

Modding board games into serious games:

The case of *Climate Policy*

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Abstract

This paper provides a case study of how a board game can be modified to generate a serious game. We argue that board games are an interesting medium for serious games, especially when the goal is to teach players about particularly complex systems. In that case, the transparency of a board game makes it possible for players to “see the whole boards” – to see all of the various moving parts at work. That transparency also makes it very easy to modify board games. To demonstrate these claims, we present a modification to the board game CO2 that accurately models different policy options with regard to global warming. We show how a few major changes to the original game’s point systems, as well as removal of certain extraneous features, can significantly improve the game, adding an instructional value. The game allows players to experiment with several policy options, including carbon taxes, carbon emissions permit sales, and clean energy research support, and lets players see how these policies interact. We discuss ways that teachers, advocates, journalists, and others can use the Climate Policy mod to more easily explain the incredibly complex interactions of power markets, carbon dioxide emissions, and public policy.

Keywords: Board game, global warming, climate policy;

1. Introduction: games and the carbon system

In recent years, many efforts have been made to apply games and game-like methods to serious issues and discussions¹. Games are an especially valuable tool for explaining how complex systems work. It is very difficult to explain in linear form – through sentences and speeches - how a nonlinear interactive system actually works. Games, however, can be treated as small models of much more complex, much larger systems. Systematic research has begun into the best methods for designing games with serious aspirations [5]. A game can shine light on important, complex phenomena that are hard to understand through basic explanation. Through a game, the player can directly push and pull different parts and then see how they affect one another. Board games in particular are an under-appreciated medium for teaching through games. Especially when the educator’s goal is to teach players about a complex system, the transparency of a board game’s rules can make them exceptional teaching aids.

One example of an important, huge, and extremely complex system, which may be fruitfully understood using a board game, is global climate change. It is a system that just about everyone today ought to try to understand better, yet many aspects of climate change are hard to explain in written or verbal – that is, linear – form. For instance, how do you explain that a regime of carbon emission permits can actually reduce the amount of carbon dioxide in the air? One of the present authors is an economist who taught and wrote about public policy for more than a decade, the present author can share many stories about the difficulties of explaining to students how different

¹ To cite just a few fine examples, see [13], [9], and [3]. The interest in serious games has led to the foundation of a new peer-reviewed journal in this space, the *International Journal of Serious Games*.



kinds of governmental controls on markets actually work. The word “permit,” in this case, suggests to most students (and other people with common sense) that the system must be allowing some pollution to happen that was not allowed before. It is difficult to explain how the permits are placed on a market; how their supply is limited; how the limited supply drives up the price; and how the connection between emissions and prices induces profit-seeking power plants to systematically move toward cleaner types of fuel. It can be done; these things can be explained. But it is easier to show students a system where the policy is in place and let them demonstrate the workings of the system for themselves.

This paper reports on an effort to build such a system, with precisely this educational goal in mind². A commercial board game called CO2 [11] was adapted into a new game called Climate Policy in order to reflect accurately the four main systems involved with global warming policy:

1. Competitive profit-seeking power companies
2. Clean energy research and development
3. Climate effects of power production
4. Public policy

The full rule set for Climate Policy can be found in the Appendix, and several tips for educators who use the mod are found in Section 3.

In addition to being a useful teaching tool on matters of climate policy, the Climate Policy mod is a case study on how to modify board games to create models of complex systems. Board games' transparency and modifiability make them excellent tools for teaching students about those systems. As we outline the broad strokes of the Climate Policy mod, we also explain the reasoning behind certain changes, and how they focus players on the problems that climate policy-makers face. The decision to make these changes was based on a basic resource economy model of money in the power-generating system, but this model is remarkably flexible and can be applied to many different contexts. We derived several valuable lessons from our work on the mod, and we share those in the final section, along with suggestions on avenues for future research.

2. Board games as serious system simulations

It has not been particularly common to use commercial board games as serious games; digital games are by far the preferred medium. However, board games, are an interesting alternative to their digital cousins because the rules of a board game are always explicit; they are never buried in computer code or a game script. Those rules can be changed quickly and easily, either by the game creator or by the players, allowing for a flexibility and swiftness of game design and modification that is unavailable in digital games. Exposing the rules has other advantages as well, in that it allows players to see in no uncertain terms the ways that a game's various mechanics link together to form complex, dynamic, and non-linear systems. This ability to “see the whole board” comes at the cost of a higher learning curve than is typical for digital games, but it may also lead to a greater appreciation of the system and its moving parts. In this section, we elaborate on these and other facets of board games that make them a valuable alternative medium for both developing and playing serious games.

2.1 Why board games?

In general, games are a good tool to use when trying to explain or discuss some sort of complex systems issue. Small complex systems can be used to help someone understand a large complex system. The difficulty, though, is often in creating that small complex system. Building digital games is hard, especially if you are not a programmer or digital artist, and even tools that were created to ease game production may have a substantial learning curve [15]. Game modding is a fruitful alternative, but for digital games the learning curve for the developer is still steep. In

² Similar motives led the author to create The Jane Austen Game, which helps players understand the complex strategic dilemma faced by Regency-era women in England. They were expected to marry while young, but they had limited information about the men whom society demanded that they marry. They also were limited in their ability to discover new information, and on top of all that they were in competition with other women. The strategic complexities of Austen's world have been described in book form in [6]. The Jane Austen Game places player directly in charge of this strategic- situation.

contrast, board game modding requires investment in nothing but the original game, some paper, and a pen. Modding existing board games has other advantages, too.

2.1.1 Breadth of topics

Many commercial board games are quite close to being high quality systems simulations. The topics addressed in the commercial board game industry have grown substantially in range and depth over the past 40 years. In the 1970s, almost all board games were hopelessly silly, or they were deep exercises in historical war simulation. As we write today, board games exist about almost any complex system one might care to name, and at varying levels of abstraction.

2.1.2 No technology

As mentioned before, board games lend themselves to modding because they are made of paper, which makes them quite malleable. With board games, you already have the playing pieces and you only need to change how they are used. This involves manipulating the rules. Getting involved with rules is the great virtue of board games. In a board game, you can do anything you want with the pieces; the only reason you handle them one way and not another is because you have agreed to follow a set of instructions and norms. The instructions and norms are laid out on the table, for everyone to see – or modify.

2.1.3 Small groups, face to face

Many complex social systems can be usefully modeled with three or more people. Moreover, small group dynamics are useful for teaching. A few people, sitting together face to face, can learn things together that are hard to grasp for people isolated in lecture halls or out on the internet. Board games are nicely suited to small group complex systems learning because they typically require the presence of three to five players. They have the added advantage that they allow players to learn both from their own experiences and those of their co-players. While one is playing, one is also directly observing the play of others, and so is seeing the game system from different perspectives.

2.1.4 Overcoming game designer's block

It is typically much easier to imagine how a finished game will look than to make the first prototype. Building a little complex system is like erecting a tent with many poles: You stand up one or two and try to hold them together while you add more poles, rigging, and skeins. One wrong move and the whole thing collapses. To be playable at all, the first build of a game must have many subsystems working together. Getting to that point is difficult. If you begin with a finished game, you already have something to work with.

2.1.5 Limiting the vision

One of the largest risks in game design is feature creep: An inability to restrict the scope of a project. ([2], Ch. 1, p. 22) Adding features to any game will make it better, just as adding stories to any building will make it bigger. And yet, at some point the building must stop and the furniture must be installed. For reasons that are not yet fully understood, people engaged in game design too often just keep building floors, leaving the furnishings for later. As a result, the final tasks in finishing a game – polishing the aesthetics, solving little problems, making it friendly to users – are too often left undone [16]. The game is built but unplayable. Many game projects end in this kind of failure, especially among inexperienced designers. An existing board game avoids this problem by constraining what can be done. The designer is working with a fixed set of pieces, a fixed theme, and a fixed scope.

2.1.6 Virality

People who buy a commercial board game and learn a mod of it in a class or workshop can take the game home and play it with others, without the need to learn technical skills. Their learning can transfer widely through a board game.

2.2 Board games as models of complex systems

A board game is a little machine, executed in two dimensions in a space no larger than a dinner table, using paper, cardboard, wood, and plastic. The machine's operations are partly delimited by physics – as when one piece sits atop another – but also by metaphysics, in the form of rules kept in the heads of the players. Quite often, a board game is a simulation of a more complex system. The board game Monopoly [7] simulates real estate markets in Atlantic City, New Jersey. Risk

[12] simulates global military competition. Chess simulates a battle. With some exceptions, most board games are these kinds of models of much larger, more complex systems.

As models of complex systems, board games are also complex systems themselves. Exploring a board game is thus completely unlike exploring a book. A book has an obvious entry point – the beginning – and introduces itself to you word by word until it comes to an end. A board game has no obvious starting point. It is rather like entering an automobile engine at the third piston or the carburetor. The first experience when entering a board game is a type of discomfort that we will refer to as game vertigo: The feeling that one has absolutely no idea what is going on, what anything is for, or what to do. The gradual evaporation of game vertigo, and its replacement by a sense of mastery, is an important source of pleasure in the playing of a complex game [10]. Game vertigo is of course an analog to what we might call system vertigo, the discomfort an inexperienced person, such as a new student at the university, feels when first confronted with a real complex system³.

Using these terms, we can say that this paper concerns itself with the process of reskinning and modding a board game, so that when the sim dissolves the player's game vertigo, it also dissolves his system vertigo about the large and complex system that the sim is modeling. This exercise might be useful in many circumstances, such as, a classroom where teachers are trying to explain a complex choice system to students, or a workshop where a policy expert is trying to help attendees understand the consequences of a policy decision. In general, we will refer to the leaders in these kinds of exercises as teachers and the participants as students.

For all of these reasons, it might make sense for a person who needs a serious game to seek out nearby board games and adapt one of them.

2.3 From Table to Computer

Our work with board games suggests several thoughts about how board and digital games might work together to amplify the reach and impact of serious games.

First, board games can be seen as the natural starting point for new serious games projects. The project we discuss in this paper began with a play session of the commercial board game. Afterwards there was a discussion of the ways that the game deviated from what would be ideal from the standpoint of teaching about global climate. And then, because the board and the pieces were right there, we could simply start moving things around, jotting new symbols in pencil on the pieces and the board, and writing down notes about possible rules changes. If we had been playing a digital game, we probably would not have been sitting together, and seeing the effects of basic modding ideas would have involved quite a bit more technology. This experience, plus the fact that many computer game designers work initially with paper prototypes, suggest that board games can be viewed as early versions of a game that might eventually go to mass distribution online.

These same considerations suggest that board games are perhaps a good seedbed and proof-of-concept arena for new computer games. Someone with no programming skills can use board game creation skills create a mockup of game mechanics and use them to illustrate how a computer game would work. A "board game," after all, might be nothing more than sheets of paper.

A partnership of board games and computer games allows designers to take advantage of the benefits of each kind of gaming: Tactile, small-group activity with easy changes on the one hand, and vast reach, immersion, and solo suitability on the other.

3. *Climate policy: responses to global warming*

The preceding sections offered general thoughts about the process of adapting a board game to serious use. In this section we provide some guidance and a case study on how to go about using board games to that end.

³ Note that the focus here is on games as systems not games as entertainment. Games are not inherently more entertaining than any other form of media. "Gamifying" something does not make it fun. Prior work in serious games in general has shown that it is not particularly fruitful to apply game-like mechanisms slapdash in the hopes of making boring material interesting. Material that is dull in linear expression will be dull in systemic expression. There is a large literature in serious games and it would be out of scope to review it here. However, good trailheads are [4], [8], and [14]. Note again, however, that most of the attention has been on digital games. The burgeoning board game industry has not been explored with as much intensity.

Suppose now that we have identified global climate change as an area of interest and want to explain something about how carbon policy regimes work. Global climate is a wickedly complex system. The science is complex, but that is only the start. Global temperature depends on economic, political, and cultural systems as well. Getting participants in a workshop or classroom to understand what is happening to our planet, and why, is a great challenge.

While it may be easy for some people to design and implement a digital game system for exploring climate policy, many of us would not know where to begin. However, there are a number of commercial board games about global climate. It may be possible to adapt one of them so that it accurately reflects the real systems.

CO₂ is one such game⁴. It was published in 2012 by the Italian game company Giochix. All the elements of the climate system are there: A board with a carbon dioxide meter, pieces representing clean energy sources (solar, bio, etc.) as well as dirty ones (coal, oil, etc.), a research track for developing clean technologies, carbon permits for regulating emissions, and money, of course. These pieces and the initial rules provide an entryway into an understanding of some of the major facets of the global climate problem. If you play the game as designed, you will understand that carbon dioxide is produced in massive amounts as a result of human power demand. You will realize that it is a global problem, one that we all share, even though each one of us contributes only partially to it. Each player in *CO₂* has to watch the global parts-per-million (PPM) of carbon dioxide in the air; if it reaches 500, the game is over and everyone loses. In avoiding this catastrophe, you will learn that clean energy technologies are possible but have to be developed. They require much prior research, and research is difficult to support.

3.1 Modifying *CO₂* to teach about climate policy

Suppose we want to teach students about climate policy and we buy the commercial game *CO₂*. The next step is to analyze it and see which elements will aid student understanding and which ones will not. As it happens, while *CO₂* does a good job of teaching players the difficulty of developing clean technologies, as well as the dangers of humanity's collective failure to do so, it is less effective at teaching players the difficulties that policy-makers face in dealing with the *CO₂* problem. Happily, *CO₂* is easily modded to meet this alternative learning goal. This section lays out some key changes to the rules of *CO₂* that facilitate that goal.

3.1.1 Victory points

The players in *CO₂* are power companies. They gather resources and do research in order to build clean power plants. When a company builds a clean power plant, it gets victory points. Although this design motivates players to navigate the thorny problem of actually developing clean energy, it is not a very good mechanic for teaching the problems of climate policy. In the real world, power companies are social actors that are motivated primarily by profits. It is their social role to make money by meeting power demand. Indeed, that is the only reason that climate policy-making is such a difficult problem. If real power companies were directly motivated to build clean energy, as the original victory point assignment of the commercial game suggests, there would be no climate problem. Power companies would happily go off and build solar power plants and everything would be clean. That is obviously not happening.

To highlight the role of power companies in climate policy, in the mod players still play power companies, but they get victory points only for money (not clean energy). Power plants are sources of money. Players are attempting to build plants so that they can accumulate money and thereby win the game. This small change in assumptions redirects players' attention to a basic fact that policy makers must face: We have a climate problem because the incentives of power companies are not to pursue clean energy, but to give consumers all the power they are willing to pay for. In *Climate Policy*, students will see that solving climate problems must involve changing the monetary incentives of power companies. In this game, we can explore what happens when you use policy to change the incentives power companies face.

⁴ To avoid confusion, for this paper we adopt the convention of referring to the game as *CO₂* and the chemical as carbon dioxide.

3.1.2 Dirty power and clean research

As designed, *CO₂* has dirty power plants that appear largely at random, and only because the players have not built sufficient clean energy to block out the dirty plants. As with victory points, this mechanic focuses players on the urgency of creating clean power, and keeps them navigating the difficult path to achieving that goal. However, it doesn't help players understand the climate policy problem, which has to do with policy-makers' twin goals of keeping power cheap and while pushing it to be clean – two goals that can be at odds with one another. In the mod, players can freely build dirty power plants. Indeed, at start, dirty power is the only option, since no one has developed any clean energy. Each dirty power plant adds to global PPMs. If unchecked by policy, the profit-seeking provision of dirty power will destroy the atmosphere.

The natural policy solution is to incentivize research into clean power, and the original game *CO₂* already has a built in mechanic for doing this: The clean power research tracks. A slight modification to the tracks is necessary, however, because in the original game, the difficult trade-offs facing real power companies are not present. To wit, a real company knows it can make significant profits today with a coal plant, but it also knows that developing solar power plant might be a smart long-run play if policy restrictions on coal power become severe. How does it spend its money – making power now or research for power later? In *CO₂*, all the power companies are busily making clean energy and the only question is, which company is more advanced in which clean energy research type. In the mod, players can put money into clean energy research if they wish. If they do so, they will eventually unlock clean energy capability. Whether or not this is a smart thing to do depends on the policy environment and the global carbon dioxide level. In light of the tremendous long-run commercial potential of green energy technology, the more advanced power plants offer quite large monetary rewards, many multiples of today's coal and oil plants. Players have to guess the future point at which it will make sense to switch to clean energy, and they have to make early research investments to enable the switch when the time comes. This focuses players' attention on the policy-makers problem of aligning the incentives of power companies with the goal of reducing carbon dioxide output.

Another modification that refocuses players on the policy issue involves the assignment of property rights. In the original game, there are no property rights - any player can propose to build a clean power plant, and that proposal opens the door for any other player to develop the proposal into a project. A third player may then transform the project into a completed plant. Each of these actions yield a reward to the players involved. Once again, this is a design choice that keeps players focused on the difficulties of developing clean technology, but it comes at the expense of an accurate portrayal of the role that property rights play when policy makers try to incentivize the development of clean technology. To that end, players should not walk away from the exercise thinking that when Tokyo Electric starts a project, it gets a bonus, and then PetroChina can simply take the thing over and complete it. The people who start projects do so at considerable cost, and they do it because they believe their ownership of the project will yield revenues later. In the mod, the process of building plants is given to each player to own, completely. If a player starts a project, only he can complete it. This property rights regime is useful for understanding the legal context in which power companies and their regulators operate.

3.1.3 Policy

As was pointed out above, the basic dilemma faced by policy makers regarding climate change is the tradeoff between incentivizing research into and production of clean energy, and the desire to keep energy cheap for other constituencies – both people and other industries.

The original *CO₂* has almost nothing to say about policy, and this is fine in a world where the policy is fixed and players are simply working to save the planet from imminent doom. But the meat of the *Climate Policy* mod to *CO₂* lies in the dynamic policy environment it sets up for players. To enable flexibility and help educators meet their teaching goals on these issues, the mod presents several different policy variants. Teachers can choose to mix and match them, to show how they work with and against one another. All of this can be contrasted to the do-nothing policy. The specific policies include:

- Carbon Emissions Permits (CEP). If a CEP policy is in place, players who build dirty power must also purchase permits equal to the amount of PPMs they spew into the atmosphere. CEPs can be traded among players. Players out of compliance – who have insufficient CEPs – have to shut down plants. (CEPs are the only policy artifact that are also found in the original game of *CO₂*, where they operate in a much more limited fashion.)

- Carbon taxes. In this variant, players who operate dirty plants have to pay taxes that depend on their emissions. Players who cannot afford the tax can sell plants to other players who can afford it. Or they have to demolish something.
- Grants. In this variant, money from carbon taxes or permit sales goes into a central fund. Money from this fund is given out to the leaders in clean energy research.
- Loopholes. In the loophole variant, players can pay money – that does not go to research – in order to receive an exemption from carbon regulations. There is a somewhat complex explanation for this aspect of policy. Clean energy is simply more expensive than dirty energy, and will remain so until new technologies make it cheaper. This means that any move to clean energy at the moment makes power more expensive. When power gets more expensive, things cost more money and people lose their jobs. Any effort to restrict dirty power and promote clean power will run up against arguments about the economic needs, even distress, of the affected populations. While we do not explicitly model these stresses, they are an important part of the system. The loophole mechanic brings them in; it allows some players to evade climate policies, through politics or bribes. The point is that, any change to the status quo will cause some pain, and some of the pain will blow back into the policy system. In an ideal use of the mod, even these complex forms of unintended feedback can be taught.

3.1.4 Complexity

An important goal for any game designer is to avoid adding unnecessary complexity to a game. This admonition takes on greater weight in the context of serious games, where unnecessary complexity can take the focus off of the lessons that we wish to teach. To that end, several subsystems that were present in the original *CO₂* were removed for the *Climate Policy* mod. For example, in the original game, research advancements were made by moving scientists from projects to research summits. Scientists could “fight” each other and knock one another off of projects. Or they could collaborate and gain knowledge together. The mod replaces this subsystem with a simple process: The company pays money, and the scientist advances along the research track of a specific type of clean energy.

Many other simplifications were made. At the same time, it must be admitted that not everything was, or should have been, simplified. The modified game is still complex. But it has to be, or it would not reflect the baffling complexity of the system it is intended to model. The advantage of a complex model over complex reality is that the model is more easily learnable: Players can play with the model and so come to grips with the larger system. Through a judicious choice of which systems to keep and which to discard, *Climate Policy* is a complex but learnable model of the issues surrounding climate policy.

3.2 Game mechanics, systems, and teaching with models

The modifications described above are all geared toward changing the game *CO₂* to focus players' attention on the problem of developing good climate policy. Notice how each modification consists of a change in a fundamental mechanic to redirect that attention. Here we review in game development terms those features that were altered to meet our teaching goals.

3.2.1 Scoring

A fundamentally important part of the modification to *CO₂* is the changes that were made to the way that players earn victory points. In the original game, there were several sources of victory points - money, CEPs, green power plants built, UN goals completed, company goals met, and expertise gained. For the mod, all of these were removed except money, which becomes the de facto source of victory points and the only way to achieve a win. The new method of scoring also creates an opposition that was not initially present – the incentives of the power company and those of the policy-maker. In all, modifying the way a game is scored can have a profound effect on the focus of a game.

3.2.2 Points as resources

Since money is also a resource, which must be expended to both provide power and research clean energy sources, the change in scoring creates a fundamental tension between the winning condition that individual players face and the losing condition (PPMs) that all players face. These two countervailing forces are linked in a very explicit way in the modification, and therefore emphasize

the problem of creating climate policy that aligns the incentives of the individuals with those of the group. Game mechanics that make points into a form of resources create difficult choices that force players to deeply consider both the costs and benefits of their decisions.

3.2.3 Property rights in investments and research

The mod changes property rights so that each player's power company owns all of its investments. Moreover, advances in clean energy research only allow new power plants for the players who make them. A research externality is introduced, in that players who research a type of energy after someone else does will be able to advance faster. For the most part, however, production and research is owned by a company and not shared. The main feature that is shared, of course, is the atmosphere. All players' pollution contributes to that.

3.2.4 Source and sink variations

Having settled upon a scoring method, it is valuable to think about what some designers have labeled the 'resource economy' that the method induces ([1], Ch.4). Variations in the game can be invented by thinking of this system in abstract way. The source of points for a player is money earned from providing power, and the sinks are power production and research. Variations in the mod emanate from adding mechanics that vary the flow of points. Thus CEPs and taxes on dirty energy are additional sinks, while grants for clean energy are additional sources. A number of other variations could be induced by creating other modifications of the resource economy.

3.2.5 Board games as models

Finally, note that a resource economy is an excellent way to model a variety of systems that are of interest to serious game developers. The *Climate Policy* economy arose naturally from thinking of the role of money in the climate policy debate, but any kind of resource imaginable can be thought of as existing within an economy that has sources and sinks. Votes, justice, energy, life, and karma are just a few examples of resources that humans produce in a limited amount, and with which we observe varying levels of stinginess or profligacy. In principal, any real-life system can be integrated into a game system by identifying the resource, its sources, uses, and sinks, and then operationalizing those features with game pieces and rules. The learning that results from an encounter with a serious board game consists of learning the model of a system that produces the problem that the serious game seeks to address.

3.3 Learning exercises

The *Climate Policy* mod enables a series of exercises that shed light on the global climate system and the way policy affects it. These illustrate the potential power of commercial board games as a teaching tool. We are also able to share the experience of having students play the game on several occasions. This is not formal research but represents a direct reporting of our experience of teaching climate policy using the mod. The ideas we present here are based on some informal play-testing in a classroom of about 20 students at a large Midwestern university. The students were from the media department, taking a course in game literacy as part of their degree studies. The game was presented to students as a learning exercise. They spent about 30 minutes learning the rules, and then they played the game for about 2 hours, in groups of 4. In any given session it was possible to see about 5 versions of the game and its rules being implemented, and our observations were taken over two sessions. The following describes the versions that students played, along with our observations of students' takeaways from the experience.

3.3.1 What have we done?

Players should first play *Climate Policy* without any policy at all, the do-nothing variant. They will happily build lots of dirty power plants and reap nice profits, cooking up the planet along the way. Only when the PPMs get close to the extinction level (500) will any player have the incentive to start developing clean energy. Participants can be asked to reflect on whether this is not in fact what we have actually done.

In classroom play, the do-nothing rules invariably smoked the planet very quickly. Facing low incentives to pursue clean energy, and making all their money from simply producing power, the players took the carbon dioxide level swiftly to 500.

3.3.2 What do carbon taxes do?

Players who must pay extra costs to use dirty power will try to avoid those costs. They will learn that carbon taxes actively encourage cleaner forms of power (natural gas) over dirtier forms (coal). Taxes also indirectly encourage clean energy research. A company feeling the pain of carbon taxes has every reason to put money into something else, like solar. Nonetheless, if the taxes are too light, the planet will still heat up to 500PPMs. The organizer can let the students experiment with different tax levels.

In classrooms, carbon taxes have the effect of slowing the growth of carbon dioxide but not providing a hard and fast limit. Players do shift from the dirtier forms of power (coal) to cleaner ones (natural gas). However, even natural gas emits carbon dioxide, and there is generally not as much incentive to switch from gas to pure clean energy, as this requires significant research costs. As a result, the pollution levels are still quite high.

3.3.3 Why do carbon permits work?

It seems strange that a regime that permits carbon could actually restrict it. It is difficult to understand why CEPs work. In *Climate Policy*, the organizer can put the CEP system in place, and students will realize that they must have a permit for each 10 PPMs they emit. By selling only 35 permits, the organizer guarantees that global PPMs will not exceed 350. Students will see that trading amongst themselves will determine who has dirty power and who has clean power. They will also see the incentives to clean energy that were provided by carbon taxes.

In classroom experience, permits imposed a hard limit on how much pollution was in the air. Students were able to understand how the system worked, once they realized they had to purchase an additional bundle of resources (the permits) in order to launch a new plant. The global limit on CO_2 became evident only later in the game, as a fairly surprising emergent effect of the policy system. Meanwhile, the costs of permits drove players fairly early into clean energy research.

3.3.4 Why are grants important?

If revenues are sent to companies doing clean energy research, a new business model emerges. Teachers can implement the grants variant and show players that it is now possible to do very little dirty power development, because clean energy research provides significant immediate revenues. This demonstrates how government support of research can move the system forward more rapidly. This will have the immediate effect of keeping PPMs lower than they are without grants. Students moved more rapidly into the research aspects of the game when this was easier to do. It was rarer that a student would hit upon the idea of doing only clean energy. Those that did got ahead early in the most advanced late-game technologies.

3.3.5 What about economic necessity arguments?

By implementing the loopholes variant, the organizer can show why the economic needs of populations, many of them poor, create such dilemmas for carbon policy. When players can buy their way around carbon regulations, the PPM level of the atmosphere goes up. Just how far it goes depends on how easy it is to get exemptions from regulation. The organizer can make loopholes easier or harder to get and show how climate problems respond. By default, this variant makes loopholes easy to get when pollution is not that big a problem. As pollution becomes more severe, however, economic necessity arguments become harder to make successfully. The system shows players that a balance is being struck, for good or ill, between the suffering caused by bad air and the suffering caused by expensive power.

In classroom experience, loopholes generally raised pollution under any climate-control policy regime. When loopholes are easier to get, carbon dioxide rises significantly. This enabled discussion of the general culture of politics and political systems and how they interact with climate systems to change air quality.

Although we did not have an opportunity to explore these strategies, upon reflection we feel that the following three strategies might also be valuable in a classroom context.

3.3.6 Comparing and contrasting experiences

One effective way to help players learn from *Climate Policy* mod is to set different groups up playing different modifications, then have them compare and contrast their experiences. This is not only an opportunity for players to reflect upon the effectiveness of the various policy regimes – it

is also an opportunity for the teacher to see whether the variants met the twin goals of both teaching an important subject and engaging the players with the various game mechanics. Was the CEP permit more enjoyable than the carbon tax variant? If so, why? How could they be improved?

3.3.7 Post-game commentary:

When teachers are able to observe the progress of a game, they can also provide some post-game analysis to players to help them understand their successes and failures. This is especially helpful in the case where some players try to “break the game”, for example by making it their goal to get the PPM meter to 500, instead of making a profit. In that case, the teacher can encourage other students to reflect on the effects of that game-breaking strategy on their own actions in the game. Alternatively, game-breaking strategies can be thought of as new, large sources of carbon, such as might result from the industrialization of developing countries over time.

3.3.8 Exposing the Model

We stated above that games can be treated as “small models” of much more complex phenomena. By taking the time and effort to build a model upon which the game system is based, a teacher can expose players to that model as part of the post-game commentary. Various modeling frameworks are available that can help educators outline models for the students. However, we believe that Dormans’s Machinations framework [1] may be particularly useful to both educators and students as a way to visualize that complex systems modeled in both board and digital games.

4. Advice for modding board games

In the course of creating and refining *Climate Policy*, we benefitted from the advice of several early play-testers. This section summarizes that received wisdom, as well as other lessons we learned along the way.

4.1 Work on game literacy

Make a practice of buying games that seem close to your subject either thematically or mechanically. Crack the games open and play them thoroughly and mindfully. Get to know how designers are approaching the systems you study. Focus on board games, where the rules are apparent and easy to modify, as opposed to computer games where the systems are hard to detect and almost impossible to change.

4.2 Test and iterate

Using the components of existing games, make prototypes of subsystems and mini-games. Test them. Throw them away and start over. Tinker with ideas and put different mechanics together. Design new systems simply for playability, or to instantiate a system that you have only seen described linearly in the past. Do it as an exercise for yourself – can I transform this game about plants and mushrooms so that it represents the diplomatic problems facing the Ottoman Empire prior to World War I? Can I use this zombie game to make a simple paper-and-wood representation of the way a virus invades and manipulates a cell? This practice may not ever result in class or workshop material, but it will enhance your ability to make useful games in the future.

4.3 Ignore aesthetics, rules docs, player aids. Focus on systems.

It is always tempting in board game prototyping to stop working on the game play and start drawing pictures and writing rules. You should not work on aesthetic elements too early. There is no point proceeding with a project if the underlying systems are broken. Only when the game’s resource systems are working smoothly, and flawlessly producing the desired player experiences, should you move on to things like writing clear rules, modifying game pieces, and so on.

4.4 Seek emergence

What exactly is meant by “working smoothly?” The standard is in the mind of the designer, but things generally work better if the experience you want the players to have emerges on its own

from underlying systems. To give an example, one could make a game about Henry VIII and have him marrying the historical sequence of wives, rolling a dice each time to see if she bears children. This would be heavy-handed and would not teach much of anything about the delicate diplomacy involved with matching royal couples. A better system would place Henry as one of several monarchs seeking wives, those wives each having their own interests and dispositions. If well designed, the latter version would produce Henry's procession through spouses in an emergent way: Spouses, yes, but not the same ones, not in the same order, and with different offspring. Players would better be able to see how the complex system of European noble weddings actually worked. The goal is to turn experiences into lessons by allowing them to emerge naturally from sensible underlying systems.

4.5 Make use of helpful tools

Speaking of which, there are several tools that can aid the resource system design process. We have already mentioned the machinations framework, but a simple spreadsheet model of a game system can provide substantial insight into a game system that is in development. These and other tools enable developers to test and iterate upon the various game systems that they create.

4.6 Seek elegance

The game should not be more complex than necessary. Games are like system poetry: Simple mechanics that invoke complex machines.

4.7 Finish

If a game mod is good and almost done, do not let it sit. Go ahead and do the boring part. Write the rules slowly and carefully. Do live tests, which means, putting the game pieces and the rules in front of people and see if they can figure out how to play. Finalize the components and put them in the box. Make player aids, little cards with rules summaries. Make the mod widely available. Announce to the world that it is done, and that you are able to share. Finalize the job and make sure that what you have done is truly playable. This will enable others to implement the mod in their own work. If the mod is good, it will spread from there.

5. Conclusion: board games for serious uses

This paper has described a board game that simulates global climate policy options and consequences. Board games are not usually considered in serious games applications, but there are many advantages as well as opportunities for using board games to enhance and promote digital serious games.

Future research in this area could follow a couple of fruitful avenues. On the one hand, it would be interesting to understand better the role that paper prototyping plays in the development of computer games. It is probably common practice in the early stages of design to go back and forth between notes and code. What can we learn about this crucial stage of the design process?

Along these same lines, more could be learned about the other end of the design process, about the way a finished board game can be translated into a computer game, and vice versa. Research in this area could perhaps focus on building a pipeline that takes game ideas from computer-illiterate people and passes them through a board game stage and on into a digitally-distributable computer game.

Lastly, it would be interesting to see research on the extent of policy-relevant boardgaming as a cultural practice. There is a hitherto-unnoticed industry of serious board games: Tabletop experiences that replicate incredibly complex systems such as climate, war, and politics. These can take many hours or days to complete. What motivates this hobby, how big is it, what are its roots, and what does its existence say about the broader culture of policymaking? The idea that making policy could be "fun" would be shocking to many policy experts. Perhaps it is so.

Games can be a tremendous asset for exploring serious issues like public policy, but it is extraordinarily difficult to make a good one. Starting with an existing game that is easy to modify – though not necessarily easy to modify well – is a comparatively fast and low-risk way to start.

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Appendix: Climate Policy: A CO2 Variant

The commercial board game CO2 simulates the race to develop clean energy. These rules add accurate models of actual climate policy to the game. Three major policy options are explored: 1) Do Nothing, 2) Carbon Taxes, and 3) Carbon Emission Permits. Options (2) and (3) can also have minor variants involving politics and research funding. Players will learn how these policies work and the way they change the incentives of power companies. The impact of policy on global climate conditions is directly observable.

In this version of the game, players are power companies seeking to earn profits. Profits are modeled as victory points (VPs), and the player with the most VPs at the end of the game wins. Victory points come from power plants, both clean and dirty. Dirty plants are worth 3 VPs each, reflecting the revenue stream that they provide. Clean plants produce at least this much revenue (and this many VPs), but may be worth more depending on their level of technology. Each dollar held at the end of the game is worth 1 VP as well. However: If the CO2 level reaches 500 PPM, no one wins.

1. Components

- Game board, with the following modifications
 - Each research track has two asterisks (*) in the following spaces:

Figure 1. Table 1

Energy Type	First Asterisk	Second Asterisk
Biomass	3rd space	6th space
Recycling	4th space	5th space
Cold Fusion	5th space	7th space
Forestation	7th space	10th space
Solar	5th space	10th space

- Power plant spaces on each continent each have a Development Cost number, written in the space from left to right:
 - Africa: First space: 1, second space: 2, third space: 3
 - Asia: 1,1, 2, 2, 3, 3
 - Europe: 1, 1, 2, 2, 3
 - South America: 1, 2, 2, 3
 - North America: 1, 1, 2, 2, 3
 - Oceania: 1, 2, 2, 3
- Coins: five 10s, ten 5s, fifteen 2s, and twenty 1s
- 100 wooden discs, 20 each in five player colors
- 20 wooden pawns, 4 each in five player colors
- 30 Dirty power plants, ten each of coal, oil, and gas
- 25 Clean power plants, 5 each of biomass, recycling, cold fusion, solar, and forestation
- Each energy type has two levels of technology, one with fewer white cubes printed on the face of the tile, and another with more. These are “Level 1” and “Level 2” technologies.
- 30 Research project tiles, 6 each of biomass, recycling, cold fusion, solar, and forestation
- 35 Carbon Permits (purple disks)
- 8 Loophole tiles (use the regional agenda tiles)
- 1 Global CO2 pollution marker
- 1 Decade counter
- 1 Round counter
- 1 First Player token
- 6 Event cards
- Things to ignore:

- All data on the face of clean power plants, except the number of white cubes listed
- All data on research projects, except the energy type
- The VP track (VPs are based on money and power plants only)
- 18 Summit tiles
- Images in the research tracks
- Images on the regional agenda tiles
- All numbers on the research tracks (asterisks should be marked by hand)
- The 3 project spaces and the CEP space by each continent
- The summit and regional agenda spaces around the market
- White research cubes, UN goal cards, company goal cards, lobby cards, and the large red disc

2. *Setup*

First, players decide on a policy variant. The rules for each variant are interspersed in each section of the rules, but they are also separated out and summarized in one section (8).

Players should first choose one of these options:

1. **Do Nothing.** No attempt is made to control CO₂ emissions. No additional funding goes to research.
2. **Carbon Taxes.** Companies who own CO₂ producing plants are taxed depending on how much CO₂ they emit.
3. **Carbon Emission Permits.** Companies are allowed to build CO₂ power plants if they own enough permits. Permits can be bought and sold among the players.

Then if Option (2) or (3) is chosen, players may choose one or both of the following:

- A. **Grants.** Funds from permits and taxes are allocated to clean energy research
- B. **Loopholes.** Energy companies can influence policy administration and obtain exceptions for economic hardship, etc.

Game versions can be identified by these numbers and letters: 2A, 3AB, 3B, etc. New players should try Policy 1 first, then 2A, then 3A. It can be debated which variant is most accurate historically. Most would say Variant 1, but it could be argued that the carbon policy has effectively been Variant 2AB: Public pressure against dirty power (which imposes costs on the companies), but with loopholes, and clean energy development subsidies.

2.1 *Common setup for all policy variants*

Mix up the dirty power plants and place them in a face-down pile by the board. Do the same with the summits. Sort the clean power plants and put them to one side.

Put all of the research projects in a cup or bag. At random, draw out a number equal to the number of players and place them by the '1' space on the market in the middle of the board. Do this for the '2' space as well, and the '3' space, and so on. Continue up to the market number that corresponds to the number of players. If there are four players, there should be four random projects on 1, four more on 2, four on 3, and four on 4.

Each player takes discs and pawns in his color, and two random dirty power plants. Determine a starting player and give him the First Player token. Players take money from the bank according to turn order: 1, 2, 3, 4, 5 takes \$8, \$9, \$9, \$10, \$10.

Place the pollution marker at 0, the decade counter at 1970, and the round counter on the number of players. Shuffle the event cards and place them face down in the place indicated on the board.

2.2 *Setup for the Do Nothing variant (1)*

No additional setup required.

2.3 *Setup for the Carbon Taxes variant (2)*

No additional setup required.

2.4 Setup for the Carbon Emissions Permits variant (3)

Place 35 purple CEPs on the market. Put 7 on the '1' space, 7 on the '2', and so on, up to space 5.

2.5 Setup for the Grants variant (A)

No additional setup required. Identify an area on the board as the Funding Pool area.

2.6 Additional setup for the Loophole variant (B)

Set the regional agenda tiles ("Loophole tiles") to one side.

3. Sequence of play

The game is played in rounds and decades. It continues until the end of the 5th decade, the 2010s, (2020s with five players). The number of rounds per decade depends on the number of players. The round marker starts on the number of players and is advanced one space per round. The decade ends when the marker reaches the end of the track. Thus with 4 players, there are 3 rounds per decade. With 3 players, there are 4 rounds per decade.

Each round has the following structure:

1. Income. All players take income from their Power Plants
2. Player actions. Beginning with the player with the First Player token, Each player in turn gets one action round, which consists of these phases:
 - a. Market phase. Players may visit the market to buy CEPs and Loophole tiles (Variants 3 and B only)
 - b. Build phase. Players may build 1 power plant
 - c. Development phase: Players may develop dirty energy capacity or clean energy capacity (not both)
3. Research Infrastructure. After each player gets one turn, move research projects down in price. The first player marker advances to the left.
4. Pass the First Player token to the left.

After the required number of rounds for the decade, the decade ends. Perform the Decade Upkeep actions, which include:

1. Event. Draw an Event card, add a dirty power plant
2. Carbon policy. Update the permits market, apply carbon taxes, award research grants, etc.

Continue decades and rounds until the end of the 2010s decade (2020s with 6 players). Do the last Decade Upkeep phase, then do the final Victory Point tally (10) and determine the winner.

Note: If at any point the atmospheric CO₂ level reaches 500 PPM, the game is over and everyone loses.

4. Starting A Round: Income

At the start of each round, give each player \$1 for every dirty power plant he owns on the board. In addition, each player receives \$1 per white cube printed on the clean plants he owns.

4.1 Continent control bonus income

If you own more power plants on a continent than any other player, you control the continent and receive a \$1 bonus each Income phase.

4.2 Debt

Once per game, a player may borrow. Take \$5 from the bank. Make a note that you are in debt. At the end of the game, subtract 6 VP from your total.

5. During a Round: Player Actions

After incomes are given out, each player in turn gets to take actions. These are all optional but must be performed in this order.

5.1 Market phase (Variants 3 and B only)

The player may buy Permits and Loopholes, if the corresponding variants are in effect. Permits are used in Variant 3. Loopholes are part of Variant B.

To purchase a good, pay the price on which it sits and put the good in your stock.

Restrictions. A player may not buy more than 4 CEPs per turn. A player may not buy more than 1 Loophole tile per turn.

Where to pay. Money from market purchases goes into the bank, unless Variant 3A is in effect. In that case, the money from Permit purchases goes into the Funding Pool for grants. Money from Loophole purchases always goes into the bank.

5.2 Build phase

You may build one plant per turn.

To build a CO₂ burning plant (“dirty power”), choose a continent. You must build in the left-most open space. A number in the space indicates location cost. These start at \$1 on the left and rise to \$3 on the right. Pay the location cost to the bank, take a dirty plant from your stock and put it in the space with one of your colored disks to indicate ownership.

If you have advanced sufficiently on a clean energy research track (see Research and Clean Energy 8), you may instead build a clean power plant. The location cost on the left-most open space must be paid, as above. In addition, clean energy plants have an extra build cost on top of the location cost:

- Biomass, Recycling: \$1 build cost
- Cold Fusion: \$3 build cost
- Forestation, Solar: \$5 build cost

Example: To build a Recycling plant on the ‘2’ space in Africa would cost \$3. Pay the \$3, take a Recycling plant from the stock, and place it on the board.

Unlike dirty power plants, you may not buy clean power plants and hold them for a future turn. Clean power plants must be placed immediately in the build phase in which they were purchased.

5.2.1 Check continent control

If you build a plant and have more plants on a continent than any other company, you control the continent. Place a disc of your color on the continent control spot.

5.2.2 Add pollution

If your plant adds CO₂ to the atmosphere, move the CO₂ marker up by the number of PPMs on the plant.

5.2.3 Upgrades and Demolition

If there are no spaces in a continent, you may select the space farthest to the right and build there. All the other plants shift to the left. The left-most plant is demolished. Demolished plants go back in the pool and can be selected and built again. If the demolished plant added CO₂ to the atmosphere, lower the CO₂ level by the amount on the plant.

Note: A player may voluntarily demolish a plant during his turn at no cost. Simply place it back in the pool and slide all other plants to the left to close up any space.

5.2.4 Loopholes (Variant B)

If you own a Loophole tile, you may place it on a plant when it is built. This plant is exempt from carbon policy.

5.3 Development phase

The player chooses one: Dirty energy development or clean energy development. You cannot do both.

5.3.1 Dirty energy development

Pay \$1 to the bank. Select three dirty energy plants at random from the face-down pool and add them to your stock. You cannot have more than 3 dirty plants in your stock. If you have more than 3, choose plants and place them in the pool, face-down, until you are down to 3 again.

5.3.2 Clean energy development

You may fund your research projects through the market circle in the center of the board. Select the project you want, pay the price it is next to, and return it to the cup or bag in which projects are being held. The money goes into the bank.

When you fund a research project, move your Scientist (wooden pawn) up one space on the associated Research track. If it is your first purchase of a line of research, put your scientist on the first space. When your pawn reaches the first '4' space on a track, you may build the first level of technology in that energy source. To build the second level of technology, your pawn must reach the end of the track. See Research and Clean Energy (8).

Research limit. You may fund no more than two research projects in a given turn

Knowledge transfer. If you fund a research project and you are two or more spaces behind the leader on that research track, you may give \$1 to the leader and move ahead two spaces instead of just one. The \$1 payment is taken from the amount you are spending on research. Instead of putting it in the bank, give it to the leader.

6. Ending a Round: Research Infrastructure and First Player

Once all players have performed their actions in a round, end the round by conducting a Research Infrastructure step that reflects the long-run benefits of investments in clean energy research. If research has been done on a clean energy type, the resulting infrastructure lowers the costs of future research in that area. To show the effects of Research Infrastructure, do steps 0 and 0 below:

6.1 Reduce costs

First check the research projects of each energy type. Starting at \$2, if there are no projects of a given type at \$1, move all the \$2 projects of that type down to \$1. Then if there are no projects of that type at \$2, move all the \$3 projects of this type down to \$2, and so on. Move each project down \$1 in price, unless there is already a project of that type at the lower price. Do this separately for each energy type.

- *Example:* Solar has one project at \$2, none at \$3, and three at \$4. Move the \$2 project to \$1, and the three \$4 projects to \$3.
- *Example:* Recycling has one project at \$1, three at \$2, none at \$3, and one at \$4. The three \$2 projects cannot move to \$1 because there is already a Recycling project at \$1. The \$4 project moves to \$3.
- *Example:* Forestation has one project at each price level. None move.

6.2 New research

Second, add new research projects at the highest price (\$5 for five players, \$4 for four, etc.). The number added equals the number of players. Draw randomly from the research project cup.

6.3 Pass First Player token

Pass the First Player token to the left. Then if this was the last round in the decade, proceed to decade upkeep. Otherwise, continue with the next round.

7. Decade Upkeep

After the Research Infrastructure step of the last round in a decade, perform the following decade upkeep actions. Then move to the first round of the next decade.

7.1 Event

Shuffle the Event deck and draw one card at random. Draw a random plant from the dirty pool and place it in the left-most open spot on that continent. This represents the general increase in CO₂ emissions from sources other than power (transportation, residential, etc.)

7.2 Carbon Policy

Depending on the variant, carbon policy effects are implemented here.

7.2.1 Carbon taxes (Variant 2)

Each company must pay \$1 per 20 PPMs emitted by all power plants they control. Fractions are rounded up. Example: The tax on 70 PPM is \$4.

Noncompliance. If a company cannot, or does not want to, pay the tax for all his plants, the company is noncompliant and must demolish plants until taxes are paid on all plants owned. Alternatively, a company may sell plants to other players (who must then pay the tax due). The players may agree on any price.

Loopholes. Plants plant with loophole tiles (Variant B) do not contribute to carbon tax liability.

Grants. If Grants are in effect (Variant A), all carbon tax monies go into the Funding Pool. Otherwise the money goes in the bank.

7.2.2 Carbon Emission Permits (Variant 3)

Each company must have one Carbon Emission Permit (CEP) for each 10 PPM of carbon his plants emit. Coal requires 4 CEPs, oil 3, and gas 2. A company without enough permits is noncompliant and must buy permits from other players, sell plants to them, or demolish plants until the company is compliant. The players may agree on any prices for these transactions.

- Loopholes. A plant with a loophole tile on it (Variant B) is exempt from carbon permit requirements.
- CEP demand adjustment. After compliance has been resolved, move all CEPs on the market down \$1 in price.

7.2.3 Grants (Variant A)

Reveal one Summit tile at random. A subsidy of \$3 each is given to the research leaders in the indicated energy sources. The \$3 grant goes to the leader in that energy type, as indicated on the research track. If there is a tie for leadership, the companies divide the \$3 grant for that track, rounding down.

All funding is taken from the Funding Pool. If the pool contains insufficient funds, give a \$3 grant to the leftmost energy type first, then proceed to the right until funding is exhausted. (With Kyoto, go across the top first, then the bottom.)

8. Research and Clean Energy

In order to build a clean energy plant, a company must have advanced sufficiently on the research track for that energy type.

8.1 Advancing research

You advance research by funding research projects during the development phase of your turn. Select a project, pay the price, and advance your scientist pawn one space on the associated track. Return the project to the stock of hidden research projects.

8.1.1 Research limits

You have only 4 scientists and can do research in only 4 energy types. You cannot fund more than 2 projects per turn.

8.1.2 Knowledge transfer

If you are two or more spaces behind the leader in a track, when you fund a research project you may pay the leader \$1 and move ahead two spaces. The \$1 comes out of the money you are paying for the research; simply give \$1 of your spend to the leader instead of the bank. The leader cannot refuse this payment. Knowledge 'leaks out.'

8.2 Unlocking technology and building plants

Each energy type has two levels of technology. The lower level has fewer white cubes. Each white cube provides \$1 in income per round, and 3VPs at game end.

When you reach the first asterisk on a research track, you may build the first technology plant in that energy type. You cannot build the second technology plant in that type until you reach the second asterisk on the track.

Figure 2. Table 2

Energy Type	First Asterisk	Second Asterisk
Biomass	3 rd space	6 th space
Recycling	4 th space	5 th space
Cold Fusion	5 th space	7 th space
Forestation	7 th space	10 th space
Solar	5 th space	10 th space

9. Policy Variants

This section collects in one place the rules for different variants and their interactions. The “Policy Experiments” sections suggest further variants on these rules that tease out different policy effects.

9.1 Do Nothing (1)

In the Do Nothing variant, there are no carbon taxes, no permits, no loopholes, and no grants. Ignore the purple CEP disks, the Loophole tiles, and the Funding Pool.

9.2 Carbon Taxes (2)

There is no additional setup for this variant. During Decade Upkeep, each company must pay \$1 for each 20 PPM his plants emit, rounding up. If he cannot pay or does not want to pay, he must sell plants to other players, who then must pay the tax. Otherwise, the plants must be demolished.

9.2.1 Grants (A)

If Grants are in effect, the carbon tax money goes into the Funding Pool.

9.2.2 Loopholes

If Loopholes are in effect, a plant with a loophole tile does not add to your carbon tax burden.

9.2.3 Policy experiments

Vary the carbon tax amount.

9.3 Carbon Emission Permits (3)

At setup, put 35 Carbon Emission Permits on the market. This will enable 350 PPM of CO₂ in the atmosphere. Put 7 permits at each price on the market, from \$1 to \$5. These CEPs are available for purchase during the Market phase of each player’s turn. A player cannot buy more than 4 per turn. Once purchased from the market, CEPs may be bought and sold among players at any agreed price.

During each decade upkeep step, the remaining CEPs on the market are moved down \$1 in price. In addition, each player must show that he has enough permits to cover his CO₂ emissions. If he does not, he has to buy permits from other players or sell plants to them. Players who buy plants must have enough permits to cover the emissions of the plants that they buy. If a player cannot come into compliance, he must demolition plants.

9.3.1 Grants (A)

If Grants are in effect, money spent to buy CEPs from the market goes into the Funding Pool.

9.3.2 Loopholes

If Loopholes are in effect, a plant with a loophole tile does not require CEPs.

9.3.3 Policy experiments

Put a different number of CEPs on the market. Give CEPs to players. Introduce CEPs midway through the game.

9.4 Grants (A)

If Grants are in effect, funds from carbon taxes or CEP sales go into a research Funding Pool. During decade upkeep, a Summit tile is chosen at random. Each energy type on the tile will receive \$3 in research grant money. The grant goes to the leader in research in that type of energy. If

players are tied on the relevant research track, the \$3 is split. If two or three are tied, each gets \$1. If more than three are tied for the lead, none receive grant funding.

9.4.1 Policy experiments

In the Do Nothing policy (1), roll a d6 during each decade's upkeep and give this money as grants. This would reflect the constantly changing commitment of governments to clean energy research. Or, select a fixed amount (\$3, \$5, \$10) and distribute it according to different rules.

9.5 Loopholes (B)

Loopholes reflect the political pressure energy companies can use to evade emission regulations, through arguments involving the need for energy and economic growth (to reduce unemployment, for example). During Setup, set aside the regional agenda tiles. These tiles are called "Loophole tiles" in this variant; the images on them serve no purpose and can be ignored.

During the Market phase, players may purchase these tiles. You may only buy one Loophole per turn. The Loophole price reflects the cost of lobbying, public persuasion campaigns, and bribes. The price depends on the current CO2 level.

- Below 300 PPM, Loophole price = \$3
- 300-400 PPM, Loophole price = \$5
- Above 400 PPM, Loophole price = \$7

The cost rises because the deteriorating atmosphere renders these arguments less plausible. When a company builds a plant, it may place a loophole tile on it. The plant is then exempt from all carbon-related policies.

9.5.1 Policy experiments

Add more or fewer loophole tiles to the market. Change their price distribution.

10. Final Scoring and Victory

Companies in this version of CO2 are like real companies, in that they receive victory points (VPs) not for their clean energy record but for their revenues. At the end of the game, each player receives VPs as follows:

- For each dirty power plant: 3 VPs
- For clean power plants: 3VPs for each white cube printed on the plant
 - Note: this does not refer to the wooden white cubes. In this variant, there is no connection between the white cubes printed on clean energy tiles and the wooden white cubes that come with the game.
- For each \$1 held: 1 VP
- For each CEP held: 2 VPs
- Debt: -6 VPs

11. Rules for 2 or 3 players

With 3 players, reduce the size of each continent by one space. With 2, reduce each continent by two spaces.

12. Credits

Original CO2 game designed by Vital Lacerda. Published by Giochix.it, 2012. Climate Policy variant designed by Edward Castronova, 2015.

CO2 Carbon Policy

PLAYER AID

1

Sequence of Play

Each Decade:

1. Rounds (depends on number of players)
2. Decade Upkeep

Each Round:

1. Start the round: Income
2. Player actions, one turn per player. Each turn:
 - a. Market Phase
 - b. Build Phase
 - c. Development Phase
3. End the round: Research Infrastructure, pass the First Player token

Income

\$1 per dirty plant
 \$1 per white cube on clean plants
 \$1 for continent control (most plants)
 Debt: Take \$5 (Note -6 VPs)

Research Infrastructure

Move each project down \$1 unless blocked by existing project. Then add more projects in highest price, equal to number of players

Decade Upkeep

Draw Event. Place random dirty plant on that continent. Then conduct carbon policies.

Market Phase

Pay indicated price, place item in stock.
 Limits: 4 CEPs and 1 Loophole

Build Phase

One plant per turn. Choose space. Pay location cost and build cost. Place plant with disk.

Dirty energy: No build cost. Add PPMs to world total

Clean energy: Build cost is 1/1/3/5/5 for Bio, Recycle, Fusion, Forest, Solar

Development Phase

Dirty: Pay \$1, draw three tiles, discard down to 3
 Clean: Purchase research projects, advance on research track. Limit 2 projects per turn.

Research Tracks

Buy research projects during Development Phase. Advance 1 space.

If behind 2 or more, pay \$1 to leader and advance 2 spaces.

First * allows construction of 1st level plant
 Second * allows construction of 2nd level plant

Victory Points

Dirty power plants: 3 VPs each
 Clean power plants: 3 VPs per printed white cube
 Money: 1 VP per \$1
 CEPs: 2 VP each
 Debt: -6 VPs

500 PPMs: ALL LOSE

Variant 1: Do Nothing

No limits on building. No grant support.

Variant 2: Carbon Taxes

Decade Upkeep: Each player pays \$1 per 20PPM. Round up.

Variant 3: Carbon Emissions Permits

Place 35 CEPs on market, seven each on \$1 through \$5.

Decade Upkeep: Players must have 1 CEP per 10 PPM or demolish plants. Then lower CEPs on market by \$1.

Variant A: Grants

All funds from carbon taxes or CEPs go into Funding Pool

Decade upkeep: Draw Summit tile.
Research track leader in each energy type receives \$3 from pool.

Variant B: Loopholes

Plants with loophole tiles are exempt from carbon regulation. Buy Loopholes during Market phase. Price depends on PPM.
Below 300: \$3, 300-400: \$5, above 400: \$7.

Reminders

No space left: If a continent is full, new plants on the right push all other plants to the left, demolishing the left-most. Demolished plants go back to the pool.

Free trade: Players may buy freely and sell CEPs, built plants, and loopholes.

Knowledge transfer: If behind 2 or more on a research track, when you buy research pay \$1 of the money you spent on research to leader and advance 2 spaces.

Turn limits: No more than 1 plant, 2 research projects, 4 CEPs, one loophole.

Clean energy plant unlocks: The first asterisk unlocks the first level plant for construction. The second asterisk unlocks the second level plant.