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Erasmus+ stratégiai partnerségek az iskolai partnerségek területén

Europe Goes Zero

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Neumann János Gimnázium, Technikum és Kollégium, Eger

Iskolánk pedagógiai programja értelmében iskolánk környezeti nevelésének célja a környezettudatos magatartás, melynek tzartalma Magyarországon is kiszélesedett a fenntarthatóságra való törekvéssel, amely az emberiség jövőjének biztosítására irányul.

Iskolánk fenntarthatósági törekvései révén elnyerte az Ökoiskola címet, melynek megtartása mellett fontosnak tartjuk fenntarthatósági törekvéseink folytatását, és az Örökös Ökoiskola cím elnyerését. Ezen célok megvalósításához aktív kiscsoportok és tágabb hazai és nemzetközi közösségek kialakítása szükséges. Előtérbe kerülnek azok a tanulásszervezési módszerek, amelyek során felerősödhet a társas részvétel, felértékelődhet a felelős együttműködés.

Ezért 2020-ban örömmel kapcsolódtunk egy négy európai iskolából álló partnerségi kezdeményezéshez, amelynek az volt a célja, hogy jó gyakorlatok és közös tréningek révén a résztvevő tanárokban és diákokban erősítse a hulladékmentes –un. zero waste- életmód megismerését és fokozatos megvalósítását.

A Europe Goes Zero projektben résztvevő partneriskolák:

- Almende College locatie Isala, Silvolde, Hollandia
- Maiju Lassilan Koulu, Tohmäjärvi, Finnország,
- Wirtshaftgymnasium West, Stuttgart, Németország
- Neumann János Gimnázium, Technikum és Kollégium, Eger, Magyarország

A projekt honlapja: https://europegoeszero.wixsite.com/europe-goes-zero

Az együttműködés egyik legfontosabb eseménye a zöldparlament megszervezése volt, amelyet 2023. május 17-én, Egerben rendeztük meg, az európai középiskolák és hat egri iskola közös részvételével. Ennek alapvető célkitűzése volt, hogy tudatosítsa a résztvevőkkel a klímaváltozás és a globális környezeti és társadalmi problémák összefüggéseit, és felismertesse, hogy ezek késleltetésére és enyhítésére csak a társadalmi összefogás reményében van lehetőség. Ennek izgalmas megvalósulását kínálta egy ENSZ klímavédelmi tanácskozás szimulációja, amely során az En-Roads internetes alkalmazást használtuk. Az En-ROADS szimilátort az MIT Sloan Initiative, a Ventana Systems és a Climate Interactive fejlesztette ki és tette bárki számára ingyenesen elérhetővé.

https://en-roads.climateinteractive.org/scenario.html?v=23.6.1

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Használata több szituációban is lehetséges (tanórai alkalmazás, műhelyfoglalkozás, szimulációs játék), az általunk szervezett ökoparlament számára az ENSZ klímavédelmi tanácskozás formájában szervezett szimuláció bizonyult a legmegfelelőbbnek.

Ökoparlamentünk megtartásával az is volt a célunk, hogy a más egri középiskolákból érkező (többnyire angol nyelvtanár) kollégáknak felhívjuk a figyelmét erre a lehetőségre, így saját iskolájukban és intézményük kapcsolati hálójában is szervezhetnek hasonló eseményeket, ehhez segítségül egy angol nyelvű kézikönyvet is készítettünk.

Az En-ROADS használatát Hollandiában ismertük, „jó gyakorlatként" szeretnénk elterjeszteni a hazai gyakorlatban. Az Ökoparlamenten hat egri középiskola tanulói delegációja és kísérőtanárai vettek részt:

- Neumann János Gimnázium, Technikum és Kollégium
- Dobó István Gimnázium
- Szilágyi Erzsébet Gimnázium
- Pásztorvölgyi Gimnázium és Általános Iskola
- Gárdonyi Géza Ciszterci Gimnázium
- Andrássy György Katolikus Közgazdasági Technikum, Gimnázium és Kollégium

A meghívott iskolák városunkban azok a középfokú oktatási intézmények, amelyek a felsőoktatásban történő továbbtanulásra készítik fel a diákokat. A jövő értelmisége és társadalmi-gazdasági döntéshozói ülnek ezeknek az iskoláknak a padjaiban, akiknek nem csupán személyes szokásai és fogyasztói döntései lesznek számottevőek, de hivatásuk révén olyan pénzügyi, gazdasági, társadalmi jellegű változásokra is hatással lehetnek, amelyek az egyszerű fogyasztói döntéseknél nagyobb volumenűek. Megítélésünk szerint sokat számít, hogy a jövőt formáló döntéseket olyan szakemberek hozzák meg, akiknek fejlett környezettudatossági kompetenciái vannak és tisztában vannak a gazdasági, társadalmi, környezeti változások bolygónkat érintő hosszú távú következményeivel.

Az ökoparlament résztvevői 6 szekcióban dolgoztak együtt:

1. Land, Agriculture &Forestry
2. Industry and Commerce
3. Conventional Energy Supply
4. World Governments
5. Clean Tech
6. Climate Justice Hawks

A parlament résztvevőinek célja az volt, közös döntéseik révén olyan jövőképet alakítsanak ki, amelyben a 21. század végére a globális átlaghőmérséklet a jelenleg prognosztizált 3,6 °C emelkedés helyett maximum 2,0 °C-kal emelkedik, vagy optimálisabb esetben 1,5 °C körül lehet tartani, de ennek elérése csak az érdekcsoportok szoros együttműködésével lehetséges.

[Ide írhat]

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EN-ROADS

Climate Calling:

Voices for a Greener Planet

The Green Parliament Guidebook

2020-2023

Funded by the European Union

Contents

Preliminary Preparations

The Green Parliament is an **event** where **young people come together to discuss global problems and suggest solutions**. In order to quickly recognise the consequences of the policies they suggest these are simulated by **En-ROADS, a** free online tool designed to explore, test and demonstrate climate solutions. https://www.climateinteractive.org/en-roads/.

Organising a Green Parliament for secondary school people is a very effective method for developing complex skills and competencies at the same time:

a. **Global Environmental Awareness:** En-ROADS can enhance students' understanding of climate change, its causes, and potential solutions. They will learn about the complex interplay of factors contributing to global warming and gain a better understanding of the global nature of climate change, the differing impacts on various regions, and the need for international cooperation. Engaging with En-ROADS may deepen students' understanding of the environment, ecosystems, and the importance of protecting the planet.
b. **Systems Thinking and Data Analysis:** En-ROADS is a system dynamics model that simulates climate systems. Students will develop skills in understanding and manipulating complex systems. Interacting with En-ROADS data and running simulations will help students analyse and interpret complex datasets related to climate change.
c. **Research Skills and Critical Thinking:** To make informed decisions within the En-ROADS model, students may need to research and gather data on various topics related to climate change. En-ROADS encourages students to think critically about the consequences of different policy and technology choices.
d. **Problem Solving:** Students will have to develop strategies and solutions to meet climate goals. They will learn how to address complex, global issues with innovative solutions.
e. **Communication and Public Speaking Skills:** Climate summits often involve discussions, negotiations, and presentations. Using En-ROADS can improve students' ability to communicate their ideas effectively to others. Presenting En-ROADS simulation results and policy proposals to a summit audience can improve students' public speaking and persuasion skills.
f. **Collaboration and leadership:** Climate change is a global problem that requires cooperation. Students working with En-ROADS in a summit will have the opportunity to collaborate with peers, negotiate, and build consensus. Participating in a climate summit using En-ROADS can cultivate leadership skills as students take on roles in negotiations and policy discussions.
g. **Innovation and Technology:** En-ROADS can spark interest in technology and innovation as students explore how new technologies can help combat climate change.
h. **Social Sustainability Skills, Empathy and Perspective-taking:** Students will learn to consider the ethical dimensions of climate change, including issues related to climate justice and equity. Learning about the potential consequences of climate change can foster empathy and a deeper understanding of the impact on different communities and future generations.

1.1 Selecting date and place

The Green Parliament takes **180 minutes**.

I. Lead-in and preparations (60 minutes)
II. Green Parliament Climate Summit (90 minutes)
III. Evaluation (30 minutes)

As it takes the form of a UN Climate Summit it is a highly effective way to merge learning and social activities of a thematic week (e.g .European Week For Waste Reduction or Sustainability Week) into a ceremonial event. Depending on the number of participants (24-48 + 8 moderators) the parliament requires a large classroom, an auditorium or a conference hall.

1.2 Invitations

Invitations to institutions delegating representatives to the event are to be sent at least a month prior. Depending on the size of the event each participating institutions should delegate at least 6 representatives. The invitation should clarify the aim and purpose of the event and emphasize that representatives are not competing but collaborating with each other.

1.3 En-ROADS

En-ROADS is a climate simulation model and interactive tool developed by Climate Interactive. It helps users explore the potential impacts of various policies and actions on global climate change. En-ROADS stands for "Energy Rapid Overview and Decision Support." It allows users to input different scenarios, such as changes in energy production, carbon pricing, and land use, to see how these choices can affect global temperature, greenhouse gas emissions, and other climate-related factors. This free online tool can be used in workshops, educational settings, and policy discussions to promote informed decision-making in the context of climate action.

Green Parliament Opening

2.1EcoBingo

To break the ice at the beginning of the event it is useful to insert a warm-up activity.

EcoBingo allows participants to mingle and focus on their own attempts to be more friendly to the environment. The aim of the activity is to cross off as many fields as possible within a period of 10 minutes - while students are also initiating short conversations with each other and are getting into a sustainability mindset.

Find someone who			
collects at least 5 different types of material selectively at home	belongs to an environmental group	mostly walks or goes to school by bike	does not use plastic bags
owns something that was made of recycled PET bottles	makes their own cleaning products and cosmetics.	is a vegan or a vegetarian	takes home-cooked meals for lunch packed in a lunchbox
composts at home	can recommend an inspiring group or film on green issues.	who does not buy disposable bottled water or soft drinks	can name a famous person known for their green activity

2.2 SustainaSprint

Representatives delegated from participating institutions (e.g. different nations or secondary schools) are placed in six groups (World Governments, Climate Justice Hawks, Commerce & Industry, Land, Agriculture & Forestry, Conventional Energy,) It is more effective to place delegates in different groups and thus further promote the idea of collaboration.

To strengthen cooperation within the six teams a quiz (SustainaSprint) is launched where the group members need to work together to guess (or deduct) the correct answers to the questions below. Any quiz game app can be used (e.g.Kahoot!, Quizlet Live, Mentimeter, Socrative, EdPuzzle … etc.) for this activity but we opted for a chair race to promote more personal interactions between the participants before the actual congress. The questions and the answers also promote discussions, so the role of a moderating teacher is essential here. The questions focus on all three pillars (environmental, social, economic) of sustainability, which is important as sustainability is often considered to be related to our

natural environment only. By making students realise that the definition of sustainability (the responsible and balanced use of resources to meet the needs of the present generation without compromising the ability of future generations to meet their own needs) implies a more holistic view of life on Earth, we also prepare them to think in complex terms when it comes to creating policies in the Green Parliament.

Quiz questions:

1. How many videos are watched every day on TikTok? *(over 1 billion videos)*
2. How many garments are made on a daily basis by fast fashion chains? *(1 million garments)*
3. How many different synthetic chemicals are used to turn raw materials into textiles?
   (8000 different synthetic chemicals)
4. How much water is required to make a cup of coffee? *(140 litres)*
5. How long does it take for a cigarette butt to decompose? *(18 months to 10 years)*
6. In 2019 women held……. per cent of managerial (top, high) positions worldwide. *(28%)*
7. Finland was the first country in the world to give women the right to vote. When was it? *(1906)*
8. At the current rate of progress, how many more years it may take for women to have the same legal rights and protections as men? *(250-300 years)*
9. How much water do we need to produce a liter of cow milk? *(628 litre)*
10. How much water do we need to produce a liter of soy milk? *(0,9 litres)*
11. How much water do we need for a pair of jeans? (7600 litres)
12. A full bath is equal to approximately _____ of water. *(50-150 litres)*
13. Recycling one ton of paper saves _____ trees. *(17)*
14. _____ people live in modern slavery today. *(50 million)*

The competition between the groups strengthens team cohesion is a good opportunity to reward the teams with equity cues (to be considered later on while creating policies during the congress).

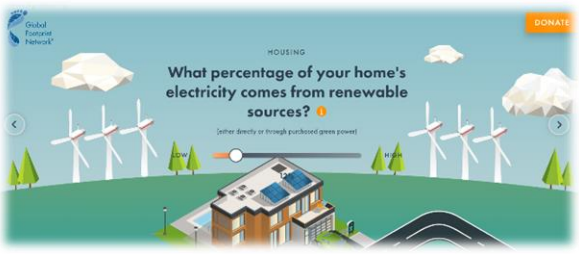
Equity cue examples (see more in appendix):

- Taxing coal can raise energy costs for households and businesses that rely on coal for energy needs.
- Carbon dioxide sequestration technologies are extremely energy-intensive.
- Eating culture is closely connected with the values and customs of individual peoples. Changing them, switching to a vegetarian or vegan lifestyle is very serious it requires a change of attitude.

1.3 EcoTrace Expedition

After creating initial contact between the participants (EcoBingo) and creating a basic sense of "us" within the six interest groups of the upcoming congress (SustainaSprint) we inserted a third step into the preparatory phase of the event – a student-friendly **footprint calculator**: https://www.footprintcalculator.org/home/en

The "footprintcalculator.org" is a user-friendly online tool that helps individuals assess and understand their ecological footprint. This calculator takes into account various aspects of life that affect your ecological footprint: energy consumption, transportation habits, dietary choices, waste management, and consumer behaviour. By examining these different areas, it provides a holistic view of one's environmental impact.



Once the assessment is completed, the calculator generates a detailed report that breaks down your ecological footprint.

The most effective element of the tool is the final calculation of one's **Personal Overshoot Day** (i.e. if everyone had the same lifestyle choices this is how long the planet's resources would last each year). This report offers clear data on how your choices compare to Earth's capacity.

The "footprintcalculator.org" provides personalized recommendations (actions you can take to reduce your footprint) as well. These recommendations cover areas like energy conservation, sustainable transportation, dietary changes, waste reduction, and responsible consumer behaviour.

After using the calculator, you can regularly return to track your progress. As you implement changes in your lifestyle, you can see how your footprint evolves over time, providing motivation and a tangible way to measure the impact of your efforts.

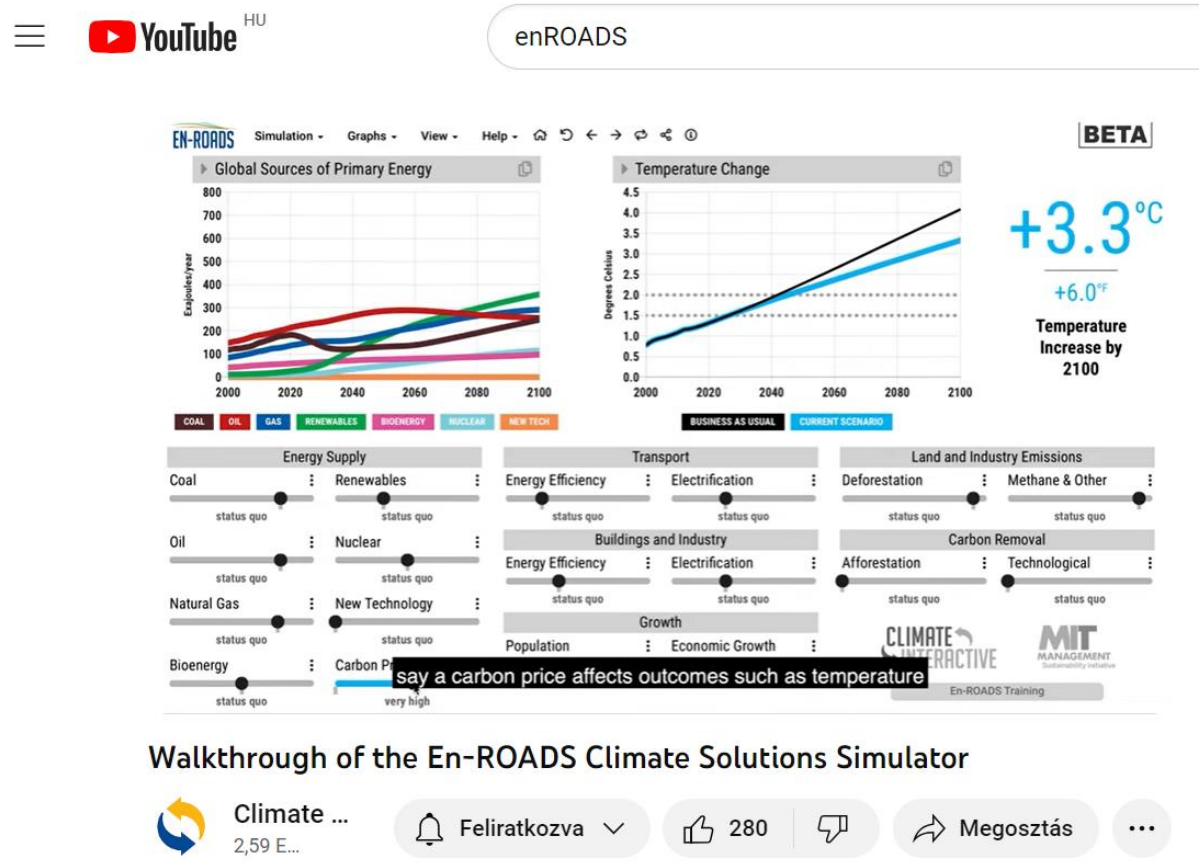
EnROADS in Action

https://en-roads.climateinteractive.org/scenario.html?v=23.10.0

3.1 Unleash the Power of En-ROADS: Sustainability at Your Fingertips

In order to use En-ROADS effectively, it is important to get familiar with it. There are many sources available to make it easier to explain how the simulator operates. The following YouTube video not only presents the basics but explains the in-depth use of the tool as well.

https://www.youtube.com/watch?v=7Muh-eoPd3g



The En-ROADS simulator is developed by the MIT Sloan Initiative, Ventana Systems, and Climate Interactive and is freely available to anyone. It can be used in several situations (class application, workshop, simulation game). It requires one or to moderator to lead the event and EnROADS offers free online trainings (8 week long). https://learn.climateinteractive.org/

3.2 From Awareness to Action: A Climate Conference

The Green Parliament is organised using the En-ROADS guidelines for a Climate Action Simulation in the form of a UN climate protection conference.

The participants of the eco-parliament worked together in 6 sections:

1. Land, Agriculture & Forestry
2. Industry and Commerce
3. Conventional Energy Supply
4. World Governments
5. Clean Tech
6. Climate Justice Hawks

The goal of the participants of the parliament is to create a vision of the future through their joint decisions in which the global average temperature by the end of the 21st century rises by a maximum of 2.0 °C. (Currently it is estimated to rise by 3.6 °C). This can only be achieved with the close cooperation of interest groups.

In order to make sure that all participants in each interest group are actively involved in the joint work, each participant is given a group function: time manager, spokesperson, clerk, negotiator, team leader, etc.

During a 90-minute meeting the 6 interest groups created their own climate action plans and took turns in presenting them in 2-minute speeches. The moderator uses En-ROADS to demonstrate the consequences of the suggested policies and encourages the delegates to elaborate, react, respond and discuss.

“Multisolving" is also an important aspect, i.e. delegates need to pay attention to the problems of disadvantaged social groups and suggest solutions that solve more than one problems at the same time. Moderator needs to explain the concept of “equity’(recognizing that we do not all start from the same place and must acknowledge and make adjustments to imbalances).

Green Parliament Closing

4.1 Eco Reflections: Thoughts That Sprout Sustainability

Once the simulated summit ends and the groups have reached their goal (or have run out of time) it is important to reflect on the experience in order to ensure that participants take the most away from it. The moderator of the event should help students explore their feelings, support them in realising how much they learned and encourage creating personal plans to introduce step-by-step changes in their lifestyle and habits.

"The world as we have created it is a process of our thinking. It cannot be changed without changing our thinking."
- Albert Einstein

"Never doubt that a small group of thoughtful, committed citizens can change the world. Indeed, it is the only thing that ever has."
- Margaret Mead

En-ROADS training materials also offer free slides for facilitators to support them during the Climate Action Simulation Event:

https://www.climateinteractive.org/en-roads-workshop-slides/

Appendix

Equity Cues

- Taxing coal can raise energy costs for households and businesses that rely on coal for energy needs.
- Low-income communities often suffer the worst health outcomes yet make up the majority of individuals who produce coal. Providing pathways for these people to find new jobs will be essential.
- Oil companies wield enormous economic and political power locally and globally. In order to discourage oil, certain industry protections must be eliminated.
- There is a history of oil refineries being located in marginalized communities and companies working to avoid or limit environmental regulations.
- Generally speaking, natural gas production in developed countries is disproportionately located near low-income and minority communities.
- There have been cases where wealthy white communities have successfully resisted natural gas development and it has shifted to low-income communities predominantly inhabited by people of colour. Low-income communities often have less ability to influence development.
- Limited data on the placements of fracking and power plant sites in developing countries exists, yet macro-level research shows that low-income communities and communities of colour disproportionately experience the negative impacts of natural gas drilling and burning.
- Land used for bioenergy crops can reduce land availability for food production and compromise food security.
- Famers livelihoods can be severely impacted by shifting agriculture markets, so steps should be taken to help workers and farmers transition to shifting crop demands.
- Although the price of renewable energy infrastructures continues to fall, many low-income communities remain unable to access the technology in both developed and developing countries. Working to ensure an equitable energy transition can help everyone to reap the benefits.
- Policies in many developed countries limit solar and wind subsidy programs to homeowners who often occupy higher income brackets.
- Nuclear power plants, uranium mines (which provide the fuel for nuclear power), and waste sites are often located in low-income, marginalized communities that often lack resources to advocate for stricter environmental regulations and oversight.
- Mining uranium poses significant health risks to miners as well as surrounding communities due to water contamination and toxic waste.
- There are unknown consequences and risks associated with new energy sources, and oftentimes these technologies can end up being located in vulnerable communities.
- As carbon taxes reach effective levels, companies may try to pass costs to customers, where the poor are most at risk of being impacted. Policies can be developed that limit this impact.
- Workers employed at fossil fuel industries risk losing their jobs if companies shrink workforces in response to higher costs of production, so job transition plans should be in place and protections for workers ensured.
- In some developed countries, such as the United States, pedestrian and cycle-friendly infrastructure has been concentrated in wealthy communities, leaving out low-income families and people of colour.
- When mass transit options improve or operating costs decrease with fuel efficient vehicle use, social equality may improve, as low-income individuals have more transportation options to meet their needs.
- Although costs are coming down, electric vehicles may not be affordable or available to everyone.
- Mining of lithium and copper, two necessary ingredients for the batteries used in electric vehicles, can be damaging to precious ecosystems and threaten the well-being of communities near mining sites.

- Electric charging station locations may not be accessible or the electric battery range may be insufficient for some situations.
- When it comes to energy efficiency of buildings and industry, the up-front capital costs of efficiency improvements may not be accessible to lower income individuals and small businesses.
- The up-front capital costs of retrofitting buildings and heating systems to be entirely electric may not be accessible to low-income individuals and small businesses.
- Exposure to household air pollution is unevenly distributed within and across countries, to which negative health effects and poverty are strongly correlated.
- Policies around population should be voluntary and empower women to make the choices that are best for them.
- A higher percentage of women of colour live in countries with severe gender inequalities in access to education, full economic and political participation, and adequate family planning. Reducing population growth necessitates a large investment in that particular group.
- There is a history of women of colour in both high- and low-income countries being forcibly sterilized to prevent giving birth; this should never be encouraged.
- Economic growth is tied to pulling people out of poverty worldwide. Although, in recent decades, many gains in economic growth have gone to the world's wealthiest. Regardless, policies must be tailored to specific local and regional circumstances.
- When GDP growth slows or contracts, governments can incur higher budget deficits, often implementing austerity measures – cutting spending and raising taxes – to offset the difference. These reforms can severely impact the poor and working class, causing job losses and all the inequities that come with loss of livelihood.
- Many cultural values are attached to certain foods, meaning a change to more plant-based diets could require a large societal shift.
- Policies implemented without care may threaten food security for certain individuals and communities. For example, rice paddies, a large methane contributor, produce a main dietary staple for many countries.
- Forest preservation efforts have sometimes restricted the land access of Indigenous people who have lived sustainably on the land for generations. Policies should be created with local stakeholder engagement.
- Afforestation entails shifting large arear of land to forest. This can sometimes result in monocultures of trees that are all the same age, which does not contribute to healthy biodiversity as much as natural forests.
- Approaches like BECCS (Bioenergy with Carbon Capture and Storage) require large areas of land that in some cases could otherwise be used for food production.
- Methods like direct air capture and enhanced mineralisation would demand large amounts of energy.

Tour of the En-ROADS Simulator

En-ROADS is a **global simulator** and it was built by MIT Sloan. It helps people see how **actions such as e.g. carbon price affects the outcomes such as temperature.** On the left is the main graph that shows various sources of energy from 2000 out to 2100, you can see coal (brown), oil (red), natural gas (blue), renewable energy (green), bioenergy (pink), nuclear energy (light blue) and new technology (orange). On the right is temperature change from 2000 out to 2100 with a final 2100 temperature in Celsius and Fahrenheit.

At the bottom are sliders, not just carbon price but many other actions that can be tested, such as energy efficiency in transport, energy efficiency in buildings and industry, taxing coal, the use of a new technology, growing more trees, cutting deforestation, electrifying, cutting methane and other actions such as carbon removal. You click the buttons and thousands of equations in the model calculate the impact. The developers at Climate Interactive and MIT Sloan built En-ROADS using the best available science on climate, energy economics, land use and agriculture with data from the United Nations, the IEA (the International Energy Agency) and the IPCC (the Intergovernmental Panel on Climate Change).

The purpose of the En-ROADS simulator is to support and frame better conversations about how to address climate change. By changing any levers a businessperson, a policymaker or a community member, a climate leader or a student can test various solutions to climate and quickly see the outcome in the long term.

Or a more advanced user may want to set a more specific carbon price, say 75 dollars a ton, phasing over a certain amount of time. In the advanced view you can find the information button where one can see examples of this policy, the big message, some of the key dynamics, co-benefits, equity considerations and the slider settings.

One can also dig even more deeply into the overall user guide and the 400-page reference guide for the model.

You can also replay the last change. The button at the top undoes the action or redoes the action so one can see what the relative impact is. Or you can do it as a movie by hitting replay last change and then letting the simulation automatically play out.

One of the more interesting views is the Kaya Graphs. It shows population, consumption, energy intensity of GDP, carbon intensity of energy – all to be multiplied together to give you CO2 emissions from energy.

The circular backwards arrow resets the previous change. The home button resets all the graphs and brings you back here.

After you make a scenario that you like; i.e. as a result of your actions you can get all the way down to below 2 degrees or 1.5 – which means it is a very successful scenario- you can hit the button and you can copy your scenario and by sending it to someone else you can share your vision for addressing climate change.

At this point temperature is the graph on the right. We often find it helpful instead to show greenhouse gas net emissions, it shows changes a good bit more than just by looking at the temperature graph. Even more advanced users may want to see the area graph (Greenhouse Gas Net Emissions) which shows all of those actions stacked and shows many of the negative emissions below the zero line. The term “negative emissions” refers to the process of removing CO2 from the atmosphere.

Greenhouse Gas Net Emissions by Gas – Area:

- land use CO2
- other CDR (Carbon Dioxide Removal – various approaches that remove CO2 directly from the atmosphere and then durably store it, resulting in negative emissions)

- energy CO2
- F-gases (fluorinated greenhouse gases – F-gases are a family of human-made gases used in a range of everyday products as well as in industrial applications. F-gases are often used as substitutes for ozone-depleting substances, because they do not damage the atmospheric ozone layer. However, F-gases are powerful greenhouse gases, with a global warming effect up to 2500 times greater than CO2.
- CH4 (methane)
- N2O (nitrogen dioxide – a gas that is mainly produced during the combustion of fossil fuels and it also comes from fertilizers

Speaking of the carbon removal and negative emissions it can be helpful to see that underneath the advanced view one can find more detailed settings and can individually set actions.

Technological Carbon Removal:

- direct air capture
- bioenergy carbon capture and storage (BECCS)
- mineralization (e.g. basalt)
- afforestation
- agricultural soil carbon capture

Most of these technologies are still undergoing pilot testing and do not exist at the level needed to deploy at a large scale.

When you consider an action of Technological Carbon Removal, you must consider its impact. e.g. approaches like BECCS require large areas of land that could otherwise be used for food production; methods like direct air capture and enhanced mineralization demand large amounts of energy

You can switch on sounds in View – happy noise when things get better, sad noise when things get worse. Also in View: Actions & Outcomes gives you a list of all the actions taken and their results. Many of the fossil fuel levers have not just a tax setting or subsidy setting option but one can also formally or fully restrict investment in new infrastructure e.g. stop building new coal infrastructure in 2025 or 2045. Also, you can reduce utilization of coal or other fossil fuels in any year.

The Business As Usual Scenario:

Think of it as a plausible scenario that is the starting point of your experimentation in the simulator. A scenario that you can compare against and see what would happen if we changed this… or that… It is not a forecast of where things are headed.

In this scenario temperature rises from 2000 out to 2100. Why is that happening? The main reason is because greenhouse gas net emissions are going up and up and up, from coal, oil, gas, but also methane, nitrous oxide and F-gases. Why is that happening? The main drivers can be seen here under Kaya Graphs:

1. Population: over 8 billion today – heading up to 11 billion UN projection by 2100
2. Consumption: goods and services, GDP per person around the world – it is growing and growing over time.

   Multiply the first two together and you get overall GDP.

3. Energy Intensity of GDP: shows how much energy it takes to deliver a trillion dollars in value (i.e. to provide those goods and services in value)

It's coming down as we shift from manufacturing towards service industry and as technologies (e.g. in manufacturing, motors, cars, lighting, HVAC systems) are getting more energy efficient and as we design more efficient transportation systems – so it takes less energy to deliver money, profit, value over time.

Multiply the firs three together and you get total energy use on Earth in exajoules per year.

4. Carbon intensity of Energy: how many megatons of carbon dioxide get emitted per unit of energy – so if energy comes from coal/oil/gas or from renewables, nuclear energy… etc. and that will dictate the carbon intensity of the energy supply.

Multiply these 4 together and you will get the last one.

5. CO2 Emissions from Energy – the chart shows that it's going up – why is it going up? It's because the growth in the first two are stronger than the reductions caused by better energy efficiency, so overall we have more and more emissions of CO2 from land use and also there are other greenhouse gases and you get 4.1 degrees.

You can see emissions from other gases – click on the miniature graphs icon and you will find Greenhouse Gas Net Emissions by Gas – black area is CO2, this is the highest ratio but CH4 is pretty bad too.

Let's look at the behaviour of various energy supplies:

- **in brown you can see coal** growing through the century – it doesn't peak like some of the others because there is a lot of coal in the world so without major intervention it is likely to have growth over the century
- **in red there is oil** which starts to get more expensive as we run into supply limitations in the latter half of the century
- **fossil gas or natural gas in blue** starts to slow its growth as we run into limits
- **renewable energy (wind and solar) in green**
- **bioenergy from burning or processing biomass or trees is pink**
- **nuclear from uranium is light blue**
- **new technology in orange** – like thorium fission or nuclear fusion. (Thorium is a silvery black weakly radioactive metallic element, solid under normal conditions, found in rock and sand – mined) Thorium fission is often referred to as the future of cheap clean energy.

The Policy Siders: all the various levers that you are able to change in order to do experiments in En-ROADS to create a different future

Energy Supply:

Coal: you can change coal in three ways – you can tax it or subsidize it or in the advanced setting there are further options e.g.: you can stop building new infrastructure, you can cut utilization, you can also imagine carbon capture and storage as some of your possibilities.

Oil and Natural Gas: same options as for coal -tax, subsidize or more advanced settings

Bioenergy: with bioenergy you have many of the same controls

Renewable energy: taxing or subsidizing, but you can't ban infrastructure in the same way. You can however change the cost of storage to imagine what would be different if we had breakthroughs in storage capacity.

Nuclear energy: similar controllers

New Technology: you can just imagine that a New Technology emerges and underneath you can pick what year that happens by using the detailed settings – set a specific breakthrough year e.g. 2028

Carbon price: you can set a one value or you can have it climb over time with many controls that are underneath

Transport:

Energy Efficiency: think of vehicles and transportation systems, you can control these factors either just in general terms or by specifying an exact percent per year improvement rate – this refers to transport but similar controls are available with energy efficiency in buildings and industry.

Electrification: You can also electrify – this just increases or decreases in transport or in buildings and industry i.e. HVAC systems driven by electricity as opposed to gas and oil and coal

Building and Industry:

Growth:

Population: you can change it within the range of UN scenarios

Economic growth: you can just shift it up and down, you can actually explore that by region, if you are interested in what's going on in different parts of the world (GDP per Capita per region – US/EU/Indi/other developed/Other developing/global)

Land and Industry Emissions:

Deforestation: you are just driving the reduction in the emissions (e.g. 5,7% per year)

Methane and Other: with methane you can break it into two area (agriculture and waste emissions/energy and industry emissions)

Carbon removal:

Afforestation: you can grow trees and set the time frame – i.e. how long it takes for such practices to diffuse around the world

Technological: you can just change everything together or you can look at them one by one (advanced view) – BECCS/direct air capture/mineralization/agricultural soil carbon/biochar

Tips when using En-ROADS: It's tempting to just move the slider and see what the result is. It's very important to think what is going to happen in the model e.g. "natural gas is going to be more expensive so the blue line of gas won't grow as fast, maybe it will actually go down" Think first, discuss, write down and then play and replay the suggested change to check if you were right or wrong. And then take the time to check out what else has changed, what the impact of the policy has been.