Understanding the challenge of the energy crisis – tackling system complexity with megagaming

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ABSTRACT

Climate change is tightly coupled to the usage of energy in different forms. Creating and using sustainable energy solutions is increasingly being recognized as the greatest challenge of our time. The energy crisis concerns everyone who consumes energy or services that rely on energy to be performed, in practice almost everything we buy. However, the temporal and psychological distance to climate change has led to a situation where the consequences of our energy usage often is considered a future problem or "someone else's" problem. Current methods to increase awareness and understanding of climate change and the need to create sustainable energy solutions are usually based on simulation or negotiation games. Methods similar to crisis management exercises are uncommon. In this paper, we propose to use Megagames, large scale social games, as a method for increasing the awareness of the challenges related to creating sustainable energy solutions. Examples from two Megagame test runs are provided and discussed.

CCS CONCEPTS

• **Human-centered computing** → *Empirical studies in collaborative and social computing*; **Collaborative and social computing design and evaluation methods**.

KEYWORDS

games, social simulations, climate change, energy systems

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1 INTRODUCTION

While consequences of climate change such as storms, heat waves, and flooding often are referred to as crisis or even disasters [13], the underlying factors contributing to climate change, and thus these crisis events, such as the use of fossil fuels, are rarely seen as a crisis. The practical and psychological distance between our collective actions and future consequences has resulted in a situation where climate crisis management is reduced to discussions and negotiations about future actions rather than the immediate response needed to mitigate the consequences of climate change. In general, humans have difficulties understanding, and relating to, phenomena such as climate change due to the lack of systems understanding, the ability to understand how multiple factors interact and multiple, sometimes conflicting, goals [9]. Climate change is an effect of complex, systemic, interactions between a large number of components. The study by Funke points to the fact that the ability to exercise causal reasoning about a limited number of factors is insufficient to cope with complex problems [9]. Research on problem solving has repeatedly shown that humans have limited ability when it comes to handling complex problems involving environmental, social, or economical systems. Challenges comprising interactions between such systems pose even larger challenges [7, 11].

One of the most important contributing factors driving climate change is the usage of different kinds of fossil fuels for transport, heating, and generating other kinds of energy such as electricity. Transforming energy systems is one of the most challenging parts of decreasing human impact on climate change. An energy system comprises both production of, consumption of, and transmission of, energy. The energy system is in turn bound to the energy market, which in turn is a part of the market. Thus, all producers and consumers are bound together, not only by technical systems, but also by financial mechanisms that in turn are affected by other aspects of the economic system. Parts of the energy system, foremost systems providing electrical power must be kept in balance, otherwise the system ceases to function. Production and demand must be balanced within very short time frames to avoid disastrous effects. Production planning is therefore typically conducted with a time frame of a few days ahead. Prices are set with a similar time horizon. Since power outage is affected by several factors, such as production demands, temperature, pricing, etc, production and demand tend to fluctuate heavily and can vary significantly on a day-to-day basis. Furthermore, consumer expectations and interpretation of the energy system shapes consumer behavior, which affects the actual power consumption at a given time. Further, the energy system comprises not only decision-makers but also the population at large. Every single person makes choices that collectively affect the energy system. The energy system must thus be viewed as a complex, adaptive, socio-technical system.

Unfortunately, this is not always reflected in common methods used to train for and increase awareness about climate change, such as simulation and negotiation games. Exercises and gaming efforts for improved understanding of climate change generally focus on environmental issues exclusively, sometimes considering economic or social factors, but rarely all three dimensions at the

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same time. This is most likely an effect of the division of science into separate topics rather than a unified whole. Different research approaches aim to solve "their" part of the problem. This is in stark contrast to the actual entanglement of the energy system within society, environment, and global climate. Currently, the authors of this paper are part of a cross-disciplinary research project called *Switching the Current*, which concerns the problem of increasing awareness and understanding of the complex challenge of creating sustainable energy systems to mitigate the consequences of climate change.

2 PURPOSE

Switching the current (STC) is a cross-disciplinary research project financed by the Swedish Energy Agency with the objective to increase knowledge on how the structure and ambition of the energy system affects the surrounding society, environment, and climate. The main goal is to improve dialogue and interaction between actors responsible for the energy system and other parties who are dependent on, or interested in, the energy system. This will be achieved by arranging a series of Megagames where participants actively contribute to co-creating the future of the energy system and thus increase their understanding of both the complexity of the energy system, and the motives and rational of other stake holders in the energy system.

This paper presents a motivation for the use of Megagames as *a way to exercise handling the climate crisis by creating sustainable energy systems.* The paper provides two examples from initial runs of the Megagame *Switching the current.* STC was designed to improve the understanding of complex challenges such as the relationships between climate change, the energy system, society, and the local environment. The outcome of the test runs are to be the basis for six further Megagame iterations in the STC project.

3 SERIOUS GAMES

The term Serious games was coined in 1970 by Abt: "We are concerned with 'Serious Games' in the sense that these games have an explicit and carefully thought-out educational purpose and are not intended to be played primarily for amusement" [1, p. 9]. Fletcher and colleagues state that "Serious games is placed at the intersection of computer science, art, design, engineering, entertainment, human computer interaction, psychology, education, and various application domains" [8]. Games have long since been used for purposes other than entertainment. Applying serious games to better understand conflicts or tensions between stakeholders is common [6]. In military contexts they have been discussed as modelling and simulation, used both for individual training (cf. riding training for cavalry or strategic understanding of a certain battle context using tin figures on scaled map models), and later on both for analytical tasks and training [12]. The term "game" implies that there should be some entertaining aspect, which may also serve as a motivation for playing the game. It also put demands on the design of the game that may not exist in modelling or simulation. The primary objective of modelling and simulation is to represent some carefully chosen aspects of a phenomena – the focus is representativeness rather than being entertaining. Turning a simulation into a game demand that values like being fun, immersive, exciting, etc. can be incorporated into a game experience. The term "serious" implies, like suggested above, that the player of the game experience something that result in new insights or new skills. Serious games normally also include the option of allowing a researcher, educator, or exercise leader to monitor and evaluate the behaviour of the player(s) [14]. This creates further design choices as decisions must be made concerning what data from the game that must be saved and what kind of analysis that may need to be performed on that data.

Kriz describes serious games as involving several players working jointly to solve a problem. Such games can be seen as a co-constructive activity, where the participants interact to build an understanding of how phenomena or systems work and are constituted [10]. Kriz also proposes that a co-constructive approach based on "systemic constructivism" can be applied to serious games. This approach combines constructivist approaches to learning with systems thinking and utilizes constructivist approaches to mentoring and de-briefing to support systems thinking by highlighting "perspective variety" and "levels of observation". In line with this perspective Aronson et al. describe how simulation training can be designed from an activity theoretical perspective [4] Sociocultural perspectives on game play have shown how expansive play expands understanding of play beyond pre-conceived expectations of play [3].

3.1 Megagames

Megagames is a specific instantiation of gaming that can, but does not have to, be a case of serious gaming. As pointed out, the purpose and the design of the megagame decides if it is to be viewed as a serious game or not. Megagames exists in the borderland between role-playing, boardgames, and strategy games and involve large numbers of participants, typically between 20-100. Megagames are run by a group of organizers usually called 'control' that manage scenario progression and rules. Participants are typically organized in sub-teams that are responsible for a certain function in the game and have team-specific goals. Megagames distinguish themselves by having people engage through scenarios and role descriptions that are detailed, realistic but at the same time hypothetical. These aspects of megagames present both an opportunity for having people engage with new roles that they are not accustomed to and might provide new perspectives on the complexities of social issues. However, they also demand detailed knowledge of the roles to be modelled, and normally incur larger costs in design and logistics for events [2].

3.2 Switching the Current - The Megagame

In the STC megagame, the participants are given roles as stakeholder representatives for different groups and functions in society. In the pilot tests, three population groups (High income, Medium income, and Low income), a power distribution company (Conglomo), a power/distance heating producer (Elementa), municipality council, a fuel supplier (Boxhome), and a regional factory (Regional industries) were included. Physically, the game is arranged around a number of tables on which the board gaming components representing fundamental aspects of each stakeholder are placed. For example, "population" boards have a scale for general happiness, financial situation, amount of carbon dioxide equivalents, as well as

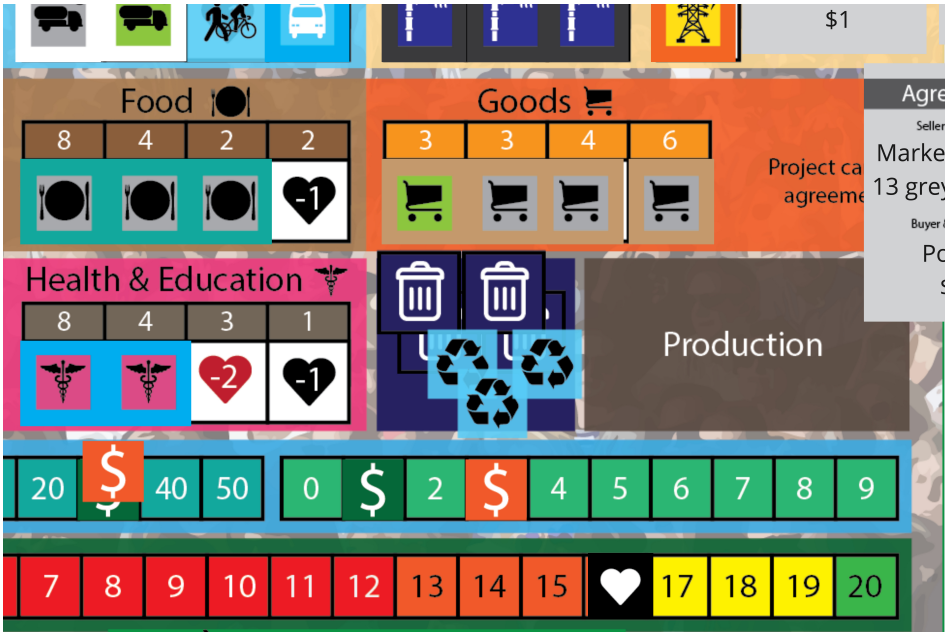

Figure 1: Population board for high income players in iteration 1

status boards for population health care resources, travel-related energy consumption, energy consumption related to housing, amount and kinds of food, etc (see Figure 1).

The game is based on a steady-state system meaning that all business transactions are controlled by contracts that affect status bars in economy. Money (credits) are not exchanged between players apart from in special cases. Instead, deals are regulated by writing new contracts. Unless a contract is altered or discontinued, there is no need to update the game board(s).

While it would take up too much space in the paper to explain all game components, some deserve to be mentioned. First, all participants in the game have a role, explained on a one-page role card. The role card explains who the player is supposed to be in the game (for example the managing director of a power distribution company) and the rationale and motives (goals in the game) of that role. Second, there are project cards, a type of game card that presents an idea that the players may try to implement in the game. For example, urban food production initiatives can be introduced to reduce the need of importing food.

4 PILOT TESTS, DATA COLLECTION APPROACH AND FINDINGS

This paper will present two test iterations, conducted during the development of the Switching the Current Megagame. The two iterations were conducted during a period of six weeks, when the Megagame was also refined for the second iteration based on feedback from the first. The pilot runs were both a test of the data collection design, as well as improvement and refinement of the Megagame. All participants gave informed consent.

Iteration 1 involved questionnaire (pre and post), recording of video and sound (using cameras on both tables and worn by selected participants), and a debriefing session.

Iteration 2 involved questionnaire (pre and post, however altered as a result of the feedback of iteration 1), recording of video and sound (with an increased number of cameras used, one for each table), and a debriefing session. This paper reports on the outcome of the questionnaires.

5 PARTICIPANTS

The two iterations involved different participants. The first test involved mainly personnel and students from Linköpings University. Individuals doing research on energy systems were targeted to stress test the game design. The second test involved mainly personnel working with energy systems or sustainability issues at the Linköping municipality office. The latter group was more diverse than the former. Table 1 presents background information about the participants.

6 MATERIAL

Two questionnaires were used: before and after the game events. The pre-event questionnaire consisted of questions about age, gender, educational background, experience of gaming and online gaming, work experience, and general interest in questions related to the energy system. The post-questionnaire looked into the general experience of participating, what they believed to have learned from participating in the game, how interaction with other players worked during the game, goal fulfilment, and if they would recommend other people to participate in the megagame.

Minor alterations to the questionnaires were made between the two iterations.

	Iteration 1 (i1)	Iteration 2 (i2)
Number of participants	14	17
Background of participants	Students	Municipality civil servants
Number of actor groups (tables)	4	5
Length of megagame, all rounds (hours)	2	2,5
Age	M=36.3; SD=8.4	M=36.3; SD=9.2
Physical gaming hours last week, physical games	M=0.92; SD=1.50	M=2.23; SD=2.29
Sex	F(7), M(4), Other (1)	F(13), M(4)
Number of completed runs	3	3
Digital gaming hours last week	M=1.83; SD=5.51	M=1,59; SD=3,63

Table 1: Participants in the two iterations

Figure 2: Participants negotiating around a table during the game

7 SETTING

Both iterations of the games were conducted in large rooms with enough space for about five tables, equipped with projectors for showing PowerPoint presentations etc. The different game boards were placed on the tables in such a manner that the players associated with the table could sit around them while still leaving enough space to allow other players to approach the table. Figure 2 shows a part of the room in which the first game was conducted. The participants are negotiating a contract. The large screen in the background presents information to the participants, in this case a news flash. On the table, the game boards for the players can be seen.

8 PROCEDURE

As the gaming events started, the participants filled out a consent form as well as the pre-questionnaire. Then, a general introduction to the megagame event and the research project STC was given. After that, the participants were introduced to their respective roles in the game. A briefing about basic game rules were given, although it was emphasized that the participants should not worry too much about the roles as members of the research team, controllers, would be available to answer questions and provide guidance during the game session. After that, the first round of the game was conducted. Each game round consists of three parts: team phase, action phase, and resolve.

During the team phase, the players gather around the table they are working on and discuss what to do during the round. This typically lasts for 10 minutes. After that, the action phase commences, under which the participants engage in interaction with other players. Such interaction often involve trying to rally support for own ambitions, strike business deals or re-negotiate business deals. In the resolve-phase, the controllers walk around and asses how the different actions taken by the players will affect the different game-boards and adjust the status of the steady state system accordingly. Usually, before the next round starts, the controllers will introduce some scenario injects, usually as one or more news flashes presented to the participants.

The first round would typically last for about one hour. Once the participants get into character and understand the basics of the game, the rounds can be executed more swiftly. During the two iterations reported in this paper, the later round took around 45 minutes. As can be seen in Table 1, three rounds were played in each game iteration.

Once the game is concluded, the participants fill in the post-game questionnaire. Then, a debriefing session begins, where the participants are divided into smaller groups. Lastly, all participants are gathered and engage in a discussion before the session is over.

8.1 Gaming experience

A majority of the participants stated that they play board games regularly (90%). In the i1-group, many participants (8/10) regularly played strategy games, where only 7/18 in the group from the i2-group did so. Time spent on gaming (estimate per week) differed between the groups: the i1-group averaged at about 1 hour and the i2-group averaged at almost 3 hours. When it came to digital games, the groups changed positions as the i1-group spent around 2 hours a week playing digital games, while the i2-group only spent about 1 hour a week playing such games.

8.2 Professional background

In terms of interests and professional background, the groups differed in their distribution of occupations. In the i1-group, the majority of participants (7 out of 11) reported working with energy or environmental issues, while only one participant worked with political decision-making. Six out of eleven participants worked with research, and all participants had a university degree, with the majority (8 out of 11) having a doctorate or pursuing doctoral studies. In contrast, in the i2-group, a larger proportion of participants (6 out of 17) reported working with energy issues, and an equal number (7 out of 17) reported working with environmental issues. 4 out of 17 participants reported working with political decision-making, and 12 out of 17 participants had a university degree, with only three having a doctorate or pursuing doctoral studies.

9 RESULTS

We collected results both about the players' perceived game experience in free-text form as well as in a structured rating form.

9.1 Game experience

When asked about their experience in participating in the STC megagame, the majority of players responded positively regardless of group. Examples of free-text answers given about the general experience of participating in the game includes:

- i1 I had a hard time keeping up at first. I didn't really know how to get started. When you begin to understand a bit, it was great fun.
- i1 It was fun and engaging but sometimes difficult to know what to do.
- i2 Fun but short on time for negotiations. Tightly defined role.
- i2 A bit difficult to prioritize efforts and to understand how to count. A lot to keep track of. However, good insights and a sense of the need for collaboration to reach climate goals.

When asked about what they learned from the game, responses varied. Many participants reported that they felt that their understanding of the complexity of the energy system and the need for negotiation had improved. Three participants in the i2-group stated that they really did not learn that much about the energy system. Examples of free-text answer to the question "What did you learn about the energy system?" are:

- i1 That industry, state, electricity market co-vary in complex ways and ultimately affect the individual in a way that is not always obvious.
- i2 The complexity. That many actors are dependent on each other.
- i2 Nothing new
- i2 Didn't feel like the game was so much about the energy system. Not with the role I had anyway
- i2 It is complex and it costs time, money, commitment to change the energy system.

Many participants highlighted the importance of collaboration and the realization that it takes a long time and significant resources to change the energy system. Regarding specific aspects of the game, participants had different preferences. Many participants appreciated the interaction with other players, especially negotiation. Participants also appreciated the freedom of action and the board game format. Examples of free-text answers on the questions "What parts of the game did you enjoy the most and why?" are:

- i1 Supply/demand becomes clear in a good way. The connection to the regional development was fun.
- i1 The interaction between different actors.
- i2 The interaction and visualization in the form of a board game and the close connection to reality

Participants also provided answers to the question"What worked well in the game?:

- i1 The "quality of life"-scale and its impact on how easy it is to create change.
- i2 That there was an opportunity to be creative - we could solve our problems according to new exciting ideas.
- i2 Complex systems become simple to understand with a visual game board.

The question "What did not work well in the game?" include answers like:

- i2 Simplification of reality. For example, do food and transport have the "same" environmental effects per route?
- i2 What could be bought/sold on the market and at what price was unclear. What exactly was my contribution to the CO2 budget (indirect contribution)?
- i2 Took an hour to grasp (round 1) how the game played out.

Aside from what can be seen in the excerpts above, when asked about what didn't work well in the game, many participants cited a lack of time, difficulties understanding the rules, and difficulty keeping up with what was happening during the game due to the large number of participants and parallel discussions:

- i2 It became overwhelming at times with all the parallel discussions/negotiations and many people pulling in one. It was difficult to get time to think and make a decision and understand the consequences of it.

Question	i1	i2
1. How realistically did the game portray energy issues?	4,7	5
2. How was your game experience?	5,5	5,7
3. How did the interaction with other players work?	4,6	5,9
4. To could you achieve the goals assigned to you in the game?	4,3	4,6
5. Was it clear what you could do in the game?	5,7	4,5
6. Did you have enough time to achieve your goals?	4,1	3
7. Has your understanding of the energy system improved?	4	3,6
8. Have your expectations of the day been fulfilled?	4	5,3
9. When did you feel that you had understood the game well enough to affect your situation in the game?	-	Second round
10. Would you recommend a friend or a colleague to participate in a megagame?	10 yes, 0 no	13 yes, 3 no

Table 2: Rating scale answers per group (1-7) in the STC megagame. Means are presented for questions 1-8. Data is not available for the i1 group regarding question 9.

i2 That time went by so fast. It seems I hadn't figured out the rules of the game before time ran out.

In general, the free-text answers suggest that the participants were positive to the Megagame format, and that they believed to have learned things about the complexity and challenges related to creating change in systems that are heavily interwoven in society, like the energy system. The large amount of participants and the limited time available caused some confusion and frustration as the participants felt that they did not have enough time and could not get a good overview of what was going on.

9.2 Rating scale questions

As a complement to the free-text answers, questions with a 1-7 Likert scale were used. Table 2 describes the outcome of each rating question for groups i1 and i2.

The Likert scale answers from the two groups are similar in many respects. However, they differ slightly for questions 3, 5, 6, and 8. The participants in the i2 group state that the interaction with other players worked better than the participants in the i1 group. Conversely, the i1 group felt the game was easier to understand than the i2-group. Participants in i1 also stated that they had more time to achieve their goals than i2. However, the i2 group stated that they expectations on the day had been fulfilled to a higher degree than the i1 group. Both groups found the game to portray the energy issues in a good way and had a positive experience of the game (the first two questions). Both groups gave average answers to the question "Has your understanding of the energy system improved?". The question on when they understood the game well enough to affect their situation was never given to the i1 group. The i2 group answered that question on average of round 2 (about 1-2 hours into the game). Both groups generally stated that they would recommend a friend or a colleague to participate in the game (the last question).

10 DISCUSSION

The results and experiences from running the events provided us with valuable material for the development of the game. The feedback on complexity and time issues can be both understood as actionable issues for us to address (in creating better guidance for players, visible rules explanations, well-structured initial rounds), but also inherent features and specific learning outcomes of the game, in that it compresses time and space for the purpose of learning about changes that have effects over several decades, and provide feedback to participants on their actions continuously during a day of intense negotiations that simulate decades of transformative action and climate events. Some participants expressed frustration about limited time and an inability to grasp what was going on in the megagame due to the large amount of participants. The limited time issue will be addressed in future games. The experienced inability to keep track of what was going on is not necessarily a liability, but rather a pedagogical point that needs to be conveyed to the participants in the post-game debriefings. After all, real decisions makers working on a societal level also have difficulties in keeping track of all parallel activities and discussions that take place. Understanding this is also an important aspect of the challenge of creating a sustainable future energy system.

Although participants stated that they only learned moderately much about the energy system per se in the rating scale answers, (3,6-4 on a scale 1-7) they still stated that they had a great game experience and would for the most part recommend others to attend similar events. Also, in the free-text answers, almost all participants point to things that they learned about the energy system and issues connected to energy consumption, somewhat contradicting the likert-scale rating. This we feel reflects a somewhat limited definition of what we mean by energy systems, and the backgrounds of participants in these initial test runs. On the one hand, they were already deeply involved in energy systems one way or the other, but they also expressed an appreciation of the new perspectives on, say, low-income households, and the different levels of agency actors in the game had. Low-income households were greatly affected by fuel price hikes, but had limited ability to change the energy regimes they operated under. One could argue that they form central agents in that they are affected by decisions around the energy system, or secondary, peripheral, in that they do not influence major infrastructure decisions.

However, making the underlying assumptions of what an energy system really is visible and a focus for conversation is something we will have to provide explicit support for. The fact that there are contested regimes for justifying the design of a particular energy system, with conflicting knowledge claims and value systems [5], needs to be made more visible to players if we are to gain broader acceptance of the notion that a game about energy systems can also include healthcare managers, or rural populations primarily affected by, but not contributing to, particular energy regimes and decisions around changes to them. Also, the data collection around their impressions from playing could be made richer by having longer conversations in focus groups, and evaluations several weeks after playing an event to collect thoughts about the implications of participating in the event for the purpose of supporting their real-life work. Revisiting Kriz's (2010) proposal and to a larger extent use a co-constructive approach to emphasize learning and systems thinking during de-briefing could improve learning among participants.

11 CONCLUSIONS

In conclusion, the STC megagame has been a valuable tool for development due to the feedback and experiences gained during the test iterations. While the participants experienced difficulties in understanding how the game worked, these can be addressed through improved guidance, visible rules explanations, and well-structured initial rounds. The compression of time and space in the game provided participants with a unique experience simulating decades of transformative action and climate events, with continuous feedback on their actions during intense negotiations. Although participants state that they only moderately learned about the energy system itself, they also stat that they had positive game experience and would recommend others to attend similar events. Making underlying assumptions of energy systems visible and addressing contested regimes for justifying the design of particular energy systems with conflicting knowledge claims and value systems is a challenge that must be addressed in future implementations of the STC megagame. Future iterations of the megagame will address these issues and have been designed to last about five rounds, addressing the concern about a lack of time to achieve different goals. Including five rounds will demand shorter rounds to fit the game within the frame of a one-day event.

Overall, the STC megagame has proven to be a valuable tool for understanding complex systems and decision-making, providing participants with a unique experience and valuable feedback. Future iterations will build upon the insights gained from the test runs and continue to provide a valuable tool for understanding and exploring complex systems, both for game participants and researchers.

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