Summary of SOCIALENERGY R&I insights and roadmap towards beyond H2020 objectives

In this newsletter, we summarize the most important SOCIALENERGY R&I insights and describe the roadmap towards beyond H2020 objectives for the future. Moreover, based on the consortium's experience throughout the whole project's lifetime, **we provide concrete recommendations to the European Commission, which may be taken into account for future calls and collaborative R&I projects**.

Obj. #1: Advanced incentive technologies towards effective use of behavioral economics in the energy efficiency and demand response sector

Table 1: Summary of R&I insights and recommendations to EC related with SOCIALENERGY objective #1

R&I insights	**Recommendations to EC**
Model the participation of an electric utility company in more energy markets (e.g. emerging flexibility/balancing markets) and apply P-RTP/B-RTP/C-RTP models in these markets, too. ESPs can thus follow stacked revenue model approaches to maximize their profits.	In SOCIALENERGY, we modelled the participation of an ESP in wholesale market and how it can incentivize its end users to adapt their energy consumption behavior in order for the latter to experience more beneficial tariffs and the ESP to minimize the cost of the energy purchased from wholesale market. This knowledge can also be used for ESP's participation in more complex electricity markets (generally called flexibility markets), which are currently emerging in several EU countries.
More work on social/behavioral/digital education sciences research in order to understand in more depth which are the weights of the various incentivization factors for each individual end user.	In SOCIALENERGY, we modeled the peer pressure mechanism as one of the main incentivization technologies that drive the end users' energy consumption behavior/ lifestyle. This knowledge can be used in conjunction with other incentive technologies in order to provide even better models for each social norm. Thus, more multi-disciplinary research is needed including social scientists, pedagogists and behavioral analysts.
Advanced mathematical models (e.g. MPEC/EPEC, network-aware optimization, strategic bidding policies, etc.) and integration of storage/RES/DR flexibility models.	In SOCIALENERGY, we assumed research problem formulations for modeling energy consumption and typical ESP's participation in wholesale and retail electricity markets. These models need to be considerably extended/ enhanced in order to include RES, storage and other types of available flexibility assets. Moreover, competition among various ESPs need to be modeled as well as interaction between the electricity markets and the operation of the electricity network. Progressive ESPs need to adopt strategic

	bidding policies in order to optimally place themselves in a liberalized electricity market context. This competition among ESPs should by all means respect the network constraints in order to ensure the security of energy supply.
More advanced mechanism design and incentive compatible techniques to allocate Demand Response gains to all participating users in a more fair way maximizing the social welfare without degrading end user's welfare, too. More work on game-theoretic models is needed.	New services for ESPs need to be developed relevant with optimal Distributed Flexibility Asset (DFA) aggregation and its automation through an online platform. The main research objectives are: - To develop models for the provision of services correlated with automated composition of DFA and for their optimal operation. - Intelligent algorithms for optimal DFAs' operation that serve the ESPs and DFA owners according to the traditional markets' (wholesale, flexibility, capacity, etc.) needs. - To develop mathematical models towards a meta-service able to optimally transform Flexibility assets (e.g. load shifts and curtailments) to Flexibility services. - To conduct an in-depth and high-quality research on the design of pricing mechanisms by indicatively combining in them KPIs such as: Optimality/efficiency, incentive guarantees/strategy proof, privacy protecting, convergence/scalability, Fairness, Externalities and constitute them competitive/sustainable. - To develop: i) optimal bidding processes, ii) allocation rules, iii) communication protocols and iv) peripheral components towards the next generation retail pricing schemes.

Obj. #2: Transfer gaming technologies into the energy efficiency sector to educate and socially include end users in best practices on energy efficiency

Table 2: Summary of R&I insights and recommendations to EC related with SOCIALENERGY objective #2

R&I insights	Recommendations to EC
Work more on gamification techniques and interaction with the end users (use of GSRN data to further understand each end user's behavior within SOCIALENERGY system).	In SOCIALENERGY, we found out that higher end user engagement is achieved when the end users understand the ultimate goal of the gamification activities. Based on SOCIALENERGY platform's data, the admin user will be able to further analyze the behavioral data from every end user and guide him/her through an optimal engagement process.
Use of interactive technologies such as Virtual Reality (VR) and Augmented Reality (AR) in order to create a cyber-physical environment in which the end users will not only play the GAME but their actions within the GAME will be transferred in the real-life environment	The SOCIALENERGY GAME is actually a simulation of real-life conditions within a future's smart home. The next step would be to further integrate the real and virtual worlds through the development of a cyber-physical environment. For example, an optimal gameplay could be transferred in the real smart home and via VR/AR technologies, the end user could be guided into performing the best combination of energy consumption actions in order to minimize his/her electricity bill and simultaneously contribute in reducing energy system's cost.
Make the learning/gaming process more personalized, interact more with LCMS and make the game player co-creator of the gameplay.	The gameplay design (as is) can be considerably enhanced by offering more interaction features to the player. For example, the player could design the stages for his/her own gameplay feeling thus that the gameplay is not boring and that s/he creates some features of it and possibly share this content with other group members.
More work is needed on mathematical models and research algorithms in order to make the gameplay more sophisticated and be able to provide many different gameplay versions (e.g. in the form of challenges) to the end users.	SOCIALENERGY GAME already includes several mathematical models for calculating and converting complex KPIs into realistic game points, which are much more understandable for the end player. Based on this background knowledge, more sophisticated mathematical models and research algorithms can be integrated into the gameplay in the future.
Work closer with teachers and digital technology educators to better understand key pedagogical aspects to enhance the related social inclusion and educational actions towards a more environmental-friendly society.	SOCIALENERGY GAME is designed in such a way that it can be played by anyone with little effort needed in order to understand the game's objectives and ways to proceed through the whole gameplay. However, this type of games can be easily adapted in order to explicitly serve educational and social inclusive purposes (e.g. in public schools). In this case, close collaboration with teachers, digital technology educators and pedagogists is needed in order to achieve

	the best possible results for the sake of a really successful behavior change towards a more environmental-friendly society.

Obj. #3: Engage end users via advanced gamification techniques towards efficient management of virtual energy communities and interaction with commercial activities

Table 3: Summary of R&I insights and recommendations to EC related with SOCIALENERGY objective #3

R&I insights	Recommendations to EC
Work more on Online Social Networks (OSN) theory (VEC creation and dynamic adaptation algorithms including more feature data).	In SOCIALENERGY, we found that an end user is much more engaged when an instruction comes from a friend or even a peer with a similar user profile. Therefore, more research is needed in order to exploit more complex OSN models, which can provide automated social network graphs and thus optimally allocate EC leader roles and optimal creation of VECs.
More work on social/behavioral/digital education sciences research in order to understand in more depth which are the weights of the various incentivization factors for each individual end user.	In SOCIALENERGY platform, we already have multiple types of heterogeneous datasets, which are somehow linked with each other. For example, we have energy-related datasets, behavioral datasets based on the use of the platform and social network datasets based on the social network actions inside the platform. This means that it is not straight-forward how to create and dynamically adapt VECs, because we often do not have explicit intuition about every possible combination of datasets. Thus, further research is needed in order to unveil the potential of heterogeneous data analytics, which are well hidden in complex software infrastructures.
Advanced data analytics (ML/AI) techniques to avoid end user frustration and disturbance.	In SOCIALENERGY, VEC creation and dynamic adaptation algorithms run periodically (e.g. every day and in smaller time granularities) and their output is used as input in context-aware reporting and recommendation mechanism. More research is needed to achieve the optimal trade-off between the end user engagement and the communication overhead. In other words, the end user may get frustrated if s/he gets too many messages or s/he may be dis-engaged if s/he is not well informed/guided in platform's processes through appropriate notification messages.

Obj. #4: Data analytics and context-aware recommendation algorithms for bringing closer the energy sector stakeholders and end users

Table 4: Summary of R&I insights and recommendations to EC related with SOCIALENERGY objective #4

R&I insights	Recommendations to EC
Work more on Machine Learning and Artificial Intelligence (ML/AI) research algorithms and techniques to provide even more interesting notifications/reports/recommendations to end users	In SOCIALENERGY, we basically consider smart meter data (at home level). However, given the fact that there are disaggregated energy data (e.g. per electric device) and other IoT/sensor data, more advanced data analytics services for end users can be developed. Moreover, Artificial Intelligence algorithms may be applied in order to comprehend more deeply the utility function of end users in order to proactively respond to end user's needs in the future (e.g. recommend more complex energy programs).
More work on social/behavioral/digital education sciences research in order to understand in more depth which are the weights of the various incentivization factors for each individual end user.	Furthermore, given the fact that end users give their consent about using demographical, building and other means of personal data, AI-based algorithms (e.g. neural network-based) can be used in order to map in much more detail the end user's behavior with the various incentivization factors. The goal is to find the optimal mix of these factors in order to provide the highest possible quality of service to end users. The results of this process may also be used by policy makers in order to better understand the behavior of EU citizens and subsequently be able to design better policies towards achieving higher level milestones (e.g. EU energy agenda for 2030/2050, EU single electricity market, etc.). Of course, in all these cases, thorough investigation of the "utility vs. privacy" problem should be undertaken.
ML/AI-based recommendation algorithms and brainstorming on new business models (e.g. B2B2X) in order to design more interesting cross/up-selling services	Electric utility companies should seek for new revenue streams taking advantage of their ongoing digital transformation with S/W platforms and digital products/services such as the ones offered by SOCIALENERGY. The EU regulation about liberalized energy markets' operation provides many opportunities for new business models and value propositions. For example, SOCIALENERGY's value proposition #3 could be easily extended to integrate more products and services that can be traded through the online marketplace. Thus, a utility company could realize more B2B and B2B2X partnerships and design even more interesting cross/up-selling services for its clientele (i.e. end users).

Obj. #5: Small-scale experiments to validate the SOCIALENERGY concept, evolve its technologies and trigger its adoption by various energy market stakeholders

Table 5: Summary of R&I insights and recommendations to EC related with SOCIALENERGY objective #5

R&I insights	**Recommendations to EC**
Further research is needed in behavioral M&V	Larger-scale pilot testing process should take place in upcoming EU projects to validate SOCIALENERGY results in large-scale deployments.
Virtual Energy Communities concept could be extended in physical communities of EU citizens through the adoption of social innovation activities like the EU RESCOOP movement	EU RESCOOP movement should be further supported via the exploitation of mature S/W platforms and tools like the ones deployed within SOCIALENERGY project. For example, SOCIALENERGY could be used as a S/W substrate for the development of a digital social innovation platform, which facilitates EU energy communities' administration, holistic energy consultancy services' provisioning, e-commerce and bottom-up clean energy investments.
Non-technical factors that affect the user engagement in the gameplay should be studied in more depth.	Closer collaboration between multi-disciplinary teams is needed and especially with expert digital technology educators and pedagogists, who can optimally design the real-life pilot process according to the diversified needs of the end users. For example, in K-12 public schools, pupils have certain requirements that should be taken into consideration in order for the learning process to be as efficient as possible.
Multi-player game development (cooperation vs. competition strategies in real-life pilots) and collaborative learning	SOCIALENERGY platform could be extended to serve for efficient bottom up and collaborative education of end users (energy prosumers), social innovators, public authorities, energy communities and energy companies. Through various gameplays, all users could easily understand their role in the community and deploy socially innovative actions towards achieving the community's goals.

Obj. #6: Create a virtual marketplace and offer Energy Information Distribution as a Service (EIDaaS) to multiple stakeholders

Table 6: Summary of R&I insights and recommendations to EC related with SOCIALENERGY objective #6

R&I insights	Recommendations to EC
Need for open data platforms, data sharing economy and data market for trading data-related assets. Need to treat data and data analytics as a commodity to traded in an online marketplace.	Energy Information Distribution as a Service (EIDaaS) introduced within SOCIALENERGY project can be extended in a way that an Energy Data Asset Marketplace (EDAM) will be created, which will drive a data economy by linking sellers to buyers and ensuring that credit will be attributed to appropriate stakeholders no matter the complexity of the business process. In this EDAM, the data seller will manage and sell the data in the marketplace. The electric utility company's objective is to make profit. The cost of supplying specific data assets should be calculated together with the financial rewards given back to data owners. Thus, the company should put a price in each SaaS offering such that the monetary benefits from selling this service/product to the market will be higher than the marginal cost of production. From the data buyers' perspective, they will be able to use a user-friendly GUI to first discover and then buy the EDAM products that they are interested in. Data Buyers may be Energy Service Companies (ESCOs) such as electric appliance retailers and vendors, building renovation companies, etc., retail companies such as shopping malls, supermarkets, etc., building construction companies, insurance companies and several other cross-domain/vertical industry market stakeholders. From a business point of view, data buyers need to calculate the value of each EDAM product that they demand. In particular, the cost of purchasing an EDAM product should be lower than the revenue streams realized by selling advanced digital services to end users. Examples of these digital services may be based on novel applications, which can provide personalized and context-aware recommendations to end users about the most suitable electric appliances, energy programs, building renovation packages, energy efficiency guidelines to lower electricity bills, discount offers for retail products purchase, etc. This type of EDAM should: - maximize GDPR compliance through innovative policy & consent management strategies along with data fuzzification techniques - incorporate standardized practices for data management and privacy preservation
Need for a trusted Data Asset Marketplace (DAM) to lower privacy barriers associated with the development of innovative data-intensive applications that consume personal data.	

	- increase the trust and the involvement of the users in this type of emerging data sharing platforms - enhance the competitiveness of the energy market stakeholders and establish solid Return On Investment (ROI) trajectories for the end users.