New approach in educating about innovative climate policy

A case study at the ISDRS

Veronika Kiss[1], Klára Hajdu[2]

[1]*Corvinus University of Budapest, veronika.kiss@uni-corvinus.hu*

[2]*Codecool, hajdu.klara.78@gmail.com*

Abstract

Limiting global warming to 1.5°C requires ambitious actions and systematic change, which need to be underpinned by a combination of innovative price and non-price policy instruments and a redirection of financial flows towards low-emission investments. Current public, financial, institutional and innovation capabilities however fall short of implementing ambitious actions in all countries. Policies including greening the economy, enhancing efficiency and Carbon Taxing proved to be inadequate to reach the 1.5°C target so far, but innovative policy instruments, having the potential to reach the target while addressing trade-offs with other policies have been already proposed. Among those, the Energy Budget Scheme (EBS) (RCC, 2015) is based on national proposals, which were debated (though eventually rejected) by national parliaments. The EBS would set an absolute limit for absolute fossil energy use, under which end users would receive energy entitlements to cover their energy consumption. End users could trade with their entitlements, for which they would gain an interest free currency. This so-called quota money could only be spent in a newly created secondary market for products and services with environmental and ethical certification. The EBS would include a Transition Fund, which would provide interest free loans on energy saving investments to everyone in need without requiring their own financial contribution. Even though the EBS has the potential to deliver systemic change in energy use, and thus reach 1.5°C target in a socially just manner, it has not caught significant attention from decision-makers, researchers or from the public. Therefore, we aim to communicate the effectiveness and sustainability impacts of EBS through a software-based strategy game, through which participants could also compare EBS with other tools aiming for CO_2 emission reduction while considering broader sustainability impacts. We believe that this innovative approach would not only bring education benefits but would also help to create a window of opportunity to debate and introduce policy innovation on a systemic level.

Keywords: Energy caps, Social justice, Interactive game, Policy innovation

1. Introduction

Limiting global warming to 1.5°C would make it markedly easier to achieve many aspects of sustainability including poverty eradication and reducing inequalities, but with the current pledges under the Paris Agreement achieving this target seems unlikely (IPCC, 2018). Meeting the 1.5°C target would require transformative systemic change based on a significantly increased ambition, which can be enabled among others by a combination of innovative price and non-price policy instruments and a redirection of financial flows towards low-emission investments (IPCC, 2018). Current policies including measures towards greening the economy and Carbon Taxes, however, proved to be inadequate to catalyse the needed transformative systematic change. "*Evidence and theory suggest that carbon pricing alone, in the absence of sufficient transfers to compensate their unintended distributional cross- sector, cross-nation effects, cannot reach the incentive levels needed to trigger system transitions" (IPCC, 2018, Chapter 4.).* Though quality policy design of measures aiming for greening the economy and their effective implementation may enhance efficiency, they alone cannot drive the needed systematic change either (IPCC, 2018). Reaching the 1.5 target while mitigating trade-offs with other policies (such as Sustainable Development Goals) necessitates stronger coordination and disruptive innovation across scales of governance, which should also provide financial, technological and other forms of support for poor and vulnerable people. This could imply among others complementing carbon pricing with sufficient transfers to compensate for their unintended distributional effects. Innovative policy instruments aiming for systematic change, while mitigating trade-offs have been, however, already proposed. The Energy Budget Scheme (EBS) endorsed by the Resource Cap Coalition (RCC, 2015), a European alliance of NGOs and scientists has the potential to meet many of these requirements in a holistic way. It is based on the Tradable Energy Quota (UK) (Fleming and Chamberlin, 2011) and the Energy Entitlement Scheme (Hungary) (Gyulai, 2011), which were debated (though eventually rejected) by national parliaments. While the EBS has the potential to deliver systemic change in

energy use and transform our production and consumption patterns in a socially just manner, the reluctance of decision-makers, researchers and the public even to debate quota schemes for delivering sustainability objectives is a huge impediment today. Therefore, we aim to communicate widely the effectiveness and sustainability impacts of EBS and compare it with other tools aimed at CO_2 emission reduction while considering broader sustainability impacts.

2. Methods

In order to compare and communicate widely the effectiveness and sustainability impacts of EBS, we developed a software-based strategy game, where game players aim to reach carbon neutrality by 2050, while enhancing some key environmental, economic and social indicators. Among environmental indicators we assess change in CO_2 emission reduction and the tendency in the other pressures on the environment, i.e. the use of natural resources and the use of land. Among socio-economic indicators we estimate the change in the ratio of the population impacted by energy poverty, change in households' savings and in unemployment rate. This choice is substantiated by the easy availability of data (Eurostat, 2019a, 2019b, 2020a, 2020b) on one hand, and their capability to indicate the social and economic performance of a given policy instrument on the other hand. The teams participating in the game can choose from three policy tools to achieve carbon neutrality by 2050, and their success will be measured by these five indicators (1. CO_2 emission, 2. change in the pressure on land and natural resource use, 3. change in the ratio of the population impacted by energy poverty, 4. change in households' savings and in 5. unemployment rate). The three policy tools are the EBS, the Carbon Tax and a Green Economy Toolbox.

The three involved policy tools apply an inherently different approach to delivering the energy transition. The EBS sets an annually decreasing cap for fossil energy use. It is based on energy consumption entitlements allocated among all energy end users (citizens, public and private entities), covering high-carbon energy use, where under-consumers and over-consumers can trade through the assigned management organisation. Under-consumers would receive interest-free 'quota-money' for their unused and traded energy entitlements. The quota-money could be exchanged in a newly created secondary market for products and services with environmental and ethical certification (e.g. outstandingly energy efficient appliances, organic food produced with low-carbon energy input, solar panels, building insulation services). A Transition Fund would provide interest free loans for energy efficiency and renewable energy investments, as well as for research and innovation to pursue relevant new technologies. The teams choosing EBS can decide the available amount of energy entitlements in the national economy (i.e. the decrease of fossil energy use), the distribution mechanism of energy consumption entitlements within the population, as well as the remuneration of over-consumption at individual and national levels. The second possible choice is applying a Carbon Tax, a policy that is already introduced in several countries. Teams following this policy approach can set the price of the tax and decide about the (re)distribution mechanism of the collected revenue. The third policy option is the Green Economy Toolbox, with a mix of policy instruments already implemented in several countries. These instruments include several awareness raising campaigns targeting either the general public or companies; corporate tax benefit for research and development; support for renewables, for alternative fuels and gasolines, for renovation of buildings and for innovative technologies applicable for companies, phasing out harmful subsidies for non-renewable energy resources, as well as greening state funds. Participants can influence how the limited state budget allocated to greening the economy could be distributed among these measures.

The game can be played either in 3-4 teams altogether by 20-40 people (e.g. decision makers, researchers, policy campaigners, students or the general public), or by a larger audience online. Each team can choose from the three different policy instruments (EBS, Carbon Tax, Green Economy Toolbox). In case not all the three tools are chosen by the groups, the software can simulate the missed tool by creating a dummy team, as well. Therefore, comparing the effectiveness of the three policy instruments in reaching environmental, social and economic goals can be still made. The game starts in 2020 with the following baseline indicators for all teams, which all correspond to the current EU average:

- 8.8 tonne CO_2 emission / capita (greenhouse gas emission in tonne of annual CO2 emission equivalent, Eurostat, 2020)[1],
- 11 % of the population living in energy poverty (as no single aggregated indicator has been used widely so far, we calculated an average from the four energy poverty indicators of the European Union: arrears in utility bill, low absolute energy expenditure, high share of energy expenditure in income, and inability to keep home adequately warm, Eurostat, 2019a)
- 12 % to gross disposable income saved by households (Eurostat, 2019b)[2]
- 6.5% unemployment (% of the active aged population, Eurostat, 2020b)

One round covers ten years, thus the game lasts for three rounds: first between 2020-2030, second between 2030-2040, the third between 2040-2050. During the 30-year period covered by the game, unforeseeable and unexpected events can impact the performance of each group in reaching carbon neutrality, while enhancing the environmental and socio-economic indicators by 2050. These events include economic recession, the arrival of climate refugees, more frequent occurrence of extreme weather events (droughts, flooding, melting glaciers, heat wave, etc.), the change in the accessibility of rare materials that are critical to the energy transition and the accessibility of fossil energy resources due to the high level of energy dependency.

At the end of each round, group members can discuss the social, environmental and economic indicators achieved by the chosen policy tool in the last ten years. In order to simulate multi-stakeholder and multidisciplinary discussion, group members have different roles to play to represent various interests. These roles can include for instance the minister responsible for climate and energy, minister of economy, minister of social issues, representatives of different interest groups including firms or socially marginalized people. In case the group agrees that with the chosen tool they are not on track to achieve the environmental, social and economic aims of the game, they are free to adjust their strategy or even switch to another tool. Each role and measure under the three policy tools have a detailed description, which group members can use in their strategising and argumentation. Group members playing the different roles while making use of the provided background materials negotiate the instruments and their implementation details that they are going to implement in the upcoming ten-year period.

We are going to organize events throughout 2020 to test and validate the three policy tools and their parameters, the socio-economic indicators, as well as models in the software. One of the events was planned for 2020 April in the framework of the Hungarian Climate Bill campaign, but this event unfortunately got cancelled due to the COVID-19 pandemic. We also aim to test the game during the ISDRS conference.

3. Results and Discussion

Teams following different policy approaches can decide upon different sets of input parameters. The impacts of these parameters have been modelled in the game based on a set of broad assumptions relying on literature review. Under the EBS, teams primarily influence the decrease of fossil energy use, i.e. how much the country aims to consume annually (see Table 1.). Secondly, they can make decisions on how the energy consumption entitlements are distributed within the population. They can choose from the following options: 2.1. everyone receives the same amount of entitlements that equals

[1] The indicator does not include emissions and removals related to land use, land-use change and forestry (LULUCF); it does not include emissions reported as a memorandum item according to UNFCCC Guidelines but does include emissions from international aviation as well as indirect CO2 emissions.

[2] The gross saving rate of households is defined as gross saving (ESA 2010 code: B8g) divided by gross disposable income (B6g), with the latter being adjusted for the change in the net equity of households in pension funds reserves (D8net). Gross saving is the part of the gross disposable income which is not spent as final consumption expenditure (ESA 2010 8.96).

the average energy consumption in the country, 2.2. a distributional mechanism is introduced considering social diffusion among households with different housing and living conditions (those receive more entitlements, who are more in need), 2.3. everyone receives the entitlements based on their current level of energy consumption, meaning that everyone is pushed to save energy from year to year as the cap tightens. Thirdly, participants who choose EBS can influence the remuneration of over-consumption at individual and national level. They can choose from the following options: 3.1. overconsumption is priced progressively and paid throughout the year, the more one over-consumes, progressively the more they pay for one extra entitlement, 3.2. the first option is complemented with a premium for all members of the society which has to be paid in case the nation does not meet the annually decreasing target. 3.3. overconsumption is paid at the end of the year, meaning that over-consumers pay their extra consumptions progressively in one amount at the end of the year, 3.4. the third option is complemented with a premium for all members of the society, which has to be paid in case the nation does not meet the annually set target, 3.5. there is no progressive pricing (every extra entitlement costs the same) and nor premium (no payment if the country trespasses the set target), 3.6. no progressive pricing exists (every entitlement used above the originally distributed amount costs the same, payment is made when over-consumers buy the extra entitlement throughout the year), premium has to be paid when the national target is trespassed.

The below table shows the list of inputs in the EBS scenario and the available parameter options for each input.

Input parameter	**Decision by teams**
1. National cap on fossil fuel consumption	Percentage as of the 2020 fossil fuel consumption level
2. Entitlement distribution	
2.1 Equal per capita distribution	One option can be chosen from among 2.1, 2.2 and 2.3
2.2. Distribution considering social diffusion	
2.3. Distribution based on current energy use	
3. Pricing mechanism	
3.1. Progressive pricing throughout the year, no premium	One option can be chosen from among 3.1, 3.2, 3.3, 3.4, 3.5, 3.6
3.2. Progressive pricing throughout the year, with premium	
3.3. Progressive pricing at the end of the year, no premium	
3.4. Progressive pricing at the end of the year, with premium	
3.5. No progressive pricing, premium	
3.6. No progressive pricing, no premium	

Table 1. *Input parameters in the EBS scenario*

Based on the data available in the literature, we have set broad assumptions on how the different options would influence the five environmental and socio-economic indicators:

- energy price influences household energy consumption,
- Income-poor households consume less energy than affluent households (Ekins and Dresner, 2004; elosztoprojekt.hu, 2019; White and Thumim, 2009),
- many poor are locked in inefficient or centrally heated dwellings (Ürge-Vorsatz, 2019), which results in that their financial status is not correlated with their energy consumption
- progressive pricing of energy overconsumption is more effective in constraining energy consumption in more affluent households than linear pricing,
- energy pricing has greater impact on energy consumption choice, if the payment is closer in time to energy consumption itself,
- the decreasing amount of energy entitlements linearly correlates with the GHG emission (Tombácz and Mozsgai Katalin, 2009; White and Thumim, 2009),
- the energy entitlement scheme has a little job creation effect (it can create in a 10 million population country 44000 workplaces, but there is no data how many jobs would be lost in related industries (Tombácz and Mozsgai Katalin, 2009),
- energy poverty can be diminished with wide-scale energy efficiency and renewable investments in the households,
- the Transition Fund can provide the capital needs for energy efficiency and renewable investments for poorer households without putting an additional pressure on household savings,
- the increasing price of fossil fuels (trends before the COVID-19 pandemic) results in an additional pressure on land and other natural resources, such as more fuelwood used for heating, biodiesel used for transport, or hydropower or wind power inevitably affecting land structures and biodiversity,

Arrows in the table 2. below aim to show the direction and the scale of influence of the chosen option on the five indicators. Green marks the most beneficial option for the given indicator among the options of a concerned input (among 2.1., 2.2., 2.3. and among 3.1., 3.2., 3.3., 3.4., 3.5., 3.6.). Horizontal lines indicate impact neutrality.

Options under EBS	GHG emission	Energy poverty	Household savings	Unemployment	Pressure on land and resource use
1. Decreasing fossil energy use by 2050					
2.1. Equal per capita distribution	Baseline: its impact is the same as of option 1.	Baseline: its impact is the same as of option 1.	Baseline: its impact is the same as of option 1.	Baseline: its impact is the same as of option 1.	Baseline: its impact is the same as of option 1.
2.2. Distribution considering social diffusion					
2.3. Distribution based on current energy use					

3.1. Progressive pricing throughout the year, no premium	Baseline: its impact is the same as of option 1.	Baseline: its impact is the same as of option 1.	Baseline: its impact is the same as of option 1.	Baseline: its impact is the same as of option 1.	Baseline: its impact is the same as of option 1.
3.2. Progressive pricing throughout the year, with premium					
3.3. Progressive pricing at the end of the year, no premium					
3.4. Progressive pricing at the end of the year, with premium					
3.5. No progressive pricing, no premium					
3.6. No progressive pricing, premium					

Table 2. *How the different options under the EBS influence the five environmental, socio-economic indicators. The arrows under options 2 and 3 are the additional impact above the baseline changes indicated in option 1. The direction of arrows shows the direction of the additional change as compared to the baseline change. Thus, for instance if an indicator is expected to decrease in the baseline option (indicated by downwards arrow), but the option selected under 2. or 3. is expected to diminish that decrease, then the arrow in 2. or 3. will point upwards.*

In table 2. we can see that the decision about the distribution method is expected to have various social and environmental impacts. Social indicators, such as the drop in the number of people living in energy poverty or the growth in household savings are expected to enhance the most (marked with green arrows), when entitlements are distributed considering social diffusion (Option 2.2.). Decisions made on the distribution mechanism, however, would not impact the two environmental indicators in the same direction as the more the CO_2 emission decreases, the more land use and resource use pressure is put on the environment in terms of enhanced biomass consumption and other types of pressures on land and natural resource use as we can see under option 2.3. Under this option even though CO_2 emission reduction is the most ambitious (marked with green arrow), pressure on the land and natural resources is the biggest (marked with red arrow). Considering both environmental and social impacts, option 2.2. would be more beneficial since it mitigates energy poverty, enhances household's savings, while delivering a major decrease in CO_2 emission at the same time. Regarding the options defining the pricing mechanism the picture is even more complex. Under option 3.2 where the highest CO_2 emission reduction can be achieved, none of the social indicators (drop in energy poverty, increase in household saving) seem to be beneficial compared to the other options. Furthermore, pressure on the land and natural resources seems to be the biggest, due to the enhanced biomass consumption. Regarding option 3.5., only the energy poverty indicator seems to be comparatively beneficial. If we consider the trade-offs among the five indicators, option 3.1. seems to deliver the best outcomes, the aggregate impact of which would be the highest from both environmental and social points of view.

Teams who choose Carbon Tax as a measure to reach carbon neutrality, while delivering other environmental, social and economic benefits need to make decisions in two areas. First is the level of Carbon Tax, namely how much EUR should be paid per consumed kilojoule. The other input concerns how the revenue gained from the Carbon Tax is spent, namely whether the revenue is spent on decreasing income tax to realise the scheme in a budget neutral way or spent on energy transition or in between.

We used the following additional broad assumptions for the modelling this scenario:

- Small and moderate level carbon taxes can only achieve moderate CO_2 emission reduction. This assumption is based on available literature showing that with carbon taxing 5-9% drop in CO_2 emission reduction can be achieved (ABC News, 2013; Dussaux, 2020). This reduction could be achieved by 23 USD tax per CO_2 tonne (ABC News, 2013) and by a tax started at 7 euros per tonne of CO_2 in 2014 increasing to 45 euros per tonne by 2019 (Dussaux, 2020). Also analysing European environmental tax reform examples with the Energy– Environment– Economy (E3) model for Europe, the results show that these reforms caused just a modest reduction in fuel use and greenhouse gas emissions (with a maximum of 5.9% decrease attributed to the reform) in all the six examined countries and a very small increase in employment and GDP. In these examples, all the ETRs were assumed to be revenue-neutral (Andersen, 2010).
- Increasing carbon taxes achieve higher GHG emission decrease (Andersen, 2010).
- Using the carbon tax revenues for financing energy transition investments has a greater potential for reducing CO_2 emissions than making the tax reform budget neutral. Based on submissions to the International Energy Agency database (International Energy Agency, 2015), the collected carbon tax in Japan is used for several measures, such as subsidies and R&D support from the start. According to the estimates for Japan, the emissions impact of the tax by 2020 is expected to be around 0.5–2.2 percent of CO_2 emissions in 1990, of which a minimal reduction results from a "price effect" (reduction in energy use through taxation) and the large majority comes from a "budget effect" (reduction through the use of tax revenue for emissions reduction measures) (submission to the IEA database).
- Higher carbon taxes increase energy poverty and decrease household savings.
- Carbon taxes do not cause a significant change in employment. The net effect of carbon tax on employment is small in magnitude and even slightly positive at +0.8%. It found in the OECD countries that "*at the firm level, a 10% increase in energy costs results in a 9% decrease in carbon emissions, and a 2% decrease in the number of full-time employees within one year. However, these jobs are not lost, but are reallocated to other firms…. Large and energy intensive firms experience greater reduction in carbon emissions and greater job reallocation than smaller and energy efficient firms*." (Dussaux, 2020).

Table 3. shows what kinds of inputs are needed from the teams that choose the Carbon Tax policy tool in order to reach the environmental, social and economic aims of the game. Participants need to make which option of the concerned input they are going to use throughout the next 10-year period of the game.

Input parameter	**Decision by teams**
1. Level of the carbon tax	Level of Carbon Tax in EUR/KJ of energy use
2. Purpose of the carbon tax revenue	
2.1.Revenue is used to decrease the income tax	One option can be chosen from among 2.1, 2.2, 2.3, 2.4

2.2. Revenue partly spent on energy transition, partly on reducing income drop	and 2.5
2.3. Revenue is spent on energy transition	
2.4. Revenue is distributed equally among members of society as carbon dividend	
2.5. Revenue distributed as carbon dividend considering social diffusion	

Table 3. *Input parameters in the Carbon Tax scenario*

Arrows in table 4. aim to show the direction and the scale of influence of the chosen option on the five indicators. Green marks the most beneficial option for the given indicator among the options (2.1., 2.2., 2.3., 2.4., 2.5.) on how revenue gained from the tax should be used. Horizontal lines indicate impact neutrality.

Options of Carbon Tax	GHG emission	Energy poverty	Household savings	Unemployment	Pressure on land and resource use
1. amount of the tax (EUR/KJ)	Based on the amount, it decreases linearly 	Based on the amount, it increases linearly 	Based on the amount, it decreases linearly 		
2.1. state budget neutral (no funds for energy transition, revenue goes for decreasing income tax)	Baseline: its impact is the same as of option 1.	Baseline: its impact is the same as of option 1.	Baseline: its impact is the same as of option 1.	Baseline: its impact is the same as of option 1.	Baseline: its impact is the same as of option 1.
2.2. Revenue partly spent on energy transition, partly on reducing income tax					
2.3. Revenue is spent on energy transition					
2.4. Revenue is distributed equally among members of society as carbon dividend					
2.5. Revenue distributed as carbon dividend considering social diffusion					

Table 4. *How the different options under the Carbon Tax influence the five environmental, socio-economic indicators.*

In table 4. we can see that decisions defining the amount of Carbon Tax as well as distributional mechanisms of revenue collected from the tax have various impacts from social and from CO_2 emission reduction point of view (since indicator of environmental pressure remains the same in all options). Social indicators, such as the rate of energy poverty and household savings is the least unbeneficial, when revenue collected from Carbon Tax is distributed in the form of carbon dividend considering social diffusion (under option 2.5.). This option, however, provides the least ambitious reduction in CO_2 emission. While option 2.3. provides the most ambitious reduction in CO_2 emission and is the only option where unemployment rate decreases, it does not perform adequate social indicators (energy poverty rate, household savings) compared to other options. Considering both environmental and social impacts, we cannot vote for a single option to deliver both environmental as well as social enhancement, we need to choose whether to reduce CO_2 emission or to enhance social well-being.

Teams that choose the Green Economy Toolbox as their policy tool need to select from the nine available options to reach carbon neutrality, while also delivering other environmental, social and economic benefits. They also have to consider the financial requirements of their choices i.e. how much burden they would place on the state budget). The options include awareness raising campaigns targeting either the general public or companies; corporate tax benefit for research and development supporting the energy transition; support for renewables and for alternative fuels and gasolines, for renovation of buildings and for innovative technologies applicable for companies, phasing out harmful subsidies for non-renewable energy resources as well as greening state funds. The latter and phasing out harmful fossil fuel subsidies can be chosen only once during the period of the game, since after choosing any of these options, it will have its effect in the short term. The relative financial requirement of each option is indicated in brackets in the below table next to the name of the measure, this relativity provides opportunity to comparison as well as to stay within the limits of the state budget.

We used the following broad assumptions related to the Green Economy Toolbox scenario:

- In case the energy bills do not mirror the level of consumption, people are not motivated to reduce their energy use. Besides bills reflecting real consumption level, the comfort of heat should be changed, practical advice on easy to use techniques, proper information but not too detailed, concrete examples from households with similar problems should be spread (Csutora et al., 2017). Residents of Budapest, however would pay even 19% more for environmental friendly products and services (Budapest Főváros Városépítési Tervező Kft., 2018).
- Buildings account for 40% of energy consumed (Cao et al., 2016) and today's annual renovation, including energy upgrade of the building stock is very low, varying from 0.4 to 1.2% in the Member States (Esser et al., 2019). Long term support for energy efficiency and saving investment, including renovation will bring benefit (Csutora et al., 2017; ENABLE, 2019). In case of proper renovation, the heating cost can be dropped to its previous one quarter on average (Sáfián, 2019).
- The expansion of renewable energy, especially solar and wind, has not only beneficially impact on people living in energy poverty (Stram, 2016). Improvements, however, have arisen through energy projects are not equal for everybody; it depends on power relationships, customs and values, access to information and one's social context in the community (Fernández-Baldor et al., 2014). This should be considered when designing the project in a view to correct the existing inequalities.
- *"Government investment in carbon capture and storage (CCS) is a large and expensive fossil-fuel subsidy with a low probability of eventual societal benefit. Deep systemic change is needed to alter the disastrous global fossil-fuel trajectory. Instead of continuing to invest billions in CCS, governments should invest more aggressively in*

technologies, policies, and initiatives that will accelerate a smooth transition to non-fossil-fuel-based energy systems. We need to divest from perpetuating a fossil-fuel infrastructure and invest instead in social and technical changes that will help us prepare to be more resilient in an increasingly unstable and unpredictable future."(Stephens, 2014, p. 1.)

- Official international and thus national targets, commitments and tools currently applied are not enough to reach carbon neutrality by 2050 (Alfredsson, 2018; Díaz et al., 2019; Ripple et al., 2017).

Table 5. shows, among which options the teams, who choose the Green Economy Toolbox can choose to reach the goals of the game. In one round participants can choose options (financial requirement of which is indicated with X) in each round until they deplete the available state budget (indicated with 4X).

Input parameter	**Decision by teams**
1. State scale public awareness raising campaign (1X)	All these options can be chosen until their cumulative financial burden (indicated with X) depletes the available state budget (4X)
2. State scale awareness raising campaign for companies (1X)	
3. Corporate tax benefit for research and development (2X)	
4. Support for innovative technologies applicable for companies (1X)	
5. Greening of state funds (0.5X)	
6. Renovation of buildings (3X)	
7. Support for renewables (2X)	
8. Phasing out harmful subsidies for non-renewable energy resources (-2X)	
9. Support for alternative fuels and gasolines (1.5X)	

Table 5. *Input parameters in the Green Economy Toolbox scenario*

Table 6. shows how the different options contribute to the enhancement of the five environmental and socio-economic indicators. Arrows show the direction and extent of these contributions, horizontal lines indicate impact neutrality. In case one cell has more arrows, it indicates that the expected impact is not linear in time, but often diminishes or on the contrary, would be felt only after some delay. Green arrows mark the most beneficial option for the given indicator.

Options under green economy box of tools	GHG emission	Energy poverty	Household savings	Unemployment	Pressure on land and resource use

1. State scale public awareness raising campaign (1X)					
2. State scale awareness raising campaign for companies (1X)					
3. Corporate tax benefit for research and development (2X)					
4. Support for innovative technologies applicable for companies (1X)					
5. Greening of state funds (0.5X)					
6. Renovation of buildings (3X)					
7. Support for renewables (2X)					
8. Phasing out harmful subsidies for non-renewable energy resources (-2X)					
9. Support for alternative fuels and gasolines (1.5X)					

Table 6. *How the different measures of the Green Economy Toolbox influence the five environmental, socio-economic indicators.*

In table 6. we can see the impacts of the various options in the Green Economy Toolbox. Social indicators, such as the rate of energy poverty and household savings are the most enhanced in the case of a building renovation programme, but this option (6.), however requires the most financial resources from the state budget (3X). While option 7.: support for renewable energy resources provides the most ambitious reduction in CO2 emission as well as a drop-in unemployment, it also requires significant financial resources from the state budget (2X). Option 4.: support for innovative technologies applicable for companies also delivers CO2 emission reduction on the long run, as well as a decrease in the rate of unemployment, while it does not require so much financial support from the state (1X).

In the below table we include the most effective options under all the three policy tools (EBS, Carbon Tax, greening the economy toolbox), which provide environmental or / and social enhancement. The size of the arrows has been modified in order to compare the three policy tools. (The arrows in tables 2., 4., 6. allowed the comparison of different options under the given policy tool). Here we need to stress that the effect of EBS and the carbon tax primarily depend on the set absolute energy consumption target and the price of the tax respectively. The more ambitious reduction target and tax price are set, the more GHG emission reduction can be achieved by the EBS and the carbon tax respectively. In table 7. we marked with green those areas, where the most significant beneficial impact can be achieved in terms of the concerned indicator.

Most beneficial options of the three policy tools	GHG emission	Energy poverty	Household savings	Unemployment	Pressure on land and resource use
EBS: 2.2. Distribution considering social diffusion	↓	↓	—	↓	↑
EBS: 3.1. Progressive pricing throughout the year, no premium	↓	↓	—	↓	↑
TAX: 2.3. Revenue is spent on energy transition	↓	↑	↓	↓	↑
TAX: 2.5. Revenue distributed as carbon dividend considering social diffusion	↓	↑	↓	—	↑
Green Toolbox: 6. Renovation of buildings	↓	↓	↑	↓	—
Green Toolbox: 7. Support for renewables	↓	↓	↓ ↑	↓	↑

Table 7. *The most beneficial options of each policy tool in terms of the chosen five indicators. The arrows indicate the absolute impacts of these options (irrespective of any comparison to a baseline option).*

We can see that EBS has the most beneficial impacts in terms of GHG emission reduction and energy poverty mitigation, especially if the energy entitlements are distributed on social diffusion consideration and are priced progressively without the duty to pay a premium if the nation exceeds the set cap. However, it must be noted that even the EBS should not be implemented in an isolated manner by the countries and accompanying measures can significantly reduce the adverse side-effects. One example for such an accompanying measure could be introducing new or tightening existing land use policies, which could prevent additional pressures made on land originating from shifting environmental pressures. Such possible accompanying measures, however, could not be included in the game for the sake of simplicity.

All the tools in table 7. has no effect on or only slightly decrease unemployment, while only renovating buildings enhances at least slightly households savings and put no more pressure on land and resource use

4. Conclusions

We find several benefits of utilising software-based strategy games in awareness raising and stimulating policy interest. The simulation game can contribute to the increased understanding of participants about the trade-offs that decision-makers

face when deciding about climate change policies. Their roles assigned within their teams force them to adopt different perspectives and test their understanding and reasoning skills during the team debates. While the background materials of the game provide some guidance and open questions on the interlinkages among the different socio-economic factors, they need to more thoroughly discover these relationships themselves and judge their relative importance. The modelling results for the ten-year periods provide direct feedback for the teams, which can be used to revaluate their approach and to modify their assumptions. In addition to their holistic understanding and analytical skills, their willingness for cooperation and compromise are also put to a test.

In addition to improving the understanding of trade-offs, the game also underlines the importance to include innovative approaches into the scientific, political and public debates. As the scientific literature suggests, the currently available policy tools are insufficient to achieve carbon neutrality in the coming decades, and it is also challenging to implement the various sectoral aims, such as the 17 Sustainable Development Goals at the same time. Innovative tools, such as the EBS might provide the missing tools to mitigate trade-offs and achieve ambitious goals.

Therefore, our game also underpins the need for further scientific studies and for modelling of different approaches. Even though some potential benefits of the EBS scheme are underlined by the strategic environmental assessment, the broader environmental, social and economic impacts would need to be modelled more thoroughly. It is also our declared aim to encourage modelling teams and research consortia to include innovative and so far neglected policy options in their modelling work.

The need for further research, however, should not prevent politicians getting familiar with new approaches, like the EBS. In addition to politicians, the public also needs to get informed about innovative and holistic proposals, as they will largely bear the burden of the energy transition. Therefore, they should be involved and given the opportunity to share their views on system level changes and new approaches. By this they could become a drive behind the energy transition as well.

Our study has, however, some important limitations. First, so far we could not test the simulation game with a real audience due to the pandemic lockdown. Real life testing will most probably reveal the weak points, where our strategy game requires improvement or fine-tuning. This testing will be realised as the pandemic situation allows. Besides, even more importantly the available literature has limited data on how the different options of the three policy tools would influence the five environmental, social and economic indicators included in our model. As described above, it would require further research into these policy tools to better substantiate our models and allow the comparison of the three tools. We believe though, that despite the scientific limitations of our models, this strategic game can still fill an important gap in communicating innovative policy options for addressing the climate change challenge, and in stimulating debate and exchange among not only researchers, but also politicians and the public.

References

ABC News, 2013. 9pc drop in emissions from power generators.

Alfredsson, E., Bengtsson, M., Brown, H.S., Isenhour, C., Lorek, S., Stevis, D., Vergragt, P., 2018. Why achieving the Paris Agreement requires reduced overall consumption and production. Sustain. Sci. Pract. Policy 14, 1–5. https://doi.org/10.1080/15487733.2018.1458815

Andersen, M., 2010. Europe's experience with carbon-energy taxation. Sapiens 3.

Budapest Főváros Városépítési Tervező Kft., 2018. BUDAPEST KLÍMASTRATÉGIÁJA.

Cao, X., Dai, X., Junjie, L., 2016. Building energy-consumption status worldwide and the state-of-the-art technologies for zero-energy buildings during the past decade. Energy and Buildings 198–213. https://doi.org/10.1016/j.enbuild.2016.06.089

Csutora, M., Harangozó, G., Zsóka, Á., Werthschulte, M., Galarraga, I., Foudi, S., López, E., Chubyk, A., Gonchar, M., Magdalinski, E., 2017. Synthesis report on the "heating & cooling" case study.

Díaz, S., Settele, J., Brondízio, E.S., Ngo, H.T., Agard, J., Arneth, A., Balvanera, P., Brauman, K.A., Butchart, S.H.M., Chan, K.M.A., Garibaldi, L.A., Ichii, K., Liu, J., Subramanian, S.M., Midgley, G.F., Miloslavich, P., Molnár, Z., Obura, D., Pfaff, A., Polasky, S., Purvis, A., Razzaque, J., Reyers, B., Chowdhury, R.R., Shin, Y.-J., Visseren-Hamakers, I., Willis, K.J., Zayas, C.N., 2019. Pervasive human-driven decline of life on Earth points to the need for transformative change. Science 366, eaax3100. https://doi.org/10.1126/science.aax3100

Dussaux, D., 2020. Carbon Tax, emissions reduction and employment: Some evidence from France.

Ekins, P., Dresner, S., 2004. The distributional impacts of economic instruments to limit greenhouse gas emissions from transport. Policy Studies Institute, London, UK.

elosztoprojekt.hu, 2019. Egy főre jutó átlagfogyasztás. Háztartások Energiafogyasztása. URL https://www.elosztoprojekt.hu/temak/haztartasok-energiafogyasztasa/ (accessed 2.28.20).

ENABLE, 2019. Empowering consumers, enabling the energy transition.

Esser, A., Dunne, A., Meeusen, T., Quaschning, S., Wegge, D., 2019. Comprehensive study of building energy renovation activities and the uptake of nearly zero-energy buildings in the EU.

Eurostat, 2020a. Greenhouse gas emissions per capita - Tonnes of CO2 equivalent per capita.

Eurostat, 2020b. Unemployment statistics.

Eurostat, 2019a. Indicators & Data, Primary Indicators.

Eurostat, 2019b. Households saving rate.

Fernández-Baldor, Á., Aristizábal, A., Lillo, P., Hueso, A., 2014. Are technological projects reducing social inequalities and improving people's well-being? A capability approach analysis of renewable energy-based electrification projects in Cajamarca, Peru. J. Hum. Dev. Capab. 15, 13–27. https://doi.org/10.1080/19452829.2013.837035

Fleming, D., Chamberlin, S., 2011. TEQs. Tradable Energy Quotas: A Policy Framework for Peak Oil and Climate Change. THE LEAN ECONOM Y CONNECTION, London, UK.

International Energy Agency, 2015. Addressing Climate Change Database.

IPCC, 2018. Global Warming of 1.5 oC. Masson-Delmotte, V., Zhai, P., Pörtner, H.-O., Roberts, D., Skea, J., Shukla, P.R., Pirani, A., Moufouma-Okia, W., Péan, C., Pidcock, R., Connors, S., Matthews, J.B.R., Chen, Y., Zhou, X., Gomis, M.I., Lonnoy, E., Maycock, T., Tignor, M., Waterfields (eds.)

Gyulai, I., 2011. Climate Change Act for Sustainable Society.

RCC, 2015. An Energy Budget scheme for Europe. URL http://www.ceeweb.org/wp-content/uploads/2012/03/energy_budget_scheme_short.pdf (accessed 2.28.2020).

Ripple, W.J., Alamgir, M., Wolf, C., Crist, E., Mahmoud, M.I., Newsome, T.M., Galetti, M., Laurance, W.F., 2017. World Scientists' Warning to Humanity: A Second Notice. BioScience. https://doi.org/doi.org/10.1093/biosci/bix125

Sáfián, F., 2019. Energiafogyasztás és energiahatékonyság a hazai háztartásokban.

Stephens, J.C., 2014. Time to stop investing in carbon capture and storage and reduce government subsidies of fossil-fuels. WIREs Clim. Change 5, 169–173. https://doi.org/10.1002/wcc.266

Stram, B., 2016. Key challenges to expanding renewable energy. Energy Policy 96. https://doi.org/10.1016/j.enpol.2016.05.034

Tombácz, E., Mozsgai Katalin, 2009. Az éghajlatvédelmi törvény tervezetének Stratégiai Környezeti Vizsgálata.

Ürge-Vorsatz, D., 2019. Energiaszegénység és éghajlatváltozás: összefüggések.

White, V., Thumim, J., 2009. Moderating the distributional impacts of personal carbon trading.

The present publication is the outcome of the project „From Talent to Young Researcher project aimed at activities supporting the research career model in higher education", identifier EFOP-3.6.3-VEKOP-16-2017-00007 co-supported by the European Union, Hungary and the European Social Fund.