DISCIPLINE-SPECIFIC MODULE

CJIT
CLIMATE JUSTICE INSTRUCTIONAL TOOLKIT

2.

Engineering and Climate Justice 2.0

What’s in this module?

Description

This module builds upon the first Engineering Climate Justice Module by examining two major climate events through the lens of engineering and climate justice. Students will apply their engineering knowledge to real world challenges. The goal is to encourage students to think critically about how engineering solutions can perpetuate or address disparities that affect different groups of people.

Activities

4 parts
1 video
22 readings
2 activities
1 optional project

Key Resources

- Empowering Practicing Engineers and planners to advance environmental justice
- Environmental Engineering for the 21st Century: Increasing Diversity and Community Participation to achieve Environmental and Social Justice
- Centering Environmental Justice in the U.S.

Learning Objectives

01

Apply Engineering Design Principles to real-world problems

02

Recognize how inequalities shape climate vulnerability

03

Build empathy and ethical reasoning as an engineering practice

Introduction

PART 1

Distinctions between “Justice” Terms

While this module focuses on climate justice, it is essential to understand the distinctions between Environmental Justice, Climate Justice, and Energy Justice. Each concept highlights different aspects of how communities are impacted by environmental and engineering decisions (UCS).

ENVIRONMENTAL JUSTICE

“The fair treatment and meaningful involvement of all people regardless of race, color, culture, national origin, income, and educational levels with respect to the development, implementation, and enforcement of protective environmental laws, regulations, and policies.”- Environmental Protection Agency

CLIMATE JUSTICE

“Climate justice recognizes the disproportionate impacts of climate chnage on low-income communities and communities of color around the world, the people and places least responsible for the problem.”- University of California Center for Climate Justice

ENERGY JUSTICE

“Energy justice refers to the goal of achieving equity in both the social and economic participation in the energy system, while also remediating social, economic, and health burdens on those historically harmed by the energy system (“frontline communities”).” - Initiative for Energy Justice

Frontline Communities

Frontline communities experience the most immediate and worst impacts of climate change.

Specific communities of concern

- Black, Indigenous, and People of Color (BIPOC)
- Low-income and working-class families
- Rural, coastal, and under-resources communities
- Communities near pollution producing industries

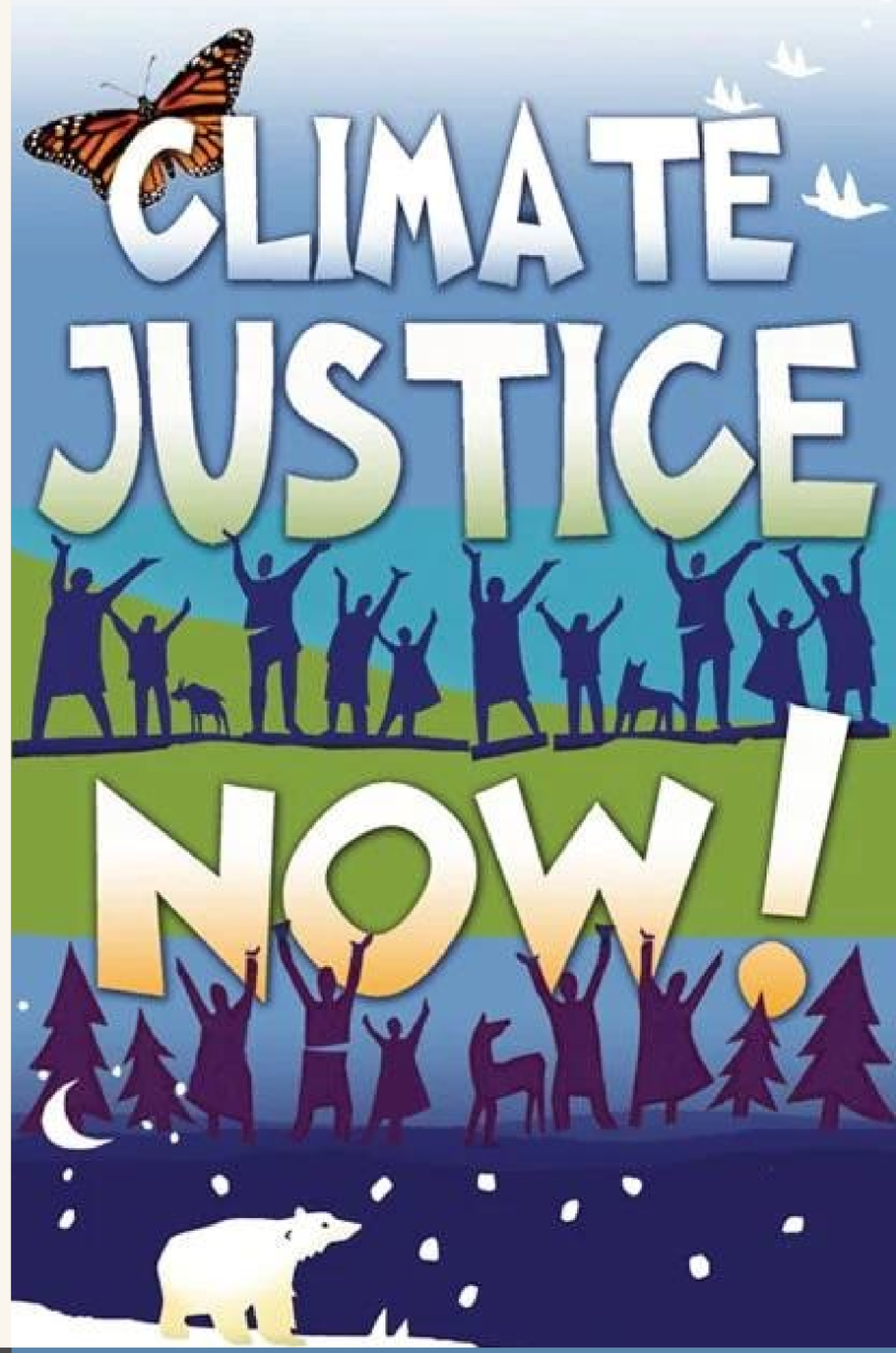
Resource to review

The US Climate Vulnerability Index uses data to visualize cumulative vulnerabilities on communities across the U.S.

Image by Ricardo Levins Morales, courtesy of Heidi de Vries on Flickr. License: CC BY.

Connection Between Engineering and CJ

Climate justice is a movement that emerged in recent decades, and is something that has begun turning into a priority for engineering and design. This module explores some of the ways in which engineering and climate justice interact, looking at the ways in which engineering and design can help mitigate climate injustices. This module follows the Engineering Climate Justice module 1.0 by assessing real-world examples of climate injustice and thinking through potential engineering solutions.



Case Study: Texas Winter Storm Uri

PART 2

CASE STUDY #1

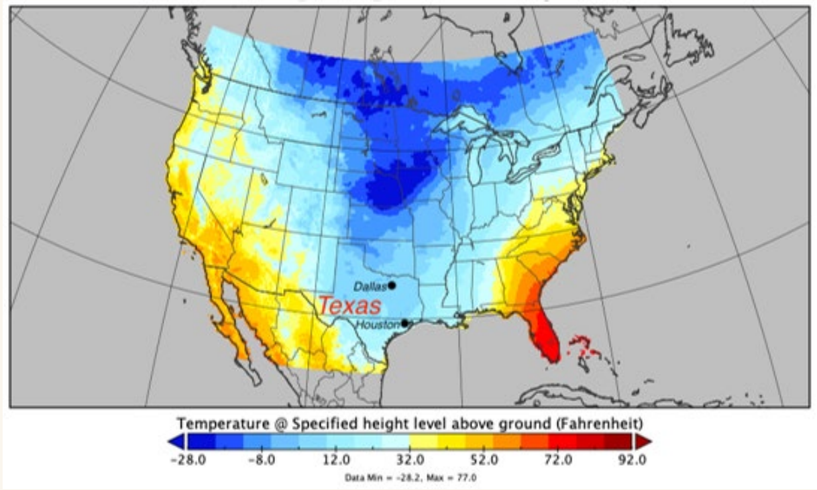
WEATHER EVENTS, THEIR CAUSES, AND IMPLICATIONS

Readings

- Extremely cold Texas in February 2021
- The Great Texas Freeze

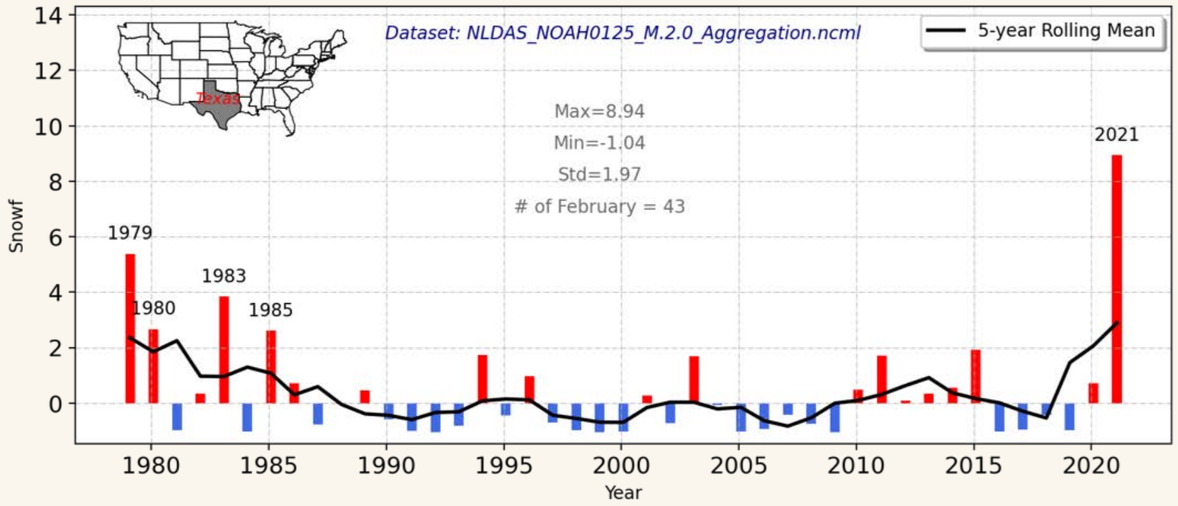
Discussion Questions

1. What meteorological events led to the development of Texas Winter Storm Uri?
2. How do polar vortex contribute to energy disruptions?



Map of air temperature across the US on February 16, taken from the North American Land Data Assimilation System (NLDAS-2). The map shows the air temperature in Texas dropped to 1 - 10°F.

The years that are labeled exceed the standard deviation. February 2021 was the snowiest February in 43 years.

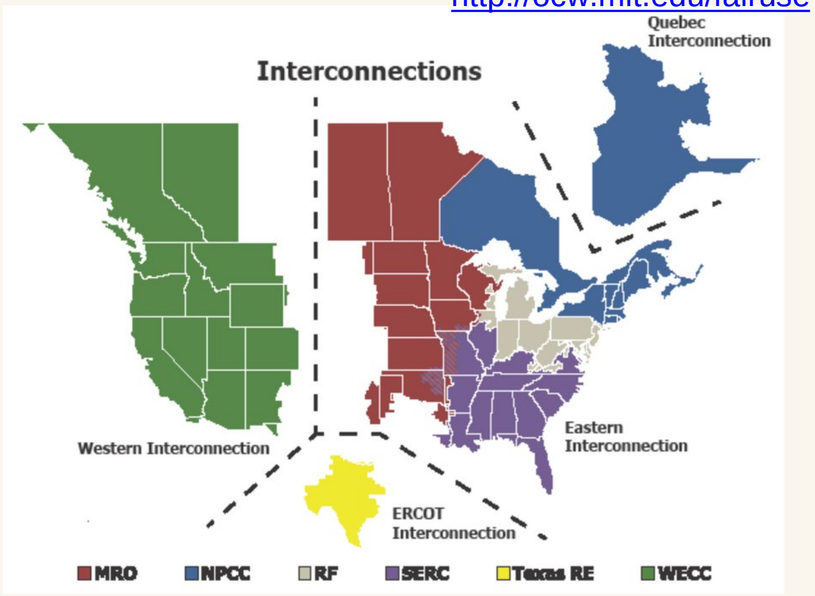


CASE STUDY #1

ENERGY GENERATION AND DISTRIBUTION

Readings

- ERCOT Winter Storm Report
- Hourly Electric Grid Monitor



Discussion Questions

1. What is ERCOT, and how does its independence from other US grids influence its ability to respond to emergencies?
2. How do transmission and distribution systems contribute to or limit energy access during a crisis?
3. How does the balance between baseload and peaking generation affect reliability during extreme weather?

Fuel	ERCOT	
Type	MW	Percent
Coal	14,703	11.9%
Natural Gas	64,202	52.2%
Nuclear	5,268	4.3%
Other	1,268	1.0%
Solar	6,202	5.0%
Wind	31,414	25.5%
TOTAL MW	123,057	

CASE STUDY #1

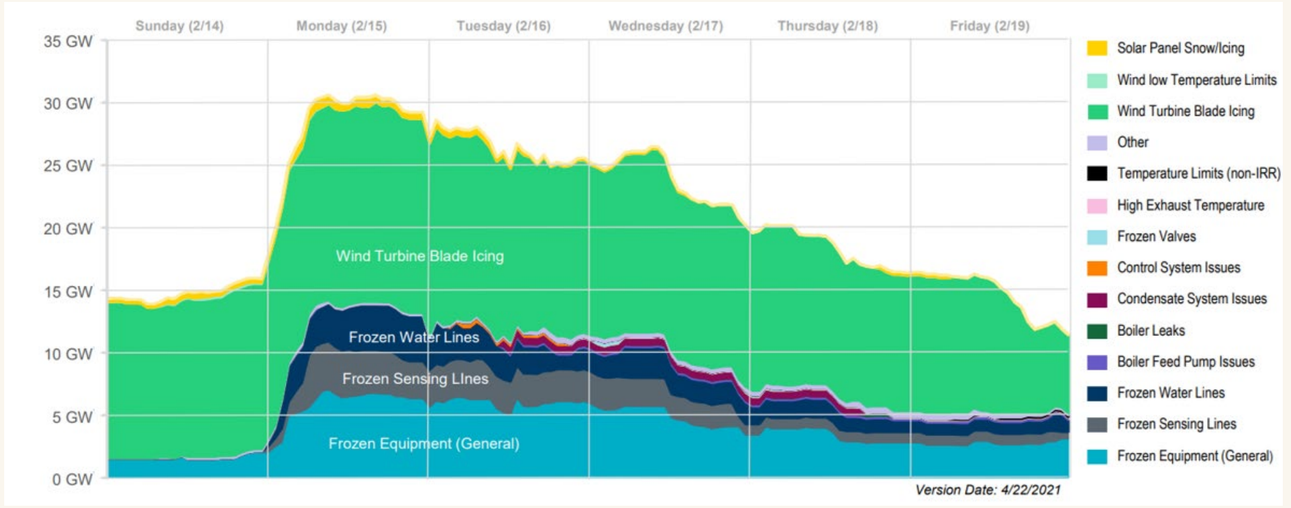
ERCOT GENERATOR OUTAGES

Readings

- ERCOT Winter Storm Report Pages – 8 - 20
- ERCOT Preliminary Report

Discussion Questions

1. Why did natural gas systems fail?
2. What could have been done before the storm to prevent blackouts?



Source: North American Electric Reliability Corp (NERC)

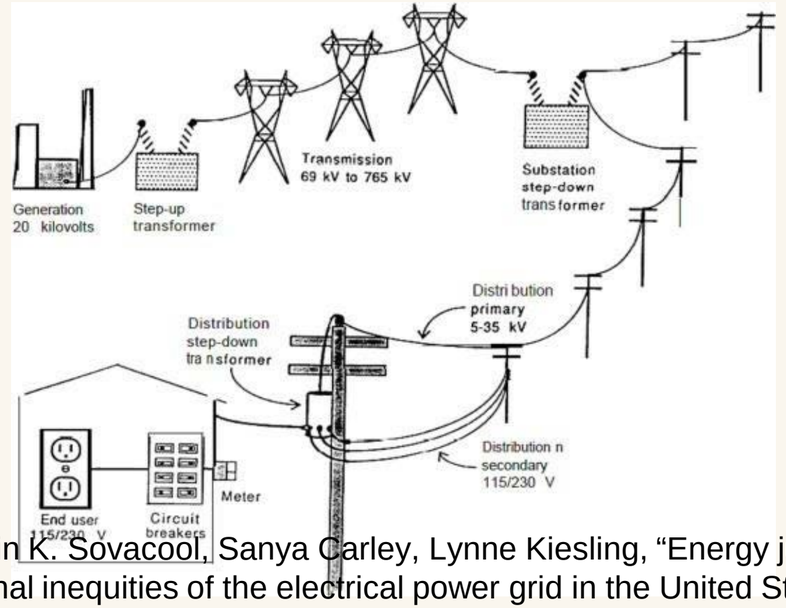


Figure from Benjamin K. Sovacool, Sanya Carley, Lynne Kiesling, “Energy justice beyond the wire: Exploring the multidimensional inequities of the electrical power grid in the United States,” Energy Research & Social Science (111), 2024. Courtesy of Elsevier, Inc., https://www.sciencedirect.com. Used with permission.

CASE STUDY #1

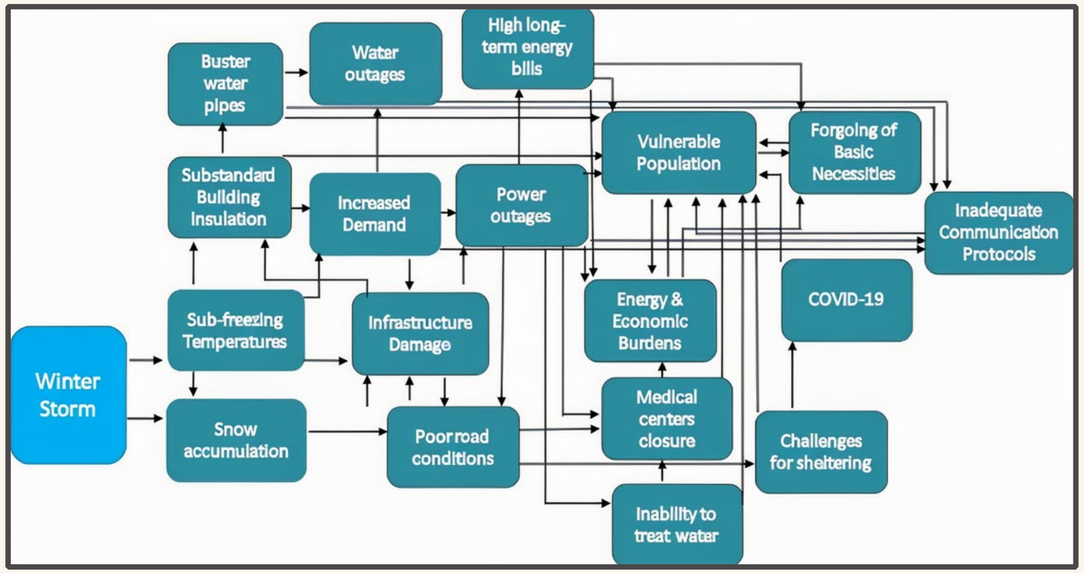
EXPLORING THE INTERCONNECTED CHALLENGES OF CLIMATE AND ENERGY JUSTICE

Readings

- A synthesis review of exacerbated inequalities from the 2021 Winter Storm (Uri) in Texas
- Energy Justice behind the wire

Discussion Questions

1. Which communities in Texas were most affected by power outages and why?
2. In what ways did the winter storm expose the intersection of climate vulnerability and social inequality?
3. How does underinvestment in public infrastructure relate to the scale of damage experienced?



Flow chart highlighting the system interdependencies related to the winter storm. (Figure from Castellanos et al., 2023, License: CC BY.)

CASE STUDY #1

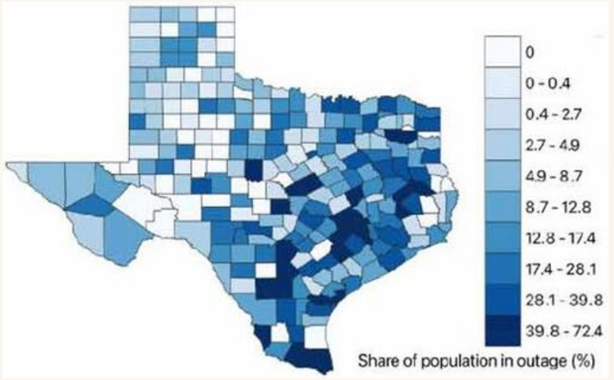
HOW CAN DATA BE USED TO QUANTIFY CLIMATE INJUSTICE?

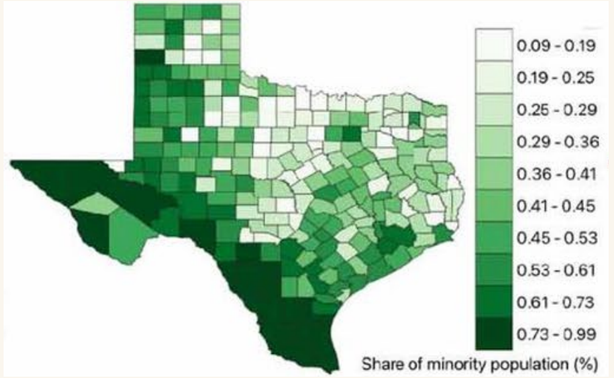
Reading

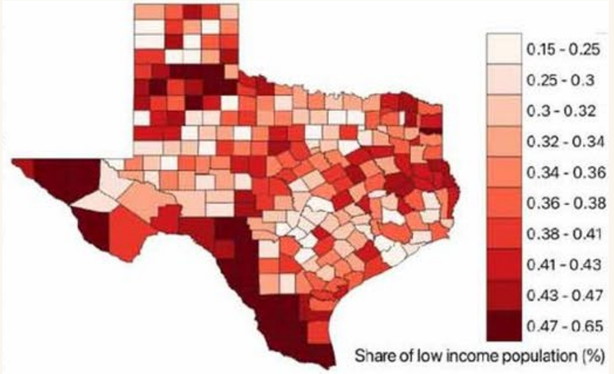
- The inequitable distribution of power interruptions during the 2021 Texas winter storm Uri

Discussion Questions

1. How can we use data to inform recovery plans and prioritize resource distribution after climate disasters?
2. How can data transparency from utilities or the government promote accountability?







Figures from Shah et al. (2023). License: CC BY.

CASE STUDY #1

CLIMATE JUSTICE

Reading

- Power Outage and Environmental Justice

Discussion Questions

1. How is energy burden used as a metric of energy injustice? What other metrics should be considered?
2. What statistical methods can be used to link infrastructure failure with socioeconomic or racial disparities?

Table 5. The statistics (*p*-value and Pearson correlation coefficient) of the correlation models between socio-economic variables and the NTL power outage ratio.

	NTL outage (county)			NTL outage (census tract)		
Population group	*p*-value	Pearson's *r*	Degree of freedom	*p*-value	Pearson's *r*	Degree of freedom
Ratio of White only	0.764	0.027	123	**0.013***	**−0.038**	4180
Ratio of African American only	0.184	−0.120	123	0.194	0.020	4180
Ratio of American Indian and Alaska Native alone	0.097	−0.149	123	0.135	−0.023	4180
Ratio of Asian	0.097	0.149	123	0.139	0.023	4180
Ratio of Latino/Hispanic	**0.000*****	**0.334**	123	**0.000*****	**0.083**	4180
Ratio of 25 years old + and hold a degree less than college degree	0.356	−0.083	123	0.546	0.009	4180
Ratio of Commute time less than 30 min	0.109	−0.144	123	**0.000*****	**−0.171**	4180
Ratio of income lower than poverty level	0.484	0.063	123	0.360	−0.014	4180
Median household income	0.331	0.088	123	0.266	0.017	4180
Unemployment ratio	0.281	−0.097	123	**0.000*****	**−0.069**	4180
Renter-occupied housing ratio	0.889	0.013	123	0.120	−0.024	4180
Ratio of constructions built after 2000	**0.022***	**0.205**	123	0.559	−0.009	4180
Median value	0.266	0.100	123	**0.018***	**0.037**	4180
Median gross rent	0.299	0.094	123	0.803	0.004	4180

***$p < 0.001$.
**$p < 0.01$.
*$p < 0.05$.

Xu et al. (2023)

ACTIVITY #1

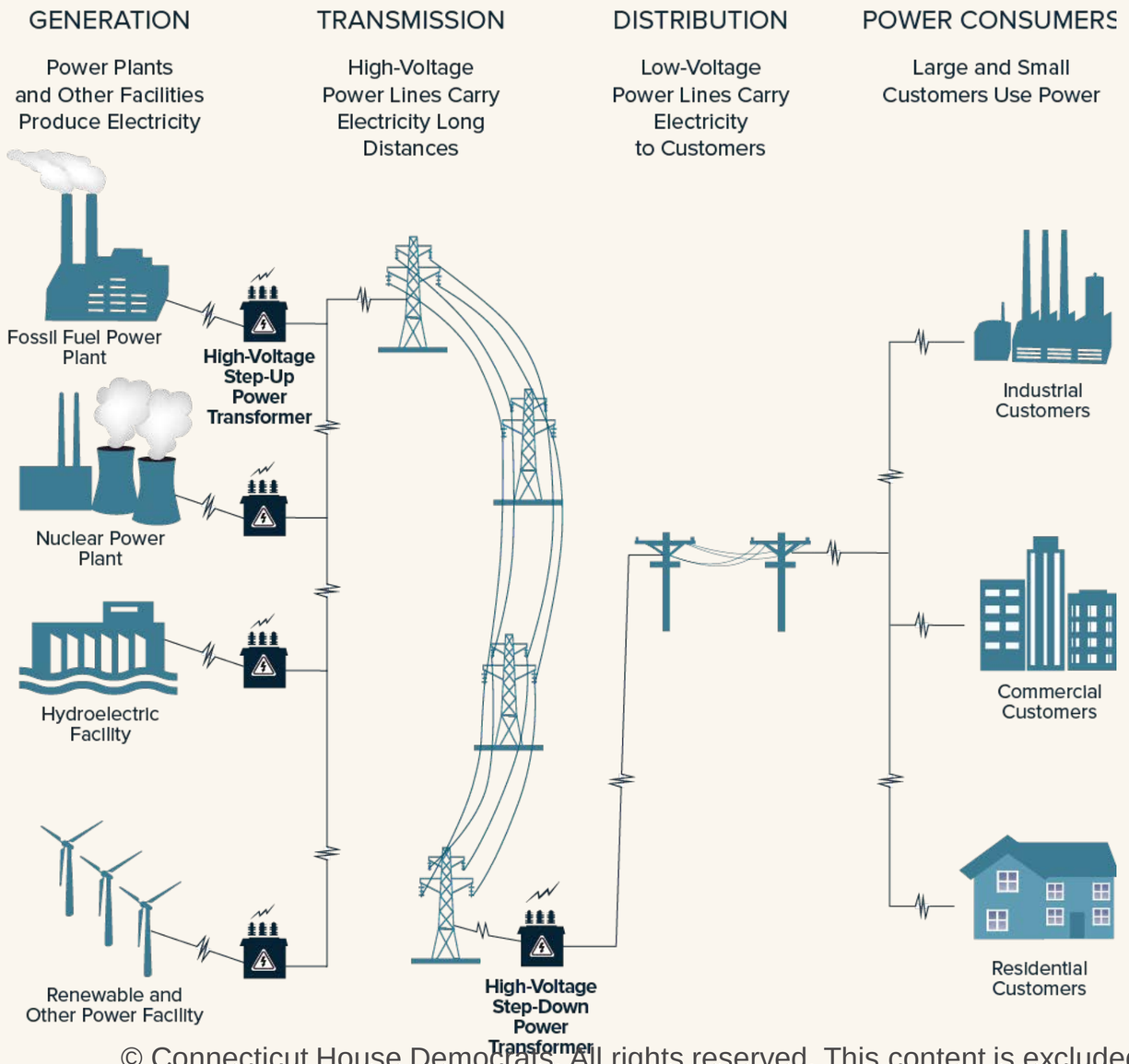
DIAGRAMING A JUST GRID

Create a diagram

Create a flow diagram of system failures and interdependencies in Texas. Highlight how grid modernization can incorporate principles of climate justice.

Discuss

How might we design a system that ensures the most vulnerable communities remain protected?



Case Study: Water Crisis Jackson, MS

PART 3

CASE STUDY #2

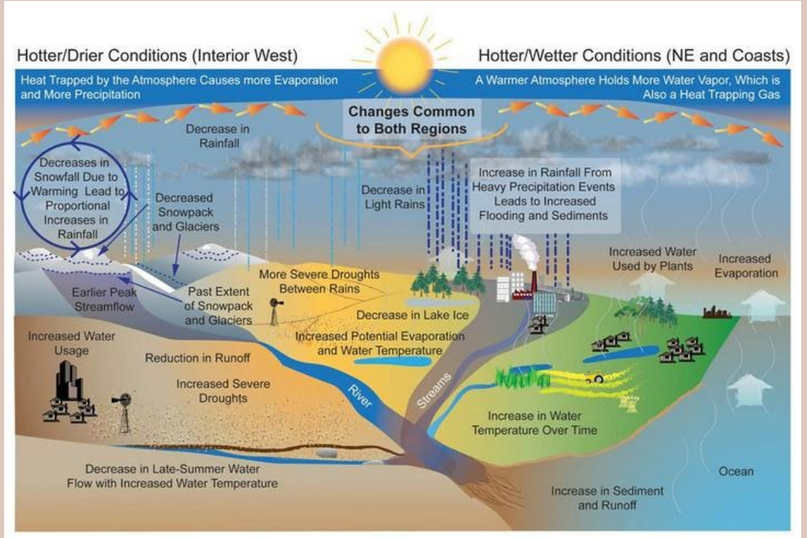
How Climate Change Impacts Water

Readings

- The Crisis in Jackson shows how Climate Change is threatening water supplies
- Flooding Treatment plant failure leaves Jackson, Mississippi without drinking water
- Lack of State Financial Support and Local Capacity Prolonged Jackson, Mississippi Drinking Water Issues (p. 1 - 7)

Discussion questions

- How are climate change and water infrastructure connected?
- Why are historically underfunded systems like Jackson more vulnerable to climate events?
- Who should be responsible for funding and implementing climate adaptation strategies in cities like Jackson?



This image is in the public domain.

CASE STUDY #2

Understanding the Technical Failures of the Jackson Water Crisis

Readings

- Decrepit pipes put Jackson, Mississippi on the Edge of a Catastrophe.
- Big Companies Cashed in on Mississippi's Water. Small Towns Paid the Price
- Jackson water crisis reveals perils of neglected infrastructure

Discussion questions

- What specific engineering systems failed during the crisis?
- What are the typical components of a municipal water system? How do they react under stress?
- How do engineers typically assess the resilience of infrastructure systems?
- How do they design for these disasters? Identify gaps in the design process.

CASE STUDY #2

RESPONSIBILITY, INFRASTRUCTURE, & DISPROPORTIONATE IMPACTS

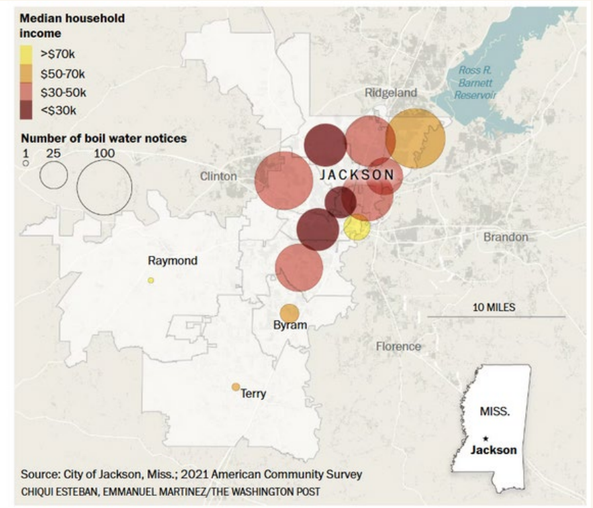
Readings

- Decrepit pipes put Jackson, Mississippi on the Edge of a Catastrophe.
- Big Companies Cashed in on Mississippi's Water. Small Towns Paid the Price
- Jackson water crisis reveals perils of neglected infrastructure

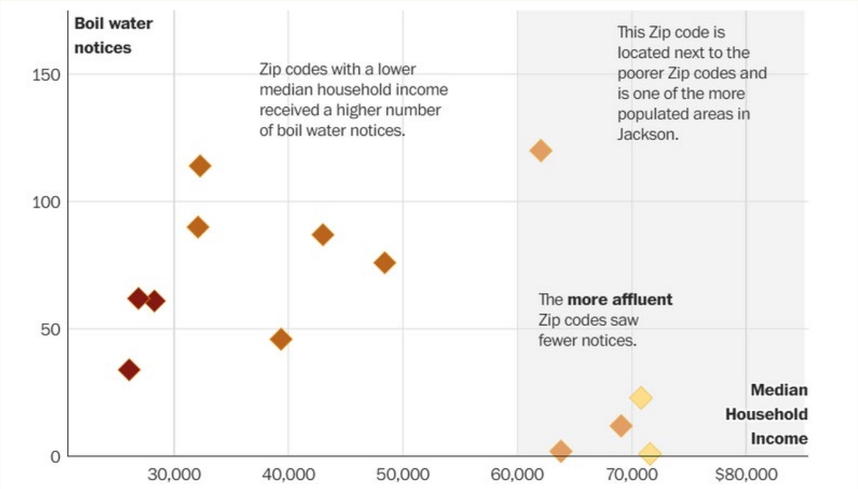
Discussion Questions

1. Why did Jackson—an overwhelmingly Black and low-income city—experience such severe consequences from a climate-related water crisis?
2. How would the response have differed if this crisis occurred in a wealthier or whiter city?
3. How should engineers prioritize projects when resources are limited—efficiency, cost, or justice?

Neighborhoods where the median household income was less than 50k saw double the boiling notices compared to neighborhoods with higher income



Poorer neighborhoods experience more problems with water connections



Images from Washington Post

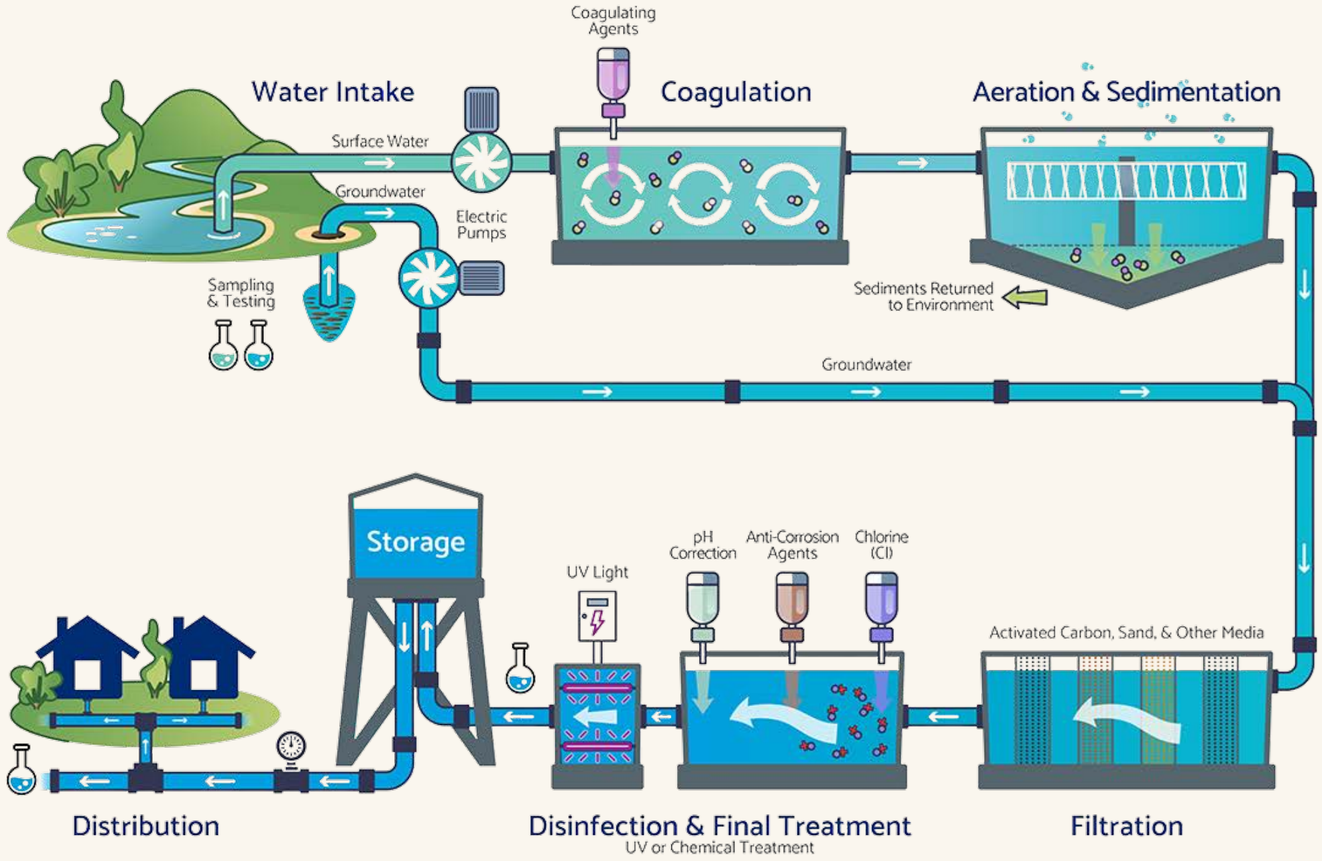
ACTIVITY #2

DESIGN

Choose 2 different components of a water distribution system. Describe how these components failed, then provide redesign suggestions of these components to maintain access to clean water during a climate-related emergency (e.g., flood, freeze, or power outage), using Jackson as a model.

Consider the following:

- Budgetary concerns (low-cost)
- Resiliency
- Population and location



Beyond the Module

PART 4

PROJECT OPTION #1

Case Study Analysis

Prompt suggestion

Work in groups to create a presentation describing the technical details of an engineering-related case study and its climate justice aspects.

Guiding questions

- What was the cause of the event?
- Who was impacted?
- How was the impact measured?
- What was the community response?

Photo by ThisisEngineering on Unsplash

For more resources on climate and environmental justice: **Please explore other modules in the Climate Justice Instructional Toolkit.**

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