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Serious games as an instrument to support energy retrofitting

Lessons from the Go2Zero City-zen Game

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Abstract

This paper presents the serious multi-player tabletop game GO2Zero and explores how such games may contribute to overcoming barriers to local energy retrofitting. The game lets actors involved in local energy retrofitting, experience the multi-actor decision-making context. In half a day, about twenty participants play a role. Roles defined are: local authority, housing corporation, tenant, homeowner, local sustainable energy supplier, grid operator, local renewable energy supplier, or a contractor offering retrofitting measures and technologies. Within the game, participants are requested to determine their energy goals, and the strategies to be used to achieve them. In four consecutive rounds, each representing several years, participants have to decide which retrofitting investments they will make, if any. They can choose from a number of retrofitting measures, and have to get an understanding of the pros and cons of each. They are confronted with the consequences of their decisions over the years, in terms of individual and collective goal achievement, carbon reduction, security of supply (network instability), land use, and affordability.

After playing the game, the participants have more insight in the different opportunities for retrofitting, the effect of different retrofitting strategies, and the dynamics of the institutionally fragmented decision-making context. The paper will report on the experiences of sessions played with local stakeholders involved in energy retrofitting in the cities of Dubrovnik, Amsterdam and Delft. The game development and sessions played have been part of the EU FP7 supported project 'City-zen, new urban energy'. The game has been developed in collaboration with DNVGL.

Introduction

The transition towards renewable, non-carbon based energy resources is a global challenge involving all industries and sectors. In search for achieving the UN climate goals, the residential sector needs to contribute as well (Ballarini, Corgnati and Corrado 2014). In the European Union (EU-28), the households are responsible for 25,4% of final end use of energy use in 2015. The contribution is even expected to rise due to global warming and continued urbanisation, leading to increased (peak) energy demand for cooling and in turn contributing to increased pollution and global warming (Ascione et al. 2017). Whereas many efforts have been put in the successful development of energy neutral and zero emission concepts for new housing, the existing building stock turns out to be resistant to many of the policies and innovations supporting the reduction of carbon-based energy and increasing the use of renewable energy (Trencher et al. 2016). In the period 2007-2015, the EU-28 final energy consumption for the residential sector fell by -3,9% compared to -15,5% by industry (Eurostat 2017). This poor result can be explained by a number of factors: high upfront investment costs, lack of awareness and knowledge by residents, home owners, but also amongst professional stakeholders as contractors and local policy makers, disruption for residents, uncertainty of return of investments, uncertain energy performance and the fragmented institutional setting, with many small stakeholders, split incentives, absence of a directing actor and of enforcement capacity (Van Bueren and De Jong 2007, Sunnika-Blank and Galvin 2012, Baek and Park 2012, Zuo and Zhao 2014, Caputo and Pasetti 2015).

In the EU FP7 project ‘City-zen: new urban energy’ (Cityzen-smartcity.eu 2017) the cities of Amsterdam and Grenoble took on the challenge to develop best practices for improving the local energy performance of buildings, districts and cities. The Go2Zero game has been developed as part of this project, acknowledging that many of the challenges in urban retrofitting are of a non-technological nature, requiring stakeholder interaction.

This paper presents the Go2Zero game, developed by TU Delft in cooperation with DNV GL in the context of the City-zen project, and the results of the first sessions played. The following sections first explain the complexity of the challenge of energy retrofit or energy renovation of the existing homes, followed by a description of the GO2Zero game and the results from the first sessions played and conclusions.

Energy retrofitting challenges

Cities, including the energy system and the housing system, can be considered as complex socio-technical systems consisting of an intractable number of variables and relationships which are difficult to control. The socio-technical complexity is recognizable in the case of energy retrofitting. There is a large variety of technological solutions to choose from, ranging from energy saving measures to the adoption of renewable energy technologies to produce energy on a household scale (e.g. through heat pumps, PV panels) and on district scale (e.g. PV farms, wind farms, and using industrial waste heat), or changing the energy mix (e.g. to use electricity instead of natural gas). This results in a large number of options to choose from, without clear indications of costs and benefits in terms of finances and energy use. The costs and benefits of options are often interdependent, making it even more difficult to determine these and to make a choice. For example, a well-insulated home reduces the return on investment of alternative forms of heat supply. Also, costs and benefits tend to be based on reference buildings, with reference occupants with reference behaviour, lifestyles and preferences. Another, often disregarded, but complicating factor is the relationship between the use of renewable energy technologies in homes and the grid changes it requires, bringing in the grid operator as another stakeholder. Grid operators might need to invest in additional infrastructure and in the capacity and balancing of the network to secure supply.

Main actors on a district level are the municipality, inhabitants of the district, the social housing corporation, businesses, but also the energy network operator and energy companies. These stakeholders operate on different levels and make decisions based on different values and act according to different regulatory frameworks. Whereas a resident mainly focuses on the direct living environment, a network operator or energy supplier acts on a larger geographical level. Although, in general, the actors would agree that the energy transition is important, the ways in which this can be achieved varies from high-level, top-down interventions to small-scale, bottom-up initiatives. Decisions of cities to expand heat grids limit the options of residents; decisions of many individual residents for decentralized technologies together demand additional investments by grid operators; subsidies from a municipality steer the selection of measures causing different performances of the system. These interactions may lead to emergent system behavior on the level of the district and consequently on the national and international scale.

Municipalities, who have an important role to play in promoting the energy retrofitting or energy renovation of the existing housing stock, thus face a difficult task. They have to encourage citizens to invest in their homes, without being able to supply them with a customized action perspectives and without significant enforcement capacities. In addition, the level of knowledge and awareness amongst municipalities is generally quite low, often concentrated in the hands of a few experts (Caputo and Pasetti 2015). It is for this setting that the Go2Zero game has been developed, as a serious role playing game to make stakeholders involved in the energy retrofitting at a local level aware of the complexities involved and possible actions and their effects. Also, it offers an environment to experiment with coordinated action strategies.

The Go2Zero game

Serious games are games developed for other purposes than mere entertainment. Simulation games offer participants a representation of a real world complex system in a simplified way (Bekebrede 2010). Participants can experience situations that are difficult to experience otherwise, and can learn from it. In the multi-player, roleplay settings, such as Go2Zero, games also offer participants the opportunity to freely experiment with different strategies and experience and reflect on the consequences of one's actions (Duke and Geurts 2004). Due to the complex nature of climate change and urban development, serious gaming is a useful support tool in this area (Mayer et al. 2005, Kwok 2017).

GO2Zero is a multiplayer tabletop game. The development followed the game design approach of Duke and Geurts (2004). The main objective of the game is to offer participants a better understanding of the challenges of the transition process towards zero carbon emissions by residential buildings and to provide an experiential space to explore different technological options and transition strategies. The game development started with a thorough analysis of the local energy system, from the energy system of individual households to the local energy infrastructure and supply. This was based on a knowledge available amongst the participants in the City-zen consortium and on interviews with different stakeholders in Amsterdam and Grenoble, to understand the main variables, relationships and challenges in energy retrofitting and the main actors involved. To make the game more playable and more focused, some simplifications were made, such as the choice for an average, mono-functional suburban residential (small) district, and the exclusion of the transportation sector.

The game GO2Zero simulates the energy transition process of existing dwellings. Multiple players, divided over different roles need to take actions to reduce energy consumption by 50%, to produce all renewable energy locally and make the district CO2 free. On a card board the residential district is represented, consisting of twelve houses with their families and gas and electricity networks. Each household has three pillars of coloured fiches representing the energy consumption (heat and electricity), the energy production, and the CO2-emissions. The potential areas for local energy production also have a place on the map showing the capacity realised.

The roles included in the game are home-owners, tenants, a housing corporation, the municipality, the grid operator, contractors supplying the energy retrofitting measures and a local energy company. A role is preferably played by 2 persons, giving them the opportunity to brainstorm, exchange ideas and discuss decisions. At the start of the game, all households have a grey energy contract with a national energy company, played by the facilitator. The grid operator is responsible for ensuring sufficient capacity on the grid. The needed capacity will change due to the actions of the families and the housing corporation, but also by newly installed production capacity of the local energy company. The participants are placed at different tables in the room, with a placemat containing information about their individual financial situation, energy contract, and assets. They are allowed to move around and communicate with each other.

A GO2zero gaming session starts with an introduction to the game after which participants have time to read the information and develop a strategy. The game takes place in maximum four rounds consisting of three steps: 1) payments, 2) negotiation, and 3) consumption. In the first step, households receive their salary and they have to pay their rent or mortgage, energy bills, grid costs and local taxes. During the second step, all stakeholders can buy technological energy measures from the contractors, negotiate about costs, make appointments, change contracts, and organize community meetings (Figure 1 left). In the third step, the district map is adapted to the new situation: based on the transactions, the pillars of fiches are reduced (Figure 1 right). A complete gaming session has four rounds, after which the final score is registered and all participants have to count their money and to produce an overview of their situation. During the debriefing, participants share and discuss their results, followed by sharing of emotions surfaced during the game, and reflect on the overall outcomes of the game. Further, they discuss what has happened and how this could be done differently. Finally, together they look forward to what this could mean for their local energy transition challenge and possible strategies.

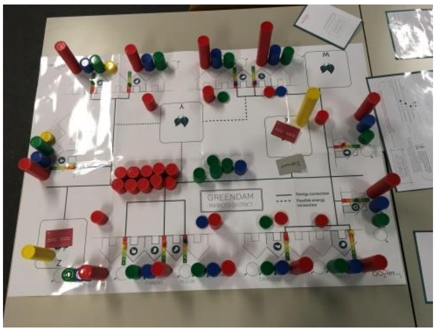

Figure Discussion amongst participants (left) and the card board (right)

Results

The game was play-tested with stakeholders from the Amsterdam region in the Netherlands and from the city of Dubrovnik in Croatia, leading to some improvements. The final design has been validated by 3 sessions with students from Tilburg University.

Game outcomes

Households in all sessions started from the same position: residents live in houses with a low energy label (G or H) and use fossil-based energy sources. We observed different strategies and results between the three sessions. Table 1 shows the outcomes on the three main objectives in the game. In none of the sessions any of the final objectives were achieved. This was hardly possible, as the game has been designed for four rounds of playing and due to time limitations, we played two rounds.

In the first session the participants clearly focused on reducing CO_2 emissions by changing the grey energy contracts to a contract with energy generated by nuclear power. This had a large impact on CO_2 emissions, but introduces another dilemma. Also, the households focused on energy reduction and local production via PV panels. They did this without any communication with the grid operator. Consequently, the network had insufficient capacity to deal with the new production, leading to energy loss and network instability. In the second round, the grid operator invested in increasing the grid capacity while the households invested in energy reduction measures. This led to an over dimensioned network and a waste of resources.

In the second session the participants strongly focused on the reduction of energy. Together with some local renewable energy contracts, they were about halfway the CO_2 reduction targets and reached the highest reduction in energy use of the three sessions. In this session, the grid operator was also not part of the discussion on how to achieve the objectives. In the debriefing, the grid operator explained that it thought it could only react on the actions of others and need to follow the dynamics.

In the third session there was a strong grid operator, who took the lead. To survive as a company, it had the strategy to focus on production of renewable energy on the district level instead of on the individual household. The students playing this role actively discussed with the local energy company the additional investments needed in the grid resulting from the increased local production. In this session, the households had less influence and paid the higher grid costs. In the results, this is not yet visible, as the installed power was not connected to the grid when this game ended. If it had been connected, the energy from local production would have been 52%, which would have been substantially higher than in the other sessions. However, the energy consumption in this third was overall higher.

The debriefings led to two general observations. First, aligning strategies amongst the participants was not easy. Although they shared ambitions, investments discussions led to a deadlock. For example, everybody had agreed that implementing a heat grid was a good solution, but nobody wanted to invest and the heat grid could not be realized. A second general observation was that stakeholders focused on the well-known measures as PV panels, insulation and double-glazing. They did not research other opportunities.

Game Experience

In the postgame survey, we asked for players' experiences while playing this game. The number of responses of the postgame questionnaire was 24 (51%). The participants agree that the game was relevant (M = 3.9, SD = 0.5) and they put themselves into their role (M = 3.9, SD = 0.6). Further, they slightly agree on the clarity of aim, the level of detail, and the realism of dynamics. In the debriefing, we observed that the students were surprised that in reality stakeholders often do not communicate well and believed that you could take decisions only with complete information. Further, they slightly agree that they enjoyed playing the game and they would like to play again. From the reactions in the open questions, we conclude that a better introduction of the different roles is needed as students lack knowledge about different roles. In addition, they asked for more time, so they would have the opportunity to finish the game. Both points influenced their experiences. In the oral debriefings of the game sessions in Amsterdam and Dubrovnik the participating professionals emphasized that the resemblance with the real-life complexity of local energy transition processes, making them realize that the complexity of the challenge is even higher than they realized.

Conclusions

The GO2Zero game achieved its goal to give participants more insights in the challenges of a transition process towards sustainable cities by focusing on the local energy transition and energy retrofitting of housing in particular. Our observations, coupled with the results of the sessions played, show that the game also provides room for testing a variety of strategies and related outcomes. Further observations showed that coordinated decision-making between different stakeholders is necessary to achieve objectives and to optimally use limited resources. Especially the role or involvement of a grid operator seemed critical in the process – a role that is not often considered in discussions on energy retrofitting. Finally, well known and easy to apply measures had been taken, while participants did not invest in other, less known measures.

Based on the results, we conclude that a game such as the GO2Zero is capable of a whole representation of a complex system, thus providing stakeholders a more profound understanding of the complexity and the need to collaborate and coordinate actions. Playing more sessions in different institutional contexts will result in better understanding of strategies used by the participants. Improvements of the Go2Zero game could be in several directions. It would be interesting to use it as an environment for experimenting with different predefined retrofitting strategies and incentives. Also, new roles, such as an energy advisor and energy service company, could be included, and new technologies could be introduced.

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