R-ACES
Energy Cooperation Platform

Serious Game “Heatopoly”

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[1] PU = Public
PP = Restricted to other programme participants (including the Commission Services)
RE = Restricted to a group specified by the consortium (including the Commission Services)
CO = Confidential, only for members of the consortium (including the Commission Services)

[2] R = Document, report
DEC = Websites, patent fillings, video, etc.
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Project Summary

The R-ACES project is an initiative promoted by 8 partners from 6 European countries, with the vision to support high-potential industry parks and clusters to become fully fledged eco-Regions that reduce emissions by at least 10 %. R-ACES means a step-change in the contribution of European Industry to the climate targets of the EU. The industry sector after all represents 25% of all energy demand – and 50% of the total cooling and heating demand on the continent; yet only 16% comes from renewables. By focusing on collective measures and clustering, the efficiency of industry can be drastically increased.

The focus of R-ACES therefore is to turn high-potential, high-impact industrial clusters into eco-Regions that achieve at least a 10% reduction in emissions. They do so by exchanging surplus energy, making extensive use of renewables and tying everything together with smart energy management systems. An eco-region is a geographic area where energy and information exchanges occur between various companies and actors to reduce waste and energy consumption. Eco-region can be centred on an (eco-)industrial park or (eco-) business park, linked to its surroundings by a 4th/5th generation district heating/cooling network.

R-ACES is the capping stone, condensing the knowledge and experience gathered throughout EU and national projects into a set of three focused tools, namely a self-assessment tool, a legal tool, and a smart energy management platform for clusters. The tools are embedded in support actions built around peer-to-peer learning, more formal coursework and webinars, and serious games. Together they enable a cluster to really become an eco-region and set up meaningful energy collaboration. The entire package of tools and support is aimed at the high-potential clusters identified in the European Thermal Roadmap. It will be validated in three eco-regions, actively deployed in another seven regions, and disseminated to identified ninety regions European wide. In addition, the tools and support methodology will be made available to third parties in a sustainable way after the end of this project.

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Partners

Institute for Sustainable Process Technology — https://ispt.eu/

Condugo — https://www.condugo.com/

Spinergy — http://www.spinergy.it/

energy CLUSTER DENMARK — https://www.energycluster.dk/

LE2C LOMBARDY ENERGY CLEANTECH CLUSTER — http://www.energycluster.it/en

pom antwerpen — https://www.pomantwerpen.be/

ESCI European Science Communication Institute — https://www.esci.eu

EUROHEAT & POWER — https://www.euroheat.org/

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Executive Summary

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1 Introduction

1.1 Objective of work package 4 "Expand"

The overall objective of the work package is to EXPAND the coordination and support action towards 10 regions in Italy, Denmark, Belgium and the Netherlands, which are the countries of the industrial partners of R-ACES. These regions are selected and approached during the project lead-time and R-ACES aims to trigger energy cooperation actions in the regions and to commit management of sites, DHC's, industrial parks to start or expand energy cooperation actions. The regions will benefit from the development of the tools and experience during validation in the three main ecoregions of the project (work package 3).

The main way to coordinate the expansion is through the means of learning communities (LC). A learning community within R-ACES refers to a local group of stakeholders that are (a) directly involved with the energy collaboration on a site; and (b) engaging in both organised and informal exchange of knowledge and best practices over the course of the project period. These groups are the first beneficiaries of instruments like the use case library, the R-ACES tools, and the R-ACES serious game. Learning communities from different sites in this project will eventually be brought into contact with each other to further stimulate the exchange of best practices. Learning communities are seen as important to facilitate innovations related to energy cooperation projects. So, they build innovation capacity in the ecoregions.

To reach the overall objective, the following actions will be conducted:

- **Formulate an expansion roadmap in which the actions to roll out the learning communities in the ecoregions are described**
- **Make a template for the learning community meetings**
- **Evaluate the learning communities as a way for capacity building**
- **Make a serious game that serves as potential content of the learning community meetings**
- **Set up an educational online environment that serves as potential content of the learning community meetings**

1.2 Objective of developing a Serious Game

Within R-ACES we want to raise awareness about and provide a basic understanding of energy cooperation. We inform practitioners in the field about the opportunities of energy cooperation activities, we make them aware of potential obstacles and provide suggestions on how to overcome these obstacles. The goal is to encourage practitioners to establish an energy cooperation project themselves. We believe that a Serious Game is an excellent way to fulfil this ambition. In this report, we will describe (1) why serious gaming is a good way for practicioners to learn about energy cooperation and (2) how the R-ACES consortium developed the R-ACES Serious Game "Heatopoly".

2 A Serious game for R-ACES

2.1 What is a Serious Game?

A Serious Game is a game that does not have entertainment as primary goal but allows players to learn. Typical goals are awareness building, applied training, or promotion. The last years, many sorts of serious games have been developed. They can be either digital or non-digital, personalized

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or not, have a mission or not. Moreover, they can have differences regarding duration, number of players, and learning goals[1].

Within R-ACES, a Serious Game is a method for learning-through-experience that presents participants with an energy cooperation case in which they have to play pre-assigned roles to each reach a pre-defined objective as quickly as possible.

2.2 Motivation for creating a Serious Game

Traditional information-based methodologies for achieving sustainable behavioural change are often insufficient (Frisk & Larson, 2011)[2]. A broader inclusion of knowledge domains is necessary to motivate sustainable behaviour. Frisk & Larson (2011) make a separation between declarative knowledge, procedural knowledge, effectiveness knowledge and social knowledge:

- **Declarative knowledge includes the description of a certain system. Technical information is an example of this type of knowledge.**
- **Procedural knowledge is about how to execute certain behaviour. It provides 'how to' information for the establishment of sustainable actions.**
- **Effectiveness knowledge is about knowing what behaviour is most effective.**
- **Social knowledge includes an awareness about the motives and intentions of other people in society.**

It is argued that addressing all four knowledge domains is most effective in achieving sustainable behaviour. For this reason, a Serious Game seems most relevant to inspire and encourage energy practitioners to establish an energy cooperation project. A Serious Game, in which different actors have to negotiate and collaborate to find the best financially attractive and environmentally friendly solution for their specific company, includes all knowledge domains.

Thus, Serious Games are of great value to inspire and encourage practitioners to actively participate in energy cooperation project. Other reasons to choose a Serious Game over traditional information-based technologies are described by the following game characteristics: (1) games can positively affect the motivation and involvement of participants in energy cooperation projects, (2) games offer a safe environment that allows taking risks and facilitates a discussion about possible energy strategies to be conducted, and (3) Serious Games create awareness and support action-orientated behaviour[1]. These positive characteristics create a fast-learning slope.

3 Theoretical background Serious Game

To develop a high-quality Serious Game some research has been done about theoretical learning principles and success factors of gaming. This theoretical background is crucial to:

- **Specify learning outcomes of the game**
- **Create a game design that reaches a deeper level of learning**
- **Create a motivating and engaging game**

[1] Cooremans et al. (2019). Play the game: learning about energy efficiency can be fun – seriously! ECEEE SUMMER STUDY PROCEEDINGS

[2] Frisk, E., & Larson, K. L. (2011). Educating for sustainability: Competencies & practices for transformative action. *Journal of Sustainability Education*, *2*(1), 1-20.

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In this chapter a summary of three learning principles and the success factors for gaming are described.

3.1 Learning theories

Here, a summary of three learning principles (,i.e. knowledge domains, Bloom's taxonomy and the learning outcome typology) is given and it is explained how they have been materialized within the R-ACES Serious Game.

3.1.1 Knowledge domains

As mentioned within paragraph 2.2, four different knowledge domains are identified by Frisk & Larsson (2011). Traditionally, information-based methodologies tend to focus on declarative knowledge: e.g. a more technical explanation of how a sustainable intervention can lead to a reduction of CO_2 emissions. Frisk and Larson (2011) argue that this single type of knowledge transfer is insufficient to stimulate action-oriented behaviour. A broader inclusion of knowledge domains is necessary to enhance the learning experience and motivate sustainable behaviour. This means including procedural, effectiveness and social knowledge. Therefore, the Serious Game aims to include all four of them. In table 1, the knowledge domains are described and linked to the theme of the Serious Game 'energy cooperation'.

Table 1: Different knowledge domains (based on Frisk & Larson, 2011)

Knowledge domain	Explanation	Meaning within the scope of energy cooperation
Declarative knowledge	Understanding of how environmental systems function	Understanding of technical and socio-economic conditions for the establishment of energy cooperation projects
Procedural knowledge	Awareness of how to undertake particular action	Awareness about the procedure of establishing an energy cooperation project
Effectiveness knowledge	Views of the outcomes of different behaviours	Understanding of what variables, e.g. business model, distance to neighbouring company etc., influence the environmental and financial outcome of your investment.
Social knowledge	Awareness of motives and intentions of other people or society	Awareness of the capacities, motives and intentions of your fellow participants regarding the participating in energy cooperation projects.

3.1.2 Bloom's taxonomy

The revised version of Bloom's taxonomy (see figure 1), developed by Anderson and Krathwohl's (2001)[3], describes the cognitive levels of an educational activity. These cognitive levels are based on knowledge dimension ranging from concrete knowledge to abstract and complex knowledge. The higher up in the hierarchy the more thinking skills are demanded from the student. Also, the higher you move up in the hierarchy, the more knowledge is acquired. The Serious Game will present different levels of Bloom's taxonomy, ranging from remembering and understanding, to evaluating. By doing so, a deeper learning experience is established[4].

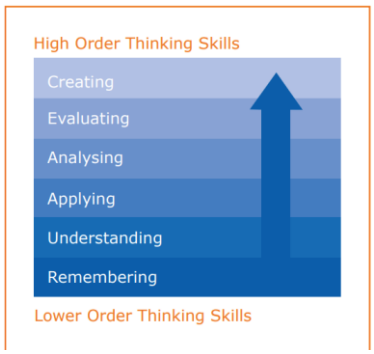

Figure 1: Bloom's Taxonomy (Source: Gordijn et al., 2018)

[3] Anderson, L. W., & Krathwohl, D. R. (2001). A taxonomy for learning, teaching, and assessing, Abridged Edition. Boston, MA: Allyn and Bacon

[4] Gordijn, F., Eernstman, N., Helder, J., & Brouwer, H. (2018). Reflection methods: practical guide for trainers and facilitators: Tools to make learning more meaningful. Wageningen Centre for Development Innovation.

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3.1.3 Learning outcome topology

Figure 2: Learning outcomes typology (Source: Gordijn et al., 2018)

A separation between three different learning outcomes can be made: knowledge, skills and attitude[4]. The Serious Game aims to move beyond traditional knowledge-based teaching methods and, therefore also includes both skills and attitudes as intended learning outcomes. Skills within energy cooperation projects concern negotiation, persuasion, trust-building, networking, handling conflict etc. Attitudes include intentions and motives for participating within an energy cooperation project or not. Both learning outcomes are addressed within various parts of the Serious Game.

3.2 Success factors of a Serious Game

To enhance the learning experience within the Serious Game "Heatopoly", various success factors for gaming are identified. The following success factors for Serious Games have been retrieved from Ravyse et al. (2016)[5] and GrowthEngeneering[6]:

1- **The game narrative**. Once the attention for attractive visuals wears off, game players are kept engaged through the game narrative or storyline.
   a. The aimed learning objectives should be intertwined in the storyline. However, there should be kept a balance between learning and playing while presenting the storyline to avoid players getting frustrated or annoyed.
   b. The possibility for the game players to (partly) create their own narrative can also keep them engaged. However, the learning style of the players can determine if one wishes to have a more linear gameplay (a game scenario with a fixed order) or an open-ended narrative. Preferably, the game adapts to the learning style of the player.
   c. The storyline should match the learning materials. If the story deviates from the learning content, players get confused which lowers their entertainment.
   d. Abstraction is necessary, while not reducing the learning effect of the game. This requires expert knowledge on the topic of the game.

2- **Realism**. The level of realism identifies how much the game resembles real life. In general, there applies: the more realistic a game is, the more appreciation it will gain.
   a. Be aware that factors that make the game more realistic (e.g. audio-visuals, game sounds, detailed role descriptions etc.) also add another level of complexity to the game. Overly complex audio-visuals or accurate role descriptions can therefore lower the effective learning. A balance between realism and details should be obtained.
   b. Creating your own player character can result in feelings of excitement and enable an opportunity for reflection. It can give the game more relevance and can help in a better immersion of the players within the game.

[5] Ravyse, W. S., Blignaut, A. S., Leendertz, V., & Woolner, A. (2017). Success factors for serious games to enhance learning: a systematic review. *Virtual Reality*, *21*(1), 31-58.
[6] https://www.growthengineering.co.uk/what-are-serious-games/

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   c. Competition or challenges are a main driving force for playing the game. This could be time pressure or beating a higher score. If the serious game feels like a fun game, it's probably successful. However, be aware that the competition element should support your learning objectives.
   d. A game provides a risk-free environment for making important decisions or practicing skills. However, adding consequences or risks to the actions in the game is essential to mimic a real-life situation.

3- **Interaction**. This is unique about serious games compared to other forms of entertaining education. Input and player actions result in certain consequences, also called game mechanics. Those game mechanics can keep the player involved.
   a. Simple interfaces are preferred to avoid frustration and an unnecessary cognitive load for the game players (especially for those with little gaming experience). They ensure that the focus is on the intended learning objectives.

4- **Feedback and debriefing**. Both in-game reward mechanisms and post-game debriefing can stimulate reflection, enhance the learning impact, and place the game into a greater context.

For the R-ACES Serious Game we tried to include all four elements for a successful game. A game narrative is created by adding an introduction to the game rules and by providing a narrative in the role description cards. Also, there is explicitly mentioned that participants are free to improvise, so that the players can create their own narrative. The level of realism is increased by basing the game on a real-life situation of a (partly failed) energy cooperation project in Moerdijk, the Netherlands. Furthermore, the Serious Game includes money and the approval of permits, so that there are consequences for the actions people take (just like in real-life). A balance between realism and simplicity is achieved through only using heat (no other energy units), only including temperature & excluding other factors to consider when building pipelines (e.g. pressure, soil type etc.) and having a limited number of chance cards (with a limited number of consequences). Thirdly, interaction is achieved within the negotiation round (where participants have to discuss for the establishment of energy cooperation projects) and in the action round (where participants can perform an action). The personal mission is included in the role description to add a driving force for playing the game. For the game itself, a simple interface is used, i.e. Mural, to ensure that the focus is on the intended learning objectives. Finally, a reflection handbook is added to enhance the learning impact.

4 Scope and Design

In the following chapter the learning objectives, game characteristics and target group are described. Together, they provide the scope of the Serious Game.

4.1 Learning objectives

The goal of the R-ACES Serious Game is to raise awareness of and encourage participants to participate in energy cooperation. To achieve this goal the following, more specific learning objectives have been formulated. Those learning objectives consider the four knowledge domains, different cognitive levels of Bloom's taxonomy and all three types of learning outcomes.

After playing the Serious Game the participants will be able to:

1. **remember** energy cooperation as a viable option for improving the energy efficiency of a region
2. **express** an understanding of energy cooperation; what it entails, it's advantages and disadvantages, and enabling or hindering factors
   a. Express an understanding of *technical/policy/social/economic factors* influencing participation in energy cooperation
3. **demonstrate** energy cooperation skills, e.g. building trust, negotiation, handling conflict etc. within an imaginative setting
4. critically **reflect** with a variety of stakeholders on their own and other's capacities, motives, intentions and possible future role to reduce emissions and achieve the EU climate targets.

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4.2Design

The design of the game follows the overall goal and learning objectives of the R-ACES Serious Game. It enables to construct a game design that closely links the foreseen behavioural change. Moving from learning outcomes to a more specific game design is defined as outcome-based education or constructive alignment (Biggs, 1996). Following this design method allows for a more integrated, relevant and better aligned learning activity.

4.2.1 Game characteristics

In this section, the characteristics of the R-ACES Serious Game will be described. These characteristics stem from consultations with R-ACES project partners. Also, they follow the defined objectives as described within the previous paragraph.

Table 2: Game characteristics of the R-ACES Serious Game

Part	Description	Learning objective	Duration	Number of players	Environment	Materials
A	Participants play a pre-assigned role of an actor within an imaginative region. The region aims to become an ecoregion through the establishment of energy cooperation projects and investment in renewable energy sources. Participants have to collaborate for the building of heat networks while at the same time compete to achieve their own personal mission. Besides, socio-economic conditions make the realization of heat networks a challenging task.	**Remember** energy cooperation as a viable option for improving the energy efficiency of a region. **Express** an understanding of energy cooperation; what it entails, it's advantages and disadvantages and enabling or hindering factors. **Demonstrate** energy cooperation skills, e.g. building trust, negotiation, etc. within an imaginative setting.	90 min.	6 – 12	Both online and offline	1. Game rules 2. Role description cards 3. PowerPoint Game Explanation 4. Mural environment 5. Score form in Excel File 6. Reflection Handbook
B	The group of participants collectively reflects on everyone's decision-making in the Serious Game and the different elements part of the Serious Game. Afterwards, some triggering questions are answered that encourage participants to think about their own motives and intentions for participation in an energy cooperation project.	Critically **reflect** with a variety of stakeholders on their own and other's capacities, intentions and possible future role to reduce emissions and achieve the EU climate targets.	45 min.	6 – 12	Both online and offline	A box including all necessary materials

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4.3 Target group

The target group includes all practitioners in the ecoregions that want to assess the potential and feasibility of joint energy services in this ecoregion. This includes representatives of all organizations in a region coming from industry, local and national government, and society. We expect ESCO, DHC managers, business park facilitators and energy professionals to be the first that are interested in the game.

In addition, the game can be used outside the ecoregions at educational institutes as a training/education tool as part of energy/sustainability courses. The multi-stakeholder collaboration in the game can provide a valuable and interesting learning experience for students studying complex societal systems (e.g. environmental sciences, public administration, behavioural sciences, communication etc.).

5 Development process

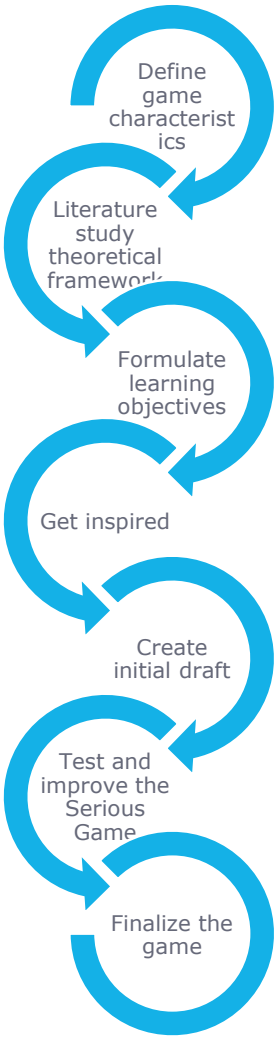

Figure 3: Development process of creating the R-ACES Serious Game

To develop the Serious Game several steps have been conducted, depicted in figure 3. Although the figure shows a linear process, the development process followed an iterative and agile order of going back and forth between different phases of the game development process. For example, a change in the reflection exercise also influenced the learning objectives of the overall game.

Within the following paragraphs the most important steps for creating the final version of the Serious Game are described. They explain the journey towards the final game version, but also the logic behind the game characteristics, game elements and game design. It explains the *what* and *why* of the game elements. Furthermore, it provides an overview of *how* the game has been validated.

1. Define game characteristics

In consultation with the R-ACES consortium the initial game objectives and game characteristics have been defined. Initially the game was supposed to be an offline board game, but because of the current COVID-19 situation there has been decided to also create an online version. The goal of the game was defined as 'get people interested in energy cooperation'. Although still following this objective, this goal has been extended towards 'to raise awareness of and encourage participants to participate in energy cooperation' which better represent the action-oriented focus of the game. Furthermore, initially there was decided to split the game up into three parts; A (easy game variant), B (difficult game variant) and C (reflection). During the development process there is decided to merge part A and B into one game. The reasons for this are (1) having limited time now that also an online game had to be developed, and (2) reducing the complexity of the game for the facilitator. Finally, the target group is defined as practitioners in an ecoregion who can join energy cooperation projects, but also policy-makers and students.

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2. Literature study theoretical framework

The R-ACES Serious Game aims to build upon existing knowledge of effective learning and success factors for Serious Games. Therefore, at the start of the game development process, a literature study has been co conducted. The information collected during the literature study provided a background on how to achieve a deeper level of learning, how to stimulate action-oriented behaviour and what factors create a successful (i.e. engaging, motivating and educative) game. The summary of the literature study is described in chapter 3.

3. Formulate learning objectives

Based on the defined game characteristic, e.g. game objective, target group etc. and the literature study, a more detailed set of learning outcomes has been defined. The learning outcomes describe what is expected from the participants after playing the Serious Game. Setting the learning outcomes at the start of the development process enables you to design a game that exactly follows your goals. This is called outcome-based education and is frequently used within educational institutions for setting up learning materials.

Throughout the game development process, the learning outcomes have been modified to keep the game objectives aligned with the game design. The final learning outcomes are described in chapter 4.1.

4. Get inspired

The development of a Serious Game is a creative process for which various sources of input have been used to get started with the game development. The inspirational sources were; an internet study of energy exchange examples, brainstorm sessions with people from the R-ACES consortium, interviews with energy brokers in the Netherlands and Belgium, meetings with energy experts, other Serious Games that relate to the topic of 'energy efficiency' (see Annex 2) and a literature study about social, economic, regulative and technical factors influencing stakeholder participation in energy cooperation projects.

Eventually, one online case was selected that serves as the basis of the game[7]. The storyline, type of companies, their heat information and role descriptions cards are (partly) based on information from this heat exchange example. Additionally, the interviews and brainstorm sessions with people from the R-ACES consortium served as complementary information/inspiration to create a comprehensive and diverse set of companies/stakeholders for within the imaginative area. The list of social, economic, regulative, and technical factors influencing the decision-making to participate in energy cooperation projects contributed to the creation of the different game elements (e.g. the permits, chance cards and information provided on the role description cards).
Finally, reviewing other Serious Games and/or simulations have influenced the set-up of the Serious Game, e.g. including a schematic map of the region in which different actors have to place pipelines to establish energy cooperation projects.

5. Create initial draft

The design of the game took place in Mural. Mural is an online environment in which various people can enter and interact through e.g. posting notes, moving objects, adding images and a chat function. It is often used to organize online meetings, but because of its simplicity it was decided to use this online environment to play the online game. Since Mural doesn't have a video call it does require to simultaneously have a second communication platform (e.g. Skype, Microsoft Teams, Zoom) running.

[7] See file:///Users/lottevandervelde/Downloads/Managementsamenvatting%20Groen%20licht%20voor%20EnergywegXL.pdf

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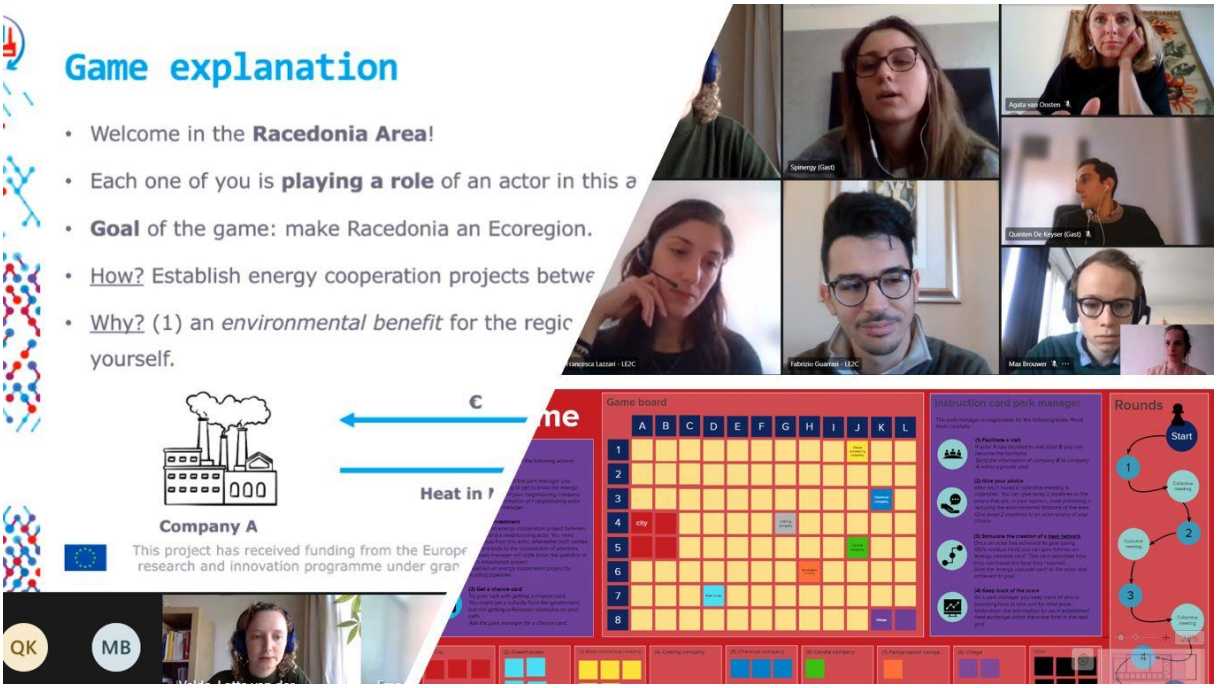

Figure 4: First time playing the R-ACES Serious Game

Within Mural a game board was developed. As mentioned within the previous paragraph there was chosen for a game board that represents a map of the imaginative region, called R-ACEDONIA. Making use of a geographical game board enables you to visualize one of the most important conditions for the establishment of an energy cooperation project, 'distance'.
Furthermore, it was decided to play the game with pre-assigned roles. This reduces your flexibility of playing the game several times (since after playing the game everyone will already know the other actors and their personal goals) but does enable the participants to better immerse themselves within the imaginative setting. Because most participants will only play the game one time, the latter option was chosen. Finally, the goal of the game was set as 'reducing the energy consumption of the R-ACEDONIA area'.

Game elements that were a part of the game from the beginning are:

- *Heat* is the only energy unit that is used. Electricity and cooling could have also been included, however, to create a balance between realism and simplicity it was chosen to only include heat.
- The game has a limited number of rounds. In each round every actor can perform 1 action.
- Participants can establish energy exchange projects by putting pipelines on the game board.
- Within the role description cards, technical information is provided regarding the heat supply/demand of each actor.
- There are rules for establishing energy cooperation projects. These rules follow real-life conditions for the establishment of energy cooperation projects.
- The different actors don't know from each other what the heat information is. Therefore, an introduction round is necessary. It includes trust-building as a skill to cooperate.
- Chance cards give a context to the game (they help in building a narrative), provide an interactive element (which stimulates engagement) and show that energy cooperation projects are sometimes a matter of luck (and by doing so increase the level of realism).

Additional materials that have been developed for playing the Serious Game were:

- An Excel sheet in which you can easily keep track of the score. This is developed for the online game version.
- A PowerPoint presentation that briefly introduces the concept of 'energy cooperation'. It is shown at the start of a game session and applicable to the online version.
- A reflection handbook in which various reflection activities are presented. It is up to the facilitator to decide what reflection activities are best fitting the audience.

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From the online version the offline version has been developed. The differences between the two versions are limited. Within the offline version the permits are more elaborate (including different parties to add a signature to the permit) and a player desk is missing (but also not necessary since everyone will be able to have all relevant items, e.g. coins, in front of them). Furthermore, the procedure of playing the game (and also facilitating the game) will be different. Where in the online version you meet on Teams/Skype/Zoom and have the possibility to show a PowerPoint presentation (as game explanation) within the offline version you have to present the game explanation without the help of an online presentation. Also, the game rules and facilitation handbook slightly differ for the online and offline game version.

6. Test and improve the Serious Game

In total a number of 6 test sessions is played to improve and validate the Serious Game (see table 3). The test sessions have been played with varying people, e.g. students, energy experts etc., to ensure that everyone from within the target group has been part of the testing phase.

Table 3: Test sessions R-ACES Serious Game

Date	Number of players	Target Group	Countries targeted	Online/ Offline
31-mrt	8	Consortium members	NL, BE, IT	Online
7-apr	9	Students	NL	Online
15-apr	8	Consortium members	NL, BE, IT, DE, G	Online
30-apr	8	Trainees	NL	Offline
30-apr	11	Trainees	NL	Offline
1-jun	10	Energy Brokers, Energy Traineeship	NL, BE, IT	Online

After each test session a round of feedback was facilitated in which all participants could share what they like and/or didn't like about the Serious Game. It resulted in many adjustments of the Serious Game. The most important changes that have been made are:

- Instead of only having one collective goal, i.e. reduce the energy consumption of the area, also an individual goal has been added. The individual goal is presented on the role description card as a 'personal mission'. This additional element increases the competition within the game and therefore enhances the engagement. Also, the level of realism increases since it is often difficult to satisfy the needs of all energy practitioners.
- Within a previous version of the game, you had to gather information from neighbouring actors as part of an action in an action round. This action has been deleted so that a continuous debate about the region's or company's strategy (of where to invest in) is possible. It enables the participants to better practice energy cooperation skills, e.g. negotiation, trust-building, handling conflict etc.
- The number of rules for the establishment of an energy cooperation project has been reduced to three rules. Initially the pressure (i.e. amount of bar) going through the pipelines was included as a condition for the establishment of an energy cooperation project. To simplify the game (especially for those that are not technically skilled) this factor is not used anymore.
- The scope of the game is broadened by including renewables, a heat exchanger, and a heat pump. This makes the game more fitting to the R-ACES project, that also stimulates the use of renewables and establishment of district heating networks. The heat exchanger and heat pump enable the creation of a bigger district heating network within the imaginative region.
- Some procedural elements for the creation of an energy cooperation project have been included, i.e. you have to ask for a permit before being able to build pipelines. It makes the game more realistic and addresses the procedural knowledge as described in paragraph 3.1.1.

7. Finalize the serious game

At the end of the game development trajectory, the game is finished and designed. The materials for the game have been finalized; the game rules, Mural environment, Powerpoint Presentation, score form and role description cards (see figures 5-7). Also, these materials are designed by a

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professional designer so that the game presents the R-ACES look and feel. Furthermore, partners from the R-ACES consortium are trained to facilitate the game themselves. A workshop of ‘*how to facilitate the Serious Game*’ is given and simultaneously a handbook about this is written. It enables the various project partners to play the game within their region.

Figure 5: Final layout of the online version (MURAL environment)

Figure 6: Box of the offline version

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Figure 7: Content of the offline version

Figure 8: Impression of playing the offline version of the serious game

6 Concluding remarks

The R-ACES consortium is very happy to present the Serious Game “Heatopoly” to you. We believe that this game is great to make people aware of the energy cooperation concept. Our experience is that the game does make people very enthusiastic to take concrete actions. If you have any questions or remarks, feel free to contact us: christa.deruyter@ispt.eu.

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Annexes

Annex 01

R-ACES definitions

Business park: An area of land in which many office buildings are grouped together with a common infrastructure (Wikipedia). Business parks, like industrial sites, often have similarities in heating and cooling demand. Certain businesses may even have residual energy streams, for example data centers. As such, business parks may also organize as an ecosystem or eco business park (EBP) and become an important stakeholder within an ecoregion.

Eco Business Park: *"An eco-industrial park is a community of businesses located on a common property in which businesses seek to achieve enhanced environmental, economic and social performance through collaboration in managing environmental and resource issues. This is known as industrial symbiosis, which is a means by which companies can gain a competitive advantage through the physical exchange of materials, energy, water and by-products, thereby fostering inclusive and sustainable development."* (United Nations Industrial Development Organization)

Communicate: professional and public coverage of the project results and achievements, benefits and potential deployment. This will be realised via the adoption of a large variety of distribution channels, including already existing platforms focusing on energy cooperation in industrial sites and business parks and energy exchange/cooperation at large.

Disseminate: exploitation of the project results to relevant stakeholders in the regions. It intends to ensure a low threshold in accessibility, usage of R-ACES tools and methods. This includes access to the tools, to the use case libraries and to the training and capacity building material and related self-explanatory instruction manuals.

DHC: Abbreviation of District Heating and Cooling. A system for distributing heating/cooling generated in a centralized location through a system of insulated pipes for residential and commercial heating requirements such as space heating/cooling and water heating/cooling.

> 4th generation DHCs: *"4GDH systems provide the heat supply of low-energy buildings with low grid losses in a way in which the use of low-temperature heat sources is integrated with the operation of smart thermal grids. Smart thermal grids consist of a network of pipes connecting the buildings in a neighbourhood, town centre or whole city, so that they can be served from centralised plants as well as from a number of distributed heating and cooling producing units (or decentralised units) including individual contributions from the connected buildings. The concept of smart thermal grids can be regarded as being parallel to smart electricity grids. Both concepts focus on the integration and efficient use of potential future renewable energy sources as well as the operation of a grid structure allowing for distributed generation which may involve interaction with consumers."* (adapted from Lund et al, Energy 68; 2014, p1-11).
>
> 5th generation DHCs: *"5GDHC is a highly optimized, demand-driven, self-regulating, energy management system for urban areas. Its key features are: 1) ultra-low temperature grid with decentralized energy plants; 2) closed thermal energy loops ensuring hot and cold exchange within and among buildings; 3) integration of thermal and electricity grids."* (D2grids, Interreg NWE)

Ecoregion: An ecoregion within the R-ACES project is a geographic area where energy and information exchanges occur between stakeholders of various types to reduce energy consumption. Geographical size does not matter (the size of an ecoregion can be as small as a business park or as large as a city). Important is that an ecoregion relies on an anchor organization responsible for managing the area (for example park management). Another aspect is the proximity of stakeholders in order to ensure interconnected energy flows (continuity of supply, quality of supply, quantity). Within an ecoregion, a wide range of assets could be involved: office parks, data centers, multimodal centers, technological centers, agro-centers, science parks, brain parks, lighthouse parks, chemical

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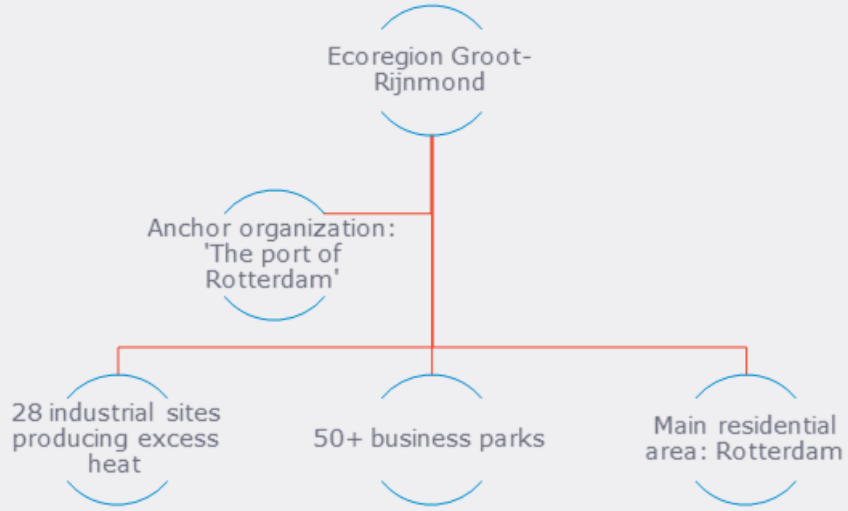
parks, eco-industrial parks, and cluster/business parks. For the demand of heat, also residential areas could be taken into account. As such, the term ecoregion functions as an 'umbrella term'.

Example of a high priority/ high impact ecoregion

An example of a high priority/high impact ecoregion is the Groot-Rijnmond region in the Netherlands. According to the Heat RoadMap the region belongs to priority group 1. The conventional excess heat is 179.65 PJ and the total heat demand is 35.53. Demand and supply are located close to each other. This means that the region has a high potential impact on primary energy savings (KPI 1). A main anchor organization of the region is 'The port of Rotterdam'. Within the region, there are 28 industrial sites that produce excess heat. There is also a large number of business parks (50+). Considering the large number of industrial sites and business parks present, the region also has a high potential impact on KPI 3.



High priority region: A high priority region is an Ecoregion, as defined above, that has balanced potential match of heating/cooling supply and heating/cooling demand in both quantitative (amount of heating/cooling) and qualitative (temperature, form of heat) terms. The region should be identified by heat roadmap studies (for example, the Heat RoadMap Europe or Stratego) or other research activities. In addition, the regions should have networking possibilities. The regions can include industrial sites, business parks and residential areas.

The table below gives an indication of the priorities. R-ACES will focus on priority group 1 +2.

Table 2.19. Excess heat ($E_{heat,o}$) and heat demand (Q_{tot}) characteristics for the definition of priority groups to identify heat synergy regions

	Characteristics			
Priority group	**Excess heat[a] [PJ/a]**	**Heat demand[b] [PJ/a]**	**Priority status**	**Comment**
1	$\Sigma E_{heat,o} > 10$	$Q_{tot} > 10$	Very high	High levels of both $E_{heat,o}$ and Q_{tot}
2	$1 < \Sigma E_{heat,o} < 10$	$Q_{tot} > 10$	High	Moderate levels of $E_{heat,o}$ and high Q_{tot}
3	$\Sigma E_{heat,o} > 10$	$1 < Q_{tot} < 10$	Moderate	High $E_{heat,o}$ and moderate levels of Q_{tot}
4	$1 < \Sigma E_{heat,o} < 10$	$1 < Q_{tot} < 10$	Low	Both $E_{heat,o}$ and Q_{tot} at moderate levels
0	$\Sigma E_{heat,o,max} < 2.5$	$Q_{tot,max} < 25$	No priority	Both $E_{heat,o}$ and Q_{tot} at low levels

[a] Maximal theoretical levels of annually available excess heat.
[b] Space heating and domestic hot water preparation in residential and service sectors.

High potential region: Within the project proposal, sometimes the term high potential ecoregion is mentioned. From now on, this term will not be used within the scope of the R-ACES project.

High impact (in R-ACES terms): Regions that have a high potential impact on the R-ACES KPIs. More specifically, regions are meant that have a high potential impact on KPI 1: Primary

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energy savings, and KPI 3: Number of plant sites and number of industrial parks where businesses commit to energy cooperation.

Energy cooperation: Energy cooperation activities between industries, which include physical clustering (e.g., of buildings and processes, energy exchange, collective production) and/ or service clustering (e.g., joint contracting). Both can deliver a more stable cumulative demand, economy of scale for larger installations with higher efficiencies and smaller spatial footprint and an optimized demand response. Within R-ACES, the focus is mainly on energy cooperation through the exchange of heating and cooling.

Energy management Platform: is an ICT-tool that makes energy flows transparent; allows energy consumption and production to be allocated to specific installations, stakeholders and nodes; and identifies anomalies and opportunities. A key feature is that it is very easy to use for a wide range of stakeholders. In this way, it is possible to deploy it in a cluster and give access to the different company and cluster managers – each at their level of detail and with the information they should have access to. On the ecoregion level, there will be a dashboard that shows different energy flows.

ESCO: Abbreviation for Energy Service Company. An ESCO is a business that provides a broad range of energy solutions including designs and implementation of energy savings projects, retrofitting, energy conservation, energy infrastructure outsourcing, power generation and energy supply, and risk management.

Facilitator: someone who helps to bring about an outcome (such as learning, productivity, or communication) by providing indirect or unobtrusive assistance, guidance, or supervision. This task does not include technical expert know-how, instead facilitators are trained to facilitate interaction between multiple actors.

Industrial cluster: Within the project proposal, sometimes the term Industrial cluster is used. From now on, this term will not be used within the scope of the R-ACES project.

Industrial park: Within the project proposal, sometimes the term Industrial park is used. From now on, this term will not be used within the scope of the R-ACES project.

Industrial region: Within the project proposal, sometimes the term Industrial region is used. From now on, this term will not be used within the scope of the R-ACES project.

Industrial site: An area zoned and planned for the purpose of industrial development. An industrial site can be thought of as a more "heavyweight" version of a business park or office park, which has offices and light industry, rather than heavy industry. They may contain oil refineries, ports, warehouses, distribution centres, factories, and companies that provide manufacturing, transportation, and storage facilities, such as chemical plants, airports, and beverage manufacturers (Wikipedia).

(R-ACES) Learning community: Local group of stakeholders that are (a) directly involved with the energy collaboration on a site; and (b) engaging in both organised and informal exchange of knowledge and best practices over the course of the project period. These groups are the first beneficiaries of instruments like serious gaming. Learning communities from different sites in this project will eventually be brought into contact with each other to further stimulate the exchange of best practices.

Learning network: *"Allow for enduring relationships built on trust to develop among companies within an industrial site. In turn these relationships encourage information sharing, creative solutions, long term planning and governance among stakeholders. Social aspects increase interactions among stakeholders and strengthen collaborations and partnerships including industrial ones"* (Scaler, 2018). To establish such learning networks, the R-ACES project will use learning communities.

(R-ACES) Legal tool: A tool that supports practitioners by giving the legal decision support for joint contracts. A low threshold for usage is a critical requirement. The tool is self-explanatory, application oriented, using well-defined and clear terminology. The tool should be able to deal with a high diversity of local situations. For practical reasons, the name of the legal tool might change during the R-ACES process. In this case, the consortium will be informed.

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LESTS framework: Abbreviation for Legal, Economic, Spatial, Technical and Social/Managerial. LESTS is a framework that is used in the project to categorize barriers and drivers in ecoregions. The different categories include: Legal, e.g. liabilities, regulatory requirements, third party contracts, service agreements, rules; Economic, e.g. cost savings, waste/ resource recovery value, funding mechanism, taxes & environmental considerations; Spatial, including geographical proximity, planning rules and environmental considerations; Technical, e.g. sharing and cascading resources, system stability, facilities; Social/Managerial, e.g. with regard to workers, consumers, local communities employment, community engagement, and capacity building.

Lock-in: Exchange of by-products will lead to long term reliance on an outside company, which will restrict flexibility of the involved companies and possibility for innovation, or possibility to relocate the site.

Longlist (for example longlist of regions): Exists of lists of items (rows), for example regions, that have been selected on the basis of loose selection criteria (columns). The long list is a first step in creating a short list. The long list should cover all potential subjects that might be of interest to the short list. Example:

Region	Region	Country	Source	# DHCS	# Industrial sites	# Business parks	Contact person	Contact details
1	Maasvlakt	Nederland	...					
2	Chemelot	Nederland	...					
3	Terneuzen	Nederland	...					

Long-term: Long-term impact of R-ACES is gained after the end of the R-ACES project (in KPI terms).

Peer2peer: A network of peers (R-ACES stakeholders) that perceive each other as equal. The peers interact with each other in order to learn from each other. The peer2peer learning context is a formal or informal setting, in small groups or online. Pear learning manifests aspects of self-organization. By this is meant, that there is no hierarchical structure within a peer2peer network (Wikipedia).

(R-ACES) Self-assessment tool: A tool that helps ecoregions to determine the next steps they have to take in the energy cooperation process. The tool exists of a number of questions practitioners have to answer. Based on the answers, the practitioners will get a score and some practical considerations they should take into consideration.

Serious gaming: A method for learning-through-experience that presents participants with a case study in which they have to play pre-assigned roles to each reach a pre-defined objective as quickly as possible. The interactive & competitive gaming element increases the attractiveness and the learning outcome of the case study. Serious gaming addresses cooperation elements among a large variety of practitioners and focus at creating acceptance and awareness, where the learning communities focus at sharing experiences between peers.

Shortlist (for example shortlist of regions): List of items, for example regions, that have been selected from a long list on the basis of (strict) selection criteria. Hereby, the advantages and disadvantages of each item are considered (OpenLearn). The shortlist contains items that have a high potential and likelihood to contribute to the R-ACES goal.

Short-term: Short-term impact of R-ACES is gained during the R-ACES project.

Use case: A written description of the sequence of steps performed by an ecoregion to come to fruitful energy cooperation.

Use case library: A library that contains multiple use cases.

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Annex 02: Overview existing games on energy cooperation

Below, an overview is given of a number of already existing serious games on energy cooperation. These games could be an inspirational source for the R-ACES serious game. One of them does fit the R-ACES requirements so well, that we might decide to include the game as an option in our learning community meetings. The list does not include any games that are only accessible if one pays a high fee because we orientate at low threshold materials for our learning communities. Within the table, every available game got a colour code:

1 **Blue: Game that can potentially be promoted by R-ACES consortium, because it matches the requirements**
2 **Purple: Game that can potentially be promoted by the R-ACES consortium. However, some modifications are necessary (for example translation).**
3 **Red: Game that does not fit the scope of the R-ACES consortium/ is not available .**

Game	Goal	Main player profile	Game type	Storyline	Mission world	Personalization	Rewards	Competition element	Language	Form	Time	Players
M-benefits[8] (Open source)	Get insight in the need of taking strategic, financial, organisational and human factors into account	Energy management professionals	Simulation and role-playing	Complex	In-game, based on real-world business case	None	Points	Against oneself	English	Online	2,5 days	3-5
Hydrogen game	The game puts players in the shoes of politicians, researchers, carriers transporting packages, producers or distributors of fuel. Together they are responsible for	A wide range of participant groups in a variety of settings	Simulation	Simple	A serious game about the transition to hydrogen-based transportation	None	-	-	Dutch, English	Offline – facilitated workshop sessions	2 hours	8-13

[8] https://www.mbenefits.eu/static/media/uploads/site-6/library/Deliverables/d4.4-serious_game-final.pdf

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	making a transition to hydrogen mobility.											
Energy transition model	Build a scenario to get insight in the influence of certain decisions on the future energy system	Energy professionals	Scenario builder	Complex	Build a scenario for the future energy system of a country	None	None	-	English	Online	1 day	1
Greencompany game	Give a picture of what’s involved in marketing a green heat product, as well as the interplay between government and industry	Energy professionals	Simulation	?	the development and consumer marketing of ‘green heat’	None	-		English	Offline – facilitated workshop sessions by CE Delft	3 hours	5-25
Carbon XXL Game	developed to see how ETS works in practice	Students & energy professionals	Simulation	Simple		Yes	Survival of the company	Against other companies participating in the game	English	Offline - facilitated workshop form by TNO	3 hours	10

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Energy transition model	Give insight in the different issues related to the energy transition	Students	Simulation	Simple	Make the energy system of a country	None	Get points on different items:	Against other players	English	Online	15 minutes	1
We-energy	Create awareness about the energy transition challenge	Students, energy management professionals	Board game with different roles	Simple	Make a city energy neutral	Yes	Get points on different items: profit, planet, people, balance, law	Againts oneself	Dutch	Offline – facilitated workshop form by We Energy or play yourself	3 hours	5-6
We heat game	Create awareness about the heat transition challenge	Students, energy management professionals	Board game with different roles	Simple	Make a city energy neutral	Yes	Get points on different items: profit, planet, people, balance, law	Againts oneself	Dutch	Offline – facilitated workshop form by We Energy	3 hours	5-6
CO Reduction game	Activate a discussion on industrial CO2 reduction	Students, energy management professionals	Board game that aims to initiate a dialogue	Simple	Make the Dutch industry climate neutral and profitable	No	CO2 reduction and money	Againts oneself	Dutch	Offline – facilitated workshop form by ISPT	1,5 hours	
We-energy	Create awareness about the energy transition challenge	Students, energy management professionals	Online game	Simple	Make a city energy neutral	None	Get points	Againts oneself	Dutch	Online	10 minutes	1
Climate cooperation game (Open source)	Create awareness about climate change	Everyone	Simulation	Simple	Save the climate on global scale	None	Saving the climate by setting high carbon prices	Together to save the climate – prisoners dilemma	English	Offline/ online	1 day	6-12
KSE Agent	Create awareness about the energy system in Poland	Students	Simulation	Simple	Make Poland environmental friendly	Yes	-	Against oneself	Polish	Online	2 hrs	Single mode or multiplayer mode

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