From efficiency to reduction

Tackling energy consumption in a cross disciplinary perspective

EDITED BY

FEDERICO SAVINI, BEATRIZ PINEDA REVILLA,
KARIN PFEFFER AND LUCA BERTOLINI

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BIO

1 INTRODUCTION

Energy consumption, lifestyle change and the challenge of feedbacks

FEDERICO SAVINI, BEATRIZ PINEDA REVILLA, KARIN PFEFFER AND LUCA BERTOLINI

In 2018, CO_2 emissions from fossil-based energy sources have reached another historical record, of about 37.1 tonnes of CO_2 a year, with an even worse prognosis for 2019. After a small stabilizing period between 2015 and 2016, CO_2 in the air has just been increasing approximately 1% each year despite that the share of renewable energies has been increasing worldwide. These figures outline the challenge of the energy transition of our society: to address the increasing need of energy – in all its forms – that our lifestyles demand each day. In the last two decades, with the mainstreaming of sustainability measures at local, national and trans-national scales, governments have engaged with large-scale plans of technological restructuring to tackle CO_2 emissions. The largest amount of policies and interventions have addressed emissions as if it is a matter of establishing a more efficient and greenest supply of energy. Investments in energy efficiency cover all dimensions of human life, both collective and individual. They include interventions in smart mobility systems and investments in housing isolation. They also include the improvement of household appliances and the strengthening of environmental performance norms.

Cities have become the laboratories of the energy transition: spaces where new technological fixes are developed in order to ensure that the energy we use to fulfill our nutrition, mobility or heating is either produced in a more environmentally friendly way or simply reduced. Across these last two decades, cities have been certainly 'greening up', but this greening process, triggered by efficiency measures, shows its weaknesses in light of the global displacement of environmental harmful productions and the rising of what can be defined as indirect emissions. CO2 emissions are often invisible within the boundaries of city-spaces and substantially displaced geographically far away in the planet. These displaced emissions are hardly a concern of urban dwellers and urban governments. These are all the emissions produced 'as a consequence' of a particular agentic activity but that are geographically and temporally displaced from that particular activity. They are the impact that we cause to the planet when we eat a steak produced in Argentina, for example. They are (partly) invisible to domestic national and regional measures and certainly invisible to us when we enter a restaurant or a supermarket.

This efficiency paradigm is hardly questioned in mainstream politics and research. To question this paradigm, means to shift from an 'efficiency' perspective and move towards a 'decency' perspective – as we defined it in this book. It means to reformulate the key research questions from those asking for the best technologies or processes to improve energy supply and demand, and move towards questions that search for the reasons why we (as households, individuals or groups) need energy at all to sustain the practices that conform our lifestyles. Yet, this second question remains a political taboo. This silence is epitomized by the statement of George H. W. Bush during the Rio Summit in 1992, who when confronted with the difficult task to place a new CO2 cap on the global economy, indicated that "The American Lifestyle Is Non-Negotiable". This statement shows the incredible challenge that research and practice is facing today: to open the contentious black box of lifestyle change in order to cope with the visible limitations of efficiency oriented technological fixes.

The present book intends to take over this challenge. It summarizes the results of a research project started in 2016 that aimed at understanding how 'energy practices' – the actual demand of energy – change in time. The project was funded by the Joint Program Initiative 'Urban Europe' and the ERA net framework. To question energy practices, we moved away from an analysis of how humans interact with technologies and how these technologies impact their behaviour, and have studied how humans interact with each other in a community to build what we defined 'energy discursive consciousness'. Building upon sociological theories that study social practices, we define energy discursive consciousness as the ability people have to put into words their own energy-related actions. It is "an awareness which has a discursive form" (Giddens, 1984, p. 374). Energy is invisible, and this is one of the difficulties of making individuals and households aware of the physical impact that energy consumption has on the planet.

We argue first, that the activation of energy discursive consciousness, within a community, allows individuals to become aware of the impact that their energy needs have on the environment and second, that this activation of energy discursive consciousness is a first step in order to challenge and reduce our need for energy. It is the searching of the awareness and its impact that has motivated the group of scholars involved in the project CODAloop to experiment with different methodologies of social research.

The study of energy practices from a consciousness perspective was built around three key assumptions. These allowed to organize the research across three different countries, five different research institutes and six urban areas in Istanbul, Graz and Amsterdam.

1) *Energy needs are defined within communities*. Individual lifestyles are expressions of social norms that are shared across community members. They are built through processes of imitation and distinction from others. As norms, they are also hard to

be questioned and their change is long term and situated in physical and relational contexts.

2) *Energy consciousness emerges as an interactive and relational process*; it is not the result of the interaction between one individual and an advanced technology. We assumed that consciousness does not derive from the knowledge of macro data and aggregated information about others. It rather occurs as a process of recognition of oneself as part of a particular community (or several communities). This process is interactive and situated in context.

3) *Interaction requires a platform of relation to be enabled*. Individuals come together and share their feelings and thoughts on energy consumption through particular physical, social and virtual means. These tools have no intrinsic value – despite they may provide data, information or spaces – but work as mediators of conversations around the issue of energy sustainability. It is the task of the researcher to set up those tools in a way that 'responds', not command, to the communicative needs of individuals.

Empirically, the research project studied the so called 'feedback loops' occurring in the interactive process between individuals within their communities. Feedback loops are communicative practices of sharing information of different nature, and when triggered they have the capacity to reinforce a particular mechanism. In the process of social change, they can strengthen the questioning of particular social norms or instead further reproduce them. The task of the researcher is to study the nature of these feedback loops, and question the extent to which they reinforce a particular lifestyle or rather allow diverting from it. Analytically, the project was organized across two feedback loops:

(1) *Individual - Community loops* consist of the relationship between information available as data (on energy consumption), individual behaviour and community norms. These are the communicative processes through which a particular individual ac-

cesses an understanding of its position within a particular community of consumers, neighbours or dwellers. This process is functional in the realization of social practices. It occurs through the exchange of different sorts of information, as data on consumption patterns, data on mobility, data on CO2 footprints of particular lifestyle choices.

(2) *Community - Policy-Environment loops* are the loops connecting energy use patterns at individual and community level with policy making at city-regional level. Policies are not simply an expression of social and political ideals. They become active factors constraining or allowing particular energy-related practices. Individuals within a community, therefore, engage with policies, and are influenced by the way policies are framed.

The study of feedback loops within community requires an action-oriented research approach. In all the cases presented in this book, the reader will recognize a direct, active, and engaged role of the researcher within the six communities analysed. Building on the experience of planning research and ethnographic enquiry, the research team has promoted, participated, registered and analysed all the interactions between individuals. It did so in order to test which types of inputs, settings and formats allow individuals to reach a degree of consciousness of their energy use and their lifestyle. However, communities have not been created or set-up artificially. The role of the researcher was that of a mediator and stimulator of interaction within already existing social networks, both virtual and physical. Despite the difficulties encountered, typical of all ethnographic and in-depth research, the communities showed a great capacity of response and resilience towards the research aim. They allowed us to learn from their views on energy. We thank them infinitely for allowing us to be part of their daily life for research purposes.

The book is structured as follows. The first chapter reveals the plurality of communicative 'rationalities' that form a particular energy lifestyle in Amsterdam. Looking at three different communities, the chapter questions the utilitarian assumption of contemporary energy efficiency policies that sees individuals as self-interested agents seeking for monetary savings through energy efficient living. The chapter instead reveal that individuals often mobilize different primary frames, oriented to alternative forms of hedonistic wellbeing and social relations, and are less dominated by economic calculations of advantages.

The second chapter reports the diverse set of activities undertaken in the municipality of Kadıköy, within Istanbul metropolitan area. This chapter shows how effective the engagement between existing communities and policy makers is. It also reveals the value of diversifying the types of interventions and roles of the researchers to generate stimulating feedback loops between households and policy makers.

The third chapter goes to Austria, showing two practices of urban redevelopment in Graz and one in Leibnitz that have been organized around the topic of energy saving and energy lifestyle. The experience of the three testbeds shows the fundamental role of mediators and specialized agencies in putting the topic of energy saving and lifestyle at the centre of urban redevelopment processes. They show that it is necessary to build the expert social links between consumers and energy providers to achieve a more responsive energy policy.

The fourth chapter is the first of two overarching chapters, and dives deeper in the cognitive complexity of behavioural change. It builds a model to analyse the feedback loops within one-person mind in interaction with its community environment. It dissects the imitative, self-evaluative, volitional, and intentional processes that interact with social norms and attitudes in the formation of behaviours.

The fifth chapter engages with the use of remote sensing and the study of lifestyles. It provides with a prototype of a tool that uses social media platforms to study framings of lifestyles. Here, lifestyles are questioned from the point of view of the user of social media. Social media can provide with effective representations of how individual perceive their food, mobility and leisure activities. This requires a content analysis of the posts and the texts to identify relevant semantic linkages between terms.

The last chapter takes a step back from the substantive results of the project, and reflects at the meta-level on the challenges of inter- and trans-disciplinary research. In this chapter, we dissect the fundamental tensions that characterize the cooperation between different disciplines and sectors. The project innovative and experimental character has made it possible to reveal that ontological and epistemological assumptions on social change are different. It concludes with a reflection on the challenge of building action-oriented research within existing communities, and suggests to build on existing social networks and calibrate their discussion towards energy consciousness, rather than create artificial interactions within prototyped social platforms.

2 UNPACKING ENERGY NEEDS

Framing decency in Amsterdam communities

BEATRIZ PINEDA REVILLA AND FEDERICO SAVINI

How do citizens adapt their daily lives in ways that address the necessity of reducing energy use? Why do they not do so even when they are aware of the urgency of reducing their impact on the climate? These questions lie at the core of any serious attempt to deal with the rising environmental impact of cities and urban life. Ecologically concerned governments, still identify citizens – households, individuals – as rational consumers, able to calibrate their energy consumption on the basis of price incentives. Very often, they treat citizens as ecologically concerned urban dwellers who are willing to install state-of-the-art technologies to reduce their dwellings' energy intake. In most cases, citizens posited simply as unwilling followers of national or European reforms that bear upon energy prices and industrial production. Policy strategies oriented towards altering production or consumption patterns, and reducing human impacts on the environment, need to deal with the (im)possibility of enabling change in how individuals live. In other words, it is impossible to undertake serious policies towards sustainability without first questioning how households consume, buy, and move, particularly in cities (Shove, 2010).

Despite the obvious centrality of households/individual daily practices in all kinds of environmental policy making, ecologically concerned governments still deploy energy efficiency strategies. 'Efficiency-led' strategies encompass investments, regulations, and discourses that are oriented towards reducing the relative intake of energy used for a particular practice in cities without questioning the social practices at the root of these energy intakes. Examples include investments in clean energy technologies and energy-efficient devices, such as smart meters or low consumption ovens, and sustainably produced meat. These actions assume that it is still possible to reduce overall energy use in a particular area (for example a city) without questioning or compromising urban dwellers' lifestyles. Despite the widely reported 'rebound effects' of this approach (Buchanan et al., 2015), technological innovations that make energy cheaper and more effective remain a primary strategy for contemporary governments around the world. In so doing, governments have not only recurrently failed to match climate targets. Paradoxically, they have also encouraged households' energy use to rebound and thus increase. The liberating effect of increasing energy efficiency has led citizens to consume more (e.g. travelling) and governments to postpone the inevitable question of changing (and reducing) individual energy consumption choices. Therefore, despite the fact that energy efficiency increased in OECD countries over the last four decades (IEA, 2013), total energy use only slightly decreased, and then only recently (IEA, 2016). Besides, fewer improvements in energy efficiency policies were introduced in the last two years, leading to an acceleration in the growth of global energy demand. Driven by economic growth and changes in consumer behavior, energy demand rose by nearly 2% in 2017 (IEA, 2018).

The limitations of efficiency-led approaches – and their evident failure in terms of reducing CO2 emissions, for example – lies in a reductionist understanding of how individuals' daily practices are formed and change. This understanding privileges private rational considerations that inform daily choices such as driving or cooking. They hardly appreciate these practices' social, interactive, and community-centered character. Think about how mobility patterns, food choices, and leisure activities are based on imitation and group dynamics. When efficiency-led policy approaches do include community considerations, they do so in an instrumental way, as a solution that maintains a particular practice in a way that uses less energy (e.g. car sharing). We lack research showing how individuals do or do not change their practices *in relation to others*, how they reflect upon their own practices, and why they find it hard to change them even when aware of their negative effects on the environment.

Over the last 3 years, the CODALoop project has attempted to shift focus from individual efficiency to social practices. It has approached this challenge from two main directions. Firstly, it addressed energy consumption from the perspective of individuals' energy demands. Efforts to reduce energy consumption should not avoid the question of reducing overall energy demand in a first place, regardless of whether this energy is sustainably or renewably produced. Focusing on reducing energy demand tackles the problem at its root. If there is less need for energy on the first place, less energy will be consumed. This entails a reconsideration of the level at which behavioral change needs to be addressed.

Secondly, the project has moved beyond the currently prevailing approach to energy efficiency – based on utilitarian individualism – for which individuals make ecologically rational choices based on price indicators or impact assessments of their practices. We have questioned the common wisdom, which predominates in contemporary policymaking and media, that consuming less energy is an individual process of awareness building that only takes monetary savings into account. To the contrary, we advance that it is only by addressing the collective spaces in which individuals interact that it is possible to understand and thus tackle the reasons why citizens engage (or not) in energy demanding practices, and how these practices affect each other or bundle in overall lifestyles. As we argue below, it is not easy to nudge individuals' habits by means of direct incentives (for a detailed overview of factors involved in habit formation, see Kollmuss & Agyeman, 2002). Part of the reason for this is that such habits are constructed in a socio-spatial context.

We define this context at the level of the 'community,' by which term we refer to the daily social space in which individuals reflect upon and adjust their own practices in response to other individuals. We see the (discursive) community as a space in which information is shared through discursive frames about practices. Individual practices are thus built by *both* one individual's perception of other individuals *and* by the interdependency of individuals' practices (e.g. dwelling) with other, collective practices (e.g. driving, public space use, consuming). By moving from the individual to the inter-subjective level, we are able to address the transformation or maintenance of lifestyles, those constellations of homogeneous social practices.

In the present work, we will set out the results of the research project. We will present the multiple frames that the research team has been identified in the context of three case studies in Amsterdam. To do so, we build on the insights of social practice theory to dissect the role of frames in activating what we term 'energy discursive consciousness.' On the basis of our results, we develop a basic taxonomy of consciousness types, identified according their specific position in the discursive framing of energy needs in the three cases. The final section will reflect on the socio-spatial boundaries of these discursive interactions, setting them in contrast with the mainstream institutional view of household practices in the Netherlands.

DECENT LIFESTYLE, 'ENERGY DISCURSIVE CONSCIOUSNESS' AND FRAMES

Frames are key elements in understanding how the process of 'energy discursive consciousness' can be activated and, as a result, lead towards the development of a (more) 'decent lifestyle.'

In our society, the need for energy is not determined by the individual. It is the result of the way in which individuals articulate multiple daily practices in their lives. It thus emerges as a combination of individual needs and perceptions and as the result of a process of social interaction that contributes to individual identity building. This process allows individuals (and communities) to build a shared understanding of what can be defined as 'decent lifestyle' (Bartiaux et al., 2011). Each culture (and, on a smaller scale, each community), determines what a 'decent lifestyle' is in its own way. At the same time, the meaning of 'a decent standard of living' differs from individual to individual. What one person finds 'decent' might seem 'austere' to another, or 'lavish' to yet another. Focusing on decency allows individuals to give meaning to their own actions. Thinking in terms of 'decent lifestyles,' requires a reflective process that questions taken-for-granted ways of life. 'How much energy do I need?' 'How much is enough?' These understandings of decency are socially constructed in and through social practices of interaction. The challenge of our project was to uncover and explain the generative mechanisms latent in this notion of the 'decent lifestyle.' We began from the expectation that individuals' daily practices, as well as their impact in terms of reducing or increasing energy demand, depend on these mechanisms. To capture them, we empirically studied different discursive frames (see below), understood as verbal and non-verbal signals that individuals within particular communities share and exchange while discussing their energy practices or lifestyles.

Understanding the hierarchy among these frames helped us unpack how the activation of 'energy discursive consciousness' takes places in the communities analyzed. In Giddens' view, discursive consciousness is "what actors are able to say, or give verbal expression to, about social conditions including especially the conditions of their own action; awareness which has a discursive form" (Giddens, 1984, p. 374). This process drives the structuration of practices into social norms, which bound social practices in turn. In our research, we mobilize this concept and explore the notion of '*energy discursive consciousness*,' defined as the ability to reflect upon one's own energy-related practices and put them into words. This enabling ability to reflect and change endows individuals with agency. This contrasts starkly with the more deterministic character of the day-to-day knowledge that performing most energy-related practices (e.g. showering, driving, etc.) requires.

These energy-related practices are more resistant to change because they belong to the sphere of 'doxa' (Bourdieu, 1976), the unconscious sphere of common beliefs embedded in the 'habitus.' 'Practical consciousness' (Giddens, 1984) plays a crucial role in this sphere of 'doxa' in that it helps individuals develop routines and know-how as to how to act in society, without which they would constantly have to expend intense cognitive effort. The question is how to transition from the sphere of 'doxa' to that of 'heterodoxy.' The sphere of heterodoxy is a realm of discussion, debate, and argumentation, in which the 'habitus' (and thus the energy-related practices and the energy needs that constitute them) is contested, challenged, and in that way perhaps also transformed into a new 'habitus' that demands less energy. The research explored how the 'habitus' of the three Amsterdam communities is currently framed. Then, in trying out different research interventions, it established that certain frames are especially able to activate discussion in a community about the amount of energy needed to live a decent life.

NEW METHODS OF SOCIAL PRACTICE RESEARCH: DIGITAL ETHNOGRAPHY IN THREE COMMUNITIES

The three communities that we engaged with were: *The Sustainable Community of Amsterdam* (SCoA), the *community of self-builders in Buiksloterham* (BSH), and *Atelier K&K* (Kans & Kracht – 'Opportunity & Strength'). These cases were selected on account of their diverse geographical boundaries (city, neighborhood, street), variable levels of motivation towards sustainability (ranging from very motivated to not motivated at all), and interactions in different types of space (physical and/or digital).

The Sustainable Community of Amsterdam (SCoA) is a Facebook group founded in 2016 by a woman who saw the urgency of talking about sustainability issues with like-minded people living in her city. Through these discussions, she hoped, members would inspire and help each other in living more sustainably. Of our chosen communities, only the SCoA focuses on sustainability at the city level. The founder's dedication to the Facebook group can be seen in the frequency of her responses to questions posed by group members and conversations among them. Her positive tone and hands-on approach to tackling daily sustainability challenges have been key to making this Facebook community an active, successful group. The community is growing rapidly. In August 2018, the group had 844 members, of whom 715 live in The Netherlands (559 in Amsterdam). 80% are women and approximately 60% of all the members are between 25 and 44 years old. As we write this book chapter (March 2019), the group has 1188 members and similar percentages apply.

The BSH, the community group of self-builders, live in Bosrankstraat and Monnikskapstraat, the first streets comprised of self-built houses to be constructed as part of a redevelopment project in Buiksloterham, an industrial area of Amsterdam North. This group of families decided to sign up for a plot in Buiksloterham in October 2011. Although they did not know each other, they were all inspired by this "raw, industrial area near the water." They define themselves as "adventurous home builders and residents" with a vision (from their blog: http://bsh5.nl). They were attracted by the space, water, relatively low location costs, and proximity to the city center and creative NDSM area (an old shipyard that has been converted in Amsterdam's new spot for artists and entrepreneurs over the last few decades). Back in 2011, not many people saw the residential appeal of this post-industrial neighborhood. Over the last five years, however, the area has rapidly transformed into a more residential and work oriented neighborhood and many new residents are moving into newly built apartments (see Savini & Dembski, 2016).

The Atelier K&K is one among many social groups that gather at *De Meevaart,* a community center located in Amsterdam's Indische Buurt (Indian Quarter). The neighborhood, which lies to the east of the city center, is primarily residential. Although it is undergoing rapid gentrification, the Indische Buurt still accommodates a high proportion of social housing. Multi-ethnic in character, it has an old housing stock developed during the 1980s. Houses are primarily owned by housing corporations, which are currently struggling to support investments in energy efficiency and develop a new 'culture' of sustainability among their tenants. People living in the neighborhood meet at De Meevaart and organize events, most of them related to educating youths and engaging with elderly people. Largely based on volunteering work, the center is also where the eastern district organizes activities related to multiculturalism, children's education, music, and art (website: https://meevaart.nl). Atelier K&K is a foundation that aims to "provide a safety net for and by vulnerable residents with a small wallet" (www.atelierkansenkracht.nl). Three main activities are organized: 'De Proeverij' (The Tasting) and 'De Gouden Handen' (The Gold Hands) for informal caregivers and ex-informal caregivers and 'Kunst uit de Kast' (Art from the Closet) for people with a psychological or social disability. For 28 hours a week, Atelier K&K employs a professional who is interested in bringing the topic of sustainability and energy consumption to the community.

During a one-year, action-oriented (digital) ethnography (2017-2018, see appendix), we conducted research-moderated social interventions among the members of these three communities. Her aim was to establish how discursive processes that challenge their members' current energy needs can be activated. This methodology allowed the researcher to find and engage with the aforementioned communities, and to establish entry points through which to discuss their energy needs. This knowledge enabled the researcher to design different interventions for each community using formats and strategies such as storytelling, documentary screenings, humor, energy quizzes, Facebook posts, screening artistic films, etc. These activities were organized according to principles of feasibility, suitability, and diversity. They had to fit in with these specific communities' activities and interests, while also enabling their members to question lifestyle frames. Throughout the project's duration, we organized activities of different kinds to capture the various ways in which both 'frames' and 'counter-frames' are mobilized. The challenge was for us to engage consistently with the communities without overly planning the content of each activity.

Research data consists of the researcher's fieldwork notes and transcripts of the recordings of some interventions (this required the participants' consent and trust between the researcher and participants). Research data was analyzed using the software Atlas.ti. An initial phase of open coding was followed by a phase of focused coding, during which conceptual codes emerged. These codes were organized into several categories. During a final phase of theoretical coding, different relationships among these categories were established, which contributed to the process of theory building. The Dutch quotes that appear in this chapter have been translated to English by the researcher. One final note: having assumed the role of researcher-as-participant, the researcher acknowledges the influence of her personal input in engaging with community members; designing, organizing, and facilitating the interventions; and finally analyzing social interactions among the members (for a timeline of the research activities and interventions, see appendix).

FOUR ALTERNATIVE FRAMES OF ENERGY LIFESTYLES

Our case studies identified four sets of frames that are differently mobilized (see below) in each community: moral, monetary, efficient, and hedonistic.

Moral frames belong to a family of narrative and discursive techniques that explicitly de-commensurate and de-rationalize energy practices. They function as community markers in the process of identifying shared understandings of a problem. As such, they are crucial to establishing the communicative conditions behind processes of interaction around a particular social practice. They provide a level playing field in communication, a basic normative statement that allows other individuals to open up and share their energy practices. Often overlooked by energy policies that grasp people as purely calculative, individualized beings, these frames are hardly nurtured in contemporary efficiency-led policies. This is unsurprising, for such policies are often based on the commonplace idea that individuals are not motivated by practical considerations of comfort, not ideals concerning sustainable living. However, we found that moral frames are mostly activated and strengthened in collective discursive interactions within communities. These frames are identified as a basic, legitimate intention to interact.

Monetary frames are a family of frames that specifically relate to the calculative advantage of changing or maintaining particular energy practices in light of commensurable and quantifiable outcomes. While it is now widely recognized that using less can save money, energy demand is a driving force in changing energy practice. It is interesting to see how these frames articulate with other frames in particular collective situations. Abstract notions of the *homo economicus*, based on the utilitarian understanding of individual choice, cast energy practices as the result of calculative choices. These frames are far from being purely calculative and quantitative. Instead, they can supplement other frames (see below). They represent an understanding of utility that is highly socialized in relation to the broad nexus of practices. In many cases it appears that saving money is the most relevant dimension, especially in poorer communities. At times, however, monetary frames are also used in a negative way, such as to point out the disadvantages of changing particular practices (e.g. taking a train instead of flying). They can also be used positively, such as to underline the positive effects of living more sustainably. Monetary frames are often combined with other utilitarian justifications, such as saving time and reducing food calories.

Efficiency frames belong to a family of discursive and narrative constructs for which changing energy practices is a necessary step towards realizing a particular energy lifestyle. In these frames, notions of decency or sustainability are contextual to the use of a specific 'tool' or technology. A particular action is framed as useful, necessary, or required in the pursuit of energy efficiency. Saving energy by changing energy practices is made possible by technological devices, which allow households to maintain particular practices while consuming less energy. This frame belongs to the category of pragmatic reasoning, which typically underlies goal-oriented rationality in social practices. Today it is the most widely mobilized frame. Unlike the monetary frame, it does not necessarily entail the quantification of social practices.

Hedonistic frames are part of a family of frames in which the notion of decency or sustainability contributes towards projects of personal satisfaction. Framed hedonistically, saving energy makes individuals feel good or satisfied. Sustainable actions are motivated by hedonistic desires for pleasure and self-realization. In our study, we discovered a subtype of this hedonistic frame, which Samuel Alexander terms 'alternative hedonistic' or 'voluntary simplicity' (Alexander, 2011). The core message put forward by alternative hedonism is that the simple things in life (e.g. spending time with friends and family, being in contact with nature, etc.) bring the most pleasure. In reacting against contemporary consumer society, alternative hedonist frames offer attractive alternative paths towards more sustainable forms of consumption.

We have established a hierarchy among these frames. Distinguishing between primary, secondary, and enabling frames, we mean to unpack the role played by each frame in activating 'energy discursive consciousness' in each community.

Primary frames are those that exert the greatest influence on the roles and responsibilities of both individuals and communities in making more or less sustainable choices. These frames relate to intrinsic motivations and can be identified by their centrality in conversations and group dynamics. Although they often kick-off conversations, primary frames tend to be left on the background as the conversation proceeds.

Secondary frames help explain why individuals and communities act as they do and are largely associated with contexts. These frames can be identified by their role as specifiers; often they are used to substantiate motivations and justify primary frames. In this sense, they are mobilized to identify external conditions or factors. Both primary and secondary frames shape the collective imaginary of individuals and communities. They are the necessary foundations upon which a fruitful space for community discussion can be set up.

Enabling frames are especially relevant in our study because they can activate the kinds of discursive exchange through which current lifestyles are contested. Working as meta-frames between primary and secondary frames, they enable discursive consciousness and shape what individuals consider a 'decent' lifestyle. These frames respond to the need to identify 'necessary steps' towards achieving a primary and secondary frame. The relationships among primary, secondary, and enabling frames are dynamic. An enabling frame for a community at a given point in time, may later become a primary frame. This mirrors the dynamism inherent to the formation of social norms and values.

ARTICULATIONS OF FRAMES IN 'ENERGY DISCURSIVE CONSCIOUSNESS'

In studying the communicative processes through which energy lifestyles are framed (and re-framed) in our three communities, we identified three ideal types of 'energy discursive conscious-

	Primary frame	Secondary	Enabling	Type of discursive consciousness
SCoA	*Moral*	*Monetary*	*Hedonism Efficiency*	*Engaged hedonism*
BSH	*Monetary hedonism*	*Moral*	*Efficiency*	*Self-centered DIY*
Atelier K&K	*Monetary*	*Efficiency*	*Moral*	*Money oriented solidary*

Table 1 Types of 'energy discursive consciousness'

ness.', see table 1. Although these are pure abstractions, they are based on our analysis of the framing processes and provide an accurate picture of the variegated reasoning that lays behind energy use.

Engaged hedonism: this type of consciousness is visible in those communities whose members all primarily use moral frames in reflecting on their energy consciousness. Members of the SCoA agree that achieving a more sustainable lifestyle requires that they consume less and therefore also reduce energy demand. All of the members of the SCA are already very aware of their actions' environmental impacts and they share a general feeling that something must be done about current energy practices, regardless of energy costs. Most members are motivated to live more sustainably, but think that this is hard. A smaller group is highly motivated and already undertakes some measures towards living more sustainably. A few individuals were still further along in their own personal transition. Energy consumption is used more as an entry point into talking about sustainability in general, which is where members' interests lie. They have different motivations for engaging with sustainability: health, especially in relation to food (much discussion focuses on how food is good for themselves, their families, and the planet); motherhood as a turning point in realizing the importance of living more sustainably; reducing single-use plastics; sustainable fashion; and learning how to make self-care products, etc. In fact, some members have built businesses around sustainability, whether they work as consultants, run shops (selling clothing and beauty products), or have start-ups.

The monetary frame remains in a secondary position, with cost-effective choices being identified as an advantageous additional consequence of their choice to change lifestyles. Whereas some members seem to care more about the energy they consume than the money they pay, others use saving money as a quantitative indication of environmental performance that they proudly share with others (e.g. less heating resulting in a reduced energy bill). In other cases, monetary value allows members to calculate the degree to which they should compensate for continuing to pursue activities that, though difficult to relinquish, are environmentally harmful (e.g. flying). In this last case, saving money can have a liberating effect in that they can 'compensate' their flying practices by paying more. In general, any new costs that accrue as a result of members changing their practices do not seem to affect their primary concern for achieving a more ecologically conscious lifestyle.

Alternative hedonistic frames were present in many online discussions. Questions about how to find pleasure in simple things, and how to need (and therefore consume) less, appeared in many discussions. This frame proved useful in enabling discussions that fit into the community's primary moral frame while simultaneously giving members practical tips for starting their own transition towards a 'minimalistic lifestyle' (as they framed it). This enabling frame was best supported by the face-to-face meetup format. During this meetup, one community member who was relatively far advanced along the path towards living simply shared her story with the other attendees. When asked about her own lifestyle, she answered:

> *I guess it's just freedom, freedom of not desiring, or wishing or having certain things to be found perhaps important for other people, wonderful houses, clothes, cars, etc. Once you know what makes you happy and you realize that these things don't make you happy and that what makes you happy is the time you have, the freedom… So, for me it's freedom of not desiring anything and also psychological freedom, that I don't have to worry 'oh, I have this big*

> *house and my mortgage is so high that I have to work so much. The less you desire, the more time you have for yourself, the more relaxed you are, the less stress you experience, so the happier you are (SCoA member_2018-07-28, Meetup).*

Her struggles and small victories sparked a discussion in which members reflected on their own lifestyles. Members were inspired to start exploring this approach by applying small tips (e.g. considering a nearby destination for the next holiday instead of flying to another country or bringing your own glass jars to shops to avoid using unnecessary plastic). Living a simpler life results in needing and consuming less and, by default, living more sustainably. Also, the researcher used weekly Facebook posts to continue the discussion online. Using alternative hedonistic frames proved an effective way of sparking discussions. Where members were not ready to consider shifting towards a more minimalist lifestyle, alternative hedonism also led to discussions about efficiency frames, according to which one might maintain one's current level of consumption while using less energy. Whereas many members referred to technology as an ally in making the task of reducing energy consumption easier, some pointed out the risk of rebound effects. In sum, in the SCoA community, moral frames did not need to be stimulated, alternative hedonistic and efficiency frames were important in enabling 'energy discursive consciousness,' and monetary frames remained secondary, yet useful.

Self-centered DIY: monetary and hedonistic frames were central and intertwined on the case of the BSH, and came back recurrently in discussion. The self-builders have made big monetary investments in building their own houses and are interested in calculating when their houses become profitable. During the discussions, it became clear that, in this community, reducing energy needs is of secondary of importance behind establishing more comfortable living conditions. The BSH community relies on technology and efficient devices to optimize comfort, convenience, and long-term economic investments. When asked about the ideal temperature at home, for example, one of the members stated that he wants to have a warm house at the minimum possible cost. To achieve this, he is willing to experiment with innovative technological solutions in his home. Another member also considers monetizing his innovative efforts as a pioneer self-builder. This member aspires to sell heat to the grid and is exploring a business model involving storing rain water in his own house plot. All of these innovative and experimental approaches were made possible thanks to the support of municipal plans for this area, which focused on enabling circular wastewater treatment on housing plots, off-grid energy supply, and new ways of reusing building materials.

Hedonistic frames were central to the discussions, as the testimony of one member shows:

> *Why am I working so hard? It's a way of life. It's not more difficult for me. I don't want clothes that were made by child labor, that were transported oversees. I don't want it. I don't feel good in it… I want to have… buy something that makes me happy. If I buy dead animals or if I buy stuff that are not made fair, I don't feel happy… (Self-builder_Testimony gathered from the documentary 'Ecological footprint'_Retrieved from: http://lab.rtve.es/huella-ecologica/es).*

When focused on sustainability and lifestyles, discussion revolved around the domain of dwelling. Sustainability was not defined as a moral priority in designing their homes. Rather, it was seen as a result of their practices of adapting housing structures. The moral argument that we 'all' need to live more sustainably was of secondary importance in relation to their individual needs (e.g. the need to have a large, comfortable home). The priority of efficiency frames over moral frames is captured in the following quote:

> *- Then, what is your real motivation in applying all of these energy solutions?*

- I didn't start [designing] my house from the perspective of energy. Energy was not the main theme. The spatial quality was the main theme. Energy is something that needs to be solved within the whole story. You want to choose the best way to solve everything... (Self-builder_Energy Story Night, 2018-11-21_translated from Dutch).

Efficiency was clearly an enabling frame that allowed the researcher to engage with the members of this community and spark 'energy discursive consciousness.' Members do not consider reducing energy needs as an option. Still, the topic of whether they would experiment with energy-efficient technologies to reduce domestic energy consumption served as an attractive entry point for discussion. Technology allows these individuals to control their own homes and, in most cases, become energy independent (they are not connected to the grid). In sharing these frames, individuals tend to detach the instrumentality of particular tools from the original aim of reducing energy. Conversation moves from sustainable lifestyles to comparing different technologies in terms of comfort. Shower wastewater recycling systems, for example, are discussed without reference to the actual practice itself – in this case, that of showering more or less.

This enabling frame was best supported by the format of the 'Energy Story Night.' Discussions were framed by efficiency – the technologies different members use to heat their homes, for example. Members found numerical data important in 'proving' that their chosen technologies work and in their ongoing processes of experimentation and learning. In conclusion, monetary and hedonistic frames were considered as essential for the members of this community, while moral frames, where present, were secondary. The most effective enabling frame in activating discussions was that of efficiency, although discussions failed to contest contemporary energy-intensive lifestyles.

Money oriented solidarity: In the case of Atelier K&K community members, saving energy primarily means reducing their energy bill. Some of the members were already considering their energy bills carefully, aware that saving energy can mean saving significant sums of money. Members' interest in environmental issues, however, was minimal or nonexistent. To them, sustainable living is of secondary importance in relation to other daily concerns (e.g. unemployment, caring for ill relatives, etc.). It is interesting to note that when it came to mobility choices (car vs. plane) in taking relatively long-distance trips (from The Netherlands to Turkey, for instance), some community members were making environmentally friendly choices (traveling by car with the whole family instead of flying) because they presented the cheapest option. When traveling alone or only with their partners, however, they prioritized convenience and only considered flying.

Although efficiency frames were of secondary importance in this community, they were mobilized in the conversation as possible ways of reducing energy bills. Most often, investments in energy efficiency were looked upon skeptically, for they imply further expenditure. To access energy-efficient devices, in other words, members needed to be able to afford them. When talking about other energy-efficient technological solutions, such as installing solar panels on the roof, it became clear that subsidies are indispensable (which again links back to monetary frames). The majority of Atelier K&K members live in social housing. In the Indische Buurt especially, such housing is often in urgent need of renovation. Were social housing developers to upgrade the housing stock, however, this would imply raising tenants' rents.

Despite their skepticism, members of this community saw clear value in building social ties around the issue of sustainable living. They deemed the sharing of good everyday practices (such as reusing warm water from cooking, switching off lights, reducing home heating one degree, etc.) more important than technologically efficient improvements. A combination of monetary and moral frames proved key in enabling individuals to communicate about these issues. One of the most successful research interventions, The Big Energy Neighborhood Quiz, used this combination of frames to spark discussions around decency and lifestyles. The main tool used during this intervention was humor; a comedian facilitated the event. The format of the quiz was straightforward. It posed 10 questions about energy issues, giving 3 options to select between per question, and awarding prizes to the winners at the end. During his performance, the comedian referred to the monetary frame many times and several questions focused on how much money can be saved if certain measures are undertaken (e.g. reducing heating by 15 degrees when leaving home, buying LED lamps as a way of saving money over the long term, etc.). These monetary frames were related to the moral frames of building a community able to share such tips. Members reportedly attended the quiz because they care about both money and community cohesion. This activity helped them strengthen friendship ties and solidarity networks around the topic of energy. Another 3 energy quizzes were conducted with sub-groups in this community. In these cases, the community founder facilitated the quizzes. Humor was replaced by trust and a feeling of solidarity among the members of these three groups, who have confidence in both each other and the organizer. Prizes were also replaced by friendly competition over who could get the answers right. In sum, monetary frames were crucial in engaging with community members and a combination of monetary and moral frames enabled discussions around energy lifestyles. Efficiency frames were secondary in this community due to affordability issues.

THE SPACE AND SCALE OF 'ENERGY DISCURSIVE CONSCIOUSNESS

In Dutch policymaking arenas, the notion of '*draagvlak'* is used to indicate the necessary social acceptance and political legitimacy of a particular national, regional, and municipal policy. Social acceptance is a crucial problem for contemporary policymakers who are attempting to nudge forward changes in how people live and consume energy in cities. Today, the so-called *Climate agreement* (Klimaatakkord) exemplifies how and why social acceptance becomes a problem for eco-efficiency strategies. The ambition of this comprehensive national policy strategy is to achieve the Paris climate targets, overseeing a reduction of CO_2 emissions by 49% by 2030 as compared to levels in the 1990s. In the Netherlands, the Climate agreement represents the first unitary policy strategy for establishing a multi-scalar and trans-ministerial agreement over everything that bears upon energy efficiency (broadly construed) and CO_2 emissions. The plans developed by the current government span technological advances in industrial production; circular waste management; an increased use of biomass for energy production; reuse of wastewater in cities; electric mobility; housing efficiency; and many more. However, the ratification of this document is currently in jeopardy on account of the Dutch population's weak *acceptance* of the actions it envisages. The key issue is the policies' costs and benefits for the everyday life of households – their energy tariffs, employment opportunities, mobility and food consumption choices, and services and products. The current draft agreement proceeds by elaborating all of the infrastructural and efficiency requirements to be met by Dutch industry and concludes by pointing out that the change in the country's productive system will reshape individuals' lifestyles only indirectly. Still, as the document also states, we do not yet know how and for which reasons citizens might be willing to adapt their behavior.

The Climate agreement is the most representative and encompassing example of how citizens lifestyles and choices are treated in top-down eco-efficiency policymaking and the scale at which social interventions are deployed. After listing all of the required actions, the government specifies key interventions oriented towards producing social acceptance of the policy. The government showcases initiatives such as national 'citizens talks,' undertaken with about 200 citizens in 2018 and 2016, and a National Platform of Citizens Participation (Nationaal platform burgersparticipatie). It calls for housing developers and social housing corporations to become more involved in 'educating' citizens in the benefits of energy efficiency in their buildings. It aims to 'nudge' technologically innovative practices through the regional programs of universities and secondary schools (i.e. developing 'techno-hubs' and 'incubators'). Overall, the government stresses the need to maintain a 'neighborhood approach' (*wijkaanpak*) to developing energy infrastructural adaptation measures in different urban areas (e.g. solar panel and wind mill installation, parking reduction, etc.). In all of these indications, citizen participation remains a national or regional endeavor. The neighborhood remains an undefined 'stage' in building legitimacy while data sharing platforms have recently gained popularity as enablers through which households might improve their own energy practices. These physical (neighborhoods) and virtual spaces (data platforms) give an indication of how the program of national energy transition approaches the spatiality of citizens' practices.

To what extent are these 'spaces' able to heighten households' awareness of their own practices and ultimately trigger change in them? In other words, how do these 'spaces' contribute towards or jeopardize the activation of 'energy discursive consciousness'? To address these questions, our research has also mapped the socio-spatial scales at which socially normative processes occur. Our analysis looked at the socio-spatial boundaries within which different frames where exchanged in activating 'energy discursive consciousness.' These socio-spatial boundaries are not only physical (e.g. rooms, streets, etc.). For the most part, they are mostly social, in that they often involve belonging to a particular group or community of consumers. Atelier K&K and the community of self-builders in BSH both have a clear physical profile. By and large, they interact within the walls of the De Meevaart community center or in their immediate living environments, respectively. For members of these two communities, face-to-face contact is a necessary condition for developing trust. Trust, in turn, enables the sharing of frames regarding their energy consumption. In these cases, the few attempts at digital interaction, through an online platform, produced only a very low level of engagement (see the *Gebiedonline* website www.buiksloterham.nl and the newly created Facebook group, www.facebook.com/buiksloterhambuurt).

In the cases we studied, the socio-spatial boundaries of social interaction appear to be much smaller than the neighborhood level. We noted that some communities, such as Atelier K&K and the community of self-builders, identify themselves with a particular street or block, or a sub-neighborhood area. Accordingly, they often require highly customized interventions to discuss their energy needs. In the case of the SCoA, the community is defined by the digital 'boundaries' of a Facebook page. Still, we noticed that despite the platform's wide reach, in this community the physical space of face-to-face interaction remains crucial to building consciousness around energy practices through the sharing of frames. While the digital platform functions as a stage for this community, physical interactions called *Meetups* are necessary for group cohesion. Face-to-face meetings among members of this community allowed them to explore the role that both online and offline spheres play in activating 'energy discursive consciousness'. In the case of the SCoA, digital and physical spaces both strengthened the process of 'energy discursive consciousness.' Neither physical nor virtual space was secondary to the other, and neither would have allowed the sharing of complex energy practices alone. Physical and virtual spaces are interwoven (see also Dourish & Bell, 2011; Jurgenson, 2012; (Korn, 2013).

The role of these spaces of face-to-face interaction in activating 'energy discursive consciousness' becomes important when establishing boundaries of *trust* and *mimicry*. We reported variegated expressions of acknowledgment and recognition of each others'efforts to live more sustainably during face-to-face exchanges. This community's discussions deepened significantly during face-to-face meetings, which occasioned a fuller exchange of frames regarding energy needs. Sharing struggles and small victories with like-minded people, as the members say themselves, helps them to keep up their motivation for living more sustainably and develop a feeling of a communal belonging. Due to their commitment to, and knowledge of, certain areas of sustainability, some members have become community 'experts.' Their suggestions guide and inform other members' choices. This appreciation is shown in others' comments and responses, during both online and offline discussions, and in the Facebook platform's the 'like' functionality.

> *What I like about the community is that there are people focusing on different areas and they are experts in different areas. If I hear that one thing that I learned only once, climate change, balance diet, etc.… with my busy life I would tend to forget it but because it's happening on an ongoing basis in a kind of digestible way from different members I really see that it works for me (SCoA member_2018-07-28, Meetup).*

Together, face-to-face and virtual interaction lay the foundation for the process of building a sense of communal belonging. This belonging, we claim, is a necessary condition for the building of consciousness among individuals. It seems that the presence of a *digital* space with a broad reach is important in allowing members of the community to share basic information about energy use. Figures and facts related to their lifestyles allows members to measure their energy needs– though often in a general and reductive way. To share this information, members use online sources that they deem trustworthy. These sources allow them to select specific information from the large amount of data that is available on the internet and in various reports. Also, platforms make it possible to share media. Indeed, many of the online discussions are supported by images, videos, graphs, etc., that members share to help them convey a message more effectively. These flows of information "keep conversation going" on a daily basis and satisfy members' need for communal engagement. This information does not allow members to calculate and recalibrate their energy practices in any immediate sense. Rather, it has the socially binding effect of maintaining group conversation. Contrary to the utilitarian and rationalistic understanding of data prevalent in current policymaking, these data are not directly generating awareness and therefore behavioral change. Instead, they indirectly sustain the building of social ties, grounded in basic expert knowledge, through which the group engages in processes of sharing and community building.

The character of information sharing is therefore often contextual rather than universal; local rather than global/aggregated; and reductive/selective rather than complex/extensive. Data do not immediately provide ‘useful’ information for social practice. Primarily it works by mobilizing interactions, most of which move beyond the specific theme of the initial data. Most of the Facebook posts we coded relate to things happening in or around Amsterdam and directly contribute to the feeling of being part of an urban collective. The SCoA’s founder encourages this. Indeed, one of the group’s initial guidelines stipulates that discussions should be kept ‘local’ and that members should avoid discussion of big issues as much as possible, for these often remain superficial. This way, members can always ask for practical advice when they are in doubt (e.g. as to where the nearest repair cafe is or how to participate in a compost initiative, etc.). The city scale seems to work well in creating this feeling of communal belonging – at least in the case of a city of Amsterdam’s size.

CHALLENGES FACING A FUTURE ENERGY TRANSITION

In the study presented here, we problematized the paradigm of energy efficiency, which assigns individuals the reductive role of calculative consumers. Instead, we showed the variegated character of both social practices and the processes that normatively shape them. The study reached the following conclusions:

First, we questioned the commonplace conception – based on the ideal of *homo economicus* – that individuals can rationally calibrate their energy practices by means of technological improvements and expert information. Instead, drawing on theories of social practice, we showed that questioning (though not yet changing) energy practices entails communicative processes that query the routine, moral, and hedonistic nature of social interaction. Members of the communities that formed our case studies seem to learn from each other in context, and to appreciate their sense of belonging to a community that is founded upon a particular framing of energy practice. Technology and technical expertise are, at best, a secondary or enabling frame when considering the activation of energy discursive consciousness.

Second, we questioned the taken-for-granted idea that monetary factors (incentives or fines) have the greatest capacity for 'activating' possible lifestyle changes. Today, this idea is used to justify extensive top-down interventions in tariffs, subsidies, tax-deduction, and technological improvements that shrink households' energy bills. Looking at different articulations of frames in specific contexts, we showed that while monetary framings of energy conscious lifestyle remains important – living sustainably is often cheaper – they are not always the primary frames in play. In fact, they are often secondary to the deeper ideal of saving energy as such. These conclusions are based on a set of three case studies, carefully selected, in which two of the three chosen communities belong to Amsterdam's high earning and highly educated middle classes. The case of the Atelier K&K, however, reveals that while monetary concerns incite members of a group to get together and share tips about reducing energy bills, monetary arguments are functional to building solidarity and support among members. The behavior of this group indicates that the significance of this solidarity extends far beyond the need to reduce energy bills.

Third, we questioned the common understanding that the most effective scales at which an energy transition can be pursued are the national, regional, and neighborhood. Looking at concrete practices of communicative interaction, we discovered that the socio-spatial scale at which discursive consciousness is enacted combined small-scale face-to-face community interaction and online interaction. A wide-reaching platform cements a community and enables it to share informative triggers such as videos and basic figures, which in turn entail further face-to-face interaction. Yet, digital platforms need face-to-face interaction to maintain trust in the community, which is a precondition for sharing experiences. These insights raise important questions about the scale and character of policies and interventions that aim to develop a new culture of decent lifestyles. Building what Alexander defines as 'voluntary simplicity' (Alexander, 2011) requires much more customized processes of physical interaction for existing ecological communities, not yet more standardized plans for technological investments across city-regions.

What is the space in which individuals build social norms and energy practices? At which scale do socially normative interactions, which generate social practice, occur? Addressing these questions is crucial to achieving two fundamental aims of an energy transition. Indeed, doing so is especially crucial if we are to question current energy practices, not simply question existing infrastructures and modalities of energy provision and consumption. We need to redefine the meaning of transition. This should be based not on an efficiency paradigm focusing on large scale networks of production and infrastructural adaptation, but on one focusing on daily practices of energy consumption. This means moving beyond current approaches that treat citizens as (un)willing receivers of national programs of infrastructural transition, exclusively grouped in terms of jurisdictional boundaries (e.g. neighborhood, region, city), or as falling into broad categories of income and home ownership (e.g. social renters, homeowners). Rather, it means appreciating the community ties that individuals build around lifestyle and consumption. Here, citizens – and their collective formations, such as households – become active and willing agents of a social transition towards new ways of living and using energy decently, rather than being the objects of an infrastructural transition.

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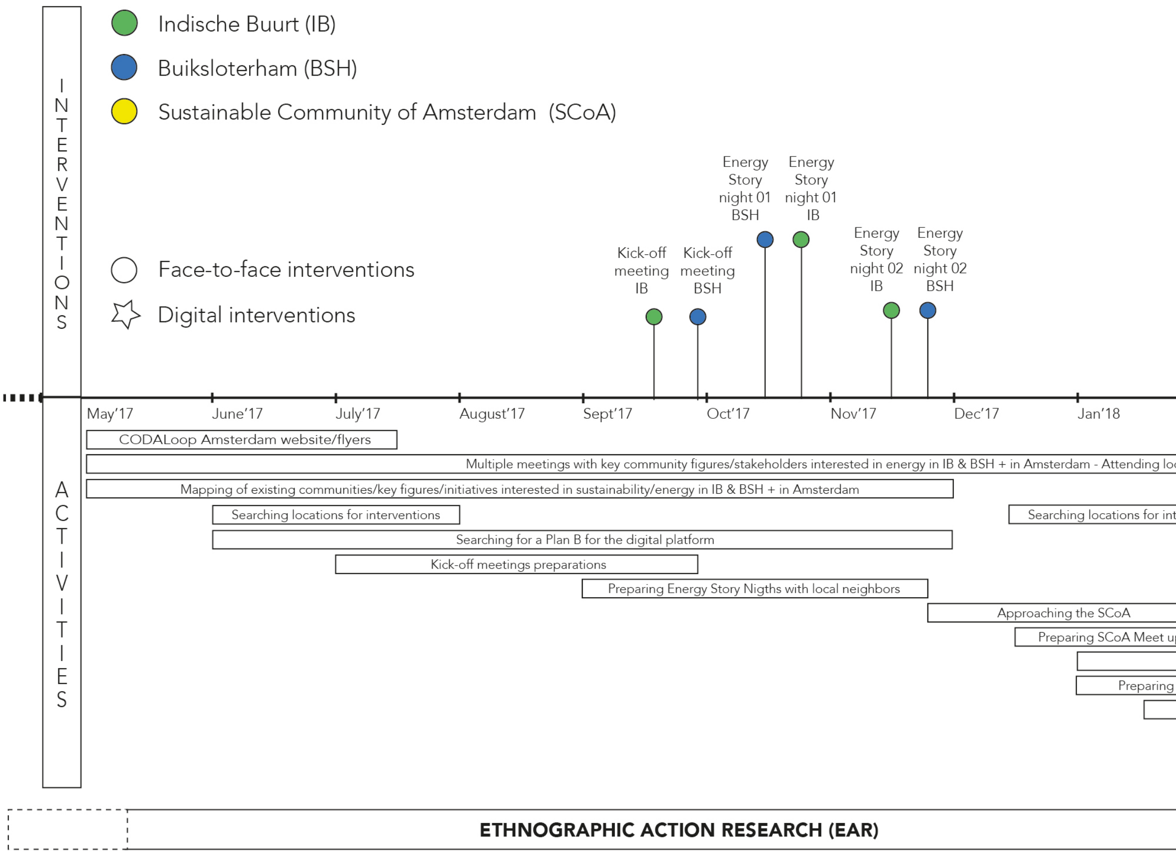

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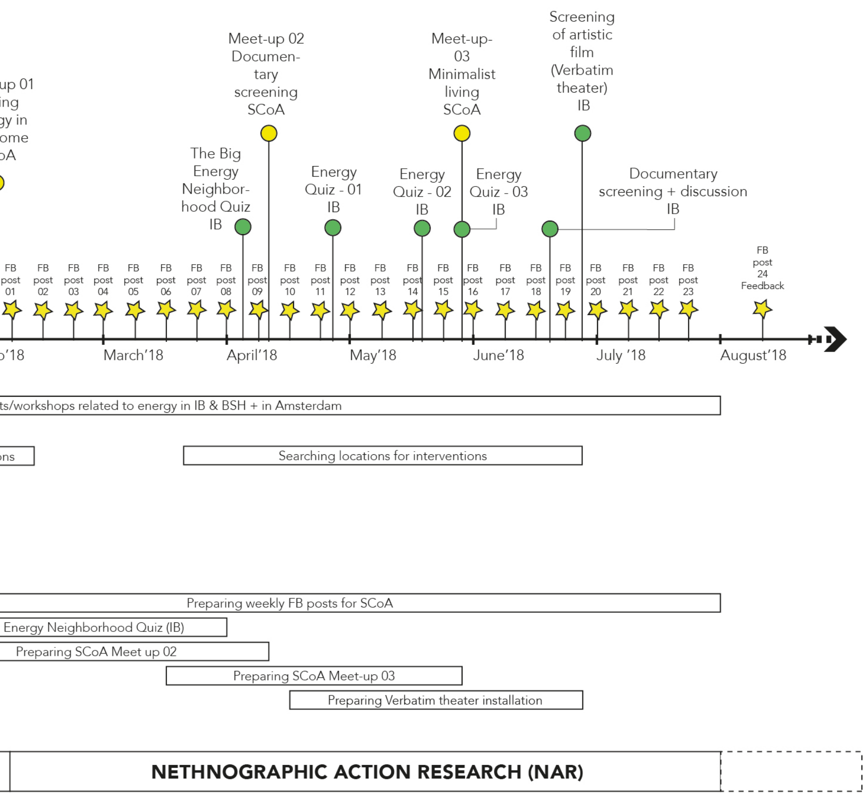
Website Gebiedonline Buiksloterham: www.buiksloterham.nl
Facebook group Buiksloterham: www.facebook.com/buiksloterhambuurt

APPENDIX

Research interventions and activities plan per community.




ECO

3 BUILDING A SMART COMMUNITY IN KADIKÖY, ISTANBUL*

RUMEYSA CEYLAN, AYŞE VELIOĞLU, ISRA HATIPOĞLU, AYŞEGÜL OZBAKIR AND ZEYNEP ENLIL

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INTRODUCTION

According to UNDP, energy is the main contributor to climate change, it produces around 60% of greenhouse gases (2019). While major transformations are underway for the global energy sector, it is also a well-known fact that policy choices made by governments as well as citizens with higher energy consciousness levels will shape the energy system of the future. Although the geography of energy consumption continues its historic shift to Asia (IEA, 2018), European countries still carry out a critical agenda on decreasing energy consumption. The European Union (EU) has committed itself to a 20% reduction of energy consumption by 2020 as compared to baseline projections. This objective is also known as the '20% energy efficiency target'. In other words, EU-28 has committed itself to have a primary energy consumption of no more than 1483 Mtoe and a final energy consumption of no more than 1086 Mtoe (per year) by 2020 (Eurostat, 2019). Similar to the EU member countries, Turkey has also adopted various policies targeting a decrease in energy consumption. Despite these efforts, implementation still lags behind targeted policy goals. Besides, population growth and increasing energy consumption patterns of the individuals make Turkey a country with a high-energy demand ratio among OECD countries[1]. Therefore, building an energy-efficient community that is focused on the behavior-based approach at individual level is one of the key strategies towards energy transition.

Considering that roughly 55% of the world's population lived in cities as of 2018, urban areas are important contributors to energy consumption[2]. Moreover, in modern information age, cities and communities -smart city and community- supported by Information and Communication Technologies (ICT) play significant roles in transforming the energy system towards a more sustainable and energy-efficient model.

Within this perspective, this chapter aims to build a new conceptual framework for citizens living in Istanbul, Turkey, where energy awareness and learning mechanisms are used as accelerators towards energy-efficient lifestyles. The main philosophy of 'energy-efficient lifestyle' covered in this chapter focuses on a holistic approach to reduce energy consumption, which involves not only the use of energy-efficient devices but also changing energy consumption behavior. Even though energy consciousness is a crucial issue globally, energy-efficient urban lifestyle is a relatively new phenomenon in Turkey.

The conceptual framework of the research has been operationalized through a novel methodology where awareness among individuals has been raised with a 'data-driven learning support system' as a first step to trigger behavioral change. To this end, first an 'energy use calculation' algorithm supported with a web-based platform has been developed. Second, a feedback and intervention plan has been designed in order to elicit behavioral change.

Both the conceptual and methodological frameworks of 'energy-efficient lifestyle' have been tested in Kadıköy District of Istanbul Metropolitan Area. Kadıköy has been selected for a case study for several reasons. First, Kadıköy Municipality has been developing ecological policies such as an 'Integrated and Participatory Climate Change Action Plan', energy-efficient building regulations and recycling projects to reduce the district's carbon footprint and energy consumption. Second, the municipality has strong relations with various neighborhood organizations and volunteer groups and works with them in different projects concerning the district.

BUILDING A SMART COMMUNITY

The 'Smart City' vision is a significant part of Sustainable Urbanism where smart city solutions aim to minimize resource consumption (energy, mobility, waste, etc.) and meet the requirements of social, economic, and environmental sustainability through advanced technologies in order to increase the life quality of citizens (Townsend, 2013; McLaren & Agyeman, 2015). Today, cities are consuming 80% of the energy production in the world (Kamal-Chaoui & Robert, 2009). Also, it is expected that global energy-related CO2 emissions will increase from 71% in 2006 to 76% in 2030 as a result of rapid urbanization (IEA, 2008). With the rising importance of climate change debates, energy efficiency has become a hot topic all around the world. In this context, the energy efficiency policies have been developed in two main areas: energy supply and energy demand. While the energy supply policies mainly focus on the alternative fuels and technologies for the industrial sector (Faaij, 2006; Zhang et al., 2010), the energy demand policies generally point out promoting and investing energy efficiency in energy consumption (Bergaentzlé et al., 2014; Pérez-Lombard et al., 2008).

As one of the main drivers of energy efficiency in demand, smart innovative solutions are widely used to reduce energy consumption (Krneta et al., 2018). However, energy efficiency improvements in smart cities are not only about smart technological solutions but also about energy consciousness of the community

(Frei et al., 2013). Yet, the energy awareness at individual, community and policy levels is generally low (Krneta et al., 2018). To increase energy consciousness, it is important to emphasize that a new type of community - *smart community* - is highly needed. This community would be capable of using Information and Communication Technologies (ICT) developed as support systems for data-driven learning (Hemment &Townsend, 2013; Hill, 2013; Granier & Kudo, 2016; Gurstein, 2014). This type of learning is a crucial component of a bottom-up approach towards feedback loops at different levels, i.e. individual to community and community to policy.

The next section will present the methodology, data analysis, and findings in an effort for building a smart community in Kadıköy, Istanbul.

THE METHODOLOGY

The methodology is based on the operational modelling of the individual to community feedback loops to build a smart community through 'data gathering and analysis', 'data-driven learning and adaptation' and 'learning support system development'. In this context, there are two main steps of the methodology: one of them is the development of a web-based platform and the other is the design of an energy behavior relational model. Living lab approach has been used during the project. A web-based platform is created (http://codalooploc.p1m1.net). The main objective of the platform is to produce a 'Decision Support System' for enabling individuals to embrace energy-efficient lifestyles in two domains: dwelling[3] and mobility[4]. The platform has five crucial functionalities: (1) an *Energy Calculator* for individuals to calculate their own energy consumption in dwelling and mobility domains, (2) a *Forum* for user interaction on current 'energy issues' through comments by users, (3) a *Map* for comparative feedbacks between users via a spatial illustration of energy consumption data, (4) a *Psychological Questionnaire* to understand individual energy consumption behavior, (5) an *Energy Saving Guide*, where individuals can monitor their previous energy consumptions and learn from 'energy saving suggestions' provided for them by the research team. Based on the living lab approach, the effectiveness of the web-platform is highly dependent on empowering users to participate in research, design, and testing processes in a real-world context (Bergvall-Kåreborn & Ståhlbröst, 2009). For this reason, the 'volunteers' of the CODALoop were included both during the development and testing processes of the web-based platform. Their contributions were also important in designing the intervention and feedback mechanisms.

The 'Energy Consumption Calculation and Saving Algorithms' have been developed to be integrated into the web-based platform to calculate the amount of energy consumption (kwh) in two domains: dwelling and urban mobility. Since individuals who live in Kadıköy do not have any access to smart sensors or technologies that can inform them about their energy consumption, the energy calculator of CODALoop has been designed as a crucial tool to raise energy consumption awareness in individuals. Both algorithms have been developed by using local standards and energy data gathered from the public authorities in Istanbul (such as IETT, ISKI, IDO and IGDAS) (Ceylan et al., 2017).

As previously mentioned, data-driven learning loops can change the behaviors of individuals and create collective consciousness among individuals, community, and policy via comparative, historical, and goal-setting feedbacks (Elzen, Geels, & Green 2004; Switzer, Bertolini, & Grin 2013). For this reason, an Energy Behavioral Relational Model is designed, which includes individual perceptions and behaviors as significant factors in building up energy-efficient lifestyles. As seen in figure 1, 'Energy Behavior Relational Model' was designed to analyze how energy data and feedbacks affect individual behavior. According to the Feedback Intervention Theory (FIT) (Kluger & Denisi, 1996), feedbacks are among the most powerful aspects to learn an energy-saving behavior (Hattie & Timperley, 2007; Siero et al., 1996; Karlin et

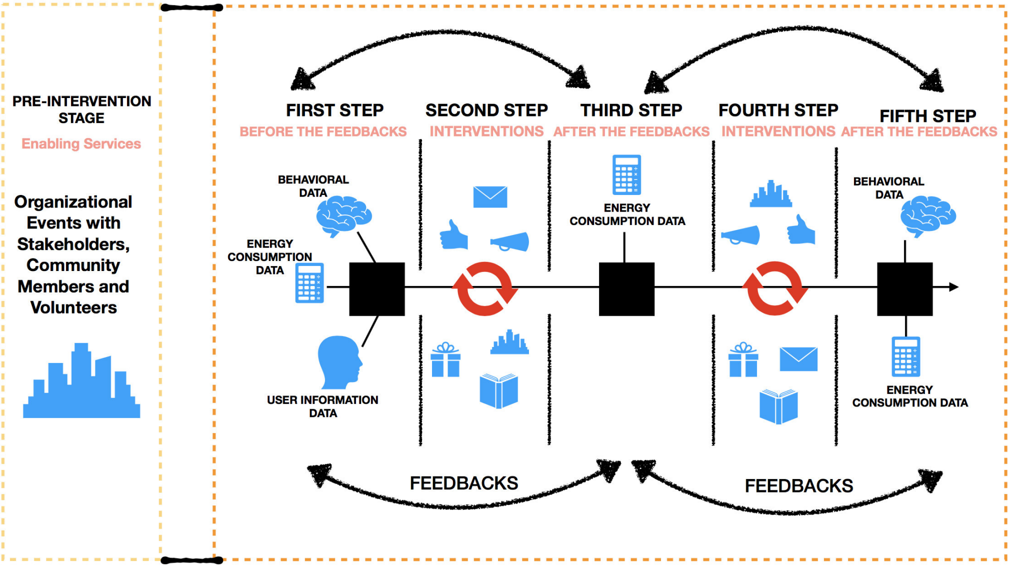

Figure 1 Energy Behavior Relational Model

al., 2015). Feedbacks, as consequences of the performance, were provided in the form of historical, comparative, and goal-setting information about energy consumption change of CODALoop volunteers at the third and fifth steps of 'Energy Behavior Relational Model' applied in the study. Also, the feedback mechanism was supported with interventions, which include face-to-face meetings, movie nights, energy diaries, historical energy reports, and others (see in Table 4).

100 volunteers received comparative, historical, and goal-setting feedbacks, which are the most effective feedback types in the literature (Siero et al., 1996; McCalley & Midden, 2002; Tang & Bhamra, 2008). Volunteers received comparative feedbacks via the 'Map' module of the CODALoop Web Platform. They could see the energy consumption level of each other on the map. Furthermore, the volunteers could follow their own energy consumption ranking at both dwelling and urban mobility domains. Moreover, face-to-face events were designed for individuals to shift into energy efficient urban lifestyle. These face-to-face interventions were: 'Movie Night' (a movie related with energy and environmental issues), 'Street Activity', 'Online Chat' (users

could communicate with each other via the online chat feature of the CODALoop Platform), meeting with private energy provider firms (informative meetings between firms and end-users), 'Energy For Kids' (this event consists of awareness games for parents and their children), energy news (weekly news to raise energy consciousness such as CODALoop Platform Guide and Energy Efficient Control Guide), 'Energy Diaries' (to take notes on their energy use experiences), 'My Energy Story Night' (to share notes from the energy diaries), individual energy reports (they include monthly energy performance values, energy saving targets and monthly energy consumption analyses of users). General and specific information about the social aspects and economic consequences of energy consumption in the world are also provided through the social media accounts of the project. Names, numbers and frequencies of the feedbacks and interventions are summarized in Table 2.

STUDY AREA DETERMINATION

Kadıköy[5] has been selected as the case district from 39 districts of Istanbul Metropolitan Area[6] because of the significant attempts of the local municipality such as building regulations and recycling policies to reduce the district's carbon footprint and energy use. In line with energy efficiency policies, Kadıköy Municipality signed the Covenant of Mayors and aims to reduce greenhouse gas emissions of the district by 2020 through an Integrated and Participatory Climate Action Plan. As a part of the plan, 'Eco-Sensitive Sustainable Sites Project' is an urban regeneration project focusing on energy efficiency. Also, the municipality develops ICT tools in order to support the projects within the plan, such as the 'closest waste point finder app'. These examples indicate that Kadıköy Municipality adopts a citizen-centered approach and includes the citizens in the policy-making processes (Kadıköy Municipality, 2014). Moreover, the diversified socio-economic structure of the district, as well as the strong

Comparative Feedbacks				Face-to-face	
Intervention Name	Total Number of intervention	Intervention Frequency	Target Level	Event Name	Explanation
Social Media	2	6	At community level	 Movie Night	A movie related to energy was watched at the events that were designed to have users attend and get social interaction with each other
Energy Diary	1	5	At individual level	 Street Activity	Challenge for pedestrians: 'What's on your road?'
Codaloop Platform	1	3	At community level	 Energy for Kids	Energy Awareness game for parents and children
Becoming a "Codalooper"	1	1	At individual level	 My Energy Story Night	Aims to share energy story experiences in the energy diaries by users
Scientific text on energy-efficient lifestyle and Energy News	24	6	At individual level	 Energy Awareness Workshop	Includes three informative games to increase energy awareness
Online (Platform) Chat	1	6	At community level	 Energy Policies Workshop	Allows sharing the opinions of individuals with policy makers and energy-related companies

Table 2 Feedbacks and Interventions Plan

connection between the volunteer groups and the local government were other factors in selecting Kadıköy as the case district.

SELECTION OF VOLUNTEER GROUPS AND DATA COLLECTION PROCESS

The citizens participating in the project were heterogeneous with different characteristics in terms of age groups, gender, income levels, education levels, and occupation. The participants were selected based on where they lived in Kadıköy whether they have an e-mail address, a computer at home with Internet access, and a social media account (Facebook or Instagram). Based on these criteria, 100 citizens volunteered to participate in CODALoop project for a period of six months. The volunteers were asked to commit themselves during this six-month period, so that their energy consumption pattern could be tracked over time. The volunteers started using the web-based platform and entering their energy consumption data at both dwelling and urban mobility domains in September 2018. Feedbacks and interventions were also provided during this six-month period. Then, second data entry step was completed by the volunteers in February 2019. Data was entered by the volunteers in September 2018 and February 2019, in order to observe the impact of feedbacks and interventions and analyze the effects of seasonal differences on energy consumption levels.

ENERGY CONSUMPTION PATTERNS IN KADIKÖY

Socio-Demographic Characteristics of CODALoop Volunteers in Kadıköy

The number of female volunteers is slightly higher than the male volunteers, where the females constitute 53% of the volunteers.

When the age distribution of the volunteers is analyzed, it is seen that the majority of them is between 25-35 years old (27%), followed by the volunteers between 46-55 years old (22%) and 36-45 years old (20%). In terms of education, 48 percent of the volunteers have a bachelor's degree, 7% have graduate education such as a master's degree or a PhD. 31 percent of the volunteers are high school graduates, while 14 percent of the volunteers graduated only from primary school. In terms of occupation; the major groups with most volunteers are sales and marketing sector (20,7% of the users), unemployed (11.8% of the users) and retirees (10.8% of the users). Regarding monthly income of volunteers, it is observed that the monthly income of 46% is between TRY2,001-4,000, 27% is between TRY4,001-5,000 and 21% is between TRY5,001-6,000[7]. The household sizes of the volunteers are dominantly recorded as 2 persons (44%) and 3-4 persons (31%) as seen in table 3.

UNDERSTANDING ENERGY CONSUMPTION DATA OF CODALOOP VOLUNTEERS

According to recent statistics, Turkey has 7.4% GDP growth rate in 2017. In addition to this, the national energy consumption is 97,162 Mtoe, and the national demand is growing by 6-8% annually. Kadıköy District has a population of 458,638 and the population growth rate (15.8%) is higher than the average of Istanbul in 2018 (TUIK, 2018). According to a report by Kadıköy Municipality, approximately 6,110,000 kWh energy is consumed annually (Kadıköy Municipality, 2014).

Based on the data obtained from the platform in October 2018, the total energy consumption was 74.320 kWh, 47% of which consists of mobility and 53% of dwelling. The spatial distribution of the total energy consumption of individuals at dwelling domain is shown in figure 2. It is observed that the energy consumption of individuals was predominant in two groups: 35% of

Variable		Frequency
Gender	Male	53
	Female	47
	Total	100
Age	18-25	13
	26-35	28
	36-45	20
	46-55	22
	55+	17
	Total	100
Education Level	Primary school	15
	High school	30
	Undergraduate	48
	Graduate	7
	Total	100
Income Level	0-2000 TL	6
	2001-4000 TL	46
	4001-5000 TL	27
	50001-6000 TL	21
	Total	100
Household Size	1	19
	2	44
	3-4	31
	5	6
	Total	100

Table 3 Socio-Demographic characteristics of volunteers (Source: from the CODALoop platform, October 2018)

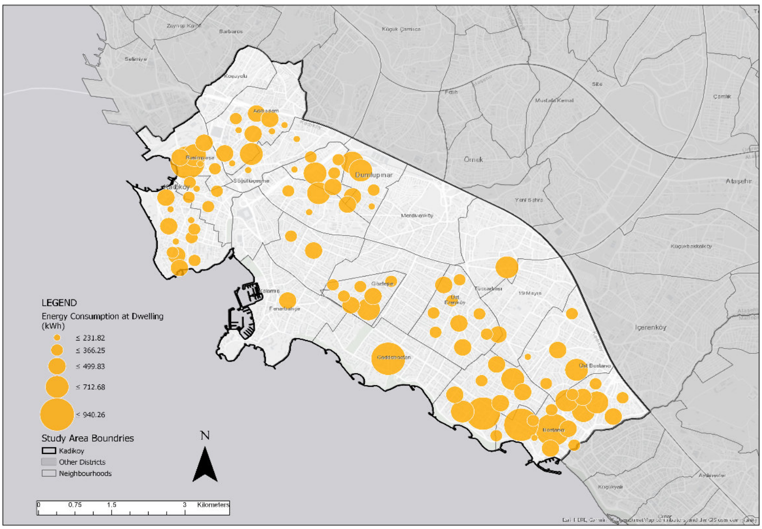

Figure 2 Individual energy consumption at dwelling (from the CODALoop Platform, October 2018)

the users consumed between 231.82 and 366.25 kWh and 30% of the users consumed between 366.25 and 499.83 kWh per month.

The highest energy in dwelling was consumed by electrical appliances, which generated 78% of the total energy consumption followed by heating (11%), lighting (10%) and water (1%)[8], see figure 3.

The average energy consumption of volunteers is shown in Table 4 according to the subdomains of dwelling.

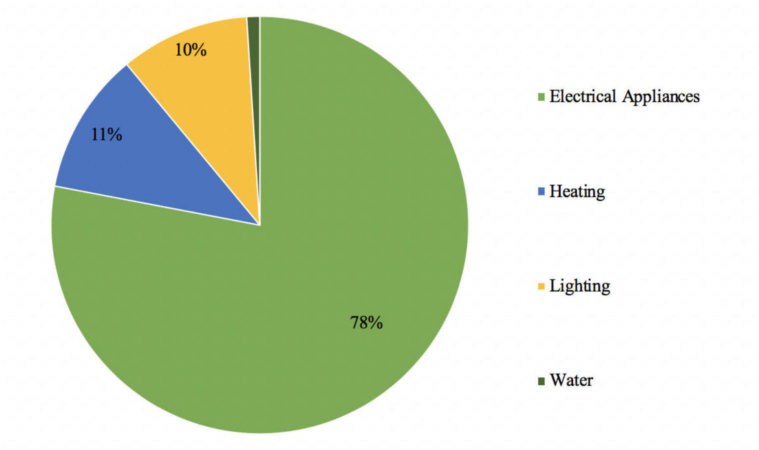

Figure 3 Energy consumption in subdomains of dwelling

Table 4 Average energy consumption of volunteers at dwelling domain

Dwelling Domain	Average energy consumption of volunteers	Volunteers consuming energy above average (%)
Total	393.8	42%
Heating	43.5	34%
Electrical appliances	306.2	43%
Lighting	40.2	37%
Water	3.8	38%

The results of mobility energy consumption indicate that the energy amount consumed by the users was 34931,64 kWh within the urban area. Figure 4 shows spatial distribution of the total mobility energy consumption of the individuals. The first two groups consist of approximately 60% of the users, who consumed energy below 422. 20 kWh (The first group is 35% and the second group is 25%).

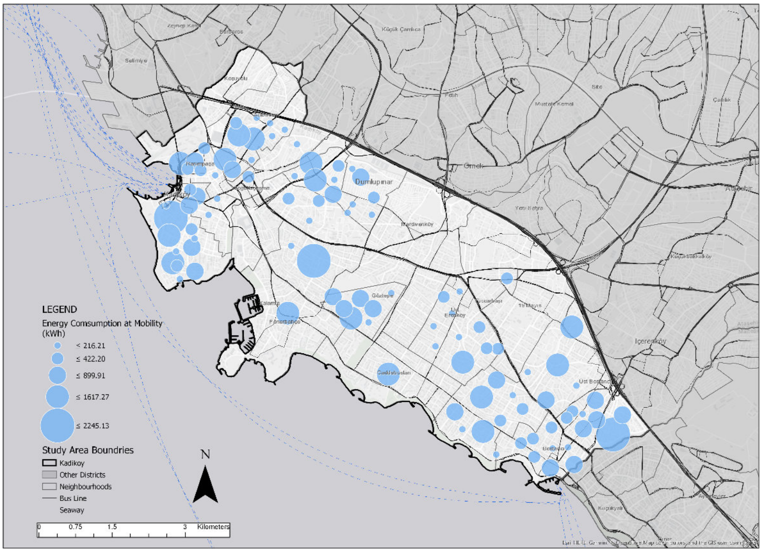

Figure 4 Individual energy consumption in mobility (from the CODALoop Platform, October 2018)

The mobility energy consumption was analyzed by five different modes of transportation. The private car group, which uses gasoline and diesel fuel, was a major energy consumer, accounting for about 49% of the total consumption. It is followed by bus (36%), taxi (8%), seaway (4%) and railway systems (3%), see figure 5. Individuals consumed 529.1 kWh energy on average for mobility, elaborated in table 6.

The average energy consumption of the volunteers is summarized in Table 5 according to the subdomains of urban mobility.

Correlation analysis was carried out in order to evaluate the relationship between the socio-demographic characteristics of the volunteers and the three different energy consumption data (total

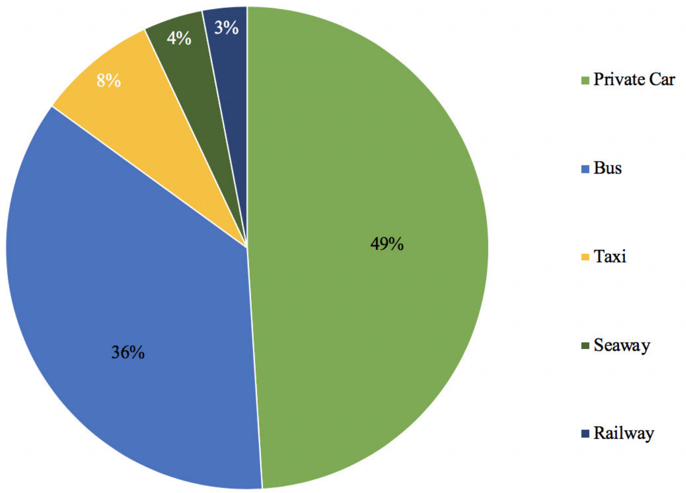

Figure 5 Energy consumption in the subdomains of urban mobility

Table 5 Average energy consumption of the volunteers at mobility domain

Mobility Domain	**Average energy consumption of volunteers**	**Volunteers consuming energy above average (%)**
Total	529.1	35%
Bus	119.1	40%
Private Car	164.6	32%
Railway	8,8	29%
Seaway	14.6	38%
Taxi	26.7	30%

consumption, dwelling consumption, and mobility consumption). The results indicate three different types of correlations. First, the correlation is that the energy consumption for mobility and the total energy consumption are significantly related to the education level of volunteers, which shows that the total consumption and the mobility consumption increase with higher education levels. Second, the energy consumption at dwellings has a strong positive correlation with the household size. Third, there is positive weak correlation between the total energy consump-

Domains	Min.	Max.	Total	Mean	Std. Deviation
Total Energy Consumption in Dwelling	112.9	940.3	39,385,28	393.85	163.3
Heating	2.5	162.0	43,567.5	43.56	48.4
Electrical Appliances	87.4	856.6	30,621.5	306.2	159.9
Lighting	5.4	183.6	4,020.1	40.20	35.7
Water	1.38	28.1	386.8	3.87	3.1
Total Energy Consumption in Mobility	28.42	2,245.1	52,913.8	529.12	496.9
Bus	0	752.6	11,913.3	119.1	140.6
Private Car	0	1,311.0	16,460.2	164.6	288.5
Railway	0	94.5	886.2	8.8	14.8
Seaway	0	95.8	1,468.3	14.6	24.2
Taxi	0	316.4	2,677.9	26.7	51.7
Total Energy Consumption	267.9	2,679.3	92,299.07	922.9	545.7

Table 6 Descriptive statistics of energy consumption data. (from the CODALoop Platform, October 2018)

tion and income levels. Finally, the income level, household size and the education level are significant variables to understand energy consumption patterns.

FEEDBACK AND INTERVENTION PLAN

As explained in the methodology section, 'Energy Behavior Relational Model' was designed to construct a relation between energy consumption data and the individual behavior towards an energy-efficient lifestyle. Furthermore, two workshops that are called the 'Energy Awareness Workshop' and the 'Energy Policy Workshop' were designed. These workshops were organized to provide both individual-to-community and community-to-policy feedback loops. Since individuals have already started learning about their energy consumption levels, 'Energy Awareness Workshop' provided a supportive environment for the volunteers to share their energy consumption experiences and learn from each other. The workshop also provided an opportunity for the

Figure 6 Final comments of the volunteers to policymakers at 'Energy Awareness Workshop' (January 19, 2019)

volunteers to identify their expectations from policymakers, see figure 6.

Energy consumption data results extracted from the platform were also used in this workshop. According to these results, fifteen CODALoopers were invited to the workshop (who had the highest and lowest consumption values) and three games were devised to increase energy consciousness. The games were:

- **CODALoop House Game** (CODALoopers tried to figure out which items in the house consume the most and the least energy in winter and summer seasons, as seen in figure 7),
- **Sort by Efficiency! Game** (CODALoopers tried to rank the most energy saving actions in the house, as seen in figure 7),
- **Urban Mobility Game** (CODALoopers marked down their daily mobility habits to reach the Kadıköy ferry point from their houses, as seen in figure 8)

The results of the 'Energy Awareness Workshop' are summarized as below:

Figure 7 CODALoop house game and sort by efficiency game at 'Energy Awareness Workshop' (January 19, 2019)

- The majority of the volunteers declared that their energy consciousness level is higher at the dwelling domain than the mobility domain.
- They are well-informed on alternative energy resources.
- They mostly prefer private cars because they are faster and more comfortable.
- The volunteers request more railway systems integrated with other public transportations in Kadıköy District.
- Continuous bikeways as well as shared bike services were also requested.
- Citizens were conscious about energy efficiency policies. However, they did not have sufficient motivation and infra-

Figure 8 Mobility game at 'Energy Awareness Workshop' (January 19, 2019)

> structure to change their energy consumption behaviors. They indicated that their energy consumption behaviors are beyond their control due to national and city-wide policies.

On the other hand, the 'Energy Policies Workshop' aimed to convey the results of energy consumption data of all the volunteers, as well as the 'Energy Awareness Workshop,' and to discuss the challenges of the macro-micro energy policies in Kadıköy, Istanbul and Turkey. The future of energy, the role of technology as a new tool and participation of individuals were discussed with different actors including local governmental bodies, energy provider firms, and non-governmental bodies during the workshop. Additionally, policymakers and other energy-related actors discussed their responsibilities and future recommendations about energy efficiency policies, as shown in figure 9.

Participants emphasized the following remarks during the workshop:

Figure 9 Photos from the 'Energy Policies Workshop' (January 24, 2019)

- For successful energy efficiency policies, policy-makers must have sufficient knowledge about the energy demand of the community and must communicate with them.

- Energy efficiency/saving needs to be defined well.

- Energy efficiency projects need to be promoted and introduced by public institutions.

- The responsibility of energy efficiency policies must be shared commonly with citizens via integrated and participatory planning approaches.

- Public service announcements and prizes for energy efficiency are important to raise awareness.

- ‘Building automation systems’ based on computer systems and controls ventilation, lighting, power systems, and fire systems of buildings need to be provided for dwellings to reduce energy consumption.

- Smart meters that can provide updated and correct energy consumption data to policymakers must be implemented.

- Energy literacy and awareness on unit energy prices should be raised among citizens.

CONCLUSION

Energy transition is a significant issue of debate in the global agenda. Many policies, innovations and scientific studies have been developed in recent years to materialize an energy transition. However, despite these attempts, energy consumptions of cities are still increasing. Although the concept of energy-efficient urban lifestyle has promising insights for reducing consumption, it is observed that citizens still have various energy consumption patterns. Such variations in energy consumption levels depend on cultural, socio-economical, educational, and urban characteristics. In respect to these challenges, data-driven learning and feedback loops methodology are designed for this research in order to change the individual energy consumption behaviors through a web-based platform tool and by triggering the energy consciousness via feedbacks and interventions. The platform has five main functions: an energy calculator for individuals, a forum for user interaction, a map for comparative feedbacks, a psychological questionnaire to understand energy consumption behaviors, and an energy saving guide.

According to the results obtained during the given six-month period, it is observed that the general profile of the volunteers is heterogeneous in terms of gender, occupation and age distribution. When the breakdown of the total consumption is analyzed, it is observed that the energy consumption of the volunteers at their dwellings was slightly higher than their consumption at mobility domain. At dwelling domain, the highest energy consumption was accounted by electrical appliances which constituted 78% of the total energy consumption. The private car group, which uses gasoline and diesel fuel, was a major energy consumer, accounting for 49% of the energy consumption at the mobility domain. When the relationship between energy consumption and socio-demographic patterns of volunteers is examined, it is seen that education level and household size have significant correlations with the total energy consumption, and mobility and dwelling energy consumption values.

Furthermore, two workshops named the ‘Energy Awareness Workshop’ and the ‘Energy Policy Workshop’ were designed to create individual-to-community and community-to-policy feedback loops. According to the major results of the ‘Energy Awareness Workshop’, it is observed that consciousness of the volunteers about energy efficiency was higher at the dwelling domain than the urban mobility domain. Next, due to the inconvenience and insufficiency of the public transportation system both at the city and the district level, the volunteers prefer to travel via their private cars in their daily commute rather than taking public transportation. The workshop provided crucial inputs for public policies, indicating the importance of the provision of a highly integrated public transportation system and efficient mode mixers as well as high quality, walkable urban areas for the pedestrians and safe routes that would encourage bicycle usage.

During the 'Energy Policies Workshop', different actors such as local governmental bodies, energy provider firms, and non-governmental organizations were invited to discuss the energy consumption results of the volunteers as well as the macro and micro policies. The participants concluded that energy efficiency/saving should be well addressed via policies at both the national and local levels. Therefore, reduction of energy consumption is not only an individual responsibility of the citizens, who are expected to shift to a more energy-efficient lifestyle, but more importantly it is the responsibility of public authorities at the policy level. They were also interested in hearing the actual real-life energy consumption values of the citizens and declared the importance of a technology-enabled tool that can provide such feedbacks to the policy-makers.

Finally, both the conceptual and methodological frameworks structured in this research had some limitations as well as future insights. First, data-driven learning platforms are extremely important towards building up an energy-efficient community in cities like Istanbul, where smart meters and other technological solutions are still not widely used. To raise energy awareness among Turkish citizens, a crucial first step is to inform them on their consumption levels and provide saving suggestions. However, sharing this knowledge with public authorities and other stakeholders is also very important while making efficient policies. One of the biggest shortcomings of the research was to apply the feedback plan. Volunteer groups were more interested in using the platform to see their consumption than to attend the events and/or react to the interventions. A recommendation for this might be to involve an already-working and established group in environmental issues as catalyzers, who have accumulated more knowledge and high interest in energy-efficient lifestyles. Another conclusion extracted from the research that can point at a future agenda is to apply creative design thinking into the web-platform, in which the user experience is rather significant. Especially new techniques like gamification, Artificial Intelligence (AI) and Internet of Things (IoT) can also support the use of these platforms in an effective way.

NOTES

1 The Outlook for Energy: A View to 2040 - Fundamentals, ExxonMobil

2 https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html

3 Energy consumption in the dwelling domain has four subcomponents: electrical appliances, heating, lighting and water. The amount of energy consumption for water and heating has been calculated via monthly bill, while for lighting and electrical appliances are calculated based on number of items, type and duration of use. When calculating individual consumption, the total energy in the household is divided by the number of people in households.

4 Urban mobility domain consists of the energy consumption due to the choices of transportation modes such as bus, railway, seaway, car, flight and taxi. Whereas energy consumption of bus, railway and seaway has been calculated according to the number of trips; using the private car and taking taxi energy consumption has been calculated according to fuel consumption, the number of passengers in the vehicle, and the taxi fare. In addition, monthly bicycle usage and walking distance information of the users were also taken, but this data was not included in the energy consumption.

5 Total population of the district is 458.638 by 2018 (TUIK, 2018).

6 Total population of approximately 15 million by 2018 (TUIK, 2018).

7 Turkey's average monthly income was TRY1,798 in 2018 (TUIK, 2018). In the same year, the minimum wage was TRY1,603 (Republic of Turkey Ministry of Family, Labor and Social Services, 2018)

8 Energy consumption data was collected in October 2018, which means that the weather temperature was not too cold for a higher heating (20,5 Celsius) in Istanbul (Republic of Turkey Ministry of Agriculture and Forest, 2018).

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ECO

4 MODELLING THE PSYCHOSOCIAL DIMENSIONS OF 'ENERGY CONSUMPTION AND BEHAVIOUR'

MICHAEL A. BEDEK AND DIETRICH ALBERT

INTRODUCTION

Hundreds of United Nations delegates have met annually at the Climate Change Conference (UNFCCC) for over two decades. They discuss, negotiate and sometimes agree on plans on how to reduce climate change at a global level. Apart from mere general criticism of top-down approaches to reduce climate change, however, it is clearly meaningless to agree on reducing greenhouse gas emissions if those who contribute significantly to these emissions do not also change their behaviour. In the final analysis the lifestyles (consumption, mobility, etc.) of individual persons, households and cities in the 'western world' are a massive factor in energy consumption, and as a consequence also for greenhouse gas emissions. Understanding the underlying cognitive and affective dimensions of energy consumption of individuals, such as motivation, cognitions, attitudes, potentials and barriers is a *necessity but is not sufficient in itself* to successfully apply concrete means for supporting people in reducing their energy consumption.

A cognitive model is a set of variables and their relations to each other, variables which are also referred to as factors or constructs by some authors. A cognitive model on behaviour or behavioural change ideally encompasses all psychological variables that allow prediction for the behaviour of individuals or groups of individuals. The benefit of such a cognitive model is at least twofold: on the one hand it allows the *predicting* of behaviour and behavioural change; on the other hand, it provides an *understanding* of why or why not individuals show some specific behaviours or behavioural changes – due to the interplay of the underlying variables in the cognitive model.

Several cognitive models that aim to predict real behaviour are available to psychology and in particular to the fields of health psychology and social psychology. We built upon these existing models and theories as well as already existing operationalisations of variables in the literature, and adapted them to the needs of CODALoop.

This chapter is therefore structured as follows: Firstly, analysis of existing cognitive models and theories on behavioural change is presented, secondly, an analysis and selection of cognitive variables is given, thirdly, a definition of the initial cognitive model, fourthly, operationalization of cognitive variables is provided, thereafter, the empirical data collection and analysis is put forward, and finally refinement of the cognitive model based on empirical results is considered.

ANALYSIS OF EXISTING COGNITIVE MODELS AND THEORIES ON BEHAVIOURAL CHANGE

The following eight cognitive models and theories on behaviour and behavioural change have been taken into account for an in-depth analysis of their empirical evidence such as validity and predictive power as well as their included variables (for details see Knoll, Scholz & Rieckmann, 2013):

- Social Cognitive Theory (Bandura, 1977, 2001),
- Health-Belief Model (Becker, 1974; Janz & Becker, 1984),
- Theory of Reasoned Action (Fishbein & Ajzen, 1975),
- Theory of Planned Behaviour (Ajzen, 1985, 1991)
- Protection Motivation Theory (Rogers 1975, 1983)
- Health Action Process Approach (Schwarzer 1992, 2008)
- Transtheoretical model (Prochaska & DiClemente, 1983; Prochaska & Velicer, 1997)
- Precaution Adoption Process Model (Weinstein et al., 1998).

As mentioned above, these models and theories on behaviour and behavioural change often originate from ‘health psychology’. In simple terms, one of the main aims of this field is to identify underlying variables that are internal (e.g. cognitive or emotional variables) and external (such as sociodemographic variables or broader life circumstances) to individuals that facilitate or hinder them from achieving a healthier lifestyle. These include prevention measures, but also increasing compliance in the case of ongoing medical treatments. A prominent use case would be quitting smoking: What are the barriers, what are the facilitating factors and variables, what is the required ‘mind-set’ of people who have successfully stopped smoking?

One of the most prominent and most often applied cognitive models is the *Theory of Planned Behaviour* (Ajzen, 1985). It is an extension of the *Theory of Reasoned Action*. These two models are thus described in more detail in the following.

Theory of Reasoned Action

The Theory of Reasoned Action proposed by Fishbein and Ajzen (1975) aims to explain the relation between attitudes and behaviour. The reason for this was that attitudes – contrary to intuitive assumptions – did not predict behaviour to a high level of accuracy.

It has been assumed that there could be a mediating variable between attitudes and behaviour: *intention*. In other words, "a person's intention to perform (or not to perform) a behaviour is the immediate determinant of that action" (Ajzen, 1985, p.12). An intention is a conscious decision of a person to perform (or not perform) a behaviour or a mandatory decision to try to reach a specific goal.

Attitudes can be considered as (sometimes emotionally-connoted) beliefs about themes, suggestions, movies, political views, etc. which have been evaluated by the individual. They represent "a summary evaluation of a psychological object captured in such attribute dimensions as good-bad, harmful-beneficial, pleasant-unpleasant, and likable-dislikeable" (Ajzen, 2001, p.28). Besides attitudes, the second main factor that has an impact on (behavioural) intention is subjective norms. *Subjective norms* are one's own beliefs about the expectations of significant others (as well as the society as a whole).

Both preceding factors are considered multiplicatively: they require a value above an absolute minimum, otherwise, combined they will have a zero-effect. In the case of attitudes, the two preceding factors are *beliefs about the consequences* of a certain behaviour (or behavioural change) and the *evaluation of these consequences*.

Subjective norms result from the interplay between *normative beliefs,* i.e. beliefs about what others expect from one and the *motivation to comply*, i.e. the motivation to meet the expectations of others. *The Theory of Reasoned Action* is represented in figure 10 and encompasses the variables above the dashed line.

Theory of Planned Behaviour

In a nutshell, the *Theory of Reasoned Action* is only applicable in situations and contexts which are under volitional control of the person concerned. This aspect is covered by the *Theory of Planned Behaviour* by also including the factor *perceived behavioural control*, which encompasses aspects of controllability ["I am able to afford organic food (and I am willing to buy it), therefore I am in control of this potential behaviour of buying only organic food"]. The *Theory of Planned Behaviour* is represented in figure 10.

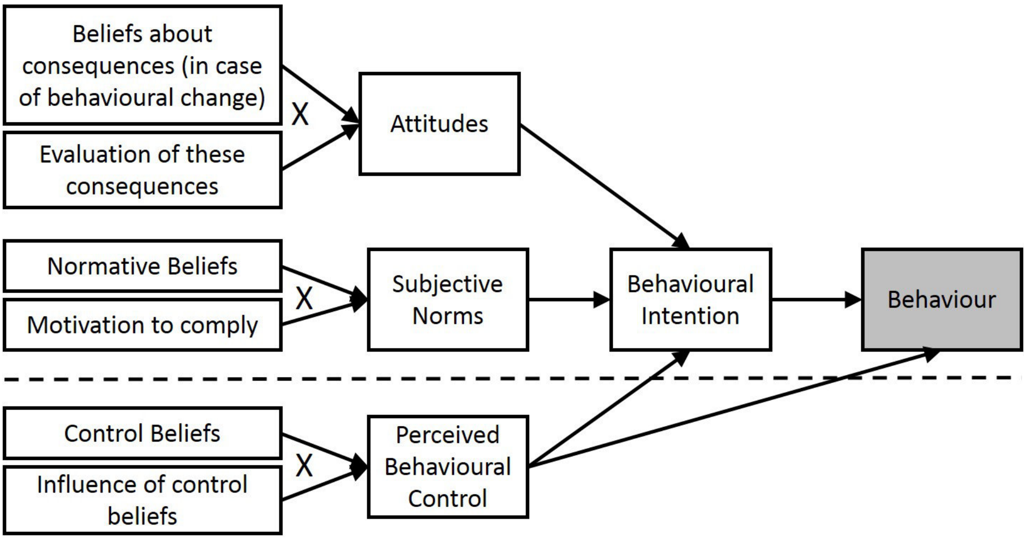

Figure 10 Theory of Planned Behaviour (figure based on Aizen, 2001). The variables above the dotted line are part of the Theory of Reasoned Action.

Similar to *attitudes* and *subjective norms*, *perceived behavioural control* has two, multiplicatively related, preceding factors: (1) *Control beliefs*, i.e. beliefs that behaviour as such and the contextual and situational factors in which the behaviour might be embedded are under one's own control, and (2) *Influence of control* *beliefs*, i.e. belief that one's own controllability of the behaviour is actually influential.

ANALYSIS AND SELECTION OF COGNITIVE VARIABLES

The variables of the eight theories and models listed above have been analysed in the context of the CODALoop project in the context of their predictive power of behaviour and behavioural change, as suggested by empirical studies. In addition to this we also analysed to what extent the variables overlap – in some cases different authors use different labels for the same (or at least very similar) variables. Based on this literature review and analysis, the following clusters of variables have been selected for the initial cognitive model:

A) *Self-efficacy* including its parts or stages: a1) *Action*, a2) *Maintain* and a3) *Recovery*-self efficacy.

B) *Perceived Behavioural Control* including its underlying factors: b1) *Control Beliefs* and b2) *Influence of control beliefs*

C) *Attitudes* as well is preceding factors c1) *Outcome expectations* and c2) *Evaluation of consequences*.

D) *Utility evaluation*, which results from the difference between d1) *Perceived benefits* and d2) *Perceived costs and barriers*.

E) *Subjective norms*, including its underlying factors: e1) *Normative beliefs* and e2) *Motivation to comply*.

F1) *Motivation*, F2) *Volition*, F3) *Intentions* and F4) *Goals* and F5) *Past behaviour* are considered as highly interrelated.

G) *Cues to action* (or generally speaking: knowledge; including about possible alternatives).

H) *Socio-structural factors* and *demographic variables*.

DEFINITION OF THE INITIAL COGNITIVE MODEL

Our initial cognitive model encompasses the *Theory of Planned Behaviour* (see figure 10) as core part and is extended by some additional variables:

Self-efficacy is a main concept of the *social cognitive theory* (Bandura, 1977, 2011) and defined as the evaluation of (and belief about) one's own competence to apply a specific behaviour, even in 'difficult' situations. It is considered as slightly more specific than *perceived behavioural control* (Ajzen, 2002). In this case, we assume an 'is-part-of' relationship and the arrow in figure 11 can be read as '*self-efficacy* contributes to *perceived behavioural control*.'

In line with the *Health Action Process Approach*, we distinguish between three stage-specific forms of self-efficacy: (1) *Action self-efficacy*, which refers to a stage in which an individual does not yet act, but a process in which he or she develops a motivation to do so, (2) *Maintenance self-efficacy*, that represents optimistic beliefs about one's capability to deal with barriers that arise during the maintenance period, and (3) *Recovery self-efficacy* that addresses the experience of failure and recovery from setbacks. We assume that the first two forms of self-efficacy directly affect different motivational factors: *Action self-efficacy* should affect *behavioural intention*, while *maintain self-efficacy* should have a direct impact on *volition*. Finally, it is assumed that *recovery self-efficacy* directly impacts *behaviour*, respectively behavioural self-regulations in case of setbacks, see figure 11.

With regards to motivational factors (F), it is assumed that *motivation* (F1) requires the existence of *goals* (F4) and *behavioural intentions* (F3), and that *motivation* is required for *volition* (F2).

In other words, without goals and intentions no motivation, without motivation no volition, without volition no behaviour. For the moment we assume simple linear relationships between the predictors (F1 to F4) and the criteria (behaviour or behavioural change). In line with a famous saying in psychology, 'the best predictor for future behaviour is past behaviour', we included *past behaviour* in the initial cognitive model and assume that it is closely related to the 'motivational cluster.' *Past behaviour*, or to be more precise, knowledge about one's own behaviour in the past and associated outcomes (successes and failures), which can be considered as *experiences,* may also have an impact on *self-efficacy* and *control beliefs*.

In the following figure 11, the arrows and their directions have been considered as causal-like relationships by the proponents of the existing models and theories listed above, in the sense of variable *A* impacts variable *B* or variable *A* causes variable *B*. The dotted line between the *socio-structural factors* and *demographic variables* on the one side and *normative beliefs* and *perceived behavioural control* on the other side, are hypotheses that have been established by the authors of this chapter.

OPERATIONALIZATION OF COGNITIVE VARIABLES

In this section, we briefly outline how the selected variables of the initial version of the cognitive model, see figure 11, have been operationalized (i.e. made assessable). Nearly all the variables mentioned above, have already been operationalized in one way or the other, so the work focused on selecting the best (in the sense of reliability and ecological validity) already existing operationalization.

For the different stage-specific forms of *self-efficacy*, Schwarzer et al. (2003, p.11) suggested the following items:

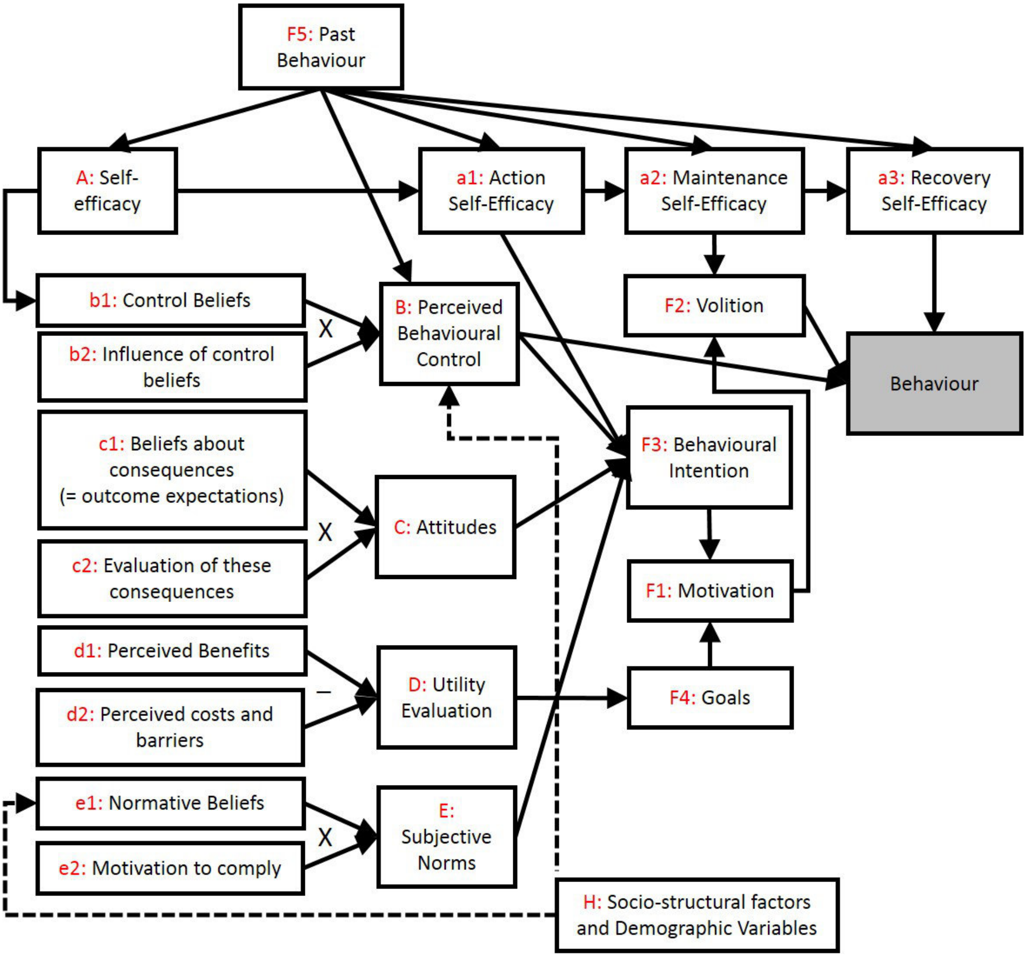

Figure 11 1st final version of the cognitive model

- "I am confident that I am able to perform / do *behaviour x* even if it is hard for me" (*action-self efficacy*)
- "I am confident that I am able to maintain *behaviour x* on the short / long term" (*maintain-self efficacy*)
- "I am confident that I am able to return to *behaviour x* even if I happen to give it up for three months" (*recovery-self efficacy*)

We followed the suggestion from Schwarzer et al. (2003) to either apply a 4- or a 7-point Likert Scale (ranging from 'completely disagree' to 'completely agree' or from 'not at all true' to 'exactly true').

Aizen (2006) suggested that the core factors of the *Theory of planned behaviour*, i.e. *Perceived Behavioural Control* (B), *Attitudes* (C) as well as *Subjective norms* (E) should be assessed directly as well as indirectly in an initial, explorative stage of the modelling process. Indirectly means to assess those three variables by assessing its underlying factors, i.e. b1) *Control beliefs* and b2) *Influence of control beliefs* for B, c1) *Outcome expectations* and c2) *Evaluation of consequences* for C, and e1) *Normative beliefs* and e2) *Motivation to comply* for E.

Items for *perceived behavioural control* have been formulated in different ways, for example in form of statements as suggested by Han et al. (2010, appendix 1, p.333):

- "Whether or not I try to perform / do *behaviour x* is completely up to me."
- "I am confident that if I want, I can try to perform / do *behaviour x*."
- "I have resources, time, and opportunities to try to perform / do *behaviour x*."

In many cases, the item format for the direct assessment of *attitudes* is a statement, followed by a semantic differential (e.g. Mayhew et al., 2009, Table 1, p.451):

- "Performing / Doing *behaviour x* within the next two months would be…"
    - Positive … Negative
    - Good … Bad
    - Pleasant … Unpleasant
    - Superior … Inferior
    - Thrilling … Boring

For the indirect measurement of *attitudes,* we define pairs of items, one for c1) *outcome expectations* and for the c2) *evaluation of consequences.*

- If I perform / do *behaviour x …*
    - …I contribute to the protection of the environment.
    - …I might need to spend some money.
    - …

For these potential *outcome expectations*, we have chosen a 7 point Likert Scale (ranging from 1 'very unlikely' to 7 'very likely'). For each of the items on *outcome expectations* an according evaluation-item has been formulated, for example…

- Protecting the environment is…
- Spending some money to perform / do *behaviour x* would be…
- ….

…that is followed by a 7 point Likert Scale (ranging from -3 'extremely undesirable' to +3 'extremely desirable').

For the direct measurement of *Subjective Norms*, following items have been selected:

- "Most people who are important to me think that I should try to do *behaviour x*" (Kim et al., 2013, p.175)
- "Most people who are important to me would want me to try to do *behaviour x*" (Han et al., 2010, p.333)
- "People whose opinions I value would prefer that I try to do *behaviour x*" (Han et al., 2010, p.333)

For the indirect measurement we identified five normative beliefs, for example:

- “Scientists think I _____ try to perform / do *behaviour x.”*
- “The authorities think I _____ try to perform / do *behaviour x.”*
- “My family thinks I ____ try to perform / do *behaviour x.”*
- ….

The response format is a 7-point Likert scale, ranging from ‘-3 should not’ to ‘+3 should’ which can be selected to complete the statement. Each e1) *normative belief* is complemented by an item on the e2) *motivation to comply*:

- “Scientists´ approval of my practice with regards to *behaviour x* is important to me.”
- “The authorities´ approval of my practice with regards to *behaviour x* is important to me.”
- “My families´ approval of my practice with regards to *behaviour x* is important to me.”
- …

For the *motivational cluster of variables*, the following items have been selected:

- “I want to perform *behaviour x* within the next 2 months.” (*Motivation*, based on Bagozzi, 1992)
- “I already made concrete plans to perform *behaviour x* within the next 2 months.” (*Volition*)
- “I intend to perform *behaviour x* within the next 2 months.” (*Intention*, based on Francis et al., 2004)
- “I expect to perform *behaviour x* within the next 2 months.” (*Goals*, based on Francis et al., 2004)
- “I already carried out *behaviour x* in the recent past.” (*Past Behaviour*)

As socio-structural factors and demographic variables we selected – in line with many of the studies mentioned in this section on operationalisation – the following (open response format and multiple choice in case of educational level):

- gender
- age
- educational level.

The final building block in the cognitive model is *behaviour* – behaviour in the sense of energy consumption in the fields of dwelling, mobility, and leisure activities. The operationalisation, i.e. assessment of energy consumption is done via own questionnaires (the so called energy matrix) which has been developed in the context of the CODALoop project. This energy matrix ideally delivers the energy consumption in the fields of dwelling, mobility, and leisure activities of an individual in terms of kWh.

METHOD

Three pairs of questionnaires have been filled out by 121 citizens from Graz and Leibnitz (Austria), Amsterdam (Netherlands) and Istanbul (Turkey), i.e. around 40+ datasets per country. With pairs of questionnaires we refer a) to the questionnaires aiming to assess the cognitive variables in the context of fields dwelling, mobility and leisure activities as well as to b) the appropriate elements of the energy matrix to determine the household's energy consumption in kWh. The 'cognitive variables questionnaires' consisted of 44 items. The three national teams in Austria Turkey and the Netherlands attempted to motivate residents in selected areas to fill out the questionnaires, either in paper-and-pencil format or by using the online platform.

EMPIRICAL DATA COLLECTION AND ANALYSIS

The participants of this empirical investigation were asked to fill out the energy matrix part first and the 'cognitive variables questionnaire' for a particular energy area (dwelling, mobility, leisure) afterwards. The reason for this is that the required thinking processes to answer the energy matrix should *prime* the participants for the appropriate cognitive variables questionnaire. The responses to the items of the cognitive variables questionnaire would thus be easier. The participants were informed that a certain 'pair' of questionnaires (i.e. energy matrix and cognitive variables for dwelling) should be filled out at once, and that they were of course permitted to have breaks between the questionnaire pairs (breaks of this kind could even last for days).

The items and variables of the cognitive variables questionnaire have been analysed with regards to the following items and variable characteristics (from highest to lowest priority for their selection for the empirically updated second version of the cognitive model):

- **Correlations of items and variables with *energy consumption:*** Considering the direction (plus vs. minus) and absolute value of the correlation coefficient with *energy consumption* as measured by the energy matrix. The direction of the coefficient should make sense from a conceptual point of view. For example, there are negative correlation coefficients (quite coherently for the different areas and countries) between *behavioural intention* and *energy consumption*; this means, that the higher the *behavioural intention* the lower the *energy consumption*.

- **Correlations of items and variables with *behavioural intention*** in the case of items and variables for *self-efficacy and perceived behavioural control*, *attitudes* and *subjective norms*. Direction (plus vs. minus) and absolute value of the correlation coefficient with *behavioural intention* were taken into account.

- **Normal distributions of the variables and items** as reflected by the *p-value of the Kolmogorov-Smirnov test*.

- **Item distribution characteristics** as reflected by *z-value for skewness* and *z-value for kurtosis.*

RESULTS

The initial plan was to define several cognitive models, separately for the different countries (Austria, Netherlands and Turkey) and the different energy areas (dwelling, mobility and leisure activities) if necessary (i.e. in case there are different main variables and factors for the different countries and / or areas). However, due to empirical evidence, i.e. our data analysis, this plan was revised and adjusted. Instead of having a series of separate cognitive models for the different countries and/or areas, there is one cognitive model, operationalized through a set of items which is basically the same for all countries and areas.

REFINEMENT OF THE COGNITIVE MODEL BASED ON EMPIRICAL RESULTS

The empirically updated, second version of the cognitive model consists of 9 variables and the according questionnaire consists of 15 items. They are basically the same for all countries (Austria, Turkey, the Netherlands) and all energy areas (dwelling, mobility, leisure activities). However, they are not identical, because the correlations and weightings between different variables, between variables and items of the questionnaire, etcetera, differ for the different countries and energy areas. As an example of this there is a higher positive correlation between *social norms* and *behavioural intention* (to reduce energy consumption) in the case of mobility (r = .441) than for leisure activities (r = .280). Using the same cognitive model for all countries and energy areas enables us to further interpret these different weights and correlation coefficients. In other words, to better understand energy consumption in different contexts; understanding of a) what are the main factors and variables that contribute to energy consumption and b) understanding how these factors and variables interact with each other.

The empirically updated cognitive model is shown in figure 12.

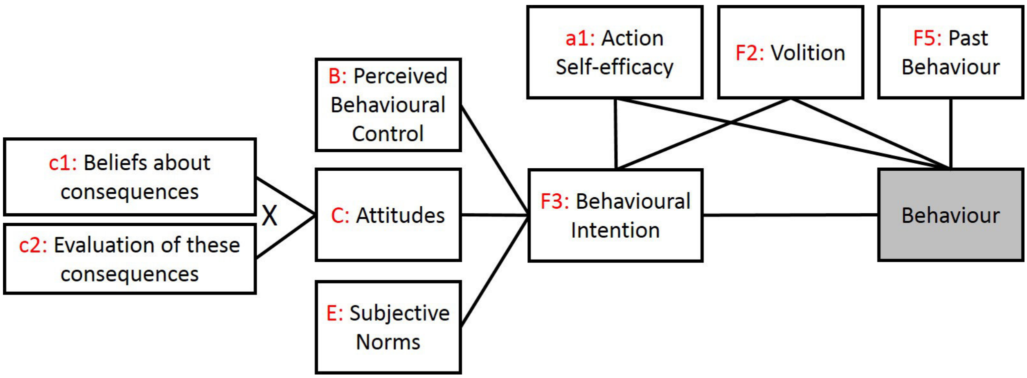

Figure 12 Final cognitive model.

The connecting lines between variables represent correlative relationships rather than causal relationships; except for c1 (*Beliefs about consequences*) and c2 (*Evaluation of these consequences*) on the one side and C (*Attitudes*) on the other side – in these cases the line should be read as 'c1 x c2 constitutes C' (indirect measurement).

There are three pairs of items for 'c1 x c2,' i.e. six items for the indirect measurement of *Attitudes* as well as two items for their direct measurement. There is one item for *Perceived Behavioural Control*, *Action Self-efficacy*, *Volition*, *Behavioural Intention*, and *Past Behaviour*, respectively. And finally, two items have been selected for the direct measurement of *Subjective Norms*.

This results in 15 items – compared to 44 items of the initial questionnaire.

CONCLUSIONS AND OUTLOOK

The final outcome of the empirical data collection and analysis is an updated cognitive model with a reduced number of variables that are predictive for the behaviour (i.e. energy consumption) of individuals in the areas of dwelling, mobility and leisure activities. As mentioned above, the relations between the variables are correlative rather than causal. Causal relationships can be assumed based on other empirical studies; in some cases, they could be logically deduced (e.g. *past behaviour* may have an impact on current or future behaviour, not the other way around). The ideal case would be either much larger data-sets to conduct other analysis methods such as structural equation modelling as it is outlined below, or a series of experiments where independent variables can be manipulated and dependent variables can be observed.

Structural Equation Modelling (SEM) allows the eliciting of (linear) relationships between many variables. Some proponents consider these relationships as causal, but this is a highly disputed premise (Bollen & Pearl, 2013). Compared to multiple regression analysis, there is not only one criterion variable which is explained by a multiple set of predictor variables – in the case of SEM, predictors are sometimes criterions by themselves, i.e. more complex structures can be modelled. The relationships between the (latent) variables is termed the structural model. 'Latent variables' refer to 'not-directly observable variables.' The structural model can be expressed via path diagrams. In the case of a SEM, the relationships are usually linear regression equations. A *measurement model* shows the relationship between one latent variable and a set of observable variables (= usually items). Thus a SEM generally consists of one structural model and several measurement models. Due to increasing computational power, SEM has enjoyed increasing popularity over the past decade. The *Theory of planned behaviour* in particular has been empirically validated by SEM (e.g. Manetti et al., 2004; de Leeuw et al., 2015).

As mentioned above, SEM requires very large data-sets to elicit relationships between the variables. On the other hand, even a smaller set of items may be considered as 'large data-set' for the individuals who are willing to fill out the questionnaire. The items and variables are considered as 'state' rather than 'trait' concepts. This means, the response patterns of the individuals is an evaluation at this particular point in time: *motivation*, *perceived behavioural control*, etc. may change over time. The questionnaires should be filled out before and after a certain *intervention*. In this case the effects of such interventions could be made explicit. Adaptive assessment procedures enable to reduce the amount of items proposed to the user.

One of such adaptive assessment procedures is based on the Knowledge Space Theory (KST) (Doignon & Falmagne, 1985, 1999). The KST focuses on mutual dependencies, so-called prerequisites, between the items. For example, a person who gives a certain response to item y (e.g. 'yes') may respond in the same way to other (binary) items, too. In this case problem x is called 'a prerequisite' of problem y (also denoted as $x \leq y$). In the case of the KST, the prerequisite relations are derived by theoretical considerations (e.g. by querying experts of the knowledge domain). The Inductive Item Tree Analysis (IITA) (Schrepp, 2003, 2006) is a 'data-driven' method to derive hierarchical dependencies between the items of a questionnaire. The underlying idea and the main principles of IITA originate from the ('classical') item tree analysis (CITA, Van Leeuwe, 1974). Based on the person's response to one item, we can surmise his or her responses to other items, and as a result we are able to provide a smaller subset of items for a questionnaire.

A surmise relationship of this kind, which in the case of the IITA is known as the 'implies-relation,' possesses properties that are *necessary but not sufficient* for causal relationships. For example, let us consider that there is an implies-relation between *motivation* and *behavioural intention* in the sense that motivation implies behavioural intention. This means, that a vast majority of people who are motivated also possess behavioural intention, *but not* vice versa (as would be the case of a positive correlation between these two variables). However, this is not sufficient to claim a causal relationship in the sense that motivation causes behavioural intention. A chronological order in the sense that one (cause) follows the other (effect) would be required at the least for this. Differences between the implies-, entails-, dependence relations and the logical consequences of these from a formal point of view have been described by Düntsch and Gediga (2001).

The main advantage of the IITA and similar approaches is that the deduced mutual dependencies between items enables intelligent adaptive assessment procedures, as outlined above. This would reduce the time required to fill out the questionnaire on a regular basis, for example before and after an intervention. A cognitive model that is based on an implies relation, or surmise relation, would also allow the provision of personalised treatments and interventions. Depending on the current state of the user, as evaluated by the adaptive assessment procedure, targeted interventions could by applied, e.g. an intervention that focuses on raising *perceived behavioural control* by elaborating – together with the user – behavioural alternatives, workarounds or potential synergies and collaborations with others, e.g. other residents in the neighbourhood.

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5 ENGAGING 'COMMUNITIES FOR ENERGY PRACTICE' IN GRAZ REDEVELOPMENT AREAS AND LEIBNITZ

Cases, Approaches, Reflections

GOSIA STAWECKA, HANS SCHNITZER, BARBARA HAMMERL AND WOLFGANG HORN

PART 1: INTRODUCTION

The current strategies for energy transition reflect the technological, commercial and industrial prevalence. However, little is known on how it is possible to promote behavioural change on a societal scale or which conditions can best accommodate strategic citizen engagement in the context of energy transitions. Lifestyle change is a distributional issue as well as a problem of motivating changes in behaviour, attitudes and values (Peters, 2010). In other words, individual change is much more likely if it is part of a collective shift (idem). This requires focusing on new forms of participation and social interaction that steer mutual learning between the individual, the community and other urban actors, while influencing changes in common values as well as individual choices in lifestyle.

Participatory approaches, including living labs and experimental approaches are increasingly considered important tools that foster motivation, participation and mutual learning, thus supporting social innovation. For the purpose of the CODALoop project, the action approach to deal with energy lifestyles in Graz and Leibnitz was designed and structured based on three different dimensions, the so-called learning feedback loops :

- **Individual feedback loop**, aiming at understanding individual learning processes that enable behavioural change in energy choices through providing access to information.

- **Individual to community feedback loop**, aiming at triggering collective learning resulting from interaction between individuals and groups of people.

- **Community to policy feedback loop**, aiming at supporting learning processes between groups of people as well as policy representatives and other experts.

In order to apply this 'action approach' in practice and to draw scientific conclusions, the project team has designed several tailored participatory formats and methods and implemented them in testbeds in Graz and Leibnitz, both cities located in the province of Styria in southern Austria. In line with living lab key principles such as co-creation, inclusiveness, and experimentation, these interventions were designed as social interactions in a way to allow three different types of learning: a) participatory formats that aim at reflecting on individual energy consumption (*individual feedback loop*), b) participatory formats that support learning processes through an exchange with other community members *(individual to community feedback loop),* c) formats that promote dialogue and exchange with energy policy makers and other energy experts *(community to policy feedback loop).*

The overall goal of this chapter is to analyse and discuss the impact of participatory approaches and formats implemented in testbeds in Graz and Leibnitz in the process of facilitating learning and behavioural change towards more energy efficient lifestyles. Based on a series of case studies from the practical work in the testbeds Waagner-Biro and Reininghaus in Graz as well as in Leibnitz, this chapter comprises theoretical and strategical considerations about engaging communities towards more energy-efficient lifestyles in urban context. What has proven itself successful and what are specific bottlenecks and barriers? Lessons learned from implementation of methods and interventions in the three Austrian testbeds are summarized, providing some insights with regard to the importance of designing context-specific interventions that increase people's motivation to change their energy-related behaviour.

PART 2: THE APPROACH AND THE PROJECT

2.1. THEORETICAL CONSIDERATIONS AND METHODOLOGICAL APPROACH FOR DESIGNING INTERVENTIONS IN AUSTRIAN TESTBEDS

2.1.1 Smart City Graz Strategy as an important tool for sustainable energy transition

In the course of the last years, the academic world has adopted a range of different understandings of 'smart cities.' For many of them 'smart cities' encompass human capital, education, social and relational capital, environmental interests, besides ICT infrastructure (Ryser, 2014).

Nowadays, there is rarely a city that does not describe itself as 'smart' or at least strives for 'smartness.' Back in 1992, at the UN Environment Summit in Rio de Janeiro, Chapter 28 of the 'Agenda 21' called on all municipalities to support the implementation of sustainability at the local level. The current challenges are to show people that all aspects of a sustainable city, including mobility, dwelling, energy, or consumption have an impact on their quality of life (Hammerl et al., 2014).

In the wake of the project 'I live Graz' (Klima- und Energiefonds, 2012) a vision for the Smart City Graz 2050 has been developed. This strategy document forms the basis for a smart and sustainable urban development of Graz and comprises the so-called '7+1 fields of action,' including energy and resource efficiency, promotion of soft forms of mobility or energy-efficient technologies, as well as enhanced citizen participation, among others.

Two out of three Austrian testbeds (Waagner-Biro and Reininghaus Süd) within the CODALoop Project are located in the area delineated as Smart City Graz. Within the next 10 years this area is to be developed into a lively and 'smart' district with modern technologies for a sustainable energy supply and resource conservation. On the other hand, Leibnitz currently runs a program that aims at making the city more resilient. This program covers aspects including energy efficiency, urban greening as well as mobility. The residents living in the immediate vicinity of the new development area are particularly affected by these changes, see figure 15 for overview of Leibnitz area. In the Waagner-Biro testbed, the StadtLABOR is responsible for district management 'vor.ort' which aims at increasing acceptance for the transformation processes among the residents, as well as raising awareness for the 'smart city' topics.

2.1.2 The three Austrian testbeds

TESTBED 1: 'WAAGNER BIRO' SMART CITY DISTRICT, GRAZ

The 'Waagner Biro' Smart City district in Graz is currently under development on a former industrial area as a mixed-use sustainable district until 2020, see figure 13. The area is expected to accommodate up to 3,500 residents and offer 1,000 jobs on 127,000 m2. The development area will include a public park covering 11,000 m2, a school campus and several demonstration projects for advanced energy production and energy efficiency, among others. In future, this area will be connected by a tram-

Figure 13 Smart City Graz Waagner-Biro Aerial. Green: City District / cyan: Smart City Quarter / white: CODALoop Testbed. Source: Satellite Image: Google Earth

line. The energy-generating infrastructure includes a 60-meter high Science Tower, inaugurated in 2016 as demonstration building within the framework of the 'Smart City Project Graz Mitte'. Currently 3,500 people live in the CODALoop test-area, including the neighbourhood consisting of residential apartment buildings from the 1960s and the 1990s as well as single-family houses. Moreover, two large apartment buildings have been finished between 2016-2018 and accommodate 1,300 newcomer residents. Since 2014 a district management 'vor.ort' is operating in this area as a hub between local residents, businesses and investors as well as the City of Graz. At present, the area is partially supplied by the district heating system and partially by individual heating units.

TESTBED 2: REININGHAUS AREA, GRAZ

In the western part of Graz, the Reininghaus Area is currently under development to a ‘smart urban neighbourhood’ (figure 14). Located just 1.8 km away from the city center, the former area of the Reininghaus brewery encompasses 110 ha and will be developed as a mixed-use district to be finished by 2025. A low temperature district heating system is planned to be developed in future using mainly renewable energy and waste heat from a neighbouring steel mill. Within the research projects ‘ECR Energy City Graz-Reininghaus’ and the sub-project ‘RPE_ECR –

Figure 14 Graz-Reininghaus Aerial. Source: Satellite Image: Google Earth

Framework-Plan Energy City Graz-Reininghaus' urban strategies for the conception, realisation and operation of an energy-efficient and an energy-self-sufficient network have been explored. A first demonstration project '+ERS Plus Energy Network Reininghaus Süd' resulted in a self-sufficient mixed-use city quarter for 500 people in the southern part of the Reininghaus area; further parts of the area are currently under construction or in the planning phase.

TESTBED 3: LEIBNITZ

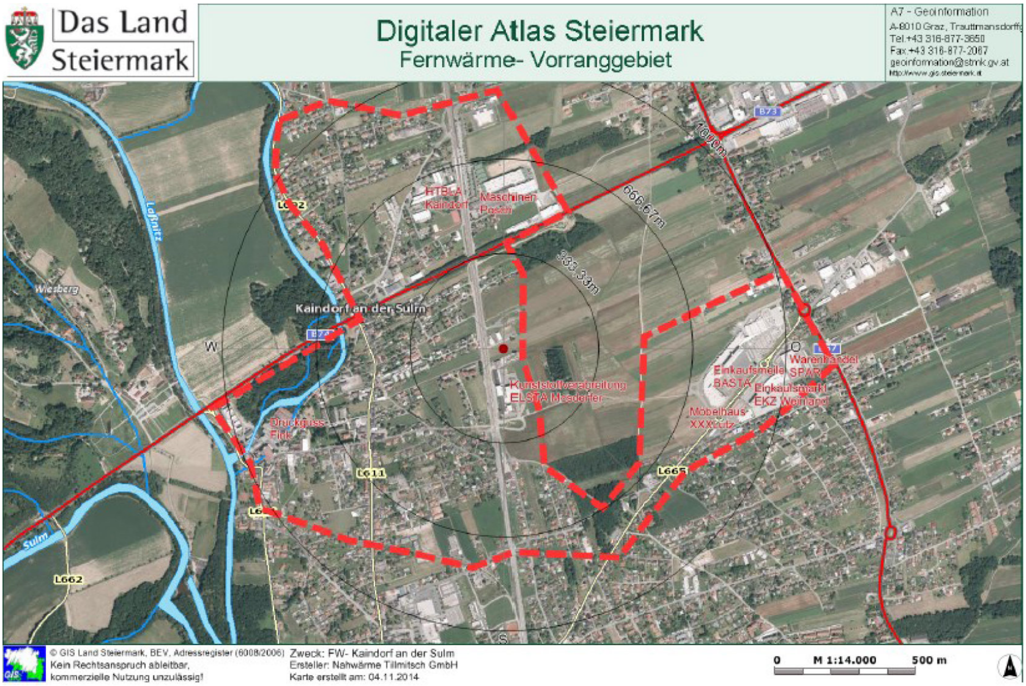

Figure 15 Testbed Leibnitz. Source: Das Land Steiermark

2.1.3 Role of citizens and social learning in the process of sustainable energy transition

The current strategies for energy transition reflect the technological, commercial and industrial prevalence. But there is growing recognition that innovation only happens if it develops as a social practice, if it changes habits. A shift in the innovation process is therefore needed, which focuses not only on technological change, but also on societal change, including cultural and behavioural aspects, which can be defined as social innovation. Social innovation can be also described as “the generation and implementation of new ideas about how people should organize interpersonal activities, or social interactions, to meet one or more common goals” (Bergman et al., 2010, p.4).

There is a growing recognition that citizens play a crucial role in the process of energy transition as drivers of innovation and change and as smart consumers, as co-producers of energy (prosumers) and investors. This process involves both creating new social institutions or movements (such as cooperatives or community-owned projects) as well as new financial and business models that would “increase acceptance of local change and awareness of energy consumption” (Morris & Pehnt 2012, p.30). Urban citizens have to build not only knowledge, but also capacities and skills to assume new roles and responsibilities or adopt new habits. This requires more inclusion of citizens in urban development processes and new forms of collaboration and organization on the one hand, and enhanced learning and adaptation processes that enable behavioural change towards reduced energy use on the other hand. However, little is known on how citizen-driven innovation works in the context of energy transition and which policy conditions can best accommodate strategic citizen engagement.

There is a growing recognition that innovation originating from small-scale local projects plays an important role in bringing about sustainable energy transition. There is plenty of literature on the role of civil society as change agent, able to create niches where new ideas and practices can be developed, (Seyfang et al., 2013; Hargreaves, 2013; Smith et al., 2013). Transition initiatives organized by civil society offer practical activities which provide a valuable platform for social learning. Through enhancement of community-based activities, better public engagement can be achieved, which brings also many benefits, including “cost savings, pleasure, sociability, sense of achievement, community, self-expression” (Seyfang & Haxeltine 2012, pp.394-395). While education can provide a valuable way of raising awareness, it does not constitute a prerequisite for lifestyle change. However, through attracting a wider range of participants, it can contribute to meeting expectations (idem).

2.1.4 Participatory approaches to foster social learning

Participatory approaches, including living lab and experimental approaches, are increasingly considered to be important tools that foster motivation, participation and mutual learning, thus supporting social innovation. Recent years have seen a rapid expansion of living labs as ‘vehicles’ for addressing social and environmental challenges. A ‘Living Lab’ as a temporary transdisciplinary platform for exchange can significantly support transformation processes by addressing relevant questions and creating a space for innovation and cooperation. (Hammerl et al., 2016). Depending on the goals of ‘Living Labs,’ they can focus on networking between different actors *(connect),* on inspiring on a topic *(awaken the spark),* on initiating new projects or ideas *(incubate),* on supporting and accelerating new ideas *(accelerate)* or on exploring new subject areas *(illuminate)*, see figure 16 for an overview (Tiesinga & Berkhout, 2014).

The most important principles of ‘Living Labs’ include opening of development processes and inclusive participation, design of suitable dialogue, learning and cooperation formats and spaces, as well as co-creation, experimentation and prototyping. Through interaction, practical testing and experimentation using ‘hands-on formats’ the gap between thinking and acting can be reduced and complex problems can become more tangible. The integration of playful learning elements and gamification principles can increase the motivation of people who otherwise have to perform tasks that are less challenging, too monotonous or too complex.

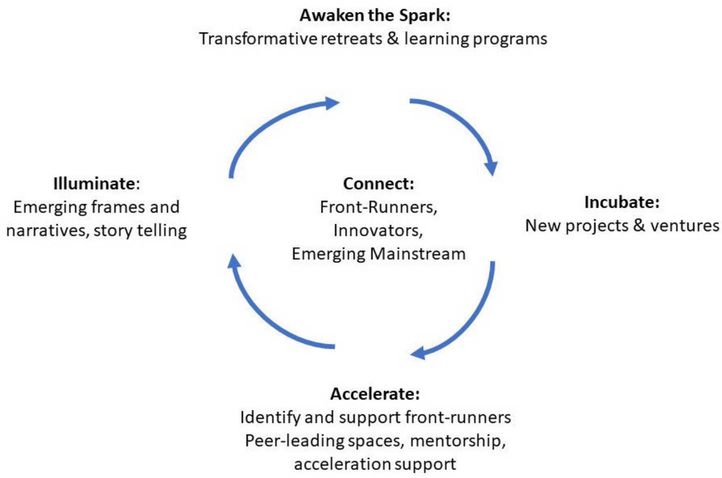

Figure 16 Different functions of 'Living Labs' (Tiesinga & Berkhout, 2014)

2.2. PARTICIPATORY APPROACHES IN PRACTICE

The StadtLABOR uses a holistic and practice-oriented approach in order to deal with sustainable urban development and transformation processes in cities. The focus is on social innovation, new forms of cooperation and inclusive participation, whereby the principles of 'Living Labs' are guiding all activities. In order to develop a platform to support learning and adaptation feedback between the local community and experts the team in Graz has organized a series of face-to-face group meetings in the three testbeds.

In the following part, experiences from implementing different participatory formats within the CODALoop project will be presented. Lessons learnt will be discussed. The interventions presented below have been chosen in consideration of all three feedback loops: individual, individual to community (neighbourhood) feedback and community to policy (utility companies, administration, politicians) feedback loops.

For the purpose of analysing the participatory methods and interventions in the Austrian testbeds a qualitative and explorative approach based on observation and discussion during interventions was used. As participants in Austrian testbeds expressed little interest towards using the online-platform, the access to quantitative data for analysing energy consumption, as originally planned, was limited. The qualitative analysis allowed to gain a deeper understanding of the effectiveness of interventions implemented in Austrian testbeds as well as to identify successful factors and bottlenecks of those interventions.

2.2.1 Case Study: Stadtmahlzeit in Waagner-Biro (community to policy feedback loop)

One of the events organized in the context of the CODAloop project was the so-called *Stadtmahlzeit* ('City Lunch'): 'Strategies for climate-friendly behaviour in everyday life' which took place at the Science Tower, an iconic energy efficient building located in testbed Waagner-Biro, see figure 17. *Stadtmahlzeit* is an open, participatory format based on the Living Lab approach during which all interested people discuss different topics related

Figure 17
Stadtmahlzeit "Strategies for climate-friendly behaviour in everyday life" (November 5, 2018). Credits: Sibyelle Braunegg, StadtLABOR

to urban development, while having lunch together. *Stadtmahlzeit* creates an open environment allowing for exchange between residents and stakeholders in the field of energy and mobility in Graz as well as creating more awareness towards more energy efficient lifestyles.

After a short input by the CODALoop project partners, four tables formed discussion rounds. The following questions have been discussed during the meeting:

- Which strategies for changing energy behaviour in the domains of housing and mobility are promising? Which challenges, barriers and solutions are there for implementing these strategies?

- How can motivation be encouraged among energy consumers?

- How to increase the interest / awareness / participation of consumers in relation to energy topics?

Thanks to a wide diversity of participants good conditions for an interdisciplinary exchange at eye-level were created, allowing also residents to get a more comprehensive picture of the topic at hand. The protocol with results has been sent to all participants, thus securing the results and providing an additional written feedback loop between community and policy.

Following the workshop, residents from the testbed Waagner-Biro present during the workshop were asked to fill out a short survey in the form of a postcard related to their own energy-saving potential (as shown in figure 18). The timing of the survey was particularly appropriate, because the residents had just intensively discussed the topic as well as exchanged their views and experiences with experts and other interested persons. This allowed, in turn, a deeper reflection on the individual energy-saving potential.

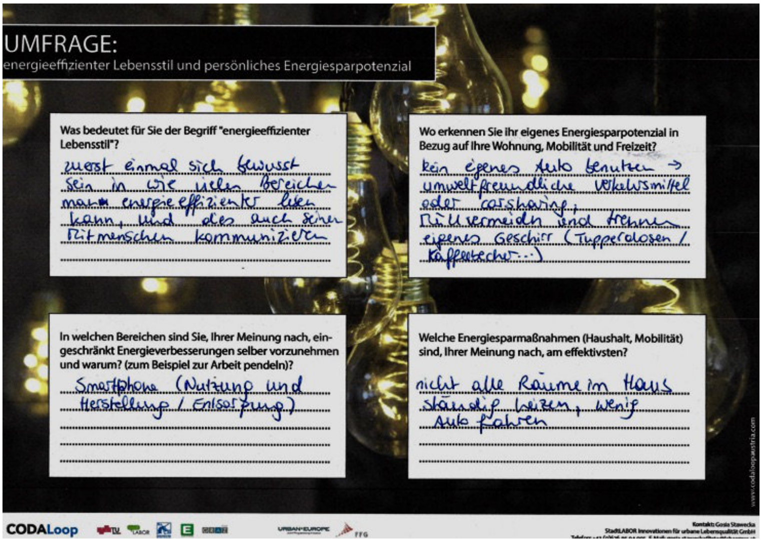

Figure 18 An example of a survey "personal energy saving potential"

2.2.2 Case study: Theme-specific interventions in Reininghaus-Süd (individual to community feedback loop)

Two different meetings aiming at supporting community exchange took place in the testbed Reininghaus Süd. Reininghaus Süd is one of the first 'plus energy neighbourhoods' in Graz. During the first CODALoop information event held in the parking area in front of a supermarket, neighbours have gained first-hand information on the energy contracting and facility system of their city district. The neighbours were able to discuss with participating experts the advantages and implications resulting from living in a passive building district, see figure 19.

Moreover, the CODALoop project partners organised a follow-up meeting to discuss the most significant topics in the city district 'Reininghaus Süd' collected during the first introductory meeting (figure 20). The participants expressed particular interest in the topic 'sharing mobility.'

Figure 19 CODALoop information event (July 4, 2018). Credits: Ernst Rainer, TU Graz

Figure 20 Follow-up meeting (September 18, 2018). Credits: Gosia Stawecka, StadtLABOR

2.2.3 Case Study: Participatory format using experimentation (individual to community feedback loop)

The testbed Waagner-Biro was also the location for an intervention aiming at individual learning through experimenting and practical group work to increase awareness on energy efficient lifestyles within the domain ‘dwelling.’ The task of one group was to detect the heat loss of buildings by using a thermal imaging camera, while another group was dealing with the measurement of the energy consumed for cooking water on different cooking plates (induction, electric). The groups documented the work using protocols. Thanks to numerous AHA-Moments learning processes among local community has been triggered.

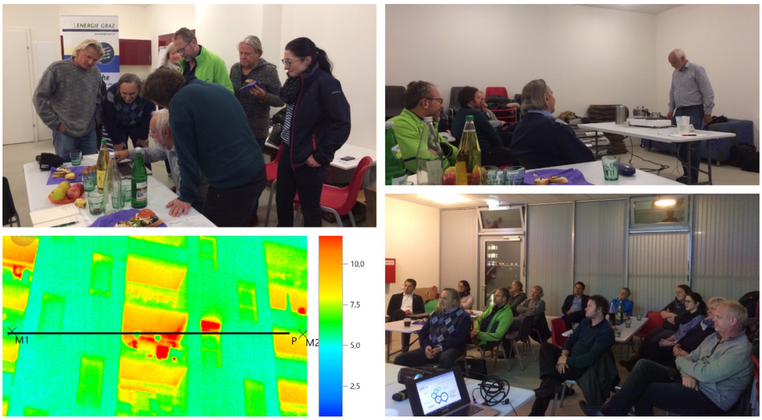

Figure 21 Intervention with neighbours aiming at individual learning through experimenting and practical work on tasks in groups. Credits: StadtLABOR

2.2.4 Case Study: Participatory format using gamification principles (individual and individual to community feedback loop)

In order to create more awareness for different simple measures that support an energy efficient lifestyle (domains: dwelling, mobility, leisure) as well as to foster exchange of ideas between neighbours, a photo contest: “Show your neighbours how energy efficient you are in your daily life" has been organised in testbeds Waagner-Biro and Reininghaus Süd, see figure 22. Different energy saving tips were published regularly on the CODALoop website to support the process of generating ideas. The original plan was to display all photos at the final photo exhibition, followed by the reflection of the presented solutions and energy-saving measures implemented by the neighbours. However, due to insufficient participation, the exhibition was not organized.

2.2.5 Case study: Leibnitz

Leibnitz, a small town with about 13,000 inhabitants, differs strongly from the testbeds in Graz. The center of Leibnitz has a grown structure and shows much higher proportion of privately owned houses and apartments. In the context of the CODALoop project, three major event formats have been implemented: events with around 50-100 participants for raising general awareness on energy-related topics, small-scale events with 10-20 participants including excursions to energy-related POIs ('energy safari') and several face-to-face meetings.

Figure 22 Invitation to photo contest: "Show your neighbours how energy efficient are you in your daily life"

PART 3: INTERPRETATION OF THE RESULTS FROM THE INTERVENTIONS

The project has shown that some of the interventions were well frequented, however, some of them had a very limited number of participants. Moreover, the development of a 'community of practice' was not possible. What are the underlying reasons for such a development? What has proven to be successful and what are specific bottlenecks and barriers? Based on a series of case studies from the practical work presented in part 2, this part of the chapter comprises a summary of lessons learned. The implementation of methods and interventions in the three Austrian testbeds provided significant insights regarding the importance of designing context-specific interventions that increase people's motivation to change their energy-related behaviour. Lessons learned and important insights regarding the activities in Austrian testbeds are summarized as follows:

- In spite of digitalization, **offline formats and face-to-face interaction are vital** in promoting motivation. The online-platform gained little interest in Austrian testbeds, therefore, the importance of such a digital platform has been questioned.

- Interventions are more successful if the contents are not presented in a general way but **address specific issues that directly affect the people in the district** (specific problems with personal relevance). The involvement of policy makers and experts in this exchange process is important. The theme-specific intervention on energy contracting and facility system in the city district Reininghaus Süd is a successful example.

- Complexity of a topic vs. participation: **Energy is a complex and challenging topic,** and as such, it seems to be intangible for ordinary people. It is therefore important to break down the contents from the very complex, metaphysical project level. Moreover, the invitation to an event must be designed in an attractive way: simple language, questions that arouse curiosity, stressing personal concerns.

- **Energy consumption (as well as climate change and its consequences in general) is a typical 'problem of the commons.'** Most people have no understanding for complex connections between weather, energy, CO2-emission etcetera. In addition, the real costs for massive energy consumption and the associated climate change are carried by the countries particularly affected by changing weather patterns, like Africa of South America or will be transferred to future generations.

- Some topics, such as urban green, are considered more **'emotional'** which generally results in higher level of participation. Unfortunately, energy is not such a topic. The emotional aspects of the topic, such as air pollution, health or intergenerational concerns, must be strongly communicated in the acquisition and marketing phase of future energy-related projects.

- A great potential lies in **testing of novel formats for dialogue, learning and cooperation** as well as chosing low-threshold places where **people from different backgrounds can meet informally**. *Stadtmahlzeit,* where experts and neighbours gathered together over lunch to discuss energy-related topics, can be considered a successful example.

- **Outreach work** inside the neighbourhoods is needed especially in the initial part of the project **in order to create awareness towards the project and increase trust**.

- **Assessment of needs** before planning an intervention: It is important to find out, based on everyday conversation, what are the real needs of the affected people. A collection of topics of interest is crucial, as proved to be successful in the testbed Reininghaus Süd.

- It is important to introduce **new, unusual, creative aspects** to the participatory interventions: **playful elements, testing, trying new things, documenting** (e.g. using a thermal imaging camera). This could serve as a trigger for working on a broader topic, as it has been shown during the participatory format using experimentation in the testbed Waagner Biro.

- Despite incentives, participatory formats requiring additional effort are not well accepted (as it has been shown in the case of the photo competition organized in testbeds in Graz). Therefore, **short, compact formats** (event series) would be preferred in future instead of time-intensive, isolated over time events. Assuring **continuity through the events** help anchor the issue at hand within a community.

- Long-term behavioural change is only possible if it leads to **measurable or at least tangible individual benefits**, such as a perceived higher quality of life (Am I healthier if I cycle to work every day?) or lower household costs. Experience from the meeting with stakeholders (*Stadtmahlzeit*) organized within the framework of the CODALoop project shows that information and knowledge alone are not sufficient to change habits and behaviour. In order to turn knowledge into action, people must be (intrinsically) motivated. In order to increase the motivation **new approaches addressing the real needs as well as the emotional side of people** have to be implemented. It is therefore important not only to inform people during the interventions and to point out certain measures and potentials towards energy saving, but above all **to show the added value**. Public opinion can be shaped through exchange with different stakeholders.

- In towns like Leibnitz **the self-efficacy and perceived behavioural control** over the living environment (i.e. investments in refurbishment, solar panels) **seems to be bigger.** Smaller towns tend to have rather grown structures and the majority of people own their houses and flats (contrary to bigger cities like Graz where most people rent the flat). Consequently, these groups seem to have a higher motivation to participate in energy transition processes, becoming prosumers or energy producers among other things.

PART 4: CONCLUSIONS

The results of the project have shown that not all successful interventions are scalable in all neighbourhoods but are rather very context-specific and audience-specific. It has been shown that knowledge level, motivation and interest differ across neighbourhoods. Therefore, is it crucial to first analyse the real needs and interests of people, involving them in the process of planning and designing interventions. Differences between the test beds ‘city’ and ‘town’ (in this case Graz and Leibnitz) can be considered crucial factors because of different forms of housing ownership and the grade to which energy consumption and the use of technologies can be influenced. In Leibnitz, for instance, where the majority of people own their houses, the self-efficacy and perceived behavioural control over the living environment is higher. Several open questions remain when it comes to planning future interventions in order to increase interest and participation. How can the topic ‘energy’ be made more tangible to ordinary people? It would be necessary to re-think the language used in any format to reduce the complexity of the topic and to brake it down from a meta-level. During the acquisition and marketing phase of any future energy-related project more emphasis should be put on the emotional aspects of the energy, such as air pollution, intergenerational concerns or health.

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6 MAPPING ENERGY FRAMES: AN INNOVATIVE APPROACH

Engaging with New Forms and Types of 'data' in Social Media Analysis to Frame Energy Demand

ANDREA MAURI, ALESSANDRO BOZZON AND ROOS DE KOK

INTRODUCTION

Understanding how individuals consume energy is considered to be a fundamental step in improving energy conservation and stimulating energy efficiency.

Multiple studies have shown how feedback loops encourage energy conservation and efficiency among policy makers and citizens. Fischer (2008), for instance, explores the ways in which a sense of competition, social comparison, and peer pressure impels people to adopt better energy consuming behavior. The online platform 'Social Electricity' allows citizens to compare energy footprints with friends, neighbors, or other users. This process, Kamilaris, Pitsillides, and Fidas (2016) argue, affects people's energy awareness, making them more sensitive to the environment and motivating them to behave more sustainably. Many other energy-saving applications have been developed (Albertarelli et al., 2018), which exploit gamification and social interaction to promote energy-efficient lifestyles.

All of these studies are only effective, however, insofar as we thoroughly understand which energy-consuming activities people perform and how they carry them out. By energy-consuming activity, here, we mean a practice that impacts energy consumption, whether directly or indirectly.

To date, researchers have used multiple methods to collect insights about energy-consuming activities. Smart meters and smart plugs provide aggregate data on domestic energy consumption. Looking at different current waveforms and voltage signatures makes it possible to isolate the signal of the single appliance (Froehilich et al., 2011; Weiss, Helfenstein, Mattern, & Staake, 2012; Parsa, Najafabadi, & Salmasi, 2017). For their part, surveys and interviews, if planned correctly, can potentially break down energy overall consumption data into detailed end uses (Vassileva, Wallin, & Dahlquist, 2012; Torriti, 2017).

In presenting composite readings, comprising both sensors and answers to ad-hoc questions, the aforementioned sources are especially reliable in terms of quantitative data and qualitative information. Nonetheless, they come with several drawbacks. Smart meters and plugs are costly to set-up. What is more, the data that they provide lacks of contextual information, and often not publicly accessible. Further still, their disaggregation of data is far from perfect (Froehilich, et al., 2011). Conducing and processing surveys and interviews is too time consuming to perform frequently.

However, hundreds of thousands of people use social media daily, sharing texts, videos, and pictures related to their activities. Unlike traditional data, social media offer semantically rich information, not to mention frequent, high-granular updates that cost little or nothing to extract. For these reasons, researchers have been using social media to study human practices (Zhu, Blanke, & Gerhard, 2016; Bodnar, Dering, Tucker, & Hopkinson, 2017) such as travel behavior (Bocconi, Bozzon, Psyllidis, Bolivar, & Houben, 2015; Rashidi, Abbasi, Maghrebi, Hasan, & Waller, 2017; Zhang, He, & Zhu, 2017), modes of transportation

(Zhang, He, & Zhu, 2017), and nutrition patterns (Fried, Surdeanu, Kobourov, Hingie, & Bell, 2014; Abbar, Mejova, & Weber, 2015; Fard, Hadadi, & Targhi, 2016).

Our hypothesis is as follows: since posts on social media refer to daily activities, they are either directly linked to energy-consuming activities or contain information about them in their semantic signature. Hence, by processing the content of a social media post, it should be possible to extract information about the energy consuming activity to which it refers. Through detailed analysis, we aim to answer the following research question: *how useful is social media as a complementary source of information in describing energy-consuming activities?*

In this chapter, we refer to four types of energy-consuming activity: (1) *dwelling*, (2) *food consumption,* (3) *leisure,* and (4) *mobility.* This typology – which is based on previous studies (Tukker et al., 2006; Backhaus, Breukers, Mont, Paukovic, & Mourik, 2013) – includes a wide range of practices impact upon lifestyles' energy footprints. Here we are interested in individuals' energy consumption; accordingly, we have set activities related to labor and industries aside. *Dwelling* encompasses the use of home appliances (e.g. washing machines and dryers); *mobility* refers to the energy required in moving among places; *food consumption* includes the use of resources for preparing, processing, and consuming food; and *leisure* refers to the energy used to perform recreational activities (e.g. watching tv, playing videogames, and socializing).

It should be remembered, though, that social media also come with disadvantages. They are biased toward a certain demographic (e.g. young people) and they can be noisy and ambiguous – this is only to be expected, since their original purpose was not to share energy-consuming activities. We will broach these drawbacks in the course of this chapter.

To address the challenges, we created an energy-consuming activities ontology, which has allowed us to identify important concepts and see how they are interrelated. It provides a structured body of knowledge about how social media posts are connected with practices in the physical world. We designed a data processing pipeline, which extracts information about energy-consuming activities from social media posts. Composed by different modules, this pipeline collects social media posts from different sources (Twitter and Instagram); enriches the data (e.g. by annotating the images); classifies the posts according in the four categories of energy-consuming activity established above (using a dictionary and rule-based classification algorithm); and, finally, publishes the information obtained in the previous steps in the JSON-LD format, presenting them as instances of the ontology in question.

Starting from our work published in de Kok, Mauri, & Bozzon (2019), this chapter elaborates on the challenges addressed in developing an energy-consuming activities ontology and data-processing pipeline. In addition, we reflect in more depth on the potential and weaknesses of our approach, before proposing future applications. The remained of this chapter is structured as follows: first we summarize the design of the ontology and data-processing pipeline, highlighting the challenges that arose during their development. We report their use in two case studies, Amsterdam and Istanbul, unpacking both the strengths and weaknesses of our approach. Finally, we discuss our results, proposing possible future research directions that can be built upon our research.

THE SOCIAL SMART METER ONTOLOGY

In creating an ontology, we intend to understand and unambiguously conceptualize, the domain of energy-consuming activities. This, we hope, will facilitate interaction among different fields of study interested in energy consumption. To do so, we aim to identify significant concepts and showing how these are interrelated, establishing terms for describing and representing this domain in a structured way that can be read by machines. While it not may be useful for end users, the ontology has allowed us to design the data processing pipeline described in the next section and others might use it to develop an IT framework in this field. Moreover, the ontology makes it possible for external services to seamlessly integrate our pipeline's outputs into their process.

To build the ontology, we used the guidelines provided by the 'Methontology' approach (Fernandez-Lopez, Gomez-Perez, & Juristo, 1997), a well-structured process for building ontologies from scratch. The requirements were defined by competency questions as provided in Suárez-Figueroa, Gómez-Pérez, & Villazón-Terrazas (2009).

Table 7 shows the competency questions created to define the ontology. We are interested in associating specific people with different energy-consuming activities. We want to understand where and when these activities took place and what kind of appliances or tools were used. Furthermore, we want to aggregate this information by time and location.

Figure 23 shows the developed ontology. An Individual consumes Energy by performing an Activity in a given Location, which might either be a single Place (i.e. a point of interest) or Path (i.e. a sequence of places). An activity can be of different types: Mobility, Leisure, Dwelling, and Food Consumption. A Mobility activity includes a Mode of Transportation, which the Individual uses to move among places. Both Leisure and Dwelling activities may use Appliances, which are divided into White (big appliances) and Brown Goods (small appliances). Food Consumption is associated with the Food being eaten, where it is produced, and how it is processed.

Figure 24 shows those elements in our ontology that relate to social media. A User, with a social media Profile, can publish Posts containing text or links to Video, Images, Events, or other resources. A Post can also refer to a Location and mention other Users.

#	Competency Question
1	Does the individual perform an energy-consuming activity?
2	If so, what type of energy-consuming activity is performed?
3	At what place is the activity performed? 1. To what category does this place belong? 2. What are the coordinates of this place?
4	At what time is the activity performed?
5	What is the duration of the activity?
6	Does the individual use an object to perform the activity? 1. If so, what kind of object?
7	In case of mobility activity, what kind of mode transportation is used? 1. What path (i.e., set of places) was taken?
8	In case of leisure activity, what kind of artifacts are used? 1. In case the artifact is an appliance, what is its power consumption?
9	In case of dwelling activity, what appliances are used? 1. What is their power consumption?
10	In case of food consumption activity, what kind of food is consumed? 1. What are the ingredients? 2. How is the food processed? 3. What kind of appliances are used to process the food? 4. Where is the food processed?
11	How many energy-consuming activities are performed during a certain time-span and within an area?

Table 7 Competency questions that form the ontology's set of functional requirements

To avoid a proliferation of ontologies covering the same concepts, and facilitate our data models' integration with other systems, we looked at existing ontologies that bear upon energy consumption, food, travel, and social media.

Table 8 summarizes existing ontologies that partially overlap with concepts included in our own. 'The Suggested Upper Merged Ontology' (SUMO) (Niles & Pease, 2001) is the largest existing formal public ontology. Since it covers many of the con-

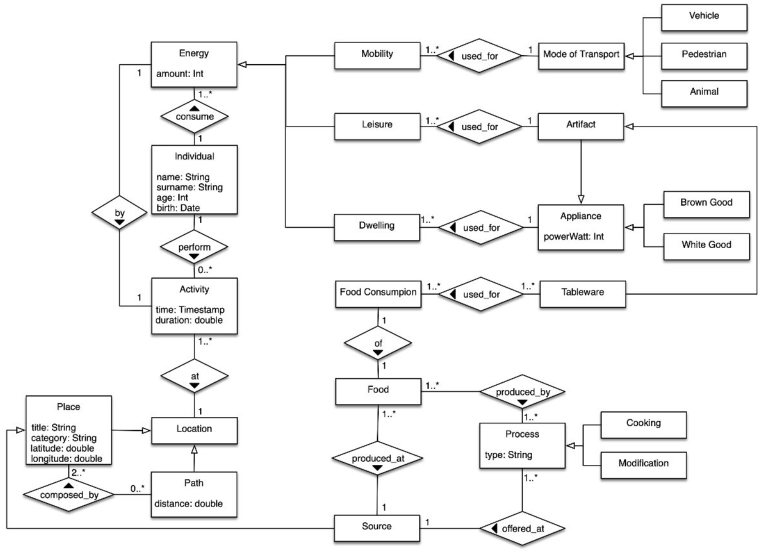


Figure 23 Conceptual model of the energy consumption ontology

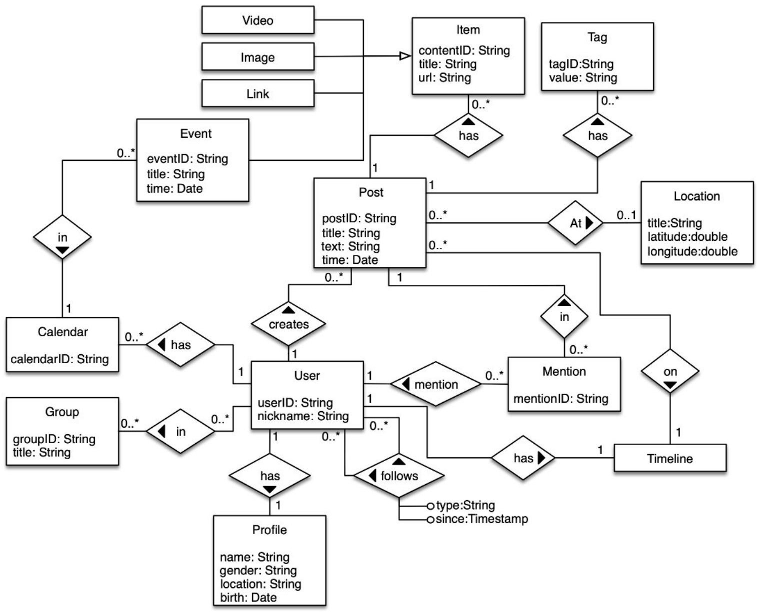


Figure 24 Social media conceptual model

cepts needed in our ontology, we used it as foundation for our model. 'The Semantic Tools for Carbon Reduction Energy Model' (SEMANCO) (Madrazo, Sicilia, & Gamboa, 2012) focuses on concepts related to energy consumption and CO2 emis-

	SUMO	SEMANCO	EU	FO	TO
Energy Activity					
• Energy units	+	+	+	-	-
• Consumption	+/-	+	+	-	-
• Individual	+	+	+	+	-
Location					
• Location	+	+	+	-	+
• Path	+	-	-	-	+
Dwelling					
• Activity	+	+	-	-	-
• Appliance	+	+	+		-
Food consumption					
• Activity	+/-	-	-	+	-
• Food	+	-	-	+	-
• Food chain	-	-	-	+	-
• Tableware	+	-	-	-	-
Leisure					
• Activity	+	+	-	-	+
• Artifact	+	-	-	-	+
Mobility					
• Activity	+	+	-	-	-
• Mode of transportation	+	-	-	-	+

Table 8 Overview of the current state-of-the-art in ontologies that focus on the domain of energy-consuming activities (+: included; +/−: covered to some extent; −: not included)

sion. We included it in our ontology to model energy consumption. In modelling the household, we also included aspects of an existing ontology: the EnergyUse platform (EU) (Burel, Piccolo, & Alani, 2016), which describes home appliances. We also included concepts related to food consumption from the BBC Food Ontology (FO) (BBC Food Ontology, 2014), which contains recipes and information ingredients and processing methods. Finally, the mobility domain was covered by drawing on the Travel Ontology (TO) (Stevens, 2009).

To cover the social media domain, we used the Friend-of-Friend (FOAF) and Semantically-Interlinked Online Community (SIOC) ontologies. They contain concepts relating to user accounts, posts, and the relations among users (i.e. friendship).

Whilst we could have built most of our ontology simply by reusing these ontologies, they were created for different purposes and needs. Having been designed to model appliances' energy consumption; describe food and ingredients; or model modes of transportation and social networks, they were not intended to describe energy-consuming activities. It is important to remember, therefore, that while we chose to include aspects of these ontologies that refer to concepts of interest, their semantic meaning may only partially cover our concept or slightly differ from it.

For this reason, we had to find the right trade-off between reusing existing ontologies and creating new elements. Although focusing purely on the first strategy would ensure maximum interoperability with existing frameworks, the resulting ontology would lack the specificity required for the domain of energy-consumption. We address this challenge in two ways:

1. Where an existing entity already covers one of our concepts, but its actual meaning differs from that concept, we have created a new entity and drawn a relation of equivalence between them. This applies to the *Energy_Quantity_And_Emission* entity in the SEMANCO ontology. Although it refers to the concept of energy consumption, its precise meaning is that of direct energy consumption. Since in our ontology we want to include indirect consumption of energy too, we have created the *Energy* entity, which is *equivalent* to the SEMANCO one.

2. Where an existing entity partially covers one of our concepts, we have created a new entity and drawn what we call an 'is-a' relation between them. The class *Cooking* in the SUMO ontology, for instance, partially covers the food processing concept. Hence, we have created the *Process* entity in our ontology. *Cooking*, we propose, *is-a Process.*

The ontology was implemented using Web Ontology Language (OWL 2 Web Ontology Language Document Overview, 2012) with Protegè, which is available on the following companion website (http://social-glass.tudelft.nl/social-smart-meter/#ontology).

THE SOCIAL SMART METER DATA PROCESSING PIPELINE

Figure 25 shows the data processing pipeline. It is composed of four main modules: Data Collection, Data Enrichment, Classifier, and Linked Data publisher.

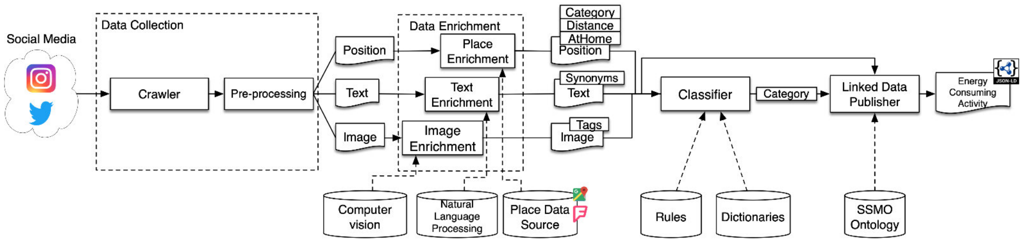


Figure 25 Data processing pipeline

First the pipeline retrieves users' posts from social media. It then enriches the data using state-of-the-art computer vision and natural language processing techniques, which respectively apply to the images and text in a given social media post. In addition, information about place is enriched by looking for its category in external data sources. The enriched information is then used to classify the social media post as corresponding to one or more types of energy-consuming activity. Finally, the pipeline publishes information about the energy-consuming activity as linked data[1] by combining the outputs of all the previous steps.

DATA COLLECTION

The Data Collection module retrieve posts using the API provided by social networks. These social networks are queried by providing the GPS coordinates as a bounding box, thus retrieving posts that are created within a specific area. The module also preprocesses the posts, removing stop-words, hashtags, and special characters from the text. It then proceeds to perform the stemming (i.e. reducing words to their root form) and tokenization (i.e. segmenting the words in a message).

DATA ENRICHMENT

The Data Enrichment module takes in the text and images included in a post, as well as its location. The text goes through a word disambiguation algorithm, in this case the Lesk algorithm (Lesk, 1986), which disambiguates a term's meaning by looking at the surrounding words. We use the 'Adapted Lesk' algorithm implementation (Banerjee & Pedersen, 2002), which incorporates the Word Net lexical database. The output of this step in our process are the words enriched with their definition and synonyms.

The modules apply the state-of-the-art techniques for visually detecting objects and scenes in images. We decided to use both since they provide complementary information about what is represented in the pictures. For object recognition, we use a convolutional neural network, 'Mask R-CNN' (He, Gkioxari, Dollar, & Girshick, 2017), which is trained on the Microsoft COCO dataset[2]. For scene recognition, we use the ResNet50 neural network[3], which is trained on the Places dataset[4]. The output of this step is a set of terms describing the objects contained in the images and the scenes that they depict.

Finally, the module uses geographical coordinates (or toponym) that locate the creation of a post in an attempt to retrieve additional information about the category of energy consumption with which it is associated. Our intuition is that the type of place where such an activity is performed will help us understand its type. There is a high chance that an activity performed in a restaurant, for instance, will belong to the food consumption category. We use Google Places, Foursquare, and their APIs to retrieve the category of the place indicated in either its name or geographical coordinates. Moreover, once we have the set of places that a user visits, we attempt to estimate his home location using a density-based spatial clustering algorithm (DBSCAN (Ester, Kriegel, Sander, & Xu, 1996)). This algorithm separates high-density clusters from low-density clusters. The home of a user, we assume, is in the high-density cluster.

CLASSIFIER

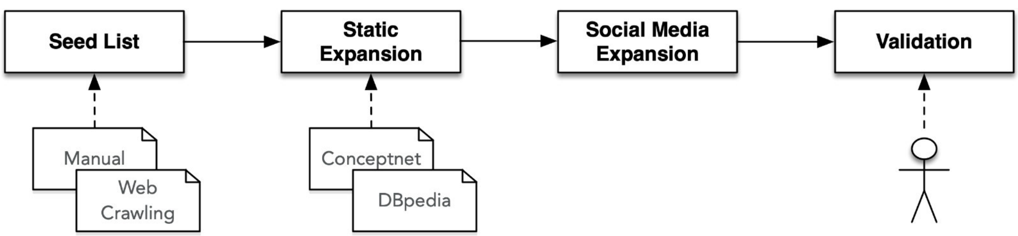
The Classifier module uses information retrieved in the previous steps to classify social media posts into one or more energy-consuming categories. State-of-the-art classifiers need a large set of manually annotated data. To the best of our knowledge, such a dataset does not exist and its creation was out of scope of this work. We have therefore chosen to take a hybrid approach to classification based on dictionaries and classification rules.

We define a dictionary as a set of terms related to a type of energy-consuming activity. Ingredients or cooking utensils, for example, are related to the category of food consumption. The underlying idea is to compare the terms extracted from the message, image, and location with the words contained in the dictionaries. We built a distinct dictionary for each of data type, because this helps to rule out ambiguity to some extent. The text token 'tram,' for instance, may refer to an activity related to mobility, while a tram present in the background of an image is not necessarily related to a user's activity.

The dictionaries for image and place tokens are predefined. They are composed respectively by the set of classes contained in the pre-trained models and the set of venue categories present in the data sources. We associate each of term with one or more type of energy-consuming activity.

The dictionary for the textual component of a social media post is more complex. Creating it manually is labor intensive and all of the relevant terms are unknown. Its creation is delegated to a

Figure 26 Overview of the process of creating the dictionary for textual components.



component shown in figure 26. This process has the following steps:

3. **Seed List**: a set of topical keywords is defined for each of type of activity being addressed (dwelling, mobility, food consumption, and leisure). The idea is to identify terms (expressed in the languages spoken in the targeted areas) that are associated with energy consumption or energy saving measures. This list is compiled both manually and by crawling web sources such as Oxford Food Reference, Wikipedia, and E-Commerce website.

4. **Static Expansion**: in enriching the set of domain-specific keywords, this semi-automatic step aims to increase the amount of relevant social media posts retrieved by the system. In this phase, each term detected in the previous step is searched in different sources, namely ConceptNet[5] and Wikipedia Category tree. ConceptNet provides a large multilingual knowledge graph that helps computers understand the meanings of the words that people use. ConceptNet expresses concepts (words and phrases) extracted from natural language text, as well as their relation to other concepts. These relations (e.g. synonym, antonym, Isa, PartOf, ExternalURL, etc) were derived from a wide variety of sources (e.g WordNet, Wikipedia, and Dbpedia etc.). We can filter out the noisy data based on its edge weight, type of relation, and number of hops pattern. The Wikipedia category tree presents the contents of each category name as a tree structure. As an example, the category name "meat" is articulated as following tree structure: Beef→ Beef dishes→ Hamburger Steak.

5. **Social media expansion** (Mauri, Psyllidis, & Bozzon, 2018): this step starts from a small set of social media posts. It retrieves a set of candidate posts, considering those that contain one of the dictionary terms established in the previous step. It then computes the similarity[6] among the candidates and the centroid of the starting set. Given a confidence

range [h, l], it labels tweets whose similarity is greater than h as positive examples, and twitters with similarity lower then l as negative, leaving the others unlabeled. A set of candidate words is then created by taking all of the terms contained in tweets labeled as positive. The process considers a word valid if it appears on a list of similar words obtained from the Word2Vec model on the Google News corpus. In this way, we are able to isolate those words that belong to the same dictionary context. The process is iterated until either all of the tweets are labeled or no more candidate tweets can be found.

6. **Validation**: We ask human validators, who are based in different countries, to validate the English terms and their corresponding translation in a given language[7]. The validators will be asked to check whether the terms are relevant to the category in which they have been placed (i.e. dwelling, mobility, food consumption, and leisure) and that the terms translation has been correctly assigned. The validators are also asked to validate the country-specific terms and add missing terms if possible.

Figure 27 illustrates the rule-based approach used to classify social media posts. We check to see whether each term obtained in the enrichment step appears in any of the dictionaries. In the case of food consumption and leisure activities, for example, we classify posts created at home as also as dwelling. Furthermore, we look at the distances among users' posts. If a distance between two posts exceeds a threshold of 0.2km[8], we classify them also as a mobility activity. In this case, we try to infer the mode of transportation by looking at the duration elapsed between posts and the distance travelled.

To address the problem of the noisiness of social media data, we model the confidence of our classifier by using three parameters: (1) for each type of data, the ratio of relevant tokens; (2) for each term, its relevance to the category of energy-consuming activities; (3) a score indicating the extent to which the type of data is

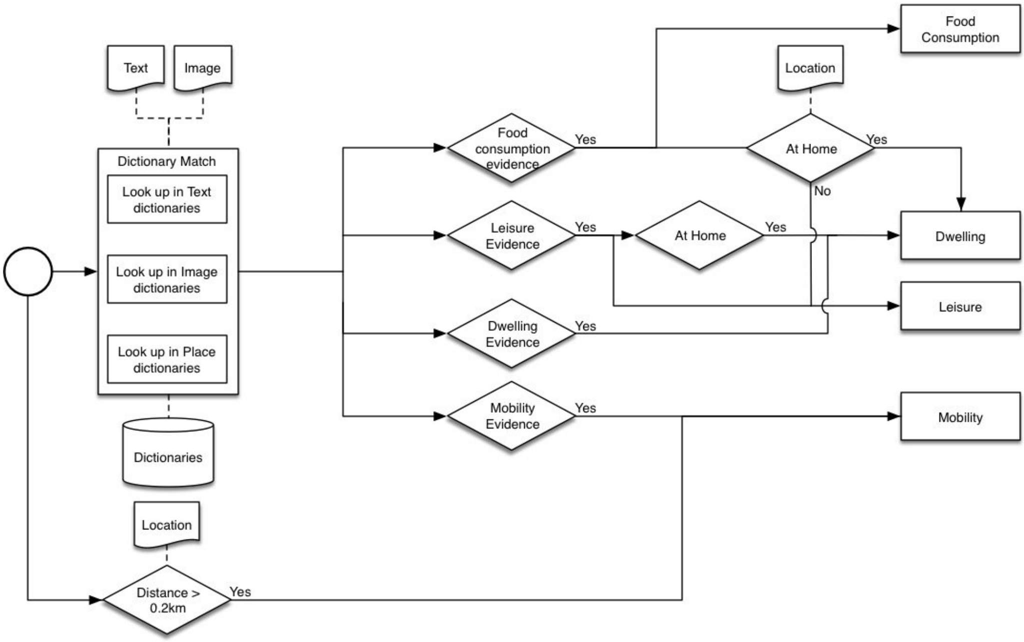


Figure 27 Illustration of the rule-based approach

informative about its category. While the presence of food in an image makes it easy to allot it to the category of food consumption activity, for example, a picture of a plane or train hardly identifies a mobility activity, for users rarely post photographs of mode of transportation while traveling.

Taking all the above into the account, we compute our classifier's confidence as follows:

$$\begin{aligned} \text{confidence}_x &= \sum_y \left(\frac{N_{relevant,x,y}}{N_{relevant,y}} \cdot w_{x,y} \cdot \frac{1}{N_{relevant,x,y}} \sum_x \text{scores}_{x,y} \right) \\ &= \sum_y \left(\frac{1}{N_{relevant,y}} \cdot w_{x,y} \cdot \sum_x \text{scores}_{x,y} \right) \end{aligned}$$

Where $N_{relevant}$ is the number of relevant terms, *w* is the informativeness score, *x* is the type of energy consuming activity, *y* is the type of data, and *score* is the vector of the scores of all the relevant terms.

The relevance scores are computed separately for each type of energy consuming activity. In the case of text token, the score is computed as the similarity between the term vector and word embeddings of the words contained in the dictionary obtained using Word2Vec. In the case of an image annotation, we use the score provided by the object or scene recognition model. For the place, we use a binary score, depending of the presence of the place category in the dictionary.

The values for the weight were defined by asking to a group of users to rank the data type according to their informativeness on a scale from 0 to 10 (*Not informative at all* to *Very Informative*). We used a sample of 100 posts, collecting 9 responses for each post. The final values were computed as an average, as shown in Table 9.

Table 9 Weight values obtained by asking user's opinions

	Text	**Image**	**Place**
Dwelling	0.35	0.40	0.25
Food	0.33	0.37	0.30
Leisure	0.35	0.32	0.33
Mobility	0.37	0.33	0.30

Finally, the classifier confidence for a category x is the average of the contribution of each data type.

LINKED DATA PUBLISHER

This component takes the output of the previous modules and combines them to create instances of the social smart meter ontology. We use an instance of TripleWave (Mauri et al., 2016), a reusable and generic tool for publishing linked data streams on the web in JSON-LD format.

The aim of this final step is to help establish our ontology's interoperability with other services by sharing a common understanding of the domain of energy-consuming activities. Now that we have published our data in JSON-LD, others can define custom queries in a standard language (e.g. SPARQL and RDF query language[9]) and perform ad-hoc aggregation to satisfy their own research needs.

EVALUATION

We conducted case studies in the cities of Amsterdam and Istanbul. Unfortunately, we were not able to perform a case study on the city of Graz since there was not enough social media activity to produce meaningful results, probably due to the size of the city.

We collected data between two periods: 22–27 June and 27– 28 July 2018. At first, to provide a first round of insights into 'the Social Smart Meter framework,' only social media posts created in Amsterdam were collected. After this, social media posts created in Istanbul were also collected, so as to compare results between the two cities. Whereas about 150k posts were collected in Amsterdam (130k from Instagram and 20k from Twitter), 120k were gathered in Istanbul (90k from Instagram and 30k from Twitter).

We collected posts regardless of language. In the case of Amsterdam, we considered terms in English and Dutch, while in that of Istanbul we considered terms in English and Turkish. It is worth noting that terms in different languages are needed only for the textual part of the social media posts, not for image labels and place categories.

For text processing, we used three pre-trained embeddings: for the English language we used the model trained on the Google News corpus[10]; for Dutch we used a model trained on the combined datasets of Wikipedia[11], Sonar500[12], and Roularta corpus[13];

while for the Turkish language we used a model trained on the Turkish Wikipedia dataset[14].

PERFORMANCE EVALUATION

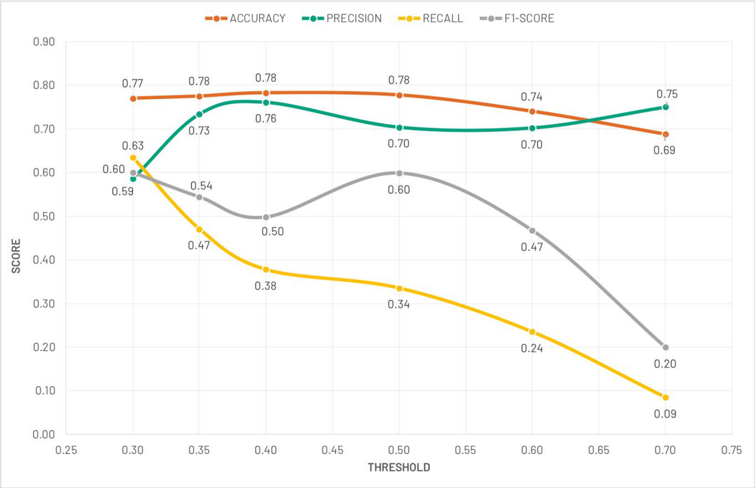


Figure 28 Accuracy, precision, recall and F1-Score at different threshold values

First, we evaluated the performance of our pipeline in terms of accuracy, precision, recall, and F1-score. Precision is the ratio between posts classified correctly in one of the categories and all of the classified posts. Recall is the ratio between posts classified correctly in one of the categories and the set of all relevant posts. Accuracy is the fraction of posts correctly classified, taking into the account the true negatives (i.e. the posts correctly classified as not belonging to any category). Finally, the F1-score is the harmonic average of the precision and recall.

Figure 28 shows the values of performance scores with respect to different threshold values. The recall scores decrease while increasing the threshold; less relevant social media posts have sufficiently high confidence scores to exceed the threshold. Increasing the threshold results in both less true and less false positives. However, the numbers of true and false positives do not decrease proportionally. Based on the plot, a threshold of either 0.30 or 0.35 appears to result in the best performance.

USE CASES

Figure 29 shows the overall distribution of posts classified as corresponding to any one of the energy-consuming activities. In Amsterdam (figure 29a), most social media posts are created around the city center, Burgwallen-Nieuwe Zijde, the neighborhood with the highest density. In Istanbul (figure 29b), multiple districts exhibit a high volume of energy-consuming activities: Başakşehir and Beşiktaş in the European side of the city and Kadıköy in the Asian side.

Figure 29 Overall distribution of energy-consuming activities in Amsterdam (a) and Istanbul (b). In the case of Istanbul, blank areas refer to district where no social media posts were found.

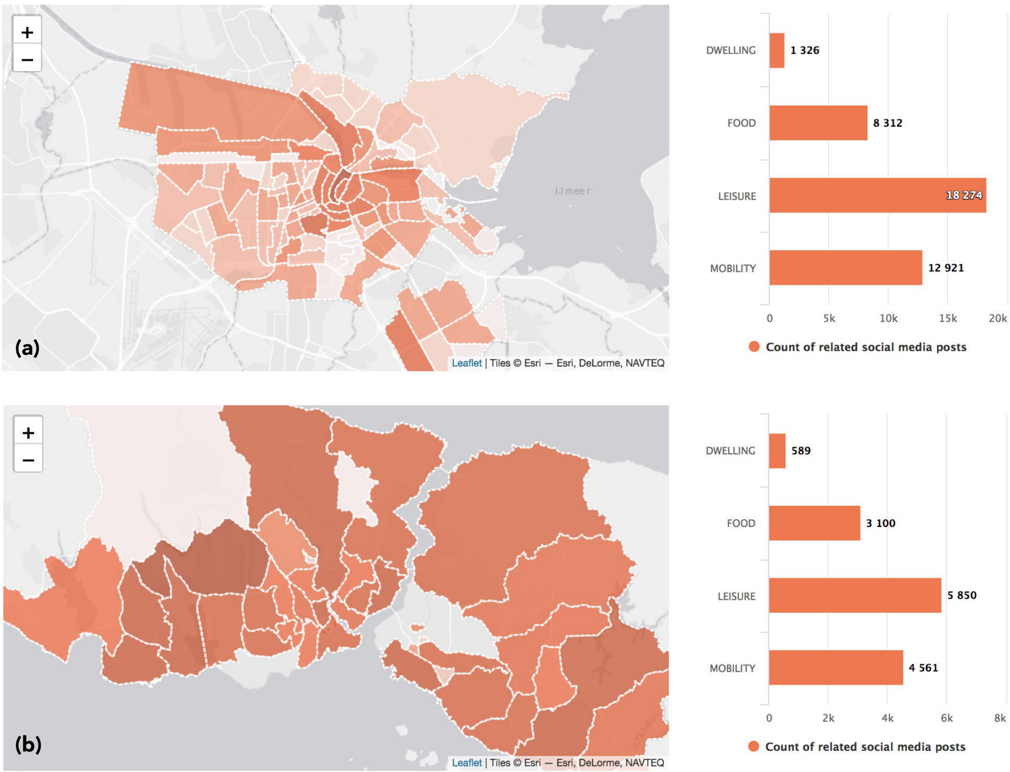


Table 10 Percentage of posts classified in any of energy-consuming activity category

	Amsterdam	Istanbul
Dwelling	3.25%	4.18%
Food	20.36%	21.99%
Leisure	44.75%	41.49%
Mobility	31.64%	32.32%

Table 10 shows the percentage of posts classified as falling into any of the energy-consuming categories. In both cities we found very few posts classified as dwelling. For both Amsterdam and Istanbul, the leisure category has the largest share (approximately 40%) of posts compared to the other categories. The mo-

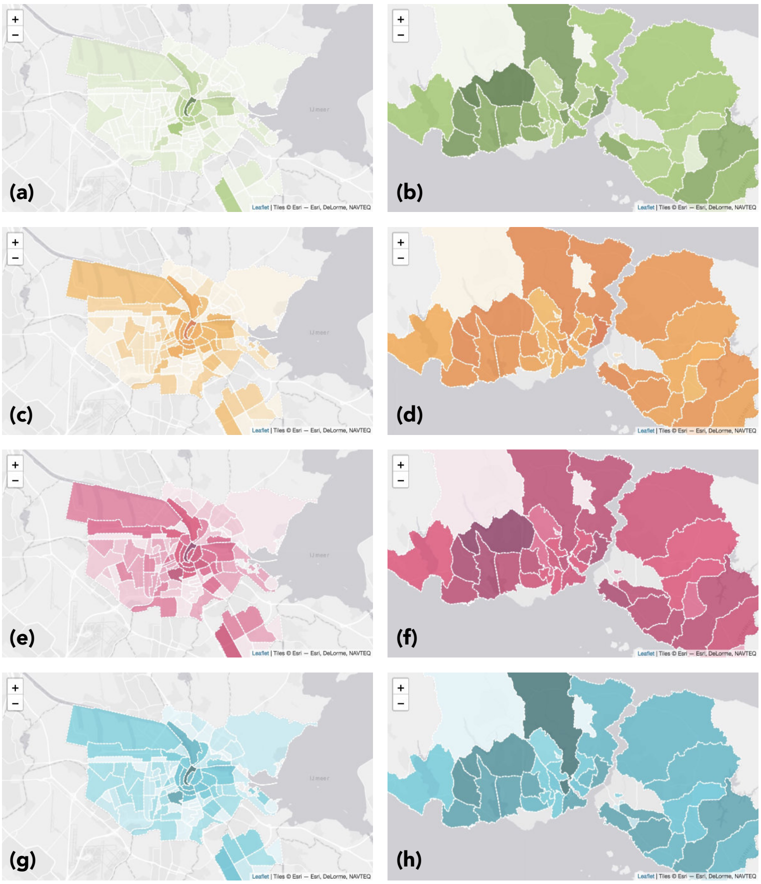
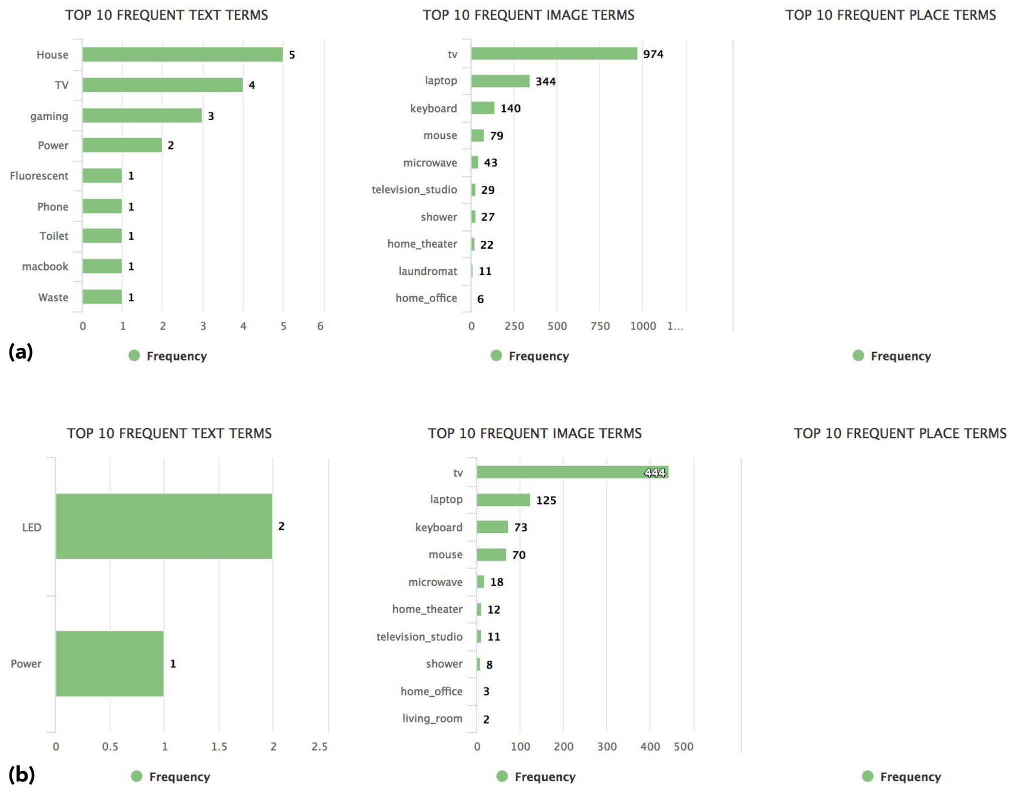


Figure 30 Map visualizing the distribution of social media posts; (a,b) refer to dwelling, (c,d) refer to food consumption, (e,f) refer to leisure, and (g,h) refer to mobility. In the case of Istanbul, blank areas refer to districts in which no social media posts were found.

bility category has the second largest (approximately 30%). The category of food consumption has a rather small share (approximately 20%).

In Amsterdam (figure 30a) dwelling activities are concentrated in the city center. In Istanbul (figure 30b) the posts are more evenly distributed, with a higher concentration in the European part of the city. As figure 31 shows, the most informative terms are *house*, *TV*, and *gaming*, while the most recognized objects are *tv*, *laptop*, and *keyboard*, indicating both recreational and work activities.

Figure 31 Bar charts visualizing the terms that occur most frequently in social media posts classified as dwelling activities in Amsterdam (a) and Istanbul (b). For the sake of legibility, the figures show English terms only.



As figure 30c shows, the highest concentration of food energy-consuming activities in Amsterdam is in the city center. Figure 30d, on the other hand, shows how in Istanbul these activities

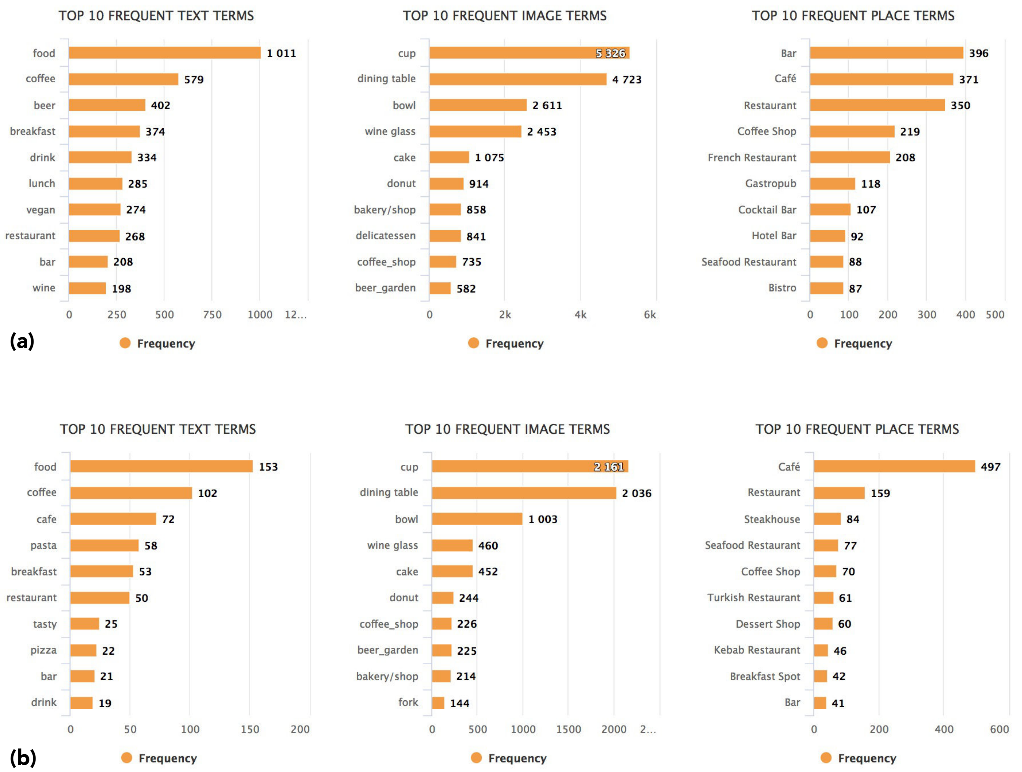


Figure 32 Bar charts visualizing the terms that occur most frequently in social media posts classified as food consumption activities in Amsterdam (a) and Istanbul (b). For the sake of legibility, the figures show English terms only.

peak in the Beşiktaş district and northern neighborhoods. Figure 32 shows that in both cities *food* and *coffee* were the most frequent text terms indicating a food consumption activity. Besides these, individuals appear to create posts related to food consumption most often while visiting a ‘Bar’ (Amsterdam), ‘Café’ (both cities), or ‘Restaurant’ (both cities).

In figure 30e, we notice that in Amsterdam the distribution of social media posts classified as corresponding to leisure activities seems to be broadly distributed over different neighborhoods. The city center (Burgwallen-Nieuwe Zijde), for instance, is frequented by numerous tourists, who socialize and drink; visit flower markets and museums; or enjoy the canals. This is reflected in the most frequent terms: *night*, *holiday*, *party* (text), *Flower Shop*, *Art Museum*, and *Hotel* (place). However, in the

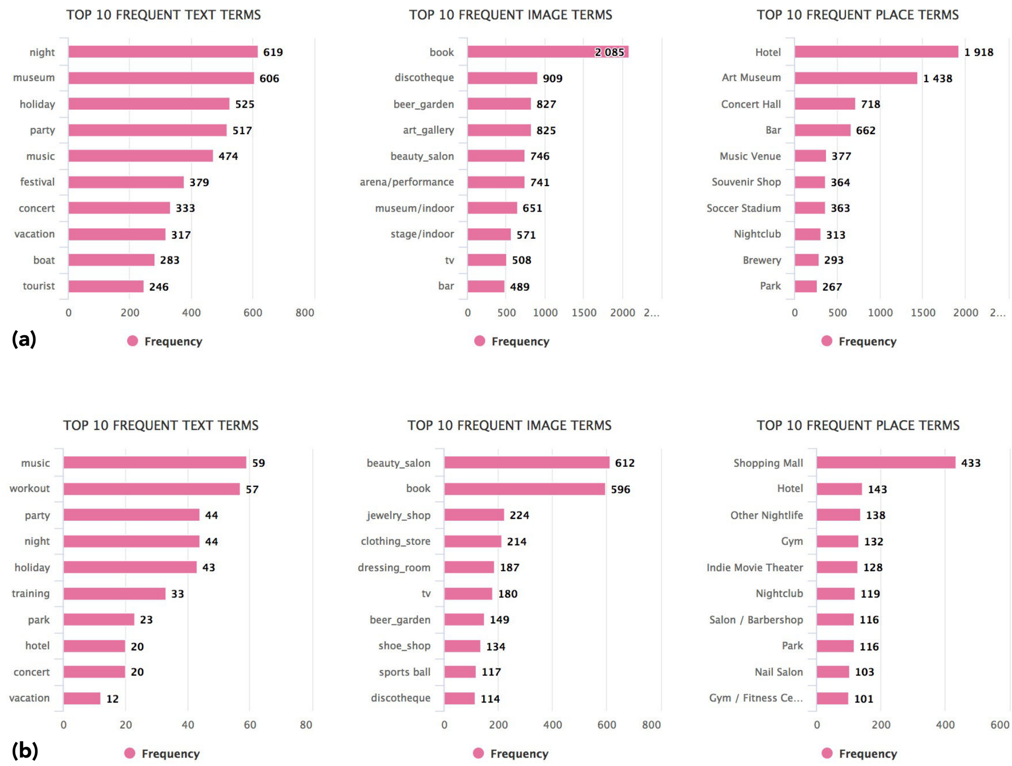


Figure 33 Bar charts visualizing the terms that occur most frequently in social media posts classified to leisure activities in Amsterdam (a) and Istanbul (b). For the sake of legibility, the figures show English terms only.

Museumkwartier, where the most famous museums are located, we found terms such as 'museum' (text), 'art_gallery' and 'museum/indoor' (image), and 'Art Museum' (place).

The distribution of the leisure-related social media posts over Istanbul's districts (figure 30f) is rather similar to that of food consumption-related posts. They are densest in the center and west (the Başakşehir district, which is also the location of the homonymous soccer team's stadium). Interestingly, figure 33 shows that in Istanbul the majority of leisure activities seem to take place in shopping malls.

Regarding mobility activities, in Amsterdam they are concentrated in the city center, where the central station is situated. Another reason this that people tend to post about canal trips, which dock there. In Istanbul, mobility activity is densest in two neigh-

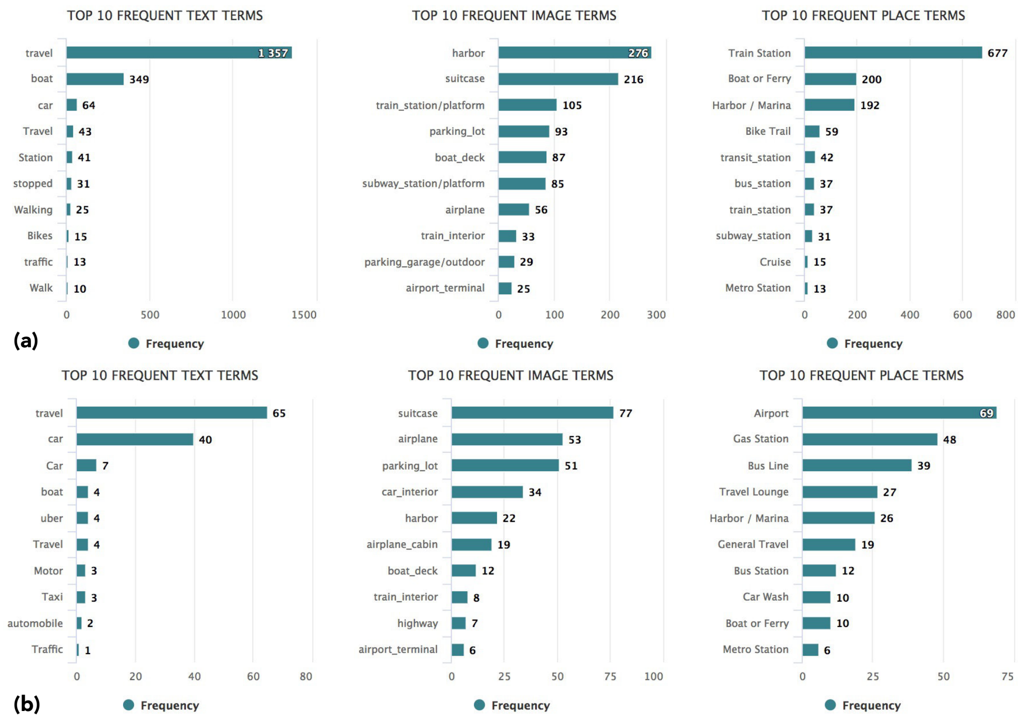


Figure 34 Bar charts visualizing the terms that occur most frequently in social media posts classified to mobility activities in Amsterdam (a) and Istanbul (b). For the sake of legibility, the figures show English terms only.

borhoods, Başakşehir and Eyüp. Multiple highways run through these districts (particularly Eyüp, which connects the Black Sea to the Golden Horn) as does a large highway junction. Looking at the terms (figure 34), we notice that Istanbul features more terms related to transportation by car (e.g. Gas Station, Car Wash, parking lot, car, etc.).

The framework captured few social media posts referring to dwelling activities in either city. This may be because social media users do not consider their regular domestic activities interesting enough to share with other social media users. Even if we look at posts related to food consumption, they appear to occur outside the home. As one might expect of social media, the majority of posts belong to the leisure energy-consuming activity. Moreover, typically people do not post directly content about their mobility activities, although we can use the distance between posts to detect whether a transportation activity was performed.

Amsterdam and Istanbul present similar ratio of energy-consuming activities, but across a different spatial distribution. This is probably due to the two cities' different features: Amsterdam has a well-defined center where the main venues are concentrated, while the main venues in Istanbul, given its different size, are scattered throughout the city. By looking at the terms that occur most frequently, we notice a small difference in how energy-consuming activities are characterized in the two cities. With regard to the food category, we see place categories that are more closely related to Turkish cuisine (e.g. Turkish restaurant and kebab restaurant) and that many leisure activities in Istanbul seem to take place in shopping malls. Finally, with regard to the mobility category, we notice a higher occurrence of terms related to transportation by car in Istanbul.

In sum, our pipeline can detect more practices that fall in the broad category of indirect energy-consuming activities. As we mentioned in the introduction, these activities are related to the production, transportation, and disposal of various consumer goods and services. As might be expected, people often post on social media when they are going out, whether to drink and dance or enjoy a special dinner. Only rarely do they share their domestic activities. This is not a flaw to our approach: rather it suggests that social media can indeed be used as a *complementary* source of information regarding energy-consuming activities, best used in combination with others. In fact, domestic activities are already partially captured by traditional data sources, while the indirect activities are either neglected or require costly methods, which have low temporal resolution (e.g. surveys).

In the case of the CODALoop project, we believe that our study has demonstrated that social media is a valid complementary source of information for understanding peoples' energy lifestyles. Social media can be used as additional source, along with data gathered in Chapter 3. In the living lab described in Chapter 5 and the intervention described in Chapter 2, social media can be used to spark additional discussions about sustainable lifestyles. Indeed, they provide additional insights into the energy lifestyles of the community members involved. Social media could show unexpected aspects of a person's energy lifestyle, for instance.

We acknowledge that our approach has limitations. Social media are inherently biased: they are used by only part of a population (e.g. youngsters, tourists, etc.) for purposes quite different to that of sharing energy-consuming activities. This is reflected by the low volume of social media posts related to the dwelling activity and the prominence of leisure and food consumption categories. A study of demographic representation, however, exceeds the scope of this research. We leave that to future work.

Information shared on social media it is often ambiguous and noisy (e.g. a picture of a tram does not mean that the user is traveling). This is partially mitigated by our rule-based approach, which has proven very promising. Language can be an issue when applying our method to areas in which English is not the native language. However, this is addressed with multi-language dictionaries and by the use of embeddings trained on the main language spoken in the relevant area (e.g. Dutch for Amsterdam and Turkish for Istanbul). In addition, this problem only concerns the analysis of the text in social media posts, not images or locations.

CONCLUSION AND FUTURE WORKS

In this chapter we have demonstrated social media's potential to serve as a complementary source of information with which to describe energy-consuming activities. We foresee several possible research directions that might stem from this work.

ADDING OTHER SOCIAL MEDIA SOURCES

In our research, we focused on Twitter and Instagram. Although these are the most highly used social media to provide easy to access to their API, they are also biased and noisy. There are other, more specialized social media, on which users post about only specific types of activity. Here we briefly discuss how Spotify and Steam could be used as additional source for social media activity.

7. Steam[15] is a gaming social platform for PCs. Having started as a digital platform for distributing games, it has evolved into a social media platform. Users have their own profile pages, which contain statistics about that games they have played. Steam also provides an API through which to access this information. Hence, we might use this data to understand when a user is playing a videogame and classify the activity as *leisure* and *dwelling* (since gameplay is most probably performed at home).

8. Spotify is a streaming platform, providing music and podcasts from record labels and media companies. It provides an API, which makes it possible, upon previous authorization, to access information about users' devices and music. With this information we can understand when users are listening to music and classify the activity as *leisure*. Moreover, if they are using Spotify on a desktop PC, we can also classify the activity as *dwelling*, since it is an activity performed – most probably – at home.

ENRICHING ACTIVITY DESCRIPTIONS WITH ENERGY CONSUMPTION AND CO2 VALUES.

Though this work we obtained a qualitative description of energy consuming-activities. For instance, we established that a user had dinner at a restaurant or that another played videogames on a console, and so forth. Although this information is useful in trying to understand how people consume energy, it would be more effective for both validation and feedback purposes if estimated values of energy consumptions and CO2 emissions could be attached to these descriptions. We envision that this enrichment to be performed in the following ways:

- Should an appliance or tool be found by our pipeline, we can directly attach energy consumption information to it by looking at manufacturers' websites or user generated databases.[16,17]

- In the case of a mobility activity being found, we can infer the mode of transportation by looking at the distance among posts or querying external services, such as GoogleMaps direction API.[18] Once we know the mode of transportation, we can attach information about energy consumption by looking at external databases.[19]

- Should a food consumption activity be found, it is possible to estimate the impact of the energy consumption by looking at the type food and where the activity takes place. Thanks to our ontology, we can consider not only how is cooked (e.g. fried, baked, etc.), but also grasp the chain of production as a whole. One study (Notarnicola, Tassielli, Renzulli, Castellani, & Sala, 2017), identified 17 groups of products and their impact on the environment. Using their findings, it is possible to associate a food consumption activity with its environmental impact. Should the type of food not be detected, we can use information about the location where the activity is registered. Extrapolating from the type of venue (e.g. Italian restaurant, vegan restaurant, bar, etc.), and the type of food that is typically served, we can infer the energy impact of the registered activity.

The main challenge presented by this step is that of handling uncertainty, for it builds on previous steps that yield estimates, not exact values (which is impossible). Moreover, there are many variables that cannot be taken into the account by looking only at social media posts. These considerations include the model of the appliances being used, whether a car is electric or not, the exact duration of an activity, and so on.

We do not claim to be able to estimate energy consumption from social media with precision. Instead, we try to provide a more concrete value, which it would be presented alongside the information retrieved by the pipeline described in this chapter.

CLOSING THE LOOP, TOWARD A PERSONAL SOCIAL SMART METER.

In our use case studies, we analyzed social media posts at the scale of two cities, Amsterdam and Istanbul. By comparing these two cities, it is possible to highlight both similarities and differences in energy consuming activities. Moreover, citizens can compare energy-consuming activities at a neighborhood scale.

Our analysis can be shifted onto the user, who might focus on the activities performed by a single individual. In this way, the user can see the footprint of his or her own energy-consuming activities and compare it with that of his or her peers. The city-level aggregation performed in this chapter was initially chosen because testing our initial hypothesis required a large amount of data, which it is not possible to gather when focusing on a single person.

Given the conclusions established in this chapter, we now envision designing a platform that would implement a process comprising the following steps:

- Users provides access tokens to their social media accounts, logging in to our platform through the standard OAuth2.0 protocol.[20]

- With these tokens, we access various information about the users, depending on the social network under consideration. We retrieve their profiles, previous posts and other activities, and friendship network.

- We reuse the data processing pipeline described in this chapter to classify users' posts according to any of the four types of energy-consuming activity.

- By combining the information extracted, we build a profile of the users' based on their energy-consuming activities. On the basis of their profiles, users can visualize and compare their activities with those of other individuals (e.g. people living in the same area or friends, if they also provided their tokens). Users can also validate the results of our analysis, providing direct feedback as their posts are processed.

Such a platform could be integrated with that described in Chapter 3 and in the processes presented in Chapters 2 and chapter 4. Moreover, it can be also used in gamification approaches (Albertarelli et al., 2018) to provide users with feedback.

NOTES

1 http://linkeddata.org/

2 https://github.com/matterport/Mask_RCNN/releases

3 https://github.com/CSAILVision/places365

4 http://places2.csail.mit.edu/index.html

5 http://conceptnet.io/

6 We use the vector representation of the tweets obtained by training a Doc2Vec model on the tweet corpus.

7 The dictionaries are available on the companion website: http://social-glass.tudelft.nl/social-smart-meter/#dictionary.

8 This value provides the best trade-off between precision and recall in our context

9 https://www.w3.org/TR/rdf-sparql-query/

10 https://github.com/mmihaltz/word2vec-GoogleNews-vectors

11 https://dumps. wikimedia.org/nlwiki/20150703

12 http://hdl.handle.net/2066/151880

13 http://www.roularta.be/en

14 https://github.com/akoksal/Turkish-Word2Vec

15 https://store.steampowered.com

16 http://www.tpcdb.com/

17 https://www.energyefficiencydatabase.com/index.html

18 https://developers.google.com/maps/documentation/directions/start

19 https://www.bts.gov/content/energy-consumption-mode-transportation

20 https://en.wikipedia.org/wiki/OAuth

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BIO

7 COLLABORATING ACROSS DISCIPLINES AND SECTORS

Rationale, experience and lessons learned

LUCA BERTOLINI, KARIN PFEFFER, FEDERICO SAVINI, AND BEATRIZ PINEDA REVILLA

The CODALoop project's far-reaching ambitions were both inter- and trans-disciplinary. Implementing the project has provided an opportunity for exploring the potentials, but also the limitations, of a diverse mix of disciplinary, sector, and multi-site analysis. This diversity is represented in the chapters of this book. In this chapter, we reflect on the project's methodological approach. We discuss its rationale (Part I), tensions that emerged during its implementation (Part II), and lessons learned over the course of the project (Part III).

I - RATIONALE

The CODALoop project addressed a number of conceptual challenges – both thematic and analytical – that dictated the rationale behind our methodological choices.

Thematic challenges

The first challenges were thematic. The project aimed to move beyond past research and policy on energy consumption, which has largely focused on increasing households' energy efficiency. Instead, we meant to emphasize the reduction of households' energy demand at its source: the activities that citizens and households perform and the things that they consume (Shove & Walker, 2014), and not just in the area of dwelling, but in and through citizens' entire lifestyles (Axsen, TyreeHageman, & Lentz, 2012).

Focusing on the theme of the energy demanded by entire lifestyles required identifying methods and techniques for measuring the amounts of energy consumed by a variety of activities, spanning the domains of dwelling, mobility, and leisure. Although some of these tools were available at the outset of the project (e.g. online energy footprint calculators), we also acknowledged the need for innovation. In particular, we identified social media usage as a new data source and big data analytics as a new analytical tool. Together, these digital techniques could potentially correct the biases and partialities of existing information (Arribas-Bel, 2014).

Analytical challenges

Analytically, the project aimed to shift the focus of energy research, which has often treated individuals – and, more specifically, cognitive processes *within* individuals – as key agents and dynamics of change. Instead, we approached communities – and, in particular, cognitive processes and social interactions *between and among* individuals – as central actors and processes of change (Davoudi et al., 2014). We called these processes 'individual to community feedback loops.' Next, the project aimed to activate not just rational 'utility maximization' arguments and mechanisms to change behaviors, but moral and emotional arguments and mechanisms too (Van Lange et al., 2013). Furthermore, and related to this, in attempting to raise awareness of the necessity of, and possibilities for, changing behaviors the project aimed to rely not only on quantitative information (e.g. energy consumption units, energy prices), but also qualitative information (e.g. personal stories, interpersonal dialogues). Finally, CODALoop aimed to shift from a focus on one-way flows of information (e.g. from the local government to communities and individuals) to an emphasis on multidirectional flows (*both to and from* the local government, communities, and individuals). We called these flows 'community to policy feedback loops.'

The analytical focus on interactions among individuals, and the choice of communities as the research context, required either an active research presence in existing communities or the skills and networks required to build new communities. To assemble a richer palette of arguments and mechanisms for behavioral change, and ways of triggering awareness of the need to change behaviors, we had to combine insights and competences from different disciplines (e.g. psychology and sociology).

Research design

Bringing together strategies for addressing these thematic and analytical challenges, we developed an original research design. As part of this design, we envisaged:

- building new, or participating in existing, place-based communities as experimental sites for the research;

- developing and implementing different types of experimental interventions in these communities (e.g. both face-to-face and online). These aimed at raising awareness about energy demand, finding ways of reducing energy demand, and enacting behavioral change;

- observing and reflecting upon the processes triggered by these interventions. On the basis of this, we would then design new or improved interventions, following an iterative, 'experiential' research design (Straatemeier, Bertolini, te Brömmelstroet, & Hoetjes, 2010);

- developing and using a digital platform that could combine the two key functions of (1) calculating lifestyles' energy footprint and (2) providing a community forum for the exchange of opinions and information. In addition, we wanted to explore the potential of endowing the digital platform with a capacity for automatic machine learning, through which it could autonomously prompt suggestions for action.

Building and maintaining experimental sites and communities, and developing and implementing the necessary tools, required the presence and integration of a variety of networks and competences in the research consortium and its immediate environment. Most significantly, these included psychological expertise about the dynamics of individual behavioral change, sociological expertise about the dynamics of changing social norms, engineering expertise about the measurement of the energy content of activities in different lifestyle domains, and policy science expertise about the relationships among individual and community actions and the wider urban policy environment. The project also required practical knowledge of local community facilitators and activity organizers, and technical and market knowledge of software developers.

II - IMPLEMENTATION AND EMERGING TENSIONS

As mentioned above, we began from the understanding that investigating feedback loops through which individuals and communities learn and adapt their behavior requires a plurality of perspectives. In this plurality, all of the relevant disciplinary perspectives (sociology, planning/geography, psychology, computer sciences, and (software) engineering) – each of which is associated with one consortium partner – contribute their body of accumulated knowledge; relevant theories; concepts and assumptions; and research methods. When effectively combined, this assemblage of knowledge can be developed to a new fundamental understanding of social learning and behavioral change with regard to energy use.

The research was organized in the following way. Each consortium partner led one (YTU, TU Delft, TU Graz, Delft, P1M1) or more (UvA) work package, and each academic partner contributed to the other work packages to differing extents. The guiding document for the research process was the research proposal, plus additional methodological guidelines developed by work package leaders with inputs from research partners. Planned research activities were adapted according to emerging opportunities and barriers.

In the following, we report on our actual research process through the lens of five tensions.

Interdisciplinarity vs. different epistemologies

The first tension concerns the feasibility of integrating different research epistemologies. On the one hand, the project aimed to construct an interdisciplinary research process in which different research methods derived from a variety of disciplinary perspectives would be effectively combined. On the other hand, full integration was somewhat hindered by different epistemological and methodological understandings, as well as by delays in the implementation of the key means of data collection (the online platform). The result of this tension, between integration and coordination between different disciplines, was a sometime disproportional influence of one expertise over the other. This made one particular epistemology, represented by one partner, applied in the case study of the others.

Accordingly, the following methods of collecting data on energy consumption were implemented in tandem with one another (for details, see the relevant chapters):

- Inductively, we employed an action research approach, in which qualitative data on energy consumption was gathered through social interactions with communities (spatial/hybrid). The aim was to explore the role of communication and discourse in contesting energy needs and shaping a 'decent lifestyle';

- Deductively, we collected quantitative data on individuals' energy consumption through an energy calculator developed for the project. This was adapted to suit the specific geographic contexts studied. A rather detailed one was used for the Istanbul case study, a more simplified one for those of Graz.

- Through big data analytics, we sourced social media data content from social media platforms (e.g. twitter) and categorized it according to energy-related items (assuming that what people tweet about energy might also say something about their energy consumption behavior and influence others).

Similarly, we gathered data on social learning and behavioral change:

- Qualitatively, data was collected by analyzing community members' social interactions during research-moderated interventions (documentary screenings, focus group discussions, energy quiz, energy stories, humor, neighborhood safaris, text messages, posts on digital platforms).

- Quantitatively, data was collected in the first phase through a paper questionnaire (the digital platform was not yet operational), on the basis of which we developed a behavioral model. In the second phase it was collected through the digital platform (P1M1 CODALoop platform: Istanbul; TU Graz platform: Graz).

In addition, to understand the feedback loops created by energy-related policies in all three cities, data on energy-related policies and policy learning were acquired by analyzing policy documents and policy workshops.

We employed cognitive modeling based on what people say about their use of energy. Our aim in doing so was to describe current energy consumption, predict future energy consumption, and measure the impact of factors that can facilitate learning. However, the plan to analyze the link between the cognitive model and interventions was not realized, since to carry out this task each research team would have had to rely on a stable community throughout the entire research process.

Overall, it proved difficult to fully integrate different epistemologies (positivist, interpretative) and methodologies (qualitative, quantitative) into the same research site and community. Some contexts relied more on some types of epistemologies and methodologies; other contexts more on others. This was not just a matter of differences in the skills available for gathering and analyzing data (though these also mattered). Also, and importantly, the issue concerned differences in terms of belief in what the data could say; could they predict behavior? Or could they just provide an understanding of behavior? As we will highlight in Part III of this chapter, however, the more 'federative,' multidisciplinary approach that emerged in dealing with this tension was able to produce its own, distinct richness.

Interdisciplinarity vs. organizational fragmentation

The degree to which the project was integrated was determined by three main factors: (1) the research resources available for each partner in their country; (2) different epistemological approaches to the problem of energy consumption and change behaviors so as to create more sustainable lifestyles; and (3) a lack of frequent and informal research exchanges due to physical distances between research institutions. Physical proximity, it turned out, is extremely important in building a shared understanding of the problem, especially given our interdisciplinary approach to the research. The difficulty of frequent daily interaction in place also is an issue in transdisciplinary cooperation bridging academic research and practice. Indeed, it is particularly challenging if the interactions between research and practice in question aim not only to disseminate research results, or feedback on them, but involves cooperating on developing useful research tools. Consider the physical distance between the Amsterdam team and the platform developers, as well as their different epistemological approaches. This made it difficult for the developers to cater for the needs of the communities selected in Amsterdam, which were already very acquainted with digital data sharing tools. For the purposes of the research in Amsterdam, the role of the platform was deliberately cast as of secondary importance to interactions with the researchers. In Graz and Leibniz there was close collaboration on activities in the existing communities selected by the Austrian partners (ranging from creating awareness to actual interventions) and cognitive modeling. The researchers in Istanbul collaborated on a daily basis with both the platform developer, who was also from Istanbul, and existing communities. Their research process was therefore largely influenced by and centered on digital data collection through the platform and data feedback loop. The work of TU Delft on developing a 'social meter' somewhat isolated from the overall research process in the communities, benefitted from inputs from all partners (e.g. an energy dictionary in different languages). Still, the results that it generated could not be integrated with the other research processes during the course of the project.

The locational fragmentation was compounded by a lack of strong central coordination, which would have not been compatible with the federative structure of the JPI Urban Europe funding and accountability framework.

Ontologies of the phenomena at hand and the dimensions of energy lifestyles

The project started with a preliminary definition of an energy lifestyle, including dwelling, mobility, and leisure; the unit of analysis used to measure energy (kWh); and a conceptualization of feedback loops. Nevertheless, consortium partners appropriated different understandings of lifestyle and, in particular, practices of energy consumption. These understandings were informed by different research epistemologies, researchers' backgrounds, and the contexts in which they were situated. The most visible differences, which in some cases precipitated discussions (see below), concerned how different collaborators understood energy consumption as a social practice and the process of behavioral change. Some saw energy consumption more as a mechanism of choice, which is informed by data on energy intakes and potentially 'mappable' through digital platforms. For others, energy consumption was more of a normative process built through imitation and routines. These researchers favored a view according to which consumption can be understood through a reflective process. With respect to behavioral change, differences in expectations as to the project's capacity triggered 'interventions' meant to change behaviors and the temporality of the process of behavioral change. Some researchers were more explorative in analyzing the impact of project interventions, testing and seeking to understand individuals' immediate reactions. Others rather sought a systematic process with which to assess the impact of project interventions. Their aim was to map or 'measure' potential changes in energy use across the project's timespan (1.5 years). Different understandings of the phenomena at hand were reflected in different research approaches across the cases. Yet these differences also testify to CODALoop's experimental attempts to bridge epistemologies and produce unexpected synergies across disciplines.

Community building processes

A fourth tension in the research process was brought about by the need to access communities interested in energy behavior. The Amsterdam team, in accordance with the project's methodological selection criteria, aimed to stimulate existing neighborhood communities to discuss issues of energy needs. Despite initial, and very common, difficulties in organizing stable community interaction around a research-driven theme, it was ultimately made possible by the availability of an existing online (Facebook) community, explicitly built around the idea of sustainable lifestyles. In Istanbul and Leibnitz, the research was conducted with existing communities. In Graz, the research was synchronized with the development of a 'smart city district' in a permanent physical location, facilitated by Stadtlabor Graz, a formal partner in the project. Different levels of accessibility to the communities involved in the project shaped the ways in which we acquired knowledge about individual and community learning and feedback loops in behavior adaptation.

The role and nature of the Platform

The project aimed to develop and use a digital platform that could accommodate a number of functions: (1) the ability to learn about the energy behavior of individuals' and communities across three geographic contexts using an energy calculator and forum, in which community members could exchange information and opinions on their energy lifestyle; (2) an automatic machine learning capability through which participants could get feedback and suggestions for action after having completed the energy use calculator. In striving to fulfill these ambitions, the design of the platform was overly complex in relation to the project's expected outcomes. What is more, there was a gap between what researchers wanted and what the platform developer could provide. The platform did not respond well to the contextual differences among the three geographic research contexts. Software development also suffered from delays in the process by which the platform developer acquired funding and recurrent changes in the staff that it assigned to the project. Eventually, the platform to be developed evolved from one centralized platform into three different platforms. Each of these corresponded to the different organizational contexts and phases entailed in the research process. Moreover, the digital platform was used in different ways in each geographic context.

The Amsterdam team, after testing and appropriating different digital platforms (e.g. Google+, Gebiedonline,nl), opted for joining an existing Facebook community. This platform functioned as a virtual, social meeting place for people interested in sustainability questions in Amsterdam. The researcher used it to post weekly messages on energy-related facts and thus stimulate conversations about energy lifestyles, as well as to organize periodic face-to-face meetups.

The Graz team, building on their earlier experience of platform development within the university (SPI calculator), developed their own platform to accommodate the digital data entry of community members' energy behavior. Through their collaboration with the Stadtlabor as a main actor in the project, the Graz team also had a social meeting place in the neighborhood, where community members could meet face-to-face.

The Istanbul team, being close to the industry partner P1M1, was able to shape platform development according to their requirements. The platform was used for energy behavior data entry, conducting a psychological questionnaire in the second phase of the project, and facilitating interventions through the display of graphics of the data analysis.

The problems that attended platform development and the integration of different components of the project raises a key issue. How is it possible to align a research design; non-linear, exploratory, and experimental research paths; and the development of unprototyped research tools? The nature of experimental research relates to the nature of the framework, the mix of disciplines, as well as the development of research tools. It is hard to manage these different components. If properly done, though, the results can be groundbreaking. In our project, we experienced difficulties in translating the incremental process of research into an adaptive software tool. The building of the platform followed a more linear approach, based on a master concept and overall development plan. The fact that it did not evolve incrementally reflects the organizational constraints of a private partner, which works according to pre-defined tasks and delivery-based design. Overall, the platform tool was hardly adaptable and lacked customization functions.

LESSONS ON HOW TO BUILD INTERDISCIPLINARY INTERNATIONAL COOPERATION IN ACTION ORIENTED RESEARCH.

There are three main areas in which we learned lessons: (1) interdisciplinary collaboration, (2) community engagement, and (3) the development and use of digital platforms (these are both forms of trans-disciplinary collaboration).

Interdisciplinary collaboration

When trying to combine methods rooted in different disciplines, the difficulty of communication should not be underestimated, irrespective of personal good intentions. As we discussed in the previous section, methodologies are not just operational tools. They also express deeper choices about ontologies (what are entities worth analyzing and what constitutes those entities?) and epistemologies (what is the place and purpose of scientific knowledge with respect to reality and how can scientific knowledge be developed?). This project contained a variety of positions on these questions, ranging from the more positivist (i.e. based on the notion that reality exists outside science and can be known by science) to the more interpretative (reality does not exist outside science, and is constructed by science, rather than simply known by it). In adhering to these different positions, researchers focus on different entities. In addition, and perhaps more problematically, they also give different values to the same entities. For some project participants, household activities such as those related to dwelling, mobility, or leisure were discrete entities that could be analyzed and intervened in separately. For other project participants, the same activities were inextricable components of a household lifestyle, which could only be analyzed and intervened in as a whole. Some project participants considered it possible to identify relatively simple intervention-outcome mechanisms in human behavior. Other project participants deemed causalities too multidirectional and diffuse to allow such identification.

Matters were further complicated by the fact that there was also a difference between those disciplines that mainly focus on understanding the world – what van Aken (2004) has described as 'explanatory' sciences (in our project these included psychology, sociology, and data science) – and disciplines that mainly focus on modifying the world – what van Aken (2004) has described as 'design' sciences (in our project these included engineering). These differences also posed a challenge, but proved less difficult to bridge. Arguably this is largely because all participants in the consortium, irrespective of their disciplinary backgrounds, were embedded in daily working environments in which policy interventions are a central object of study, if not the ultimate goal of research (e.g. technical universities, urban planning programs, government, or market consultancies). In other words, all participants already had experience of, or a positive attitude towards, the translation of analytical insights into suggestions for policy interventions. Still, it was not always easy to shift between an analytical and an interventionist or 'prefigurative' mode of thinking and operating, and sometimes this was a source of confusion and miscommunication.

There are merits and drawbacks in each of these approaches. One central aim of the project was to try to combine strengths and compensate weaknesses, following the rationale of interdisciplinary and transdisciplinary collaboration (Alvargonzález, 2011). However, fruitful collaboration among different disciplines depends on a number of conditions (Klein, 2008). Many of the achievements, but also some of the frustrations in CODALoop related to the degree to which the project has been able to realize these conditions. The conditions are as follows. First, all participants need to *both* understand *and* appreciate the contributions of all the other participants. This also implies that they acknowledge the insurmountable limits of their own approach. Second, a common language has to be found or developed through which ideas can be exchanged. Third, there should be continuity and regularity in communication and information flows, both face-to-face and virtually. With regards to the first condition, while there was enough openness on a personal, emotional level, it sometimes proved more difficult to achieve as much openness on a professional, cognitive level. With regards to the second condition, each dialogue brought some progress towards a common language. Still, this progress also required expending a lot of effort and the necessary time always had to be carved out amid the pressing, short term logic of project deliverables. With regards to the third condition, a combination of biannual face-to-face meetings and intensive online interaction by a variety of means (e-mail, Skype, Etherpad) proved vital. This combination could serve as the model for subsequent multi-site research projects. However, communication in the project still often fell short of the degree of interaction required by a truly co-creative process.

The difficulties that we encountered should have not surprised us, for they are characteristic of attempts to integrate disciplines (Jahn, Bergmann, & Keil, 2012). Indeed, we had anticipated them to a certain degree, and allocated time and resources to overcoming them. We did however underestimate the extent to which developing understanding and appreciation among very different approaches requires continuous and intensive engagement between people. Not enough time and resources were devoted to this. Considering these problems retrospectively, it is possible to see that engagement could have been enhanced by longer project meetings (perhaps a whole week's duration), for instance. It could also have been improved by project meetings in which project participants not only update each other on content progress, provide reciprocal feedback, and solve management issues, but also jointly conduct a research activity or group exercise designed to facilitate understanding and collaboration among different disciplines. Furthermore, we could have ensured that all PhD students were co-supervised by a senior researcher from a different discipline to their main supervisor's and spent a significant amount of time (e.g. six months) engaged in joint research activities in a different location and disciplinary environment. This format, which resembles PhD training networks such as the Marie Skłodowska-Curie Innovative Training Networks (ITN), should be more explicitly and seriously considered as an option in future JPI Urban Europe calls aiming to foster 'deep' interdisciplinarity.

Within the practical constraints of the project, however, further engagement among project participants proved unfeasible. The more pragmatic solution was to downgrade the project's ambitions for interdisciplinarity. It moved from a model of integration to one of complementarity – that is, from interdisciplinarity to multidisciplinarity. This book testifies to the fact that this more 'federative' approach can generate rich and original insights. It also includes instances of cross-fertilization (e.g. combinations of 'interpretative' qualitative interventions, aimed at triggering awareness of necessity of reducing energy demand, with 'positivistic' calculations of energy footprints).

Community engagement

A second area in which we learned valuable lessons is that of community engagement, which is a form of transdisciplinarity (i.e. a research collaboration among scientific and societal partners) in its own right. This project focused on the interactions between and among individuals in communities as the object of analysis and intervention, and on communities as the key experimental site. This required that we either built a new community for the purpose of the project or engage with an existing community. As discussed in the preceding section, and more extensively in other chapters in this book, different points of departure and strategies of engagement were adopted in different contexts. In

Istanbul the project had formal political support: its aims were aligned with the local governments, and existing community organizations and spaces could be enrolled for use in the project. In Graz and Leibnitz the project also aligned with local government objectives and could count on political support. In addition, specific community organizational and physical spaces were not just available to the project, but explicitly dedicated to the shared goal of facilitating an energy transition. The situation was quite different in Amsterdam, where the issue of energy consumption was not on the political agenda at the outset of the project. At that time, policies pertained instead to renewable energy sources (solar panels) and energy-efficient housing construction. Today, the local municipality is recognizing the need to work on the 'social acceptance' of climate policies. Still, policies are still heavily orientated towards big data analytics, solar panel installations, and large scale social housing adaptation driven by housing associations. This is particularly the case in one of the two neighborhoods chosen in Amsterdam (Indische Buurt). The lack of both external resources for the project and a consolidated civic association specializing in energy issues hindered our attempts to secure long-term commitment from a group of urban inhabitants. This meant that, unlike the other two cases, responsibility for activating the community around the particular theme of the research was left solely to the researchers, and the PhD student in particular. Notwithstanding her effort and creativity, the question remains whether a different set-up could have fulfilled the initial ambitions. This further underlines the fact that it is extremely challenging to build a stable community around issues of sustainability from scratch, especially without institutional and financial back-up. For long term engagement, it is essential, yet not necessarily sufficient, that research questions are co-defined with the existing communities before an action-oriented research project begins.

The broader organizational context did not make it possible to compensate for these imbalances. Indeed, it exacerbated them, largely as a result of financial mechanisms. The amount of funding available in Turkey made it possible to enroll research assistants in addition to the PhD student. In Austria it was possible to enroll not just researchers but also community facilitators. In the Netherlands, however, there was funding available for only one PhD student and limited research supervision time.

In this respect, a first lesson is this: A research funding program promoting 'living lab' settings, which engage with local communities, should make possible the mobilization of human and other resources dedicated to facilitating community engagement, *in addition* to resources dedicated to scientific research. This is not only a quantitative issue (i.e. the amount of funding), but also a qualitative one, for the skills and activities required for community engagement differ from those required in scientific research (even if the two skill sets are often complementary).

There is, of course, an alternative lesson that could be derived here. Mainstream living lab approaches seek to intervene in or create a living local community. These ambitions may be illusionary. Indeed, they may even reproduce technocratic understandings of social innovation, which in reality is much more autonomous or even disorganized (Savini, 2019). Dominant expectations about the possibility of creating new communities, which characterize frameworks such as JPI Urban Europe, could be revised and downgraded. This could be done in a way that reframes the actual object of 'innovative' research and action towards a more modest, but possibly more effective focus on understanding existing practices. However, this would run contrary to the foundational conceptions underlying a program like JPI Urban Europe with regard to research, innovation, and the form of research aiming to realize a city's potential as a research and policy laboratory (Evans, Karvoren, & Raven, 2016; Karvoren, Evans, & van Heur, 2014; Savini & Bertolini, 2019). This alternative, downsizing approach would also risk creating great imbalances between participants and activities in different countries, and only compound the difficulties of inter-disciplinary collaboration discussed earlier. Whatever the case, it seems inescapable that future work should make clearer choices about the role of community engagement, the nature of research-practice cooperation, and resource mobilization consistent with these choices at the research funding program level.

Development and use of digital platforms

A third and final area in which we learned valuable lessons is in developing and using a digital platform in research and, related to this, in collaborating with an industry partner (another form of transdisciplinarity).

At the outset of the project, we placed a lot of hope in a dedicated digital platform, and the possibilities that it might open up. Developing a platform befitting an inevitably explorative and evolving research project, however, proved difficult. This was not least because the company was used to business clients' much more narrowly defined and fixed specifications. This difficulty was compounded by the project's locations. Although the industry partner was located in Istanbul, we envisaged the platform being used in Graz and in Amsterdam too, with the overall project being coordinated from Amsterdam. While all partners contributed to developing the platform, ultimately it was only used in Istanbul, and even there not to the full extent that was originally envisaged. When it became clear that it was unlikely that the digital platform would be available in the projected timescale, pragmatic solutions were sought and found in both Graz and Amsterdam. While they did not necessarily match the project's initial ambitions, these alternative solutions also opened up new, alternative avenues for developing and using a digital platform. In particular, we learned that existing social media platforms fulfill the function of community forum very well, and may already have been in use for this purpose by the existing communities targeted in the project. As such, social media might provide a ready-made platform for use in research, with just small adaptations. This proved to be the case with the Facebook-based Sustainable Community of Amsterdam, for instance. Other platform functions, such as the energy footprint calculator, were often found to be available on the Internet already. These were either usefully employed in the project or developed as a relatively simple add-on, as was the case with the 'Energanz' platform developed and employed in Graz.

This experience taught us two lessons. First, it is crucial to identify the role of private agencies in public research projects. The private partner involved in the project has to internalize a full sense of 'project-ownership' and responsibility if a research tool is to be effectively developed and used. To achieve this, the internal organization, funding, and location of the private agency involved seem crucial. Project ownership is a necessary initial condition, to be arranged at the project's outset, not during it. A second lesson is that research funding schemes and research institutes should be more critical about both the costs and benefits of developing a new digital platform within the scope of a single research project. Can existing platforms not be used instead? Do all of the envisaged functions need to be newly developed? Are there alternative, and possibly more effective, ways in which to employ the substantial resources needed for developing a new digital platform (by investing in local community and living lab facilitators instead, for instance, or supporting existing local platforms)? More generally, we should avoid falling in the double trap of uncritically assuming that technological tools (1) offer solutions and (2) do not raise problems of their own. Foremost critics of smart city discourses have been stressing these points for some time (Morozov, 2011), and a growing number of researchers are acknowledging their pertinence (Kitchin, 2015; Luque-Ayala & Marvin, 2015; Mcfarlane & Söderström, 2017). First, the employment of a particular digital technology may not add value to research. The involvement of a technological tool in research, IT, or indeed any other kind of project needs to be carefully pondered in light of the problem statement and research aim on which the project is based. Second, digital technology always comes with its own complexities, risks, and problems. These problems arise not from a given technological tool's intrinsic properties but from its combination with the research aim and research epistemologies. If – and only if – we are able to avoid these two traps, we might then also be able to identify situations in which employing digital technology could be of value, and develop original applications that are able to contribute value. We need, in sum, to develop an attitude towards digital technology that is *both* more 'aware' *and* more 'self-reflective' (Morozov & Bria, 2018).

Altogether, we believe this project has made us much more aware of both the opportunities and challenges of inter- and trans-disciplinary, multi-sited collaborations. Other chapters in the book, and the book as a whole, show what can be achieved, which remains unique. In this more critical reflection, we have shared the lessons learned, in the hope that we might help others wanting to pursue a similar path.

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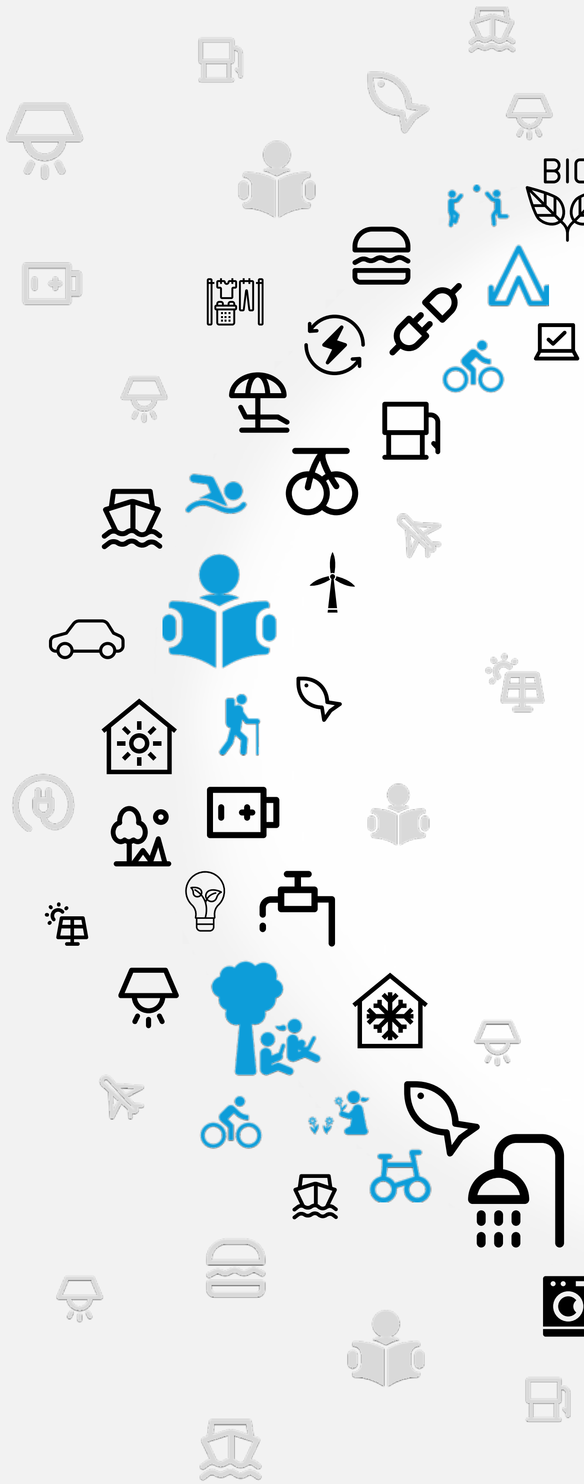
This book presents the results of the international research project CODALoop: Community Data Loop for Energy Conscious Lifestyles. It dissects the energy practices that make urban households demanding energy in their daily life and reveals the pathway towards reducing this energy demand. To unpack energy practices, the authors of this volume move away from efficiency problems studying the interaction between human and new technologies. Instead, they use a repertoire of different analytical instruments to study how interaction between humans, and between humans and data, change the social norms that shape energy needs. The volume offers a synthesis of a cross-disciplinary study of energy reduction carried out in three different countries through multiple methodological approaches. The project at the source of the book was funded under the Joint Program Initiative 'Urban Europe' and the ERA-net framework.



CODALoop

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