Energy inequality as a risk in socio-technical energy transitions: The Swedish case of individual metering and billing of energy for heating

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Abstract. Improved energy efficiency in the housing stock is an important undertaking in the energy transition but is associated with both opportunities and risks. While there are possibilities to reduce energy inequalities in the housing stock, inequalities also risk being aggravated as actions for energy efficiency usually aim at the least energy efficient—and thus sometimes the least privileged—parts of the housing stock. In this paper, we use two different energy performance metrics (kWh/m² and kWh/capita) to investigate the energy inequality in the Swedish multifamily building stock and explore the effects of these inequalities in the energy transition. More specifically, we investigate the implementation of individual metering and billing of energy for heating, which was recently implemented in the least energy efficient part of the housing stock. It was found that low-income households were overrepresented in the affected buildings. The consequence of this implementation is thus that the strongest protection against energy poverty in Sweden (collective billing for heating) is removed in a part of the housing stock where two of the predictors for energy poverty—low income and low energy performance—are overrepresented. It was concluded that acknowledging inequalities is crucial to avoid risks associated with the energy transition.

1. Introduction

National and international actions for improved efficiency and sustainability in energy systems are all part of an energy transition [1]. As approximately 40% of the energy in the European Union (EU) is used in the building stock [2], improved energy efficiency in buildings is an important part of the EU’s energy transition [3].

Considering that buildings are socio-technical systems, residents are not left unaffected by the energy transition of the housing stock. Instead, improved energy efficiency in the housing stock is part of a socio-technical energy transition that is associated with both opportunities and risks [4, 5]. Among the opportunities are those of improved indoor climate and reduced energy poverty [6].

Energy poverty is a growing concern in the EU and is often described as a state in which a household either is unable to keep their home adequately warm or must spend a relatively high share of their disposable income on energy to maintain adequate indoor comfort [7]. As energy poverty is directly connected to households’ energy affordability, energy poverty is an important challenge to overcome in order to reach Sustainable Development Goal (SDG) #7 Affordable and clean energy.
Some of the factors that have been found to contribute to an increased risk for energy poverty are high energy prices, low income, and a low energy performance of the building [8]—the latter is why improved energy efficiency in the housing stock can help alleviate energy poverty. Among the consequences that residents can experience from energy poverty are reduced health and well-being, as well as economic distress when the energy bill is payed at the expense of other necessities [9, 10].

However, while energy poverty has been widely studied across the EU, it has been, and still is, considered a non-issue in Sweden and in the Swedish multifamily building stock. The reasons for this are manifold. First of all, Sweden has a strong social support system compared to many other EU member states, and there are e.g. regulations that prevent energy cut-offs when there is a risk for harming the residents [11, 12], and regulations that ensure a minimum indoor temperature for all households [13]. Second of all, Sweden has expansive networks of district heating, with the vast majority of all multifamily buildings receiving district heating [14] which is often a more affordable alternative compared to other energy carriers for heating [15]. Finally, and most importantly, Sweden has a custom of collectively paying for heating in multifamily buildings, unlike many other EU member states. This means that costs for heating are usually fixed and included in the rent. Tenants thus have the benefit of predictable costs, regardless of their energy use for heating and the outdoor temperature, at the expense of a lack of influence over their (seemingly invisible) heating costs.

However, recent studies have indicated that there are significant correlations between buildings’ energy performance and residents’ income in the Swedish multifamily building stock, where lower income households are more likely to live in buildings with low energy performance [16, 17]. Such correlations could be viewed from the perspective of energy inequality. Hitherto, little is known regarding the effects of such inequalities in the energy transition of the housing stock. It is thus motivated to re-evaluate the Swedish situation of energy poverty, starting from the view of energy inequality. What does energy inequality look like in Sweden, and what are its consequences as we are transitioning towards a more energy efficient housing stock?

This study aims to explore these questions within the framework of the Energy Efficiency Directive (EED) [18], the EU’s guiding directive in the energy transition. In order to comply with EED, Sweden is now implementing individual metering and billing of energy for heating in the multifamily buildings with the lowest energy performance. Considering the indicated energy inequality in Sweden, this is associated with a potential risk for energy poverty among energy-vulnerable households [7]. The consequence of this inequality could in this case be that one of the strongest protectors against energy poverty (collective billing for heating) is being removed from a part of the housing stock where two of the predictors for energy poverty—low income and low energy performance—are overrepresented.

To provide a nuanced view of the energy inequality in Sweden, two different energy performance metrics will be used: the frequently used kWh per square meter, and the less frequently used kWh per capita. The reason for including the metric kWh per capita is to emphasize residents as the end users of energy rather than buildings, which constitutes an especially important perspective when metering and billing of energy for heating are individualised.

In this paper, we will consider the case of implementing individual metering and billing of energy for heating in Sweden to investigate (i) the current state of energy inequality in the Swedish multifamily building stock using two different energy performance metrics (kWh/m² and kWh/capita), and (ii) the consequences of energy inequality when actions for improved energy efficiency are targeted towards the buildings with the lowest energy performance. The aim of this study is to gain a better understanding of how inequalities should be considered in socio-technical energy transitions, with the ultimate goal to achieve affordable and adequate housing for all in accordance with SDG #11 Sustainable cities and communities.

2. Materials and Methods
In this section, the data used for analysis is first described, followed by a description of the case that will be subject for analysis.
2.1. Data on the Swedish multifamily building stock

Energy inequality in the Swedish multifamily building stock is analysed using data on buildings’ energy use, residents’ income, and number of residents. This is done using data from Energy Performance Certificates distributed by The National Board of Housing, Building and Planning (Sw. Boverket), as well as data from Statistics Sweden. The Energy Performance Certificates are issued on building-level whereas data from Statistics Sweden are available on property level. More information about the data can be found in Table 1.

Data from Energy Performance Certificates were matched with data from Statistics Sweden on property-level using a unique identifier. The number of residents for each property was then distributed to each building on the property using building area as base for allocation. The median income for each property was assumed to apply to all of the property’s buildings.

Table 1. Metadata about the data used for analysis.

| Variable                  | Data source                                      | Year of retrieval | Level of aggregation | Coverage   |
|---------------------------|--------------------------------------------------|-------------------|----------------------|------------|
| Buildings’ energy use     | The National Board of Housing, Building and Planning | 2015              | Building             | National coverage |
| Residents’ income         | Statistics Sweden                                 | 2016              | Property             | National coverage |
| Number of residents       | Statistics Sweden                                 | 2017              | Property             | National coverage |

2.2. Case: The Swedish implementation of the EU-requirements on individual metering and billing of energy for heating

Pursuant to Article 9 of EED, all member states shall require households’ energy use for heating, cooling, and domestic hot water to be metered and billed on apartment-level by installation of individual energy meters [18]. The reason is to provide economic incentives for households to reduce their energy use by letting the energy bill be an accurate reflection of the households’ actual energy use. However, the installation of individual meters is only a requirement “in so far as it is technically possible, financially reasonable and proportionate in relation to the potential energy savings” [18].

In their implementation of Article 9 in EED, member states have for themselves to determine whether an installation of individual meters meets the mentioned criteria or not. When the Swedish Board of Housing, Building and Planning investigated how Article 9 should be implemented in Sweden, the result was two reports (in 2014 and 2015 respectively) that both concluded that installation of individual meters for heating, cooling and domestic hot water was never financially reasonable in a Swedish context [19, 20]. On the Swedish Board of Housing, Building and Planning’s recommendation, the Swedish government thus decided not to implement a regulatory requirement on individual meters.

However, this decision led to the EU commission initiating an infringement procedure against Sweden in 2018 as they considered that Sweden failed to comply with Article 9 in EED. Consequently, the Swedish government put forward a new proposal for regulatory requirements of individual meters in the summer of 2019, and the proposal was later accepted in November 2019. In the context of this study, it is first and foremost the regulations regarding individual metering and billing for heating (not for cooling and domestic hot water) that are of relevance. Starting from 1st of July 2021, the regulatory requirements for installation of individual meters for heating are [21]:

- The owner of a multifamily building in Jämtland, Västerbotten, or Norrbotten region with an energy performance above 180 kWh/m² and year must install a system for individual metering and billing of energy for heating.
The owner of a multifamily building in all other regions with an energy performance above 200 kWh/m² and year must install a system for individual metering and billing of energy for heating.

The new regulation is based on investigations showing that installation of individual meters for heating is cost-effective when installed in buildings with the lowest energy performance (>200 kWh/m²) and in buildings in the most northern regions of Sweden with an energy performance above 180 kWh/m². Exceptions from the regulation are allowed if the owner is planning energy efficiency measures that would improve the energy performance enough to evade the limits of 180 respectively 200 kWh/m² and year, or if the owner in some other way can prove that installation of individual meters would not be cost-efficient.

3. Results
The results are divided into two parts. The first part details the situation of energy inequality in Sweden while the second part shows the effects of energy inequality on the implementation of regulations for individual metering and billing of heating in the buildings with the lowest energy performance.

3.1. Energy inequality in the Swedish multifamily building stock
To shed light from several angles on energy inequality in the Swedish multifamily building stock, energy use per square meter as well as energy use per capita was mapped for each income decile of the residents. The results can be seen in Figure 1. It can be seen that there is a clear correlation between energy use per square meter and income, where energy use per square meter decrease as the residents’ income increase. The highest energy use per square meter is found in the lowest income decile.

However, the correlation between energy use per capita and residents’ income follows the opposite pattern as energy use per square meter. The highest energy use per capita is found in the highest income decile, where the energy use per square meter is the lowest. Likewise, the lowest energy use per capita is found in the lowest income decile, where the energy use per square meter is the highest.

![Figure 1. The correlation between residents’ income, energy performance, energy use per capita and square meters per capita.](image-url)
The energy use per capita is a product of energy use per square meter multiplied by square meters per capita, and the residential density thus significantly influences the energy use per capita. In this case, the higher residential density (i.e. lower square meters per capita) in low-income households that can be seen in Figure 1 has enough impact to offset the relatively high energy use per square meter, leading to a relatively low energy use per capita in the lower income deciles. Likewise, the lower residential density in high-income households that can be seen in Figure 1 leads to a relatively high energy use per capita in high-income households, despite a relatively low energy use per square meter.

The results in Figure 1 showcase the importance of metrics for our perception of the status quo and thus our perception of where actions need and need not be targeted.

3.2. Case: The Swedish implementation of the EU-requirements on individual metering and billing of energy for heating

To see the effect of energy inequality as actions for energy efficiency aim at the least energy efficient part of the housing stock, a mapping of residents affected by the new regulations for individual metering and billing of energy for heating was performed. The results can be seen in Figure 2. It can be seen that the number of affected residents increase as the residents’ income decrease, and a remarkably high number of residents in the lowest income decile are affected compared to in the other income deciles. Specifically, almost three times as many residents are affected in the lowest decile compared to the highest decile.

The results in Figure 2 showcase how the energy performance inequality affects the distribution of responsibility and burden among residents when actions for energy efficiency is targeted towards the buildings with the lowest energy performance. More so, these results suggest that there will be an unprecedented risk for energy poverty in the Swedish multifamily building stock as collective payment of heating (a previous protection against energy poverty) predominantly is removed in buildings where two of the predictors for energy poverty—low income and low energy performance—are present.

Figure 2. The number of residents in each income decile affected by the new regulation for individual metering and billing of energy for heating.
4. Discussion

The results of this paper confirmed the indicated energy inequality in the Swedish multifamily building stock, with low-income households being overrepresented in buildings with low energy performance. Consequently, low income households are facing two primary disadvantages: a higher risk for a poor indoor environment and a higher energy demand for heating. Targeting energy efficiency actions towards these buildings could thus remove these disadvantages, and the energy transition constitutes a promising opportunity for this cause. However, an understanding of the involved risks is crucial. To improve the energy efficiency of low-income, low-energy efficient housing, solutions that increase energy efficiency without increasing costs for residents are needed. There are two reasons to why individual metering and billing of energy for heating does not appear to constitute such a solution.

First, individualisation of heating costs does not improve the energy efficiency of a building. It might, however, contribute to a reduced energy use for heating due to changes in behaviour or decreased indoor temperature—with potentially adverse effects on well-being and health. But if incentives for energy savings are to be allocated to residents, they should be allocated to the residents with the highest individual energy use. As the results in Figure 1 show, the highest energy use per capita is found in the highest income decile. Yet, these residents are the least affected by the individualisation of heating costs. This raises questions regarding the impact of energy performance metrics on the distributive justice of burdens in the energy transition. While a building’s energy use per square meter can reveal a lot about its technical efficiency, it ignores the fact that energy use in buildings is in fact the energy use of residents in buildings. If the energy transition of the housing stock will rely as much on energy performance metrics as is indicated here, it will be necessary to introduce metrics that include the residents in the equation. If not, there are risks for unjust distributions of costs and responsibilities in the energy transition.

Second, trade-offs between indoor comfort and heating costs are likely to gain more weight in low-income households than in higher-income households. From an energy savings perspective, it might thus be favourable that individualisation of heating costs is targeted towards low-income households. However, from an energy poverty perspective, it is problematic. While residents will still be protected from energy cut-offs, low-income households in low-energy efficient buildings are nevertheless likely to either spend a relatively high share of their income on heating, or to keep a relatively low indoor temperature as a consequence of the individual metering and billing of energy for heating.

The results of this paper showcase how income-related energy inequality can further increase the vulnerability for low-income households in energy transitions. The fact that actions for improved energy efficiency are often targeted towards the least energy efficient buildings puts this case study into a wider context of distributive justice in the energy transition. One of the currently contested issues within this context is the conflict between energy retrofits and affordable housing [22, 23], where phenomena such as ‘renoviction’ and ‘ecological gentrification’ are commonly debated [24]. These phenomena can be observed when energy retrofits result in significant rent increases—usually in buildings where rents previously have been relatively low, and where low-income households are overrepresented. Such cases constitute notorious examples of when the opportunities of the energy transition are wasted rather than seized as prevailing inequalities are magnified rather than offset. The results of this paper can thus be used to initiate a discussion where questions regarding energy inequality can be put in the context of distributive justice in the energy transition of the housing stock. An increased awareness of the balance between who contributes to energy use and who is faced with requirements for energy savings will facilitate a just energy transition as all EU member states are proceeding in the energy transition of the housing stock.

Indeed, the energy transition of the housing stock is associated with both opportunities and risks. There are great possibilities to reduce inequalities in energy performance and standard of living—i.e. to contribute to both SDG #7 Affordable and clean energy and SDG #11 Sustainable cities and communities—while there also is a risk of aggravating the existing inequalities. But for risks to be avoided, a first step is to acknowledge them. However, as there are no exceptions or alternative
approaches in the EED that could alleviate the vulnerability of low-income residents, the Swedish implementation of individual metering and billing of heat has led to increased social risks. The effects of this implementation are yet to be evaluated, but it can be concluded that the energy inequality in the Swedish multifamily building stock unnoticedly contributed to an enhanced exposure of low-income households to the risk of energy poverty. Without recognition of social inequalities and the risks they pose, the energy transition is unlikely to resemble a sustainable transition of any sorts.

5. Conclusions
In this paper, the effect of income inequalities in buildings’ energy performance during socio-technical energy transitions was investigated using the Swedish case of implementation of individual metering and billing of heating. Collective payment of heating has been the custom in Swedish multifamily buildings, but in 2021, individual metering and billing of energy for heating will be required in the least energy efficient multifamily buildings in Sweden. It was found that energy performance inequalities in Sweden, where low-income households more often live in low energy performing buildings, caused low-income households to be more affected by the individualisation of heating costs than high-income households. As collective payment has acted as a safety against energy poverty in Sweden, the consequence of the individualisation of heating costs was that the protection against energy poverty was removed in the buildings where the risk for energy poverty is the highest.

More so, it was found that the way energy performance is measured has a great impact on where the “best” and “worst” performing buildings are found. For example, whereas the highest energy use per square meter was found in the lowest income decile, the highest energy use per capita was found in the highest income decile. A discussion on what energy performance metrics to use is crucial when these metrics are used as guidelines on where to target actions for energy efficiency. Especially in a socio-technical energy transition, constituted of both buildings and their residents, it is important to include metrics that recognise the residents as the end users of energy—not the buildings. In order to reach SDG #7 Affordable and clean energy and SDG #11 Sustainable cities and communities, an increased recognition of social equality and justice is needed in the energy transition of the housing stock.

Acknowledgements
This work was supported by The Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning (Formas) [grant number 2017-01449] within the project National Building-Specific Information (NBI). The authors have no conflicts of interest to declare.

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