The game design for Learning about Energy Transition

## Overview

As we move towards the NetZero emissions future, our energy systems must transition from centralised to distributed and decentralised generation. However, nearly all of us who use electricity/energy every day have yet to learn what moving to a different energy system means. This game aims to help the user understand and experience new energy concepts. Gameplay inspired by *“Stacklands”*.

## Game mechanics

Players can drag and drop any number of cards onto the card stack. When a card stack meets certain combinations, it automatically produces or consumes new cards and affects specific indicators like the nature and humanities indicators. Players can understand the relationship between the content mapped by each card through simple operations.

Players can drag money cards to market place to buy the resource card they want.

Players can hover over certain cards or elements in the game to get additional information about them.

Players can pause or speed up the game as they see fit. This feature is intended to allow players to spend time thinking about the allocation of resources in peace. It will also help them reduce the time they have to wait.

## Game base rule

The game will be turn-based. Players need to generate enough electricity cards within each turn. To find the balance between humans, energy production and nature.

At the beginning of each turn, a weather card will be randomly drawn from the weather card deck as the current turn's weather effect affects some cards’ efficiency. At the same time, all electricity cards that have not been stored will also be automatically consumed. Adjusting the price of cards in the market and supplementing the cards players had purchased the last term.

In each turn, players need to drag and drop cards to allocate resources reasonably. Certain card combinations will cause changes in the natural and humanities indicators. If the value of the indicator is above or below certain discounts, rewards or penalties will be given, and then the indicators will be reset. Usually, these indicators will be displayed as a numerical bar on the screen. More details and content will be elaborated on the **design of game elements.**

At the end of each turn, the corresponding number of electricity cards will be consumed. The number of electricity cards consumed at the end of each turn will be determined by the number of electricity consumption cards in the play area. If the number of electricity cards in the current turn is insufficient, the game ends. Otherwise, the game continues.

## Design of game element

* **Card**

Cards are the primary interactive unit in the entire game. Typically, each card corresponds to a building or resource.

1. Electricity Card

The card represents electricity. It is also the one that players need to focus on producing in each round. Electricity is the most used energy source in modern society. Typically, electricity is generated by converting various types of resources, such as fossil fuels and mechanical energy. All unspent electricity cards will be automatically consumed at the beginning of each turn.

1. Coal Card

The card represents coal. Coal, as the most used fossil fuel for power generation, typically needs to be mined from coal mines. At the end of each turn, stacking a large number (5) of coal cards in the same stack will affect the natural indicators, reflecting the impact of storing large amounts of coal on the environment. The specific impact will be explained in detail in the natural indicators.

1. Coal Mine Card

The card represents a coal mine. One of the ways to obtain coal in the game. Each coal mine card will have 20 mining attempts which means it can produce at most 20 coal cards. To reflect that coal is a non-renewable resource in the short term.

1. Human Card

The card represents humans. Human resources are also an indispensable part of energy production. At the same time, humans also play the role of consumers in energy production, usually indirectly consuming electricity by using electrical appliances. Therefore, the number of human cards will be limited by the number of house cards. If there are more human cards than the accommodation provided by the house cards at the end of the turn, one human card will be randomly selected to disappear, indicating that they have moved out of the community.

1. Home Card

The card represents human habitation. One home card will provide three living spaces. The number of home cards will also affect the amount of electricity needed at the end of each turn. Each home card will increase the electricity consumption per turn by 2.

1. Lithium Card

The card represents lithium. Lithium cards can be obtained by mining lithium mines and are used as raw materials for batteries. Like coal cards, stacking them in large quantities will affect the natural indicators.

1. Lithium-ion Mines Card

The card represents a lithium mine. Similar to coal cards but produce lithium cards instead.

1. Battery Card

The card represents lithium-ion batteries. It can store up to 10 electricity cards and automatically consumes corresponding electricity cards at the beginning of each turn based on the stored electricity. 1-5 electricity cards will consume one card, and 6-10 electricity cards will consume two cards. The resource count in the bottom right corner of the card will represent the number of stored electricity cards.

1. Ideal Storage Plant Card

The card represents the ideal storage plant which means it can store infinite electricity cards without any waste. This card is used to demonstrate how much the flexibility of the power grid could be improved if such a form of electricity storage exists.

1. Power Station Card

The card represents fossil fuels power station. A card that can convert fossil fuel cards like coal into electricity. Generally, one fossil fuel card can yield one electricity card. Although, such a high conversion rate cannot be achieved in reality. Therefore, at the end of each turn, each power plant card will consume two electricity cards to reflect the power consumption and the electricity required to maintain the normal operation of the power station.

1. Solar Panel Card

The card represents solar panels. It automatically produces electricity cards. The efficiency of the solar panel card will be affected by the weather. The default efficiency is 10 seconds to produce an electricity card. More detail will be elaborated on in the **weather card** section. The number in the bottom right corner of the card will represent the lifespan. At the beginning of each turn, the lifespan is reduced by one. If the lifespan is zero at the start of the turn, the card will be removed. This card can be repaired with a human card. No work will be performed while the card is being repaired. Each repair will increase the lifespan of the card by ten but will not exceed the maximum lifespan of 20.

1. Wind Turbine Card

The card represents wind turbines. Almost the same as the solar panel card. However, it has a maximum lifespan of 15.

1. Factory Card

The card represents processing plants. It can process raw materials into building materials. More detail will be elaborated on the **combination of cards**.

1. Pumped-storage Hydroelectricity Card

The card represents a pumped-storage hydroelectricity power station. It is different from a power station card but similar to a battery card. It does not actively produce electricity cards but is a unit for storing them. Unlike battery cards, it takes 2 seconds of play time to store an electricity card. This represents the process of converting electricity into the water and mechanical energy. Similarly, the weather also affects the amount of energy stored. More detail will be elaborated on in the **weather card** section. Maximum capacity is 20.

1. Climate Summit Card

The card represents the Climate Summit. It belongs to a type of reward card that is generally obtained by achieving humanities standards. By stacking two Human cards and waiting for 10 seconds of game time, it will provide an ideal solution card.

1. Ideal Solution Card

The card represents an ideal solution card that can solve the pollution weather. By stacking one human card and waiting for 10 seconds of game time. The pollution card in the weather card will be removed.

1. Money Card

The card represents currency. It can be obtained or used in the market. More detail will be elaborate on **market** section.

* **Weather Card**

Weather cards belong to a type of scene state card. Weather cards are added to the weather card deck, and at the beginning of each round, a random card will be drawn by the player as the weather for the current round. This will affect some cards in the playing area. The weather card set consists of default weather for each season and additional weather. Additional weather includes unique seasonal weather and penalty weather like air pollution.

1. Sunny Day

Solar panel cards produce an electricity card in 10 seconds.

Wind turbine cards produce an electricity card in 20 seconds.

1. Windy Day

Solar panel cards produce an electricity card in 20 seconds.

Wind turbine cards produce an electricity card in 10 seconds.

1. Rainy Day

Solar panel cards stop producing this turn.

Wind turbine cards produce an electricity card in 20 seconds.

Add 3 to the resource count of all pumped-storage hydroelectric Cards.

1. Air pollution.

Solar panel cards produce an electricity card in 26 seconds.

Wind turbine cards produce an electricity card in 26 seconds.

At the end of the turn, all wind turbine card lifespan minus 3.

If humans work in the mine card under this weather, the humanities indicator will decrease by 7 points after each work session.

During the turns affected by air pollution, the humanities index will not increase at the beginning of the round.

1. Urban heat island (summer only)

Solar panel cards produce an electricity card in 10 seconds.

Wind turbine cards produce an electricity card in 14 seconds.

If humans work in the mine card under this weather, the humanities indicator will decrease by 1 point after each work session.

Double the amount of electricity required to be produced for the current turn.

1. Rainstorms (summer only)

Solar panel cards stop producing this turn.

Wind turbine cards produce an electricity card in 7 seconds.

Fill up the capacity of all pumped-storage hydroelectric Cards.

1. Snowy Day (winter only)

Solar panel cards stop producing this turn.

Wind turbine cards produce an electricity card in 15 seconds.

At the end of the turn, all wind turbine card lifespan minus 1.

Add 3 to the resource count of all pumped-storage hydroelectric Cards.

* **Season**

Twelve rounds make up one cycle, with three rounds for each of the four seasons: spring, summer, autumn, and winter. Each season has a different weather card deck. The number of electricity cards required for each turn will vary in some seasons.

1. Spring

In the spring turn, there are no other additional rules. The weather card deck includes two sunny cards, two rainy cards, and two windy cards.

1. Summer

In the summer turn, the electricity card consumption of all home cards is increased by one. Because people tend to use air conditioning during the summer, electricity consumption is usually higher in the summer than in the spring. If there are more than four home cards, two additional weather cards, Urban Heat Island and Rainstorms, will be added to the weather card deck. Under the Urban Heat Island weather condition, the specific electricity card consumption for the current turn is calculated by first applying the effects of the season and then applying the effects of the weather condition.

1. Autumn

Like the spring turn, there are no additional rules or unique weather in the autumn round. However, the default weather deck is modified to include three sunny cards, two rainy cards, and one windy card.

1. Winter

­In the winter turn, the electricity card consumption of all home cards is increased by two. In this game, heat pumps will be used instead of traditional natural gas heating for warmth. Two snowy cards will be added to the weather deck.

* **Indicator**

Indicators are used to provide rewards or penalties for certain player actions in the game. The relationship between a player's game actions and the indicator values reflects the correspondence between human activities in the real world and humanistic or natural factors.

1. Nature

This indicator represents the environment of the plant. Stacking some resources or using fossil fuels for production will have a negative impact on this indicator. Ideal solution cards will have a positive impact on this indicator. In addition, at the beginning of each round, the natural indicator will increase by 3 points to reflect the self-healing ability of nature, although it is very small. When the value reaches -50, add two "air pollution" cards to the weather card deck, and reset the value to zero. When the value reaches 50, 3 permanent residential slots will be provided to humans, similar to the effect of the "Home" card, but without any additional power card consumption at the end of each round. Then reset the value to zero.

1. Humanities

This indicator is similar to HDI (Human Development Index) and is used to evaluate the level of human happiness within the game. Working under harsh conditions will have a negative impact on this indicator. At the beginning of each turn, if there is no weather card effect (such as air pollution), this index increases. The value added will be related to the number of consecutive turns without air pollution. It starts from 3 and increases cumulatively. For example, if there are three consecutive turns without air pollution, the added values in these three turns are 3, 4, and 5, respectively. When the value reaches 50, it will provide a Climate Summit Card to allow players to clear the air pollution in the weather deck. Then reset the value to zero. When the value reaches -50, the human cards will go on strike, and the strike will last for the remaining time of the current turn and the entire next turn.

* **Other**

1. Market Place

Market is a place where players can exchange electricity cards or money resources. To encourage players to produce electricity independently, buying electricity cards in the market will always be more expensive than selling them. The conversion prices will also vary in different seasons. In spring and autumn, players are allowed to buy one electricity card with one money card, and two electricity cards can be sold for one money card. In summer and winter, players are allowed to buy one electricity card with two money cards, and one electricity card can be sold for one money card. The transaction between electricity and money cards in the market is settled directly. In addition to this, the market also sells some equipment cards like solar panel cards and ideal storage plant cards, which cost three money cards each. After purchasing an equipment card, it will be displayed as "sold out." The purchased equipment card will be provided at the beginning of the next round.

## Interface design (TODO)

**(Figure)**

**Element explanation**

* **Play area**
* **Humanities and natural bar**
* **Smart meter**

There will be a virtual smart meter displayed at the centre top of the interface. The smart meter will show the current residential population and the maximum residential capacity, as well as the required power card consumption at the end of the current round.

* **Current turn state and timer control**

**Setup**