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Editors

Environmental Informatics

A bogeyman or saviour to achieve the UN Sustainable Development Goals?

Adjunct Proceedings of the 35th edition of the EnviroInfo – the long standing and established international and interdisciplinary conference series on leading environmental information and communication technologies

Berlin, Germany, September 27-29, 2021

German Informatics Society

FACHAUSSCHUSS UMWELTINFORMATIK

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Preface

This book presents the main research results of the 35th edition of the long-standing and established international and interdisciplinary conference series on environmental information and communication technologies (EnviroInfo 2021).

The conference was held from 27 to 29 of September 2021. It was organized by the Berlin University of Applied Sciences under the patronage of the Technical Committee on Environmental Informatics of the Gesellschaft f ü r Informatik e.V. (German Informatics Society - GI)

This book presents a selection of peer-reviewed research papers that describe innovative scientific approaches and ongoing research in environmental informatics and the emerging field of environmental sustainability. Combining and shaping national and international activities in the field of applied informatics and Environmental Informatics, the EnviroInfo conference series aims at presenting and discussing the latest state-of-the-art development on information and communication technology (ICT) and environmental-related fields. A special focus of the conference was on the question whether Environmental Informatics is a bogeyman or a savior to achieve the UN Sustainable Development Goals.

The respective articles cover a broad range of scientific aspects including advances in core environmental informatics-related technologies, such as Sustainable Mobility Digital Sharing Economy and Sustainability, Sustainable Usability and User Experience, Earth System Observation and Computational Analysis for Sustainable Development, Modelling and Simulation in the Environmental and Earth Sciences Artificial Intelligence and Sustainability, Environmental Health Informatics, and other relevant topics in the field of Environmental Informatics.

We would like to thank all contributors for their submissions. Special thanks also go to the members of the program and organizing committees, for reviewing all submissions and Franziska Mai for layouting and organizing the submissions in this book. In particular, we like to thank our local organizers at the GIU Berlin for the local organizing support.

Last but not least, a warm thank you to our sponsors that supported the conference.

Berlin	Volker Wohlgemuth
Magdeburg	Hans-Knud Arndt
Bielefeld	Grit Behrens
Birkenfeld	Stefan Naumann

Berlin, September 2021

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ADVANCES AND GAPS IN RISK INFORMATION MANAGEMENT: CHALLENGES IN IMPLEMENTING THE UN SENDAI FRAMEWORK

Fighting climate risk through gaming by an energy transition game, utopia or reality?

Charles Hieronymi[1], Théo Francart[1] and Alberto Susini[2]

1. Introduction

Climate change risks mitigation actions are discussed in the present paper, by an initiative which purpose is to raise awareness among city stakeholders by gaming. The main concept within the chosen risk management approach is to address specific targeted stakeholders involved in CO_2 reduction initiatives at local level in City management. The project approach is to put forward climate risk analysis in modeling and simulation activities on daily operational issues at local level. The first key feature of climate change is that CO_2 is a global pollutant, rather than a local pollutant but that can be locally contained. First proposals explaining the high interest to couple the use of computerized gaming with climate change risks are reported back in 1980 [1]. They put forward the potentiality of gamming in obtaining a broader spectrum of behavioral responses than a model builder can conveniently assume. A gaming approach of the climate risks will allow a broader view of behavioral responses by stakeholders in order to address the strategic decision-making aspects of the CO_2 debate.

To set the gaming actors in motion on climate change issues, UNEP created the Green Game Jam initiative in 2021, to empower millions to play for the planet [2]. Today, the video games industry is involved and committed to take action in response to the climate crisis [3]. The Pentagon included the risk of climate change in their simulations and gaming [4]. An existing similar initiative financed by the EU fund CORDIS was launched in 2018 with similar approaches like tackling the energy inefficiency of public buildings with the help of a mobile game to educate and change behavior [5]. Its simulation draws on real data to demonstrate the human aspects of building use, such as ingrained attitudes and the pursuit of comfort. This paper describes the goal of creating a physical computing game, and concentrates on the specific elements of the software engine.

2. Context

2.1 The project's objectives

The implementation of a new game engine for physical computing serious games aims to change behavior in terms of energy production and consumption. The proposal is to develop a non-coercive process, which offers a reward to residents, employees or officials as well as to businesses and institutions in the form of

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a reduction in their electricity bill and CO_2 emissions. The aim is to develop a specific research and analysis methodology, a framework of operations adapted to groups of populations, a collaborative game and implementation procedures with, ultimately, a results verification strategy.

The necessity and urgency of communication about the issues and challenges of climate change and possible solutions to advert or at least reduce this risk by setting up an energy transition and reorganize cities within the framework of the smart-city model, is leading the way to new educational projects. Gamification is an effective way to communicate complex ideas and concepts and increase stakeholder engagement [6]. Smart City Game and Transition Today are two electronic physical board games that share a common software engine that is briefly described in this paper.

2.2 Physical computing game architecture

The project, offers two collaborative management games between board game and video game, on energy transition and the smart city. The Smart City Game and Transition Today projects are not based on a pre-existing console. Our biggest challenge is the design and the realization of a hardware solution in perfect adequacy with the needs of the software. To better understand these needs, the project was cut into a vertical system of layers. The higher the layers, the more they rely on the proper functioning of the lower layers. Tab. 1 shows the layered architecture of the gameplay at the hardware layers.

<table>
<tr><td>board skin /special figurines / project SD cards</td><td colspan="3"></td></tr>
<tr><td>figurines / 3D prints</td><td colspan="3">screen micro-computer/tablet/smart phone</td></tr>
<tr><td colspan="4">micro-controllers</td></tr>
<tr><td>wood structure</td><td>LED GPIO</td><td>(e-paper)</td><td>potentiometer</td></tr>
<tr><td>bottom layer</td><td colspan="3">electronics / cables</td></tr>
</table>

Tab. 1 Hardware layers

The eight following goals are in the scope of the project:

1. understand the risks of climate change/energy/smart city and smart grid issues; [7]
2. popularize a complex technical problem;
3. offer dialogue at all levels of society;
4. improve collaboration;
5. open up perspectives and create bridges between the stakeholders (urban associations of inhabitants, politicians, firms, millennials (generation Y))
6. address political, societal and technological issues;
7. make the player responsible for Citizen action and participation;
8. encourage vocations in the new economy linked to the energy transition.

3. Technical achievements

3.1 Smart City Game - First tests of the Prototype

A first small-scale prototype has been realized. It simulates the interactions of 3D printed figurines (with physical connectors on the game-plate), the game-plate and an e-paper screen. A short video presents the gameplay [7], the interaction of the players in this collaborative experience.

3.2 Smart City Game - Communication tool to mitigate Climate Risk

Smart City Game is a communication tool that aims to create an interactive experience that can be used by municipal representatives, civil servants, associations of inhabitants and smart city professionals for meetings and presentations. The interactive experience immerses the user in the management of a municipality in the form of a reduced model with the task of reducing its carbon footprint. The user's objective involves optimizing the city's energy flows and therefore mitigation of climate risks. He has a limited number of possible actions to implement solutions that optimize the energy flows of his municipality.

3.3 Game play - Smart City

Smart City Game is a turn-based game: players are put in the responsibility of a region. A series of decisions guides the players to influence the future of their region and to achieve a smooth transition towards a successful smart city model. In each turn, the players will have to reorganize the city and make budgetary, strategic and environmental decisions. Since the model is systemic, it is as the game progresses that players come to understand the impact of their decisions over time. The various Smart City services comprize mobility, lighting, waste management, energy, optimization of road traffic, green spaces, etc. The wooden game board represents the topology of a city (Fig. 1).

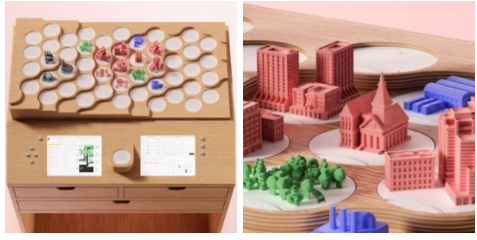


Fig. 1 Top view of Smart City table game board with interactive screen (left) and used figurines (right).

3.4 Transition Today - a collaborative game to reduce Switzerland's carbon footprint

Transition Today is a collaborative game which main goal is to reduce Switzerland's carbon footprint. This game offers an intuitive visualization of energy flows and makes it easy to identify the major factors of

carbon generation. The blueprint of the gameplay is based on a Swiss solar and climate plan [8]. It is a tool designed to bridge the climate risks agenda with the need to make the energy transition a reality. It is intended for the general public for awareness-raising actions, private sector technical solution providers, local political actors, and for those involved in public policies related to the climate change agenda.
The game aims to reach the following targets: to have the characteristics of a collaborative game, to reach the target of the energy transition, to be fun, didactic and interactive and finally to be present on a physical and digital level. The vision of this tool is to create bridges between different city stakeholders like representatives of the inhabitants, politicians, Private Sector, millenials (generation Y), NGO's in order to allow a constant dialogue between these stakeholders on energy transition and climate risks. At the crossroads of serious game and management game, this game uses a medium that creates a strong connection with its user and promotes a better understanding of a complex subject by popularizing it.
The serious game experience is only prevalent if the user is emotionally and physically engaged in the game. To emotionally engage the player, a simulation game was developed. This category of game gives players a significant degree of control at the macro level. It allows the user to test strategies and at the same time be able to make mistakes virtually, that is without having to face the consequences of bad decisions.
The game is played over ten turns and physically stages the energy production sources with removable figurines placed on the game board. The player can test different scenarios for adopting renewable energies by setting up investments. (e.g. research, public subsidies, innovations, evolution of production park, etc.).
To physically engage the player, we offer a physical computing game. The association of a material object connected to a digital feedback, allows the player to physically modify the information. First testing on a limited level of a prototype made in 2018 showed that the initial goal to change behavior in terms of energy production and consumption was reached by the testing team.

3.5 Transition Today – Components - Characteristics and technical features

The game consists of two major components that communicate wirelessly: a touch pad and a game board.

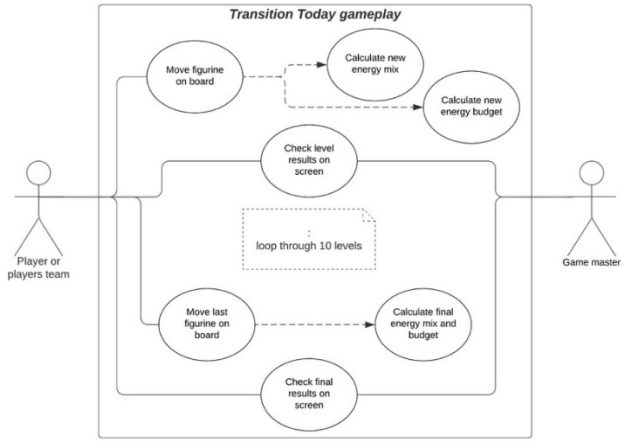
Fig. 2 The box and elements (left), the physical board (center) and the screen (right)

The tablet shows the energy consumption. On an intuitive graph, we see the flow of energies and its equivalent in carbon footprint. The information on the screen updates with each player's action on the board.
The board consists of two distinct elements; a map showing in a simplified way the local energy production and various game data with goals of decarbonization and financial indicators of investment.
Transition Today is intended for both the general public and professionals. The board is based on a figurine recognition technology specially developed for this project. It incorporates a microcontroller that connects

to any type of tablet using a Bluetooth Low Energy (BLE) connection. The game is playable on both iOS and Android devices connected to the Internet.

3.6 Transition today - Use case

Three main groups of potential users of the Transition Today game were identified and illustrated in the simplified use case below as "the Player" (Tab. 2). First, the educational system trains the young generation and can generate vocations in the new economy. Then, the political institutions are guarantors of a successful implementation of the energy transition. Finally, the economic world, where energy consumption is significant. The latter is also the source of creation of the technologies and financing of the energy transition [9], [10]. The use case below shows the interaction between The Player (student, politician, business employee, etc), the "Game master" who supervises the game and the game engine itself.



Tab. 2 A simplified use case of the Transition Today gameplay.

4. Software engine: a visual glimpse at graph and code

4.1 Code: Smart City game virtual board and arrays

The game is controlled by an online server that manages all the steps and progress of the gameplay: it collects data from the players including figurine moves, progress of the game and state of the regional settings on the physical board (buildings, factories, transportation system, heat systems) (Fig. 3).
At each move or step, the game recalculates automatically the energy mix, the budget and the consumption of the local community. The physical board communicates through electronic controllers with the online model, that will send back data to the board and light the position of the figurines with LEDs.

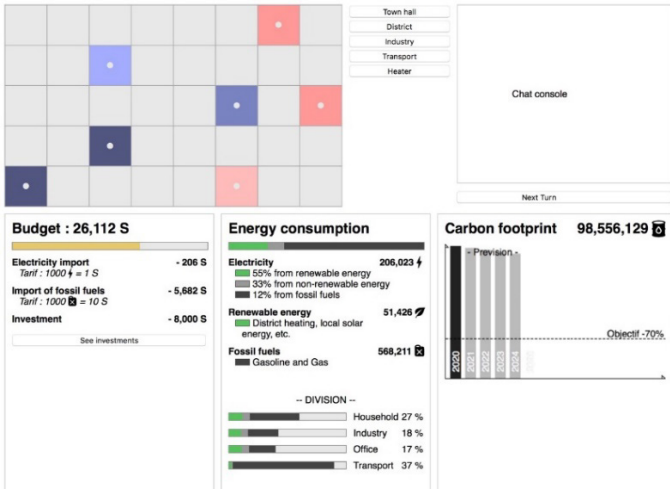


Fig. 3 View of the prototyping screen of the Smart City game

4.2 Code: Structure of key sectorial variables and energy types

The use of JavaScript and node.js as the main scripting language help to make it easy to modify for entry level computing coders. Some Arduino scripting is developed to interface the controllers on the physical board: this allows figurine recognition, modification of financial and energy variables. The project uses arrays of variables to model sectorial consumption of energy (households, industry, offices and transportation) and type of energy consumption (different type of fossil fuels, renewables) (Fig. 4).

```
// --- ------------------------- ---
// --- STRUCTURE OF KEY VARIABLES  ---
// --- ------------------------- ---
  /*
  CITY TABLE

    |  0 |  1 |  2 |  3 |  4 |  5 |
  --|----|----|----|----|----|----|
  0 |  0 |  0 |  0 | [x]|  0 |  0 |
  1 |  0 |  0 | [x]| [x]|  0 |  0 |
  2 |  0 |  0 |  0 |  0 |  0 |  0 |

  [ ID PIECE, N° , STATUT ]
                  └-> STATUT 0 = NOT PUT DEFINITELY
                  └-> STATUT 1 = ON
                  └-> STATUT 2 = TO REMOVE
                  └-> STATUT - = NOT PUT ON THE TABLE

  SECTOR CONSUMPTION TABLE

                  |------- VARIABLES --------|
                  |  0  |  1  |  2  |  3  |  4  |
  SECTORS         |-----|-----|-----|-----|-----|
  |               |  0  | 27.2| 30  | 29  | 30  | 11  | [0] Households
  |               |  1  | 18  |  9  | 44  | 41  |  6  | [1] Industry
  |               |  2  | 17.1| 23  | 25  | 45  |  7  | [2] Tertiary
  |               |  3  | 36.2| 94  |  0  |  4  |  2  | [3] Transport
  |                                                     -> [4] Other
  |                                                     -> [3] Electricity
  |                                                     -> [2] Gas/Wood
  |                                                     -> [1] Oil
  |                                                     -> [0] EnergyTotal

  PARTS MODIFICATION TABLE = tablModifPieces

    [ID PIECE, N°, STATUT], Sector, Variable, ----------------
    [ID PIECE, N°, STATUT], Sector, Variable, ----------------
    [ID PIECE, N°, STATUT], Sector, Variable, ----------------
    [ID PIECE, N°, STATUT], Sector, Variable, ----------------
```

Fig. 4 Use of variable definition by sector and energy sources

4.3 Code: arrays and loops to calculate game progress

At each move, the script recalculates the energy mix and progress of the games through a multidimensional array (Fig. 5). The coding approach is a mix of scientific calculation and simulation and pure game design approach for artistic installations and video games.

```
// CREATE A MULTIDIMENSIONAL ARRAY WITH NUMBER OF FORECASTS + 1 TIME THE SECTOR TABLE
    // le +1 compense pour l'AN0
    let SecteursProxy = [];
    for(i=0; i<General.nombrePrevisions+1; i++) {
        SecteursProxy[i] = [];
        SecteursProxy[i] = JSON.parse(JSON.stringify(tablSecteur));
    }

    /*
```

	0	1	2	3	4
0	27.2	30	29	30	11
1	18	9	44	41	6
2	17.1	23	25	45	7
3	36.2	94	0	4	2

```
                                                    -> SecteursProxy[4] AN+4
                                                -> SecteursProxy[3] AN+3
                                            -> SecteursProxy[2] AN+2
                                        -> SecteursProxy[1] AN+1
                                    -> SecteursProxy[0] AN
    */
logMaj && console.log("Behind the multidimensional array");

// APPLY PARTS AND INVEST MODIFICATIONS LINE BY LINE
    /*
        Change of methods compared to V0.1,
        Changes no longer apply per year
        but modifications by modifications.
        This should save the address calculations.
    */
    for(i=0; i<tablModifPieces.length; i++) { // Scroll in lines
        let adresseX = tablModifPieces[i][1]; // edits the targeted addresses
        let adresseY = tablModifPieces[i][2];
        // console.log(" Adresse = " + adresseX + adresseY);
        for(j=0; j<General.nombrePrevisions+1; j++) {
            // Apply changes to the address every year until AN + nbPresvisions
            SecteursProxy[j][adresseX][adresseY] += tablModifPieces[i][j+3];
        }
    }
```

Fig. 5 Comments of array definition the steps and game progress (Smart City game)

4.4 Code: Connection of the screen with a micro-controller

Instead of using an in-built screen, we have created a connection between an Aduino Nano 33 BLE that is implemented in the board and any device available to the player that has a screen (Figure 6).

Fig. 6 Aduino BLE micro-controller

For environmental reasons, it was not necessary to create a project with a new screen because most teachers or players have a personal computer, a digital tablet or a smart phone. Thus green gaming guidelines are implemented. The BLE connection uses a low consumption Bluetooth protocol to communicate with a device that will show instructions and the progress of the game. The board itself acts as a smart controller, and the external devices connects to a website where the actual script of the game is stored.

5. Discussion

The code is made available on a free and open source basis to be modified by the user community. The main idea behind the project is to boost an interest in environmentally and risk-related games and to develop educational physical computing projects in this area [11]. The philosophy of the Arduino and Raspberry Pi community drives the spirit of writing the code of our game engine [12]. Real-world social and gaming issues were identified together with hardware and software solutions that will fit to a variety of physical computing and game boards and that comply to the guidelines of green gaming.

The creation of a new physical digital game console to be used as an educational tool for serious games is the start for a variety of projects that can be implemented in many different situations and use cases. The standardization of the use-cases, software structure, as well as the decision-making processes and the continuous improvement of the quality of the computer code, can generate interest in a multitude of simulation and educational programs helping the target of facing the climate risks agenda.

An important target was also reached by the fact that the projects show that it is possible to obtain a very broad spectrum of behavioral responses that can accelerate public awareness of climate risk changes with a high personal motivation and implication.

The project helps to explain the possibility of greenhouse gases reduction by showing the feasibility of implementing new renewable electricity technologies which will mitigate climate risks. These findings are combined with managerial and policy making approaches. These new public awareness sensitization opportunities offered by gaming will contribute to implementing the United Nations Sustainable Development Goals [13] on local, national and international levels.

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