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Abstract:  
This document presents the basic behavioural energy efficiency requirements that will guide the core ENTROPY business logic as stem from feedback, social norms, personalization, gamification, serious gaming and of course the objectives of ENTROPY.

Keywords: Functional, requirements, behavioural, gamification, serious games, M&V, energy efficiency  

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# Revision History

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Executive Summary

There is recent academic literature arguing that it is the consumption reduction practices themselves that need careful scrutiny as they tend to lock consumers into patterns that are more and more energy intensive [1]. Apparently, the behavioural aspect is one of the dominant components that should be wisely considered when it comes to energy efficiency intervention design. The current document briefly describes the behavioural interventions that ENTROPY will realise and then maps the functional requirements that will guide the design and development of the ENTROPY platform so as to account for the optimal behavioural change approach. A list of categorized KPIs for evaluating energy efficiency and tracking the achieved behavioural change are also provided as an additional component for conceptualising the set targets and better acknowledging the functionalities needed, from a goal perspective. The suggested functional requirements aim to pave the way for the proper deployment of the ENTROPY recommendation mechanism that will undertake to deliver as personalised content and feedback as possible, the ENTROPY gamification framework that will foster participants’ engagement, satisfaction and excitement, and finally the ENTROPY social aspect that will allow social effects to emerge, social interaction to be realised and social triggers among participants to take behavioural change a step further.

In particular in this phase, ENTROPY:

- Identifies what energy-using behaviours can and should be addressed
- Elaborate on how different interventions could impact the energy efficiency level of the pilot’s participants taking into account the differences in their personal characteristics
- Goes beyond the use of indirect feedback on past energy use and pricing strategies to shift or reduce demand and consider solution beyond investment behaviours (i.e. the energy efficiency that can be achieved as the result of the installation of insulation or the purchase of energy-efficient appliances)
- Determines a set of KPIs required for the quantification of energy efficiency and behaviour change in a real-world setting, either observed or self-reported
- Provides a full list of functional requirements that can drive behavioral change towards energy efficiency
- Considers the constraints behind implementing all suggested functionalities
- Matches functional requirements with system architecture to facilitate the deployment of functionalities

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1. **NOTATIONS, ABBREVIATIONS & ACRONYMS**

IT (Information Technologies)
ICT (Information & Communication Technologies)
KPIs (Key Performance Indicators)
NPV (Net Present Value)
QST (Quantified Self Technologies)
DR (Demand Response)
GS (Gamification Settings)
MDA (Mechanics, Dynamics, Aesthetics)
2. INTRODUCTION

The ultimate goal of the document is to highlight how the behavioural-based solutions proposed by ENTROPY can be the differentiation point and competitive edge in the relevant field of energy efficiency deployments that can bring about the desired behavioural change and viable energy savings, by engaging ENTROPY pilot participants into sustainable actions while working on improving their decision making towards rational outcomes with joint benefits.

Hence, the ENTROPY project builds on an integrated behavioural framework aiming to address the deployment of behaviour-focused interventions towards energy efficiency improvements. Academic literature, best-practices, tested application, market-oriented solutions, ideal frameworks and recommended methodologies are all explored and fed with input the current deliverable that constitutes the manual for developing behavioural platform-based interventions with great potentials for attitudinal change and energy savings.

The different sections are structured so as to rationalise the recommended interventions for managing energy consumption and justify the conclusion of a set of core functional requirements that constitute the drivers of an integrated engagement platform suitable to deliver maximum energy savings. At the end, the link between the functional requirements with the different architecture parts is clearly performed to facilitate the application deployments.
3. **BEHAVIOURAL ENERGY EFFICIENCY**

3.1 **Definition of Behavioural Science and its role to the Energy Market**

As traditional economic theory postulates, human behaviour and decision making rest on purely rational choice. More recent neoclassical economic approaches are also aligned with the fundamental assumptions of rational choice theory. In particular, people’s preferences over outcomes are rational and they strive to maximise their utility, while act in an independent way when full or relevant information is provided [2]. Hence, traditional economic models predict that given budget constraints, people make decisions that yield the optimal result. In order, however, to improve their choice, it is required to provide more information either by increasing knowledge and awareness or by increasing the number of available choices.

In contrast to traditional and neoclassic economic theories, behavioural economics demonstrate through field experiments that people rarely make rational decision. More specifically, empirical evidence shows that consumers’ choices and actions systematically deviate from rationality, due to fundamental and persistent biases in human decision-making that regularly produce behaviours that such assumptions cannot account for [3]. Most of these biases stem from simple mental ‘shortcuts’, ‘rules-of-thumb’ and ‘heuristics’ that tend to alleviate the need for stressful information processing and thereby hasten the speed of problem-solving and decision-making, especially in situations of high choice complexity, risk and uncertainty [4].

Below are outlined the most powerful and pervasive biases that seem to influence consumers’ energy usage pattern including among others the status quo bias, the temporal and spatial discounting, the loss and risk aversion and the availability bias. Other psychological phenomena such as the normative social influence, the effect of intrinsic and extrinsic rewards, and the perceived trust are also considered. Even if cost–benefit calculations would suggest individuals to opt for more beneficial choices, they persist in displaying seemingly irrational, yet predictable tendencies to:

*Retain their status quo.* i.e. individuals stick to default settings, or entirely defer decision making (inertia), particularly when the complexity of information increases. For instance, people have a tendency to resist change to ‘go with the flow’ of pre-set options, even if alternatives yield a better personal or collective outcome. In such cases it should be considered providing optimal default options since it does not only save people’s time but is also perceived as the best option since it is ‘recommended’ by experts [5]. There is much evidence of status quo bias across a range of experimental and applied contexts, including residential energy consumption [6][7].

*Satisfice “best options” for “good enough options”* by exerting only the effort needed to achieve a satisfactory rather than an optimal result [8]. When individuals are overloaded with information, they are often incapable of ‘optimising’ and are inclined to choose not necessarily the best option, but rather the first available option or solution that suffices, or satisfies the minimum requirements. People typically process only enough information to reach a satisfactory decision rather than processing all available information to reach an optimal decision, as the latter demands much more time, effort and resources than would ordinarily seem justified by the prospective increase in utility or satisfaction.

*Be loss averse* since individuals weigh losses more heavily than equal sized gains, especially when the stakes rise [9][10]. People typically focus on the costs or risks associated with adopting a new behaviour. Questions such as “what will it cost me?”, “is it safe/healthy?”, “how do others
think and act?”, “how environmental friendly are my choices?”, “does a new behaviour fit my routine?”, and “how will I feel after adopting a new behaviour?” are critical but the equivalent gains and benefits seem to be discounted. When faced with making a decision, individuals perceive the disutility of losing something as far greater than the utility of gaining something. This tendency is reflected in contingent valuation research that clearly shows a willingness to accept over a willingness to pay [11][12].

**Be risk averse** when faced with high probability gains or low probability losses, but more risk-seeking when faced with certain losses or uncertain gains [13][14]. In general, individuals prefer to avoid risk given the prospect of a positive outcome, but the reverse holds given the prospect of a negative outcome. This simply means that **individuals are more willing to gamble in order to avoid a certain loss than to secure an equivalent gain** [15]. However, risk aversion and risk-seeking also depend on what is at stake, with risky decisions often to concern smaller-stakes gambles. This tendency of less risk averse while more risk-seeking for small-stakes gambles compared to larger-stakes, is known as the ‘peanuts effect’ [16] which basically suggests that risk-seeking decreases when stakes are high.

**Persist with an endeavour** once valued resources such as time, effort and money have been invested, a phenomenon known as the “sunk cost” effect [17]. People seem to irrationally stick on ‘recovering’ losses that already have suffered, while discounting future costs and benefits. Having invested effort or money, they persist in a choice or maintaining a certain action even if it might be risky, if not impossible to reach the desired result. Some studies have attributed this tendency to an over-generalisation of the ‘don’t waste’ rule that might be learned during childhood [18]. The “sunk cost” effect has been observed in both personal and business decision-making [19]. In the residential energy consumption domain, it seems like consumers who outlay time, effort and money to purchase an electrical appliance tend to use it more, even when it is not necessarily required.

**Temporal and spatial discounting** trigger individuals to perceive things as less valuable due to a time or space distance, even if such things afford long-term benefits [20]. For instance, individuals often ‘discount the future’ by favouring smaller immediate rewards over larger rewards in the future, and thus they avoid actions that are costly in any way for them in the short-term such as purchase new energy-efficient appliances or making an effort to switch their habits, despite the fact that such option offer longer-term benefits such as reduced electricity bills. This tendency to be short-sighted and make time-inconsistent judgements often leads to procrastination, inertia and decreased cooperation in group settings [21][22].

**Make social comparisons**, in other words, follow the behaviour of others and conform to social norms. This happens because there are explicit and implicit ‘rules’, norms and behavioural expectations within social groups and the whole society that shape what is deemed desirable and normal [23]. And so individuals get influenced by the attitudes and behaviours of others, and tend to follow the injunctive and descriptive norms that guide what is socially approved. The normative social influence is powerful and pervasive, and stems from the tendency to conform by ‘following the herd’ and ‘jumping on the bandwagon’ [24][25][26]. Individuals also make social comparisons and re-evaluate their own performance, possessions and wellbeing based not in absolute terms, but rather relatively to others [27][28]. Further, the relative comparison can be extended to support participants to have the optimal level of equity in terms of perceived effort / reward ratios (i.e. Equity Theory [29]) to enhance their trust in the system as well as engage with free-riders.

**Be motivated by rewards and incentives**, both intrinsic such as the ‘warm glow’ effect which suggests to act altruistically, and extrinsic such economic rewards [30][31]. Larger incentives drive greater behavioural responses. However, the effects of economic incentives are often short-
lived and inconsistent while result in behaviour reverting back to baseline levels when the reward is removed [32]. There are also cases where a negative response to extrinsic rewards was observed when effects such as the loss of motivation, over-justification and moral licensing were presented [33], especially when the intrinsic motivation of the target behaviour was already high. When a person is intrinsically motivated, providing monetary reward to incentivise the desired behaviour is not the best option as it may provoke the counteractive effect of ‘crowding out’ the intrinsic motivation [34]. The ENTROPY project will follow Self Determination Theory principles to support intrinsically oriented experiences [35].

**Reduce effort, contribute less or withhold resources**, if individuals know that they can gain the same benefits without paying for them, or at least believe there are others enjoying the same benefits without contributing. This effect is called free-riding effect [36]. Additionally, there is evidence for social loafing, an effect that suggests individuals to exert less effort to achieve a goal while working in a group compared to when working independently [37], with motivation further declining the more dispensable one’s own efforts appear to group success [38].

**Draw on trust** when assessing risk and making cost-benefit appraisals, due to decision-making heuristics that rest on apparent expertise and experience, as well as perceived honesty, openness and concern for others [39][40]. For that reason **public awareness campaigns are most of the times effective**, because they depend on the perceived credibility of the communication source [41]. In contrast, when the source of a message seems untrustworthy, incompetent or unfair, individuals react defensively and often disengage.

**Use readily available information** since there is availability bias that allows all personal narratives of family/friends, customer testimonials, as well as all recent, vivid, frequent, salient, emotive and concrete examples to be easily accessed and spring to mind [42]. As a result, individuals heavily draw information most readily available in memory in order to evaluate the frequency of future events, and so they inevitably produce biased estimates about the likelihood of the different outcomes that their decision-making will induce [43].

ENTROPY is going to exploit all these key insights from behavioural and psychology science in order to ensure the effective design of consumer-focused strategies and the deployment of interventions that aim to improve commercial and residential energy conservation. In particular, ENTROPY will deliver solutions that:

- Identify the personality characteristics and predispositions of participants on the aforementioned biases
- Capitalise on message framing
- Consider choice architecture
- Account for incentivisation towards shift through intrinsic and extrinsic rewards
- Step on normative social influence, Equity and Self Determination.
- Examine status quo bias and defaults
- Boost the perceived trust
- Try to identify “free-riding” and “social loafing” effects
- Provide full information in order to enhance rational decision-making
3.2 Behavioural Science and Energy Efficiency

3.2.1 Behavioural Energy Efficiency Case Studies

Energy behaviour represents an important underexploited resource in the context of end-use energy efficiency, especially in the residential sector. Energy savings through behavioural factors may reach 20%, but values vary among different case studies [1][44]. The consumption of energy is unlike most consumable goods. It is abstract, invisible, and untouchable and without a tangible manifestation, home energy usage often goes unnoticed. The advances in resource monitoring systems provide real-time data on electricity, gas, and water usage at home. Such tremendous amount of data produced are then analysed and fed back to the user, creating a rich space of opportunities for research in a variety of domains, from the socioeconomic field to the Information and Communication Technologies (ICT) one.

A study conducted to evaluate the energy consumption of 10 identical Habitat for Humanity all-electric homes outfitted with the same appliances and equipment. Homes were found to exhibit a large range in energy consumption, with the most energy intensive home consuming 2.6 times more energy than the least energy intensive [45]. Indeed, it has been consistently found that energy use can differ by two to three times in identical homes, occupied by people with similar demographics [46][47]. Such findings reveal how differences in human behaviour can significantly affect energy consumption and suggest that intervention strategies to promote sustainable behaviours could result in significant energy savings.

A literature review of 2000 references in 37 articles and books made clear that the changing energy related behaviour can potentially save about 19% (±5%) of energy consumption [48]. The savings are due to changes in conservation, lifestyle, awareness, low-cost actions, or some small investments.

A similar study for American households [49] reports how much of an energy efficiency gain might be supported through smart or improved behavioural decisions in the household sector. The researchers explored 100 different conservation and energy efficiency cost-effective measures that could be taken in a short period of time. A Monte Carlo probability simulation resulted in an energy saving potential of about 220 Mtoe compared to current use. Results are shown in Table 1.

<table>
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<th>Category of actions</th>
<th>Potential national energy savings (in Mtoe)</th>
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<td>Conservation by lifestyle, awareness, low-cost actions</td>
<td>123 (57% of total savings)</td>
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<tr>
<td>Investment decisions</td>
<td>93 (43 % of total savings)</td>
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<td>Total energy savings</td>
<td>216 (22% of household energy)</td>
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Table 1: Prediction of Energy Savings based on certain actions

Another study concerning the potential savings from household behavioural change in the United States [50] examined a total of 24 types of behaviour. The behaviours were divided in 4 classes namely, weatherization, i.e. work on the exterior of a building to reduce energy consumption, energy-efficient equipment, adjustment and management, and daily activities or routines. The results revealed that a fully-fledged programme could lead to an adoption rate of 80% of measures in 10 years period. The overview of the findings for the particular study is summarized in Table 2.
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<th>10 year</th>
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<td>2.8 %</td>
<td>5.8 %</td>
</tr>
<tr>
<td>Other equipment</td>
<td>4.6 %</td>
<td>9.8 %</td>
</tr>
<tr>
<td>Adjustment and management</td>
<td>1.3 %</td>
<td>2.9 %</td>
</tr>
<tr>
<td>Daily activities</td>
<td>3.7 %</td>
<td>4.0 %</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>12.5 %</strong></td>
<td><strong>22.4 %</strong></td>
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Table 2: Energy Savings potential of behaviour change actions

However, curtailing energy usage at home is a difficult task. Most people have no means of judging their household energy usage other than a monthly (or bi-monthly) energy bill, and much less means of assessing the environmental impact. In addition, energy consumption is rarely a goal within itself but rather a by-product of a wide variety of diverse actions such as doing laundry, driving to work, staying warm, or watching television. Moreover, some of the largest consumers of energy at home are always-on appliances such as the water heater or refrigerator, which are not easy to control. Additional to that, much information about energy use is presented in dull, uninteresting formats so although valuable information may be present, it is unlikely to be read (or remembered). The manner with which consumers perceive and understand energy has implications for designing effective feedback systems (e.g. in determining what should be sensed and how it should be presented), economic policies for promoting energy efficiency and all relevant models.

The motivation for the ENTROPY project is the realisation that household electricity consumers are unaware of the factors influencing their consumption patterns and current practices do not provide the essential tools to consumers in order to guide them to make informed decisions about their electricity consumption according to their particular circumstances, profiles, behaviour and preferences. Hence, ENTROPY takes advantage of a set of deployed technologies and actions that can increase knowledge and awareness in order to enable the conceptualisation and justification of energy savings in occupants’ mind and so enhance the adoption of energy efficiency in the long-term.

### 3.3 Behavioural Energy Efficiency Methodology for ENTROPY

#### 3.3.1 Planning & Evaluation model for behavioural change in Pilot Sites

In order to properly plan the interventions that should take place within the ENTROPY pilots and then evaluate their impact in terms of behavioral change, it is crucial to develop a robust model. Figure 1 presents a step-by-step planning and evaluation model of the behavioural change in the pilot sites that steps on the proposed by Green and Kreuter [51] model, originally aimed at promoting health and directed behavioural change towards the adoption of healthier lifestyles. However, many insights can be drawn from this model very useful in the field of energy conservation too.

The ENTROPY planning and evaluation model [52] is a helpful tool for tracking behavioural change in the area of energy conservation and consists of six basic steps and two phases divided as follows.

**Phase I: The Design phase**

- **Step 1:** Problem orientation and specifications of goals, objectives & KPIs;
- **Step 2:** Analyses of determinants & target groups;
- **Step 3:** Design of the intervention
Phase II: The Evaluation phase

Step 4: Implementation of the intervention, i.e. has the intervention been carried out as planned? What were the barriers that had to be dealt with?

Step 5: Monitoring & evaluation of the process & change in determinants, i.e. to what extent has there been a change (improvement) in the determinants of change? Which target groups were involved?

Step 6: Impact evaluation, i.e. to what extent were the ultimate and intermediate goals achieved? Were KPIs affected and by how much?

Figure 1: Planning & Evaluation model [52]

Sometimes it is better to “begin at the end”. In other words, it might be optimal to start with a clear definition of the problem followed by the desired solutions. ENTROPY’s model first asks what exactly the outcome that needs to be achieved is. It is extremely important to define the exact problem before moving ahead. Next comes to look at the factors that influence the process of ENTROPY’s objectives. This is also a critical step because in the field of energy conservation especially, there still is a strong tendency to develop objectives that focus on instruments, rather than on the problem itself. In the following paragraphs, a more thorough description of the ENTROPY’s model for planning and evaluation are presented.

Step 1 – Problem orientation and specification of goals, objectives & KPIs

The level of detail in which objectives are formulated and the nature of KPIs may vary. In all cases it is crucial to translate the expected results very precisely into specific goals, objectives and KPIs that answer what should be changed, when and to what extent and among whom.
The difficult part is basically the distinction between behavioural and contextual factors because they are usually so closely related, even if changes are always related to specific target groups. A simple distinctive feature is that behavioural factors usually play a direct role, while contextual factors an indirect one. For instance, behavioural factors are related to the purchase, investment or usage of a product, whereas contextual changes are linked to the availability of a product. The possible interventions involve the prevention of certain actions, such as de-motivating the purchase of a highly energy consuming product, or the influence of existing behavioural patterns towards a more efficient direction such as the rational use of hot water, or even the learning of new behaviours, such as using green electricity from renewable energy sources.

ENTROPY follows an inventory of these factors to look at the relative weight (frequency and level of influence) and their ability to induce a behaviour change (change current habit). Based on this ranking, ENTROPY prioritises possible interventions with high interest but also promotes interventions with low or unknown impact since this might lead to the development of new innovative approaches with great potentials in their aim. Hence, ENTROPY focuses on what changes will be realised within each target groups and how to start formulating objectives in terms of ‘when’, ‘what’, ‘who’ and ‘how much’.

Performing a detailed customer segmentation analysis is a critical step for ENTROPY, since it facilitates the later on implementation of activities tailored to the specific segments. Target groups are carefully selected so that activities are specifically set for the behavioural changes that are expected for each specific group, rather than sticking with a one-size-fits-all approach.

Step 2 – Analysis of determinants and target groups

The second step consists of analysing the determinants that underlie the desired behaviour change. Three categories of influencing factors are considered by ENTROPY:

- **Predisposing factors** include all the cognitive & affective determinants; in order for occupants to intentionally change their energy behaviour, they must become aware of their energy use, pay notice to it, and be informed about the consequences. They must also be motivated to use the available information and instruments to control their energy use.

- Enabling factors are external factors that facilitate achievement of motivation and allow new behaviour to be realised. Often, the acquisition of new skills is required in order to observe the desired behavioural change.

- Reinforcing factors include factors that motivate, support and reward the desired behaviour change through positive while engage occupants to continue performing the desired behaviour.

An additional source of influencing factors is socio-demographic factors. Indicatively, age, gender, income, education level and the composition of the household are some of these factors. However, such factors cannot be affected when interventions are carried out. They are just ‘used’ to determine the segmentations of target groups.

In most of the cases, when it comes to changing energy-related behaviour, attention is given only to the predisposing factors. However, ENTROPY also analyses both enabling and reinforcing before proceeding to the development of interventions per target group.

The process of analysing the aforementioned ENTROPY factors includes three core steps:
1. Conduct an inventory of all the factors and place them in the three categories (as can be seen above)

2. Choose priorities between the categories (all the categories are treated equally within ENTROPY)

3. Choose priorities within the categories (the priority of factors within ENTROPY will be an on-going data-driven and performance-based task)

Hence, the frequency, urgency and ability of the different determinants for behaviour change will be data-driven and will determine the relative weights assigned to each factor, periodically.

**Step 3 – Design of the intervention – match with the instruments**

To allow predisposing, enabling and reinforcing factors influence behaviour, ENTROPY undertakes a number of activities such as motivating the target groups by increasing their knowledge in energy efficiency issues, providing feedback about the effects of their behaviour and deploying technologies that ease the energy savings monitoring.

The adoption of the desired behaviour per target group requires creating the necessary conditions. Thus, apart from the technical instruments, ENTROPY also involves behavioural instruments such as training courses, rules, rewards, social support, etc.

Deepening into the influencing factors will provide better insights on how their effectiveness could be improved. Next sections contain all the valuable information required in order to design and properly develop these influencing factors before determining their relative weight that will maximise their dynamics for achieving the initially set goals of energy savings and behavioural change. Table 3 displays an overview of the factors that ENTROPY eventually employs and which seem to play a prominent role in bringing about behavioural change, along with the average amount of change that may be expected from them.

<table>
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<tr>
<th>Categories</th>
<th>Influencing factors</th>
<th>Expected Energy Savings$^1$</th>
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<td><strong>Predisposing factors</strong></td>
<td>Awareness &amp; knowledge through personalised content</td>
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<tr>
<td></td>
<td>Relative rank about attitudes &amp; beliefs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Perceived capabilities</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Personal preferences</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Intrinsic motives</td>
<td></td>
</tr>
<tr>
<td><strong>Enabling factors</strong></td>
<td>Availability &amp; accessibility of resources</td>
<td>10%-20%</td>
</tr>
<tr>
<td></td>
<td>Technical developments</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Judicial resources</td>
<td></td>
</tr>
<tr>
<td></td>
<td>New skills</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Serious game</td>
<td></td>
</tr>
<tr>
<td><strong>Reinforcing factors</strong></td>
<td>Peer comparison feedback</td>
<td>5%-15%</td>
</tr>
<tr>
<td></td>
<td>Household feedback</td>
<td></td>
</tr>
</tbody>
</table>

$^1$ There is an extended literature review and a strong debate about the savings that could be achieved by deploying the particular influencing factors. Entropy assumes that the expected savings could be reached the proposed level in a cumulative way per category of factors. To evaluate and validate the true energy savings, Entropy will utilize an experimental design to examine the effect of each factor on energy savings, individually. Then the actual energy savings will be compared to the proposed expected savings. However, accumulating energy savings between categories and expecting to reach the top 55% should not be taken for granted as the maximum level of savings is mostly determined of the building’s potentials for savings.
Relative measures  
Rewards (economic, points, badges etc.)  
Social norms  
Gamification

**Table 3: Entropy factors for achieving behavioural change**

**Steps 4 and 5 – Implementation of the intervention and Monitoring & evaluation of process and change in determinants**

Step 4 is the first step to be taken in Phase 2 of ENTROPY model. During the implementation phase of the interventions, it is critical to maintain a structured way. Therefore, steps 4 and 5 will be carried out simultaneously, even if listed as separated steps.

Monitoring means providing internal feedback to the ENTROPY consortium to check whether the interventions are on track with the set goals, objectives and expected performance of the KPIs by conducting data-driven evaluation. Hence, insight is going to be gained from answering to questions related to the ENTROPY’s objectives:

- Were the interventions carried out as intended?
- Did interventions reach the different segments at stake? Did the groups understand the intervention?
- How did the target groups appreciate the kind of interventions that were carried out?
- Did the interventions meet the groups’ expectations?
- What is the perceived effectiveness of the interventions in the view of its developers, intermediaries, representatives of the end target groups?
- What were the stimulating and restricting factors in the implementation process?

Answers to these questions along with the evaluation of the designated ENTROPY KPIs (see the full list in section 5.2) are important to develop an understanding of the reasons/explanations why certain effects do, or do not occur. This kind of information is also of great benefit to the developers of future interventions in order to learn from ENTROPY lessons and compose effective programs.

The ENTROPY process evaluation is also known from the literature as the ‘formative evaluation’ or ‘summative evaluation’. Such kind of evaluation attempts to describe the process of an intervention in a structured way and so it also turns possible to gain insights into the reasons behind the success or failure of interventions. Data is gathered in order to determine if the ENTROPY has met its objectives set in step 1.

Additionally, such evaluation enables to find out to what extent the changes linked to the three categories of influencing factors, as described in step 2, were also met within each target group, separately.

**Step 6 – Evaluation of the extent to which intermediate and end-goals were reached**

In the last step, focus is put on the ultimate goals of the ENTROPY programme. The most important questions to be answered in this step are:
• To what extent have changes been established in terms of behavioural and energy efficiency level; and

• To what extent have these changes contributed to pure energy savings and reduction of CO2 emissions.

3.3.2 The impact of Feedback

In general, feedback strategies seek to change consumer’s energy consumption behaviour by expanding the energy-related information available to the consumer. As shown in Figure 2, there are two types of feedback:

1. Direct feedback, which provides information about energy consumption in real-time (or near real-time) through the meter or in-home display

2. Indirect feedback, which provides information about energy consumption to the customer at some later point in time [53]

Within each feedback type, further delineation may be made based on the level of data disaggregation and frequency of energy information feedback.

Aside from the volume and frequency of information flow, the success of a feedback critically depends on how the information is displayed and how consumers are motivated to interact with and use the information provided [54]. In essence, there are three main approaches to engage consumers and affect their behaviour: 1) target an individual’s specific consumption habits, 2) make normative comparisons with peer groups, and 3) target the community.

Figure 2: Types of behavior-based energy efficiency strategies & approaches
Within these three categories, energy feedback can occur as: one-time feedback, interval (indirect) feedback and real-time (direct) feedback. Each of these feedback types guides the deployment of different functionalities and different designs. In particular, ENTROPY exploits indirect feedback to build a peer comparison functionality and drive gamification. Then leverages indirect and direct feedback to feed the personalised feedback mechanism that in turn will facilitate occupants’ monitoring on their household/building energy consumption. Lastly, engages occupants into a serious gaming that informs participants about the real energy savings that can be reached due to a community-based effort.

However, since there are different types of energy use behavioural changes, ENTROPY realises the importance of also narrowing down the feedback interventions in order to select the most suitable types of feedback. The main feedback categories include how spacious of a home one desires, what types of appliances one purchases, and how often one leaves the television or lights turned on. The purpose of ENTROPY is to categorise these different types of behaviour and then assign well-defined recommendations in terms of what changes a household may adopt to improve its energy efficiency.

Figure 3 below illustrates an example of the four different behavioural types that feedback interventions should focus on.

<table>
<thead>
<tr>
<th>Investment</th>
<th>Habital Recurring, repetitive or frequent actions</th>
</tr>
</thead>
</table>
| **Low Cost/No Cost** | Weather stripping  
Caulking  
More efficient light bulbs | Turn off lights, appliances, heating/cooling when not in use  
Cold wash clothes washing |
| **Higher Cost** | Efficient HVAC/heat pumps  
Efficient appliances  
Whole-house retrofit | Changes in habitual behaviors can occur through technology automation, including sensors, smart thermostats, smart appliances and home energy automation systems |

Figure 3: Example of the different behavioural types of feedback

Rather than building on the high-cost investments such as the replacement of more efficient appliances, which falls under the traditional incentive-based energy efficiency programs, ENTROPY focuses primarily on habitual decisions, such as turning off lights when not in use, or set the temperature of thermostats at an optimal level.

Modest shifts in occupancy behaviour (between 5-25%) usually have a cumulative impact not just on the energy saving of a building, but also on the complete peer network, as neighbours can create a durable social influence on each other [55]. Acknowledging that such small changes can drive significant gains in terms of environmental quality if they are added up in an incremental way, ENTROPY attempts to shift occupants’ behaviour towards sustainable outcomes step-by-step and in a long-term and sustained fashion.

Hence, the core feedback messages of behaviour change that ENTROPY exploits focus on areas that occupants can enact change in. Such areas include among others:

- Electrical plug loads
- Electrical lighting loads
• Internal temperature control
• Lift use vs. internal stairs
• Equipment on standby (TVs, computers, phone chargers)
• Electrical equipment use (computers on, outside of hours)
• Personal comfort through passive means (clothing, exercise)

3.3.3 Social Norms

ENTROPY incorporates social norms to enhance behavioural change. Taking advantage of the proposed by Rimal and Real normative social behaviour model [56][57], ENTROPY considers three parameters that effect the translation of social norms into behaviour. In particular, social identity, norm interaction (i.e. injunctive norms) and outcome expectations are these three parameters that moderate the influence of descriptive norms on behaviour. Figure 4 below presents the complete social norms framework and illustrates how the three parameters add to the behavioural change:

![Figure 4: Social Norms Framework](image)

To allow the normative mechanics impact the occupants and alter their behaviour, ENTROPY basically intervenes to the communication aspect by developing two social related functionalities, the peer comparison functionality and the social media integration. Hence, ENTROPY ensures that the bottom level effects will be realised and the occupants will get the maximum positive influence from their energy efficient peers.

To evaluate the prospects of social norms for behavioural change, ENTROPY will also run qualitative research through surveys before and after its intervention. Table 4 and 5 shows respectively these two indicative surveys [58][59].
### Table 4: Survey to evaluate social norms impact - before Entropy intervention

<table>
<thead>
<tr>
<th>Factor</th>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Descriptive Norms</td>
<td>How many people in your department turn off office or lab equipment when they have finished using it?</td>
<td>Five point scale: • very few • 25% • 50% • 75% • Nearly everyone</td>
</tr>
<tr>
<td></td>
<td>How many people in your department turn off their computers before leaving work for the day?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>How many people in your department turn off their monitors before leaving work for the day?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>How many people in your department turn off the lights at their desk/office before leaving work?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>If the other people in your department saw that a computer was left on when the user was not at work, they would turn off the computer before leaving work for the day</td>
<td>Five point scale: • strongly disapprove • disapprove somewhat • neither approve nor disapprove • approve somewhat • strongly approve</td>
</tr>
<tr>
<td></td>
<td>If the other people in your department saw that a monitor was left on when the user was not at work, they would turn off the monitor before leaving work for the day</td>
<td></td>
</tr>
<tr>
<td></td>
<td>If the other people in your department saw that an individual's lights were left on when he/she was not at work, they would turn off the lights before leaving work</td>
<td></td>
</tr>
<tr>
<td></td>
<td>If the other people in your department saw that office or lab equipment had been left on when it was not in use, they would turn off office or lab equipment before leaving work</td>
<td></td>
</tr>
<tr>
<td></td>
<td>By changing our behaviour, employees and students like me can reduce the department's energy use</td>
<td>7 point Likert scale from strongly disagree to strongly agree</td>
</tr>
<tr>
<td></td>
<td>The department should do more to save energy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>I am concerned about the amount of energy that the department uses</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Energy conservation should not be a priority for the department now</td>
<td></td>
</tr>
<tr>
<td></td>
<td>I am very interested in what others think about the department</td>
<td>7 point Likert scale from strongly disagree to strongly agree</td>
</tr>
<tr>
<td></td>
<td>When I talk about the department, I usually say 'we' rather than 'they'</td>
<td></td>
</tr>
<tr>
<td></td>
<td>When someone praises the department, it feels like a personal compliment</td>
<td></td>
</tr>
</tbody>
</table>

### Table 4: Survey to evaluate social norms impact - after Entropy intervention

<table>
<thead>
<tr>
<th>Factor</th>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Descriptive Norms</td>
<td>How many people in your department turn off office or lab equipment when they are finished using it?</td>
<td>Five point scale: • very few • 25% • 50% • 75% • Nearly everyone</td>
</tr>
<tr>
<td></td>
<td>How many people in your department turn off their computers before leaving work for the day?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>How many people in your department turn off their monitors before leaving work for the day?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>How many people in your department turn off the lights at their desk/office before leaving work?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>If the other people in your department saw that a computer was left on when the user was not at work, they would turn off the computer before leaving work for the day</td>
<td>Five point scale: • strongly disapprove • disapprove somewhat • neither approve nor disapprove • approve somewhat • strongly approve</td>
</tr>
<tr>
<td></td>
<td>If the other people in your department saw that a monitor was left on when the user was not at work, they would turn off the monitor before leaving work for the day</td>
<td></td>
</tr>
<tr>
<td></td>
<td>If the other people in your department saw that an individual's</td>
<td></td>
</tr>
</tbody>
</table>
lights were left on when he/she was not at work, they would turn off the lights before leaving work
If the other people in your department saw that office or lab equipment had been left on when it was not in use, they would turn off office or lab equipment before leaving work

- approve somewhat
- strongly approve

I discussed energy use with other occupants
I discussed ENTROPY platform with other occupants
Such opportunities for discussion encouraged my use of ENTROPY platform
I discussed with other occupants about how ENTROPY platform helped me reduce my energy use
I encouraged other occupants to use ENTROPY platform
I use ENTROPY platform because other occupants use it
Because I used ENTROPY platform I now know more other occupants
Because I used ENTROPY platform I now talk to more occupants
Because I used ENTROPY platform I now know other occupants better

I felt a duty to department managers to use ENTROPY platform
I felt a duty to other occupants to use ENTROPY platform
I felt a duty to the team who developed ENTROPY platform
I felt pressure from my managers in the department to use ENTROPY platform
I felt pressure from my colleagues to use ENTROPY platform
I felt pressure from the team who developed ENTROPY platform

Table 5: Survey to evaluate social norms impact - after Entropy intervention

3.3.4 Personalization through a rule-based recommender system for behavioural change

ENTROPY exploits the potentials of rule-based systems in order to deliver as personalised as possible content that will maximize occupants’ experience and boost the energy efficiency results. Hence, a well-designed rule-based system that relies on well-defined specifications is the key for successful personalisation.

The role of the rule-based system is to generate new knowledge to the ENTROPY pilot participants through a data-driven approach by following a forward chaining inference engine (Table 6).

<table>
<thead>
<tr>
<th>Objective</th>
<th>Inference Engine</th>
<th>Attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production Systems: Generate new knowledge</td>
<td>Forward Chaining</td>
<td>Data-driven</td>
</tr>
</tbody>
</table>

Table 6: Brief overview of Entropy rule-based system

In general, a rule-based design system is comprised of three parts [60]:

- A set of rules
- A database of knowledge
• An algorithm for applying the rules to the knowledge (inference engine)

The selection over production systems is not stochastic. It is rather a sophisticated choice since production systems utilise forward chaining to produce new facts from a knowledge base, can synthesise structure from behaviour and are extensively used in cognitive modelling to study the effects of knowledge. The process of forward chaining takes the following 4 steps in order to be completed [60]:

1. Forward chaining starts with the available facts and uses the rules to conclude new facts.
2. Each rule is checked to determine whether the if-clause is true according to the known facts
3. If a rule is found, then the statements in the then-clause are added to the knowledge base
4. The process is repeated until no more rules can be fired, or a goal state is reached

Rule-based System Architecture

![Rule-based System Architecture](image)

In order to guide behaviour change towards energy efficiency, ENTROPY will undertake to deliver content that meets participant’s needs, preferences and realistic energy savings potentials. To achieve this, the following data sources should feed with input the rule-based system:

- Demographics
- Psychographics
- Analytics & other behavioural data (ex. data from user stories)
- Sensor data (includes thermostat data)
- Smart meter data
- Appliances’ data (disaggregation)
- Billing data
- Past energy consumption data

Triggers

Triggers are used in order to fire the rules. ENTROPY acknowledges the importance of triggers in order for the recommender system to be effective in its goals and offer a true personalised
experience to the participants. To form the triggers, the major prerequisite is to carefully examine the different user stories. This allows ENTROPY team to meet the pilot participants’ basic habits that derive from their daily routine and prevent the “cold start”\(^2\) blocking issue. Then, all the available data sources are also explored to feed with input the rules.

However, more intuitive information about the formation of both triggers (conditions) and behavioural interventions (actions) as well as the interaction between knowledge base and the system, are provided under the section 4.

**Rule-based system as an instrument for personalised interventions**

The execution of an effective behavioural-based program that ensures the desired energy efficiency is not an easy task and involves the thorough designing of personalised applications that enable ENTROPY pilot participants to raise their awareness, conceptualise the cost of their habits, re-think their actions and willingly change their behaviour. ENTROPY interlaces the following predisposing, enabling and reinforcing-based strategies to achieve its objectives.

**Increase Knowledge and Awareness through personalised content**

- Send content for educating participants on energy efficiency issues taking into account their current knowledge level
- Send tips that address curtailment behaviour based on participant’s identified habits, comfort level and potentials for savings
- Send quizzes that account for the already sent content
- Send articles, videos and other material for sustainability that meets participant’s interests and preferences
- Send any possible material that user can interact with and entertain such as tests and self-assessments

**Provide personalised self-evaluation tools**

- Peer comparison feedback about energy savings
- Household feedback on energy savings
- Feedback on taken quizzes, tests & other self-assessments
- Relative (peer comparison) & absolute feedback on training progress
- Behavioural feedback based on the ENTROPY metrics (see section 3.3.7)
- Feedback on behaviour change through the KPIs
- Feedback on undertaken challenges
- Feedback on participants’ and his team’s performance in serious game

**Personalised experience**

- Personalised invitations to challenges
- Personalised invitations for DR and peak demand management
- Personalised invitation to the serious game

\(^2\) *Cold start is a potential problem in computer-based information systems which involve a degree of automated data modelling. Specifically, it concerns the issue that the system cannot draw any inferences for users or items about which it has not yet gathered sufficient information.*
• Personalised notifications about win badges, points and other gamification rewarding elements
• Personalised real-rewards based on participant’s preferences

Personalised Game

• Use of avatar that simulate the participant himself in a virtual world
• Personalised game tips for better decision-making

### 3.3.5 Gamification Framework for Behavioural Energy Efficiency

Gamification is an approach that uses game-based mechanics, aesthetics and game thinking to engage people, motivate action, promote learning and solve problems. Gamification is appropriate for everyday non-leisure contexts when it is needed from a business perspective to engage individuals in activities that on themselves are not motivating on their own accord.

ENTROPY is built on a gamification design that puts most of the emphasis on human motivation since the major objective is to boost energy efficiency and guide individuals towards the adoption of a “greener” lifestyle. In essence, gamification in ENTROPY is introduced to add a layer of playful interactions with the target users and to support them in the process of adopting an energy efficient lifestyle by acting and reacting with their energy consuming surroundings. In order to design the optimal gamification architecture the ENTROPY gamification relies on the theoretical foundations of the top level and widely adopted “MDA Framework” by Hunike et al [61]. The MDA Framework stands for Mechanics, Dynamics, Aesthetics Framework and is a game design Framework that consists of three levels of abstraction that support the game design process as a continuum of iterative stages based on (a) the selected game elements, (b) potential modes of interaction from the player side and lastly (c) the expected emotional response from the producer side directed to the players. The analysis of the MDA Framework, has the Mechanics as “the particular components of the game, at the level of data representation and algorithms”, the Dynamics as “the run-time behaviour of the mechanics acting on player inputs and each others outputs over time” and lastly the Aesthetics as the “desirable emotional responses evoked in the player, when she interacts with the game system” as illustrated in the following figure.

![MDA Framework](image)

**Figure 6: MDA Framework**

Having the MDA Framework as a conceptual starting point, ENTROPY utilizes the “Octalysis” framework that is human-focused rather than being purely function-focused [62]. The combination of the two frameworks and the mapping of the Octalysis to the MDA enables ENTROPY to build a specific gamification framework that will account for the gamification architecture for all potential end-users of the systems. Figure 7, shows the complete “Octalysis” framework along with the basic gaming mechanics, aesthetics and elements.
Octalysis suggests that the core drives on the right are considered Right Brain core drive and are related to creativity, self-expression, and social aspects. The Right Brain core drives have a tendency of being based on Intrinsic Motivations which means that the motivation is that the activity itself is rewarding on its own and one is not thwarted to the activity. The Left Brain core drives have a tendency of being more based on Extrinsic Motivation which means that the motivation is external to oneself (e.g. to obtain something, whether it is a goal or a physical reward). The core drives on the left are considered Left Brain core drives and are associated to logic, calculations and ownership. Both parts should be introduced and represented in the gamification of ENTROPY in order to be able to meet the motivation needs of both intrinsically and extrinsically motivated participants as well as to be able to provide intrinsically and extrinsically oriented incentives.

The 8 core drives of the “Octalysis” gamification framework are summarised below in order to facilitate the deployment of the ENTROPY gamification framework for the support of gamified experience and then they are transformed so as to be suitable for the ENTROPY pilots’ participants [63].

**Epic Meaning & Calling**

Epic Meaning & Calling is the core drive where a player believes that he is doing something greater than himself or he was “chosen” to do something. An outcome of this is a player that devotes a lot of his time to maintaining a forum or helping to create things for the entire community (think Wikipedia or Open Source projects). ENTROPY gamification should be designed for the creation of simulations that will support learners to practice energy efficient behaviours. For example they may get challenged to decide on the optimal energy appliances’
usage, participate into DR and peak demand management, become a facility manager, perform certain measurable green actions and undertake the role of sustainability instructors. The simulation will engage the learners in a narrative that will involve elicitation of information to apply energy efficiency, familiarisation with energy conservation behaviours, real-case scenarios with impact on energy savings and valuable feedback. Thus, the platform will be considered as a tool that strongly supports meaning.

Development & Accomplishment

Development & Accomplishment is the internal drive of making progress, developing skills, and eventually overcoming challenges. The word “challenge” is very important, as a badge or trophy should reflect actual accomplishments. This is also the core drive that is the easiest to design for and coincidently is where most of the GSs mostly focus on.

ENTROPY should provide an environment that promotes and supports a step-by-step process for the learners to achieve a set of milestones linked to the learning goals. Milestones should be associated with points and badges to be won as the user’s achievement level increases.

Empowerment of Creativity & Feedback

Empowerment of Creativity & Feedback is when users are engaged with a creative process where they have to repeatedly figure things out and try different combinations. People not only need ways to express their creativity, but they need to be able to see the results of their creativity, receive feedback, and respond in turn. Additionally the existence of empowerment of creativity will enable the participants to experience Autonomy that leads to intrinsically motivating experiences [35].

ENTROPY should be based on an unlocking mechanism that will be linked to certain milestones and will be controlling the narrative and the way that the activity advances in real-time. With respect to the feedback, the users should be provided with instant feedback and awarding elements such as monetary and other incentives to boost learners’ performance. Additionally multiple narratives will enable the participants to navigate freely in a plethora of choices and perceive the activity as having many choices from which they can select.

Ownership & Possession

This is the drive where users are motivated because they feel like they own something, known as the endowment effect. When a player feels ownership, he/she innately wants to make what he/she owns better and own even more. Besides being the major core drive for wanting to accumulate wealth, this deals with many virtual goods or virtual currencies within systems. Also, if a person spends a lot of time to customize his/her profile or avatar, he/she automatically feels more ownership towards it too. This is what makes people collecting stamps or enjoying completing puzzle pieces.

ENTROPY gamification design should strongly support ownership and possession, as the whole concept of the platform will be based on simulations, with custom made virtual worlds, appliances, building as well as avatars and narratives. In addition, small instant games such as puzzles & crosswords will be developed to allow players feel they possess the knowledge and the skills to solve them out while experiencing fun and relaxing moments. The result of the choices in the specific part will enable ENTROPY to also better understand each participant in order to tweak the content to best meet his/her needs, mode of learning and self-representation.

Social Influence & Relatedness
This drive incorporates all the social elements that drive people, including: mentorship, acceptance, social responses, companionship, as well as competition and envy. When someone sees a friend that is amazing at some skill or owns something extraordinary, he/she becomes driven to reach the same level given that he/she is predisposed in such an activity. Also, it includes the drive for drawing closer to people, places, or events that the person can relate to. For example, when someone sees a product that reminds of his/her childhood, the sense of nostalgia would likely increase the odds of that person buying the product; the same is expected to happen in case neighbours produce energy savings.

ENTROPY will leverage gamification with social media and peer comparison functionalities in order to optimize the project’s social strategy, and so social influence and relatedness will be supported by the platform. Social influence and voting are interesting concepts with potentially strong benefit for learning to be exploited.

**Scarcity & Impatience**

This is the drive of wanting something because you can’t have it. Many games utilise “appointment dynamics” such as “come back 2 hours later to get your reward” since the fact that people can’t get something right now motivates them to think about it all day long. Additionally the utilisation of “appointment dynamics” enables the creation of scheduled revisits while other participants make progress respectively. Lastly scarcity enables the creation of difficult to attain goals. If all can have the same badge, then the meaning of the badge is lost. If there are badges, however, that few can get based on difficult achievements then that (a) creates a path towards excellence and (b) enables social comparison based on rare / hard to collect items.

The deployed for ENTROPY gamification should account for scarcity and impatience by several means (e.g. introducing the unlocking mechanism, incorporating appointment dynamics) to trigger users to come back to the learning process, soon.

**Unpredictability & Curiosity**

Generally, this is a harmless drive of wanting to find out what will happen next. If you don’t know what’s going to happen, your brain is engaged and you think about it often. Many people watch movies or read novels because of this drive. Unpredictability and curiosity will be supported through the recommended for ENTROPY gamification design by introducing visual storytelling, gradually discovering clues and collecting information that will allow the creation of the broader images of a simulation based on which decision making by the user can occur.

**Loss & Avoidance**

This core drive is based upon the avoidance of something negative happening. On a small scale, it could be to avoid losing previous work. On a larger scale, it could be to avoid admitting that everything you did up to this point was useless because you are now quitting. Also, opportunities that are fading away have a strong utilisation of this core drive, because people feel like if they don’t act immediately, they will lose the opportunity to act forever. Loss aversion in the context of gamification as means for engagement was introduced in the Foursquare app where participants initially had to continue checking-in in order not to lose gained points on the 7-day period. That was later changed to a fixed schedule.

To enable the impact that loss and avoidance can bring, the ENTROPY gamification should increase the level of challenge each scenario poses. Moreover, adding a countdown timer to

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3 [https://foursquare.com/](https://foursquare.com/)
some of the deployed small instant games could also affect positively the performance of users since the learners will have to play against time to meet the game’s goal. The game ends once the allocated time has expired. An interesting concept that could increase or sustain engagement would be to add a factor of negative marking such as losing points or boosters that have been gained, that could be linked to time that a task is completed or the learner to progress to the next level.

Finally, in order to account for the aforementioned and in parallel to the ENTROPY Gamification Framework the framework and resulting apps (personalized app and serious games) should comprise the following among others in terms of Game Mechanics, Dynamics, and Aesthetics:

- **Points’ allocation**: Fundamental building blocks as interval-scaled measure to express progress in various dimensions. Subtypes: Experience points, Redeemable points, Reputation points, Karma points and Skill points [64][65][66].

- **Achievements setting**: Building block with nominal and ordinal counterpart of expressing progress. Achievements describe goals whose fulfilment is stored outside the scope of individual game sessions. Subtypes: Expected, Unexpected, Partially (un-)expected [66][67][68].

- **Goods setting**: Objects as rewards for completing various goals. Subtypes: Virtual items and Physical items [64].

- **Roles setting**: Functional roles where “responsibility for different types of game actions can be divided between participants” or players [69].

- **Missions Settings**: Predefined structures of what has to be achieved within the game with a concrete, achievable and rewarding way: Status of missions “Unavailable, Available, Completed”. Subtypes: Individual, Collective [70].

- **Gamification Feedback**: In order to enable the player to “get the promise that the goal in question is reachable”. Subtypes: Informational (Points, Notifications, achievements, Narrative context), Corrective (Notifications) [71].

- **Events**: To define external or internal actions in the game space. Subtypes (Operative, Resultant, External, Internal [70].

- **Notifications**: Form of feedback that conveys information as direct and intermediate feedback mechanism in terms of progress, positive messages and hints for improvement [71][72].

- **Narrative Context**: While notifications describe results of actions, narrative can be used to reinforce curiosity, attention and engagement [69].

- **Avatars**: Avatars are the virtual representation of the physical end participants and foster engagement, curiosity and self representation. Avatars can be either fictional characters or even photos of the players [69].

- **Leaderboards**: The aggregation of individuals’ or teams’ points with respect to a point category in ascending or descending order. They are used to compare individuals and teams within or between groups in the same point category [64][72].
• Teams: Team formation enables the system to support collaboration towards commonly pursued goals [69][71].

Overall the ENTROPY gamification framework should account for the creation of exciting, enjoyable and engaging experience with the utilisation of game mechanics, dynamics and aesthetics across the personalised applications and the serious games.

### 3.3.6 Serious Games

ENTROPY brings serious gaming to the frontline in order to smoothen the daily energy while foster engagement and guide behavioural change. Since there are multiple linked energy sensors in buildings and rooms, ENTROPY develops a multiplayer computer game that can promote changes in energy use in the context of compelling play and community participation. The primary serious game’s concept is the alignment of personal motivations such as the increased involvement encouraged by timely reinforcement, the achievement of recognition, and the sense of belonging something, with community environmental goals such as the reduced electricity usage and the time-shifted energy use. Hence, ENTROPY results in sustainable behaviour change that is personally rewarding as well as socially responsible.

The five core components of the ENTROPY serious game design are summarised as follows:

• A game platform that links state-of-the art energy sensing, i.e. smart meters and other building sensors, with multiplayer game play

• The platform-based serious game is offered for the conduction of empirical tests that will validate any positive influence over the three primary game ingredients, namely the self-representation, the feedback across the multiple game scopes and the competition progress between the teams with respect to energy use behaviour

• The game environment simulates real-world, enables the credible representation of real conservation cases and introduces the player to virtual decision making with real/realistic impact

• The selected game mechanics aim to take player’s engagement constantly increases

• The game fosters the interaction and cooperation among players that belong to the same team in order to allow higher energy savings to occur

ENTROPY serious games also possess the following gaming traits [73]:

**Backstory and story line:** As in every game, so ENTROPY’s serious game has a backstory, a story upon which it is based. This story line is not the game play itself, but rather the rationale for the game play. The story line will be based around rational what energy-using behaviours can and should be addressed.

**Game mechanics:** ENTROPY game’s mechanics specify its functions, including information such as how the game’s physical world behaves, in-game weather, and the actions each game character takes when given a command.

As outlined in D1.1 the game mechanics that are incorporated into a gamified software system or application may have a significant impact on type of player or user, who may or may not efficiently use those techniques and get maximum benefits from it. As ENTROPY is aiming to address different types of players, and social interaction and sharing being the important aspect
of the gamification strategy, such as: achievers, explorers and socialisers, the following game mechanics will be used:

1. Feedback gamification mechanics
   a. Appointment dynamics – at a predetermined times a user must return for a positive effect
   b. Combos - reward skill through doing a combination of things

2. Behavioural gamification mechanics
   a. Goals (shortand/or longterm) - missions or challenges give players a purpose for interaction, and educate players about what is valued and possible within the experience
   b. Epic meaning - users will be highly motivated, if they believe they are working to achieve something great, something inspiring, something bigger than themselves
   c. Discovery or exploration - players love to discover and to be surprised
   d. Community - Community gives meaning to goals, badges, competitions, and other mechanics. Sharing participant achievements creates energy in the community by making people aware of what others are doing. They learn about goals, badges, and rewards that they may want to pursue
   e. Community collaboration - Connect users as a team to accomplish larger tasks, to drive competition, and to encourage knowledge sharing. Show team members how they are contributing to the group’s success. No one wants to let down their team members

Rules: The corollary to game mechanics are the game rules, i.e. the constraints concern the game play that exist on every player’s abilities and actions.

Immersive graphical environment: ENTROPY defines the sensory representation of the experience layer of the game, including 2D/3D graphics, sound, and animation. In general, the game environment can be static, i.e. it resets at the end of each player session, or persistent, i.e. it continues to evolve even when a player isn’t logged in. ENTROPY game’s environment. It is envisaged that serious games will incorporate 3D graphics element which will be enable more immersive experience, while personalized application will implement 2D graphics.

Interactivity: This trait describes the impact a player’s actions have on the real world while includes issues of persistence and the players’ interaction. The games will incorporate augmented reality elements which will enable interactive mode through scanning markers and triggering AR content.

Challenge/competition: Constitutes the heart of any game. The competition might be against one’s self, against other players or even against the game itself. There are also risks and consequences but only within the game, since such consequences of an action or decision do not impact the real world.
The players will be in the position to create teams and to collaboratively work on achieving a set of energy efficiency goals. While doing so they will be competing with other teams in an attempt to achieve the highest energy efficiency gains while complying with the set constraints. The pilot buildings will be modelled together with a range of deployed smart devices thus allowing the players to combine different approaches, supported by the analytics tools provided by the project. Challenges/competitions will be created and leaderboards will be used to display achievements:

- Leaderboard will display the behaviours and activities that are most important to reaching goals.
- More than one leaderboard will be used. For instance, leaderboards will be created for each building, as well as for individual tasks.
- Everyone will be given the ability to search for players.
- Leaderboards will be “wiped out” at the end of the week and everyone will be given a fresh start.

Versatile presentation system: This trait describes the ability of the developed game to show different content (version) of the same game on selected individuals that will support the experimentations for the calibration of the incentives/rewards/effort. For example a set of users if found to be prone to competing to enable the leaderboard, whereas if users are found to be negative influenced to be able to hide the leaderboard at administrator level.

These issues will be further addressed in Task 3.3 and specified within D3.3 which deals with gamification framework.

### 3.3.7 Behavioural metrics to boost behavioural shifting

ENTROPY seeks to evaluate the potentials of 5 behavioural metrics, namely the “Engagement”, “Participation”, “Knowledge”, “Influence” and “Effectiveness” metric, with respect to the behaviour change that can induce to the occupants. There is much public dissent about whether a system can actually measure and classify a user or not, especially when it comes to quality measures. It may be difficult to detect, analyze and make conclusions about someone’s behaviour, although with the appropriate metrics and methods, results are possible to be produced. ENTROPY tracks all available analytics such as logins, interaction with content, challenges and serious gaming to associate them with the occupant’s profile and gain insights on the level of motivation that such metric trigger for behaviour change.

By providing such information, ENTROPY intends to create one more channel of feedback that clearly comprises the positive effects of the Quantified Self Technologies (QST) [74]. The emerged trend of QST first adopted within the domain of fitness-tracking through the wearables, but recently has started gaining ground in a wider market.

In essence, the human interaction with QST coincides with the growth of design for behaviour change [75][76] and persuasive technology [77] while involves the mechanics of collection and reflection in order to display occupant with “self-knowledge through numbers”, the design and effectiveness of different kinds of feedback, how presentation affects understanding, the effects of increased connectivity as well as how users understand wider networks, and finally the potential societal and economic impacts of QSTs.
Hence, the ENTROPY metrics\(^4\) will enable the self-assessment of occupants and taking the self-assessment as step further will also allow for peer-comparison to be again realised.

**Engagement**

One of the most important metrics is *Engagement*, due to the fact that it takes into account all interactions the occupant has with the means utilised for the ENTROPY’s interventions, i.e. the mobile and web platform. Critical factors to calculate occupant’s engagement are among others the frequency of interaction as well as the quality of interaction. ENTROPY also promotes and supports the engagement loops, i.e. actions that occupants do over and over again as an indicator for the proper engagement with the platform. Engagement loops start with motivation, followed by action, and finally is feedback.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Estimation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Click-Depth Index (Ci)</td>
<td>Engagement: $\sum (Ci+Ri+Di+Fi+li+Li)$</td>
</tr>
<tr>
<td>Recency Index (Ri)</td>
<td></td>
</tr>
<tr>
<td>Duration Index (Di)</td>
<td></td>
</tr>
<tr>
<td>Feedback Index (Fi)</td>
<td></td>
</tr>
<tr>
<td>Interaction Index (li)</td>
<td></td>
</tr>
<tr>
<td>Loyalty Index (Li)</td>
<td></td>
</tr>
</tbody>
</table>

**Table 7: Calculate ENTROPY “Engagement” metric**

**Serious Game & Challenge Participation**

The quantification of the occupant’s participation in the ENTROPY designed challenges and serious game constitutes a separate behavioural metric and undoubtedly is one of the most critical metrics. Participation is planned to track the actions occupants do and approve their active involvement with the challenges and serious gaming. Participation is first calculated on an individual level and then it is either aggregated to provide a robust summary of the overall performance of occupants, or it is displayed as a measure for comparison among the occupants, through a leaderboard. Within this challenge-based and serious game context, participation follows a progression of increasing difficulty called cognitive flow (Figure 8).

\[\text{Concrete goals with manageable rules} + \text{Goals that fit player’s capabilities} + \text{Clear & timely feedback} + \text{Eliminate distractions} \rightarrow \text{COGNITIVE FLOW}\]

**Figure 8: The Cognitive Flow**

\(^4\) The metrics are indicative and thus are prone to change during the next deliverables of the ENTROPY project. Additionally, this section will be enriched with serious game metrics as well as some metrics for the personalized aspect of the platform.

\(^5\) The proposed calculation of the “Engagement” metric is indicative and is going to be enhanced during the next steps of ENTROPY project.
**Parameters**  
<table>
<thead>
<tr>
<th>Number of pageviews related to challenge/serious game (P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average of pageviews (per day) (AP)</td>
</tr>
</tbody>
</table>
| Visit game (per day)  
Yes: 1 / No: 0 (VG) |
| Number of events per challenge/serious game (E) |
| Average of events per challenge/serious game (per day) (AE) |
| Average players' time spend (in sec) in game section (active time only) (per day) (T) |
| Average player's time spend (in sec) in mobile app or web platform (active time only) (per day) (AT) |

**Estimation**

| Participation: 0.25*(P/AP)+0.25*(VG)+0.25*(E /AE)+0.25*(T /AT) |

**Table 8: Calculate ENTROPY “Participation” metric**

**Knowledge**

It is really difficult to measure the actual knowledge gains, since to achieve pure knowledge is a demanding task that takes many steps to be completed according to the cognitive science. The Bloom’s taxonomy [78] is utilised to provide the full evaluation framework of the knowledge gains. In particular, the Bloom’s taxonomy suggests the following six steps:

1. Knowledge
2. Comprehension
3. Application
4. Analysis
5. Synthesis
6. Evaluation

However, ENTROPY accounts for the quantification of the knowledge progress throughout the pilot by tracking the corresponding Knowledge metric. The Knowledge metric measures the absolute knowledge level for each occupant independently by evaluating the education content the occupant has interacted with. Then, such information is spread between users to trigger social effects, motivate and finally engage all occupants into the educational process.

**Parameters**

| Number of tips taken (per day) (TT) |
| Number of tips sent (per day) (TS) |
| Number of questions sent (per day) (QS) |
| Number of questions taken right (per day) (QTR) |
| Number of questions taken (per day) (QT) |

**Estimation**

| Knowledge: 0.5*(TT/TS)+0.2*(QT/QS)+0.3*(QTR/QT) |

**Table 9: Calculate ENTROPY “Knowledge” metric**

---

6 The proposed calculation of the “Participation” metric is indicative and is going to be enhanced during the next steps of ENTROPY project.

7 The proposed calculation of the “Knowledge” metric is indicative and is going to be enhanced during the next steps of ENTROPY project.
Influence

Since ENTROPY’s platform integrates social media, it becomes crucial to identify the occupants that consider having the ability to drive action. Influence is the behavioural metric that ENTROPY utilises to rank occupants based on their influence potentials. When someone shares something on social media or in real-life, and people respond to this action, that’s influence. So, the more influential some is, the higher will be the influence metric.

Influence metric is based on another well-known metric, the Klout Score [79]. Klout Score is calculated based on:

- How many people someone influences
- How much someone influences others
- How influential those others are

Effectiveness

The last behavioural metric that ENTROPY utilises and shares among occupants to activate the adoption of more sustainable lifestyles, is Effectiveness. This metric actually represents the energy savings achieved as a result of the occupant’s effort not only in an individual level but also as a collective outcome. In order to quantify Effectiveness, ENTROPY first evaluates the exact energy savings by exploring the energy consumption in relation to the typical consumption of the baseline and taking into account all available meter and billing data (see section 5.3.1).
4. **ENTROPY Energy Efficiency & Behavioral KPIs**

One of the major ENTROPY’s objectives is to create insightful KPIs for tracking energy savings but also for evaluating the behavioural change of the occupants after its intervention. Hence, ENTROPY explores and presents a wide range of KPIs along with a methodology for measuring them aiming to guide governments on green policies, form best practices and address the future deployment of behavioural interventions towards energy efficiency.

The data availability will determine which of the recommended KPIs will be evaluated within the ENTROPY project. Assuming that ENTROPY can access all available data sources in order to collect the required data, ENTROPY will attempt to build all baselines presented below. Though, wherever is difficult to define the baseline for the proposed KPIs, ENTROPY will also consider using ‘proxy data’.

<table>
<thead>
<tr>
<th>Perform Energy Audits</th>
<th>Possible success criteria</th>
<th>Possible KPIs</th>
<th>Possible baselines</th>
<th>How to measure</th>
</tr>
</thead>
</table>
| Occupants’ awareness on energy efficiency increased | - The occupants’ energy efficiency awareness level  
- The number of investments realized within ENTROPY  
- The number of intervention performed  
- The number of times awareness evaluation was performed  
- Any related costs to customer awareness increase | - Initial awareness level  
- Evaluate past investments and/or interventions | - Run survey to determine awareness level before and after ENTROPY intervention  
- Correlate investments & intervention with awareness before and after ENTROPY |
| Energy consumption reduction | - Theoretical savings potentials of the implemented measures, what are the expected energy savings and the corresponding financial costs  
- Measured savings at the site level shows whether implemented measures actually reduce the energy consumption as expected and also assess the related financial costs  
- Verified results, usually a statistical study of results in relation to the theoretical savings for the implemented measures | - Energy consumption before ENTROPY Intervention  
- Occupants’ impression about energy savings before ENTROPY  
- Number of already implemented interventions | - Estimation of the theoretical savings during the planning phase of ENTROPY  
- Evaluation of actual savings after the implementation of ENTROPY measures  
- Correlation between proposed and discovered results  
- Evaluation of perceived energy savings through surveys |

- Number of new energy management practices adopted  
- Self-reported energy savings
### Perform Energy Audits

<table>
<thead>
<tr>
<th>Possible success criteria</th>
<th>Possible KPIs</th>
<th>Possible baselines</th>
<th>How to measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>High satisfaction level of occupants &amp; stakeholders for the achieved energy savings</td>
<td>Occupants and stakeholders satisfaction in terms of: - Energy savings</td>
<td>Prior occupants &amp; stakeholders satisfaction &amp; expectations</td>
<td>Conduct a satisfaction survey that includes occupants’ ratings and other qualitative data</td>
</tr>
</tbody>
</table>

Table 10: Energy Audits KPIs

### Energy Efficiency

<table>
<thead>
<tr>
<th>Possible success criteria</th>
<th>Possible indicators</th>
<th>Possible baselines</th>
<th>How to measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reaching a large number of people</td>
<td>- Number of occupants utilize the ENTROPY platform - Number of engaged occupants with the ENTROPY platform - Number of engaged occupants per functionality</td>
<td>- Actions taken before ENTROPY</td>
<td>- Track interaction with the platform - Track behavioral metric “Engagement”</td>
</tr>
<tr>
<td>Mapping problems and offering suitable solutions (personalization effectiveness)</td>
<td>Relevance of delivered content with respect to: - The occupant’s profile - The occupant’s preferences - The occupant’s needs</td>
<td>No direct baseline</td>
<td>- Conduct a survey for assessing personalization effectiveness using quantitative and qualitative data</td>
</tr>
<tr>
<td>Promotion of energy efficiency behaviors &amp; improvement in energy management interventions</td>
<td>- Number of occupants started performing a certain desired action after intervention vs. those acting green due to intrinsic motives - Number of achievements completed in individual and team level</td>
<td>- Level of intrinsic motives before ENTROPY</td>
<td>- Number of occupants acting in a desired way e.g. via energy diary Level of intrinsic motives post ENTROPY engagement</td>
</tr>
<tr>
<td>Instant/Interval energy savings after a recommendation</td>
<td>- Correspondence to real-time interventions</td>
<td>- No direct baseline</td>
<td>- Savings occurred either instantly or within a certain time interval after a personalized intervention</td>
</tr>
<tr>
<td>Occupants report lower energy bills, improved comfort/convenience &amp; adoption of more efficient lifestyles</td>
<td>Occupants satisfaction in terms of: - Lower energy bills - Improved comfort level &amp; convenience - Improved energy efficiency lifestyle</td>
<td>- Occupants expectations</td>
<td>- Monthly energy savings (either bill or meter-based data) - Comfort level survey data - Energy efficiency lifestyle survey data</td>
</tr>
<tr>
<td>High satisfaction level of occupants &amp; stakeholders about the ENTROPY intervention plan</td>
<td>Occupants and stakeholders satisfaction in terms of: - The project’s execution - The processes followed - The final outcomes</td>
<td>Prior occupants &amp; stakeholders satisfaction &amp; expectations</td>
<td>Conduct a satisfaction survey that includes occupants’ ratings and other qualitative data</td>
</tr>
</tbody>
</table>
### Table 11: Energy Efficiency KPIs

<table>
<thead>
<tr>
<th>Monetary &amp; Environmental Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Possible success criteria</strong></td>
</tr>
<tr>
<td>Energy savings</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Oil savings</td>
</tr>
<tr>
<td>Carbon footprint reduction</td>
</tr>
<tr>
<td>Promotion of low-carbon solutions such as appliances, technology, systems of provisions, behavior options</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Cost-effectiveness</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>High satisfaction level of occupants &amp; stakeholders about the economic and environmental benefits that ENTROPY induced</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Table 12: Monetary & Environmental Benefits KPIs
<table>
<thead>
<tr>
<th>Possible success criteria</th>
<th>Possible indicators</th>
<th>Possible baselines</th>
<th>How to measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>High effectiveness of educational content</td>
<td>- Quality of content</td>
<td>- Baseline knowledge level</td>
<td>- Conduct a surveys/interview to evaluate perceived knowledge gains, the quality and the suitability of content</td>
</tr>
<tr>
<td></td>
<td>- Suitability of content</td>
<td>- Expectation for knowledge gains</td>
<td>- Track behavioral metrics “Knowledge”</td>
</tr>
<tr>
<td></td>
<td>- Effectiveness of content/knowledge gains</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Effectiveness of Missions related to knowledge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High effectiveness of challenges</td>
<td>- Duration of challenge</td>
<td>- Baseline for individuals perceptions of challenges</td>
<td>- Conduct a surveys/interview to evaluate the effectiveness of a challenge</td>
</tr>
<tr>
<td></td>
<td>- Number of participants per challenge</td>
<td></td>
<td>- Track behavioral metrics “Participation”</td>
</tr>
<tr>
<td></td>
<td>- Effectiveness of challenges</td>
<td></td>
<td>- Survey on perceptions for challenges post ENTROPY interventions</td>
</tr>
<tr>
<td></td>
<td>- Individual / Aggregate contributions per teams per challenge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High effectiveness of serious gaming</td>
<td>- Participation to serious gaming</td>
<td>- No direct baseline (Game play habits Survey)</td>
<td>- Conduct a surveys/interview to evaluate the effectiveness of a serious game</td>
</tr>
<tr>
<td></td>
<td>- Perceived competency</td>
<td></td>
<td>- Measure competency &amp; the perceived intrinsic enjoyment, EGameFlow</td>
</tr>
<tr>
<td></td>
<td>- Perceived intrinsic enjoyment</td>
<td></td>
<td>- Track behavioral metrics “Participation”</td>
</tr>
<tr>
<td></td>
<td>- Effectiveness of serious game</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Existence of social effects</td>
<td>- Number of shares through social media</td>
<td>- No direct baseline</td>
<td>Survey, self-reported behaviour</td>
</tr>
<tr>
<td></td>
<td>- Number of social media related Missions, challenges, events</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Social norms</td>
<td>- Level of social norms score before ENTROPY</td>
<td>- Survey, self-reported behaviour (see section 3.3.2 Social Norms)</td>
</tr>
<tr>
<td>Changes in behaviour</td>
<td>Self-reported behaviour</td>
<td>Pre-project survey on energy efficiency level</td>
<td>Survey, self-reported data</td>
</tr>
</tbody>
</table>

Table 13: More Behavioral KPIs

### Metering & feedback
<table>
<thead>
<tr>
<th>Possible success criteria</th>
<th>Possible indicators</th>
<th>Possible baselines</th>
<th>How to measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effectiveness of feedback</td>
<td>- Most triggering feedback method</td>
<td>- No direct baseline</td>
<td>- Survey on occupants' feedback preferences in order to rank the different methods</td>
</tr>
<tr>
<td></td>
<td>- Number of times the user access feedback per week</td>
<td></td>
<td>- Export &amp; evaluate platform analytics</td>
</tr>
<tr>
<td></td>
<td>- Time spent within each feedback session.</td>
<td></td>
<td>-----------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Reduced energy use after real-time feedback</td>
<td>- Track interval changes in energy use after real-time feedback is provided</td>
<td>- Energy use before provision of feedback</td>
<td>- Load sif</td>
</tr>
<tr>
<td>High satisfaction level of occupants about the feedback</td>
<td>Occupants satisfaction in terms of - Effectiveness per feedback method - Preference per feedback method</td>
<td>- Occupants’ expectations about feedback effectiveness</td>
<td>- Conduct a satisfaction survey that includes occupants' ratings and other qualitative data</td>
</tr>
</tbody>
</table>

**Table 14: Metering & feedback KPIs**

Additionally, there is a list of KPIs per application as depicted in Figure 9 below.
Figure 9: KPIs per application
5. **Requirements Compilation**

Taking into account all the available motivational factors and the Entropy objectives, the following functional requirements have been emerged.

<table>
<thead>
<tr>
<th>ID</th>
<th>BEHAVIOURAL.1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Title</strong></td>
<td>Behavioural Profile representation to the Behavioural Semantic Model</td>
</tr>
<tr>
<td><strong>Involved Roles</strong></td>
<td>Software Developer, Semantic Web Expert</td>
</tr>
<tr>
<td><strong>Description</strong></td>
<td>The behavioural semantic model has to be able to represent concepts that can lead to grouping of end users based on their behavioural profile (e.g. categorise users based on demographics, energy consumption profile, mechanisms that motivate them (peer comparative motivation, community focus motivation), psychometrics, gameplay profiles, gamification profiles). Additionally it has to be able to represent concepts that can lead to mapping and matching end user characteristics to appropriate intervention strategies (e.g categorise interventions to user types)</td>
</tr>
<tr>
<td><strong>Constraints</strong></td>
<td>Complexity on representing human behavioural aspects</td>
</tr>
<tr>
<td><strong>Priority</strong></td>
<td>Top</td>
</tr>
<tr>
<td><strong>Architectural Part</strong></td>
<td>Behavioural Semantic Model, Semantic Enrichment Component</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ID</th>
<th>BEHAVIOURAL.2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Title</strong></td>
<td>Interconnection with Social Media</td>
</tr>
<tr>
<td><strong>Involved Roles</strong></td>
<td>Software Developer, Semantic Web Expert</td>
</tr>
<tr>
<td><strong>Description</strong></td>
<td>The personalised applications and serious games should support publication of motivational messages/rewards to end users social media accounts (e.g. make an automated post to an end user’s Facebook account telling that his team is the most energy efficient in the campus).</td>
</tr>
<tr>
<td><strong>Constraints</strong></td>
<td>Privacy issues. Need for permission from end users.</td>
</tr>
<tr>
<td><strong>Priority</strong></td>
<td>Medium</td>
</tr>
<tr>
<td><strong>Architectural Part</strong></td>
<td>Personalised Applications, Serious Games</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ID</th>
<th>BEHAVIOURAL.3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Title</strong></td>
<td>Rules creation based on actions related with behavioural profile</td>
</tr>
<tr>
<td><strong>Involved Roles</strong></td>
<td>Software Developer, Semantic Web Expert</td>
</tr>
<tr>
<td><strong>Description</strong></td>
<td>Taking into account the end user behaviour in terms of energy efficiency, apply specific rules that match its profile. Provide recommendations based on types of behaviour based energy efficiency strategies (household focus, peer comparative focus, community focus, see Figure 3) as well as performance within personalised apps</td>
</tr>
<tr>
<td><strong>Constraints</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Priority</strong></td>
<td>Medium</td>
</tr>
<tr>
<td><strong>Architectural Part</strong></td>
<td>Recommendation Engine</td>
</tr>
<tr>
<td>ID</td>
<td>BEHAVIOURAL.4</td>
</tr>
<tr>
<td>-------------</td>
<td>-------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Title</td>
<td>Provide energy consumption rates in an easily interpretable format to cause/increase awareness</td>
</tr>
<tr>
<td>Involved Roles</td>
<td>Software Developer, End User</td>
</tr>
<tr>
<td>Description</td>
<td>Support a nice user interface for providing information related to energy consumption, highlighting cases of mis-performance.</td>
</tr>
<tr>
<td>Constraints</td>
<td></td>
</tr>
<tr>
<td>Priority</td>
<td>Medium</td>
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<tr>
<td>Architectural Part</td>
<td>Personalised Applications, Serious Games</td>
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<tr>
<th>ID</th>
<th>BEHAVIOURAL.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title</td>
<td>Provide energy consumption information easily comparable with real world examples or relevant cost</td>
</tr>
<tr>
<td>Involved Roles</td>
<td>Software Developer, End User</td>
</tr>
<tr>
<td>Description</td>
<td>Support a set of examples for comparative purposes, or refer to the cost (or benefit) of an action in order to motivate end users (e.g. provide an indication that based on your energy consumption reduction, the corresponding CO₂ emissions in the outdoor environment will be less).</td>
</tr>
<tr>
<td>Constraints</td>
<td></td>
</tr>
<tr>
<td>Priority</td>
<td>Medium</td>
</tr>
<tr>
<td>Architectural Part</td>
<td>Personalised Applications, Serious Games</td>
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<tr>
<th>ID</th>
<th>BEHAVIOURAL.6</th>
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</thead>
<tbody>
<tr>
<td>Title</td>
<td>Support awareness campaigns</td>
</tr>
<tr>
<td>Involved Roles</td>
<td>Software Developer, End User</td>
</tr>
<tr>
<td>Description</td>
<td>Support campaigns with participation from end users, targeting at greater engagement (e.g. motivate participants to create energy labelling for the appliances that they use)</td>
</tr>
<tr>
<td>Constraints</td>
<td></td>
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<tr>
<td>Priority</td>
<td>Medium</td>
</tr>
<tr>
<td>Architectural Part</td>
<td>Personalised Applications</td>
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<td>ID</td>
<td>BEHAVIOURAL.7</td>
</tr>
<tr>
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<td>---------------------------------------------------</td>
</tr>
<tr>
<td>Title</td>
<td>Define and measure behavioural change indicators (i.e. the behavioral metrics defined in section 3.3.7 among others)</td>
</tr>
<tr>
<td>Involved Roles</td>
<td>Software Developer, End User</td>
</tr>
<tr>
<td>Description</td>
<td>The development of the behavioral metrics should be aligned with the definition and the proposed calculation of the behavioral metrics. Further details about the frequency and the conduction of calculations, i.e. offline/over-night or real-time calculation, should also be considered and evaluated in terms of system performance. The monitoring of these metrics should be available through the visual reporting mechanism of the Entropy platform.</td>
</tr>
<tr>
<td>Constraints</td>
<td>Priority Medium</td>
</tr>
<tr>
<td>Architectural Part</td>
<td>Analytics Tools, Personalised Applications</td>
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<tr>
<th>ID</th>
<th>BEHAVIOURAL.8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title</td>
<td>Prioritization of recommendations</td>
</tr>
<tr>
<td>Involved Roles</td>
<td>Software Developer, End User</td>
</tr>
<tr>
<td>Description</td>
<td>Support mechanisms for prioritizing recommendations in terms of impact of accepting them as an end user. Provide firstly the high priority recommendations and avoid to “overload” end user with dull information that do not fit his profile</td>
</tr>
<tr>
<td>Constraints</td>
<td>Priority Medium</td>
</tr>
<tr>
<td>Architectural Part</td>
<td>Recommendation Engine</td>
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<tr>
<th>ID</th>
<th>BEHAVIOURAL.9</th>
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<tbody>
<tr>
<td>Title</td>
<td>Provide information regarding energy consumption per set of indicators (e.g. per capita, KWh, m², KWh/m²)</td>
</tr>
<tr>
<td>Involved Roles</td>
<td>Software Developer, End User</td>
</tr>
<tr>
<td>Description</td>
<td>Definition of set of metrics and formulas for estimating energy consumption per metric. Provision of such information in a personalised way.</td>
</tr>
<tr>
<td>Constraints</td>
<td>Priority Medium</td>
</tr>
<tr>
<td>Architectural Part</td>
<td>Analytics Tools, Personalised Applications</td>
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<tr>
<th>ID</th>
<th>BEHAVIOURAL.10</th>
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</thead>
<tbody>
<tr>
<td>Title</td>
<td>Provide learning material to end users</td>
</tr>
<tr>
<td>Involved Roles</td>
<td>Software Developer, End User</td>
</tr>
<tr>
<td>Description</td>
<td>Provide learning material through the personalised applications and serious games. The learning material should support quizzes, tips, articles, videos etc.</td>
</tr>
<tr>
<td>Constraints</td>
<td>Priority Medium</td>
</tr>
<tr>
<td>Architectural Part</td>
<td>Personalised Applications, Serious Games</td>
</tr>
</tbody>
</table>
### BEHAVIOURAL.11
**Title**: Allow the realization of challenges with certain goals  
**Involved Roles**: Software Developer, End User  
**Description**: Build specific challenges linked to certain goals and invite end-users to participate through the personalised applications and serious games. The challenges should account for feasible and well-defined goals.  
**Priority**: High  
**Architectural Part**: Personalised Applications, Serious Games, Challenges

### BEHAVIOURAL.12
**Title**: Support real-time recommendations through the personalised applications  
**Involved Roles**: Software Developer, End User  
**Description**: Provision of recommendations based on the built semantic model and the gathered sensor data  
**Priority**: Medium  
**Architectural Part**: Recommendation Engine, Personalised Applications

### BEHAVIOURAL.13
**Title**: Support non real-time recommendations through the personalised applications  
**Involved Roles**: Software Developer, End User  
**Description**: Provision of recommendations based on historical data, the recognised patterns of consumption and taking into account the effectiveness the same recommendations previously had on similar end-users.  
**Priority**: Medium  
**Architectural Part**: Recommendation Engine, Personalised Applications

### BEHAVIOURAL.14
**Title**: Support direct (real-time) feedback  
**Involved Roles**: Software Developer, End User  
**Description**: Build a feedback mechanism that enable the realization of real-time feedback after an observed efficient or inefficient actions has been performed. The feedback should be properly assigned to a corresponding positive or negative message, respectively. Additionally the feedback should account for Informational and Corrective messages and notifications.  
**Priority**: Medium  
**Architectural Part**: Recommendation Engine, Personalised Applications, Feedback Mechanism, Gamification
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<tr>
<th>ID</th>
<th>BEHAVIOURAL.15</th>
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<tbody>
<tr>
<td>Title</td>
<td>Support indirect feedback</td>
</tr>
<tr>
<td>Involved Roles</td>
<td>Software Developer, End User</td>
</tr>
</tbody>
</table>
| Description | Indirect feedback about the end-user’s performance should be delivered:  
  - After the user has completed a psychographic survey (absolute & relative measures)  
  - When a challenges has been fulfilled or completed (expired)  
  - When a DR event has been completed  
  - As a weekly report about the end-user’s energy efficiency progress  
  - When a user is being identified to “free-ride”  
  - When the serious game has been completed  
  - When points have been awarded (aggregate not real time)  
  - When achievements are attained  
  - When goods (Virtual / Physical) have been obtained  
  - When Roles have been assigned / Teams have been formed  
  - When missions are available / completed  
  - When the Narrative has been progressed |
| Constraints |                   |
| Priority    | Medium           |
| Architectural Part | Recommendation Engine, Personalised Applications, Feedback Mechanism, Challenges, Serious Games, Gamification |

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<tr>
<th>ID</th>
<th>BEHAVIOURAL.16</th>
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<tbody>
<tr>
<td>Title</td>
<td>Leaderboard &amp; Loss aversion</td>
</tr>
<tr>
<td>Involved Roles</td>
<td>Software Developer, End User</td>
</tr>
<tr>
<td>Description</td>
<td>There should be an available leaderboard for the end-user to visit and track the progress of the gained rewarding elements such as points, badges, trophies, titles etc. It is also important to apply withholding of benefits due to non-compliance in order to allow “loss aversion” effects trigger users’ actions and behaviour. The leaderboard should be customizable in varying levels of slice and dice (e.g. individual, social, geographical, team based)</td>
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<tr>
<td>Priority</td>
<td>Medium</td>
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<tr>
<td>Architectural Part</td>
<td>Gamification, Serious Games, Personalised apps</td>
</tr>
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<tr>
<th>ID</th>
<th>BEHAVIOURAL.17</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title</td>
<td>Default options</td>
</tr>
<tr>
<td>Involved Roles</td>
<td>Software Developer, End User</td>
</tr>
<tr>
<td>Description</td>
<td>When an invitation about a challenge, the serious game or a DR/Peak demand management, is delivered to the user and it is requested a status confirmation, the default option should be always the “Participate” option, i.e. the most beneficial option.</td>
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<tr>
<td>Constraints</td>
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<tr>
<td>Priority</td>
<td>Medium</td>
</tr>
<tr>
<td>Architectural Part</td>
<td>Gamification, Serious Games, Feedback Mechanism</td>
</tr>
<tr>
<td>ID</td>
<td>BEHAVIOURAL.18</td>
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</tr>
<tr>
<td>Title</td>
<td>Integrate pictograms, emoticons, colours and sounds as indicators for accepted actions or inefficient behaviours</td>
</tr>
<tr>
<td>Involved Roles</td>
<td>Software Developer, End User</td>
</tr>
<tr>
<td>Description</td>
<td>Any feedback related functionality such as the visual reporting mechanism, the feedback message, the peer comparison functionalities etc., should include pictograms, emoticons, colors and/or sounds that will act as indicators for desired or undesired individual actions or evaluated performance.</td>
</tr>
<tr>
<td>Constraints</td>
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<tr>
<td>Priority</td>
<td>Medium</td>
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<tr>
<td>Architectural Part</td>
<td>Analytics Tools, Personalised Applications, Serious Games, Feedback Mechanism</td>
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<tr>
<th>ID</th>
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</thead>
<tbody>
<tr>
<td>Title</td>
<td>Selection of peers – Team formation</td>
</tr>
<tr>
<td>Involved Roles</td>
<td>Software Developer, End User</td>
</tr>
<tr>
<td>Description</td>
<td>The selection of peers apart from being taking into account the pilot sites and the user story, should also consider similarities based on demographics, psychographics and behavioral data using clustering methods and exploit filtering and funnelling methods to identify users' true closest friends. The reason is that end-user might get better affected by the green actions their friends have been performed. The ability of team formation will enable collaborative missions, challenges and team feedback as well as roles within teams</td>
</tr>
<tr>
<td>Constraints</td>
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<tr>
<td>Priority</td>
<td>Medium</td>
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<tr>
<td>Architectural Part</td>
<td>Analytics Tools, Personalised Applications, Serious Games, Feedback Mechanism, Gamification</td>
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<tr>
<th>ID</th>
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<tbody>
<tr>
<td>Title</td>
<td>Real and Virtual prizes as a reward for high energy efficient users (concerns end-user with above threshold intrinsic motives towards energy efficiency)</td>
</tr>
<tr>
<td>Involved Roles</td>
<td>Software Developer, End User</td>
</tr>
<tr>
<td>Description</td>
<td>Real prizes should be first available for end-users that are intrinsically energy efficient. In particular, it is crucial to identify those end-users with high intrinsic motives towards energy efficiency and upon verifying that they are indeed energy efficient through their energy data, prizes should be allocated to them as a rewarding action. Such a rewarding mechanism will also motivate the rest users with lower intrinsic energy efficiency level.</td>
</tr>
<tr>
<td>Constraints</td>
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<tr>
<td>Priority</td>
<td>Medium</td>
</tr>
<tr>
<td>Architectural Part</td>
<td>Personalised Applications, gamification</td>
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<tr>
<th>ID</th>
<th>BEHAVIOURAL.21</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title</td>
<td>Real prizes &amp; goals (concerns end-user with below threshold intrinsic motives towards energy efficiency)</td>
</tr>
<tr>
<td>Involved Roles</td>
<td>Software Developer, End User</td>
</tr>
<tr>
<td>Description</td>
<td>Alternatively, the available real and virtual prizes can be linked to certain goals (challenges) designed for end-users with lower intrinsic motives towards energy efficiency. In other words, certain goals expressed through the challenges functionality might attribute specific prizes to the end users that tried hard and eventually fulfilled the set goals.</td>
</tr>
<tr>
<td>Constraints</td>
<td></td>
</tr>
<tr>
<td>Priority</td>
<td>Medium</td>
</tr>
<tr>
<td>Architectural Part</td>
<td>Personalised Applications, Challenges</td>
</tr>
</tbody>
</table>
### ID: BEHAVIOURAL.22

**Title**: Real and Virtual prizes & point system (all end-users are rewarded based on their engagement & commitment with ENTROPY intervention)

**Involved Roles**: Software Developer, End User

**Description**: Finally, available real prizes can be linked to the point system so as the acquisition of prizes to be relevant to the difficulty level of acquiring the required points. Hence, the higher the value of the prize, the more points should be required to get collected by the user. For instance, low-cost prizes such as restaurant discount coupons, bill discounts or rebates will be easier to be claimed by the user compared to high-cost rewards such as iPads or smart thermostats. Additional and complementary to real prizes virtual prizes can be utilized to support a low cost rewarding mechanism. The point system concerns all ENTROPY functionalities and reflects the end-user’s interaction with them. The most engaged users will be those who will increase their chances to be the prizes’ winners.

**Constraints**

- **Priority**: Medium
- **Architectural Part**: Personalised Applications, Serious Games, Point System

### ID: BEHAVIOURAL.23

**Title**: Conceptualise the effect of certain actions within a virtual world.

**Involved Roles**: Software Developer, End User

**Description**: ENTROPY platform should introduce end-user into a virtual world that simulates real-world and allow user to interact with multiple decisions and actions in order to conceptualise their effect and evaluate true energy savings of real-cases scenarios that would be impossible to observe and evaluate in the short-term, in real life. Thus, the user will experience the environmental costs and benefits of his behaviour and decision-making, and escape from spatial and temporal discounting effects.

**Constraints**

- **Priority**: Medium
- **Architectural Part**: Serious Games

### ID: BEHAVIOURAL.24

**Title**: Educate end-user through games

**Involved Roles**: Software Developer, End User

**Description**: Develop small (instant) games that will allow user to familiarise himself about energy efficiency core issues (e.g. the appliance’s consumption level – rank appliances from the top consuming to the least one)

**Constraints**

- **Priority**: Medium
- **Architectural Part**: Serious Games
<table>
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<tr>
<th>ID</th>
<th>BEHAVIOURAL.25</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title</td>
<td>Improve end-users decision-making</td>
</tr>
<tr>
<td>Involved Roles</td>
<td>Software Developer, End User</td>
</tr>
<tr>
<td>Description</td>
<td>Provide not only tips for energy efficiency, but also statistics and research data on the environmental, health and economic costs the inefficient behaviours bring about. Such information can be in a separated/dedicated section called “News” or something relevant. The more a user interacts with a certain category of news, the more topics from the particular category will be promoted.</td>
</tr>
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<td>Constraints</td>
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<tr>
<td>Priority</td>
<td>Medium</td>
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<tr>
<td>Architectural Part</td>
<td>Serious Games, Personalised Applications, “News”</td>
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<tr>
<th>ID</th>
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</tr>
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<tbody>
<tr>
<td>Title</td>
<td>Summary of effort progress</td>
</tr>
<tr>
<td>Involved Roles</td>
<td>Software Developer, End User</td>
</tr>
<tr>
<td>Description</td>
<td>The end-user should get informed about his effort progress. An informative summary that will include data about when the user started his effort (i.e. signed up into the platform) and the most important achievements of the user (i.e. the number of tips read, the number &amp; name of challenges achieved etc.) should be either periodically presented to the user through a report, or constantly provided in the user’s profile section.</td>
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<td>Constraints</td>
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<tr>
<td>Priority</td>
<td>Medium</td>
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<tr>
<td>Architectural Part</td>
<td>Personalised Applications, “Profile” or weekly report</td>
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<th>ID</th>
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<tbody>
<tr>
<td>Title</td>
<td>Enable Points allocation</td>
</tr>
<tr>
<td>Involved Roles</td>
<td>Software Developer, Platform administrator</td>
</tr>
<tr>
<td>Description</td>
<td>Support the existence and allocation of different types of points (e.g. Experience, Redeemable, Reputation, Karma, Skill points). The points should be able to be awarded to individuals as well as teams (combined or with different weight based on contribution). The relative weights and importance of each type of point rewarding actions should be directed by the Gamification expert in parallel to the Platform Administrator.</td>
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<tr>
<td>Constraints</td>
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<tr>
<td>Priority</td>
<td></td>
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<tr>
<td>Architectural Part</td>
<td>Personalised Applications, Serious games, Gamification</td>
</tr>
<tr>
<td>ID</td>
<td>BEHAVIOURAL.28</td>
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</tr>
<tr>
<td>Title</td>
<td>Enable and Evaluate Achievements</td>
</tr>
<tr>
<td>Involved Roles</td>
<td>Software Developer, End User, Platform administrator</td>
</tr>
<tr>
<td>Description</td>
<td>Support the existence and operationalization of different types of achievements (e.g. Trophies, Badges, Virtual goods). The achievements also should be able to be offered in different dimensions (Expected, Unexpected, Partially [un-]expected). The results of these achievements (success/failure) should be available to be analyzed in order to provide input to the next round of application and launch.</td>
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<td>Constraints</td>
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<tr>
<td>Priority</td>
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<tr>
<td>Architectural Part</td>
<td>Personalised Applications, Serious games, Gamification</td>
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<th>ID</th>
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<tbody>
<tr>
<td>Title</td>
<td>Availability of Roles within teams</td>
</tr>
<tr>
<td>Involved Roles</td>
<td>Software Developer, End User, Platform administrator, Gamification expert</td>
</tr>
<tr>
<td>Description</td>
<td>Support the existence and allocation of different types of roles (e.g. team leader, team member) in the context of cooperative challenges and missions.</td>
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<tr>
<td>Constraints</td>
<td></td>
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<tr>
<td>Priority</td>
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<tr>
<td>Architectural Part</td>
<td>Personalised Applications, Serious games, Gamification</td>
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<th>ID</th>
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<tbody>
<tr>
<td>Title</td>
<td>Availability and evaluation of missions</td>
</tr>
<tr>
<td>Involved Roles</td>
<td>Software Developer, End User, Platform administrator,</td>
</tr>
<tr>
<td>Description</td>
<td>Support the existence and formulation of missions (individual and collaborative) in different dimensions (available, unavailable and completed) as well as present the platform administrator with feedback and status on their completion rates and results.</td>
</tr>
<tr>
<td>Constraints</td>
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<tr>
<td>Priority</td>
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<tr>
<td>Architectural Part</td>
<td>Personalised Applications, Serious games, Gamification</td>
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<tr>
<th>ID</th>
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<tbody>
<tr>
<td>Title</td>
<td>Availability of self representing avatars</td>
</tr>
<tr>
<td>Involved Roles</td>
<td>Software Developer, End User</td>
</tr>
<tr>
<td>Description</td>
<td>Support the existence of avatars (in simple or complex form) and enable the change driven from the user side (e.g. upload image) or the platform side (newbie to master progression)</td>
</tr>
<tr>
<td>Constraints</td>
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<tr>
<td>Priority</td>
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</tr>
<tr>
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<td>Personalised Applications, Serious games, Gamification</td>
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### ID \ BEHAVIOURAL.32

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<th>Title</th>
<th>Availability of Roles within teams</th>
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<tbody>
<tr>
<td>Involved Roles</td>
<td>Software Developer, End User, Platform administrator, Gamification expert</td>
</tr>
<tr>
<td>Description</td>
<td>Support the existence and allocation of different types of roles (e.g. team leader, team member) in the context of cooperative challenges and missions.</td>
</tr>
<tr>
<td>Constraints</td>
<td></td>
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<tr>
<td>Priority</td>
<td></td>
</tr>
<tr>
<td>Architectural Part</td>
<td>Personalised Applications, Serious games, Gamification</td>
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### ID \ BEHAVIOURAL.33

<table>
<thead>
<tr>
<th>Title</th>
<th>Support and evaluate narrative context in terms of energy efficiency</th>
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<tbody>
<tr>
<td>Involved Roles</td>
<td>Software Developer, End User, Platform administrator, Gamification expert</td>
</tr>
<tr>
<td>Description</td>
<td>Support the existence of narrative that enables the end-user to follow through different parts a story that describes his/her/their accomplishments in the ENTROPY context. Also enable the respective narrative progression results to the platform administrator to support informed decisions.</td>
</tr>
<tr>
<td>Constraints</td>
<td></td>
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<tr>
<td>Priority</td>
<td></td>
</tr>
<tr>
<td>Architectural Part</td>
<td>Personalised Applications, Serious games, Gamification</td>
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### ID \ BEHAVIOURAL.34

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<tr>
<th>Title</th>
<th>Enable the allocation of end-users to different visual versions of the app</th>
</tr>
</thead>
<tbody>
<tr>
<td>Involved Roles</td>
<td>Software Developer, End User, Platform administrator, Gamification Expert</td>
</tr>
<tr>
<td>Description</td>
<td>Support the existence of different parallel versions of the app in terms of enabling and disabling parts of the user interface and selecting different values on selected variables. (e.g. Some people to not have access to a leaderboard, some to have and some people to receive a badge after X effort others after Y) This will enable the Platform administrator to conduct pre-launch tests in order to fine tune the initial deployment of the gamification operationalization.</td>
</tr>
<tr>
<td>Constraints</td>
<td></td>
</tr>
<tr>
<td>Priority</td>
<td></td>
</tr>
<tr>
<td>Architectural Part</td>
<td>Personalised Applications, Serious games, Gamification</td>
</tr>
</tbody>
</table>

### ID \ BEHAVIOURAL.35

<table>
<thead>
<tr>
<th>Title</th>
<th>Most effective actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Involved Roles</td>
<td>Software Developer, End User</td>
</tr>
<tr>
<td>Description</td>
<td>The end-user should get informed about the effectiveness of certain “green” actions either as such effectiveness has been explicitly stated by the users or has been implicitly derived through energy data.</td>
</tr>
<tr>
<td>Constraints</td>
<td></td>
</tr>
<tr>
<td>Priority</td>
<td>Medium</td>
</tr>
<tr>
<td>Architectural Part</td>
<td>Feedback mechanism</td>
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<td>ID</td>
<td>BEHAVIOURAL.36</td>
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<tr>
<td>----------</td>
<td>---------------------------------------------------</td>
</tr>
<tr>
<td>Title</td>
<td>Evaluate interventions</td>
</tr>
<tr>
<td>Involved Roles</td>
<td>Software Developer, End User</td>
</tr>
<tr>
<td>Description</td>
<td>Support the creation and dissemination of surveys in order to collect feedback on interventions deployed within specific groups of users.</td>
</tr>
<tr>
<td>Constraints</td>
<td></td>
</tr>
<tr>
<td>Priority</td>
<td>Medium</td>
</tr>
<tr>
<td>Architectural Part</td>
<td>Personalised Applications</td>
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<tr>
<th>ID</th>
<th>BEHAVIOURAL.37</th>
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</thead>
<tbody>
<tr>
<td>Title</td>
<td>Creation and dissemination of questionnaires</td>
</tr>
<tr>
<td>Involved Roles</td>
<td>Software Developer, End User</td>
</tr>
<tr>
<td>Description</td>
<td>Support the creation and dissemination of questionnaires per user in order to collect demographics and psychographics information.</td>
</tr>
<tr>
<td>Constraints</td>
<td></td>
</tr>
<tr>
<td>Priority</td>
<td>Medium</td>
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<tr>
<td>Architectural Part</td>
<td>Personalised Applications</td>
</tr>
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</table>
6. CONCLUSIONS

The current document presents a detailed overview of the Entropy behavioural-based interventions, focusing primarily on the related functional requirements. The contribution is aligned with the ENTROPY objectives and addresses the full-deployment of the Entropy platform, the core tool for disseminating energy efficiency awareness and promoting behavioural change to the pilot participants.

The deliverable accounts for the different pilot needs since the recommended functionalities step on a modular design and allow different content to be delivered through a rule-based system. Feedback, gamification, serious gaming, social norms and finally behavioural metrics are all individual interventions that should be embedded into the Entropy platform to trigger the different occupants’ profiles and lead to a gradual but steady behavioural change, in the most suitable way.

Finally, a constantly updated corpus of metrics along with a set of energy efficiency and behavioral KPIs are also presented in the context of the project intending to lead forthcoming deliverables associated with pilot’s specifications, performance evaluation measures and acceptance criteria.
BIBLIOGRAPHY – REFERENCES


[74] Buchanan, Kathryn, and Dan Lockton. "Understanding human connectivity and the Quantified Self."


