Climate Hero Spotlight: Engineers

Opening Activity: Design Thinking

Practice using the design thinking process to plan how to create a bookstand for a student desk. For this challenge, you may only use ten index cards and two objects currently on your person (per person in your pair or small group). You have five minutes to complete the steps below, so think quickly!

What problem will your solution solve?:

What are your constraints and materials?:

Who will use your solution? How will they use it? How will it help them?:

How will you know if your solution is a success? What does success look like for your solution?:

How would you test your solution to make sure it works?:

What could your solution look like? What features will it include?:

The Big Question

How do engineers play a critical role in designing climate solutions?

My Climate Goals

When you complete this lesson, you'll be able to:

1. Describe how engineers contribute to climate-critical projects
2. Identify the skills and training needed for engineering careers
3. Describe the aspects of an engineering career that align with your skills and interests.

Notes:

Engineering Feasibility Study

Instructions

Your group has been hired to look into the most practical changes that might be made to the existing clean energy systems in Sunnyville. You have detailed information about all current solar arrays and battery banks in their system and possible upgrade and expansion options. Work with your group to recommend improvements for Sunnyville that meet their criteria and constraints. Consider each option's benefits and drawbacks and prepare to present your recommendations to the class.

Scenario Details

Sunnyville, MA

Sunnyville is a small town with a population of 5,000. It operates a community solar electric power system with multiple solar arrays and battery storage locations. The town wants to evaluate its system to ensure it operates efficiently and explore potential upgrades or improvements.

The town council has agreed on three goals:

- **Optimize energy efficiency**: Increase energy output and reduce energy loss.
- **Improve reliability**: Ensure power availability during peak demand and outages.
- **Reduce maintenance costs**: Minimize operational costs without sacrificing performance.

Constraints

- **Limited budget**: Sunnyville's budget for all upgrades is $150,000.
- **Limited installation space**: The town has no room for additional ground-based solar arrays; rooftop and tracking system improvements are feasible.

Energy Demand

- **Residential Demand**: 120,000 kWh/year
- **Commercial Demand**: 80,000 kWh/year
- **Industrial Demand**: 90,000 kWh/year

Feasibility Study Presentation

- Identify challenges or areas of underperformance within the current system.
- Recommend improvements or upgrades while considering the town's constraints.
- Explain how your plan addresses Sunnyville's goals.

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Current Solar System Data

Sunnyville has three solar arrays installed in various locations throughout the town. Your team's findings on each are below.

Array A: Sunnyville's Town Hall rooftop

- **Size**: 50 kW capacity
- **Efficiency**: 18%; produces an average of 60,000 kW per year.
- **Lifespan**: Installed 5 years ago, with 20 years of useful life remaining.
- **Maintenance Cost**: Moderate; $2,500 annually for cleaning and minor repairs.
- **Issues**: Shading from nearby trees and taller buildings reduces output by 10-15%, especially in winter and late afternoon.

Array B: Ground-based system in an open field near the community park.

- **Size**: 75 kW capacity
- **Efficiency**: 15%; produces an average of 80,000 kW per year.
- **Lifespan**: Installed 10 years ago, with 15 years of useful life remaining.
- **Maintenance Cost**: Low; $1,500 annually for general upkeep.
- **Issues**: Panels are outdated, and the aging panels have decreased output by 20%.

Array C: Tracking system on the outskirts of the Industrial Zone.

- **Size**: 100 kW capacity
- **Efficiency**: 20%; produces an average of 120,000 kW per year.
- **Lifespan**: Installed 8 years ago, with 12 years of useful life remaining.
- **Maintenance Cost**: High; $7,500 annually due to mechanical repairs.
- **Issues**: Tracking system increases production by 15% compared to stationary arrays, but frequent mechanical failures disrupt optimal performance, increasing downtime.

Would improving Array A, B, or C have the most significant impact on Sunnyville's goals? Why?

Current Battery Storage Data

Sunnyville stores the clean energy generated by its solar arrays and other systems in three locations. Your team's findings on each are below.

Battery Bank 1 (Lithium-Ion): Near Array A, serving Town Hall and surrounding businesses.

- **Capacity**: 12 kWh
- **Efficiency**: 90%; Reliable storage.
- **Lifespan**: Installed 8 years ago, with 2-3 years remaining.
- **Maintenance Cost**: Low; $500 annually.
- **Issues**: System will need to be replaced soon to maintain storage capacity and reliability.

Battery Bank 2 (Lead-Acid): Adjacent to Array B, supporting residential neighborhoods and the school.

- **Capacity**: 8 kWh
- **Efficiency**: 75%; Suffers from frequent downtime during peak demand periods.
- **Lifespan**: Installed 5 years ago, with 5 years remaining.
- **Maintenance Cost**: Moderate; $1,000 annually.
- **Issues**: Insufficient capacity for high-demand periods and frequent maintenance requirements reduce cost-effectiveness.

Battery Bank 3 (Saltwater): Near Array C, supporting the industrial zone.

- **Capacity**: 4 kWh
- **Efficiency**: 70%; Environmentally friendly but offers minimal storage capacity.
- **Lifespan**: Installed 6 years ago, with 4 years remaining.
- **Maintenance Cost**: Low; $250 annually.
- **Issues**: Bank's low capacity limits its usefulness during power outages or peak demand for the industrial zone.

Would improving bank 1, 2, or 3 have the most significant impact on Sunnyville's goals? Why?:

Recommendations Planning

After conducting the feasibility study and reviewing your collected data, your team has identified several possible upgrades and improvements for Sunnyville's system. Work with your group to recommend improvements for Sunnyville that will significantly impact the Town Council's goals and fit within their constraints.

Quick Reference Table for Upgrade Options

Upgrade	Cost	Considerations	Disruptions
Replace Panels on Array A (Rooftop)	$75,000	Increases overall capacity	Temporary restrictions to roof access during panel installation
Reduce shading by Array A (Rooftop)	$15,000	More cost effective than replacing panels; lower impact on efficiency	May involve tree trimming or building modifications to nearby structures
Replace Panels on Array B (Ground)	$95,000	Increases energy output	Area around the ground system will be closed during installation, potentially affecting park use
Upgrade Array B to a New Tracking System	$120,000	Improves energy production by 15-20%; better efficiency in low sunlight conditions	Short-term downtime for Array B during system upgrades
Replace Tracking System on Array C (Tracking)	$60,000	Improves efficiency and reduces maintenance costs	Short downtime for industrial area during system replacement
Switch Array C to a Fixed Ground-Based System	$75,000	Reduces maintenance costs; sacrifices some energy production efficiency	Temporary disruption to industrial zone power supply during installation
Replace Battery Bank 1 with new Lithium-Ion Batteries	$20,000	Replacement is critical to maintain backup storage	Minimal; can integrate seamlessly into existing system
Replace Battery Bank 2 with new Lead-Acid Batteries	$25,000	Would help address maintenance and reliability concerns	Short-term downtime for connected residential areas during replacement
Replace Battery Bank 3 with new Saltwater Batteries	$13,000	Eco-friendly option but with limited scalability	Minimal; replacement is a straightforward swap of components

Quick Reference Table for Expansion Options

Expansion	Cost	Considerations	Disruptions
Add a new Rooftop Solar Array (40 kW)	$80,000	Increases energy generation capacity for residential areas; requires suitable roof space	Potential temporary access restrictions to rooftop during installation
Install a new Ground-Based Array (60 kW)	$100,000	Expands renewable energy production; requires available open space	May require clearing land or reconfiguring park or open land usage
Add Battery Bank 4 (Lithium-Ion, 12 kWh)	$30,000	Increases backup capacity and reliability for emergency situations	Minimal; additional space needed for installation
Expand Battery Bank 1 with New Modules (+8 kWh)	$18,000	Cost-effective way to boost capacity with existing infrastructure	None; designed to integrate into the current system
Install Advanced Energy Management System	$50,000	Optimizes energy flow, minimizes losses, and improves overall efficiency	None; implementation is software-based with minimal physical disruptions
Add community solar subscriptions	$10,000 setup cost; 5,000/year support	Engages more community members to participate in solar energy	None; primarily an administrative and outreach effort
Install new High-Capacity Battery Bank 5 (24 kWh)	$45,000	Improve storage for peak demand; ensure reliability during outages	None; can replace one of the older banks directly

Define the Problem: What specific issues or opportunities have you identified?

Consider Constraints: What are the limits and challenges?

Which improvements align most closely with Sunnyville's goals?

What specific upgrades or improvements could address the identified issues?

Which potential solutions would you prioritize? Why?:

How would these changes improve performance and align with the town's goals?:

Lesson Key Points

- Engineers drive innovation in clean energy.
- There are a variety of engineering roles involved in finding climate solutions.
- Engineers require a wide range of skills and a problem-solving mindset.
- Engineers have a huge impact on sustainable development.

Additional key points:

Closing Activity

What can we learn from how engineers approach problem-solving?

What is one question you still have about how engineers support climate solutions?

What interests you about becoming an engineer?