Constraining Wicked Problems:

Oklahoma's Entangled Energy, Pollution and Ecological Challenges

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On Extreme Design and Wicked Problems: Overview

Problem

A Wicked Problem is one that is difficult or impossible to solve because of incomplete, contradictory, or changing requirements that are often difficult to recognize. Finding solutions to such problems requires special constraints.

Example

In this presentation, I discuss example Wicked Problems in medicine delivery, OKC Environmental Justice, and Houston Zoning. Finally, I will give an example of Energy in Oklahoma and ask you why it is a Wicked Problem. This will be a quiz.

Approach

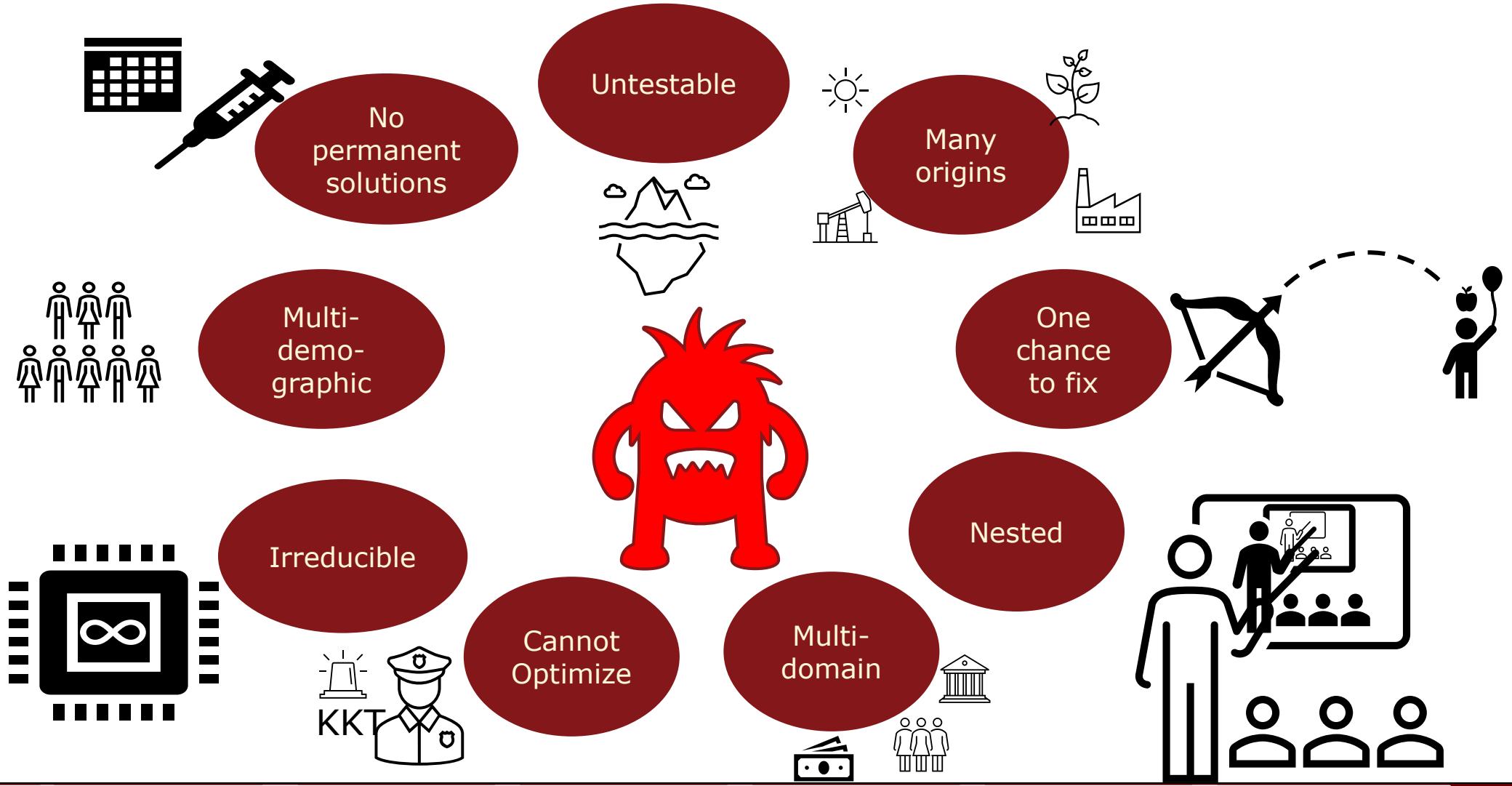
The proposed method for resolving Wicked Problems involves considering a problem from the viewpoint of multiple stakeholders and indicating the consequences of various possible solutions so that stakeholders can agree on a way forward.

Anticipated Results

1) You will learn a little about challenges you might not be aware of.
2) You will learn how Wicked Problems are described and constrained.
3) You will engage with me about how your project might fit the Wicked Problem classifiers and how you might resolve this.

Some Characteristics of a "Wicked Problem"

Source: NASA/NSF workshop



Democratizing Medical Supply Delivery

(NSF/NASA Workshop - August 2022)

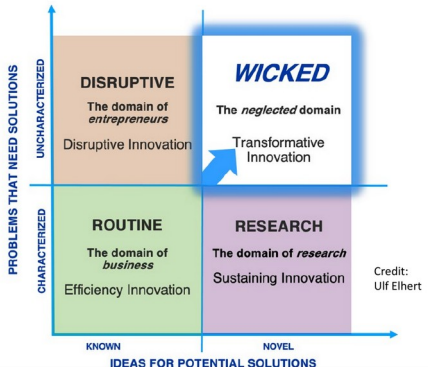
NSF EDSE Program:
Engineering Design and Systems Engineering

With Interest in **Extreme Design**

- Extreme scales
- Extreme environments
- Extreme physical qualities
- Extreme constraints
- Extreme risks
- "Impossible things"

NASA Aeronautics Project:
Convergent Aeronautics Solutions (CAS)

With Interest in **Wicked Problems**

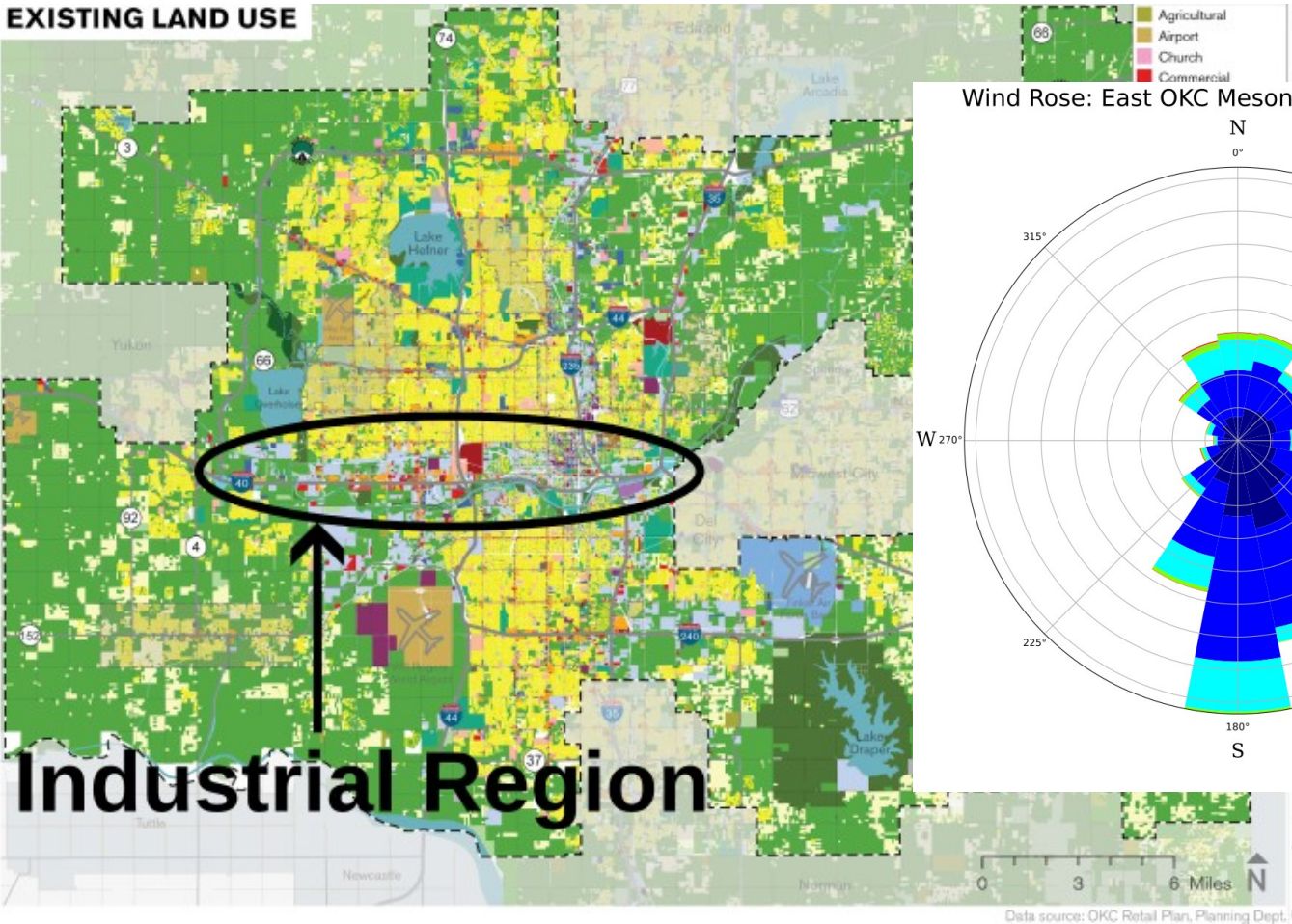


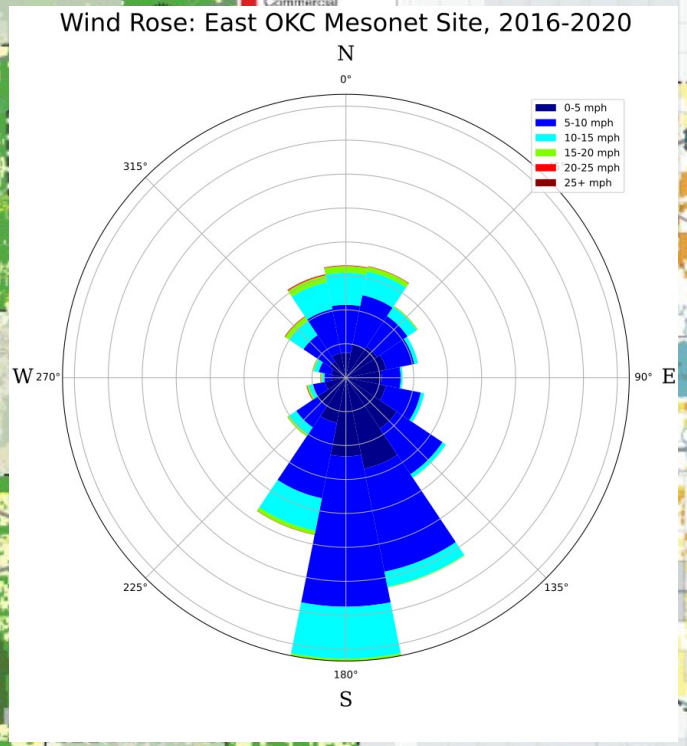
Extreme/Wicked Problem #2:
Democratizing Medical Supply Delivery

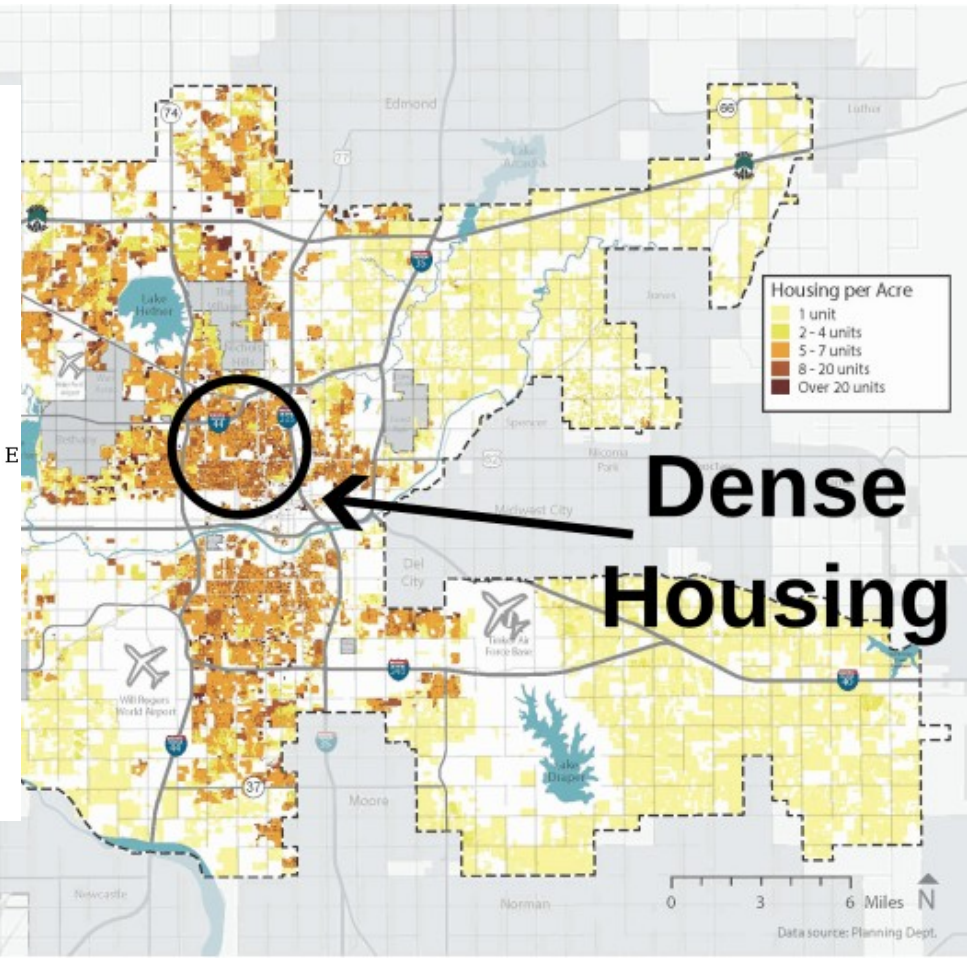
- Current medical supply transport is plagued by losses, including a relatively high temperature excursion rate.
- Delivery includes a diverse supply chain.
- Access to medical supplies is limited in some communities in the U.S. and abroad.
- Current U.S. regulatory and liability frameworks do not account for medical transport by non-traditional vehicles, such as drones.

Environmental Justice: OKC

How might this framework provide answers for historical and social problems in relation to local weather uncertainty?



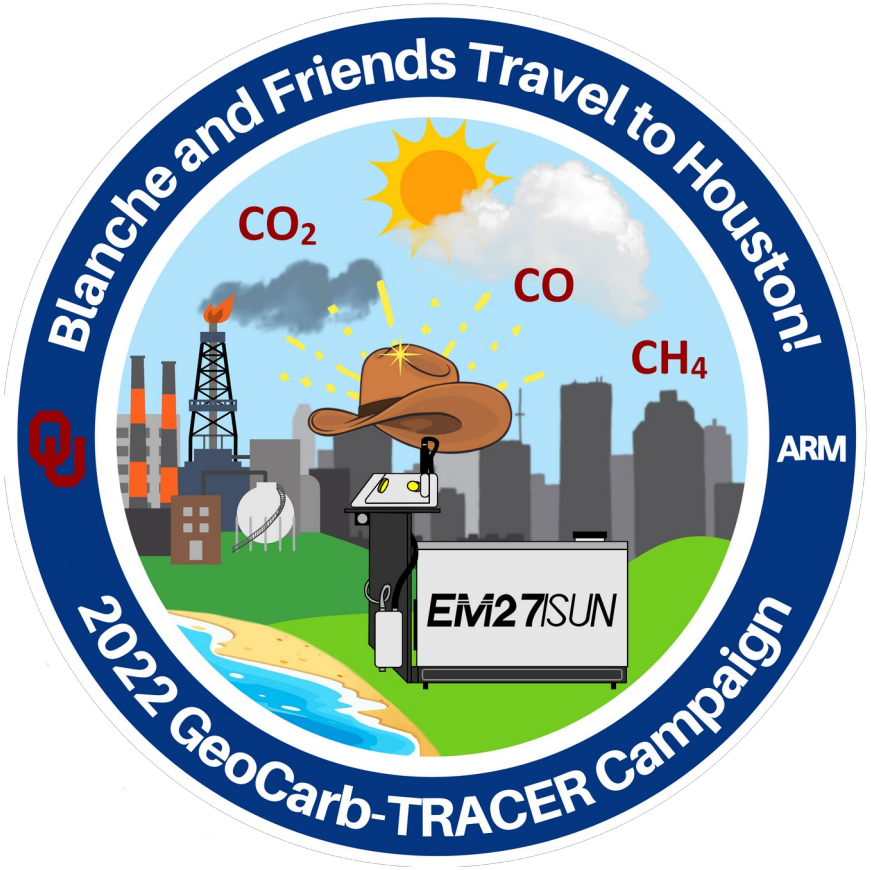




Basara, J.B., Hall Jr., P.K., Schroeder, A.J., Illston, B.G., Nemunaitis, K.L., 2008. Diurnal cycle of the Oklahoma City urban heat island. Journal of Geophysical Research: Atmospheres 113.
The City of Oklahoma City, 2019. Resolution of Intent of the Mayor and Council of the City of Oklahoma City Setting Forth a New MAPS Program to be Known as "MAPS"
Tierney, S., Petty, C., 2015. Gentrification in the American heartland? Evidence from Oklahoma City. Urban Geography 36, 439-456. https://doi.org/10.1080/02723638.2014.977038

Environmental Justice: Houston Pollution and Zoning

How do spatial decisions impact pollution?

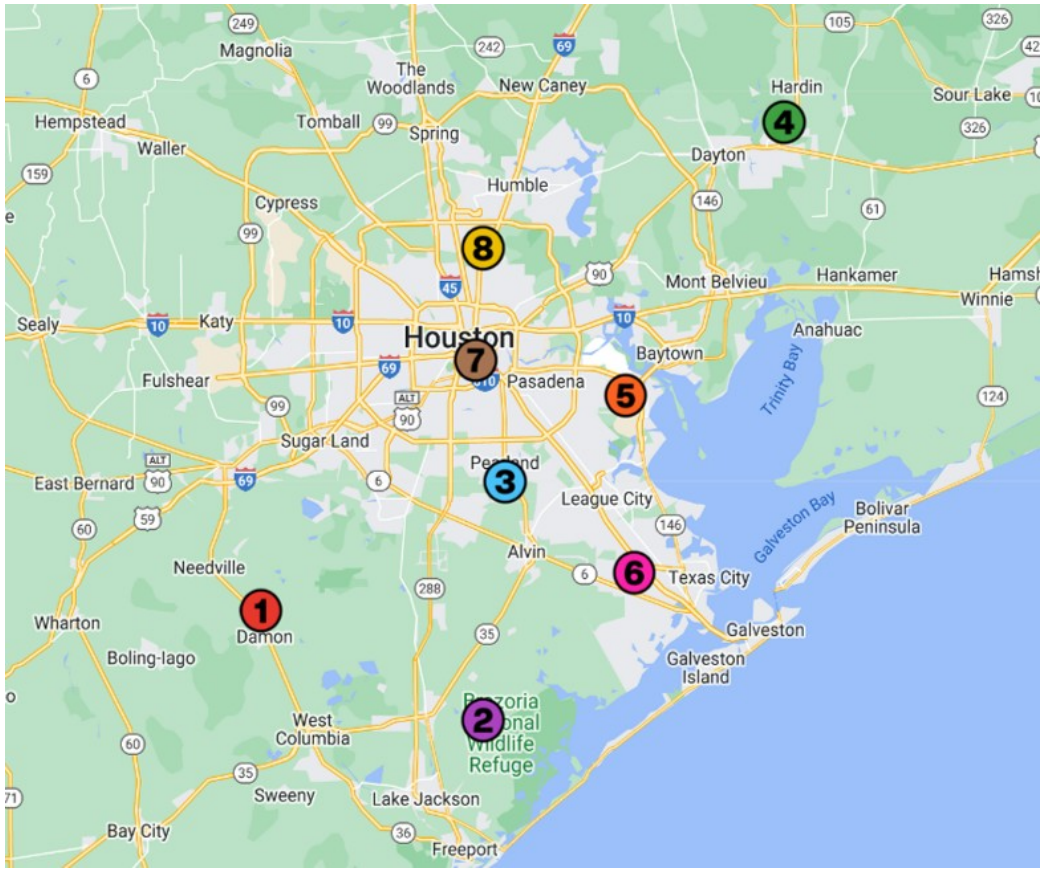


Pollution on the ABL

Image credits this page: Elizabeth Spicer

Environmental Justice: Houston Pollution and Zoning

What is making Houston so gross?



May

September

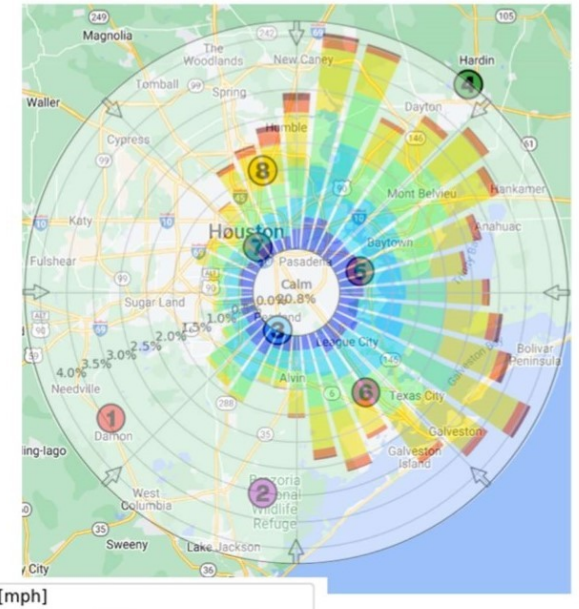
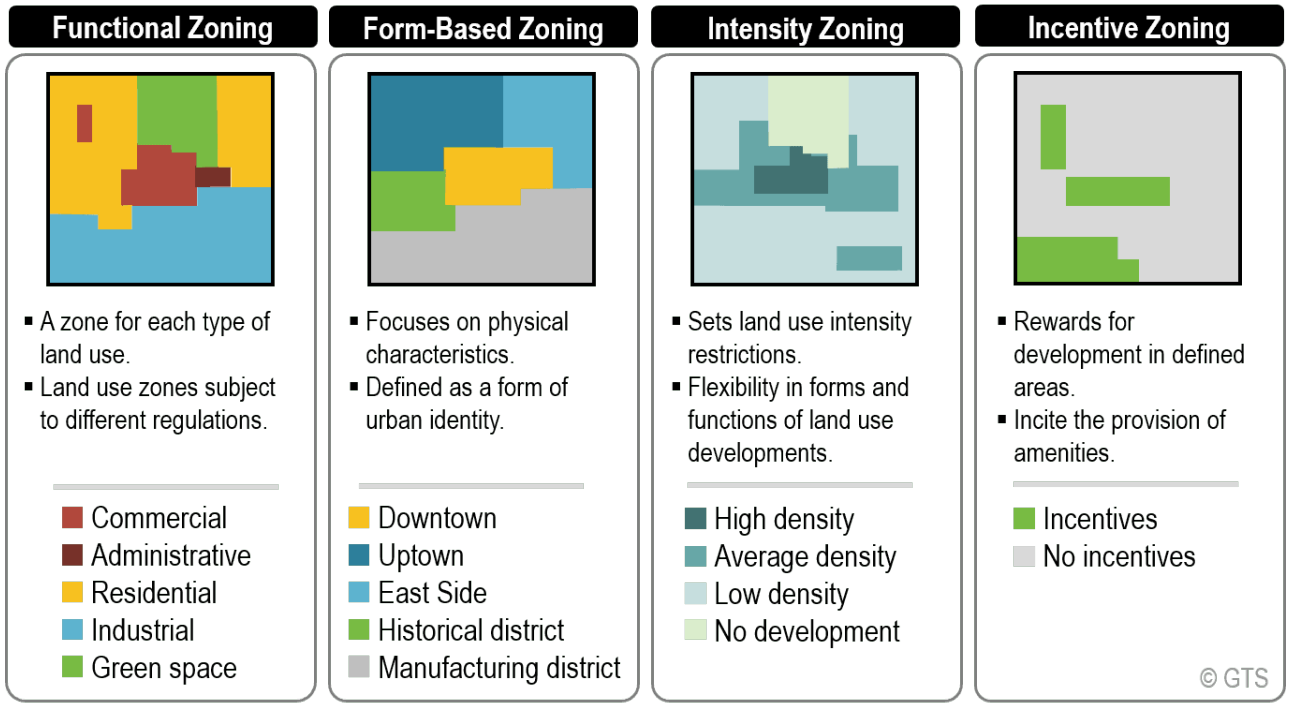


Image credits this page: Elizabeth Spicer

Environmental Justice: Houston Pollution and Zoning

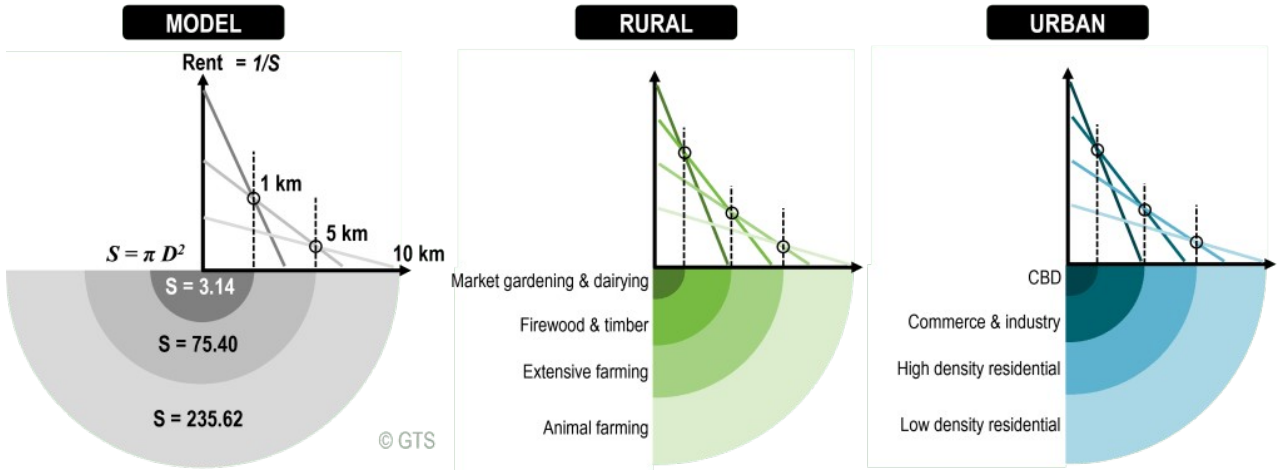
How do spatial decisions impact pollution?



Rodrigue, J.-P., 2020, *The Geography of Transport Systems*.

Environmental Justice: Houston Pollution and Zoning

How do spatial decisions impact pollution?



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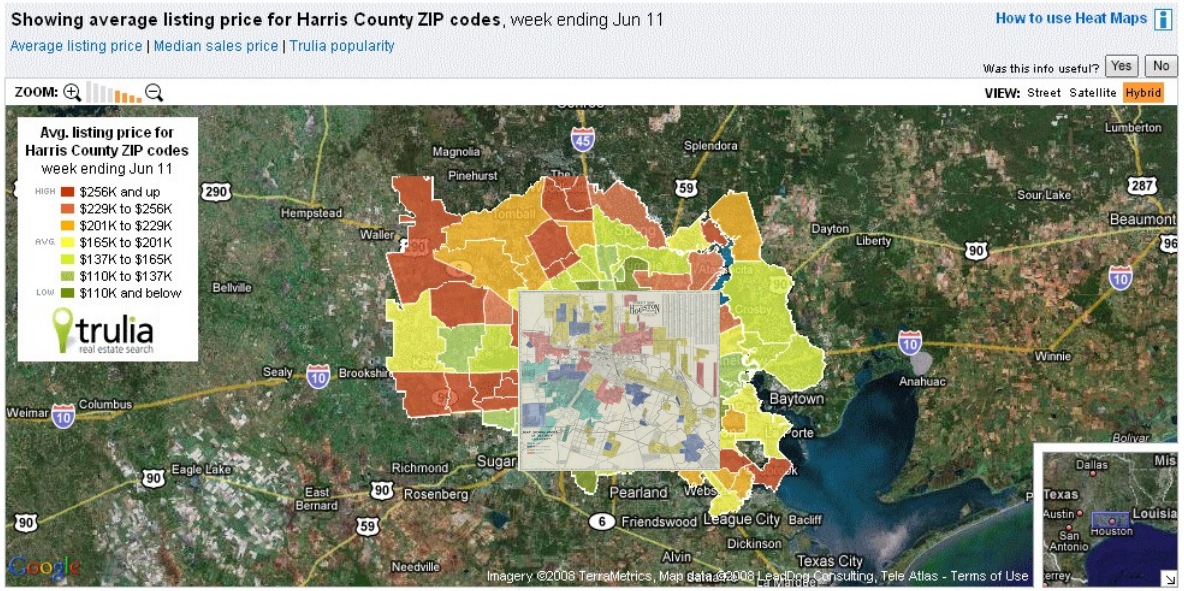


Texas Map & Blueprint Co., “Street Map, City of Houston, Texas, circa 1930.”

Recap: Houston Zoning as a Wicked Problem

Does it pass the test?

Wicked Problem Test Question	✔/✖?	Give One or More Reasons
Does the challenge have many origins?	Yes✔	Many pollution sources, many policy reasons
Does the challenge exist across domains?	Yes✔	Urban planning, industrial emissions, demographic grouping
Does the challenge involve many demographics?	Yes✔	Houston is still (somewhat) segregated
Is the challenge nested within itself?	Yes✔	Economics, social groups, etc. drive each other
Is the challenge irreducibly complex?	Yes✔	Many actors, many actions
Does the system change when we act?	Yes✔	Pollution patterns and housing may change
Will any solution be permanent?	No✔	The city is always evolving
Are we able to test the entire system?	No✔	No data source reports everything here
Is there an optimum solution?	No✔	Let's hope not when race is involved

Oklahoma's Energy Transitions

The 1900's oil boom in "Indian Territory" created the American state Oklahoma

Michael Vance1: https://www.flickr.com/photos/miklvance/46249282192/in/photostream/

Oklahoma's Energy Transitions

The Shale Gas Revolution – Re-Tapping old resources

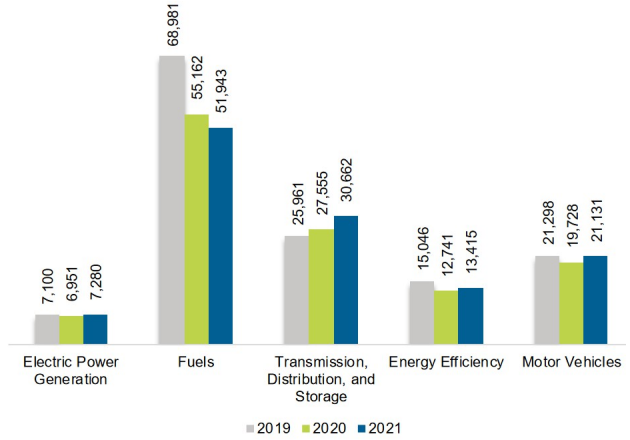
Oklahoma's Energy Transitions

Numbers

- >440,000 known wells in Oklahoma
- >180,000 wells are currently active
- #3 state for natural gas production
- #4 state for oil production
- Lowest price for electricity in the US
- Largest power supplier to states in this region
- Energy directly employs >124,000 people in OK of 1,650,300 non-farm workers (July 2021), roughly 8%
- Arguably, all other non-farm jobs in OK depend on the energy sector performance

Oklahoma had 124,431 energy workers statewide in 2021, representing 1.6% of a energy jobs. Of these energy jobs, 7,280 are in electric power generation; 51,943 i fuels; 30,662 in transmission, distribution, and storage; 13,415 in energy efficiency 21,131 in motor vehicles. From 2020 to 2021, energy jobs in the state increased b 2,293 jobs, or 1.9%. The energy sector in Oklahoma represents 7.9% of total state employment.

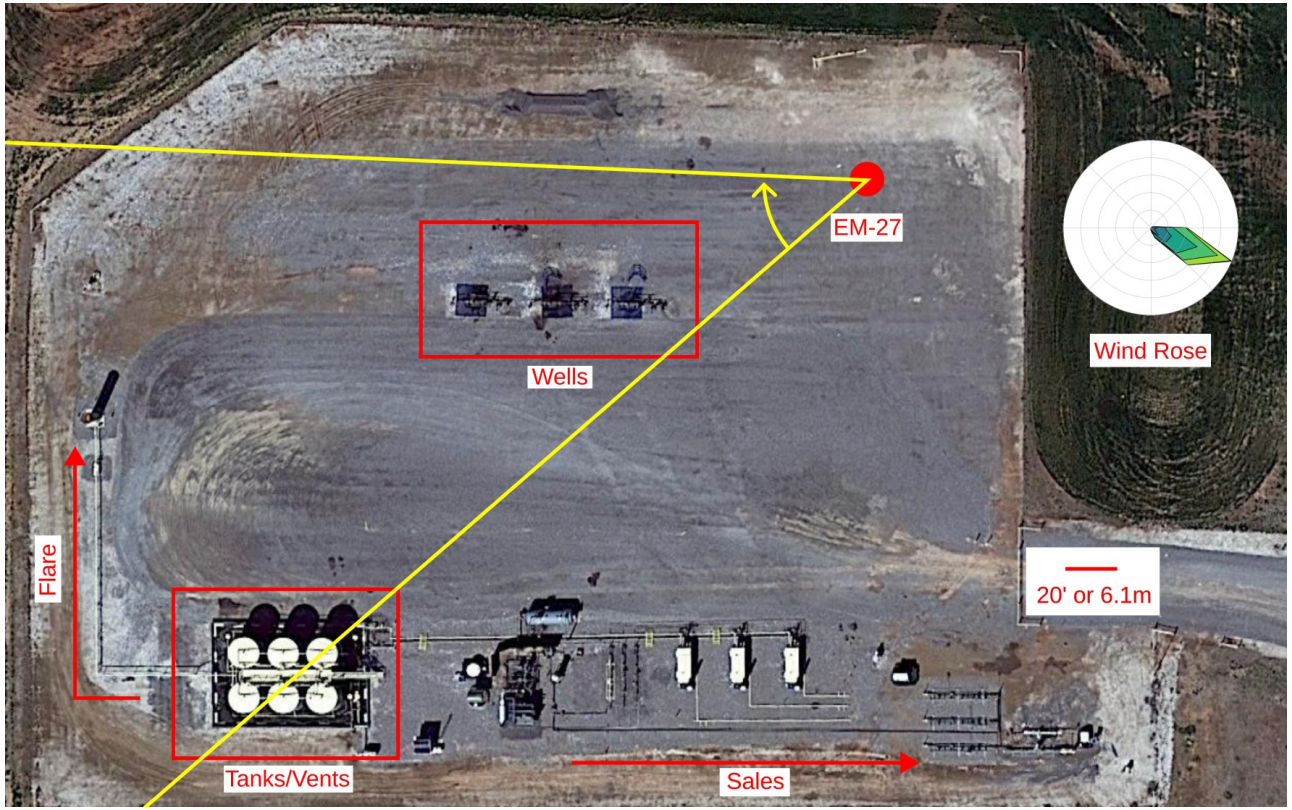
Figure OK-1.
Employment by Major Energy Technology Application

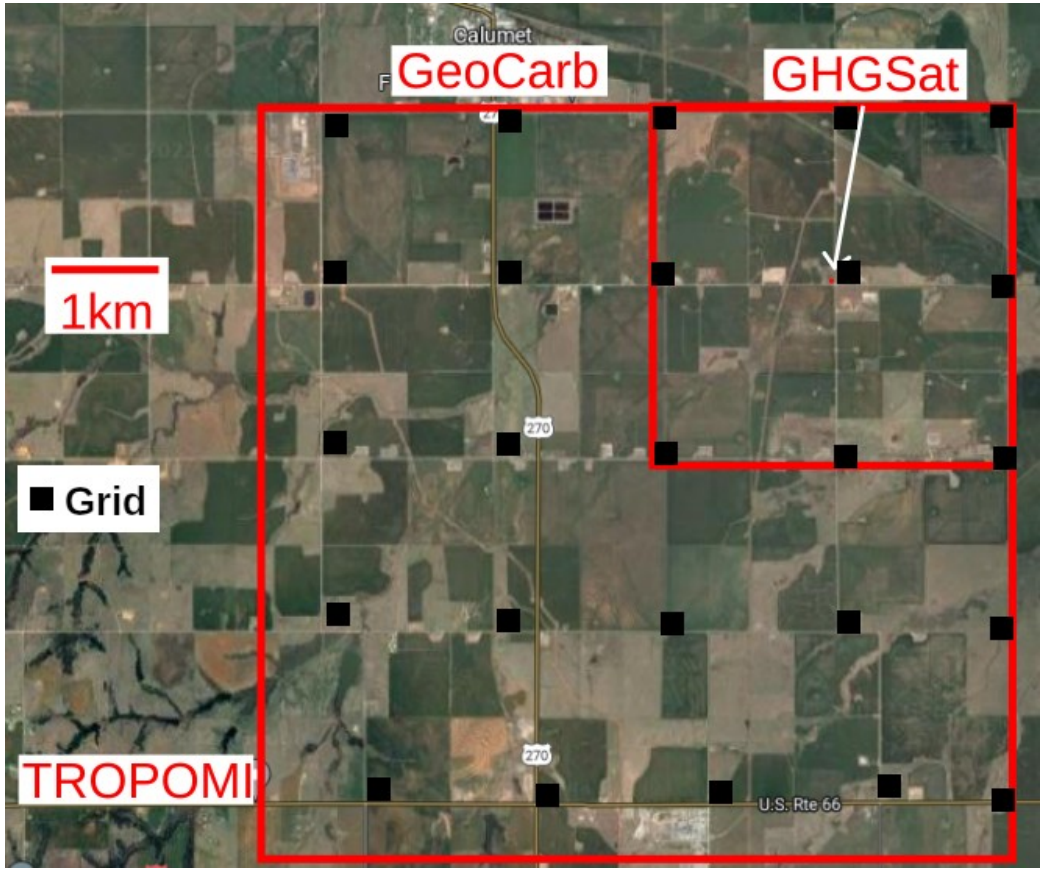


[1] Oklahoma Corporation Commission, 2022, "RBDMS Wells."
[2] The Office of the Secretary of Energy & Environment, 2021, *Oklahoma State Energy & Environment Plan 2021*, Oklahoma City, OK.
[3] U.S. Department of Energy, 2022, *Oklahoma Energy and Employment - 2022*.
[4] Oklahoma Employment Security Commission, "Current Employment Statistics," Employment Security Commission [Online]. Available: https://oklahoma.gov/oesc/labor-market/current-employment-statistics.html. [Accessed: 22-Jan-2024].

Oklahoma's Energy Transitions

Visualizing the Scope





Oklahoma's Energy Transitions

Oklahoma Policy Strongly Favors Energy Status Quo

Caleb Long; Wikimedia Commons

"Petunia"

Oklahoma's Energy Transitions

State (and National) Policy Prioritizes Energy Security and Existing Petrochemical Fuels

Natural Gas Emergency Response Menu

Type of Emergency	Supply or Demand Side	Measure	What it Does	Recommended Steps	Shortage Level
Natural Gas	Supply	Temporarily lift wellhead restrictions on the production of natural gas.	Allows companies to pump as much gas as possible.	OCC regulates this through rulemaking, every 6 months holding a market demand hearing which sets maximum flow for wells. This hearing can occur on an accelerated schedule if necessary (emergency rulemaking).	4
Natural Gas	Supply	Allow pipeline pack to increase reserve supplies available.	Allows pipeline companies to store additional natural gas in the pipelines. This is generally done in anticipation of elevated demand.	The allowable pipeline pressure increases are regulated by federal law.	1 2 3 4
Natural Gas	Supply	Local gas distribution companies (LDC) can purchase additional gas in order to meet demand.	Mainly a preventative measure to be used when shortages can be anticipated —there must be an adequate gas supply available to purchase additional gas. The price of this purchased gas, contract details, the availability of gas transmission capacity, and the ability of the company's system to accept additional supply may impact the amount that can be purchased.	This activity will be conducted by private gas companies; OCC should remain actively involved in understanding anticipated supply shortages.	1 2 3
Natural Gas	Supply	Gas companies that are drawing gas from storage facilities can increase the rate of withdrawal.	Helps meet increased short-term demand.	No special permissions needed. Companies make these decisions independently-- contractually they may go up to their maximum withdrawal rate without notifying state officials.	2

The Office of the Secretary of Energy & Environment, "Natural Gas Emergency Resposne Menu," NatGasResp1 [Online]. Available: https://ee.ok.gov/wp-content/uploads/2021/07/NatGasResp.pdf. [Accessed: 22-Jan-2024].

Example questions to help communities can identify energy infrastructure dependencies

- **Energy Sources:** Who are the local energy suppliers? Who are the key points of contact at each company/supplier that can assist in helping the community understand energy infrastructure dependencies?
- **Generation Fuels:** What fuels are used to generate local electricity? Coal, natural gas, other? How are these fuels transported?
- **Energy Infrastructure:** What is the local energy infrastructure in terms of facility and station locations and routing? Is this information available in one place (map, file, etc.)?
- **Energy Distribution:** How many independent routes are there from for the energy source (for electric power, natural gas, liquid fuels) to the community? Is each one capable of supplying the whole community? Is the energy network in the community fully interconnected or are there areas that can only be supplied from one source? Where are the key single points of failure? Are there critical spares available for the single points of failure?
- **Gas Supplies:** What are the routes of the major natural gas pipelines within the community and do they cross under (or very close to) critical facilities?
- **Liquid Fuel Supply:** Where do liquid fuels (e.g. gasoline, diesel, etc.) come from – pipelines, tank farms, distributor sites (commonly known as "racks" in the industry)? How much supply is stored locally by the distributors? How much of each fuel is stored by the community and do these facilities have back up electric power sources? Are there any gravity fed systems locally?
- **System Interdependencies:** What other local infrastructure systems require reliable power or fuel supply to operate, such as transportation, water, buildings, and communication?
- **Event Response:** Which physical assets in each infrastructure system are critical to emergency operations and recovery efforts within the community? What are practical ways to provide energy assurance to these assets following hazard events?
- **Social Vulnerabilities:** Which social institutions are most affected by the loss or degradation of energy supply? What are practical ways to provide energy assurance to these communities?

McAllister, T., 2016, *Guide Brief 5: Assessing Energy System Dependencies*, NIST SP 1190GB-5, National Institute of Standards and Technology, Gaithersburg, MD.

Oklahoma's Energy Transitions

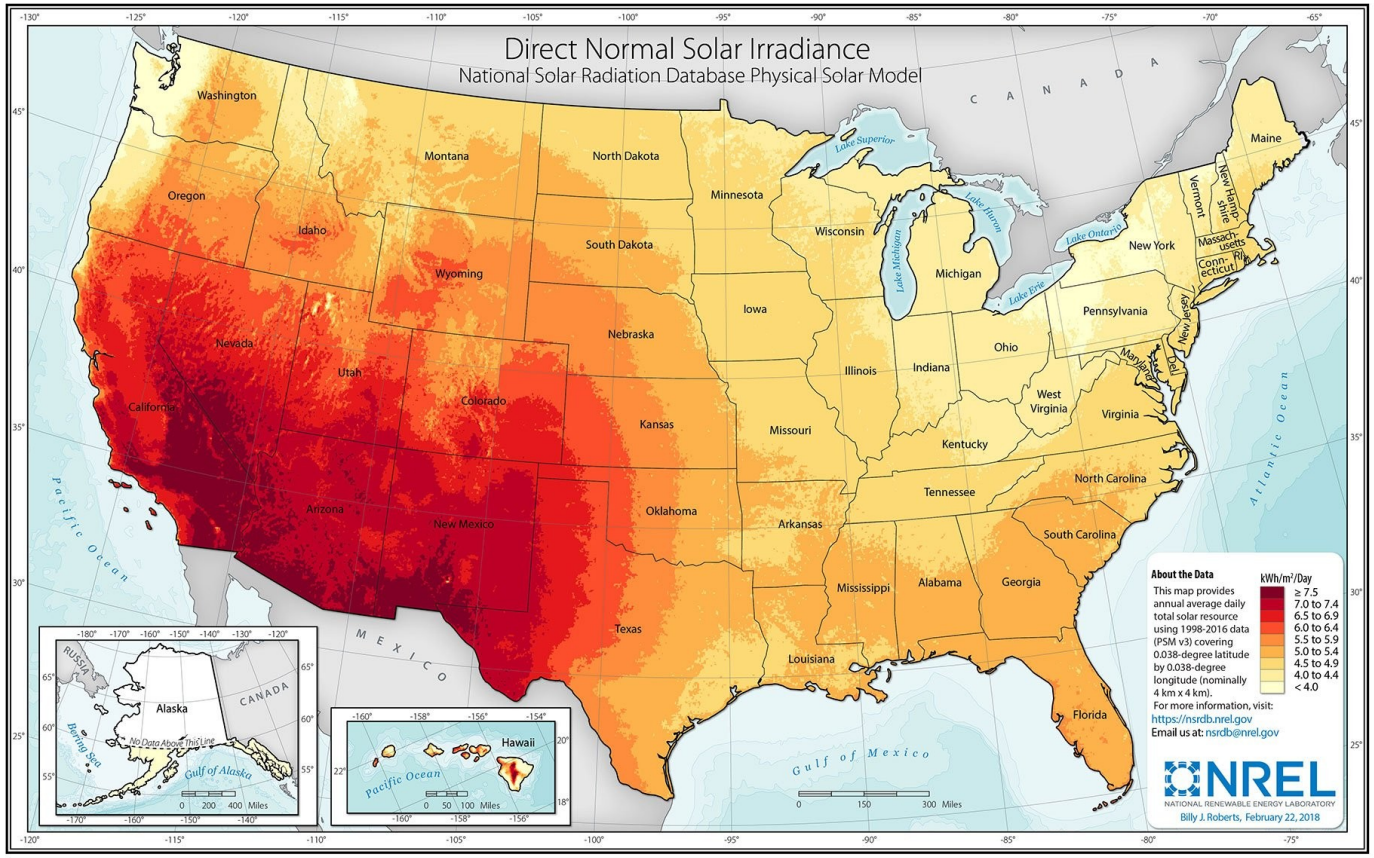
Petroleum is currently an environmental disaster

W.carter; Wikimedia Commons

- The greatest contributor to climate forcing molecules CO_2 and CH_4 is the oil & gas industry.
- There are cleaner ways to produce and use, but the industry chooses not to use those.
- OK prioritizes production to build the economy.
- Petroleum extraction is finite.
- Jobs and way of life depend on moving oil & gas.
- The energy sector is unstable employment; job locations depend on tax subsidies to employer.
- Energy is a Marshallian commodity: price will always drive consumption to maximize utility.
  - Not Hicksian? – There is no set utility for energy.
  - Not Giffen Good? – There is no quality…yet.

Oklahoma's Energy Transitions

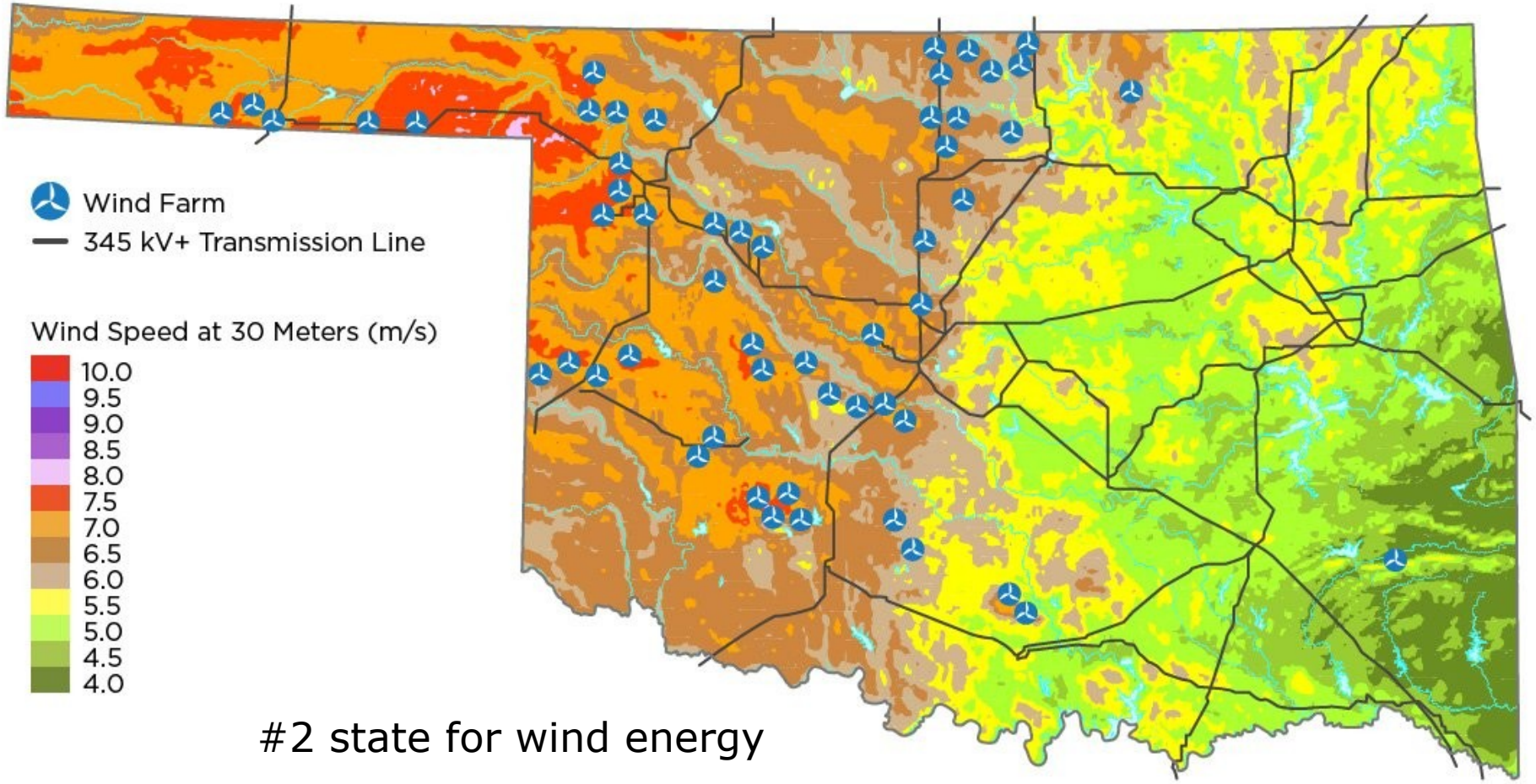
Solar isn't the best here, but it's still viable



Sengupta, M., Xie, Y., Lopez, A., Habte, A., Maclaurin, G., and Shelby, J., 2018, "The National Solar Radiation Data Base (NSRDB)," Renewable and Sustainable Energy Reviews, **89**, pp. 51–60.

Oklahoma's Energy Transitions

"Where the wind comes sweeping down the plains"



#2 state for wind energy

[1] Oklahoma Department of Commerce, "Renewable Energy," Oklahoma Department of Commerce [Online]. Available: https://www.okcommerce.gov/doing-business/business-relocation-expansion/industry-sectors/renewable-energy/. [Accessed: 22-Jan-2024].
[2] The Office of the Secretary of Energy & Environment, 2021, *Oklahoma State Energy & Environment Plan 2021*, Oklahoma City, OK.

Oklahoma's Energy Transitions

This is not just one group's land

Home › Legal › Federal judge orders removal of wind turbines from Osage Mineral Estate

Legal

News

Federal judge orders removal of wind turbines from Osage Mineral Estate

OMC Chairman Everett Waller: "We will defend the Mineral Estate against anyone that does not comply with the law and tries to take our lands and resources"

Written by **Allison Herrera, Freelance Author**

✉ aherrera@osagenation-nsn.gov

Why you can trust Osage News

December 21, 2023 — 5541 Views

Eighty-four wind turbines have been ordered to be removed from the Osage Mineral Estate after a 12-year legal battle. Osage News File Photo

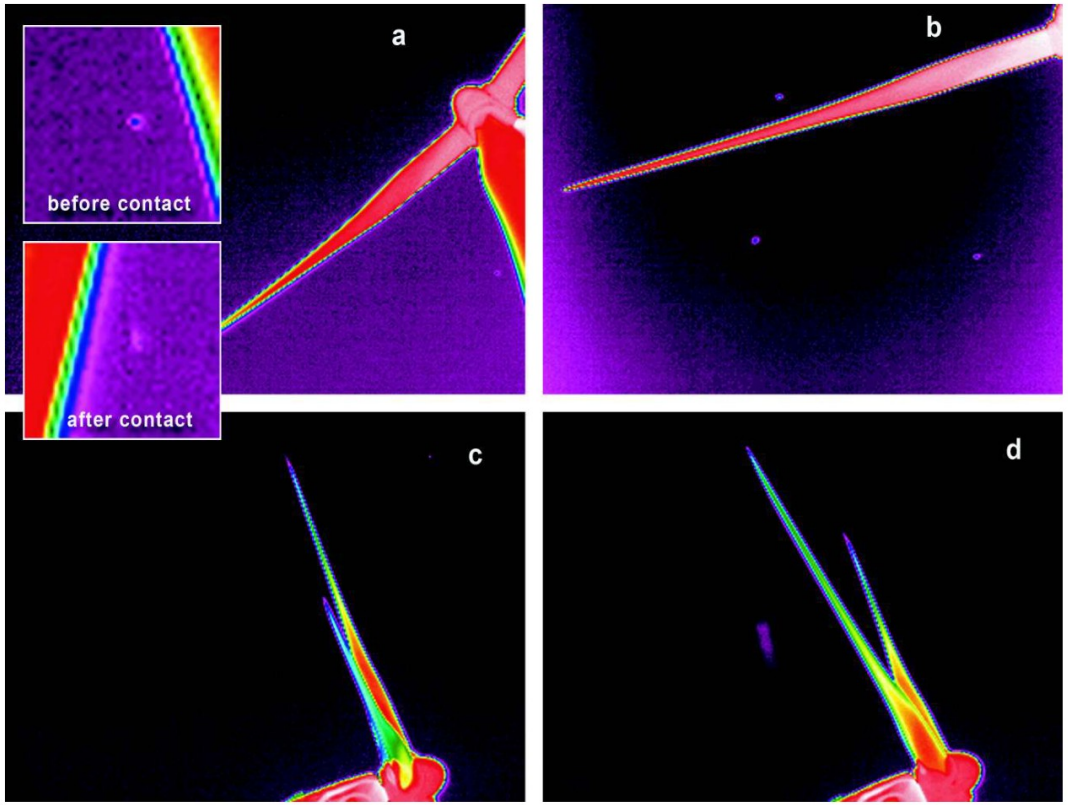
A nearly decade-long case that wound its way through state and federal courts could be over after a federal judge ruled the wind turbines on the Osage Reservation constituted continued trespass.

U.S. District Court Judge Jennifer Choe-Graves ordered wind turbines located north of Pawhuska on the Burbank Field to be removed and said their continued presence on the

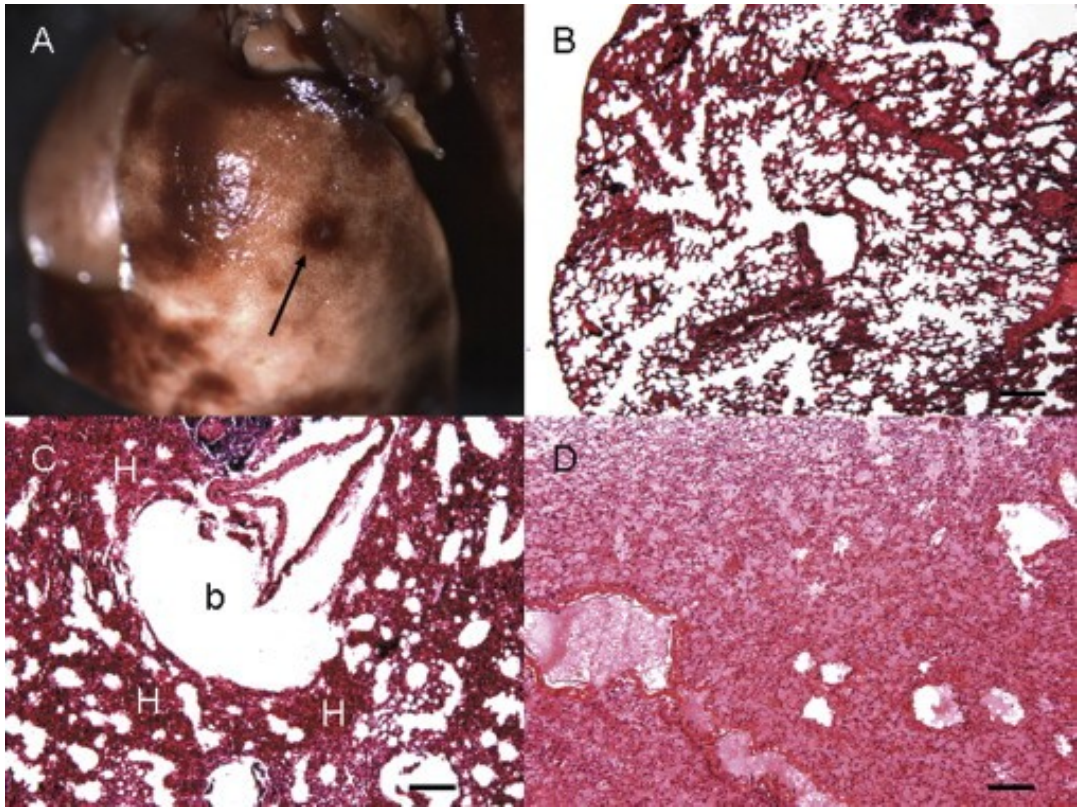
Herrera, A., 2023, "Federal Judge Orders Removal of Wind Turbines from Osage Mineral Estate," Osage News.

Oklahoma's Energy Transitions

Wind energy is incompatible with aerial species



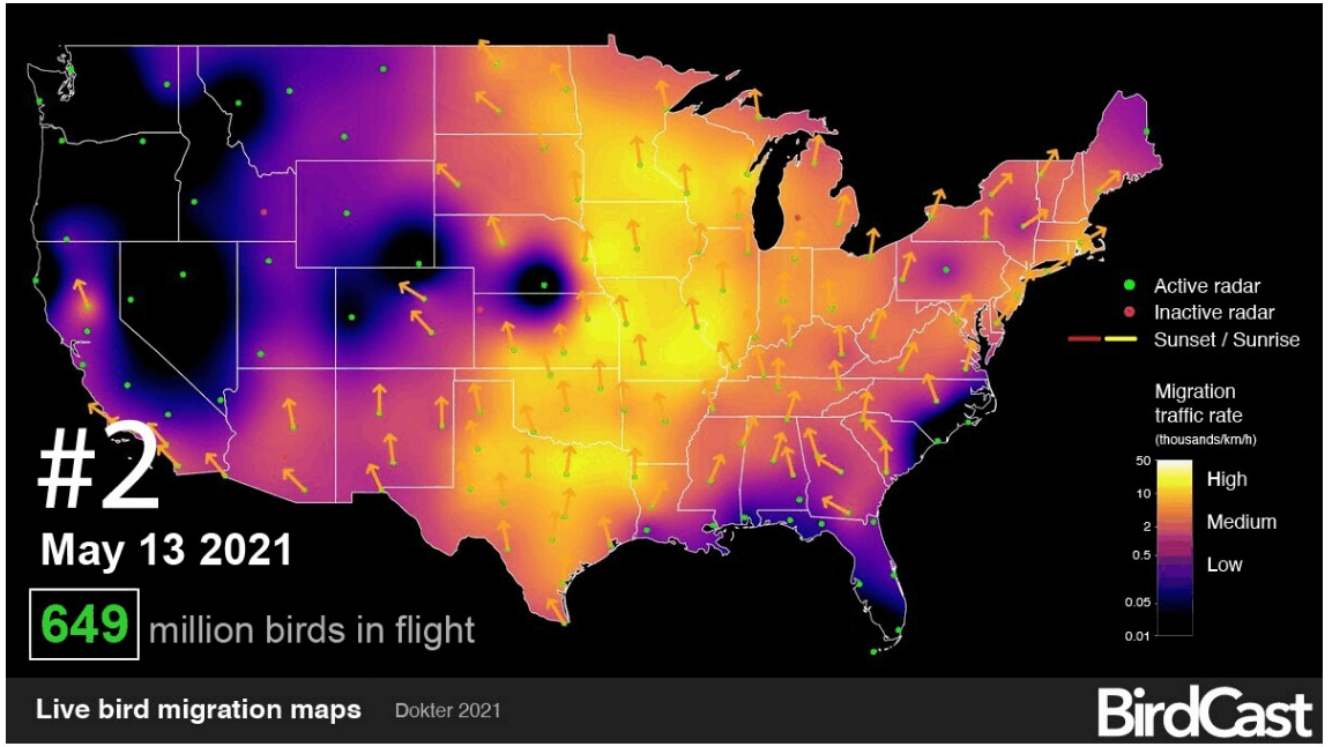
Horn, J. W., Arnett, E. B., and Kunz, T. H., 2008, "Behavioral Responses of Bats to Operating Wind Turbines," The Journal of Wildlife Management, **72**(1), pp. 123–132.



Baerwald, E. F., D'Amours, G. H., Klug, B. J., and Barclay, R. M. R., 2008, "Barotrauma Is a Significant Cause of Bat Fatalities at Wind Turbines," Current Biology, **18**(16), pp. R695–R696.

Oklahoma's Energy Transitions

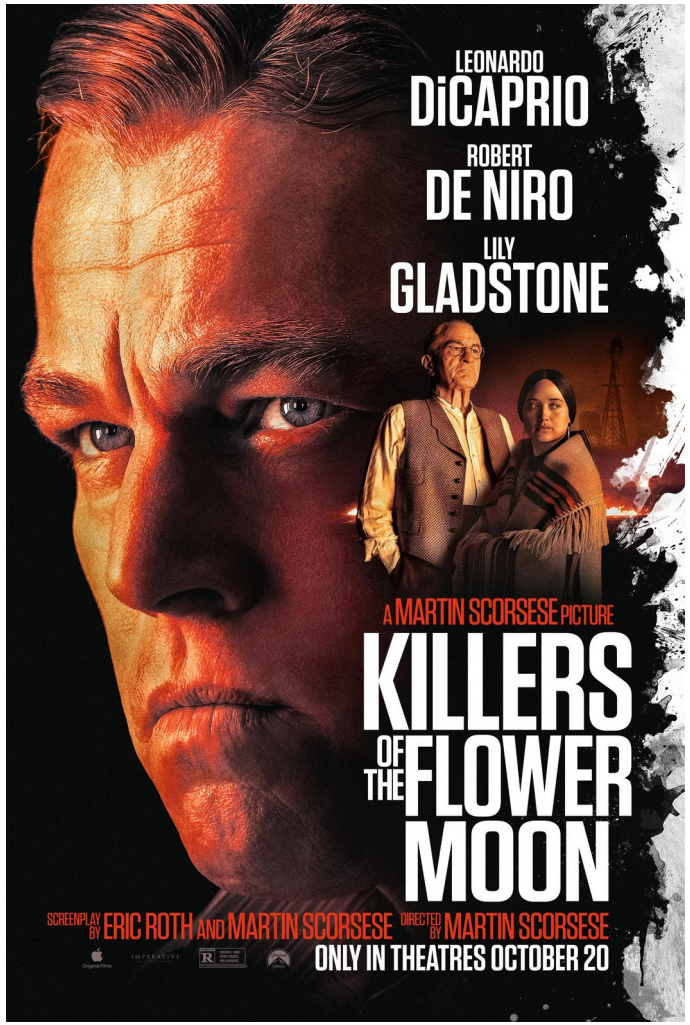
Oklahoma is in the Great Plains Flyway and We Can't Own the Sky

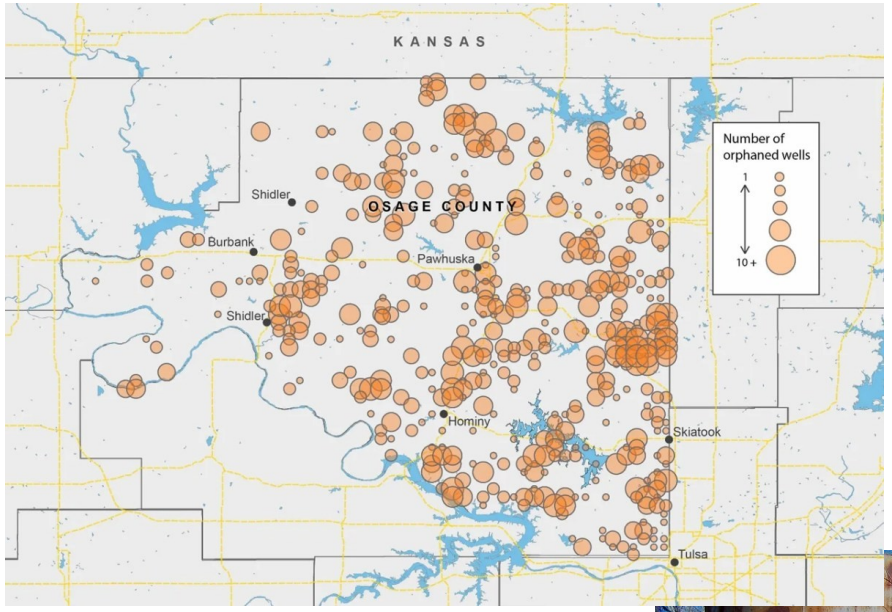


[1] Van Doren, B. M., and Horton, K. G., 2018, "A Continental System for Forecasting Bird Migration," Science, **361**(6407), pp. 1115–1118.
[2] May, R., Reitan, O., Bevanger, K., Lorentsen, S.-H., and Nygård, T., 2015, "Mitigating Wind-Turbine Induced Avian Mortality: Sensory, Aerodynamic and Cognitive Constraints and Options," Renewable and Sustainable Energy Reviews, **42**, pp. 170–181.
[3] Shipley, J. R., Kelly, J. F., and Frick, W. F., 2018, "Toward Integrating Citizen Science and Radar Data for Migrant Bird Conservation," Remote Sensing in Ecology and Conservation, **4**(2), pp. 127–136.

Oklahoma's Energy Transitions

The Lasting Legacy of the Oil Boom





Herrera, A., 2023, "2,600 Abandoned Oil Wells Are Leaking Toxins across the Osage Nation. Why Aren't They Being Plugged?," Fast Company.

2022, "Oklahoma to Receive $78 Million from Feds for Abandoned Well Cleanup Today." - Oklahoma Energy

Oklahoma's Energy Transitions

No Industry is Clean – Extraction of Environmental Capital Rarely Includes Cleanup

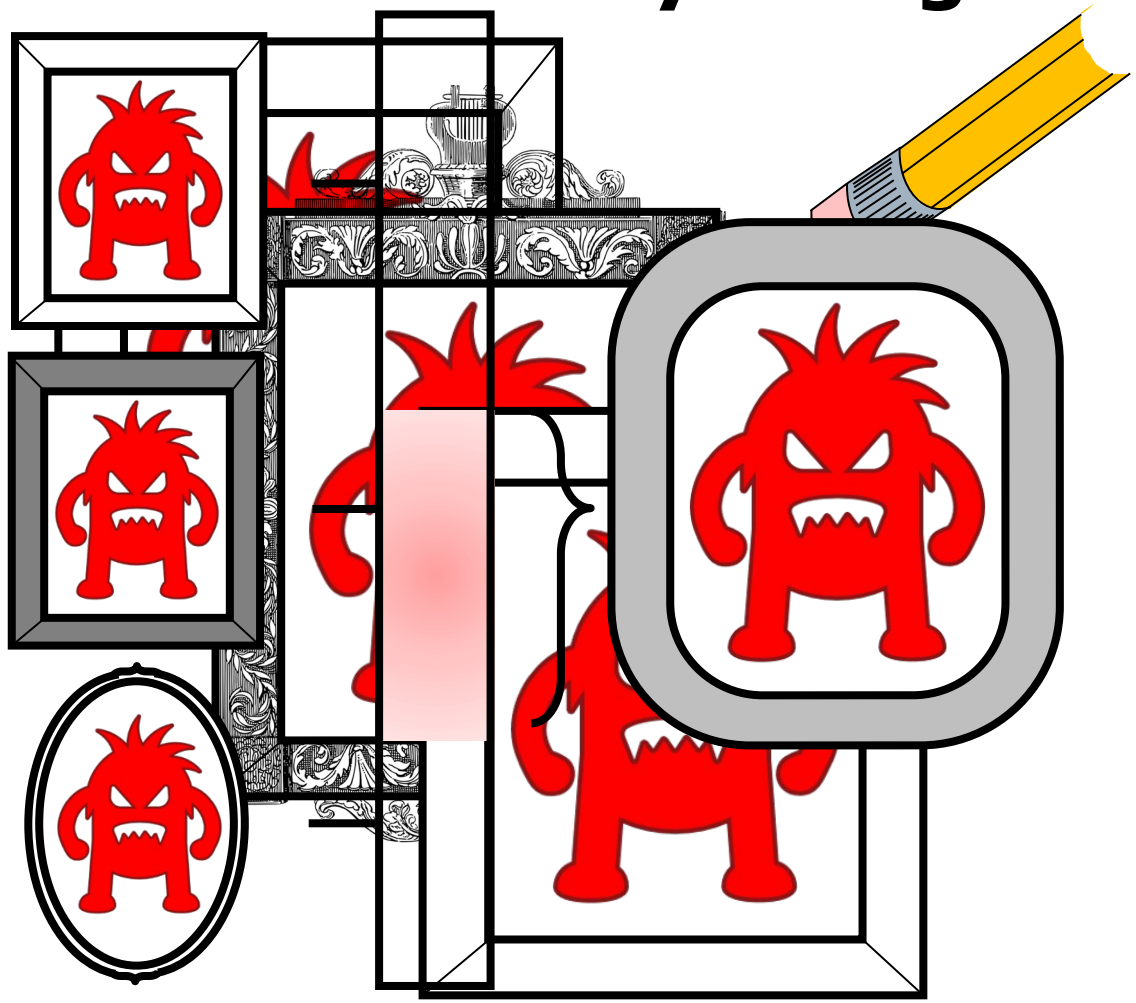
Money, J., "'What I Saw Gave Me Fear': As Public Safety Concerns Mount, What's next for Oklahoma Wind Farm?," The Oklahoman.

Engage: Oklahoma's Energy Transitions

Does it pass the Wicked Problem test?

Wicked Problem Test Question	✔/✖?	Give One or More Reasons
Does the challenge have many origins?	Yes✔	
Does the challenge exist across domains?	Yes✔	
Does the challenge involve many demographics?	Yes✔	
Is the challenge nested within itself?	Yes✔	
Is the challenge irreducibly complex?	Yes✔	
Does the system change when we act?	Yes✔	
Will any solution be permanent?	No✔	
Are we able to test the entire system?	No✔	
Is there an optimum solution?	No✔	

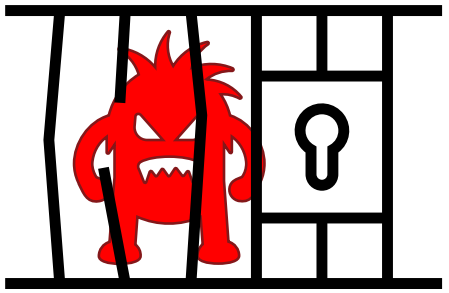
Key Design Requirements



- Correctly framing a problem is as crucial as a complete description—design options are dependent on formulation quality.
- Minimized computational complexity allows contextualization of the problem.
- Model processing must be iterative for an evolving system, including assimilation of physical measurements and simulations.
- Recommending multiple alternatives with consequences of their implementation gives the best options to stakeholders.
- A single solution is impossible for an evolving and complex problem. Policymakers must have agency to adjust for drift and shift in group preferences.

Addressing the Monster

Policymakers, designers, and researchers experience challenges when addressing Wicked Problems



Effective Formulation and Exploration of Satisficing Solution Space

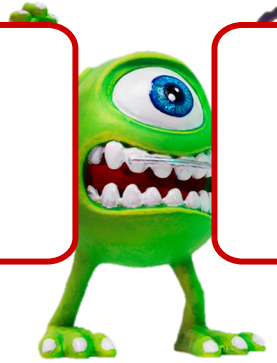
WICKED PROBLEM

Key variables across the verticals

Impact of variables on goals

Reduction of variables in the model

Model significant interactions



Analysis and Formulation

EFFECTIVE STEPS IN ADDRESSING A WICKED PROBLEM

Robust Satisficing Solutions

Design Options

Addressing Wicked Problems by exploring design options through robust satisficing solutions.

Generalizing From Design Principles

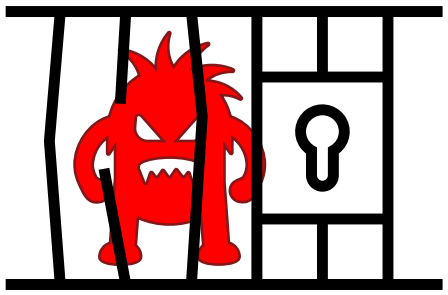
Research objectives

1. Can "design principles" be used to generate options based on preferences and objectives for public/social entities?
2. At a general level, what are key issues to converge design engineering and decisions made by public/social entities?

"Design Principles"
- What do the stakeholders actually use?
- Do we provide appropriate solutions?

…preferences, objectives, alternatives
- What do stakeholders actually want?
- What is the taxonomy of stakeholders?
- Do the engineering design influence the stakeholders' preferences and objectives?

Key convergence issues
- What does NOT work when working with public entities?
- What are the gaps to acceptance of engineering design in public policy?



Dialog

You may study a Wicked Problem.
Does your research oeuvre pass the test?
How can you design solutions that address everything?

Wicked Problem Test Question	✔/✖?	Give One or More Reasons
Does the challenge have many origins?	Yes✔	
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