relations, it is important to highlight that, when examining environmental conflict situations, it is crucial to consider additional factors that influence how those affected react to the developments around them. Stakeholders' perceptions of a given process can differ along a number of dimensions: cultural background, education, age or gender (Chukwumerije, 2010; Nagy, 2019). These also have important practical implications for the development of socio-economic processes (Málovics, 2012) and determine the attitudes of members of society.

Discourses on geothermal energy development often refer to social acceptance of the development and moral aspects of the existing power relations. These are defined as a source of conflict and strongly depend on the location of the geothermal project, especially its distance from residential areas. The majority of studies highlight the inadequacy of the level of participation and, in several cases, make recommendations to remedy this negative scenario (Pellizzone et al., 2017; Manzella et al., 2019; Shortall and Kharrazi, 2020; Vargas-Payera et al., 2020). Frequent, well-timed and accurate communication based on facts and data is essential for the success and acceptance of projects (Kubota et al., 2013). Fragmentation of information and uncertainty increase negative perceptions and conflicts by social actors during project implementation (Manzella et al., 2018). Resolving this conflict is an important aspect, as actors will always relate projects to their own individual and collective experiences and knowledge (Vargas-Payera, 2018; Cuppen et al., 2020). Therefore, satisfactory stakeholder information should not be seen as an isolated interaction, but rather as a power dynamic that accompanies the relationship between stakeholders and developers throughout the entire geothermal project (Trutnevyte and Ejderyan, 2018). Sherry Arnstein's 8-step public participation 'ladder' illustrates the evolution of participation levels in a planning process (Table 1) where, in the ideal state, the three levels at the top of the 'ladder' (8. citizen control; 7. delegated power; 6. partnership) represent the true community participation. The lower levels, where influence is still possible (5. reconciliation; 4. consultation; 3. information) are the middle third of the ladder, while lack of participation (2. therapy; 1. manipulation) are the lowest forms of information exchange (Arnstein, 1969; Csanádi, et al. 2010).

Table 1. Arnstein's 8-step public participation 'ladder'.

8. Community control 7. Delegated power functions	Degrees of community power (control possible)
6. Partnership	
5. Reconciliation 4. Consultation 3. Information degrees of community power	Degrees of symbolism (influence possible)
2. Therapy	Lack of participation (no influence possible)
1. Manipulation lack of participation	

Source: Arnstein, 1969.

If the information provided is insufficient or if local stakeholders do not feel ownership of the investment, negative opinions can easily develop, leading to protests and demonstrations (Van der Horst, 2007). This has become a slogan, known as 'Not In My Backyard' (NIMBY), which is a protectionist attitude of local people who are defending their environmental interests to ensure that the project is not carried out in their immediate vicinity (Dear, 1992; Wolsink, 1994; Burningham, 2000; Van der Horst, 2007).

Geothermal energy development therefore involves a number of factors that have a direct impact on society as a whole. These impacts are highly dependent on the political and economic history and development trajectory of the region. The lack of environmental justice, communication and sufficient participation in the CEECs is a characteristic feature of the situation, and therefore uncertainty often prevails in the case of a development, where even short-term inconveniences can trigger strong public resistance.

In order to better understand the geothermal energy development, it is important to review the socio-environmental dimensions specific to Hungary. The subject of energy is important from an economic, political and technological point of view (Törőcsik, 2011) and is linked to a number of factors, particulalry climate change and its consequences, globalization, environmental awareness, ecological problems and sustainability (Törőcsik et al., 2014). In the case of

Hungary, geothermal projects have been implemented along these lines (Tóth and Bobok, 2010; Kerékgyártó, 2017; Szűcs et al., 2018; Szanyi et al., 2021). Given its geographical location, the country is well suited to harness geothermal energy, which can help contribute to a carbon-free future and improve sustainability (Manzella et al., 2019).

However, in many cases, the implementation of environmental developments has failed to take into account, or has taken only minimal account of the factors that cause negative externalities. The reasons for this are partly determined by the country's past structure and legacy, in which the interests and opinions of the affected population were not taken into account, or only to a moderate extent, when considering environmental factors (Kronenberg et al., 2020). Therefore, inequitable aspects fully pervade environmental policy concepts and development investments, thus creating higher risk of environmental pollution (Ember, 2007). Consequently, particular attention needs to be paid to conflicts between social groups and political investors, which are often caused by the lack of participation or exchange of information (Enyedi, 2003). Linked to this general distrust is the issue of noise pollution as an inherent part of geothermal development, an important aspect of environmental justice. Noise is an unwanted sound that causes a disturbance or annoyance. The noise impact significantly affects the quality of life of nearby residents during the drilling period (Soltani, 2021) generating social conflict between the stakeholders and the investor.

3. SAMPLE AREA AND METHODOLOGY

The area of research is located in the city of Szeged, the third largest regional municipality in Hungary and the centre of the Southern Great Plain region. The city lies in the area with the largest geothermal potential in Hungary (Tóth and Bobok, 2010) and most of the regionally explored thermal water extracted here is used for municipal purposes (SZETÁV, 2020). The intervention areas of the 2018 Crowdthermal project for the geothermal transformation of district heating in Szeged, are primarily located in the metropolitan residential areas of Szeged, with a total of 23 plants in operation.

The main issue was related to the underlying situation of the technology being developed, which is essentially based on geothermal heat extracted from deep underground, which requires drilling wells. The drilling sites were located within the residential areas of the city, in many cases in the immediate vicinity of residential buildings, in order to minimize heat loss and to ensure efficient connection to the existing assets (Fig. 1). This includes our selected drilling area "North 1/B", which is entirely covered by prefabricated housing and includes an extraction well and an injection well.

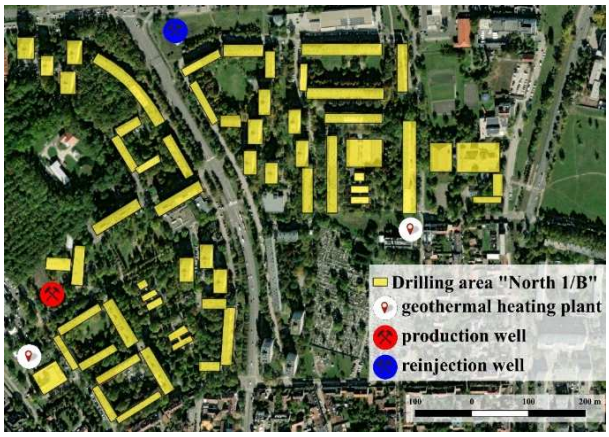

Fig. 1. Drilling locations and supplied panel buildings for the North 1/B sample area.

For this research a survey and content analysis methodology were employed to reveal the social conflicts related to geothermal drilling. Conflicts were modelled into a system that includes the population and online media, with different dynamics between these two groups (Fig. 2). The media can be understood as a kind of "intermediary medium" that receives information from the city administration and local service providers and transmits this information to the local population, but the media also often report on public opinions and dissatisfaction.

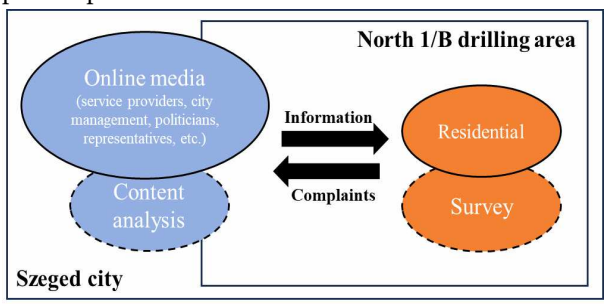

Fig. 2. Survey of opinions and relationships of actors related to the geothermal district heating renovation program.

As a first phase of the research, the perceptions of people living in buildings with geothermal energy in the "North 1/B" drilling area were assessed using questionnaires. The main reason for choosing this area was that basically the panel houses in the immediate vicinity of the drilling, which are connected to the district heating system, are heated with local geothermal energy.

The sampling procedure was carried out along a pre-designated route in the selected sample area to cover the entire area of the affected buildings. The sampling was carried out using a systematic sampling method (Babbie, 2001). Systematic sampling is based on sorting the population of interest by some criterion, and then including every X^{th} item in the list in the sample, based on a predefined numerical value X. A random number (1-10) was generated at the starting points of the selected routes to select the respondents. Data collection lasted two months, between December 2020

and January 2021, and a total of 407 relevant questionnaires were completed in the sample area. The units of analysis were individuals living in the household, where the socio-demographic variables were mostly based on gender, age, highest educational attainment and labour market status (Table 2).

Table 2. Main descriptive characteristics and baseline data of the survey sample based on respondents.

Category	Respondents (capita)	Proportion (%)
Gender breakdown		
Male	151	37.1
Female	256	62.9
Total	407	100.0
Highest level of education		
Primary or less	33	8.7
Upper secondary	228	56.7
Tertiary	141	35.1
Total	402	100.0
Employment status		
Student	47	11.8
Employed	200	50.0
Retired	115	28.7
Other (unemployed, with child, etc.)	38	9.5
Total	400	100.0

Source: own editing based on the results of the survey.

The questions in the short survey were divided into three distinct dimensions: the first half of the questionnaire inquired about the general perception of noise by people living in the drilling area, and the disturbing effects of noise in general. In the second part, we asked about the specific geothermal drilling near their residence, their awareness and its disturbing effects, using a four-level Likert scale and open-ended questions. The third part consisted of the demographic questions mentioned above.

In addition to descriptive statistics of the data, mathematical-statistical methods were used to show associations between the social context and the attitudes of the respondents. Due to the nature of the responses, different procedures were used to detect correlations. Procedures based on the relevant literature were applied (Sajtos and Mitev, 2007; Dusek and Kotosz, 2016). Nominal variables (e.g. gender) and ordinal characteristics (e.g. educational attainment) were measured against variables concerning respondent attitudes, using crosstabs and Spearman's correlation (Sajtos and Mitev, 2007). Where metric scales had to be measured against metric data, Pearson's correlation (Sajtos and Mitev 2007) was used to examine co-movements. In the second phase of the research, local online media content was reviewed using a keyword search on the topic to retrieve relevant articles and introduced observational criteria for analysis. These observation criteria included the place and time of publication of the article, the occurrence of the article's search keywords, the location of the drilling, the level of noise pollution in the articles, the political aspects of the articles, the exploration of different points of view in the articles, and the categorization of the general conflicts. The units of analysis were the articles, and a total of 132 articles from four locally specific and relevant news portals were collected (Table 3).

Table 3. The appearance of articles used in the content analysis by different news portals.

News portal	Previous articles on geothermal drilling (pcs)	Previous articles on Crowdthermal project (pcs)	Total articles per news portal	Percentage of articles on previous geothermal drilling (%)	Percentage of articles on Crowdthermal project (%)
Szegedma.hu	33	13	46	55.9	17.8
Délmagyar.hu	6	24	30	10.2	32.9
Promenád.hu	7	1	8	11.9	1.4
Szeged.hu	13	35	48	22.0	47.9
All articles by relevance category	59	73	132	100.0	100.0

Source: own editing based on content analysis.

The period covered by the analysis was from 2004 to 2023. The rationale behind the starting year is that the emphasis on urban noise exposure and mitigation has been strengthened by the entry of Hungary to the European Union. (Bite and Bite, 2003). In our assessment, the articles related to the Crowdthermal project are considered relevant, but it is also necessary to be aware of and research other geothermal projects occurring in the city, as the responses of the local population in the questionnaire do not clearly distinguish the knowledge related to the Crowdthermal project from the developments in previous years. The diversity of the theoretical interpretations of the research topic makes it difficult to measure and detect relevant information. Every research methodology has limitations and interpretative boundaries, and it is important to note that the research methodology adopted also has an impact on the results. Therefore, in summary, the methods outlined have been used to capture the characteristics of noise conflicts associated with the geothermal district heating renovation programme from both a statistical and qualitative perspective. The sample area was digitized using ESRI ArcMap 10.3 software and statistical analyses were performed using Microsoft Excel and IBM SPSS 25.

4. RESULTS AND DISCUSSION

4.1. The perception of residents in the sample area of the noise impact associated with geothermal drilling

The first part of the questionnaire was focused on the general noise sensitivity of the respondents. When asked how much the respondent was bothered by urban noise in general, 32.9% of the respondents were not bothered at all, and 29% only sometimes, while 38.1% said that only major noises (27,5%) or all noises (10,6%) were bothersome. In general, no significant correlation was found with gender or level of education in terms of noise sensitivity. However, only 28.3% of the respondents reported a conflict due to noise, and among the respondents, the highest number of respondents under 60 years of age were affected. About 63.2% of respondents were not aware that drilling would be carried out in their immediate neighbourhood. Educational attainment is not a significant determinant of whether the respondent had prior knowledge of the drilling. The backbone of the questionnaire was formed by questions on the assessment of noise exposure from geothermal drilling, which first required a Likert scale measuring from 1 to 4 to rate statements related to drilling (Fig. 3) with the mode of the scales marked by a red outline.

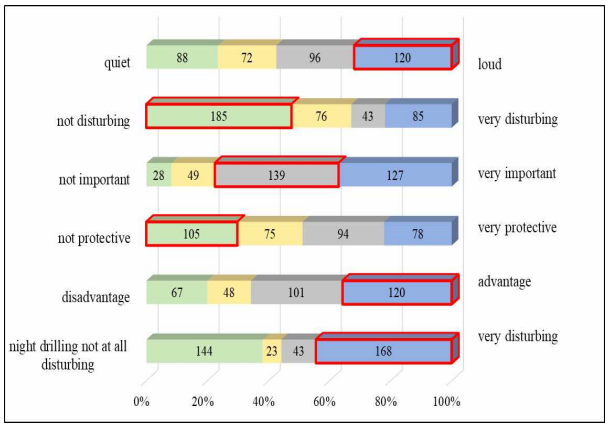

Fig. 3. Appearance of statements related to geothermal drilling on a Likert scale.

The noise of geothermal drilling was mainly classified as loud by respondents who were admittedly working (employees and entrepreneurs). The correlation values typically took medium values of -0.54, with the statement associated with the noise protection wall in most cases, while the strongest correlation of 0.714 was between the first two statements (quiet-loud, not disturbing-very disturbing).

Table 4. Distribution of noise conflicts by age group.

Category	Distribution of respondents (%)	Phi & Cramer's V value (φ)	Sig. (p)
Conflict due to noise	**28.3**	0.131	0.038
From respondents under 40 years	38.5		
From respondents 40-60 years	37.7		
From respondents 60-X years	28.9		
No noise conflict	**71.7**		

Source: own editing based on the results of the survey.

Table 5. Comparison of the existence of a previous noise conflict survey question and the presence of geothermal noise problems.

Comparison of questions (survey question about the noise conflict / Likert-scale questions)	Cramer's V	p (sig.)
Conflict due to noise / quiet-loud perception of drilling	0.276	0.000
Conflict due to noise / not disturbing - very disturbing perception of drilling	0.282	0.000
Conflict due to noise / not important – important perception of drilling	0.113	0.228
Conflict due to noise / not protective – very protective noise wall	0.181	0.010
Conflict due to noise / disadvantage – advantage from noise	0.098	0.364
Conflict due to noise / night drilling not at all disturbing – very disturbing	0.157	0.026

Source: Own editing based on the survey.

Based on the mode values of the responses, respondents interpreted the effects of noise pollution from drilling in a complex way. While the average opinion was more negative on aspects related to noise pollution, respondents were much more accepting on statements related to development (how important they consider drilling to be, benefits or disadvantages of drilling) (Fig. 3). From the perspective of labour market activity, employed people were the most sensitive to the noise of drilling. They considered drilling very loud (φ = 0,281 – Phi & Cramer's V; p= 0.001 – level of significance); they deemed the noise wall that was installed insufficient (φ =0,232; p= 0.029) and were most bothered by the noise of drilling at night (p= 0.001).

In contrast, retired people were tolerant in greater numbers, so the response rates for the four-point scales were evenly distributed. They also rated drilling negatively in relation to the respondent's previous noise conflict, as verified by the Khi-square test (statistical test to analyse the relationship between two qualitative variables) (Table 5).

To complement the questionnaire's identification of noise problems associated with geothermal drilling, a Likert scale comparison was used, comparing the noise from geothermal drilling with examples of other noise categories (community and transport) and determining which noise was more disturbing (Fig. 4.).

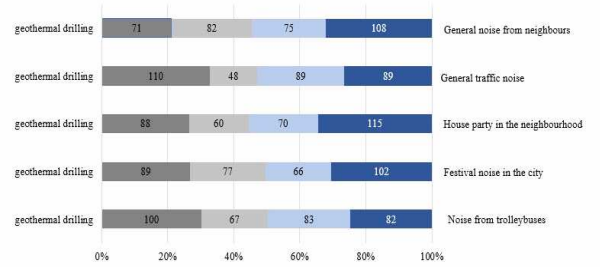

Fig. 4. Comparing different sound effects with geothermal drilling noise.

As both car traffic and public transport are significant in the immediate vicinity of the drilling, these two factors were assessed separately. In addition, for community noise, we included festivals that occur in the city, as well as two neighbourhood-related sound effects, neighbours' home entertainment (e.g. loud music) and general noise from neighbours. By noise category, on average, community noise was the most disturbing to respondents compared to drilling, including general noise from neighbours, followed by noise from their home entertainment and noise from festivals in the city. For these, the mode was the highest on the Likert scale, at 4. However, in the comparison of traffic noise, it was the noise from geothermal drilling that was more disturbing, i.e. the mode value of the data was 1.

To further explore the public's knowledge of the geothermal project, we used open-ended questions to ask about the benefits of geothermal potential at the local level and who the respondent thought would benefit from such a development. However, a significant proportion of respondents were reluctant to answer the questions, which may have been caused by fear of a 'wrong answer'. Relevant responses were grouped into broad categories depending on the subject matter of the response. Cost factors were cited as a benefit of drilling in 35.9% of the responses. Some 28.3% of the respondents mentioned positive environmental factors (reduction of CO_2 emissions, improvement of air quality), whilst 15.2% mentioned positive economic factors and 14.6% said that they did not have enough information on the subject. On the question of who benefits from geothermal development, the responses were much more evenly spread, with the most common responses being "the public" (27.7%) and "the environment" (26.2%), about 15.2% saying that the investor/executor benefits from the project, and 10% of respondents declaring that the city and "everyone" have benefits. This latter statement is highlighted because the experience of the data collection showed that it was said by respondents who were more uncertain, and therefore rated similarly to the "don't know" category. In the "other factors" group, the local university was a typical response as the developer for the geothermal investment, but respondents could not provide any further information on what they based this statement on.

4.2. Geothermal projects and their noise impact in online local media

In order to address the research questions and to provide a broader understanding of the topic, online media content related to local geothermal drilling was analysed, which further nuances the results of the questionnaire survey, complemented by the opinions of city actors, politicians and experts that appeared in the media (132 articles) and a questionnaire survey. First, we looked at the locations (see Table 2.) where the articles appeared and their relevance, in order to see the role of the media in providing the local population with as broad a knowledge as possible about geothermal drilling. To collect the articles, we collected search keywords that reflected the topic. Thus, the more keywords appeared in an article (18 keywords, in total), the more relevant it was considered to be to the research topic. Most of the hits were for the words "geothermal" (38.9%), "drilling" (13.2%), "district heating" (10.1%) and "noise" (7.4%), and generally 1-3 keywords were associated with an article, covering 91.7% of the articles. In 65.9% of all articles, some keyword also appeared in the title of the article, further increasing its relevance. In terms of online news, délmagyar.hu and szeged.hu are the media platforms where keywords can be used to find information and the most relevant in terms of the metric of the research.

Another aspect of relevance is the difference between the Crowdthermal project, which started in 2018, and other local geothermal investments developed in previous years. The topics covered in the articles typically fall into three main categories: the earliest articles dealing with biomass and geothermal projects, geothermal investments related to university buildings, and the 2018 Crowdthermal project. In previous years, geothermal investments have been the subject of several positive, typically educational articles on renewable energy, with experts and local operators providing answers on the long-term benefits of such developments. The issue of noise pollution did not appear in these articles, but discussions on sustainability efforts often took a political turn, with politicians from the right and left speaking in the media, resulting in several articles reflecting on the same topic. Political references of any kind were found in 23.5% of all articles, which was highly dependent on the news portal: politics appeared in the same proportion (48.9%) on szeged.hu and szegedma.hu, but mostly

these two news portals represented opposite political sides. While the former wrote about the projects of the current left-wing city administration in a supportive style, the latter represented the local opposition right.

The supply of geothermal energy to universities was the subject of 35 articles. Several of them already mentioned drilling-related noise, but typically the articles on news portals were informative, drawing the attention of residents to the duration of drilling, the noise impact and night drilling.

The Crowdthermal project appeared in half of the articles collected, and the survey sample area (North 1/B) accounted for 15.2% of all articles. Most of the articles related to the project were published on szeged.hu (47.9%), but if we also take into account the occurrence of noise pollution related to the project, we can talk about 16.5% of all articles. The articles varied from reports on public complaints to reports on drilling noise - typically at night - and its effects and problems. The company coordinating the project and the local operator have been interviewed several times by news portals, informing the public about the duration of the drilling, the noise emissions and the reasons for drilling at night. After reviewing the media content, it can be concluded that public complaints about night drilling are typically concentrated in the summer (46.8%) and autumn (41.4%), based on the time the reviewed columns were published. Most of the articles on mechanical noise from drilling were presenting a complaint from a member of the community and then reflecting on this by interviewing experts or project coordinators to explain the origin of the noise.

At the launch of the project, the coordinating organizations pointed out that the official public forum to launch the project was not successful, due to barely a dozen people attending. Public information was provided through leaflet distribution at the entrances of the directly affected blocks of flats, and several informative videos of events and film screenings organized by the local gas company. However, there was little media coverage of the long-term, broad economic (e.g. on the reduction of electricity bills) and environmental benefits of the project, while the cost of the investment varied in several articles. In the light of this, the level of involvement can be considered low when measured on the Arnstein ladder of citizen participation.

The Crowdthermal project also presented other challenges in the residential environment: articles on landscaping after the drilling was completed, and in several cases complaints from local residents appeared in the media (e.g. destruction of natural landscape, dirt, dust, damage done by machines to the roads). When discussing the changes in the living environment, the residents concerned, appearing in the media, repeatedly expressed their lack of understanding of why drilling was taking place in a place where there were residential buildings in the immediate vicinity. They also reported a loss of residential property value (noise is a disadvantage when selling a property) and mentioned damage and cracks caused by vibration. The media did not have a positive perception of physical noise walls, which were mostly made of containers and did not provide adequate protection for dwellings at higher levels.

5. CONCLUSIONS

The aim of this study was to explore and understand the knowledge and conflicts related to geothermal energy development from the perspective of the local population of Szeged and the media, focusing on the noise impacts of drilling. The results show that the knowledge of the local population is fragmented and uncertain, while online media cannot provide consistent information. The level of information and involvement is rudimentary, which the project managers have tried to improve. Despite the developer's efforts the communication does not always reach the wider population and the project is confused with previous geothermal developments. The responses to the public questionnaire survey raised additional questions about past and current Crowdthermal geothermal developments. The reason for this is that the differences in the timing of the developments were difficult for the local population to interpret and identify, which calls for a deeper analysis. A further questionnaire survey and a background analysis could be carried out to explore this and to comprehensively investigate the knowledge of the topic. This way, trends in public awareness of geothermal developments can be obtained with time-series data, which could guide future urban environmental developments in terms of communication and acceptance.

In relation to the theoretical background outlined above, the results of the study fit into the Central and Eastern European literature (Jocić et al., 2020), where discourses on geothermal energy developments often address the social divisions of the developments, the difficulties caused by power relations, political aspects, and the purely short-term - typically negative - impacts of the developments.

In the case of conflicts related to geothermal drilling, residential changes (landscaping problems, property devaluation) in addition to the noise pollution from night drilling have been mentioned, and local residents have expressed their concerns in the media on several occasions. Respondents to the questionnaire have a complex understanding of the impacts of drilling, mostly accepting the project, but not understanding why hot water extraction is taking place in their immediate residential area. In this context, the so-called "NIMBY" effect (Olympia and Sofia, 2020; Magnani et al., 2021) can also be observed in relation to the project. Respondents are also finding geothermal drilling noisy and disturbing, especially compared to the noise from

traffic that they are used to, but not as disturbing as the noise of festivals.

This research presented a case study of the relationship between the local population and the media in relation to geothermal energy developments where information and public involvement is still rudimentary and ineffective. Fitting the results into Arnstein' ladder of citizen participation model, the results show that, although there was an opportunity to express public opinion, communication was not fully successful due to the lack of interest on the part of the local population. This was also reflected in interviews with the media. Overall, in our experience, it can be a slow but successful path to public understanding, acceptance and ownership of environmental policy ideas and developments, as it is, essentially, a slow process to shape public opinion and knowledge. While having a number of negative consequences in the short term, geothermal development will have a positive impact on urban liveability and social well-being in the long term, which can be appreciated by the population over time.

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