Comparative evaluation of city dwellers' perspectives on household energy use based on housing tenure: survey results from Northern Sweden

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Abstract. The successful implementation of energy efficiency measures in the residential sector will depend to a large extent on the attitudes and perceptions of the end-users since they are the final decision maker. The tenure of the housing could influence the perspectives of the building occupants on energy issues. As per our knowledge, studies that compare occupants' energy use perspectives, based on their home tenure, are limited. In this study we have conducted a comparative evaluation of perspectives on energy use of three categories of households: those living in single family houses, tenants and owners' of apartment. The analysis is based on responses of a mail-in questionnaire by approximately 660 residents living near to a University in a northern Swedish city. The survey, based on a random sampling method, was carried out during February-April 2016.

Majority of the respondents believed that their annual household energy use is less. Respondents who believed that their annual electricity and heat energy use as high are approximately 15% and 20%, respectively. Residents in single-family houses, as compared to the other two types of tenure of the housing, were more likely to believe their heat energy use as high and likely to take actions to reduce the energy use in their household. More apartment owners (39%) and tenants (34%) as compared to owners of single-family households (22%) were satisfied with their current energy use and sees no reason to reduce it. Financial incentives such as subsidy or lower interest rate were preferred by most of single-family homeowners (45%) to motivate them to take actions to reduce energy use. While personalized information to reduce energy use and lower interest rate and reduced rent are preferred by more residents in the other two categories. The implications for promoting energy efficient measures among city dwellers based on housing tenure is discussed.

Keywords: Perception, Occupants, Energy efficiency.

1 Introduction

Buildings account for approximately 30% of the global carbon dioxide (CO_2) emissions [1]. There is a large potential for reducing greenhouse gas emissions in this sector [2]. Moreover, a significant number of mature energy efficiency measures in buildings could result in CO_2 emissions reduction that have net benefits rather than costs [2]. Several countries have introduced building codes with energy efficiency requirements

for new buildings and the Energy Performance Building Directive stipulates that all new buildings in the EU should be nearly zero energy by the end of 2020. However, the addition of new buildings to the existing stock happens slowly, especially in developed countries. For example, in Sweden, the number of residential units increased by approximately 10% from 1991 to 2008, which corresponds to an average increase of roughly 0.5% in new housing units per year [3]. Hence it is important to influence the residents of existing buildings to reduce their household energy use.

Sweden has approximately 4.5 million dwellings, of which single-family houses constitute approximately 45% of the dwellings while the rest are apartments in multi-family buildings [3]. The ownership pattern of multi-family buildings in Sweden can be categorised into municipal, private and tenant-ownership. Approximately 40% of apartments in multi-family buildings belong to municipal housing companies, while the rest is equally shared by private companies and co-operative housing associations. The municipal housing and private companies give their apartments for rent, while the co-operative sector resembles a condominium sector [4].

The buildings in Sweden are relatively energy efficient as compared to several other countries. Nevertheless, there is a large potential to improve the energy efficiency of Swedish residential buildings [5]. The successful implementation of energy efficiency measures will depend largely on the attitudes and perceptions of the end-users' since they are the final decision maker. Swedes in general have high awareness about climate change issues and also have a positive attitude towards protecting the climate system [6]. Majority of homeowners in Sweden may undertake non-investment measures as against investment measures in their quest to reduce household energy use [7].

The tenure of the housing could influence the perspectives of the occupants on energy issues. Residents in different home tenure's could have different priorities and limitations related to household energy use. A tenant usually live in a house for relatively shorter duration, for example an American study showed that the renters move every two years [8]. Hence the tenants may not be interested to invest in energy efficiency improvements. A tenant may like to reside in an house with lower rent, especially when all other important factors that influence their housing choice are same. If they could reduce the rent by energy efficient behaviour then the tenants may have a positive attitude to reduce energy use. However, if the energy cost is included in the rent which makes the energy cost "fixed" then the tenants may be less inclined to make efforts to reduce their household energy use. In Sweden, more than 80% of multi-family buildings are heated by district heating [9], and usually the apartments do not have a separate heat energy meter and the heating cost is included in the monthly fee/rent. The electricity cost is usually paid separately by the residents. Nevertheless in some co-operative housing associations (and also in some rented apartments) the electricity cost is included in a monthly fee the apartment owners pay to the association.

The apartment owners also face certain limitations in-terms of their household energy use. For example, an apartment owner as an individual, especially in Sweden, cannot choose the heating energy supplier. Apartment owners' also cannot make decision related to building envelope improvement. In Swedish housing associations the decisions pertaining to the buildings are usually made by the executive board which is

headed by a chairperson. Moreover, for majority of the apartments in Sweden the heating energy cost is included in the monthly fee (towards maintenance, common services, loan repayment, if any) the apartment owners pay to the association. Hence, in housing associations unless several households reduce their heating energy and thereby reducing the monthly fee, the apartment owners may not get a financial benefit from their actions to reduce the heating energy use.

Among the different categories of home tenures, owners of single-family houses are better positioned to influence their energy use as they are the direct beneficiary of their actions and also have the ability to choose. Nevertheless, a survey in Sweden suggest that a significant percentage of single-family households did not feel a need to improve the energy efficiency of their building envelope [10]. A prerequisite for the residents to adopt energy efficiency measures is that they should feel a need for it [11]. The need to improve energy efficiency could be trigged by various factors such as physical condition of the building component(s), high annual energy cost. If the residents are satisfied with the existing energy use in their houses then they are less likely to implement/adopt measures to reduce the energy use.

This case study aims to provide pointers on possibilities and barriers in reducing the household energy use among residents in a subsection of a city. The analysis is based on the perception of household energy use by three categories of residents living near to a University in northern Sweden.

2 Methodology

The analysis is based on a mail-in questionnaire survey to 3000 residents living near to the Umeå University, Sweden. The survey, based on a random sampling method, was conducted to study the residents perspectives on various aspects related to the sustainable development of the city. The questionnaire had different sections and include questions on travel/mobility aspects, perception and attitude on household energy use, views on energy use feedback, perspectives on various measures (separate questions on mobility and energy use in buildings) related to sustainable development of the city, safety aspects on the city they live, values important for them, and a few question related to socio-economic aspects. Majority of the responses were evaluated on a 7-point Likert scale. For example, to understand respondents' attitude to reduce household heating energy use we asked the question *"How important it is for you to reduce your household heating energy use?"* Respondents answered the question using a 7-point Likert scale (1= not important, 7= highly important). For simplifying the analysis, we reclassified the responses in a 7 point Likert scale into three (for example, *important, neither nor, not important*) by grouping options 5-7 as *important* and options 1-3 as *not important*, while option 4 is the neutral option which is *neither nor*.

The addresses were collected from Umeå municipality. The survey was carried out during February-April 2016, and 657 filled-in questionnaire were received. Since the survey was conducted among people living near to a University, some characteristics of the respondents' could be different from that of Swedish population. For example, approximately 60% of the survey respondents had University/college education ≥ 3 years (Table 1), while about 24% of the Swedes in the age group of 20-74 years has a

University/college education ≥ 3 years [12]. Hence the survey sample, though may be typical to a Swedish University neighbourhood, is not representative for the country. Accordingly, generalization of the study results to the entire population is limited.

3 Results

As the target groups were people living near to the University, a large percentage of respondents were living in apartments, either as tenants or as apartment owners. 23%, 24% and 53% of the respondents were single-family homeowners, apartment owners and tenants, respectively. Approximately 70% of single-family homeowners live in a house larger than 125 m^2, whereas 63% apartment owners and 78% tenants live in an apartment size less than or equal to 75 m^2. The demographic composition of the respondents are provided in Table 1.

Table 1: Demographic composition of the respondents

	% of respondents*			
	Single-family homeowners (N=149)	Apartment owners (N=154)	Tenants (N=343)	Total survey respondents (N =646)
Gender				
Male	48	44	46.5	46
Female	52	56	52	53
Other	-		1.5	1
Age				
<= 25 years	4	13	36	23
26-35 years	7	23	36	26
36-45 years	20	11	9	12
46-55 years	24	2	6	11
56-65 years	23	24	7	13
>65 years	22	27	6	15
Marital status				
Married/Living together	88	64	43	58
Single	12	36	57	42
Annual household income				
<200 000 kr	5	15	45	29
200001-300 000 kr	4	14	14	12
300 001-400 000 kr	7	19	16	15
400 001-500 000 kr	10	10	8	9
500 001 – 600 000kr	12	16	6	9
> 600 000 kr	62	24	11	26
Education				
Upto High school	20	27	33	29
University/college (<3 years)	9	11	12	11
University/college (≥ 3 years)	71	62	55	60
Employment				
Full time job	57	41	32	40
Part time job	11	10	8	9.5
Student	5	14	45	28.5
Pensioners	24	29	8	16.5
Others	3	6	7	5.5

*11 respondents didn't mention the category of their house and their responses were excluded from the analysis.

62% of the apartment owners and 76% of the tenants responded to the survey stated that the monthly fee/rent they pay to the housing association/company included the heating cost. 25% of the apartment owners and 31% of the tenants stated that the cost of electricity is included in the monthly fee/rent.

The respondents' perception on annual heating energy and electricity use in their homes is presented in Table 2. Majority of the respondents in all the three categories of home tenures did not consider that their heating and electricity use was high. Among the respondents, residents of single-family houses were more likely to consider that their household energy use was high. Similarly, it was found that majority of the respondents consider that their heating and electricity cost was low (Table 3). Among the three categories of residents, single-family homeowners were more likely to consider that their annual heating and electricity cost was high.

Table 2: Respondents' perception on annual energy use in their home

	% of respondents		
	High	Neither nor	Low
Heating energy use[a]			
Single-family homeowners	25	35	40
Apartment owners	7	38	55
Tenants	10	35	55
Household electricity use[b]			
Single-family homeowners	16	37	47
Apartment owners	6	36	58
Tenants	10	35	55

[a] Statistically significant relationship with chi-square test $p \leq 0.001$
[b] Statistically significance with chi-square test $p \leq 0.1$

Table3: Respondents' perception on annual household energy cost

	% of respondents*		
	High	Neither nor	Low
Heating energy cost[a]			
Single-family homeowners	30	40	30
Apartment owners	8	33	59
Tenants	6	36	58
Household electricity cost[b]			
Single-family homeowners	20	42	38
Apartment owners	8	30	62
Tenants	9	35	56

[a,b] Statistically significant relationship with chi-square test $p \leq 0.001$

*16% of the single-family households and 11% of respondents living in apartments reported that their dwellings are heated partly/fully by electricity. It may be difficult for these households to differentiate between heating and household electricity cost.

More number of single-family homeowners believed that their heating use and cost were high as compared to their electricity use and its cost. However, among apartment owners and tenants there was not much difference on their perception towards heating energy and electricity use and cost. Though majority of respondents consider their annual household energy use and its cost was not high, a large percentage of them consider it important to reduce their household energy use (Table 4). Single-family homeowners were more likely to have a positive attitude towards reducing the heating energy use. However, no statistically significant relationship was found between respondents' home tenure and their attitude to reduce their electricity use.

Table 4: Attitude to reduce household energy use

	% of respondents		
	High	Neither nor	Low
Heating energy use[a]			
Single-family homeowners	50	17	33
Apartment owners	34	17	49
Tenants	31	19	50
Household electricity use			
Single-family homeowners	45	17	38
Apartment owners	39	17	44
Tenants	40	18	42

[a] Statistically significant relationship with chi-square test $p \leq 0.01$

A large percentage of respondents were of the opinion that they have done whatever possible to reduce the use of heating energy and electricity in their household (Table 5). Among the respondents, single-family homeowners were more likely to agree that they have done whatever possible to reduce the heating energy use in their home. However, no difference was found between residents' home tenure and their belief that they took whatever actions possible to reduce their electricity use.

Table 5: Respondents view on whether they have done what is possible to reduce energy use in their household

	% of respondents		
	Agree	Neither nor	Disagree
Heating energy use[a]			
Single-family homeowners	54	19	27
Apartment owners	48	16	36
Tenants	39	21	40
Household electricity use			
Single-family homeowners	45	25	30
Apartment owners	48	20	32
Tenants	44	21	35

[a] Statistically significant relationship with chi-square test $p \leq 0.05$

The non-investment behavioural measures (switching off lights) was the most common energy efficiency measure adopted among apartment owners and tenants (Table

6). 87% and 85% of apartment owners and tenants, respectively, reported to have switched off the lights when they leave the room. Low-investment measure (replacement of bulbs with LEDs) was also a popular energy saving measure among the residents. As expected tenants were less likely to implement investment oriented measures to reduce electricity. Hot water reduction and water conservation measures were preferred by less number of households.

Table 6: Measures residents undertook in the last three years (2014-2016) to reduce household energy use

Options to reduce household energy use	% of respondents		
	Single-family homeowners	Apartment owners	Tenants
Switch off lights when I leave room	69	87	85
Lowering indoor temperature	42	32	23
Purchased energy saving equipment (refrigerators, freezers)	56	46	12
Replace electrical equipment such as TVs	37	40	18
Replaced bulbs with LED lamps	84	79	73
Installed water saving equipment	33	36	8
Use less hot water	22	25	30
Invested in home (for example, added insulation)	40	4	1

As compared to residents of single-family houses more apartment owners and tenants were satisfied with their daily energy use (table 7). Approximately 25% respondents among the three categories of residents agreed that they would consider reducing their household energy use, however, they were not sure on how and when they could do it. More number of single-family homeowners (27%) were aware of the energy aspects in their house and were reflecting on it. In general, single-family homeowners seems to be having more favourable plan to reduce their daily energy use. Only a few percentage of respondents thought that they could not influence the energy use in their house.

Table 7: Respondents' views to reduce daily energy use in their household

	% of respondents		
	Single-family homeowners	Apartment owners	Tenants
I am satisfied with the level of energy use in my household and sees no need to reduce it	22	39	34
I would like to reduce the household energy use but at the moment it is impossible for me to do it	6	5	12
I will consider to reduce my household energy use. At the moment I am not sure on how and when I could do it	27	23	23
I have a target to reduce energy use. I know actions I can take but not gone from words to actions yet	17	9	6
I am aware of energy aspects in my house and I am reflecting on it	27	20	17
I cannot influence the energy use in my house and so reducing it is not an option for me	1	4	8

The respondents' view on various stimuli that may encourage them to reduce household energy use is provided in Table 8. 46% of residents of single-family houses were of the opinion that financial support and possibility to have a lower interest rate on home loans when implementing energy efficiency measures may motivate them to take actions to reduce household energy use (Table 8). 40% of apartment owners and 42% of tenants think that financial incentives, in the form of reduced rent, may motivate them to reduce the indoor temperature. A large number of respondents in all categories of homeowners think that access to reliable and customized information on energy efficiency measures may motivate them to take actions to reduce household energy use.

Table 8: Perspectives on various stimuli that could encourage the respondents to reduce household energy use

	% of respondents agreed		
	Single-family households	Apartment owners	Tenants
Reduce the rent if the indoor temperature is reduced (by 1-2 Deg C)	5	40	42
Financial support/subsidy to install energy saving measures	46	19	23
Possibility to borrow/rent tools	4	7	14
To have reliable information on costs and benefits of energy efficiency measures	29	33	33
Personalized information on ways to reduce energy use	37	33	42
Possibility to have a lower interest rate on home loans when implementing energy efficiency measures	46	43	28

4 Discussion and Conclusions

Majority of the survey respondents from three categories of home tenures didn't consider their annual household energy cost as high. The perceived lower energy cost may be a barrier among majority of respondents, especially those living in apartments, to take actions to reduce their household energy use. For majority of respondents who are living in apartments, the heating energy cost is included in the rent or monthly payment to the association/housing company. Moreover, as the heating energy cost is "hidden" in the monthly payment/rent, the residents of apartment may not be aware of their actual heating energy use and cost. This situation may be partly responsible for the large percentage of (approximately 50% among apartment owners and tenants) respondents non-favourable attitude to reduce the heating energy use. Among the three groups of respondents, the residents of single-family houses were more likely to consider that their heating energy and electricity cost is high. Further, relatively large number of residents in single-family houses were likely to take actions to reduce their daily household energy use. The perceived higher energy cost may be a motivation for their energy efficiency improvement plans.

Majority of respondents didn't consider their household energy use as high. Nevertheless, a larger percentage of residents consider it as important to reduce their household energy use (both heating energy and electricity). This suggest a positive attitude among a large number of city dwellers towards environment.

Majority of the respondents undertook switching-off lights as an energy saving measure, which supports earlier findings that the homeowners are more likely to undertake non-investment measures as against investment measures [7]. Individuals may undertake non-investment measures because these efforts could be *visible*, such as switching off lights [13], because they involve no investment risk or simply because they are habits. Though switching off lights when not needed is a positive action towards sustainability, the energy saving potential for such a measure may be limited and may have implications on residents' further energy efficiency behaviour. For example, Kempton et al. [13] noted that when people cannot realize the anticipated energy cost savings through measures they have adopted, such as switching off lights, they may become disillusioned with energy efficiency measures in general.

Reducing the indoor temperature, which is another non-investment measure is preferred by relatively less number of respondents. Tenants were less likely to reduce their indoor- temperature as an energy saving measure. However, a large number of tenants also mentioned that they might do so if they receive some financial incentive for their action to reduce the indoor temperature.

A number of residents are interested to reduce their household energy use, however, they are not sure on how and when they could carry out the measures. Without accurate information that are accessible, many homeowners may believe that whatever they are doing to reduce their energy use is sufficient [14] and hence may miss measures that could significantly reduce their energy use. Providing relevant information on energy efficiency measures that are perceived reliable may facilitate these group to take (start) energy reduction initiatives. Approximately, one third of the respondents consider that access to reliable information on costs and benefits of energy efficiency measures could motivate them to implement measures to reduce their household energy use. Moreover, a large number of respondents also believed that customized information could motivate them to take actions to reduce the energy use. A large percentage of homeowners, especially single-family homeowners believed that they have done whatever possible to reduce their household heating energy. This perception of the end-users may create challenges in communicating to these residents' about further energy efficiency improvements, if any. This is because people may ignore information about energy use reduction measures due to *selective exposure* as such measures might be inconsistent with their existing needs, attitudes and beliefs [11].The results from this study reiterates the importance of provision of effective and reliable information, especially customized information as a policy tool to promote energy efficiency in the residential sector.

Sweden uses a mix of regulatory, fiscal and informational policy instruments to promote energy efficiency measures in the residential sector. However, the target group for several such policy instruments are often single-family households. For example, the target group for municipality energy advisers which provide impartial advice on energy issues are mainly single-family households [15]. Major subsides, especially those related to thermal energy use reduction are also usually aimed for single-family

houses. Hence apartment residents, which constitute more than 50% of the total dwellings may not be reached sufficiently through policy instruments. It is important to include this segment's concerns and needs while introducing policy tools to facilitate the energy reduction targets in the residential sector.

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References

[1] IEA (International Energy Agency).: Energy Technology Perspectives 2010. Scenarios & Strategies to 2050. IEA publication, France (2010).
[2] IPCC (Intergovernmental Panel on Climate Change).: Climate change 2007: Residential a nd Commercial buildings (Chapter 6). Fourth Assessment report (2007).
[3] SCB (Statistics Sweden).: Yearbook of Housing and Building Statistics 2012 [Bostads- och byggnadsstatistisk årsbok 2012], ISSN 1654-0921 (2012).
[4] Turner, B.: Housing Cooperatives in Sweden: The Effects of Financial Deregulation. Journal of Real Estate Finance and Economics, 15: 2, 193- 217 (1997).
[5] Nässén, J., Holmberg, J.: Energy efficiency – a forgotten goal in the Swedish building sector? Energy Policy, 33, 1037-1051 (2005).
[6] Eurobarometer: Europeans' attitudes towards climate change (2008).
[7] Nair, G., Gustavsson, L., Mahapatra, K.: Factors influencing energy efficiency investments in existing Swedish residential buildings. Energy Policy 38, pp. 2956-2963 (2010).
[8] U.S. Department of Housing and Urban Development: American Housing Survey for the United States: 2007 (2008).
[9] Statistics Sweden.: Yearbook of Housing and Building Statistics 2012. [Bostads- och byggnadsstatistisk årsbok 2012] ISSN 1654-0921 (2012).
[10] Nair, G., Gustavsson, L., Mahapatra, K.: Owners perception on the adoption of building envelope energy efficiency measures in Swedish detached houses. Applied Energy 87. 2411-2419 (2010).
[11] Rogers, E.M.: Diffusion of innovations. 5th Edition. Free Press. New York (2003).
[12] Statistics Sweden: Population by level of education, sex, age and born in Sweden/foreign born 2016. https://www.scb.se/en/finding-statistics/statistics-by-subject-area/education-and-research/education-of-the-population/educational-attainment-of-the-population/, last accessed on 2017/10/13 (2017).
[13] Kempton, W., Darley, J.M., Weihl, J.: Do consumers know "what works in energy conservation? Marriage and Family Review 9, 115-133 (1985).
[14] Attari, S.Z., DeKay, M.L., Davidson, C.I., de Bruin, W.B.: Public perceptions of energy consumption and savings. PNAS 107, 16054–16059 (2010).
[15] Mahapatra, K., Nair, G., Gustavsson, L.: Swedish energy advisers' perceptions regarding and suggestions for fulfilling homeowner expectations. Energy Policy 39, 4264-4273 (2011).