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Play the Game: Learning about Energy Efficiency Can Be Fun—Seriously!

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Abstract

Industrial and service sectors offer potential for cost-effective energy savings. Yet underinvestment in energy efficiency is observed in all EU countries. This is called the "energy-efficiency gap". In order to be implemented by companies, energy-efficiency measures have to be analysed and communicated, taking into account the various professional interests and cultures which prevail in a corporate context. Well beyond the mainstream energy saving analysis, a multidisciplinary approach is needed, which requires engineers to be trained in energy efficiency.

Classical training for energy engineers focuses on lectures in combination with individual exercises. This training has several shortcomings:

- exercises usually focus on simple techno-economic assessments;
- the variety of information sources and interests in a company are improperly represented;
- strategic concepts, such as competitive advantage or core business, are not included.

Therefore, classical training does not develop the skills needed to deal with the multidisciplinary aspects of energy-efficiency measures. It is also well known in pedagogical science that in professional training, the motivation for learning increases when participants can directly apply what they are taught.

By providing a virtual training environment, serious games offer the opportunity to manage complex problems and to directly apply any theoretical framework in a fun and collaborative way.

This paper introduces a new serious game developed as a training tool for a capacity-building programme on the multiple benefits of energy efficiency. This game puts participants in the context of an industrial company where they play the role of an energy manager who wants to get an energy-efficiency project approved by the Investment Selection Committee. The paper concludes with the preliminary results of training sessions using this serious game.

Introduction

Underinvestment in cost-effective energy efficiency — the "energy-efficiency gap"— is observable in all countries and there is a significant potential to improve energy performance by firms in all sectors of energy consumption (Brunke and Blesl, 2014; DeCanio, 1998; Granade, *et al*., 2009; Johansson and Söderström, 2011; Moya, *et al.,* 2010; Schleich, 2009; Sola and Xavier, 2007; Thollander and Ottosson, 2008; Venmans, 2014).

On the business side (in industrial facilities and commercial or administrative buildings, the energy-efficiency gap can be explained by several factors. One important factor is the fact that firms do not consider energy, or energy use, as a contributor to their competitive advantage (Cooremans, 2011). As the budget for investment within a company is limited, investment projects that are considered more relevant to core business, *i.e.* in contributing to increase company's competitiveness, often win out for resources and implementation. Investments in energy efficiency, usually only promoted in terms of energy savings, are typically not considered as a contribution to core business. As a result, they face highly stringent financial criteria (one to two years pay-back time) and they are not chosen.

However, many benefits other than merely energy savings can be included in energy-efficiency projects (whether this be upgrade and optimization of existing equipment, or new investment projects). Commonly referred to as "Multiple Benefits" (MBs) or "non-energy benefits" of energy efficiency, they include important core business benefits, such as improved product quality, greater flexibility, reduced production time and losses, or reduced risks. Similar to energy benefits, MBs of energy efficiency result in financial benefits for the investor.

Therefore, MBs raise the strategic character and financial attractiveness of energy-efficiency investments. As emphasized by the IEA report (2014:134), "identifying the multiple benefits that may be linked to energy-efficiency measures in industry could enhance the business case for action". Unfortunately, MBs are often not included in energy-efficiency investment evaluations or in energy audits. This can be explained by a lack of method, know-how and evidence base: engineers in charge of energy-efficiency audits or projects (inside and outside companies) lack the analytical and communication tools necessary to take the MBs of energy efficiency into account in their projects.

Within this context, the project M-Benefits[1] was selected by the European Commission call H2020, with the goal of increasing the capacities for actual implementation of energy-efficiency measures in industry and services. It is a three-year project (2018-2021) involving 14 partners from 11 European countries.

M-Benefits proposes a harmonised approach and methodology to include MBs in project analysis in order to identify, categorise and assess them as from the beginning of projects, in technical, operational, strategic and financial terms.

A *serious game* approach (as defined in the next section) has been chosen as an efficient pedagogical tool to disseminate the methodology to the professionals targeted by the methodology, *i.e.* the energy professionals in charge of conceiving and implementing energy-efficiency projects in companies (as companies' staff members or as external consultants, such as Escos).

The goal of this paper is to describe the serious game M-Benefits. The paper is organised into three parts. The first part describes the generic concepts of a serious game and its application to the energy field. The second part describes the main goals and features of M-Benefits serious game, after a summary of the M-Benefits methodology for the identification and evaluation of the Multiple Benefits of energy-efficiency projects. The third part of the paper describes the results of the first M-Benefits serious game test session. In conclusion we summarise the effects of this pedagogical tool, and how it can contribute to the success of public programmes promoting energy efficiency.

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[1] M-Benefits Valuing and Communicating the Multiple Benefits of Energy-Efficiency Projects. www.mbenefits.eu

Serious Games: Concepts and Methods

A serious game is a game designed for a primary purpose other than pure entertainment, *e.g.* awareness-building, learning, health promotion, advertising, applied training, *etc*. In this article, we will only consider serious games that are implemented on computers, although non-digital serious games are also quite common. Moreover, we will focus on simulation games: these are games which produce a simplified but realistic representation of a real-world complex system. Participants can thus "live" situations that are difficult to experience otherwise (*e.g.* because they are too expensive or dangerous). Since they are playing in a forgiving virtual environment, they have the opportunity to manage complex problems and are nevertheless allowed to make errors and learn from these experiences. Serious games thus enable players to directly apply any theoretical framework in an uninhibited, fun way.

Serious games for pedagogical purposes have become more widespread lately, in a wide range of sectors, from the health sector to engineering or management. Whereas their real benefits on the learning experience are progressively being confirmed (Boyle, 2011), interactive teaching strategies have more generally proven to increase student attendance and engagement (Deslauriers, *et al*., 2011) and to foster higher performance (Freeman, *et al*., 2014).

The Wegas Serious Games Platform

In this project we selected the Wegas[2] serious games platform, as it had already proven its qualities in the creation of previous educational digital games. Wegas is a web-based game authoring and execution platform. It has been designed with a strong focus on scenario definition capabilities, in order to allow educators to adapt contents to evolving learning objectives. The platform supports both hybrid on-site classroom learning and remote e-learning. It also supports the creation of multi-lingual games, which is a strong advantage in the international setting of European projects.

Wegas serves as the basis for a broad range of games, essentially of an educational nature, among which the new M-Benefits game and its predecessor ManagEnergie (described by Chollet, 2014), which has been used on a regular basis since 2013. In order to empower educators, Wegas offers a dedicated dashboard screen with a real-time overview of player positions inside the game. This is to help identify students in difficulty. The dashboard also enables the teacher to review or impact player sessions, *e.g*. in order to give a hint to a player as if it came from one of the game's virtual characters, or to grant more time to solve a problem.

The platform supports the generation of trace data, in order to systematically log all choices made by the players (*i.e.*, answers to questions or decisions made inside a game). It also logs all values taken by numeric variables defined inside the game (representing, for example, game phases or player performance indexes). This feature opens the door to highly refined *learning analytics* (Ferguson, 2012), *e.g.* for eliciting and comparing problem-solving strategies developed by the players (Jaccard, *et al*., 2016).

The Wegas platform and the M-Benefits game are open source and can be downloaded from www.github.com/Heigvd/Wegas

Energy Serious Games

Most energy games have been designed as a means of influencing citizens' energy consumption (Johnson, *et al*., 2017; Fijnheer & Oostendorp, 2016). A review of 25 such games in (Johnson, *et al.*, 2017) confirms that gamification and serious games appear to be of value within the domain of energy consumption, conservation and efficiency. The four most significant positive outcomes identified by this study are: 1) enjoyment during game play; 2) cognitive outcomes such as self-awareness of energy conservation issues, motivation to engage in eco-friendly behaviour after the game; 3) behavioural outcomes including both actual and intended behaviour after the game (*i.e*. in the real world) in a broad definition of eco-friendly actions; 4) learning and knowledge acquisition outcomes such as gain of explicit knowledge of environmental and energy consumption issues.

The serious game *2020 Energy* (www.2020energy.eu) was designed within the framework of a European awareness programme for teenagers, in order to encourage more responsible and efficient behaviours in energy consumption and to promote renewable energies. Boomsma, *et al.* (2018) describes a serious game which is used as an educational and behavioural change tool within the specific context of social housing.

Fijnheer & Oostendorp (2016) review ten existing household energy games from the perspective of game design. The authors selected these games on the basis of their realism and expected real-world impact on players.

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[2] Project home page: www.albasim.ch

Because these games are targeted at ordinary people, their study does not entirely apply to our case. For example, their recommendation that the player should feed the game with household power consumption data in order to measure player progress in real time. This would be awkward to implement in a company context where energy data is distributed and difficult to implement inside a game in real time. Moreover, this would only represent one of the relevant indicators for energy efficiency. However, if we try to apply their classification scheme to our case, we can state that our game has the following main characteristics:

- Purpose: education (as opposed to research or entertainment)
- Main player profile: energy management professionals
- Game type: simulation and role-playing
- Storyline: complex
- Mission world: in-game, based on a real-world business case
- Personalisation: none
- Rewards: points (management support and confidence in the information collected)
- Competition: against oneself
- Duration: two days including an introductory course

Whereas most games target households, some games address a business or community environment: *Energy Chickens* (Orland, *et al*., 2014) tries to encourage employees to make energy savings in their office environment. In the European *GAIA* project (Mylonas, *et al*., 2017), students, staff and parents join forces in order to identify energy waste in public educational buildings. The *BPMS-Game* (Mancebo, *et al*., 2017) is a tool that combines the concepts of gamification, sustainability, and business processes to support the creation of games that promote sustainability in business environments, especially in the IT industry. The objective is to employ game mechanics to motivate workers of an organization to follow a series of green initiatives in the business processes they interact with.

Go2Zero (Bekebrede, *et al*., 2018) is a game designed not so much for citizens as for decision makers in cities (*e.g.* local governments, construction companies, and local energy suppliers). The game enables players to explore different strategies to reduce carbon emissions while going beyond a purely technical perspective.

The next section describes the M-Benefits serious game and its contributions to the field of energy efficiency in corporate contexts.

M-Benefits: A Serious Game on the Multiple Benefits of Energy Efficiency

The novelty of the serious game M-Benefits is that it is aimed at a highly qualified target group of energy professionals. Moreover, its intention is not to communicate the importance of energy savings, but the need to take strategic, financial, organisational and human factors into account in order to have energy-efficiency projects approved by top management. Thus the game teaches the players to adopt a systemic and multidisciplinary view without which it is difficult to obtain support for new energy-efficiency projects in a corporate context.

Energy-efficiency investment decision-making in for-profit companies

An under-investment in energy efficiency—an “energy-efficiency gap”—is observable across all countries and business activities, including energy-intensive industries (Brunke and Blesl, 2014; DeCanio, 1998; Granade, *et al*., 2009; Jakob and Häberli, 2012; Johansson and Söderström, 2011; Moya, *et al*., 2010; Schleich, 2009; Sola and Xavier, 2007; Thollander and Ottosson, 2008; Venmans, 2014). This energy-efficiency gap is also observed by public institutions (EU, 2005; Benoît, 2014). In 2017, the Swiss Federal Office of Energy (SFOE) estimated an energy saving potential of 15% in Swiss trade and industrial sectors. [3]

Research shows that significant and profitable investment opportunities are identified by audits, with pay-back time in less than one to three years. The success of audits[4] is difficult to evaluate and compare because of a lack of details regarding the profitability of energy-efficiency measures (EEMs) and the criteria by which this profitability is assessed, as well as regarding characteristics of the audited companies. However, based on figures

[3] http://www.bfe.admin.ch/themen/00519/00522/index.html?lang=en

[4] Measured in terms of the ratio between EEMs recommended and EEMs implemented, or by the percentage of energy savings.

provided by researchers, the average EEMs adoption would be around 40 to 50 % (Anderson and Newell, 2004; Fleiter, *et al*., 2012; Gruber and Schleich, 2008; Gruber, *et al*., 2011; Sæle, *et al*., 2005; Schleich, 2009; Thollander, 2007). This percentage takes into account both implemented and planned measures.[5]

According to the theoretical framework proposed by Cooremans (2011, 2012a, 2012b), one main cause of the energy-efficiency gap lies in the way projects are presented to decision makers in companies. Energy engineers only mention the energy savings and the corresponding financial savings from an energy-efficiency project (Killip, *et al*., 2018). This approach is rooted in mainstream neo-classical economic theory, which states that profitability drives investment decision-making. Therefore, according to this theory, if a project appears to be profitable, it will be chosen.

However, contrary to the mainstream view, investment profitability appears as a generally necessary but insufficient condition (Cooremans, 2012a). The strategic character of an investment, defined as its contribution to a company's competitive advantage in performing its core business, is a decision-making driver more powerful than investment profitability (Cooremans, 2011). Therefore, the investment decisions which win out between different projects within organisations are not the most profitable but the most strategic.

Figure 1 describes the four levels of an energy analysis in a company producing goods or services: Level 1 is the level of the production process, whose steps are represented using a business management method, process mapping.[6] Level 2 represents the energy services feeding the process: heating, hot water, cooling and refrigeration, lighting, ventilation and air conditioning (VAC), motive power, lighting and automated processing of information and communication technologies (ICT). Level 3 includes all machines and equipment consuming energy to produce energy services and ultimately, goods or services. Level 4 is the level of the energy carriers feeding equipment and machines.

Level 1 is the responsibility of process people while Levels 3 and 4 are the responsibility of energy experts. Level 2 is—in theory—a shared responsibility between energy and process people. In theory—although they are vital to companies' activities and operational excellence—energy services are the blind spot between energy and process analyses. They are not taken into consideration because process people are not competent to evaluate the quality and security of the energy services feeding the value chain, and energy specialists focus on machines and energy carriers.

Therefore, there is not only an energy-efficiency gap in companies, there is a gap between professional cultures, which have different interests and languages: on the one hand, cultures which are business management-oriented and, on the other hand, cultures technically and/ or energy-oriented. Because of this gap, there is a lack of understanding and communication between company professionals. This gap is highlighted by the fact that Level 2 of Figure 1 usually remains unanalysed.

University and professional education in engineering is, despite all efforts to foster interdisciplinary approaches, still very much focused on disciplinary competences. Curricula focus on the classical engineering topics and cover economic assessments only marginally. If such topics are covered, the exercises usually focus on simple techno-economic assessments of energy-efficiency measures (EEMs).

The broad variety of information sources available in a company as well as the various impacts of energy-efficiency measures apart from energy savings are usually improperly represented.

Classical training and teaching concepts for energy engineers focus on lectures in combination with individual exercises. Strategic concepts such as energy management can only be described theoretically in such a context. A real-life experience with this concept is only possible during internships or after graduation. The use of interdisciplinary project courses, where the students take the role of individual actors in a simulated context is still rare and rather expensive to implement (Dirsch-Weigang, *et al*., 2018).

New and innovative educational approaches are therefore needed to teach the required competencies for the multidisciplinary and intercultural challenges of energy efficiency.

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[5] If only implemented measures are taken into account then EEM adoption figures are lower, because planned measures have to be taken cautiously (Cooremans, 2013).

[6] "At operational level, process mapping is the common analytical tool used by companies' process people. Process mapping consists of identifying all steps (and/ or substeps) forming the process, and representing them in a chart. A process map is a helpful tool not only to represent a process but also to gain a critical perspective on it. A good process map must have carefully defined boundaries" (Cooremans, 2015:127). See for instance George, *et al*., 2005, for more information on this tool.

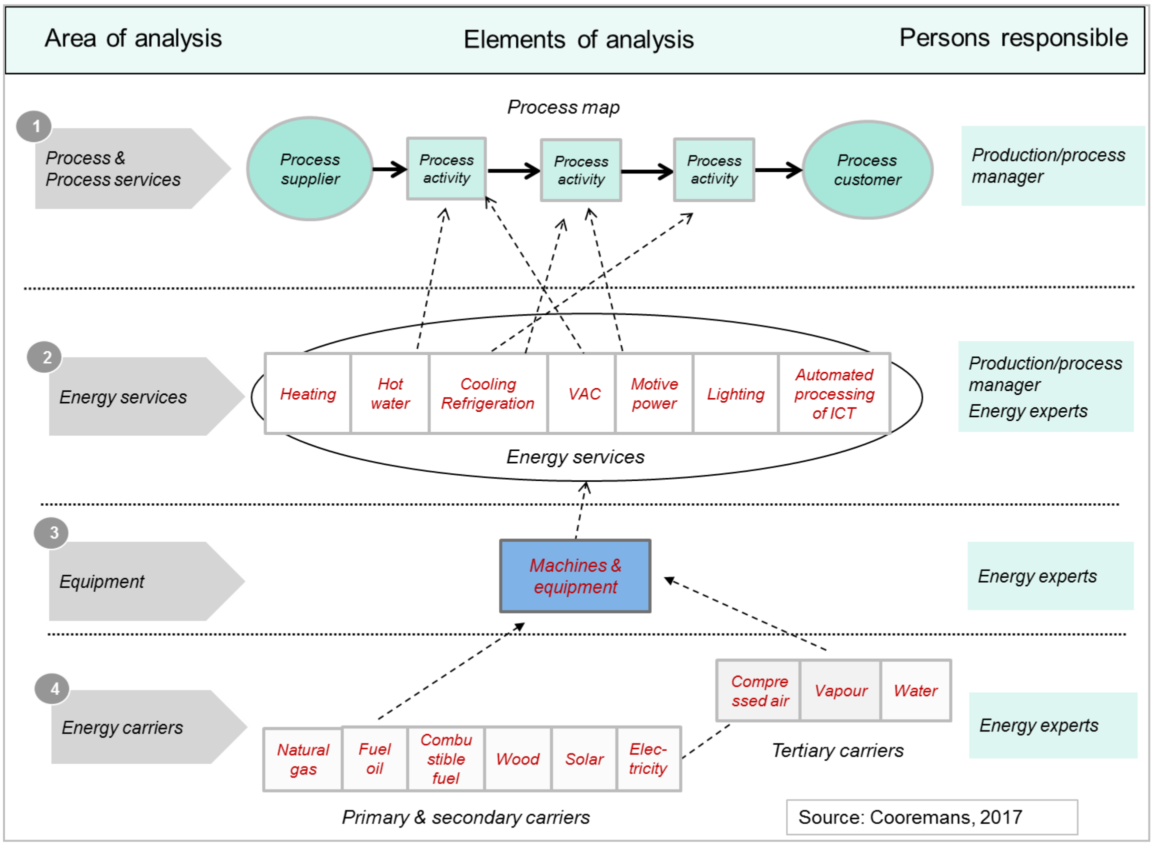

Figure 1 – Putting together energy and operational analyses

Multicultural professional environments

Cultural[7] differences in and between organisations regarding energy issues have been analysed in very little research (Cooremans, 2012b). A useful theoretical concept for understanding the impact of culture in organisations is that of “interrelated spheres of cultures”. According to Schneider and Barsoux (2003:47), six interrelated spheres of culture influence the worldview, behaviours and decisions of decision-makers and of all other actors in the organisation, whether individuals and groups: the national, regional, professional, functional, business sector and corporate spheres of culture. Each sphere creates particular mental schemes within people's minds, but also involves different approaches: engineers, financial people or sales and marketing people apply different concepts, use different methods and tools, look at different issues with different lenses and speak different languages. Sometimes they simply do not understand each other.

Bridging the gap between corporate or professional cultures is not an easy task. To get energy engineers to broaden their analyses from a technical approach to a business management approach presents two main difficulties: they must want to do it and they must be able to do it.

The first difficulty— the willingness of energy specialists to broaden their technical approach to projects in order to take into account aspects more appealing for companies—is an interesting and delicate point.

This issue is not documented in other research. According to the experience of the lead author of this paper, engineers in charge of energy audits or energy-efficiency projects almost all recognize that the energy-efficiency measures they advocate are often not decided upon by their client companies, sometimes to their surprise since

[7] One good definition of organisational culture is proposed by Cossette (2004:121): "Culture is an organizational scheme, mainly composed of values which are more or less shared, more or less consciously, by organization members. It is a normative system of ideas, ultimately shaped by the actors involved themselves; thus culture is created, maintained and transformed by individuals who, themselves, have schemes, some of those being of a normative nature, *i.e.* composed of these individuals' personal values. This organizational scheme of culture is in close relationship with other organizational schemes, even if the influence of one scheme on another goes through individuals… The concept of culture almost always refers to values, defined as what is desirable in a given spatio-temporal context".

some EEMs seem quite irresistible (to them). In many cases, the engineers performing energy audits have no financial interest in having the identified EEMs decided upon.

To our knowledge, no research has ever studied how energy practitioners perceive their results regarding energy-efficiency projects approval by companies, and their possible frustrations with the non-approval of certain projects. There is potential for research in this field. The main interest of such research would be to highlight how and why energy engineers are motivated—or not—to have the EEMs they recommend decided upon and implemented by companies. Their first motivation could be the “culture of efficiency” of the engineers themselves, which leads them to be unsatisfied in the case of unnecessary consumption for resources (regardless of the type of resource). If an absence of motivation was highlighted by research, ways to motivate energy engineers towards implementation of the EEMs identified would have to be sought out, since higher engineers' motivation could lead to more measures being adopted, thus increasing the success of subsidized audit programmes.

The second difficulty refers to the energy engineers' skills. Engineers have technical skills, but they generally do not have the managerial skills that would allow them to analyse and communicate EEMs taking the view of companies' key actors (Cooremans, 2014). Besides a company's CEO, key actors include managers of production, finance, and marketing and sales. These are the most powerful functions or in other words, the decision-making functions, especially with regard to resource allocation decisions (*i.e.* typically investment decisions).

Understanding the concepts and language of other professional disciplines is neither straightforward nor easy. It means accepting stepping outside of one's own professional skills and taking risks. In the field of energy-efficiency investments, this implies that energy professionals be able to apply key business management concepts such as business model and value proposition, process mapping and operational excellence, and corporate finance and strategy.

The first objective of the M-Benefits serious game, as described in the next section, is to provide the means to overcome the two difficulties described above by:

- highlighting the logic of decision and action in companies so as to increase energy engineers' awareness and motivation;
- providing energy engineers with the basic skills enabling them to convince the most powerful corporate actors of the interest of improving energy efficiency.

The second objective of the M-Benefits serious game is to allow the players—mainly energy engineers in charge of the design and "sale" of energy-efficiency projects—to become familiar with the M-Benefits methodology for identifying, evaluating and communicating the multiple benefits of energy-efficiency projects. The methodology is described in the next section.

Multiple Benefits evaluation and communication methodology

The Multiple Benefits methodology (Cooremans, 2015) is intended to provide a comprehensive and systematic roadmap to be used by energy engineers to identify and evaluate not only the energy benefits but also the non-energy benefits of energy-efficiency projects. Based on the conceptual framework (Cooremans, 2011, 2012a, 2012b) synthesised in the previous section, this methodology is conceived to be applied to any type of business activity, in industrial companies as well as in services or real estate companies. It is intended for companies consuming yearly large amounts of energy (electricity and/ or thermal energy).

The first step of the method is to understand the business model and decision-making process of the company analysed, which will constitute the general framework in which all other analyses will take place. After this global company-level analysis, project-level analysis starts with the energy and operational analysis, which is intended to identify not only EEMs (conventional technical approach), but to understand how the EEMs identified can contribute to reinforcing or improving energy services and more generally, the company's production process (within a pre-defined boundary).

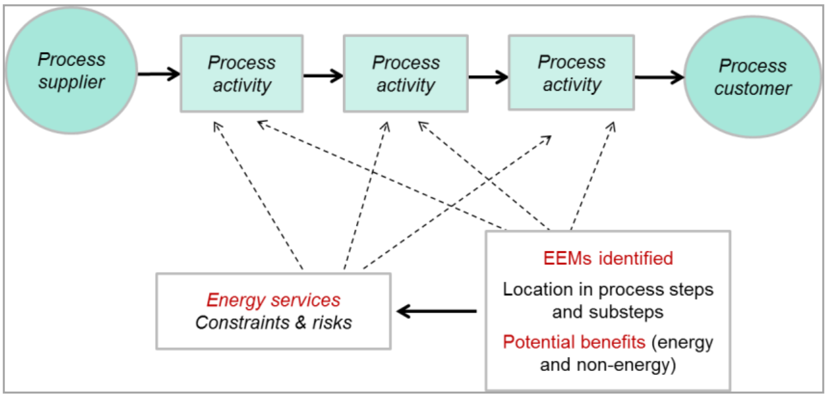

Figure 2 – Energy services and EEMs mapping

In the energy and operational steps, different aspects of an energy-efficiency investment project are analysed following the conceptual framework described in the previous pages: energy analysis and identification of potential energy-efficiency measures; operational analyses (process mapping); energy services analysis (identification of the main energy services implied in the process; identification of their key contributions to the process). At the end of this analysis, the EEMs are located on the process map, as shown in Figure 2, and analysed in operational terms, to highlight their potential contribution to process quality and security, and to other aspects of operational excellence. Based on these analyses, the more interesting EEMs are selected.

In order to bridge the energy, operational and strategic levels, the next analytical step consists of translating the findings of the operational analysis in strategic terms. As per our conceptual framework (Cooremans, 2011), an investment is strategic if it contributes to a company's sustainable competitive advantage; competitive advantage is formed of three interrelated constituents: the value of the products for the customers, and the costs and risks borne to produce this value. Therefore, by assessing the contribution of an EEM to value proposition improvement, cost reduction and risk reduction, we assess the more or less strategic character of this EEM.

Once the strategic aspects of each EEM have been assessed, the last part of the analysis consists of translating strategic aspects into financial terms. A strategicity analysis is a good basis for financial assessment, since its three components can have impacts on investment profitability: improved value proposition will bring additional turnover; risk reduction can translate into additional turnover or reduced costs. On the cost side, many costs can be reduced in addition to the energy costs. This implies analysing the data available for each measure and each type of benefit identified: type of data, its accuracy and its source in the company (*i.e.* the department or person); the corresponding indicator; the variable to be measured; whether it is a quantitative or qualitative variable.

Once the multiple benefits have been estimated in monetary terms, a conventional financial assessment (using the most common evaluation methods, *i.e.* Net Present Value; Internal Rate of Return; Pay-Back Time) can be applied to evaluate the financial attractiveness of each EEM or of a group of linked EEMs (forming the investment project). Risk impacts can also be evaluated in qualitative terms, using risk management tools.

Figure 4 represents the whole method, including firm-level analysis and communication which, thanks to the different analytical lenses (energy, operational, strategic, and financial) will be adapted to the various interests and professional cultures of companies' departments.

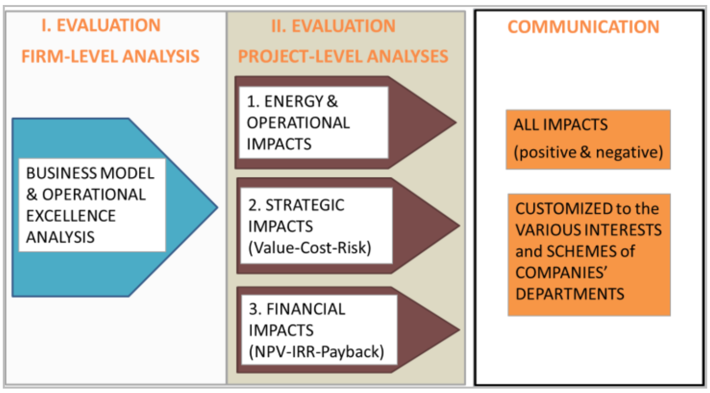

Figure 3 – A comprehensive approach to firm-level Multiple Benefits, integrating strategic and cultural factors

M-Benefits Serious Game

The game places the participants in the context of an operational food & beverage industry in Europe.[8] In teams, participants (mainly but not exclusively energy engineers) play the role of the company's energy manager, who wants to get an energy-efficiency project approved by the company's Investment Selection Committee.[9]

The course of the game is the following: at the very beginning of the game, the player meets the company's CEO, Elisabeth Vilnius (each staff member or manager interacting with the player has a name and a photo that gives her/ him a physical identity). Mrs Vilnius describes the company and some important criteria driving investment decision-making. She gives the player an energy audit made some time ago by an external consulting company.

Within the course of the game, players will have the opportunity to collect information through virtual meetings with the company's staff and managers. Based on the information collected, players select the EEM(s) which they consider the most useful to sustain the company's business model and the most attractive to the Investment Selection Committee.

At the end of the game, players enter a role-playing game, with a presentation describing their energy-efficiency investment project and they present their project to the Investment Selection Committee.[10]

The most important features of the game are the following:

- Participants are organised in teams. Teams are put together before the start of the game by the trainers, with as much diversity as possible, in order to share participants' different points of view on investment decision-making.
- Players access the online software part of the game through a portable computer.
- Two training sessions take place before and during the game to describe the most important concepts underlying the M-Benefits methodology, enabling the players to convince the most powerful corporate actors of the interest of improving energy efficiency: strategic analysis concepts (business model, value proposition and competitive advantage); financial analysis concepts (investment flows and the main evaluation methods).
- During the course of the game participants have different tasks to perform, at the request of the company managers. These tasks enable them to better understand the logic of decision and action in companies and to advance in their analysis and selection of the EEM(s) to be presented to the selection committee.
- The steps to be performed by the player in the game follow the steps of M-Benefits methodology for the identification and evaluation of the non-energy benefits of EEMs. The players have to identify, analyse and evaluate in operational, strategic and financial terms, the non-energy benefits of the EEMs described in the energy audit.[11]
- In order to succeed, participants have to (virtually) interact with the company's managers or staff members to obtain the information necessary to move through the game's steps. This is also a way for participants to better understand other professionals' ways of thinking and making decisions, and to create contacts. Thus it enables them to become more aware of cultural differences between companies' professionals.
- As in every serious game, the game M-Benefits uses game principles and mechanics in order to achieve objectives (*i.e*. learn the M-Benefits methodology).

Testing the M-Benefits Serious Game

The third part of the article presents the results of an initial test session using the serious game, which took place at the end of January 2019.

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[8] The case and all information is based on a real company. We would like to thank this company, especially its energy manager, for their collaboration and time, and for the information given to us. We cannot give the company's name for reasons of confidentiality.

[9] In real-life decision-making processes, the Investment Selection Committee is the body formally responsible for making investment decisions.

[10] Which is composed of the game trainers and the other participants.

[11] The energy benefits of each EEM are given by the energy audit.

This test session brought together 19 participants representing professional, political and academic communities active in the field of energy efficiency. The test session was held over one day, condensing what the future two-day training sessions will be like. The organisation of the test day was based on what will be the organisation of future sessions, *i.e.* a combination of theoretical inputs and their application in the serious game.

During the test, while participants were at work in the serious game, informal observations were made, regarding both participants' behaviour and discussions among them. These direct observations were completed at the end of the day with participants' feedback in the form of an open discussion, followed by an individual questionnaire. This was completed by an *a posteriori* analysis of the logs on the serious game server, making it possible to trace the path of each team in the serious game.

The questionnaire was designed by grouping the questions on three axes: utility, usability, and pleasantness of the serious game. Eighteen out of 19 participants responded to the survey.

The "Utility" axis includes three questions on the usefulness of the serious game in terms of methodology training, understanding of the methodology and the desire to use the methodology. The questionnaire responses confirm the open observations and feedback from participants: the serious game is indeed a useful training tool for the M-Benefits methodology.

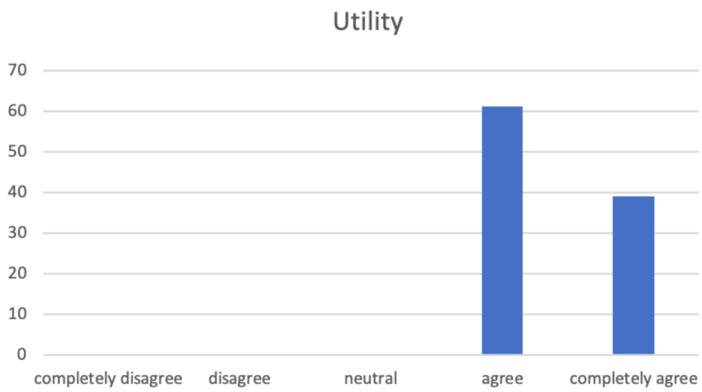

Figure 4 – Synthesis of the percentages of responses to the three questions related to Utility

The "Usability" axis includes five questions on understanding the general use of the serious game. The answers to the questionnaire confirm observations and analysis of the logs, which is necessary to further guide and inform the participants about objectives to be achieved in the serious game, as well as in the work to be done. Initial adaptations have already been implemented and will be evaluated at the next training session. It should be noted that in order to best test usability, no information, demonstrations or user manuals were provided to participants.

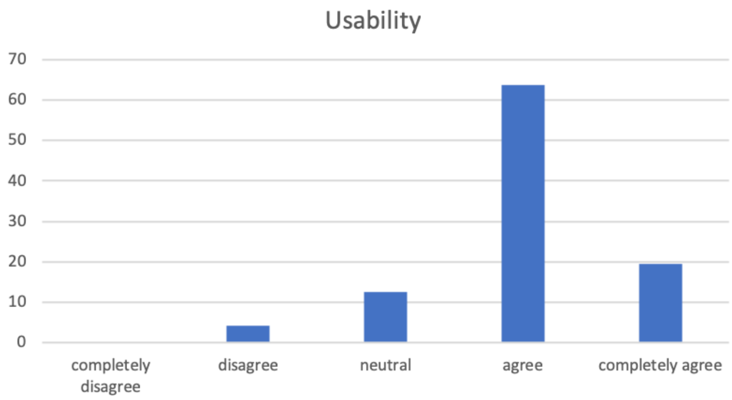

Figure 5 – Synthesis of the percentages of responses to the questions related to Usability

The Pleasantness axis was the subject of a single question, "Generally speaking, is the serious game pleasant to use?" The results of the questionnaire confirm the observation and feedback on the "pleasant" side of the serious game as a complement to traditional training methods.

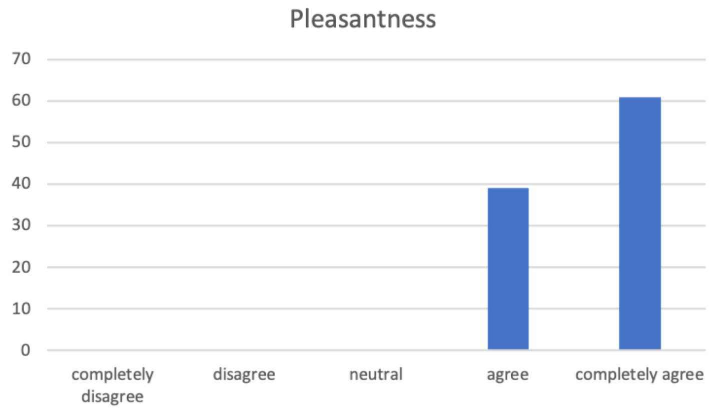

Figure 6 – Synthesis of the percentages of responses to the questions related to Pleasantness

All these observations confirmed the utility, usability and pleasant nature of training based on the serious game. It is interesting to note that despite a lower score on usability, utility and pleasantness remain high. Overall observations made it possible to detect points of improvement both in the game's interfaces and content (usability), as well as in the overall organisation of the training day and the articulation of the serious game with the theoretical inputs.

Conclusion

This paper has described the generic concept of a serious game and the new serious game M-Benefits.

M-Benefits serious game, a deliverable of the EU H2020 project M-Benefits, is conceived as a tool to help engineers in charge of energy-efficiency projects understand how important it is to adapt to different professional cultures and business management interests in order to succeed in promoting their projects.

Bridging the gap between corporate or professional cultures is a challenge. Inciting energy engineers to broaden their analyses from a technical approach to a business management approach presents two main difficulties: they must want to do it and they must be able to do it. This is why the M-Benefits serious game was created. The first test session with this game confirms that these objectives are being met.

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