Chapter 9
A Method for Developing a Game-Enhanced Tool Targeting Consumer Engagement in Demand Response Mechanisms

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Abstract This work focuses on enhancing consumer engagement in demand response mechanisms through the employment of gamification techniques. Demand response mechanisms are employed by electricity suppliers, other market parties, and transmission and distribution system operators as options for market optimisation, balancing supply and demand, and ensuring system security. Gamification is the use of game design elements in non-game contexts, and the use of game principles in the design of certain systems to enhance engagement with these systems and make the interaction more motivating. The development of flexibility mechanisms at the demand-side is considered a key aspect for an effective energy transition, which requires the active participation and empowerment of consumers in the energy system. However, a significant barrier to realise the full flexibility potential is insufficient consumer engagement and awareness regarding energy usage. Serious games, and gamification, can effectively empower consumers by enhancement of engagement and stimulation of collaboration between them. The goal is to enable a playful interaction between technology, such as smart metering

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systems, energy management systems and smart appliances, and consumers that will result in higher engagement in demand response. An overview of demand response is provided, and the linkage is made between retail markets, markets at the wholesale level and ancillary services. The role of gamification techniques is discussed based on literature review, focusing on strategies to increase consumer engagement in demand response mechanisms. A user-centred, iterative design method is proposed for the development of a game-enhanced tool in which also collaboration between players can be stimulated, whereas the impact of applying the game-enhanced tool on consumer engagement can be empirically verified.

Keywords Demand side management · Demand response · Consumer engagement · Gamification · Serious games · Tool design method

9.1 Introduction

In recent years, the topic of consumer engagement in smart grid projects has received increasing attention at a European level. Projects involving consumers are characterised by the pursuit of two main objectives: gaining deeper knowledge of consumer behaviour and engaging the consumer (Gangale et al. 2013). Consumers increasingly need to be empowered, especially considering the complexity of products and markets and the increasing flow of information and new requirements in consumers' decision-making in liberalised market environments (European Commission 2011; Carreira et al. 2017). Improved decision-making by consumers can also have a significant impact on the competitiveness of the economy (European Commission 2011). Active users at the demand-side can contribute to solving the challenges of electricity systems and receive significant benefits for their participation. A significant barrier to realising this potential is insufficient consumer engagement and awareness regarding their own energy consumption (Gangale et al. 2013). Gamification is the use of game design elements in non-game contexts as well as use of specific system design features to make engagement with these systems more motivating (Johnson et al. 2016). Serious games, and gamification of real world processes, can effectively convey new knowledge and skills to people (Sitzmann 2011; Wouters et al. 2013; Wouters and van Oostendorp 2013; Boyle et al. 2016; Clark et al. 2016; Ke 2009, 2016); foster collaboration between consumers (Hummel, et al. 2011; Ter Vrugte and de Jong 2017; Wouters and van Oostendorp 2017; Chen and Law 2018); empower consumers, enhance engagement, change attitudes and improve behaviour in the desired direction (Deterding et al. 2011; Aronson et al. 2013; Catalano et al. 2014; Soekarjo and van Oostendorp 2015; Fijnheer and van Oostendorp 2016).

In recent years, there is a growing consensus among academics, practitioners, policy makers and market participants that demand-side flexibility, through Demand Response (DR) mechanisms, is a critical resource for achieving a low carbon and efficient electricity system (EDSO 2014; ENTSO-E 2015a; Eurelectric 2015; European Commission 2015; SEDC 2015; CEER 2016). However, it is expected that energy consumers will require support in making informed decisions and engaging in energy applications (Carreira et al. 2017). In this paper, we propose a method for developing a game-enhanced consumer tool to address consumer engagement in DR mechanisms through gamification techniques. The envisioned tool will enable a playful interaction with consumers and/or prosumers via a web-based platform; and will be supplemented with elements to stimulate and organise collaboration between them. Such a tool is expected to lead to a significant increase in consumer engagement in DR mechanisms, as well as enhanced flexibility in energy usage. The method includes the design, development and validation phases of a tool, employing game elements, for engaging consumers in real-life energy management, increasing awareness and collaboration between consumers, and stimulating behavioural change in energy usage and flexibility provision. The envisioned tool will provide accurate information about energy usage in buildings through smart metering systems, and will employ gamification techniques for consumer engagement in DR mechanisms. The method for the design and development of a game-enhanced consumer tool is based on a user-centred design approach. The envisioned tool will integrate game elements with energy analytics, smart metering systems, and smart appliances to address certain DR programmes. The proposed method can be employed by: researchers studying the effect of gamification on consumer engagement in energy applications; technology developers, targeting the development of game-enhanced tools; and energy service companies, providing services and offerings to retail customers.

The paper is structured as follows: in Sect. 9.2, an overview of DR is provided. In Sect. 9.3, the role of serious games and gamification techniques in consumer engagement are discussed. Section 9.4 deals with strategies for consumer engagement in DR applications. In Sect. 9.5, a method targeting the development of a game-enhanced tool for consumer engagement in DR mechanisms is proposed. The paper ends with conclusions and recommendations for future work.

9.2 Demand Response

In recent years, the topic of Demand Side Management (DSM) is becoming more important than ever, in parallel with the further deregulation of the electricity sector; and the increasing integration of intermittent renewable energy sources (RES). DSM includes DR options, such as the management of resources at the customer side of the meter, i.e. distributed generation, energy storage, controllable loads and other on-site resources (CIGRÉ 2011). DR is a term used in economic theory to identify the short-term relationship between price and quantity, when the actions and interactions of substitutes and complements are taken into account. In the energy sector, DR programmes are designed to incentivise end-users to alter their short-term electricity usage patterns by scheduling in time and levelling the instantaneous power demand (Lampropoulos et al. 2013). DR mechanisms are employed by electricity system planners, market parties and operators as resource options for market optimisation, balancing supply and demand and ensuring system's security. DR has been recognised by academics and practitioners as a tool that allows response to challenges related to the intermittency of RES in a cost-effective and environmentally-responsible manner. The Council of European Regulators regards the participation of customers in the electricity market as essential; and that realising the flexibility potential of the demand-side provides a pathway to enhancing consumers' participation (CEER 2016). The electricity industry considers DR as one of the building blocks of future wholesale and retail markets, offering electricity consumers the opportunity to reap the full benefits of their flexibility potential (Eurelectric 2015). The Association of European Distribution System Operators (DSOs) for smart grids considers that the provision of system flexibility services for voltage control and congestion management could provide clear benefits for DSOs, grid users and society as a whole (EDSO 2014). Grid operators are potential users of flexibility services in order to: perform their core tasks in grid planning and operation; defer network reinforcements and investments; and reduce grid losses (European Commission 2015). The European Network of Transmission System Operators for Electricity advocates the further development of DR due to the numerous associated benefits, such as energy cost reduction for consumers, making the system more flexible and increasing market competition (ENTSO-E 2015b). The European Commission Task Force for Smart Grids considers the development of flexibility mechanisms on the demand-side as the key to a successful transition to a new energy paradigm, which requires the active participation and empowerment of customers in the energy system (European Commission 2015). Apparently, there is a growing consensus among policy makers and market participants that demand-side flexibility, through DR mechanisms, is a critical resource for achieving a low carbon and efficient electricity system (SEDC 2015).

DR propositions are offered by intermediaries (suppliers and/or aggregators) to retail customers in the energy market in the form of optional programmes with voluntary subscription. A DR programme consists of a contractual agreement that sets the legal and technical requirements for operation and verification of DR, as well as the incentives for customers' participation. DR programmes can be classified along two main categories (Albadi and El-Saadany 2008), i.e. incentive-based (see Sect. 9.2.1) and price-based programmes (see Sect. 9.2.2), as illustrated in Fig. 9.1. DR mechanisms may also address self-consumption schemes (see Sect. 9.2.3).

Serious games are a promising approach for DSM and DR that aims at heightening consumer engagement and active participation (Papaioannou et al. 2018). In this paper, we propose a method for developing a game-enhanced consumer tool to address consumer engagement and participation in DR mechanisms, i.e. certain DR programmes, and/or self-consumption schemes. In Fig. 9.2, the linkage between retail offerings (including DR programmes and self-consumption schemes), and markets at the wholesale level and ancillary services is illustrated. Intermediaries, such as suppliers and/or aggregators, act between the consumers and/or producers, and the markets (wholesale and/or markets for ancillary services).

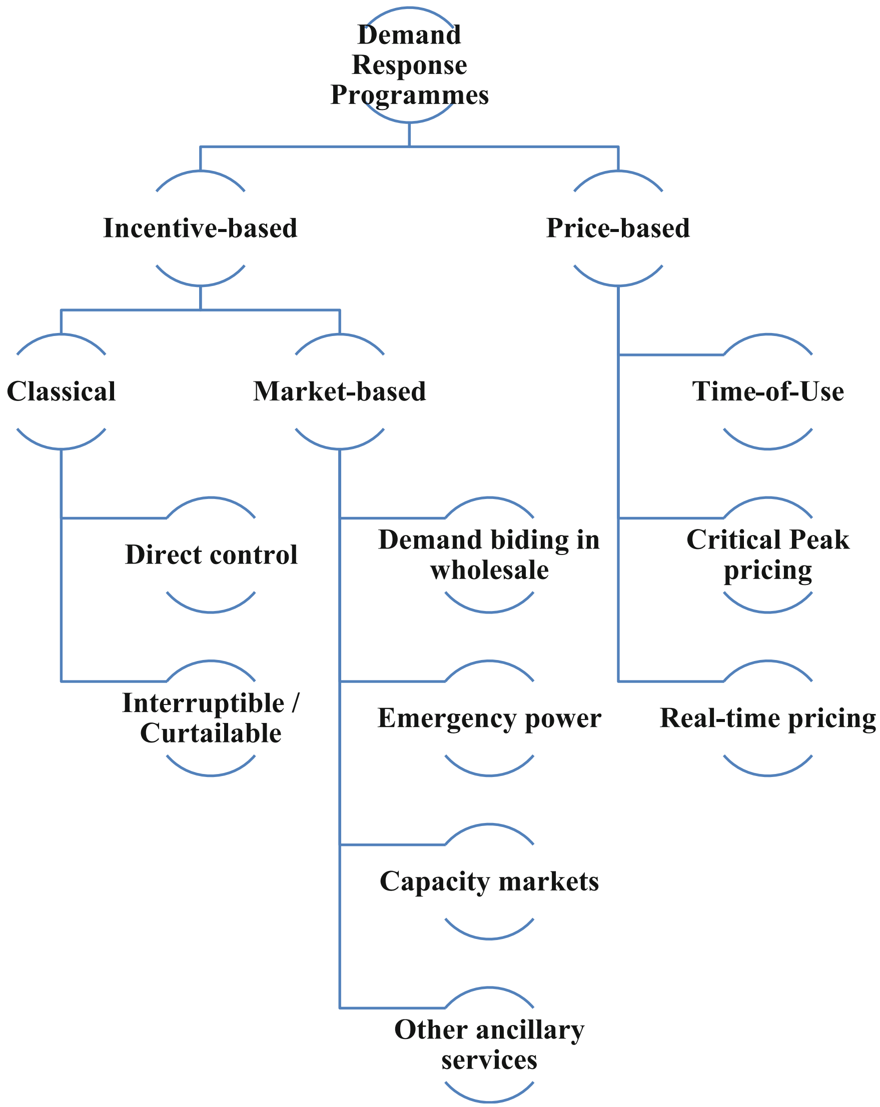

Fig. 9.1 Classification of demand response programmes (Albadi and El-Saadany 2008)

Serious games and/or gamification techniques for consumer engagement are applied at the interface between the DR programmes and the consumers and/or producers. For the convenience of the reader, the overall system architecture of the physical power system and the electricity sector organisation in the European context, including a description of the main actors and their roles, can be found in Lampropoulos et al. (2017).

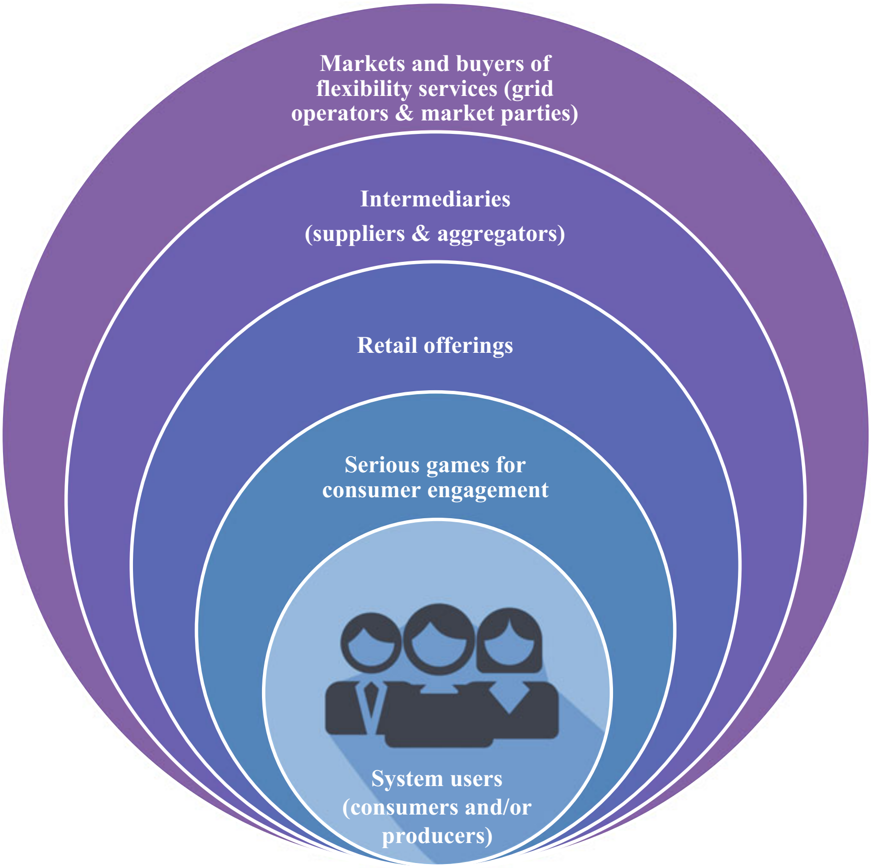

Fig. 9.2 Illustrating the linkage between retail offerings (including demand response programmes and self-consumption schemes), and wholesale and ancillary services markets. Suppliers and/or aggregators act as intermediaries between the retail customers (consumers and/or producers) and the wholesale markets and markets for ancillary services

9.2.1 Incentive-Based Programmes

Incentive-based programmes include classical programmes, and market-based programmes linking to wholesale and ancillary services markets.

Classical incentive-based programmes can be further distinguished into direct load control programmes and interruptible/curtailable load programmes, where participating customers receive payments, usually in the form of a bill credit or a discount rate (Albadi and El-Saadany 2008).

Market-based programmes can be further distinguished into demand bidding in wholesale markets, and DR participation in ancillary services markets (emergency power, capacity markets, and other ancillary services), where participating customers receive a remuneration according to the market rules. In recent years, many Regional Transmission Organizations (RTO), Independent System Operators (ISO) and Transmission System Operators (TSO) are structuring the rules of ancillary services markets, such that DR resources can participate alongside with conventional supply side resources (Lampropoulos et al. 2013, 2018).

9.2.2 Price-Based Programmes

Price-based programmes are based on variable pricing rates in which electricity tariffs fluctuate, following the real-time cost of electricity. The ultimate objective of these programs is to flatten the demand profile by offering higher prices during peak periods and lower prices during off-peak periods (Albadi and El-Saadany 2008). Price-based control involves indirect load control in the form of differentiated tariff structures such as Time of Use (ToU), Critical Peak Pricing (CPP) and Real Time Pricing (RTP) (Lampropoulos et al. 2013). These developments are supported by bi-directional communication systems between the control centre and the end-users. ToU tariff schemes refer to time-invariant rates that are utilised in an attempt to lower peak demand by providing price signals, which encourage customers to shift their consumption from peak demand periods to off-peak periods. CPP tariffs is a dynamic pricing scheme that extends the time-invariant rate scheme of ToU tariff, with a flexible pre-set high price during periods of system stress. RTP of electricity refers to frequent adaptation of retail electricity prices to reflect variations in the cost of the electricity supply.

9.2.3 Self-consumption Schemes

The idea of self-consumption is that locally generated energy, such as the photovoltaic (PV) generated electricity, will be first used for local consumption and the surplus can be injected into the grid (Masson et al. 2016). The injected electricity can be compensated depending on several options that vary between countries or regions (Masson et al. 2016). Due to the decreasing revenues from the surplus electricity injected into the grid in some countries, as well as the possible negative effects on the grid, caused by over-generation of PV electricity, mechanisms promoting self-consumption are becoming increasingly important. DR has been suggested by different studies as one of the important mechanisms for reaching higher self-consumption levels. The increase of the self-consumption ratio can be achieved with either a change in the demand profile at the consumption point (through DSM/DR), or by storing electricity when the PV production exceeds the consumption and use it during peak periods (Masson et al. 2016).

A serious game can set targets and provide rewards to a customer when, for instance, a certain level of self-consumption is achieved. The social influence can also be incorporated in the game either in the form of competition (see Sect. 9.4.3), e.g. by comparing a customer's self-consumption level with other customers, or collaboration (see Sect. 9.4.4), e.g. self-consumption at a neighbourhood level (Alskaif et al. 2018).

9.3 Serious Games and Gamification Techniques

Serious games, digital games with educational or training objectives, can effectively convey new knowledge and skills to people as shown in many recent meta-reviews (Sitzmann 2011; Ke 2009 and 2016; Wouters et al. 2013; Wouters and van Oostendorp 2013; Boyle et al. 2016; Clark et al. 2016). Persuasive games are a sub-category of serious games and are focused on attitude change. These can be effective means to change people's attitude towards energy-related behaviour (Fijnheer and van Oostendorp 2016). When people are highly engaged in a game they are apt to adopt the attitude that is promoted in the game (Ruggiero 2015). These games can lead to higher awareness of relevant factors involved in, for instance, energy savings. In effect, attitude may be positively changed by higher awareness, and as such trigger a change in energy saving behaviour itself. The assumed chain of events, i.e. from awareness (or knowledge) enhancement to attitude change and subsequently behaviour change, is what persuasive games try to establish (Aronson et al. 2013; Catalano et al. 2014; Soekarjo and van Oostendorp 2015). In a review of ten different energy-related games, the authors conclude that the empirical effects of the games in changing knowledge, attitude and (energy consumption) behaviour were positive (Fijnheer et al. 2016). Gustafsson et al. (2009) drew the same conclusion, though the effects in behavioural change (like reduction of energy consumption) were either characterised of short duration or limiting in terms of behaviour change. That is, actual reduction of energy consumption could not be demonstrated in the long term. The transfer of behaviour in the game context to behaviour in the external, real world situation was limited. In this respect, a new development in games and game design can be promising, and that involves gamification of processes in the real world (Deterding et al. 2011; Nacke and Deterding 2017).

Gamification is the use of game design elements in non-game contexts and to use specific system design features to make engagement with these systems more motivating (Johnson et al. 2016). These elements correspond to the provision of information, a rewarding system, social connection, a user interface, and performance status (Alskaif et al. 2018). Integrating these elements with home smart metering systems is expected to lead to longer attention to it, and higher willingness to change attitude or behaviour, such as reduction of energy consumption. For several theoretical reasons, including these gamification elements in already on-going every-day conduct can be effective: they can engage and motivate the player (user) and provide promising triggers to optimise the transfer to real world behaviour (Johnson et al. 2016). Several recent publications indicate the promising character of including gamification into technology focused on energy efficiency (Fraternali, et al. 2017; Garcia et al. 2017; Morganti et al. 2017). Alskaif et al. (2018) have performed a survey of relevant research projects and revealed that the main focus of past projects was on applications targeting energy efficiency, whereas DR and self-consumption applications are gaining more attention in recent years. This trend is expected to continue in the future, in parallel with the further development of DR mechanism and distributed energy storage, as well as with the further integration of RES at the distribution level, which requires active control and energy management solutions.

9.4 Strategies for Consumer Engagement

Several strategies to engage consumers with DR programmes in the long term have been identified, ranging from the provision of education and energy usage feedback (in a simple and easily understandable form), comparative feedback, linking the energy usage of individuals with the collective usage issues, and the deployment of user-friendly interfaces for the interaction of users with technology (devices used to deliver consumption data, smart appliances etc.) (ADVANCED 2015).

In this section, first we review the motives as well as the concerns of consumers to engage in smart grid projects in Europe (Sect. 9.4.1); subsequently we elaborate on strategies for consumer engagement in DR applications by employing game design elements, such as the provision of information (Sect. 9.4.2) and social connection game elements (Sects. 9.4.3 and 9.4.4), and building on top of identified strategies for consumer engagement in smart grid projects. So far, most research on suitable attributes in DR programmes focused on economic aspects as the prime motive for consumers to participate, and therefore assess mainly the impact of monetary incentives. In reality, the decision-making of consumers is often influenced by a number of factors, including sentiments or interest about the social norm, as opposed to strict monetary incentives; and the interface with which the incentive scheme is addressed to the consumers is also a decisive factor (Papaioannou et al. 2018). Studies that look into the application of game design elements as a motive to engage consumers in DR programmes can be considered as a rather recent development (Gnauk et al. 2012).

9.4.1 Motivational Factors and Concerns

The motivational factors, commonly used to stimulate consumer engagement by smart grid projects in Europe, are (Gangale et al. 2013; ADVANCED 2015): (i) the reduction of electricity bills; (ii) more control over energy usage; (iii) environmental concerns; and (iv) better comfort, i.e. the provision of technological solutions, allowing the optimisation of comfort and more control over own energy use. The motivational theme, focusing on the reduction of electricity bills, constitutes a main motive for consumers to engage in smart grid applications; while it also reflects a high risk in the case that consumers will not be able to actually achieve the expected cost savings, notwithstanding their behavioural change. This might hinder the consumer engagement process and result in low social acceptance, due to low trust; and eventually create a major blockage for the further development of DR (Gangale et al. 2013).

Alskaif et al. (2018) identify the key requirements for energy-related behaviour change by using the Trans-Theoretical Model (TTM), which classifies the process of behaviour change into a number of stages. An overview of the motivational factors commonly used to stimulate consumer engagement by smart grid projects in Europe, as well as the concerns of consumers to participate in energy related applications are summarised in Table 9.1.

Table 9.1 Motives and concerns for consumer engagement in energy applications (Gangaleet al. 2013; ADVANCED 2015)

Consumer segment	Motives/Drivers	Concerns
Residential	• Increase awareness of their energy use (and therefore learning how to reduce their energy consumption) • Environmental concerns • Reduction of electricity bills • Better comfort, i.e. the provision of technological solutions allowing the optimisation of comfort and more control over own energy use • Become part of innovative initiatives based on the use of new technologies • Supporting the local community through their participation	• The cost of hardware, such as metering devices, smart appliances, etc. • The installation of the devices composing the technical solution • The effect that using these devices could have on appliances • The impact that reducing energy consumption could have on lifestyles and comfort • The privacy of data • Protection of data (including security)
Commercial and industrial	• Money saving opportunities in energy cost, given that the security of their production process can be guaranteed • The reduced need for larger contract sizes for grid connection and grid expansion • The opportunity to optimise their business, e.g. decide whether to increase/decrease production over a time period, given the corresponding cost of energy	• The contractual complexity behind the participation in demand response programmes •The perceived risk of incurring penalties in case peaks exceed the limits as defined in the contractual agreement

9.4.2 Energy Analytics and User's Feedback

Feedback on energy consumption contributes positively to energy savings (Carreira et al. 2017). The value of feedback as a learning tool is undeniable, however, depending on the context, the outcomes from feedback can also sometimes be improved by using it in conjunction with advice and information (Darby 2006). The provision of feedback to the consumers about their energy usage, through smart metering systems and a user interface, can increase awareness and is expected to drive consumer engagement in DR mechanisms. Furthermore, feedback functionality, integrated into a game-enhanced consumer tool and (partly) based on gamification techniques, can create insight into consumer preferences for retail services, perspectives and concerns, and possible pathways of smart appliances adoption. Such feedback functionality is expected to enable consumers to be involved in the design of DR programmes. The underlying idea is that effectiveness of DR programmes is higher when it is designed from the consumer perspective, because consumers have other motivations, understanding and technology awareness than professionals in the energy sector (Stern 1999).

9.4.3 Comparative Feedback

The comparative type of feedback provides information about social comparison by comparing the performance of individuals to those of others, e.g. performance in terms of energy consumption. A comparative feedback may evoke feelings of competition, social comparison and social pressure that may be especially effective when relevant others are used as a reference group (Gangale et al. 2013; Alskaif et al. 2018).

9.4.4 The Collective Dimension and the Collaboration Element

The consumer is mainly regarded as an individual, whereas the collective dimension of consumer behaviour is still largely set aside (Gangale et al. 2013). A strategy to engage consumers with programs in the long term should address the link between household usage levels and collective usage, so people understand that what they achieve in their own household can impact on wider energy goals, e.g. at district or system level (ADVANCED 2015). Furthermore, by increasing awareness about the potential of aggregation of distributed energy consumption and/or production, another game design element that is highly relevant to DR applications concerns collaboration between players, e.g. consumers and/or prosumers. In a recent meta-review, Wouters and Van Oostendorp (2017) showed that collaboration in serious games had positive effects on learning, whereas also positive effects on motivation are mentioned (Ter Vrugte and De Jong 2017; Chen and Law 2018). Developing game design elements focused on engaging consumers in a collaborative way with gamification (aimed to stimulate and organise collaboration between consumers) has two advantages. First, the collaboration element can stimulate consumers to play an active role, because consumers can become part of a community in which they can socially interact. Second, these activities can empower consumers and increase their benefits because of the aggregation of their activities, e.g. use their collaboration power in wholesale energy markets, and for the provision of system services. Collaboration can stimulate consumers to share knowledge, collectively solve problems and answering questions (e.g. from neighbours). In the empirical literature on serious games, positive effects are found on the element of collaboration (the last one also demanding coordination activity) (Wouters and van Oostendorp 2017), particularly when the collaboration is guided or scripted, so that consumers know what to do (Hummel et al. 2011; Chen and Law 2018).

9.4.5 Considerations for Consumer Engagement in Demand Response

The employment of gamification techniques in DR applications can impact the following aspects of user awareness, behaviour and engagement:

- Educate the user about commercial offerings, e.g. retail offerings (including DR programmes and self-consumption schemes).
- Create awareness about individual and collective energy usage and associated costs/savings, through Advanced Metering Infrastructure (AMI) and consumer interfaces.
- Motivate the acquisition of smart grid technologies and smart appliances.
- Motivate active day-to-day participation in DR programmes and self-consumption schemes (provision of flexibility services) through the provision of incentives.
- Lead to changes in behaviour measured by key performance indicators (see Sect. 9.5.1).

9.5 A Method for Developing a Game-Enhanced Tool

In this section, a method is proposed for the design, development, validation and evaluation of a tool to enhance consumer engagement in DR; and to account for consumer behaviour in the design of DR programmes in order blockages due to

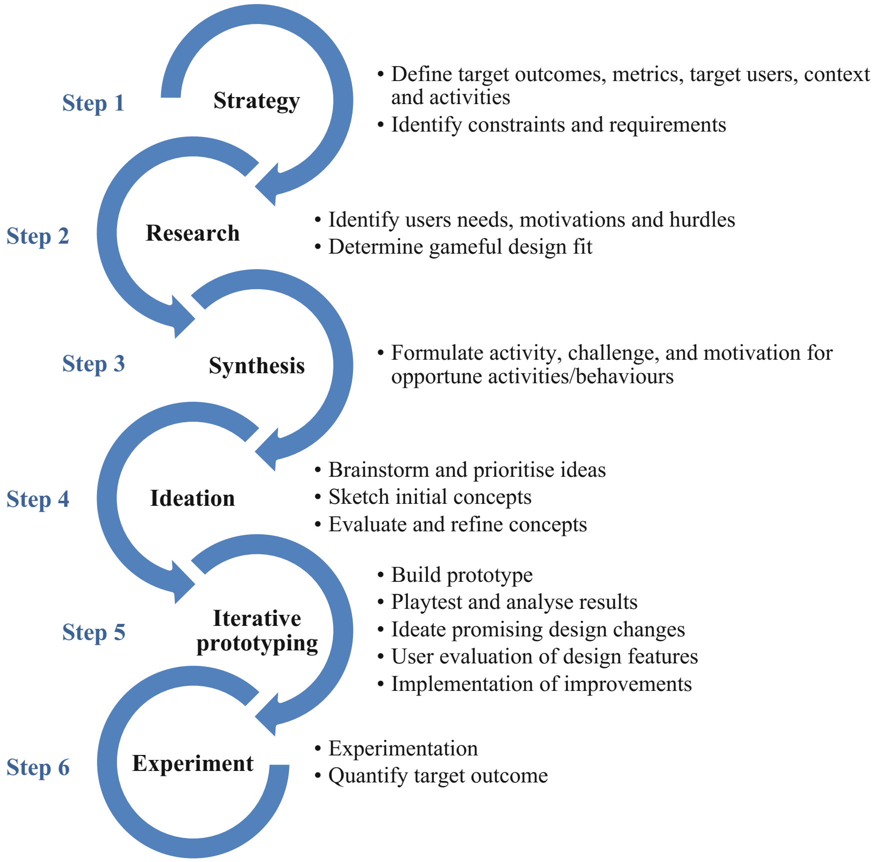

Fig. 9.3 Designing and developing a game-enhanced consumer tool as a six steps' sequential process (Deterding 2015; Fijnheer and van Oostendorp 2016)

social acceptance through the employment of game elements to be avoided. A distinct 6-step method, i.e. strategy, research, synthesis, ideation, iterative prototyping, and experiment, has been devised which is detailed in Fig. 9.3.

The method is based on a user-centred design approach, and is illustrated as a sequential design process that entails six steps (Fig. 9.3). The design of the game-enhanced consumer tool is mainly addressed in steps 1–4, which are based on a design method introduced by Deterding (2015). The implementation of the prototype tool is addressed in the fifth step, which is also complemented by activities, where potential users evaluate the prototype and provide feedback for adjustments and improvements, as suggested by Fijnheer and van Oostendorp (2016), in order to address the users' perspective and attribute a user-centred element in the design process. It is generally recommended that potential users of the game are involved in the development process (Benyon 2010). Finally, the last step addresses an experimentation phase, where four different user groups are assessed through pilot experiments.

The 6-step method for designing, developing and evaluating a game-enhanced consumer tool, i.e. strategy, research, synthesis, ideation, iterative prototyping, and experiment, is elaborated respectively in Sects. 9.5.1–9.5.6.

9.5.1 Strategy Definition

Defining a strategy for gameful design entails the first (1st) step of the method (see Fig. 9.3). A strategy is about defining the target outcomes, metrics, target users, context, activities; and identifying constraints and requirements. Alskaif et al. (2018) identify energy-related behaviour change requirements necessary to achieve an active and long-term participation of households in energy applications, including DR programmes and self-consumption schemes. The experiments and associated conditions, with focus on consumer engagement through gamification techniques, should be outlined, including the definition of performance metrics (see Sect. 9.5.1) and the clustering of consumers, by defining participating groups of consumers in the experiments and developing appropriate methods to address each group as well as the ways each group might respond to different behaviour change techniques. The performance metrics represent the main variables with which the behavioural changes can be determined. This step includes an analysis of consumer groups and the key behavioural barriers to consumer engagement in retail energy markets. Activities that represent collaboration between consumers are identified, as well as how they can be designed in order to stimulate and organise activities in the final game.

Performance metrics
Relevant metrics and specific Key Performance Indicators (KPIs) for a game-enhanced consumer tool might include average users logged in the DR engagement platform per week/month/DR-event, average time of platform usage/user group, ratio of accepted DR requests, ratio of executed DR actions, flexibility and reliability metrics of DR procedures, digital metrics of interaction with relevant DR content, game elements usability metrics/game/gamified DR-event, KPI correlations with demographics and psychographic user profiles, etc. Based upon Fijnheer et al. (2016), the player's behaviour and flexibility in energy usage can be monitored during playing as well as by recording how often the player logs in and what he/she is doing and for how long. Smart metering systems shall be developed to monitor the energy usage characteristics and to stimulate the energy saving behaviour, whereas the player can receive feedback during playing. The energy usage and savings shall be displayed both in terms of energy and monetary terms, including the potential annual savings. Graphs can be used to give the player an overview of the energy usage. A set of preliminary performance metrics and KPIs

shall be defined at the stage of strategy definition, in accordance with the research goals, to support the design process. Metrics and KPIs can be revised up to the stage of iterative prototyping (see Sect. 9.5.5), following the evaluation of game design elements by the users.

9.5.2 Research

The research (2nd step in Fig. 9.3) is about identifying the consumers' needs, motivations and hurdles. A game-enhanced tool shall address the motives and concerns of consumers (see Sect. 9.4.1). Furthermore, an analysis shall be performed on the interaction of consumers with such a tool in order a gameful design fit to be defined (Benyon 2010). Based on the research, a selection of gamification functions shall be selected for further implementation in the envisioned game-enhanced tool. Alskaif et al. (2018) present a compilation of the most commonly used game design elements, which are classified into five categories, i.e. information provision, rewarding system, social connection, users' interaction and performance status.

9.5.3 Synthesis

This task entails the 3rd step of the method for gameful design, as illustrated in Fig. 9.3. Specifically, this task is about formulating activities, challenges, and motivations for opportune activities/behaviours. For each targeted activity or behaviour, motivations and inherent skill-based challenges are identified, then the results are presented as clusters in the form Activity > Challenge > Motivation and serve as the main input for ideation (Deterding 2015).

9.5.4 Ideation

The ideation step (4th step in Fig. 9.3) is about brainstorming and prioritising ideas, sketching initial concepts, evaluating and refining the prioritised concepts. These activities may be part of co-design workshops. A co-design process could engage game developers, energy experts and end users in order to the game design elements be identified, which in turn can be used for guiding the design of the final application. Two approaches can be central here: how to promote collaborative activities between consumers and how to design engaging gamification features. The engagement can be measured by using questionnaire of Likert-type before, during and after playing; while possible standardised measures can be used (Lessiter et al. 2001; Jennett et al. 2008; Boyle et al. 2012).

9.5.5 Iterative Prototyping

This step entails the activities corresponding to the iterative prototyping (5th step in Fig. 9.3): build prototype, play test and analyse results, ideate promising design changes (e.g. adjust the duration of the game or the frequency of interaction with user), user evaluation of design elements, and implementation of improvements. It is suggested that a game-enhanced tool shall be accompanied by a Web and Mobile interface (instead of an in-home display); and combine user digital KYC operations (Know Your Customer questionnaires) to find out more contextual information about the platform users, various digital features, and specific DR updates in order to be ready to offer DR services under pilot deployments with real system users. The engagement prototype approach shall consist of at least three layers, each one of them with a discrete role and a set of assigned functionalities, namely: The Automatic Meter Reading (AMR) layer, the Data Modelling layer and the Gamification and Analytics layer.

The *AMR layer* is responsible for the deployment of the network communications infrastructure and the interconnection of the smart metering systems with the data aggregation components. The networking infrastructure consists of a set of wireless and wired sensor nodes, deployed in various areas and being able to monitor energy consumption and production parameters. Data aggregation is realised based on a set of heterogeneous data sources, including the sensor nodes. Alskaif et al. (2018) present the architecture of the technical system, which includes hardware solutions [i.e. smart metering systems, energy management systems (EMS), network, devices, etc.] as well as software solutions (i.e., mobile and web applications, data analytics, storage, etc.).

The *Data Modelling layer* (Meter Data Management, MDM) is responsible for the visual representation of data, based on the description of appropriate engagement models and the data fusion of energy, sensors and mobile app data, according to the business needs of the application scenario and/or pilot. The representation of the energy and behavioural data is realised based on the input from AMR layer and from the mobile app.

The *Gamification and Analytics Layer* is responsible for the design and deployment of a set of algorithms and mechanisms for the provision of recommendations (recommender engines) to end-users for adopting energy efficiency and the support of lifestyles, the realisation of advanced behavioural analysis over the collected data as well as the deployment of a gamification DR framework to be used towards the development of a game (offered though a mobile app or the web) in relation to DR programmes. Recommendations are provided based on analysis and reasoning over the collected data (energy and behavioural), upon being mapped to the above-mentioned engagement models; and is in some cases interlinked to other available datasets. The deployed recommenders focus on the generation of suggestions for energy efficient ways of living and DR personalised events and managing the buildings' infrastructure. For the analytics extraction part, a wide range of algorithms is supported, including algorithms for: classification of available data, energy consumption patterns recognition, forecasting and trends reporting algorithms with regards to energy consumption and/or production and the associated costs; analysis of the user's behavioural collected data from the mobile app. Gamification techniques are also providing description and interconnection of the concepts and situations with regards to the engagement of end-users in daily energy related activities, providing the fundamental building blocks for the transformation of these activities in game-like experiences, with predefined scope and goals. Finally, it will be examined how the element of collaboration between consumers can be built in order collaborative activities to be stimulated and organised.

Consumer engagement is a key aspect across all phases of the retail energy services lifecycle, including design, development, deployment and operation. The development of retail energy services is increasingly based on co-creation approaches, which emphasise consumers' collaboration. In general, consumers do not have the same motivations, understanding or technology awareness as professionals in the energy sector; and possible solutions are most effective when designed from the consumer's perspective (Stern 1999). It is important to note that successfully engaging the consumer involves iterative rather than consecutive phases, where continuous observation of consumer response allows adjusting the engagement strategy to the feed-back obtained (Gangale et al. 2013). After the implementation of improvements, the envisioned tool can be evaluated in pilot experiments, which may involve residential, commercial and industrial customers.

9.5.6 Experimentation and Evaluation of Results

The last step of the method addresses an experimentation phase, where four different user groups are tested under the four conditions illustrated in Fig. 9.3. This experimentation is focused on getting more insight into the underlying causes of effects: whether gamification is really needed or the DR program in itself is sufficient or both are needed. The prototype, developed in the 5th step (see Fig. 9.3), is tested in pilot experiments and the data are analysed. The players' behaviour shall be constantly tracked and evaluated in terms of energy usage and flexibility through specific metrics and KPIs (see Sect. 9.5.1); and be correlated with DR requests/events and game interventions in order to validate their behavioural change. The evaluation phase assesses the impact of gamification and behavioural changes to DR programmes/events and results into recommendations for further improvements. The focus is on summative validation, i.e. in an actual study, consumers and/or prosumers will use the developed tool and the evaluation will be performed by using an experimental 2×2 factorial design with the factors Game (Game versus

No-game as values) and DR (DR versus No DR Programme, i.e. a conventional control situation), making up 4 conditions. Energy consumption shall be monitored a priori, before the game starts, to set a good baseline of average energy consumption. For instance, households will play the game or not and get a control, dashboard version, and interact with the technology in one of the four conditions as indicated for some months. Before the starting point and at the end of the period there shall be four measures on engagement, energy awareness (knowledge), attitude and energy usage and flexibility in usage (actual behaviour) (Soekarjo and van Oostendorp 2015; Fijnheer et al. 2016).

In the empirical studies, all four effects of playing the game shall be measured. Engagement can be measured by using questionnaires before and after playing, by monitoring player's behaviour during playing and monitoring how often the player logs in and what he/she is exactly doing for how long. Knowledge can be measured by using questionnaires before and after playing and the scores of quizzes in the game. Attitude can also be measured by using questionnaires before and after playing. Energy usage and flexibility in usage shall be constantly monitored through smart metering systems, and evaluated based on pre-defined performance metrics.

Concerning the technical architecture, real-time connections between the smart metering systems and the individual appliances and game server can be accomplished by data-loggers with an Internet connection, and utilising Wi-Fi networks e.g. in the households. The game itself may consist of Internet pages that are uploaded by a device (e.g. tablet) when the player logs in via its Internet browser or in the form of a mobile app. All four conditions consist of a number of consumers and/or prosumers, randomly assigned to condition. The data shall be statistically analysed by analysis of variance.

The hypotheses to be tested can be as follows:

- The specific DR programme will have positive effects on energy usage and flexibility in usage.
- Playing the game will have a positive effect on energy usage, flexibility in usage and engagement.
- Playing the game will have particularly a positive effect in DR conditions on behaviour change, i.e. energy usage, flexibility in usage and engagement.

In terms of variance of analysis, we expect main effects of Game and DR programmes, and an interaction effect of Game and DR on engagement, and energy usage and flexibility. When consumers are engaged in a game they are apt to pay attention to relevant concepts and become aware of energy-related knowledge. This can enhance the attitude that is promoted in the game and consequently lead to energy saving behaviour and establish higher flexibility in energy usage (Aronson et al. 2013).

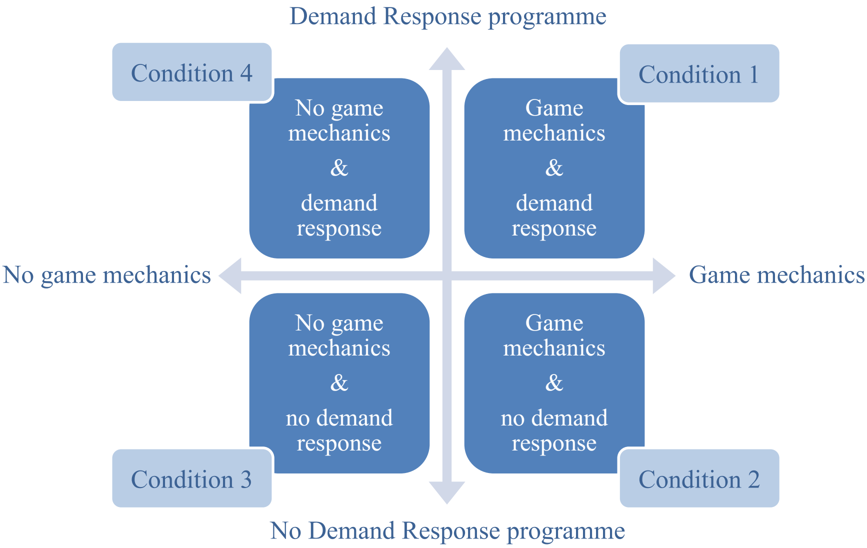

Fig. 9.4 Grid matrix illustrating the two concepts along two axes, the utilisation of a DR programme and the use of gamification techniques. The four quadrants capture the four conditions and user groups to be tested in the project

As can be seen in this grid matrix in Fig. 9.4, the focus is on coupling the utilisation of a DR programme with gamification techniques. The four quadrants capture the four conditions and user groups to be tested. Gamification research has shown that the integration of serious games into real life applications can result into positive effects on attitude and behaviour (Deterding et al. 2011; Johnson, et al. 2016).

Assessing consumer behaviour in DR is about consistently trying to answer the following questions:

- Can DR programmes influence end-users to change their short-term electricity usage patterns by scheduling in time and levelling the instantaneous power demand?
- This question is examined by comparing Condition 1 and 4 against Condition 2 and 3 (see Fig. 9.4). In other words, is there a (main) effect of the DR programme?
- Can serious games and gamification enhance consumer's empowerment by increasing engagement in sustainable energy management and applications, subsequently resulting in an increase in consumer awareness and attitude change, and ultimately in an improved response in DR programmes?
- This question is examined by comparing Condition 4 and 3 to Condition 1 and 2. In other words, is there an effect of game playing? In the game to be built, several game design elements may be combined referring to the: existence of missions involving social connection, such as competition or collaboration,

provision of information, rewards, performance status indicators, such as levels and badges, availability of a narrative, customisation, etc. The game may be a so-called eco-feedback, multiplayer, role-playing and point & click adventure exercise.

- Will game playing have an additive or interactive influence on the effect of technological solutions?

For instance, technological effects are only found when energy usage of end users is enhanced by playing a game. In this case an interaction effect of playing a game and presence of technological solution has to be present: the difference in engagement, awareness, attitude and energy consumption between Condition 1 and 2 is much bigger than between Condition 3 and 4.

9.6 Conclusions and Future Research

The proposed method, as presented in this work, is meant to be applied to the development of a game-enhanced consumer tool, targeting consumer engagement and empowerment in Demand Response mechanisms. The method also addresses an experimentation phase, where the developed tool can be tested in pilot experiments with actual system users in different locations through the participation of their associated suppliers and/or aggregators. The envisioned game-enhanced consumer tool will integrate gamification features with home energy management systems in order to stimulate longer attention and higher willingness to change attitude or behaviour, resulting thus in more flexibility in energy usage. Additionally, it may be complemented with a collaboration element in order to both strengthen the positive effect of collaboration on learning and encourage consumers to use their collaborative power in energy markets (for example enabled by local energy cooperatives). The preferences and concerns of users with respect to data privacy and protection shall be fully taken into account in the data management processes. The employment of gamification techniques in Demand Response programmes is expected to stimulate user behaviour and engagement in real-life applications, but also to contribute to the further development of these programmes by including the users' perspective on their design elements. The motivation is to assess the role of games in encouraging engagement of consumers, building trust between stakeholders and co-creating Demand Response programmes.

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