A Needs-Based Approach towards Fostering Long-term Engagement with Energy Feedback among Local Residents

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Abstract

In order to reach the current climate goals, energy consumption needs to decrease in all sectors, including households, which produce 20% of the European emissions. However, it is difficult to increase residents’ engagement in their household electricity consumption as it is an ‘invisible’ form of energy, the monetary incentives are often too small and environmental incentives are not very effective. Building on the idea that an engagement mechanism should be based on user needs, and recent research showing that social influence can be an effective way to affect consumption behaviour, this thesis examines the potential of a neighbourhood-based digital local social network providing feedback on household electricity consumption as an engagement solution. By helping neighbours to know each other better, such a network could meet the basic human need of belonging to a group, while also taking advantage of the social influence between neighbours to increase the effectiveness of the energy feedback provided.

This thesis sought to: 1) Identify needs of residents that could be served by a local social network and explore whether such a network could provide a beneficial context for energy feedback; 2) identify and evaluate a set of design principles for energy feedback and use them to propose a prototype feedback design suitable for use in a local social network; and 3) design and implement a baseline study for measuring changes in aspects of social and environmental sustainability in a neighbourhood that introduction of a local social network can achieve, such as social cohesion, trust, safety, and energy attitudes and behaviour.

In order to achieve these objectives, the Research Through Design methodology was used. This resulted in mixed methods research using quantitative (household survey) and qualitative (focus group interviews, stakeholder consultation workshop) methods. The research was conducted in two eco-districts in Stockholm, Sweden: Hammarby Sjöstad and Stockholm Royal Seaport.

Regarding the first objective, results from the household survey indicated a need for increased interaction between neighbours in Stockholm Royal Seaport, while the focus group discussions revealed local communication needs that a local social network could meet. However, the possibility to use social influence between neighbours in increasing the intention to save
energy was shown to be rather weak, possibly because of the current low level of connection between neighbours. Regarding the second objective, a set of design principles was identified using a literature study. They were used to create a design prototype of energy feedback that was presented to potential end-users in a stakeholder consultation workshop and then refined using suggestions given in the workshop. The workshop indicated support for many of the design principles as they were indirectly mentioned in the discussions. The design principle of fair feedback was further explored, suggesting use of typical household consumption as part of a fair comparison metric and when setting reduction goals. Regarding the third objective, an evaluation method with baseline survey and follow-up surveys was suggested. The household survey served as a baseline for measuring social and environmental sustainability aspects in a neighbourhood. Further research is needed on the effectiveness of a local social network as an engagement mechanism for energy feedback.

**Keywords:**
Energy feedback; Consumer engagement; Energy behaviour; Social networks; Smart grids; Design principles;
Sammanfattning

För att nå de nuvarande klimatmålen måste energiförbrukningen minska i alla sektorer, även för hushåll som står för 20% av de europeiska utsläppen. Det är dock svårt att öka medborgarnas engagemang kring förbrukningen av hushållsel då el är en "osynlig" energiform, de monetära incitamenten ofta är ofta för små och miljöincitament inte är särskilt effektiva. Baserat på idén att en engagemangsmechanism bör baseras på användarbehov samt ny forskning som visat att socialt inflytande kan vara ett effektivt sätt att påverka konsuntionsbeteendet, undersöker denna avhandling potentialen i ett grannskapsbaserat digitalt lokalt socialt nätverk som tillhandahåller feedback på hushållens elförbrukning som en engagemangsösning. Genom att hjälpa grannar att lära känna varandra bättre kan ett sådant nätverk uppfylla det grundläggande mänskliga behovet av att tillhöra en grupp, samtidigt som det sociala inflytandet mellan grannar kan utnyttjas för att öka effektiviteten hos den tillhandahållna energiåterkopplingen.

Denna avhandling hade tre mål: 1) Identifiera behov hos boende som kan tillgodoses av ett lokalt socialt nätverk samt undersöka huruvida ett sådant nätverk skulle kunna tillhandahålla en bra kontext för energiåterkoppling, 2) identifiera och utvärdera en uppsättning designprinciper för energiåterkoppling, och använda principerna för att föreslå en prototypdesign för energiåterkoppling lämplig för användning i ett lokalt socialt nätverk och 3) utforma och genomföra en baseline-studie för att mäta förändringar i aspekter av social och miljömässig hållbarhet i ett grannskap skulle kunna främjas av införandet av ett lokalt socialt nätverk, exempelvis social sammanhållning, tillit, säkerhet samt energiattityder och beteende.


Beträffande det första målet indikerade hushållsundersökningen ett behov av ett ökat samspel mellan grannarna i Norra Djurgårdstaden.

Fokusgruppdiskussionererna avslöjade lokala kommunikationsbehov som ett lokalt socialt nätverk skulle kunna möta. Möjligheten att använda socialt
inflytande mellan grannar för att öka intentionen att spara energi visade sig dock vara ganska liten, möjligen på grund av den nuvarande låga nivån av sammanhållning mellan grannarna.


**Nyckelord:**
Energiåterkoppling; konsumentengagemang; Energibeteende; Sociala nätverk; Smarta elnät; Designprinciper;
List of appended papers

Paper I


*My contribution to this paper was: development of the research idea and survey in cooperation with the co-authors, analysing parts of the survey data, writing the paper, and acting as corresponding author during publication.*

Paper II


*My contribution to this paper was: development and maintenance of the digital data collection system, data analysis, and data provision to the co-authors.*

Paper III


*My contribution to this paper was: development of the research idea, conducting the literature study, development of the stakeholder consultation workshop script in cooperation with the co-authors, coding and analysing the workshop results, developing the idea of the feedback prototypes in cooperation with the co-authors, and writing the paper.*

Relevant additional publications

List of abbreviations

DSO        Distribution system operator
FG         Focus group
GHG        Greenhouse gas
HCI        Human-computer interaction
P#         Design principle, # = number
RAA        Reasoned Action Approach
RTD        Research Through Design
TPB        Theory of Planned Behaviour
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1. Introduction

1.1 Research rationale

The aim of this work is to contribute to ongoing research on the energy reduction efforts needed to reach the current global and national climate goals, with the focus on the Swedish household sector. The main motivation is derived from the current difficulties in increasing residents' awareness and willingness to reduce their household electricity consumption in response to energy feedback (e.g. Fischer, 2008; Hargreaves et al., 2013; Strengers, 2014; Nilsson, Wester et al., 2018). This thesis examines the potential of a digital social online networking service, hereafter called a ‘social network’, to provide a context for energy feedback that could be effective in increasing awareness and inducing change in the electricity consumption behaviour of residents.

In order to reach the climate goals set by the Paris Agreement (United Nations, 2015), greenhouse gas (GHG) emissions need to decrease sharply, even more sharply than was previously believed (IPCC, 2018). Within the field of energy, this is mainly achievable in two ways: i) reducing energy consumption and ii) increasing the share of renewable energy sources (International Energy Agency, 2016). To better handle the intermittent production from renewable sources, there is ongoing work to upgrade the electricity infrastructure to so-called 'smart grids'.

Households are associated with 20% of European GHG emissions (Eurostat, 2016). They are thus important contributors to the emissions reduction effort and need to be engaged in order for smart grids to reach their full potential (Strbac, 2008). In the future, increasing automation of loads such as electrically heated hot water tanks, washing machines, fridges/freezers and charging electric vehicles may decrease the user engagement required. These loads would be able to temporarily reduce their consumption or switch off completely without requiring user input and without noticeably reducing user comfort, thus facilitating optimisation of energy use in the household. However, equipment capable of this type of automation is still uncommon outside pilot studies, as it is expensive (He et al., 2013), complicated to use and does not have features of interest to most users. There is also no widely accepted, standardised way of centrally controlling such devices (ibid.). Thus, recognising that widespread automation is still far away
while also understanding that some consumption will still be driven by user behaviour, another type of approach is needed.

One of the most common interventions to engage residents is to provide them with feedback on their household electricity consumption. The basic assumption is that when residents receive more information, their awareness or knowledge increases, leading to a change in their energy use behaviour and thus a decrease in consumption (Wilhite and Ling, 1995). The aim of the feedback is usually to provide residents with information on their current and previous energy consumption and show that by reducing their energy use, they can save money, the environment, or both. However, comfort is often more important for residents than the relatively small amount of money saved when set against their overall income (Hargreaves et al., 2013; Murtagh et al., 2014). Moreover, appealing to environmental concerns is not very effective in practice, even though the environment is often mentioned as one of the top motivators by residents (Cialdini and Schultz, 2004; Nilsson, Lazarevic et al., 2018; Nilsson, Wester et al., 2018).

Further, the long-term effects of energy feedback are unclear. When feedback is introduced into the household (e.g. using energy apps or in-home energy monitors), there may be initial interest, but it usually fades over time (Hargreaves et al., 2013).

This fade in interest may be partly due to the fact that in many engagement approaches, residents and their behaviour are seen as ‘problems’ (DiSalvo et al., 2010) that can be ‘fixed’ by providing them with enough information - a view often referred to as the ‘information deficit model’ (e.g. Schultz, 2002). Energy companies and distribution system operators (DSO) launch websites and apps with energy feedback in the hope that residents will use them. However, information may be necessary, but not enough, to make people change their behaviour (e.g. Schultz, 2002; Marteau et al., 2002; Katzef et al., 2017), and these types of technology push-oriented approaches often fail (Pierce et al., 2010; Goncalves Da Silva et al., 2012). One reason for this is information overload (Eppler, 2015; Stephens, 2017), i.e. the residents are already exposed to an increasing amount of information from a multitude of sources (Bohn and Short, 2012; Eppler, 2015), which makes it difficult for yet another source of information to draw their attention. As people need to prioritise what information to read and what to disregard, it is especially difficult for information perceived as irrelevant or uninteresting, which is often the case with electricity consumption, to attract their attention. Apart from paying their electricity bills, most people do not reflect on
their electricity use, as it is a more ‘invisible’ form of energy consumption (Fischer, 2008) than tangible forms such as burning wood, filling a car with petrol or filling a bath with hot water. Thus, as it is already challenging to make residents pay attention to energy feedback that they currently receive, the chances of them actively searching for information regarding their electricity consumption, e.g. by downloading an energy app, are even smaller.

Evaluating the long-term effects of an engagement approach such as energy feedback is another important aspect that is lacking in many energy-saving competitions and pilot studies. Feedback has been shown to give a consumption reduction during a few weeks or months, but the effects are rarely followed up over longer periods (Hargreaves et al., 2013; Delmas et al., 2013; Vine and Jones, 2015; Liebe et al., 2018). There is also a lack of evaluations spanning multiple countries (Liebe et al., 2018), which is important since cultural differences could affect how these types of non-monetary incentives are received (ibid.). Furthermore, when evaluating an urban metabolic flow such as household electricity, it is important to have access to baseline and consumption data of sufficient spatial and temporal resolution for the purposes of the evaluation (Shahrokni et al., 2015; Paper II). A lack of a baseline data limits the possibility to accurately detect changes (Nilsson, 2018), while low-resolution data such as monthly, quarterly or yearly electricity measurements, which are still relatively common, makes it impossible to evaluate short-term behaviour (Paper II) such as load shifting. In summary, getting residents to engage persistently with their electricity consumption using energy feedback and evaluating the effects appears to be a complex task that current approaches have not managed to solve.

In order to combat the information overload, engagement and evaluation issues described above, a different, needs-based approach to encourage residents to engage with their electricity consumption is explored in this thesis. Instead of viewing residents as “problems” that need to be managed, any proposed intervention should meet a need and thus solve a problem for residents, while also supplying energy feedback with the aim of engaging residents.

There are many types of needs that could be met for residents. That chosen for further exploration in this thesis is the basic need to belong to a group (Maslow, 1970). People’s social engagement with their neighbours as part of local organisations was relatively high until the 1950s (Putnam, 1995). However, with the advent of the digital age, people are becoming “globally connected but locally...
isolated” (Hayes, 2007). It is increasingly common to be “globally connected” using communication tools that emerged in recent decades such as social networks that let people keep in touch with friends, family and colleagues, regardless of where they are, and follow public figures and organisations. At the same time, there is an increasing trend of ‘local isolation’, exemplified by the fact that more than 50% of Americans (Smith, 2010) and over 70% of all Swedes living in an apartment (Svenska Postkodlotteriet, 2016) only know a few, if any, of their neighbours well. This is unfortunate, as neighbours can be supportive in people’s daily lives by offering help, providing information that is not readily available elsewhere or collaborating to maintain and improve the facilities and area in which they live. In the long run, this isolation threatens to erode the local social capital (Putnam, 1995) that holds societies together. Therefore it is valuable to explore whether a sustainability-oriented local social network designed from a user-needs based perspective could provide a suitable context for presenting persistently engaging energy feedback to residents in a neighbourhood.

1.2 Aims and objectives

The overall aim of this thesis is to examine the potential of a local social network as an engagement solution for providing energy feedback. Specific objectives are to:

1) Identify needs of residents that could be served by a neighbourhood-based local social network, and explore whether such a network could provide a beneficial context for presenting energy feedback (Papers I and III)
2) Identify and evaluate a set of design principles for energy feedback, and use them to propose a prototype feedback design suitable for use in a local social network (Papers II and III)
3) Design and implement a baseline study for measuring changes in aspects of social and environmental sustainability in a neighbourhood, such as social cohesion, trust, safety and energy attitudes and behaviour, that introduction of a local social network can achieve (Paper I)

1.3 Scope

The research was performed in two city districts in Stockholm, Sweden: Hammarby Sjöstad and Stockholm Royal Seaport.

Hammarby Sjöstad is Stockholm’s first environmentally profiled district (Stockholms Stad, 2017), since it was originally intended as an Olympic village for
the Summer Olympic Games in 2004 (Stockholms Stad, 2018) and was thus expected to meet the Olympic environmental guidelines first applied in Sydney in 2000 (Borne, 2003). Stockholm was not chosen to hold the 2004 Olympic Games, but Hammarby Sjöstad continued to be built according to the original environmental vision. It currently has around 9000 households with 21,000 residents. These numbers are expected to rise to 12,700 and 31,000 respectively, when the district is finished in 2020 (Stockholms Stad, 2018). In 2017, over 60% of the residents had some form of higher education and they have an upper middle-level income.

Stockholm Royal Seaport is Stockholm’s second eco-district. It is still under development and is expected to have about 12,000 households and 35,000 workspaces when it is finished in 2030 (Stockholms Stad, 2017). Its residents are mainly well educated (>70% with higher education) with an upper middle-level income. In the process of planning and building Stockholm Royal Seaport, knowledge and lessons learned from the evaluation process of Hammarby Sjöstad (Pandis Iverot and Brandt, 2011) were used to improve the planning process and goal setting (Stockholms Stad, 2017).

These districts were chosen because the City of Stockholm has sustainability programmes for both areas (Stockholms Stad, 2017, 2019), which means they are suitable testbeds for sustainability-related experiments and activities. Furthermore, Stockholm Royal Seaport was chosen as it would allow for future comparison of two types of energy feedback provided within the same district: real-time feedback displayed by a home energy management system (Nilsson, Wester et al., 2018; Nilsson, Lazarevic et al., 2018), and feedback presented as a part of a local social network as introduced in this thesis.

The research was conducted within two projects: Citizen Communication Platform funded by Sweden’s innovation agency VINNOVA, with reference number 2015-00305, and InteGrid funded by the European Union’s Horizon 2020 research and innovation programme, under grant agreement No. 731218.
2. Background

2.1 Theoretical background

The behaviour of residents has a great effect on the energy consumption of households (Vassileva et al., 2012; Holmstedt et al., 2018 - Paper II; Mäkivierikko et al., 2018). It is therefore important to get a better understanding of how behaviour can be predicted, understood and changed at household level, but at the same time within the broader context of a neighbourhood. The neighbourhood is relevant to study since it is the level on which the presently examined engagement mechanism of a local social network would operate, but also because it is a societal building block containing converging energy and material flows directly associated with its residents (Shahrokni et al., 2015). These flows can be of interest to analyse for the increasing number of neighbourhoods that have environmental goals that need to be evaluated (ibid.). From the point of view of electricity distribution, a neighbourhood often consists of a low-voltage electricity grid supplied by one or more secondary substations. If the electricity demand within such a local grid could be controlled by e.g. affecting the consumption behaviour of its connected households, the stability of the grid could be improved (Vivekananthan et al., 2014; Rahman et al., 2018) and the load on the grid equipment could be decreased (Poudineh and Jamasb, 2014), allowing further investments in grid infrastructure to be deferred (ibid.).

Among many theories concerning behaviour change (Webb et al., 2010), the Theory of Planned Behaviour (TPB) (Ajzen, 1991) is one of the most commonly used (e.g. Blue, 1995; Armitage and Conner, 2001; Webb et al., 2010; Bögel and Upham, 2018). However, it has been criticised for not taking into account the social influence of the groups to which an individual may belong. On the other hand, this is the strength of social identity theory (Tajfel, 1974). Thus, combining both theories, as was done by Fielding et al. (2008), gives a fuller picture of how the behaviour of an individual is formed and better explains the effect of social influence on behaviour. The theories, and the rationale behind combining them, are explained in detail below.

2.1.1 Theory of Planned Behaviour and Reasoned Action Approach

The Theory of Planned Behaviour (Ajzen, 1991) states that the behaviour of an individual is affected by his or her behavioural intention. The intention is in turn affected by three factors: i) attitudes toward the behaviour, i.e. whether the
behaviour is seen as a positive or negative; ii) perceived behavioural control, i.e. whether the behaviour is seen as possible to perform, and iii) subjective norm, i.e. what the person believes that other people important to the person think of him or her performing the behaviour. In the Reasoned Action Approach (RAA) (Fishbein and Ajzen, 2010), a successor to TPB, the subjective norm evolves to the concept of perceived norm, which in turn consists of two types of norms: injunctive norms, i.e. how individuals think people important to them would like them to behave, and descriptive norms, i.e. how individuals think people important to them actually behave. This distinction between injunctive and descriptive norms is used in the feedback design presented in this thesis (Paper II), since it has been shown that both types are needed for energy feedback to be effective. The descriptive norm can be more effective than economic or environmental factors in making people reduce their consumption (Cialdini and Schultz, 2004), while the injunctive norm is useful for preventing energy-efficient households from increasing their consumption when they find out that others consume more (Schultz et al., 2007).

Although there are successful examples such as those cited above, the effect of norms on behaviour has been shown to be relatively weak in other studies (e.g. Blue, 1995; Armitage and Conner, 2001). A reason for this is that the notion of ‘important others’ is often limited to a small set of people, typically family and friends, while not taking into account the normative effects of relevant societal groups to which the individual may belong (Terry and Hogg, 1996; Terry et al., 1999). Taking into consideration the context of the neighbourhood-based social network explored in the present thesis with the aim of making neighbours connect, neighbours are a relevant group to study as their attitudes could be an important component of the social norms that affect individual behaviour. Therefore, in order to get a fuller picture of the effect of social norms arising from the group of neighbours, in this thesis TPB was complemented with Social Identity Theory, which is described in the next section.

2.1.2 Social identity theory

Social identity theory (Tajfel, 1974) attempts to explain how being a member of certain groups, not being a member of others, and the perceived difference in e.g. status between these groups affects a person (Abrams and Hogg, 2010). Tajfel (1974: p. 69) defines social identity as “the part of an individual’s self-concept which derives from his knowledge of his membership of a social group (or groups) together with the emotional significance attached to that membership”. An individual can be part of many types of groups, either by being born into them
(such as nationality), choosing or being chosen into a group, or being willingly or unwillingly categorised into a group by others. However, it is only when the individual *himself or herself* thinks that a specific group membership is important, i.e. has emotional significance, that the group has a possibility to affect the individual’s behaviour (Abrams and Hogg, 2010). This so-called self-categorisation is affected by how frequently an individual categorises with a group, how relevant the categorisation is in any given situation, and how similar or different the individual is compared with other members of the group (Abrams and Hogg, 2010 cit. Oakes et al., 1994). To improve one’s social identity and thus self concept, an individual seeks to become and/or remain a member of those groups that are important and contribute positively to his or her social identity, while trying to leave or avoid being associated with groups that affect this social identity, and thus the individual’s self-concept, in a negative way (Tajfel, 1974). Receiving positive evaluations from the group is one way to increase the self enhancement associated with social identity. Therefore, the individual strives to increase his or her similarities with in-group members by e.g. adhering to the attitudes and norms held by the members of that group, while further attempting to differentiate himself or herself from out-group members.

Fielding et al. (2008) combined TPB with social identity theory and showed that higher group identification was correlated with stronger adherence to group norms. Groups with which an individual identifies strongly should thus be considered an extension to the TPB concept of ‘important others’. For the particular behaviour examined by Fielding et al. (2008), the group norms were in fact the only norms that influenced the behaviour, as the ‘traditional’ subjective norms of TPB had a minimal effect.

### 2.2 Social networks

In the context of this thesis, the term ‘social network’ refers to a *digital online social networking service* featuring social media concepts of being a Web 2.0-based internet application, relying on user-generated content, having profiles for users and groups, and allowing users to communicate with other users/groups (Obar and Wildman, 2015). Within a few decades, social networks have evolved from being used by a small group of technically knowledgeable people to a phenomenon used by vast numbers of people all over the world. An example of this is Facebook, which started in 2004 as a hobby project for a university campus, became globally available in 2006 (Obar and Wildman, 2015), and grew in a decade from 100 million users in 2008 (Statista, 2018a) to become the world’s
largest social network in 2018 with over 2.3 billion active monthly users (Statista, 2018b). A reason for this growth is that the social networks fill a need for people by allowing them to communicate and keep in touch with their friends and family.

**Local social networks**

The main focus of most mainstream social networks is to facilitate communication with already familiar people, thus increasing the ‘global connection’ identified by Hayes (2007). To combat ‘local isolation’ (ibid.), however, a local social network that is geographically restricted to the neighbourhood could be a solution. A local social network could bring two benefits. First, it could help neighbours get to know each other better, thus filling the need of belonging to a group (Maslow, 1970) while also increasing several aspects of local social capital such as trust (Rohe, 2004), safety (Dallago et al., 2009) and place attachment (Lewicka, 2004, cit. Lewicka, 2005, p. 392). Second, it could offer solutions for everyday needs that the neighbours have, thus making it a technology-pull-driven solution that would be used because it facilitates people’s lives. A number of such local social networks have evolved over the past decade, the largest being the US-based NextDoor¹, which has since expanded to other countries and acquired locally-based networks such as the UK-based Streetlife² and the Australian Nabo³. Other examples are the German Nebenan⁴, the French Smiile⁵ and Mesvoisins⁶, Hoodi⁷ in the United Arab Emirates, and the Finnish Nappi Naapurin.⁸ These networks all have a slightly different focus depending on the country and the type of issues that are of interest to the local population. However, despite the increasing concern about climate change among the general population, none of these networks focuses on sustainability. Therefore, a sustainability-oriented social network could be a concept worth exploring, while at the same time helping to make neighbourhoods more sustainable.

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¹ [http://nextdoor.com](http://nextdoor.com)
² [https://streetlife.com](https://streetlife.com)
⁴ [https://nebenan.de](https://nebenan.de)
⁵ [https://www.smiile.com](https://www.smiile.com)
⁶ [https://mesvoisins.fr](https://mesvoisins.fr)
⁷ [https://hoodi.co](https://hoodi.co)
⁸ [https://www.nappinaapuri.fi](https://www.nappinaapuri.fi)
2.3 Local social networks as a provider of context for energy feedback

There are several reasons for testing the approach of a local social network that provides a context for energy feedback. As a digital medium, a social network allows for frequent and interactive feedback, while also being a scalable solution that can reach many users at a minimal cost. More importantly, as social networks provide information that fits the need and provides value to its users (Eppler, 2015), they are technology pull-driven solutions that would be used for reasons other than energy feedback, thus avoiding the challenges with technology-push oriented solutions demonstrated by e.g. Pierce et al. (2010) and Goncalves Da Silva et al. (2012). In contrast to environmental information campaigns (Geller, 1981; Schultz, 2002; Schultz and Kaiser, 2012) and energy feedback provided in a conventional way, using e.g. invoices or stand-alone energy apps, energy feedback provided within a social network would be provided in tandem with information that the user has requested. The feedback could therefore have greater potential to cut through the information overload barrier and reach the user (Figure 1). The first phase of this barrier ‘cutting’ is to make the user of the social network aware that their normally ‘invisible’ energy consumption (Fischer, 2008) can in fact be made visible through the possibility to receive energy feedback. If this possibility is advertised in a social network, it has the potential to reach a wider audience that would not normally seek information about their energy consumption. The second phase is to make the user to sign up to receive the feedback. To increase the chances of users signing up, they need to be presented with compelling reasons and given a simple and clear registration process, both of which could be offered within the local social network. The third phase is to make the user pay attention to the energy feedback presented, giving it a chance to have the desired effect on energy consumption behaviour. Well-designed feedback increases this possibility (section 2.4).
Another advantage of a social network is that its inherently social nature would enable the utilisation of social influence as part of the energy feedback, something that was explored in Paper I and is described in section 2.1. Using social norms in feedback messages has been shown to be a cost-effective way to reduce peak loads (Allcott, 2011). However, according to Social Identity Theory, for the social influence to be fully effective in the context of a neighbourhood, two conditions need to be met: i) the neighbours need to have the desired attitude (i.e. be positive to saving energy), and ii) residents needs to feel a strong enough identity with their neighbours. It is therefore of interest to check whether these conditions are met in a neighbourhood, which was done in Paper I. Further, by virtue of increased neighbour-to-neighbour interactions, it is likely that a sense of stronger group identity could emerge on the building or neighbourhood scale, which in turn could promote pro-environmental behaviours (Uzzell et al., 2002), and subsequently reduce electricity consumption.
Even with these advantages, the idea of presenting energy feedback using a social network has not been widely explored outside short pilot studies using ‘ordinary’ (i.e. non-local) social networks. Examples of such are StepGreen (Mankoff et al., 2010), a website that provided a plugin to the MySpace social network that suggested energy-savings actions to its users and which, when accepted, were visible on the user’s profile page; EnergyWiz (Petkov et al., 2011), an design prototype of an Android app testing different forms of comparative feedback, letting the user challenge a Facebook friend for a week-long energy-saving competition and also see a ranking among similar Facebook-connected EnergyWiz-users; and Wattsup9 (Foster et al., 2010), a Facebook app offering comparison and ranking with participating friends. Problems in common to these three solutions were that they existed as short-lived pilot studies, and thus were not able to measure long-term effects of the feedback provided; they were not designed to be scalable with respect to e.g. recruitment of residents or metering equipment; and, since they used existing social networks, they were limited to using the subset of these networks’ features available to third-party developers.

2.4 Feedback design

Research on eco-feedback, i.e. feedback on human consumption of natural resources with the aim of reducing the environmental impact on mankind, has been underway since the 1970s, promoted by the realisation that a combination of new technology and human behaviour change is needed to reduce the environmental impact of humans (Froehlich, 2010). The widespread use of computers, smartphones and tablets has provided new possibilities for creating appealing and interactive feedback. How this feedback should be designed in order to be effective has captured the interest of researchers both within the energy and environmental fields (e.g. Darby, 2006; Fischer, 2008; Ehrhardt-Martinez et al., 2010) and within the human-computer interaction (HCI) community (e.g. Froehlich, 2010; Spagnolli et al. 2011). Further, the roll-out of smart meters has made it possible to automatically collect consumption data and thus provide more frequent feedback compared with monthly or quarterly electricity bills (Froehlich, 2010; Olmos, 2011). However, the feedback has been criticised for being designed for a nearly utopian type of consumer: the ‘Resource Man’ as Strengers (2014) calls him (or her, but it is often a ‘him’), who is interested and engaged in energy consumption and is ready to learn about and use smart technologies to reduce his

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9 Not to be confused with the messaging application WhatsApp
energy use. However, this design does not take into account the everyday realities of the majority of residents and the dynamics of households (ibid.), as residents do not constantly consider their energy consumption or actively search for ways to optimise it. The concept of the ‘Resource Man’ stems from the previously commonly held view in behavioural psychology that the individual makes rational choices based on individual self-interest and cognitive deliberation (Jackson, 2005). However, this view has been criticised, because much of the everyday behaviour is the product not of the type of deliberate, cognitive thought process often connected to TPB, but instead of a more automated process based on habits, routines or previous knowledge of similar situations, and is also affected by emotions (Jackson, 2005). Further, behaviour is not purely driven by self-interest but is also affected by the social setting, moral view and willingness to do good for others (ibid.).

There are thus many aspects to take into consideration when designing feedback for ‘real’ people. It should not only be understandable, appealing, relatable, fair (Fischer, 2008; Olmos et al., 2011; Eppler, 2015; Escudero Guirado et al., 2018; Nilsson, Wester et al., 2018; Paper II) and actionable (Ajzen, 1991; Eppler, 2015), but also go beyond self-interest values such as monetary savings and take into account the habitual, social and altruistic aspects that affect behaviour. Further, the feedback needs to be adapted to the context where it is shown, i.e. a local social network. Therefore, in Paper III, a set of design principles was compiled and adapted to the context of a local social network.

From a theoretical point of view, the critique of ‘Resource Man’, and thus TPB, gives another compelling reason not to focus solely on TPB, but to combine it with other theories such as the Social identity theory to capture a wider array of features that are important for creating effective feedback design.
3. Methodology

3.1 Research Through Design (RTD) methodology

The overarching methodology used in this thesis is Research Through Design (RTD). The term was coined by Frayling (1993) and, although there is no exact definition of RTD, Zimmerman et al. (2007) describe it as aiming to integrate the theoretical research conducted in the field of human-computer interaction (HCI) with the practical design work done by designers, while also highlighting the importance of documenting the different design steps and decisions. The outcome of the RTD process is a design artefact that “can transfer the world from its current state to a preferred state” (ibid.). Further, Zimmerman et al. (2007) suggests a more formalised version of the theory, including a set of criteria that can be used to evaluate the quality of design contributions, while Zimmerman and Forlizzi (2014) list five steps that an RTD project could follow:

1. Select - choose a research problem.
2. Design - conduct a literature review and then create an initial framing of a product or service idea that would be one way (of many) to solve or improve the research problem. This idea is then continuously refined.
3. Evaluate - throughout the refinement process, the idea is continually evaluated. In this process, the design moves, the rationales to introduce these moves, and whether different hunches did or did not work out are documented.
4. Reflect and disseminate - reflect upon the evaluations and disseminate them in e.g. peer-reviewed journals
5. Repeat - to get the best results, the whole process should be repeated one or more times.

The RTD methodology was used for two processes in this thesis: i) the overarching process of finding a way to engage residents with their household electricity consumption (Paper I); and ii) the narrower process of designing energy feedback to be displayed in the local social network (Paper III).

As part of the evaluation step in RTD, both qualitative (focus group interviews, stakeholder consultation workshop) and quantitative (household survey) methods were used, which means that a variant of the mixed methods research approach was applied. The aim of mixed method research is to combine quantitative and qualitative methods into a single study, using the strengths of both while
minimising their weaknesses (Johnson and Onwuegbuzie, 2004). The use of mixed methods allows for interdisciplinary research where the expertise of researchers from multiple fields can be combined. There are two main types of mixed method research: mixed-model, where multiple methods are used to investigate the same research question from different angles, and mixed-method, where the methods are used in different phases of the research (ibid.). The latter type was used in this thesis for the purpose of expansion, i.e. “to extend the breadth and range of inquiry by using different methods for different inquiry components.” (Greene et al., 1989: p. 259).

The execution of the RTD steps, the methods used in each step, and the outcomes from both of the processes studied are shown in Figure 2 and described in sections 3.1.1 and 3.1.2. The research objectives, methods used, and RTD steps to which they belong are shown in Table 1.

Figure 2. Diagram showing the work flow following the Research Through Design (RTD) steps for the different parts of the research presented in this thesis. The blue boxes show the design artefacts from the process.
Table 1. Research objectives, methods used, steps in the Research Through Design (RTD) methodology and the papers in this thesis (I-III) in which they are described.

<table>
<thead>
<tr>
<th>Research objective</th>
<th>Method</th>
<th>RTD step</th>
<th>Paper</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Identify needs of residents that could be served by a neighbourhood-based local social network, and explore whether such a network could provide a beneficial context for presenting energy feedback</td>
<td>- Household survey (quantitative), - Focus group interviews (qualitative)</td>
<td>2,3</td>
<td>I, III</td>
</tr>
<tr>
<td>2) Identify and evaluate a set of design principles for energy feedback, and use them to propose a prototype feedback design suitable for use in a local social network</td>
<td>- Literature review - Stakeholder consultation workshop (qualitative)</td>
<td>2,3</td>
<td>II, III</td>
</tr>
<tr>
<td>3) Design and implement a baseline study for measuring changes in aspects of social and environmental sustainability in a neighbourhood, such as social cohesion, trust, safety and energy attitudes and behaviour, that introduction of a local social network can achieve</td>
<td>- Household survey (quantitative)</td>
<td>3</td>
<td>I</td>
</tr>
</tbody>
</table>

3.1.1 RTD steps for finding a mechanism that creates persistent engagement among residents (Paper I)

**Step 1: Choose a research problem**
The overall research problem addressed in this thesis and in detail in Paper I is that discussed in the introduction: to find a way of creating persistent residential engagement and behaviour change regarding household electricity consumption in response to the increasing challenges to the electricity grid posed by renewable energy sources and capacity bottlenecks.

**Step 2: Design**
The research problem led to the overarching research idea of a local social network that provides a context for energy feedback, which this thesis aimed to explore by achieving the three research objectives stated in section 1.2. Literature on behavioural change theories and energy feedback was reviewed to understand the importance of social influence in feedback that could be utilised using a local social network.
The idea of a local social network was refined in step 3 and led to design of communication on three different geographical scales (see section 4.1.2).

**Step 3: Evaluate**
To validate the need for a local social network, the need for people to have better social relations with their neighbours was measured by a survey, while focus group interviews were held with the aim of finding potential local user needs that a local social network could help solving, thus helping to refine the conceptual design of the social network in step 2 into an actual product.

The survey was simultaneously used as a baseline, which is the first step in long-term evaluation of the effects of a local social network on certain aspects of social and environmental sustainability.

A final evaluation of the efficiency of a local social network that provides a context for energy feedback will be performed in the future. It will be based on results from a follow-up survey, which will be compared against those of the baseline survey, and an examination of actual energy consumption data of residents provided with energy feedback within the local social network.

**Step 4: Reflect and disseminate**
Development of the concept of a local social network that provides a context for energy feedback is reflected on and disseminated as part of this thesis and more specifically in Paper I.

The final evaluation results will be presented in future papers.

**Step 5: Repeat**
After the future final evaluation of the concept of providing energy feedback, it will be apparent whether the concept is effective in changing residents’ energy behaviours. The functionality may need to be improved, thus going back to the design stage (step 2). If the evaluation shows that the concept is not effective, it may be necessary to go back to step 1 and find a new solution to the engagement problem.

3.1.2 RTD steps for designing energy feedback within a social network (Paper III)

**Step 1: Choose a research problem**
The research problem was to make a prototype design of energy feedback to be used within the local social network.

**Step 2: Design**
A literature review was performed to identify design principles for energy feedback. Based on these, a first design prototype showing part of the energy feedback was made.

Based on the feedback from the focus group discussions in step 3, an updated design prototype was made and subsequently implemented.

**Step 3: Evaluation**
A stakeholder consultation workshop was held, where the design prototype was discussed and feedback was obtained on it in focus groups.

**Step 4: Reflect and disseminate**
The process of developing the energy feedback is disseminated as part of this thesis and in more detail in Paper II.

**Step 5: Repeat**
In the future, the energy feedback will be further refined based on pilot tests with actual users.

### 3.2 Household survey
A survey is a systematic method for collecting and analysing mainly quantitative data from a sample of a large population (Groves et al., 2004). Data collection and analysis can be done in a relatively quick and objective way, and the results can be generalised if the sampling is carefully performed (Johnson and Onwuegbuzie, 2004). Thus, when needing to sample a larger population, a quantitative method such as a survey is often more suitable than qualitative methods such as interviews, which tend to be relatively time- and resource-intensive.

The questionnaire used in the survey conducted in Paper I was designed to:
- Measure the current status of certain aspects of social sustainability, including the connection between neighbours
- Measure the current status of energy awareness energy behaviour
- Measure the group identification with the neighbourhood
- Explore whether group identification affects the attitudes toward energy consumption

The parts of the questionnaire concerning attitudes and group identity were mainly based on that designed by Fielding et al. (2008), who used questions and scales based on Social Identity Theory (Tajfel, 1974) such as “How important are the people in Stockholm Royal Seaport to you?” or “In your opinion, how many of the people in Stockholm Royal Seaport believe that it is good that you are saving energy in your household?”, and TPB (Ajzen, 1991), for example “To save energy in your household, how good do you think it is?”, “How much effort have you been putting into saving energy in your household?” or “How well do you agree with the following statement: I plan to save energy in my household during the next 6 months.”. The parts measuring aspects of social ties in the neighbourhood used questions adapted from Eriksson et al. (2010), such as “How many neighbours do you think you know in the place where you live?” or “Do you feel that you can trust people in Stockholm Royal Seaport?” while the questions measuring energy-saving actions, such as “Have you [...] turned off the lights when not needed”, were adapted from Stockholm's Stad (2016). The parts of the survey that were related to group identity used two groups relevant to this study: the neighbours living in an individual’s building or housing co-operation; and the neighbours living in an individual’s neighbourhood.

Data collection was conducted in a phone survey in May 2018 in Stockholm Royal Seaport. It was performed by the marketing research company Novus, using 300 randomly chosen households in order to get a representative sample of households in the area. A detailed description of the survey design, including theoretical background and questions used, can be found in Paper I.

3.3 Focus group interviews

In Paper I, focus group interviews were used. This is a research method where a group of participants, chosen because they are expected to provide valuable contributions (Liamputtong, 2010), are led by one or more focus group leaders in an informal discussion about a specific subject. The interactions and discussions that take place between the participants often make them “explore and clarify their points of view” (ibid: p. 6) and thus “uncover aspects of understanding that often remain hidden” (ibid: p. 5) in surveys or in-depth interviews.
The aim of the focus group discussions was to identify neighbourhood needs that would be facilitated by a local social network. Therefore, potential future users among residents in the district of Hammarby Sjöstad in Stockholm, Sweden, were involved. During autumn 2015, five focus groups consisting of between 4-8 members were formed, holding on average 2-3 meetings. One group discussed general neighbourhood needs, while the others discussed local needs within four thematic areas: homeowner associations; environment; culture and local associations; and school. Notes were taken from the discussions.

More details about the composition of the focus groups can be found in Paper I.

3.4 Literature review of design principles

A literature review was conducted in Paper III as part of step 2 (Design) of the RTD process to find design principles for energy feedback design. It consisted of two parts: the first concerned psychological theories that have been used in the field of energy behaviour, mainly the Theory of Planned Behaviour (Ajzen, 1991) but also Self-Determination Theory (Ryan and Deci, 2000) and Social Identity Theory (Tajfel, 1974). From these theories, a list of design principles was derived. The second part was based on a meta-study providing design principles for energy feedback (Escudero Guirado et al., 2018) that was led by the Comillas Pontifical University in the European Commission-funded smart grid project “InteGrid”. This was complemented with an interview study at Stockholm Royal Seaport (Nilsson, Wester et al., 2018) that covered some of the principles. More details about the literature review on design principles can be found in Paper III.

3.5 Stakeholder consultation workshop

For the evaluation work done in Paper III (step 3 of the RTD process), a stakeholder consultation workshop was held with the main purpose of gathering opinions about the prototype of the energy feedback that had been developed based on the design principles, but also to find out indirectly whether the participants supported the design principles identified in the literature review. Part of the workshop used the thought-listing technique (Cacioppo and Petty, 1981), where the participants are subjected to a stimulus - here a printed image of the feedback - and are then given a few minutes to talk about what comes into their mind. Although the technique is often used with individuals, it was used here in a focus group setting because that type of interaction between group
participants can uncover thoughts or lines of reasoning that are not captured in surveys or interviews (Liamputtong, 2010).

The workshop was held in the city district of Hammarby Sjöstad, Stockholm, Sweden, in May 2018. There were 18 participants of mixed age, eight of whom were female. Ten of the participants were residents of Hammarby Sjöstad, some of the others came from surrounding districts, and a few were from the local distribution system operator (DSO). These latter participants thus had above-average knowledge about electricity, as was also the case for some of the Hammarby Sjöstad residents who had been involved in a project to introduce electric vehicles to the district. The participants were split into four groups of 4-6 people. To explore differences in how individual-level compared with group-level feedback was perceived, two of the groups were given images showing only apartment-level feedback, while the other two groups were given images showing only collective feedback on building and neighbourhood level. Both groups were led by a moderator, who used a pre-defined script based on a stepwise information process to help the participants express their opinions regarding the prototype design. First, a set of images presenting the energy feedback were handed out to the participants without prior explanation, in order to capture the spontaneous reactions to the feedback. This was followed by an explanation of the feedback, following a set of short group discussions collecting opinions about whether the feedback was understandable, actionable, relevant and motivating. More details about the stakeholder consultation workshop can be found in Paper III.
4. Results

4.1 Resident needs served by a local social network and its suitability providing a context for energy feedback

The first objective was to identify needs of residents that could be served by a neighbourhood-based local social network and explore whether such a network could provide a beneficial context for energy feedback. The needs and insights were then used to make a conceptual design for a local social network as a resulting artefact of the RTD methodology. The needs identified, the relevancy of a local social network that provides a feedback context, and the conceptual design of the network are presented below.

4.1.1 The need for a social network

In order for the social network to be needs-based, by definition it needs to meet user needs. In this thesis, two types of needs were explored: i) the existence of a ‘local isolation’ and thus the basic need to be part of a group, and ii) everyday user needs that a local social network would be able to solve. These are described below.

4.1.1.1 The existence of local isolation

The first type of need was indicated by the baseline survey conducted as part of Paper I. One of the questions considered the social bonds of the respondent. As can be seen in Figure 3, the group of neighbours is distinguished as a group with which a large share of respondents (over 40%) do not have good social bonds. Another question, about how often the respondent has social meetings with his or her neighbours, revealed that more than half of the respondents never or very seldom have such meetings (Figure 4). It could thus be concluded that there is a room for improvement in the social relations between neighbours, something that a local social network could facilitate.
4.1.1.2 Local everyday needs

The second types of needs explored were those that a local social network could solve, thus facilitating the daily life of its users. This was done using focus group discussions. A recurring theme in the discussions was the lack of information and communication possibilities at different levels. Focus group 1 (FG1; Residents) wanted a comprehensive list of local events and better coverage of local news, and also better information from the local municipality. FG2 (Homeowner associations) wanted a better way to communicate with their members, a members-only discussion forum where sensitive issues could be discussed, and better communication between homeowner associations regarding co-operatively owned spaces. Like FG1, FG4 (Culture and local associations) expressed a desire for an event calendar that would allow them to share information about their events with the residents in the neighbourhood, ideally with the possibility to rate events. FG5 (Schools) did not see a need to use a local social network for
communication, as the schools in the area already used other digital tools. Its members had concerns that children might be exposed to additional advertising, but also saw some potential in a local social network as a platform for sharing news about the school or content created by the students, such as performances or projects, with a wider local audience.

FG3 (Environment) discussed energy matters and saw a need for education of residents; many people seemed to think that, since they are using district heating, they are already sufficiently environmentally friendly. FG3 also envisaged difficulties with getting homeowner associations interested in the environment using arguments other than monetary gains. A desire for comparison of energy consumption between associations was mentioned, as this could help boards of wasteful associations to take action. Another need was to communicate energy-saving tips to residents.

Ideas connected to possibilities of a local social network came from FG1, which reported that using Sweden’s largest classifieds site Blocket does not always feel safe, hinting that a local solution would be better.

In conclusion, there seem to be everyday needs that a local social network could solve for its users, thus making it a platform that they would use relatively often.

4.1.2 Benefits of a social network providing a context for energy feedback
Having confirmed that a social network has the potential to be a needs-based engagement approach, the next step is to take a closer look at the benefits it might have when providing a context for energy feedback.

4.1.2.1 Utilisation of group identity
It was found in the literature study in Paper I that one important benefit of a local social network providing a context for energy feedback is the possibility to use different forms of social influence. A local social network can be used to display various types of comparative feedback or competitions on different levels. On the individual/household level, social comparisons are generally most effective among friends, but they are also effective among neighbours, much more so than among complete strangers (Wheeler and Miyake, 1992). Obtaining socially visible rewards such as badges (Hakulinen et al., 2015) or seeing that neighbours are performing well (Cialdini and Schultz, 2004) can increase the motivation to perform better.
Collective goals and/or competitions are another type of motivator that can be used in a local social network (Paper III). Even if the resident does not have intrinsic motivation to change energy behaviour, feeling that one’s effort is part of a larger group could increase the willingness to participate, since that would be beneficial for the group. However, this type of feedback is dependent on the existence of social influence between neighbours. Therefore, Paper I made a closer study of group identity within a neighbourhood based on the social identity theory (Tajfel, 1974) concept that if an individual positively identifies himself or herself with a group, the attitudes of the group will affect the attitudes of the individual. In the context of this study, the group was the neighbours and the attitude was the intention to save energy over the next six months. To study the potential effects of group identity, the survey included questions to measure i) the amount of identification with the group, ii) the attitudes of the group, and iii) the intention to save energy, together with several other factors that typically influence the energy-saving intention. In order to analyse the importance of each factor, two hierarchical multiple regression models were used, in accordance with Fielding et al. (2008). The survey revealed that energy-saving attitudes among the neighbours were high, but that, in contrast to findings by Fielding et al. (2008), group identity had a negligible effect on the intention to save energy. A possible explanation for this was that the identification with the neighbours was not strong enough, or in any case lower than that in Fielding et al.’s successful experiment. If this is the case, increasing the level of identification with the neighbours would strengthen the group identity. As the local social network is in fact designed to increase the social interaction and interaction with neighbours, it would appear that it provides a suitable feedback context in this regard.

4.1.2.2 Other potential benefits

Regardless of the strength of social influence between neighbours, the mere existence of other users’ energy data has some potential benefits. Comparisons against other households give a frame of reference that helps residents understand whether their household consumption is high or low. Further, having other residents in other buildings or even other neighbourhoods whose consumption changes over time introduces a changing element into the feedback that could prevent it from becoming ‘backgrounded’ (Hargreaves et al., 2013). Providing periodical posts in the user’s feed about energy performance could keep up the interest among the participating households and also spread information on how
the building or neighbourhood is performing to users who have not (yet) signed up their household.

4.1.3 Resulting concept - LocalLife, a sustainability-oriented local social network on three geographical scales

As a result of the focus group discussions and further verified by the need to get to know one's neighbours better, the author was an integral member of the core team for developing a sustainability-oriented local social network called LocalLife. To fulfil the various communication needs expressed by the focus groups, the network has been designed to enable communication across three geographical scales: i) the building or the homeowner association, ii) the neighbourhood, and iii) the surrounding neighbourhoods (Table 2). Furthermore, interest groups can be created on building and neighbourhood scale to allow for discussions that are not of interest to the general population.
Table 2. Features of the social network on different urban scales connected to residential communication needs identified in focus group (FG) discussions.

<table>
<thead>
<tr>
<th>Geographical scale</th>
<th>Features</th>
<th>Fulfilled needs identified by the focus groups (introduced in Table 5)</th>
</tr>
</thead>
</table>
| i) Building / homeowner association | - Allows for private communication within the cooperative to discuss sensitive matters  
- Gives the board an easy way to communicate with its members and supplies recent contact details for each member | - FG2: An internal discussion forum for the homeowner association  
- FG2: Need for an updated list of members |
| ii) Neighbourhood | | |
| iii) Surrounding neighbourhoods | - Provides a channel for communication and for spreading information about local news and events.  
- Serves as a way of citizen empowerment by facilitating discussions about important community matters. | - FG1: Better information about current local events  
- FG1: Better coverage of local news  
- FG1: Better and more frequent information from the municipal authority and city hall  
- FG4: Need for an events calendar  
- FG5: Need for channel for school pupils to create local content |
| i/ii) Interest groups (at building or neighbourhood scale) | - Creates bonds between neighbours  
- Allows local organisations to spread information to the neighbourhood. | - FG4: Channel for local groups/organisations to inform others in the area about events etc. |

Although LocalLife is designed as a needs-based intervention that aims to fulfil the communication needs identified, its primary focus is local sustainability. Being a local social network, LocalLife is not intended for general discussions or sharing of global news or articles, or posting images from the latest vacation or of cute animals. Instead, it is designed to serve as a forum for discussing questions, issues, events or local recommendations connected to the neighbourhood, i.e. using the collective intelligence of the neighbours to coordinate valuable information about the neighbourhood, thereby facilitating the local life of the residents. In doing so,
LocalLife is designed to strengthen key aspects of social sustainability such as social identity, trust and safety.

While the current focus of LocalLife’s community engagement for environmental action is electricity, the methods and technology can be used to engage with other local energy and material flows, including tap water and waste generation. The data is collected and fed back at household level, but also aggregated on building and neighbourhood level. The aggregated feedback allows for collective goals and competitions, which can be used to fulfill the first identified design principle in section 4.2. Lastly, the aggregated data can provide additional sustainability benefits to society by enabling academia or local governments to leverage the collective intelligence to get responses to questions on local social or environmental sustainability aspects, e.g. to inform new policies.

Compared with earlier approaches where a social network has been used to convey energy feedback, the proposed approach offers some improvements regarding the signup and data collection process. The call to sign up to the energy service is shown from, and done within, the social network, which eliminates the need for users to be chosen to be part of a pilot study and then learn how to install a specific energy plugin (Mankoff et al., 2010; Foster et al., 2010) or smartphone app (Petkov et al., 2011). Further, data collection is done using smart meters (which exist in almost every Swedish household), and the data is then obtained from the DSO after having signed a digital contract developed as part of LocalLife. Unlike previous approaches (Foster et al., 2010; Petkov et al., 2011), there is no need to install specialised metering hardware in the household or to submit manual meter readings. These improvements are expected to lower the barrier to users signing up and starting to receive energy feedback.

More details regarding the development of LocalLife can be found in Paper I.

4.2 Design of energy feedback as part of a local social network

The second objective of this thesis was to identify and evaluate a set of design principles for energy feedback and use them to propose a prototype feedback design suitable for use in a local social network. This was done in Paper III and is summarised below, starting with results of the literature review to find design principles. Section 4.2.2 presents a suggestion on how feedback design can be improved regarding fairness (one of the design principles identified) using typical
household consumption. Finally, section 4.2.3 describes the creation and improvement process for the prototype feedback design.

4.2.1 Design principles

The literature review on design principles in Paper III resulted in a set of 24 principles being identified or derived (Table 3). A set of prototype feedback screens for smartphones was then developed (see section 4.2.3), based on those principles deemed most relevant and technically feasible for the chosen screens. These feedback screens were shown to, and discussed with, potential end users during the stakeholder consultation workshop (section 3.5). In the workshop, 17 of the principles were mentioned by the participants, as can also be seen in Table 3.

### Table 3. List of design principles identified in the literature review, whether they were applied in the feedback system developed, and the number of times they were mentioned in the stakeholder consultation workshop and by how many groups.

<table>
<thead>
<tr>
<th>No.</th>
<th>Design principle</th>
<th>Used</th>
<th>No. of mentions (groups)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Findings from behavioural psychology</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P1</td>
<td>Make the user feel that energy saving/shifting is important and that his/her contribution counts.</td>
<td>Partly</td>
<td>2 (1)</td>
<td>Theory of Planned Behaviour (Ajzen, 1991), Reasoned Action Approach (Fishbein and Ajzen, 2010), Practical findings regarding social norms (Schultz et al., 2007; Allcott, 2011)</td>
</tr>
<tr>
<td>P1a</td>
<td>Use collective goals</td>
<td>Yes</td>
<td>6 (3)</td>
<td></td>
</tr>
<tr>
<td>P2</td>
<td>Make the feedback actionable</td>
<td>Yes</td>
<td>3 (2)</td>
<td></td>
</tr>
<tr>
<td>P3</td>
<td>Use comparative feedback to other households</td>
<td>Yes</td>
<td>4 (3)</td>
<td></td>
</tr>
<tr>
<td>P4</td>
<td>Use encouraging means to reward users that perform well</td>
<td>Yes</td>
<td>2 (1)</td>
<td></td>
</tr>
<tr>
<td>P5</td>
<td>Make the feedback interesting and actionable without pressuring the user to feel “forced” to act against his/her will.</td>
<td>Yes</td>
<td></td>
<td>Self-determination theory (Ryan and Deci, 2000)</td>
</tr>
<tr>
<td>P6</td>
<td>Provide positive feedback</td>
<td>Partly</td>
<td>4 (3)</td>
<td></td>
</tr>
</tbody>
</table>
Table 3. (continued)

<table>
<thead>
<tr>
<th>No.</th>
<th>Design principle</th>
<th>Used</th>
<th>No. of mentions (groups)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Findings from pilot studies with energy feedback, energy competitions and meta</td>
<td></td>
<td></td>
<td>(Abrahamse and Steg, 2013; Knowles, 2013; Nilsson, Wester et al., 2018; Escudero Guirado et al., 2018)</td>
</tr>
<tr>
<td>P7</td>
<td>Provide multiple forms of feedback</td>
<td>Yes</td>
<td>6 (2)</td>
<td>(Abrahamse and Steg, 2013; Knowles, 2013; Nilsson, Wester et al., 2018; Escudero Guirado et al., 2018)</td>
</tr>
<tr>
<td>P8</td>
<td>Tailor the feedback to the individual user and his/her preferences</td>
<td>Partly</td>
<td>2 (2)</td>
<td>(Desmedt et al., 2009; Abrahamse and Steg, 2013)</td>
</tr>
<tr>
<td>P9</td>
<td>Give a frame of reference</td>
<td>Yes</td>
<td>1 (1)</td>
<td>(Darby, 2006; Holmstedt et al., 2018 / Paper II; Nilsson, Wester et al., 2018; Escudero Guirado et al., 2018)</td>
</tr>
<tr>
<td>P10</td>
<td>Include a changing element</td>
<td>Yes</td>
<td></td>
<td>(Hargreaves et al., 2013; Nilsson, Wester et al., 2018)</td>
</tr>
<tr>
<td>P11</td>
<td>Use a more suitable metric than kWh/m2 for household electricity comparisons</td>
<td>Yes</td>
<td></td>
<td>(Mäkivierikko et al., 2018; Holmstedt et al., 2018 / Paper II)</td>
</tr>
<tr>
<td>P12</td>
<td>Use the number of residents in the household as part of feedback calculations</td>
<td>yes</td>
<td></td>
<td>(Mäkivierikko et al., 2018; Holmstedt et al., 2018 / Paper II)</td>
</tr>
<tr>
<td>P13</td>
<td>The feedback needs to be fair</td>
<td>Yes</td>
<td>3 (3)</td>
<td>(Nilsson, Wester et al., 2018; Escudero Guirado et al., 2018)</td>
</tr>
<tr>
<td>P14</td>
<td>Provide real-time feedback</td>
<td>No</td>
<td>2 (1)</td>
<td>(Escudero Guirado et al., 2018)</td>
</tr>
<tr>
<td>P15</td>
<td>Provide frequent feedback</td>
<td>Yes</td>
<td>2 (2)</td>
<td>(Escudero Guirado et al., 2018; Holmstedt et al., 2018 / Paper II)</td>
</tr>
<tr>
<td>-----</td>
<td>--------------------------</td>
<td>-----</td>
<td>-------</td>
<td>------------------------------------------------------------------</td>
</tr>
<tr>
<td>P16</td>
<td>Provide push and pull information</td>
<td>Yes</td>
<td></td>
<td>(Escudero Guirado et al., 2018)</td>
</tr>
<tr>
<td>P17</td>
<td>Provide per-appliance feedback</td>
<td>Not known</td>
<td>10 (3)</td>
<td>(Nilsson, Wester et al., 2018; Escudero Guirado et al., 2018)</td>
</tr>
<tr>
<td>P18</td>
<td>Distinguish between appliances or behaviour that the user can affect with his/her behaviour or not</td>
<td>Partly</td>
<td></td>
<td>(Nilsson, Wester et al., 2018; Escudero Guirado et al., 2018)</td>
</tr>
<tr>
<td>P19</td>
<td>Show the amount of money saved</td>
<td>Not known</td>
<td></td>
<td>(Nilsson, Wester et al., 2018; Escudero Guirado et al., 2018)</td>
</tr>
<tr>
<td>P20</td>
<td>Avoid using hard-to-understand energy units such as kWh</td>
<td>Yes</td>
<td></td>
<td>(Nilsson, Wester et al., 2018; Escudero Guirado et al., 2018)</td>
</tr>
<tr>
<td>P21</td>
<td>Avoid using hard-to-understand environmental units such as CO2</td>
<td>N/A</td>
<td></td>
<td>(Nilsson, Wester et al., 2018; Escudero Guirado et al., 2018)</td>
</tr>
<tr>
<td>P22</td>
<td>Use health-based metrics such as air pollution</td>
<td>No</td>
<td></td>
<td>(Escudero Guirado et al., 2018)</td>
</tr>
<tr>
<td>P23</td>
<td>Avoid information overload</td>
<td>Yes</td>
<td>3 (3)</td>
<td>(Escudero Guirado et al., 2018)</td>
</tr>
<tr>
<td>P24</td>
<td>Make the feedback appealing to the whole family, including children</td>
<td>Partly</td>
<td>3 (2)</td>
<td>(Escudero Guirado et al., 2018)</td>
</tr>
</tbody>
</table>
4.2.2 Using typical household consumption as a fairer comparison baseline

The need for fair feedback was found to be a design principle (P13 in Table 3) and was also mentioned both during the workshop and in another interview study by Nilsson, Wester et al. (2018). It is challenging to make fair comparisons and provide fair energy saving goals, as the characteristics of households can differ widely. Paper II revealed that one of the most commonly used indicators for energy consumption comparisons, energy per floor area [kWh/m²], is not optimal for household electricity consumption since the consumption was shown to vary greatly between households with similar floor area. Paper II concluded that there must be other important factors that affect consumption and called for indicators that could better take these factors into consideration. Mäkivierikko et al. (2018), included in Paper III, showed that the number of residents is a major factor affecting consumption and offered a possible solution for fairer feedback by introducing an indicator taking multiple factors into account. The importance of the number of residents can be understood by considering that a small three-room apartment with a family of four people is likely to consume more than a five-room apartment of two people. From a fairness aspect, the smaller apartment should not be penalised for having more residents, but this would be the case if kWh/m² was used to compare the two apartments. The proposed solution is to:

1. Choose a small set of the most important factors that affect energy consumption.
   For Swedish households, four factors were chosen:
   a. i. Number of residents
      ii. Number of people at home during work hours
      iii. Floor area
      iv. Whether a washing machine is used (as many apartments have access to a shared laundry)
2. Use these factors to calculate the typical consumption for a similar household.
3. Compare the household’s actual consumption against the typical consumption in order to see whether the household is efficient, wasteful or average.

As the most important factors were included in step 2, deviance from the typical consumption can be assumed to be caused mostly by the behaviour of the residents, which is incidentally what energy feedback attempts to affect. As Figure 5 shows, household A with higher absolute consumption than B is significantly more efficient than B when the households are compared in terms of their respective typical consumption. Thus, percentage of typical consumption can be used as a comparison metric. It allows for comparison of households with vastly different characteristics and also allows fairer energy savings goals to be set, as can be seen in Figure 5: instead of giving all households the same percentage reduction goal, wasteful households that can easily reduce their consumption can be given a
larger goal, while already efficient households that find it challenging to reduce their consumption further can be given a smaller percentage goal.

Figure 5. Example of personalised goal setting using typical consumption (horizontal line).
4.2.3 First version of energy feedback

Using the relevant subset of design principles found in the literature review, example screens of energy feedback for smartphones were developed and shown in the stakeholder consultation workshop. Figure 6 shows an example of such a screen, while its connection to the design principles is described in Table 4.

Table 4. Design elements of the first prototype and the rationale behind their inclusion.

<table>
<thead>
<tr>
<th>No.</th>
<th>Design element</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1</td>
<td>Goal in textual form</td>
<td>P2: Makes the feedback actionable on a high level by showing the goal.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>P7: Shows the goal in multiple forms</td>
</tr>
<tr>
<td>D2</td>
<td>Goal achievement</td>
<td>P10: A changing element - the achievement will change each day.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>P20: Uses % instead of kWh.</td>
</tr>
<tr>
<td>D3</td>
<td>Comparison with other apartments in building /</td>
<td>P3: Uses comparative feedback to other households (or other buildings/</td>
</tr>
<tr>
<td></td>
<td>neighbourhood (average goal achievement)</td>
<td>neighbourhoods depending on the level chosen)</td>
</tr>
<tr>
<td>D4</td>
<td>Avatar (bulb dragon)</td>
<td>P4: Uses an encouraging avatar to give feedback regarding the last day.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Prevents ‘boomerang effect’.</td>
</tr>
<tr>
<td>D5</td>
<td>Textual feedback (about previous day’s achievement)</td>
<td>P6: Provides positive feedback</td>
</tr>
<tr>
<td></td>
<td></td>
<td>P7: Show comparisons to other households in a slightly different way.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>P10: Show feedback in multiple forms</td>
</tr>
<tr>
<td>D6</td>
<td>Energy-saving tip</td>
<td>P2: Makes the feedback actionable on a practical level.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>P18: Will give tips about standby appliance consumption if it is deemed to</td>
</tr>
<tr>
<td></td>
<td></td>
<td>be exceptionally high.</td>
</tr>
<tr>
<td>D7</td>
<td>“Details” button</td>
<td>P23: Prevents information overload by simplifying the initial feedback</td>
</tr>
<tr>
<td></td>
<td></td>
<td>view and keeping longer explanations, detailed charts etc on another page.</td>
</tr>
</tbody>
</table>

Figure 6. Main screen of prototype design for energy savings goal.
4.2.4 Improved version of feedback based on input from stakeholder consultation workshop

The stakeholder consultation workshop yielded a set of suggestions for improvement, which were considered when producing improved versions of the feedback screens. There were two main conceptual changes. First, the energy savings screen showing the progress toward a weekly goal was replaced by a screen showing the electricity consumption of the household compared with that of other households, using the percentage of typical consumption metric described in section 4.2.2. This was mainly done to avoid the stressing feel of constantly being in an energy saving competition. Second, as the concept of load shifting was difficult to understand, it was changed to a concept called ´pause hour´, in which the user actively chooses to participate. All suggestions and subsequent design changes are listed in Table 5, while the updated feedback screens can be seen in Figures 7b and 8. Although not within the scope of the original design, a main screen for “My energy” was added (Figure 7a), showing a summary of the previous day’s energy consumption and data for the most relevant pause hour.
<table>
<thead>
<tr>
<th>Issue/suggestion</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Difficult to understand geographical levels.</td>
<td>The user should already be familiar with the different levels as they are an integral part of the LocalLife social network and are introduced in the onboarding when the user joins LocalLife.</td>
</tr>
<tr>
<td>Explain concepts prior to start.</td>
<td>There will be an onboarding flow that introduces the concepts. In the feedback, there will be screens explaining the concepts in more detail.</td>
</tr>
<tr>
<td>Unclear goals.</td>
<td>The energy savings screen has been changed (Figure 7):</td>
</tr>
<tr>
<td>Use of multiple percentages hard to understand.</td>
<td>- Instead of showing a savings goal that should be achieved, the consumption as a percentage of typical consumption (see section 4.3.2) is shown, i.e. less is better. Thus the user gets feedback about current consumption without there being a savings goal at all times that needs to be reached.</td>
</tr>
<tr>
<td>Avoid having constantly ongoing competitions.</td>
<td>- Savings goals running over a week/month will probably still be provided from time to time.</td>
</tr>
<tr>
<td>Understand comparisons/averages.</td>
<td>- To reduce the number of visual elements, only the user’s own performance is shown as a percentage. The comparison with neighbours and the top 10% is done graphically.</td>
</tr>
<tr>
<td>Use bars instead of circle diagrams.</td>
<td>- The avatar messages are simplified and do not contain percentages.</td>
</tr>
<tr>
<td>Show decreasing consumption (less = better) instead of reduction goal.</td>
<td>- The information is shown using bars instead of a circle diagram.</td>
</tr>
<tr>
<td>Too much information on one screen.</td>
<td>- To simplify the comparison concept, there is only one average to compare against: apartments in the neighbourhood. The comparison with apartments in the building is removed.</td>
</tr>
<tr>
<td>Does not increase awareness of consumption.</td>
<td></td>
</tr>
<tr>
<td>See more/all energy saving tips instead of only one.</td>
<td>A page with all tips will be provided.</td>
</tr>
<tr>
<td>Load-shifting concept hard to understand.</td>
<td>Instead of “load shifting”, the concept will be called “pause hour”; an hour to take a pause from electricity-consuming activities. It will be introduced in the onboarding. The load shifting will have a savings goal in kWh, i.e. “save 0.2 kWh between 17.00-18.00 h”, that needs to be completed, see Figure 8.</td>
</tr>
<tr>
<td>Find a better term for ‘load-shifting’.</td>
<td>The load-shifting goal will be accompanied by examples calculated from the energy amount that should be saved, see Figure 8b.</td>
</tr>
<tr>
<td>Know how to achieve goals.</td>
<td></td>
</tr>
<tr>
<td>Give detailed statistics on consumption.</td>
<td>For the electricity consumption, there will be a separate “details” page that shows hourly/daily/monthly consumption in kWh. The main screen still needs to use % in order to use the “% of typical consumption” metric described in section 4.3.2.</td>
</tr>
</tbody>
</table>
Figure 7. a) New entry screen and b) re-designed energy feedback screen for the household level.
Figure 8. Re-designed pause hour interface a) before and b) after the user has chosen to participate in the pause hour.

4.3 Method for evaluating the effects on social and environmental sustainability in a neighbourhood

The third and final objective was to design and implement a baseline study for measuring changes in certain aspects of social and environmental sustainability that the introduction of a local social network can have on a neighbourhood, provided that it succeeds in facilitating interactions between neighbours and providing energy feedback that gets noticed and acted on by the residents. A
baseline survey was therefore developed in Paper I and is part of the suggested method for long-term evaluation of the changes: i) Conduct a baseline survey to measure the necessary aspects around the time of launching the social network in an area, and then ii) conduct one or more follow-up surveys after a sufficient period of time (probably between 6-12 months) after the introduction, to see if any of the variables has changed.

The baseline survey includes multiple constructs to measure relevant aspects:
- Social bonds with neighbours
- Group identification with people in the building and the neighbourhood
- Trust
- Safety
- Willingness to participate in sharing economy activities
- Place attachment to the neighbourhood

Figure 9 shows a conceptual model of how the introduction of a social network in a neighbourhood could increase these aspects, thus increasing pro-environmental attitudes, sharing economy activities and ultimately increasing the environmental sustainability in the neighbourhood. As described in section 2.2, the idea of a local social network is to make neighbours connect, i.e. to increase the social bonds. This can in turn lead to increased feeling of safety (Dallago et al., 2009) and trust (Rohe, 2004) between neighbours. Trust is needed for people to be willing to participate in the sharing economy activities (e.g. Walter, 2017; Teubner and Hawlitschek, 2018). Social bonds also helps build social identity within the group of neighbours and, according to social identity theory, if the neighbours in general think the environment is important, this will influence any new neighbours. The increase in social bonds also goes hand in hand with place attachment/identification (Lewicka, 2004, cit. Lewicka, 2005, p. 392), which can lead to increased pro-environmental attitudes in some cases (Uzzell et al., 2002) although this is debated (Upham et al., 2018). Finally, according to TPB (Ajzen, 1991), these pro-environmental attitudes play an important part in changing the behaviour of the residents.
Figure 9. Conceptual model of the sustainability effects of introducing a local social network into a neighbourhood. ¹) Connection lacking scientific consensus.
5. Discussion and conclusions

5.1 Discussion

The aim of this thesis was to explore the potential of a needs-based solution to encourage residents to engage more in their household electricity consumption. The solution proposed in this thesis is a local social network where electricity feedback is provided. The idea behind this engagement solution, which is shown in Figure 10, is to leverage user needs as an engagement mechanism that makes residents use the social network, which provides users with energy feedback based on design principles. There also has to be a way to evaluate the solution from several aspects: first, to understand whether it increases the social ties to neighbours and thereby increases aspects related to social sustainability such as safety and trust, and second, whether it affects the energy saving attitudes and behaviour of its users.

![Figure 10. The three components of the engagement solution proposed in this thesis.](image)

The objectives of this thesis were to: i) explore the potential of the network for providing a context for energy feedback; ii) suggest how energy feedback could be designed within this social network; and iii) design and implement a baseline study to measure change in certain aspects of social and environmental sustainability that introduction of a social network could bring about.

The first objective was explored in two steps. The first step was to determine whether a local social network could be a needs-based approach, i.e. one that meets user needs. As suggested by nationwide surveys in Sweden (Svenska Postkodlotteriet, 2016) and the USA (Smith, 2010), and in light of the relatively low level of friendship and social interaction with neighbours found in a survey in the district of Stockholm Royal Seaport (Paper I in this thesis), a state of ‘local isolation’ (Hayes, 2007) seems to exist. A local social network could help to
reverse this local isolation by getting people to connect more with their neighbours, thus helping to meet the human need to belong to a group (Maslow, 1970). It should be noted that there are individual and cultural differences in how much people actually want to interact with their neighbours but, since half the survey population reported barely knowing their neighbours, this should provide a large enough potential user base. Furthermore, the focus groups discussions showed that there were several needs, primarily relating to local communication, that could be facilitated by a local social network. Thus, there appear to be needs that could be facilitated by introducing a local social network, making it a technology pull-driven solution that could overcome user acceptance issues present in the technology push-based solutions pointed out by Goncalves Da Silva et al. (2012).

Having found indications of a need for a local social network, the second step in achieving the first research objective was to analyse the suitability of such a local social network to provide a context for energy feedback. This was done using the survey mentioned in the first step (Paper I). The somewhat unexpected results indicated that neighbours’ attitudes have a minimal effect on the respondents’ intention to save energy, i.e. the positive group identity effects demonstrated by Fielding et al. (2008) could not be replicated. A possible reason, in line with social identity theory (Tajfel, 1974), is that the degree of identification with the group was not high enough for the group’s attitudes to be significant. In that case, introducing a local social network that increases group identification with neighbours would increase the effectiveness of the social aspects of energy feedback. Another reason could be that the attitude to electricity consumption is not easily affected by the group: i) because it is not discussed within the particular group of neighbours and thus not seen as relevant for “membership” of the group (Tajfel, 1974); ii) because the residents do not consider energy consumption due to its ‘invisibility’ (Fischer, 2008), and it is thus not seen as relevant for any group membership; or iii) because the user already holds a strong positive attitude that is not affected by a less positive attitude of the group (Secchi and Bui, 2018).

Regardless of the reason, if neighbours’ pro-environmental attitudes do not affect, or cannot be made to affect, the individual, the social network as an engagement mechanism will not work as well as envisioned. Residents not already interested in energy will probably not feel as obliged to sign up to receive energy feedback. For those that sign up and receive the suggested feedback, including comparisons with their neighbours, the injunctive norm (i.e. what you think others think you should do) in TPB/RAA (Ajzen, 1991; Fishbein and Ajzen, 2010) will be weakened. This
can be assumed to make efficient households consume more (the ‘boomerang effect’). If, on top of this, the descriptive norm (i.e. what you think others actually do) is not effective, the effects of social influence would be minimal, reducing the envisioned effect of comparative feedback and thus the usefulness of a social network that provides a feedback context.

Not all feedback features are dependent on social influence, however. Comparison with the household’s own previous consumption (envisioned but not included in the screens designed) would inform households of relative changes, while comparison with typical consumption would give a sense of overall efficiency, even though this could also be perceived as a form of collective, and thus uninteresting, measurement. The ‘pause hour’ concept could still work, as it is partly based on gamification principles rather than comparisons. These features would require the resident to have some degree of environmental interest, which is something that a sustainability-oriented social network could help to foster, thus still being useful providing an energy feedback context to some extent.

Another aspect that makes a social network a suitable context for providing energy feedback is its possibility to provide the feedback for extended periods and thus also make a long-term evaluation of the effectiveness of the feedback possible. Most existing energy feedback studies are relatively short pilot studies with a duration of a few weeks to a few months, and the lack of long-term studies is cited as a research gap in many of these studies (e.g. Foster et al., 2010; Petkov et al., 2011; Vine and Jones, 2015; Nilsson, Lazarevic et al., 2018). A social network that fills user needs has the potential to be used for many years by its users and, provided that they give their consent, energy consumption data can be collected and energy feedback can be provided during this period. This makes it possible to measure user interactions with the feedback and compare it with their actual consumption, in order to measure the effectiveness of the feedback. Further, if the consumption stays at a reduced level or if consumption is reduced during pause hours without the user participating, it could be argued that the feedback has created a persistent behaviour change.

Continuing to the second research objective, regarding the design of the energy feedback, a set of design principles that should make the feedback more effective was formulated. Many of these design principles were further supported by the workshop discussions, where about half of the principles were indirectly mentioned without specifically being asked for. However, actual practical
The implementation of this feedback is not an easy task and, as both one of the principles and the workshop discussions revealed, one type of feedback does not fit all. This also highlights the importance of using a methodology such as RTD (Frayling 1993; Zimmerman et al., 2007; Zimmerman and Forlizzi, 2014) that includes collecting feedback on the proposed design from actual end users.

One result to highlight from the workshop discussions was that the participants had difficulty understanding the concept of load shifting and why it is important, indicating how easy it is to fall into the trap of designing for the ‘Resource Man’ imagined by Strengers (2004). The suggested re-wording of the concept as a ‘pause hour’, when people take a pause from their energy-consuming activities and socialise more, is in line with the idea presented in this thesis of increasing the social capital through a local social network. It is also in line with what Strengers calls designing for “slow time”, when the pace of activity is reduced and alternative household activities that require a minimal amount of electricity are encouraged. Another thing to note is that the users’ suggestions do not always seem to go hand in hand with the best practices in design. An example of this is the suggestion to see all energy saving tips at once (Table 5), which can seem contradictory to the best practice of avoiding information overload. The suggestion could indicate that users sometimes do not fully understand the consequences of what they are asking for. In this case, however, users would not be ‘bombarded’ with all the energy saving tips from the start, but would rather be provided with information that they specifically ask for, understand and thus are interested in, so the information would likely not be perceived as an ‘overload’ (Eppler, 2015).

The third and final research objective was to devise a method for evaluating changes in certain aspects of social and environmental sustainability induced by a local social network. The method developed in this thesis was to create a survey that can measure these aspects, conduct a baseline survey at the time when the social network is introduced in a neighbourhood, and measure changes using one or more follow-up surveys. A baseline survey was designed. Based on TPB and social identity theory, it measured how the social influence of neighbours affected residents’ intention to save energy. It also measured energy attitudes, energy actions and social relations to neighbours. The baseline survey was conducted in Stockholm Royal Seaport as a first step towards making a full evaluation of the local social network approach presented in this thesis. Future versions of the survey may need to be altered if new aspects to measure are found. It may also need to be shortened, as the baseline survey was perceived by multiple users as too
long and repetitive. This shows that it is not a simple task to find a balance between reliability (i.e. long multi-question scales) and user-friendliness in survey development.

5.2 Limitations

When assessing the need for a local social network, results from the focus groups and the survey were combined. Although both studies were performed within the same city (Stockholm), the survey indicating ‘local isolation’ was held in the district of Stockholm Royal Seaport during spring 2018, while the focus group discussions on neighbourhood needs were held in the district of Hammarby Sjöstad during autumn 2015. Nevertheless, the relatively close proximity of these two districts, their special environmental profile and their relatively homogeneous upper middle-income population should make the results combinable and valid for similar types of neighbourhoods. However, it should be noted that these two districts are designated eco-districts, which to some extent attract residents whose environmental interest is higher than average. This means that the results, especially those concerning environmental attitudes and pro-environmental behaviours, are not necessarily generalisable to other city districts. Moreover, the needs of the focus groups could have changed during the 2.5 year difference in time between the focus group discussions and survey, although there are no indications that this was the case.

5.3 Conclusions

Motivated by the growing need, but considerable difficulties, in encouraging residents to engage in their household electricity consumption and change their consumption behaviour, the work in this thesis centered on the idea that a successful solution for long-term energy engagement among residents must be based on their actual needs. To this end, a local social network was investigated as a needs-based solution for providing energy feedback. The focus was on three aspects: i) identifying user needs that could be met by a local social network; ii) obtaining theoretical and practical insights on how energy feedback within a social network could be designed; and iii) developing a survey-based method for measuring some of the most important effects of a local social network on social and environmental sustainability. The research conducted was relatively complex, in that it combined the technical requirements of smart grids with human behaviour and perceptions. Design methodologies such as the Research Through Design approach selected for use in this thesis are a good fit for these types of
complex problems, and can lead to a fruitful interdisciplinary collaboration using knowledge from the fields of energy, industrial ecology, behavioural psychology and human-computer interaction.

The results indicated a need for better social relations between neighbours and for better communication possibilities at different levels within neighbourhoods. This resulted in the development of a social network called LocalLife. The set of theoretical design principles developed for energy feedback, which were supported by discussions in a stakeholder consultation workshop, were useful in creating a prototype design of energy feedback to be displayed in LocalLife. Many of the principles are sufficiently general to be useful when creating energy feedback in other settings. Combining the needs-based local social network, which is expected to keep users engaged for a relatively long time, with the proposed evaluation method, in which the baseline survey designed in this thesis is the first step, should make it possible to help overcome the current lack of knowledge regarding the long-term effectiveness of energy feedback. The feedback will be tested in at least two countries, thus increasing knowledge about how feedback is received in different cultural settings.

Further studies are needed to follow up on the sustainability effects and the efficiency of the feedback. If shown to be effective, the suggested approach can be of interest as a low-cost engagement option for distribution system operators. Above all, it can help residents take the necessary steps toward environmentally and socially sustainable neighbourhoods.
6. Future research

This licentiate thesis is the first step in work to examine the potential of using a local social network as an engagement mechanism for energy feedback. There is still much left to explore, including:

- Implementing a first version of the updated energy feedback design into the social network, evaluating it and conducting pilot tests to understand what further changes are needed.
- Evaluating the effectiveness of the feedback, possibly even different forms of it, by looking at households’ change in energy consumption and participation in ‘pause hours’, combined with changes in energy attitudes.
- Evaluating the effectiveness of the social network as a tool for improving the social sustainability in the neighbourhood, by measuring the changes in social sustainability over time, including neighbourhood relations, in follow-up surveys.
- Making a comparison of the effectiveness of energy feedback provided within a local social network as studied here with real-time feedback displayed by a home energy management system (e.g. Nilsson, Wester et al., 2018; Nilsson, Lazarevic et al., 2018).

Other aspects not directly related to the topic of this thesis could also be further investigated, for example the following aspects raised by the focus groups:

- Investigating potential benefits of using a local social network to improve the spread of information and two-way communication between the municipality and its residents.
- Investigating whether the social network could be used for reporting, discussing and following up issues/errors at the household, building and neighbourhood level.
References


levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty.


