Power law of engagement

Transferring disengaged householders into retrofitting energy savers

Christopher Weeks
System Centre
University of Bristol
Bristol
Email: mrcweeks@gmail.com

Charles Delalonde
EDF Energy R&D UK Centre
52 Grosvenor Gardens
London
Email: charles.delalonde@edf.fr

Chris Preist
System Centre
University of Bristol
Bristol
Email: chris.preist@bristol.ac.uk

***Abstract*—How can we take householders from being disengaged passive energy consumers towards being highly motivated retrofitting energy saving masters? In this paper the "Power law of engagement model for energy saving" is introduced, which breaks down the process of engaging householders into 8 defined stages. The model is based on the householder's level of engagement and commitment, but applies Fogg's behaviour model at key stages to help evaluate the decision process of the householder. The focus of the model is both to build up the levels of commitment and engagement of the individual, and to allow them to provide feedback into the community to build a more widely spread culture of retrofitting. The paper then describes a set of tools which can be used to take the householder on an energy-saving journey and help them progress through the 8 stages. Throughout these descriptions key examples of where ICT can help are highlighted.**

***Index Terms*—retrofitting, energy efficiency improvements, energy consumption, householder engagement, behaviour change, householder commitment behaviour, ICT**

I. Introduction

The EU and the UK government have set themselves a number of key targets to achieve a reduction in greenhouse gases. Firstly the EU committed to a 20% reduction in its greenhouse gas emissions and to achieving a target of deriving 20% of the EUs final energy consumption from renewables sources, both by 2020 [1]. Secondly, the UK government made it the duty of the Secretary of State to ensure that the new UK carbon account for the year 2050 is at least 80% lower than the 1990 baseline [2]. In 2010, 53% of total final energy consumption in the UK was attributed to the domestic sector [3] and in 2012 the domestic sector accounted for 15% of the CO_2 emissions created [4]. Over the last 25 years, the UK's national energy consumption has continued to rise [5]. These facts stress the important role the domestic energy market plays in meeting both of the above targets.

In the academic research a large focus has been placed on changing householders' behaviour [6] [7], but simple behaviour change can only save a limited amount. Examples of behaviour change include turning your thermostat down by 1°C from 19 to 18°C (which saves about 13% per year on energy used for space heating [8]), and turning off radiator valves in unused rooms (which saves around 4% per year [8]). The low potential energy savings highlight the need to drive householders into making larger commitments through energy efficient retrofitting of their property: the installation of improved insulation, heat recovery system and low-carbon and renewable energy sources. This is particularly true in the UK, where much of the housing stock is 50-150 years old and poorly insulated. Research has shown that retrofitting can yield potential energy savings which range from 45% [9] up to 80% in some cases [10]. Young [11] has also shown that behaviour change techniques used to reduce energy consumption are reliable in the short-term but struggle at achieving durable change. Retrofitting, however, results in long-term energy efficiency improvements. Despite the positive benefits it provides, retrofitting requires a major commitment of time, energy and money by householders - and so currently has low penetration in the UK.

Currently, communities are locked into a social norm of not considering energy efficiency when renovating (beyond a legal minimum), and only those who are seriously committed for environmental reasons go against this norm. As has been discussed before, IT has a role in changing community norms [12]. In this paper, we consider the process that can be used to 'lead' householders towards the commitment required to take on retrofitting despite the prevailing norm, and more broadly to change the norm over time to one in which energy efficiency measures are at least actively considered, and often implemented.

Social, economic and political factors are aligning to make this both possible and desirable, with a number of stakeholders desiring or benefiting from such work. On the macro level, Member States of the EU have been putting direct requirements on the energy distributors and suppliers through energy saving obligations and white certificates schemes [13]. The schemes predominantly focus on the end-use sector (excluding generation and network savings) [13], therefore both national governments and energy companies are driven to help householders improve their energy efficiency. Substantial fines can be imposed on the energy companies that fail to meet their obligations. Meanwhile on the micro level, there has been a growing concern around energy costs in households, and a desire to reduce bills, though this does not always translate into a consideration of energy efficiency during renovation. There is also a growing number of installers who are capable of energy efficient retrofitting, both large and small, who wish to

stimulate the market for their services. Finally, between macro and micro levels sit local and regional government bodies, who often have carbon emissions reductions targets for their areas, and what to actively stimulate retrofitting to help them meet these targets.

For these reasons, this paper presents a model which starts by defining how to promote small behaviour changes in the householder, but with the final goal of encouraging the householder towards taking more substantial retrofitting actions. The paper starts by reviewing current models for behaviour change and householder engagement, then introduces the "Power law of engagement" model. It then reviews current ICT tools which can enhance the engagement of householders, and looks to examine how these tools can be combined to push the householder towards undertaking retrofitting measures.

II. Review of research on behaviour change and householder engagement

A number of theories of behaviour change have been proposed in academic research. We now review some of the key literature, and summarise the insights they offer to the particular problem we are exploring. Lewin's influential change theory defines behaviour change as having three states: freezing, unfreezing and refreezing [6]. The problem we face can be considered as a number of 'steps' of unfreezing and refreezing at different levels of commitment to domestic energy efficiency. Other theories provide more details on what can result in unfreezing and refreezing of behaviour. Kaplan [14], adopts an evolutionary psychology perspective on behaviour change. He emphasises three key elements that affect our behaviour and motivation:

1) *"People are motivated to know, to understand what is going on; they hate being confused or disoriented.*
2) *People also are motivated to learn, to discover, to explore; they prefer acquiring information at their own pace and in answer to their own questions.*
3) *People want to participate, to play a role, in what is going on around them; they hate being incompetent or helpless. [14]"*

In Kaplan's research, the key factor is that it is not about telling people what to do, but about encouraging people to learn and discover about new behaviours, and along the process to guide them to more environmentally responsible behaviour. Kaplan's work provided insights about appropriate empowerment strategies to move between the different stages of engagement. Another model of persuasive behaviour that is appealing due to its simplicity is Fogg's behaviour model (FBM) [15] Fig.1, which looks to break down behaviour into three factors: motivation, ability and trigger. In Fogg's research, he shows that you need either high motivation or high ability in order to perform a task, but without a trigger to set the action in motion, the behaviour change will fail. This model provides a good framework for considering the psychological and environmental factors which encourage particular behaviours. While the models of Kaplan and Fogg provide insights into short-term factors influencing an alternate behaviour, the transtheoretical model [16] considers the longer term processes involved in unfreezing and refreezing at a given level. It was originally designed to be applied to health behaviour change, but has also been applied to provide insights into domestic energy use [17].

Fig. 1. Fogg Behaviour Model

The model proposes six stages to any change: 1) pre-contemplation, 2) contemplation, 3) preparation, 4) action, 5) maintenance and 6) termination. The model is interesting for a number of reasons: firstly, it breaks down the process of behaviour change into a number of stages which change over time; secondly, the work illustrates the importance of the stages before and after an action; and finally, the work emphasises that different approaches are needed at different stages in order to encourage people to change their behaviour. The models presented so far have been mainly focused on behaviour change for individuals rather than for the wider society, however, one interesting area of research is community-based social marketing [18]. Work in this area takes a slightly different approach, identifying all the barriers that could prevent a pro-environmental action from taking place. It then describes five tools that can be used to overcome these barriers and encourage behaviour change, including:

1) Commitment - It is hard to get people to commit to the large change of retrofitting. However, we can increase the likelihood of doing so through asking people to make a small commitment first, followed by a larger commitment later [19].
2) Prompts - Prompts can be used in a similar way to triggers within the Fogg's behaviour model (FBM), and they can catalyse the behaviour change.
3) Social Norms - The people around us have a major influence on our behaviour [20], it is therefore important that these social influences push neighbourhoods towards retrofitting. It has been shown that up to a 6% reduction in energy usage can be achieved through the application of social norms [21].
4) Communication - In community-based marketing there are a number of key communication principles, including: captive information, using credible sources, framing

of the message, making the message easy to remember, providing personal or community goals, emphasising the personal context and providing feedback [18].

5) Incentives - When it comes to energy usage, incentives are broken down into two main types: financial and moral [21]. Incentives need to be used close to the performance of the desired behaviour, and must be used only when the behaviour is positive; however, care must be taken both when removing incentives and when deciding the size of the incentive [18].

The defining element of the community-based social marketing approach is that it starts to include social elements to increase people's engagement. This can be through commitments, social norms and communication, but this is only part of the story when it comes to engagement. One area of engagement research is examining, social media and open source projects. In this field, a ladder of participation [22] splits people into a number of groups, including: inactive, spectators, joiners, collectors, critics and creators. The interesting idea behind the ladder of participation is the way it represents people's engagement. At one end of the scale, we have a large proportion of people who are inactive or just spectators; these people have a low engagement threshold, and low motivation when it comes to social media. At the other end of the scale, however, we have the creators and critics; these are at the highest level of engagement or motivation, and provide a vast amount of knowledge to the social media world. A graphical representation of the power law of participation can be found on a Ross Mayfield blog [23] (Fig.2). For a full description of this model please see [22].

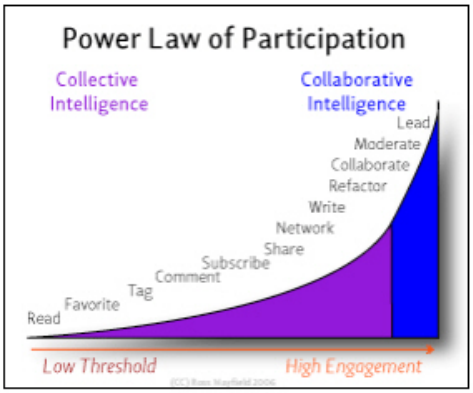

Fig. 2. Power Law of Participation.

The power law of participation can guide us to a structure for promoting long-term householder engagement, which has been shown to be an issue in a number of pro-environmental behaviour change projects [11] [24]. If we ask householders to make little commitments to start with (spectate), then build them up to making the large commitment of retrofitting (collectors), to finally pushing the householder into a energy saving master (creators), we can start to develop sustained behaviour change. This idea will be further addressed in section III. Summarising the insight of the theories explored in this section, we see:

1) the importance of guiding householders to learn and discover about sustainable behaviour,
2) that the right level of ability or motivation along with the right trigger can cause behaviour change,
3) that we need to look not only at the desired behaviour change, but also at the time before and after,
4) the importance of social aspects on a householders decision, plus the importance of allowing people to demonstrate their behaviour change,
5) that a long-term vision, with the right structure, can play a vital role in encouraging retrofitting.

These 5 points are the defining reason for developing the Power Law of Engagement model, which will be expounded next.

III. Power Law of Engagement for Energy Saving

In this section, a novel model of householder engagement is presented, which captures the insights of the theories presented above and applies them to energy retrofitting. The model is called the "Power Law of Engagement for Energy Saving" (Fig.2). The first element of the model, its defining structure, is taken from the Power Law of Participation model [23], but instead of looking at the levels of collective intelligence it looks at both the levels of engagement and commitment towards energy saving. The advantage of this structure is that it draws attention to the idea that different householders can play different roles within the community. It also promotes the concept that if householders are given the right tools and support, we start to generate a positive feedback loop of communication, whereby successful retrofitting individuals act as advocates and recruit others who in turn take on the energy efficiency technologies. This has been observed, for example, in open homes projects [25]. This positive loop will at some point lead to a critical mass of advocates, and a normalisation of the technology, meaning that active intervention is no longer necessary, and it will sustain itself without constant support. The second element, stages of engagement, looks to generate a similar staging approach to the one found within the transtheoretical model [18], but the stages are defined in terms of commitment to retrofitting. The stages are discussed in detail in section III-B. The staged approach has a number of benefits; firstly, it provides the concept of a journey with set milestones for the householder to reach; secondly, individual techniques and tools can be defined for each stage. The importance of communication, community and social norms must be recognised within the model. The model depends on householders at the later stages providing guidance and support to those at the earlier stages, which is consistent with the community-based social marketing approach. Finally, it is extremely important to understand that at each stage the householder has a different level of motivation and ability, and that different triggers will be needed for behaviour change at each stage. Therefore, an interpretation of the Fogg Behaviour

Model (FBM) has been applied to key stages throughout the model. This will be presented in section III-B. The interpretation of the FBM is made up of two elements: the two axes which are taken from the FBM (ability and motivation), and the operating environment the householder is working within. This can include a large number of defining parameters which affect the actions of the householder, including salary, time and environmental views. As each householder's operating environment is different, it can be hard to define all of the parameters contained within it. However, defining the key factors would a rich area for future research.

A. Engagement, Commitment and Energy Consumption

Fig.3 illustrates the model, and provides a qualitative plot of levels of commitment and energy consumption against the stages of engagement. We hypothesise, based on anecdotal evidence from retrofitting projects such as Digital Green Doors [25] that as engagement increases, so does their willingness to make commitments to take action and support others in doing so. The plot shows qualitatively a possible relationship, though the exact nature of this relationship requires further research. This illustrates that as people's engagement increases, so does their commitment at a rapid rate, especially in the later stages. Householders can make a large amount of small commitments in the early stages, but it comes to a point where they have to start making substantial commitments (time, finance, or lifestyle changes). If the relationship between commitment and engagement can be understood, then it becomes easier to support the householder through the process of retrofitting. The second line plotted on the graph looks at the relationship between the stages of engagement and the level of energy consumption. Due to the nature of the householder there will be a minimum and maximum amount of energy that can be saved at each stage. Knowing these boundaries is important for two reasons:

1) It shows householders the potential savings that can be achieved with greater commitment.
2) It can be used to demonstrate the limits of energy saving to householders in the lower stages of engagement.

B. Stages of engagement

The stages of engagement look to break down the journey of retrofitting; this allows for an evaluation of the decisions a householder faces. At the lowest level of engagement we have disengaged householders, while at the top end of the scale we have the energy masters. It is important to highlight that a householder can remain in a single state for a long period of time, and it will take an increase in both commitment and engagement to move into the higher stages, but we must note that people can move down stages, similar to relapsing in the transtheoretical model [18]. There are 8 defined stages:

1) Disengaged: Has extremely low levels of engagement, and their commitment to energy saving is minimal. The householders at this level do not care about their energy usage, and they rarely discuss it with friends or family. To create a graphical representation of their views on energy saving, we can start by applying the adapted FBM, as shown in Fig.4. This representation of the model allows us to start looking at which energy saving action would be most successful for the individual. It has already been shown that the initial cost of retrofitting can be very unattractive to householders [26], and this barrier is heightened when you have a householder within the stage shown in Fig.4. In this case, it does not matter how effective the message presented to them is, nor how well we use persuasion techniques, the combination of a highly disengaged householder and the large financial commitment required renders retrofitting nearly impossible. However, if work can be done to get Disengaged householders to start being aware of energy, (this could be through community-based engagement or through the bills they receive), this can start the increase in both motivation and engagement. It is critical to present the proposed behaviour change in terms of triggers that motivate the Disengaged householder. For example, the DEFRA pro-environmental behaviour framework [7] shows that Disengaged householders are not naturally pro-environmental, therefore showing CO_2 savings is unlikely to work, whereas demonstrating monetary saving could have a greater effect. Finally, interventions must be proactively brought to Disengaged householders, as they do not seek out energy related content by themselves.

2) Listener: Has a heightened awareness of energy related media (consisting of, for example, news, bills, and promotional material). The benefit of this is that necessary information can start to be presented to the Listener, but it is important to keep adding social pressure to Listeners, as due to their level of engagement and commitment the Listener has not yet taken any actions towards saving energy. To get the householder to move to the next stage we need a well placed trigger that will encourage them to take simple actions (lower thermostat set point, stop heating unused rooms, etc.). The trigger could be a piece of hardware or a new billing method, but it must be something that disrupts their usual interaction with energy, and lifts both their motivation and perceived ability.

3) Simple Actor: Still has a relatively low level of engagement and limited energy knowledge, meaning that some of their actions may actually consume more energy not less. For instance, there is still credence given to myths such as turning a thermostat up higher will heat a room quicker [27]. Two things must be noted: firstly, the householder will only take actions on the easy-to-do ability spectrum, and secondly, the householder is willing to learn if information is presented in an engaging way. The vital point here is that once the householder has taken the simple actions, they must be provided with feedback. The feedback should provide the householder with enough information to start them exploring and discovering about their property and retrofitting, similar to the way Kaplan [14] describes behaviour change. The feedback should work as a triggering method to start the householder questioning

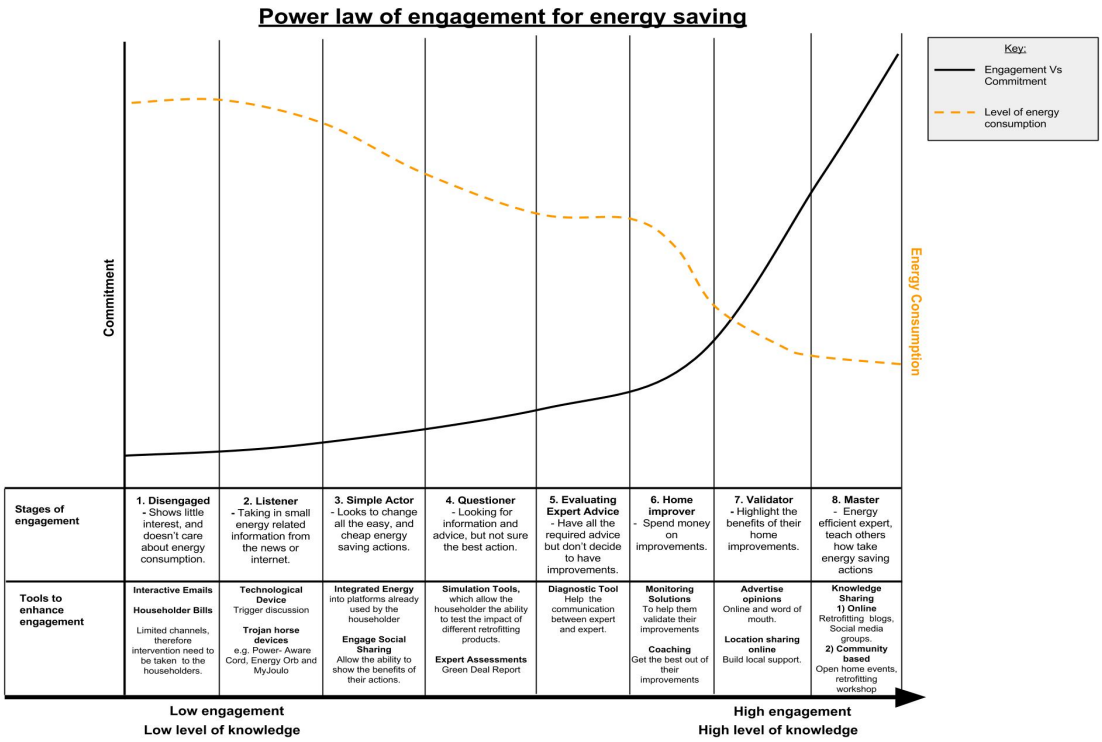

Fig. 3. Power law of engagement for energy saving.

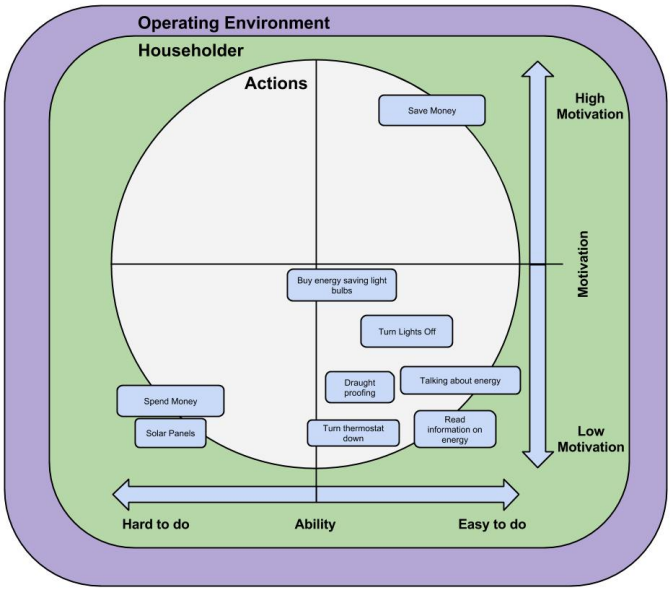

Fig. 4. Energy disengaged householder

their energy consumption, which starts to move them onto the next stage.

4) Questioner: Has completed a number of small actions, but these actions have limited energy saving potential, and to achieve larger savings the householder will need to make physical changes to their property. The physical change to a householder's property can throw up a large number of barriers [28], therefore the householder seeks to find out a lot of information and looks towards advice services such as the UK's Energy Saving Trust [29]. The process of information gathering allows the householder to build up evidence to support their commitment to retrofit their property. However, if a well timed trigger is supplied during this moment, it can increase the likelihood of energy actions. In this stage we need an increase in communication from energy companies, suppliers, installers, and also from people who are close to the householder. The people close to the householder are very important, as they are a credible source and have a large influence on the householders decision process [18]. The householder in this stage has a different set of decisions to make compared to the disengaged (see Fig.4 and Fig.5 to compare). The Questioner is focused on which type of retrofitting will be best for them. It should also be noted that in Fig.5 a larger proportion of the decisions are now towards the right hand side of the ability scale, and have risen up on the motivation scale, including willingness to spend money. The final point on the Questioner is that information must be presented to them which is concise, relevant and helpful, without giving them information overload or choice paralysis.

5) Evaluating Expert Advice: While this householder has sourced a large amount of information both from publicly available and expert sources, this is still a state where the

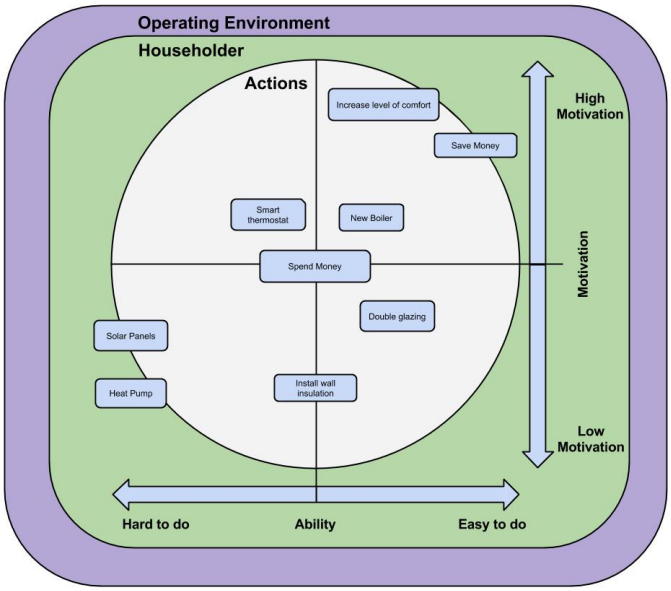

Fig. 5. Energy questioner householder.

householder does not take the action to retrofit their property [30]. There could be a number of reasons for this: initial cost, disruption caused by building work, and poor integration of supply chains [31]. At this stage a large amount of effort needs to be made to help reduce the impact to the householder, and it is important to maintain their levels of motivation and commitment. Nonetheless, a set of targeted triggers need to be developed to push the householder's level of commitment upward and take them into the home improver stage. It is essential to have a set of tools, as one solution will not fit all householders. The triggers also need to look at approaching the problem from a number of angles, both on a personal and social level.

6) Home Improver: Has taken on board all the expert information, and has made the decision to retrofit their property. This is a significant step, as the Home Improver has shown a large level of commitment and a genuine level of engagement. It is important to show the Home Improver all possible improvements, as they have the right level of commitment and engagement to retrofit. It is in this stage where the most progress can be made toward reducing CO_2, with estimated reductions of about 50%, and in some cases up to 80% [10]. However, anecdotal evidence from conversations with householders involved in the Digital Green Doors project [25] and Green Deal participants suggest that a significant concern of the householder is to prove that the changes to their property are both financially and environmentally beneficial. This is where monitoring tools can be advantageous. If they can start to validate the rewards of retrofitting, both their level of engagement and commitment intensify, thus pushing them on to the next stage: Validator.

7) Validator: Has undertaken retrofitting and seen the benefits. Their levels of motivation are considerable, and they have already shown a substantial level of commitment. The Validator has limited decisions to make about energy improvements, as the only actions left to take are on the hard to do scale of ability, or not possible without a sizeable change to their life (moving home). The Validators play a vital role through sharing their knowledge and experience with the rest of society. Validators must be given a platform to display their accomplishments to other householders, as they provide information which is both creditable and from a trusted source, thus improving their ability to change other householders' behaviour [18]. The process of providing feedback plays two vital roles: firstly, social pressure is built upon disengaged householders as the norm moves [21], and secondly, according to Albert Bandura's social learning theory [32], other householders have a chance to take onboard the learnings of others without the large commitment. As the householder starts to become established in providing feedback into society, they start to develop into the final stage of the model: the master.

8) Master: Some of the validators become enthusiastic as 'critical advocates' of retrofitting, and proactively wish to help other householders by sharing their experience and knowledge. We refer to these as 'Masters'. They are willing to push the limits of their property to make it as environmentally friendly as possible. Similar to the Validators, they are very engaged and highly motivated, therefore the only improvements left to make are on the very hard to do scale of ability see Fig.6. Their level of commitment is excessively high, and their decisions are driven by the environmental benefits rather than money saved or levels of comfort in their property. They are likely to be what is characterised as 'positive green' in attitude [7]. Their story of retrofitting can be used to provide information and experience to householders in less engaged stages. To take advantage of this, work must be done to harness their intense commitment and allow them to share their experiences through public engagement (lectures, workshops, and open home events). Masters can play an important role in changing social norms through their visibility, advocacy and expertise. This process of giving back to the community must be stimulated to build energy leaders. It has been shown that people like to work with experts rather than on their own [14], and if there is a set of leaders who distribute information, they could work in a similar way to Burn's recycling "block leaders" [33].

The 8 stages of the model have now been defined, however it is important that the concept of communication and community is emphasised within the model. The framework depends on householders at the later stages providing guidance and support to householders in the earlier stages, driving them to retrofit their properties. Without this the model begins to breakdown. At each stage, the householder has a different mindset; by taking the approach of breaking householders into stages, it allows for development of tailored tools for each stage [7]. The tools should be seen as bread crumbs which lead us both towards the perfect energy saving property, and towards householders who are highly energy conscious. The

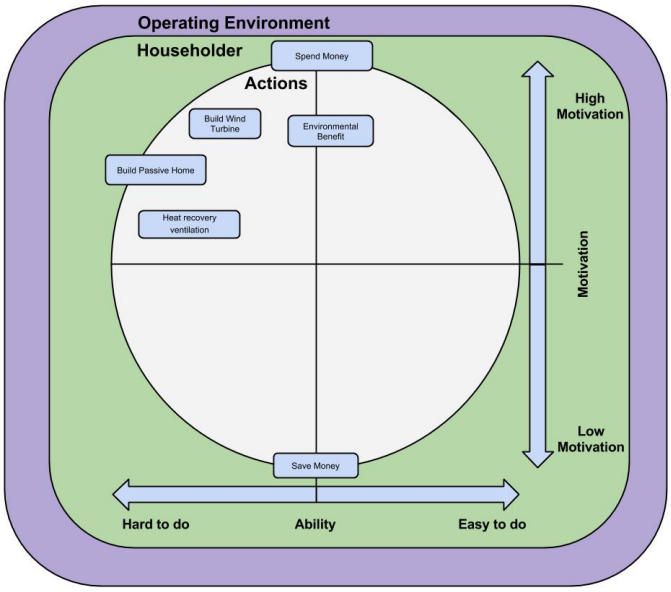

Fig. 6. Energy master householder.

tools must all connect to each other, and be in a structured order based on the householder. These tools to transfer a householder from one stage to another will be different, and will now be considered.

IV. Tools to enhance engagement and the role ICT plays

In this section, the tools and techniques that could be used to enhance engagement at each stage of the process will be introduced, with a focus on the role ICT plays. These tools should not be disconnected from each other and should create an homogeneous solution that expands over a long time frame.

1) Disengaged: The greatest challenge at this stage is that there are extremely limited points of contact. This is heightened firstly by the move to online billing and direct debit payments, allowing people to effectively ignore their energy consumption should they choose, and secondly, by the fact that the most vulnerable householders are provided with heating benefits through fixed payments. Therefore, the message of energy saving has to be taken to the householder and any interaction must be used to develop their engagement. In online billing, we need to look at embedding engagement techniques into the emails the householder receives, these techniques must push the householder into finding out more information. The emails should point to interactive services and start a two way conversation between the householder and the energy company. The interactive element could be a graphical representation of a thermostat that, when the householder turns it down, shows the potential savings, or an interactive game, where the householder must guess which applications in their property consumed the most energy last month. In the final stage, the householder should have the ability to share the email with friends and family, to help the development of the communication feedback loop. On top of this, as bills are the only other channel for reaching the Disengaged, work must be done to improve the information presented. As Wilhite and Ling showed, more informative bills result in energy savings of about 10%, but more interestingly their research showed that householders were more likely to spend time discussing their bills with others [34]; again this stimulates the communication feedback loop.

2) Listener: Once the householder starts to take in information, an awareness of their energy consumption starts to develop. However, the householder does not know the best course of action yet. Therefore, in this stage it is key to get the householder connecting to the community of people who have more knowledge, and encourage them to take simple actions. A technological device can be used as a trigger to start the conversation between householders, providing comparable data and triggering a discussion about the device. In order for the device to be successful with householders who have low levels of engagement it must be:

1) Aesthetically pleasing, exciting and new;
2) Simple to use, as the householder will only undertake tasks which are low on the ability scale;
3) Provide simple feedback on actions taken;
4) Cheap, due to low commitment levels the householder will not spend money;

There are currently a number of tools which meet some of the criteria stated above: Power-Aware Cord [35], Energy Orb [36] and MyJoulo [37]. These tools can work as a Trojan horse to sneak energy efficiency into a house by allowing householders to get used to monitoring energy consumption, while only requiring a low level of commitment. However, as time increases the level of engagement can drop off very rapidly.

3) Simple Actor: Encouraging the householder to continue to take action can be a challenge. To counter work must first be done to integrate energy consumption into the householder's daily routines. Ouellette's research [38] showed formulation of habits is most likely when the behaviour is followed by an immediate and positive consequence, plus the behaviour is repeatable. Secondly, a new dimension of social interaction must be added. Modern social networks (Twitter, Facebook) and online tools (Google Calendar, web browser plug-ins) meet both these needs, meaning that integration with these technologies is essential at this stage. Some good examples include "Power Ballads", which deploys aversive energy feedback through Facebook [39], and stepgreen.org, which provides plugins for both MySpace and Facebook [40]. By applying these tools it provides two benefits: firstly, householders are provided with constant feedback on their energy consumption and secondly, the social element increases the feedback into the community through online sharing. These technologies have been used outside the energy sector with great success to encourage an increase in exercise (Nike+ [41]).

4) Questioner: In this stage the tools must allow the householder to discover and explore the possible retrofitting scenarios; as Kaplan showed [14], discovering and exploring

are key factors both from a behavioural and motivational point of view. It is vital that the tool meets a number of requirements:

1) Display benefits and drawbacks of retrofitting,
2) Show information based on the householders property,
3) Allow simulation of different scenarios to help the householder find the best solution,
4) Incorporate data collected from the householders property,
5) Be freely available and easy to access, as the levels of motivation are still low.

A tool that meets these requirements allows the householder to build up evidence to support their decision to retrofit. Two examples of websites that work well are, the Energy Saving Trust's "Home Energy Check" , which allows the householder to see the potential savings of retrofitting, and "Heat Bleed" [43], which calculates the heat loss of your property. However, both these tools are limited on the simulation of different scenarios and the ability to include data collected from the householder's property. The tools should also not only show financial or CO_2 savings, but potentially could include factors like level of comfort, level of disruption and the turnaround time to install. Such factors could be more important to certain householders. The tools allow the householder to build up their knowledge, but there is only so much information that can be provided by ICT tools. Therefore, the next step is for the householder to organise an expert evaluation, for example by engaging Green Deal Advisors [44] or Parity Projects [45], which requires an increase in both time and financial commitment.

5) Evaluating Expert Advice: In this stage the householder is right on the edge of retrofitting and the experts have told them the best solution. However, the householder can start to feel helpless in this stage, as the experts start to take control of their decisions. As Kaplan demonstrated, helplessness can have a big effect on the decision process [14]. To help with this issue the householder needs to be provided with a diagnostic tool (small sensor equipment, installed only for a short period) to help them evaluate their property, but more importantly help stimulate the negotiation between the householder and the expert. The negotiation will help the householder gain more control over the decision making process, plus help the expert to understand the householders requirements. It is important that the communication turnaround time between the expert and householder is quick, as in this stage the householder is very close to retrofitting; to achieve this, a shared online portal would be beneficial. The diagnostic tool can also be a trigger that increases both their motivation and removes the fear of retrofitting. The tool should apply Freedman's concept that if someone has agreed to a small request he is more likely to comply with a larger request [19]. The small request can be getting diagnostic sensors installed, and this can push them into the larger request, retrofitting. Finally, work needs to be done to make it simple to take out measures; if the householder has to wait for a quote or pay for another evaluation this will cause their motivation to decrease and they will relapse back into the Questioner stage.

6) Home Improver: In this stage the main driver for the householder is validation that the decisions they made are both financially and environmentally sound. To enable this they need to be provided with monitoring tools. The monitoring tools need to perform a number of tasks to be successful:

1) Facilitate the ability to compare energy usage before and after retrofitting,
2) Provide regular feedback to the householder, over a long time frame [46],
3) Integrate with smart devices installed in the household, this allows for a breakdown of energy usage [46],
4) Provide methods to share their feedback with other householders.

There are already a large number of monitoring tools, both in the academic research and provided by industry which could meet these requirements with few adaptions, e.g. Foster's "WattsUps" Facebook application [27] and Efergy "engage" platform [47]. Finally, the Home Improver needs to be connected to a community expert. The community expert will help the householder learn about the equipment that has been installed and highlight any lifestyle changes that are required to get the best energy savings.

7) Validator: The Validator has seen the benefits of retrofitting and has had experiences of what worked well and less well. Therefore, it is important to get the householder to start sharing their feedback with the community. The first type of feedback is the householders opinions of the work that has taken place. This could be shared through online reviews of installers, suppliers or equipment. They can also share their experience of the process of retrofitting through stories and anecdotes, posted through blogs and online discussion groups for those considering such measures. This will encourage social learning in the community - word of mouth through friends and family and online content have been shown to be completely or somewhat trusted a majority of the time, 92% and 72% representatively [48]. The second channel of feedback should be through sharing their location on an interactive online map. This can help other householders see what retrofitting measures have been carried out within their local area and how successful these measures have been. This will increase the communication feedback loop and help encourage the disengaged to think about retrofitting, and so move towards influencing community norms. The techniques described in [12] can be used in this context.

8) Master: We can help Masters in their role of advocates and experts in a number of ways, both through online media (energy blogs, Facebook groups, or retrofitting websites) and through public events (open home events, retrofitting workshops, or community drop in sessions). Two examples of these type of tools include "SuperHomes Network" [49] and "Digital Green Doors" [25], which both organise open home events and provide online information. However, with the development of smart devices, these platforms need to evolve to include the ability to allow people to compare energy consumption and temperature data from householders'

properties. Furthermore, smart devices can be used to support others in engaging with Masters - such as selecting which Masters have appropriate experience for a face-to-face visit, and collating relevant information from the Master during such a visit, as is demonstrated in the Digital Green Doors project [25].

In this section a selected number of different techniques and tools have been introduced to help stimulate the progress from one stage to the next, however it must be noted that these tool are a guideline and that each householder is different. Therefore, we must build up a collection of tools to meet each householder's motivation [17].

V. Discussion

This paper has presented the Power Law of Engagement model and a number of tools have been introduced that fit into the model. However, it is the integrated solution which is missing. The model is in the early stages, therefore there is still a large amount of further research that needs to be completed.

Firstly, we must develop a methodology that defines both what stage the householder is in as well as where within that stage they are. This was also an issue for research completed by He et al. [17]. When defining the methodology, we must be aware that householders can state intentions to be environmentally friendly but actually act differently; it has been shown that 20% of householders are willing to pay a premium of 10-20% for environmentally friendly electricity, however, the market share is often below 1% [50]. Therefore asking the householder directly could yield misleading results. To solve this problem, future research needs to look at logging both consumption data and the interaction with the householder, as this can provide a view of their energy patterns and engagement.

Secondly, the paper has suggested a number of tools which could be applied to each stage. In this process it has raised a number of questions that researchers need to think about when developing tools to engage householders, including:

1) What level of commitment, ability and motivation is required to use the tool?
2) Which tool is most effective for the householder at this current time?
3) What is the lifetime of the tool? (How quickly does the householder get bored of it?)
4) Does the tool increase the likelihood of pushing the householder to retrofit?
5) Can this tool be used to introduce a more advance tool, which has the potential to save more energy?

Answering these questions will help maximise the take up of engagement tools and lead to a more long term solution.

Finally, it is important to understand the householder's operating environment at each stage, as these can vary greatly between individuals. Finding the key barriers and drivers within the householder's environment will allow for the development of techniques that both minimise the barriers and maximise the drivers.

VI. Conclusion

In this paper a novel model has been presented (the Power Law of Engagement Model for Energy Saving), which looks to provide a framework that can be followed to get disengaged householders retrofitting their property. The research has built on existing models that have been shown to simulate behaviour change and increased engagement, but the proposed model has put a focus on the concept of developing a communication feedback loop, driving the highly engaged to help the disengaged householders.

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