

Simulation & Gaming

<http://sag.sagepub.com/>

Climate Change Gaming on Board and Screen: A Review

Diana Reckien and Klaus Eisenack

Simulation Gaming published online 13 March 2013

DOI: 10.1177/1046878113480867

The online version of this article can be found at:

<http://sag.sagepub.com/content/early/2013/03/13/1046878113480867>

Published by:



<http://www.sagepublications.com>

On behalf of:

Association for Business Simulation & Experiential Learning

International Simulation & Gaming Association

Japan Association of Simulation & Gaming

North American Simulation and Gaming Association



Playful Methods. Serious Results

North American Simulation & Gaming Association

Society for Intercultural Education, Training, & Research

Additional services and information for *Simulation & Gaming* can be found at:

Email Alerts: <http://sag.sagepub.com/cgi/alerts>

Subscriptions: <http://sag.sagepub.com/subscriptions>

Reprints: <http://www.sagepub.com/journalsReprints.nav>

Permissions: <http://www.sagepub.com/journalsPermissions.nav>

>> [OnlineFirst Version of Record](#) - Mar 13, 2013

[What is This?](#)

Climate Change Gaming on Board and Screen: A Review

Simulation & Gaming
XX(X) 1–19
© 2013 SAGE Publications
Reprints and permissions:
sagepub.com/journalsPermissions.nav
DOI: 10.1177/1046878113480867
sag.sagepub.com


Diana Reckien¹ and Klaus Eisenack²

Abstract

Climate change (CC) is an increasing societal concern for many countries around the world, and yet international negotiations continue to make slow progress. CC is an issue that is proving difficult to address using traditional approaches to information provision and education. This article reviews the development of climate and CC games and simulations in recent years as an alternative and novel way of addressing CC issues and communicating with decision makers. It gives an overview of published CC games and analyses a selection of 52 sophisticated CC games in detail. The results allow comparisons of the temporal development of climate games, actors involved in CC game development, game formats, and game subjects. Many climate games appeared around the time of the UN climate negotiations in Copenhagen in 2009, with an increasing number of commercial game developers entering the field. Role-play and management games dominate the scene, but we see a rapid increase in the number of online games or games with an online component. Both local and global mitigation issues are frequently addressed and as yet few games focus on adaptation to CC.

Keywords

adaptation, analysis, CC, challenges, climate change, climate change games, climate change simulation, computerized simulation/games, decision making, developer, development, gaming, global, knowledge base, language, local, manual simulation/games, mitigation, negotiation, review, role-play, simulation, simulation/game format, societal concern, sophistication

¹Columbia University, New York, NY, USA

²Carl von Ossietzky University Oldenburg, Germany

Corresponding author:

Diana Reckien, Center for Research on Environmental Decisions, Columbia University, 406 Schermerhorn Hall–MC5501, 1190 Amsterdam Ave., New York, NY 10027, USA.
Email: dianareckien@columbia.edu

The world urgently needs to address the causes of climate change (CC) and prepare for climatic and environmental consequences (Intergovernmental Panel on Climate Change [IPCC], 2007; see also the guest editorial in this issue). As international negotiations appear to make slow progress and regional initiatives have limited geographical reach, we see an urgent need for parallel initiatives to promote behavioral change by individuals and to educate the public. Novel methods and innovative approaches, such as simulation and gaming (s/g), are being explored as political solutions seem ever more remote. The public has to be made acquainted with the underlying processes of CC, with its causes and consequences (i.e., social, natural, economic, and geopolitical impacts), as well as with possible responses and management options. The translation of scientific results into a common language that can be understood by the lay public is of utmost importance.

In this context, it is easy to understand the increasing interest in the use of s/g for the exploration of climate and CC issues. S/g is an innovative and unconventional method that fosters learning, particularly in complex, highly interactive, or multi-stakeholder environments. S/g facilitates understanding across disciplines, which is applicable to various research fields and problems (Crookall, 2010). In view of these advantages, it is not surprising that s/g is being used to help addressing a wide range of complex human-nature interactions, including CC. This is not a new phenomenon. More than a decade ago, Ulrich (1997) compiled a collection of simulation games that addressed environmental and sustainability issues. In 2007, Barreteau, Le Page, and Perez (2007) coedited a special issue of this journal, *Simulation & Gaming*, on “*Simulation and gaming in natural resource management*.” More recently, Al Gore’s Climate Reality Project has encouraged the design and development of creative games that convey messages on how to deal with CC (PSFK, 2011). Lack of understanding and communication across disciplines are increasingly recognized as an impediment to the study of human-nature interactions and the sustainable management of natural resources. Many environmental and resource problems involve aspects of collective choice, where there is a basic tension between cooperation and defection (e.g., Ostrom, 1990). Thus, we see increasing interest in the potential of s/g as an aid to decision making in these contexts.

In the editorial of the 40th Anniversary Symposium of *Simulation & Gaming*, the field of s/g is described as comprising of

an array of methods, knowledge, practices, and theories, such as simulation, gaming, serious game, computer simulation, computerized simulation, modeling, agent-based modeling, virtual reality, virtual world, experiential learning, game theory, role-play, case study and debriefing. (Crookall, 2010, p. 899)

The same diversity of approaches characterizes research on CC and its various relations to the environment and society. Therefore, when looking at CC and s/g today, we can expect to find a broad spectrum of applications, with games differing in thematic

outlook, thematic depth, methodological format, target groups, type, and motivation of game development.

This review addresses climate games and CC games in particular. To our knowledge, it is the first comprehensive, structured collection and analysis of climate/CC gaming. The terms *climate games* and *CC games* are used interchangeably, because in fact climate games are often developed to illuminate aspects of CC. The article has three objectives:

1. To enlarge the knowledge base regarding climate games in general,
2. To structure the wide range of climate/CC gaming applications available and introduce representative examples,
3. To analyze a selection of more sophisticated games in detail.

The review is divided into four parts. Following this introduction, the section titled “Definitions and Method” defines key terms and outlines the methodology underpinning this review. The “Results” section presents an overview of climate games in general and provides a detailed analysis of a selection of 52 more sophisticated climate games. It looks at a number of aspects, including the development of CC gaming over time, actors involved in game development, target groups, formats, and thematic foci. The concluding section discusses the results and the potential of climate games for communication and learning. The appendix contains references to all games selected for detailed review.

Definitions and Method

Climate games, CC games, or global warming games belong to the genre of “serious games.” The notion of serious games can be traced back to Abt (1970). He used the term for games which are entertaining and used in both education and learning. Another source describes serious games as a method to simulate and explore real-life issues and to educate players in an interactive environment (Houston Advanced Research Center, n.d.). Those descriptions of serious games are not uncontested and there has been much argument about how the terminology should be applied in s/g science (see, for example, Crookall, 2010). While there is general agreement that serious games provide education to deal with real-life issues, some apply the term in a more limited way to “computerized s/g for training and learning” (Crookall, 2010, p. 905). In practice, the term *serious game* is mostly used for digital games whose purpose exceeds pure entertainment. In this context, it is also relevant to note that games are distinguished from simulations by the existence of goals. Goals are central to games and not existent as such in simulations (Egenfeldt-Nielsen, 2003, p. 2). This review looks at games on climate and CC in both computerized and traditional formats.

To achieve the aims of this article, we conducted a two-step analysis. The first step was a general web-based review, the second a detailed analysis of a selection of the

climate games found in the first step. The selection describes the situation as of August 2011. Both analytical steps are described in more detail hereafter.

Step I consisted of an Internet search for games with both the English keywords “climate” and “game” and the German keywords “*Klima*” and “*Spiel*.” We performed an ad hoc analysis of the formats of the games found, their degree of sophistication, the organizations that developed them, and their target audiences. The results allowed for a refinement of our concept of climate games and the selection of games for more detailed analysis.

In **Step II**, we selected those games that matched a more narrow definition of climate games, that is, games in which CC is at the center of the storyline, and excluded those where CC was a minor additional aspect. At this stage, we also excluded applications that were called “game” by their publisher(s) or reviewer(s), but that did not match our definition of game given above. Specifically, we excluded applications that did not set goals for the players, for example, CO₂ calculators. Games also differed in the degree of involvement of the player(s); those with a very limited level of interaction were excluded. Examples of this were applications that merely allow the visualization and demonstration of scientific simulations or calculations (e.g., CLIMATE MOMENTUM SIMULATION, n.d., where the only possible activity of the player consists of moving a slider). Applications that were very simple in content, such as quizzes or games with a limited storyline, were likewise ruled out. In addition, online/computer games with a poor-quality technical realization were excluded, although it is worth noting that a substantial number of such applications are available. In contrast, so-called simulations with a pronounced interactive and therefore game-like character were accepted.

The analysis categorized the games with respect to a number of characteristics:

- Year of appearance or first publication: For most games, it was possible to determine the year of first publication, though not for all. For a small number of the selected games, either the earliest date on the Internet, the earliest implementation with pupils at a certain school, the latest update of a website, the date of a later edition whose release year was available, or the year of publication of an article describing the game was selected.
- Formats of games: For example, simulation, role-play/management game, online game, video game, board game, card game, or other.
- Actors who developed the game: That is, private companies, government agencies, nongovernmental organizations, or academic institutions.
- Languages/geographical outreach.
- Type and scale of issues: Games were classified according to the particular aspect of CC they addressed, and by scale, that is, local, global, EU, other or multiple scales.

Finally, we introduce a broad set of representative or interesting games, which are described in detail at the end of the “Results” section.

Results

Step I: Simulations and Games Dealing With CC in General

Not many years ago, there were only a few games dealing with CC issues (Ulrich, 1997). In recent years, however, a large number of games with a focus on climate or CC issues have been developed and become available. Our research yielded about eight dozen games and provided a good overview of available CC applications. A number of websites, such as Ecokids (2012) to name but one, offer a variety of small CC gaming and simulation applications. For the vast majority of games, CC is at the center of attention and the key issue to be communicated. Some games are available, though, which integrate climate issues into a broader set of foci. However, the sheer number of entertaining education applications available, such as on the Ecokids and other websites, is a strong indication that CC has become a major topic of interest for the gaming community.

Among this great diversity in climate games, the diversity in formats and thematic scope is correspondingly broad. A substantial number of games are quite simple. They are based on a few rules and focus on the one-dimensional mediation of information and the reproduction of knowledge, such as quizzes that end with disclosure of the correct solution. More sophisticated games comprise an active component, where players have to respond to different aspects of the experience of CC and take forward-looking action. These games are not plenty. Related to their sophistication, games can be differentiated according to the need for prior knowledge, and intellectual and educational levels required for playing. Climate games are available for players at all levels, and with more or less prior knowledge of CC.

With respect to formats, digital games clearly dominate the field. Both serious games with sophisticated plots and simple applications are numerous. Computer-based serious games have been developed by government agencies and scientific institutions as well as by commercial game developers. In particular, private companies and public bodies now employ climate games for awareness raising and as part of their political agenda. Climate games are often used as a public relations (PR) instrument, for example, by Microsoft, OXFAM, RWE (a large German utility), and Starbucks, among others.

The principal target group for CC games is children and school students between the ages of approximately 12 and 18. In second place, a number of games target players in higher education and management training. As for their purpose, these games—while varying in format—usually incorporate some form of role-play as a means of knowledge transfer and to provide training in decision making. Finally, the general public is also an important target group.

Step II: Selection of More Sophisticated and Targeted CC Games

We now turn to the 52 climate and CC games selected for more detailed analysis, as described above. The complete list of games with weblinks and references (where available) is provided as appendix (see Figure 1 for an overview).

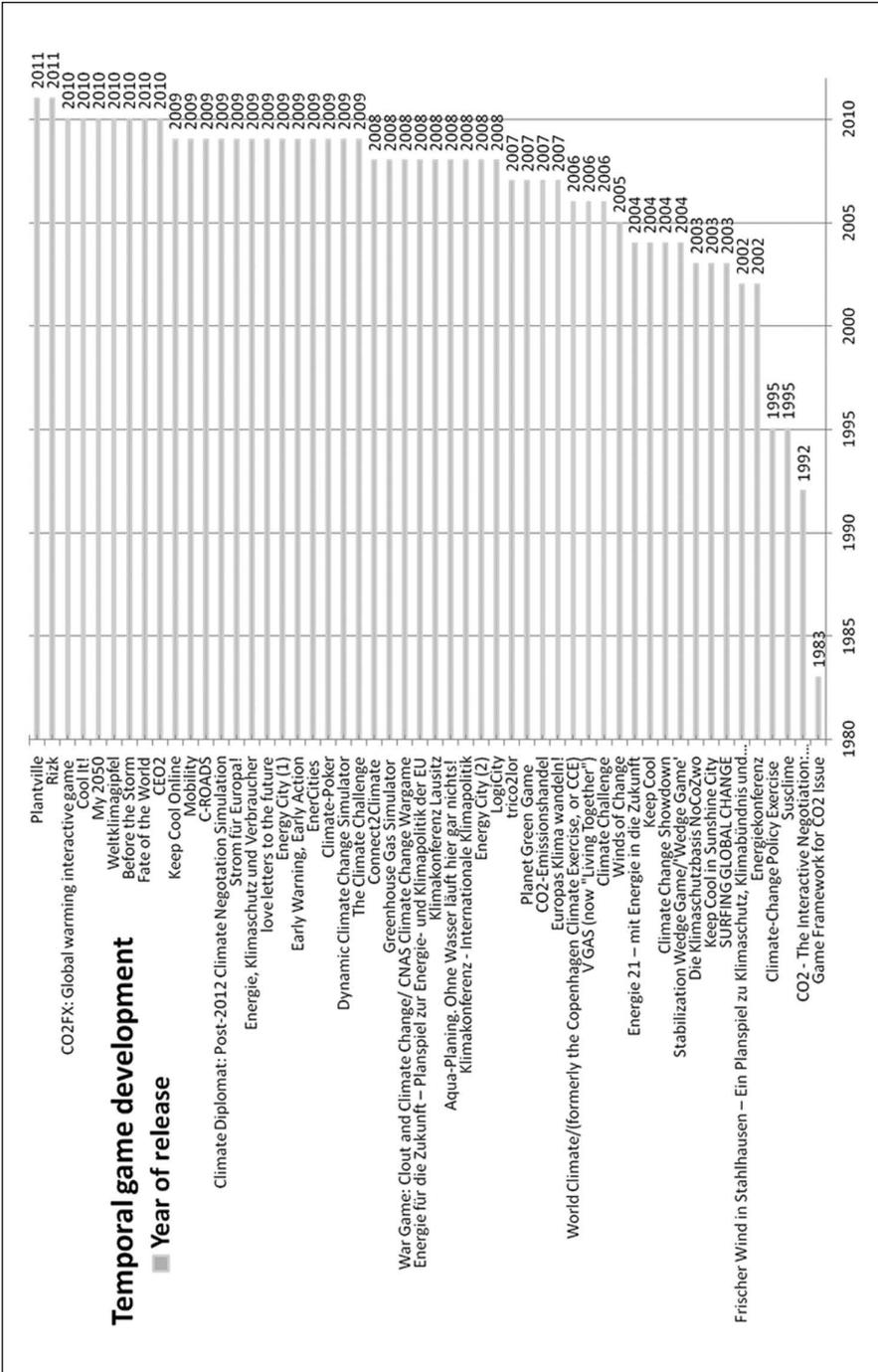


Figure 1. Release years of more complex climate change games and simulations (to August 2011).

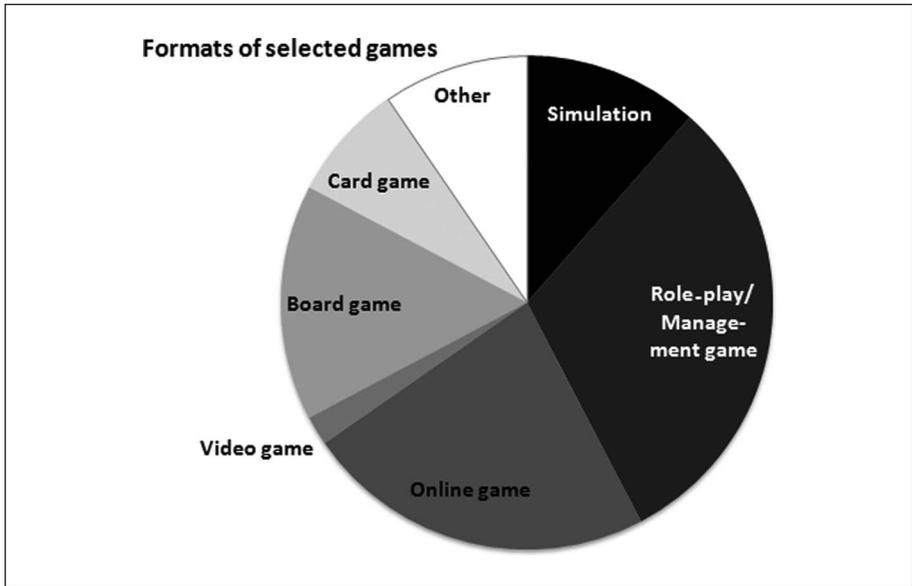


Figure 2. Format of sophisticated climate games and simulations.

Development of Selected Climate Games Over Time. Figure 1 reveals that the field of CC games has mainly evolved over the last 25 years, with the most dynamic evolution occurring in the last 10 years. The year 1983 is the release year of the oldest publication on CC gaming that we found (although this is basically a framework for CC games, which we included for historical reasons). Particularly since 2002, the number of games available has grown tremendously; only 5 sophisticated games on climate/CC issues existed before that date. The majority, that is, 48 games, were released after 2002, with a growing number of new games becoming available each year. To date, 2009 was the year with the highest number of releases (14 new games).

Format of Selected Climate Games. The selected climate games include online and video games, card and board games, and simulations and role-plays. While many games use a combination of formats, the games selected were grouped according to their most dominant format. The category “other” mainly refers to games for mobile phones (see Figure 2).

Role-plays and management games dominate the scene. Online games or games that have predominantly an online component are the second largest category. Games frequently, and increasingly, mix formats. Almost all the recent games use more than one format.

The Actors: People Who Request, Develop, and Release Climate Games. This review distinguishes between various actors involved in game development: academic (universities

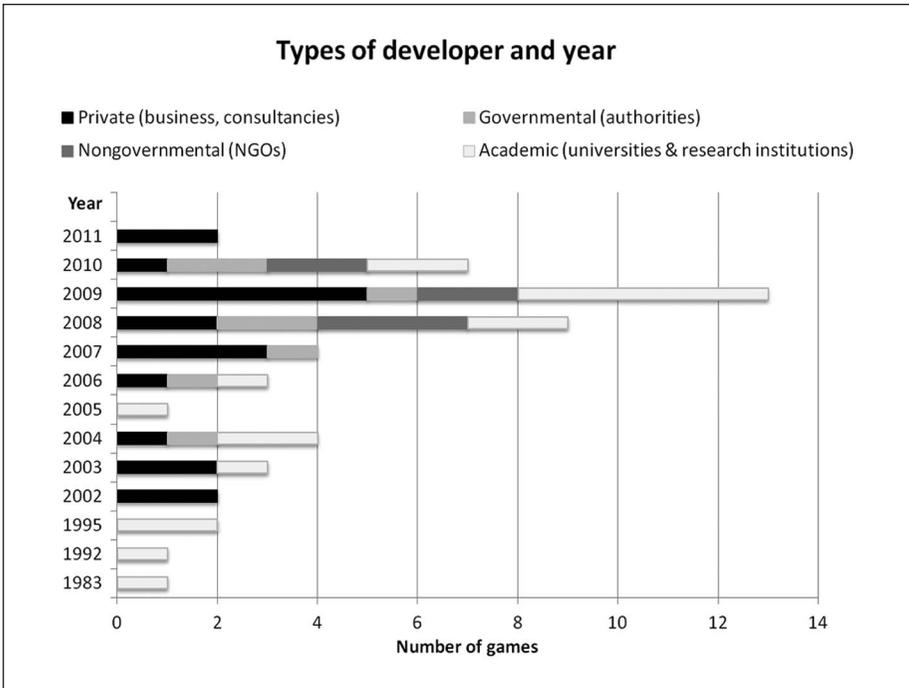


Figure 3. Participation by four categories of actors in game development over time.

and research institutions), public/governmental (authorities), nongovernmental, and private (business, consultancies). However, a clear-cut categorization is often difficult, as actors of different types cooperate. Conclusions have to be drawn with caution.

Figure 3 shows that the early game developments were driven by academics. Later, private companies (e.g., RWE, Starbucks, Siemens), nongovernmental organizations, and government agencies (e.g., environmental protection agencies in the United Kingdom, the United States, and Germany, among others) became involved, either by commissioning climate games or developing games themselves. The share of academic initiatives decreased over time, while private and public bodies increasingly moved in.

Language and Geographical Outreach. Most games appear to be written in English or have at least an English version. This reflects the status of English as a universal language, which corresponds to the global relevance of CC. However, English is also appropriate for CC games because it is the main language used for international climate negotiations and political debate (and these are the focus of numerous management games). In addition, the use of the world wide web as a resource platform as well as the English language format of online games symbolize modern lifestyle, of which these games are a part. English games are numerous, but there are also many climate games available only or additionally in German. A limited number of the selected games are additionally available in other languages (see Figure 4).

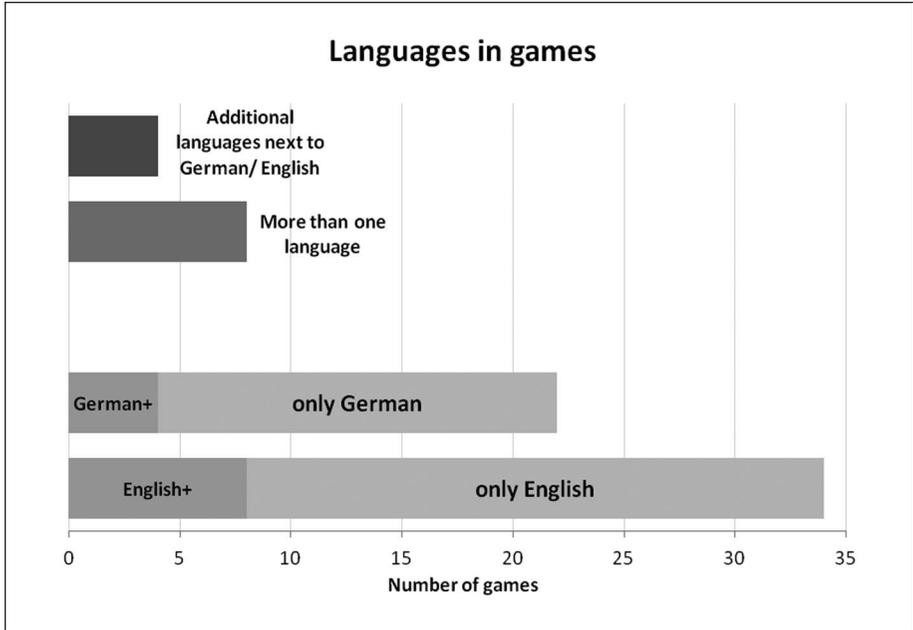


Figure 4. Languages in which games are available.

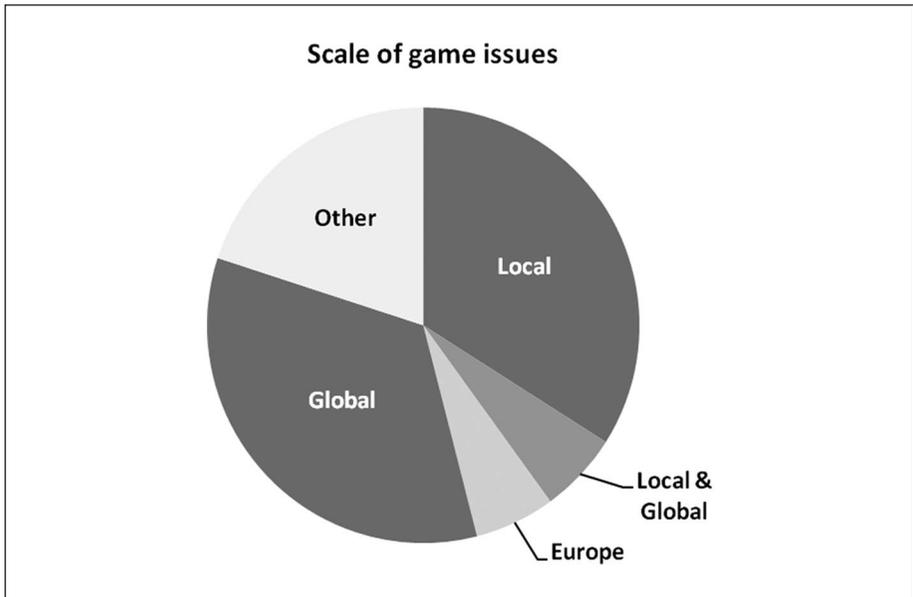


Figure 5. Scale of issues considered in the selected games.

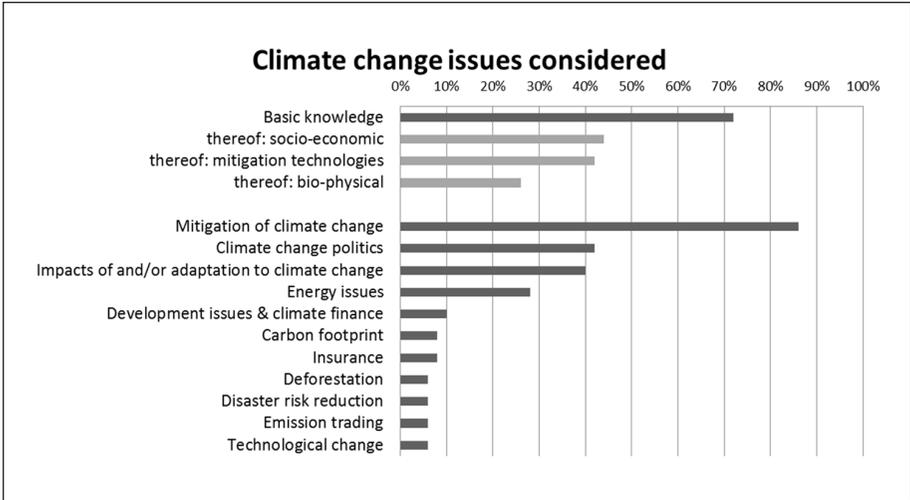


Figure 6. Issues addressed in the selected games. Multiple categories may apply to a single game. The category ‘basic knowledge’ applies if at least one of the three named categories of basic knowledge is addressed. See the editorial for a description of some of the terminology used in the figure.

As Figure 4 shows, 34 games (57%) are at least available in English, 22 games (37%) are additionally or only available in German, while four games (about 7%) are provided in other languages than English or German. “Other languages” comprise several other European languages and Chinese. Eight out of the 52 games are available in more than one language. We are aware of and acknowledge the limitations of our analysis with regard to geographical outreach, as the investigation was conducted in German and English only. Therefore, the game needed to be available in one of these two languages in order to be detected and included in the analysis.

Despite these limitations, the analysis lends support to the conclusion that it is worth analyzing other regional markets to assess the use and effectiveness of games in CC education and training. It is also interesting to see that several game developers have chosen a multilingual approach.

Issues Addressed. CC is a topic with multiple facets, and the selected games focus on a variety of sets of issues. These can be framed on different scales (see Figure 5). The local scale refers to decisions taken by private households in the context of a virtual city or region. A large fraction of games operate primarily on this scale. Many of them consider individual or community decisions to reduce greenhouse gases or policy making from a local perspective. Many of these games aim to draw a connection between CC and everyday individual experience and decision making.

A similar proportion of games consider mainly the global dimension. These games frequently simulate international climate negotiations and/or compute the consequences of global decisions. Not many games explicitly link global and local perspectives (with

CLIMATE CHALLENGE, 2006, being an interesting example of a game that does), and only a few focus primarily on an intermediate scale between global and local, or on decision making at the European level. The few games addressing the European level of government refer in particular to the preparation of the new EU energy strategy (adopted in 2010, for example, EUROPAS KLIMA WANDELN, 2007).

Finally, a substantial number of games do not fit into these categories at all. Some of these games take a more abstract perspective and focus on specific issues, or they present many issues in form of a more sophisticated quiz (e.g., COOL IT, 2010).

In sum, two subjects predominate among the selected games: (a) international negotiations and (b) local and private decision making to reduce carbon emissions. We also investigated content-related aspects, that is, themes and issues that are addressed by the games. Figure 6 reveals a broad diversity of approaches; however, some commonly occurring topics can be identified.

Most games aim to provide some basic knowledge on CC and related issues. This is sometimes achieved by accompanying game material, debriefing, or role description (e.g., CLIMATE DIPLOMAT, 2009). Some games integrate teaching basic knowledge of climate change related issues into the mechanics of the game (e.g., KEEP COOL, 2004; LIVING TOGETHER, 2006), but this seems to be difficult to do. An astonishingly large number of games cover the basic issues superficially or assume that participants already have the necessary basic knowledge. Most of the games that provide more extensive coverage of basic knowledge focus on the socioeconomic conditions required to deal with or responsible for causing CC, or on technological options for greenhouse gas mitigation (frequently in relation to renewable energy sources). Interestingly, fewer games emphasize or attempt to teach the biophysical basis of CC (climatology, greenhouse gases, greenhouse effect, etc.).

The primary topic in games is mitigation of greenhouse gases. Those games that do not focus on mitigation mainly consider impacts of CC and adaptation. Less than half of the games incorporate adaptation (20 games), and many of them are relatively new on the market (9 games, for example, EARLY WARNING, EARLY ACTION, 2009). Some of these focus on disaster risk reduction (e.g., BEFORE THE STORM, n.d.). Another topic addressed by almost half the games is the politics of decision making on CC, be it on the local or the international scale. Games seem particularly suitable for this subject. Energy- and resource-related issues are very widespread too: They play an important role in about one quarter of the selected games. A number of further issues are touched upon infrequently, but by more than two games. Some games consider relations between developed and developing countries, and/or options for financing mitigation and adaptation measures in developing countries (e.g., WORLD CLIMATE, 2006). Some of the games that consider local decision making on the adoption of mitigation technologies make explicit reference to carbon footprint, which is determined by decisions taken during the game (e.g., PLANET GREEN GAME, 2007). The role of insurance and the financial industry is considered by only a few games; some of these are sponsored by the reinsurance industry, which is active in the field of CC (e.g., WINDS OF CHANGE, 2005). Carbon emissions from deforestation

play an important role in the international negotiations, and this issue is addressed by one game (WORLD CLIMATE, 2006). Technological progress and learning rarely play an explicit role in games (but KEEP COOL is one example). Few games deal with emission trading (e.g., CO₂ EMISSIONSHANDEL, 2007), although it seems that this issue is very suitable for games.

Furthermore, CC-related issues that are the primary focus of just a few games of the selection include transport (MOBILITY, 2009), geo-engineering (GAME FRAMEWORK FOR CO₂ ISSUE, Robinson & Ausubel, 1983), security (CLOUT AND CC, 2008), water management (AQUA-PLANING, n.d.), intergenerational justice (TRICO2LOR, 2007), and business decision making (CEO2, 2010).

Examples of CC Games

In the following, we briefly describe a number of, to our mind, interesting climate and CC games. The selection criteria were that the game should display a degree of sophistication and be a representative example for the broad range of diversity among the games reviewed.

- A game framework for scenario generation for the CO₂ ISSUE: the first game on the issue of CC. This work appears to be the first in the field of climate and CC games. It is a publication available in paper form and lays out a framework of issues that might be considered in a CC game.
- CLIMATE DIPLOMAT: Example of a game focusing on negotiations. This is an eight-person multistakeholder negotiation simulation of the Bali Action Plan for a post-2012 climate regime under the United Nations Framework Convention on Climate Change (UNFCCC). The simulated negotiation addresses aspects of mitigation, adaptation, technology transfer, and climate finance.
- CLIMATE CHANGE SHOWDOWN (2006): Example of a local emission reductions game. This game encourages team work as students collaboratively move around a game board, learning about positive and negative environmental consequences that result from individual and societal actions and behavior. The game is a component of a workshop-based program consisting of three main elements:
 1. a video and talk that provides an understanding of the science of CC,
 2. an interactive board game that encourages students to connect choices made today with future outcomes, and
 3. a take-home contest that challenges students and their families to take measurable actions to reduce greenhouse gas emissions.

The results of the take-home contest are collected by the game developer in order to calculate program impacts.

- STROM FÜR EUROPA (2009): example of a climate game that considers the European Union level as intermediate between local and global decision

making. This educational resource is a simulated series of events that places young people in the role of European decision makers. As members of the European Parliament and ministers, they have to decide on CO₂ reduction targets, an increase in the share of renewables, and on how to improve European climate policy in general. By doing so, they get to know the modes of operation of the European institutions responsible for CC policy making.

- **KEEP COOL:** The first commercial CC board game integrating multiple global and local issues. In this negotiation game, each player takes the role of an actor in global climate politics and has to pursue the actor's main strategic business interests. Actors include, among others, the USA and their partners, Europe, the developing countries, emerging economies and the former Soviet Union, as well as lobbying groups, that is, the oil industry and environmental nongovernmental organizations. During the game, players have to choose between climate protection measures and actions to further their own strategic business interest. However, actions can be thrown off course by unpredictable catastrophes. Whoever achieves his or her strategic goals first wins, yet if players are not cooperative enough, all players can lose.
- **ENERGIEKONFERENZ (2002):** A quiz. This quiz is similar to Trivial Pursuit and was kept in the selection because of its high degree of complexity compared with other quizzes. The winner is determined through the number of right answers to energy-related questions that are raised in or outside of energy conferences, and with or without the formation of syndicates. The aim of the game is to be awarded an energy pass.
- **TRICO2LOR:** Example of how games can address the issue of intergenerational justice. This role-play highlights the implications of personal decisions on energy use for global warming. It simulates the actions of at least three generations and their use of fossil fuel, and adoption of more efficient or renewable energy sources. The actions of one generation have an impact on all future generations. One generation can win, but in order to take care of the climate, intergenerational conferences are possible. It comprises a board game and a visual representation of the world climate on the Internet.
- **LOVE LETTERS TO THE FUTURE (2009):** An example that stretches the definition of a game, but illustrates further ways to approach the issue. This is a cross-platform multimedia experience designed to raise awareness about the rapidly expanding danger of global warming. It is an innovative online game, buried artfully in a website that contains user-generated letters about the future of our planet. It was launched prior to the UN Climate Change Conference in Copenhagen in December 2009. It has been nominated in the Best Activism category of SXSW Web Awards and has won two Webby Awards.
- **FATE OF THE WORLD (2010):** Complex, first commercial computer game. This PC strategy game simulates real social and environmental impact of global CC over the next 200 years. It focuses on global governance, with goals ranging from improving living conditions in Africa, to preventing catastrophic CC or

exacerbating it. It is based around an intricate model of global population, economic production, and greenhouse emissions based on real-world data. *Fate of the World* was the sequel to the BBC-funded game *CLIMATE CHALLENGE*, and won several prizes. For every purchase of the charity edition, donations are made to the nonprofit partners.

Discussion and Conclusion

This review aimed to give an overview of CC-related games in general, structure the wide range of CC gaming applications, and analyze a selection of games with respect to temporal development of the field, actors involved in game development, formats, and thematic foci. Our analysis has found that CC games are not a niche product anymore. More than 50 sophisticated games were selected for detailed review; most of these are serious means of communication, educational resources, and contributions to the discussion of climate and CC issues. They make a valuable contribution to efforts to look for solutions to CC.

CC is a topic increasingly addressed by s/g, and the number of applications has increased greatly over the last three decades. Over the last 10 years, the years 2009 and 2008 saw the greatest number of new games launched, probably driven by the climate conference COP15 in Copenhagen.

The increasing sophistication of climate games is reflected in the increasing number of formats in which they are available. CC games come as board games, card games, role-plays, or digital games (video games, online or offline computer games), and can incorporate a modeling component, simulation and/or a game theory focus. They rely on virtual reality, augmented reality, or real-life applications. Often, these formats are combined and enfolded in different levels of reality. In recent years, the application of web-based resources has increased tremendously, although role-plays and management games still account for the largest proportion of CC games. Increasingly, single games are based on multiple formats.

Most CC games focus on local and global aspects of the problem; it is difficult to combine the two scales and this is rarely attempted. Many games concentrate on climate protection with a major focus on international negotiations and local technologies for greenhouse gas reduction. Applications that consider adaptation to CC are far less frequent.

The Houston Advanced Research Center (n.d.) considers that the three primary objectives of CC games are as follows:

1. to teach knowledge and provide familiarity with the issue of CC,
2. to make the players aware of the challenges associated with global warming, and
3. to encourage players to develop solutions.

We found all objectives addressed by our selection of more sophisticated climate games, although to our surprise the first of these aims is rarely explicit. Most CC games presuppose familiarity with the topic, thereby not (fully) exploiting the educational and learning potential of games.

Our approach has a number of limitations. Our search presupposed online availability, which meant that a game had to be traceable on the Internet via search engines to be included in the analysis. Although the Internet is a powerful and widespread means of communication, one should not assume that all games are marketed through the Internet. Another limitation was the language selection, which demanded that at least one edition of the game was available in English or German. Games in other languages might have been missed out. In addition, the categorization of game formats is sometimes problematic, as these are increasingly mixed.

However, we conclude that the recent upsurge and wide range of CC games and simulations available indicates a widespread belief in the potential of CC games and simulations to contribute to learning, mitigation, and adaptation in response to CC.

Appendix

List of 52 More Sophisticated Games Selected for Detailed Analysis

AQUA-PLANING. Ohne Wasser läuft hier gar nichts!	http://www.bpb.de/methodik/HT0Z6T,0,0,Details.html?planspiel_id=193
BEFORE THE STORM	http://www.climatecentre.org/site/games-exercises ; http://petlab.parsons.edu/redCrossSite/games.html
CEO2	http://knowledge.allianz.com/search.cfm?592/climate-game-ceo2-green-leader
CLIMATE CHALLENGE	http://www.bbc.co.uk/sn/hottopics/climatechange/climate_challenge/aboutgame.shtml
CLIMATE CHANGE SHOWDOWN	http://www.bcsea.org/learn/resources-for-educators/climate-change-showdown
CLIMATE DIPLOMAT: Post-2012 CLIMATE NEGOTIATION SIMULATION	http://eeocw.org/environmental-negotiation/climate-diplomat-post-2012-climate-negotiation ; http://eeocw.org/environmental-negotiation/climate-diplomat-post-2012-climate-negotiation/climate-diplomat-negotiation-simulation
CLIMATE-CHANGE POLICY EXERCISE	http://www.iiasa.ac.at/Admin/PUB/Documents/WVP-96-090.pdf ; Parson, E. A. (1995). Global CC Policy Exercise: Results of a Test Run. Working Paper, International Institute for Applied Systems Analysis.
CLIMATE-POKER	http://www.spieledealer.de/bewitched/bewitched.php?menu=1&menu2=11&language=_e&anchor=
CO ₂ - The Interactive Negotiation: GLOBAL WARMING	http://www.systemdynamics.org/conferences/1997/paper191.htm ; Edward A. Parson, Mehrdad A. Baghai (1993). CO ₂ , the interactive negotiation on global warming. Strategic Environmental Simulations Inc.
CO ₂ -EMISSIONSHANDEL	http://www.mvv-muenchen.de/de/service/lehrerinformationen/rollen-und-planspiele/index.html ; http://www.mvv-muenchen.de/web4archiv/objects/download/1/textco2-planspiel.pdf
CO ₂ FX: Global warming interactive game	http://www.globalwarminginteractive.com/index.htm
CONNECT2CLIMATE	http://www.gamesforchange.org/play/connect2climate/
COOL IT!	http://www.ucsusa.org/publications/cool-it-card-game/cool-it-climate-change-card-game.html
C-ROADS	http://climateinteractive.org/simulations/C-ROADS
DIE KLIMASCHUTZBASIS NoCoZwo	http://www.noco2wo.de/
DYNAMIC CLIMATE CHANGE SIMULATOR	http://cmu.flintbox.com/public/project/4743/ ;
EARLY WARNING, EARLY ACTION	http://www.hss.cmu.edu/departments/sds/ddmlab/
ENERCITIES	http://petlab.parsons.edu/newWeb/index.php?content=none&project=redcross
	http://www.enercities.eu

(continued)

Appendix (continued)

ENERGIE 21 – mit Energie in die Zukunft	http://www.spieltriebbr.de/spiele/energie-21.html
ENERGIE FÜR DIE ZUKUNFT – Planspiel zur Energie- und Klimapolitik der EU	http://www.eu-planspiele.de/
ENERGIE, Klimaschutz und Verbraucher	http://www.energie-plenspiel.de/ http://www.energie-plenspiel.de/Onlinegame/Schuelerhandbuch_Energie_plus_Teil1.pdf
ENERGIEKONFERENZ	http://www.ubb.de/htm/umweltspiele/einzel.php?spiel_id=87
ENERGY CITY (1)	http://www.jason.org/digital_library/8239.aspx
ENERGY CITY (2)	http://www.scooltour.info/no_cache/presse/pressemitteilungen/news-einzelansicht/browse/1/article/freizeitpass-hoch-3-setzt-lichtzeichen.html?tx_ttnews[backPid]=4
EUROPAS KLIMA wandeln!	http://www.europarl.de/view/de/Jugend/Planspiele_fuer_Schueler/Europas_Klima_wandeln2.html
FATE OF THE WORLD	http://www.guardian.co.uk/technology/2010/oct/31/fate-of-the-world-review; http://fateoftheworld.net/
FRISCHER WIND IN STAHLHAUSEN – Ein Planspiel zu Klimaschutz, Klimabündnis und Nachhaltigkeit	http://www.suedwind-noesued.at/archiv/start.htm
A Game Framework for Scenario Generation for the Co2 Issue	http://www.bpb.de/methodik/HT0Z6T,0,0,Details.html?planspiel_id=221 http://www.deepdyve.com/lp/sage/a-game-framework-for-scenario-generation-for-the-co2-issue-2XCHYa8w2T
GREENHOUSE GAS SIMULATOR	http://scripts.mit.edu/~jsterman/climate/master/
KEEP COOL	http://www.bpb.de/methodik/HT0Z6T,0,0,Details.html?planspiel_id=124; http://www.spiel-keep-cool.de/ ; Eisenack, K. (2012). Interdisciplinary communication and education with a board game on CC, this issue.
KEEP COOL IN SUNSHINE CITY	http://www.ubb.de/htm/umweltspiele/einzel.php?spiel_id=85
KEEP COOL ONLINE	http://www.keep-cool-online.de/
KLIMAKONFERENZ - INTERNATIONALE KLIMAPOLITIK	http://www.planpolitik.de/en/pdf/simulation%20game_climate.pdf
KLIMAKONFERENZ LAUSITZ	http://www.bpb.de/methodik/HT0Z6T,0,0,Details.html?planspiel_id=199; http://www.carpus.org/default.aspx?ID=81&DetailID=160
LOGICITY	http://www.logicity.co.uk/game/ ; http://www.newscientist.com/blog/technology/2007/11/climate-change-in-virtual-world.html
LOVE LETTERS TO THE FUTURE	http://thachr.com/love-letters-to-the-future/
MOBILITY	http://www.umweltspiele.eu/mobility.htm ; http://www.oekonews.at/index.php?mdoc_id=1039031
MY 2050	http://my2050.decc.gov.uk/
PLANET GREEN GAME	http://www.planetgreengame.com/ ; http://www.treemedia.com/treemedia.com/Starbucks_Planet_Green.html ; Game is no longer available, it seems.
PLANTVILLE	http://www.plantville.com/index.php
RIZK	http://www.sciencemuseum.org.uk/rizk
STABILIZATION WEDGE GAME/"Wedge Game"	http://cmi.princeton.edu/wedges/ ; Pacala, S. & Socolo, R. (2004). Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies. <i>Science</i> , 305(5686), 968-972.
Strom für Europa!	http://www.bpb.de/lernen/unterrichten/planspiele/65586/planspiele-detailseite?planspiel_id=313
SURFING GLOBAL CHANGE	http://www.friends-partners.org/GLOSAS/Global_University/Global%20University%20System/List%20Distributions/2007/MTI1891_I1-29-07/SGC%20booklet%202007%20%28DE%20+%20EN%29%20copy.pdf ; http://doebe.li/bibliothek/t03595.html#links ; Ahamer, G. (2006). Ready-to-use simulations: SURFING GLOBAL CHANGE: Negotiating sustainable solutions. <i>Simulation & Gaming</i> , 37, 380-397.

(continued)

Appendix (continued)

SUSCLIME	http://nws.chem.uu.nl/publica/Publicaties%202008/NWS-E-2008-256.pdf , p. 43 ff.; Bert de Vries (1998). <i>Suslime: A Simulation/Game on Population and Development in a Climate-Constrained World</i> . <i>Simulation & Gaming</i> , 29(2), 216-237.
THE CLIMATE CHALLENGE TRICO2LOR	http://www.theclimatechallenge.org/ http://www.trico2lor.ch/download/0902_Factsheet_triCO2lor.pdf ; http://uics.ch/ref/reftrico2lor.html
V GAS (now "Living Together")	http://www.xplora.org/ww/de/pub/myeuropa/home/practice/teaching_ideas/vgas.htm ; official website not online anymore; http://myeuropa.eun.org/www/en/pub/myeuropa/home/practice/teaching_ideas/vgas.htm
WAR GAME: Clout and CC/ CNAS CC Wargame	http://www.cnas.org/node/964
WELTKLIMAGIPFEL	http://www.bpb.de/methodik/HT0Z6T,0,0,Details.html?planspiel_id=319
WINDS OF CHANGE	http://www.european-climate-forum.net/fileadmin/ecf-documents/Press/ECF_press_release_280405.pdf
WORLD CLIMATE/(formerly the Copenhagen Climate Exercise, or CCE)	http://climateinteractive.org/simulations/world-climate

Acknowledgment

The authors thank Stefanie Wölfle for her support in the compilation of the games and in preparing the manuscript.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The authors disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: Diana Reckien was funded partly by the German Ministry for Education and Research (BMBF) Grant 01LG0506E and the German Science Foundation (DFG) RE 2927/2-1.

References

- Abt, C. C. (1970). *Serious games*. New York, NY: Viking Press.
- AQUA-PLANING. (n.d.). Floersheim-Weilbach: Germany. Retrieved from http://www.bpb.de/lernen/unterrichten/planspiele/65586/planspiele-detailseite?planspiel_id=193
- Barreteau, O., Le Page, C., & Perez, P. (2007). Contribution of simulation and gaming to natural resource management issues: An introduction. *Simulation & Gaming: An Interdisciplinary Journal*, 38, 185-194.
- BEFORE THE STORM. (n.d.). [Developed by Red Cross/Red Crescent Climate Centre.] The Hague: Netherlands. Retrieved from <http://www.climatecentre.org/site/games-exercises>
- CLIMATE CHANGE SHOWDOWN. (2006). [Developed by BC Sustainable Energy Association.] Victoria: British Columbia, Canada. Retrieved from <http://www.purplepaw.com/2009/04/british-columbias-climate-change-board-game/>
- CEO2. (2010). Berlin: Germany. *LGM Interactive*. Retrieved from <http://knowledge.allianz.com/climate/?592/climate-game-ceo2-green-leader>

- CLIMATE CHALLENGE. (2006). [Developed by Red Redemption Ltd.] Oxford: UK. Retrieved from http://www.bbc.co.uk/sn/hottopics/climatechange/climate_challenge/aboutgame.shtml
- CLIMATE DIPLOMAT (2009). [Developed by Hart, C. A., The Energy + Environment Foundation/Alston & Bird LLP.] Washington: DC. Retrieved from <http://eeocw.org/environmental-negotiation/climate-diplomat-post-2012-climate-negotiation>
- CLIMATE MOMENTUM SIMULATION. (n.d.). [Developed by Jones, D., & Owens, N.] *Climate Interactive Network*. Retrieved from <http://climateinteractive.org/simulations/climate-momentum-simulation/climate-momentum>
- CLOUT AND CC. (2008). [Developed by Center for a New American Security.] Washington: DC. Retrieved from <http://www.cnas.org/naturalsecurity/consequences/climate-change>
- COOL IT. (2010). [Developed by Union of Concerned Scientists.] Cambridge: MA. Retrieved from <http://www.ucsusa.org/publications/cool-it-card-game/cool-it-climate-change-card-game.html>
- CO₂ EMISSIONSHANDEL. (2007). [Developed by Muenchner Verkehrs-und Tarifverbund/ TexteSatt.] Muenchen: Germany. Retrieved from <http://www.mvv-muenchen.de/de/service/lehrerinformationen/rollen-und-planspiele/index.html>
- Crookall, D. (2010). Serious games, debriefing, and simulation/gaming as discipline. *Simulation & Gaming: An Interdisciplinary Journal*, 41, 898-920.
- EARLY WARNING, & EARLY ACTION. (2009). [Developed by PetLab.] New York: NY. Retrieved from <http://www.gamesforchange.org/play/early-warning-early-action/>
- Ecokids. (2012). *CC games and activities*. Retrieved from http://www.ecokids.ca/pub/games_activities/climate_change/index.cfm
- Egenfeldt-Nielsen, S. (2003). *Review of the research on educational usage of games*. Unpublished manuscript, IT-University Copenhagen, Denmark.
- ENERGIEKONFERENZ. (2002). [Developed by Schmalwieser, J.] Muenchen: Germany. Available from <http://www.umweltspiele.eu/>
- EUROPAS KLIMA WANDELN. (2007). Muenchen: Germany. Retrieved from http://www.europaimunterricht.de/e_i_u_planspiele.html
- FATE OF THE WORLD. (2010). [Developed by Red Redemption Ltd.] Oxford: UK. Available from <http://fateoftheworld.net/>
- Houston Advanced Research Center. (n.d.). *Global warming educational games*. Retrieved from <http://www.texasclimate.org/Education/EducationalGames/tabid/462/Default.aspx>
- Intergovernmental Panel on Climate Change. (2007). *CC 2007: Synthesis report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on CC*. Cambridge, UK: Cambridge University Press.
- KEEP COOL—Gambling with the Climate. (2004). [Developed by Eisenack, K., & Petschel-Held, G. (Board game).] Wiesbaden, Germany: Spieltrieb. Available from www.spiel-keep-cool.de
- LIVING TOGETHER (formerly “V GAS”). European Commission. (2006). Retrieved from http://ec.europa.eu/clima/sites/campaign/living_together/
- LOVE LETTERS TO THE FUTURE. (2009). [Developed by Thacher, S.] Available from <http://www.loveletterstothefuture.com> [This game is no longer available]
- MOBILITY. (2009). [Developed by Renoldner, K.] Available from <http://www.umweltspiele.eu/>
- Ostrom, E. (1990). *Governing the commons*. Cambridge, UK: Cambridge University Press.

- PLANET GREEN GAME. (2007). [Developed by Starbuck Company and Global Green, USA.] Retrieved from http://treemedia.com/treemedia.com/Starbucks_Planet_Green.html [This game is no longer available]
- PSFK. (2011). *Gaming for good: Concepts to support the reality of CC*. Retrieved from <http://www.psfk.com/2011/12/gaming-for-good-al-gores-finalist-picks-announced.html>
- Robinson, A. J., & Ausubel, J. (1983). GAME FRAMEWORK FOR CO₂ ISSUE. A game framework for scenario generation for the CO₂ issue. *Simulation & Gaming: An Interdisciplinary Journal*, 14, 317-344.
- STROM FÜR EUROPA. (2009). Muenchen: Germany. Retrieved from http://www.bpb.de/lernen/unterrichten/planspiele/65586/planspiele-detailseite?planspiel_id=313
- TRICO2LOR. (2007). [Developed by UCS Ulrich Creative Simulations/Langenbruck Eco-Center/myclimate.] Retrieved from <http://www.trico2lor.ch/index.php>
- Ulrich, M. (1997). Games/Simulations about environmental issues—Existing tools and underlying concepts. In Proceedings of the 28th Annual Conference of the International Simulation and Gaming Association (pp. 301-311). Tilburg, Netherlands: Tilburg University Press.
- WINDS OF CHANGE. (2005). *European Climate Forum*. Retrieved from <http://www.global-climateforum.org/index.php?id=89>
- WORLD CLIMATE. (2006). [Developed by Massachusetts Institute of Technology/Climate Interactive.] Retrieved from <http://climateinteractive.org/simulations/world-climate>

Author Biographies

Diana Reckien is a research scholar at the Center for Research on Environmental Decisions, Earth Institute, Columbia University, USA. She has worked at the Potsdam Institute for Climate Impact Research from 2000 to the beginning of 2012, where she started to test the explanatory power of games for climate change (CC) issues in urban planning environments. She is interested in modes of learning and decision making, particularly for complex environments such as urban areas, CC, and planning. Her current research focuses on climate and weather impacts and adaptation options and their social differentiation in large urban areas in India, Europe, and the United States.

Contact: dianareckien@columbia.edu.

Klaus Eisenack is an assistant professor for environment and development economics at Carl von Ossietzky University Oldenburg, Germany. He worked at the Potsdam Institute for Climate Impact Research from 2001 to 2008. He is interested in institutions to govern long-term sustainability issues. His current research focuses on adaptation to CC. Since 2008, he is head of the Chameleon research group that investigates adaptation of public and private utilities. In 2006, he received a PhD in mathematics at the Free University Berlin with work on qualitative and nonstandard modeling techniques with applications to natural resource management. Further interests are modeling of policy instruments, game theory, archetypical patterns of social-ecological systems, and games on global change.

Contact: klaus.eisenack@uni-oldenburg.de.