A Gaming and Social Networking Platform for Evolving Energy Markets' Operation and Educating Virtual Energy Communities

H2020 ICT-731767

SOCIALENERGY use cases and requirements' analysis

Deliverable D2.1

Document Information

Scheduled delivery	30.04.2017
Actual delivery	28.04.2017
Version	1.0
Responsible Partner	SOFIISKI UNIVERSITET SVETI KLIMENT OHRIDSKI (SU-NIS)

Dissemination Level

Public

Contributors

All SOCIALENERGY partners (ICCS, INTELEN, NUROGAMES, SU-NIS)

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Acknowledgements

The research leading to these results has received funding from the EC Framework Programme HORIZON2020/2014-2020 under grant agreement n° 731767.

Glossary of Acronyms

Project management

Acronym	Definition
D	Deliverable
DoA	Description of Action
EC	European Commission
PM	Project Manager
PO	Project Officer
WP	Work Package
UC	Use Case

Technical terminology

Acronym	Definition
AMI	Automatic Metering Infrastructure
API	Application Programming Interface
CPP	Critical Peak Pricing
CRISP-DM	Cross Industry Standard Process for Data Mining
CSP	Concentrated Solar Thermal
DR	Demand Response
DSM	Demand Side Management
DSO	Distribution System Operator
EC	Energy Community
ECC	Energy Consumption Curve
EC-RTP	Energy Community Real Time Pricing
EE	Energy Efficiency
EIDaaS	Energy Information distribution as a Service
EP	Energy Program
EPC	Energy Performance Contract
ESC	Energy Supply Contract
ESCO	Energy Services Company
GSMaaS	Gamified Social Marketing as a Service
GSRN	Green Social Response Network
GUI	Graphical User Interface
HVAC	Heating, Ventilation and Air Conditioning
IBR	Inclining Block Rates
ICT	Information and Communications Technology
ILP	Individual Learning Plan
KPI	Key Performance Indicator
LCMS	Learning Content Management System
LO	Learning Object
MDM	Meter Data Management
MTOE	Million Tonnes of Oil Equivalent
P-RTP	Personalized Real Time Pricing

PB-DR	Price Based Demand Response
RES	Renewable Energy Sources
RTP	Real Time Pricing
SVR	Support Vector Regression
S/W	Software
TIPI	Ten Item Personality Index
ToU	Time of Use
USaaS	Utility Selection as a Service

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Document History

The aim of this deliverable is to exploit the output of Tasks 2.1-2.3. It includes the SOCIALENERGY use cases, system operation scenarios and technology transfer assets. It also includes the requirements' analysis both from the end user's and the entire SOCIALENERGY system's perspective.

Table 1: Document History Summary

Revision Date	**File version**	**Summary of Changes**
03.02.2017	v0.1	Draft ToC circulated to the entire consortium
22.02.2017	v0.2	Final ToC has been agreed among all partners
17.03.2017	v0.4	1st round of contributions from ICCS
31.03.2017	v0.5	1st round of contributions from INTELEN, NRG and SU-NIS
20.04.2017	v0.8	2nd round of contributions from all partners based on coordinator's comments
26.04.2017	v0.9	Reviewed version
28.04.2017	v1.0 (final)	Final enhancements/changes and submission to EC portal

Executive Summary

This report is the first official deliverable of H2020 SOCIALENERGY project dealing with the description of the SOCIALENERGY's use cases, system operation scenarios and functional requirements' analysis. Moreover, the deliverable includes details about SOCIALENERGY's business positioning in the current converged ICT/energy markets in Europe including the innovative services, involved business stakeholders and end users. SOCIALENERGY is an innovation project and its implementation will be based on the upgrade of existing S/W toolkits and platforms, whose technology readiness level is quite mature, meaning that the S/W prototypes have already been pilot tested and initially demonstrated in relevant environments (i.e. TRL 5). These technology assets are transferred from various diversified sectors such as: gaming, ICT, energy, education and social sciences. These will be used in the SOCIALENERGY project's context and are extensively described in this report. In particular, the structure of the deliverable is the following.

Chapter 1 describes the main SOCIALENERGY idea, innovative features, scope and purpose. The technical objectives are outlined and briefly described. The draft version of the system architecture is illustrated together with all major subsystems, while the multi-dimensional aspects of the expected impact are also stated.

Chapter 2 provides a list of the major stakeholders/users that will interact with SOCIALENERGY platform. It presents their role and their usual business models. Additionally, the interaction that SOCIALENERGY envisages with them is analysed as well as the services that SOCIALENERGY offers to them. This work is very important in order to define the exact business positioning of SOCIALENERGY before the architecture design and S/W implementation phases.

In chapter 3, we present the strategic goals of SOCIALENERGY that are able to act as the catalyst that will bring closer stakeholders with end users and the virtual energy communities (EC) that they form. We also define the technology transfer assets that will be exploited for the SOCIALENERGY system from the following perspectives: a) gaming/gamification-related assets to be applied to the energy efficiency sector, b) educational/learning-related assets to be applied to the specific requirements of SOCIALENERGY and c) scientific-related assets meaning all clustering, dynamic pricing, profiling, recommendation and resource management algorithms which will be utilized for SOCIALENERGY's intelligence.

Based on: a) the stakeholders' needs (chapter 2), b) end users' needs (chapter 2), and c) the project's strategic goal and key performance indicators (chapter 3), the two use cases have been described in chapter 4. The first use case is the realization of the "SOCIALENERGY's Real World - GSRN platform" and the second one is the realization of "SOCIALENERGY's Virtual World – Energy Efficiency Game". Each use case consists of a few system operation scenarios that better specify the use of SOCIALENERGY S/W platform. The ultimate project's goal is for the final SOCIALENERGY S/W platform to support both use cases and all system operation scenarios by enabling the digital-physical interaction between SOCIALENERGY's real and virtual worlds.

Finally, in chapter 5, the end user and system requirements are analysed. Four major subsystems have been identified, namely: a) the core Green Social Response Network (GSRN) developed by INTELEN, b) the SOCIALENERGY game (GAME) developed by NRG, c) the Research Algorithms' Toolkit (RAT) developed by ICCS, and d) the Learning Content Management System (LCMS) developed by SU-NIS. The requirements for all the technical Application Programming Interfaces (APIs) for the interaction among the various subsystems have also been specified.

Conclusively, during the next months, SOCIALENERGY consortium will elaborate on the current work presented in this deliverable towards designing the final version of SOCIALENERGY system architecture and starting the S/W implementation work.

1 Introduction

1.1. R&I motivation, scope and main SOCIALENERGY purpose

The increase of energy stability and self-sufficiency will not only turn Europe into a safer and more environmental friendly environment, but also into a more suitable place for business. Towards this goal in 2014, the European Commission announced the 2030 Energy Strategy framework[1] that among others included three core objectives for sustainability. The first implied a 40% emission reduction compared to 1990 levels. The second was about an at least 27% share of renewable energy sources, while the third suggested another 27% energy savings compared with the business-as-usual scenario. Moreover, on November 30th 2016, EC released a package of measures to keep the European Union competitive as the clean energy transition is changing global energy markets[2]. The Commission envisages that EU will lead the clean energy transition and will not only adapt to it. For this reason, the EU has committed to cut CO2 emissions by at least 40% by 2030, while modernising the EU's economy and delivering on jobs and growth for all European citizens. Today's proposals have three main goals: a) putting energy efficiency first, b) achieving global leadership in RES, and c) providing a fair deal for energy consumers.

Hence, it is rather easy to foresee that these strategic targets will have a great impact on the expected development of electricity generation, but also on the evolution of demand. There are three significant and widely accepted goals towards these three core objectives, which are:

- The **creation of advanced Demand Response (DR) Energy Programs (EP)**. DR is the adaptability of the electricity demand to the availability of supply. At its core, DR aims at "smoothening" energy consumption loads that exhaust the installed generation capacities, especially during peak hours of increased power consumption, thus reducing carbon emissions, too. Along with providing flexibility and ensuring the reliability of the electric system, DR can be a direct source of revenue for both energy providers (e.g. utilities) and residential energy consumers. EPs are contracts – agreements between energy providers and energy consumers (e.g. householders). In Europe, DR EPs are still immaturely developed and it may take long, until DR is being treated as the mutually (for consumers and producers) beneficial solution for energy savings and energy efficiency. However, it is imperative to consider the development of DR, if Europe wants to seize the opportunity for a more sustainable world and keep pace with the newly introduced innovations at the other side of the Atlantic.
- The **development of energy efficiency-related products and services** that lead to the reduction of the energy consumption. Information and communication technologies (ICT) can facilitate the transition towards a more sustainable energy system via the development of innovative ICT platforms and infrastructures. Moreover, recently, there is a huge effort from the industry to design electric appliances, insulation materials, building architectures and other products, which are efficient in terms of the energy that they consume. On the other hand, their adoption is still far from the desirable one.
- **The education of the societies on the usefulness of the aforementioned activities.** The exploitation and the impact of: i) DR EPs, and ii) energy efficient products and services

[1] https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/2030-energy-strategy
[2] https://ec.europa.eu/energy/en/news/commission-proposes-new-rules-consumer-centred-clean-energy-transition

are often complex processes and difficult to be understood from the majority of EU citizens. ICT and gaming industry can overcome the non-technological barriers that prevent energy consumers from taking full advantage of EU liberalized energy markets, which are continuously emerging and converging in the whole EU area. As a result, an easy and deep interaction among people and between them and the involved stakeholders (e.g. utilities, energy efficiency companies) towards their collective, bottom-up and self-organized online education is a key issue.

The use of ICT and the technology transfer of gaming industry's assets to the energy efficiency sector is a catalyst towards these goals, which the business world on the other side of Atlantic has already started to adopt in a rapidly accelerating way. IDC Energy Insights[3] predicts that by the end of year 2015, utilities have spent $13.5 million on gamification worldwide, rising to $65 million in 2016. By then, 60% of "progressive" energy retailers would be using at least one gamified solution. On the negative side, Europe has been relatively late in understanding the high significance and vast impact of these efforts.

*Under the aforementioned scope, **the purpose of SOCIALENERGY** is the easy, rich and deep communication among the energy sector stakeholders and residential energy consumers that will allow them to: i) discover each other and their needs, ii) educate themselves towards a better understanding of the difficulties and the challenges that each one faces and iii) interact and trade with each other especially in the form of DR energy programs. All these will lead to a more energy efficient, free from energy dependencies and environmentally friendly society.*

1.2. SOCIALENERGY objectives

The SOCIALENERGY project's objectives can be summarized as follows:

1. To apply and evolve recent incentive technologies (localized social externalities) towards effective use of behavioral economics in DR and energy efficiency sector.
2. To develop "SOCIALENERGY virtual world" by transferring gaming technologies into the energy efficiency sector, so as to educate and incentivize utility customers organized in ECs towards understanding and adopting modern DR programs.
3. To develop "SOCIALENERGY real world" by engaging the users via advanced gamification techniques towards self-organization and management of ECs and efficient interaction with SOCIALENERGY's commercial activities.
4. To provide a single point of hosting and advertisement services to energy consumers, energy communities, utilities and companies related to energy efficiency products and services via the development of context-aware recommendation algorithms.
5. To perform small scale and diverse experiments that involve: i) real users, ii) utilities, iii) companies active in energy efficiency products and services in order to: a) validate the concept of SOCIALENERGY, b) evolve its technologies, c) trigger its adoption from these markets.
6. To offer Energy Information Distribution as a Service (EIDaaS) to multiple stakeholders and commercialize information related with energy efficiency.

[3] http://www.idc.com/prodserv/insights/energy/index.jsp

In order to motivate/engage energy consumers and energy efficiency companies to deeply interact and to pleasantly educate both parties, SOCIALENERGY will exploit gaming and gamification technologies that will be "transferred" to the energy sector via the development of the "SOCIALENERGY's virtual world", that is the SOCIALENERGY game. Based on DoA, there are three (3) main gaming/gamification-related objectives, which are:

- Education and social inclusion towards energy efficiency, DR and environmental awareness
- Stakeholder interaction and commercialization
- User engagement and profiling

1.3. SOCIALENERGY concept, main idea, and architecture

In Figure 1, the general idea of the proposed "Green Social Response Network" (GSRN) concept is illustrated. There are three (3) main gamification steps: 1) gamify the user engagement in DR and energy efficiency programs, 2) gamify the process (i.e. EC management), 3) gamify the results and feed them back to step (1).

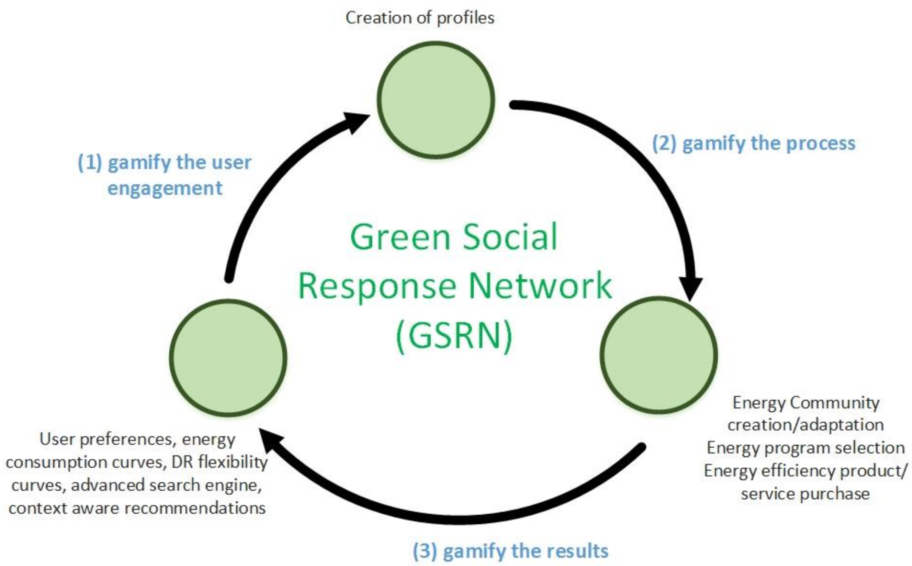

Figure 1: The perpetual information flow and life cycle of the proposed Green Social Response Network

Figure 2 summarizes the high-level functional architecture of SOCIALENERGY. In a nutshell, there are 2 worlds: 1) the SOCIALENERGY's "real world", and 2) SOCIALENERGY's "virtual world". All types of users are playing modular, multi-user and self-evolving games in the virtual world and are thus educated in good practices for DR actions and decisions to be made for the use of proposed GSRN platform in the real world. Results from the virtual world are provided as feedback to the real world. In the real world, energy consumers are monitored, are self-organized to Energy Communities (ECs) and the profiles of both are created and dynamically adapted according to context-aware recommendations generated by GSRN. GSRN also facilitates interaction among energy consumers via facebook, ECs' interaction with utilities/ESCOs and other related energy efficiency companies. In order to boost user engagement, SOCIALENERGY exploits gamification components like the adoption of virtual currency and credit distribution policies. As a result, an environment is generated where ECs select dynamically and online EPs from utilities and energy efficiency and DR products and services that optimally fulfill their needs. The output of this complex process (Figure 2) is far beyond marketing of EPs and energy efficiency products and services. It is well educated ECs and evolved energy efficiency business.

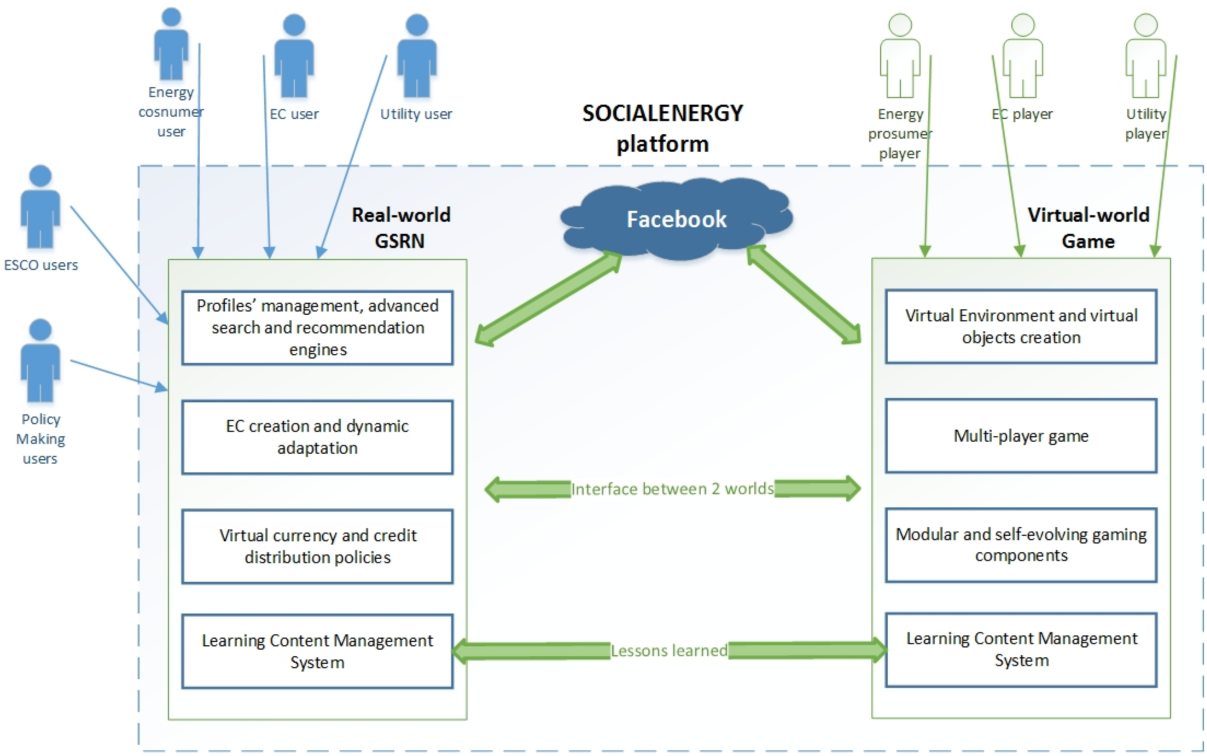

Figure 2: High-level SOCIALENERGY architecture (DoA)

1.4. Expected impact

The expected impact of SOCIALENERGY concept's adoption and use as a real-market commercial product will affect the following three main sectors, namely:

1. Gaming technologies in non-leisure contexts
2. Education and social inclusion sector
3. New businesses and applications generated by SOCIALENERGY in the converged ICT/energy/gaming sector that is currently emerging

As of (1), by exploiting, integrating and advancing technologies such as gaming, gamification and social networking, SOCIALENERGY will fast bridge the gap between successful trials of DR programs and wide user adoption. We envision that the proposed platform is a very promising bottom-up learning and education way, which will lead to widespread user adoption.

Regarding (2), SOCIALENERGY will facilitate and deepen the communication between stakeholders as: i) utilities and ESCOs, ii) companies related with manufacturing and marketing of energy efficiency products and services (e.g. electric appliances, building renovation companies, etc.), iii) public authorities (e.g. municipalities, ministries, etc.) that own a lot of buildings (e.g. schools, hospitals, government, etc.), iv) grassroots community organizations active to environmental and energy efficiency issues. In this way, SOCIALENERGY can be seen not only as a platform towards energy efficiency, but also as a tool towards social inclusion and even electronic democracy though interaction, bottom-up learning and education. DR and generally liberalized energy markets involve quite complex processes, whose operation aspects and potential gains are difficult to be understood from the majority of the society and especially for "weak" social groups (e.g. low education, elder people, etc.). SOCIALENERGY paves the way towards familiarizing people with good practices on energy efficiency via the exploitation of widespread social networks.

Finally, regarding (3), SOCIALENERGY bridges the gap between each progressive utility and its customers by providing a Gamified Social Marketing as a Service (GSMaaS) that focuses in the easy and deep communication among them towards the widespread adoption from the latter of advanced DR EPs that the former provides. Moreover, SOCIALENERGY, through its intelligent and advanced recommendation and advertisement services, facilitates its ECs to select the utility that fits to them. We can call this process Utility Selection as a Service (USaaS) and we believe that USaaS will highly motivate utilities towards more advanced and personalized EPs. From the customers' perspective, USaaS will act as a "tutor" that will help them to lower their energy bills and live in a more environmental friendly way. Finally, SOCIALENERGY will exploit its intelligent and advanced recommendation and advertisement services in order to create new markets related with energy efficient products and services. In more detail, SOCIALENERGY will bridge the gap between the consumers of advanced DR EPs and the electric appliances and house upgrades that they need in order to fulfil the objectives that the EPs set. These new business actors will be able to have a central role in the energy efficiency sector and considerably grow their business by utilizing the SOCIALENERGY web platform services in the long-term.

2 SOCIALENERGY services, stakeholders and end users

This section lists the major stakeholders/market players/users that will be able interact with SOCIALENERGY platform. It briefly presents their role and their modern business models. Additionally, it analyzes the interaction that SOCIALENERGY envisages with them and the services that SOCIALENERGY offers to them.

2.1. Utilities

The traditional utility business model is being threatened by market conditions, industry and social trends. It depends on: i) the sale of electricity to the wholesale markets, ii) making capital investments in generation, pipelines, and wires and, iii) in the case of the investor-owned utility. In these ways utilities earn a regulated rate of return. At present, utilities are facing new competition for revenue from new players (Figure 3) that exploit: i) customer mindshare, ii) workforce attention and iii) fuel from emerging economies at a time when energy demand is shifting. Utility leadership must act now to address erosion of earnings and to continue to meet the demands of shareholders, customers, and regulators.

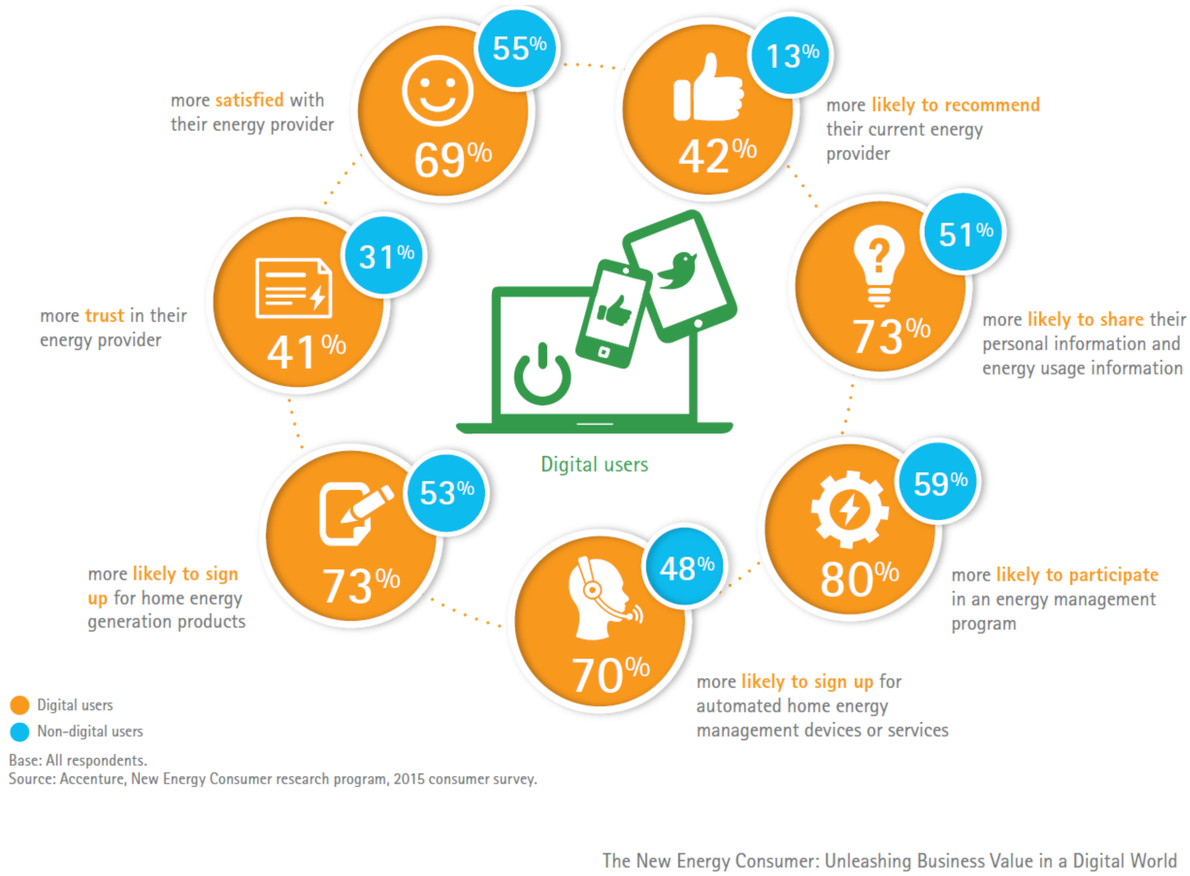

Figure 3: The new type of digital energy consumer: Unleashing business value for electric utilities

The biggest threat that utilities face today is from outside the industry. In a survey conducted with European utility executives in spring 2015, two out of three European utility executives indicated non-utility companies as the most serious contenders to their business model. Non-utility companies — including Google and Amazon, consumer electronics manufacturers, and telecommunication companies — have brands that have better consumer appeal, stronger ability to extract value from data, and deeper relationships with their customers. In addition, they enjoy better customer trust (and much better net promoter scores) and are digitally more mature.

Utilities can choose to continue with their current business model, relying on approval for rate increases and advocacy for new rate structures as a way to address their situation. However, raising rates may give customers further incentive to leave the system. Forward-looking or else the so called "progressive" utilities are looking at developing new business models.

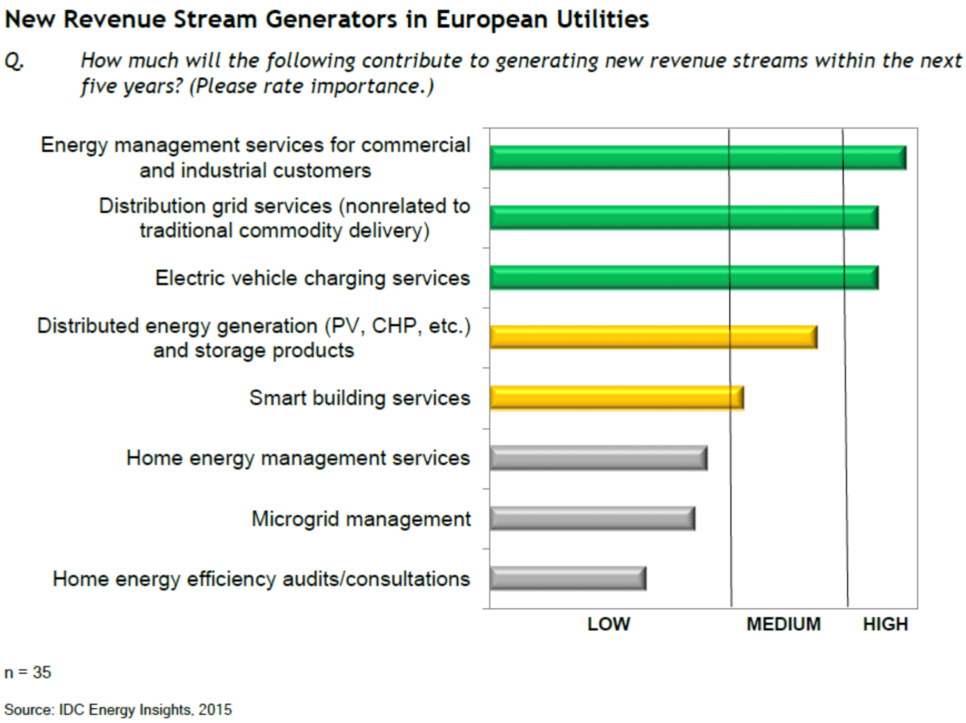

Figure 4: New Revenue Stream Generators in European Electric Utilities

Various Business models (Figure 4) have already been deployed from forward-looking utilities: Smart buildings, DR aggregation, ESCO vertical services, Energy Management, Community Solar, Storage services, PV Management, Electric Vehicles, DER (Distributed Energy Resources) are among them.

INTELEN already cooperates with many utilities and consulting companies in Europe and US (Essent, Protergia, Labiris, EY), by offering digitization services to enhance their consumer engagement. SOCIALENERGY will enhance this interaction and these new revenue streams, in between end-users and utilities, by digitizing the whole experience and by introducing new disruptive techniques such as Gamification and Gaming. SOCIALENERGY as a modular platform, will enable new utility services and will help them in acquiring more data from their customers, in order to personalize and digitize their experience.

2.2. Energy efficiency product vendors

The role of many Energy Efficiency vendors and market players has changed recently. The reason is that digitization introduced a new role for them: the role of a 3rd party integrator to the vertical energy efficiency model of a utility.

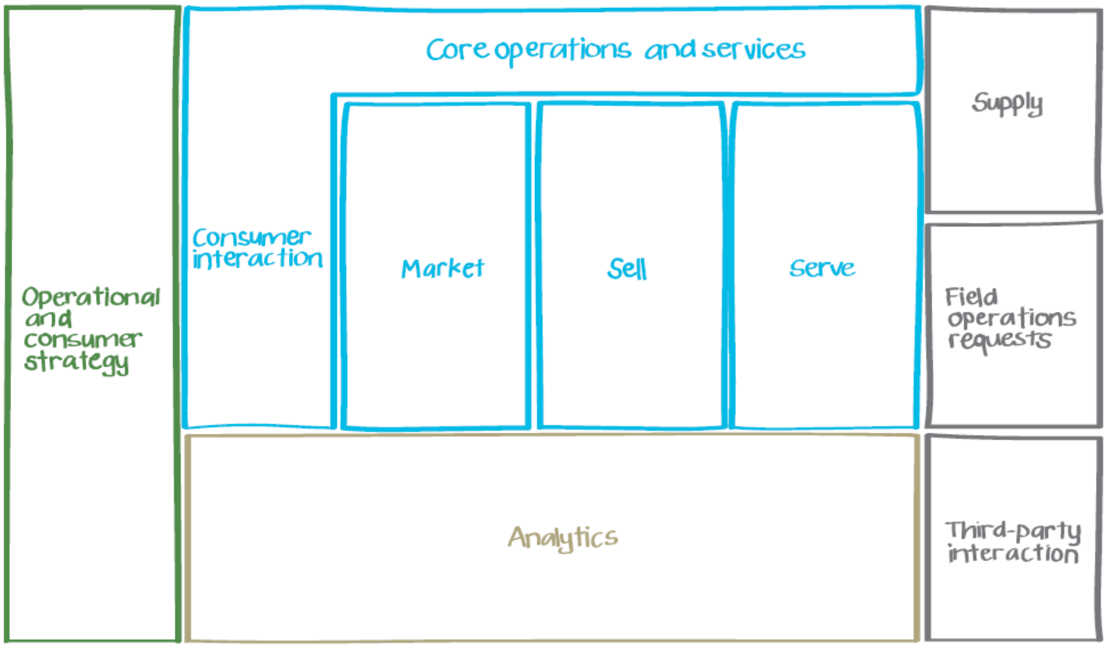

Figure 5: Digital Utility Marketplace as one of the most promising business models for the energy efficiency sector

As shown in the figure above, 3rd party interaction is crucial today for the formation of complex business models. One of them is the so called: "**Utility Marketplace"**. Over the past decade, digital marketplaces have rapidly upended the dynamics of many established industries. The remarkable rise of companies like Uber, Airbnb and Amazon has challenged and re-invented the customer experience across transportation, hospitality and e-commerce transforming the way that these industries do business.

Utility marketplaces are re-imagining the buying process of energy management solutions, making it easier than ever before for utility customers to purchase energy-saving products and implement projects.

There are two emerging sets of marketplace categories:

- **Project marketplaces** connect customers interested in energy-efficiency solutions with contractors that can implement those technologies.
- **Product marketplaces** are e-commerce-style websites, where customers can purchase products for self- or contractor installation.

Selecting the right type of marketplace to deploy depends heavily on the end-customer segment that is being targeted, whether it is residential, SMB or large commercial. In either case, digital marketplaces can improve the buying experience for utility customers in a few key ways, as detailed below.

A digital marketplace can be a strategic advantage for any utility that is looking to deepen its customer engagement. To make marketplaces a success, utilities must ensure that they are delivering a strong user experience and creating sufficient value for the entire value chain. Before deploying this type of offering, it is essential to successfully market the value proposition of the marketplace to both customers and contractors by employing messages and offers designed for their needs. Upfront engagement is critical because without a critical mass of buyers and sellers, the marketplace won't reach its full potential.

Marketplaces will help utilities improve their customer satisfaction, increase adoption of programs and services, and if successful, unlock innovative business models to animate the market like never before -- allowing utilities to write their own disruptive story in the face of a changing industry.

SOCIALENERGY will develop an innovative marketplace, in order to increasingly engage the users for energy efficiency, during their interaction with the utilities. INTELEN has an extensive experience with utility marketplaces (already offering at Protergia S.A., etc.) and ensures that SOCIALENERGY will create and use a digital marketplace efficiently. 3rd party partners could be MediaMarkt (Saturn) or Kotsovolos SA (Dixons), two big electrical appliances retail companies with a pan-European expansion.

2.3. Storage companies

Energy storage can generate much more innovation value when multiple, stacked services are provided by the same device or fleet of devices. The prevailing behind-the-meter energy-storage business model creates value for utility customers and the grid, but leaves significant value on the table. Currently, most systems are deployed for one of three single applications: demand charge reduction (DR), backup power, or increasing solar self-consumption. This results in batteries sitting unused or under-utilized for well over half of the system's lifetime. For example, an energy storage system dispatched solely for demand charge reduction is utilized for only 5–50% of its useful life.

With appropriate valuation of those services, such battery business models can also provide net economic benefit to the battery owner/operator or to the utility that owns this storage device or devices. Nowadays, the modern power systems are undergoing a revolution towards smart grid energy dimension. Smart energy microgrids incorporate ICT-based tools into the electricity distribution network to allow producers and consumers to play an active role in managing their energy resources, reduce energy consumption, promote the use of renewable energy sources, and better manage the electricity network. The heart of a smart grid is, apart from advanced communications technologies, the use of intelligent decision support mechanisms and control systems, able to optimize the energy performance resulting in an active management and responsive system.

SOCIALENERGY will work towards the deployment of EPs for utilities and extensions (Prosumer DR services), in line with the standardization efforts of the Smart Grid Task Force and its Expert Groups. Overall, SOCIALENERGY could have a remarkable innovation potential to create an intelligent smart grid with bundled services to the relevant stakeholders (DSOs/RTO, Utilities, DR Aggregators, etc.). INTELEN has experience in working with storage companies (i.e. SonnenBattery), too, which are expected to come into the smart grid commercial foreground during the next few years.

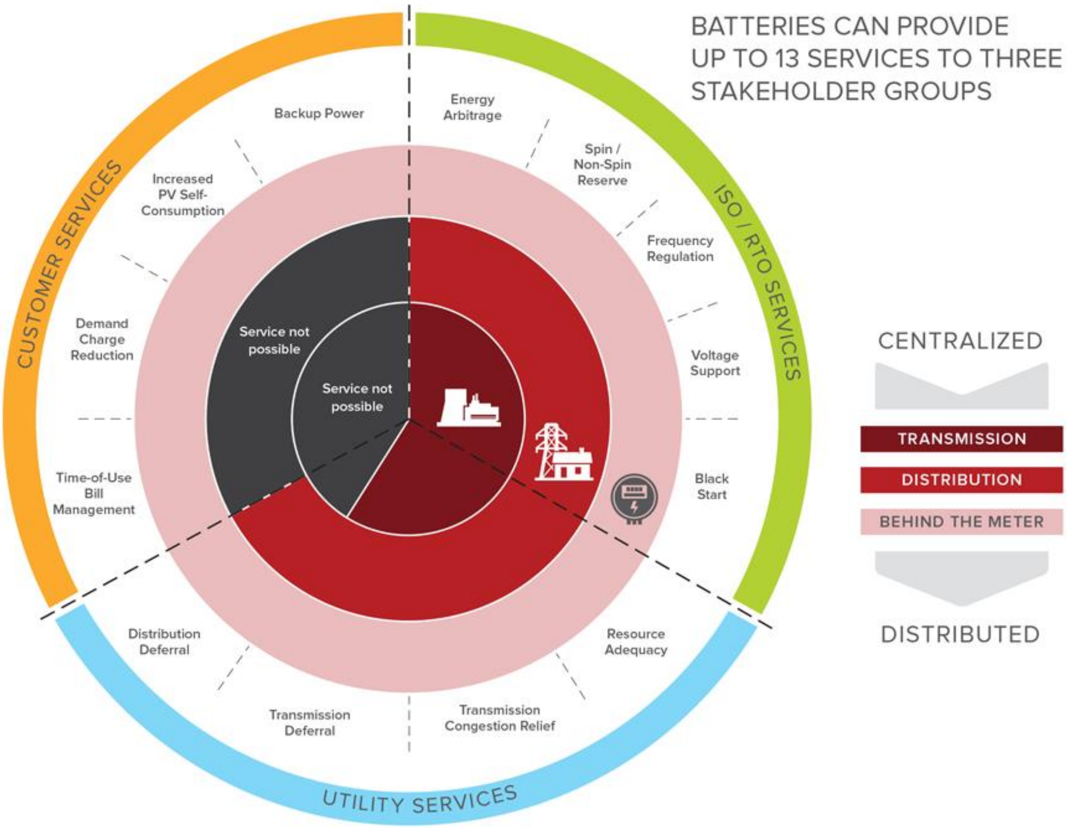

Figure 6: Storage companies can provide up to 13 services to three stakeholder groups

2.4. Energy Service Company (ESCO)

ESCO is a commercial or non-profit business providing a broad range of energy solutions including designs and implementation of energy savings projects, retrofitting, energy conservation, energy infrastructure outsourcing, power generation and energy supply, and risk management. The energy services market is envisaged as a key factor for implementing energy efficiency measures and achieving energy savings in buildings.

ESCO models were developed in the USA and afterwards brought to Europe and have been used since the 1970s. Several ESCO models are now being applied. These include energy performance contract (EPC), energy supply contract (ESC), integrated energy contracts (IEC) and build-own-operate-transfer (BOOT).

However, due to a set of barriers, these types of models are not yet generalized. The main barrier seems to be the lack of awareness and information on the complexity of the ESCO concept, leading to distrust by end-users and also by financial institutions. Other aspects that hinder ESCO market deployment include legal and political barriers, such as erratic legislation, lack of official or generally accepted ESCO definition, certification and standards; ambiguous legislation and lengthy procurement; financing limitations, like problems with bank financing, aversion to loans by potential ESCO clients and high transaction costs. Recently, ESCOs have been incorporated and integrated with utilities, so a utility can have an internal ESCO division, offering advance energy efficiency services to the end users.

Unlike ESCOs, most utilities are regulated to some extent by commissions appointed by state or local governments. While this regulation can limit investment returns, it also allows for lower investment risk, as regulators virtually guarantee returns based on energy demand projections. In this context, there is a long history of utilities offering energy efficiency services for regulatory reasons, usually with prescribed spending limits. However, utilities are increasingly looking to energy efficiency services as a profit-center separate from their main business of supplying energy to customers, leveraging existing relationships and brand identification.

The future of the energy efficiency business will largely be determined by the role that these business models play in the market. It is not an easy market; besides the diet industry, there are not too many companies that make money off of a lack of something. And there are also many "agency" issues, with one party paying the bills and another party receiving the benefits. But as the size of the opportunity becomes more apparent and the need to realize these opportunities becomes more urgent, the market dynamics of these business models will determine the nature of the energy efficiency industry in the years ahead.

SOCIALENERGY by offering DR and Energy efficiency services in a unique digital way (Games, Marketplaces, etc.), becomes automatically a great partner/tool for ESCOs or for internal Utility ESCO divisions. As the efficiency market evolves, different challenges confront each industry. For ESCOs, who rely on making sales to individual corporations and other entities (government, residential, etc.), the challenge is to develop tools and models that allow for low-touch, high volume energy efficiency solutions. ESCOs have to convince each energy consumer that they would benefit from their services.

Utilities are also challenged to effectively market energy efficiency as a product/service, but have the inherent advantage of strong pre-existing customer relationships. However, utilities must make a much tougher sale to regulators in order to create a sustainable business model.

2.5 End users and virtual energy communities

Solar, energy storage, and microgrids are offerings for communities of customers (ECs). Rooftop solar is not available for all consumers in buildings without good orientation or with multi-tenancy. A few utilities are offering community solar as an alternative for their customers. R&D and product development groups at forward-looking utilities are investigating whether their knowledge of energy management could be put to good use implementing and managing microgrids for campuses and communities.

Currently, local communities are supplied by a centralized energy system. This top-down architecture is due to the presence of economies of scale, possibilities to ship conventional fuels such as coal and gas to a desired location etc. However, technological and economic progress is shifting the energy production and consumption towards a smart grid paradigm that is increasingly concerned with climate change mitigation. We are at the cross-roads of re-designing our energy systems to integrate distributed energy resources. The energy system is being transformed to a combination of top-down and bottom-up systems, being incentivized by the vulnerability and insecurities associated with centralized energy infrastructure, depletion of fossil fuels and climate change. This enables communities to control generation and demand, leading to social innovation in management of community energy systems.

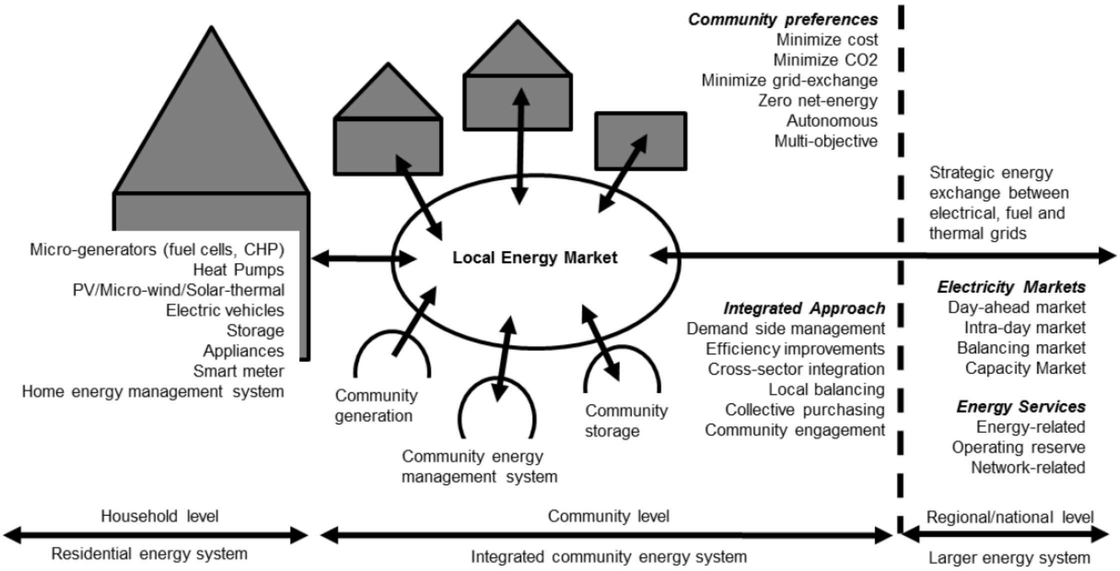

Figure 7: Virtual energy communities as a new R&I paradigm

The advantage of extending to multiple buildings and communities lies in the variation of demand profiles and availability of multiple generation and consumption sources, in this way increasing the flexibility of the system and overall extracted value. When consumers co-operate, more energy options become feasible at a community level due to economies of scale and local balancing. On the other hand, we do not define strict boundaries as they are up to the community wishing to integrate to make that decision according to evolving needs. Typically, a cluster of households within a distribution transformer are part of an energy community. It may even be the case that all connected users, commercial and residential alike, are part of the flexible community.

Hence, in the SOCIALENERGY context, we propose the following assessment criteria for an energy system to qualify to be used with the proposed GSRN platform as an Energy community: locality, modularity, flexibility, intelligence, synergy, customer engagement and efficiency.

Locality: *The system should have a larger proportion of local investment and ownership. It should be operated locally. Local generation should be used for self-provision through local energy exchange.*
Modularity: *The system should be able to cope with entry and exit of its members. Household and community level technologies could be added later to adapt with rising demand.*

Flexibility: *One of the important criteria for energy community in SOCIALENERGY is flexibility, which can be achieved through local demand response, local balancing, flexible load and supply. This flexibility can be utilized to provide energy and system services*.
Intelligence: *For the co-ordination of energy and information flow to match supply and demand locally, an energy community should be intelligent.*
Synergy: *The system could allow synergies between different sectors such as electricity, heat and transport as well as between different technologies.*
Customer engagement: *The system should engage customers through different means such as investment, ownership, local energy exchange and economic incentives.*
Efficiency: *The system should be both technically as well as economically efficient.*

SOCIALENERGY will use the above criteria to form energy communities, and through these interactions energy savings and engagement scenarios will be deployed and measured.

3. Strategic goals and technology transfer assets

In this section, we present the strategic goals of SOCIALENERGY that are able to act as the catalyst that will bring closer stakeholders with end users and the communities that they form. We also define the technology transfer assets that will be exploited for the SOCIALENERGY system from the following perspectives: i) gaming/gamification-related assets to be applied to the energy efficiency sector, ii) educational/learning-related assets to be applied to the specific requirements of SOCIALENERGY, iii) scientific-related assets meaning all clustering, dynamic pricing, profiling, recommendation and resource management algorithms which will be utilized towards SOCIALENERGY's intelligence.

3.1. Strategic goals

According to the Federal Energy Regulatory Commission, **demand response (DR) is defined as**[4]: "*Changes in electric usage by end-use customers from their normal consumption patterns in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized*". DR includes all intentional modifications to consumption patterns of electricity to induce customers that are intended to alter the timing, level of instantaneous demand, or the total electricity consumption. **DR programs are designed to decrease electricity consumption or shift it from on-peak to off-peak periods depending on consumers' preferences and lifestyles**. DR can be defined as "a wide range of actions, which can be taken at the customer side of the electricity meter in response to particular conditions within the electricity system (such as peak period network congestion or high prices). DR is a reduction in demand designed to reduce peak demand or avoid system emergencies. Hence, DR can be a more cost-effective alternative than adding generation capabilities to meet the peak and or occasional demand spikes. The underlying objective of **DR is to actively engage customers in modifying their consumption in response to pricing signals**. The goal is to reflect supply expectations through consumer price signals or controls and enable dynamic changes in consumption relative to price.

The design of an efficient DR program for residential users (e.g. households) is far more complicated, compared to industrial/commercial customers, mainly due to their near-random consumption patterns that require vigilant modeling. This task can be achieved by designing residential load management programs that either reduce or shift power consumption. The reduction of power consumption is realized through the encouragement of energy-aware consumption patterns and the construction of buildings with high energy efficiency. However, by shifting consumption from peak demand to off-peak hours, a significant reduction of the peak-to average ratio can be achieved. Consequently, there are possibly abundant opportunities for the DR application in domestic areas. Nevertheless, the applied DR program should not assume that all customers have the same power consuming behavior. As reported in [VENK12], residential consumers can be grouped into different

[4] https://en.wikipedia.org/wiki/Demand_response

categories: a) short range consumers, who are only concerned about the power price at the current time instant, b) real-world advancing customers, with consumer perception in current and past periods only, c) real world-postponing consumers, whose perception depends on current and future prices only, d) real-world mixed consumers, who are a mixture of postponing and advancing customers, and e) long range consumers, who are able to shift their consumption over a wide range of time. Following the same rationale, many more categorizations can be devised. During the last few years, research is focused on behavioral DR combining inter-disciplinary notions from social sciences, behavioral economics, education/pedagogy and gaming/gamification sectors.

3.1.1. Demand shifting

Usually, the goal of demand side management (or else demand response) is to encourage the consumer to use less energy during peak hours, or to move the time of energy use to off-peak times such as night time and weekends. Peak demand management does not necessarily decrease total energy consumption, but could be expected to reduce the need for investments in networks and/or power plants for meeting peak demands. An example is the use of energy storage units to store energy during off-peak hours and discharge them during peak hours. A newer DR application is to aid grid operators in balancing intermittent generation from wind and solar units, particularly when the timing and magnitude of energy demand does not coincide with the renewable generation[5]. As shown in Figure 8, all generated energy that surpasses demand is wasted at each time instant. The purpose of demand shifting is to not only to move end users' loads from high-demand to low demand but also to follow the intermittent RES supply curve as efficiently as possible. This means that when the sun shines or the wind blows, elastic demand loads should be shifted to this time period. When there is no sunshine nor wind, demand could be postponed to future timeframes in order for the energy cost to be minimized. The ultimate goal is for total demand and base power supply curves to converge as much as possible and in the case of large RES mix in the total power supply, the goal is for total supply and demand curves to be harmonized with the least possible deviations. This will lead to a much more energy efficient and environmental-friendly society. However, it should be noted that demand shifting can only happen via causing inevitable discomfort to the end consumers. This means that end consumers should be aware of all these fundamental changes being realized by smart grid technologies and change their behaviour and lifestyle in the way they consume energy during the day. This will provides more degrees of freedom for demand shifting and loads' scheduling taking always into consideration the fact that the user satisfaction levels should be kept above pre-defined thresholds that the user has agreed to experience the DR-related benefits.

[5] FP7 EU project VIMSEN 2014-2017, http://ict-vimsen.eu/

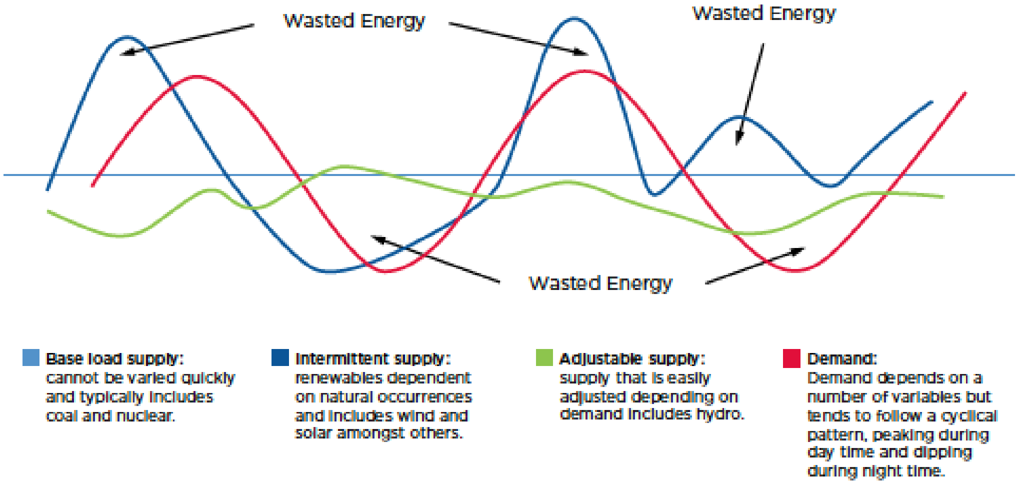

Figure 8: Example of electricity supply and demand and the need for their harmonization via demand shifting and/or demand reduction techniques[6]

3.1.2. Demand reduction

Shedding loads during peak demand is important because it reduces the need for new power plants and/or increases the autonomy in case of RES exploitation. To respond to high peak demand, utilities build very capital-intensive power plants and lines. Peak demand happens just a few times a year, so those assets run at a mere fraction of their capacity. Electric users pay for this idle capacity through the prices they pay for electricity. According to the DR Smart Grid Coalition, 10%–20% of electricity costs in the United States are due to peak demand during only 100 hours of the year. DR is a way for utilities to reduce the need for large capital expenditures, and thus keep rates lower overall; however, there is an economic limit to such reductions because consumers lose the productive or convenience value of the electricity not consumed. Thus, it is misleading to only look at the cost savings that DR can produce without also considering what the consumer gives up in the process. In other words, there is a clear trade-off between electricity bill reduction via DR actions and incurred user dissatisfaction (or else discomfort) because of the fact that he/she curtailed a percentage of his/her usual energy consumption at home.

3.1.3. Personalized marketing

SOCIALENERGY 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 over marketing campaigns and marketplaces. Hence, a well-designed rule-based system that relies on well-defined specifications is the key for successful personalization.

The role of the rule-based system is to generate personalized messages and actions for SOCIALENERGY GSRN platform (marketplace) through a data-driven approach by following a forward chaining inference engine. In general, a rule-based design system is comprised of three parts:

- A set of rules

[6] https://www.nesta.org.uk/sites/default/files/the_challenge_of_shifting_peak_electricity_demand.pdf

- 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 synthesize 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:

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.

The rule-based SOCIALENERGY system architecture for personalization in marketing is depicted below in Figure 9.

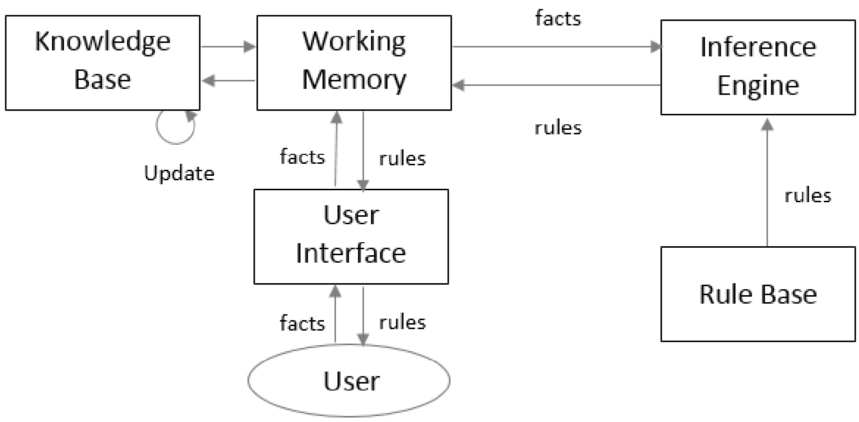

Figure 9: Rule-based System Architecture

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

- ✓ Demographics
- ✓ Psychographics
- ✓ Analytics & other behavioural data (ex. data from user stories)
- ✓ Smart meter data
- ✓ Appliances' data
- ✓ Billing data

- ✓ Past energy consumption data

The rest of this section presents briefly the functionalities of SOCIALENERGY that will lead to an efficient personalized marketing and their impact.

Triggers

Triggers are used in order to "fire" the rules. SOCIALENERGY acknowledges the importance of triggers in order for the recommender system to be effective in its goals and offer a true personalized experience to the participants. To form the triggers, the major pre-requisite is to carefully examine the different user stories. This allows SOCIALENERGY to meet the pilot participants' basic habits that derive from their daily routine and prevent the "cold start" blocking issue. Then, all the available data sources are also explored to feed with input the rules.

Rule-based system as an instrument for personalized 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 personalized applications that enable SOCIALENERGY pilot participants to raise their awareness, conceptualize the cost of their habits, re-think their actions and willingly change their behaviour. SOCIALENERGY interlaces the following predisposing, enabling and reinforcing-based strategies to achieve its objectives.

Increase Knowledge and Awareness through personalized 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 personalized 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 SOCIALENERGY metrics on behaviour change through the GSRN KPIs
- Feedback on undertaken challenges
- Feedback on participants' and his team's performance in serious game

Personalized experience

- Personalized invitations to challenges
- Personalized invitations for DR and peak demand management
- Personalized invitation to the serious game
- Personalized notifications about win badges, points and other gamification rewarding elements
- Personalized real rewards based on participant's preferences

3.1.3.1. Personalization and Marketplaces in Energy and Electric Utilities

One of the core concerns of SOCIALENERGY platform is to develop a large-scale energy advisory service for households that are facing difficulties with their energy bills. This purely social aspect of the project will start by leveraging all data sources to detect consumer cases that satisfy a set of criteria and KPIs.

At the top of the interest will remain to understand consumers' consumption habits, check appliances, distribute and install energy saving devices and various related products, provide advice on how to implement energy saving measures, analyse long-term solutions, and link local actors / 3rd party companies within a local action plan and a unique digital marketplace.

The methodology that will be following includes among others:

- Development and implementation of replicable energy consultation schemes (services) tailored for households to achieve significant and quantifiable savings of electric power, and especially appliances energy through low-or-no-cost measures
- Raising awareness for the rational use of energy in households via in-home consultations and such immediate actions as installing small saving devices that will be offered through a personalized marketplace.
- Producing materials and tools such as: digital training modules and calculation tools to assess the actual and future consumptions of the households before and after the project intervention
- Deployment of peer comparison functionalities and product comparison features that will allow only similar consumers to assess their energy savings with respect to their peers savings, restricting any negative effects that could have emerged in case of blending high other consumers too.

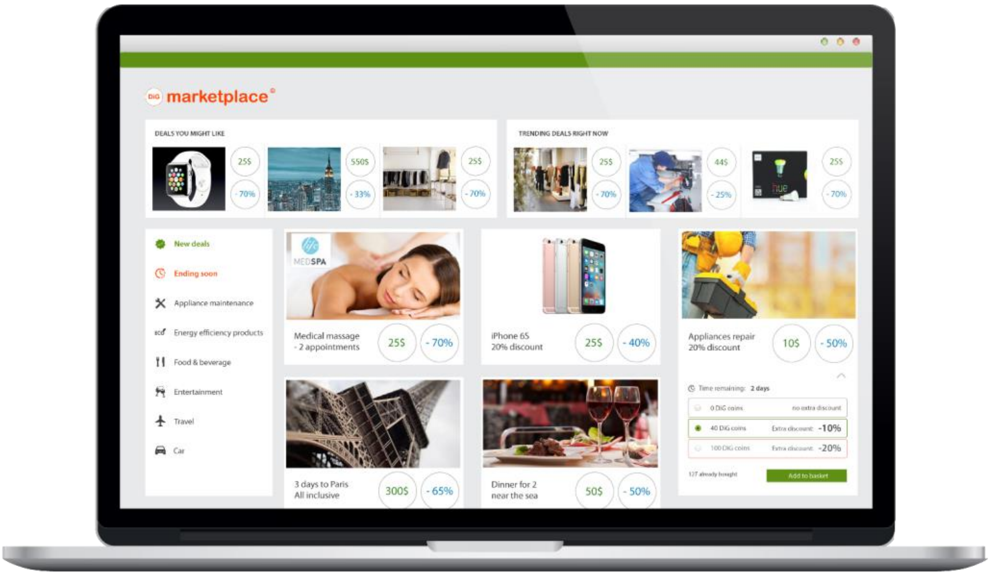

Figure 10: SOCIALENERGY MarketPlace (draft DEMO teaser version)

3.1.3.2. Evaluating the potentials of a "SOCIALENERGY Green" Marketplace

SOCIALENERGY intends to support consumers in their purchasing decisions by providing up-to-date information about the most energy efficient products on the market. The proposed solution will essentially act as a personal advisor for energy saving shopping in order to guide European consumers on two levels: the shopping assistance mode and the day-to-day mode. In addition, Facebook, Twitter, and other social media channels will encourage consumers to share this information with friends and family.

The summary of the impact points includes:

- Identify and evaluate the most efficient feedback mechanism to empower households in saving energy.
- Launch a platform focused on empowering energy consumers by providing energy services that respond to their demands.
- Provide insight-based services (such as informative bills and market products that can lead towards savings) and software tools for household empowerment.
- Create guidelines and recommendations for energy market stakeholders and policy makers.
- Raise awareness in civil society on the importance of enforcing eco-design and energy labelling regulations, as well as better centralise and share best practices in this area.

3.1.4. Education through Gaming and Gamification

The concept of play and games as a facilitator of education is not a new process and has been actively used in many teaching and learning processes nowadays. The very first steps in education of any child begin with learning by playing basic games. Kapp et al.[7] defines

[7] *The Gamification of Learning and Instruction: Game-based Methods and Strategies for Training and Education*. Pfeiffer. ISBN 978-1118096345.

gamification of learning as an educational approach to motivate students to learn by using video game design and game elements in learning environments. This particular approach is applied to maximise the enjoyment and engagement throughout the learning curve during educational process. The most basic and well known form of learner's assessment includes giving student marks based on their performance, which is itself is a reward system and can be seen as a gamification element.

It is a specific goal of many behavioural researchers and scientists to understand, analyse and ultimately help the user to attain better results by designing various interventions to keep the learner engaged in activities in such a way that the probability of completion and deep comprehension is increased. Game-based learning showed a fast growth in the past years as various research and demonstrators show its clear impact on the effectiveness in students' learning activities. With the prevalence of children playing leisure games on a daily basis, the potential to use such games to facilitate learning became a major point of interest among the educators and European policy makers. Although entertainment is the first thing that attracts players to games, the engaging learning experience is of great importance for the educational sector. The general principles embedded in Serious Games create positive learning results through a number of motivational aspects, learners' engagement and opportunity to critically think, experience and solve tasks in problem-based and no-risk context. The effectiveness of game-based learning was studied by many researches showing that Serious Games or interactive simulations show better results in cognitive gains, motivation, attitudes towards learning, problem solving skills and spatial cognition [VOGEL06] [DIVJAK11] [YOUNG12] [MAYER10].

The general principles embedded in Serious Games create positive learning results through a number of motivational aspects: a) multi-sensory active learning; b) opportunity to critically think, experience and solve tasks in problem-based and no-risk context; c) activation of previous learning needed to advance in the game; d) immediate feedback enabling players to learn from their actions; e) self-assessment through scoring and reaching different levels and f) improving social skills by fostering relationships between players [OBL04] [PIVEC04]. Such software and applications have increased the literacy rate and also educated the younger generation intrinsically.

There exist a number of ways to introduce education through gaming scenarios and most of the time they come down to the following choices:

- Simulation: games within which a certain subset of the real world is suggested and modelled on a smaller scale by providing human recognizable output.
- Strategy: applied where the ability to present a more complex scenario with strategic solutions (diplomatic, aggressive, thought through in advance) to achieve the goal of the game. Can be Real Time (RTS) and Turn Based (TBS).
- Action: require users ability to perform physically and mentally as well as to coordinate actions under pressure through sensory input.
- Role-playing: introduced through a rich contextualized environment, where the player is able to interact with the world through alternate self.

3.2. Technology transfer assets

This subsection presents the major technologies that SOCIALENERGY will exploit based on the consortium's background knowledge that will bring inside the SOCIALENERGY project. Furthermore, it analyses the features that they have and how these features serve the project's requirements.

3.2.1. Gaming/gamification-related assets

To best address the needs of the community and propose an effective intervention method as part of the SOCIALENERGY platform, a number of processes have to be considered and the most suitable gaming/gamification-related assets identified. We look at the following five processes:

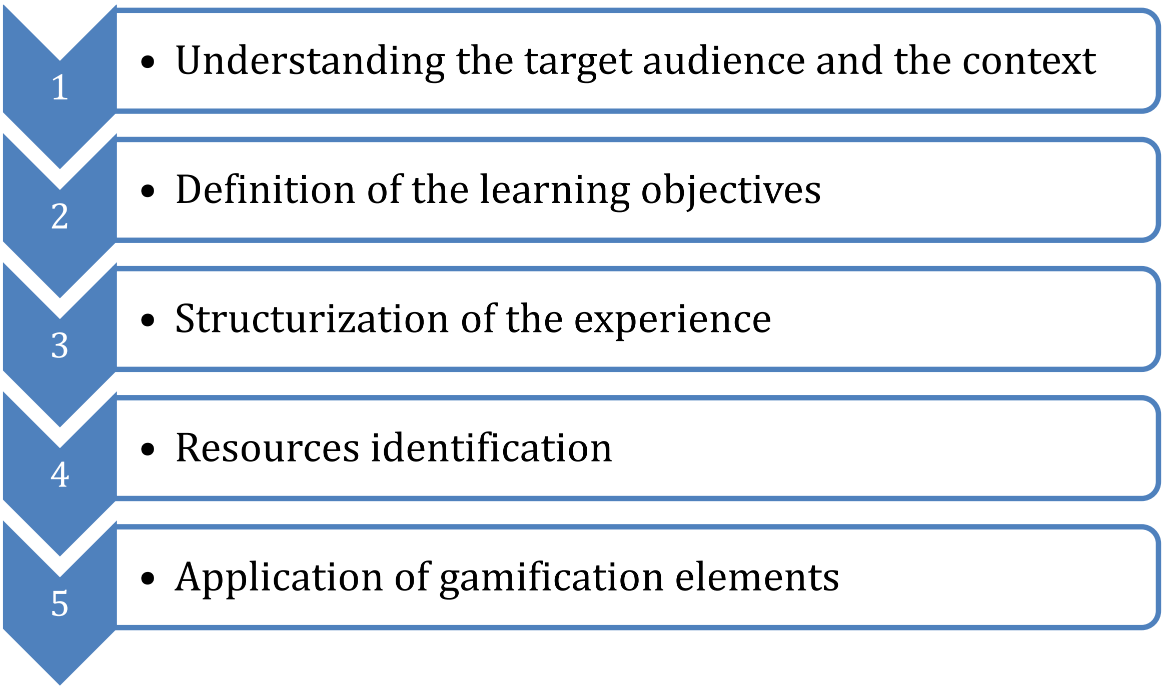

Figure 11: Five processes for exploiting gaming/gamification assets in SOCIALENERGY project

When designing a serious game, specific determinants of the gameplay shall be considered: i) tracking mechanism – a certain tool within the game, which provides the capability to track and measure player/learner progress within the game (e.g. learning scenario); ii) currency – this unit can be introduced in a number of ways like points, coins, energy bars, money, time; iii) leveling system – to provide the user with a feel of completion and set a clear objectives. Once the player/learner accomplishes a task/goal/assignment, they we will be free to move on the next level/objective; iv) rules – rules are important within any serious game, as they set the boundaries for a player within the virtual environment. This is to ensure that all users are equal within the game, the learning process is fair to everyone as well as to be certain that a given user in not only rushing through the game levels, but also understands the concepts by imposing some sets of rules of answering all the questions correctly; v) feedback – crucial part of serious games to introduce a mechanism to the learner through which they can understand whether the progress is made or not, pin point the wrong or correct actions and fix the gaps in their understanding.

The gamification elements that might be used within the SOCIALENERGY scenario all come down to the definition of the learning objectives. Given that one of the major objectives is to stimulate learning and understanding, suitable gamification elements that can be applied to the learning program have to be picked. Therefore, we differentiate the game mechanics of the future solution in two classes of elements: self-elements and social elements.
Self-elements in this case can be introduced by levels, achievement badges, virtual goods, aesthetics and points, basic goal of which is to stimulate the player/learner to compete with themselves and afterwards recognize a self-achievement. The social elements at the same time can be introduced through the competition or cooperation like leaderboards. This is done to place the user in a community in order to compete/progress/communicate together and the results of such actions are exposed to all the users.

3.2.1.1. Gamification Motives, Interaction Design and Design Elements

We want to define the optimal interaction characteristics of the gamified application, so that it will adhere to the end-users' profile. Towards this end, the questionnaire includes questions that identify the app characteristics that will make it more desirable, more usable and more popular to the participants. Specifically, we investigate the following characteristics:

- Interaction with other players: Team play, Individual play
- Incentive types: Prizes & Rewards (Individual/Collective)
- Goals within the game: Individual goals, Collective goals, Incremental Goals
- Game difficulty: Easy, Difficult
- Playing mode: Single, Team
- Game type: Educational, Recreational

Through these questions, we will be in a position to assess the participants' game design needs, based on the HEXAD player typology, suggested by [DIAM15]. Different player types correspond differently to the various game elements, as well as present different game preferences.

Personalizing gameful systems to each user is important because personalized interactive systems are more effective than one-size-fits-all approaches. Several studies have indicated the need for personalizing gamified systems to users' personalities. However, mapping user personality onto design elements is difficult. Personalization can be used in game design to tailor game mechanics to the player or in gameful design to tailor inter- action mechanics to the user. Using player or user typologies to understand individual preferences is one of the common approaches for personalization. Hexad is a gamification user types model that attempts this mapping through six user types:

- ✓ ***Philanthropists*** are motivated by purpose. They are altruistic and willing to give without expecting a reward.
    - *Suggested design elements:* collection and trading, gifting, knowledge sharing, and administrative roles.

- ✓ ***Socialisers*** are motivated by relatedness. They want to interact with others and create social connections.
    - o *Suggested design elements:* guilds or teams, social networks, social comparison, social competition, and social discovery.
- ✓ ***Free Spirits*** are motivated by autonomy, meaning freedom to express themselves and act without external control. They like to create and explore within a system.
    - o *Suggested design elements:* exploratory tasks, nonlinear gameplay, Easter eggs, unlockable content, creativity tools, and customization.
- ✓ ***Achievers*** are motivated by competence. They seek to progress within a system by completing tasks, or prove themselves by tackling difficult challenges.
    - o *Suggested design elements:* challenges, certificates, learning new skills, quests, levels or progression, and epic challenges (or "boss battles").
- ✓ ***Players*** are motivated by extrinsic rewards. They will do whatever to earn a reward within a system, independently of the type of the activity.
    - o *Suggested design elements:* points, rewards or prizes, leaderboards, badges or achievements, virtual economy, and lotteries or games of chance.
- ✓ ***Disruptors*** are motivated by the triggering of change. They tend to disrupt the system either directly or through others to force negative or positive changes. They like to test the system's boundaries and try to push further. This type is derived from SDT, but from empirical observation of this behaviour within online systems. Although disruption can sometimes be negative (e.g., cheaters or grievers), this is not always the case because disruptors can also work to improve the system.
    - o *Suggested design elements:* innovation platforms, voting mechanisms, development tools, anonymity, anarchic gameplay.

Some motivations underlying these user types are related, but the user types themselves overlap slightly. Achievers and Players are both motivated by achievement, but differ in their focus: Players focus on extrinsic rewards, while Achievers focus on competence. Philanthropists and Socialisers are both motivated to interact with other players. However, they differ because a Socialiser's interest is in the interaction itself, while a Philanthropist is motivated by interaction to help others. Finally, Free Spirits and Disruptors are both motivated by autonomy and creativity. However, Free Spirits stay within the system limits without a desire to change them and Disruptors seek to expand beyond these boundaries to change the system. It is also worth noting that, although these motivation clusters are presented as user types, individuals are rarely motivated by one of them exclusively. Although users are likely to display a principal tendency, in most cases they will also be motivated by all the other types to some degree.

Therefore, to further personalise the specific preferences of the users, we will identify the participants' individual personal preferences for game elements (e.g. points, leaderboards etc.) to appear in a game that aims at reducing energy consumption at the workplace. The categorization of game elements, as well as their definition, is based on the review by [SEA15]. We describe each element in order for each participant to be in a position to understand its meaning and express how important it is to appear in a gamified application towards the reduction of energy consumption at the workplace.

Based on the participants' answers, we will be in a position to design the SOCIALENERGY gamified DR procedures with personalised functionalities that make it more desirable to the participating employees and, thus, increase the chances to include it in their work routine.

3.2.1.2. Personality Profile

The Ten Item Personality Index (TIPI), is a personality assessment test that is used to assess users according to five different personality traits, also called the "Big Five" personality traits. The Big Five personality traits (also known as the five factor model (FFM)), is a model that describes personality, based on five factors: openness to experience, conscientiousness, extraversion, agreeableness, and neuroticism. It has been used in a wide variety of applications, and connected to a large number of individual behaviours, including the behaviour within games.
A connection between the Big Five personality characteristics and the style of play of the participants has been observed [BEAN14]. In addition, the Big Five personality traits have also been found to be related to various motivations to play games [PARK13]. Agreeableness has been positively related to the relationship motivation, whilst extraversion and agreeableness to the adventure motivation. Extraversion and agreeableness have also been found to be positively related to the escapism motivation. Moreover, age was positively related to the escapism motivation. Extraversion could predict the relaxation motivation. Extraversion and agreeableness were positively related to the achievement motivation. Openness to experience has been positively related to discovery and role- playing motivation, and conscientiousness to escapism motivation. In addition, extraversion has been positively related to teamwork motivation, and agreeableness to advancement motivation. Furthermore, neuroticism has been negatively related to teamwork motivation [JENG08]. Difficulty adaptation methods in games have also been found to bear a relationship with the Big Five personality traits [NAG16]. Therefore, based on the personality profiles of the players, an appropriate difficulty adaptation method can be selected. The Big Five dimension Conscientiousness has been negatively correlated with speed of action. The game variable Unlock Score per Second correlates most often and most strongly with Conscientiousness and Extraversion. Unlock Score per Second is a measure of how much a player varies his play style [TEK13].

3.2.1.3. How to Engage SOCIALENERGY Game Players

Reeves et al. [REE12] suggest leveraging the engagement of games to change energy behaviour. In addition, they suggest that the **engagement mechanisms common in popular games may be leveraged to promote desired real-world energy behaviours among players**. Popular game environments offer insight for energy applications. Games engage people with elements like self-representation, timely feedback, community connections, ranks and levels, teams, virtual economies, and compelling narratives. However, the engaging effect of any measure depends on the current level of the participants' engagement, recorded within the engagement section of this questionnaire.

In addition, by recording the participants' game design preferences, as well as their gamer profile characteristics, we shall be in a position to suggest specific game design elements to cater to the different user profiles. In that way, we will have the capability to further personalise the application, to match the needs and preferences of its prospective users. In addition, by analyzing the participants' Big Five profile we will, among others, be able to predict which motives to play are of most interest to them, their in-game preferences, as well as the optimum difficulty adaptation mode, improve the recommender system functionality, and adapt our application accordingly.

Finally, by recording the energy consumption profile of the participants, we will have the ability to assess the current situation in the different sites, regarding energy consumption behaviours. Additionally, we can also use this information to compare the resulting energy consumption behaviour through the SOCIALENERGY platform, to the declared behaviour of the users before its introduction. That way, we will have the additional ability to assess the self assessed behavioural effect of the SOCIALENERGY platform, after its introduction to the various sites.

3.2.1.4. Game Elements' Preferences

Regarding the importance of game elements to exist in a game focused on energy conservation, the following table includes the participants' preferences in descending order of importance:

Table 2: Indicative list of game elements' preferences

Order of Importance	**Game Element**	**Comments**
1	Progression	85% of the participants believe that it is important, whilst only 6% find it unimportant; and the remaining 9% remaining neutral.
2	Levels	74.2% of the participants feel they are important, 7.2 unimportant and 18.6% neutral.
3	Points	72.4% of the participants feel they are important, 14.3 unimportant and 13.3% neutral.
4	Rewards	64.6% state they feel they are important, 20.2% unimportant and 15.2% neutral
5	Status	60.4% state they think it is important, 24% unimportant and 15.6% neutral
6	Leaderboards	59.8% state they feel it is important, 23.7% unimportant and 16.5% neutral
7	Badges	57.3% state they feel it is important, 27.1% unimportant and 15.6% neutral
8	Roles	53.1% state they feel it is important, 28.6% unimportant and 18.4% neutral

Thus, we can conclude that in order to increase the chances for users to embrace these services and use them daily in their work life, the SOCIALENERGY gamified services will comprise at least:

- ✓ progression
- ✓ levels
- ✓ points
- ✓ rewards
- ✓ leaderboard

3.2.1.5. Behavioral Technologies for DR and User Engagement/Education

Energy behaviour represents an important under-exploited 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. 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 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. The savings are due to changes in conservation, lifestyle, awareness, low-cost actions, or some small investments. A similar study for American households 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 the following table:

Table 3: Prediction of Energy Savings based on certain actions

Category of actions	Potential national energy savings (in Mtoe)
Conservation by lifestyle, awareness, low-cost actions	123 (57% of total savings)
Investment decisions	93 (43 % of total savings)
Total energy savings	216 (22% of household energy)

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.

In addition 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 SOCIALENERGY 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, SOCIALENERGY 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.

The SOCIALENERGY planning and evaluation model 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:

<u>Phase I: The Design phase</u>
Step 1: Problem orientation and specifications of goals, objectives & KPIs;
Step 2: Analysis of determinants & target groups;
Step 3: Design of the intervention

<u>Phase II: The Evaluation phase</u>
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?

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. SOCIALENERGY's model first asks what exactly is the outcome that needs to be achieved. It is extremely important to define the exact problem before moving ahead. The next thing to do is to look at the factors that influence the process of SOCIALENERGY'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.

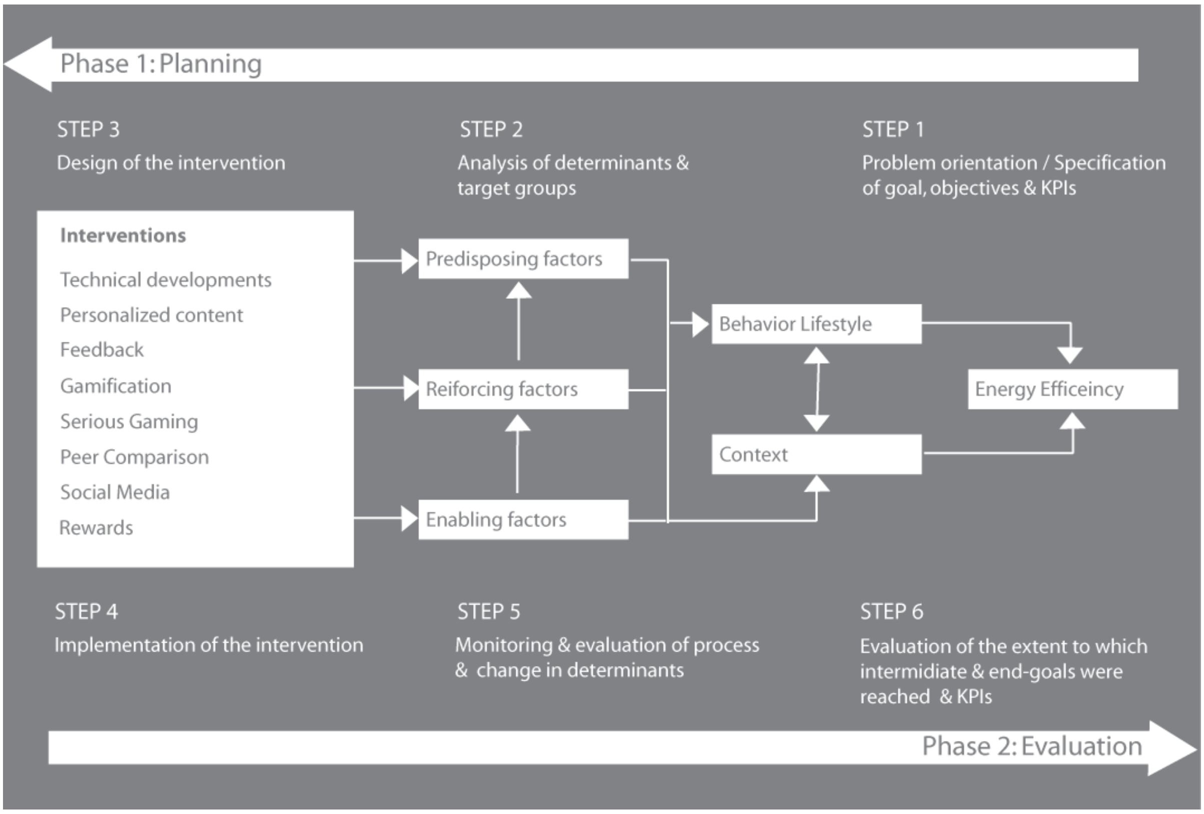

Figure 12: SOCIALENERGY Planning & Evaluation model

3.2.2. Educational/learning-related assets

The LCMS implementation will be based on the free and open-source software learning management system Moodle, which has a large and diverse user community. It is a learning platform developed as a single, robust, secure and integrated system for the creation of personalized learning environment. Moodle provides to educators, administrators and learners a set of learner-centric tools and collaborative learning environment. Moodle is provided freely as Open Source software under the GNU General Public License, which means that Moodle is also continually reviewed and improved to suit the evolving needs of users. It is a web-based platform with a default mobile-compatible interface and cross-browser compatibility.

A common profile for each user shall be created for the three systems (GSRN, LCMS and GAME). After the user registration and first login, the system guides him/her step by step to develop his/her profile. This profile contains common information for the user, which includes basic personal information, extracted from the user registration and additional information such as data about his/her utility (housing space, number of family members, electric appliances – type and number of, etc.), user competences, communities and contacts from the GSRN: game levels achieved, rewards (game points, bonus points, badges, ranking) etc.

A competence is 'a complex combination of knowledge, skills, understanding, values, attitudes and desire, which lead to effective, embodied human action in the world, in a particular domain [DEAK08]. Competence is distinguished from skill, which is defined as the ability to perform complex acts with ease, precision and adaptability. For measuring the competences, we need a complex **competence assessment system**. Assessment systems that focus on the process of competence development take into account the amount of competence development activities that are undertaken by individuals. Such systems stimulate engagement in competence development activities, focusing both on the input (attendance at a learning activity) as well as to the outcome (the change in competences or the improvement in learner attainment).

The competences are structured according to tailor-made taxonomy of competences in the energy efficiency domain. This taxonomy is common for the three systems (GSRN, LCMS and game). The competences of this taxonomy are associated with each individual user profile and this could be done in different ways:

- The user could identify herself/himself competencies by choosing them from a list of optional competences
- Through analysis of the results of a pre-test specifically developed for the purpose of user competence identification
- Depending on user behavior in the GSRN, LCMS and game

The user can acquire new competences through social activities in GSRN, playing into the game, and/or by performing learning activities in LCMS.
Each Learning Content Management System is providing the learning content in electronic form, named as Learning Objects. There is a formal standard for defining what a Learning Object is, how to be represented, described, searched and reused. The most widespread explanation of the concept of Learning Object is: autonomous learning activity or set of learning resources, which when used from the learner, will lead to solving specific learning goal.

The competences are related with defined in the LCMS Learning Objects (LOs). LO is a resource in the system (learning activity, task, lecture, simulation, etc.). In the LCMS, there will be used the following main types of LOs:

№	Types of Learning Objects (LOs)	Description	Examples
1.	Reading material LOs	Written material intended to be read, that present educational content primarily through text, but also contain appropriate graphics, diagrams, illustrations etc. *Represented in to the LCMS through:* text files (e.g. pdf, txt, docx), presentations, embedded web pages	● Basic educational materials on energy efficiency; ● Short materials of a type "Did you know that?" – contain specific facts related to energy saving, presented in an intelligible manner, with appropriate illustrations; ● "Helpful Hints" – short and simple tips on how to save energy, presented with appropriate illustrations; ● Information for the end users about specific usable energy efficient solutions (appliances, devices, etc.); ● "How To" – contains description of short operational procedures/algorithms

2.	Video tutorial LOs	A video that represents a short portion of educational content with examples and information on how to complete a certain task *Represented in to the LCMS through:* embedded videos	Video tutorials that demonstrate/illustrate tips for saving energy (they can be connected latter with quizzes) Video tutorials regarding some indicative game play instants to help game users further understand the ways that the game is well played.
3.	Simulation LOs	The representation of the behaviour or characteristics of one system through the use of another system (especially a computer program designed for the purpose)	The user is put in a simulated environment of his own home. She/he has tools that allow them to determine certain environment parameters as: the number and size of the house rooms, the number of the family members living in the house, number, type, and class of appliances and lighting in his home, the approximate duration of use of the individual appliances per day, marking the appliances as seasonal/working on periods (e.g. air conditioners, heaters, etc.), etc. On the base of the set parameters the simulation calculates the daily consumption of electricity in the house. Then there will be simulation tools that give opportunities to the user to change the number of appliances and fixtures that work at a certain moment of time; the duration of their work; to replace some appliances with similar but of a higher energy-saving class; to replace bulbs with more energy-saving ones, to install solar panels, etc., i.e. to have the opportunity to adjust various parameters that influence the energy consumption in order to reduce its cost.

4.	Quiz LOs	A set of questions and/or problems used as a means of evaluating the abilities, aptitudes, skills *Represented in to the LCMS through:* question bank with a set of different types of questions grouped into different categories; specific quizzes consisting of specific questions or a set of questions randomly drawn from the question bank	• Short quizzes that follow certain small portions of educational content on the topic, with the purpose to check the extent to which it is understood. They can be accompanied by short videos illustrating certain behaviour of the energy consumer, indicating mistakes s/he has made, (e.g. "S/he left the lights on, when brought the dog for a walk", etc.) • Pre-test/post-test quizzes - that examine the user knowledge on certain topic(s) before, and after specific learning events. In this way not only the amount of learning can be assessed, but also the appropriateness and effectiveness of the learning materials itself.
5.	Podcast LOs	A digital audio or video file or recording, usually part of a themed series, that can be downloaded	• Provide information for example on energy productivity, demand response etc. • Provide hints related to energy savings • Interviews with experts in the field of energy efficiency • Discussions • Oral storytelling on the topic of energy efficiency • Series of short podcasts related to quizzes
6.	Performance recommendation s / Performance appraisal LOs	KPIs	Simulation type activity that analyses the performance behaviour of a user with respect to energy saving/efficient use, and gives optimisation recommendations. Exemplary online tools: e.g. http://www.buildingenergysoftwaretools.com/

According to user competences, the LCMS will create and offer an Individual Learning Plan (ILP) to the user through which to develop competences that s/he does not possess. **The ILP is a combination of the necessary LOs and produces an individual time-and-knowledge-bound learning package for every learner at each particular stage of their learning**. The main learning goal of the ILP is to increase the user's competences. Each ILP includes different LOs related to different competences from the taxonomy of competences. Each competence is related with a set of LOs. In order to acquire a specific competence, the user shall perform specific learning activities and tasks represented in the LCMS by LOs. When the user acquires new competences s/he receives a some kind of reward (bonus points, badges etc). The new competence and overall progress is reflected in her/his profile, which is visible and accessible from the three systems (GSRN, LCMS and game). In it s/he can also view its ILP and the degree to which it is fulfilled and her/his rewards.

The user can review, learn and download learning resources. S/he can perform learning activities and tasks such as uploading files, fill in tests, reply with a text answer etc. Beyond the included in the ILP learning resources, the LCMS provides to the user options to search additional learning resources. The user could apply advanced search filters, according to competences, themes etc. The LCMS also can offer additional learning materials. The LCMS allows the user to connect with other users by sending messages, initiate and participate in a forum discussion and share knowledge and learning materials. For more complex communication with other users, the LCMS provides link to GSRN, where the user can interact further. The LCMS allows the user to view a list with other users; to search for users by name. LOs will not repeat, but complement the learning process achieved through the portal, and/or the serious game. The LCMS may provide also a special group of learning materials - the game tutorial. In such a case, the LCMS will have a special section providing educational resources in order to better prepare the users how to use and play with the game.

3.2.3. Scientific-related assets

3.2.3.1 Dynamic energy pricing

A great deal of recent research has focused on developing new, smarter pricing models with the purpose of dynamic load shifting and load reduction in order to harmonize energy production and energy consumption.
The common **flat price model** provides zero motivation for the users to re-shape their energy consumption curve (ECC). The follow-up model of **Inclining Block Rates (IBR)**, charges a higher per unit price of electricity to users with high consumption profiles. This model is an effective motivator towards lower consumption but it does not address the issue of making the user's profile more convenient with respect to the time of consumption (load shift). **Time-of-use pricing (ToU)** models were introduced, where a generally different per-unit price was applied for each hour of the day (e.g. peak load pricing). Users were thus motivated to shift loads into low pricing hours. The model's shortcoming though was that it was still static and the prices are not: i) reflecting the real-time needs of the grid, thus often resulting in congestion problems during the low-priced hours and ii) acting as effective motivators towards load shifting. Recently, **Real Time Pricing (RTP)** models were proposed in order to directly connect the generation, transmission & distribution costs to the charging price and harmonize in this way production with consumption. Towards the realization of real time pricing, the first step is the development of a two-way communication system between the utility/energy provider and the end users. Then, through a limited number of message exchanges, prices are derived in real time resolving the trade-off between pricing requirements, which are:

- The minimization of electricity cost (electricity cost varies in time according to the way that the energy is generated and the aggregated energy consumption) [Req. 1]
- The maximization of user comfort (load shifts and load cuts increase user's discomfort) [Req. 2]

- The fair distribution of the costs to the participating users (each user should be billed according to the cost of its consumption and the discomfort that load shift and load shedding introduces to her/him) [Req. 3]

In [SAM10], an algorithm is presented that converges to the optimal prices, the objective being to maximize user comfort, while minimizing energy costs. Users are thought exclusively as consumers. A similar approach is adopted in [CHEN11], where storage capability and battery operation costs are additionally considered, but without the possibility of feeding energy back to the grid. In [SAM13], the utility's objective is considered to be profit maximization, which is not the same with energy cost minimization. The "fairness" issue is not given sufficient attention in the above works: prices are different for each time instant but are the same for all users, regardless of the user's contribution to the system's costs. In [ZAH13], the "fairness" of the pricing model is improved by employing the concept of Shapley value. Therefore, each user is charged based on his/her impact on the total cost of the system at each time instant. However, their model only takes into account the user's real time load contribution to the total system load, meaning that naturally high-consumption users (such as businesses and factories) are exposed to higher per-unit prices, although they might contribute more in terms of load rescheduling. This makes the model quite unfair to such users. Moreover, users are assumed to evenly distribute their load throughout the acceptable timeframes and the user's dissatisfaction is disregarded. In a nutshell, some generally desired (and mutually-conflicting) requirements (reqs) for designing a pricing scheme are: i) the minimization of the system's (energy) cost, ii) the maximization of user's satisfaction, and iii) fairness (each user should be billed according to his contribution). Models from existing literature cope either with one or two from the above reqs. Further examples include: [SOL14] copes only with req 1. [JIN14] copes only with reqs 1 & 2. Fairness-related works, like [ZAH14] & [YAA15], disregard either req 1 or req 2. To the best of our knowledge, there is no prior work that directly assesses the issue of designing a pricing scheme that best accomplishes all three of the above reqs.

SOCIALENERGY will develop innovative Energy Programs (EP) by investing in its innovative concepts, which are: Personalized RTP (P-RTP) and Energy Community RTP (EC-RTP).

P-RTP: In more detail, in almost all existing RTP models price per unit is the same for all end users in a specific time instant (p(t)). By making it different for each user i p (i,t) are added extra degrees of freedom and can be achieved better trade-offs with respect to pricing requirements. The Energy Consumption Curve (ECC) of each user i and the aggregated ECC determine p(i,t), whose objective is to enforce the desirable behavioral change (e.g. harmonization between energy production and consumption) is put as input to P-RTP.

EC-RTP: An additional effective tool towards behavioral changes that SOCIALENERGY envisages is the pricing of energy according to the community's (set of users) energy consumption curve (C-ECC). In this way, a social "peer pressure" is generated that acts as an additional motivation towards the desired behavioral change.

3.2.3.2. Multi parametric communities for participation in advanced EPs

A new issue that has come into the research and business foreground is ways to achieve efficient aggregated DR targets in the residential sector (i.e. too many consumers with relatively small individual energy consumption). The recently years proposed Virtual Power Plants (VPPs) [KEMA09] concepts aim to integrate the operation of supply- and demand-side assets in order to meet customer demand for energy services, in both short- and long-term periods . The main functionality is based on a centralized model, which connects, controls and visualizes a schedule plan of distributed generators. VPP provides an opportunity to lower the load in the power network. For the short-interval load fluctuations, the VPP makes extensive use of information technology, advanced metering, automated control capabilities, and electricity storage. On the other hand, in a long-term load period, reduction is achieved through energy efficiency investments, distributed generation, and verified demand response (DR) [SU09] actions. In addition to the above attempts aggregators [GKATZ13], a new entity in the electricity market that act as mediator between users and the utility, has been introduced. (DR) Aggregators possess the technology to perform DR and are responsible for the installation of the communication and control devices (i.e. smart meters) at end-user premises. Since each aggregator represents a significant amount of total demand in the DR market, it can negotiate on behalf of the home users with the operator more efficiently. As a result, the clustering procedure has been introduced as a strategy that allows individual prosumers to aggregate their consumption in order to: a) overcome entry barriers to the market and enhance their individual small negotiation power, b) optimize the profits for each cluster [GKATZ13, KIM11] and c) conform to a given contract. The task of conforming to a given contract is quite challenging. Therefore, there is a need to heavily rely on accurate forecasts of consumption from local electricity market participants as forecasting errors result in financial penalty costs and opportunity losses [GONS14]. Forecasting individual demand/supply often leads to large errors. However, these errors can be reduced through the creation of prosumer clusters, which should be as small as possible for greater efficiency of the aggregators' portfolio. Therefore, the need that multiple small energy prosumers (i.e. mainly residential households) are orchestrated into bigger associations towards optimizing the association's benefits has come into the research foreground [MAM15]. In ICCS previous work [VERG16], we focused on the impact analysis of energy prosumers' clustering on penalty reduction and the respective benefits that virtual associations realize in comparison with the case, where they participate as individual entities in the liberalized electricity market. Various clustering algorithms were presented and the results show that clustering of prosumers can offer clear benefits for market participation in terms of their potential to reduce economic penalty costs incurred by short-term demand/supply imbalances.

Even though the above entities represent a significant new direction in utility planning and operations, fewer achievements have been made to the direction of community aggregation. In general, the amount of energy that a prosumer is able or willing to consume/produce depends on many factors, such as: network charges, congestion, taxes, policy cost, local balancing, etc. As a result Energy Communities (EC) creation and prosumer allocation into EC groups is necessary. By the term "EC groups", we refer to clusters that maximize one or more parameters essential for the optimal cluster functionality. The results of the community grouping process contain some well and worse performing clusters. Best-performing clusters will be able to succeed difficult tasks, improve efficient behavioral changes or participate in more and more competitive energy programs for more profits realization. Less optimal clusters will be able to improve their skills through user engangement in order to become more competitive in the future. Following this concept, we will examine clustering algorithms that try to form a coalition of prosumers, that will be capable of satisfying the local demand and to manipulate the community price, by limiting the energy consumption. Three different approaches are examined, namely: multi-parametric spectral clustering, multi-parametric genetic algorithm, and a multi-parametric

dynamic adaptation technique. The objective of each clustering algorithm will be the ability to cluster together different prosumers into groups, so that the aggregate imbalance of each group, and the corresponding energy consumption are minimized.
In order to better manage aggregated energy consumption in the residential DR sector, social media and serious games are becoming an emergent form of end user involvement in complex business-related operations. Both social networks and gamified interfaces are currently used as communication tools that are now beginning to influence one another via various socio-economic techniques for behavioral change, which can be summarized with the new term "peer pressure". Gamification approaches are being pursued in energy products and services more and more using social pressure to change people's consumption behaviour [BEH11]. Social engagement through gameful design offers feedback rewards and social competition among players resulting to encouraging participation in energy efficiency programs. Recently, there are some positive indications on the effect of game-like mechanics in motivating energy efficiency at the social level due to the constant process of learning of shared goals, constructive strategies and commonly solved complexities [JARV09]. In the proposed SOCIALENERGY platform, the main goal is to merge personal interests about energy efficiency with community and environmental goals. Successful evaluation will considerably impact on people's behavior in short and long-term.

SOCIALENERGY will exploit and adapt the aforementioned algorithms towards the formation of Energy Communities (EC) suitable to participate in advanced EPs that offer EC-RTP. In this way, a social "peer pressure" is generated that acts as an additional motivation towards the desired behavioural change in energy consumption. The determination of the optimal size of ECs falls into SOCIALENERY's objectives. They must be large enough in order to offer a degree of flexibility (include a subset of users eager to change their behaviour each time instant) and small enough in order to allow to their end users to dispose a significant portion of energy consumption by making them important and worth to be "pressed".
The efficiency of the communities will be maximized in case that (among others): i) their members have real social relationships (derived from their links in social networks), and ii) have complementary skills (derived from their behaviour in SOCIALENERGY platform).

3.2.3.3. Advanced profiling and recommendation algorithms

Energy consumer engagement is a broad term that involves consumer interest, motivation, comprehension, evaluation, reflection and personal characteristics. It refers to the environmentally responsible behavior of the energy consumers and the motivation for this. Behaviors related to energy savings can be divided into two categories: efficiency and curtailment behaviors.

- Efficiency behaviors are typically performed by replacing obsolete appliances with new ones that are more energy efficient or by investing in more energy efficient methods and technologies (e.g. insulation).
- Curtailment refers to reducing energy consumption, e.g. by turning off lights or appliances when nobody uses them or by lowering thermostat settings. Even though the energy-saving potential of efficiency behaviors is considered greater than that of curtailment behaviors, they may suffer from the so-called 'rebound effect', i.e. using the new appliance much more than the older one, due to its higher efficiency, which may cancel the saving in energy usage.

Goals and objectives for energy savings

Consumers may be motivated to save energy if they have a specific goal to attain. For example, a household may have a goal to reduce electricity consumption by 10% compared to the previous month. The goal provides motivation as well as a clear target for the consumers to focus their efforts. Energy saving goals can be set from the consumers themselves or from outside the household (e.g. the energy provider, the building administrator, etc.). A goal should not be too ambitious, to cause frustration, or too easy to be fulfilled, to fail to provide motivation and engagement.

When consumers are given an energy saving goal, they should also be given direction, guidelines and advice on how to change their behavior in order to reach this goal in the most effective way. In addition, households should receive feedback, so that they learn the effect of their efforts, as well as 'positive feedback' that will stimulate their efforts and possibly rewards for improving their energy related behavior.

Mapping generic models to specialized models - Data mining context

The data mining context drives mapping between the generic and the specialized level in Cross Industry Standard Process for Data Mining (CRISP-DM). Four different dimensions of data mining contexts will be utilized:

- The application domain will be the specific to evaluate the Energy Consumer Engagement
- The data mining problem type will be focused on Consumer Segmentation
- The technical aspect will be responsible to manage different technical challenges that usually occur during data mining such the management of missing values and outliers
- The tool and technique dimension will determine which data mining tool(s) and/or techniques will be applied during the data mining (Mineset, R, Matlab, weka)

CRISP-DM Life Cycle

The Cross Industry Standard Process for Data Mining (CRISP-DM) is the life cycle model that will be utilized for properly mining all the available data in order to gain insights about the engagement of consumers with energy efficiency. The following figure illustrates the steps to be taken in order to determine which intervention strategies maximize the consumers' engagement with energy efficiency and what is the exact level of possible achieved savings between the different consumer groups.

Business understanding

This initial phase focuses on understanding the Project objectives and requirements from a business perspective, then converting this knowledge into a data mining problem definition and a preliminary plan designed to achieve the objectives.

Data understanding

The data understanding phase starts with initial data collection and proceeds with activities that will enable to become familiar with the data, identify data quality problems, discover first insights into the data, and/or detect interesting subsets to form hypotheses regarding hidden information.

Data preparation

The data preparation phase covers all activities needed to construct the final dataset, i.e. data that will be fed into the modelling tool(s), from the initial raw data. Data preparation tasks are likely to be performed multiple times and not in any prescribed order. Tasks include table, record, and attribute selection, as well as transformation and cleaning of data for modelling tools.

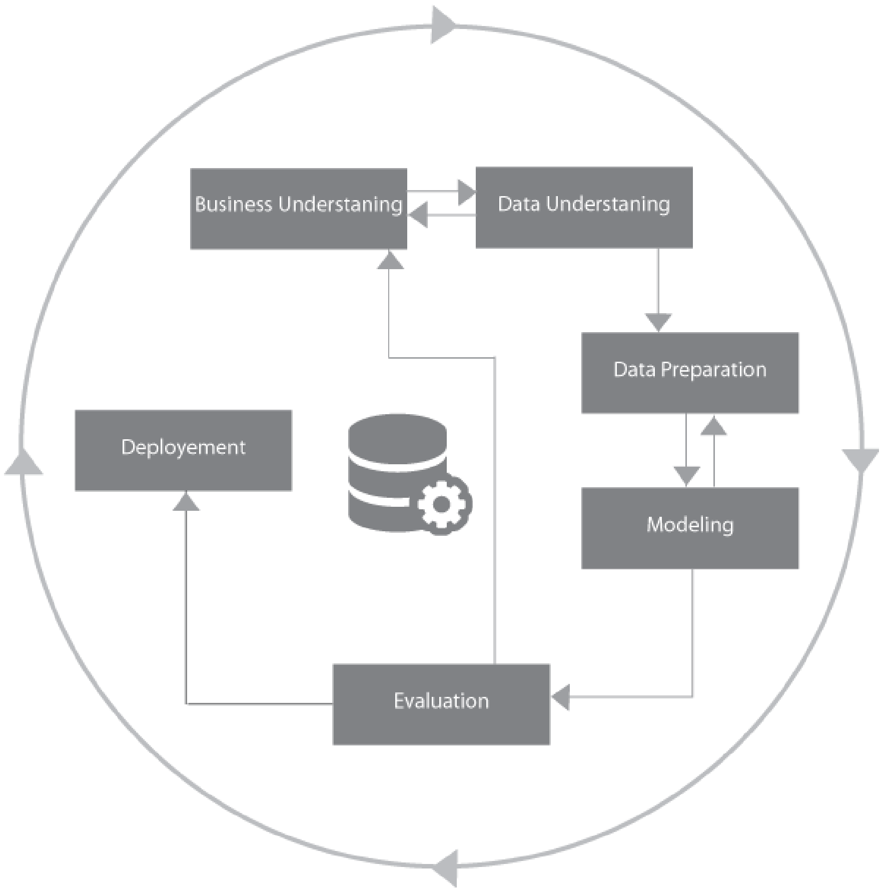

Figure 13: Life cycle for data mining available data in order to assess the effect of the Project's strategic interventions with respect to energy consumer engagement

Modelling

In this phase, various modelling techniques will be selected and applied, and their parameters will be calibrated to optimal values. Typically, there are several techniques for the same data mining problem type. Some techniques have specific requirements on the form of data. Therefore, going back to the data preparation phase might be necessary.

Evaluation

At this stage, models that appear to have high quality from a data analysis perspective will be built. Before proceeding to final deployment of the models, it is important to thoroughly evaluate them and review the steps executed to create them, to make sure that the models properly achieve the business objectives. A key objective will be to determine if there are any important business issues that have not been sufficiently considered. At the end of this phase, a decision on the use of the data mining results will be reached.

Deployment

Creation of the model is generally not the end of a project. Even if the purpose of the model is to increase knowledge of the data, the knowledge gained will need to be organized and presented in a way that the consumers can use and understand. Hence, the discovered intervention strategies that maximize consumers' engagement with energy efficiency will be again tested. This is due to the fact that in many cases, it is the consumer and not the data analyst, who should carry out the deployment steps.

Feedback and goal-setting are more effective when they are specific and proximate instead of aggregated and distal. Specific feedback improves error management by allowing consumers to see where actions misalign with goals, and adjust accordingly. It also provides confirmation about the effectiveness of consumers' actions, which is reinforcing and increases similar future behaviour. Instead, aggregate feedback is limited given it places the burden of disaggregation on the consumer, i.e. people typically get useful information from aggregate data by recollecting their activities and mentally decomposing a data graph, and consumers are likely to have difficulty discerning appliance patterns nearly as well as algorithms. It is worth noting that goal-setting has repeatedly enhanced the effectiveness of feedback in a variety of fields, including energy conservation, although it is not yet common in energy feedback programs.

Figure 14 illustrates the residential savings due to energy consumption feedback. The five left-most bars are derived from 36 different residential electricity studies. The right-most bar has been added to illustrate that disaggregation and its associated services (diagnostics, recommendations, channelling to programs, new behavioural techniques, targeted marketing, etc.) could be pivotal in achieving greater electricity savings. Achievable energy savings in residential buildings are estimated to be around 20%, taking population penetration into account.

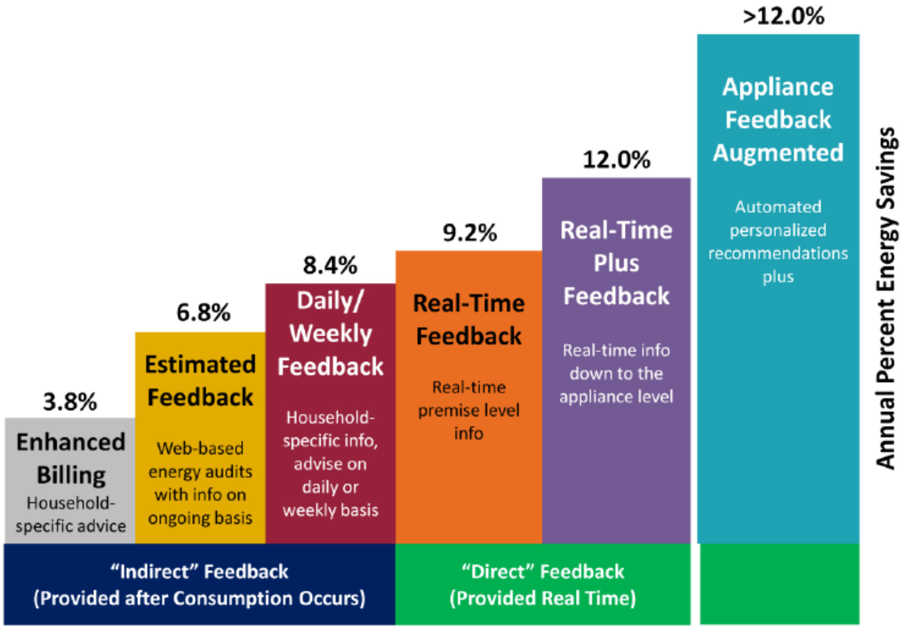

Figure 14: The effectiveness of different feedback approaches in terms of energy savings

The most important reason why appliance information facilitates greater energy reductions is that it enables automated personalized recommendations since identifies which specific Heating, ventilation and air conditioning (HVAC) systems, appliances, or electronics out of the dozens present could most effectively reduce energy use for a given household or business, and then enables the automated provision of additional information to overcome barriers and foster action.

Recommendations can take into consideration cost, projected energy savings over time, life-cycle energy impact, rebate offers, and local services, and even channel folks into such programs by geographically mapping options and scheduling services. Diagnostics can be performed, for example, to achieve auto-commissioning, i.e. recommended adjustments to the building operation to improve performance and efficiency and fault detection notifications if, for instance, an appliance should be fixed because it is consuming more energy than it should due to a malfunction or if an appliance should be replaced because the lifecycle energy use of a new appliance would be less than the current energy hog. When automated diagnostics are difficult, appliance data could enable remote or virtual diagnostics by experts. Hence, determining how much energy is consumed by different appliances is a first step, and automated recommendation and action systems come next to realize savings.

The quantification of behavioral change due to SOCIALENERGY intervention is not an easy task. It requires the ability to measure energy savings that derive from pure behavioral change. To achieve so, we will use advanced predictions algorithms along with an experimental design that can verify the cause-effect relationship between SOCIALENERGY and savings, as well as techniques such as A/B Testing. More specifically, we will involve (randomly at the beginning following a normal distribution) two or more groups to study the presence of statistically significant savings into the treatment groups (cause is presented) compared to a control group (the cause is absent). Additionally, in order to control over significant differences related to the variability of users' energy consumption data (due to different behavior or appliances features), the use of consumption predictions algorithms are required.

On a daily basis past meter measurements will be used to forecast the total expected consumption (in kWh) until current month's end (in short term of 1hour ahead and long term in day-ahead 24hr). The core algorithm used will be a machine learning-based regression model (support vector machines) that takes into account time-related and weather-related attributes in order to forecast energy consumption. Those features (attributes) are:

- Day-related attributes (day of week, business/working days) in order to capture typicality trends in consumption profile.
- Daylight hours for the specified time period.
- Weather-related (temperature, humidity and temperature-humidity index)

On each algorithm execution, the forecasting model is trained and fitted for each meter and then used to predict total consumption for the remaining days for the particular pilot site implementation. After prototyping the various alternatives described at the Prediction algorithm section above, we concluded that the most appropriate methods for the datasets at hand is the support vector regression (SVR). SVR yielded very good results with average root mean square error of ~10%. The overall SVR design is the following. Target variable is energy consumption (in kWh) while some important the features that will be used are:

- Temperature & Pressure: The average temperature & pressure during the day (or hour)
- Is Working day: A Boolean (yes/no) attribute indicating whether or not a particular day is business day or weekend/vacation day
- Total number of daylight hours for each day – or in the case of a single hour an indicator of whether that particular is hour of daylight
- Previous day consumption
- Previous week (or 3 weeks back) consumption for the same day/hour
- Weekday index

Since not all individuals will have the same potentials for savings due to different demographics, different comfort level, different environmental awareness level etc., not all individuals should be treated the same. Thus, a specific methodology will be used, depicted in Figure 15.

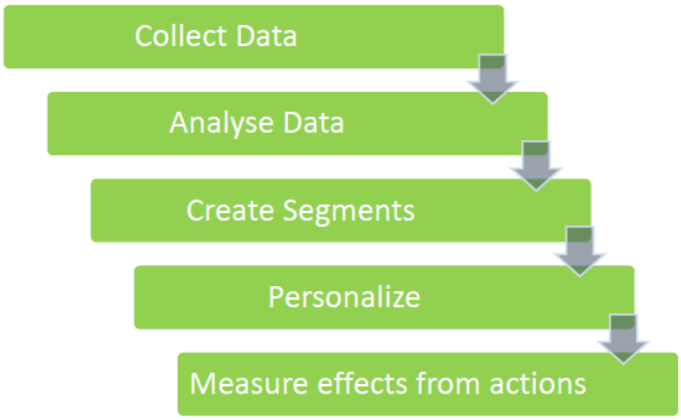

Figure 15: Behavioral M&V method/steps to follow in order to calculate actual savings from behavioral change

4. SOCIALENERGY use cases and system operation scenarios

In this section, we present the 2 SOCIALENERGY major use cases and respective scenarios (per use case) that together justify the motivation behind the development of SOCIALENERGY platform. The definition of use cases is based on: stakeholders' needs (see section 2), b) end users' needs (see section 2), and c) the strategic goals/key performance indicators (see section 3). In other words, we present how stakeholders and users/communities (section 2) can interact with each other towards realizing win-win situations. SOCIALENERGY is built around two use cases that interact with each other towards the maximization of user engagement. The first is SOCIALENERGY's educational and personalized e-commerce platform (GSRN). The second is SOCIALENERGY's virtual world (online Game).

4.1. Use Case no. 1

Use Case id	**UC 1**
Use Case Name	**SOCIALENERGY's Real World - GSRN platform**
Scope/Purpose	The scope of this use case is to define all main functionalities and steps that take place on the GSRN platform of SOCIALENERGY. All users will have a unique account on the GSRN portal that will be the starting point of their SOCIALENERGY user experience. GSRN will connect through APIs to all other components.
Detailed Description	GSRN will be the main core platform of SOCIALENERGY that will connect users and user profiles/demographics/user inputs, energy data, games and gaming interactions with stand-alone connected games, learning content through e-learning objects and relevant learning interfaces, marketplace and cross-selling services, virtual currency procedures for the rewarding schemes, will also connect to Facebook by creating social connected communities/users and finally will be using advanced analytics for recommendation engines and data monetization. GSRN will be the central S/W component of SOCIALENERGY, connected with APIs with: 1) an e-learning system (e.g. learning objects) to provide learning digital material to users (i.e. the LCMS), 2) a stand-alone Games and gaming ecosystems (API over single-sign-on procedures with a universal player/user ID), 3) of advanced analytics APIs (i.e. RAT subsystem), 4) MDMs – Meter Data Management systems for energy analysis. GSRN will have embedded functionalities that will be connected with all other SOCIALENERGY subsystems (i.e. LCMS, RAT and

	GAME). Users will create an online profile account (sing in also with facebook) and will be able to: • Track and manage/be informed on their energy consumption and various energy metrics on DR and Efficiency sectors. • Manage securely personal data, demographics and feed/input information about preferences, questionnaires, behavioural data input. • Get learning content (e-learning, training digital material, multimedia, etc.) and webinars/seminars/educational material/digital stuff based on their profiles, needs, energy performance feedback, interactions and gaming experience; This will be on a personalized approach using recommenders. Personalization will also apply to content and education, gaming, rewarding schemes and marketplace. • Download related mobile/stand-alone games, connect (login/sign-on) to the game (virtually connected to the GSRN platform) and play, by feeding data and interactions the GSRN user account. • Have access to personalized rewards, prizes and services through a push-pull marketplace; this will have a highly personalized approach. • Get transparent access to many analytics, reports and graphs. • Enjoy gamification elements (e.g. badges, leader-boards, coins). • Get and use virtual currency features, in order to redeem prizes and services from the embedded market place. • Follow friends and other users, by forming communities and monitor their individual GSRN timelines (follow, like, track, etc.) on a real-time basis over Facebook APIs. • The user will have a unique, unified Player/User ID, that will use it to play games, buy online services from marketplaces, track the DR and Energy performance, be part of on-line and off-line training and educational services and be identifiable on the analytics procedures. • Create a virtual character of the user, that will engage to games and to the physical experience, by connecting two worlds: the digital and the physical reality. • Connect this virtual character with a unique ID in order to exploit: educational levels, gaming level profile, preferences, specific energy and DR performance metrics and buying profile.
Actors	• SOCIALENERGY users/consumers • Utilities • ESCOs • 3rd Party players for Market Place
Current Status	Under design

Innovation	The uniqueness of the system is the combination of various external components on a unified dashboard that will enable SOCIALENERGY partners to assess and measure behavioral interactions and to calculate their impact on energy savings. Behavioral impact could be due to the DR, due to the gamification or gaming components or could be due to the personalized marketplace, or a combination of all the above.
Prerequisites, Constraints/ Restrictions	**Prerequisites** - All SOCIALENERGY APIs should be functional - MDM and real energy measurements - SOCIALENERGY Game deployed (App) - Questionnaire filled in for every user - External database of energy efficiency products - Learning content deployed **Constraints/ Restrictions** - Privacy of data will be secured according to the EU regulation and EU Ethics
Challenges	To sync all APIs to work together, assessing the impact of behavioral changes on actual energy savings (Behavioral M&V)
Relevance to WPs	WP3, WP5

In the rest of this subsection, the scenarios that UC 1 is able to host and serve are analysed.

4.1.1. Behavioural DR

Scenario id	**Scenario 1A**
Scenario name	**Behavioral DR**
Scope/Purpose	The scope of this use case is to define all main functionalities and steps that take place for the Behavioral DR case study of the GSRN users (SOCIALENERGY).
Detailed Description	The behavioural DR Case Study will be simple and participants will be suggested to reduce their energy consumption during certain hours of specific days. Every user will receive a specific message to drop his energy consumption by a specific amount in % in a specific slot of the day. The message will be through email, GSRN in-app message and through mobile txt message if necessary (synced at the same time). The user will acknowledge reception and GSRN will monitor the user's performance during the DR event and will assess savings after (M&V procedure).

	Users will be notified about their performance and will be able to see the actual savings in combined overlapped graphs and the community statistics they are part of.
Actors	• SOCIALENERGY users/consumers • Utilities
Current Status	Under design
Innovation	To adapt DR messaging to each user's profile and personality.
Prerequisites, Constraints/ Restrictions	**Prerequisites** - MDM Energy data/15 mins intervals - User questionnaires filled in - User emails/mobile numbers/GSRN accounts - User should be part of GSRN platform **Constraints/ Restrictions** - Energy data should have at least 1hr interval
Challenges	To find behavioral ways to engage users in this type of activities.
Relevance to WPs	WP3, WP5

4.1.2. Behavioural DR with Gamification

Scenario id	**Scenario 1B**
Scenario name	**Behavioural DR with Gamification**
Scope/Purpose	The scope of this use case is to define all main functionalities and steps that take place for the Behavioral DR case study with gamification extensions.
Detailed Description	The behavioural DR Case Study with gamification will be simple and participants will be suggested to reduce their energy consumption during certain hours of specific days in order to earn points that will lead to badges on a leaderboard. Every user will receive a specific message to drop his energy consumption by a specific amount in % in a specific slot of the day in order to earn points that will be communicated to users before the DR event. The message will be through email, GSRN in-app message and through mobile txt message if necessary (synced at the same time). The user will acknowledge reception and GSRN will monitor the user's performance during the DR event and will assess savings after (M&V procedure) and give him/her points based on his/her performance.

	Users will be notified about their performance and will be able to see the actual savings in combined overlapped graphs and the community statistics they are part of. Moreover, they will be able to see their points and badges and to compare their performance with other users.
Actors	• SOCIALENERGY users/consumers • Utilities
Current Status	Under design
Innovation	To adapt DR messaging to each user's profile and personality and also adapt the gamification rewards to achieve deep personalization on actual incentives.
Prerequisites, Constraints/ Restrictions	**Prerequisites** - MDM Energy data/15-min intervals - User questionnaires filled in - User emails/mobile numbers/GSRN accounts - User should be part of GSRN platform **Constraints/ Restrictions** - Energy data should have at least 1hr interval
Challenges	To actually map user psychographic profile with his/her energy profile and the incentive rewarding mechanism adapted to his/her personality (Social Norm).
Relevance to WPs	WP3, WP4, WP5

4.1.3. Participation in advanced energy programs (EPs)

Scenario id	**Scenario 1C**
Scenario name	**Energy Communities formation and advanced energy programs**
Scope/Purpose	The scope of this use case scenario is to define all main functionalities and algorithmic processes that take place for the creation and dynamic adaptation of Energy Communities (ECs) as well as the novel dynamic pricing mechanisms, which define the cost for each user and the respective credit distribution policies that are used by the proposed "Green Social Response Network" (GSRN) platform.
Detailed Description	In substitution of the traditional flat electricity tariff, pricing schemes include: Inclining Block Rates (IBR) pricing, time-of-use (ToU) pricing as well as real-time pricing (RTP) models. In the latter, the Utility solves an optimization problem (typically of minimizing the system's cost) in real-time and adjusts the prices for achieving the optimal solution, the major constraint being that all loads must be served within the entire time

	horizon. On the user's side, a different optimization problem is solved in response to the prices (typically of minimizing the electricity bill, while maximizing user satisfaction). The output of the latter is the loads' scheduling for all time instances in the scheduling time horizon. The new demand profiles are communicated back to the electric utility and used as feedback for re-adjusting the prices. The problem converges to the optimal prices and optimal load scheduling. By re-adjusting the prices according to the demand profiles, the "reverse peaks", that have been the problem of ToU models, are avoided. **SOCIALENERGY will develop innovative Energy Programs (EP) by investing in its innovative concepts, which are: Personalized RTP (P-RTP) and Energy Community RTP (EC-RTP).** Another prerequisite for participation in advanced EPs is the execution of "Energy Communities' creation and dynamic adaptation algorithms" that form the ECs that will participate in SOCIALENERGY platform and adopt the EC-RTP scheme. Most of today's aggregated demand response algorithms use statistical multiplexing techniques and only energy consumption curves (ECC) as input to realize gains for a set of multiple consumers, who "cooperate" to achieve a common goal, which is usually the cost minimization. In SOCIALENERGY, the creation of the ECs is based on multiple parameters that actually serve as input to the algorithms. An indicative list of these parameters is the following: a) ECC and DR flexibility curves of each user, b) real social relationships/connections, c) complementary user skills, d) demographics, e) user's will for participation as a result of the peer-pressure incurred by the use of SOCIALENERGY platform, f) underlying energy network topology. In this way, a social "peer pressure" is generated that acts as an additional motivation towards the desired behavioural change in energy consumption. **The determination of the optimal size of ECs falls into SOCIALENERY's objectives. They must be large enough in order to offer a degree of flexibility (include a subset of users eager to change their behaviour each time instant) and small enough in order to allow to their end users to dispose a significant portion of energy consumption by making them important and worth to be "pressed".**
Actors	• Utility (or else energy provider or energy supplier) • SOCIALENERGY platform (i.e. virtual energy communities) • Users (i.e. energy consumers)
Current Status	Dynamic PB-DR schemes: the pricing schemes that are used today are: a) flat price, b) IBR, c) ToU, and d) RTP. The EC creation schemes that are used today are using (as input parameter) only ECC and DR flexibility curves neglecting behavioral DR and other social and education-related KPIs. These schemes try to achieve better results by grouping/clustering multiple consumers in one group/cluster in order to harvest gains from the statistical multiplexing. The state-of-the-art results indicate that the best option is to group all

	consumers in one cluster (i.e. the larger the size of the cluster, the better).
Innovation	The novelty of the proposed pricing algorithms is that they achieve: a) optimality in terms of minimizing the system's cost, b) optimality in terms of maximizing user satisfaction, and c) fairness (i.e. each user should be billed according to his/her contribution). The novelty of the proposed EC creation and dynamic adaptation algorithms is that the optimal size of the EC should be defined as well as the multi-parametric inputs towards deciding each EC's size. The dynamic adaptation of an EC can be achieved by recommending some users to take another more beneficial EP or participate in a more efficient EC.
Prerequisites, Constraints/ Restrictions	**Prerequisites** - All required inputs for the research algorithms' execution should be available. **Constraints/ Restrictions** - Regulation-related constraints of some EC member states that do not permit the adoption of some of the proposed pricing schemes for real-life pilots and market uptake.
Challenges	To integrate the above-mentioned algorithms, which will run at the "Research Algorithms' Toolkit - RAT" S/W component into: • The GSRN for the credits' distribution to all real end users of SOCIALENERGY platform • The GAME mechanism for the calculation of the game's total points and score.
Relevance to WPs	WP3, WP5

4.1.4. Personalized marketing technologies and serious games exploitation

Scenario id	**Scenario 1D**
Scenario name	**Personalized marketing**
Scope/Purpose	The scope of this use case scenario is to define all main functionalities and steps that take place for the Personalized marketing Case study, combined with DR or other energy efficiency actions.
Detailed Description	Every user will be receiving specific push notifications/messages to drop his energy consumption in order to earn discounts to buy specific efficiency appliances from an online marketplace. The GSRN marketplace will also generate ad-hoc personalized offers for users, based on their energy profile and psychographics, without any DR generated event.

	The messages/offers will be through email, GSRN in-app message and through mobile txt message if necessary (synced at the same time). The user will acknowledge reception and GSRN will monitor his buying profile and his ability to use the new product to save energy. Users will be notified about their performance and will be able to see the actual savings in combined overlapped graphs and the community statistics they are part of. Moreover, they will be able to see other users' marketplace statistics and savings achieved by buying new relevant products from the GSRN marketplace.
Actors	• SOCIALENERGY users/consumers • Utilities 3rd Party companies in the marketplace
Current Status	Under design
Innovation	To adapt each user's profile and personality with his energy efficiency potential and his ability to buy specific efficiency appliances that will boost his green performance.
Prerequisites, Constraints/ Restrictions	**Prerequisites** - MDM Energy data/15-min intervals - User questionnaires filled in - User emails/mobile numbers/GSRN accounts - User should be part of GSRN platform - Product data base with specific KPIs from 3rd party companies (marketplace) **Constraints/ Restrictions** - Energy data should have at least 1hr interval - Products should have minimum description and kWh/CO2 information
Challenges	To actually map user psychographic profile with his energy profile and his buying potential adapted to his personality (Social Norm on Marketplaces)
Relevance to WPs	WP3, WP5

4.2. Use Case no. 2

Use Case id	**UC 2**
Use Case Name	**SOCIALENERGY's Virtual World - Game**
Scope/Purpose	The primary purpose of the virtual game will be to maximize the knowledge of its players regarding ways that they can improve their habits for more efficient energy consumption. For this particular reason, the consortium relies on the applied gaming and gamification principles.
Detailed Description	The concept of the SOCIALENERGY solution is to introduce the player to a number of game scenarios to reach the objective of shaping the energy consumption of a household or individual at the same time maximizing monetary profits and user satisfaction as well as to stimulate such behavioral shift on individual and community levels in a safe, risk-free environment of a virtual world – game. In such a virtual world, the player has to manage a virtual house with respect to energy consumption and following specific energy programs. For this, the player will have to accomplish a number of jobs that are going to be assigned to him/her during the course of the game. To achieve the scope and purpose set by the use case, a combination of a simulation and strategy game genre is selected. To better ensure the relatedness and engagement of the user, the virtual world will give a certain "freedom" to the player to design his/her own virtual world, although some boundaries and rules will be applied. The virtual home is represented in an isometric view with tile based squared objects. It is predefined so that all users have the same requirements. The player can: i) customize the virtual home by choosing different electric appliances and possibly decoration objects. In this case, the different balancing for multi-player mode must be considered, ii) unlock and place new devices (e.g. electric appliances), and iii) pay with a virtual currency to buy new devices.
Actors	Player (energy consumer)
Current Status	In concept and design phase
Innovation	The innovation in the game will be its ability to nudge the player in virtual environment and influence their real-life habits.
Prerequisites, Constraints/ Restrictions	**Prerequisites** - Android/iOS smartphone **Constraints/ Restrictions** - N/A
Challenges	To create an attractive game to be played by as many users as possible.
Relevance to	WP4, WP5

WPs	

4.2.1. Gaming Scenarios

There will four gaming scenarios representing the main energy programs. Each scenario has similar game goals and objectives, but substantially differs mainly due to the different energy program and pricing mechanism that is assumed.

Scenario id	**Scenarios 2 A-D**
Scenario name	**Four game scenarios based on the four main energy programs and pricing mechanisms**
Scope/Purpose	The player has to satisfy the needs of his avatar that lives in a virtual home by achieving the minimum energy consumption or the maximum energy efficiency. The needs of the player's avatar are influenced by interactions of the player with virtual electric appliances of the virtual home. The interactions are described and defined in "Jobs" the player must do (for example cook, wash, heat, work). These Jobs are related to the electric appliance, timeframes, time points, and durations. The electric devices are predefined and have parameters (i.e. size, energy consumption) the player can influence (i.e. switching on or off manually, reducing power, selecting mode, etc.).
Detailed Description	This overall main goal can be played in **four different scenarios** that treat the respective use case. The scenarios can be selected in a menu before the player starts to play. The menu shows the following scenarios: 1. **Fixed Pricing:** The user participates an energy program with fixed pricing and has to satisfy the needs of his avatar by achieving the minimum energy consumption or the maximum energy efficiency. 2.**Time-of-Use Pricing:** The user participates in an advanced energy program with dynamic pricing and has to satisfy the needs of his avatar (i.e. user satisfaction) by achieving the minimum energy consumption or the maximum energy efficiency, while the price is affected by his decisions. 3. **Real Time Pricing:** The user participates an advanced energy program with real time pricing and has to satisfy the needs of his avatar (i.e. user satisfaction) by achieving the minimum energy consumption or the maximum energy efficiency while the price is affected by his/her decisions and by the energy consumption from other energy consumers. 4. **Energy Community Pricing:** The user joins a community and participates an advanced energy program with real time pricing and has to satisfy the needs of his avatar (i.e. user satisfaction) by achieving the minimum energy consumption or the maximum energy efficiency, while the price is affected by his/her decisions and by the energy consumption

	from other energyconsumers. They have to communicate and make arrangements with each other in order to achieve the goal.
Actors	End-Users/Players
Current Status	In concept and design phase
Innovation	The innovation in the game will be its ability to nudge the player in virtual environment and influence their real-life habits.
Prerequisites, Constraints/ Restrictions	**Prerequisites:** - Android/iOS smartphone - EP formation - Electric appliances models **Constraints/ Restrictions** - Device OS and capabilities
Challenges	Attractive to end users, educational in terms of EE and EP understanding.
Relevance to WPs	WP4, WP5

5. End User and System Requirements' Analysis

This section analyses the major functional requirements based on the aforementioned use cases and scenarios from both end user and system perspectives. According to these requirements, the technical objectives and specifications of SOCIALENERGY are derived and they drive the technologies that are able to fulfil them. All these will be the foundation towards the development of the architecture of SOCIALENERGY that will be presented in D2.2 (Month 6).

5.1. Definition of SOCIALENERGY End User Requirements

There are various types of end users that will use the SOCIALENERGY S/W platform. The most important user categories are the following:

- Individual energy consumer (SOCIALENERGY real world's end user)
- Game player (SOCIALENERGY virtual world's end user)
- EC leader user
- ESCO user (or else system administrator user)
- Electric utility user
- Other external users (e.g. 3rd party entities, researchers, policy makers, etc.)

Below, there is a concise description per end user category:

Individual energy consumer (SOCIALENERGY real world's end user)	
End User Requirement description	This is the basic type of SOCIALENERGY system's end user. Each individual energy consumer should be able to log in to SOCIALENERGY platform and visualize various types of information from the GSRN GUI. The end user should also be able to perform various actions and to check/see his/her information, profile and relevant KPIs. Moreover, the user should be able to have access to the LCMS and to the Marketplace module from where he/she can purchase various energy efficiency products and energy programs. The user can also see his/her rewards, statistics and recommendation offers to switch to another more beneficial energy program. Finally, the user will be able to login to SOCIALENERGY platform via his/her facebook/twitter account and thus post any news to these social networks.

SOCIALENERGY game player user (SOCIALENERGY virtual world's end user)	
End User Requirement description	This is the SOCIALENERGY game player user. As the SOCIALENERGY GAME will be a game that can be played by any individual, even by those who are not directly enjoying SOCIALENERGY's services, the game player user will be able to download the game and install in his/her smartphone, tablet and any other mobile device that supports Android and iOS. Of course, every SOCIALENERGY real world's end user should be able to login to the virtual world (i.e. game), too by using the same credentials (i.e. single sign-in procedure). The game player user will then be able to play the energy efficiency game in a simulated world that simulates the energy consumption/operation of his/her own household receiving tasks/jobs, which will enable them to move on through the course of the game.

EC leader user	
End User Requirement description	The Energy Community (EC) leader user has got the same requirements with the individual energy consumer user described above. However, this user account should have some additional "super-user" rights such as: a) monitoring the KPIs and performance of the virtual energy community that he/she is leading, b) recommending learning content/material to the members of his/her EC, c) engaging the members of the EC to various new features of the SOCIALENERGY S/W platform, etc. The EC leader will also be able to enjoy some more services from the SOCIALENERGY platform such as greater discount coupons for purchasing energy efficiency products.

ESCO user (system administration user)	
End User Requirement description	The ESCO user is the one who administers the whole SOCIALENERGY S/W platform. SOCIALENERGY aims at becoming a commercial product after the end of project's lifetime and it will be owned by an Energy Services Company (ESCO). As a result, there should be an ESCO user (or else system administration user), who should be able to decide about all platform's updates, material/content uploads, reporting and recommendation rules, etc. The ESCO user should also be able to create learning plan templates and coordinate the use and learning materials/content of the LCMS. The ESCO user should also have access to the RAT subsystem to execute algorithms under different scenarios, visualise the results, and send actuation commands to the other modules, as well as recommendations to the end users. Based on RAT simulation results, the ESCO user should be able to update the company's policies and business strategy (e.g. create more and smaller ECs, introduce a new EP and/or withdraw an EP that is not popular among the individual energy consumers, etc.).

Electric utility user	
End User Requirement description	The electric utilities are the main customer segment of SOCIALENERGY's business model, while most of the value propositions are closely inter-related with the utility's business. As a result, the utility user should be able to log in to the SOCIALENERGY S/W platform and administer the various (dynamic pricing) energy programs (EPs). For example, the utility user should be able to track/monitor the ongoing performance of all available EPs and various user engagement KPIs. Finally, the utility user should be able to run simulation algorithms in RAT subsystem to identify the best utility's strategy for the future.

Other external users	
End User Requirement description	GSRN platform will be able to offer various open APIs for data access from 3rd party entities (EC, policy makers, companies, etc.) based on the Open Data approach. Data privacy and anonymity will be preserved according to EU Data Privacy directives and Ethical Laws. As a result, various types of external users should be able to have access to the Energy Information Distribution as a Service (EIDaaS) offered by SOCIALENERGY S/W platform. The external user should also be able to use RAT in order to set his/her own simulation scenario and run a specific SOCIALENERGY research algorithm. Then, he/she will be able to visualize the performance evaluation results and possibly extract them in a single file in case of further need for editing. In other words, the user will be able to set his/her own input parameters and experiment with the results. An individual researcher should be able to exploit RAT as an e-infrastructure for algorithms' experimentation (i.e. dynamic pricing algorithms for smart grid and EC creation and dynamic adaptation) for academic purposes.

5.2. Definition of SOCIALENERGY System Requirements

In this subsection, the functional requirements per S/W component, subsystem and system as a whole are defined by using a specific template. In more detail, the requirements for: GSRN, RAT, game and LCMS as long as requirements for peripheral functionalities of SOCIALENERGY are presented. In addition, the requirements for the interactions among the aforementioned subsystems are depicted.

The next step (after the requirements' analysis) will be the definition of the technical specifications in D2.2 (Month 6).

5.2.1. Requirements for the core GSRN platform

In the following table, the list of the GSRN platform's S/W modules is presented. Moreover, in the figure below, the technical APIs between the GSRN platform and all other SOCIALENERGY subsystems (or else S/W components) are also depicted.

Table 4: GSRN Software modules

	S/W module	Description
1	e-learning module/training	Everything about digital e-learning
2	Market-Place module	Cross market-place services
3	Rewarding Mechanism module	Virtual currency and rewarding scheme

4	Analytics module/Visualization	Analytics outputs/KPIs/metrics/graphs
5	Energy module	Energy graphs/DR/Efficiency/M&V
6	User Profile module	User inputs/surveys/behavioral
7	Gaming profile module	Gaming KPIs/game performance
8	External APIs modules	API/Data monetization
9	Social/FB module	Social features/timeline/FB/community

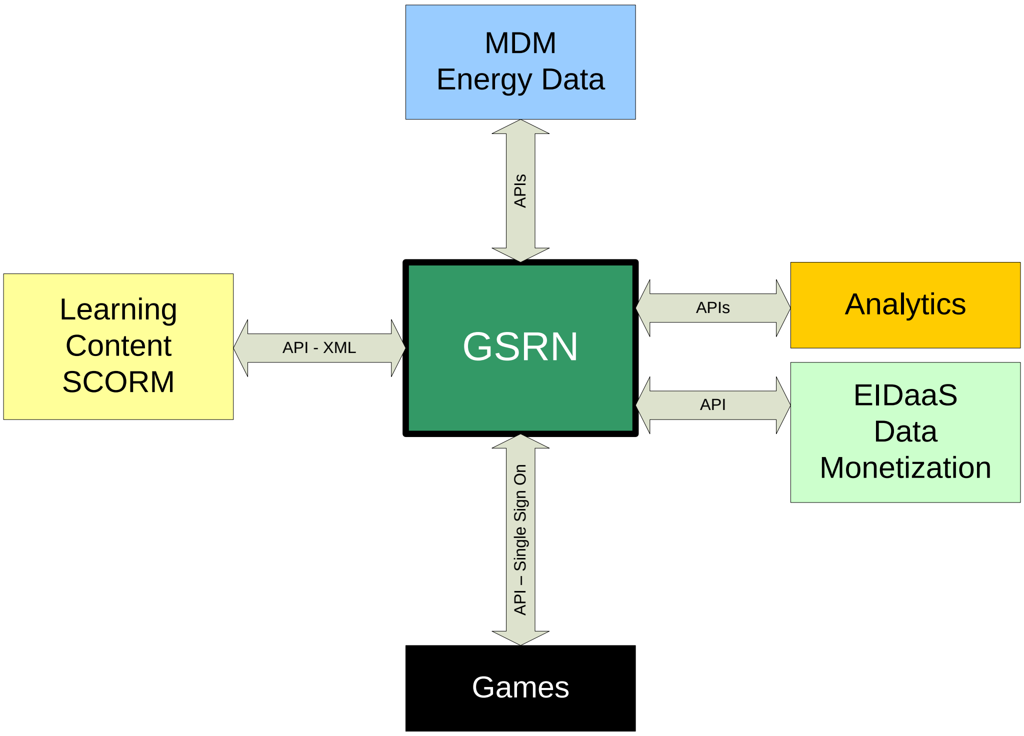

Figure 16: GSRN interactions with all other SOCIALENERGY subsystems

Title		
GSRN Central User DashBoard		
Code	**Component**	**Priority**
GSRN-RQT_01	GSRN	Essential
Description		
GSRN will have a central dashboard, where the users will be able to perform various actions and to check/see their information and relevant KPIs; The central dashboard will get data from various APIs from all other SOCIALENERGY components and will visualize: energy data (Energy module), User information (User Profile module) and the leaderborads/rewards (rewarding mechanism module and Gaming module). Also the user will have access to various reports (Analytics and Reporting module)		
Notes		
All APIs will be bi-directional to and from the GSRN platform.		

Title		
GSRN e-learning/Training		
Code	**Component**	**Priority**
GSRN-RQT_02	GSRN	Essential

Description
GSRN will give access to the external e-learning module, where users will be able to take part in educational programs, regarding SOCIALENERGY activities; GSRN e-learning module will get back educational KPIs for analysis and for the user interaction (grades, educational engagement, drop outs, etc). Also existing and new modules and courses will be visible in the dashboard.
Notes
A specific API will be used.

Title		
GSRN marketplace		
Code	**Component**	**Priority**
GSRN-RQT_03	GSRN	Essential
Description		
GSRN will have a marketplace module, where all external products and services (efficiency, appliances, etc) will be accessible to the users. User will see prices, kWh, C02 emissions and savings potential and will be able to buy on line. Products and services will also have relevant KPIs to help users in the decision process and for analytics purposes later on (reporting, impact analysis, etc)		
Notes		
A specific API will be used.		

Title		
GSRN External APIs		
Code	**Component**	**Priority**
GSRN-RQT_04	GSRN	Essential
Description		
GSRN platform will be able to offer various open APIs for data access from 3rd party entities (EU tools, companies, etc.) based on the Open Data approach. Data privacy and anonymity will be preserved according to EU Data Privacy directives and Ethical Laws.		
Notes		
Various APIs will be published and will be available for Open Data initiatives.		

Title		
GSRN Social modules		
Code	**Component**	**Priority**
GSRN-RQT_05	GSRN	Essential
Description		
GSRN system will also have the ability to connect with Social platforms (Facebook and Twitter). Users may have the ability to log in using their Social Net credentials and will be able to post actions and news from the GSRN platform to their social accounts. Social interactions will be used for analytics and impact analysis. Also communities will be formed based on user's social graphs and KPIs.		
Notes		
Facebook and possibly Twitter APIs will be used.		

5.2.2. Requirements for the SOCIALENERGY game

Title		
The virtual game should be a mobile end-user interaction point with the virtual world		
Code	**Component**	**Priority**
GAME-RQT_01	GAME	Essential
Description		
The virtual game on Android/iOS will contain a simulated world, where the users can play as they are in there own household and will receive tasks, which will enable them to move on through the course of the game. The future mobile game will be developed using cocos2d-x game engine – a suit of open-source, cross-platform game development tools. The game will be easily recognizable to a broader public as a selected style will replicate an isometric view of many commercially successful games on the market.		
Notes		
The game will be developed by an industrial partner using proprietary engine therefore IP protected.		

Title		
Straightforward solution for communication between variety of subsystems/components of SOCIALENERGY platform		
Code	**Component**	**Priority**
GAME-RQT_02	GAME	Essential/Optional
Description		
The RESTFul Competency API will allow the SOCIALENERGY game to easily communicate with the GSRN platform, the RAT and the LCMS.		
Notes		
N/A		

Title		
Attractive GUI is of crucial importance		
Code	**Component**	**Priority**
GAME-RQT_03	GAME	Essential/Optional
Description		
To ensure user relatedness, adherence enjoyment and consequently educational and behavioural change processes, apart from engaging gameplay, the game and virtual world have to have appealing look and feel presented through an attractive GUI.		
Notes		
The scope here is the high level of attraction and engagement of end users.		

Title		
The game should ensure longevity		
Code	**Component**	**Priority**
GAME-RQT_04	GAME	Essential/Optional

Description
To ensure that the educational process lasts over time and does not end upon completion of certain tasks, the game should have an open-end (in other words won't end if the user completed all the tasks and reached the highest level). New tasks will be constantly generated adapting the difficulty levels of the game and receiving new EPs from RAT subsystem.
Notes
N/A

Title		
Addressing ethical issues within the game		
Code	**Component**	**Priority**
GAME-RQT_05	GAME	Essential/Optional
Description		
The relatedness of the user to the virtual world can be ensured through the introduction of the avatar that interacts with virtual objects in the game. Along with this feature, additional requirements arise such as the gender of the avatar, skin colour, etc. For this reason, the proposed solution is to offer an avatar editor, where the user will have the possibility to design its own avatar.		
Notes		
This feature might be complex and time consuming and therefore the granularity of the avatar editor will be defined later.		

5.2.3. Requirements for the Research Algorithms' Toolkit - RAT

The "Research Algorithms' Toolkit" (RAT) is one of the major SOCIALENERGY subsystems and communicates with technical APIs (i.e. RESTful APIs and/or Message-Oriented Middleware – MOM) with the other SOCIALENERGY subsystems such as the MDM subsystem, the GAME and the GSRN platform. The RAT requirements' analysis is provided below:

Title		
RAT should be an open-source S/W offering a user-friendly web interface		
Code	**Component**	**Priority**
RAT-RQT_01	RAT	Essential
Description		
The S/W implementation will be based on open-source code in order for the toolkit to be further exploited beyond project's lifetime by other EU projects, individual researchers and even business companies. The web interface will be user-friendly so that the user can be easily and efficiently navigated through all of its features and functionalities.		
Notes		
RAT S/W will be uploaded at public repository (e.g. GitHub) and be publicly accessible.		

Title		
RAT should have a fine-grained API with the MDM subsystem to receive all energy consumption datasets		
Code	**Component**	**Priority**
RAT-RQT_02	RAT	Essential
Description		
RAT will receive all energy consumption curves and DR flexibility curves from the Meter Data Management subsystem. The API will be designed in a way that any combination of individual and/or set of energy consumers will be retrieved upon request by RAT. These datasets will then be stored in RAT's database.		
Notes		
More technical details about the structure of this API will be provided in D2.2.		

Title		
RAT should offer efficient visualization capabilities regarding the energy consumption curves (ECC) and other user and EC profiling data		
Code	**Component**	**Priority**
RAT-RQT_03	RAT	Essential
Description		
RAT will have a visualization interface in order for the user to be able to visualize any possible individual consumption profile for any given timeframe and for any given time granularity (e.g. 15-min, 1-hour, 1-day, etc). Any combination of ECCs of multiple energy consumers can also be visualized via graphical representations. User/EC DR flexibility, cost and satisfaction curves can also be visualized.		
Notes		

Title		
RAT should allow multiple user categories		
Code	**Component**	**Priority**
RAT-RQT_04	RAT	Essential
Description		
The RAT module should allow for access to the system, through differentiated access levels. Normal users will be able to access only their own data/profiles, whereas administrative users will be able to execute algorithms under different scenarios, visualise the results, and send actuation commands to the other modules, as well as recommendations to the end users.		
Notes		

Title		
A well-designed web GUI should be available for the end user to run the various research algorithms and visualize the performance evaluation results		
Code	**Component**	**Priority**
RAT-RQT_05	RAT	Essential

Description
The user of RAT will be able to set his own simulation scenario and run a specific SOCIALENERGY research algorithm. Then, he/she will be able to visualize the performance evaluation results and possibly extract them in a single file in case of further need for editing. In other words, the user (experimenter) will be able to set his/her own input parameters and experiment with the results.
Notes
The user should be able to exploit RAT as an e-infrastructure for algorithms' experimentation (i.e. dynamic pricing algorithms for smart grid and EC creation and dynamic adaptation) for academic purposes.

Title		
Results from the research algorithms' execution should be easily stored, accessed, retrieved and possibly further exploited in the future		
Code	**Component**	**Priority**
RAT-RQT_06	RAT	Essential
Description		
The proposed research algorithms (i.e. the most important variants) regarding the dynamic pricing and the EC creation and dynamic adaptation should be integrated in RAT. The user should be able to provide his/her input parameters via a web GUI, then see the execution of the algorithm and visualize the results. Results should then be stored in RAT database and should be easily accessed and retrieved by the user in order to make any further data process.		
Notes		
Following the open source S/W rationale, there should be indicative instances of the most important and representative results of some algorithms' execution publicly available. For example, these instances may be the ones presented in published scientific journal and international conferences mainly by ICCS.		

Title		
All data should be efficiently stored and retrieved from the RAT's database		
Code	**Component**	**Priority**
RAT-RQT_07	RAT	Essential
Description		
RAT Database should be able to store consumer's initial information, when he/she is registered in the SOCIALENERGY system for the first time. All datasets coming from the various APIs with the other SOCIALENERGY subsystems (i.e. MDM, GAME and GSRN) should be efficiently stored in the database. During the execution of the RAT algorithms, the appropriate data should be efficiently retrieved by the database and the respective results should be then stored (in real-time basis) in the same database.		
Notes		
More technical details about the structure of the RAT DB will be provided in D2.2 (M6).		

Title		
User/EC profiling and searching functionalities should be supported		
Code	**Component**	**Priority**
RAT-RQT_08	RAT	Essential

Description
The RAT provides a web GUI from which the user is able to search and select any combination of consumer/EC category and thus be able to visualize and extract any subset of consumer and/or EC. Profiles of energy consumers are created via static information (e.g. age, gender, location, education level, habits, etc) and dynamic information (e.g. energy consumption curve history, EC participation history, EP participation record, purchase of energy efficiency services/products, points gained from playing with GSRN platform's gamification components and SOCIALENERGY's game). The profile of each consumer will be continuously updated and RAT will be informed about any change periodically receiving information from GSRN and the GAME (e.g. about any new badge, game level, points/score milestone achieved by the user/player, etc.).
Notes
The continuously updated profiles will be utilized as input for task's 3.2 algorithms and task's 3.3 credit distribution modules.

Title		
Intelligent Reporting and Recommendations for the participation in advanced EPs should be supported		
Code	**Component**	**Priority**
RAT-RQT_09	RAT	Essential
Description		
The results of EC creation and dynamic adaptation algorithms should be used to provide reports, suggestions and recommendations to consumers and/or EC leaders to take a more beneficial EP, to participate in another EC that falls within their particular interests and competences, etc. This functionality should be supported in cooperation with GSRN platform.		
Notes		
More context-aware recommendations will be provided by: a) GSRN based on the real users' activity within the platform, and b) LCMS recommender system based on the learning-related activities that each user may experience.		

Title		
EC creation S/W module should host the EC creation algorithms		
Code	**Component**	**Priority**
RAT-RQT_10	RAT	Essential
Description		
In this S/W module, the EC creation algorithms will be running. Different variants of the multi-parametric algorithms (i.e. various combinations of input parameters that are taken into consideration) will be integrated in RAT.		
Notes		

Title		
Dynamic EC adaptation S/W module should host the EC dynamic adaptation algorithms		
Code	**Component**	**Priority**
RAT-RQT_11	RAT	Essential

Description
In this S/W module, the dynamic EC adaptation algorithms will be running. Based on specific thresholds that can be set as input parameters, the ECs will be able to change and some members of one EC to move in another EC for various reasons (e.g. the size of the community is too large or too small, the competences of the user match better with another EC, the DR flexibility profile of a user has changed, etc.).
Notes

Title		
Dynamic pricing S/W module should host all proposed dynamic pricing algorithms and policies		
Code	**Component**	**Priority**
RAT-RQT_12	RAT	Essential
Description		
This S/W module should be able to host the execution of various dynamic pricing algorithms such as (indicatively): inclining brock rates (IBR), Time-of-Use (ToU), real-time pricing (RTP), Personalized RTP (P-RTP) and EC-RTP.		
Notes		
Mathematical equations (in their simplistic form) for all dynamic pricing algorithms will be provided to the GAME and the GSRN for the total game points/score calculations and the credit distribution policies among GSRN user respectively.		

Title		
RAT should have a fine-grained API with the GSRN subsystem to receive all real user behavioural data from GSRN		
Code	**Component**	**Priority**
RAT-RQT_13	RAT	Essential
Description		
The RAT-GSRN API should support the information exchange about the complex profiling of the real users. This profile includes some static data (e.g. age, gender, location, education level, habits, etc) and dynamic information (e.g. energy consumption curve history, EC participation history, DR flexibility and reliability curves' history, EP participation record, purchase of energy efficiency services/products, points gained from playing with GSRN platform's gamification modules, etc. In addition, the RAT module should return to the GSRN algorithmic results.		
Notes		
More technical details about the structure of this API will be provided in D2.2 (M6).		

Title		
RAT should have a fine-grained API with the GAME subsystem to calculate the game's total points and scores and receive all players' behavioural data from the GAME		
Code	**Component**	**Priority**
RAT-RQT_14	RAT	Essential

Description
The RAT-GAME API should be able to support the information exchange that allows the RAT algorithms to get informed about the evolution of the game play for each user/player in order to be able to update the user's profile, which is used as input in the EC creation and dynamic adaptation algorithms. The algorithms need to be periodically updated regarding the game status and imply the learning level of each participating user/player within a given timeframe. In addition, the RAT may return algorithmic results (e.g. EC membership) to the GAME
Notes
More technical details about the structure of this API will be provided in D2.2 (M6).

5.2.4. Requirements for the Learning Content Management System - LCMS

Title		
LCMS should be a free and open-source software learning management system		
Code	**Component**	**Priority**
LCMS-RQT_01	LCMS	Essential
Description		
The LCMS should be free and open-source. It should be easy for users to work with the LCMS. It should be flexible, with accessible and responsive design.		
Notes		
Source code will be available in public source code repository.		

Title		
LCMS should support competency based education		
Code	**Component**	**Priority**
LCMS-RQT_02	LCMS	Essential
Description		
LCMS will provide personalised learning combined with possibilities for collaborative learning and group learning. It will allow personalised dashboard and individual learning plan. It should support all major pedagogical methods for learning. Teachers can create learning plan templates and apply them to entire groups or individual learners.		
Notes		
Source code will be available in public source code repository.		

Title		
LCMS should provide competency based learning		
Code	**Component**	**Priority**
LCMS-RQT_03	LCMS	Essential
Description		
LCMS should support competency based learning and assessment. It will provide to users functionalities for creating competency frameworks and link them to courses; manually add competencies to any task of course; generate competency report for each learner; submit evidence of validity that the learner has reached a level of competence that are appropriate for the purposes of training plan.		

Notes
Source code will be available in public source code repository.

Title		
LCMS should follow open standards		
Code	**Component**	**Priority**
LCMS-RQT_04	LCMS	Essential
Description		
LCMS should be interoperable, standards compliant, support external modules inclusion, external digital repositories and sophisticated file management. It should support open standards like integrated Badges (motivate learners and reward participation and achievement with customised Badges), open assessment (different flexible outcomes and rubrics), select from advanced grading methods to peer and self-assessment, built-in activities such as workshops and surveys, as well as to support various marking workflows.		
Notes		
Source code will be available in public source code repository.		

Title		
LCMS should support social functions		
Code	**Component**	**Priority**
LCMS-RQT_05	LCMS	Essential
Description		
Users can easy communicate through flexible system of forums and communication channels. They can form user groups and send messages to other learners and teachers. The system should support various methods for helping novice learners.		
Notes		
Source code will be available in public source code repository.		

Title		
LCMS should provide a RESTful Competency API		
Code	**Component**	**Priority**
LCMS-RQT_06	LCMS	Essential
Description		
The RESTFul Competency API will allow LCMS to communicate with the other subsystems learners' competencies and levels' of proficiency, searching for LOs identified by a competencies from the EED-KM.		
Notes		
More technical details about the structure of this API will be provided in D2.2 (M6).		

Title		
LCMS should provide an Authentication API		
Code	**Component**	**Priority**
LCMS-RQT_07	LCMS	Essential

Description
Users must use a single ID and password to gain access to each subsystem without using different usernames or passwords. The Authentication API should support identity protocols like OpenID Connect, OAuth 2.0.
Notes
More technical details about the structure of this API will be provided in D2.2 (M6).

6. Conclusions

Conclusively, during the next months, SOCIALENERGY consortium will elaborate on the current work presented in this deliverable towards designing the final version of SOCIALENERGY system architecture and starting the S/W implementation work. Step-wise, the actual work schedule plan is the following:

- Tasks 2.1-2.3 dealing with the: a) definition of use cases, system operation scenarios, technology transfer assets (Task 2.1), b) analytics for GSRN platform's users, components and educational modules (Task 2.2), and c) analytics for gaming, gamification components and virtual objects (Task 2.3) have been successfully accomplished and the results are incorporated in the current report.
- Until Month 6 (M6), the consortium will elaborate on D2.1 results to design the final version of SOCIALENERGY system architecture and provide the technical specifications for all SOCIALENERGY subsystems as well as the technical APIs for the interaction among the various subsystems (D2.2).
- Meanwhile, all partners have started the initial S/W implementation. Each partner works on its own subsystem and has a very concrete role.
- From M9 onwards, all partners will start collaborating towards integrating each individual subsystem into the single SOCIALENERGY S/W platform.

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