Quick Start Guide

For the Computer Game Version of Megawatts & Marbles

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Learning Outcomes

How does our electrical power system work, from the power plant to the light bulb?

What are the challenges of integrating variable renewables like wind and solar?

What would your ideal system look like?

In this computer game, you will build your own marble-based "electricity grid" which will be used to explore these and other questions.

In playing the game, there are five intended learning outcomes; namely

1. Understanding that electricity generation must always match demand, exactly, at every instant.
2. Understanding that electricity generators have different characteristics and operate with different (physical) rules.
3. Understanding that too much generation causes similar problems as too little generation (e.g. equipment damage, power outages, etc.).
4. Understanding that demand varies during the day based on people's schedules.
5. Understanding the difference between energy (i.e., Joules [J] or kiloWatt-hours [kWh]) and power (i.e., Watts [W]).

The Game

Basic Idea

The basic idea of the game is threefold

1. The game simulates an electricity grid through a marble system; and,
2. A marble track simulates the power lines and connects remote generators with consumers (i.e. the plinko city); and,
3. When playing in a team, each team member (or pair of members) takes on the role of a single generator type.

The "Marbles" Part of Megawatts & Marbles

With respect to the "Marbles" part of Megawatts & Marbles

1. Marbles represent packets of electrical energy flowing from generators to consumers.
2. Each marble represents 1 gigaWatt-hour [GWh] of energy.
3. Different types of generator produce marbles according to different rules.
4. Marbles are consumed by the population of Plinko City.

Game Play

With respect to game play

1. The game simulates a whole day in twenty four 1-hour time steps.
2. Each step consists of three actions:
   (1) The current electricity demand (i.e., number of marbles required by Plinko City) for that step is revealed (demand varies throughout the day).
   (2) The player(s) decide how many marbles each generator type should produce in that step.

(3) Marbles are released from the generators, flow to Plinko City, and scoring for that step is computed and displayed.

3. The goal is to exactly meet the electricity demand in each step (not too little, not too much).

4. When playing in a team, the team coordinates to meet the electricity demand for the whole system.

5. If playing in teams, teams may compete to see who can achieve the highest score.

Player Roles

With respect to player roles, when playing in a team, 1 - 2 (ideally two) players operate each generator type. They collaborate with the other generator types in the system to produce the right amount of marbles.

Generator Types

The generator types implemented in the computer game version of Megawatts & Marbles are

1. Coal Plant
2. Combined Cycle Natural Gas Plant
3. Nuclear Fission Plant
4. Geothermal Plant
5. Hydropower Plant
6. Peaker Natural Gas Plant
7. Solar Photovoltaic Plant
8. Energy Storage System (batteries)
9. Tidal Energy Plant
10. Wave Energy Plant
11. Wind Energy Plant

Prescribed Generation Mixes

There are three prescribed generation mixes that one can use when playing Megawatts & Marbles; namely,

1. British Columbia (Canada); or,
2. Bavaria (Germany); or,
3. The worldwide average.

These prescribed generation mixes are defined below in Tables 1 - 3.

British Columbia (Canada)

A rough model of the British Columbia (Canada) generation mix can be represented in game according to Table 1.

Table 1: British Columbia (Canada) generation mix.

Generator Type	**Installed Capacity [GW]**
Coal	9
Peaker Gas	3
Wind	3
Hydro	18

Bavaria (Germany)

A rough model of the Bavaria (Germany) generation mix can be represented in game according to Table 2.

Table 2: Bavaria (Germany) generation mix.

Generator Type	**Installed Capacity [GW]**
Coal	12
Peaker Gas	3
Wind	10
Hydro	8

Worldwide Average

A rough model of the worldwide average generation mix can be represented in game according to Table 3. Note that this worldwide average generation mix is actually quite similar to the generation mix of Alberta (Canada).

Table 3: The worldwide average generation mix.

Generator Type	**Installed Capacity [GW]**
Coal	18
Peaker Gas	3
Wind	3
Hydro	9

Suggested Procedure

The suggested procedure to follow when first starting out with Megawatts & Marbles in a classroom setting is

1. Watch the introduction video on YouTube. (11 min)

   `https://youtu.be/1X6M-HGNJXY`

2. Divide the students into teams. Each team corresponds to one instance of the game, and there should be 1 - 2 team members per generator type. (5 min)

3. Select and play through one of the prescribed generation mixes. (15 min)

4. Debrief the prescribed play session. (15 min)

5. Conduct a free play session where the teams design their own generation mixes. (15 min)

6. Debrief the free play session. (15 min)

TOTAL PROCEDURE TIME: 76 minutes

With respect to the debriefs (which are important!), be sure to consider the following (adjusting for the level of the students)

1. Lessons learned. What did the players take away from the game?

2. How do the lessons learned impact the student's idea(s) for our future generation mix?

3. Suppose that we want to use more renewable energy sources. What does this mean for the power system? What complications does this introduce? How do we deal with these complications? What solutions / new technologies exist to facilitate renewable energy integration? (e.g., energy storage technologies, etc.)

4. The game focuses primarily on the supply side, but what about the demand side? What demand-side management actions (e.g., load shifting, energy efficiency measures, etc.) could be taken to reduce the load on the supply side?

5. What future technologies (e.g., nuclear fusion, etc.) can, or should, STEM professionals (i.e., scientists and engineers) be working on to reduce reliance on fossil fuels?

6. What about the political side of things? What policies / laws can, or should, be introduced / amended / repealed in order to either motivate, or simply make easier, the transition to a cleaner and more sustainable generation mix?

7. Any other questions / concerns?

Contact Information

University of Victoria
Institute for Integrated Energy Systems
Engineering Office Wing, Room 108
Victoria, BC V8W 2Y2
Canada

Phone: 250-721-6295
Email: iesyinfo@uvic.ca

Key Bindings

Table 4: Megawatts & Marbles key bindings.

Key(s)	**Action(s)**
A, D	cycle through plant slots
W, S	cycle through plant types, assign tokens, muster marbles
Spacebar	select, commit
T	show tutorial
B	show key bindings
I	show plant information
E	show energy overlay
F	show forecast overlay
L	perform load deferral
P	quit play session and restart
Escape	exit game
M	pause / resume music
,	go to previous music track
.	go to next music track