Towards Data-Driven Policymaking for the Urban Heat Transition in The Netherlands: Barriers to the Collection and Use of Data

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Devin Diran and Anne Fleur van Veenstra

Netherlands Organization for Applied Scientific Research TNO, Anna van Buerenplein 1, 2595 DA The Hague, The Netherlands
{devin.diran,annefleur.vanveenstra}@tno.nl

Abstract. The transition of our society towards a sustainable, low-carbon reality is challenging governments at all levels to establish, implement and monitor policies that can realize this transition. In the Netherlands, cities are developing data-driven policies to ensure that the urban environment will make the transition from the use of natural gas to sustainable alternatives. However, the collection and (re-)use of data is not without its challenges, which may hamper policymaking, and thereby the ambitions for the transition. Therefore, this paper explores barriers to the data collection and use for the urban heat transition, based on literature and practice. First, an overview of barriers is derived from literature. Subsequently, we interview policy makers of eight frontrunner cities to explore which barriers they encounter in practice. We find that cities need different data in different phases of the strategy development, and that the main barriers for the collection and re-use of data are the required amount of effort and time, and the experienced difficulties to take decisions based on data that is poor in quality, level of detail and topicality.

Keywords: Energy Transition, Data-Driven Policymaking, Open Data, Data Sharing, Data Collaboration, Barriers, Smart Cities.

1 Introduction

The Netherlands is on a journey towards climate neutrality in 2050. The Dutch Climate Agreement, following the Paris Agreement and EU policy, is aiming to transform 1.5 million dwellings into sustainable dwellings by 2030 [1]. This transition in the built environment entails the shift from the natural-gas dominated heat supply, towards the supply of sustainable heat, commonly known as the *heat transition*. For this transition cities are in the lead on the local level, with decisions to be made regarding the timing when districts will be made subject to the transition, the new infrastructure for sustainable heating, and the support towards citizens to adopt the new technologies [1].

To develop effective heat transition strategies and implementation plans, cities aim to use data from different stakeholders to improve the quality of their policies [2–4]. *Data-driven policymaking* aims to use new data sources and data analytics for

policymaking [5–7]. However, this is not without its challenges [8, 9] which may hamper the ambitions for the heat transition in local governments. For the heat transition in the Netherlands, local governments are making efforts to gather and utilize new data sources to support their decisions. However, in these early stages various, the implementation of data-driven policymaking for the heat transition is very challenging [2]. Therefore, the goal of this paper is to investigate the barriers local governments experience regarding data collection and utilization for the heat transition, and how this may impede data-driven policymaking. So far, we have not found any papers investigating the barriers experienced by local governments to data-driven energy policymaking.

First, we identify barriers to data collection and use for data-driven policymaking based on literature. Then, we explore the barriers that cities encounter when they develop data-driven policy for natural gas-free districts by examining eight frontrunner cities in The Netherlands using a combination of interviews and desk research. This paper is structured as follows. In section 2 the theoretical background on data-driven policymaking for the energy transition, including its barriers, will be presented. This is followed by the methodology for the empirical study among eight frontrunner cities in section 3, and the presentation of the results of our empirical study in section 4. In section 5 we discuss the findings, and the paper is concluded in section 6.

2 Theoretical background

2.1 Data-driven policymaking

Data-driven policymaking uses new data sources and data analytics to improve the 'evidence-base' of policy [5–7]. It, thus, builds on the notion of evidence-based policymaking [10, 11], but it can be distinguished by its focus on the use of big and open data and data analytics for policymaking [5–7]. Before elaborating on data-driven policymaking, it should be mentioned that the implementation of evidenced-based policymaking is still facing challenges. Widely reported challenges include: the access to validated and accurate evidence [12, 13]; the transformation of quantitative and qualitative evidence to policy [14]; the increasing complexity of policy challenges, the related evidence, and the stakeholders involved in establishing the evidence [12,14]; the lacking skills of policymakers to derive insights from the evidence [13,14]; the high up-front costs [13]; and the cultural difference between policymakers, scientists and other practitioners [15].

While data-driven policymaking aims to increase the quality and legitimacy of policymaking, it faces additional challenges to evidence-based policymaking [2,7,9]. Challenges include those related to: the use and integration of data from different domains and stakeholders [2,8,9]; the impact on policymaking [9]; and the involvement of relevant stakeholders and citizens [7]. Data-driven policy adoption differs between domains and sectors; sectors that have actively picked up on it include the safety and security domain, including the police [16], while others are slower to adopt data-driven approaches [17,18].

To accelerate the urban energy transition, ample research is conducted on data-driven methods and tools, e.g. to predict energy demand and building energy

performance, to optimize asset management and operation of energy infrastructure, and to test energy saving measures [19–22]. In addition to these technical aspects, research targets the social and behavioral aspects of an energy transition [23]. For instance, [24] study a method to derive citizen perception of energy solutions from social media data, and [25] derive the energy cost load for households through energy audit data. However, these models and tools are not always used to support local governments' energy policies, implying a gap between the state of the art in data-driven methods and tools and its adoption in energy policymaking [2,17,18].

2.2 Barriers to data collection and use in data-driven energy policymaking

In literature, several barriers that local governments encounter when developing data-driven energy policies were found. These barriers cover different phases, including data collection, and data use consisting of the processing and analysis of data. These barriers are displayed in Table 1.

Table 1. Barriers found in literature on data collection and use in heat transition policymaking.

Category	Challenge or barrier	Source
Data collection	Poor or missing meta-data	[21, 26, 27]
	Scattered distribution of data	[21, 26, 27]
	Data access restrictions and costs	[21, 26, 27]
	Inconvenient interfaces	[21, 26, 27]
	Data providers limited by human and financial resources	[26]
	Data providers lack domain expertise, and policymakers lack data expertise	[26]
	Decentralized energy data challenges data agencies	[26]
	Real-time collection and (pre) processing of data	[28]
	Lacking willingness and trust to share data	[2]
	GDPR and privacy restrictions	[2, 29, 30]
Data processing and analysis	Lack of, or insufficient data formats and standards	[2, 19, 22, 26, 27, 30–32]
	Poor Data Quality	[26]
	Data lacking detail level	[23]
	Missing or incomplete data	[21, 26, 27, 33, 34]
	Large computing capacity required	[28, 30, 35]
	High paced technological development	[2, 20]
	Outcome difficult to comprehend	[2, 35]
	Resource intensive data preparation	[27, 36]
	Lacking inclusion and involvement of stakeholders	[2]
	Organizational immaturity for data	[2, 30, 36]
	High perceived investment costs	[2, 30, 36]

Barriers to data collection may lead to inconvenient data access, availability and findability; [21,26,27] report several barriers contributing to this, such as poor or missing meta-data, data dispersed among different actors, restricted or inconvenient data access,

availability and findability, and inconvenient interfaces. Barriers to data collection can be related to challenges faced by the data provider [26]. Data providers, such as statistics organizations, can be challenged by limited resources, resulting in trade-offs between quality and quantity, and the need to coordinate distributed energy data [26]. Moreover, the lack in trust and willingness to share data [2], e.g. among citizens towards the government, and inexperience with GDPR legislation [2, 29, 30] are barriers towards data collection. Furthermore, a lack of energy domain expertise by data providers and a lack of data expertise by policy makers was found to be a barrier [26], as well as the collection and processing of real-time data [28].

Data processing and analysis include many barriers related to the interoperability [2, 19, 22, 26, 27, 30–32], quality [26], and level of detail [23] of the often incomplete data [21, 26, 27, 33, 34]; and to the lack of processing power [28, 30, 35] or the high paced technical developments [2, 20]. This leads to resource intensive data preparation or limitations in data analysis [27, 36], and eventually reluctance to take decisions based the data [2, 35]. Furthermore, barriers were found on stakeholder involvement [2], organizational immaturity [2, 30, 36], and the perceived high investment costs [2, 30, 36].

3 Research methodology

The goal of this study is thus to explore the barriers to data collection and use in data-driven urban heat transition policymaking in the Netherlands. To this end a multi-case study among eight frontrunner Dutch cities was carried out: Utrecht, Rotterdam, Amsterdam, Groningen, Nijmegen, Haarlem, Hengelo and Den Haag. These cities were selected based on their leading role pertaining to the policies put in place and the role of data in that policymaking process for the heat transition. This selection was done in collaboration with the National Program on Natural gas free Districts which monitors the progress of cities [3]. Interviews are the main method used for data gathering, in combination with desk research of background information, e.g. policy documents, provided by the case cities. The semi-structured interview protocol was established by taking into account the barriers in data-driven policymaking derived from literature, and as presented in section 2.2. The interview protocol was built around the following questions: *For which activities in the urban heat transition do local governments use data?*, *Which barriers complicate data collection?,* and *Which barriers complicate data processing and analysis?*. The interviewees, were selected based on their mandate in heat transition policymaking, reflected in a direct and active role, and their experience with the collection and use of data for this process.

All interviews took place online during December 2019 and January 2020, lasting around 60 minutes. The analysis combines a structured approach as proposed by [37], with a semi-structured approach to give meaning to the qualitative data by means of the researchers' impression as proposed by [38]. The initial framework with barriers for data collection and use derived from literature, functions as the primary data analysis protocol. In line with [38], analysis occurred in-between interviews, and the framework of barriers could be tested and adjusted based on the empirical findings. The empirical findings also included the activities and decisions for which data is used. With all

interviews conducted, categorical aggregation based on the combined theoretical and empirical framework was the chosen strategy towards the final findings.

4 Empirical exploration and findings

4.1 The state of the Dutch urban heat transition

For the urban environment in the Netherlands, space heating, warm water and cooking are mainly fueled by natural gas, making up 82% of the energy demand [39]. Currently, regulated network operators maintain a fine-mazed network to supply natural-gas to dwellings for the generation of heat through individual installations. The heat transition entails the transition towards a situation with a mix of various infrastructure and technologies, both centralized and decentralized, for sustainable heat supply. Examples are collective district heating networks fed with heat from biomass, geothermal or aquathermal sources; or individual electricity powered heat pumps or infrared panels in dwellings substituting the gas boilers [1, 2]. As mentioned in the introduction, the city will be in the lead to facilitate this transition and ensure that the goals are met with a shift from national policymaking towards more local policymaking [1]. In other words, the municipal governments are assigned with new responsibilities regarding energy policy. They are considered to be positioned best with local knowledge and with strong ties to the local stakeholders necessary to realize the heat transition.

4.2 The use of data for heat transition policymaking by cities

The digitalization of the energy sector and cities is picking up pace in the Netherlands [4, 40, 41]. The role of data is acknowledged within energy transition policymaking, e.g. the theme on data-driven planning in the National Program on Natural-gas free Districts [3]. Related to the newly assigned responsibilities of cities, table 2 presents an overview of activities by a city government, and data needs derived from the interviews.

Table 2. An overview of activities and data needs of the cities

Phase	Main activities	Data use/needs
Phase 1: Strategy development, entailing the sequence of districts to disconnect from natural gas by 2030 and the preferred alternative for sustainable heating	- Exploration of the current situation, e.g. with GIS tools and dashboards - Technical-economic analysis of heating alternatives to decide on the heating solution, with assessment models	- The heat demand, based on the number and type of dwellings and users - Dwelling ownership, type, age and technical installation - Energy infrastructure (e.g. natural gas, electricity and district heating networks) and its characteristics (e.g. location, age and capacity)
Phase 2: Implementation plans for districts	- Developing district implementation plans. This calls for detailed data on the heterogenous building stock and citizens	- The technical state of dwellings and sustainability measures taken - The state of energy infrastructure, e.g. capacity and connections - The potential capacity and location of sustainable heat sources

	- Implement, monitor and adapt plans	- Residents' and large consumers' behavior

4.3 Barriers to the collection of data

From the interviews with the eight case municipalities, the barriers experienced during the process of finding and collecting the relevant data are presented in table 3.

Table 3. Barriers to data collection among the eight cities.

Barrier to data collection	Experienced by
GDPR and privacy restrictions	8/8 cities
High investments in time and costs	6/8 cities
Lack of expertise and skills	3/8 cities
Scattered distribution of data	7/8 cities
Poor data findability and access	5/8 cities
Lacking access rights	2/8 cities
Many formats and standards	5/8 cities
Lack of awareness, trust and openness in data sharing	3/8 cities

GDPR and privacy restrictions: ensuring data protection is a challenge shared by all eight cities. It takes a lot of time and legal expertise to deal with this properly. Risk-averse behavior, and unknowns about privacy legislation, result in assumptions that data, e.g. smart-meter data, is not available or very difficult to obtain. Moreover, data with potential commercial sensitivity is not widely shared, although necessary, and thus difficult to obtain. "How to deal with privacy sensitive data? There are significant obstacles to access and share data. Address linked data cannot be shared" - Utrecht.

High investment in costs and time: is mentioned as a barrier by six cities. "It takes a lot of time and effort to acquire the necessary data. How do you ask the right questions, to the right people to get the right data?" - *Utrecht*. Moreover, costs are high. These include payment for external data and hiring data specialists and consultants. Several cities state that costs can be saved if the city itself, or together with other cities, collect and process data. "Setting up the collective knowledge center is expensive, but worth it. A regional data authority was founded with the benefits of scale" - *Hengelo*.

Lack of expertise and skills: Three cities mention that expertise and skills to collect and (pre)process data is not always available internally. In in Rotterdam, Amsterdam and Haarlem external experts are hired, while the other cities primarily rely on internal data expertise, often supplemented with external expertise.

Scattered distribution of data sources: Six cities state that fragmentation of data sources within the city and among various external parties means that a lot of time is needed to find and collect data. The lack of data standards and agreements about which data is needed, combined with the fragmentation of data, leads to ad hoc data collection, whereby the data must be requested from various parties. For some parties this is not a priority and it takes a long time; for other parties, data must be paid for. "You really need to search within the city for which information is already available." - *Groningen*. "The fragmentation of data over the various parties involved in collecting the data and

building models is immense" - *Haarlem*. "A lot of data has not been digitized yet within the city. This knowledge and data is in people's minds and is conveyed orally." - *Rotterdam*. "A lot of data is available, but the problem is to know where it is" - *Nijmegen*.

Poor data findability and access, as a result of, among others, the scattered distribution of data. Five cities mentioned this barrier.

Lack of data access: Two cities mention this as a challenge, particularly for the detailed district implementation plans. Here more detailed and potentially more sensitive data is needed, relative to the city scale. To share this data, it is essential to have mechanisms in place that 1) guarantee data security, and 2) control access and use.

Different formats and standards: Five cities mention missing data standards or questions on how to deal with standards, making data collection and processing resource intensive. "There is no routine in data supply, you have to be precise on what you need, and external data providers do not think along" - *Nijmegen*.

Lack of awareness, trust and openness in data sharing: Three cities state that creating openness and trust takes time; a good relationship with data owners is essential. In these relationships it is necessary to explain what a city will do with the data. "External stakeholders are commonly reluctant to share data. Openness is essential, but many parties remain cautious. It took six months to get data on the natural gas network" - *Rotterdam*. "Housing corporations often find it difficult to share data, they often fail to recognize that it is also in their best interest to share data" - *Haarlem*.

4.4 Barriers to the processing and analysis of data

Table 4 presents the barriers experienced during the actual utilization of data.

Table 4. Barriers to data use among the eight cities.

Barrier to data use	Experienced by
Cautious to make decisions based on insights from data	4/8 cities
Data lacking quality and consistency	4/8 cities
Incomplete and missing data	1/8 cities
Data not up to date	5/8 cities
Data is not always validated	6/8 cities
Data lacking detail level	1/8 cities
Lack of supporting tools	4/8 cities
Difficult to determine the value and purpose of data	2/8 cities
Data preparation is resource intensive	3/8 cities
Difficult to link, analyze, and visualize data	3/8 cities
Resources at the limits to process the quantity of data	2/8 cities
Legal limitations to data use	2/8 cities

Caution to make decisions based on insights from data is mentioned by four cities. This barrier is related to the cultural challenge for cities to take decisions based on data. Moreover, the following five barriers pertaining to data quality and reliability may contribute to this barrier.

Lacking data quality and consistency, is mentioned by four cities. The quality of the data is influenced by the technology used and the human involvement in generating the data, but also in cleaning and processing data and the choices made for generalizing, calibrating, formatting data, etc. “We used the Cadaster database for the surface of buildings, but these surfaces are incorrect. Important decisions are to be made based on this information, it must be correct. I spend a lot of time cleaning the data.” - *Nijmegen*.

Incomplete and missing data: While several cities underline missing and incomplete data, one city mentions it explicitly as a barrier. In the Cadaster databases, with data used by all cities and considered essential for heat transition policy, there are approximately 8% missing values.

Data is not up to date: This is mentioned by five cities. For many relevant data, there is a significant delay between data generation and publication. As a result, the analyzes are based on outdated data. “The reality changes quickly, but data is not adjusted as quickly. You make a plan for districts based on old data that is currently available, whereas it is a dynamic reality” - *Rotterdam*. “A major challenge is the lack of timeliness of data, e.g. energy labels and energy consumption. Especially during the implementation, it is crucial that this data is up to date” - *Hengelo*.

Data is not validated: Six cities mention that many data sources cannot confirm whether the data is validated. The quality of insights derived from the data is difficult to assess if the data is of insufficient quality or not validated.

Data lacking detail is mentioned by one city, limiting analysis opportunities.

Lack of supporting tools for data-driven policymaking is mentioned by four cities, or they mention that the available resources do not meet requirements. Resources provided by the national government, were often found to arrive late, and to require additional resources to be enriched with local data. Each city interviewed uses its own (developed or purchased) tools. “We use our own tools, we have the internal capacity to develop our own tools, such as GIS maps.” - *Rotterdam*.

Difficult to determine the value and purpose of data: This barrier is mentioned by two cities and relates to 1) the challenge to describe the purpose of data, and 2) a lack of data analysis expertise to give value and meaning to the data.

Data preparation is resource intensive: Three cities mention that processing data takes a lot of time. "My time consists of 80% preparing data and 20% data analysis. Many cities outsource this” - *Nijmegen*.

Difficult to link, analyze, and visualize data: Three cities mention that the diversity in data formats and standards makes it difficult to link and analyze data. This is common, due to the great diversity in heterogeneous data sources, between which there are no agreements about data standards.

Resources at the limits to process the quantity of data: Two cities address that even in the early phases of data-driven analysis, the local hardware is at the limits to facilitate the volume of data available. “We see the technical limits of our equipment: we receive 90,000 records, but the spreadsheet only facilitates 60,000” - *Nijmegen*.

Legal limitations to data use: Two cities address that data may not be used due to restrictions on the purpose, e.g. citizen data on social services. This data is available within a city, but cannot be used for energy transition purposes, where it also is relevant.

5 Discussion

Considering the increasing amount and variety of data becoming available, local governments in the Netherlands are starting to use data in their energy transition policymaking, in particular for the urban heat transition. Data-driven models and tools, such as economic assessment models and dashboards are developed to support decision-making and inform citizens and stakeholders on the progress and need for action. As presented by [19–22, 24, 25], there are many opportunities for data-driven energy policymaking. However, based on literature, several barriers and challenges are identified both for data collection and data processing and analysis.

The eight case cities that were investigated in our empirical study follow an iterative 'learning-by-doing' process for collecting and analyzing data and encounter many barriers in this process. The main obstacle for cities is that data collection and processing costs them a lot of time and effort, often because of the fragmentation of data between a myriad of stakeholders. Barriers include a lack of agreements on data formats and standards, skills for data processing, and a lack of proper tools. Data quality, detail and topicality are also often an obstacle. To make decisions with significant social and economic impact, it is essential that there is confidence in the data quality, so that decisions can be justified based on data. These barriers complicate data-driven policymaking among the frontrunner cities and may hamper further adoption of data in the policymaking process. While most of the barriers identified in our empirical study among eight cities validate the barriers found in literature, we also identified some other barriers. Barriers pertaining to data quality, detail level, scattered distribution and heterogeneity, inconsistent data standards and formats, resource intensity to find and prepare data, and GDPR legislation are mentioned in literature and common among the eight case cities. Barriers identified in the empirical study that have not been widely reported on in literature include policymakers' reluctance to formalize policy based on insights from data. Respondents mention several causes for this, e.g. the challenge to explain how insights are derived from the data and the lack of data reliability and quality due to the lack of quality assurance mechanisms. While this is not widely mentioned in literature on data-driven energy transition policymaking, it was mentioned by e.g. [9, 14, 42]. Other barriers found in the literature, e.g. on meta-data and barriers pertaining to data suppliers, were not confirmed in our study, which may be explained by the outsourcing of much of the work on data processing and on the limitation of this study to only interview representatives from local governments. Moreover, in literature a myriad of tools and their barriers can be found to support energy transition policymaking in a wide range of styles, e.g. [19–22]. This study finds that many of the available tools are considered superfluous due to a lack of detail, inclusion of social aspects, and poor timing in when these tools are made available, relative to the policymaking timeline of local governments. This points to the importance of timeliness and fitness for purpose of tools, building on insights from evidence-based policymaking, which not only includes systematic research, but also 'practice', and political judgement [43].

Our study was limited to interviews with representatives of local governments. While this resulted in an extensive overview of barriers and a rich interpretation of those barriers, the outcome could benefit from expanding the interviews towards data

providers. The extended insights on the data providers' perception of barriers, could benefit the identification of structurally effective measures to tackle the barriers. Moreover, from the variety in approaches to incorporate data-driven policymaking in the heat transition found among the eight cases, including the intensive interaction with stakeholders, future research is recommended to understand the factors influencing the chosen data governance structure, such as described by [44, 45]. Developing data governance models and policymaking processes that cope with the recurring barriers, based on the lessons learned by the frontrunners, will be of great practical value, especially to cities which lack resources to experiment with these efforts.

6 Conclusion

This study investigates the collection and use of data for policymaking in the urban heat transition and the barriers local governments encounter based on literature and practice. The local governments in The Netherlands are in the lead for the urban heat transition and need to develop binding heat transition strategies and implementation plans. For this, local governments embark on data-driven policymaking. Based on an empirical study among eight frontrunner cities we find that their main challenge is related to the effort that goes into collecting and using data for heat transition policymaking. Furthermore, we find that a number of barriers, such as data quality, topicality and detail level, and lack of data-driven expertise among policymakers, affect the confidence of cities to use data and data-driven tools for energy policymaking, which has great economic and social impact. This calls for collaboration and standardization between data providers and users for these barriers in heat transition policymaking. This study is initially limited to the local governments, however, heat transition policymaking is a joint effort of the policymakers together with stakeholders such as utility companies and citizens. Barriers encountered by other stakeholders along the ecosystem, influence data use by the local governments. Further research is thus recommended to investigate the ecosystem-wide barriers, to work towards comprehensive data governance models and process designs for effective and supported data-driven policymaking.

Acknowledgement

Knowledge and Learning Program, as part of the National Program on Natural gas free Districts, and its commissioned study entitled "Data for the Transition Vision Heat and District Implementation Plans".

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