

Hazard Literacy Center

Hazard Literacy Education Program

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Change the Variables, Change the Results! Analyzing Wind Power Systems with NetLogo



1. Program Overview

This program is designed to help students explore relationships between variables and outcomes in wind power systems through simulation and use those relationships to analyze issues related to energy transition. Students first use a simple ecological simulation to understand that simulations simplify and represent selected features and rules of reality. They examine how outcomes change when variables are manipulated and recognize that different variables can have different levels of influence on results. Students then use a NetLogo-based wind power simulation to analyze how variables such as wind speed, blade length, number of wind turbines, and installation location affect power generation. They also compare simulation results with real-world situations and consider that installation location may affect not only power generation but also environmental and social impacts. Through this process, students understand that wind power and energy transition are not simply technological issues, but complex systems in which outcomes change through interactions among multiple conditions and factors.

Grade Level	Grades 6	Instructional Methods	Lecture, Computer-Based Activity, Discussion
Learning Environment	Classroom equipped with computers or tablets (NetLogo installed in advance)	Duration	80 minutes (40 minutes × 2 class periods)
Required Materials	Computer for each group or individual		

2. Learning Objectives (Hazards Literacy Framework)

① Understand what a simulation is and identify variables in a wind power system.
② Analyze through simulation how variables such as wind speed, blade length, number of wind turbines, and installation location affect power generation.
③ Compare renewable energy produced in the simulation with energy consumption and evaluate the feasibility of energy transition policies.

Learning Objectives	Knowledge & Understanding		Reasoning & Skills					Values & Attitudes			Psychology & Emotion			Behavioral & Practical Enagement		
	A1	A2	B1	B2	B3	B4	B5	C1	C2	C3	D1	D2	D3	E1	E2	E3
Objective ①	O			O												
Objective ②	O		O		O											
Objective ③		O			O		O	O								

3. Key Concpets

· Simplifying and Representing Systems Through Simulation

· Relationships Among Wind Speed, Blade Length, Number of Turbines, Installation Location, and Power Generation

· Differences in Power Generation and Variable Effects Caused by Variable Manipulation

· Analyzing Energy Transition by Comparing Renewable Energy Production and Energy Consumption

4. Program Sequence

Learning Activities	
Introduction	·Understand simulation as a tool that simplifies and represents selected features and rules of reality ·Identify the concept of variables by examining adjustable elements in the NetLogo interface
Development 1	·Run a NetLogo-based fish simulation and observe changes in fish populations and food over time ·Examine how results change when variables are manipulated ·Explore differences in the magnitude and way each variable affects the results
Development 2	·Identify major variables in the NetLogo-based wind power simulation, such as wind speed, blade length, number of wind turbines, and installation location ·Analyze differences in current power output and total power generation caused by variable manipulation ·Interpret relationships between variables and outcomes in the wind power system
Development 3	·Compare simulation results with real-world wind power situations ·Examine how power generation, environmental impacts, and social impacts may differ depending on installation location and number of turbines ·Evaluate the feasibility of energy transition policies by comparing renewable energy production with energy consumption
Wrap-up	·Discuss and summarize judgments about the feasibility of energy transition policies

5. Theoretical Background and Activity Design for Disaster Education

Energy-related issues often produce different outcomes depending on the interaction of multiple conditions, so learning that directly explores relationships between variables and outcomes can be effective. Complex systems in particular include processes that are not directly visible and changes over time, making tools such as computer simulations useful for understanding them. NetLogo is a representative agent-based modeling tool that can simulate natural and social phenomena, and it has educational value because learners can directly manipulate various factors and observe the resulting changes.

The program first uses a fish simulation, shown in Figure 1, to help students understand that a simulation is a model that simplifies and represents selected features and rules of reality. Students explore how changing particular numbers and conditions changes the outcome. They then use a wind power simulation, shown in Figure 2, to manipulate variables such as wind speed, blade length, number of wind turbines, and installation location and analyze changes in power generation. By comparing renewable energy production with energy consumption, students also evaluate the feasibility of energy transition policies. This sequence helps students move beyond simply checking results and consider which variables have greater influence and how simulation results can be interpreted in relation to real-world issues.

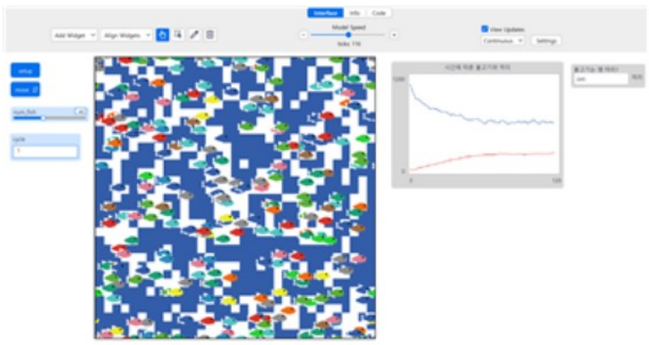


Figure 1. NetLogo-based simulation of changes in fish population

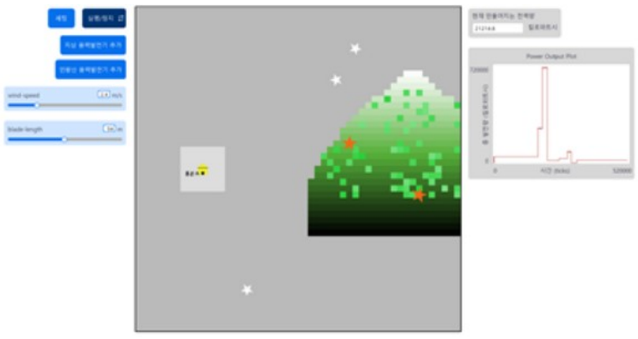


Figure 2. NetLogo-based wind power simulation

6. Instructional Considerations

It is important that students do not treat simulation results as correct answers for reality and fully understand that simulations are models that simplify selected features and rules of the real world. When exploring variables, teachers should guide students to control other conditions and manipulate only one variable at a time rather than changing several conditions simultaneously. Students should also be encouraged to interpret relationships rather than simply checking whether numerical results increase or decrease, using questions such as “Why did this variable have a greater effect?” and “Why might the results differ when the installation location changes even under the same conditions?” During NetLogo activities, students may create errors while modifying code, so teachers should clearly explain in advance which parts can be changed. In the later part of the activity, simulation results should be connected to real wind power issues so that students consider not only power generation but also environmental and social impacts and maintenance issues associated with installation location. This allows students to use simulation evidence to make reasoned judgments about real-world problems.

7. References

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Lesson 2: Change the Variables, Change the Results!

Theme	Analyzing Wind Power Systems with NetLogo
What Will We Learn?	① Understand what a simulation is and identify variables in a wind power system. ② Analyze through simulation how variables such as wind speed, blade length, number of wind turbines, and installation location affect power generation. ③ Compare renewable energy produced in the simulation with energy consumption and evaluate the feasibility of energy transition policies.

1 Getting Familiar with Simulations

- Write down words that come to mind when you hear “simulation.”

- Read the rules of the fish simulation again and circle the numbers or words that can be changed in the code

1) A fish loses 1 unit of energy when it swims and gains 2 units of energy when it eats food.
2) When its energy is greater than 15, one baby fish is born.
3) Food in the ocean recovers over time and reappears.

- Fill in the blanks with numbers to complete the code.

```
turtles-own [energy]
patches-own [day]

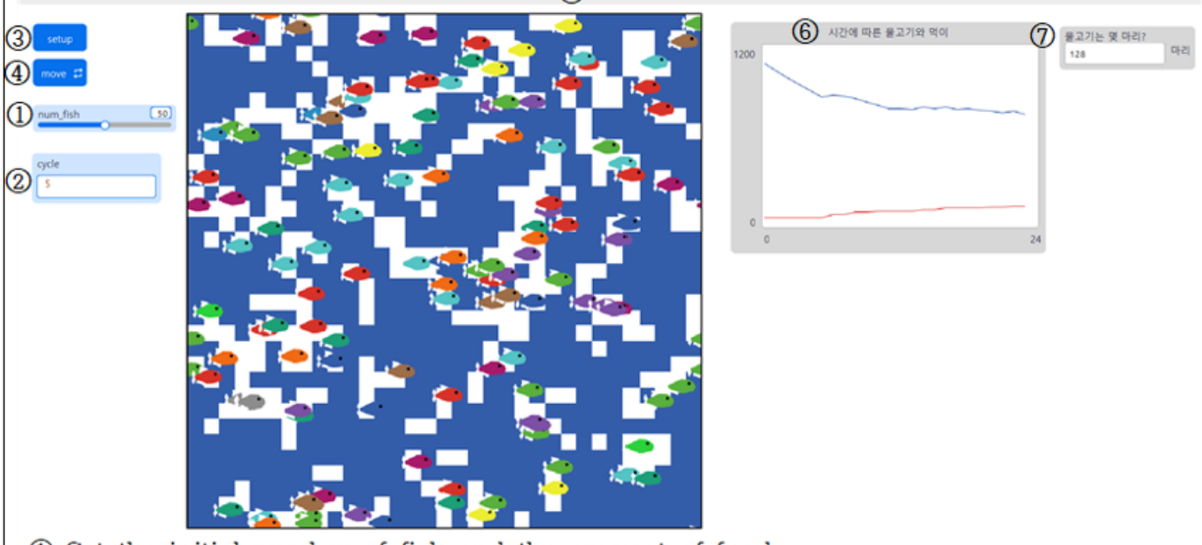
to setup
clear-all
crt num_fish [
set energy 10
]
ask patches [
set pcolor blue
set day 0
]
ask turtles [
setxy random-xcor random-ycor
set shape "fish"
set size 2
]
reset-ticks
end

to move
ask turtles[
rt random 90
lt random 90
fd 1
set energy energy - [ ]   Energy lost
if energy <= 0 [ die ]
if pcolor = blue [
set pcolor white
set energy energy + [ ]   Energy gain
]
if energy > [ ]   Energy needed to reproduce
[
hatch 1 [set energy 10]
set energy energy - 10
]
]

ask patches [
if pcolor = white [
if day = cycle [
set pcolor blue
set day 0
]
set day day + 1
]
]
if count turtles = 0 [stop]
wait 0.05
tick
end
```

2 NetLogo Activity 1: Fish Simulation

※ NetLogo Guide



① Set the initial number of fish and the amount of food
② Set the time needed for food to recover
③ Increase food in the ocean
④ Run / Stop the simulation
⑤ Shows how much time (ticks) has passed
⑥ Graph showing changes in the number of fish and amount of food over time
⑦ Shows the current number of fish
⑧ Click Use Code to modify the code

- Record the Simulation Results

Initial Number of Fish (①)	Time (ticks) (⑤)	Current Number of Fish (⑦)	Food Recovery Time (②)

- Think about the questions below and present your ideas.

1) Looking at Graph ⑥, how do the number of fish and the amount of food change?

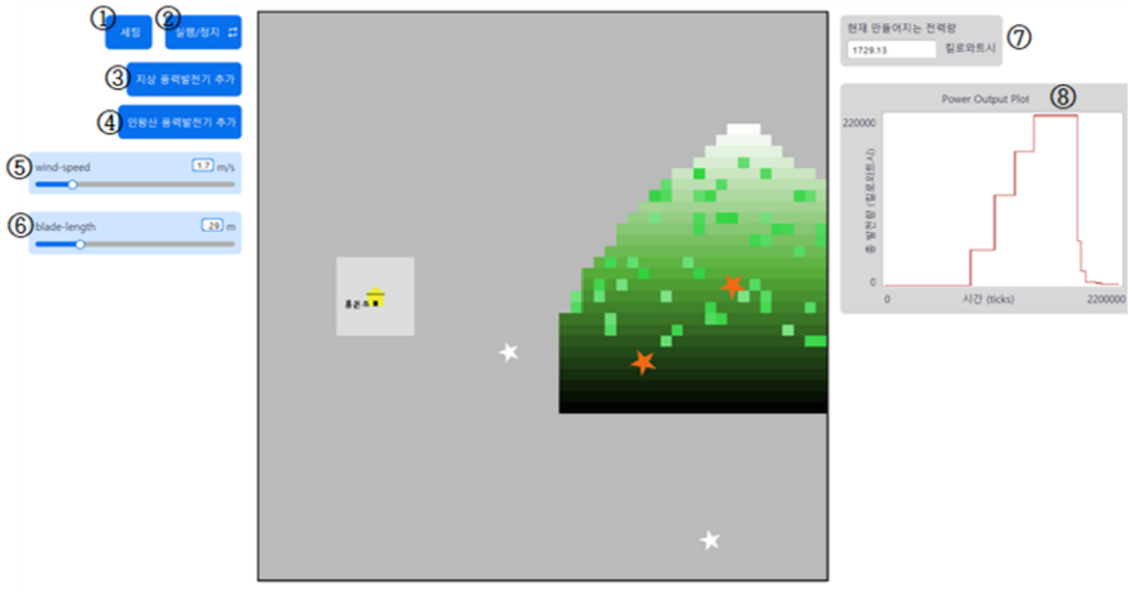
2) What do you think will happen as more time passes?

3) To increase/decrease the number of fish ⑦, which variable should you change, and how?

3 NetLogo Activity 2: Wind Power Simulation

- If you were to represent a wind power system as a simulation, what variables would it include? Find and write them down.

- Try the Simulation



① Setup / Reset
② Run / Stop
③ Install a wind turbine in the city (lowland)
④ Install a wind turbine on Gwanaksan Mountain
⑤ Adjust wind speed (0-10 m/s)
⑥ Adjust blade length (10-100 m)
⑦ Shows the current power output
⑧ Shows the total power generation over time

◎ What is different when you compare the simulation with the real-world situation?

- Fill in the blanks to complete the rules of the simulation.

1) The _____ the wind speed, the more power one wind turbine generates.

2) The _____ the blade length, the more power one wind turbine generates.

3) The _____ the number of wind turbines, the more power they generate.

4) Installing a wind turbine at a _____ altitude produces more power.

4 What If We Use Wind Power in Our Community?

- Discuss the issue of "installing wind turbines in our community" with a classmate.

1) Where would be a good place to install wind turbines?**
(https://youtu.be/1rxkrRO62wc?si=GZAAWq5XwptIcw87)

2) Find the actual average wind speed in our community and use the simulation to determine how much electricity could be generated.
(https://data.kma.go.kr/climate/RankState/selectRankStatisticsDivisionList.do)

3) How much electricity does Korea / our district / our household use in one year? Compare it with the amount of electricity shown in the simulation.

4) What might the "stakeholders" affected by wind turbines think?

→ Examples of stakeholders: local residents, tourism businesses, animal protection groups, wind power construction companies, etc.