The E-CITY 2020 Game: The Use of Simulation Games can accelerate Market Model Design for the Electric Vehicle Charging Infrastructure

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***Abstract*— The charging of electric vehicles forms a new market, which is emerging partially from existing energy markets. The emergence of such a new market requires a definition of a market model; the description of roles (e.g. charge spot owner, charge spot operator) in terms of responsibilities and interactions between those roles (the processes they engage in). The development of a market model for a yet nonexistent market is often complex and tends to remain abstract, since the dynamics of this future market are difficult to imagine, let alone understand. Simulation games are a proven method to help dealing with such complexities and are used in various environments from policy simulations to day-in-life training simulations. However, gaming simulations have rarely been applied on the new market model design. This paper describes the novel E-CITY 2020 simulation game that has been developed to examine the contribution of gaming simulation to market model design for Dutch energy related markets. The game simulates a market model for the charging infrastructure in a fictive city in 2020. The game results in increased insight in the dynamics and interactions in a new market for both designers and participants. Furthermore, the gaming simulation is attractive to participate in and creates shared and increased understanding of the future market model from different perspectives. Finally, it also identifies requirements for successful implementation of the market model. These results lead us to conclude that simulation games are an effective tool to overcome complexities in future market model development.**

I. Introduction

INCREASING dependency on oil imports from unstable political regions, declining oil supplies, increasing awareness of the contribution of CO_2 emissions to the global warming processes is asking for solutions in the energy and private transport sector [1]. These aspects are rapidly driving innovations to electric driven vehicles [2]. However, there are still many barriers to overcome in the fields of technology, customer acceptance and organization..

One of the most important barriers to a large scale introduction to Plug-in Electric Vehicles (PEVs) is an effective charging infrastructure to fulfill customer requirements. The 'chicken-egg' problem, which describes the reluctance of car manufacturers to introduce alternatives for the Internal Combustion Engine (ICE) in the absence of infrastructure or the other way around, slowed down the progressions on electric transport [3]. The new market for charging infrastructure overlaps with existing markets, among which markets that can be regulated to a certain degree, e.g. the transport of electricity. This complicates the emergence of a new market since it is unclear which parties can play which role. In such a market a 'market model' facilitates the market and contains agreements on market roles, responsibilities and processes. It sets preconditions under which a market can function given objectives. These agreements can be anchored on different levels, from formal law & regulation to informal agreements between market parties. The emergence and growth of the market for charging EV's can be accelerated if a market model can be agreed upon in an early stage.

The expectation is that an electric car driver wants to charge on more spots a day (at home, at work or at the gym for example). The current market model for the Dutch electricity sector does not facilitate this, since the system does not allow for daily or even hourly switching of energy suppliers on the same grid connection. Netbeheer Nederland and EnergieNed acknowledged the urgency to accommodate agreements for charging and payment for charging electric vehicles in a market model. The result is the kick-off for dialogue document '*Study market model charging infrastructure for electric transportation'* provided by Accenture which contains a design of roles, responsibilities and processes of a preferred market model.

However, a future market and its dynamics of processes and interaction are difficult to imagine, let alone understand, due to two faces of complexity. First, there is technical-economical complexity which stems from the emergent complexity among the physical-technical-economical entities within the market [4]. Second, complexity which is the result of strategic interaction between different actors with different stakes who are interdependent on each other in realizing their goals [5; pp.15, 6].

A market model is not constructed in one day, but has to be developed over time. We defined that market model development consists of five main phases. Phase I, analysis

Manuscript received June 14, 2011. This work was supported in part by the TU Delft and Accenture.

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and global design, is already performed by a consultant company. The market model for the electric vehicle charging infrastructure in The Netherlands is proceeding at the moment in phase II 'Refinement of global design'. A market model however should be accepted by all relevant stakeholders to make it effective. It is therefore important to initiate a dialogue with stakeholders to refine the market model and ultimo arrive at an accepted market model that is addressing all issues [7, 8 : pp. 8]. Phase II is therefore aimed at discussing, refining, finding consensus and settling the developed market model. The first step is to present and / or communicate the message of the discussion document to key stakeholders from the market in order to start-up interaction and refinement [8: pp.26]. The environment in which this all has to be performed though is characterized by: An uncertain and hard to imagine future; A market in which many different actors interact and can behave strategically; A situation in which there are no clear agreements between stakeholders yet.

Methods used in these phases such as conceptual modeling, market consultation and traditional presentations and workshops do not suit to convey, understand and further develop these complex processes and dynamics of a market model.

Gaming simulation is a tool that can deal with complexity [4]. A typical gaming simulation problem is a very complex real world situation characterized by: many variables interacting, no realistic basis for quantification of variables, no proven conceptual model and a 'futures' context [9 : pp.364]. Interaction has a central role in simulation games, which makes them interesting to create insights into the interaction between parties and the results of this interaction on the market. Gaming simulation is therefore a method which makes it possible to address the technical-economical and multi-actor complexity and might be valuable during the design of market models. However it is not explicitly applied and described as tool for market model design. Therefore the main question addressed in this article is: *What is the contribution of simulation games to market model design?*

The novel E-CITY 2020 simulation game was developed to examine the contribution of gaming simulation to market model design for Dutch charging infrastructure market. The game simulates the preferred market model for the charging infrastructure in a fictive city in 2020. The game was played in January 2011 with a representative group of senior Accenture employees with a background in the utilities and resources. Evaluation data were gathered by observations during the game, a group discussion and debriefing on roles, responsibilities, processes and information and a questionnaire before and after the intervention. The remainder of this article describes the E-CITY 2020 game and the results.

II. THE CONCEPTUAL MODEL OF E-CITY 2020

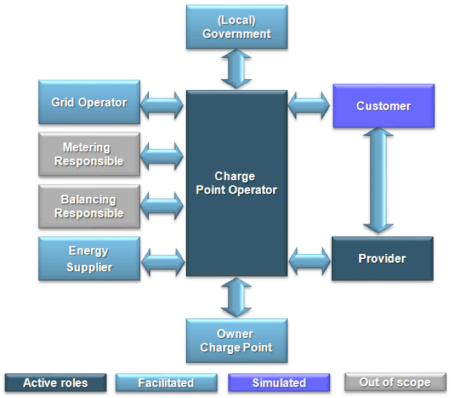

Fig. 1. E-CITY 2020 game roles.

The design of E-CITY 2020 is based on the preferred market model as presented in the report '*Study market model charging infrastructure for electric transportation'* provided by Accenture (2010).
The translation to the game roles is depicted in Figure 1. The market roles are divided into:

- Active game roles: comprising the most central roles of the preferred market model; the charge spot operators (CSOs) and charge service providers.
- Facilitated game roles: local government, grid company, energy supplier are facilitated roles, which pose constraints on the behavior of the CSOs and providers from their framework in the current energy market.
- A simulated role by a computer model: customers.

Furthermore, the preferred market model distinguishes various processes classified into pre-charge processes, charge-processes (e.g. identification and measuring) and post-charge processes (e.g. billing, paying and settlement). The E-CITY 2020 intervention is focused on the pre-charge processes; all processes around charge spot realization and contracting on access terms.

III. THE E-CITY 2020 INTERVENTION

The main purpose of the simulation is to involve important stakeholders and to first create shared insight: (i) In the roles, responsibilities, and interactions (processes) and dynamics between the between the different stakeholders within the preferred market model. (ii) In requirements for success for implementing the market model.

E-CITY 2020 is a custom-built market model simulation of a future preferred market model for the Dutch charging infrastructure for electric transport. It is a three hour simulation which combines a role-playing game with a setting that simulates a charging infrastructure market in the fictive E-City around 2020. Through stimulating government action, increased customer awareness for green transport and the breakthrough of attractive electric cars the number of electric cars is expected to surge. E-CITY is a fictitious conglomeration made up of six regions. Characteristics are

the inclusion of fast and normal charge spots in E-CITY and segmentation of customers in private and business.

Course of intervention

The E-City 2020 intervention consists of three main parts: the introduction (Part I), the game (Part II) and the evaluation (Part III). Furthermore a questionnaire is used to recover knowledge on the participants and their knowledge levels.

Questionnaires

The participants were offered a questionnaire before and after the intervention. The questionnaire is used to identify the motivation and learning of the participants to support answering the research question of this paper.

Part I: In the role of the customer

After a brief presentation on electric transport the participants start getting acquainted with E-CITY and the materials;
Let them think from a customer's perspective by engaging bottlenecks for electric car customers. This puts the participants in the right setting for the remainder of the intervention.

Part II: Infrastructure realization

In part two the participants experience realization of infrastructure from the management view of a CSO or service provider. The purpose of part two is to experience the dynamics, roles and interactions. The game simulates the period 2020-2023. Every year (round) is divided into trimesters. The individual goal for every actor is to maximize profit and gain market share in the market for charging infrastructure in E-CITY by attracting customers to electric vehicles by offering attractive charging services. The attractiveness criteria are price setting, coverage are and occupancy rate. These criteria are provided by the computer model.

Part III: Evaluation

The debriefing is used to let the participants share their experiences, identify learning points and to make the transfer to the market model reality. The debriefing was triggered by questions related to the game objectives.

Social contract

One of the aims of the intervention is to involve industry key stakeholders in the process of further market model refinement. It is therefore desirable that they commit to further market model design and cooperation.

IV. Results and Discussion

A literature review, combined with findings from the E-CITY 2020 intervention, has resulted in four statements on the contribution of gaming simulation to market model design:

In this section we will motivate the statements by providing supportive arguments from literature, the questionnaire results, observations during the game and discussions of the debriefing.

A. Gaming simulation increases the understanding of the participants of the preferred market model from different perspectives

Understanding of the preferred market model is crucial in this phase to involve industry stakeholders to help further refine the proposed model and finally arrive at consensus. Gaming simulation is a method that can be useful for visualizing and identifying critical elements of a complex problem. At a higher level of abstraction they help to understand the big picture [10]. E-CITY 2020 has resulted in several indications that support the ability of a simulation game to increase the understanding of both participants and designers on the preferred model. We start with the main arguments coming from indications from the debriefing's discussions.

The level of substantial discussions that were raised in the debriefing of the intervention demonstrates the understanding of the roles, responsibilities and interaction between roles (processes). We will list a few discussions and questions from the debriefing to support this: (i) Participants raised the urgency for clear frameworks for different roles. They were trying to understand where they had to go for permits, connections, information on customers etc. (ii) The participants also discussed possibilities for differentiation of the providers. (iii) They discovered that it is important for the CSO to quickly build relationships on the one hand and realize infrastructure on the other hand. (iv) The participants experienced many dependencies between the provider and CSO such as: (a) The need for influence of the provider on charge spots (b) Need for CSO to perform market analysis. (c) The need for the provider to be able to account the CSO for charge spot availability. Quotes from the debriefing: *"We as providers did have contracts with the CSOs, but they did not have their infrastructure working… We are very dependent on the CSOs.."* and *"…The result of the fact that the CSO is closing contracts with all kind of providers is a declining service level for the current providers, since their charge spot availability will decrease due to higher demand. How can we call the CSO to account for this?"* (d) The participants discovered how income and cost flows through the value chain. (v)They raised the question which role should be responsible for charge spot registration?

The second purpose of E-CITY 2020 is to create knowledge on the market model. The intervention has provided the following two main learning points which are regarded as requirements for success in the further design of the charging infrastructure market model: Price setting is a very complex process, because of mutual dependencies between providers and CSOs. The balance in risk was not fairly divided in the market model. Both parties incorporated large margins in the prices to cover risk, which resulted into accumulated prices. The question is how to divide the risk? Can this market model support a market in this way? Bottlenecks in the process were also identified and should be

carefully taken into account in further design; limited grid capacity for example became just obvious very late in the process chain for realizing a charge spot.

We believe that the fact that the participants were able to share and discuss these experiences concretely in the debriefing are an indication for understanding of the roles, responsibilities and the constraints.

Increased insight in the roles and responsibilities is further supported by the questionnaire results. The questionnaire shows that the participants increased their knowledge on these questions. The questionnaire included seven questions on roles and responsibilities of the preferred market model. The value of the questionnaire results, which are used to complete the findings from the debriefing, can be argued. Arguable are the fact of: lack of anonymity of the respondent, the number of respondents, and background of the respondents. Because the value of some answers in the questionnaires can be argued, the evaluation relies mostly on the observations during the game and the discussions raised by the participants during the debriefing.

Furthermore, gaming simulation has supported to think from different perspectives such as the customer. Gaming simulations allow for pushing players into different roles. In E-CITY 2020, this is actively designed into the game, such as in part I of E-CITY where participants are pushed in a customer's role in which they experienced bottlenecks for the user. During game feedback some participants mentioned that the brief experience of this warming up game had helped to understand the customers need. Thinking from a customer's perspective also became clear in the debriefing. First, participants indicated that they would like to have more information and interaction with the customer. Second, they have put the customer in the center of the discussion. This is caused by the fact that consequences of their decisions are reflected by the behavior of the customer. Finally, experiences from negotiating and interacting have helped to see other points of view. These experiences are shared in the group evaluation, which helps the group of participants to understand the different perspectives.

We conclude that gaming simulation increases the understanding of the participants and can create more knowledge on the preferred market model. By letting people experience their decision-making processes it is shown in E-CITY 2020 that consequences for the system such as the accumulated risk can be revealed. As Sophocles quoted around 400 B.C.: "*One must learn by doing the thing, for though you think you know it, you have no certainty until you try"*. This is true for E-CITY as well. Not only knowledge is transferred from the market model developers to participants, but by experiencing unexpected dynamics new knowledge is also created on the market model which can be used in further refinement of the market model.

B. Designing a simulation game increases the level of understanding on the market model of the designers

Besides the above mentioned learning points for both participants and designers we also observed that the designers increased their understanding during the design of the game. Druckman and Ebner (2008) have evaluated the effect of the design of a gaming or simulation exercise even more positive than participating in a game. By experiments they showed that participants in designing the game were even more motivated and had a better understanding of the concept than the participants of the game only [11]. Probably the synthesis part, which is learning about the relationships between different concepts, is the best learning element accomplished by the game design process. For design one "*needs to have systemic understanding – seeing the connections among roles, goals, resources, constraints and contingencies*" [12].

We have found indications that support the great learning performance over the design trajectory. We observed a steep learning curve of the game designers, but also the designers of the market model have indicated learning points on their own market model. These learning points mostly came in workshops when the goals and possible actions of the different roles for the game were defined. For example when thinking-up of the customer's motivations and actions we recovered that first the customer not only wants a charge spot if he does not have the ability for home charging, but that he also wants his own parking spot to make sure that he is always able to charge when coming home. Another example was when thinking about the incentives and differentiation options for the providers and CSOs. Would they want to make contracts exclusive in order to have a better availability of charge spots for their customers or the other way around?

The market model designers indicated that they have "*explored the boundaries of the market model by thinking about drivers for a game. By not only touching upon the processes and roles but also on the need for customer demand and business models it has helped them to put the market model in a wider context of challenges and problems"*. These relations become clear since the designers were forced to think about motivations and goals and had to link them to other roles and games in order to be able to make them concrete for the game. Understanding on the 'real' incentives of the roles in the market model was needed in order to 'model' these into the game to 'simulate' realistic behavior of the played roles by the participants.

These observations lead us to attribute the value of game design to increasing the understanding of the market model system. However, in our case there were no primary industry stakeholders, who have to conclude market model agreements, included in the design team. Since for the designed intervention consultants from the industry were used, the knowledge increase of the system does not occur within the primary stakeholders of the industry. The value of game design to market model development can be increased

when industry representatives are included in the game design process. A sounding board that consists of industry bodies could be an implementation of this recommendation. The game designers can facilitate the design process by enabling the sounding board to use their industry knowledge to meet the challenges future market model and related processes, roles and responsibilities will bring.

C. *Gaming simulation helps to create a shared understanding among the participants of a possible future for the preferred market model*

Having a shared understanding of this difficult to imagine future of the market model would help in finding consensus. The E-CITY 2020 game brings people together in a room to explore an alternative future in a condensed time frame, so following literature it should help to create a shared understanding and shared formulations of problems and solutions [10].

There are three types of indications that support this argument. First, questions on the knowledge of market roles show that differences in understanding of the roles on beforehand are converged to common ideas about the roles afterwards.

Second, questions on trust in electric transport and the preferred market model were included in the questionnaire. It was found that the gaming intervention has leveled the views on expected different interests. Before the intervention 57% of the participants were expecting large contrary interests between roles in this market model, whereas after the intervention most people have changed to a neutral stance or even did not expect large opposite stakes anymore. This supports the fact that the intervention has funneled their view on the market model. If parties feel that they have shared interests and can funnel these interests, this will increase trust which will be of benefit to the process.

The third indication is the fact that we observed that people were actively sharing their experiences of the game in the debriefing. The discussions of which a few were described under the conclusion of increased understanding point out the ability to share and discuss experiences and problems. Kolb *[13; pp.21]* acknowledges this as *"when human beings share an experience, they can share it fully, concretely and abstractly"*. One of the observations that demonstrates the shared experience of solutions and problem is the fact that a participant mentioned in the discussion on accumulated risk coverage in consumer prices due to mutual dependencies between provider and CSO: "*You can also say, we are going to cooperate as provider and CSO in order to make a strategy together and recognize the risks together as well"*

In line with the expectations on gaming simulation as stated by different gaming simulation experts gaming simulation can help to create a shared understanding of a market model through its ability to let participants experience a certain future.

D. *People seem to be better motivated to attend a simulation game than a traditional presentation or workshop*

It is important in this phase of market model design to involve stakeholders. To be willing to participate the most important is that parties need to have a sense of urgency and know that there is something in it for them [14]. Besides a needed sense of urgency we believe that the attractiveness of the intervention also can help to bring people together. We expected that a 'traditional' workshop or presentation does not sound interesting enough to attract people in some occasions. A presentation or workshop might be again just one of those millions that people are engaged with, whereas a gaming simulation creates an experimental learning environment in which people interact in a possible future their selves which is fun to play [10, 15]. A gaming simulation therefore is expected to better differentiate from other workshops or events. This should make it easier to get people involved for the first time.

We found several indications that people are better motivated to attend a simulation game than a presentation. Questions on the attractiveness were included in the questionnaire. 100% of the respondents were expecting both an interesting and informative session. Furthermore, 28% indicated that they would not have reserved three hours time to come to this meeting if they knew that it would be a presentation or workshop on the market model instead of a game. 42% doubted to come to a presentation and took a neutral stance.

On hindsight all participants thought that was a fun and informative session and 83% of the participants would participate in a following gaming simulation in their field of experience. This demonstrates that a simulation game does not only seem to be attractive on beforehand, but the participants also experienced the intervention as interesting, which increases the chance on a social contract for further participation.

V. Conclusion & Recommendations

The charging of electric vehicles is a new market that is emerging, partially from existing markets. The emergence of such new markets requires the definition of new roles and responsibilities. However, the development of an abstract market model for a future market is complicated since the dynamics of future markets are difficult to imagine, let alone understand. The methods used in the design process such as conceptual modeling, market consultation and traditional presentations and workshops do not suit to convey, understand and further develop these complex processes and dynamics of a market model. E-CITY 2020 was developed to evaluate the contribution of simulation game to further market model design. Based on the findings the authors draw the following conclusions on the contribution of gaming simulation to market model development:

A. *Gaming simulation increases the understanding of the participants on the preferred market model from different perspectives.*
B. *Designing a simulation game increases the level of understanding on the market model of the designers.*
C. *Gaming simulation helps to create a shared understanding among the participants of a possible future for the preferred market model.*
D. *People seem to be better motivated to attend a simulation game than a traditional presentation or workshop.*

Based on the increased understanding of the market model we recommend paying attention to at least the following requirements for success when further refining the market model for the electric transport charging infrastructure: First, scrutinize the mutual dependent relation between CSO and provider. Pay attention to risk distribution, cooperation and the results on consumer prices. Second, optimize the request process for a charge spot, paying attention to the sequence of process steps to be performed by the CSO to realize a charge spot. The CSO is currently running risk by entering into contracts or buying permits, meanwhile experiencing problems with for example connecting its charge spot due to grid limitations.

The authors also have recommendations to increase the value of E-CITY 2020 to further market model design: Integrate the game on the short term for this phase of the design (Step II.A of the framework in the appendix) with the other processes and roles of the preferred market model. Only some of the processes of the preferred market model were included in the game so far, but the results are already satisfying. It is recommended to extend the game with the important part of the market model on payment and settlement. Second, extend and use the game on the longer term towards an implemented market model. We believe that E-CITY 2020 is a perfect starting point for extending and mutating the game along the improvements made to the market model during the refinement iterations in step II.B. It could be a start for a multi-day multi-player game in which a next version in step II.C of the market model is fully tested with enhanced customer segmentation, roles, processes and insights. It is then a tool that helps along the decision trajectory towards consensus on a market model to be implemented.

Finally, we have two main recommendations for further researching the value of gaming simulation to market model development in order to increase the arguments behind the conclusions: (i) More cycles of interventions are required with primary industry stakeholders instead of consultants. The primary market firms have to conclude market model agreements. They may have different interests and stakes within that market, which could have biased the results. The element whether stakeholders are willing to close a social contract and commit themselves to further market model refinement can then be tested. (ii) It is recommended to further co-develop the game with primary industry stakeholders to increase the level of knowledge on the system model of these stakeholders themselves. Since, it is time-consuming to involve all market parties to the design team, a sounding board that consists of industry bodies could be an implementation of this recommendation. The game designers can facilitate the design process by enabling the sounding board to use their industry knowledge to meet the challenges future market model and related processes, roles and responsibilities will bring.

ACKNOWLEDGMENT

The authors give their special thanks to Paul Ubbink, Rutger Deenen and Ivo Wenzler who have supervised Sjoerd Helmer during his graduation project at Accenture. S. Helmer also wants to thank his supervisors from the TU Delft faculty Technology, Policy and management; Rens Kortmann, professor Alexander Verbraeck and Zofia Lukszo.

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