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

H2020 ICT-731767

The overall SOCIALENERGY architecture design and system specifications

Deliverable D2.2

Document Information

Scheduled delivery	30.06.2017
Actual delivery	28.06.2017
Version	Final
Responsible Partner	INTELEN

Dissemination Level

Public

Contributors

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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 terminology

Acronym	Definition
D	Deliverable
DoA	Description of Action
EC	European Commission
WP	Work Package
UC	Use Case

Technical terminology

Acronym	Definition
API	Application Programming Interface
CBE	Competence Based Education
CP	Configuration Panel
DAM	Data Acquisition Module
DB	Data Base
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
ESCO	Energy Services Company
GL	Game Loop
GPA	Gaming Profile Administrator
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
LM	Learning Manager
LO	Learning Object
LTI	Learning Tool Interoperability
MDMS	Meter Data Management System
PA	Price Administrator

PB-DR	Price Based Demand Response
P-RTP	Personalized Real Time Pricing
PSM	Profiling and Searching Module
RAM	Research Algorithms Module
RES	Renewable Energy Sources
RTP	Real Time Pricing
SCORM	Sharable Content Object Reference Model
SVR	Support Vector Regression
S/W	Software
TIPI	Ten Item Personality Index
ToU	Time of Use
UAD	User Admin Dashboard
USaaS	Utility Selection as a Service

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Document History

The aim of this deliverable is to exploit the output of Task 2.4. It includes the overall SOCIALENERGY architecture design and technical specifications. These are based on the D2.1 work on use case scenarios and requirements' analysis from both the end user's and system's perspective.

Table 1: Document History Summary

Revision Date	File version	Summary of Changes
17/03/2017	v0.1	Draft ToC circulated within the entire consortium.
04/04/2017	v0.2	Final ToC has been agreed among all partners during the 2nd project's plenary meeting in Athens.
10/05/2017	v0.3	ICCS provided its 1st round of contributions and provided writing guidelines to all partners.
30/05/2017	v0.4	1st round contributions by SU-NIS, NRG and INTELEN.
09/06/2016	v0.7	2nd round contributions by all partners based on comments from the 1st round internal review.
16/06/2017	v0.9	INTELEN has incorporated material from all partners and provided the pre-final version for review.
28/06/2016	Final	ICCS reviewed the deliverable and after some required enhancements, the deliverable was submitted in ECAS portal.

Executive Summary

This report is the second official deliverable of H2020 SOCIALENERGY project dealing with the in-depth description of the SOCIALENERGY's architecture design and analysis of the system specifications. D2.2 elaborates on the contents of D2.1, which refer to the SOCIALENERGY use cases, system operation scenarios and functional requirements' analysis. SOCIALENERGY is an innovation project and its implementation is 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 interacting multi-disciplinary technology assets aim at the development of new innovative functionalities in the converged ICT/energy commercial sector.

SOCIALENERGY system consists of four (4) main subsystems (or else S/W components), namely the:

- **Green Social Response Network (GSRN) web platform**, whose concept is based on an existing commercial product, which is called DiG[1] and belongs to INTELEN's portfolio. It is offered (at the time being) to existing electric utilities/retailers, whose aim is to offer advanced energy services to their customers (i.e. energy consumers). GSRN will be the core S/W platform of SOCIALENERGY, in which all the other subsystems will be integrated.
- **SOCIALENERGY GAME**, which is developed mainly by Nurogames (NRG). The GAME is actually a virtual world (or else virtual home), where the user (i.e. energy consumer) is seamlessly educated on best practices regarding energy efficiency and the operation of liberalized electricity markets. The goal is for the user to be able to apply the knowledge experienced from the virtual world to the real world, which is actually done through the use of the GSRN platform. NRG will develop the GAME from scratch and by exploiting its business experience on serious/applied games as well as classic entertainment games[2].
- **Research Algorithms' Toolkit (RAT)**, which provides all the required "intelligence" towards making SOCIALENERGY product competitive enough and commercially successful in a sustainable manner. It provides "data analytics" services mainly to GSRN, but also to the GAME (by integrating the sophisticated mathematical modeling in the GAME scenarios and score calculations). ICCS elaborates on the implementation of the existing VIMSEN Decision Support System (DSS) toolkit[3] by exploiting the existing algorithms and by incorporating new algorithms related with innovative Energy Programs (dynamic pricing) and virtual energy communities' creation and adaptation.
- **Learning Content Management System (LCMS)**, which is developed by Sofia University (SU-NIS). In LCMS, the user/player educates himself/herself offline to consolidate the new knowledge about good practices on energy efficiency. The role

[1] INTELEN's DiG platform, https://intelen.com/us/solutions/dig.html
[2] NUROGAMES portfolio on Applied games: https://www.nurogames.com/appliedgames/ and related R&I projects https://www.nurogames.com/research/
[3] FP7 ICT-619547 VIMSEN project (2014-2017), https://github.com/vimsen, https://dss.ict-vimsen.eu/

of the LCMS is important because it provides the user the opportunity to better comprehend the new concepts in the liberalized smart grid markets and inter-relate the "lessons learned" from the GAME with the real-life conditions (cf. GSRN) in order to be able to efficiently interact with his/her electric utility/retailer.

The above-mentioned subsystems are complemented by two more S/W components, which are the Meter Data Management System (MDMS) and the innovative Energy Information Distribution as a Service (EIDaaS) API. MDMS actually serves as SOCIALENERGY's database, where all energy-related datasets and models are available. EIDaaS aims at providing "data monetization" services and bridging the gap between energy consumers and companies as well as among multiple other stakeholders related to the energy efficiency sector.

The structure of the deliverable is the following:

Chapter 1 describes the main SOCIALENERGY idea, scope and purpose. The technical objectives are outlined and briefly described. Finally, a clear roadmap until the end of project's lifetime is derived regarding the S/W implementation activities with respect to project's milestones, too.

Chapter 2 summarizes the contents of D2.1 (M4) regarding the work that has been already done during the first 4 months of the project (i.e. use cases, system operation scenarios, requirements' analysis from both end users' and system's perspective, etc.).

Chapter 3 provides an overview of the overall SOCIALENERGY architecture. Each one of the S/W components and respective S/W modules are described as well as the application programming interfaces (APIs) and interactions among the various S/W components (inter-subsystem interactions) and the various S/W modules (intra-subsystem interactions).

Chapter 4 lists all technical specifications by following a specific template format. Based on these specifications, the S/W implementation per subsystem has already started by the consortium's S/W development team. At a first stage, each partner focuses on the individual implementation of each subsystem, while initial S/W integration activities will start taking place after M9.

Finally, chapter 5 concludes the report and summarizes the major action points of the consortium for the upcoming months.

1 Scope and purpose of deliverable

This chapter summarizes SOCIALENERGY's scope, its technical objectives, its expected impact, its high-level (functional) architecture design and provides a concrete implementation plan until the end of SOCIALENERGY's lifetime (i.e. June 2019).

1.1. SOCIALENERGY objectives and expected impact

The ultimate inspiration as well as goal of SOCIALENERGY is the easy, rich and deep communication among the energy sector stakeholders and residential energy consumers that will allow them to: a) discover each other and their needs, b) educate themselves towards a better understanding of the difficulties and the challenges that each one faces and c) interact and trade with each other especially in the form of innovative energy programs that will soon be introduced in EU's liberalized electricity markets. All these will lead to a more energy efficient, free from energy dependencies and environmentally friendly society.

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.

In order to motivate/engage energy consumers and energy efficiency companies to deeply interact and to pleasantly educate both parties, SOCIALENERGY exploits gaming and gamification technologies that are "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

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.

1.2. 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). As depicted in the figure, there is a perpetual information and knowledge flow among the 3 gamification steps in a way that all types of users (i.e. individual energy consumers, EC leaders, electric utilities, ESCO users) are continuously educated towards understanding their role in the smart grid market/system and the needs/interests of all other related market stakeholders in a liberalized electricity market context. The proposed GSRN S/W platform is "Green", because it facilitates and enables the use of clean energy and good practices on energy efficiency focusing on the residential sector. It is also "Social", because its users are able to participate in virtual/online energy communities and communicate with other peers, who have the same interests or even communicate with other commercial stakeholders understanding better their needs/interests. Finally, GSRN is also "Response Network", because it enables/facilitates efficient demand response procedures to take place and motivates the individual energy consumers to change their behavior in the way that they consume energy in their everyday lives. The result of this process will ultimately lead to environment-friendly use of energy resources, the efficient operation of liberalized electricity markets and the realization of new businesses and revenue streams from both new and existing smart grid market stakeholders correspondingly.

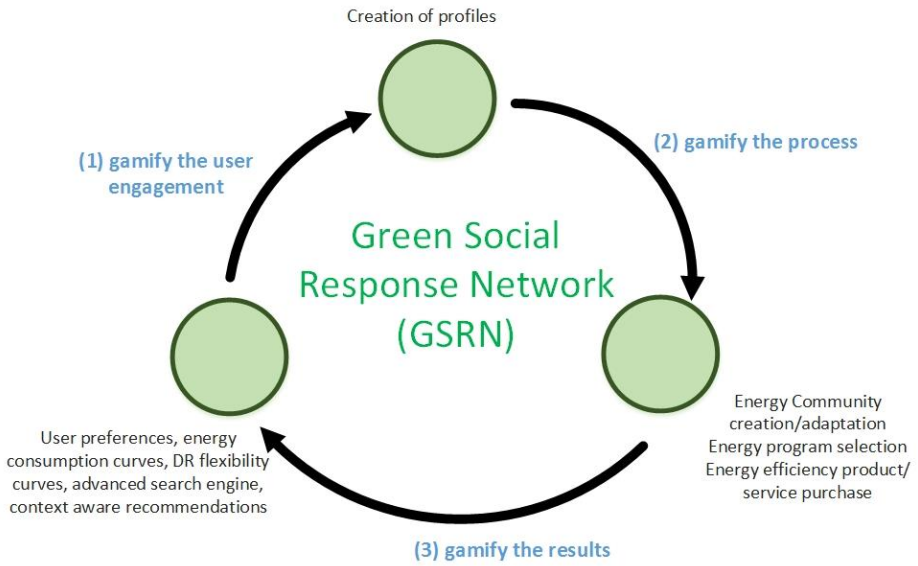


Figure 1: The perpetual information flow and life cycle of the proposed Green Social Response Network

The perpetual information flow and life cycle presented in Figure 1 can also be depicted as interactions between the SOCIALENERGY's subsystems (see Figure 2 below). There are six (6) subsystems (or else S/W components) as follows:

- MDMS (Meter Data Management System),
- GSRN (Green Social Response Network) Platform or else SOCIALENERGY's real world,
- Energy Efficiency GAME or else SOCIALENERGY's virtual world,
- RAT (Research Algorithms' Toolkit)
- LCMS (Learning Content Management System)
- EIDaaS (Energy Information Distribution as a Service)

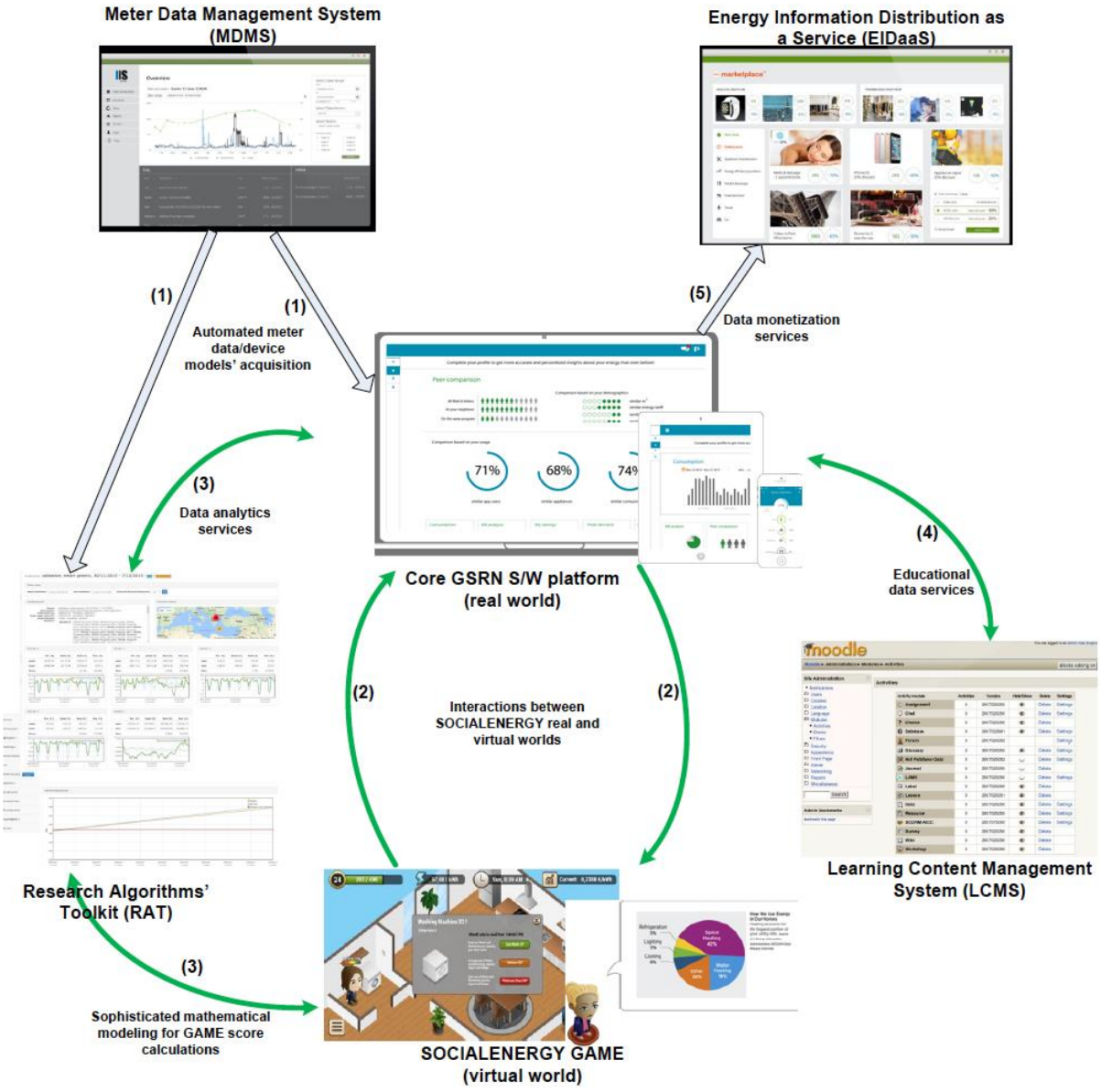


Figure 2: High-level architecture design of SOCIALENERGY system as a whole

Details about the functionalities that each subsystem offers to the users are provided in section 3.

1.3. Work progress and implementation plan until the end of SOCIALENERGY

In Figure 3 below, the work progress that has been made so far (i.e. until Month 6) together with the time plan for the next 2 years is graphically presented. The project's achievements until June 2017 (i.e. M6) are related with the 3 milestones that have been accomplished as follows:

- Milestone 1 (MS1) regarding WP2 work on use cases, system operation scenarios and requirements' analysis from both end users' and system's perspectives. MS1 is linked with tasks 2.1-2.3 activities and the results have been delivered via D2.1 in April 2017.
- Milestone 2 (MS2) regarding WP6 work on the initial business modeling and value propositions, market analysis and the derivation of data management, dissemination, communication and exploitation plans. MS2 is directly linked with the results documented via D6.1 (delivery date: 30 June 2017).
- Milestone 3 (MS3) regarding WP2 work on architecture design and technical specifications, whose results are reported in the current deliverable D2.2.

Based on the timeplan, each partner has started (M5) working on the subsystem that is under its own responsibility. Therefore, ICCS works on RAT, INTELEN works on GSRN and MDM, NRG works on GAME and SU-NIS works on LCMS. An initial draft DEMO per subsystem will be shown at the 1st review, which will take place in Luxembourg (October/November 2017). Then, until M15, the first release of SOCIALENERGY functionalities will take place (cf. MS4). During the 2nd review that is scheduled for M18, Milestone 5 (MS 5) should have been accomplished, so that the pilot setup plan and the release of first S/W prototype of the overall SOCIALENERGY system will be realized via the delivery of D5.1 and D5.2 (M18). This means that the S/W integration activities (i.e. collaboration among partners for the deployment of the technical APIs) will start at M12, so that a first DEMO to be released and presented during the 2nd review.

During the last year of the project (M19-M30), the consortium will focus further on the S/W integration activities in order to release the final S/W prototype in M27 (cf. MS 6 & MS 7). In the meantime, final business modeling and plans towards commercialization will take place mainly via communication activities with targeted customer segments. The final SOCIALENERGY product will be pilot tested in real-life conditions and in cooperation with a couple of electric utilities, which have already expressed their business interest in SOCIALENERGY's innovative functionalities and services. As a result, Milestones 8 & 9 (MS 8 & 9) will be accomplished at the end of SOCIALENERGY (M30).

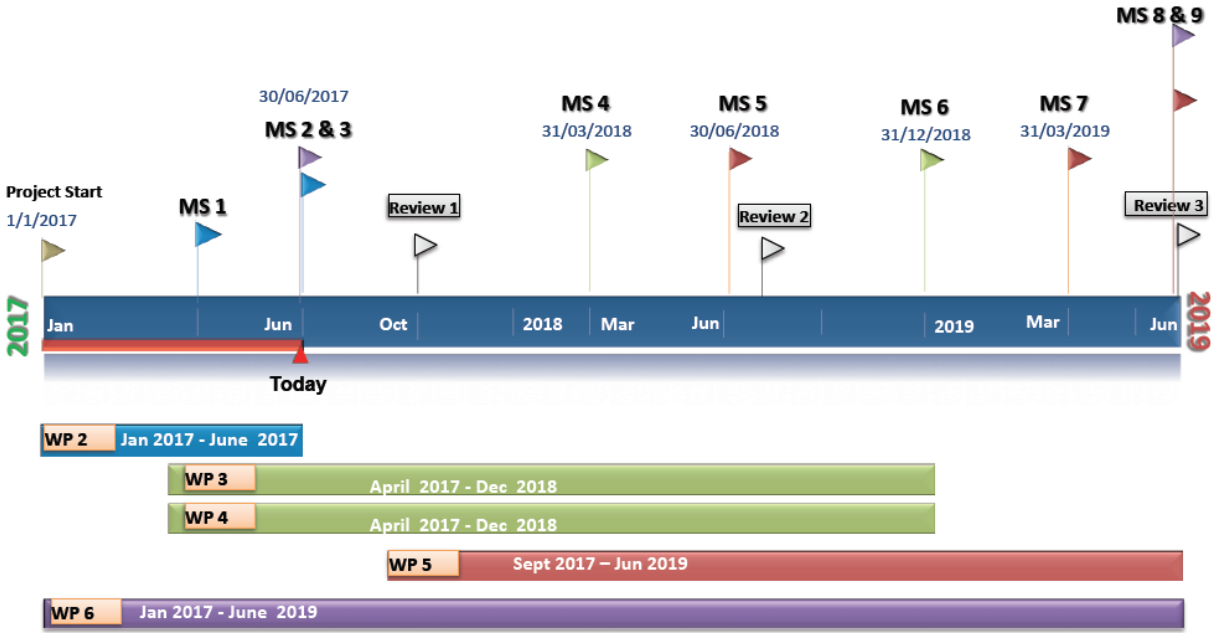


Figure 3: Implementation work plan until the end of project's lifetime

2 SOCIALENERGY use cases and requirements' analysis

This chapter provides a summary of D2.1 in the form of accumulative tables about the use case scenarios and categorization of the requirements.

2.1. SOCIALENERGY use cases and scenarios

Use Case no. 1 entitled "SOCIALENERGY's Real World – GSRN platform" defines all main functionalities and steps, taking place in the GSRN platform as the core platform, which connects through APIs to all other S/W components (or else subsystems), namely: a) the Learning Content Management system (LCMS), b) the SOCIALENERGY game (GAME), c) the Research Algorithm Toolkit (RAT), and d) the Meter Data Management System (MDMS). All these external components are combined in a unified dashboard, enabling all partners to assess and measure behavioral interactions.
GSRN S/W platform is a starting point of all users, who will have a unique account on the GSRN platform. Users will be able to track and manage energy consumption and metrics, manage securely personal data, get learning content, connect to the game, enjoy gamification elements, form communities, possess unique user ID, create virtual character etc.
The following use case scenarios are envisioned, which are described in the table below:

- 1A: Behavioral DR
- 1B: Behavioral DR with Gamification
- 1C: Energy Communities formation and participation in advanced energy programs
- 1D: Personalized marketing

Use Case no. 2 entitled "SOCIALENERGY's Virtual World – Game" aims at maximizing the knowledge of its players regarding ways that they can improve their habits for more efficient energy consumption based on applied gaming and gamification principles. 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.
The envisioned four gaming scenarios represent some main innovative energy programs. Each scenario has similar game goals and objectives, differing mainly due to the different energy program and pricing mechanisms. The innovation in the game will be its ability to nudge the player in virtual environment and influence their real-life habits.

Table 2: SOCIALENERGY Use-Cases and Scenarios (taken from D2.1)

Use Case		**Scenarios**	
1	GSRN S/W platform operation	**1A**	*Purpose:* **Behavioural DR** use case scenario defines all main functionalities and steps that take place for the Behavioural DR case study of the GSRN users. *Description:* Participants will be suggested to reduce their

			energy consumption during certain hours of specific days. GSRN will monitor user's performance during DR event and assess savings after that. Users will be notified about their savings and be able to see actual savings combined with overlapped graphs and community statistics. *Innovation:* DR messaging will be adapted to each user's profile and personality.
		1B	*Purpose:* **Behavioural DR with Gamification** scenario defines all main functionalities and steps that take place for the Behavioral DR case study with gamification extensions. *Description:* Participants will be suggested to reduce their energy consumption during certain hours of specific days in order to earn points, which will lead to badges on a leaderboard. GSRN will monitor user's performance during DR event and assess savings after that. Users will be notified about their savings and be able to see actual savings combined with overlapped graphs and community statistics and be able to see their points and badges and compare their performance with other users. *Innovation:* DR messaging will be adapted to each user's profile and personality and adapt gamification rewards to achieve personalization on actual incentives.
		1C	*Purpose*: **Participation in advanced energy programs (EPs)** scenario defines all main functionalities and algorithmic processes that take place for the creation of virtual/online Energy Communities (ECs) and novel dynamic pricing mechanisms, defining cost for each user and respective credit distribution policies used by the proposed Green Social Response Network platform. *Description:* SOCIALENERGY will develop innovative Energy Programs (EP) by investing in its innovative concepts, which are: Personalized Real-Time Pricing (P-RTP) and Energy Community Real-Time Pricing (EC-RTP). The creation of ECs is a prerequisite for participation in advanced EPs and it is a project's objective to determine their optimal size in order to offer both a degree of flexibility and allow end users to dispose significant portion on energy consumption by making them important. *Innovation:* The novelty of proposed dynamic pricing, EC creation and dynamic adaptation.
		1D	*Purpose:* **Personalized marketing technologies and serious games exploitation** use case scenario defines all main functionalities and steps that take place for the Personalized marketing Case study, combined with DR or other energy efficiency actions. *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. GSRN marketplace will generate ad-hoc personalized offers for users, based on their energy profile and psychographics. GSRN will monitor user's buying profile and ability to use new products to save energy. Users will be notified about their savings and be able to see actual savings combined with overlapped graphs and community statistics and be able to see other users' marketplace statistics and savings achieved by buying new relevant products from the GSRN marketplace. *Innovation:* The adaptation of each user's profile and personality with his energy efficiency potential and ability to buy specific efficiency appliances that will boost his green performance.
2	SOCIALENERGY game	**2A**	**Fixed Pricing:** The user participates in 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.
		2B	**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.
		2C	**Real Time Pricing:** The user participates in 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.
		2D	**Energy Community Pricing:** The user joins a community and participates in 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. They have to communicate and make arrangements with each other in order to achieve the community's goal.

2.2. End user requirements' analysis

Among various types of end users, who 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.)

End User		Requirement Description
1	Individual energy consumer (SOCIALENERGY real world's end user)	*Basic type of system's end user. Each individual energy consumer shall be able to:* • Log in to SOCIALENERGY platform and visualize various types of information from the GSRN GUI. • Perform various actions and check/see his/her information, profile and relevant KPIs. • Have access to the LCMS and to the Marketplace module from where he/she can purchase various energy efficiency products and energy programs. • See his/her rewards, statistics and recommendation offers to switch to another more beneficial energy program. • Login to SOCIALENERGY platform via his/her facebook/twitter account and thus post any news to these social networks.
2	SOCIALENERGY game player user (SOCIALENERGY virtual world's end user)	SOCIALENERGY 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. • Login to the virtual world (i.e. game) by using the same credentials (i.e. single sign-in procedure). • 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.
3	EC leader user	Energy Community (EC) leader user has the same requirements with the individual energy consumer except for additional "super-user" rights, which are: • Monitoring the KPIs and performance of the virtual energy community that he/she is leading. • Recommending learning content/material to the members of his/her EC. • Engaging the members of the EC to various new features of the SOCIALENERGY S/W platform. • Enjoy some more services from the SOCIALENERGY platform such as greater discount coupons for purchasing energy efficiency product.

4	ESCO user (system administration user)	ESCO user is the one who administers the whole SOCIALENERGY S/W platform. ESCO user (or else system administration user) should be able to: • Decide about all platform's updates, material/content uploads, reporting and recommendation rules, etc. • Create learning plan templates and coordinate the use and learning materials/content of the LCMS • 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.) ESCO user shall 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.
5	Electric utility user	Electric utilities are the main customer segment of the SOCIALENERGY's business model. The utility user should be able to: • Log in to the SOCIALENERGY S/W platform and administer the various (dynamic pricing) energy programs (EPs). • Track/monitor the ongoing performance of all available EPs and various user engagement KPIs. • Run simulation algorithms in RAT subsystem to identify the best utility's business strategy for the future.
6	Other external users	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, while data privacy and anonymity are preserved. Thus, various types of external users should be able to have access to the Energy Information Distribution as a Service (EIDaaS) and will be able to: • Use RAT in order to set his/her own simulation scenario and run a specific SOCIALENERGY research algorithm. • Visualize the performance evaluation results and possibly extract them in a single file in case of further need for editing and processing. • 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, too.

2.3. System requirements' analysis

Functional requirements per S/W component, namely: a) the GSRN, b) the RAT, c) the GAME and d) the LCMS as well as requirements for peripheral functionalities of SOCIALENERGY are presented below. Moreover, the requirements for the interactions among the aforementioned subsystems are briefly described. More details can be found in D2.1 (M4).

Table 3: Requirements for the core GSRN S/W platform

Requirement Title	Description
GSRN Central User DashBoard	The central dashboard: • Users perform various actions and check information, relevant KPIs. • Gets data from various APIs from all other SOCIALENERGY components and visualizes: energy data (Energy module), User information (User Profile module) and the leaderboards/rewards (rewarding mechanism module and Gaming module) • User will have access to various reports (Analytics and Reporting module).
GSRN e-learning/Training	Access to e-learning module, where user will be able to: • Take part in educational programs, regarding SOCIALENERGY activities. • Get back educational KPIs for analysis and user interaction. • View existing new modules and courses visible on the dashboard.
GSRN marketplace	Marketplace module, where all external products and services are accessible to users: • Users will be able to see prices, kWh, C02 emissions and savings potential. • Products and services will have relevant KPIs to help users in decision process and for analytics purposes.
GSRN External APIs	GSRN platform will offer various open APIs for data access form 3rd party entities based on Open Data approach and preserved according to EU Data Privacy directives and Ethical Laws.
GSRN Social Modules	GSRN will connect with social platforms (Facebook and Twitter). Users will be able to: • Log in using their Social Net credentials. • Post actions and news from the GSRN platform. Social interactions will be used for analytics and impact analysis and virtual/online energy communities will be formed based on user's social graphs and KPIs.

Table 4: Requirements for the SOCIALENERGY game

Requirement Title	Description
The virtual game should be a mobile end-user interaction point with the virtual world	• Virtual game on Android/iOS containing simulated world, where users play and receive tasks • Future mobile game to be developed using cocos2d-x game engine • Game style will replicate isometric view of commercially successful games on the market
Straightforward solution for communication between variety of subsystems/components of SOCIALENERGY platform	RESTFul Competency API will allow the SOCIALENERGY game to easily communicate with the GSRN platform, the RAT and the LCMS.
Attractive GUI is of crucial importance Code	In order to ensure user relatedness, adherence enjoyment and consequently educational and behavioural change processes.
The game should ensure longevity	The game should have an open-end and new tasks will be constantly generated adapting the difficulty levels of the game and receiving new EPs from RAT subsystem.
Addressing ethical issues within the game	Relatedness of the user to virtual world will be ensured through introduction of an avatar, including avatar editor in order the user to be able to design its own avatar

Table 5: Requirements for the Research Algorithms' Toolkit – RAT

Requirement Title	Description
RAT should be an open-source S/W offering a user-friendly web interface	Based on open-source code in order for the toolkit to be further exploited beyond project's lifetime with user-friendly web interface.
RAT should have a fine-grained API with the MDM subsystem to receive all energy consumption datasets	RAT will receive all energy consumption curves and DR flexibility curves from the Meter Data Management subsystem. API design in order to combine individual and/or set of energy consumers retrieved upon request by RAT.
RAT should offer efficient visualization capabilities regarding the energy consumption curves (ECC) and other user and EC profiling data	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 and any combination of ECCs of multiple energy consumers, user/EC DR flexibility.
RAT should allow access to multiple user categories	RAT module allows for access to the system through differentiated access levels: normal users be able to access only their own data/profiles; administrative users will be able to execute algorithms.

A well-designed web GUI should be available for the end user to run the various research algorithms and visualize the performance evaluation results	User to be able to set his/her own simulation scenario and run a specific SOCIALENERGY research algorithm, visualize the performance evaluation results and extract them in a single file.
Results from the research algorithms' execution should be easily stored, accessed, retrieved and possibly further exploited in the future	The proposed research algorithms regarding the dynamic pricing and the EC creation and dynamic adaptation should be integrated in RAT, user provides his/her parameters via web GUI and see execution. Results stored in RAT database and could be accessed and retrieved by user.
All data should be efficiently stored and retrieved from the RAT's database	RAT Database stores consumer's initial information when s/he registers in the system for the first time and all datasets coming from various APIs with other SOCIALENERGY subsystems. Appropriate data efficiently retrieved and results stored in the same database.
User/EC profiling and searching functionalities should be supported	RAT provides web GUI from which user searches and selects combination of consumer/EC category, profiles are created via static and dynamic information and are continuously updated and RAT informed about any change.
Intelligent Reporting and Recommendations for the participation in advanced EPs should be supported	Results of EC creation and dynamic adaptation algorithms provide reports, suggestions and recommendations to consumers and/or EC leaders.
EC creation S/W module should host the EC creation algorithms	EC creation algorithms running and different variants of multi-parametric algorithms.
Dynamic EC adaptation S/W module should host the EC dynamic adaptation algorithms	Dynamic EC adaptation algorithms running, ECs will be able to change and member of EC to move in another.
Dynamic pricing S/W module should host all proposed dynamic pricing algorithms and policies	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
RAT should have a fine-grained API with the GSRN subsystem to receive all real user behavioral data from GSRN	RAT-GSRN API should support the information exchange about the complex profiling of the real users, including static data and dynamic information. RAT module return to the GSRN algorithmic results.
RAT should have a fine-grained API with the GAME subsystem to calculate the game's total points and scores and	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 update user's profile. Algorithms periodically updated regarding game status and imply learning level of

receive all players' behavioral data from the GAME	each participating user/player. RAT can return algorithmic results to the game.

Table 6: Requirements for the Learning Content Management System – LCMS

Requirement Title	Description
LCMS should be a free and open-source software learning management system	The LCMS should be free and open-source, easy for users to work, flexible, with accessible and responsive design.
LCMS should support competency based education	LCMS will provide personalized learning combined with possibilities for collaborative and group learning, allowing personalized dashboard and individual learning plan, supporting major pedagogical methods for learning.
LCMS should provide competency based learning	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 appropriate for the purposes of training plan.
LCMS should follow open standards	Interoperable, standards compliant, support external modules inclusion, external digital repositories and sophisticated file management, supporting open standards like integrated badges, open assessment, advanced grading methods selection, built in activities and support marking workflows.
LCMS should support social functions	Users can easily communicate through flexible system of forums and communication channels, form user groups and send messages to other learners and teachers.
LCMS should provide a RESTful Competency API	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.
LCMS should provide an Authentication API	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.

3. SOCIALENERGY architecture

In this section, we present the overall SOCIALENERGY architecture, which is comprised of six (6) subsystems that we also call S/W components. Each SOCIALENERGY sub-system is depicted and described at a high-level of abstraction together with all interfaces among all subsystems. Moreover, for each one of the main four (4) subsystems, namely the: 1) core Green Social Response Network (GSRN) platform, 2) energy efficiency GAME, 3) Research Algorithms' Toolkit (RAT), and 4) Learning Content Management System (LCMS), all S/W modules and their main functionalities are described in subsections 3.2-3.5. Furthermore, every subsystem (or else S/W component) consists of several S/W modules. Subsequently, for every subsystem, all technical interfaces between the respective S/W modules are presented.

A well-known S/W tool for developing system architecture design for ICT systems has been used, which is ARCHIMATE tool[4]. *ArchiMate*® constitutes an open and S/W independent language/tool for coherent specification and description of: systems' architecture, technical components and their relationships. *ArchiMate*® provides the directives to present different domains of a system, ranging from business services to technical system architecture and specific components, in a coordinated form. It enables forward and backward traceability between the high-level functional business services and their implementation at component level. More details regarding the Archimate's modeling language, entities and notation are provided in Annex A of the current document.

3.1. Overview of the overall SOCIALENERGY architecture

In the figure below, the overall SOCIALENERGY architecture (including all subsystems and technical interfaces) is depicted. There are six (6) subsystems (or else S/W components) as follows:

- **MDMS** (Meter Data Management System),
- **GSRN** (Green Social Response Network) Platform,
- Energy Efficiency **GAME**,
- **RAT** (Research Algorithms' Toolkit)
- **LCMS** (Learning Content Management System)
- **EIDaaS** (Energy Information Distribution as a Service)

[4] http://www.archimatetool.com/download

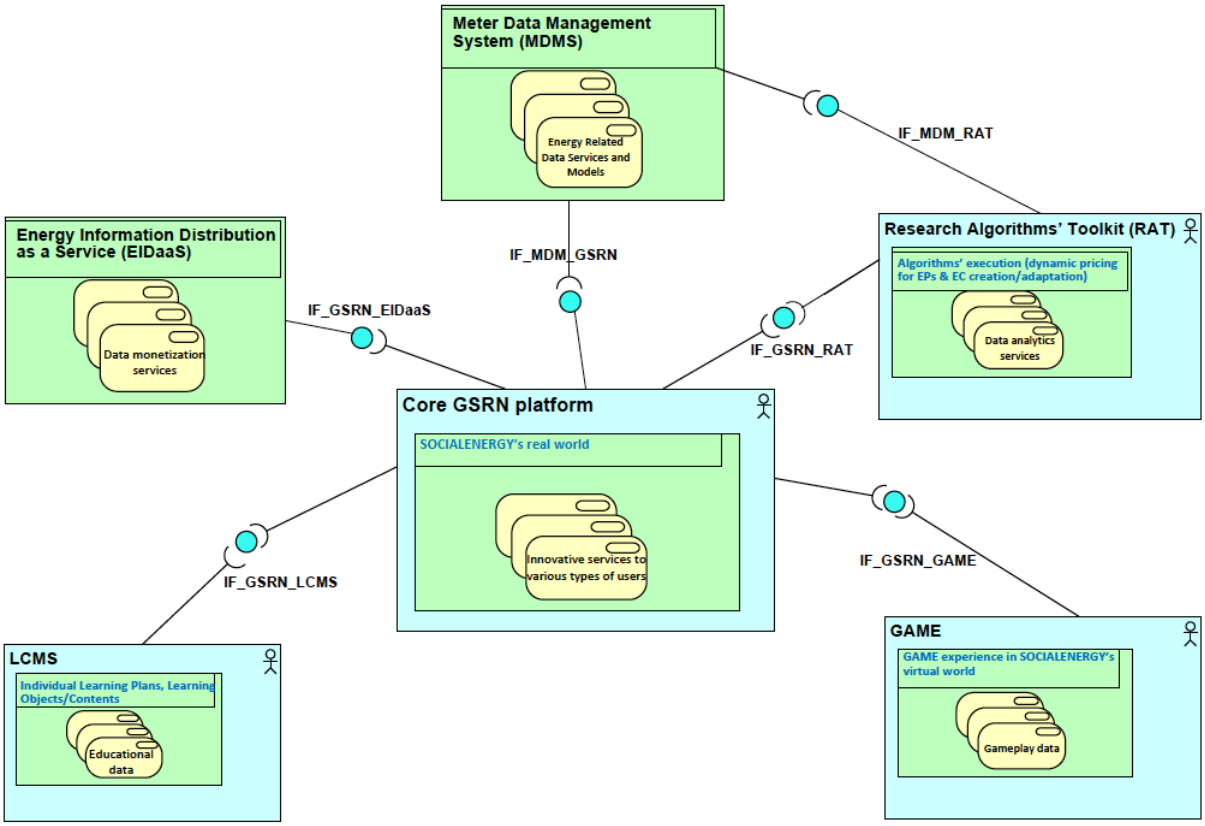


Figure 4: SOCIALENERGY architecture (all subsystems and technical interfaces)

In MDMS, all energy consumption related data is collected. MDMS actually serves as SOCIALENERGY's database, where all energy-related data models are also available (e.g. electric appliance consumption models). The datasets that will be used for SOCIALENERGY purposes come from real energy consumers of various types (e.g. residential vs. commercial, high vs. low educational level, different locations/countries, etc.). This energy consumption will be made available in various time granularities. Moreover, based on INTELEN's business experience, data models for a wide range of electric appliances/devices will also be available.

The GSRN is the core S/W platform of the SOCIALENERGY system, in which all types of SOCIALENERGY users (e.g. individual consumers, EC leaders/managers, electric utility/retailer user, ESCO user, etc.) are able to log in and visualize/experience many innovative functionalities. GSRN has technical interfaces with all other five (5) subsystems integrating several multi-disciplinary functionalities ranging from the scientific/research sector (cf. RAT) to the gaming/gamification sector (cf. GAME) and the educational sector (cf. LCMS). GSRN is also being fed with real-life energy consumption data from MDMS. It also offers EIDaaS-like services to various targeted stakeholders such as building renovation companies and electric appliance vendors/retailers, who aim at indirectly exploiting SOCIALENERGY system's results towards realizing new revenue streams for their businesses.

The SOCIALENERGY GAME will be played by the user in a range of platforms starting from a basic web-based implementation and possibly being extended to a mobile application, too. After the SOCIALENERGY user (i.e. individual consumer) is logged in the GSRN, she/he uses the same credentials to download the game and start the gameplay. The GAME is an applied game on energy efficiency, combining characteristics by both serious games and classic

entertainment industries. The player creates/enters a virtual world (i.e. virtual house) with all electric appliances and tries to maximize the energy efficiency KPIs by striking to find an optimal trade-off between the energy cost and the discomfort incurred through the load shedding and shifting. Via the gameplay, the user is seamlessly educated in best practices about energy efficiency and this is done in an enjoying manner. Furthermore, the users can customize the GAME's settings and create a virtual environment that is similar to their real house. As a result, GAME can also serve as (near) real-life testbed to help in quantifying user's behaviour and change through time, which is very important from both a research and commercial exploitation point of view. It should be noted that the GAME is also interacting with the RAT (by integrating all sophisticated mathematical modelling, which provides the basis for the GAME's long-term success in the market). GAME also incorporates references to offline educational material (e.g. in the form of small pop-up windows) that the users can find in the LCMS and search for more details therein.

The RAT subsystem is very important for SOCIALENERGY's operation because it provides all the intelligence that is required towards making SOCIALENERGY S/W platform competitive enough and commercially successful in a sustainable manner. It provides "data analytics" services mainly to GSRN, but also to the GAME (by integrating the sophisticated mathematical modeling mainly in the energy pricing and score calculations). Various research algorithms are executed regarding the dynamic pricing models that are adopted in the various innovative Energy Programs (EPs) and the Energy Communities' (ECs) creation and dynamic adaptation algorithms, which are required for the online management of the virtual energy communities. RAT also provides context-aware recommendations to GSRN and is also a toolkit to be used by the system administrator for business/strategy analysis by running various simulations (short/medium/long-term horizons).

The LCMS is the subsystem, where the user/player educates herself/himself both online and offline to consolidate the new knowledge about good practices on energy efficiency. LCMS interacts with GSRN. Thus, the latter can provide recommendation services to the user according to the educational content that is mostly keen on watching next based on her/his current educational profile and experiences in both SOCIALENERGY's real and virtual worlds. The role of the LCMS is important because it provides the user the opportunity to better comprehend the new concepts in the liberalized smart grid markets and inter-relate the "lessons learned" from the GAME with the real-life conditions in order to be able to efficiently interact with her/his electric utility/retailer.

Finally, via the EIDaaS, SOCIALENERGY bridges the gap between energy consumers and companies as well as among multiple other stakeholders related to the energy efficiency sector. Using the SOCIALENERGY platform, the profile of its energy consumers is created (e.g. energy consumption history, social networking activities, commercial actions' history, etc.). This profiling could be exploited from stakeholders in order to: i) design energy efficiency products and services more appealing to their audience, ii) allow ECs to participate in the design by giving their opinions, iii) exploit ECs as cells within which they will enable group trading and iv) generally sell Energy Information Distribution as a Service (EIDaaS) to whom it may concern in the long-term future. SOCIALENERGY will create an API through which it can commercialize this idea of "data monetization" service.

Furthermore, as shown in the architecture design above (Figure 4), there are six (6) technical interfaces for the efficient information exchange between the various subsystems as follows:

- **IF_MDM_GSRN**, in which data flows uni-directionally from MDMS to the GSRN providing energy-related data and models to the core GSRN S/W platform.
- **IF_MDM_RAT**, in which data flows uni-directionally from MDMS to the RAT, following the same API structure with IF_MDM_GSRN.
- **IF_GSRN_RAT,** in which there is a bi-directional data flow. The RAT provides the data analytics services to GSRN and the latter provides all the required real user and energy community data to the RAT.
- **IF_GSRN_GAME,** in which there is a bi-directional data flow. The GAME provides all the gameplay data to GSRN and the latter provides the single sign-on procedures and real user profiling data to be used for the GAME customization.
- **IF_GSRN_LCMS,** in which there is a bi-directional data flow. The LCMS provides all the educational data that come from the execution of each user's individual learning plan (ILP) to the GSRN, and the latter provides the user profiling data to be used for LCMS customization.
- **IF_GSRN_EIDaaS,** in which data flows uni-directionally from GSRN to the EIDaaS providing data monetization services to multiple stakeholders from the energy efficiency business, who are keen on purchasing an innovative service for their personalized/community marketing strategies.

In subsections 3.2 – 3.5, the four (4) main subsystems of SOCIALENERGY are extensively described. There is one responsible partner for the deployment of each one of SOCIALENERGY's subsystems (or else S/W components), namely: INTELEN is responsible for the GSRN deployment, NRG is responsible for the GAME deployment, ICCS is responsible for RAT work and SU-NIS for the LCMS work.

3.2. GSRN platform – SOCIALENERGY's real world

GSRN is considered the central SOCIALENERGY dashboard and system that users interact (login, logout, etc.).

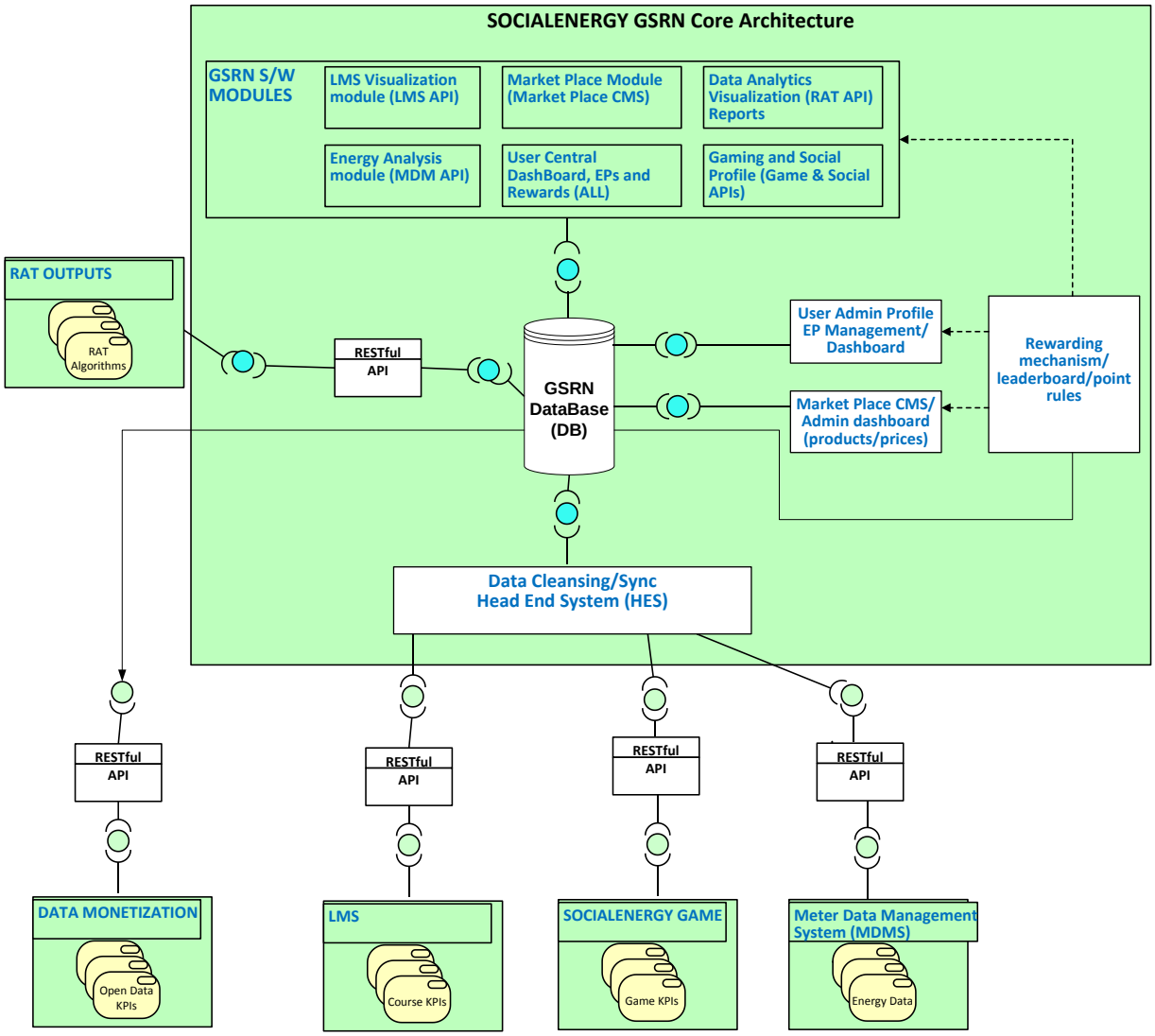


Figure 5: GSRN core platform architecture

3.2.1. E-learning/training S/W module

GSRN's E-learning/LCMS Visualization module will be responsible for the integration and visualization of all educational material and relevant interactions coming from the GSRN-LCMS API. The training module will visualize all on-line courses taken from the user, the grades, the difficulty and the relevant connections with the actual subjects (efficiency, recycling, etc.). The module will be connected with the individual User Profile so that users will be informed of all available courses and related educational actions. Subject personalization will be feasible over the RAT OUTPUT-API.

3.2.2. Market place S/W module

GSRN's Marketplace module will be responsible for the electric appliances' database that will be uploaded on to the system, through the Marketplace CMS sub-module and will be available to the users through the rewarding scheme (redeem prizes). Various electric appliances will have details such as kWh, Class, C02 emissions, price, discounted price, etc., so that the user will be able to choose and proceed with an online payment gateway.

Various appliances will be pushed to the User Profile, based on personalization and RAT-API or LCMS-API or GAME-API in order to map user performance with rewards.

3.2.3. Rewarding mechanism S/W module

GSRN's rewarding mechanism works at the backend and computes the individual points for all users' activity in the GSRN. The Rewarding mechanism connects also to the GAME-API in order to feed GSRN User Profile module with game leader-board and relevant points from the user's game performance. The mechanism will be flexible to the administrator to set up the point system and the redeemable points, based on users' stage, points and performance. Points will have two categories: Actual points and Experience points, indicating activity engagement and knowledge engagement. Experience points will be connected to the LCMS-API.

3.2.4. Data analytics S/W module (visualization)

GSRN's Data Analytics module will visualize all RAT-API outputs and will provide a visualized KPIs dashboard to the users to check their overall performance. This will include user comparisons and general statistics on game, points, EP contracts, courses and all RAT outputs from the respective dynamic pricing and EC creation/dynamic adaptation algorithms (see more details about the RAT algorithms' outputs in section 3.4 below).

3.2.5. Energy S/W module

GSRN's Energy module will be connected to the MDM-API and RAT-API in order to visualize real energy consumption from users' meters or billing systems of the MDM-API. Energy-related measurements will be made available from GSRN to RAT. Users will be able to see their energy consumptions, get historical curves or aggregated ones. The objective is to see on the real graphs the anticipated energy savings potential, due to gamification and user engagement.

3.2.6. User profile S/W module

GSRN's User profile, will be the central page of the GSRN administration, where users will have a general view of all modules and functionalities, will be able to change them, adapt them and also change their personal details and password.

3.2.7. Gaming profile S/W module

GSRN's Gaming profile module will connect directly to the GAME-API and get all relevant details from the game, regarding this specific user. User will get badges, leader board, performance, stages, points and all available GAME-API inputs. The Game profile will inform the user how s/he is performing in the mobile games and how his/her performance is compared with others. RAT-API outputs will be also used on the Data analytics module.

3.2.8. Social/FB S/W module

GSRN's Social module is also working at the backend and will be used to get FB and other social net user info, as the user logs in the system. Social module will be combined with all other modules to provide personalization and further analytics.

3.2.9. Data monetization API (EIDaaS)

GSRN's Energy Information Distribution as a Service will be an open API, giving access to third party users and entities in order to get anonymous secured and anonymized data for further data monetization. These will be anonymous statistics, trends, appliance statistics and many more anonymous data, following the "OpenData" philosophy.

3.3. Energy efficiency game – SOCIALENERGY's virtual world

The Game will exchange data with other S/W components (i.e. SOCIALENERGY subsystems) through GSRN. The game will receive profile data, recommendations and prices. Then, it will process them for player login and gameplay and produce statistics and game results. The statistics and results will be sent to the other S/W components through GSRN. RESTful APIs will connect the GAME with all other subsystems of SOCIALENERGY.

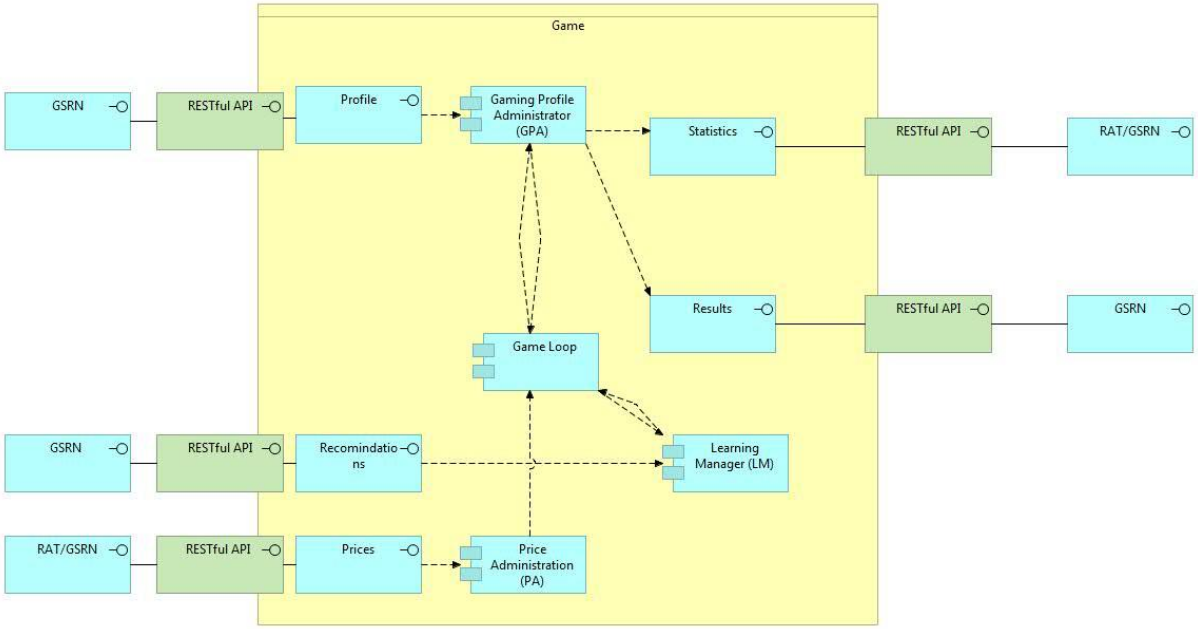


Figure 6: SOCIALENERGY GAME architecture design

3.3.1. User Administrator S/W module (UA)

The User Administrator Module (UA) receives the User Profile and Gaming Profile from GSRN. It sends the Gaming Profile of the user to the Gaming Profile Administrator (GPA) Module. This module is in charge of user logging into the game.

3.3.1.1 Interface between GSRN and UA Module

The user will login into the game and the UA will send a request to GSRN with login credentials of the player to get the user profile and the gaming profile. This can be done with

all profiles or UA can save the recently active profiles and send requests only for new and no longer active profiles.
Note: Keeping profiles in UA can reduce the response time for users but could produce profiles out of sync.

3.3.2. Gaming Profile Administrator S/W module (GPA)

The Gaming Profile Administrator (GPA) gets the gaming profiles from User Administrator Module. The gaming profile is used in the communication with the 'game loop' and getting values back from the 'game loop'. GPA is also in charge of sending the game produced values to the other SOCIALENERGY subsystems. The values of the gaming profile like score and achievements are sent to RAT directly and through GSRN. GSRN will receive game results for its calculations. LCMS gets the information about the newly achieved badges through the GSRN.

3.3.2.1 Interface between GSRN and GPA module

GPA sends the player's score and satisfaction values as feedback to GSRN for the calculation of virtual currency, badges, challenges and making recommendations. This also means that LCMS is informed through GSRN about the new badges. The communication will be periodic or on demand of GSRN.

3.3.3. Game Loop S/W module (GL)

The Game Loop (GL) module is the game as such. It includes the game interface, gameplay and controls. It gets the gaming profile from the Gaming Profile Administrator Module, prices from Price Administrator (PA) Module and learning content from Learning Manager (LM). This is what the users see from the game. GL is also responsible to process the information about the appearance of user's virtual house.
Important Note: Detailed information about the game design and technical specifications of all the game's S/W modules will be delivered via D.4.1 in September 2017 (Month 9).

3.3.4. Learning Manager S/W module (LM)

The Learning Manager (LM) is constantly interacting with the Game Loop Module. Features like score and game status are calculated and the Individual Learning Plan for the user is processed here. The Learning Manager gets the Learning Recommendations from GSRN and integrates them into the game. LM is also in charge of game levels with their scenario and goals.

3.3.4.1 Interface between GSRN and LM Module

The Learning Manager gets the recommendations calculated from LCMS through GSRN, as the result of the feedback sent to GSRN from the Gaming Profile Administrator. The recommendations can be sent in periodically. The period depends on the sending period of the GPA to GSRN Interface. Another possibility is that the Learning Manager sends a recommendations request at the beginning of every new session.

3.3.5. Price Administrator S/W module (PA)

The Price Administrator Module (PA) receives the prices and sends them to the Game Loop to be integrated into the game. The prices are coming either directly from RAT or through GSRN (see more details about pricing models in the description of RAT subsystem below).

3.3.5.1 Interface between GSRN and PA

The PA gets the data for electric appliances and the dynamical pricing from RAT through GSRN. This information will be gathered by Price Administrator sending a price update request once in a certain period of time (see more details about RAT algorithms' operation in the description of RAT subsystem below).

3.4. Research algorithms' subsystem/toolkit (RAT)

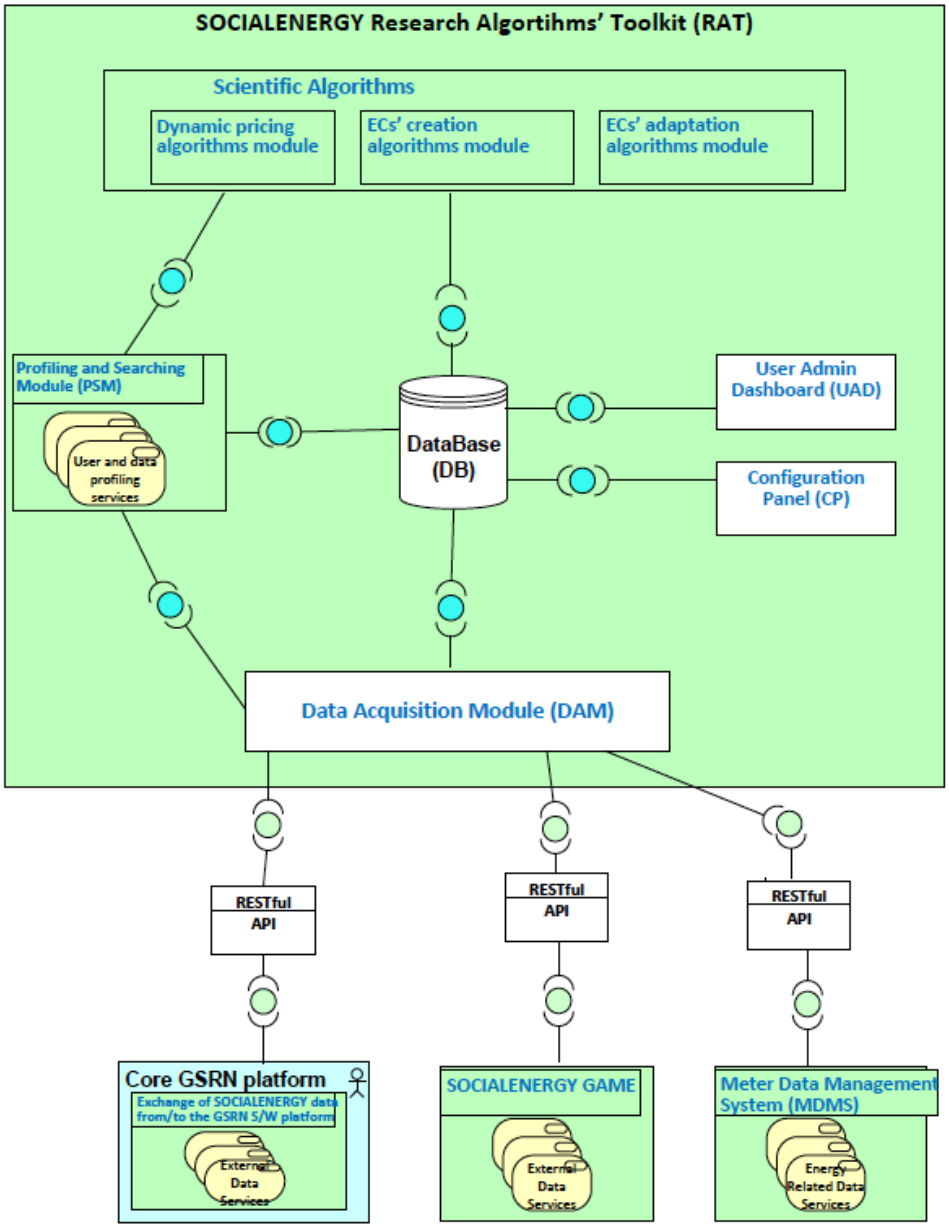


Figure 7: RAT architecture design

In Figure 7 above, the Research Algorithms' Toolkit architecture design is depicted together with the various S/W modules and interfaces within this subsystem and APIs with other SOCIALENERGY subsystems. Furthermore, each S/W module's operation and main functionalities are then extensively described.

3.4.1. RAT Database (DB)

The RAT database stores all the data that is essential input for the operation of the SOCIALENERGY research algorithms. These datasets will include: i) historical data related to the energy consumption/flexibility/performance of each individual consumer and virtual energy communities, ii) behavioural data taken from the core GSRN platform and the game, iii) pricing data from the various markets, iv) various results (outputs) from the algorithms' operation, etc.

3.4.2. Data Acquisition Module (DAM)

The Data Acquisition Module (DAM) is responsible for obtaining data from external (to the RAT) sources. The data acquisition is performed either periodically, or on-demand, as required by the algorithms of the RAT. Individual RESTful APIs are implemented for interacting with the SOCIALENERGY subsystems, namely the core GSRN S/W platform, the SOCIALENERGY game and the Meter Data Management System (MDMS). In the following paragraphs, the technical interfaces (i.e. APIs) are briefly described.

3.4.2.1. Interface with the core GSRN platform

The SOCIALENERGY user will be able to sign in to the system and enjoy the core GSRN platform's functionalities. From the GSRN S/W platform's web interface, the ESCO user (i.e. system administrator) will be able to select the "RAT" tab and then a new window will navigate him/her to the RAT's functionalities. As already described above, RAT includes all the SOCIALENERGY's intelligence, which is realized via the GSRN-RAT interface. In particular, there will be a RESTful API, from which the RAT will get the GSRN and LCMS score for each individual user and/or energy community either instantly or periodically. Of course, historical data can also be acquired at various time granularities and timeframes. Via the GSRN-RAT interface, the RAT receives all social, demographic and personal preferences data for each user and energy community. Moreover, the LCMS-related score is also acquired by RAT. Then, the ECs' creation algorithms module is able to create and possibly adapt the structure of the ECs when needed. Regarding the RAT-GSRN interface, the GSRN gets the energy costs, energy/money savings per user according to EP involved to be used for GSRN credits' distribution policies. The outcome of the ECs' adaptation algorithms module, that are reporting and recommendations are used from multiple types of users (e.g. ESCO user to consumer/ECs, EC user to users of his/her community, etc.).

3.4.2.2. Interface with the MDM subsystem

Via the MDM-RAT interface, the RAT can get any type of energy consumption and DR flexibility curves at various time granularities and timeframes. It can also get "DR responsiveness" curves indicating the user's engagement in demand response actions. The Meter Data Management System (MDMS) is SOCIALENERGY's database. It includes the following energy consumption datasets: a) real energy consumption profiles from real utility

customers (brought by INTELEN) to be exploited by GSRN for real-life pilot tests, b) real historical energy consumption profiles from hundreds of energy consumers (brought by ICCS and INTELEN) to be exploited by Research Algorithms' Toolkit (RAT) for research algorithms' development and performance evaluation.

3.4.2.3. Interface with the SOCIALENERGY GAME

Via the GAME-RAT module, the RAT is able to acquire game-related data such as the score and game status of each player (e.g. which game level has he/she reached?). This can be used as one more parameter to EC creation algorithms module. Moreover, the RAT will provide all the required data models for electric appliances (A/Cs for heating and cooling, heat pumps and water heaters for bathing, kitchen for cooking, dishwasher, washing/dryer machine for clothes' washing/drying, electric vehicles for going out for work/leisure, etc.). The mathematical equations for the dynamic pricing mechanisms and the user's utility function (i.e. USER SATISFACTION - COST) is also given by RAT to the GAME in order for the GAME score to be automatically calculated throughout the whole gameplay's duration and lifecycle.

Note: The API implementation for the direct exchange of data between the RAT and the GAME subsystems is optional. This means that the outcome of the research activities taking place for RAT implementation can be fed in an offline mode to the GAME and the game-related data can be first provided to GSRN and subsequently become available to RAT via GSRN-RAT API.

3.4.3. Profiling and Searching Module (PSM)

Via the Profiling and Searching Module (PSM), the user of RAT is able to request any type of information and then retrieve and visualize it in the RAT's web interface. For example, the ESCO user can select any timeframe (from an online calendar) and feature that wants to visualize (e.g. which is the set of users that are highly engaged in energy efficiency, which is the percentage of consumers, who participate in a specific set of energy programs, which is the profile of the consumers that are not easily engaged in energy efficiency, which is the average percentage of energy/money savings for a specific group of consumers or EC, which are the benefits in energy/money savings for a specific consumer/EC if he/she switches to a more beneficial EP for a given time horizon, etc.). In other words, via targeted queries to the RAT DB, the ESCO user can have a holistic view of his/her portfolio in order to be able to take effective strategic decisions for his/her business. Hence, PSM can be seen as a "business analytics" module, which can be very useful for an ESCO user from a managerial point of view. Clustering algorithms based on both static and dynamic information taken from the other SOCIALENERGY subsystems will be running on PSM.

3.4.4. User Admin Dashboard (UAD)

The User Admin Dashboard (UAD) is the interface that the system administrators will use for administering the operation of RAT. A graphical user interface (GUI) is implemented, that allows for setting up the details of each consumer, as well as the parameters that allow for the configuration of the various algorithms that will be implemented in the RAT.

3.4.5. Configuration Panel (CP)

Apart from the user administration interface, another GUI is implemented for the users of the RAT to configure their participation and navigate through all the RAT's functionalities. Configuration Panel (CP) incorporates all data visualization capabilities that the users may have on the RAT. It should be noted that this CP may be used by SOCIALENERGY ESCO user, who will be able to enjoy the SOCIALENERGY system's intelligence and visualize performance evaluation results from the execution of various scientific algorithms like the ones described below.

3.4.6. Research Algorithms Module (RAM)

This is the most important S/W module of RAT. RAM is responsible for executing intelligent algorithms that will be used in the operation of RAT as a standalone toolkit as well as for providing intelligence to both GSRN and GAME subsystems. RAT has an API with both the GSRN and the GAME in order to provide the business flexibility for these two subsystems to be commercially exploited in the future. The RAM consists of three basic sets of algorithms that will be integrated, namely the: a) dynamic pricing algorithms, b) EC creation algorithms, and c) EC adaptation algorithms.

3.4.6.1. Dynamic pricing algorithms

In this S/W module, various pricing algorithms (or else innovative SOCIALENERGY's energy programs) are running. The baseline EP is based on the fixed/flat pricing policy, which is the most common way of utilities' charging in most of the EU countries today. The follow-up model of Inclining Block Rates (IBR) charges a higher per unit price of electricity to users with high consumption profiles. Time-of-Use (ToU) based EPs will also be incorporated. This type of energy program can be customized according to the ESCO/utility user's needs (i.e. the price curve within a day will be customizable). Real-Time Pricing (RTP) energy programs and associated algorithms will be part of this module, too. Furthermore, several innovative research algorithms will be proposed within SOCIALENERGY context such as the personalized RTP (P-RTP) and the Energy Community RTP (EC-RTP).
Within the SOCIALENERGY context, the ESCO/utility user will be able to:

- Select a specific consumer or EC and visualize the financial savings comparing all the available EPs. The most beneficial EP could then be recommended to this individual consumer or EC.
- Run simulations with various customizable parameters to realize the pros and cons of each EP.
- Run real-life experiments with users, who have agreed to switch to a more beneficial EP. Even results from the real-life gameplay of SOCIALENERGY game can be fed as input to a dynamic pricing algorithm to realize the pros and cons of each EP. Some basic KPIs will be minimization of electricity cost, maximization of user comfort, maximization of ESCO's/ utility's profits, fair distribution of the costs to the participating users, etc.).

3.4.6.2. Energy Community creation algorithms

This sub-module incorporates various algorithms for the creation of ECs based on multiple parameters, that is the clustering of consumers is not only made based on their energy

consumption curves (ECC)/profiles but also based on: a) their connections in social media, b) their personal habits, character and demographic data, c) their behavior regarding demand response actions (retrieved from GSRN), d) their will for participation/engagement in innovative energy programs and services offered by SOCIALENERGY, e) their learning curve, competences and skills regarding good practices in energy efficiency sector (taken from LCMS and GAME), etc. Via this multi-parametric clustering approach, the ECs that are created can achieve better results in terms of energy efficiency/savings, monetary profits and long-term engagement in good energy efficiency practices. This is achieved via the inherent social-based or else "peer pressure" that takes place among the members of each EC. Within the SOCIALENERGY context, the ESCO/utility user will be able to run various simulations to understand the social dynamics and analyse the behaviour of his/her customer portfolio. An EC user will be able to understand whether it is beneficial to add/remove more members to the EC that he/she is leading and realize indicative metrics about which EC member is over- or under-performing.

3.4.6.3. Energy Community adaptation algorithms

In this module, the initial "clusterings" or else ECs can change in case a pre-defined threshold is being surpassed/violated. In particular, a multi-dimensional space is created in which all consumers are depicted via a point that has multiple coordinates. In this graph, all "distances" between all possible combinations of points are measured and thus based on a constraint that is defined by the administrator (e.g. ESCO/utility user), the "clusterings" are created. As the time goes by, the profiles of the energy consumers are continuously changing, so an EC adaptation algorithm should be run in order for the new ECs to be formed. This means that maybe some energy consumers may switch to another more beneficial EC or the administrator or EC leader may choose to add/remove some members from his/her EC. As a result, this sub-module can also be seen as a reporting and recommendation engine, whose results can be retrieved by GSRN and become very useful to the SOCIALENERGY's business scenarios.

3.5. Learning Content Management Subsystem (LCMS)

SOCIALENERGY project will follow up the paradigm shift to competence-based education, where the outcomes at the end of the educational pathway are assessed via a competence-based system. Competencies describe the level of understanding or proficiency of a learner in certain subject-related skills. Competence-Based Education (CBE), also known as Competence-based learning or skills-based learning, refers to systems of assessment and grading, where students demonstrate these competencies.

Thus, based on the proposed competence-based system, further trainers or automated recommendation systems will be able to design in advance the end-users best learning path and learning activities according to the competences that they need to acquire, to excel and to improve. Therefore, the competence taxonomy framework will respond to the learning profile of the SOCIALENERGY project's end-users and virtual energy communities. End-users competence taxonomy framework aims to identify the structure of the competences that will be directly addressed by the learning objects developed in the SOCIALENERGY project. Furthermore, they will help to assess the end-user's competences and level of proficiency after completion of the specific e-learning activities.

The SU-NIS team identified several competence frameworks in the field of Energy efficiency, energy management, energy savings and energy efficiency behavioral change. However, most of these competence frameworks are designed mainly for employees and staff working in the field of energy management and energy efficiency. Therefore, a new competence taxonomy framework needs to be implemented, responding more closely to the needs of the SOCIALENERGY project's target groups.

Competency frameworks are a hierarchical list of Competencies (usually defined by a standards body or central authority). In the case of SOCIALENERGY, project partners will develop their own competency framework, which will fully respond on the subject domain, target user needs and specifics of the project activities.

Thus, the SOCIALENERGY competence framework aims:

- To allow competency-based learning and assessment, based on taxonomy of competencies.
- To allow the use of rich set of learning resources and activities related to achieving the needed competences.
- To support various modes of assessment of learner's knowledge and competences and relevant grading according to achieved results.
- To allow learning based on individual learning plans related to competences.

The competences should be linked to specific learning activities. This way, learning activities or learning resources can be related and mapped to specific competency and end-users can be evaluated for possessing competencies related to specific learning domain.

It should be noted as well the success of behavior change programs to reduce energy consumption in homes and businesses. The behavior change programs are based on social science research and typically combine multiple behavioral science-based strategies (e.g., public commitment, goal setting, and comparison to others' behaviors). As SOCIALENERGY project will work actively with social setting, involving communities' interactions, the social elements will be largely implemented in the competence taxonomy framework.

In the following figure, the Learning Content Management System (LCMS) architecture is depicted together with all its S/W modules and the main information exchanges/flows among them. Furthermore, each S/W module's operation and main functionalities are then described.

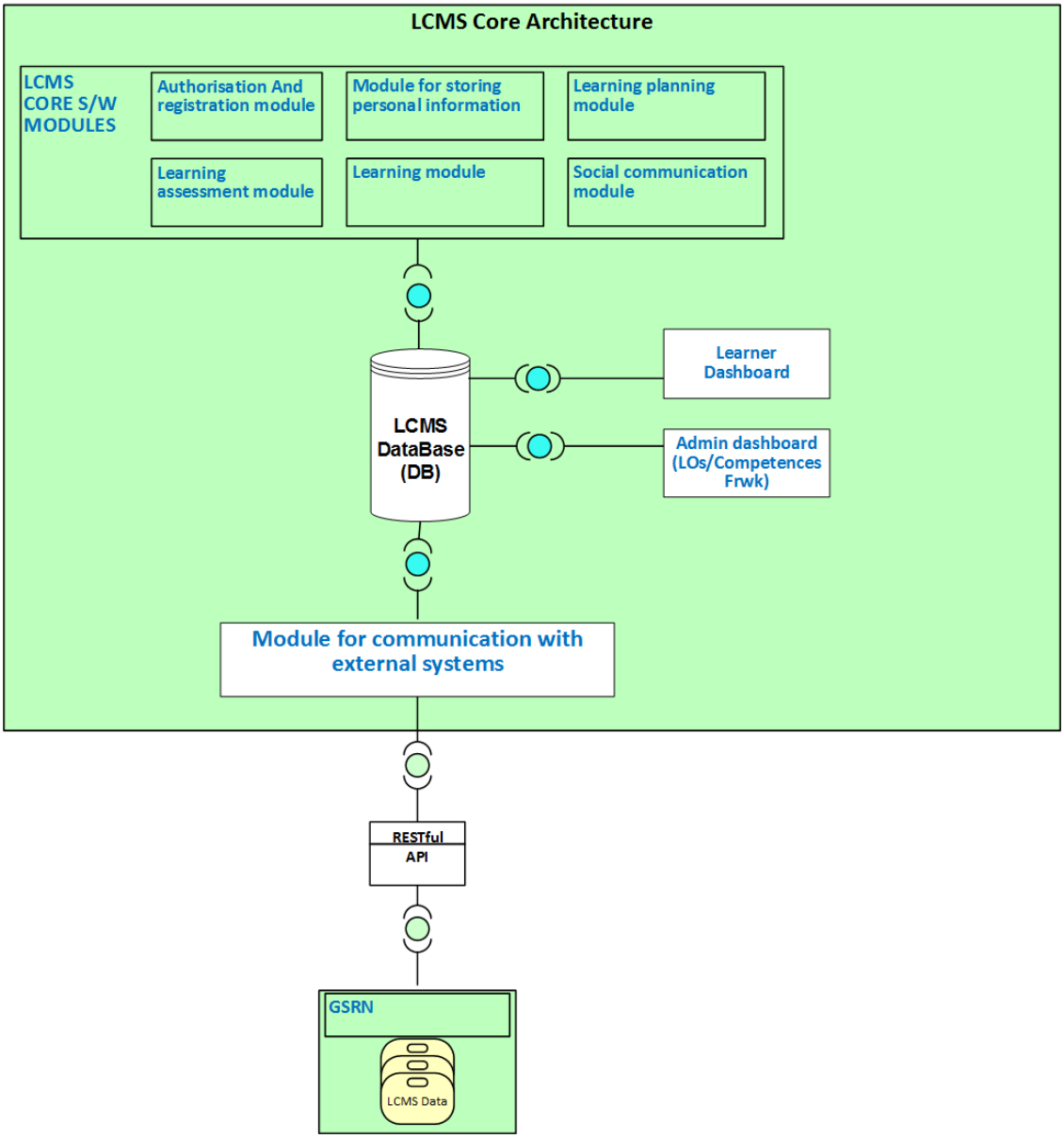


Figure 8: LCMS architecture design

3.5.1. Authorisation and registration module

Users will use a single ID and password to gain access to each subsystem without using different usernames or passwords. This module is related to identifying uniquely each learner and making use of such unique information across several other SOCIALENERGY subsystems. LCMS will support user authentication using various open mechanisms like LDAP, the Shibboleth protocol, CAS or FirstClass. User enrolment can be supported also on the base of external LDAP server or through suitable IMS standards (like LTI).

3.5.2. Module for storing personal information

In this S/W module, LCMS user personal information is stored about the learner's competences, grades, results, assessments, courses and learning resources used, etc. This information will be visualised to the respective user through her/his LCMS Learner

Dashboard. The collected information will be also used by the GSRN platform and appropriate parts of it will be visualised through the GSRN Central User DashBoard.

3.5.3. Individual Learning planning module

This module will receive the created Individual Learning Plan (ILP) from GSRN for each individual user. The ILP is based on the SOCIALENERGY competences' framework, realised, fully supported, and served by the LCMS. On the base of the ILP, this S/W module will create a set of learning objects (courses or learning resources/activities), covering the required competences in the learner's ILP, which later on the system will offer to the learner.

3.5.4. Learning assessment module

This is a S/W module for supporting various modes of assessment of learner's knowledge and competences like quizzes, tests, tasks, etc. with clear and transparent rules for grading. Competency-based assessment will be supported by grading related to activities, where students demonstrate the relevant competencies. As a result, learners will receive a list of outcome competencies, achieved as a result of performing specific learning objects (set of activities and/or courses). Each course (learning object) will have its own Gradebook. Some activities, such as Assignment and Quiz will automatically send grades to the Gradebook. The system will enter and arrange grades into the Gradebook. Grades calculation formula can be set up to the Gradebook for grading each competence. The obtained assessment results (including competences) will be presented in the LCMS Learner Dashboard and submitted to the GSRN for presenting them to the Central User Dashboard and making available to the other GSRN subsystems (e.g. RAT).
On the base of the set of achieved competences, the user will receive respective awards in the form of badges, and eventually (upon ILP completion) – printable PDF certificates.

3.5.5. Learning module

This module provides sets of rich learning objects (activities and/or resources) for each individual learner, based on the required competences in his/her individual learning plan. The activities and resources are related to one or more required competences, and can include, for example, lessons, video lectures, reading materials, demonstrations, simulations, explanations, discussions, feedback, surveys, etc. Progress tracking allows all finished learning activities, visited learning resources, etc. to be guided by individual learning plans for each learner. Learners can follow their success through the course by viewing the respective progress bar. The system can indicate for each course item how it will be registered as complete. Learners may either mark this learning activity complete manually, or the course item will automatically be marked as complete, when learner meets the specified criteria. These criteria will indicatively include: viewing a resource, submitting an assignment, performing an activity, posting in a forum or other relevant output. In addition, badges can be awarded by the system using activity completion settings in a course. Learners may be awarded badges at different stages of the course for different levels of progress. Also, PDF certificates/diplomas can be issued automatically and awarded to learners in a course, after the successful completion.

3.5.6. Module for communication with external systems

LCMS should be able to communicate with all other SOCIALENERGY modules and subsystems. In order to achieve this, the LCMS should support APIs and standards for integration with other systems, like the LTI (Learning Tool Interoperability), in order to consume learning resources and other relevant information from external systems, as well as to publish (or offer) similar information to external systems, in well agreed (in advance) format. The LCMS should be able to import and export any achievement results, such as badges, following and supporting standards like Mozilla's Open Badges.
LCMS will support the import of Reusable Learning Objects, packaged according to the SCORM/AICC/IMS Content Packaging standards, or according to the IMS Common Cartridge import and export specifications. The use of XML for content import/export will also be supported.
Since the LCMS core API and the modules will communicate on the base of events, this type of communication will allow population of LCMS actions and data of interest to external systems through their public APIs (e.g. new course created, new LO added, LO deleted, new competence added etc.)

3.5.7. Social communication module

This module will enable learners to be grouped by their interests or using other relevant features, like competence levels, etc. They can communicate in their groups using many different forms using various tools like a chat, forum, dialogue, messages, wikis, tags, ranking, etc. The LCMS will use the GSRN functionality for connection with social platforms (Facebook and Twitter). The users will be able to post to the social networks actions and news from the LCMS about their achievements (e.g. achieved competences, awarded badges, obtained certificates, etc.).

3.5.8. Data models

3.5.8.1. The model of learning, organized in the set of Learning Objects

Each learning object will provide set of learning resources, activities and/or learning assessments, related to achieving some predefined learning goals in terms of achieving some particular competencies. Each learning object can be represented internally as an organizational unit, for example a course. There will be well-defined sets of available learning resources, activities and assessments. The set of learning resources will include: lecture note, video lecture, hand-out, blog, message, rank, book, external site (URL), literature, etc.
The set of learning activities will include: forum, glossary, wiki, assignment, quiz, choice (poll), SCORM player, database, simulation, group (of learning activities), learning path, workshop, checklist, news, calendar, programmed lesson etc.
The list of assessments will include: quiz, test, assignment, gradebook, peer evaluation, portfolio etc. The model of learning will be implemented in the learning module (see 3.5.5 above).

3.5.8.2. Grading (assessment) model

This model should allow simple and flexible possibilities for giving individual grades for each individual learning activity, or for a set of such learning activities organised as a learning

object (or course). This could be done automatically dependent on pre-set rules in advance. This model will be implemented in the module for grading and assessment.

3.5.8.3. Competencies model

The LCMS will support competency frameworks, based on the taxonomy for defining the three structures of the competency names and their dependencies, and competency scales for defining the competency levels existing for each individual competency.
The LCMS will support the export and import of competency frameworks by using some well-defined internal format.
Competency rules will be used for automatically marked competencies as complete at some scale depending on other competencies' completion. Linking competencies to course activities through competency rules will also enable automatic setting of these competences, when the learner will successfully complete these course activities.

3.5.8.4. Learner profile model

This model will allow storing information related to competencies, which a learner possesses (to be imported from GSRN, or via API), and learning plans assigned to learners (again from GSRN). Other relevant information may be stored as well.
When an action takes place concerning a KPI update, the LCMS will notify the GSRN system through the RESTful APIs (e.g. badge awarded, competence achieved, learning plan completion). Moreover, the LCMS can provide KPI information by request from GSRN.

4. SOCIALENERGY system specifications

Elaborating on chapter 3, where all SOCIALENERGY subsystems have been described, Chapter 4 presents the technical specifications for each subsystem, which will be used as input for the S/W development work. Each one of the 4 S/W components (i.e. subsystems) consists of several S/W modules. For each S/W module, we define the technical specifications. This is actually a continuation of the requirements' analysis work which has already been reported in D2.1 (M4). In particular, in D2.1, we have analysed all the requirements for each subsystem, the system as a whole and SOCIALENERGY's use cases (UC-1, UC-2). In this report, we elaborate on this work being specific about what datasets/processes/content/algorithms/information flows run in each S/W module, among S/W modules and among S/W components.

4.1. GSRN technical specifications

Table 7: Green Social Response Network (GSRN) platform specifications

GSRN platform user login	
Specification#	GSRN-SPEC_1
System/component	Login as GSRN end user
Type of spec	Functional
Description	This initial GSRN functionality is used for the sign in of a certified (existing) user to the GSRN platform. After the certification of the user the GSRN Platform returns an authentication token to the client. That token gives him access to specific GSRN resources with respect to her/his role. Every GSRN user will have a unique ID upon sing-in that will be also used for the interaction of GSRN with all other SOCIALENERGY components.
Use Case#	UC-1
Relevance to WPs	WP3

GSRN platform connectivity with MDM Data and sensors	
Specification#	GSRN-SPEC_2
System/component	Retrieve MDM energy DATA
Type of spec	Communication
Description	This GSRN functionality is used from its clients (i.e. RAT functionality or End Users) to provide energy consumption profiles and information on a tabular or graphical interface from utilities for: research algorithms development and performance evaluation. The UC uses authentication method to define a user and its meter consumption and then gets all related data and meter types. Also, time dimension will be acquired as well from the API, so consumption will be defined in days, weeks and months.
Use Case#	UC-1
Relevance to WPs	WP3

GSRN platform tracking of User Engagement KPIs	
Specification#	GSRN-SPEC_3
System/component	Retrieve GSRN user's engagement
Type of spec	Functional
Description	This GSRN functionality is used for the clients, to retrieve GSRN user's engagement. User Engagement tracking uses a list of respective KPIs (Key Performance Indicators) that describe a combination of users' interaction with the Game (logs, interactions, time for playing, etc), the GSRN platform and the LMS module (time spent, logs, etc). User engagement is also a function of user digital interaction with the GSRN functionalities (Marketplace, efficiency metrics, savings potential, etc). User's engagement will be a unique, variable vector of KPIs that will define the dynamic engagement of each user in the GSRN platform. The vector will be daily updated and stored in the GSRN DB.
Use Case#	UC-1
Relevance to WPs	WP3

GSRN platform tracking of GAME and LCMS KPIs	
Specification#	GSRN-SPEC_4
System/component	Retrieve LCMS user's engagement / badges
Type of spec	Functional
Description	This GSRN functionality is used for the users to retrieve directly specific metrics from the LSMS module and the GAME module of GSRN. GAME metrics (badges, leader board, points, etc) and LCMS metrics (grades, content, quizzes, courses) are gathered and used to compute the combined user engagement KPI.
Use Case#	UC-1
Relevance to WPs	WP3

GSRN platform connection with RAT	
Specification#	GSRN-SPEC_5
System/component	Retrieve RAT user's profiles
Type of spec	Functional
Description	This GSRN functionality is used for GSRN to get pricing data for each user, based on the RAT module. RAT, runs analytics and computes the predictions and the respective prising signals for each user. This is based on the utility package and the user demand profile, which is provided by the MDM and GSRN APIs (SPEC_2). As soon as all information is in place, RAT computes the pricing signals and the proposed pricing package for each user. Prising signals are provided to the GSRN user dashboard based on this UC (see D2.1).
Use Case#	UC-1
Relevance to WPs	WP3

GSRN platform connection with GAME	
Specification#	GSRN-SPEC_6
System/component	Retrieve user's score from game (NRG)
Type of spec	Functional
Description	This GSRN functionality is focused on the real time GSRN-GAME connection (API) in order for the GSRN user profile to be updated with the user GAME score from the live GAME. The GAME score is a variable that changes almost every day or after every user's interaction with the gaming scenario and game application.
Use Case#	UC-1
Relevance to WPs	WP3

GSRN platform connection with EIDaaS module	
Specification#	GSRN-SPEC_7
System/component	GSRN connection/export to EIDaaS
Type of spec	Functional
Description	This GSRN functionality is using a central API to publish open data (based on the new GDPR regulations from EU) for data monetization services to 3rd party partners. The present functionality will also use input from the RAT module, in order to produce statistical indices and analytics outputs that will be a good monetization source for external clients and partners. GSRN will follow a subscription-only revenue model (among other revenue streams that will be described under the Exploitation task) in order to export metrics, trends, KPIs, statistics and other anonymous data, coming from the GSRN platform and its modules.
Use Case#	UC-1
Relevance to WPs	WP3

4.2. Game technical specifications

Table 8: SOCIALENERGY GAME specifications

Receiving Data From GSRN	
Specification#	GAME-SPEC_1
System/component	Energy Efficiency Game
Type of spec	Communication
Description	The game will receive required data for gameplay from GSRN. The starting point of the player will be determined by his/her initial input after being processed by LCM. The LCM will send the result of this processing through GSRN back to the GAME. Login of the player and the data needed for it will be transferred from GSRN. Inside the Game, the progress of the player is monitored and reflected through the exchange of data between the GAME and GSRN. The exchanged data will be above other experience points, level, score, virtual currency, activity level and multiplayer interaction events. The progress of a player will be accessible to all players through the "GSRN dashboard".
Use Case#	UC-2
Relevance to WPs	WP4

Dynamic Pricing	
Specification#	GAME-SPEC_2
System/component	Energy Efficiency Game
Type of spec	Functional
Description	In the beginning, the player will have fixed prices, which are provided to the game by RAT through GSRN. The energy consumption is based on consumption of different electric appliances. The electric appliance's models will be provided by MDM (in cooperation with RAT). As the game progresses, the pricing will start to depend on player's actions. These dynamical prices will be calculated through the RAT mathematical formulas and support of the GAME-GSRN-RAT communication. The game will send progress, energy consumption and satisfaction level of the player to RAT for processing and price correction. With increasing level of the player, this communication will also include the actions of other players, making the price depending on actions of other players, too.
Use Case#	UC-2
Relevance to WPs	WP4

Energy Community Data and pricing	
Specification#	GAME-SPEC_3
System/component	Energy Efficiency Game
Type of spec	Functional
Description	The game will incorporate Community Data and will generate prices depending on decisions and energy consumption of other players, who are members of the same virtual energy community. The Community goals will be more difficult to achieve, as the individual players should interact with each other (or else each player's actions affect all other players' gameplay). They will need to either minimize their energy consumption or maximize the energy efficiency. This will enforce players to make arrangements (either in an explicit or implicit manner) with each other.
Use Case#	UC-2
Relevance to WPs	WP4

Jobs	
Specification#	GAME-SPEC_4
System/component	Energy Efficiency Game
Type of spec	Functional
Description	According to the level of each player, s/he needs to do several jobs within a given time horizon. After player's login, the game will determine how many and which jobs s/he needs to fulfil within this time horizon (i.e. day). This also means getting the first step of each job, as every job is divided in several steps. After each step, the next step must be gathered from a predefined script. Fulfilling a job, effects the avatar's satisfaction level, which is directly related with the score achieved within the game. The result of the job is sent to RAT to calculate the effect on the avatar. If any device was used, the data must be first collected from MDMS/RAT.
Use Case#	UC-2
Relevance to WPs	WP4

Objects	
Specification#	GAME-SPEC_5
System/component	Energy Efficiency Game
Type of spec	Functional
Description	The Objects are divided in electric appliances, functional objects, decoration objects and inventory objects. The electric appliances have the most data, which will be provided through MDMS. These objects influence the energy consumption depending also on the upgrade level and other parameters such as: the capacity, the mode of operation, the energy class of the appliance and the duration of each energy consumption task. Upgrading electric appliances gives rewards to the player and better game scores in the future. The functional objects are objects without energy consumption, but still have some data related to a job like action duration.Decoration objects are rewards for the player. They can't perform any action and have only date about the requirements for their unlocking. Inventory Objects are used while performing a job. They can be used with electric appliances or with the functional objects. Inventory Objects will be represented in player's inventory or as functional object, before they are picked up.
Use Case#	UC-2
Relevance to WPs	WP4

Development Platform	
Specification#	GAME-SPEC_6
System/component	Energy Efficiency Game
Type of spec	Functional
Description	The game will be developed as a Web application in HTML5. For the game development, the "UNITY" game engine[5] will be used. The game will be controlled through mouse interaction. The connection between Game and GSRN Platform will be performed via a web based RESTful API.
Use Case#	UC-2
Relevance to WPs	WP4

Game Parameters	
Specification#	GAME-SPEC_7
System/component	Energy Efficiency Game
Type of spec	Functional
Description	The game will provide the GSRN Platform with certain data. This data will consist of: experience points, game level, avatar satisfaction status, avatar appearance, cash, credits, electric appliance status, playtime, unlocked objects and badges. The LCMS and RAT components can get this data through the GSRN Module. Thus, the game (i.e. virtual world) will act not only as an educational game but also as a testbed-like application for the real-life evaluation of the research algorithms. Finally it will also provide extra behavioural analytics data to GSRN (i.e. real world).
Use Case#	UC-2
Relevance to WPs	WP4

[5] https://unity3d.com/

Avatar	
Specification#	GAME-SPEC_8
System/component	Energy Efficiency Game
Type of spec	Functional
Description	The Avatar will be generated according to GSRN Profile depending on gender and age. Depending on required effort, a small avatar editor can be implemented. This would add customization options to the avatar. The avatar could be further used as a profile picture on GSRN Platform.
Use Case#	UC-2
Relevance to WPs	WP4

Game Scenario Setup/customization	
Specification#	GAME-SPEC_9
System/component	Energy Efficiency Game
Type of spec	Functional
Description	The Game Scenario for the player could be chosen through a scenario screen or automatically selected depending on the results of the LCMS-Pre-test. In case of dependency on the Pre-Test, the LCMS will send through GSRN the right scenario to the game (e.g. a naïve player will be more keen on playing the “fixed pricing” game scenario, while an advanced player will be keen on playing a “P-RTP” and/or an “EC-RTP” game scenario).
Use Case#	UC-2
Relevance to WPs	WP4

Score Calculation	
Specification#	GAME-SPEC_10
System/component	Energy Efficiency Game
Type of spec	Functional
Description	The score calculation is divided in daily satisfaction score and daily energy cost score. The daily satisfaction score is depending on the jobs that the player has accomplished. The jobs can have certain timeframe, in which they provide the most points. The maximum points you can get per day are 100 points. Daily cost will be calculated through RAT and provided to the Game through GSRN. The overall score is the sum of the daily scores. More details about the score calculation specifics will be provided in D4.1 (M9).
Use Case#	UC-2
Relevance to WPs	WP4

Virtual World Time	
Specification#	GAME-SPEC_11
System/component	Energy Efficiency Game
Type of spec	Functional
Description	The Virtual World time will be provided to the game by RAT Platform. The game will synchronize with the virtual world time in a high frequency. The synchronization is important for time relevant jobs and efficiency calculation. The synchronization is also important for providing players the possibility to play as energy communities.
Use Case#	UC-2
Relevance to WPs	WP4

Virtual house customization	
Specification#	GAME-SPEC_12
System/component	Energy Efficiency Game
Type of spec	Functional
Description	At the beginning of the game, all virtual houses will be the same to give all players the same prerequisite. The rooms will stay the same, but the objects can and will change over the course of the game. Player can buy and upgrade new electric appliances. In progress of the game, player will be rewarded with new decoration objects. The data from the objects will be provided to the game from MDM through the GSRN Platform.
Use Case#	UC-2
Relevance to WPs	WP4

Multi-player Interactions	
Specification#	GAME-SPEC_13
System/component	Energy Efficiency Game
Type of spec	Functional
Description	Some scenarios are containing multiplayer interactions (Energy Communities). These interactions will be shown through the GSRN Platform. The game will get them and display them to the player.
Use Case#	UC-2
Relevance to WPs	WP4

Social Interaction	
Specification#	GAME-SPEC_14
System/component	Energy Efficiency Game
Type of spec	Functional
Description	The activity and social interactions will occur on the GSRN Platform. The GSRN Platform can provide the information to the game for creating an activity level.
Use Case#	UC-2
Relevance to WPs	WP4

Note: It should be noted that there is a deliverable D4.1 explicitly dedicated to "SOCIALENERGY's Game Design", which will be delivered in September 2017 (Month 9). Therefore, more details about the technical specifications (e.g. game parameters, avatar, electric appliances, functional/decoration/inventory objects, game scenario setup/customization, Jobs, score calculation, energy cost calculation, user satisfaction calculation, virtual world time, virtual house customization, self-evolving game features, multi-player, social interaction, etc.) will be included therein.

4.3. Technical specifications for the research algorithms' toolkit - RAT

Table 9: Research Algorithms Toolkit (RAT) specifications

RAT receives real energy consumption related data from the MDM	
Specification#	RAT-SPEC_1
System/component	Research algorithms' toolkit
Type of spec	Functional, communication
Description	A fine-grained Application Programming Interface (API) will be implemented in order for energy consumption related data to be efficiently retrieved upon demand from the Meter Data Management System (MDMS) of SOCIALENERGY. This API will also be used by the core GSRN platform and will have a similar structure. RAT will deploy a stand-alone API client in order to cope with any minor S/W implementation changes that might be needed during the whole project's development lifecycle. Via this API, RAT will be able to receive energy consumption curves for all types of: a) users (e.g. residential, commercial, industrial), b) timeframes (e.g. select any dates of preference), c) time granularities (e.g. 5-min, 15-min, hourly, daily datasets). These Energy Consumption Curves (ECCs) can be directly used for online algorithm's execution or else be stored in RAT's database in order to be available for all offline research algorithms' execution and respective simulations. Furthermore, RAT extracts the utility function per device and per consumer, which represents the relation (i.e. trade-off) between the device/consumer comfort level and the respective energy flexibility level that can be achieved. Finally, the energy cost curve of the utility (or else energy provider) is also retrieved that calculates the cost per generated unit.
Use Case#	UC-1 (especially scenario 1C)
Relevance to WPs	WP3

RAT receives information from the core GSRN platform via GSRN-RAT API	
Specification#	RAT-SPEC_2
System/component	Research algorithms' toolkit
Type of spec	Functional, communication
Description	A two-way API will be implemented for the RAT-GSRN communication channel. The GSRN-RAT API's structure will contain: a) static data for individual consumers (i.e. age, gender, location, education level, number of houses registered in the system, type/energy class of house, etc.), b) semi-static datasets, which may be periodically updated (e.g. once a month) such as: the total points, badges, "challenges", trophies gained per user, the LCMS level, the GAME level of each user, the type of Energy Program that he/she participates, the EC that he/she is involved, the history of energy efficiency products' purchases, the social media graph, etc., c) dynamic information (sent from GSRN to the RAT upon the occurrence of a significant system-level event) which is triggered based on specific system rules and when pre-defined thresholds have been surpassed (e.g. a malicious/cheating user is detected, a user has just switched to another EP or EC, etc.).
Use Case#	UC-1
Relevance to WPs	WP3

RAT sends information to the core GSRN platform via RAT-GSRN API	
Specification#	RAT-SPEC_3
System/component	Research algorithms' toolkit
Type of spec	Functional, communication
Description	Via RAT-GSRN API, all useful outputs from the RAT's scientific algorithms should be sent to the GSRN in order for all types of SOCIALENERGY users (i.e. individual consumer, EC leader, ESCO user, utility user, other external users) to be able to visualize significant energy-related graphs, SOCIALENERGY KPIs and statistical metrics, which are useful for improving their: a) engagement in SOCIALENERGY's functionalities and b) real-life business operations. In particular, the RAT provides data analytics-related services to the core GSRN platform as follows: a) regarding the individual consumer, he/she is able to visualize his/her energy costs and compare his/her energy/cost savings with other EPs that he/she could select in the future. He/She can also visualize his/her energy behaviour change over time and thus better understand his/her achievements so far as well as the extent of the new potentials that the system can offer to him/her, b) regarding the EC leader and ESCO user, he/she can visualize graphs related with the achievement of his/her EC or customer portfolio (e.g. retrieve the top-10 best/worst behaving consumers), c) regarding the utility user, he/she can visualize the profit margin of the utility's business and run various simulations to understand the ways that these profits can become greater without deteriorating the quality of service offered to the customers. S/he can also customize the various parameters of an energy program (or else pricing mechanism) in order to be able to understand whether a new EP can be sustainable from a business point of view and which is the customer group that best fits to the specifications of each EP, d) regarding the electric appliance retailer user, he/she will be able to identify the group of consumers, which are more keen on purchasing a specific electric appliance (e.g. A/C) based on the way they use this device in their everyday life.
Use Case#	UC-1 (especially scenario 1C)
Relevance to WPs	WP3

RAT provides the required device, cost, user satisfaction models and pricing equations for the SOCIALENERGY GAME operation	
Specification#	RAT-SPEC_4
System/component	Research algorithms' toolkit
Type of spec	Mathematical models and equations
Description	Based on the research activities that take place within WP3 context, RAT incorporates all the mathematical/analytical work, which is needed for the calculation of the GAME metrics such as the cost of energy and the user satisfaction. Each virtual house within the GAME will have a specific energy consumption model based on the energy consumption curves of each individual electric device. The energy cost for a consumer is derived based on the pricing model that is used. , All mathematical equations, which are used in RAT for the various pricing models will be incorporated in the GAME's online operation. The mathematical function that defines the user satisfaction level vs. his/her energy flexibility will be alsoincorporated in the GAME's online operation. GAME points' calculation is based on a form: USER SATISFACTION – COST. The terms of this form will be dynamically adapted according to the game level's difficulty.
Use Case#	UC-2
Relevance to WPs	WP3 & WP4

RAT receives information from the SOCIALENERGY GAME via GAME-RAT API	
Specification#	RAT-SPEC_5
System/component	Research algorithms' toolkit
Type of spec	Functional, communication
Description	The GAME-RAT API will have the same structure with the GAME-GSRN API, which will be developed by INTELEN and NRG (see more details about this technical specification in sections 4.1 and 4.2 above). Via this API, RAT will get all players' behavioural data from the GAME (e.g. history of game points, participation in single-player and/or multi-player mode, level of game engagement, game levels accomplished), which is useful as input for the EC creation and adaptation algorithms' modules, too. From the RAT's perspective, a client web API will be deployed by ICCS based on the GAME-GSRN API structure.
Use Case#	UC-2
Relevance to WPs	WP3 & WP4

RAT has a single data acquisition node where all acquisition data is gathered	
Specification#	RAT-SPEC_6
System/component	Research algorithms' toolkit
Type of spec	Functional
Description	RAT provides integrated acquisition services via its Data Acquisition Module (DAM). The latter serves as a data stream gateway interconnecting RAT's S/W modules with other SOCIALENERGY subsystems (or else S/W components) such as the core GSRN platform, the MDMS and the GAME. Web APIs will be implemented for all these interactions. In DAM, data is temporarily stored, until the inherent SOCIALENERGY intelligence "allows" it to be forwarded to other S/W modules/components. Data related with SOCIALENERGY's real and virtual world is acquired from the GSRN and the GAME respectively. Energy consumption related data is acquired from the MDMS. DAM's intelligence basically lies on the timeliness of the SOCIALENERGY's data delivery and its context-aware management.
Use Case#	UC-1
Relevance to WPs	WP3

RAT includes a database for all scientific results and related datasets to be stored, retrieved and managed	
Specification#	RAT-SPEC_7
System/component	Research algorithms' toolkit
Type of spec	Functional
Description	RAT has a centralized database, which provides restful APIs to all other RAT S/W modules (i.e. RAT algorithms, Profiling and Searching Module (PSM), Data Acquisition Module (DAM), UAD and CP). RAT database includes static, semi-static and dynamic SOCIALENERGY datasets, which can be efficiently stored, retrieved and managed. Static datasets mainly include: energy consumers' initial information upon registration to SOCIALENERGY platform, basic rules and policies, fixed algorithms' inputs, regulatory-related restrictions/constraints, electricity-market-related threshold/constraints basically related with energy programs, etc. Semi-static datasets come up after relatively simple arithmetic calculations and do not change so often (e.g. EC's structure and features, calculation of simple system metrics, etc.). Dynamic datasets include temporary data, which come up during/after the execution/completion of RAT algorithms. RAT database's operation is closely related to the functionalities of DAM, which provides context-aware SOCIALENERGY intelligence about storage, retrieval and management of data according to SOCIALENERGY system's operational status.
Use Case#	UC-1
Relevance to WPs	WP3

RAT derives several energy pricing models and simulates the operation of various innovative energy programs	
Specification#	RAT-SPEC_8
System/component	Research algorithms' toolkit
Type of spec	Software
Description	Several energy programs and respective energy pricing models will be designed, implemented and integrated in RAT algorithms' S/W module. The results of this research work being undertaken within Tasks 3.2 and 3.3 by ICCS will be integrated in RAT in order to be exploitable for business purposes by both GSRN platform and the GAME. Apart from the traditional flat pricing energy program, five (5) more families of EPs will be integrated in the RAT algorithms' module: a) Inclining Block Rates (IBR) EPs, b) Time-of-Use (ToU)-based EPs, c) Real-Time Pricing (RTP) EPs, d) Personalized RTP-based EPs, and e) EC-RTP EPs. The basic inputs used for the algorithms' operation are: a) a 'utility' function for each user representing the relation between the price vs. flexibility (or else comfort level) of each user, b) cost of the generated energy needed to meet the demand (plus the energy provider's business profit), c) energy consumption curves (ECCs) of all consumers. Based on these inputs, a classic market clearing algorithm is applied that finds the price per energy unit (i.e. €/KWh), in which the supply meets demand curve. The basic outputs of these algorithms are the following: a) total cost of electricity, b) energy cost/savings for each consumer/EC, c) welfare of all users (i.e. sum of comfort levels), d) energy provider's profits, e) fairness index in the distribution of cost benefits among the consumers. Based on these outputs, several more metrics can be derived so that the various EPs to be easily compared.
Use Case#	UC-1 (especially scenario 1C), UC-2
Relevance to WPs	WP3, WP4

RAT calculates the energy costs and savings and virtual currency per individual consumer and energy community	
Specification#	RAT-SPEC_9
System/component	Research algorithms' toolkit
Type of spec	Software
Description	Following up the results described in RAT-SPEC_8, RAT is able to recommend the most appropriate EP to each individual consumer and EC. The algorithmic and data analytics results will also be useful for the ESCO and utility/energy provider/retailer user, who will be able to visualize the results via GSRN platform and then decide which is the best business strategy to follow regarding the pricing model and the all the prerequisites of the EPs that have in their business portfolio. Based on RAT results, SOCIALENERGY develops an objective distribution policy aiming at rewarding the best-performing consumers and ECs. However, SOCIALENERGY will also keep an open policy that allows stakeholders to give distribution credits to any subset of energy consumers any time that they like by triggering in this way gamification of any activity. In this way, ECs reward collectively their members for their activities (e.g. discovery of attractive EPs, management of ECs, help in the user and company profiling, facilitation in GSRN marketing etc.). The SOCIALENERGY admin user (i.e. ESCO user) will be able to customize a few parameters of the credit distribution policy and based on this input, the P-RTP and EC-RTP algorithms will provide the virtual currency results that each individual consumer and/or EC has gained so far in the SOCIALENERGY platform.
Use Case#	UC-1 (especially scenario 1C)
Relevance to WPs	WP3

RAT creates the virtual Energy Communities (ECs)	
Specification#	RAT-SPEC_10
System/component	Research algorithms' toolkit
Type of spec	Software
Description	Within the EC creation algorithms' S/W module, several clustering algorithms are executed in order for the most appropriate network of virtual energy communities to be formed. The basic inputs of these algorithms are: a) the energy consumption curve (ECCs) and price vs. flexibility curve for each consumer, b) an "energy graph", which represents each consumer as a graph's node and each edge represents the correlation between two consumers' energy consumption profiles (e.g. positively correlated ECCs may be appropriate to be members of the same EC for a specific EP), c) a "social network" graph, which represents how close each consumer is with all other consumers belonging to the same business portfolio. Then, an objective function is created, which calculates the 'distance' that all consumers have among each other both from energy and social perspectives. Subsequently, several types of clustering algorithms will be applied such as spectral clustering, genetic, k-means, etc. The output of these algorithms will be the formation of virtual energy communities (VECs) operated and managed by SOCIALENERGY platform. Each VEC will have all the appropriate characteristics in order for high peer pressure levels to be achieved towards the desired behaviour change of its members.
Use Case#	UC-1
Relevance to WPs	WP3

RAT adapts the structure of virtual energy communities	
Specification#	RAT-SPEC_11
System/component	Research algorithms' toolkit
Type of spec	Software
Description	Following up the results described in RAT-SPEC_10, RAT is able to automatically adapt the structure of VECs whenever a set of system parameters/thresholds have been violated. In particular, the SOCIALENERGY admin user (i.e. ESCO user) is able to set bounds for: a) the size of each EC, and b) the min/max aggregated flexibility level that one EC may have. He/She can also set triggers and respective rules in case of a new/abnormal event (e.g. a consumer wants to engage to another EP, a new/old customer has registered/unregistered, the system profile of a customer has changed substantially, malicious/cheating actions have been identified, etc.). Based on this type of inputs, re-clustering algorithms will be executed in RAT algorithms' module. The output will be the new structure of the ECs (i.e. which consumer belongs to which EC).
Use Case#	UC-1
Relevance to WPs	WP3

RAT provides intelligent reporting and recommendation functionalities	
Specification#	RAT-SPEC_12
System/component	Research algorithms' toolkit
Type of spec	Software
Description	Based on the results from RAT-SPEC_10 and 11, RAT will provide intelligent reporting and recommendation services to GSRN platform. The pre-requisite is that the SOCIALENERGY admin user sets a group of system rules and personalized messages (from business perspective) that sends to its customers. As RAT is periodically fed with new GSRN data (see GSRN-RAT interface specification above), the EC creation/adaptation algorithms can provide an updated EC infrastructure. According to it GSRN is able to provide reporting and recommendation services to its customers towards efficient and long-term user engagement in SOCIALENERGY's platform functionalities and potentials.
Use Case#	UC-1
Relevance to WPs	WP3

RAT provides profiles' management and searching functionalities together with associated visualization capabilities to different types of SOCIALENERGY users	
Specification#	RAT-SPEC_13
System/component	Research algorithms' toolkit
Type of spec	Functional
Description	Via the Profiling and Searching Module (PSM), the user of RAT is able to request any type of information and then retrieve and visualize it in the RAT's web interface. For example, the ESCO user can select any timeframe (from an online calendar) and feature that wants to visualize (e.g. which is the set of users that are highly engaged in energy efficiency, which is the percentage of consumers, who participate in a specific set of energy programs, which is the profile of the consumers that are not easily engaged in energy efficiency, which is the average percentage of energy/money savings for a specific group of consumers or EC, which set of users has used SOCIALENERGY platform the most during the last month, etc.). In other words, via targeted queries to the RAT DB, the ESCO user can have a holistic view of his/her portfolio in order to be able to take effective strategic decisions for his/her business.
Use Case#	UC-1
Relevance to WPs	WP3

RAT provides configuration capabilities to the associated users	
Specification#	RAT-SPEC_14
System/component	Research algorithms' toolkit
Type of spec	Functional
Description	RAT provides configuration capabilities the user via the "Configuration Panel (CP)". This is actually the web-based platform via which the various types of SOCIALENERGY users can perform manual actions related to SOCIALENERGY operation. In other words, various RAT operations, which are automatically made by the pre-mentioned RAT software modules (i.e. research algorithms) can also be done manually by the RAT's users. This is a very important capability that RAT should include especially for periodic events' handling, to set up strategies', policies' and algorithms' parameters of the toolkit and RAT algorithms' operation.
Use Case#	UC-1
Relevance to WPs	WP3

RAT provides user administration services	
Specification#	RAT-SPEC_15
System/component	Research algorithms' toolkit
Type of spec	Functional
Description	RAT provides SOCIALENERGY user administration services via the "User Admin Dashboard" (UAD). Various types of SOCIALENERGY users exist such as EC leader, ESCO user, electric utility user, researcher, policy maker, other external user, etc. Each type of RAT user will have diversified authentication/authorization credentials thus having access to information that is required to know.
Use Case#	UC-1
Relevance to WPs	WP3

4.4. Learning Content Management System technical specifications

Table 10: Learning Content Management System (LCMS) specifications

Competence-based Individual Learning Plan (ILP)	
Specification#	LCMS-SPEC_1
System/component	Learning Content Management System
Type of spec	Functional
Description	The competence-based individual learning plan (ILP) is based on the SOCIALENERGY competences' framework that LCMS fully supports. Based on the ILP, the LCMS will retrieve learning objects (learning resources/activities) that cover the competences required in the plan and will create a set of LOs. Each of the learning objects included in this set is related to one or more competencies included in the ILP. In order to support competency-based learning, LCMS will offer this set of learning objects to the learner with relevant ILP. *Implemented in: Learning planning module (see also section 3.5.3 above)*
Use Case#	UC-1
Relevance to WPs	WP3, WP4

Learner identification across SOCIALENERGY systems	
Specification#	LCMS-SPEC_2
System/component	Learning Content Management System
Type of spec	Functional
Description	The learner identificator aims at identifying uniquely each learner and make use of such unique information across several other SOCIALENERGY systems. Users will use the same ID and password to gain access to each SOCIALENERGY subsystem including the LCMS. As there will be a single sign on in SOCIALENERGY if the user is already signed in some of other subsystems, and decides to access the LCMS s/he will be automatically signed in the LCMS. There will be no need of additional authentication in LCMS subsystem. *Implemented in: Authorisation and registration module (see also section 3.5.1 above)*
Use Case#	UC-1
Relevance to WPs	WP3, WP4

Learner information database storage	
Specification#	LCMS-SPEC_3
System/component	Learning Content Management System
Type of spec	Functional
Description	The learner information database storage aims at storing personal information about learners – competences, grades, results, courses, assessments, learning resources used, etc. This information will be collected from the user' ILP and his/her activities in the LCMS (for example competences that s/he achieved, results from assignments that s/he has completed, etc.). This information will be visualised through his/her LCMS Learner Dashboard. The collected information will be used also by the GSRN platform. *Implemented in: Module for storing personal information (see also section 3.5.2 above)*
Use Case#	UC-1
Relevance to WPs	WP3, WP4

Learner competency taxonomy	
Specification#	LCMS-SPEC_4
System/component	Learning Content Management System
Type of spec	Functional
Description	The learner competency taxonomy aims at allowing competency-based learning and assessment. It is based on taxonomy of competencies related to the learning domain. The learner competency taxonomy is represented in the LCMS through the SOCIALENERGY's competences framework. It is the basis on which the competencies, from the generated individual learning plan which will be received by GSRN, will be linked to specific learning objects in the LCMS. *Implemented in: Learning planning module information (see also section 3.5.3 above)*
Use Case#	UC-1
Relevance to WPs	WP3, WP4

Competence-based assessment	
Specification#	LCMS-SPEC_5
System/component	Learning Content Management System
Type of spec	Functional
Description	Competence-based assessment supports various modes of assessment of learner's knowledge and competences and relevant grading according to achieved results. The assessment in the LCMS is based on the different types of tasks (assignments, quizzes) related to different parts of learning content that represented in the LCMS. The types of tasks depend on the types of the respective learning materials and related competences. In order to support this type of assessment, the LCMS should be able to define competencies (list of standards) to a course from a variety of competence taxonomy (standards) defined in a competencies catalogue in advance. Alternately, LCMS should allow teachers to write their own standards to use in a course. The LCMS should allow, when teachers and authors create assignments, to select the standards that the related activity is supposed to cover. The LCMS should allow "teachers" to monitor how the "learners" master each standard (competence). Students can view their own progress related to competence achievement in the course as well. The LCMS should allow the use of rules to assist learners depending on their competence development. *Implemented in: Learning module (see also section 3.5.5 above)*
Use Case#	UC-1, UC-2
Relevance to WPs	WP3, WP4

Competence-based Learning Objects (LOs)	
Specification#	LCMS-SPEC_6
System/component	Learning Content Management System
Type of spec	Functional
Description	Competence-based Learning Objects allow the use of rich set of learning resources and activities towards the achievement of the needed competences. Each learning object (course or learning resource/activity) in the LCMS is related to one or more competences from the SOCIALENERGY competences' framework. In order to achieve a certain level of competence, the user has to work with related learning objects (for example, to perform a task related to that competence, to read related learning material, to answer questions concerning this material, to view videos, etc.) *Implemented in: Learning module (see also section 3.5.5 above)*
Use Case#	UC-1
Relevance to WPs	WP3, WP4

Learner's monitoring methods	
Specification#	LCMS-SPEC_7
System/component	Learning Content Management System
Type of spec	Functional
Description	Learner's monitoring methods aim at providing tools for monitoring learners, feedback and support them. The LCMS should offer different methods to monitor student progress within a course and give students feedback on their performance. It should support the basic grading items recording in a table, like Gradebook. The LCMS should be able to provide various tools for measuring learners' progress and provide facilities for using these tools to develop a more comprehensive picture of learners' performance in a course. In order to allow the learner to gain more awareness of their performance, LCMS should provide flexible system for giving feedback to learners depending on their performance. The example methods for monitoring can include notifications when certain events happen in a course, giving extensive reports, regarding various stages of learning history, provide various statistical analysis functions, learning analytics methods related to different events like security, logs and social activity, etc. *Implemented in: Learning module (see also section 3.5.5 above)*
Use Case#	UC-1
Relevance to WPs	WP3, WP4

Learner's rewarding methods	
Specification#	LCMS-SPEC_8
System/component	Learning Content Management System
Type of spec	Functional
Description	Learners rewarding methods aim at providing recognition of learners' achievements like badges, certificates, Easter eggs and others. The LCMS should be able to assign points to learners for doing: various tasks, activities and achievements. It should support flexible reward system that identifies and represents student learning achievement, using experience points, badges and achievement titles. Competences and skills attitudes, as well as other types of knowledge and achievements (not assigned by the grading system) can be validated with alternative rewards. The LCMS should also support portfolios and other relevant forms for saving all kinds of rewards and achievements of the learners. *Implemented in: Learning module (see also section 3.5.5 above)*
Use Case#	UC-1
Relevance to WPs	WP3, WP4

Social communication methods	
Specification#	LCMS-SPEC_9
System/component	Learning Content Management System
Type of spec	Functional
Description	Social communication methods provide tools for social communication between learners. LCMS should support social functions for social communications. Users can easily communicate through flexible system of forums and communication channels, form user groups and send messages to other learners and users. The LCMS should support some basic forms of social communications like discussions, forums, blogs, email, messages, etc. Users should be able to attend common social events organized by calendars and other relevant means. The LCMS should also support various forms of collaboration spaces and activities, like wikis. *Implemented in: Social communication module (see also section 3.5.7 above)*
Use Case#	UC-1
Relevance to WPs	WP3, WP4

Methods for exchange of information with external systems	
Specification#	LCMS-SPEC_10
System/component	Learning Content Management System
Type of spec	Functional
Description	The methods for exchange of information with external systems will ensure data flow among different SOCIALENERGY's systems. They also can be used for linking SOCIALENERGY system with external systems. The main method LCMS should provide a RESTful Competency API. RESTFul Competency API will allow LCMS to communicate with the other SOCIALENERGY subsystems learners' competencies and levels' of proficiency, as well as personal information related to users. The LCMS can communicate with other software systems using external functions, which are functions defined in LCMS using the External API. These are functions suitable to call from web services, or call directly from other parts of the LCMS.
Use Case#	UC-1
Relevance to WPs	WP3, WP4

Open standards and interoperability specifications	
Specification#	LCMS-SPEC_11
System/component	Learning Content Management System
Type of spec	Functional
Description	Open standards and interoperability specifications will be ensured. The LCMS will support open standards in order to be able to support inclusion of external modules providing additional functionalities, to support external digital repositories and sophisticated file management for using various data collection schemes. In order to be able to easily exchange information with other SOCIALENERGY modules, as well as with external systems, the LCMS will support:i) additional open standards supporting easy integration and exchange of badges (Open Badges), ii) various forms of open standardized forms of assessment (import and export items, questions and question banks in various formats), iii) advanced grading methods selection. The LCMS will support some of more widespread open e-learning standards like IMS LTI, and to be SCORM-ADL compliant. The LCMS should be open source and support Open Source Initiative, as well as to be used, modified and freely distributed under the terms of the General Public License(GNU). The LCMS will be free and open-source, easy for users to work, flexible, with accessible and responsive design.
Use Case#	UC-1
Relevance to WPs	WP3, WP4

5. Conclusions

Conclusively, the consortium has now reached Milestones 2 and 3, meaning that all the architecture design and technical specifications work has been successfully finished and all the technical APIs for the interactions among the various subsystems have been agreed among the involved partners. At the end of Month 6, the consortium has also agreed on an initial business modelling and a long list of value propositions that could potentially be offered to targeted customer segments, such as: electric utilities, retailers, ESCOs and governmental authorities. The consortium has also clear plans for data management, dissemination/communication and exploitation of project's results. The afore-mentioned achievements and work progress give pace to the core S/W implementation work that has already begun. Step-wise, the actual work schedule plan is the following:

- The core S/W implementation work will take place in the context of technical Work Packages 3 and 4. Partners will work mostly individually on the subsystems, which fall into their responsibility during the upcoming 3 months.
- Initial S/W integration procedures will take place from M9 onwards, in order for an initial DEMO to be shown during the 1st review in Luxembourg.
- Research work is being undertaken by the academic partners. ICCS works on the dynamic pricing models for the various innovative energy programs (EPs) as well as on the algorithms for EC creation/adaptation and the context-aware reporting and recommendations. SU-NIS works on the data modelling for LCMS and the user taxonomy competence framework. Thus, it will identify the structure of the competences that will be directly addressed by the learning objects (LOs) that will be developed in the context of SOCIALENERGY project. Furthermore, this work will help to assess the end-user's competences and level of proficiency after completion of the specific e-learning activities.
- The two commercial partners are focusing on the business/market analysis to further identify the customer segment's needs and interests and feed back the consortium with specific implementation ideas to be adopted during the S/W integration and pilot testing phase, which will start after M13.

Annex A: SOCIALENERGY Architecture Design Notation

A.1 Modeling language

The methodology selected for the description of the SOCIALENERGY system architecture and specifications follows the basic rules indicated by the *ArchiMate*® modeling language (version 2.1) (http://pubs.opengroup.org/architecture/archimate2-doc/). *ArchiMate*® constitutes an open and S/W independent language/tool for coherent specification and description of systems' architecture, technical components and their relationships. *ArchiMate*® provides the directives to present different domains of a system, ranging from business services to technical system architecture and specific components, in a coordinated form enabling forward and backward traceability between the high level functional business services and their implementation at component level.

A.1.1. *ArchiMate*® Directives

ArchiMate® defines three main levels of specialization. Each level is called *layer* and represents a group of homogeneous services and entities that usually encompasses one or more domains:

- The *business layer* specifies services exposed to external users/customers through specific business processes.
- The *application layer* supports the business layer with application services, which are realized by (software) applications.
- The *technology layer* offers infrastructure services needed to run applications (e.g. processing, storage and communication services), realized by computer and communication hardware and system software.

With regard to SOCIALENERGY system, the business layer will identify and describe the main functional entities and relevant interactions -practically defining the SOCIALENERGY system functional architecture-, the application layer will identify and describe the software components, modules, interfaces and data structures that implement the services above -practically defining the SOCIALENERGY system software architecture- while the technology layer will define the physical infrastructure and how software modules are distributed among hardware components -practically defining the SOCIALENERGY system low level software and hardware infrastructure.
In the context of this deliverable, the SOCIALENERGY architecture is presented at the business layer along with initial high-level application and (where necessary, technology) layer specifications. More detailed application layer specifications and the detailed technology layer will be defined in the context of work done in WP3, WP4 and WP5 and will be provided in the relevant deliverables.

A.1.2. ArchiMate® entities and notation

The *application* and *technology layer ArchiMate®* entities and relationships that are relevant for the VIMSEN definition of the system architecture and technical specifications are summarized in the following tables. (More details can be found under: http://pubs.opengroup.org/architecture/archimate2-doc/.)
To achieve better readability of the VIMSEN specifications figures, and realize the interconnection between the various layers different colours have been used for each of them: green for the business layer, yellow for the application layer and blue for the technology layer.

Table 11: Business layer entities notation

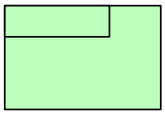
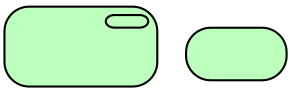
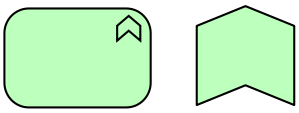
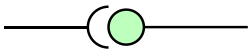
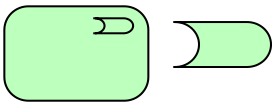
Entity	Definition	Notation
Product	A coherent collection of services, accompanied by a contract/set of agreements, which is offered as a whole to (internal or external) customers.	
Business service	An externally visible unit of functionality, which is meaningful to the environment and is provided by a business role.	
Business function	A unit of internal behaviour that groups behaviour according to, for example, required skills, knowledge, resources, etc., and is performed by a single role within the organization.	
Business interface	Declares how a business role can connect with its environment.	
Business object	A unit of information that has relevance from a business perspective.	
Business event	Something that happens (internally or externally) and influences behaviour.	

Table 12: Application layer entities notation

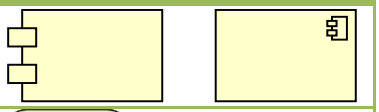
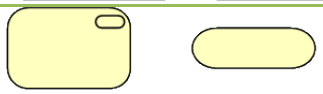
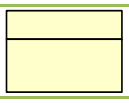
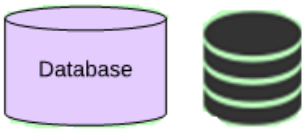
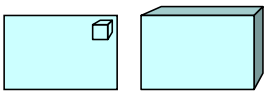
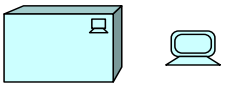
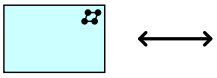
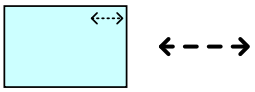
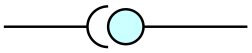
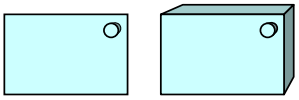
Entity	Definition	Notation
Application component	A modular, deployable, and replaceable part of a system that encapsulates its contents and exposes its functionality through a set of interfaces.	
Application service	An externally visible unit of functionality, provided by one or more components, exposed through well-defined interfaces, and meaningful to the environment.	
Application function	A coherent group of internal behaviour of a component.	
Application interface	An application interface declares how a component can connect with its environment.	
Data object	A coherent, self-contained piece of information suitable for automated processing.	
Data base	Storage of a number of data objects.	

Table 13: Technology layer entities notation

Entity	Definition	Notation
Node	A computational resource upon which artefacts may be deployed for execution.	
Device	A physical computational resource upon which artefacts may be deployed for execution.	
Network	A physical communication medium between two or more devices.	
Communication path	A link between two or more nodes, through which these nodes can exchange information.	
Infrastructure interface	A point of access where the functionality offered by a node can be accessed by other nodes and application components.	
System software	A software environment for specific types of components and objects that are deployed on it in the form of artefacts.	
Infrastructure service	An externally visible unit of functionality, provided by one or more nodes, exposed through well-defined interfaces, and meaningful to the environment.