



# MICRO-GRID MANIA

**HF710 - Prototyping and Interaction Design**

- Product Demo -

Individual Project by Keyur Patel

# AGENDA



1. Design  
Problem



2. Current  
Tool



3. User  
Stories



4. Prototype  
Demo



5. Next Steps

# THE DESIGN PROBLEM

The principles of microgrids are complex and students lack intuitive tools to apply their knowledge and explore practical scenarios effectively.

# CURRENT TOOL

# Community Microgrid Simulation Game

## Overwhelming with Text

### Community Microgrid Simulation Game

This tool lets you try out different configurations of a community-scale microgrid system. Choose the capacities of different technologies and their dispatch order, then run the system to see how it does on fuel costs, emissions, and load served!

You have a budget of \$10 million to install a microgrid. There are four technologies you can choose from and their capital costs, fuel costs and emissions are outlined in the table below.

	Capital Cost	Fuel Cost	Emissions
Diesel Generator	500 \$/kW	4 \$/gallon	22.45 lbs CO2/gallon
Fuel Cell	2000 \$/kW	2 \$/CF	121 lbs CO2/CF
Solar	1600 \$/kW	0	0
Battery	800 \$/kWh	0	0

#### Step 1: Choose the capacity of each technology in your microgrid:

Diesel Generator Capacity (kW):

1000

- +

Fuel Cell Capacity (kW):

2000

- +

Solar PV Capacity (kW):

2500

- +

Battery Capacity (kWh):

1500

- +

Total microgrid cost: \$9700000

Your microgrid is within the budget.

## Unengaging features

Diesel Generator Capacity (kW):

1000

- +

Fuel Cell Capacity (kW):

2000

- +

Solar PV Capacity (kW):

2500

- +

Battery Capacity (kWh):

1500

- +

Total microgrid cost: \$9700000

Your microgrid is within the budget.

#### Step 2: Choose the order in which you will use (or dispatch) your technologies:

Choose the order:

Fuel Cells x

Solar PV x

Batteries x

Diesel Generators x

⌵

#### Step 3: Run simulation for a random date or choose one?

Choose simulation mode:

☐ Random date

☒ Select a date

Select a date for simulation:

Month

12

⌵

Day

12

⌵

#### Step 4: Test it!

Run simulation

## Lack of User Guidance

Run simulation

Configuration

Diesel Generator (kW)

Fuel Cell (kW)

Solar Panel (kW)

Battery (kWh)

1000

2000

2500

1500

Results for 12/12

Fuel Cost (k\$)

Emissions (MTCO2)

Load Unserved (%)

7

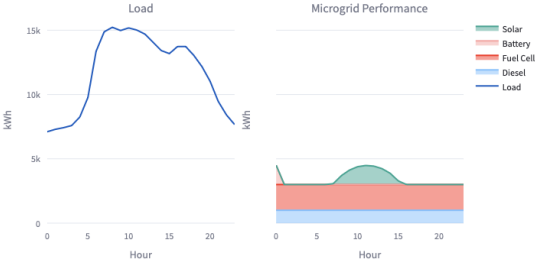
30

70

Hourly Results

Load

Microgrid Performance



Use fullscreen mode (hover over the top right corner of the table for the button) or use the scroll bar at the bottom of the table to see all the different columns. You can also put the app in wide mode using the three dots in the top right corner, choose Settings, and check the box next to Wide Mode.

Hour	Load (kWh)	diesel dispatched (kWh)	fuel cell dispatched (kWh)	solar pv dispatched (kWh)	battery dispatched (kWh)
0	7,105	1,000	2,000	0	
1	7,295	1,000	2,000	0	
2	7,421	1,000	2,000	0	
3	7,586	1,000	2,000	0	
4	8,241	1,000	2,000	0	
5	9,773	1,000	2,000	0	
6	13,355	1,000	2,000	0	
7	14,876	1,000	2,000	67	
8	15,227	1,000	2,000	693.1954	

# USER STORY – STUDENT I

- Goals
  - Make strategic choices to optimize microgrid simulation without second-guessing or relying on trial and error
  - Gain practical knowledge about microgrids in an interactive and straightforward manner
- Pain Points
  - Encountering too much text and unclear explanations
  - Struggling to understand how each technology fits and impact on simulation results

## USER STORY – STUDENT 2

- Goals
  - Understand how different seasons and weather influence the performance of my microgrid
  - Test and compare previous simulations to understand how to optimize microgrid performance
- Pain Points
  - Uncertainty of what specific microgrid terminology means
  - Lack of visual graphs to better analyze the data
  - No statistical feedback or guidance on overall efficiency on my microgrid simulations

# PROTOTYPE DEMO






**Micro-grid Mania**

*Master the Balance of Power  
Ready to Begin?*

**BEGIN**


# PROTOTYPE DEMO



## MICRO-GRID MENU

1 Choose the capacity of each technology in your micro-grid


2

  
FUEL CELL

+ - 0

\$2000 /kW


2

  
SOLAR

+ - 0

\$1600 /kW


2

  
BATTERY

+ - 0

\$800 /kWh

2

  
DIESEL

+ - 0

\$500 /kW

2 Capacity Cost

FUEL CELL \$ 0

SOLAR \$ 0


BATTERY \$ 0


DIESEL \$ 0


Budget: \$10 Million


Total Cost \$ 0

2 DISPATCH ORDER

1  SOLAR

2  FUEL CELL

3  BATTERY

4  DIESEL

RESET

NEXT



# PROTOTYPE DEMO

The interface is titled "MICRO-GRID MENU" and instructs the user to "Choose the capacity of each technology in your micro-grid". It features a sidebar with a lightning bolt icon, a bar chart icon, and a settings gear icon. The main area is divided into several sections:

- Technology Selection:** A list of four technologies with their respective icons, unit costs, and capacity input fields (all set to 0):
  - FUEL CELL:** \$2000 /kW
  - SOLAR:** \$1600 /kW
  - BATTERY:** \$800 /kWh
  - DIESEL:** \$500 /kW
- Capacity Cost Summary:** A table showing the capacity cost for each technology, all set to 0.

Technology	Capacity Cost
FUEL CELL	\$ 0
SOLAR	\$ 0
BATTERY	\$ 0
DIESEL	\$ 0
- Budget and Total Cost:** Displays "Budget: \$10 Million" and "Total Cost: \$ 0".
- Dispatch Order:** A list of four technologies in a specific order, each with a 3x3 grid icon:
  - SOLAR
  - FUEL CELL
  - BATTERY
  - DIESEL
- Buttons:** "RESET" and "NEXT" buttons are located on the right side.

- STUDENT I

- PAINT POINT - Encountering too much text and unclear explanations

# PROTOTYPE DEMO

The interface is titled "MICRO-GRID MENU" and instructs the user to "Choose the capacity of each technology in your micro-grid". It features a sidebar with a lightning bolt icon, a bar chart icon, and a settings gear icon. The main area is divided into several sections:

- Technology Selection:** Four technologies are listed with their respective icons, unit costs, and capacity input fields:
  - FUEL CELL:** Icon of a fuel cell stack, unit cost \$2000 /kW, capacity 2000.
  - SOLAR:** Icon of solar panels, unit cost \$1600 /kW, capacity 2500.
  - BATTERY:** Icon of a battery, unit cost \$800 /kWh, capacity 1500.
  - DIESEL:** Icon of a diesel generator, unit cost \$500 /kW, capacity 1000.
- Capacity Cost Summary:** A table showing the total capacity cost for each technology:

Technology	Capacity Cost
FUEL CELL	\$4000000
SOLAR	\$4000000
BATTERY	\$1200000
DIESEL	\$500000
- Budget and Total Cost:** A summary box showing the budget and total cost:

Budget: \$10 Million  
Total Cost: \$9700000
- Dispatch Order:** A section where the user can select the dispatch order for the technologies. The current order is:
  - SOLAR
  - FUEL CELL
  - BATTERY
  - DIESEL
- Buttons:** "RESET" and "NEXT" buttons are located at the bottom right.

A tooltip for the SOLAR technology provides additional information:

**What It Is:** Converts sunlight into electricity using photovoltaic cells.  
**Pros:** Renewable, zero emissions during operation, low operating cost.  
**Cons:** Dependent on sunlight; limited or no production at night or in bad weather.  
**Best For:** Areas with high sunlight exposure and for reducing carbon footprint.

- STUDENT I

- PAINT POINT - Encountering too much text and unclear explanations

- STUDENT I

- GOAL - Gain practical knowledge about microgrids in an interactive and straightforward manner

# PROTOTYPE DEMO

The interface is titled "MICRO-GRID MENU" and instructs the user to "Choose the capacity of each technology in your micro-grid". It features a sidebar with a lightning bolt icon, a bar chart icon, and a settings gear icon. The main area is divided into several sections:

- Technology Selection:** Four technologies are listed with their respective icons, unit costs, and capacity input fields:
  - FUEL CELL:** Icon of a fuel cell, unit cost \$2000 /kW, capacity 2000.
  - SOLAR:** Icon of solar panels, unit cost \$1600 /kW, capacity 2500.
  - BATTERY:** Icon of a battery, unit cost \$800 /kWh, capacity 1500.
  - DIESEL:** Icon of a diesel generator, unit cost \$500 /kW, capacity 1000.
- Capacity Cost Summary:** A table showing the total cost for each technology and the overall budget and total cost.

Technology	Capacity Cost
FUEL CELL	\$ 4000000
SOLAR	\$ 4000000
BATTERY	\$ 1200000
DIESEL	\$ 500000

**Budget:** \$10 Million  
**Total Cost:** \$ 9700000
- Dispatch Order:** A list of four technologies with their dispatch order (1-4) and a "RESET" button.

Order	Technology
1	FUEL CELL
2	SOLAR
3	BATTERY
4	DIESEL
- Buttons:** "RESET" and "NEXT" buttons are located at the bottom right.




- STUDENT I

- PAINT POINT - Encountering too much text and unclear explanations

- STUDENT I

- GOAL - Gain practical knowledge about microgrids in an interactive and straightforward manner

# PROTOTYPE DEMO



2


## Simulation Run Time

Select the run time for the simulation

?


### Select Season

Spring




Mar - May

Summer




Jun - Aug

Fall



Sep - Nov

Winter



Dec - Feb

←

December

→

Mon	Tue	Wed	Thu	Fri	Sat	Sun
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Selected Season:

No Season Selected

BACK

RESET

NEXT

# PROTOTYPE DEMO



2

## Simulation Run Time

Select the run time for the simulation



### Select Season

Spring



Mar - May

Summer



Jun - Aug

Fall



Sep - Nov

Winter



Dec - Feb

←

December

→

Mon	Tue	Wed	Thu	Fri	Sat	Sun
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Selected Season:

Winter

Solar Efficiency:

Reduced due to shorter daylight hours and potential snow coverage. Expect solar to contribute less to the energy mix.

Balanced Technologies:

Diesel and fuel cells will likely play a critical role in maintaining energy reliability due to decreased solar output.

Battery Use:

Batteries may be drained faster to compensate for reduced renewable energy generation.

Energy Demand:

Higher heating requirements can increase overall energy consumption.

BACK



RESET

NEXT



- STUDENT I
  - GOAL- Make strategic choices to optimize microgrid simulation without second-guessing or relying on trial and error

# PROTOTYPE DEMO




2


## Simulation Run Time

Select the run time for the simulation


The season you choose can affect the performance of different energy technologies in your microgrid. For example, solar energy is most effective during sunny months, while fuel-based technologies may be more efficient during colder months.




### Select Season




Mar - May



Jun - Aug



Sep - Nov



Dec - Feb

← December →

Mon	Tue	Wed	Thu	Fri	Sat	Sun
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

**Selected Season:** Winter

**Solar Efficiency:** Reduced due to shorter daylight hours and potential snow coverage. Expect solar to contribute less to the energy mix.

**Balanced Technologies:** Diesel and fuel cells will likely play a critical role in maintaining energy reliability due to decreased solar output.


**Battery Use:** Batteries may be drained faster to compensate for reduced renewable energy generation.

**Energy Demand:** Higher heating requirements can increase overall energy consumption.

BACK

RESET

NEXT



- STUDENT 1

- GOAL- Make strategic choices to optimize microgrid simulation without second-guessing or relying on trial and error

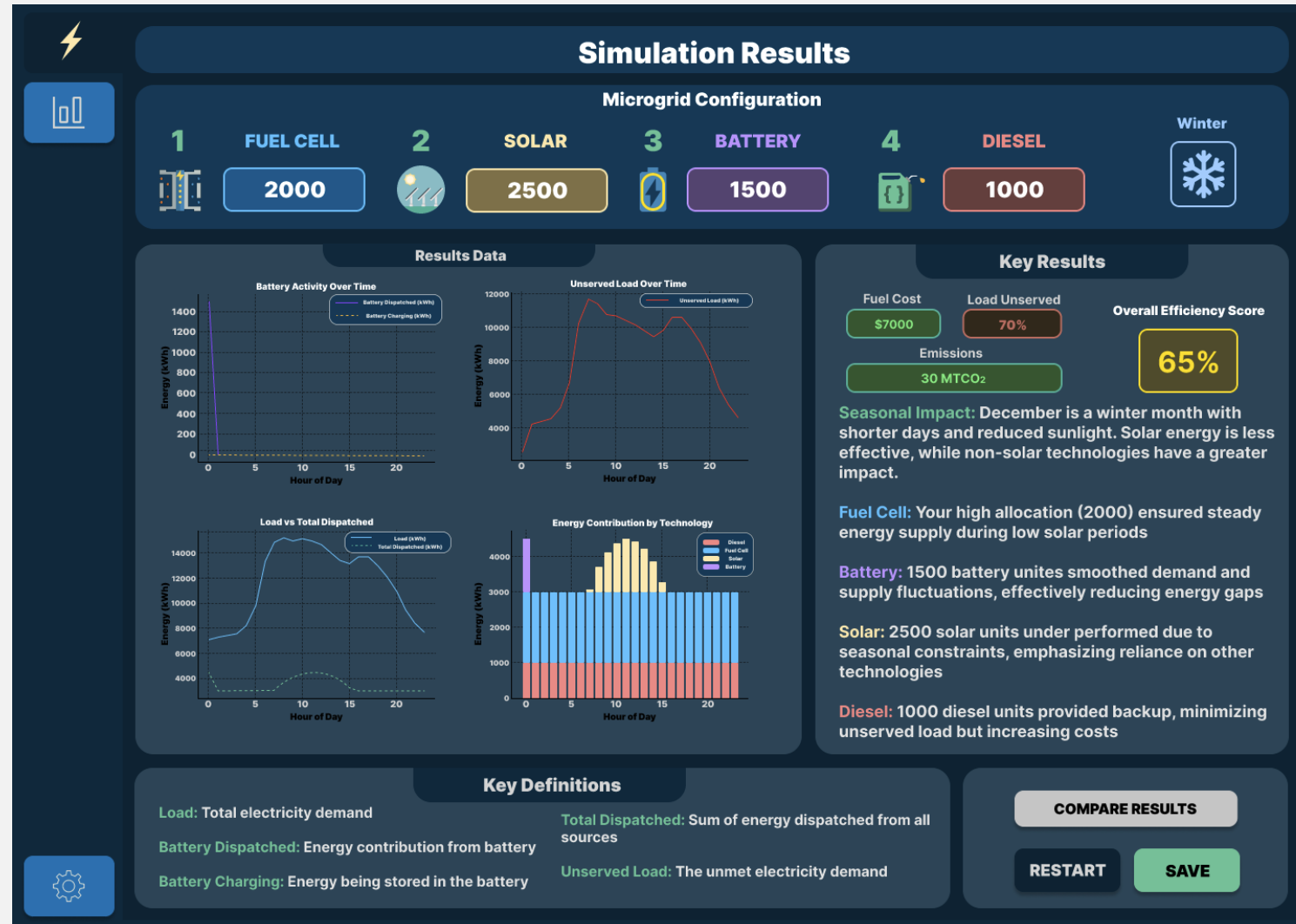
- STUDENT 2

- GOAL - Understand how different seasons and weather influence the performance of my microgrid

# PROTOTYPE DEMO



# PROTOTYPE DEMO



#### Battery Activity Over Time

Hour of Day	Battery Dispatched (kWh)	Battery Charging (kWh)
0	1400	0
5	1000	0
10	800	0
15	600	0
20	400	0

#### Unserviced Load Over Time

Hour of Day	Unserviced Load (kWh)
0	4000
5	5000
10	11000
15	10000
20	5000

#### Load vs Total Dispatched

Hour of Day	Load (kWh)	Total Dispatched (kWh)
0	7000	7000
5	8000	8000
10	11000	11000
15	10000	10000
20	7000	7000

#### Energy Contribution by Technology

Hour of Day	Fuel Cell (kWh)	Solar (kWh)	Battery (kWh)
0	3000	0	0
5	3000	0	0
10	3000	8000	0
15	3000	7000	0
20	3000	0	0

Fuel Cost

\$7000

Load Unserved

70%

Emissions

30 MTCO<sub>2</sub>

Overall Efficiency Score

65%

**Seasonal Impact:** December is a winter month with shorter days and reduced sunlight. Solar energy is less effective, while non-solar technologies have a greater impact.

**Fuel Cell:** Your high allocation (2000) ensured steady energy supply during low solar periods

**Battery:** 1500 battery units smoothed demand and supply fluctuations, effectively reducing energy gaps

**Solar:** 2500 solar units under performed due to seasonal constraints, emphasizing reliance on other technologies

**Diesel:** 1000 diesel units provided backup, minimizing unserved load but increasing costs

Load: Total electricity demand

Battery Dispatched: Energy contribution from battery

Battery Charging: Energy being stored in the battery

Total Dispatched: Sum of energy dispatched from all sources

Unserviced Load: The unmet electricity demand

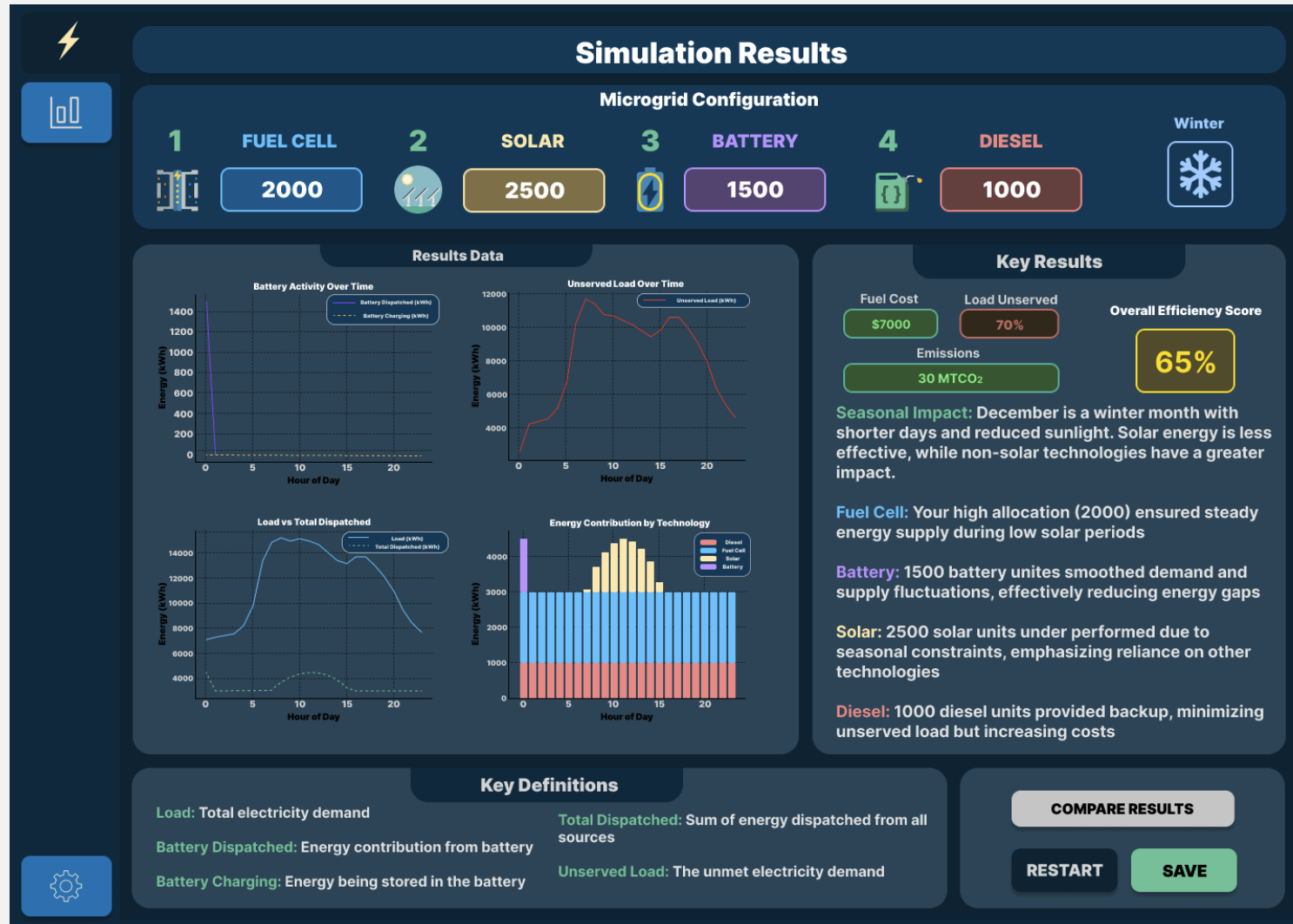
COMPARE RESULTS

RESTART

SAVE



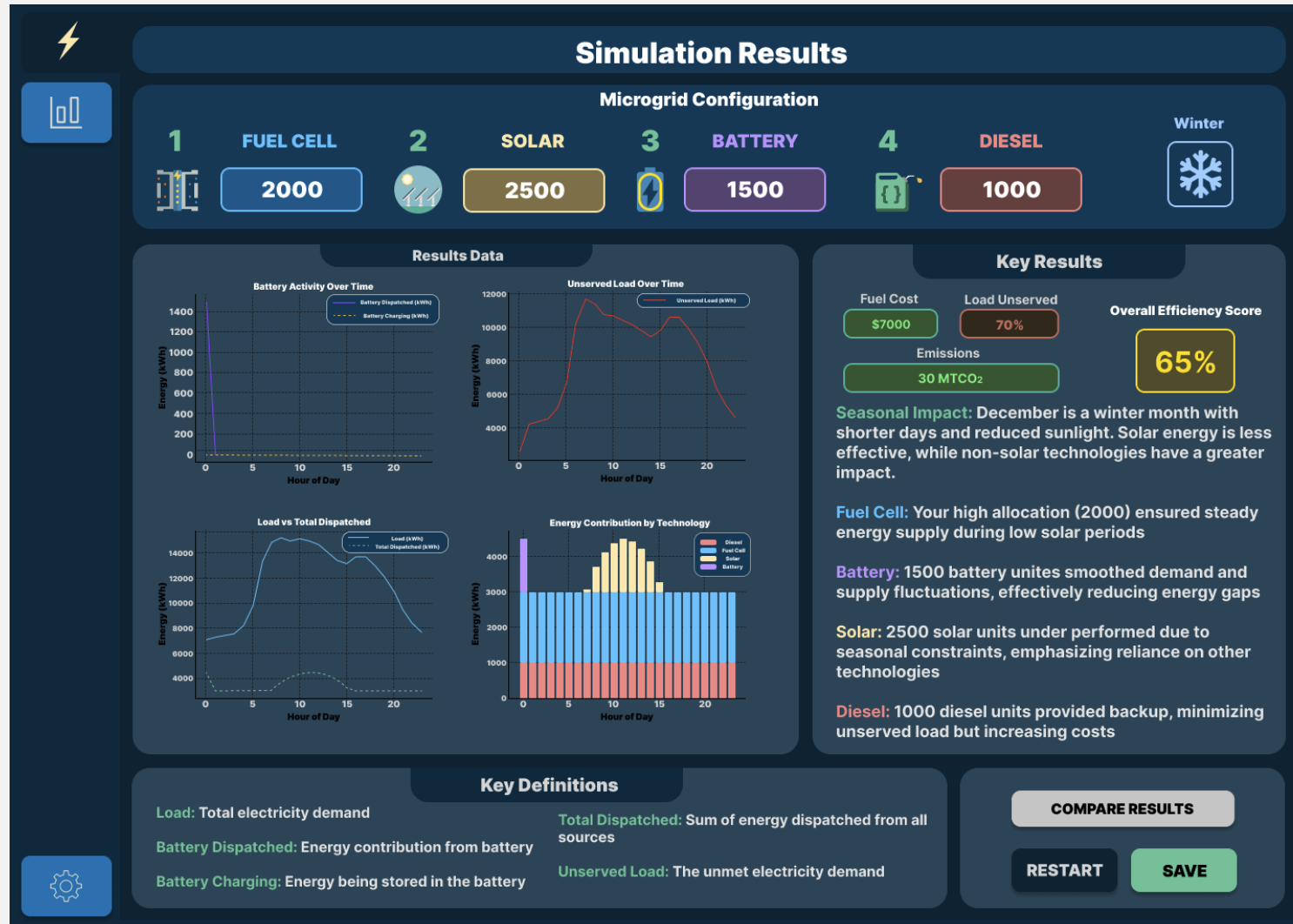
# PROTOTYPE DEMO



- STUDENT 2

- PAINT POINT - Lack of clear visual graphs to analyze the data

# PROTOTYPE DEMO



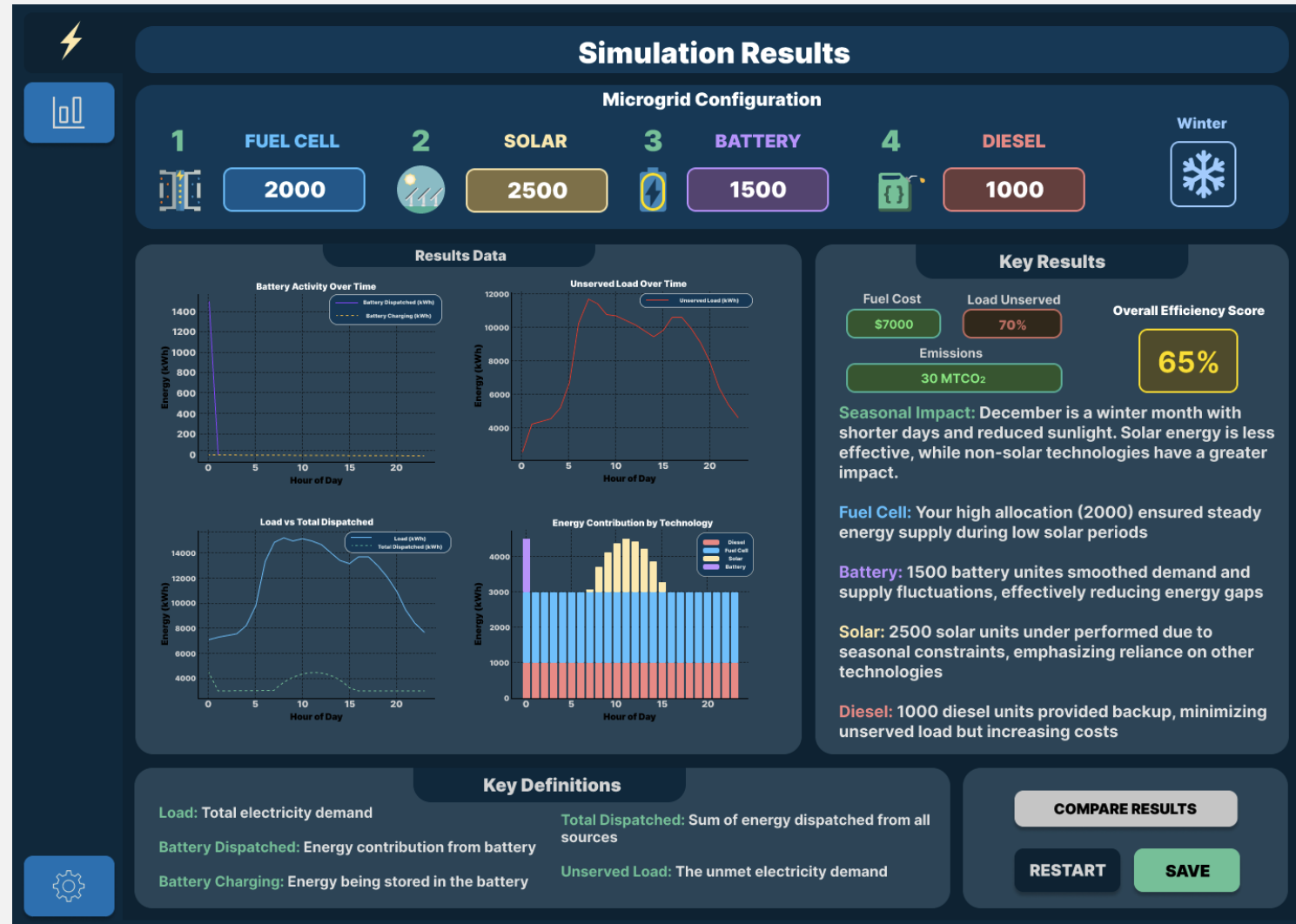
- STUDENT 2

- PAINT POINT - Lack of clear visual graphs to analyze the data

- STUDENT 2

- PAINT POINT - Uncertainty of what specific microgrid terminology means

# PROTOTYPE DEMO



- STUDENT 2

- PAINT POINT - Lack of clear visual graphs to analyze the data

- STUDENT 2

- PAINT POINT - Uncertainty of what specific microgrid terminology means

- STUDENT 1

- PAINT POINT - Struggling to understand how each technology fits and impact on simulation results

# PROTOTYPE DEMO

Simulation History			
<div><div></div><div>MM / DD / YYYY</div></div>			
Select	Date Created	Status	Overall Efficiency Score
<input checked="" type="checkbox"/>	12 / 5 / 2024 2:00 PM	COMPLETE	65%
<input checked="" type="checkbox"/>	12 / 5 / 2024 1:45 PM	COMPLETE	90%
<input type="checkbox"/>	12 / 3 / 2024 12:00 PM	INCOMPLETE	NA
<input type="checkbox"/>	09 / 2 / 2024 9:00 AM	COMPLETE	50%
			COMPARE

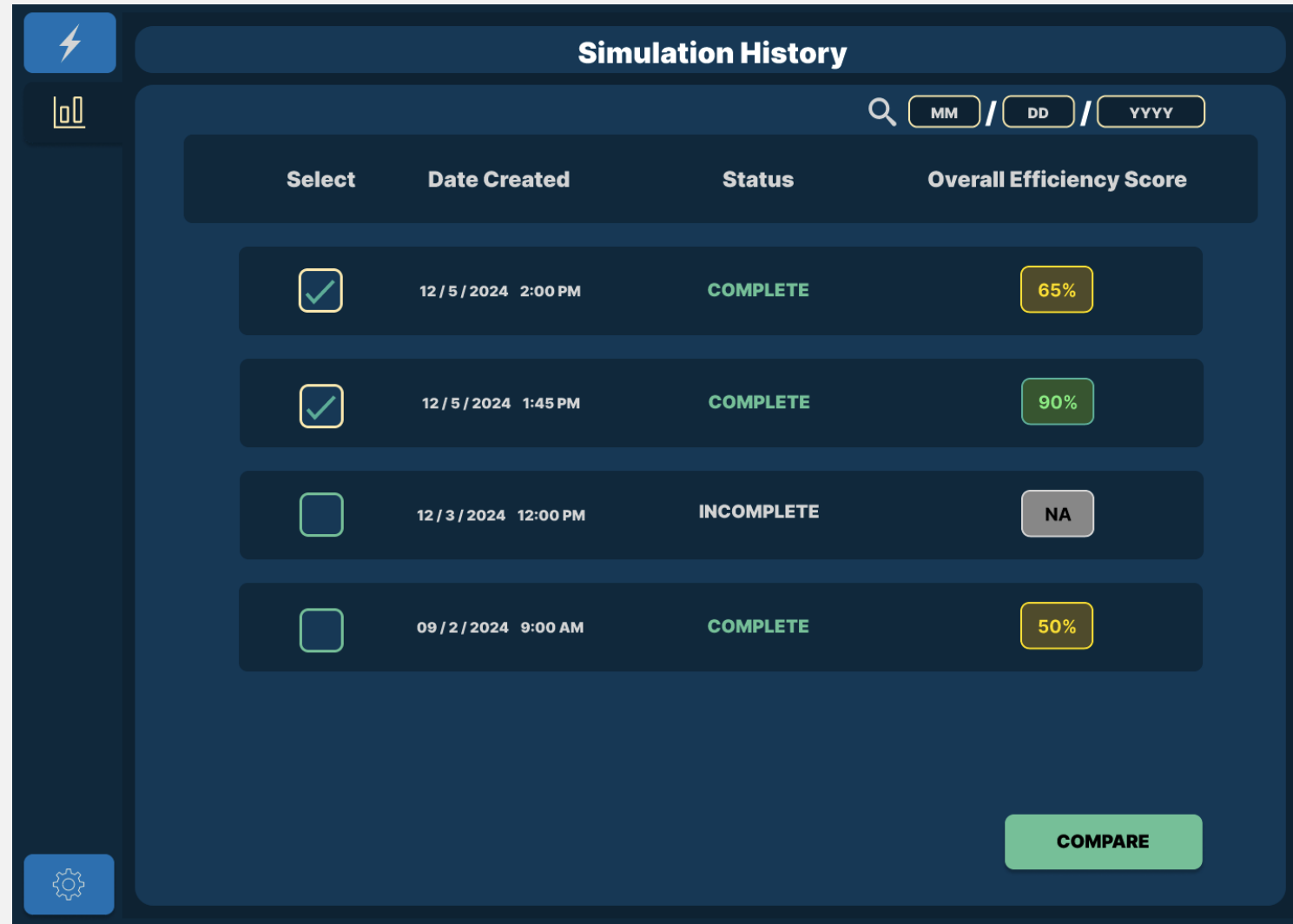
# PROTOTYPE DEMO

- STUDENT 2

- GOAL - Test and compare previous simulations to understand how to optimize microgrid performance

Simulation History			
<div><div></div><div></div><div></div></div>			
Select	Date Created	Status	Overall Efficiency Score
<input checked="" type="checkbox"/>	12 / 5 / 2024 2:00 PM	COMPLETE	65%
<input checked="" type="checkbox"/>	12 / 5 / 2024 1:45 PM	COMPLETE	90%
<input type="checkbox"/>	12 / 3 / 2024 12:00 PM	INCOMPLETE	NA
<input type="checkbox"/>	09 / 2 / 2024 9:00 AM	COMPLETE	50%
<div>COMPARE</div>			

# PROTOTYPE DEMO



The image shows a UI prototype for a 'Simulation History' interface. It features a dark blue background with a sidebar on the left containing three icons: a lightning bolt, a bar chart, and a gear. The main content area is titled 'Simulation History' and includes a search bar with a magnifying glass icon and three input fields for 'MM', 'DD', and 'YYYY'. Below the search bar is a table with four columns: 'Select', 'Date Created', 'Status', and 'Overall Efficiency Score'. The table contains four rows of simulation data. The first two rows are marked as 'COMPLETE' with green checkmarks and efficiency scores of 65% and 90% respectively. The third row is marked as 'INCOMPLETE' with an empty checkbox and a score of 'NA'. The fourth row is marked as 'COMPLETE' with an empty checkbox and a score of 50%. A green 'COMPARE' button is located at the bottom right of the table area.

Select	Date Created	Status	Overall Efficiency Score
<input checked="" type="checkbox"/>	12 / 5 / 2024 2:00 PM	COMPLETE	65%
<input checked="" type="checkbox"/>	12 / 5 / 2024 1:45 PM	COMPLETE	90%
<input type="checkbox"/>	12 / 3 / 2024 12:00 PM	INCOMPLETE	NA
<input type="checkbox"/>	09 / 2 / 2024 9:00 AM	COMPLETE	50%

COMPARE

- STUDENT 2

- GOAL - Test and compare previous simulations to understand how to optimize microgrid performance

- STUDENT 2

- PAIN POINT - No statistical feedback or guidance on overall efficiency on my microgrid simulations

## NEXT STEPS



### User Testing and Feedback

Conduct usability tests to identify pain points and areas for improvement.



### Refine Design and Features

Enhance UI elements like information guidance and scoring mechanisms to better meet user needs.



### Expand Functionality

Introduce additional scenarios and improve simulation realism.



### Launch and Evaluate

Deploy the game and measure its impact on learning outcomes and engagement.

**THANK YOU!**