Sustainability designed with(out) people? Understanding for what energy is (over-)used by tenants in an energy efficient public housing in Milan

Giuseppe Salvia
Dept. of Architecture and Urban Studies, Politecnico di Milano. P.za L. Da Vinci, 32 - 20133 Milan.
Giuseppe.Salvia@Polimi.it
Federica Rotondo
Dept. of Architecture and Urban Studies, Politecnico di Milano. P.za L. Da Vinci, 32 - 20133 Milan.
Giuseppe.Salvia@Polimi.it
Eugenio Morello
Dept. of Architecture and Urban Studies, Politecnico di Milano. P.za L. Da Vinci, 32 - 20133 Milan.
Eugenio.Morello@Polimi.it
Andrea Sangalli
end-use Efficiency Research Group, Dept. of Energy Politecnico di Milano – Via Lambruschini, 4 - 20156 Milan.
Andrea.Sangalli@Polimi.it
Lorenzo Pagliano
end-use Efficiency Research Group, Dept. of Energy Politecnico di Milano – Via Lambruschini, 4 - 20156 Milan.
Lorenzo.Pagliano@Polimi.it
Francesco Causone
end-use Efficiency Research Group, Dept. of Energy Politecnico di Milano – Via Lambruschini, 4 - 20156 Milan.
Francesco.Causone@Polimi.it

ABSTRACT

Techno-centric approaches to sustainability and energy optimization are not sufficient to achieve the international targets for CO2 emissions reduction. This applies to our case study, engaging 500+ tenants of a public housing in Milan, deeply renovated in 2014. The 14mln euros invested in technical implementations risk to be vanished by tenant's ways of living which are not consistent with expected or optimal uses of the building infrastructure and devices.

This study frames changes towards more sustainable patterns of energy use by analysing how people carry on conventional practices and for which energy is required.

The study is based on a multi-disciplinary methodology pairing quantitative data from energy monitoring with qualitative understandings of tenants' practices through ethnographic and participatory methods. This paper presents interim findings drawn from a first set of semi-structured interviews to tenants in order to unpack people's understandings of technical implementations, ways of doing for reaching thermal comfort and personal satisfaction, leverage of personal skills and aspirations to implement change in practice.

Key Words: energy use; public housing; case study; design for sustainable consumption.

1. INTRODUCTION

In 2011, the European Commission's Communication 'Roadmap to a low carbon economy in 2050' established that greenhouse gas (GHG) emissions should be cut down by at least 80% by 2050 from their 1990 levels (ECC 2011). The domestic sector accounts for about a third of total energy used in Italy (ENEA 2016), where this study operates, and with similar figures in other European countries, including Sweden (Swedish Energy Agency, in Palm and Reindl 2015) and the UK (DECC 2018). More specifically, buildings construction and operations (especially for residential purposes) accounted for 36% of global final energy use and nearly 40% of energy-related carbon dioxide (CO2) emissions in 2017 (IEA 2018). Global buildings sector energy use continues to grow since 2010 (IEA 2018). The majority of domestic energy is used for space and water heating, which account for up to 80% in the UK for instance (DECC 2018), although these building end uses are the most improved over time (IEA 2018).

Retrofitting buildings to increase their energy efficiency in use and expectedly reduce the final demand of energy results in a main strategy to achieve the GHG emissions cut target through major investments and plans of funding across European countries. In Italy, the adopted measures included fiscal deductions for implementing domestic energy efficiency in multiple ways, most notably by improving building insulation and increasing the energy efficiency of their appliances (ENEA 2016). Such measures have been implemented also in public and social housing to unleash the potential of relatively inefficient conditions.

Although interventions aimed to increase the efficiency are relevant, techno-centric strategies for energy optimization are not sufficient to achieve the CO2 emissions reduction target (Allwood et al 2012). Technical innovations alone may even lead to unintended consequences and increase energy use (Alcot 2005).

Such rebound effects are reported also in the case study of the project here presented, EnerPOP, which aims (also) to identify the factors of the gap between the expected (calculated) energy savings and the actual (measured) ones, and to propose actions to reduce this and inform prospective plans of retrofit intervention at least in Milan.

Multiple factors contribute to the gap, including variations of actual climate with respect to the one adopted in the simulations (Erba et al., 2017), differences between the designed comfort conditions and those set in practice by the building manager and/or by the tenants (Sfakianaki et al., 2011), inappropriate management by users of active and passive systems and their controls (El-sharkawy et al., 2015). Such factors are not accounted for the calculation and certification of the energy efficiency of the buildings as per European Commission instructions (e.g. European Parliament 2010). Negotiations of relevant matters for the definition of energy measures in the procurement document is often black-boxed (Palm and Reindl 2015). As clearly inferred by Guerra-Santin et al (2017:165) in their Dutch social housing study, "actual occupancy patterns and their effect on energy use are currently not reflected in the 'standard' occupancy patterns defined in norms and simulation tools." More analytical understanding of tenants' ways of living may generate more accurate energy assessment during design phase (Becchio et al 2016:1035).

Few scholars have been encouraging a renovated understanding of energy use and renovation from a social science perspective (e.g. Palm and Reindl 2015; Moezzi and Janda 2014), encouraging a reconceptualization of the relationship between buildings and people as mutually constitutive and co-evolving (Chiu et al 2014).

Our study aims at contributing towards this direction, by pursuing a multi-disciplinary approach which merges quantitative data deriving from energy use monitoring with qualitative understandings of tenants' everyday practices, shared norms and aspirations. In this paper, the focus is on the identification of energy using factors for being comfortable in winter time, i.e. heating and hot water, where major inconsistencies between expected and actual consumption rates are reported. The supporting data derive mainly from a first set of interviews with tenants of a large public housing in Milan, complemented with indoor measured parameters and on-site observations. The Municipality of Milan counts a total of about 66 thousand public houses, of which 28 thousand are owned by the Municipality itself and managed by Metropolitana Milanese SpA (MM) (investee company of the Municipality of Milan), including the one of our case study. About 25 thousand families live in public housing in Milan, for a total of about 51 thousand tenants (MM SpA, 2017), 17% of which are foreigners and 33% are over 65 years old. Between 2015 and 2017, the Municipality of Milan invested about 180 million euros for ordinary and extraordinary maintenance of public residential buildings, of which approximately 50 million euros specifically dedicated to energy efficiency implementations. Nevertheless, preliminary findings report inconsistencies between the potential efficiency to be reached through such interventions and the actual ones. A main result of this investigation informs about how energy use for keeping the house comfortably warm is the result of concurrent, sometimes interconnected factors. Beyond the expected factors affecting domestic fuel consumption, such as the number of households, efficiency measures … (DECC 2018), some other less tangible, quantifiable yet significant elements emerged. These are presented in the following pages.

2. METHODOLOGY AND CASE STUDY

The findings of this paper are based on a case study, a methodology which enables to deal with the specific connotations of a phenomenon in relation to peculiar conditions. Necessarily, a single case study is not sufficient to provide descriptors of more generic situations, including those addressing social dynamics in energy efficiency (Belafi et al. 2018). In fact, we do not aim at generalising, but rather scoping, identifying and analysing limitedly explored dynamics through complementary disciplines and their methods. The main result of the project is an assessment of the validity of the approach to unpack underexplored dynamics leading to inefficient consumptions. Therefore, this case study may represent the source for a methodological approach to be implemented in similar contexts.

Out case study is a retrofitted public housing building located in the southern-east periphery Milan, with evidences of substantially inconsistent (even doubled) rates of energy use with respect to estimated ones at the design stage (i.e. 34 kWh/m2*yr); more specifically, in the two preceding heating seasons, a reduction of the outdoor temperature was accompanied by an increase in energy use unexpectedly (Sangalli et al. 2019). The building consists of five floors above ground, with 154 apartments, about half of which are small two-room apartments (ca. 40 m2), and the rest four-room apartments (ca. 65 m2 to 85 m2).

Since 2013, the building has undergone a major energy refurbishment for improving thermal comfort and air quality, in addition to the removal of asbestos. The retrofitting consisted in the installation of a) external thermal insulation coating system and new windows; b) novel heating system, also for hot water production, connected to the district heating network; c) programmable thermostats in every apartment; d) centralized mechanical ventilation system; e) air-to-water heat pump, which allows recovery of heat from the air extracted from the rooms and eventually preheats the domestic hot water; f) photovoltaic panels providing electrical energy to the heat pump and the common parts. Additional sensors were installed in the apartment in order to monitor the performance of the building, which included g) thermal energy meters (in each apartment), to measure the thermal energy required to reach and maintain the value of air temperature set on the programmable thermostats; h) temperature, humidity and CO2 sensors installed in the corridor(s) of 17 apartments. The environmental data are recorded hourly and can be accessed remotely and exclusively by the Municipality and Politecnico di Milano through access to an online platform, protected by a password.

Since 2014, the apartments were assigned to (new) tenants, progressively reaching a nearly full occupancy of about 500 people mainly represented by elderly Italians (single or couple) and families of first-generation immigrants with children. Specifically, about 30% of the inhabitants are under the age of 15, and 60% of the families are foreign, including more than 30 different nationalities. In all families, at least the head of the family is able to speak Italian.

Data are collected and analysed with an STS perspective, according to which "buildings' energy systems are situated in sociomaterial practices involving knowledge, institutions, technology, and methods." (Palm and Rindl 2015:249)

A mixed-methods approach is used in this study, confronting quantitative data on the local conditions of the apartments (through the thermal and environmental sensors) with qualitative data from the interaction with the tenants and also with stakeholders. In this paper, interim findings are drawn mainly from the first activities of the ethnographic investigation, mainly consisting of semi-structured interviews to tenants, as well as conversations at different levels of formalization (e.g. scheduled meetings, unscheduled visits) and occasional observations with different levels of participation by the researchers. This paper includes the insights gained through the first set of interviews: specifically, with nine tenants residing in six family units, five of which were selected among those living in the 17 apartments equipped with environmental sensors and who expressed availability to collaborate with the researchers. The sampling operation was initially aiming to an equitable representation for the placement of the apartment (floor, exposure), size of the family (single, couple, family with children), nationality. The selected interviewees were asked to participate to an interview lasting about 60 minutes in their home, on a voluntary basis (without reimbursement) and according to their time preferences (date and hour). Several ones have declined the invitation, especially among foreign families. In order to avoid over-representation of domestic habits and practices by the same type of families that agreed to be interviewed (typically small families of Italian origin), the sample is currently being expanded towards families of foreign origin, although residing in apartments without the aforementioned environmental sensors.

Interviews were audio-recorded with the interviewees' consent and paired with notes which were (not fully verbatim) transcribed to enable coding operations through NVivo software.

The semi-structured interviews covered not only practices and routines closely related to thermal comfort both in summer and winter season (e.g. use of radiators or aircon, clothes), but also questions regarding the way of living both inside and outside the building (e.g. relationship with other tenants, personal interests and skills) in order to identify additional factors to frame energy use and potential interventions to encourage its optimisation.

3. INTERIM FINDINGS

A preliminary analysis of the interviews reflects a wide variability of social practices and perceptions of thermal comfort, as it might be expected. The difficulty in understanding how the building infrastructures work and how to maintain the ideal temperature in the home is common, and it influences the interaction with programmable thermostats, thermostatic radiator valves, windows and accessory devices to achieve the ideal temperature, both in summer and in winter. A selection of main factors determining practices for regulating comfort indoor are presented below.

3.1. Thermal comfort, ideal temperature, fresh air and cultural background

Interviewees tend to agree on the building capability to maintain warm temperatures indoor, which is particularly appreciated by the family who lived in under-heated public housing formerly. Higher temperatures are appreciated in winter time, yet these are perceived as uncomfortable in summer season, possibly because of inadequate use of solar protections and natural ventilation strategies, coupled with high insulation of the building envelope. The ideal temperature varies with tenants. An older tenant confessed to easily feel cold (e.g. she wears light pullovers even in summer mornings). Observations, anecdotes and environmental sensors prove that 27 °C are set and reached in some households, against the upper limit of 20 °C set by regional law during the heating season.
Cultural aspects necessarily play their role. Researchers' informal encounters with tenants and preliminary data analysis highlight the possibility for tenants coming from countries where the climates are warmer than Italy to prefer warmer indoor temperatures. Even if tenants are aware that mechanical ventilation system are installed to grant healthy indoor conditions, they may keep the windows open to let (additional) fresh air come in.

3.2. Adaptation to routines and family needs

The temperature is set or adjusted according to the needs and timing of the householders, as it may be expected. For instance, the heating system may be set to turn on before getting up in the morning and to turn off when out for work. However, punctual regulation is not always the case for all the interviewees. As witnessed also with the analysis of the environmental sensors data, high temperatures are captured even when householders are absent. This may be due also to the potential annoyance deriving from the regulation of the programmable thermostat and thermostatic radiator valves installed in each apartment as addressed below.
Higher energy demand may be the result of the attempt of families to preserve the health conditions of members with special needs. For instance, in the case of children and people affected by diseases living in the household – both of which are relatively common situations in our case study – higher temperature and longer heating times than those set in the regulation may be preferred and set.

3.3. Familiarity, skills and preferences with the thermo-regulating devices

Interviewees report diverse approaches to thermo-regulating devices installed in their flats. An interviewee declared (and provided evidence) to fully respect the regulation and precisely set the programmable thermostat within the limits. A couple of other households had the programmable thermostat set with the help of the former household and do not fully manage this for occasional adjustments. Another household instead keeps adjusting temperature through the thermostatic radiator valves, thus skipping the programmable thermostats. Programmable thermostats are reported to be hardly comprehensible, at least without dedicating sufficient attention to the instruction booklet, as the interface is counterintuitive and even confusing. For instance, icons of a sun, moon and ice flake indicate comfort, energy-saving and non-icing temperature respectively – rather than daytime, night-time and cooling as some may interpret. If present, only one person in the family is capable of effectively setting or adjusting the programmable thermostats, which may turn out to be an occasion of tensions too. The constant use of thermostatic radiator valves is reported to let them break more easily and being rarely replaced for their relatively high cost. In such case, the temperature of the radiator is set as per last adjustment.

3.4. Expenses and value attribution

Financial aspects were covered during the interviews to understand how expenses impact on personal balance and if savings may be a lever for changing patterns of consumption. The types of expenses covered included both rent and utilities. The sum of the rent variates with the financial situation of the tenants. They report to pay advantageous

fares ranging from 50 to less than 200 euros per month for their apartments, the market value of which is estimated at about 700 euros per month by one of the interviewees. The rent is paired with the cost for heating and public utilities, both proportional to the surface of the apartment (not per actual consumption). Heating accrues to about 40 euros per month.
The individual utilities for consumed gas (almost exclusively for cooking) and electricity accrue to about 30-40 euros per month per apartment. When prompted about the impact of such expenses on their financial stability, the interviewees tend to consider these amounts as reasonable or even cheap, especially utilities possibly because also of the advantageous fares that some of them benefit from. Likewise, the cost of the rent tends to be considered appropriate, although not affordable for everyone. In fact, at least a third of the tenants accumulated a debt with the managing company.

4. CONCLUSIONS AND OUTLOOKS

The preliminary insights gained through the first set of semi-structured interviews confirm that people – rather than buildings – use energy, to satisfy needs and accomplish practices, especially related to thermal comfort. Setting and adjusting ideal temperature within each household are entangled in webs of practices and factors determining the final demand of energy. Deeper understanding of what energy is used for results of fundamental importance for effective modelling, design and interventions intended to increase energy efficiency and reduce GHGs.
This may sound obvious, yet analytical investigations unveil how these are entangled with multiple practices and daily routines (e.g. laundering, enjoying spare time), understandings of technical devices and skills for their use (e.g. programmable thermostat, building infrastructures), cultural background and rooted beliefs (e.g. need for fresh air). These are not necessarily tangible, measurable, rational elements, which effect consistently on building energy use. Therefore, the development of interventions with tenants aiming at the reduction of energy use are challenging and tricky. Most notably, monetary savings on bills result in a limitedly appealing option to the interviewees, although potentially vulnerable conditions apply to them. Therefore, incentives and interventions leveraging on reducing expenses may not result as effective as per researchers' former hypothesis. Environmentally beneficial practices may clash with routinized actions and cultural elements, such as opening the windows when the heating system is on for the need of let fresh air come in, although the mechanical ventilation is active.
Effective communication is occasionally suggested in literature to encourage tenants in adopting low energy practices or more sustainable behaviours (e.g. Becchio et al 2016). Although reasonable, how an effective or strong communication may be arranged is a highly variable and hardly verifiable. In our case study, former uses of notice boards for encouraging respectful habits and practices towards other tenants or the building have been repeatedly reported as ineffective, possibly because these are not captivating, understandable or relevant for them. Social practice theory helps in framing how routines and practices in general are in competition for time. Therefore, the strategy we intend to pursue is to promote the transition towards less energy-intensive practice by leveraging on shared interests, such as improved health and wellbeing, higher comfort, enjoyable and effective use of common areas, preserving the positive elements of the building, feeling part of a community.
The researchers will proceed with additional interviews, onsite collaborative activities with tenants and stakeholders, and more analytical comparative data analysis to further unpack what energy is used for in order to identify potentially relevant elements to be connected to energy saving interventions. The ultimate outcome of the project consists of a document pairing building retrofit interventions with actions for tenants' engagement in sustainable practices, ranging from effective energy provision to initiating communities of practice which may catalyse the potential of the local assets. Designer play a fundamental role in delivering tools, methods and approaches which pair the two – technical and social oriented – components in a synergetic fashion.

ACKNOWLEDGMENTS

The research informing this paper is funded by the Polisocial Award 2017 of Politecnico di Milano, under the project called EnerPOP.

BIBLIOGRAPHY

Alcott, B. (2005). Jevons' paradox. *Ecological economics*, *54*(1), 9-21.

Allwood, J. M., Cullen, J. M., Carruth, M. A., Cooper, D. R., McBrien, M., Milford, R. L., ... & Patel, A. C. (2012). Sustainable materials: with both eyes open (p. 64). Cambridge, UK: UIT Cambridge Limited.

Becchio, C., Bello, C., Corgnati, S. P., & Ingaramo, L. (2016). Influence of occupant behaviour lifestyle on an Italian social housing. Energy Procedia, 101, 1034-1041.

Belafi, Z. D., Hong, T., & Reith, A. (2018). A critical review on questionnaire surveys in the field of energy-related occupant behaviour. Energy Efficiency, 1-21.

Chiu, L. F., Lowe, R., Raslan, R., Altamirano-Medina, H., & Wingfield, J. (2014). A socio-technical approach to post-occupancy evaluation: interactive adaptability in domestic retrofit. Building Research & Information, 42(5), 574-590.

DECC (2018) Energy Consumption in the UK - July 2018.

ECC (2011), COM/2011/0112 final/COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS - A Roadmap for moving to a competitive low carbon economy in 2050.

ENEA (2016) Italy's Energy Efficiency Annual Report - 2016 Executive Summary.

Elsharkawy H., Rutherford P. 2015. Retrofitting social housing in the UK: Home energy use and performance in a pre-Community Energy Saving Programme (CESP). Energy and Buildings, 88, 25–33.

Erba S., Causone F., Armani R. 2017. The effect of weather datasets on building energy simulation outputs. Energy Procedia, 134, 545–554.

European Parliament (2010) Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings OJ L 153, 18.6.2010, p. 13–35.

Guerra-Santin, O., Boess, S., Konstantinou, T., Herrera, N. R., Klein, T., & Silvester, S. (2017). Designing for residents: Building monitoring and co-creation in social housing renovation in the Netherlands. Energy research & social science, 32, 164-179.

IEA - International Energy Agency and the United Nations Environment Programme (2018), 2018 Global Status Report: towards a zero-emission, efficient and resilient buildings and construction sector.

MM SpA, Le case popolari di Milano – Focus gestione e piano interventi 2017. Retrieved from

https://mediagallery.comune.milano.it/cdm/objects/changeme:76791/datastreams/dataStream10779933440224056/content?pgpath=/SA_SiteContent/SFOGLIA_NEWS/Notizie_Primo_Piano/archivio_dal_2012/sindaco/case_popolari_milano_2017

Moezzi, M., & Janda, K. B. (2014). From "if only" to "social potential" in schemes to reduce building energy use. Energy Research & Social Science, 1, 30-40.

Palm, J., & Reindl, K. (2015). Understanding energy efficiency in Swedish residential building renovation: A practice theory approach. Energy Research & Social Science, 11, 247-255.

Sangalli, A., Pagliano, L., Causone, F., Salvia, G., Morello, E. (2019) Energy efficiency and occupants' behavior: analysis of a public housing case study. In proceeding of AICARR 51st international conference, Venice 20-22 February.

Sfakianaki A., Santamouris M., Hutchins M., Nichol F., Wilson M., Pagliano L., Freire A. 2011. Energy Use Variation due to Different Thermal Comfort Categorization Introduced by European Standard EN 15251 for New Building Design and Major Rehabilitations. International Journal of Ventilation, 10(2), 195–204.