Engineering for One Planet

Engineering for One Planet Framework:

Vetted Teaching Activities for a Thriving Future in a Changing Climate

Powered by The Lemelson Foundation

Co-created for educators by engineers, climate experts, and teaching faculty

EOP Resources

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UK ENGINEERS WITHOUT BORDERS

Environmental Defense Fund

SEFI
European Society for Engineering Education
Europäische Gesellschaft für Ingenieur-Ausbildung
Société Européenne pour la Formation des Ingénieurs

GEDC
Global Engineering Deans Council

HOW TO CHANGE THE WORLD

IABEE

IEEE Technology for a Sustainable Climate
IEEE

ICSI
International Coalition for Sustainable Infrastructure

IFEES
International Federation of Engineering Education Societies

WORK ON CLIMATE

Vetted Teaching Activities for a Thriving Future in a Changing Climate

Introduction

Created in response to faculty requests, this teaching guide serves as a companion to the **Engineering for One Planet (EOP) Framework**. The EOP Framework provides a menu of sustainability and leadership competencies that every graduating engineer, regardless of subdiscipline, needs to acquire to design, code, and build in ways that protect the Earth and the lives it sustains.

Climate education is one of the most pressing gaps across all engineering disciplines. Engineering faculty are looking for effective and efficient ways to incorporate climate topics into their existing courses, which are often overloaded or seemingly unrelatable to climate issues. This teaching guide aims to remove those barriers by inspiring and equipping faculty to bring key climate topics into diverse engineering courses and programs.

This guide:

- Is designed to aid faculty in updating or creating course content to educate engineering students on fundamental sustainability and professional competencies related to climate change.
- Includes curricular examples for core learning outcomes from each of the nine topic areas in the EOP Framework: Systems Thinking; Environmental Literacy; Responsible Business and Economy; Social Responsibility; Environmental Impact Assessment; Materials; Design; Critical Thinking; and Communication and Teamwork.
- Is flexible - faculty can modify suggested levels, descriptions, activities, time allotment, prompts, etc., to best fit their specific context, teaching and learning goals, and time constraints.
- Can be adopted and adapted for non-engineering disciplines and learners.
- Was created to support engineering educators' first steps into climate education.
- References Bloom's Taxonomy, ABET Criteria 3 Student Outcomes, and the United Nations Sustainable Development Goals. Please see the **EOP Framework** for an explanation of the icons.
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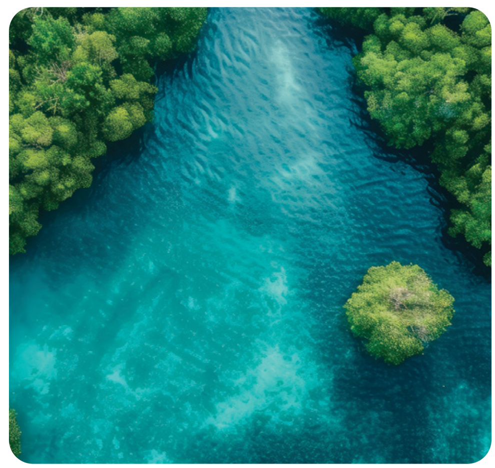
The Need

The demand for social, environmental, and economic sustainability skills among engineers is growing quickly in response to planetary-scale challenges, including the climate crisis, environmental degradation, social inequality, and biodiversity loss.

Engineering activities can mitigate or worsen these issues. Driven by regulatory, economic, and moral imperatives, employers increasingly seek engineers who pair technological proficiency with a deep understanding of the social and environmental impacts of their work. Yet, engineering curricula often lack the necessary content required to prepare graduates to safeguard and enhance quality of life for people and the ecosystems that sustain all life on Earth. System-wide curricular and programmatic transformation in engineering education is necessary to accelerate the preparation of the future engineering workforce and make sustainability a core tenet of the profession.



About Engineering for One Planet

The Engineering for One Planet initiative strives to prepare all engineers with fundamental competencies in social, environmental, and economic sustainability along with teamwork, critical thinking, and communications skills.

EOP is one among a growing cadre of sustainability-focused educational change initiatives which are redefining sustainability as foundational knowledge in all disciplines. Launched in 2020, EOP collaborates with a global, cross-sector community to identify and address the most challenging obstacles in curricular change. Through curated, open access teaching tools, grants, awards, and communities of action, EOP enables educators and their institutions to accelerate educational change for a more sustainable future.

Importance of Climate Education

In 2024, Eric Lemelson, Board Member of The Lemelson Foundation, shared in his visionary **sustainability definition**, that "a sustainable world supports thriving ecosystems and the sentient beings that depend on them for their survival and prosperity, including human societies, animals, and plants." In 2025, Judge Yuji Iwasawa, President of the International Court of Justice, made a **landmark statement** based on the Court's advisory opinion that "greenhouse gases are unequivocally caused by human activities" and asserted that countries bear a legal obligation to address climate change. It is evident that urgent change is needed to create a sustainable world, and we must work together to address the climate crisis.

Climate education, as described in the updated **Climate Literacy Guide**, is critically important in engineering education because it is foundational to understanding the systems that both drive climate change and are affected by it. Engineers who gain climate-related sustainability and leadership skills, knowledge, experience, and mindsets will be uniquely positioned to:

- Accelerate the transition to clean energy and decarbonization.
- Develop and implement solutions for climate mitigation, resilience, and adaptation.
- Ensure engineered solutions promote thriving ecosystems, climate justice, and equity.

Climate education fosters agents of positive change, supports informed decision-making regarding resources and policy, and equips the future workforce with essential skills to develop and accelerate climate solutions.

The Climate Guide at a Glance

This resource strives to provide inspiration and guidance through step-by-step activities and materials for teaching climate change learning outcomes. The guide opens with an approachable and rigorous primer on climate for all faculty and students to establish foundational knowledge and common language for climate science. This is followed by nine step-by-step teaching activities that were designed by educators and climate experts to ensure scientific accuracy and maximize the ease of integrating content into courses across diverse disciplines, including required and core courses. Each teaching activity is introduced with climate framing, is aligned with an essential principle from the **Climate Literacy Guide** — which encompasses climate action within climate literacy — and is mapped to one core learning outcome from each of the nine topic areas in the **EOP Framework**. Terminology, including "course levels," follows North American educational conventions as outlined **here**.

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START HERE

CLIMATE 101

Whether you're joining the climate conversation, new to teaching climate education, or you want to update your existing climate knowledge, a good place to start is by taking this free, online module Climate 101: Science, Impacts, and Society. This module serves as a primer for anyone who wants to build an evidence-based foundation about climate.

Establishing a Common Knowledge Base

Take the Climate 101 module to establish a common knowledge base about climate science and its impacts. The module takes about 90 minutes to complete, is appropriate for faculty and students from all engineering disciplines, and ensures everyone shares a baseline understanding of the:

- Physical basis of climate change (energy balance, greenhouse gases, etc.).
- Human drivers and impacts across systems.
- Urgent and systemic nature of the climate crisis.

This module aligns with the Essential Principles described in the Climate Literacy Guide, including 3B (Causes): "Three-quarters of all greenhouse gases emitted by human activities come from the use of fossil fuels, primarily coal, oil, and natural gas, for transportation and energy. The rest come from industrial processes, agriculture, landfills, and land-use changes such as deforestation."

Connecting Engineering to Systems Thinking

The Climate 101 module explicitly shows how engineering systems (materials, energy, transportation, water, computing, etc.) contribute to and can mitigate climate impacts, illustrating why it is integral to position climate education not as an add-on to engineering, but rather as core to design ethics, risk management, and innovation.

Scientific Integrity

The resources (videos, data visualizations, and educational modules) provided by the National Oceanic and Atmospheric Administration (NOAA) in the Climate 101 module are built using science and data directly from the US Global Change Research Program (USGCRP) and the 2023 National Climate Assessment (NCA). The Climate 101 module is grounded in physical and natural science and focuses on what's currently happening at the regional, national, and global scales while being neutral and apolitical.

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Systems Thinking

1 Using Whole Systems Mapping to Develop Climate Action Solutions to Reduce Food Waste

Contributed by Cynthia Anderson and Dustyn Roberts; modified Systems Thinking activity from the EOP Framework: Quickstart Activity Guide.

Citation: The Lemelson Foundation (2026). Engineering for One Planet Framework: Quickstart Activity Guide. Cynthia Anderson, Cindy Cooper, and Dustyn Roberts (Eds). The Lemelson Foundation, Portland, Oregon, USA.

Time to complete activity: Several class periods
Type of activity: Small groups

Climate Framing

Global food systems are a major contributor to greenhouse gas (GHG) emissions — responsible for roughly 30% of the total GHGs — due to use of fossil fuels, as well as deforestation for agriculture. Reducing food waste, deforestation for food production, and the overall energy and fossil fuels required to grow, process, and transport food are crucial strategies for combating climate change, as these actions directly lower emissions and conserve valuable resources, including water and land. Minimizing food waste promotes a more equitable, resilient, and secure food system by improving food access and aligning with environmental and social justice principles. Understanding how whole systems function and interconnect, as well as how to use estimated Life Cycle Assessments (LCA) for general categories of products, is critical for making design decisions that reduce climate impacts.

Detailed Description

The Whole System Mapping design method is a powerful tool that engages students in systems level thinking and introduces them to a popular method of environmental impact measurement through LCA. The context to reduce food waste provides a real-world design application to develop climate action solutions.

Part 1: Current Reality of the Global Food System (1 hr)

Students watch The Problem with Food and Climate — And How to Fix it video and read the United Nations Climate Change article "Food loss and waste account for 8-10% of annual global greenhouse gas emissions; cost USD 1 trillion annually."

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Systems Thinking

Discuss as a class, in small groups, and/or have students reflect on the content in writing.

Consider prompts like:
- *What was one thing you learned about the food waste issue?*
- *What are some climate change implications of the food production industry?*

Part 2: Introduction to Life Cycle Thinking (30 mins)

Students watch the **Whole Systems Design: Introduction to Life Cycle Thinking** video about the design of a household dryer. Discuss as a class, in small groups, and/or have students reflect on the content in writing.
Consider prompts like:
- *What is a part of the whole system of the dryer that you wouldn't have thought of before?*
- *What was one solution to a more sustainable dryer that didn't involve the dryer at all?*

Part 3: Whole Systems Design of a Refrigerator (2-4 hours)

In much of the world, refrigerators or ice boxes are the main way to reduce food waste by keeping food cool and temperature-controlled to prevent rapid degradation. Students follow the Whole System Mapping design method for the (re)design of a refrigerator.

There are four steps in the Whole System Mapping design method:
- Step 1 (30-60 mins): Visually map a refrigerator's system (Figure 1).
- Step 2 (5-10 mins): Use the estimated LCA (Figure 2) to set environmental priorities, then balance with business or other priorities, including climate change mitigation.
- Step 3: Brainstorm new ideas/design solutions on the system map created.
- Step 4: Choose winning ideas/solutions based on your priorities and your estimates of idea performance.

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Systems Thinking

The Whole System Mapping exercise can be condensed to fit into a single class period or expanded over several weeks. For example, students can be provided with an existing system map (Figure 1), and use an estimated LCA for general product categories (Figure 2) along with an environmental, business, or social priority like "reduce lifetime cost of usage" or "reduce GHGs by reducing energy and fossil fuel use" in order to brainstorm new ideas and choose the best ones based on your educational priorities.

Or you might choose to share the existing map (Figure 1) only after the students have generated their own whole system map for a refrigerator and use the map as a comparative reference for the students to explore what they thought of that wasn't on the map or what they missed.

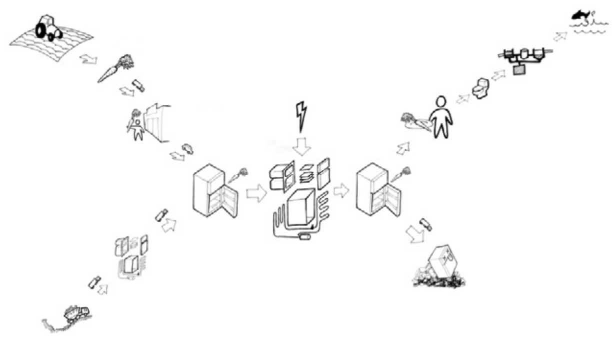

Figure 1: Whole system map of a refrigerator.
Image Credit: Faludi Minneapolis College of Art and Design (MCAD) Classwork (2010)

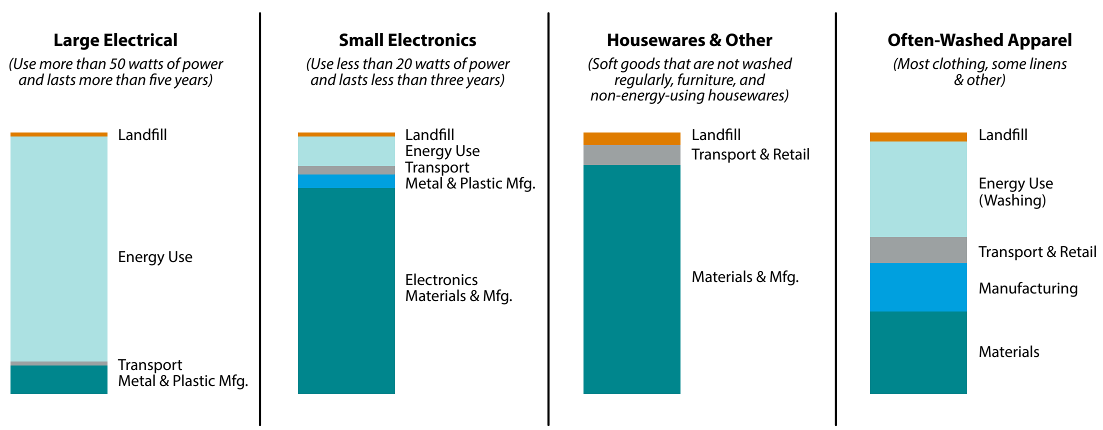

Figure 2: Estimated Life Cycle Analysis (LCA) for general categories of products

Discuss each group's whole system map as a class, in small groups, and/or have students reflect on the content in writing.

Consider prompts like:

- *What was an area of your map that you wouldn't have considered before?*
- *With large electrical appliances, generally, saving energy is the biggest area for improvement and reduction of GHGs. How does your idea/solution use less energy, thereby reducing reliance on fossil fuels, and still reduce food waste?*

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Systems Thinking

Supporting Resources

- NCA5: Focus on Risks to Supply Chains - Fifth National Climate Assessment (NCA5)
- Jonathan Foley: The Problem with Food and Climate — And How to Fix it - Ted Talk (12 mins; 2024)
- Food Loss and Waste Account for 8-10% of Annual Global Greenhouse Gas Emissions; Cost USD 1 Trillion Annually - United Nations Climate Change (UNCC) article, 2024
- Drawdown Food - Project Drawdown website
- Systems Thinking: A Cautionary Tale (Cats in Borneo) - YouTube video (3 mins; 2014)
- Whole Systems Design: Introduction to Life Cycle Thinking - Autodesk Sustainability Workshop Series YouTube video (6 mins; 2015)
- Whole System Mapping: Deep Dive - Jeremy Faludi YouTube video (26 mins; 2020)
- Whole System Mapping Exercise - VentureWell's Tools for Design and Sustainability website

Assessment Guidance

- Why is it important to consider the “whole” product system?
- What is one part of your whole system map that you had never considered before? How does this part of your map relate to climate change?
- How can technological (re)design(s) of a refrigerator help to reduce food waste, and thus, contribute to the reduction of GHG emissions by reducing use of fossil fuels?
- How are human-made designs, such as a redesign of a refrigerator, interconnected or related to the climate impacts of global food production?

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Systems Thinking

Course Integration	
Course title: Introduction to Systems Thinking	**Suggested Course Level:** 200
Course description: Define and apply the systems thinking process to understand the world as a system of interconnected parts and to apply this perspective to solve complex problems.	

EOP FRAMEWORK Learning Outcome Alignment
EOP Core Learning Outcome: Systems Thinking C.1.
EOP Framework Learning Outcome: Explain interconnectedness (e.g. intersecting, related, and/or connected systems; human actions, infrastructure, and global environmental, climate and social impacts, risks, future impacts, and consequences; synergies and rebound effects) and how all human-made designs and activities rely upon and are embedded within ecological, physical, climate, and social systems. (2, 4) (2, 4, 11-13, 17)

CLIMATE LITERACY GUIDE (CLG) Essential Principles Alignment
CLG 3B (Causes): "Three-quarters of all greenhouse gases emitted by human activities come from the use of fossil fuels, primarily coal, oil, and natural gas, for transportation and energy. The rest come from industrial processes, agriculture, landfills, and land-use changes such as deforestation."
Climate-related tags: Agriculture, climate change, climate mitigation, climate science, deforestation, food production, food storage, food waste, fossil fuels, GHGs, greenhouse gases, industrial farming methods, methane, refrigeration, resilient food system

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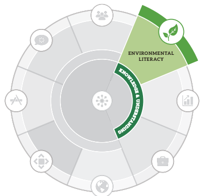
Environmental Literacy



2 Connecting the Dots About Ecosystem Services

Contributed by Jennifer Farmer, Modupe Jimoh, *and* Matthew Thomas

Time to complete activity: 1 week individual work
1 hour class time for paired work
Type of activity: Individual and pairs

Climate Framing

Natural systems, such as energy, water, and carbon cycles, are critical for the regulation and support of carbon, water, and biodiversity. Knowledge and understanding of ecosystem services is fundamental for the design of resilient and sustainable solutions that will mitigate climate change or enable humans to adapt to a changing climate. By embedding ecological understanding into all engineering practices, engineers will become better equipped to align human development with ecological integrity.

Part 1: Individual Research (1 week)

- Students select any two global ecosystem services (e.g., water, carbon, energy, and nitrogen cycles, as well as nutrient cycling, soil formation, pollination, waste decomposition).
- Students prepare a two-sentence statement to explain both of their selected global ecosystem services.
- Students conduct individual research to determine:
  - What is the main role of each of the ecosystem services selected?
  - Are the two ecosystem services interconnected? If so, how does the absence of one affect the other and people/society?
  - What United Nation Sustainable Development Goal(s) (SDGs) are related to the two ecosystem services?
  - How are ecosystem services impacted by climate change?

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Environmental Literacy

Part 2: Discussion in Pairs (1 hr)

- During class time, students pair up and share their statements and discuss their research findings. Students explore topics including but not limited to:
  - Importance and interconnectedness of ecosystem services
  - Connection to SDGs
  - Positive and negative impacts of engineering on ecosystem services and relationship to climate change
  - Role of Green Chemistry to mitigate impacts

Supporting Resources

- **NCA5 Chapter 8: Ecosystems, Ecosystem Services, and Biodiversity** and **Key Message 3 from Chapter 8: Impacts to Ecosystem Services Create Risks and Opportunities** - Fifth National Climate Assessment (NCA5)
- **The 17 Goals** - United Nations
- **Ecosystem Services** - California Academy of Sciences, YouTube video (9 mins; 2014)
- **Ecosystem Service** - Wikipedia
- **Recognizing Ecosystem Service's Contribution to SDGs: Ecological Foundation of Sustainable Development** - Science Direct Article (Geography and Sustainability; Xu and Peng, 2024)
- **Green Chemistry** - Beyond Benign

Assessment Guidance

- What SDG(s) are aligned with the chosen ecosystem services? Identify topics and indicators within the aligned SDGs.
- What engineering inventions positively or negatively impact interconnected ecosystem services? What are ways that engineering may address negative impacts on ecosystem services?
- What is the role of Green Chemistry to support natural systems?

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Environmental Literacy

Course Integration	
Course title: Physical Chemistry	**Suggested Course Level:** 100
Course description: Using models and laws to better understand chemical behavioral/systems in the engineering industry.	

EOP FRAMEWORK Learning Outcome Alignment
EOP Core Learning Outcome: Environmental Literacy C.3.
EOP Framework Learning Outcome: Examine key global ecosystem cycles and services and Nature's Contributions to People (e.g., water, carbon, energy, and nitrogen/phosphorus cycles, as well as nutrient cycling, soil formation, pollination, waste decomposition, etc.), how they are interconnected, their relationship to nature, biodiversity, and climate change, and how they impact design solutions. (1, 2) (6, 9, 13-15)

CLIMATE LITERACY GUIDE (CLG) Essential Principles Alignment
CLG 8E (Hope & Urgency): "Human well-being is dependent on natural and managed ecosystems, which provide crucial functions and resources for nearly everything we eat, make, and do. Nature-based solutions can provide climate adaptation and mitigation benefits, protecting ecosystems and the services they provide while also benefiting people."
Climate-related tags: Carbon, climate literacy, ecosystem services, energy, natural systems, nitrogen, Green Chemistry, pollution, SDGs, systems thinking, toxicity, United Nations Sustainable Development Goals, water

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Responsible Business and Economy

3 Climate Implications and Hydrostatic Dams

Contributed by the Interdivisional Town Hall Participants from the 2023 ASEE Annual Conference; modified Responsible Business and Economy activity from the EOP Framework: 11 Step-by-Step Ideas for Integrating Sustainability into Core Engineering Courses guide.

Citation: The Lemelson Foundation and Interdivisional Town Hall Participants from the 2023 ASEE Annual Conference (2026). Engineering for One Planet Framework: 11 Step-by-Step Ideas for Integrating Sustainability into Core Engineering Courses. Cynthia Anderson and Cindy Cooper (Eds). The Lemelson Foundation, Portland, Oregon, USA.

Time to complete activity: 3 hours or expand over several classes
Type of activity: Homework assignment, class assignment, or multiple class assignments

Climate Framing

Climate change, driven by increased greenhouse gases primarily generated by burning fossil fuels, is having profound impacts on weather, climate, and infrastructure — including dams — around the world. The planet is warming, leading to more frequent and intense extreme weather events including heavier rainfall, heatwaves and droughts, and more storms with hurricane-force winds. Dams are vital to communities to provide water supply, clean and renewable energy generation, irrigation, and flood control, but when weather and other ecological conditions are exacerbated by climate change, dams can pose health and safety risks to communities and habitat through dam failure, overtopping, and erosion. Understanding climate impacts to the environmental, social, and economic factors that relate to dam location, construction, maintenance and repair, restoration, and ultimately dismantling, is of vital importance to engineers and their collaborative decision-making process with community members.

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Responsible Business and Economy

Detailed description

Share a classic hydrostatic dam design problem with students, where students use principles of physics and engineering to analyze the trade-offs in dam construction: the relationship between dam height, structural integrity, and potential energy generation. The modification of this activity is the inclusion of a real-world scenario where students will explore the competing demands of dam construction costs and energy demands with social and environmental concerns.

Part 1: Climate Change Impacts on Dams (1 hr homework assignment)
Students review reading and video resources in Supporting Materials. Students reflect on the content in writing and discuss it as a class.

Consider prompts like:

- *What surprised you about the impacts of climate change on dams?*
- *Why is it important that engineers consider more than dam construction when building a dam for a community? What non-environmental factors need to be considered? Why?*
- *In what ways are dams inextricably linked to climate change?*

Part 2: Real-world Scenario (30 mins)
Use the following real-world scenario or develop another example. Students are divided into small groups (3-5 people).

Student teams imagine they are part of a civil engineering team hired to design a new hydrostatic gravity dam on a large, inland freshwater lake to produce hydroelectric power for a local community of a few thousand residents in a rural community. The dam will be built in a valley where the community will rely on the dam to generate clean, renewable energy for the region while preserving social, environmental, and economic integrity. Locals have expressed clearly that they want and need a dam for energy production, but they also want to protect the health and well-being of themselves, future generations, as well as the fish and other wildlife of the region. Their cultural traditions are also very important to them, which include utilizing the freshwater for drinking, ceremonies, fishing and hunting, and recreating. Rivers downstream of the lake and dam support fish and other wildlife habitat. The region is well-known for its beauty and attracts hundreds of thousands of visitors each year to recreate on and around the lake and watershed. Community members and small businesses rely on the tourist economy as their main source of revenue.

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Responsible Business and Economy

Part 3: Team Recommendations (2-4 hours with homework assignment)
Student teams are tasked with the following:

- Determine the optimal dam location and size (width and height) for their current budget and future energy needs.
- What are the tradeoffs and long-term social, economic, and environmental factors that must be considered when determining where the dam will be located and how large it will be? Who are the key people impacted that should be included in the design and decision process?
- Discuss the ways climate change will likely impact the dam and potential consequences of building a dam in this location to the local human and non-human communities. How will the dam be resilient to climate change? How will it control potential periods of flooding and drought?
- Make a data-informed recommendation as to whether or not the community should move forward with the dam project.

Student teams draft a brief report (i.e., five pages) with recommendations that answer the task list above. Discuss the scenario and outcomes as a class. Consider prompts like:

- *What are the tradeoffs and long-term factors of dam construction that must be considered with climate change? When should a community decide not to build a dam? What conditions would merit dam removal?*
- *Is the team's recommendation resilient to climate change? How does it reduce reliance on fossil fuels?*
- *How would the team's recommendations change if it was known that annual precipitation will decrease by 10% each year for the next decade due to climate change impacts on snowpack and rainfall?*
- *How might climate change impact the tourist economy, energy production, habitat conservation, etc.?*
- *Which of the community's concerns was the most difficult to weigh and balance? Why? How did the team resolve the issue?*

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Responsible Business and Economy

Supporting Resources

- NCA5 Chapter 2: Climate Trends and Key Message 2 from Chapter 2: Extreme Events Are Becoming More Frequent and Severe - Fifth National Climate Assessment (NCA5)
- Water in a Warming World - American Society of Civil Engineers (ASCE); 2022
- Climate Change is Increasing Stress on Thousands of Aging Dams Across the US - The Conversation article; 2024
- 10 Massive Dam Failures Caught on Camera - Underworld, YouTube video (19 mins; 2022)
- Climate Change Challenges to Dams: A Wave is Building - Factor This article; 2024
- Remove Dams to Fight the Climate Crisis - High Country News; 2023
- How Dams Impact Our Ecosystem - California Department of Fish and Wildlife, YouTube video (3 mins; 2022)

Assessment Guidance

- What community and cultural implications should be considered when selecting a dam location? Who should be invited into this conversation? Why?
- What ecological considerations should be taken into account? Who will represent the voices of the plants, animals, and ecosystems that have no voice?
- How will climate change influence the landscape of the location/region selected? The design of the dam? The decision to build or remove a dam?

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Responsible Business and Economy

Course Integration	
Course title: Fluids	**Suggested Course Level:** 300
Course description: Movement of compressible and incompressible media around and through objects.	

EOP FRAMEWORK Learning Outcome Alignment
EOP Core Learning Outcome: Responsible Business and Economy C.5.
EOP Framework Learning Outcome: Weigh the short- and long-term social and environmental costs and value of their work. (2, 4) (8, 9, 11-15)

CLIMATE LITERACY GUIDE (CLG) Essential Principles Alignment
CLG 4D (Impacts): "Climate change is already increasing the severity, geographic scale, and frequency of extreme events, such as heatwaves, floods, strong storms, droughts, and wildfires around the United States and the world. As the world warms, these events will become even more extreme, worsening existing social inequalities and leading to greater health, resource, and migration challenges. Existing societal challenges, intensified by increasing climate change, will exacerbate the drivers of instability and threaten both national and global security. To deal with the direct effects of extreme events, as well as the increased instability resulting from them, the need for humanitarian assistance will increase worldwide."
Climate-related tags: Climate change, dams, dam failure, dam removal, hydrostatic dam

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Social Responsibility

4 Design and Climate Justice Investigation

Contributed by Minal Mistry

Time to complete activity: Semester-long project
Type of activity: Group and small team (desirable) or individual

Climate Framing

This activity is designed to recognize and acknowledge that design itself is not a neutral activity and that certain communities (e.g., predominantly persons of color, poor neighborhoods, rural settings, etc.) have historically been and may currently be marginalized and underserved through intentional design choices. These communities continue to be disproportionately negatively affected over time and experience diminishing well-being generationally. With the addition of climate stresses, it is critical that solutions intended for climate resiliency, mitigation, and/or adaptation also be intentionally human-centered designs that examine assumptions, design parameters, and tangential consequences of material life cycles — beyond the immediate project scope — to ensure inclusive, just, and equitable outcomes are maintained intact over time and to prevent marginalization from being further perpetuated.

Detailed description

Students evaluate both design and climate justice implications as well as the potential for the proposed concept, prototype, or implementation plan. This activity promotes intentional, iterative critical evaluation of assumptions and design parameters to engender lasting inclusive, just, and equitable design practices and outcomes.

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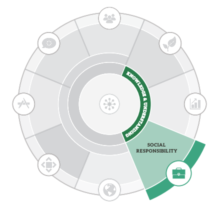
Social Responsibility



In this activity, students will center people — the voices of those who are directly affected by the design process — and iteratively evaluate their design or engineered solution to enhance well-being by considering the following:

- Identify known structural injustice within your assignment: Consider effects and outcomes that can enhance and/or degrade the human experience selectively depending on who one is. How, where, and by whom the product, service, or system is designed, built, and used are important factors to consider. For infrastructure design and construction (e.g., bridges, highways, walking paths, public transport, etc.), consider for whom the design might — and might not be — desirable. How might extreme weather events due to climate change exacerbate structural injustice? How might the intended user/demographic change over time?
- Engage with marginalized and underserved communities: Engage in responsible, cooperative, and constructive ways when developing products, services, or systems to be operated within — or for — communities, particularly those that have historically been negatively impacted or left out of decision processes. For example, consider the disproportionate pollution, cancer, and other health risks to the predominantly Black communities of the petrochemical industrial corridor along the Mississippi River in Louisiana, known as Cancer Alley. Consider the intersectionality of impacts and burdens between design and climate, as within this example.
- Reduce imposed risks and harms: Know where the materials and components in your concept/project come from (i.e., the material life cycle from extraction of resources onward). Identify potential risks and harms by proactively identifying unintentional risks to the user and local communities. For example, for a product that uses lithium-ion batteries, consider the risks of exposure to workers and their communities (e.g., food and water sources, etc.) during resource extraction. Or, consider broader sectoral aspects, such as persistent hazardous working conditions or forced labor propensity.
- Conduct critical evaluation: Have your design, plan, or proposal reviewed by others in the class or students from a different section.
- Engage in reflection: Consider how design and climate justice have affected your perceptions and design, plan, or proposal.

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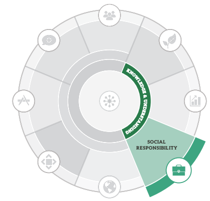
Social Responsibility



Supporting Resources

- NCA5 Chapter 20: Social Systems and Justice and Key Message 3 from Chapter 20: Climate Justice Is Possible If Processes like Migration and Energy Transitions Are Equitable - Fifth National Climate Assessment (NCA5)
- Climate and Economic Justice Screening Tool (CEJST) - NDC (Nationally Determined Contributions) Partnership
- Designing Spaces for Racial and Cultural Justice, Bryan C. Lee Jr. - WRLDCTY video (13 mins; 2023)
- Climate Change is a Matter of Justice - Here's Why - United Nations Development Programme (UNDP) article; 2023
- Design Justice Network
- Design for Freedom
- Justice Network
- Robert Bullard: How Environmental Racism Shapes the US - Public Broadcasting Service (PBS) video (17 mins; 2020)
- A Brief History of How Racism Shaped Interstate Highways - National Public Radio (NPR) audio and text story (7 mins; 2021)
- Fenceline (Co-created by Louisiana State University students Ria Salway and Claire Sullivan) - YouTube Documentary film (1 hr 25 mins)
- How 'Modern-day Slavery' in the Congo Powers the Rechargeable Battery Economy - National Public Radio (NPR) audio and text story (36 mins; 2023)

Assessment Guidance

- How does making design choices based on established parameters such as efficiency, cost, performance, and/or quantification of impacts affect embodied (in)justice?
- What surprised you about your design choices with regard to perceived inclusivity (who was/wasn't involved), perceived justice (who was/wasn't impacted)? Who was privileged?
- How have human-centered design thinking and climate justice affected your project from inception to finished product?

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Social Responsibility

Course Integration	
Course title: Introduction to Design	**Suggested Course Level:** 100 and higher. Suitable for all levels for design build/engineering courses. Essential for upper level courses.
Course description: Work collaboratively to critically consider each design choice to promote inclusive, equitable, and just outcomes that serve specific unserved needs.	

EOP FRAMEWORK Learning Outcome Alignment

EOP Core Learning Outcome: Social Responsibility C.4.

EOP Framework Learning Outcome: Examine the ways in which some communities and populations (e.g., low income, children, elderly, women, people with disabilities, people of color, etc.) have historically been and continue to be negatively impacted and/or intentionally marginalized and underserved, and continue to be disproportionately negatively impacted by engineering activities. (4) (1, 3, 5, 10, 11, 13, 16)

CLIMATE LITERACY GUIDE (CLG) Essential Principles Alignment

CLG 5A (Equity): "With careful planning and execution, actions to reduce greenhouse gas emissions and adapt to climate risks can be carried out in ways that promote climate justice in the United States, which involves ensuring benefits from climate action are shared equitably and fairly. Achieving sustainable outcomes that promote equity in the United States, rather than exacerbate inequities, involves understanding how the impacts of and responses to climate change affect different groups of people, including those who have been marginalized and underserved. Including affected communities in decision-making can help reduce risks and distribute benefits equitably."

Climate-related tags: Climate change, climate equity, climate justice, design justice, environmental justice, equity, human-centered design, inclusivity, pollution

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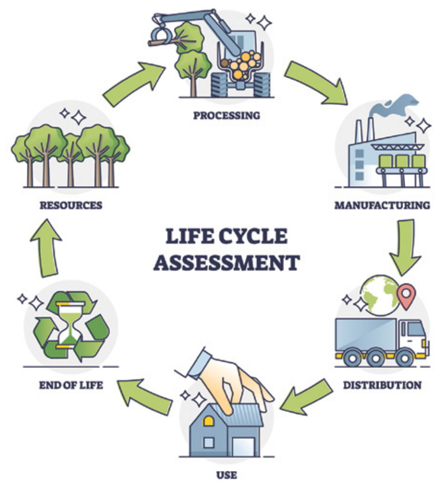
Environmental Impact Assessment

5 Improving a Product's Life Cycle to Reduce Climate Impacts

Contributed by the Interdivisional Town Hall Participants from the 2023 ASEE Annual Conference; modified activity from the EOP Framework: 11 Step-by-Step Ideas for Integrating Sustainability into Core Engineering Courses *guide.*

Citation: The Lemelson Foundation and Interdivisional Town Hall Participants from the 2023 ASEE Annual Conference (2026). Engineering for One Planet Framework: 11 Step-by-Step Ideas for Integrating Sustainability into Core Engineering Courses. Cynthia Anderson and Cindy Cooper (Eds). The Lemelson Foundation, Portland, Oregon, USA.



Time to complete activity: One or several class periods
Type of activity: Small group

Climate Framing

"Take-Make-Waste" or "Cradle-to-Grave" linear models that most product designs and industries traditionally use are resource-intensive, wasteful, and lead to significant environmental, social, and climate impacts, with industry contributing approximately 20% of global greenhouse gas emissions. However, more and more industries — from fashion to packaging to electronics to heavy industries, such as steel and cement production — are moving from linear, open-loop systems to circular systems, also referred to as closed-loop, Cradle-to-Cradle, Circular Economy, or circularity. In circular approaches, intentional decisions are made to reduce energy use and improve the product's lifetime impact by designing for durability, disassembly, recycling, repair, and to support upgrades. Additionally, "waste" or by-products from the various stages of the product's life cycle are captured, reclaimed, and utilized as a valuable resource to reduce the use of raw materials, water, and energy. Sometimes entirely new businesses are created to use by-products of the primary industry.

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Environmental Impact Assessment

Being able to use Environmental Impact Assessments, especially Life Cycle Assessments (LCA), as quantitative tools to measure and estimate the carbon footprint of materials and products is critical to being able to make data-driven design decisions that reduce energy use, conserve resources, and reduce climate impacts. LCA can be used to improve the circularity of a product, which is an effective climate action strategy, especially when applied at the design stage. Knowledge of alternative business and product design models that embrace circularity is fundamental to changing design processes to maximize their positive – and minimize their negative – environmental, social, and climate impacts.

Detailed description

Use any current course project in a traditional Introduction to Engineering course and add at least one component that involves examining the outcomes of an environmental impact assessment using a basic LCA of an existing product.

Part 1: Introduction to Life Cycle Assessments (LCA) (2-4 hours)

Students watch LCA Lecture from Supporting Resources, which is an introductory lecture on LCA focusing on "fast track" or scoping LCA. The video explains: What is LCA for? What does LCA measure (and not measure)? How do I conduct an LCA?
Discuss as a class, in small groups, and/or have students reflect on the content in writing as part of a homework assignment.
Consider prompts like:

- *Why is it important to use "fast track" or scoping LCA early in a product's design process?*
- *Why is LCA a good way to estimate climate change impacts?*
- *What cannot be measured using LCA? Why?*

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Environmental Impact Assessment

Part 2: Measuring Impact (2-4 hours)

This exercise can be condensed into a single class period or expanded over several weeks. Students select an existing product they are familiar with (e.g., cell phone, computer, car, etc.) and measure at least one component of its life cycle to measure its environmental impact (e.g., energy use, raw material use, transportation, disposal, etc.) using LCA.

Students reflect on their outcome in writing as part of a homework assignment.
Consider a prompt like:

- *Where in your product's life cycle is the best place to reduce the environmental impact through reduction of greenhouse gas emissions? Where can you directly and/or indirectly reduce the use of fossil fuels?*

Part 3: Product Redesign (2-4 hours)

This exercise can be condensed to fit into a single class period or expanded over several weeks. Students explore the Circular Economy section in **VentureWell's Tools for Design and Sustainability** website and watch the short videos from the Autodesk Sustainability Workshop Series to learn about designing for a product's lifetime, how to design for closed-loop/circularity/circular economy by designing for durability, disassembly, recycling, repair, and to support upgrades.

Students recommend one design change that will both improve their product's lifetime as well as reduce climate impacts. Students present their ideas to class and discuss.
Consider prompts like:

- *Why did you make this design decision?*
- *How will it lessen your product's environmental impacts?*
- *What are other ways you could make changes to your product's life cycle to reduce its use of fossil fuels, reduce embodied and operational energy, extend its life, and improve its circularity?*

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Environmental Impact Assessment

Supporting Resources

- NCA5 Chapter 32: Mitigation and Key Message 2 from Chapter 32: We Know How to Drastically Reduce Emissions - Fifth National Climate Assessment (NCA5)
- Inventing Green: A Toolkit for Sustainable Design - VentureWell, 2017
- LCA Lecture - Jeremy Faludi, YouTube video (58 mins; 2020)
- Measuring Sustainability - VentureWell's' Tools for Design and Sustainability website
- Circular Economy - VentureWell's' Tools for Design and Sustainability website
- Design for Lifetime: Introduction & Overview - Autodesk Sustainability Workshop, YouTube video (4 mins; 2015)
- How to Design for Durability - Autodesk Sustainability Workshop, YouTube video (4 mins; 2015)
- How to Design for Disassembly and Recycling - Autodesk Sustainability Workshop, YouTube video (6 mins; 2015)
- How to Design for Repair and Upgrade - Autodesk Sustainability Workshop, YouTube video (4 mins; 2015)
- Corporate Climate Action Essentials: An Introductory Series - E-learning Course by Environmental Defense Fund (EDF)

Assessment Guidance

- What broader energy, climate, water, wastewater, air pollution, and land-use implications did you discover when conducting an LCA?
- Why is using closed-loop or circular design better for the environment and a viable way to combat climate change?
- What are two design mechanisms to extend a product's lifetime?

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Environmental Impact Assessment

Course Integration

Course title: Introduction to Engineering	**Suggested Course Level:** 100
Course description: Survey course on basics of engineering.	

EOP FRAMEWORK Learning Outcome Alignment

EOP Core Learning Outcome: Environmental Impact Assessment C.1.

EOP Framework Learning Outcome: Explain high-level environmental impact assessments (e.g., Life Cycle Assessments, carbon accounting, energy impact assessments, and life cycle hazards), how they work, their scope, what information they require, how to incorporate their findings, and why they matter. (2, 6) (6, 7, 9, 11-15)

CLIMATE LITERACY GUIDE (CLG) Essential Principles Alignment

CLG 7F (Mitigation): "Technologies and approaches that are already available can dramatically reduce greenhouse gas emissions from the highest emitting sectors. These include improvements in energy efficiency, electricity generation from solar and wind energy, electrification of transportation and heating, less emissions-intensive diets, and protection and restoration of forests and ecosystems."

Climate-related tags: Carbon footprint, circular economy, circularity, EIA, Environmental Impact Assessment, fast fashion, fossil fuels, GHGs, greenhouse gases, LCA, Life Cycle Assessment, product design

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Materials

6 Simulation of Different Materials for Modular Insulation Panels for Use in Sustainable Building Retrofits

Contributed by Andrew Cowell

Time to complete activity: 6 hours total (3 hours x 2 sessions)
Type of activity: Small groups

Climate Framing

Designing solutions that prioritize low impact, resilience, and long functional lifetimes is essential to reduce material consumption, fossil fuels usage, and GHG emissions. These are key design factors that support climate mitigation. Using simulation software to model and test material selections within specific design parameters is instrumental for practicing iterative design methods, measuring embodied carbon, and improving performance in a changing climate.

Detailed description

Part 1: Background and Research (3 hours)

- Introduction and briefing: What materials are traditionally used for insulation of buildings? Why is using sustainable materials important?
- Concept design: Provide the geometry and temperature conditions for the insulation panels to develop your design.
- Materials selection and justification: What materials were chosen? Why? How is this choice better than traditional materials in reducing energy and fossil fuels usage?

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Materials

Part 2: Simulation and Findings (3 hours)

- Set up and simulate using a software simulation platform.
- Present the design and reflect on the process with class.

Supporting Resources

- NCA5 Chapter 32: Mitigation and Chapter 1: Overview, Figures 1.3 - Fifth National Climate Assessment (NCA5)
- Circular Ecology
- Engineering Materials Database - MatWeb website
- Greener Materials - VentureWell's Tools for Design and Sustainability
- Hempcrete - Wikipedia

Assessment Guidance

- What materials are traditionally used for insulation? How does hempcrete compare? How does your chosen material support low impact, resilience, and a long functional lifetime?
- What is the embodied carbon of hempcrete? How does this material contribute to climate change mitigation?
- Based on the simulation results, what changes would you make to improve your insulation panel design for better thermal performance to reduce GHG emissions and fossil fuels use?

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Materials

Course Integration	
Course title: Engineering Design	**Suggested Course Level:** 400
Course description: Use computer-aided tools to design products and simulate manufacturing processes.	

EOP FRAMEWORK Learning Outcome Alignment
EOP Core Learning Outcome: Materials C.5.
EOP Framework Learning Outcome: Demonstrate sustainable design literacy — i.e., select materials for design alternatives and trade-offs that enable a long functional lifetime, promote circularity, support nature-based and regenerative solutions, reduce energy consumption and reduce/prevent hotspots, have net zero greenhouse gas emissions impact, cause minimal or no environmental and social harm, and/or are restorative to social, cultural, and environmental systems. (2, 4) (4, 7-9, 11-15)

CLIMATE LITERACY GUIDE (CLG) Essential Principles Alignment
CLG 8H (Hope & Urgency): "Substantially reducing human-caused greenhouse gas emissions and taking actions to adapt and build resilience involves all levels of society. Actions by individuals, organizations, businesses, and governments can support adaptation and mitigation goals. In the United States, states, cities, Tribes, companies, and other organizations have adopted a range of climate actions and policies."
Climate-related tags: Alternative materials, carbon, embodied carbon, fossil fuels, green materials, greenhouse gases, GHGs, materials, materials selection, materials screening

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Design

7 The Impact of Climate Change on Structural Design and Resilience

Contributed by Amanda Bao

Time to complete activity: 3-5 hours, homework assignment
Type of activity: Group of 2-3 students

Climate Framing

Human-induced climate change is affecting weather and climate extremes in every region across the globe. Addressing these impacts requires creative responses to infrastructure design, maintenance, and construction to withstand rapid and intensifying weather conditions. Social factors, including climate and environmental justice, need to be considered due to disparities in the exposure that different communities face, as well as their resilience to disasters, which depends on a community's social vulnerability, economic conditions, and social capacity. These critical factors must be addressed when designing for climate resilience, adaptation, and mitigation.

Detailed description

As a homework assignment, students identify the changes in wind loads, snow loads, and heatwave impacts in the US over the past 30 years due to climate change caused primarily from burning fossil fuels and address the disparities in communities' exposure and resilience to disasters depending on a community's social vulnerability, economic conditions, and social capacity. Social impacts on engineering decisions — including climate equity and climate justice — will be incorporated.

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Design

Part 1: Choose a geographical location and use the ASCE Hazard Tool and/or the Climate Mapping for Resilience and Adaptation platform to compare the extreme weather changes in this location over the past 30 years.

Part 2: Communities suffering the most damages from disasters often struggle with insufficient infrastructure services, such as degraded electric power systems, deteriorated water and sanitation systems, inadequate transportation networks, and aging school buildings – all indicators of climate injustice and climate inequity. Social vulnerability can be represented by higher percentages of people from racial and ethnic minorities who have historically been marginalized and underserved, those who live in rural locations, and communities with larger proportions of people facing financial difficulties, age-related challenges, lack of insurance, homelessness, disabilities, and language barriers. The resilience of and climate equity within these communities is usually low due to inadequate social and economic resources to prepare for, withstand, adapt to, and recover from a disaster.

Pick one disaster (e.g., heatwave, wildfire, hurricane, flood, blizzard, etc.) in the selected geographical region, identify the location/community where the most damage occurred, and explain why. Discuss the environmental, social, and economic dimensions of sustainable and resilient design.

Part 3: Prepare a 5-minute, in-class presentation to share findings.

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Design

Supporting Resources

- NCA5 Chapter 20: Social Systems and Justice and Key Message 3 from Chapter 20: Climate Justice Is Possible If Processes like Migration and Energy Transitions Are Equitable - Fifth National Climate Assessment (NCA5)
- ASCE Hazard Tool
- US Climate Resilience Toolkit and Climate Mapping for Resilience and Adaptation – US Federal Government, 2025
- The Social Benefits of Sustainable Design - Office of Energy Efficiency and Renewable Energy (EERE), US Department of Energy
- Resilience of Critical Structures, Infrastructure, and Communities - Pacific Earthquake Engineering Research Center, 2016
- How to Make Infrastructure More Resilient Against Climate Change - ASCE, 2022
- Climate Justice - MIT website
- The Father of Environmental Justice Reflects on the Movement He Helped Start - Scientific American, YouTube video (5 mins; 2023)

Assessment Guidance

- Has extreme weather due to climate change primarily from burning fossil fuels over the past 30 years impacted the structural design in this region? Propose long-term design solution(s) to tackle one or more of these weather challenges (extreme heat, cold, wind, etc.).
- What has been the trend for extreme weather changes in this region over the past 30 years?
- How does climate change exacerbate the weather patterns in this region?

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Design

Course Integration

Course title: Structural Steel Design

Suggested Course Level: 400

Course description: The Structural Steel Design course focuses on the design of structural members and frames and their connections in steel structures.

EOP FRAMEWORK Learning Outcome Alignment

EOP Core Learning Outcome: Design C.3.

EOP Framework Learning Outcome: Create long-term, systems thinking-based approaches for tackling urgent challenges (e.g., climate mitigation and adaptation), preventing negative environmental and/or social impacts (e.g., reduction in greenhouse gas emissions, reduction in energy and resource use, greater resilience, etc.), including use of innovative and disruptive solutions within supply chains, design of new technologies and materials, use of nature-based solutions, etc. (2, 4) (7, 9, 11-17)

CLIMATE LITERACY GUIDE (CLG) Essential Principles Alignment

CLG 6A (Adaptation): "Adapting and building resilience to climate impacts in all aspects of society saves lives; reduces structural, environmental, and economic damage; protects natural resources; helps preserve cultures; and often results in improved quality of life."

Climate-related tags: Climate equity, climate justice, environmental justice, extreme weather events, heatwave, snow load, structural design, structural integrity, wildfire, wind load

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Critical Thinking

8 Climate Change Perspectives Seminar

Contributed Contributed by Alan Faulkner-Jones, Maria Jobenius, *and* Elizabeth Robertson

Time to complete activity: 2 hours prep, 1 hour in class

Type of activity: Short, individual piece of writing (1-page statement) and participation in a group discussion

Climate Framing

Social norms, cultural values, and implicit biases strongly influence how climate issues are understood, which solutions are pursued, and whose voices are heard and prioritized in decision-making. Normative ways of thinking and understanding can privilege certain groups and worldviews, while sidelining others. Unexamined, implicit biases and accepted norms can undermine sustainability objectives and inadvertently reinforce the problems they seek to address. Critical thinking, including self-reflection, inclusive mindset, and intercultural competence are essential to recognizing these influences and advancing more equitable, just, and effective responses to climate change.

Detailed description

Part 1: In advance of the seminar:

- Students create a one-page statement titled, "My Perspective on the Climate Crisis." Students share their own beliefs, understanding, and plan for future climate actions based on all aspects of the climate crisis, including human causes, human impacts (including climate equity and justice), and severity of climate events around the world.
- Statements are prepared in advance of the seminar (Part 2) and circulated by the instructor to groups of 3-5 people in advance of the seminar.
- Students review supporting materials on bias, norms, and behavior change.
- Each student reviews each statement assigned to their group in advance of the seminar.

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Critical Thinking

Part 2: Students engage in a 1-hour guided seminar.

- Papers will not be read or presented at the seminar.
- Group discussions are focused on the following discussion questions about shared statements assigned to each group:
  - Where is there agreement on perspectives?
  - What values were shared that inform perspectives?
  - What are key differences in perspectives?
  - How are these key similarities and differences linked to culture, values, beliefs, biases, and norms?
  - What are ways these cultures, values, beliefs, biases, and/or norms influence your own perspectives?

Supporting Resources

- **NCA5 Chapter 18: Sector Interactions, Multiple Stressors, and Complex Systems** and **Key Message 3 from Chapter 18: Collaborations Among Diverse Knowledge Holders Improve Responses to Complex Climate Challenges** - Fifth National Climate Assessment (NCA5)
- **Transformative Skills Guide: Expanding the Definition of Climate Literacy** - Report (Transformative Skills Guide Collaborative, 2025).
- **Types of Bias** - CPD Online College
- **Why Do We Follow the Behavior of Others?** - The Decision Lab
- **Social Norms and the Expression of Prejudice: How the Norm Changes** - Science Direct Article (Current Opinion in Psychology; Álvarez-Benjumea, 2025)
- **Social Norms as a Powerful Lever for Motivating Pro-climate Actions** - Science Direct Article (One Earth; Schneider and van der Linden, 2023)
- **The Secret Life of Social Norms, Michele Gelfand, PhD (TedXTalks)** - YouTube video (18 mins; 2018)
- **Changing Social Norms: Behaviour Change for the Climate**- Oxford Climate Society, YouTube video (1 hr 20 mins; 2020)

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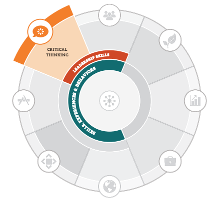
Critical Thinking



Assessment Guidance

- Finding consensus or agreement is not the objective of this activity. Instead, this activity strives to encourage students to self-reflect, become more self-aware, and practice listening to and learning about others' perspectives. The instructor conducts assessment during the seminar. Are the students:
    - Actively engaged?
    - Listening?
    - Sharing perspectives?
    - Reflecting?
    - Advocating?
    - Persuading?
    - Debating?
- Did students improve their understanding of their perspectives, culture, norms, values, and behaviors? Did students become more aware of the similarities and differences in perspectives, culture, norms, values, and behaviors compared with others?
- What unexamined, implicit biases and accepted norms did students learn about themselves that underlie their behaviors? How do they relate to their motivation around working in the sustainability field, developing climate solutions, fostering climate equity and justice, and/or taking climate action in their personal and professional life?

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Critical Thinking

Course Integration

Course title: Engineering Practice	**Suggested Course Level:** 100

Course description: Communication skills (report writing, presentation skills, data analysis) in the context of group work.

EOP FRAMEWORK Learning Outcome Alignment

EOP Core Learning Outcome: Critical Thinking C.5.

EOP Framework Learning Outcome: Examine social norms, cultural values, and implicit biases that underlie their behaviors (e.g., normative thinking, cognitive dissonance, etc.) and how these influence ethical and equitable decision-making and adaptive responses to sustainability challenges, including climate change. (4) (5, 10-13, 16)

CLIMATE LITERACY GUIDE (CLG) Essential Principles Alignment

CLG 5H (Equity): "Participatory research and planning processes can help reduce inequities and the chances of causing unintended harm through climate actions. Taking inclusive and equitable approaches to addressing climate change in the United States requires that the characteristics of a community, the factors that shaped them, and the interests of those affected are central to designing and implementing climate solutions. Approaches to decision-making that are based on broad and meaningful participation by all affected groups can build trust, promote social cohesion, and increase support, implementation, and efficacy for adaptation and mitigation strategies and plans."

Climate-related tags: Behavior change, biases, climate action, climate apathy, climate equity, climate justice, culture, environmental justice, equity, inclusion, motivation, norms, power

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Communication and Teamwork

9 Climate-based Applications of Bernoulli's Principle

Contributed by Jon-Erik Dahlin, Robert Hesketh, Leonie Krab-Hüsken, *and* Manoj Ravi

Time to complete activity: 2-4 hours (2 class sessions) or homework assignment
Type of activity: Small group activity

Climate Framing

Knowledge and understanding of Bernoulli's Principle and aerodynamics are imperative in the creation, maintenance, and spatial placement of energy-efficient designs, such as for wind turbines. This knowledge is critical for optimizing wind power and overall energy production, contributing to clean energy goals and the reduction of GHGs due to reduced use of fossil fuels.

Detailed description

Part 1: In small groups, students design their own experiment to demonstrate Bernoulli's Principle which states that as the velocity of a fluid increases, the pressure decreases. For example, in an airplane wing, the curved upper surface causes air to move faster over the top than the flat bottom, resulting in lower pressure above and generating lift.

Part 2: Students relate this experiment to three examples to exemplify the Bernoulli Principle: 1) levitating a ping-pong ball, 2) air flowing over an airplane wing, and 3) air flowing over a wind turbine blade.

Part 3: Each student team records a 5-minute video to verbally explain and physically demonstrate their experiment to show Bernoulli's Principle. In this video, students explain the similarities and differences between their experiment and at least one of the three other examples (ping-pong ball levitation, the flow of air over an airplane wing, and flow of air over a wind turbine blade).

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Communication and Teamwork

Supporting Resources

- NCA5 Chapter 5: Energy Supply, Delivery and Demand - Fifth National Climate Assessment (NCA5)
- Bernoulli's Principle - Wikipedia
- Bernoulli's Principle Explained with Fun, Easy Experiment #STEM - Exploration Place, YouTube video (2 mins; 2022)
- How Does a Wing Actually Work? - Veritasium, YouTube video (3 mins; 2012)
- Lift: Bernoulli's Principle (How Things Fly Demonstration) - Smithsonian National Air and Space Museum, YouTube video (2 mins; 2020)
- The Physics of Windmill Design - MinutePhysics, YouTube video (3 mins; 2021)

Assessment Guidance

- Using easy-to-understand language, verbally communicate and explain Bernoulli's Principle by sharing the similarities and differences between the three experiment examples (ping-pong ball, airplane wing, and/or wind turbine blade).
- How could Bernoulli's Principle be used to design more efficient wind turbines to increase energy production and efficiency?
- How might Bernoulli's Principle be utilized to champion sustainability-focused approaches to maintain the integrity of design criteria across environmental and human dimensions?

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Communication and Teamwork

Course Integration

Course title: Fluid Mechanics	**Suggested Course Level:** 200

Course description: Introduction to fluid mechanics and hydrostatics where topics covered include Bernoulli's Principle.

EOP FRAMEWORK Learning Outcome Alignment

EOP Core Learning Outcome: Communication and Teamwork C.6.

EOP Framework Learning Outcome: Champion sustainability-focused values and approaches to maintain the integrity of design criteria across environmental, ecological, and human dimensions. (3-5) (3, 4, 8, 9, 11-16)

CLIMATE LITERACY GUIDE (CLG) Essential Principles Alignment

CLG 8F (Hope & Urgency): "Improving climate education, increasing access to information, and communicating effectively can improve people's understanding of risks and their ability to address them."

Climate-related tags: Aerodynamics, alternative energy, Bernoulli's Principle, clean energy, drag, energy, energy production, fossil fuels, GHGs, greenhouse gases, lift, wind power, wind turbine

Thank You to Our Dissemination Collaborators

Thank you to all of the collaborators who have partnered with Engineering for One Planet on distributing this climate-focused teaching guide developed by educators, engineers, and climate experts.

ABET prepares the next generation of professionals to build a world that is safer, more efficient, inclusive, and sustainable. Through strategic collaborations — such as its partnership with The Lemelson Foundation and its Engineering for One Planet initiative — ABET champions the integration of sustainable design principles into higher education. ABET drives meaningful change by preparing students to enter the workforce ready to address the complex challenges of today.

Acredita CI is committed to high quality standards in the awarding of accreditation within engineering programs in Chile, with excellence, independence of opinion, and transparency in decisions, spreading the value of the continual improvement of the training process. Acredita CI is a provisional signatory of the Washington Accord and full member of European Network for Accreditation of Engineering Education and Lima Accord.

The **American Society for Engineering Education (ASEE)** is a nonprofit organization of individuals and institutions committed to furthering education in engineering and engineering technology. In pursuit of academic excellence, ASEE develops policies and programs that enhance professional opportunities for engineering and engineering technology faculty members and promote inclusive and equitable environments in which ALL citizens can participate in the engineering enterprise.

The **American Society of Civil Engineers (ASCE)** represents more than 160,000 members of the civil engineering profession in 177 countries. Founded in the US in 1852, ASCE is the nation's oldest national civil engineering society, providing technical and professional conferences, continuing education, and serving as an authoritative source for codes and standards that protect the public. ASCE stands at the forefront of a profession that plans, designs, constructs, and operates society's economic and social engine — the built environment — while protecting and restoring the natural environment.

The **American Society of Mechanical Engineers (ASME)** advances engineering for the benefit of humanity. Through its purpose to inspire, train, and convene changemakers and innovators to engineer a safer, healthier, and more sustainable world, ASME empowers the global engineering community to drive solutions that improve lives and create lasting impact.

Council of Engineers Thailand (COET) is the national body responsible for engineering regulation, education accreditation, and professional development. As part of its mission to promote sustainability, COET works with international partners and supports the development of engineers' global mobility. The Net Zero Engineering Committee furthers this mission by building essential sustainability skills and climate-resilient practices to support Thailand's move toward a low-carbon future.

Engineering Change Lab – USA (ECL) is a non-profit, social change lab that seeks to catalyze change within the engineering community that will increase the contributions of the engineering community to the challenges of the 21st century. ECL serves as a connector, convener, and communications hub, complementing the work of other engineering organizations.

Engineering Professors' Council (EPC) is the representative body and voice of engineering academics at all levels in United Kingdom higher education. It serves as a forum for exchanging ideas on engineering education, research, and other matters of common interest, while being an influential and authoritative conduit for representing engineering departments' interests to key audiences. With 85 institutional members encompassing nearly 9,000 academic staff, the EPC is a unique network representing all branches of engineering.

Engineers Without Borders UK is leading the transition to globally responsible engineering, ensuring the profession meets the needs of both people and the planet. By reimagining how engineering is taught and practiced, Engineers Without Borders UK equips individuals, teams, and organizations with the skills and mindset to accelerate this transformation. As part of a global movement of over 50 Engineers Without Borders organizations, Engineers Without Borders UK is shaping a future where engineering contributes to a safe and just world for all.

With more than 3 million members, **Environmental Defense Fund (EDF)** creates transformational solutions to the most serious environmental problems. To do so, EDF links science, economics, law, and innovative private-sector partnerships to turn solutions into action.

The **Global Engineering Deans Council (GEDC)** is an international leadership organization comprising engineering deans and academic leaders from institutions worldwide. Its mission is to strengthen engineering education and research by fostering collaboration, advancing leadership excellence, and promoting innovative, inclusive, and globally relevant practices that address societal and economic challenges.

How to Change the World's mass experiential learning programs bring together students and professionals from across higher education, communities, and businesses. Participants collaborate globally, develop critical workforce skills, and create lasting impact, together. How to Change the World is a social enterprise spun out from University College London.

Indonesian Accreditation Board for Engineering Education (IABEE) is an independent accreditation body that assures the quality of engineering and computing programs in Indonesia. As a signatory to the Washington Accord and the Seoul Accord, IABEE promotes international recognition, academic excellence, and sustainable development through continuous improvement in higher education.

The **Institute of Electrical and Electronics Engineers (IEEE)**, a public charity, is the world's largest technical professional organization dedicated to advancing technology for the benefit of humanity. IEEE and its members inspire a global community through its highly cited publications, conferences, technology standards, and professional and educational activities.

The **International Coalition for Sustainable Infrastructure (ICSI)** is the global movement for engineering action on infrastructure sustainability, resilience, and climate change. It places engineers at the forefront of climate action, harnessing their ability to provide solutions and matching it with urgent demand.

The **International Federation of Engineering Education Societies (IFEES)** is a nonprofit organization founded in 2006 that engages a diverse global network of nearly 100 organization representatives in engineering education from 30+ countries. IFEES members and partners actively connect, contribute, and collaborate to leverage collective strength to improve engineering education worldwide.

Work On Climate (WoCl) is a non-profit on a mission to mobilize humanity's talent to build the regenerative economy. It is home to the world's largest professional climate community with 38,000+ professionals, 3,400+ of whom WoCl helped find jobs in climate. WoCl is now working to decarbonize key sectors of the economy by mobilizing professionals within these sectors to become agents of change in their companies, industries, and communities.

SEFI Special Interest Group for Sustainability is a special interest group within the **European Society for Engineering Education (SEFI)**. The SEFI Special Interest Group for Sustainability's mission is to leverage sustainability principles, competencies, and transformative mindsets as catalysts for creating awareness, fostering engagement, and inspiring action. Through this, the group aims to promote more sustainability education in engineering education within the SEFI community.

Contributor Acknowledgment

We deeply thank each of the individual contributors for the content and edits they have provided to this climate-focused EOP teaching guide. Their expertise, collaboration, and generosity make it possible to accelerate climate education and action. Click links to navigate to LinkedIn profiles.

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Resources

EOP Resources are all available for free, online on the **Engineering for One Planet website**.

*The Lemelson Foundation (2026). **The Engineering for One Planet Framework: Foundational Learning Outcomes to Prepare Engineers to Protect and Improve Earth and the Life it Sustains (2026)**. Cynthia Anderson and Cindy Cooper (Eds). The Lemelson Foundation, Portland, Oregon, USA.*

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*The Lemelson Foundation and Interdivisional Town Hall Participants from the 2023 ASEE Annual Conference (2026). **Engineering for One Planet Framework: 11 Step-by-Step Ideas for Integrating Sustainability into Core Engineering Courses**. Cynthia Anderson and Cindy Cooper (Eds). The Lemelson Foundation, Portland, Oregon, USA.*

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Glossary of Common Terms

With the exception of the definition for Climate Equity, which was cited from the ***Sustainability Directory****, the terms cited below are from the US Global Change Research Program (USGCRP)'s* **Climate Literacy: Essential Principles for Understanding and Addressing Climate Change (2024)**. *US Global Change Research Program.*

ADAPTATION
In human systems, the process of adjustment to actual or expected climate and its effects to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects. Human intervention may facilitate adjustment to expected climate and its effects.

BIODIVERSITY
The variety of life, including the number of plant and animal species, other life forms, genetic types, habitats, and biomes in an ecosystem.

CARBON CYCLE
The series of processes by which carbon compounds flow among reservoirs in the environment, such as the incorporation of carbon dioxide into living tissue by photosynthesis and its return to the atmosphere through respiration, the decay of dead organisms, and the burning of fossil fuels. In the carbon cycle, carbon flow or output from one reservoir transfers carbon to other reservoirs of carbon dioxide into living tissue by photosynthesis and its return to the atmosphere through respiration, the decay of dead organisms, and the burning of fossil fuels.

CARBON DIOXIDE (CO_2)
A naturally occurring gas, as well as a byproduct of burning fossil fuels from fossil carbon deposits, burning biomass, land-use changes, and industrial processes (e.g., cement production). CO_2 is the principal anthropogenic greenhouse gas that affects Earth's radiative balance. As the reference gas against which the radiative forcing of other greenhouse gases are measured, it has a global warming potential of 1.

CLIMATE
Climate, in a narrow sense, is usually defined as the average weather or, more rigorously, as the statistical description in terms of the average and variability of defining factors over a period of time ranging from months to thousands or millions of years. The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organization. The relevant quantities are most often surface variables such as temperature, precipitation, and wind. Climate, in a wider sense, is the state, including a statistical description, of the climate system.

CLIMATE CHANGE

Changes in average weather conditions that persist over multiple decades or longer. Climate change encompasses both increases and decreases in temperature, as well as shifts in precipitation, changes in frequency and location of severe weather events, and changes to other features of the climate system.

CLIMATE EQUITY

The fair distribution of climate impacts and benefits, demanding systemic change for a just, sustainable world. Climate equity requires recognizing that climate change exacerbates existing inequalities and that solutions must be designed and implemented in a way that promotes fairness and justice. It shifts the climate conversation from solely focusing on environmental metrics to also prioritizing social and ethical considerations. This broader perspective is essential for creating effective and just climate solutions.

CLIMATE JUSTICE

Within the United States, the recognition of diverse values and past and ongoing harms, equitable distribution of benefits and risks, and the procedural inclusion of affected communities in decision-making processes.

CLIMATE LITERACY

An understanding of how the climate system works, how human actions influence the climate, and how the climate influences people and other parts of the Earth system. A climate-literate person:

- understands the essential principles of Earth's climate system and the options to address human-caused climate change;
- recognizes credible information about climate change and knows where to find it;
- communicates about climate change in accurate and effective ways; and
- is able to make informed decisions related to climate change.

CLIMATE RESILIENCE

The capacity of interconnected social, economic, and ecological systems to cope with a climate change event, trend, or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure. Climate resilience is a subset of resilience against climate-induced or climate-related impacts.

EMISSIONS
The release of climate-altering gases and aerosols into the atmosphere from human and natural sources.

ENVIRONMENTAL INJUSTICE
Environmental actions, behaviors, laws, and policies that have not been fair, that have limited meaningful involvement in environmental decision-making, or that have unjustly allocated the risks and benefits of environmental action across communities, most often based on race, color, national origin, income, and gender identity, among others.

GREENHOUSE GAS (GHG)
Gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of radiation emitted by Earth's surface, by the atmosphere itself, and by clouds. This property causes the greenhouse effect. Water vapor, carbon dioxide, nitrous oxide, methane, and ozone are the primary GHGs in Earth's atmosphere. Other GHGs include sulfur hexafluoride, hydrofluorocarbons, chlorofluorocarbons, and perfluorocarbons; several of these are also ozone-depleting (and are regulated under the Montreal Protocol).

MITIGATION
Measures to reduce the amount and rate of future climate change by reducing emissions of heat-trapping gases or removing carbon dioxide from the atmosphere.

RENEWABLE ENERGY
Any form of energy that is replenished by natural processes at a rate that equals or exceeds its rate of use.

WEATHER
The state of the atmosphere, mainly with respect to its effects on life and human activities. As distinguished from climate, weather consists of short-term (minutes to days) variations in the atmosphere. Popularly, weather is thought of in terms of temperature, humidity, precipitation, cloudiness, visibility, and wind.

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