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Intellectual output 3. Educational support content targeting instructors

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Executive summary

This document introduces a collection of end-to-end learning activities designed on the HERA serious game for building problem-based learning skills. The purpose of the activity descriptions is to foster the deployment of the HERA game in learning. Activities may be used directly by educators to engage students. They may also provide inspiration for the design of additional educational scenarios.

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1. City preparedness for Covid-19

Topic: preparedness, prevention, infection, control

1.1 Introduction

The current Covid-19 pandemic constitutes a global emergency. All regions of the world are affected, with the disease having spread often too quickly for cities to organize a response.

The Covid-19 pandemic has the potential of challenging even well-designed health systems. In the absence of a solution such as a vaccine, addressing the current Covid-19 pandemic requires well thought planning for stopping the spread of and limiting the harm from the disease. Cities need scaling-up their health care plans within existing budgets for ensuring that citizens receive the necessary care for overcoming infection at home or in the hospital.

As the number of cases increases, cities need to develop additional health care infrastructures, such as hospitals or smaller scale facilities, as well are supporting services for access and education in relation to desirable behavior that helps contain the pandemic.

1.2 Context

The game is situated in a city that needs to prepare for preventing the spread of Covid-19 infection through infrastructure and planning. The city authorities need to plan for ensuring that health care facilities are adequate for the population of the city.

Figure 1. The scenario starts with a basic city that includes housing as well as energy, internet, and phone networks.

Role 1: **Health care response planner**

The response planner aims to ensure that health care facilities, such as hospitals and other services, are adequate for addressing the needs of the city population. To achieve this goal, she must build hospitals in easy to access locations that address the needs of different neighborhoods in the city. This task may require changing the function of existing buildings if there is not enough space in dense areas

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for building new ones. Finally, the response planner must ensure that health care services are equipped with the appropriate vehicles for transporting patients.

Figure 2. Students are called to introduce city enhancements that support health provision to inhabitants.

Role 2: **Urban planner**

The urban planner designs a traffic network that ensures easy access through roads to health facilities around the city. The urban planner further develops energy, internet, and telephone infrastructures that are critical communication and an effective response to Covid-19.

Role 3: **The city mayor**

The city mayor is responsible for ensuring the smooth function of all city services and that quality of life is high in the city. In practical terms, for the scenario purposes this means that citizens are happy. The city mayor is also responsible for ensuring that the city financial resources are responsibly used towards building the necessary infrastructure. The mayor can contribute to the development of infrastructure as well as businesses and industrial activities that contribute to city revenue.

Role 4: **Education planner**

The educator aims to raise awareness on the characteristics of the virus and to build knowledge on how responsible behavior helps contain the pandemic. The education planner builds educational and cultural facilities that may be used for awareness building and response training in relation to Covid-19.

The following picture demonstrates the activities of each role and the interaction between them.

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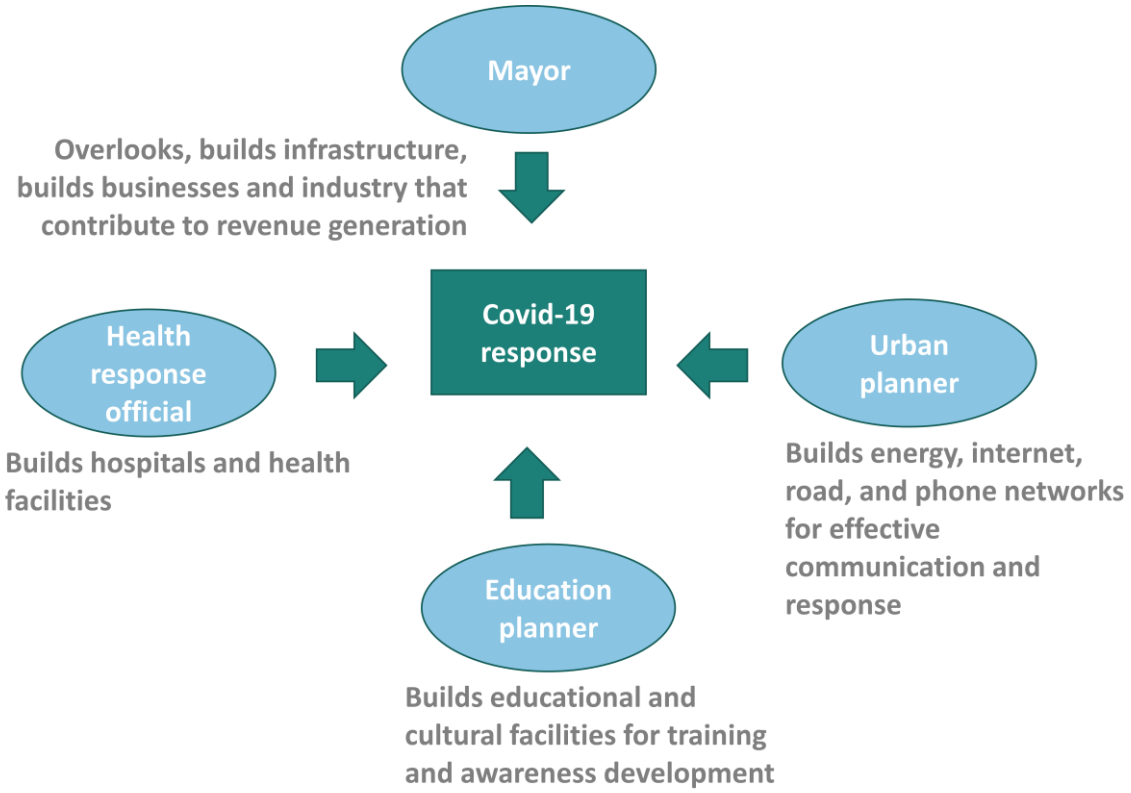

Figure 3. Role actions and dependencies.

1.3 Learning goals

Upon completion of the activity students will:

- Understand the threat and consequences of the Covid-19 pandemic.
- Have developed critical thinking towards synthesizing a coordinated response towards addressing the pandemic, containing the spread, and minimizing the harm.
- Have developed responsible behavior in the pandemic area.
- Have experienced how to achieve cooperation between different parties with different goals and needs.
- Have built capacity to prioritize objectives and to work within a specific budget.

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1.4 Prerequisites

The activity is built on the common experience of all individuals today in relation to the Covid-19 pandemic. It does not require extensive medical knowledge. Rather, it requires students to be exposed to the emerging challenges that society faces today in relation to pandemics.

1.5 Audience

The activity is interest to all engineering and economics as well as more general audiences. It can be deployed for raising awareness on pandemic challenges and management.

Figure 4. Office buildings provide working space for city economic activities.

1.6 Core concepts

- **Pandemic:** An epidemic of an infectious disease that has spread across a large region and affects a broad number of individuals.
- **Virus transmission response and preparedness:** A strategy and plan for addressing the spread of a virus and reducing harm.
- **Emergency care:** The first point of contact of the health system with infected individuals.

1.7 Description of the scenario

The overall objective is to design an appropriate response and preparedness plan for addressing the Covid-19 threat and minimizing the harm from the pandemic.

This can be achieved by designing a comprehensive strategy that addresses therapy measures at home and in the hospitals while at the same time educating citizens on how they can contribute to containing the spread.

Students are encouraged to think out of the box and to introduce alternative potential ideas the combination of which may lead to a city-wide strategy for protecting public health.

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1.8 Class activity

1. The teacher presents the problem to the class and introduces the scenario and game.
2. The students are challenged to critically analyze the problem and to reflect on how the pandemic affects individuals, communities, social cohesion, and the economy.
3. The students are encouraged to introduce a breath of ideas towards mitigating the spread of the virus. The ideas do not necessarily need to be a complete solution, but each may address a specific aspect of emergency preparedness and response.
4. The students are asked to prioritize their ideas and to select the ones that will be integrated into a cohesive response plan.
5. The teacher allocates roles and allows the necessary time for students to explore the learning scenario through the HERA game.
6. The students play the game according to their roles striving to achieve individual and group objectives.
7. The students discuss their experiences, findings, and results; the teacher and their peers provide feedback.

1.9 Assessment methods

The activity is open-ended and aims to build student awareness on the Covid-19 threat, to encourage them to behave responsibly, and to build critical thinking towards understanding Covid-19 response solutions. There is not a single correct answer to the problem. Rather, student teams introduce their own solutions. A class discussion follows in which the students can present their work, to see that of others, and to reflect on different approaches. Students receive constructive feedback from the teacher and their peers. Alternatively, during the class discussion a common solution may be introduced that combines the suggestions of all teams.

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2. How to create a city: energy grids

Topic: creating basic energy infrastructures in HERA

2.1 Introduction

This learning sheet builds practical, hands-on skills on how to develop a city in the HERA learning game. It is a step-by-step tutorial that familiarizes students and educators with the basic functionality of the HERA game, that they will need for creating more complex learning scenarios and/or for playing the game.

Creating a city simulates real-life urban design. Students and educators will be challenged to introduce installations and services that enrich quality of life, such as housing, commercial buildings, education provifders, industry, farms, health providers, cultural providers, energy providers, telephone providers, internet providers, roads, parks, and more.

This learning sheet demonstrates how to create an energy grid in a HERA city.

2.2 Context

The activity may be used as a starter kit, to get students and instructors familiarized with the HERA game functionality. It may be used as a pre-requisite, to be deployed before focusing on more complex game scenarios.

2.3 Learning goals

Upon completion of the activity students will be able to design an energy network for a functional HERA city.

2.4 Prerequisites

Students need to have a basic understanding of the function of electricity grids. The activity may be deployed as a first step for initiating students and instructors into the HERA problem-based learning intervention.

2.5 Audience

Engineering and economics students and instructors using the HERA game for developing problem-based learning skills.

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2.6 Core concepts

- **Electricity:** Electricity is necessary for the functioning of all buildings and infrastructure of the city, including houses, offices, industry, farms, hospitals, museums, schools, commercial buildings, and a lot more.
- **Energy grids:** Energy infrastructure, including diverse energy production plants, such as nuclear, coal-based, or renewable energy based, energy transformers from high, to medium, and low voltage, and power lines that transport energy to homes, businesses, and industry.
- **High voltage:** High voltage electricity is produced by power plants. To be used for powering industry or residences, it needs to be transformed to medium or low voltage.
- **Medium voltage:** Medium voltage electricity is typically used to power industrial plants.
- **Low voltage:** Low voltage industry is typically used to power residences.
- **High to medium voltage transformer:** A facility that transforms energy from high to medium voltage, suitable for industrial use.
- **Medium to low voltage transformer:** A facility that transforms energy from medium to low voltage, suitable for residential use.
- **Road grids:** Road networks allow the different parts of the city to interconnect. In HERA, they are obligatory for a proper function.

2.7 Description of the scenario

During the activity students design a functional energy network, including energy production facilities and power lines that transport energy to houses, commercial buildings, industry, hospitals, educational buildings, and other city infrastructure.

To ensure that the network works properly, students and educators need to follow specific guidelines described below.

2.8 Suggested class activity

1. Create a small neighborhood with houses by selecting the housing button ( ) at the bottom of the screen menu (see Figure 5 below). Each house shows through a

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thumbnail above it its needs for functioning properly. In this case, the house needs a road for accessing it ( ) and low voltage electricity ( ).

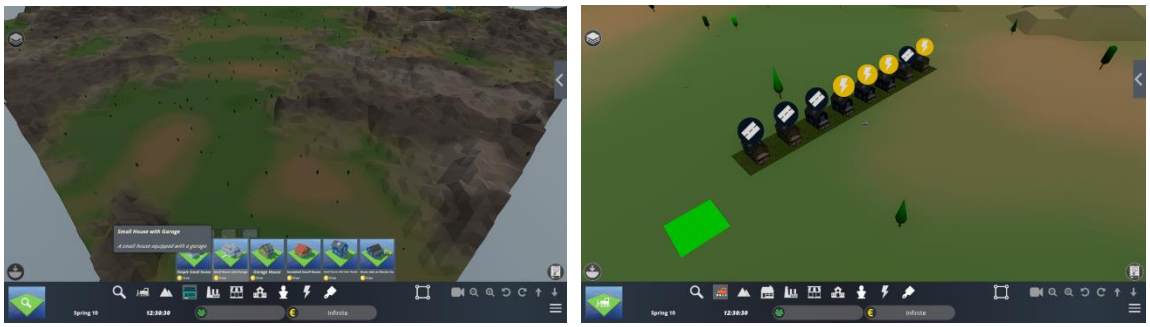

Figure 5. Create a small neighborhood with houses by selecting the housing button (left). Each house shows its needs for functioning properly, such as a road and low voltage electricity (right).

2. Build an electricity plant by selecting the infrastructure button, then the energy tab. For this example select a nuclear power plant, although any type will work. You may install the power plant at the edge of the city.

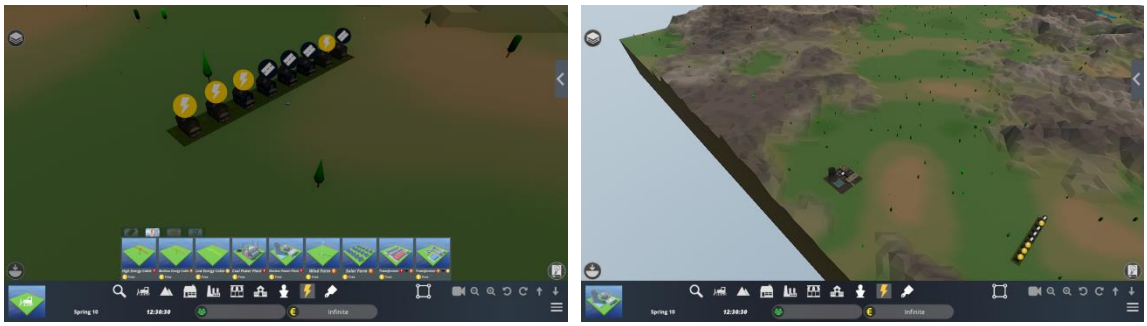

Figure 6. Build a nuclear power plant by selecting the infrastructure button, and then city energy (left). You may install the plant at the edge of the city (right).

3. Introduced energy voltage transformers next to the power plant: a) a high to medium voltage transformer and b) a medium to low voltage transformer. You may do that by clicking on the infrastructure button, then the energy tab at the bottom of the screen menu (see Figure 7 below). Through the thumbnails at the top of each installation you can see that the power plant needs a road; the high to medium voltage transformer needs to be connected to the power plant with a high voltage cable ( ); and the medium to low voltage transformer needs to be connected to the high to medium transformer with a medium voltage cable ( ). Connect the transformers using the

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appropriate cables for high ( ) and medium voltage ( ) respectively using the infrastructure button and then the energy tab at the bottom of the screen menu.

4. Build a road that reaches the power plant and each of the transformers (see Figure 7 below). Now you see that the power plant and transformers work properly, as no thumbnails appear on top of the installations.

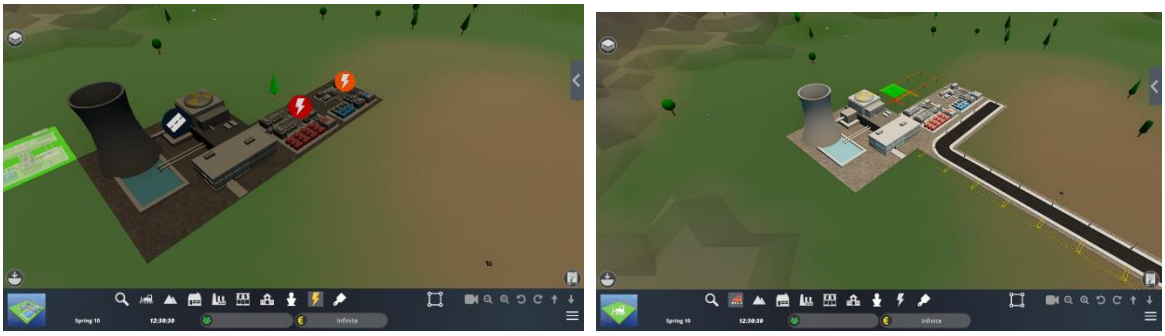

Figure 7. Build high to medium and medium to low voltage transformers next to the power plant (left). Connect them with the appropriate cables and build a road (right).

5. Make sure that the road connects the power plant with each house. Make sure that the houses are connected to the power plant with a low energy cable ( ). Select the low energy cable using the infrastructure button and then the energy tab at the bottom of the screen menu (see **Error! Reference source not found.** below). You will notice that the houses now function properly, as no thumbnails are highlighted over any house.

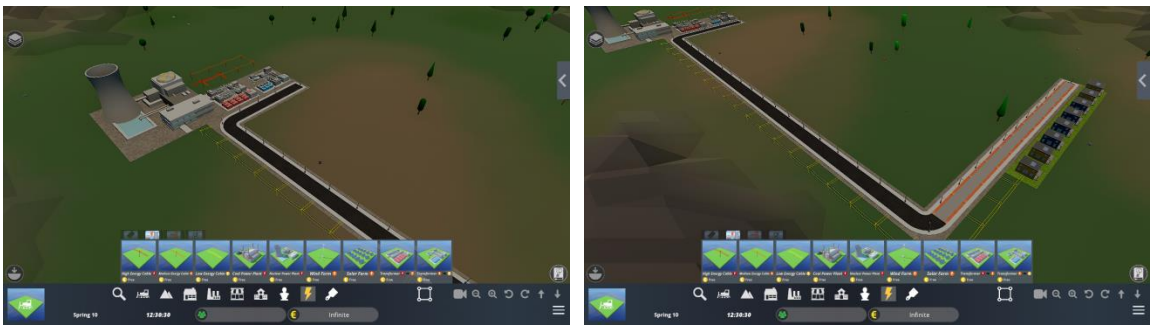

Figure 8. Make sure that the power plant is connected to the houses with a road and a low energy power cable.

6. You may also add some parks to the neighborhood. To do that, click on the public services button at the bottom of the screen menu and then select parks (see **Error! Reference source not found.** below). You will notice through the thumbnails

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appearing on top of each park that they need a road to function properly. Add a road, and your scenario is complete.

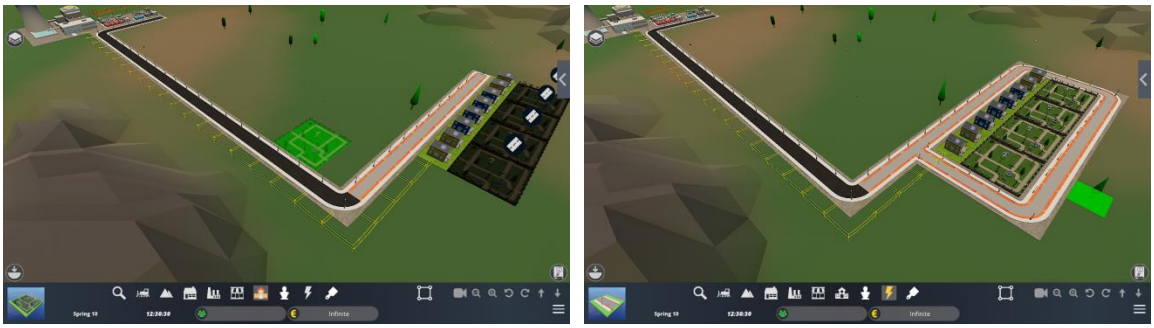

Figure 9. The user may add parks to the neighborhood (left); for the parks to function properly you need to make them accessible through a road (right).

2.9 Assessment methods

This activity aims to build basic skills on the deployment of the HERA learning game. Assessment of the skills developed may be performed using authentic models, namely models that encourage students to demonstrate the newly developed knowledge hands-on. More specifically, students may be asked to demonstrate the creation of a city for the benefit of themselves, their fellow students, and the instructor. Alternatively, students may be asked to submit a video recording in which the creation of their city is demonstrated.

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3. How to create a city: internet network

Topic: creating basic internet and phone networks in HERA

3.1 Introduction

This learning sheet builds practical, hands-on skills on how to develop a city in the HERA learning game. It is a step-by-step tutorial that familiarizes students and educators with the basic functionality of the HERA game, that they will need for creating more complex learning scenarios and/or for playing the game.

Creating a city simulates real-life urban design. Students and educators will be challenged to introduce installations and services that enrich quality of life, such as housing, commercial buildings, education provifders, industry, farms, health providers, cultural providers, energy providers, telephone providers, internet providers, roads, parks, and more.

This learning sheet demonstrates how to create an internet network in a HERA city.

3.2 Context

The activity may be used to get students and instructors familiarized with the HERA game functionality. It may be used as a pre-requisite, to be deployed before focusing on more complex game scenarios.

3.3 Learning goals

Upon completion of the activity students will be able to design an internet network for a functional HERA city.

3.4 Prerequisites

Students must have completed the “creating a small city – energy grids” activity. Students need basic understanding on phone and internet network design.

3.5 Audience

Engineering and economics students and instructors using the HERA game for developing problem-based learning skills.

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3.6 Core concepts

- **Internet:** A global computer network providing a variety of information and communication services through standardized protocols.
- **Fiber optic cable:** An assembly similar to an electrical cable but containing one or more optic fibers that are used to carry light, providing higher data network capacity.
- **DSL cable:** An assembly for data transfer used in internet and phone networks.

3.7 Description of the scenario

During the activity students design a functional internet network that includes an ISP provider, ISP street stations, fiber optic, and DSL cables. To ensure that the network works properly, students and educators are encouraged to follow specific guidelines described below.

3.8 Suggested class activity

7. To demonstrate the design of an internet network, first create a hospital in your city by selecting the public services button and then the hospital tab at the bottom of the screen menu ( ).

   You will notice that to function properly the building requires medium voltage electricity, an internet connection, and a phone connection as indicated by the thumbnails that appear on top (see Figure 10 below).

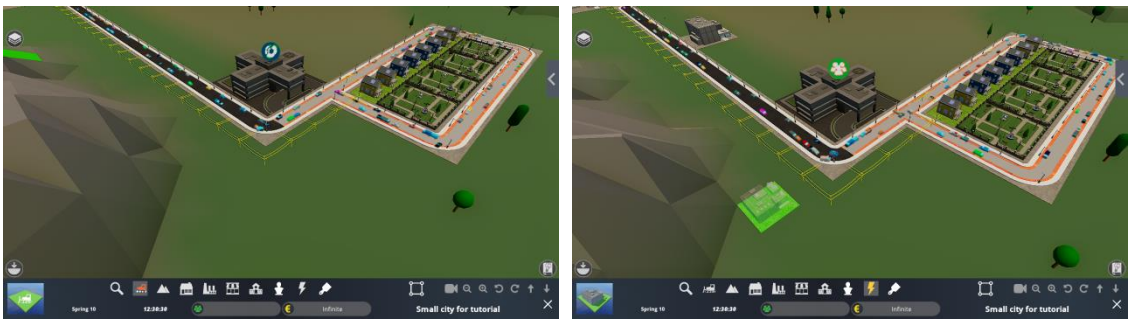

Figure 10. Build a university (left); then build an ISP core building (right).

8. If the ISP building is built adjacent to the road, as demonstrated in the figure, you will not need additional energy network connectivity as the road is “conductive”. If the building is not built adjacent to the road, then you will need to connect it to the electricity network as any other building.

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9. Build an ISP street station by clicking on the infrastructure button ( ) then selecting the internet tab at the bottom of the screen menu. Connect the ISP core building to the ISP street station with a fiber optic cable; then connect the ISP street station to the university with a DSL cable. You may also connect the ISP street station to the neighborhood houses with a DSL cable. The internet network is now functional (see Figure 12 below).

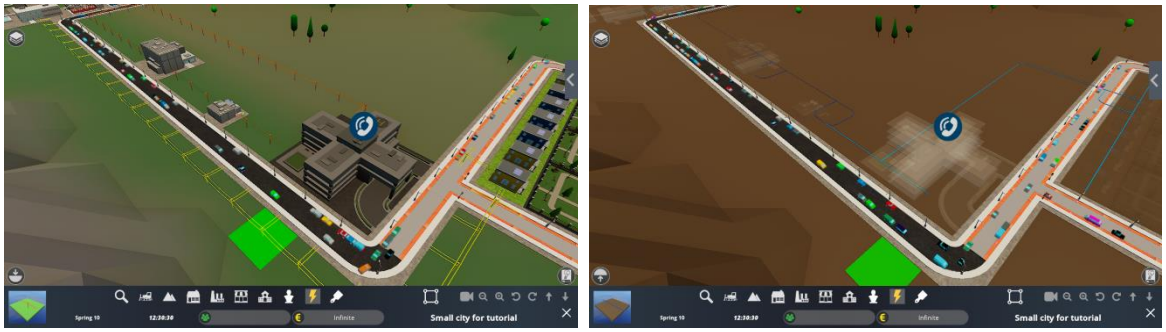

Figure 11. Create an ISP street station (left); connect the ISP core building to the ISP street station with a fiber optic cable; connect the ISP street station to the university with a DSL cable (right).

10. Connect the hospital with the medium voltage transformer through medium voltage cables using the infrastructure button and then the energy tab at the bottom of the screen menu (see Figure 12 below).

11. Install an antenna of your choice to introduce phone services to the hospital by clicking on the infrastructure button and then selecting the phone tab at the bottom of the screen menu. The antenna needs to be connected to the ISP street station with a DSL line. In this example, the DSL line already exists. The hospital is now functional, meaning it has access to energy, internet, and phone services.

Figure 12. Connect the hospital to medium voltage energy (left); to introduce phone services, install a phone antenna and connect it to the ISP street station using a DSL cable (right);

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3.9 Assessment methods

This activity aims to build basic skills on the deployment of the HERA learning game. Assessment of the skills developed may be performed using authentic models, namely models that encourage students to demonstrate the newly developed knowledge hands-on. More specifically, students may be asked to demonstrate the creation of a city for the benefit of themselves, their fellow students, and the instructor. Alternatively, students may be asked to submit a video recording in which the creation of their city is demonstrated.

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4. e-Commerce infrastructure for a city

Topic: e-Commerce, infrastructure, industry, business, culture, quality of life

4.1 Introduction

e-Commerce has been gaining momentum and market share over the past decades. In the COVID-19 era, e-Commerce has emerged as a viable option for ensuring the continuation of economic activity. Supporting e-Commerce relies on low fixed operational costs, fast internet connections and information technology infrastructure, energy infrastructures, and a healthy economy that supports consumer spending. All of these can lead to increased economic activity that ultimately leads to better quality of life.

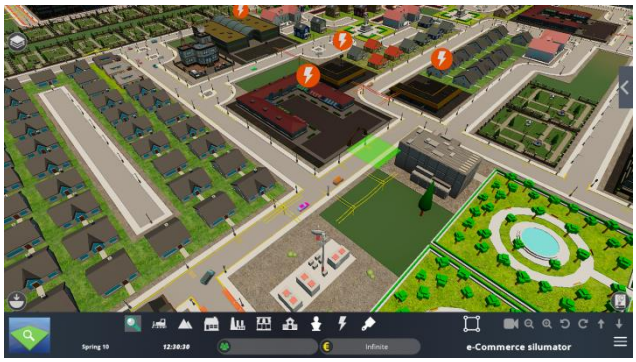

Figure 13. Neighborhoods and parks provide a friendly living environment for city inhabitants.

This activity simulates the design of a city in which e-Commerce can thrive as a result of effective urban design and quality of life. Students are challenged to design a city that has sound infrastructures, which may include business facilities in both high and low-cost areas for supporting high growth based on low operational costs, energy networks, internet service providers, and an urban design that promotes quality of life through the inclusion of elements related to education, culture, health, and safety.

4.2 Context

The activity is designed for deployment in wider learning contexts that combine both engineering and economics principles. It may be deployed, for example, in the context of economics courses in engineering departments or in ICT supported e-Commerce courses in economics departments. The simulator is open ended and allows students to experiment with their own solutions towards achieving the scenario goals.

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Participants can assume 1 of 4 foreseen roles. They have a common goal as well as individual goals. The common goal of the participants is creating a buzzing e-Commerce scene. The individual roles and their objectives are:

Figure 14. Museums, sports facilities, and festive markets introduce cultural interest in the city.

Role 1: e-Commerce developer

The e-Commerce developer aims at increasing the amount of e-Commerce that takes place in the city. She achieves this by building small and large industries, which engage in e-Commerce. Her goal is for the city to achieve a healthy industrial and commercial income.

Role 2: Urban developer

Figure 15. Hospitals ensure health services for city inhabitants.

The urban developer aims at increasing the population of the city. He achieves this by making the city an attractive place to live in. The urban developer builds housing and public services such as parks, schools, universities, fire stations, hospitals, and police stations that address the needs of the city population. His goal is for the city to reach a predefined number of inhabitants in the city and to raise the happiness indicator. The inhabitants will populate the city as the urban developer provides desirable services.

Role 3: Culture developer

The culture developer aims at increasing culture activities in the city. He achieves this by building museums and other facilities. These services promote quality of life in the city and well-being, which makes the city a happier place and more livable place for inhabitants

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Role 4: Technical infrastructure developer

Figure 16. Nuclear power plants ensure adequate energy provision.

The technical infrastructure developer aims at introducing the digital services that will allow the development of e-Commerce. This includes an energy network, an internet network, and a phone network. The technical infrastructure developer has high goals. She needs to ensure that most of the population has access to internet and phone, while almost the entirety of the city has access to electricity. These 3 services combined will promote the engagement of a large percentage of the city population in e-Commerce.

The following figure demonstrates the roles and the interactions between them.

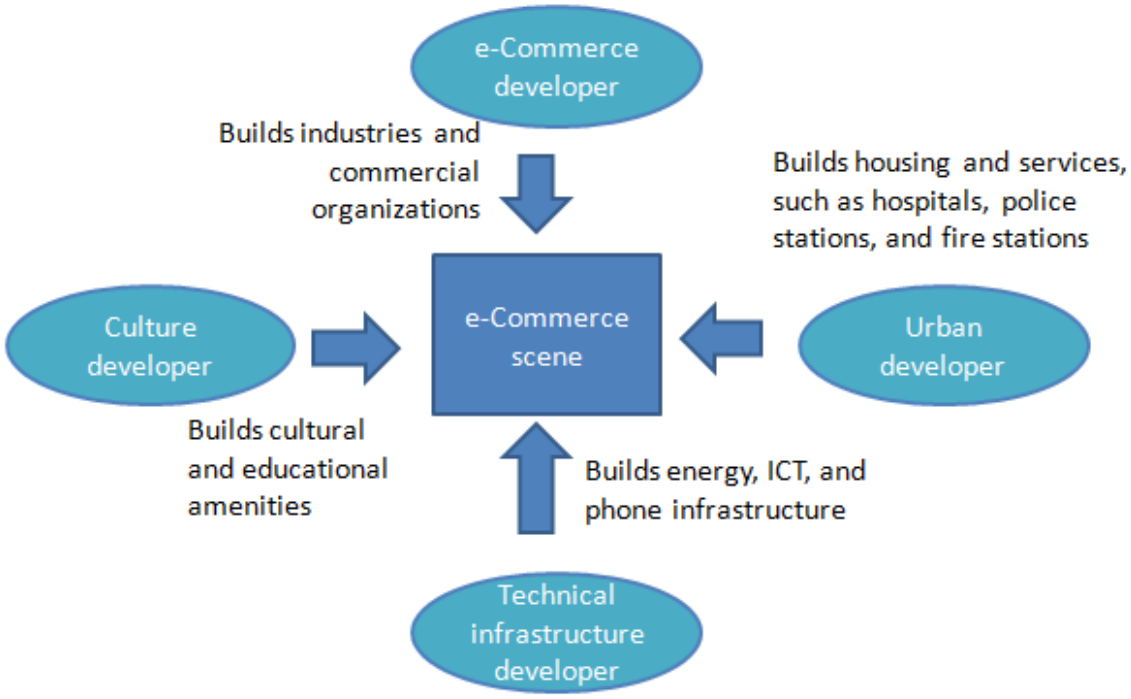

Figure 17. Roles, actions, and interactions.

4.3 Learning goals

Upon completion of the activity students will:

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- Understand and apply e-Commerce concepts.
- Understand and apply ICT infrastructure design.
- Understand and apply concepts related to public services urban design for promoting quality of life.
- Have enriched their critical thinking skills, collaboration capacity, independent research skills, and innovative thinking.

4.4 Prerequisites

The activity can be introduced to students with minimum pre-required information. It self-contained. All concepts may be introduced by the teacher during an initial briefing. Students need only to have basic understanding of the function of electricity and internet networks and the curiosity to design a city environment that will make e-Commerce flourish.

4.5 Audience

e-Commerce is relevant to both computer engineering and economics students as it relies equally on technology and business. The suggested activity targets economics and engineering students enrolled in both undergraduate and graduate learning offerings related to e-Commerce design and the deployment of ICT in economic development.

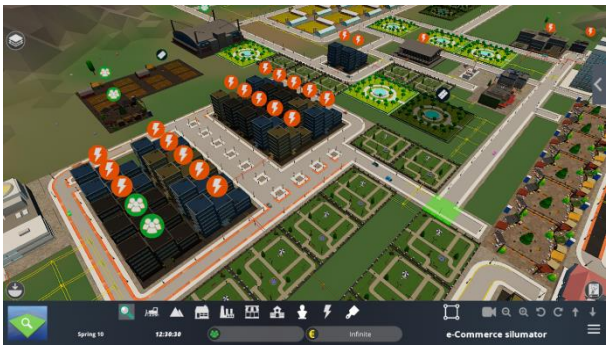

Figure 18. Office buildings provide working space for city economic activities.

4.6 Core concepts

- **e-Commerce:** Economic activity that takes place over the internet. Through e-Commerce individuals and business can buy and sell products and services on-line.
- **Energy grids:** Energy infrastructures, including diverse energy production plants, such as nuclear, coal-based, or renewable energy based, energy transformers from high, to medium, and low voltage, and power lines that transport energy to homes, businesses, and industry.

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- **Culture:** Arts and other manifestation of human intellectual achievement. In the context of this scenario, culture refers to all activities that promote education, expression, and athletics and foster a high quality of life.
- **Internet and phone service provider:** A company that provides access to the internet for both personal and business customers. The service requires a network infrastructure, including servers and cables for connectivity and processing of information.
- **City management:** Managing the services, revenues, and expenses of a city.
- **Transversal skills:** collaboration, critical thinking, analytical thinking, innovative thinking.

4.7 Description of the scenario

Figure 19. Universities provide educational services.

The scenario encourages students to think of creative ways through which they can create a flourishing e-Commerce environment in their city.

To achieve this goal, students need to work collaboratively. The work is divided into roles, none of which has the capacity to achieve all goals individually. However, collectively the team members have all the capabilities required for succeeding in the scenario objective of building a buzzing e-Commerce environment. This requirement for collaborative work makes the scenario challenging and prepares students for their future professional roles in multidisciplinary teams.

The division of work is both realistic and promotes teamwork. More specifically, the scenario simulates the real life roles of an urban designer, who builds effective city plans for fostering development and quality of life, a technical infrastructure engineer, who ensures that the city is functional through network and energy grids, a cultural director, who coordinates educational and cultural activities, and an e-Commerce director, who benefits from the work of the other roles for supporting businesses and industries ensuring that the city will thrive economically.

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Students are encouraged to experiment with the scenario city, which is pre-built. They are allowed to alter the pre-built city, introducing additional services such as educational buildings, internet connectivity, energy plants, fire stations, police stations, health providers, businesses, industry, and more. By adding new elements in the city, students make it more attractive and increase the economic activity towards achieving their collective team objectives for industrial and commercial city income generation.

4.8 Suggested class activity

1. The teacher introduces the HERA game. She then introduces the e-Commerce scenario objectives and the individual role objectives.
2. Students break into teams of 4 individuals, each of whom assumes one of the foreseen roles.

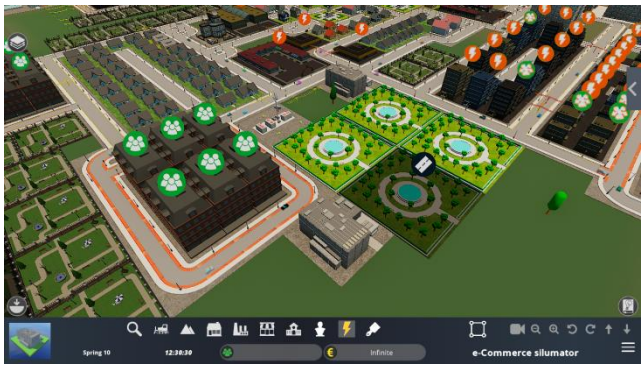

Figure 20. Internet service providers facilitate e-Commerce.

3. Team members brainstorm to understand the problem and the parameters within which they have to work. This includes the city budget and the individual role objectives, as these are described above.
4. Students are encouraged to come up with as many ideas as possible through brainstorming. Techniques of design thinking could be used for promoting innovative design and the introduction of a human-centered solution that address actual needs of city citizens.
5. Each student logs into the game. Team members individually use the resources available to them and the role capabilities as these are defined in the game scenario to build city infrastructures and services for achieving their individual objectives.
6. The students discuss the game results and their roles; the teacher gives feedback.
7. The teacher may introduce questions for initiating class discussion, such as:
    - What would happen if the city included more businesses?
    - Would you choose a different city plan, and how would the city plan affect economic activity?

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- How would you attract more inhabitants into the city? What services would be desirable, leading to higher city population?
- How would you measure the happiness of the inhabitants?
- Does culture and education add to the scenario and promote e-Commerce because of higher quality of life?

4.9 Assessment methods

Figure 21. An industrial park hosts industrial activity.

This is a collaborative, open ended activity in which not a single solution exists. The purpose of the activity is to encourage students to think of creative ways to design city services for promoting economic activity over the internet.

Self assessment would offer students the benefit of taking responsibility of their learning. Students may discuss their roles within their group and reach a decision on whether and to what degree they achieved their goal.

Students may further present their solution to the entire class receiving evaluation from their peers.

Finally, the class may decide on the more creative solutions among all teams.

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5. Enhancing arts and sports

Topic: arts, sports, culture, quality of life

5.1 Introduction

Figure 22. The scenario starts with a new city in which students are called to introduce cultural services.

Culture provides important social and economic benefits. With improved learning and health, increased tolerance, and opportunities to come together with others, culture enhances quality of life and increases overall well-being for both individuals and communities.

This activity simulates the design of a city in which cultural experiences can thrive as a result of effective urban design and quality of life. Students are challenged to design a city that offers opportunities for leisure, entertainment, learning, and sharing experiences with others.

5.2 Context

Figure 23. The initial city that students are called to work on includes residential buildings and parks.

The activity is designed for deployment in wider learning contexts that combine both engineering and economics principles. The simulator is open-ended and allows students to experiment with their own solutions towards achieving the scenario goals.

Participants can assume 1 of 2 foreseen roles. They have a common goal as well as individual goals. The common goal of the participants is to create a cultural scene, with enhanced arts and sports. The individual roles and their objectives are:

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Role 1: The arts enhancer

Figure 24. The art enhancer introduces cultural services such as museums and educational organizations.

The art enhancer aims at increasing culture activities in the city. The player achieves this by building museums, educational organizations, including schools and universities, and more.

These services promote quality of life in the city and well-being, which makes the city a happier place.

Role 2: The sports enhancer

The sports enhancer aims at increasing sports activities in the city. This player is responsible for building and configuring all athletic stadiums aiming in the best physical situation of the people.

The following figure demonstrates the roles and the interactions between them.

Figure 25. The sports enhancer aims to increase sports activities.

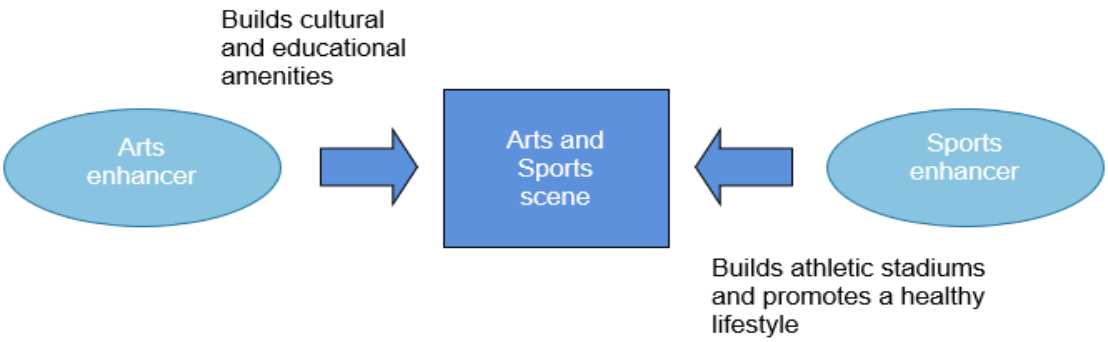

Figure 26. Roles, actions, and interactions.

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5.3 Learning goals

Upon completion of the activity students will:

- Understand and apply concepts related to arts for promoting quality of life.
- Understand and apply concepts related to sports for promoting a healthy lifestyle.
- Have enriched their critical thinking skills, collaboration capacity, independent research skills, and innovative thinking.

5.4 Prerequisites

The activity can be introduced to students with minimum pre-required information. It self-contained and all concepts may be introduced by the teacher during briefing. The student needs only to have the curiosity to design a city environment that will make arts and sports flourish.

The activity may be deployed in wide contexts in engineering, economics, and more.

5.5 Audience

Culture is relevant to both computer engineering and economics students. Cultural engineering's growth is linked to the development of art and culture, the professionalization of its actors, and the growing integration of cultural processes and projects into social-economic continuums.

It integrates art and human genius into a complementary and interdependent approach, necessary for creative, production, infrastructure, organization, and political issues.

Figure 27. The activity addresses engineering and economics students but may be deployed in broader contexts.

5.6 Core concepts

- **Culture:** Arts and other manifestation of human intellectual achievement. In the context of this scenario, culture refers to all activities that promote education, expression, arts, and athletics and foster a high quality of life.

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- **Transversal skills:** Collaboration, critical thinking, analytical thinking, innovative thinking.

5.7 Description of the scenario

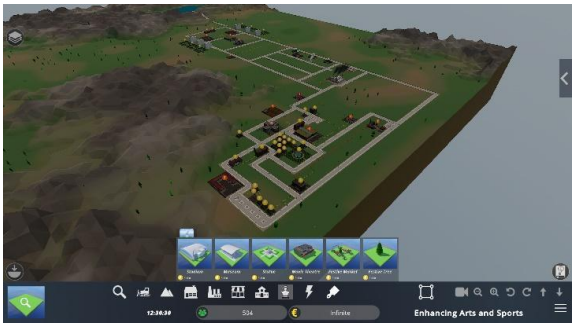

Figure 28. Students are challenged to think creatively to enrich cultural and sports activities that promote well-being.

The scenario encourages students to think of creative ways through which they can create a flourishing environment in their city. To achieve this goal, students need to work collaboratively. The work is divided into roles, none of which has the capacity to achieve all goals individually. However, collectively the team members have all the capabilities required for succeeding in the scenario objective of building an environment with enhanced arts and sports. This requirement for collaborative work makes the scenario challenging and prepares students for their future professional roles in multidisciplinary teams.

Students are encouraged to experiment with the scenario city, which is pre-built. They are allowed to alter the pre-built city, introducing additional services such as educational buildings, internet connectivity, energy plants, fire stations, police stations, health providers, businesses, industry, and more. By adding new elements in the city, students make it more attractive and increase the economic activity towards achieving their collective team objectives for arts and sports enhancement.

5.8 Suggested class activity

1. The teacher introduces the HERA game. The teacher then introduces the scenario objectives and the individual role objectives.
2. Students break into teams of 2 individuals, each of whom assumes one of the foreseen roles.
3. Team members brainstorm to understand the problem and the parameters within which they have to work. Students are encouraged to come up with as many ideas as possible through brainstorming. Techniques of design thinking could be used for promoting innovative design and

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the introduction of a human-centered solution that address actual needs of city citizens.

4. Each student logs into the game. Team members individually use the resources available to them and the role capabilities as these are defined in the game scenario to build city infrastructures and services for achieving their individual objectives.
5. The students discuss the game results and their roles; the teacher gives feedback.
6. The teacher may introduce questions for initiating class discussion, such as:
    - What would happen if the city included more businesses?
    - Would you choose a different city plan, and how would the city plan affect economic activity?
    - How would you attract more inhabitants into the city? What services would be desirable, leading to higher city population?
    - How would you measure the happiness of the inhabitants?
    - Does culture and education add to the scenario and promote arts and sports as a result of higher quality of life?

5.9 Assessment methods

Figure 29. Students are challenged to think of the benefits of different city plans.

This is a collaborative, open ended activity in which not a single solution exists. The purpose of the activity is to encourage students to think of creative ways to design city services for promoting arts and sports. Self-assessment would offer students the benefit of taking responsibility of their learning. Students may discuss their roles within their group and reach a decision on whether and to what degree they achieved their goal. Students may further present their solution to the entire class receiving evaluation from their peers. Finally, the class may decide on the more creative solutions among all teams.

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6. Festive holiday lights

Topic: festive lights, decoration, city and business development

6.1 Introduction

The year-end holidays are synonymous with family time, a time of giving and sharing with those around us. But the year-end holidays are also synonymous of social life. During that time not just families but also friends and communities like to join together and share time and feelings in the open streets, markets, restaurants, etc. Moreover, the tradition of giving presents during these days is magnified making these holidays one of the important shopping seasons of the year.

6.2 Context

During year-end holidays people celebrate, come together with family and friends, travel, and follow traditions. As a result, the year-end holidays are considered as a key event in many cities that is related to both the happiness of their citizens and opportunities for business and city development. To further underscore the festive spirit cities introduce festive lights and decorations in main squares, sites of cultural interest, shopping areas, and more.

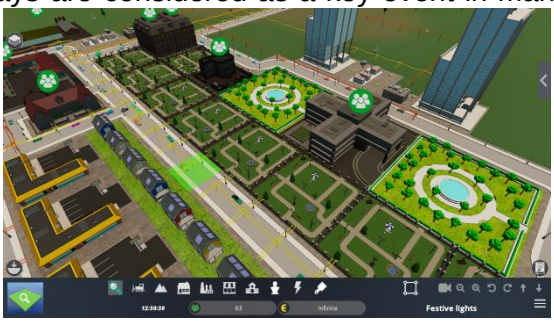

Figure 30. The scenario challenges students to develop festive decorations in a city for year-end holidays.

This game involves the organization and implementation of festive light decorations in a city. The main task that students must complete is deciding on the decorations that will introduce a festive aura in their city. This includes various types of lights such as colorful light decorations, building decorations, street decorations, tree decorations, automated light changes, fair wheels, and more that will be used on structures, during parades, and other events.

Following is a description of the scenario roles:

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Role 1: The city mayor

Figure 31. The city includes infrastructures such as energy, internet, and phone services that the students may enrich.

The city mayor decides on the services offered by the city to its citizens. The mayor can create public services, such as hospitals, museums, educational organizations, and infrastructures such as roads, internet, and phone networks that increase quality of life in a city.

Role 2: The financial planner

The financial planner manages the revenues and expenses of a city in collaboration with the mayor. The financial planner collaborates with the mayor in the creation of the conditions that facilitate the growth of economic activity in the city, including infrastructures such as roads, internet, and phone networks, residences, business spaces, and more.

Role 3: Business owners

The business owners own stores, restaurants, or other services in the city and have the option of participating in the festive light decorations of the city. They can build small and larger businesses that generate revenue for themselves and for the city.

Role 4: The environmentalist

The environmentalist overlooks energy consumption and resulting emissions from the deployment of festive decorations. The environmentalist can create energy infrastructures, including both traditional ones and based on renewable resources that help contain pollution in the city.

The following image demonstrates the roles and interactions between them.

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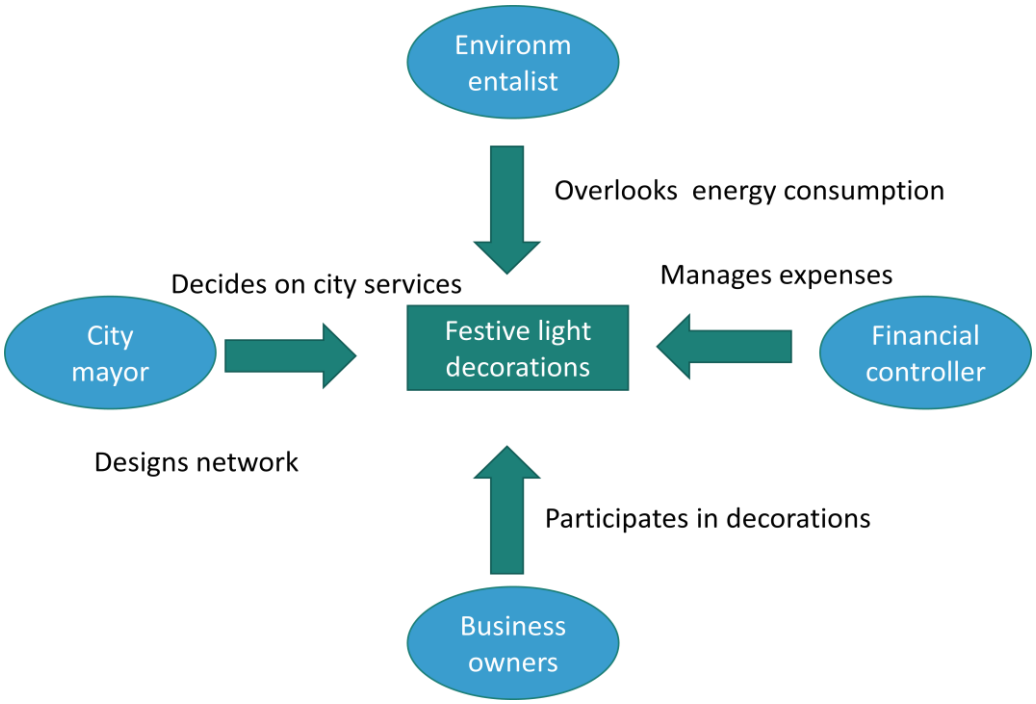

Figure 32. Role actions and interactions.

6.3 Learning goals

Upon completion of the activity students will:

- Understand the connections between environmental, social, and economic aspects of everyday life.
- Have experienced how to achieve cooperation between different parties with different goals and needs.
- Built competence in taking an integrative approach in researching city management and related environmental issues.
- Create conditions necessary for navigating the challenges modern society and environmental changes pose for the public and private sector.

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6.4 Prerequisites

The scenario takes a purposefully high-level view of city planning. It has been designed as an introductory activity into the HERA learning game. It is self-contained and does not require specialized knowledge from students. Students simply need to understand the basic functionality of the HERA game in terms of developing infrastructures and services.

Figure 33. The city further includes small and large housing for inhabitants as well as parks.

6.5 Audience

The scenario is of interest to both engineering and economics students as it combines technical elements, such as infrastructure design, and economic elements, such as increasing the revenue of businesses. It can be deployed among all students, including students at the beginning of their curricula, given its high-level approach to problem-solving.

6.6 Core concepts

- **Sustainability:** Encouraging decision making in terms of environmental protection and the impact of human activities on their surroundings both short- and long-term.
- **Festive lights:** Decorations that introduce a festive aura in a city, installed at major events, such as year-end holidays.
- **Energy consumption:** This is related to all services of a city, but for the purposes of this scenario the focus is on energy consumed by festive light decorations.
- **Environmental impact:** The impact on the environment that results from the energy consumption for festive lights decorations.
- **City management:** Managing the services, revenues, and expenses of a city.
- **Transversal skills:** Collaboration, critical thinking, analytical thinking, innovative thinking.

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6.7 Description of the scenario

The overall objective of the activity is to organize the festive lights decoration for a city in a manner that allows citizens to celebrate in an affordable and sustainable way considering both environmental and economic indicators.

Figure 34. The city further includes small and medium business for supporting economic activity.

Depending on their role, students must decide about what decorations to install, where, and when. Citizens can decide to be in favor or against the city major festive activities plan. They must decide to what degree they wish to participate in the city celebrations and in which locations. This depends on their wellness level, weather conditions, economic robustness, and other parameters.

The mayor decides on the level of festive decorations to install in the city. He needs to take into consideration the available budget, the environmental impact of energy consumption, weather conditions, and other parameters. The game offers a rich collection of decorations for the mayor to choose from: diverse weather conditions, including cold and warm variations, string lights, beam lights, various building lights as well as a collection of light colors to choose from.

Business owners can decide the degree to which they will invest in festive decorations as part of their business development campaign. They will need to consider several variables to facilitate decision making. For example, if they decide to spend a large amount of funds on festive decorations but the city major does not propose an attractive offer they may end up with less profit at the end of the holidays. On the other hand, if the city major decides to implement rich celebrations but they don't invest enough in their business they will miss the opportunity for profiting from the mayor's initiative. Eventually, if they do not have profit, they will not be able to pay more taxes and the city budget may suffer. From a more practical point of view, students will select from a pool of decorations offered by the game to be installed in their shops, restaurants, or other business.

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The financial planner aims to develop the commercial and industrial activity of the city in order to increase city income. This can be achieved by introducing industry and commercial activities, which need to be supported by the necessary infrastructure, such as roads, internet, phone, and energy services.

Finally, the environmentalist aims at ensuring that pollution produced by energy consumption is within acceptable levels ensuring the wellness of the inhabitants. This can be achieved by replacing existing energy infrastructures by clean alternatives that do not contribute to emissions.

Figure 35. The city also includes farms that generate produce for inhabitants.

6.8 Suggested class activity

1. The teacher presents the problem to the class and introduces the scenario and game.
2. The students and the teacher define the parameters according to which they will evaluate an effective solution such as increase of the city budget as a result of increased business and resulting tax returns, increase on median business income, increase of visitors to the city, environmental impact of raised energy consumption as a result of festive light decorations, and more.
3. The students discuss the restrictions they face, such as budget availability.
4. The teacher forms groups and gives students their roles in the game. Each team member may assume a different role such as mayor, business owner, and citizen. Each team member must achieve their individual objectives within the scope of the scenario.
5. The students discuss to understand the diverse parameters and design a solution that maximizes benefits and minimizes negative aspects such as pollution.
6. The students are encouraged to brainstorm towards reaching a solution. Design thinking techniques could be applied to encourage innovative thinking, sharing of ideas, building on each other's suggestions, and thinking out of the box.
7. From the pool of generated ideas, the students will decide which to implement in order to achieve their goal while staying within the limits of their resources.

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8. The students play the game according to their roles.
9. The students discuss the game results and their roles; the teacher gives feedback.

6.9 Assessment methods

This is an open-ended activity in which no single correct answer exists. Students will use self- and pee-assessment methods to decide the degree to which they have achieved their goal on developing festive decorations that enrich the festive spirit of the city while considering the environmental impact.

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7. The strategic flood master plan

Topic: management, floods, disaster, ecology, sustainability, nature based solutions, buildings

7.1 Introduction

Already half of the world population lives in urban areas. One of the main challenges related to water is the increasing number of the water-related disasters such as floods and droughts. Unsustainable urbanization and climate change leads to drought and flooding because in cities there is much less opportunity for rainwater to filtrate naturally into the ground because of the number of hard surfaces, such as roofs, roads, driveways, etc. This results in large volumes of surface water during heavy rainfall which puts pressure on existing drains and sewers and leads to flooding and pollution. Thus, there is a need to identify and implement ways to rehabilitate urban ecosystems. Urban water planning, development, and management are in urgent need of new strategies. Usage of ecosystem services through nature-based solutions has proved to be a cost-effective measure for adapting cities to climate change, and for reducing the risk of current and future extreme weather events with the added advantage of bringing multiple co-benefits, for example, increased biodiversity and more green spaces for leisure.

7.2 Context

It is widely recognized that dealing with large amounts of water and avoiding floods is impossible and too expensive through enlarging the sewage system or building dams and concrete channels for redirecting the natural flow paths of the water. There are several uncertainties in climate projections, but the overall pattern indicates the growing risks for extreme events. Extreme weather events cannot be managed by conventional pipe systems and their occurrence becomes more difficult to predict. Eliminating all flooding is not a realistic objective; however, the consequences may be reduced, and the risks lowered for property damage and public health.

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Government policy has a strong role to play in increasing the amount and pace of eco-innovation in urban water delivery that is critical to the improved management of urban water. Strict environmental and economic regulations, constantly growing cities, and the general need for adaptation to climate change put pressure on utilities to find new ways to optimize the water and sewer systems. Integrated urban water management is the key element to reduce adverse impacts on surface waters and minimize future investment costs. Cities can contribute to water resources management and ecosystems and biodiversity conservation, through their design and making their infrastructure more ecological with the help of nature-based solutions.

The following roles may be used for exposing students to the scenario:

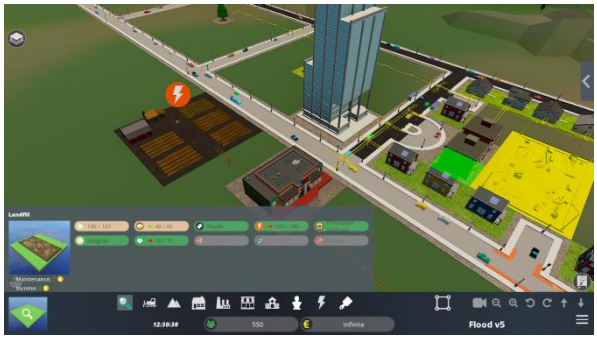

Figure 36. The scenario introduces concepts on flood management in a city.

Role 1: City manager

The city manager ensures that the city has proper infrastructure, and it is capable of managing flash floods. The manager also needs to administer the city's budget and generate income to expand the city. The manager is also responsible for the happiness of the citizens. This role can build and bulldoze everything besides housing.

Figure 37. The city includes features such as housing, a landfill, farms, and movie theaters.

Role 2: CEO of the water company

The CEO of the water company designs the city fortifications against flooding. This may include implementing projects that alter the landscape to allow water to flow through the city without causing damage or use already existing landscape for smart design. The CEO also needs to monitor the pollution levels of water and ground. This role can terraform, build, and bulldoze infrastructure, industries, and public services.

Role 3: Safety inspector

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The safety inspector ensures that the infrastructure follows safety measures and needs. The inspector has the capability of destroying dangerous or falsely built infrastructure. They will also need to provide citizens with housing and ensure their health. The inspector can build housing, public services, and culture and bulldoze everything.

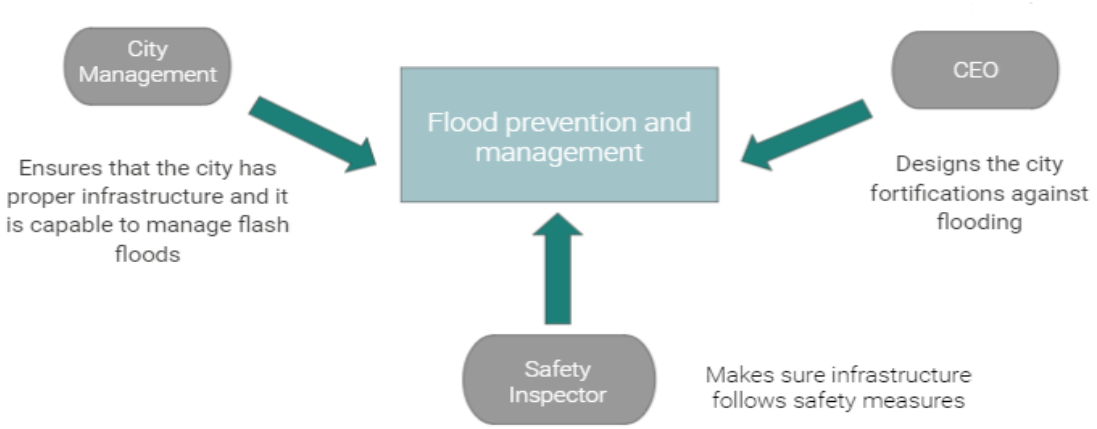

Figure 38. Roles and activities.

7.3 Learning goals

Upon completion of the activity students will:

- Understand the connections between environmental, social, and economic aspects of everyday life.
- Have experienced how to achieve cooperation between different parties with different goals and needs.
- Built competence in taking an integrative approach in researching city management and related environmental issues.
- Create conditions necessary for navigating the challenges modern society and environmental changes pose for the public and private sector.

7.4 Prerequisites

Understanding the concept of flooding and water absorption.

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7.5 Audience

The screnario is relevant to both engineering and economics students as any solution for the management of natural disasters, such as flooding, needs to consider both technological advances and economics principles for implementing a solution within realistic boundaries.

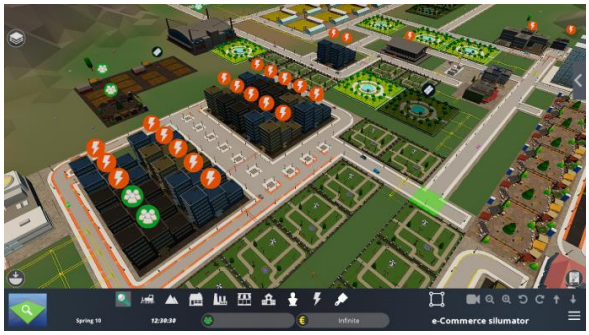

Figure 39. Office buildings provide working space for city economic activities.

7.6 Core concepts

- **Sustainability:** Encouraging decision making in terms of environmental protection and the impact of human activities on their surroundings both short- and long-term.
- **Nature-based solutions:** Solutions to real-life challenges that are based on processes the functioning of nature.
- **Ecosystem services:** Services and systems that directly or indirectly benefit communities.
- **Urban water management:** Managing and/or conserving freshwater, wastewater, and storm water of an area through sustainable methods.
- **City management:** Managing the services, revenues, and expenses of a city.
- **Water treatment systems:** Systems that control the quality of drinkable water at homes or in businesses.
- **Transversal skills:** Collaboration, critical thinking.

7.7 Description of the scenario

The overall objective is to ensure the water supply and wastewater treatment for the population and help the city to deal with extreme rain events and flash floods.

Flooding cannot be managed effectively by the city government acting alone; all parties have to work together in order to manage flood risks sustainably.

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This can be achieved through planning for a sustainable drainage system. The choice of solution will be determined by the local characteristics of the site including its size, topography, soil, land-cover flood risk, and the available discharge points, such as rivers, drains, or sewers. A combination of measures can be employed in real life: green roofs, permeable paving, bioswales, soak-aways, basins, ponds, wetlands, storm water attenuation tanks, and rainwater recycling.

Students must understand that the key is to reduce the amount of rainwater entering into combined sewerage systems from road and land drainage. In most urban areas sewage and rainwater are still collected in combined sewers. This way rainwater can overload the sewers causing flooding and pollution and costing billions every year to collect, pump and treat.

One solution is to replenish the drainage systems on large commercial sites, such as shopping centers and industrial estates, and the government estate, including schools, hospitals, and other service buildings. Replace the regular pavement in strategically located parking lots with natural or cultivated grassland and create nature-based surface water drainage systems such as ponds, wetlands, and wet woodland to meet the future drainage needs. This water can also provide environmental and recreational value like for walking, hiking or just relaxing with a family and friends.

Figure 40. The city is built next to a river and mountainous area.

7.8 Suggested class activity

1. The teacher presents the problem to the class and introduces the scenario and game. The teacher has pre-designed a town that students need to fortify and re-design against flooding.
2. The students must understand the problem and define possible solutions.
3. Teacher forms groups and gives students their roles in the game.
4. The students are encouraged to come up with as many ideas as possible through brainstorming. Techniques of design thinking may be used.
5. Team members evaluate ideas, combine them, and prioritize them towards designing the best possible solutions.

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6. The students validate their ideas by playing the game according to the role assigned to each.
7. The students discuss game results, their experiences, and the knowledge they developed. The teacher provides feedback.

7.9 Assessment methods

This is a collaborative, open ended activity that aims to raise awareness among students on emerging risks related to flood protection as a result of climate change as well as effective urban water management. Students design their cities and enhance them in terms of smart design that allows water to flow through the city without flooding. Students present their solutions for a specific town and discuss alternatives in the classroom. This allows students to build on each other's ideas and to understand issues related to optimization of potential flood management approaches.

7.10 Supplementary materials

UN Water and cities: https://www.un.org/waterforlifedecade/water_cities.shtml

Sustainable Water: https://www.aquatechtrade.com/news/water-treatment/sustainable-water-essential-guide/

Cloudburst Management Plan: https://oppla.eu/casestudy/18017

Urban Green-Blue Grids: https://www.urbangreenbluegrids.com/measures/bioswales/

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8. The Olympic Games come to our city

Topic: city planning, efficiency, sustainability

8.1 Introduction

Hosting the Olympic Games is a great achievement for any city, but it comes with some challenges. The Olympics have evolved dramatically since the first modern games were held in 1896. Starting in the 1960s, both the costs of hosting and the revenue produced by the spectacle grew rapidly, making the decision of hosting such an event a source of controversy.

Building all the sports facilities, accommodation, and infrastructure needed while containing costs, making enough revenue to make the event profitable or even sustainable, or minimizing the environmental cost are some of the challenges that must be addressed to host the Olympic Games.

8.2 Context

The game is situated in the context of a city intended to develop a new Olympic Village to host the upcoming Olympic Games. The players are responsible for building the needed sports facilities, infrastructure, and accommodation for the event. The new area should also have commercial areas, public services, and everything needed to make it functional and enjoyable. This is also an opportunity to improve other aspects of the city that the students may consider if they manage to fit it in the budget, like pollution control, public services coverage, overall happiness, etc.

Figure 41. The city is ready to cost the Olympic Games.

The solution can be approached in different ways. Students can create a separate village connected to the existing city or integrate the new elements in the city taking advantage of some of the existing assets.

Four roles are foreseen that students will play simultaneously, each one with its own objectives to fulfill and its own capabilities. They are:

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Role 1: Private builder

The private builder is responsible for the construction of 5 stadiums, accommodation for 1.200 athletes and 800 visitors, and culture offerings in the Olympic village. This role can build and bulldoze housing and culture/sports.

Figure 42. The city's infrastructure of residences, sports buildings, parks, and more can be enhanced to better support the Olympic Games.

Role 2: Public builder

The public builder is responsible for the construction of public roads, transportation, and public services in the Olympic Village. Any terraforming needed must be executed by the public builder. The public builder can also support the pollution control manager with this task. This role can build and bulldoze infrastructure and public services.

Role 3: **Communications and commerce manager**

The communications and commerce manager is responsible for providing internet and phone coverage to the Olympic Village fixing any possible problems with those in the city and building new commercial establishments. The public builder can build and bulldoze commerce and infrastructure.

Role 4: Energy and pollution manager

The energy and pollution manager is responsible for providing a clean and affordable energy solution for the new Olympic Village, while keeping pollution in line and reducing it if possible. Pollution control task can be supported by the public builder.

There are some interactions and dependencies among the different roles, as shown below in Figure 43. All participants depend on each other to design the layout of the new village, since they have to share the space and budget to accommodate all the buildings and services. The location of some elements, like mobile antennas, is critical for the efficiency of the system, conditioning the design. The layout determines the amount of network and energy cables needed, affecting the budget.

Besides this, the public builder must support the energy and pollution control manager with pollution control as the only role in control of the garbage collection system. The private builder can support the public builder with terraforming.

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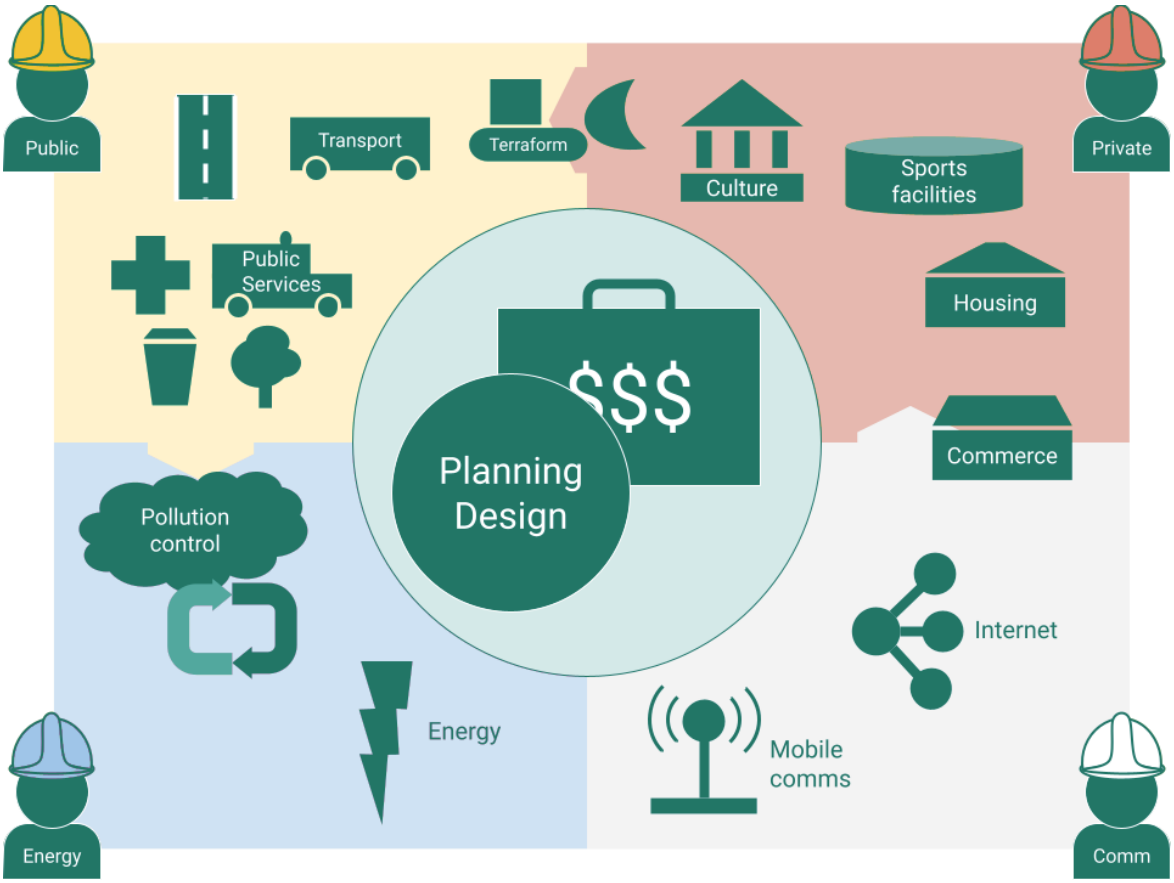

Figure 43. Role actions and dependencies.

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8.3 Learning goals

Upon completion of the activity students will:

- Be aware of the importance of planning to get to a more efficient solution.
- Understand the challenges modern society and environmental changes pose for the public and private sector.
- Understand the connections between environmental, social, and economic aspects of everyday life.
- Have enriched their critical thinking skills, collaboration capacity, independent research skills, and innovative thinking.

8.4 Prerequisites

The activity can be introduced to students with minimum pre-required information. It is important to have a good knowledge of the basic game dynamics, involving the capacity to create new elements and to check the status of the different elements and layers involved in the game: energy coverage, pollution, happiness, etc. Regarding the scenario, it is self-contained, and all concepts may be introduced by the teacher during briefing. The student needs only to understand the function of electricity, internet networks and the curiosity to design a sustainable Olympic game infrastructure.

8.5 Audience

The suggested activity targets economics and engineering students as the construction of infrastructures that support the Olympic Games is a complex technological challenge while at the same time respecting budget constraints is significant not only in the context of a learning scenario but also in real-life.

8.6 Core concepts

- **Sports facilities:** There is a minimum of sports facilities needed to host the Olympic Games. They will generate costs that need to be compensated with new income sources.
- **Income sources:** Accommodation, commerce, and culture items provide revenue for the city. However, sometimes high revenue comes with a disadvantage. For

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instance, skyscrapers can host a lot of people and provide high revenue through taxes, but also have a high amount of energy consumption. The players must balance all this.

- **Energy sources:** The city has polluting or high-risk energy sources. Players can improve this by using wind farms or solar panels to replace old energy sources and by building housing with solar roofs to reduce the amount of energy needed.
- **Communications:** The city needs to have suitable communications coverage.

8.7 Description of the scenario

The overall objective is to build an Olympic Village as an expansion of a city in a sustainable and efficient way.

Building an Olympic Village is a huge undertaking by itself considering the costs and maintenance of the infrastructure and buildings and the environmental impact. An expansion like this needs more electrical power, more communications, more roads and buildings, which imply more costs and more pollution. To keep these in line, the expanded city needs renewable energy and stable income sources to remain sustainable in the long run. Besides, in order to function normally, it also needs all the standard services like communications, health coverage, etc.

Figure 44. Industry and an airport support the city's economic activity and well-being.

Students must understand that there are three main elements that will lead to success in this scenario:

- Developing enough income sources to make the new city sustainable economically.
- Reducing pollution and switching to sustainable energy, even if it implies changing the current power sources of the city.
- Keeping a high coverage of the main city services, like health, police, communications, etc.

8.8 Suggested class activity

1. The teacher presents the problem to the class and introduces the scenario and game.

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2. The students discuss to understand the problem and define possible solutions. They further discuss to understand the parameters that define success, such as increasing city incomes while increasing the overall maintenance cost of the city or reducing pollution as much as possible while providing all the services demanded. They further discuss the limitations set in the scenario such as restricted budgets, availability of locations for installing recycling installations and how these influence the capacity of proposed waste management building, diverse waste management techniques and related costs, and more.
3. The students are encouraged to come up with as many ideas as possible through brainstorming. Techniques of design thinking may be used to promote innovative thinking, brainstorming, sharing are building upon each other's ideas, and thinking from the perspective of city inhabitants in terms of designing a sustainable solution.
4. The students are asked to jointly decide on the ideas to implement from the pool of suggestions that they came up with considering restrictions, such as city plans and budget. The teacher forms groups and gives students their roles in the game.
5. The students play the game according to their roles striving to achieve individual and group objectives that may be conflicting. For example, they share a common budget.
6. The students discuss the game results and their roles; the teacher gives feedback.

8.9 Assessment methods

This is an open-ended learning activity in which no single correct solution exists. Rather, the activity aims to raise awareness among students on the importance of efficient and sustainable city design and to build their knowledge on related methodologies and strategies.

Students discuss their roles and the outcomes of their activity and decide by using self- and peer assessment methodologies to what extent they have achieved their goal of developing a sustainable Olympic Village their city.

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9. Towards a recycling circular economy

Topic: waste management, recycling, circular economy, nature based solutions, sustainability

9.1 Introduction

Figure 45. The recycling scenario challenges students to manage waste in an environmentally friendly manner.

Waste management includes the activities and actions required to manage waste from its inception to its final disposal. This includes the collection, transport, treatment, and disposal of waste together with monitoring and regulating the waste management process.

Waste management deals with all types of waste, including industrial, biological, and household. In some cases, waste can pose a threat to human health. Waste is produced by human activity, for example, the extraction and processing of raw materials. Waste management aims to reduce the adverse effects of waste on human health, the environment, or aesthetics.

Waste management practices are not uniform. Countries, including developed and developing nations, regions, including urban and rural areas, and residential and industrial sectors can all take different approaches.

Solid waste management is the biggest challenge for authorities of both small and large cities in developing countries. This is mainly due to the increasing generation of solid waste and the burden posed on the municipal budget in relation to its management. In addition to high-cost solid waste management is associated with lack of understanding over different factors that affect the entire handling system.

Population increase, rapid urbanization, booming economy, and the rise in the standard of living in developing countries have greatly accelerated the rate, amount, and quality of municipal solid waste generation.

This learning scenario is inspired on the processes currently being implemented in most countries towards the creation of an increasingly circular economy, where inputs are recovered at the end of the product life cycles. It is an alternative to the prevailing linear

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economy model, in which the destination of the products is not managed in any way other than transfer to landfill. The process of recovering the inputs used to generate new products requires a global change in vision and involvement throughout society. In addition, it is also needed the investment of a significant amount of resources to design, create, and maintain infrastructures that allow the recovery of the inputs used in the products once they reach the end of their use (or their useful life), reintroducing them into the production processes of those same products, other related products, or reusing them in various ways. This game scenario transfers the recycling and circular economy problem in a simplified way to young students to sensitize them, on the one hand, and to contribute to their training for decision-making in environments of high complexity, uncertainty, and social impact.

9.2 Context

The game is situated in the context of a city intended to develop a new recycling program. A selective collection system based on two different types of residues will be implemented distinguishing among: organic waste, and the rest of garbage. Of course, there is the option of waste that may be discarded directly to the landfill. The goal of the team is to minimize the amount of garbage that goes to the landfill.

Figure 46. Students work with a city with basic infrastructures to add waste management services.

Four roles are foreseen that students will play simultaneously, each one with its own objectives to fulfill, which is based on approaching the theoretical limit as closely as possible.

The four roles are:

Role 1: Garbage manager

The garbage manager is public representative responsible for the management of garbage in the local public administration. Her objective should be to minimize the garbage sent to landfill. He can build or destroy public recycling infrastructures such as areas where garbage containers can be located around the city but has to manage a limited budget. If not enough garbage collectors are available a public health problem can appear.

Role 2: Recycling manager

The recycling manager is a representative of a recycling consortium whose objective is to maximize the results of the consortium. This can create and destroy the consortium recycling

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infrastructures that are recycling plants for different types of waste and take decisions on the number of garbage trucks to deploy and their routes. The consortium also sells recycled products to final consumers, particularly organic and organic compost, or compost to local producers of organic products. The activity depends on the amount of garbage collected in an appropriate way and the potential consumers of recycled products.

Role 3: The city mayor

The city mayor aims to maximize the health and happiness of citizens, especially in this case by promoting recycling through communication campaigns. This role decides the budget that will be invested in recycling in the municipality and will be able to build and destroy public infrastructures such as roads and power plants and also allocate space for local ecological markets.

Role 4: Consumer and recycling association representative

The consumer and recycling association representative must ensure that local producers have the maximum possible benefits. The person undertaking the role will be able to create and destroy ecological gardens and farms that can be sold in local markets.

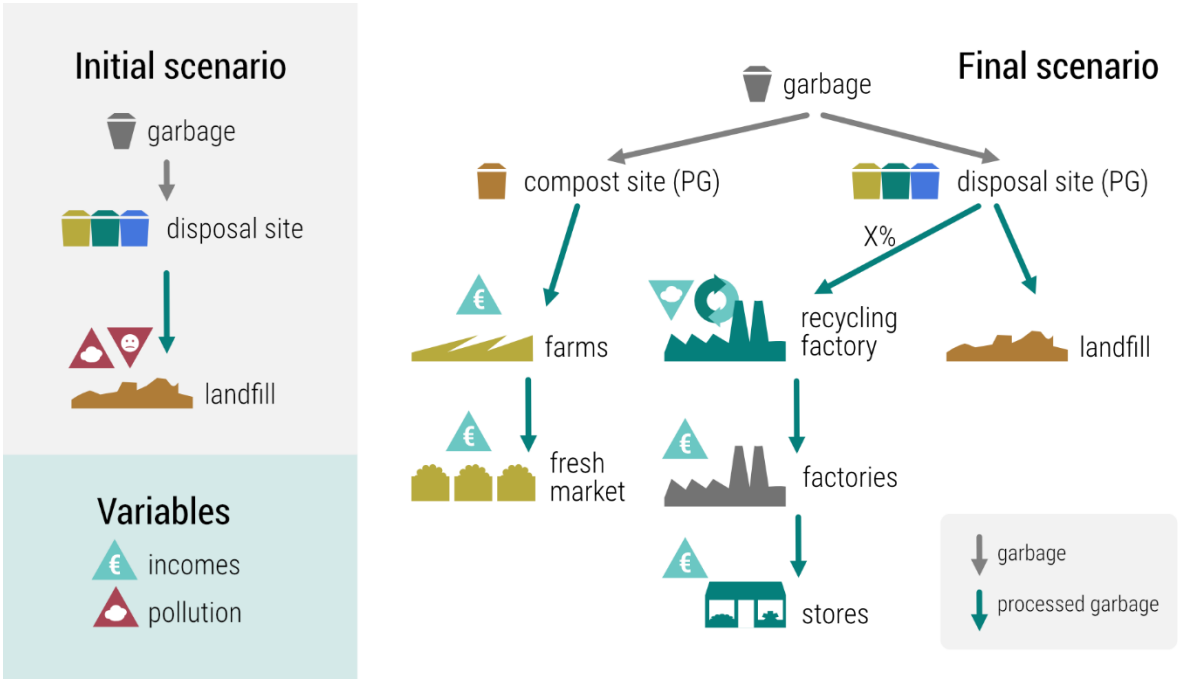

Figure 47. Scenario initial and final states.

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There are some dependencies among the different roles. The number of recycling points will determine the action of the person in charge of the consortium that will operate the recycling plants, and which will therefore be conditioned by the distance to the collection points. Local producers of organic products will also be conditioned by the distance to the collection points. The location of the ecological gardens and farms will determine the action of the mayor because he must presumably decide that the places where the markets are held are close to those production spaces and to the final customers, who will be the inhabitants of the city. The municipality's recycling budget affects all 4 roles that must balance their expenses.

Figure 48. The starting city includes rich amenities, such as cultural services in the form of museums and sports facilities.

9.3 Learning goals

Upon completion of the activity students will:

- Understand the connections between environmental, social and economic aspects of everyday life.
- Have experienced how to achieve cooperation between different parties with different goals and needs.
- Built competence in taking an integrative approach in managing the waste in a city.
- Have created the conditions necessary for navigating the challenges modern society and environmental changes pose for the public and private sector.

Figure 49. Students introduce interventions for promoting a cyclical economy.

9.4 Prerequisites

Students need a basic understanding of recycling and waste management principles.

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9.5 Audience

The activity targets general audiences in engineering and economics, challenging students to explore alternatives in waste management that help preserve the environment and promote quality of life.

9.6 Core concepts

- **Recycling points**. To simplify, the installation of containers will be carried out at recycling points that will be placed in the different points. Each container has cost and a certain capacity both in volume and weight. There are two main types of waste that initially go to the landfill:
    - Organic waste, which must be deposited in the compost container.
    - General waste, which must be deposited in recycling plants.
- **Recycling plants**. They have a cost and a certain capacity to process waste of a certain type. Therefore, there should be a plant for each type of waste. They will be operated by the consortium of companies that the municipality has chosen for it.
- **Ecological farms**. Managed by farmers or ecological concerned citizens, they will have a cost and a production capacity of ecological products. These products will have a unit cost related to the management of the fertilizer transport, and their transport to local markets. The kind of land and the availability of natural water supplies could be considered in the calculation of production costs.

Figure 50. The city includes parks and residential areas for promoting quality of life.

- **Markets and stores**. They will be held in places decided by the industry and commerce representative with the approval of the city mayor. They have a cost but will also involve benefits if they become a place where producers and consumers can meet and take advantage of the recycling program.

9.7 Class activity

1. The teacher presents the problem to the class and introduces the scenario and game.

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2. The students discuss to understand the problem and define possible solutions. They further discuss to understand the parameters that define success, such as achieving reducing pollution as much as possible with an overall objective of achieving zero-waste, considering city plans that may limit the locations on which students may install waste management buildings, the available budget, and more. They further discuss the limitations set in the scenario such as restricted budgets, availability of locations for installing recycling installations and how these influence the capacity of proposed waste management building, diverse waste management techniques and related costs, and more.
3. The students are encouraged to come up with as many ideas as possible through brainstorming. Techniques of design thinking may be used to promote innovative thinking, brainstorming, sharing are building upon each other's ideas, and thinking from the perspective of city inhabitants in terms of designing an environmentally sound solution to waste management.
4. The students are asked to jointly decide on the ideas to implement from the pool of suggestions that they came up with considering restrictions, such as city plans and budget The teacher forms groups and gives students their roles in the game.
5. The students play the game according to their roles striving to achieve individual and group objectives that may be conflicting. For example, they may need to share a common budget.
6. The students discuss the game results and their roles; the teacher gives feedback.

9.8 Description of the scenario

The overall objective of the scenario is to ensure the appropriate management of the waste produced in a city. Waste cannot be managed effectively by the city government acting alone; all parties must work together to manage garbage sustainably.

This can be achieved through planning for a sustainable recycling system. The choice of solution will be determined by the local characteristics of the site including its size, population, and distances.

Students must understand that **the key is to reduce the amount of waste going to landfill**. To achieve this, students need to introduce traditional and alternative waste management services.

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9.9 Assessment methods

This is an open-ended learning activity in which no single correct solution exists. Rather, the activity aims to raise awareness among students on the importance of effective waste management and recycling and to build their knowledge on related methodologies and strategies.

Students discuss their roles and the outcomes of their activity and decide by using self- and peer assessment methodologies the degree with which they have achieved their goal of developing a zero-waste economy in their city.

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10. Renewable energy

Topic: renewable energy, sustainability, pollution mitigation

10.1 Introduction

Cities rely on energy distribution to be able to provide settling and development conditions for the persons, industries, services, etc. Energy distribution is normally ensured by private or public operators beyond the scope or control of the city. However, as cities can become centers of pollution due to production, even if this takes place outside the city limits, and use of that energy it is in the interest of the city inhabitants to ensure that the production of energy is as clean as possible. The city managers can also implement policies and regulations that contribute to the local clean production of energy, such as promoting the use of solar panels on the roofs, micro-wind centrals, and other technology. Also, city managers can introduce policies that encourage mobility based on clean energy, therefore reducing the level of pollution. The main objective of this lesson plan is to encourage students design energy supply for the city mainly based on renewable energies.

10.2 Context

Figure 51. A large city grid allows players to experiment with renewable energy solutions.

The city major was elected to a city with a lot of pollution due to the use of fossil fuel. Citizens are not happy and want a cleaner and less polluted city! The mayor must work with other stakeholders towards reducing the emissions produced through energy use.

Following are some suggestions for roles that students may undertake:

Role 1: Energy manager

The energy manager ensures that all city inhabitants have access to energy for residential, business, and other purposes. The mayor must work with energy providers to ensure the best deals but also to guarantee that the cleanest sources of energy are used. The mayor is further responsible for creating policies related with the local micro-production of energy.

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Role 2: Treasurer

The treasurer ensures that the enhancements to the city infrastructures and energy distribution networks can be implemented with the existing budget.

Role 3: The city mayor

As the head of the city, the city mayor has the final word about energy production policies, for example electric vs. fossil fuel mobility, and supporting infrastructures, such as roads, buildings, energy distribution facilities, and more. The mayor must ensure that citizens have access to clean energy taking into account fluctuations to energy demand due, for example, to changing weather conditions. The city mayor is really keen on being re-elected, so she is interested to ensure the happiness of inhabitants through the reduction of pollution.

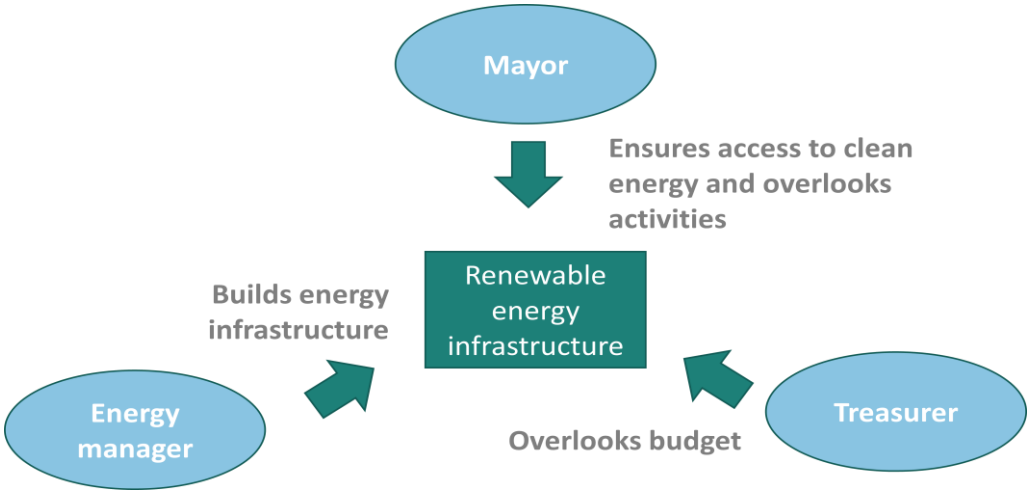

Figure 52. Roles, actions, and interactions.

10.3 Learning goals

Upon completion of the activity students will:

- Understand the connections between environmental, social, and economic aspects of everyday life.
- Have experienced how to achieve cooperation between different parties with different goals and needs.
- Built competence in taking an integrative approach in researching city management and related environmental issues.

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- Create the conditions necessary for navigating the challenges modern society and environmental changes pose for the public and private sector.
- Understand the importance of the energy supply in real life.
- Understand the importance of the renewable energy and its positive and negative aspects.

10.4 Prerequisites

The activity can be introduced to students with no pre-required information. Teachers can deliver an initial briefing about sustainable energy and mobility options and strategies.

10.5 Audience

This scenario is suitable for students in all engineering and management principles. In terms of engineering, the goal scope is closer to the learning objectives of electrical engineering students, but students enrolled in other engineering programs won't have any problems in implementing the scenario.

Figure 53. One of the goals of the scenario is to reduce pollution.

10.6 Core concepts

- **e-Commerce:** Economic activity that takes place over the internet. Through e-Commerce individuals and business can buy and sell products and services on-line.
- **Energy grids:** Energy infrastructures, including diverse energy production plants, such as nuclear, coal-based, or renewable energy based, energy transformers from high, to medium, and low voltage, and power lines that transport energy to homes, businesses, and industry.

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- **Culture:** Arts and other manifestation of human intellectual achievement. In the context of this scenario, culture refers to all activities that promote education, expression, and athletics and foster a high quality of life.

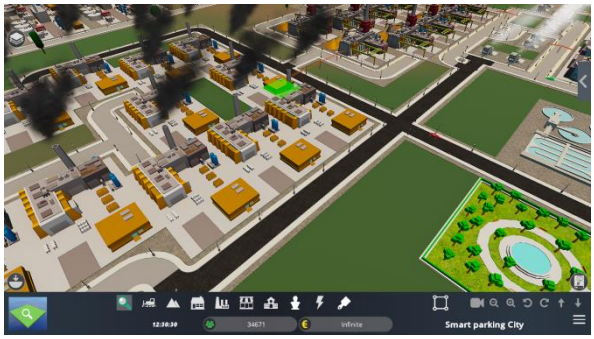

Figure 54. One of the goals of the scenario is reducing pollution.

- **Internet and phone service provider:** A company that provides access to the internet for both personal and business customers. The service requires a network infrastructure, including servers and cables for connectivity and processing of information.
- **City management:** Managing the services, revenues, and expenses of a city.
- **Transversal skills:** collaboration, critical thinking, analytical thinking, innovative thinking.

10.7 Description of the scenario

Figure 55. Small and large residential buildings support the needs of city inhabitants.

The overall purpose of the scenario is to allow students to experience the conflicts of interests and the difficulty of implementing changes when a major city aspect, such as energy, must be dramatically reconfigured with implications on the infrastructure but also on the individual way of thinking about access to energy. It demands good collaborative skills, making compromises towards achieving common goals in a team, critical thinking, and a good flair for optimizing decisions.

The scenario explores the full HERA game using the communication and planning facilities in the game. Students are encouraged to discuss, negotiate, and agree on decisions that they can subsequently implement digitally through the scenario simulated environment.

Participants can explore the consequences of their decisions and insights into what it means in real-life to work with complex decisions. The scenario is based on a city grid that is non-

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trivial including rich enough facilities for students to meaningfully engage in a complex discussion related to energy issue. The initial city grid, on which students will start working, has a traditional energy approach focused on fossil fuel which leads to pollution. Students are challenged to introduce interventions towards clean energy production. As an added difficulty, the city can have climatic events that raise energy demands, therefore creating peaks.

10.8 Suggested class activity

1. The teacher presents the problem to the class and introduces the scenario and game.
2. The students brainstorm to understand the problem and the parameters within which they have to work. This includes the available city budget; the city plans with the current energy schemes and the restrains on what can be built.
3. The students are encouraged to come up with as many ideas as possible through brainstorming. Techniques of design thinking could be used for promoting innovative design and the introduction of a human-centered solution that address actual needs of city citizens.
4. The students are asked to jointly decide on the ideas to implement from the pool of suggestions that they came up with considering restrictions, such as city plans, budget, and energy production.
5. The teacher forms groups and gives students their roles in the game.
6. The students play the game according to their roles.
7. The students discuss the game results and their roles; the teacher gives feedback.

10.9 Assessment methods

This is a collaborative, open ended activity in which not a single solution exists. Self-assessment is useful in this scenario offering students the benefit of taking responsibility of their learning. Students will discuss their roles within their group and reach a decision on whether they achieved their goal or not. Students may further present their solution to the entire class receiving evaluation from their peers. Finally, the class may decide on the more creative solutions among all teams.

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11. Smart parking in the city

Topic: smart parking, traffic, critical thinking, collaborative skills

11.1 Introduction

Many city centers experience extra traffic due to difficulties in finding parking. In some cities it has been estimated to be around 30% of the traffic which is affiliated with the driving around for parking. This increases the CO2 emissions significantly and car owners as well as pedestrians are not very happy about this searching for parking.

11.2 Context

With technology it is possible to create a smart sensor, internet-based system in the city to optimize the search time for parking and direct cars towards nearest available parking facilities, called smart parking, the parking problem can be diminished and herby the CO2 emissions. However, the establishment of the smart sensor internet infrastructure comes with a cost as do the establishment of parking facilities.

The smart sensor internet infrastructure must be built to fit the roads and the parking facilities and therefore, there must be internet coverage in the city so that the smart parking system works. The parking facilities need to be established in a city where there probably not are many vacant spots in the city center for the smart parking facility. Therefore, a negotiation needs to take place among the stakeholders of the city in relation to whether it is best to tear down existing buildings to build smart parking spaces or to live with the traffic. Additionally, some inhabitants of the city do not favor the idea of having cars in the city center and will therefore possibly argue against the idea of smart parking.

Following are suggestions for roles that students may undertake:

Role 1: The city mayor

The mayor can give permission to build internet infrastructure, establish smart parking lots, build building, and tear down existing buildings. Also, the maire is a person in the city that needs to make all inhabitants happy. The mayor, therefore, must keep an eye on creating happiness for inhabitants and car owners, but also to lower pollution, and keeping the city's money at a good, sound level. The mayor must work to establish compromises amongst the

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other roles of the scenario game. The mayor has many interests: to increase happiness in the city, to increase the revenue of the city, and to reduce air pollution in the city.

Role 2: The internet service provider

The internet service provider has an interest in building as much internet infrastructure in the city as possible and best so that the city has 100% coverage. The internet service provider can build ISP buildings to ensure the internet infrastructure but at the same time this role needs permission by the mayor of the city and needs money to establish the ISP buildings. The internet service provider additionally needs to talk with the parking contractor to figure out where to prioritize the ISP buildings and internet coverage first. The internet service provider has an interest in establishing internet in the city but also to increase the revenue of the role.

Figure 56. Internet service infrastructure helps the network connectivity of the city.

Role 3: The parking contractor

The parking contractor has a commercial interest in establishing smart parking lots. The parking contractor an only establish smart parking lots with a permission from the maire to tear down or establish the smart parking facilities. Additionally, the parking contractor needs to agree with the internet service provider where the internet must have best coverage to support the smart parking. The parking contractor can tear down existing buildings and establish a smart parking facility in agreement with the internet service provider. The parking contractor has an interest in establishing smart parking in the city reducing traffic in the city center, which is a special traffic focused area in the game. He also has an interest to build revenue from parking services.

Figure 57. Parking facilities facilitate easy access to the city center.

Role 4: The lobbyist

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The lobbyist is both a city inhabitant as well as an individual that has a saying in the city administration. The lobbyist is not fond of cars in the city center. She has an overall goal to reduce pollution as well as traffic. The lobbyist is not fond of tearing down buildings to establish more parking in the city center. She works against promoting more effective public transport. The lobbyist works towards influencing the mayor to give fewer or less admissions to tear down buildings and to approve the smart parking. The lobbyist aims to make inhabitants happy and to reduce pollution in the city center as a result of less traffic.

Figure 58. Residential areas and industries create increased needs for parking.

The following figure demonstrates the roles and the interactions between them.

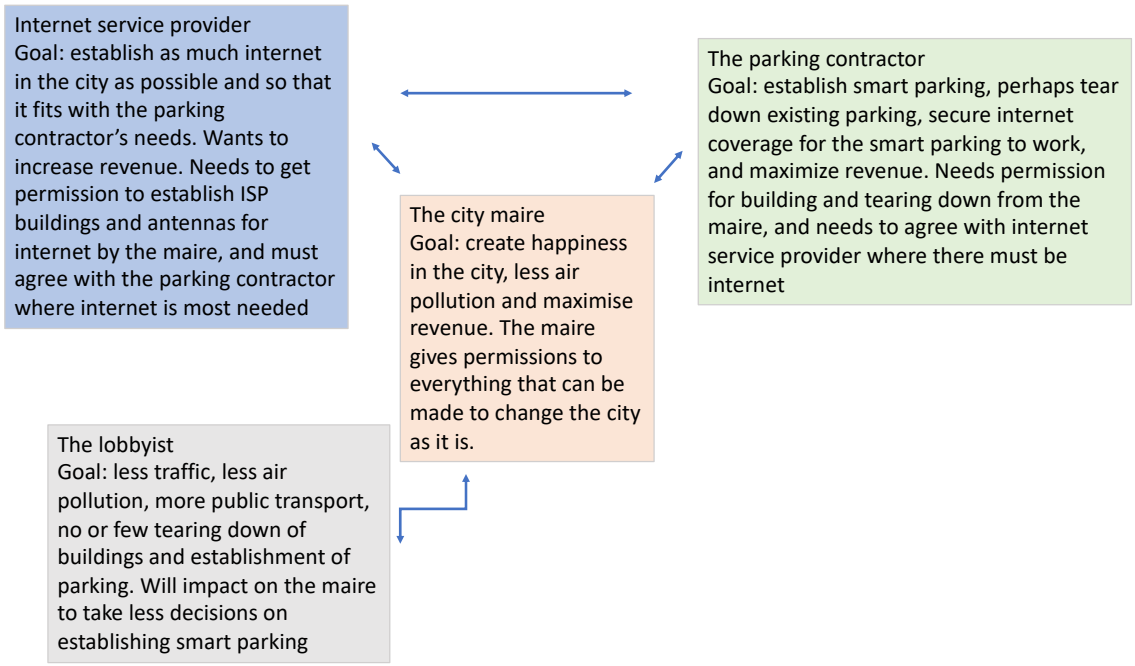

Figure 59. Roles, actions, and interactions.

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11.3 Learning goals

Upon completion of the activity students will:

- Understand the connections between environmental, social, and economic aspects of everyday life.
- Have experienced how to achieve cooperation between different parties with different goals and needs.
- Built competence in taking an integrative approach in researching city management and related economic and environmental issues.
- Created the conditions necessary for navigating the challenges modern society and environmental changes pose for the public and private sector.

11.4 Prerequisites

Students need to understand how the HERA game works. It could be a good idea, to start building a scenario from the beginning to let the students try this, and then as the second exercise to do the scenario on the smart parking city. Also, students must know something about what is needed for creation of smart parking – ISP buildings and fiber network, to support the internet-based support for parking. Additionally, students must be willing to work together and find compromises to satisfy all suggested rolls.

11.5 Audience

The suggested activity targets economics and engineering students. The design and implementation of smart parking requires knowledge on urban planning, behavioral science, and effectively managing a project within the constraints of a pre-defined budget, subjects that are of interest to broad groups of higher education students.

11.6 Core concepts

- **Air pollution:** Encouraging decision making in terms of environmental protection and the impact of human activities on their surroundings both short- and long-term.
- **Ecosystem services:** Services and systems that directly or indirectly benefit communities.

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- **Smart parking:** A complete system that allows drivers to find parking when needed by regulating supply and demand.
- **City management:** Managing the services, revenues, and expenses of a city.
- **Transversal skills:** Collaboration, critical thinking, analytical thinking, innovative thinking.

11.7 Description of the scenario

The overall purpose of the smart parking scenario is to allow students to experience the conflicts of interest there are in a real city when it comes to establishment of just one part of a city's infrastructure (parking). It demands good collaborative skills, compromises, critical thinking, and of course a good flair for complex problem solving.

The smart parking scenario explores the full HERA game using the communication and planning facilities in the game to discuss, negotiate, and agree on decisions that then can be implemented in the simulation of the scenario.

Participants can explore the consequences of their decisions and insights to what it means in real life to work with complex decisions. As a prerequisite of the game there should be established a city, that has a city center with shops, roads and culture, to resemble the old town of the city. Around there must be several other roads, culture, industry and all the elements of the large city which typically has traffic issues. There can be created different cities with variations in size and infrastructure to vary the differences in challenges and solutions. The game will be more challenging the bigger the city is and the more possibilities there exists for smart parking and need for removing existing infra-structure to build the smart parking.

As an additional prerequisite the students must be aware of that there is a need to exchange arguments, knowledge and use skills to persuade other rolls in the game to permissions or various actions. Therefore, the board and chat tools in the game can be used with great advantage amongst the players.

11.8 Class activity

1. The teacher presents the problem to the class and introduces the scenario and game.
2. The students brainstorm to understand the problem and the parameters within which they have to work. This includes the available city budget, the city plans that restrict

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the locations on which parking spaces may be built and may influence their capacity, installation and management costs, citizens commuting patterns, and more.

3. The students are encouraged to come up with as many ideas as possible through brainstorming. Techniques of design thinking could be used for promoting innovative design and the introduction of a human-centered solution that address actual needs of city citizens.
4. The students are asked to jointly decide on the ideas to implement from the pool of suggestions that they came up with considering restrictions, such as city plans, budget, and commute patterns.
5. The teacher forms groups and gives students their roles in the game.
6. The students play the game according to their roles.
7. The students discuss the game results and their roles; the teacher gives feedback.

11.9 Assessment methods

This is a collaborative, open ended activity in which not a single solution exists. Self-assessment is useful in this scenario offering students the benefit of taking responsibility of their learning. Students will discuss their roles within their group and reach a decision on whether they achieved their goal or not. Students may further present their solution to the entire class receiving evaluation from their peers. Finally, the class may decide on the more creative solutions among all teams.

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12. Sustainable city

Topic: teamwork, sustainability, environment, pollution, financial management, interdependency

12.1 Introduction

As the world keeps pursuing continuous economic growth our natural environment continues to degrade. The accelerating rate of extraction of natural resources and destruction of habitats to provide for our rapidly growing population are not sustainable anymore. Pollution levels are also steadily increasing, people are unhappy as ever and around 1.3 billion people live in multidimensional poverty. We need to change our ways of living and develop a plan for a more sustainable way of meeting our needs and ensuring a future for new generations. Since cities are an important hub for the economy and house about 68% of the world population it is important to learn to manage them sustainably and keep balance between consumption, pollution and maintaining natural environment. Sustainability isn't only about the protection of natural resources but is a broad discipline merging ecology, economy, politics, social development and psychology among many others. It is time for society to become more aware of their impact on the environment and on themselves and break free from self-serving ways for a happier society.

Figure 60. The sustainable city scenario challenges students to collaborate for enriching quality of life.

12.2 Context

In this scenario students create with limited resources a city that is as sustainable as possible. This scenario has three different roles where each has a specific area of responsibility. In the scenario, a financial manager, an environmental specialist, and the mayor need to manage a joint budget and to cooperate in the quest of city planning. The goal is to create an "ideal" city: wealthy, sustainable, safe, pollution free, and with a high happiness index. This requires thorough planning, fine balance, and collaboration among participants because the scenario is specifically designed to introduce role objectives that introduce dependencies among the

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activities of the players towards achieving a common goal. Will the players be able to collaborate in order to create an exemplary result?

Following is the description of the suggested roles:

Role 1: Financial manager

The financial manager is responsible for managing city revenue. She needs to build commerce and industries to create a steady income for the city. The income is the basis for the development of the city and other players' work. The financial manager has the ability to build and bulldoze commercial and industrial buildings, with each category generating different income. This is meant to encourage the player to use both types of structures and enhance immersion in the game.

Figure 61.Students start working on a small but functional city, which needs to be enhanced towards sustainability standards.

An ideal city has clean water, soil and air, high employability, and happy residents. It might sound tempting to ignore all those factors but in order to generate income the financial manager should keep environmental damage and workers' happiness in mind. Otherwise she might be risking being disrupted by their city's fellow representatives who have the ability to bulldoze unsustainable design. The financial manager's success is dependent on that of other players. For example, without proper electrical coverage the city cannot generate revenues. As a result, the financial manager relies on the infrastructure created by the environmental specialist in order to have more space for businesses and electricity. In order to achieve the desired goals teamwork is paramount.

Role 2: Environmental specialist

The environmental specialist has an overseeing role. He is responsible for the city's environmental wellbeing and sustainability. His goal is to provide the city with infrastructure and manage the electrical network and pollution levels. In order to achieve that, the environmental specialist needs to monitor the financial manager's and the mayor's work and ensure it is environmentally friendly because their decisions affect his ability to reach his personal goals. One example is low pollution levels. If other players go overboard on

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introducing buildings, the pollution levels rise and this makes it hard to achieve the goals in hand. To reinforce sustainability, the environmental specialist has the ability to bulldoze anything that conflicts with his goals. In addition, the environmental specialist's responsibilities include building infrastructure, providing the city with electrical coverage, and expanding the city by building roads. This provides a basis for the development of the city, its size, and its capacity to generate revenue.

Role 3: Mayor

The mayor is responsible for societal management. The mayor is in charge of the city's inhabitants' wellbeing: their happiness, health, security, education, and entertainment. The mayor needs to provide citizens with housing, businesses, services, culture, and reduce possible criminal activities. In addition, a happy citizen requires wealth and a pollution free environment so the mayor needs to work with his fellow representatives to achieve the goals in hand. In order to avoid the financial manager overpowering the city scene with a purpose to simply get rich the mayor is provided with the ability to bulldoze industries that do not follow the sustainability guidelines and prohibit them from reaching their personal goals. But the balance lies in between and the mayor should still take the city's ability to generate revenues under consideration. Otherwise there might not be enough funds to build housing, public services, and cultural buildings. Most of the objectives have a high percentile (90%) in order to encourage the player to think thoroughly about all of the aspects and try out the different options HERA provides. Teamwork is paramount in order to succeed and find a fine balance between one's own personal pursuits and allowing fellow representatives to do the same without stepping on each other's toes.

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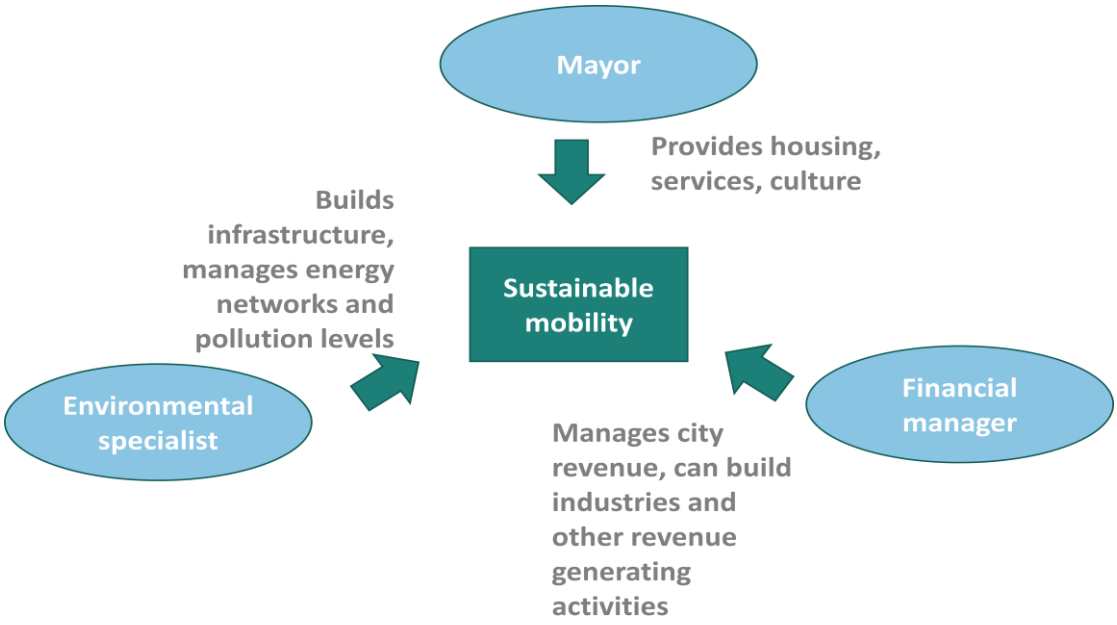

Figure 62. Roles, actions, and dependencies.

12.3 Learning goals

Upon completion of the activity students will:

- Understand the connections between environmental, social, and economic aspects of everyday life.
- Have experienced how to achieve cooperation between different parties with different goals and needs.
- Built competence in taking an integrative approach in researching city management and related environmental issues.
- Have created the conditions necessary for navigating the challenges modern society and environmental changes pose for the public and private sector.

12.4 Prerequisites

Students need to have basic understanding of concepts related to sustainable development.

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12.5 Audience

Sustainable development is a goal that can be achieved only through the collaboration of scientists, engineers, and economists that offer diverse, complementary knowledge. The scenario is of interest to students in all of the above disciplines.

12.6 Core concepts

- **Sustainability:** Encouraging decision making in terms of environmental protection and the impact of human activities on their surroundings both short- and long-term.
- **City management:** Discussing what a well operating city needs and how to manage these aspects.

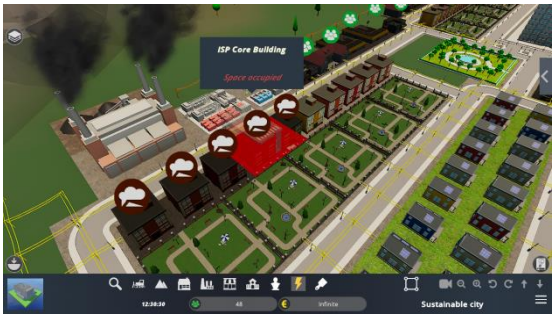

Figure 63.Students need to address issues related to pollution.

- **Environmental impact and pollution:** Seeing how it can occur in cities, how it affects the population and some countermeasures that can be done about it.
- **Interdependence:** An essential element for sustainable development where the dynamics encourage collaboration, trust and alliance over competitiveness and dominance.
- **Happiness index:** Citizens' wellbeing and its relation to the surrounding environment. Which aspects aid in creating a thriving community.
- **Transversal skills:** Collaboration, communication, critical thinking, problem-solving.

12.7 Description of the scenario

The overall objective is to create an "ideal" city, namely a city that is wealthy, sustainable, safe, pollution-free, and with a high happiness index.

Sustainable development cannot be implemented effectively if parts of the government act separately or when some are out for their own individual gain. Succeeding in sustainability requires knowledge from vast areas, understanding relations and environmental impacts. All parties have to work together in order to create a healthy and pleasant city for everyone.

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This can be achieved by starting with designing a comprehensive and an orderly strategy for developing the city. Through planning and seeing the weak spots we prevent faulty design and stagnation in the implementation process. The choice of the solution will be determined by the local characteristics of the site including its size, population, revenues, and landscape. The plan can be adjusted throughout the game. This scenario demands good analytical skills, innovative and critical thinking and compromises.

Students must understand that a sustainable city cannot be achieved by one player dominating the scene for personal gains for which countless examples of similar behaviors can be found in the real world. The key is to work together and create interdependence. Here, we hope to prompt sustainable mentality and showcase the importance of interdependency instead of competitive and codependent ways. If done correctly it helps to lighten the workload for each representative and achieve a living environment that is pleasant to everyone, including for the representatives themselves who presumably live in the area.

Figure 64.Students further need to increase the population of the city by making more services available.

One solution is to use pre-built plateaus for establishing a wind park. This is a green alternative to nuclear or coal-based energy production and takes advantage of windy areas while being away from the city center. Some energy can also be produced by recycling stations. However, all trash sites should be set up somewhere in the outskirts. Since factories create pollution it's important to have water, ground and air treatment stations as a countermeasure. Industrial and residential areas should be separated in order to keep the population away from potentially hazardous chemicals. Although water bodies don't interact with pollutants directly in the game it is not wise to build industries on the shores because of potential leaching that would occur in real life. In addition to chemical impacts it will reduce the value of the milieu as well. Natural areas should be kept clean and accessible for the public in order to provide cultural ecosystem services. These areas can be used for relaxing, picnics, sports, events and other free time activities. Terrain tools could also provide creative options for design - mountains control the winds, provide shade and scenery; water bodies provide habitats, aesthetic enjoyment and could even act as a supply of drinking water for the city. After all, a city must have a water supply. This of course requires water treatment services. Another way of exhibiting sustainable thinking is considering farmlands, parks and

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trees as means to provide natural environment (for example absorbing and retaining water, offering cooling effects and shade, providing habitats and enhancing biodiversity) and as an important part of the milieu. What comes to societal management there should be a lot of different facilities provided. In order to avoid wasting land, resources and fuel placement of different areas should also be thought out. Factors like security, education, presence of nature, employment, health, electricity and internet connection should all be taken under consideration for a happy citizen.

12.8 Suggested class activity

Figure 65.Students have a lot of flexibility to introduce services that address the needs of inhabitants.

1. The teacher presents the problem to the class and introduces the scenario and the game. The teacher has pre-designed part of the city for starters that students need to develop further.
2. The students have to understand the problem and define possible solutions.
3. Teacher forms groups and gives students their roles in the game.
4. The students must get to know their roles and understand their abilities as well as aspects where they are limited and need to collaborate.
5. Team members need to develop an orderly plan to start developing the city. Evaluating ideas, combining them, and prioritizing them towards designing the best possible solutions.
6. The students follow through with their ideas while adjusting the plan according to the flow. Using the agile system in-game is encouraged for communicating each role's needs and for avoiding stagnation.
7. The students discuss game results, their experiences, and the knowledge they developed and the teacher provides feedback.

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12.9 Assessment methods

This is a collaborative, open-ended activity in which a single solution doesn't exist. Self-assessment is useful in this scenario offering students the benefit of taking responsibility for their learning. Students will discuss their roles within their group and reach a decision on whether they achieved their goal or not. Students may further present their solution to the entire class receiving evaluation from their peers. Finally, the class may decide on the more creative solutions among all teams.

12.10 Supplementary material

1. UN and Sustainable cities: https://www.unep.org/regions/asia-and-pacific/regional-initiatives/supporting-resource-efficiency/sustainable-cities
2. Environmental Management Tools and Techniques: https://info.undp.org/docs/pdc/Documents/BTN/Env%20mgt%20tools%20and%20techniques.pdf
3. Possible things to take under consideration when building a city: https://www.theguardian.com/cities/2015/jun/30/how-build-city-step-by-step-diy-guide
4. World Happiness Report: https://worldhappiness.report/ed/2020/cities-and-happiness-a-global-ranking-and-analysis/

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13. Sustainable mobility

Topics: mobility, transportation, environment, pollution, sustainability

13.1 Introduction

Cities may experience traffic gridlocks as the result of the mobility being ensured mostly by private transportation. This also causes a lot of pollution in the city. Sustainable mobility ensured by green public and private transportation can solve many of these issues. Policies related to public and electric transportation vs. private transportation and infrastructures, including roads, buildings, etc., must be adapted to this new mode of mobility. That means creating bicycle and electric vehicles lanes, parking, public green transportation lanes, etc.

13.2 Context

The city major was elected to a city with a lot of gridlocks as the result of a mobility taking place mostly by private transportation. This is also causing a lot of pollution in the city. Citizens are not happy!

Figure 66. The sustainable mobility scenario challenges students to design interventions that allow inhabitants to get easily to their destination.

Following are some suggestions for roles that students may undertake:

Role 1: Mobility manager

The mobility manager ensures that traffic flows swiftly in the city so that everyone can get to their destination easily and quickly. Therefore, the mobility manager is responsible for the traffic infrastructure of the city. He also manages the public transportation system.

Role 2: Treasurer

The treasurer ensures that the changes to the city infrastructure and the maintenance of the public transportation system can be implemented within the existing budget.

Role 3: City mayor

The city mayor has the final word on policies related to public and electric transportation vs. private transportation and the supporting infrastructure: roads, buildings, etc. She must ensure

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that citizens experience easy mobility, preferably through clean transportation. Decisions need to take in consideration the season as in the winter few inhabitants will likely use bicycles or electric scooters. The city mayor is keen on being re-elected, so she wants the inhabitants to be happy as a result of pollution reduction.

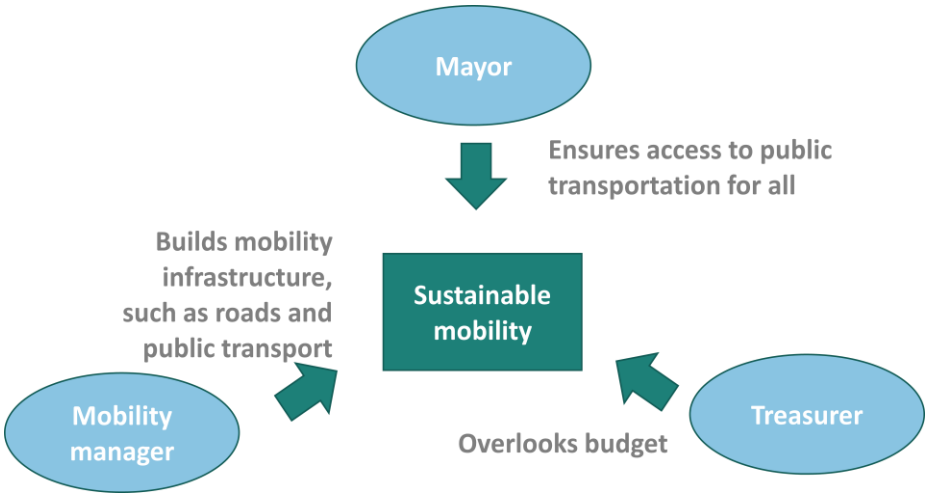

Figure 67. Roles, actions, and dependencies.

13.3 Learning goals

Upon completion of the activity students will:

- Understand the connections between environmental, social, and economic aspects of everyday life.
- Have experienced how to achieve cooperation between different parties with different goals and needs.
- Built competence in taking an integrative approach in researching city management and related environmental issues.
- Created the conditions necessary for navigating the challenges modern society and environmental changes pose for the public and private sector.

13.4 Prerequisites

The activity can be introduced to students with no pre-required information. Teachers can do a previous briefing about sustainable mobility options and strategies.

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13.5 Audience

Figure 68. Students are called to enhance a rich city that includes residential areas, industry, culture, and other services.

This scenario is suitable for students enrolled in broad engineering, economics, and management programs. It is closer to programs related to civil engineering, but students enrolled in other engineering principles will not face any problems in implementing the scenario.

13.6 Core concepts

Figure 69. The scenario explores concepts of sustainability, effective mobility, city management, and pollution control.

- **Sustainability:** Encouraging decision making in terms of environmental protection and the impact of human activities on their surroundings both short- and long-term.
- **Nature-based solutions:** Solutions to real-life challenges that are based on processes the functioning of nature.
- **Ecosystem services:** Services and systems that directly or indirectly benefit communities.
- **City management:** Managing the services, revenues, and expenses of a city.
- **Transversal skills:** Collaboration, critical thinking, analytical thinking, innovative thinking.

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13.7 Description of the scenario

The overall purpose of the scenario is to allow students to experience the conflicts of interests and the difficulty of implementing changes when a major city aspect, such as mobility, has to be dramatically reconfigured with implications on infrastructure, for example roads, but also on the public transportation and on the individual way of thinking about mobility. It demands good collaborative skills, ability to compromise for reaching common goals, critical thinking, and a good flair for optimizing decisions.

The scenario explores the full HERA game. Students use the communication and planning facilities in the game to discuss, negotiate, and agree on decisions that they can subsequently implement through the scenario simulation.

Participants can explore the consequences of their decisions and insights to what it means in real-life to work on complex decisions. The scenario is based on a non-trivial city design that includes rich enough facilities to allow meaningful decisions encouraging students to meaningfully engage in a complex discussion related to mobility issues. The starting city of the scenario may deploy a traditional mobility approach focused on private transportation which will lead to traffic gridlocks challenging students to introduce smart mobility enhancements. As an added difficulty, the starting city can include events that result in a lot of inhabitants converging to the same place at the same time creating specific mobility issues.

13.8 Suggested class activity

1. The teacher presents the problem to the class and introduces the scenario and game.
2. The students brainstorm to understand the problem and the parameters within which they must work. This includes the available city budget; the city plans with the current mobility schemes and the restrains on what can be built.
3. The students are encouraged to come up with as many ideas as possible through brainstorming. Techniques of design thinking could be used for promoting innovative design and the introduction of a human-centered solution that address actual needs of city citizens.
4. The students are asked to jointly decide on the ideas to implement from the pool of suggestions that they came up with considering restrictions, such as city plans, budget, and commute patterns.
5. The teacher forms groups and gives students their roles in the game.

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6. The students play the game according to their roles.
7. The students discuss the game results and their roles; the teacher gives feedback.

13.9 Assessment methods

This is a collaborative, open ended activity in which not a single solution exists. Self-assessment is useful in this scenario offering students the benefit of taking responsibility of their learning. Students will discuss their roles within their group and reach a decision on whether they achieved their goal or not. Students may further present their solution to the entire class receiving evaluation from their peers. Finally, the class may decide on the more creative solutions among all teams.

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14. Towards a smart, sustainable city

Topic: smart city, sustainable city, critical thinking, collaborative skills, complex decision making

14.1 Introduction

Many large cities were built over many years, decades and even 100 of years. This means that many large cities are a total mix of houses, industry, and more that are based on old building principles and brand-new building principles. Sustainability is one of the essential principles and goals that societies of today have, as well as the introduction of technology and internet to build more smart cities that can support to create less traffic, secure automatic shopping, and many more use cases. This is referred to as the smart city. In this scenario, the task is to transform the traditional city to what can be named a smart, sustainable city.

14.2 Context

With internet applications in cities and not just people's living rooms, cities can become smart. This can mean that traffic signs change according to the intensity of cars, that signs can direct ambulances through the traffic in the best and shortest way, that robots and sensors can be used to automate and optimize the waste and the way we handle waste in the city and many more. The concept of the smart city goes well with the purpose of transforming cities into sustainable cities. Sustainable cities can be defined very broadly as a city that handles the waste in a correct and biologically way, that energy comes from renewable sources and that new buildings are built with sustainable, biodegradable elements and that changes to older buildings are done with the same kind of considerations. One of the major challenges of this scenario is for the players to define how they perceive the concept of the smart, sustainable city and to create changes to an existing city so that it fulfills the idea of the smart, sustainable city.

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Following are some suggestions on different roles that the scenario may support:

Role 1: Private contractor for commerce and housing

This role represents real estate contractors who build and sometimes tear down buildings to build new. The private contractor for commerce and housing has the overall purpose of increasing the commercial as well as the housing proportion of the city. This role has no specific interest in sustainability but needs energy for the buildings and internet coverage since that is essential for the inhabitants in the city.

Figure 70. Residential building provide housing.

Role 2: City energy manager

The city energy manager wants to transfer all energy production, waste management etc. to renewable energy. Additionally, this role has an interest in trying to impact the private contractor so this person will bulldoze existing not energy efficient buildings and replace with building that are more energy friendly. The city energy manager also has an interest in securing that waste management can take place under the best optimal conditions by use of technology, internet, and automation. The role therefore has a specific interest in lowering the energy consumption of the city, general pollution reduction and waste management in a more sustainable form.

Figure 71. Energy infrastructures support residential and industrial activities.

Role 3: Private internet and technology contractor. This role is responsible for securing that the city has internet coverage overall to allow for smart city solutions and for energy friendly solutions. The private internet and technology contractor will work to make the city bigger so that there is more

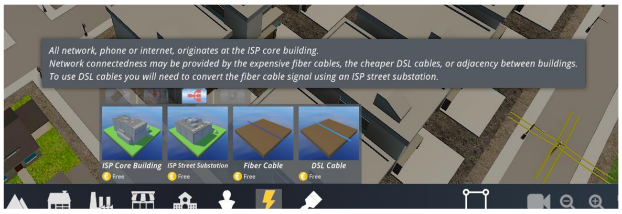

Figure 72. Network infrastructures promote business practices and economic growth.

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internet that needs to be placed in the city. The overall purpose of this role is to establish so much internet coverage as possible work for more housing and commercial buildings and support the happiness in the city by the smart internet-based solutions.

In the following figure, the roles and interactions are displayed.

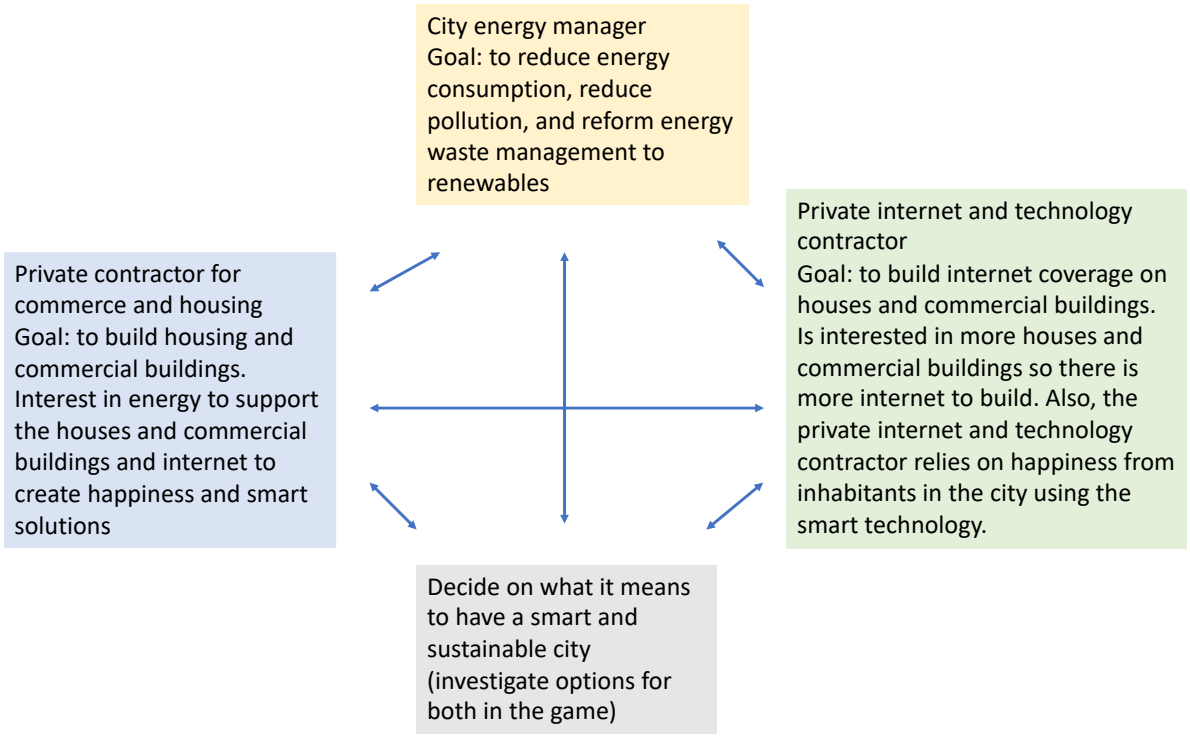

Figure 73. Roles, actions, and interactions.

14.3 Learning goals

Upon completion of the activity students will:

- Understand the connections between environmental, social, and economic aspects of everyday life.
- Have experienced how to achieve cooperation between different parties with different goals and needs.
- Built competence in taking an integrative approach in researching city management and related environmental and technological issues.

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- Created conditions necessary for navigating the challenges in modern society that needs to change according to new goals and challenges.

14.4 Prerequisites

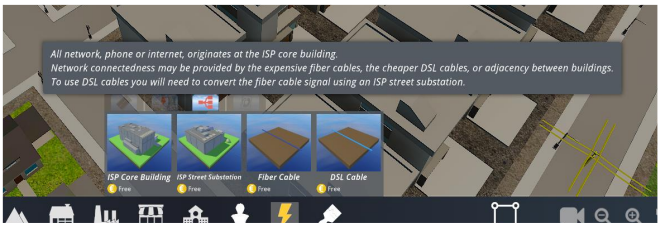

Figure 74. Energy infrastructures support residential and industrial activities.

The students must understand the way the game works with respect to electricity, internet, pollution etc. It can therefore be a good idea for students to try to build a city by themselves as a first assignment, to learn how the different dependencies are between buildings, antennas, pollution, roads, etc. This scenario is a difficult game to play. Partly students must define and agree on what it means to create a sustainable and smart city. Then they need to agree on individual parts of this example city to find out where they create more value to go in the direction of the goals. The students also must be willing to compromise and find common solution for all rolls to be fulfilled.

14.5 Audience

The suggested activity targets economics and engineering students. The design and implementation of sustainability-supporting infrastructures is directly linked to technological advances as well as effectively managing a project within the constraints of a pre-defined budget.

14.6 Core concepts

- **Sustainability:** Encouraging decision making in terms of environmental protection and the impact of human activities on their surroundings both short- and long-term.
- **Sustainable city:** A city that is built on principles for sustainability and lower energy consumption and pollution.
- **Smart city:** An internet-based city that allows for smart solutions and can benefit the inhabitants of the city.

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- **Transversal skills:** Collaboration, critical thinking, analytical thinking, innovative thinking, complex decision making, and problem solving.

14.7 Description of the scenario

The overall purpose of the scenario is to understand, experience, and build skills on addressing the challenges related to the management of a city when different central city representatives have different goals and perspectives. The scenario demands that the students assuming the roles discuss different possibilities for fulfilling the goal of a smart, sustainable city. Through the suggested activities students develop understanding on some of the real-life challenges current city representatives are facing today. The scenario demands good analytical skills, creative and innovative skills, critical thinking, and making compromises towards achieving common goals.

Playing the scenario can be supported with the functionalities in the HERA game relating to chat and board tools where aspects of the game can be discussed, negotiated, and agreed upon by the different roles.

The participants can explore the consequences of their decisions and to a real-world complex problem transforming a traditional city to a smart, sustainable city. The scenario is based on a non-trivial city design that includes rich enough facilities to allow meaningful decisions, such as commercial areas with shops, shopping centers, cultural establishments, sports facilities, traditional waste management facilities, traditional energy production, and more that can be adapted using renewable strategies. It will be most interesting to play the game if there is potential for changing the status of energy consumption towards reducing pollution levels. There is no need to start the game with a very large city, since that can complicate matters and dependencies among energy, housing, internet, and happiness factors. But if the students are more experienced, a larger city can be used for the game.

14.8 Suggested class activity

1. The teacher presents the problem to the class and introduces the scenario and game.
2. The students brainstorm to understand the problem and the parameters within which they have to work. This includes the available city budget, the city plans that restrict the locations on which parking spaces may be built and may influence their capacity, installation and management costs, citizens commuting patterns, and more.

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3. The students are encouraged to come up with as many ideas as possible through brainstorming. Techniques of design thinking could be used for promoting innovative design and the introduction of a human-centered solution that address actual needs of city citizens.
4. The students are asked to jointly decide on the ideas to implement from the pool of suggestions that they came up with considering restrictions, such as city plans, budget, and commute patterns.
5. The teacher forms groups and gives students their roles in the game.
6. The students play the game according to their roles.
7. The students discuss the game results and their roles; the teacher gives feedback.

Figure 75. Factories further contribute to the economic activity of the city.

14.9 Assessment methods

This is a collaborative, open ended activity in which not a single solution exists. Self-assessment is useful in this scenario offering students the benefit of taking responsibility of their learning. Students will discuss their roles within their group and reach a decision on whether they achieved their goal or not. Students may further present their solution to the entire class receiving evaluation from their peers. Finally, the class may decide on the more creative solutions among all teams.

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