POWER & PEOPLE

SYMPOSIUM

Mapping Community Exposure to Energy Infrastructure

Insights from first-of-its-kind database for healthy and just energy transitions

MAY 7, 2024

Held at the BU Center for
Computing & Data Sciences,
665 Commonwealth Ave, Boston, MA

BOSTON UNIVERSITY

Institute for Global Sustainability
School of Public Health

POWER & PEOPLE

Understanding the Connection Between Energy Systems and Health

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Our thanks to:

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Agenda

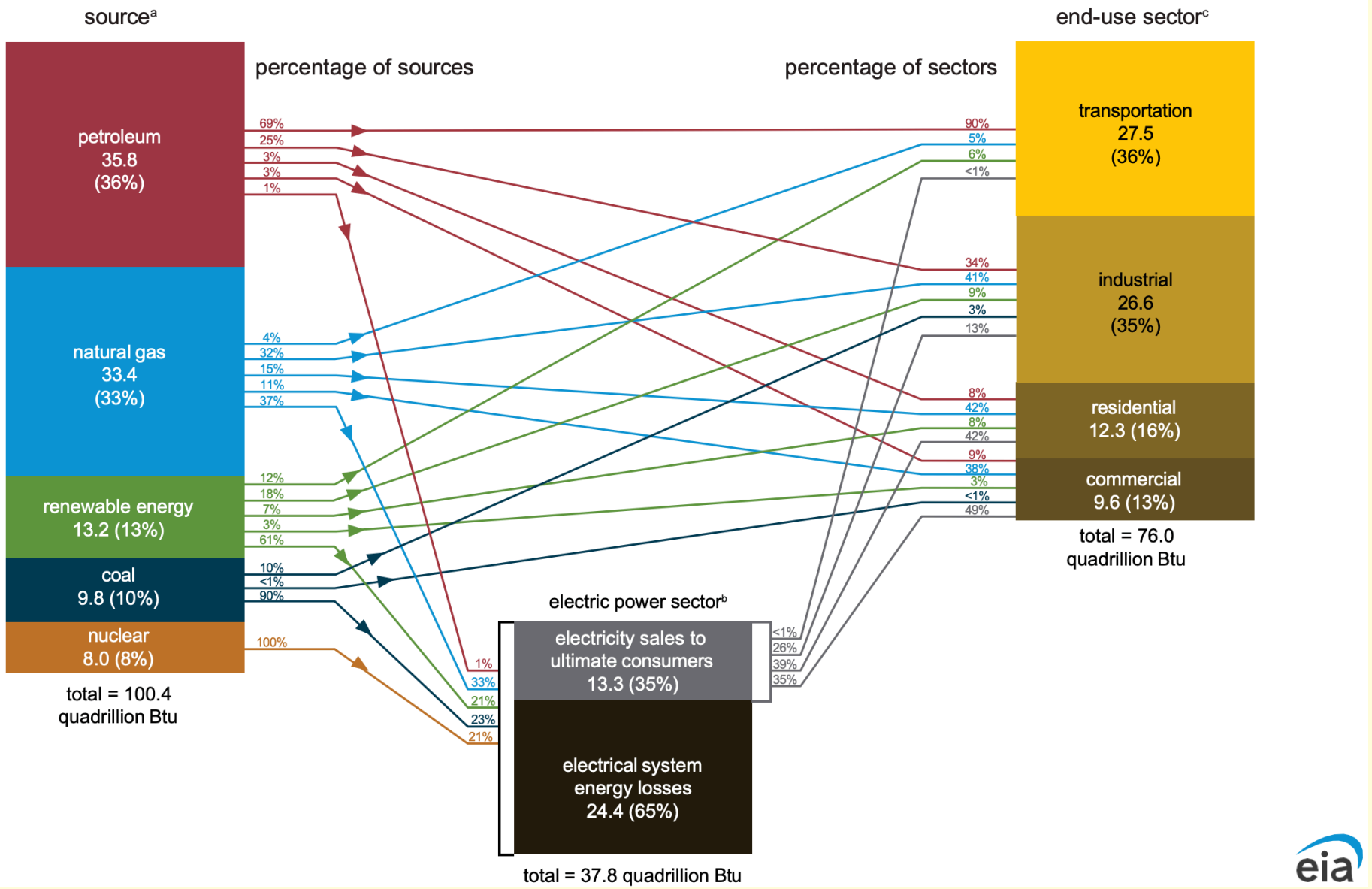
- 10:15a – 11a: Understanding the Connection Between Energy Systems and Health
- 11a – 11:15a: Coffee Break
- 11:15a – 12:15p: Introducing the Energy & Equity Exposure Database
- 12:15p – 1:15p: Lunch and poster session
- 1:15p – 2p: The Climate and Health Equity Co-benefits of Energy Infrastructure
- 2p – 3p: Energy Justice Hotspots and Epidemiology in Marginalized Communities
- 3p – 3:45p Closing Remarks and Cookies

Motivation and disclaimer

- Every piece of infrastructure has its own history and context
- Local community knowledge is key
- We are not necessarily the local experts
- Goal is to understand **nationwide** patterns and impacts

U.S. energy consumption by source and sector, 2022

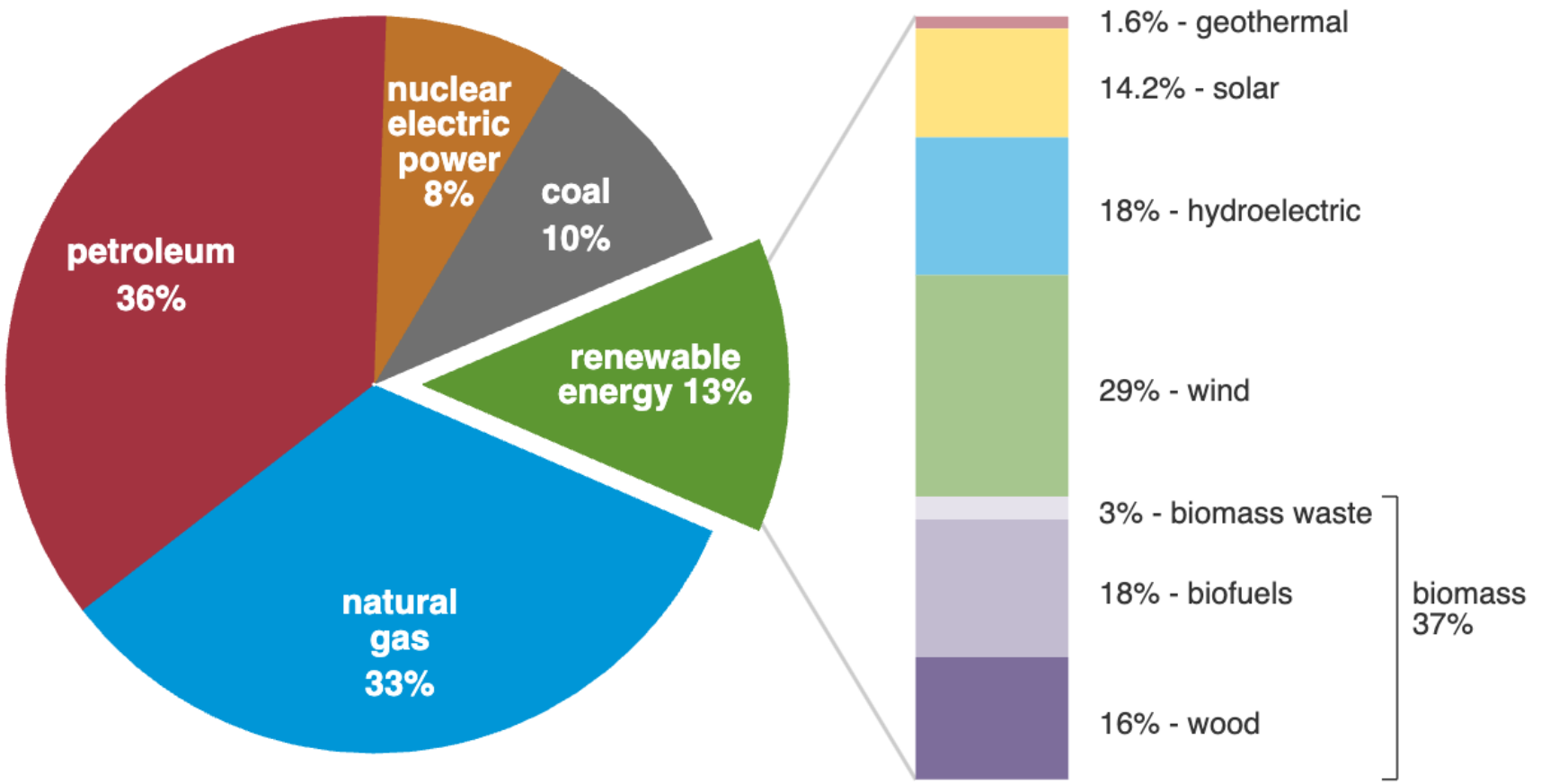
quadrillion British thermal units (Btu)



U.S. primary energy consumption by energy source, 2022

total = 100.41 quadrillion British thermal units (Btu)

total = 13.18 quadrillion Btu

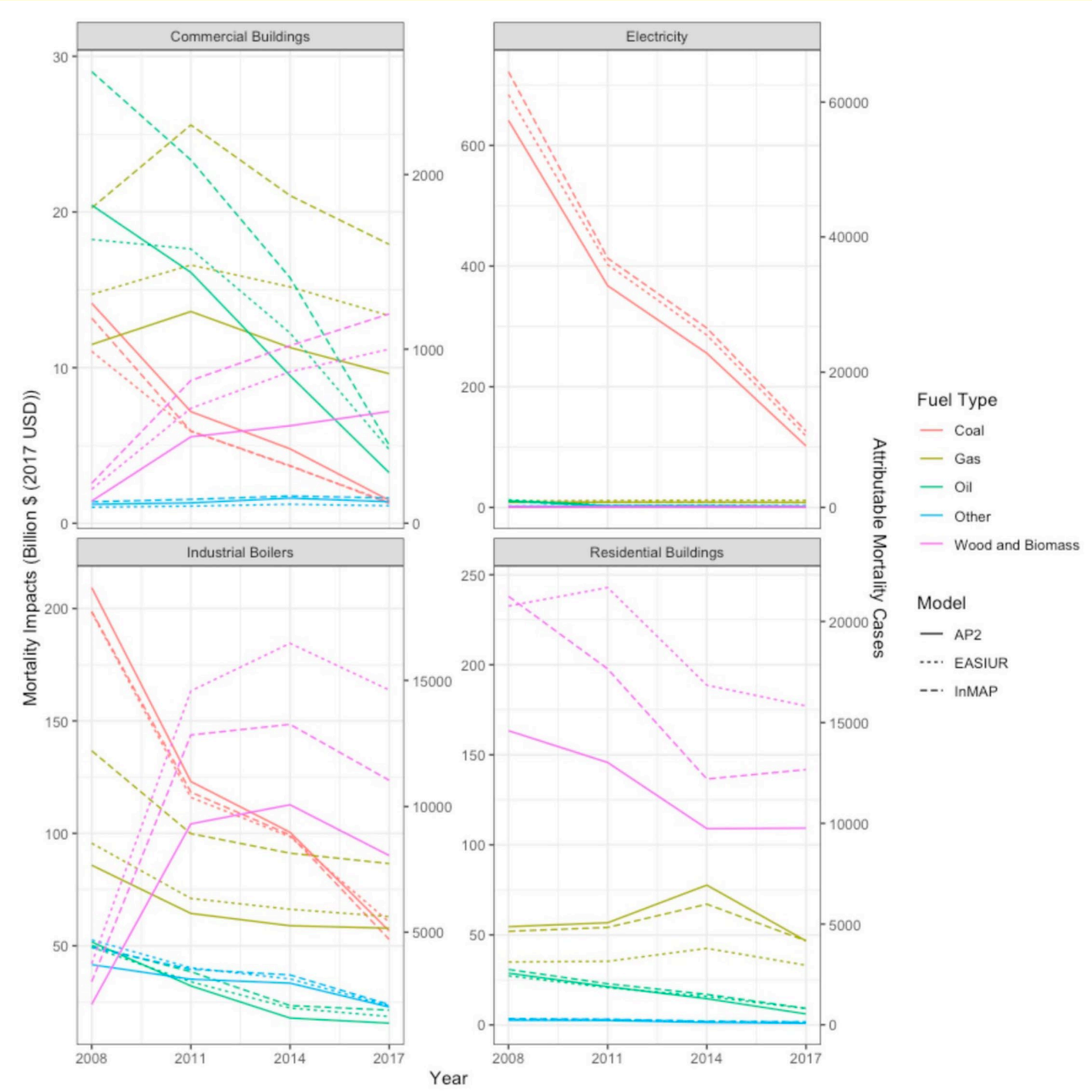


Data source: U.S. Energy Information Administration, *Monthly Energy Review*, Table 1.3 and 10.1, April 2023, preliminary data

Note: Sum of components may not equal 100% because of independent rounding.

Public Health Burdens Historically are Well-Understood

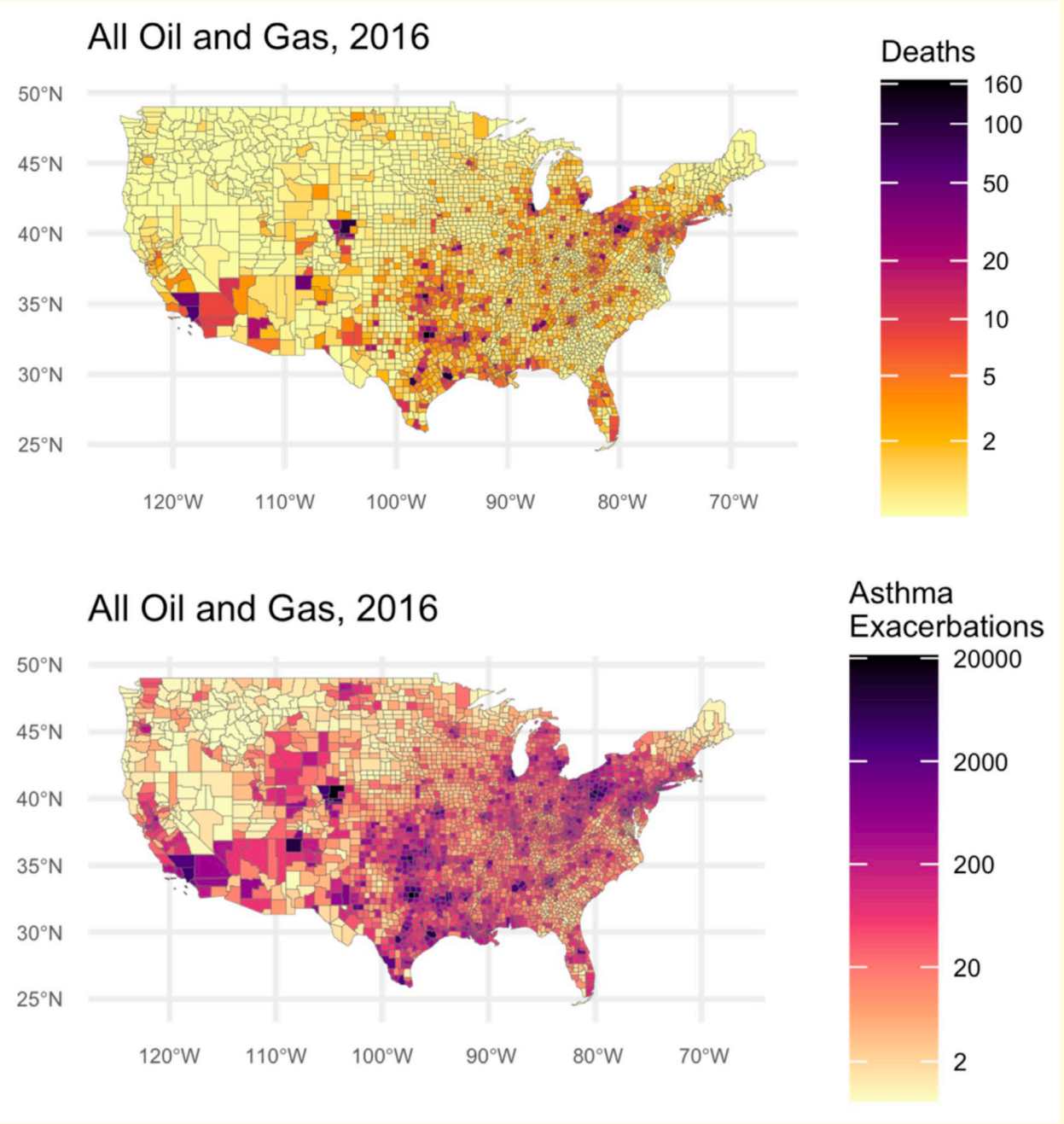
- Electricity: 59-66k in 2008 to 10-12k in 2017
- Industrial Boilers: 37-42k in 2008 to 22-29k in 2017
- Commercial Buildings: 4.2-5.9k in 2008 to 2-3.5k in 2017
- Residential Buildings: 22-29k in 2008 to 15-20k in 2017



Buonocore *et al.*, 2021

Health Impacts of Regional Air Pollution from Oil & Gas Production are Well-Understood

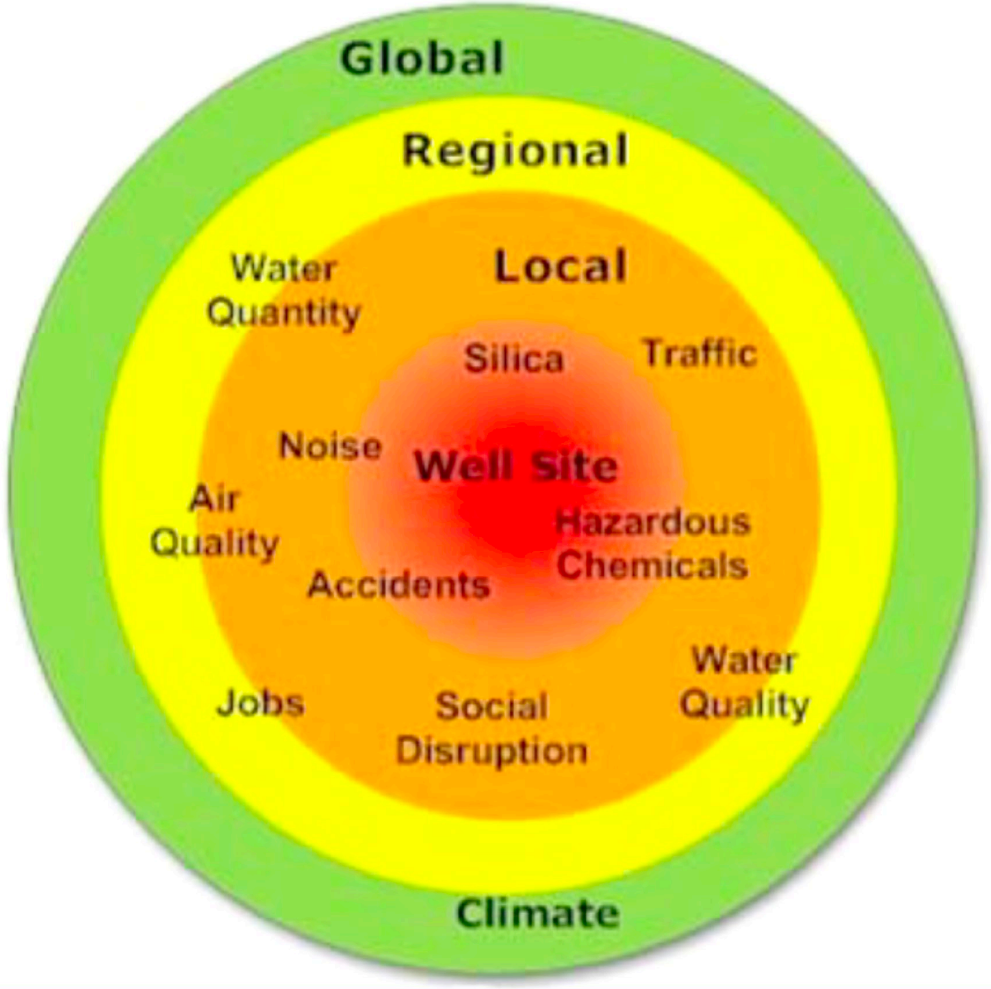
- 7,500 deaths (95% CI: 4,500 – 12,000)
- 410,000 asthma exacerbations (95% CI: 9,200 – 810,000)
- $77 billion in health impacts (95% CI: $27 – 170 billion)
- Combination of $PM_{2.5}$, NO_2, and ozone



State of Health Evidence

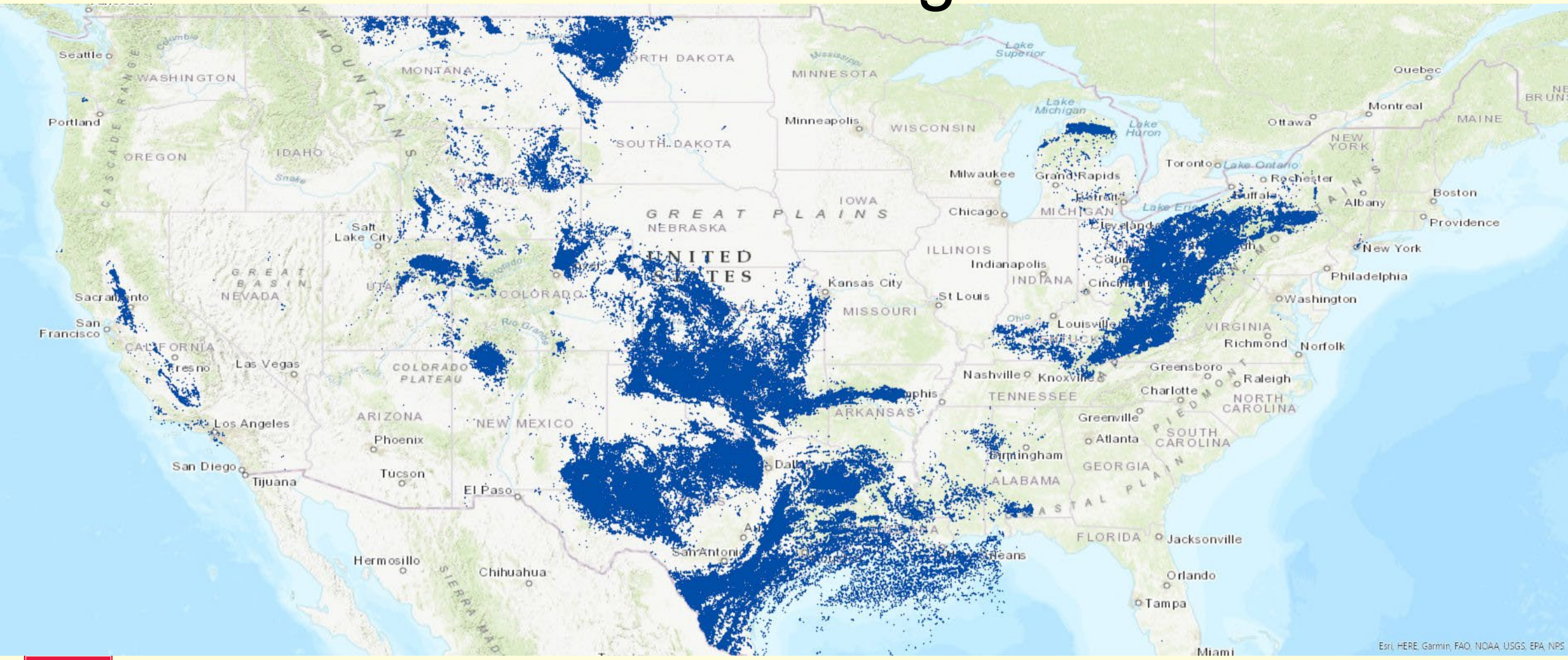
There is much more impact from oil & gas than just regional air pollution

- Surface water pollution
- Soil & groundwater contamination
- Noise & light pollution
- Nose, eye, and throat irritation
- Asthma
- Headaches and Fatigue
- Increased Hospitalizations
- Preterm birth, low birth weight, birth defects
- Childhood hematologic cancer



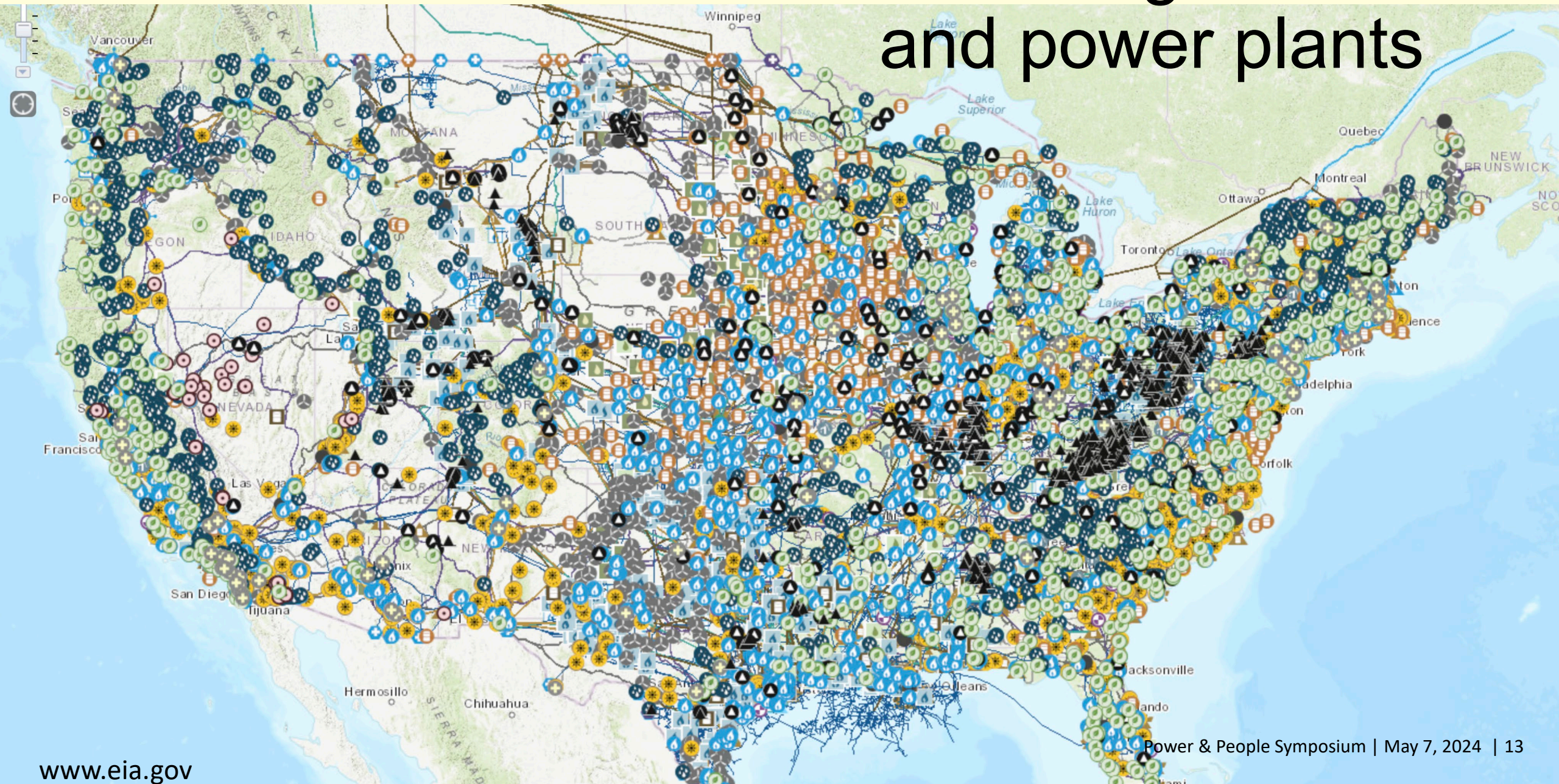
Adgate et al., 2014
Czolowski et al., 2017

~17.6 million people in the U.S. live within ~1 mile of an oil & gas site



Czolowski et al., 2017

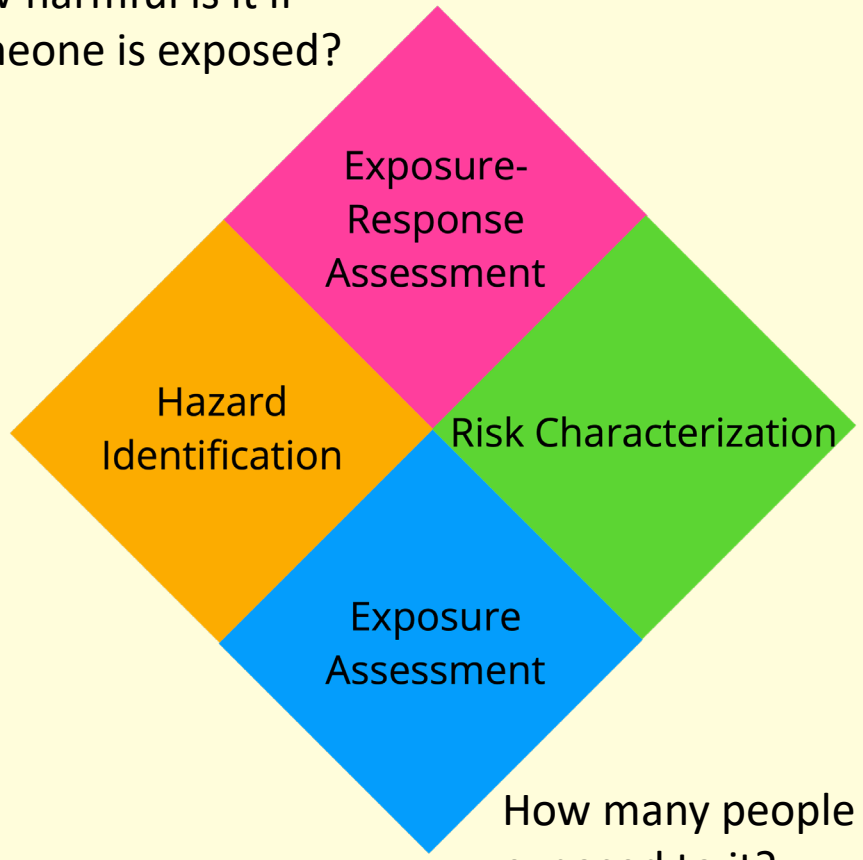
There is much more than oil & gas sites and power plants



www.eia.gov

How we (and the U.S. EPA) think about environmental health risks

How harmful is it if someone is exposed?

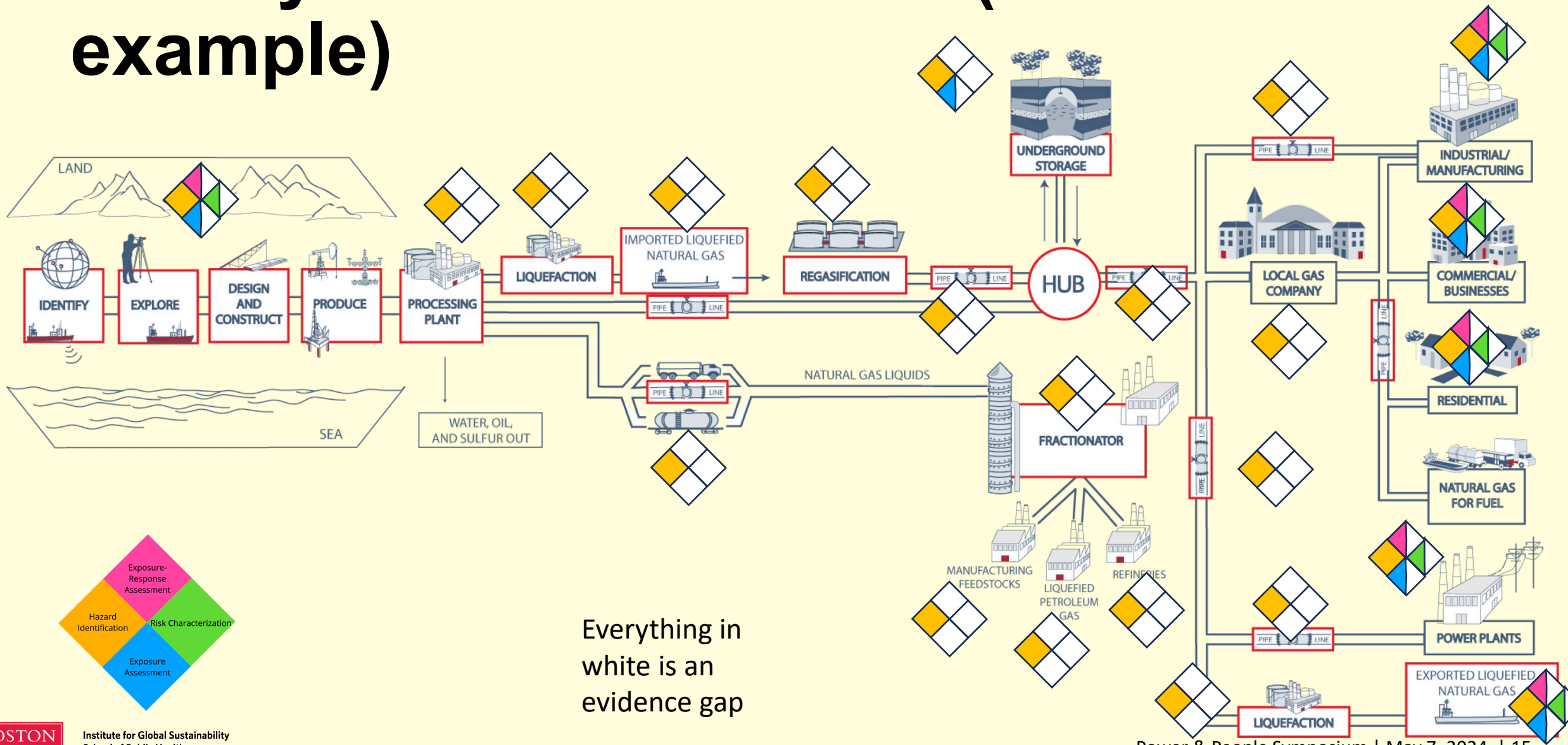


Is there something that might be harmful?

How big of a deal is this really?

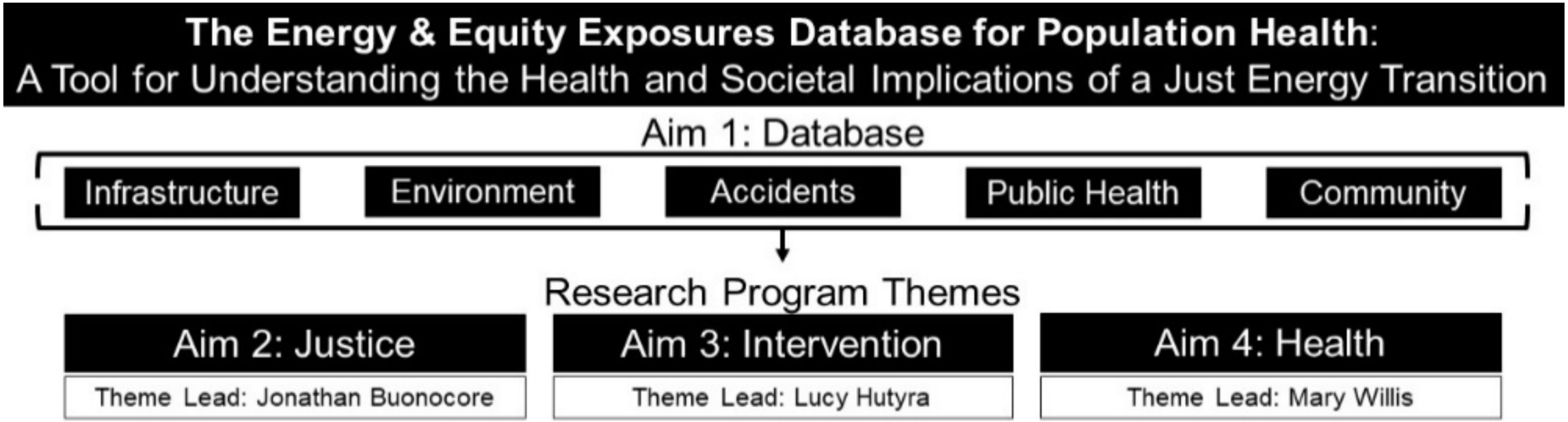
How many people are exposed to it?

Life Cycle of Natural Gas (as an example)



Everything in white is an evidence gap

Our Main Aims



Pervasive Infrastructure in Oil & Gas Regions

Oil storage tanks

Oil extraction well on standby

Two oil extraction wells on standby, next to disassembled pipeline

Photos from in and around Warren, PA, by Jonathan Buonocore

Pervasive Infrastructure in Oil & Gas Regions

Oil extraction well near a dirt road

Active oil well in a cemetery leaking gas

Oil well behind a wooden fence in a cemetery

Photos from in and around Warren, PA, by Jonathan Buonocore

Pervasive Infrastructure in Oil & Gas Regions

Valves and pipes associated with East Brach Storage, LLC an underground gas storage facility in Ludlow, PA.

Photos from in and around Ludlow, PA, by Jonathan Buonocore

Pervasive Infrastructure in Oil & Gas Regions

A refinery and oil wells in very close proximity to homes

Photos from in and around Warren, PA, by Jonathan Buonocore

Our goal was to create:

A database of energy infrastructure in the U.S. that is:

- Harmonized and consistent
- Inclusive of all energy types
- Inclusive of entire energy life cycle/supply chain

And then construct:

- An index of intensity of exposure to different energy infrastructure, differentiated by fuel type and location in supply chain

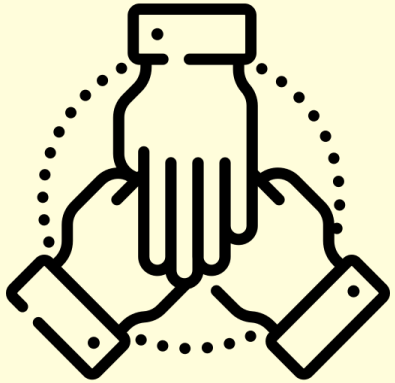
And then:

- Perform case studies demonstrating utility of this dataset for environmental justice, renewable energy policy, and health

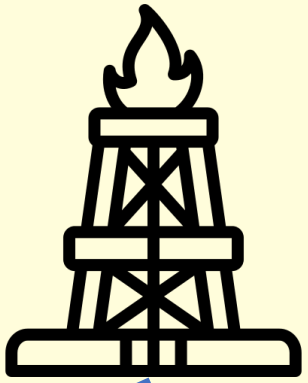
Multidimensional Community Impacts

Economic

Demographic

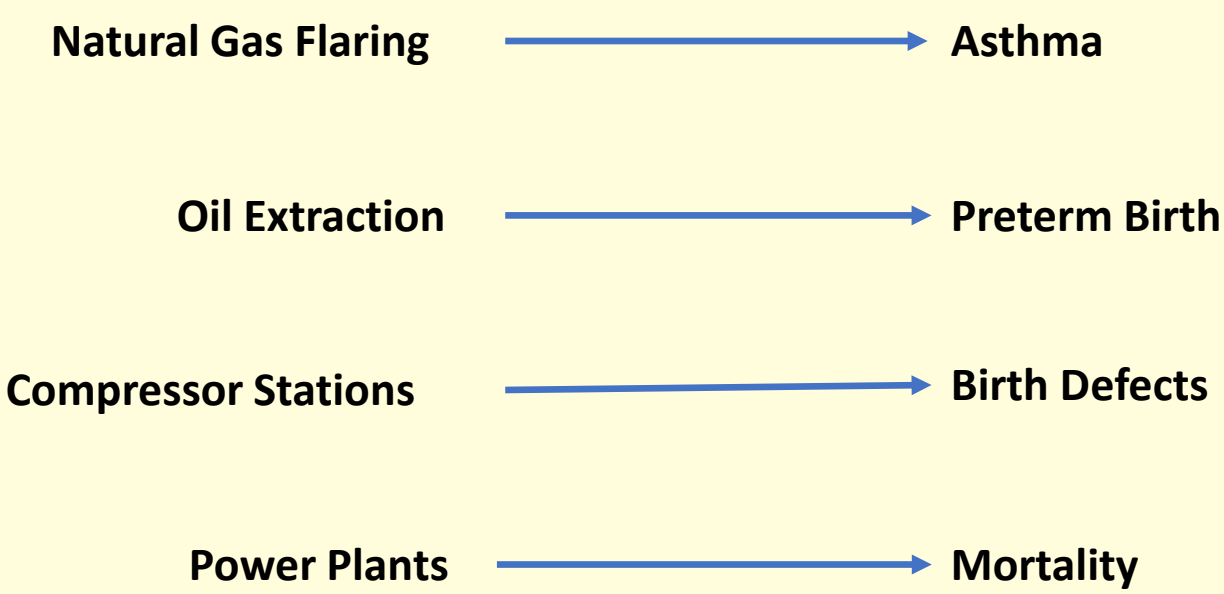


Environment

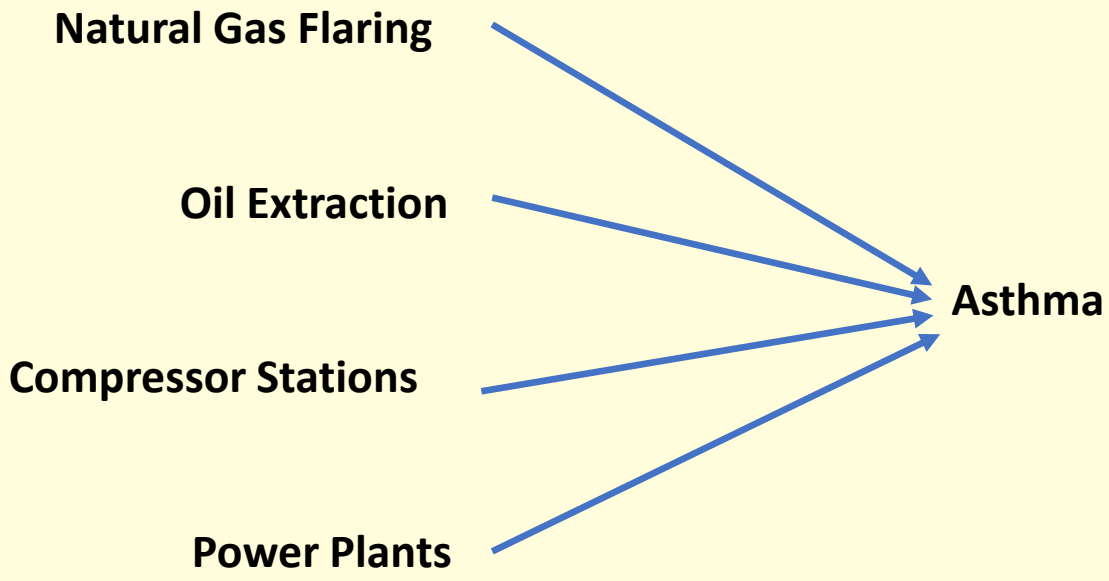


Population Health

Typical studies examine one potential hazard at a time…



… however, in reality, there are often several hazards occurring at once



This analysis is tricky to perform without a comprehensive, harmonized database

Motivation and Relevance: Current Impacts

- Fuller understanding of health and environmental justice impacts of energy ***systems***, rather than individual hazards or pieces of infrastructure
- Expand focus of health research to all components of fossil fuel ***supply chains***
- Compare health and justice implications across ***different energy types***

Motivation and Relevance: Energy System Transitions

- ***Prioritize communities*** for renewable energy infrastructure
- ***Better siting*** of future energy and climate infrastructure – renewable energy, carbon capture and storage pipelines, among others
- Understand health impacts of ***legacy, decommissioned, and retired infrastructure*** in order to mitigate impacts of decommissioning existing energy systems

Sample Research Directions

- **Population characterization for many pieces of energy infrastructure** – how many people live near these structures?
- **Environmental justice evaluation of communities near energy infrastructure** – to what extent are persistently marginalized groups disproportionately burdened?
- **Exposure assessment to ascertain emissions** – what levels of key pollutants are emerging from the understudied pieces of infrastructure?
- **Epidemiologic analysis to understand health effects** – how do the emissions from the energy sector influence population health?
- **Accountability studies of energy policy decisions** – to what extent does a given policy protect population health, including persistently marginalized communities?

However, this effort has proven to be challenging…

- Missing/confidential/secure infrastructure
- Multiple Federal agencies with jurisdiction
- Lacking temporality (when were things built, active, etc..)
- Lack of consistent data on environmentally-relevant activity (no emissions data, water injection in wells, resource use, etc.)
- Differences in state reporting
- Higher quality data exists… but it's behind paywalls (and data use agreements)
- Not much coordinated national energy policy – lots of agencies involved!

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Introducing the Energy & Equity Exposure Database

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Research Team

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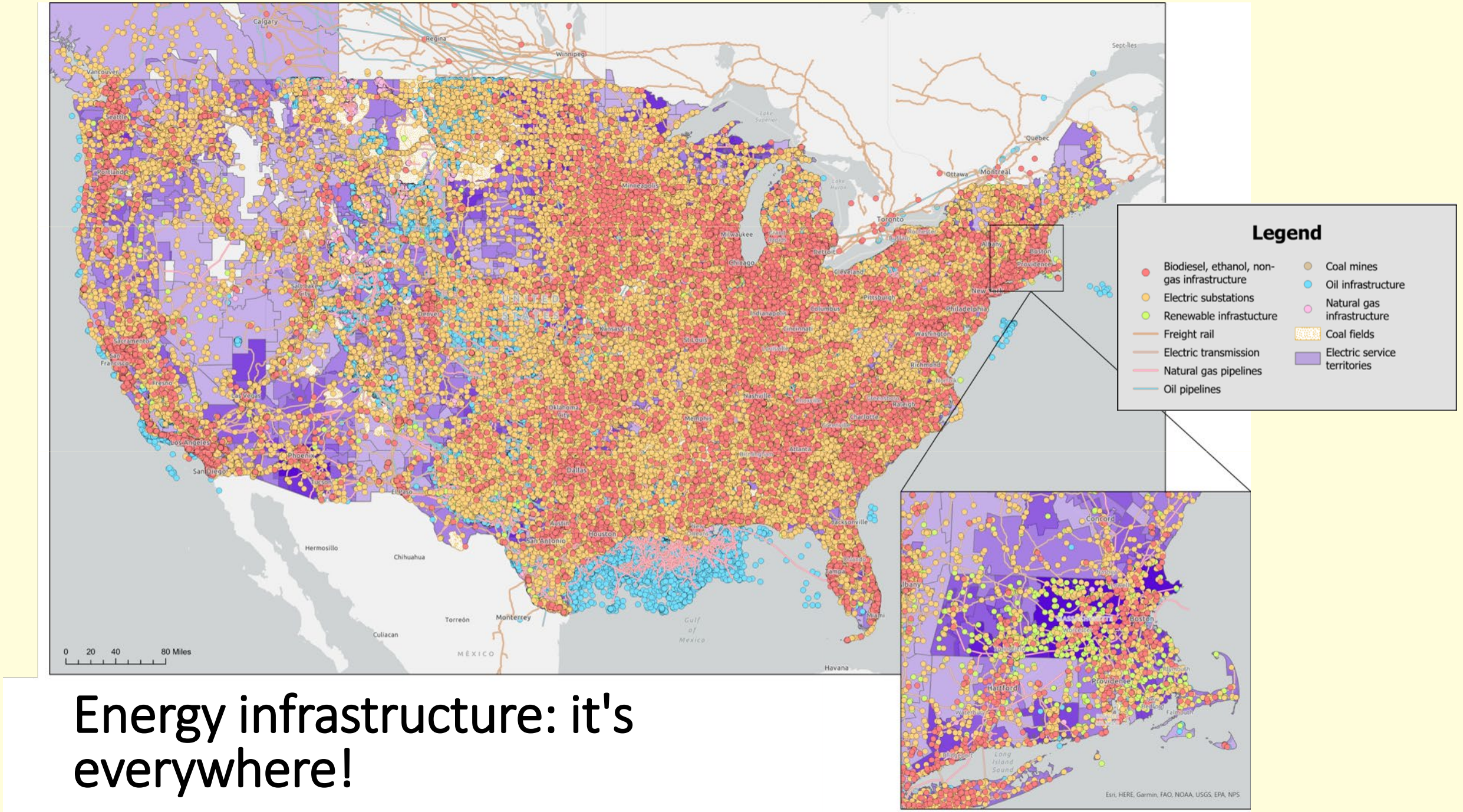
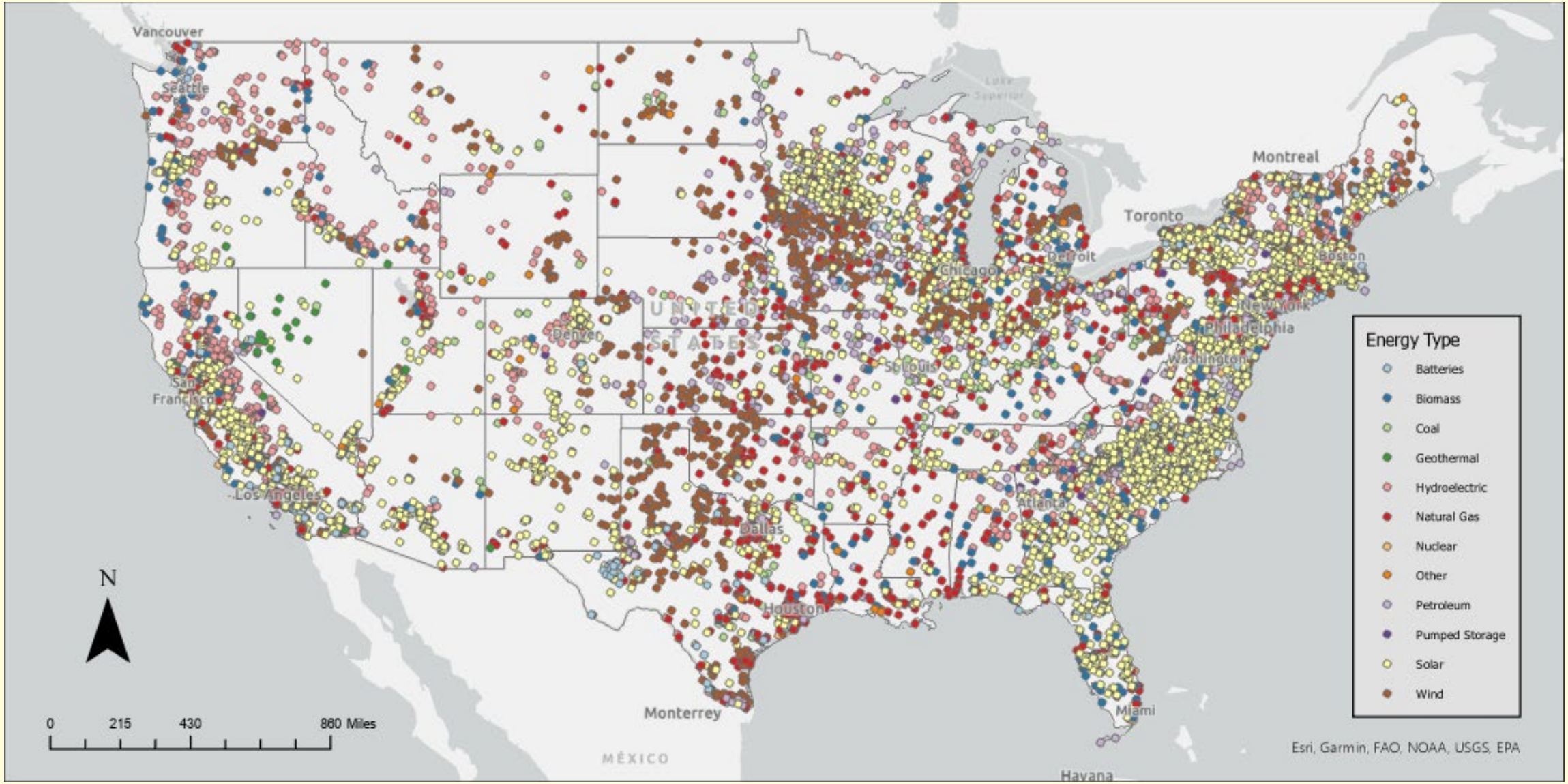
Breanna van Loenen, BA



Energy infrastructure: it's everywhere!

Power Plants in the U.S. by Energy Type

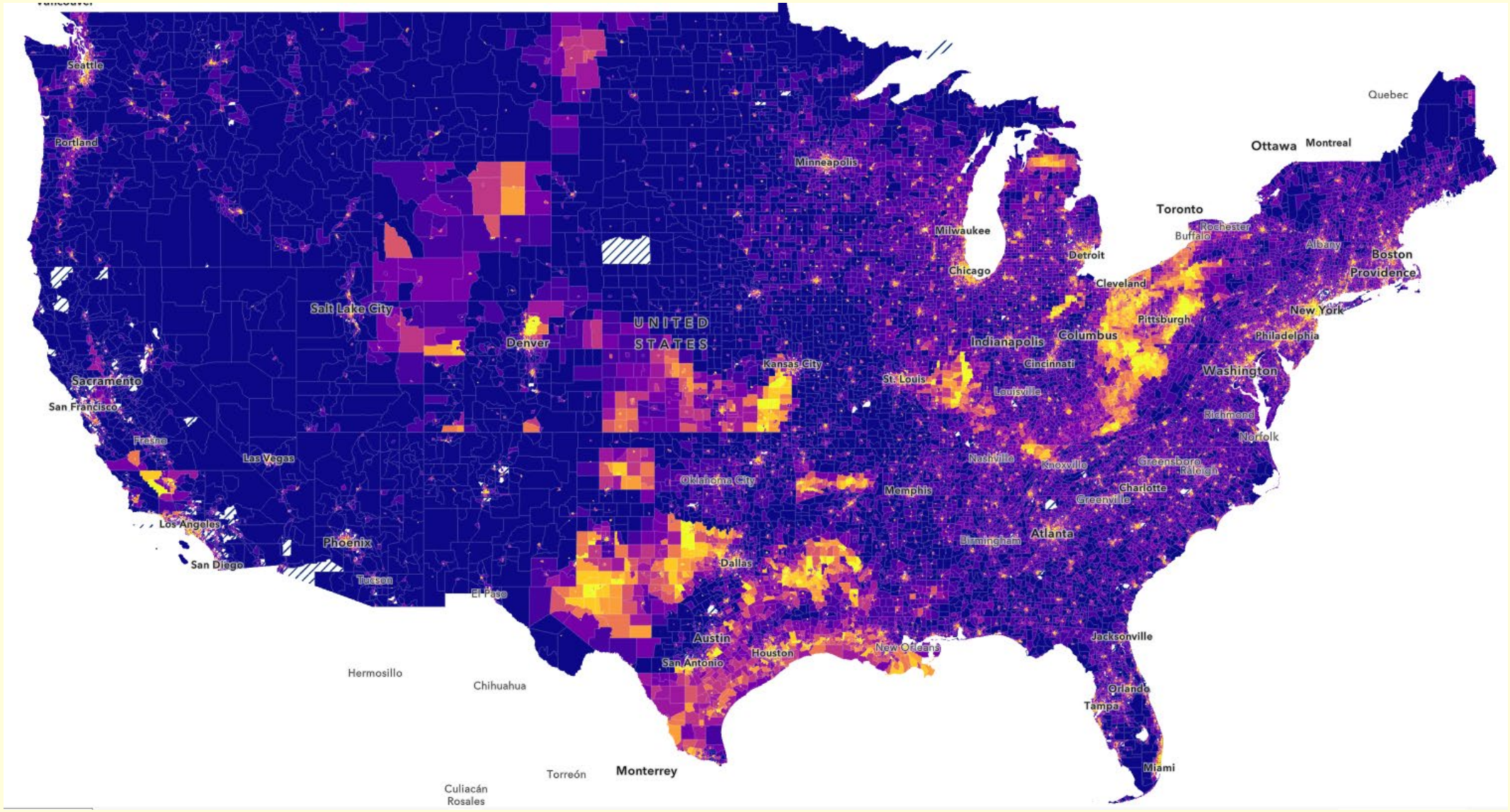


Energy Type	Extraction	Processing	Storage and Transmission	Distribution	End Use
Coal	Mines	Rail (not included)			Power plants
Oil & gas	Well sites	Processing plants, Refineries, Flaring	LNG storage, Petroleum Reserves, Peak Shaving Facilities, Terminals (Product, Rail, Import/Export), Market Hubs, Compressor Stations, Pumping Stations, Underground Storage, Ports	Delivery Points, Gasoline storage tanks	Power plants, homes (not included), industrial sites (not included)
Biomass		Biodiesel and ethanol plants	Intermodal freight facilities		
Non-emitting Renewables					Power plants
Electricity			Power lines	Power lines	

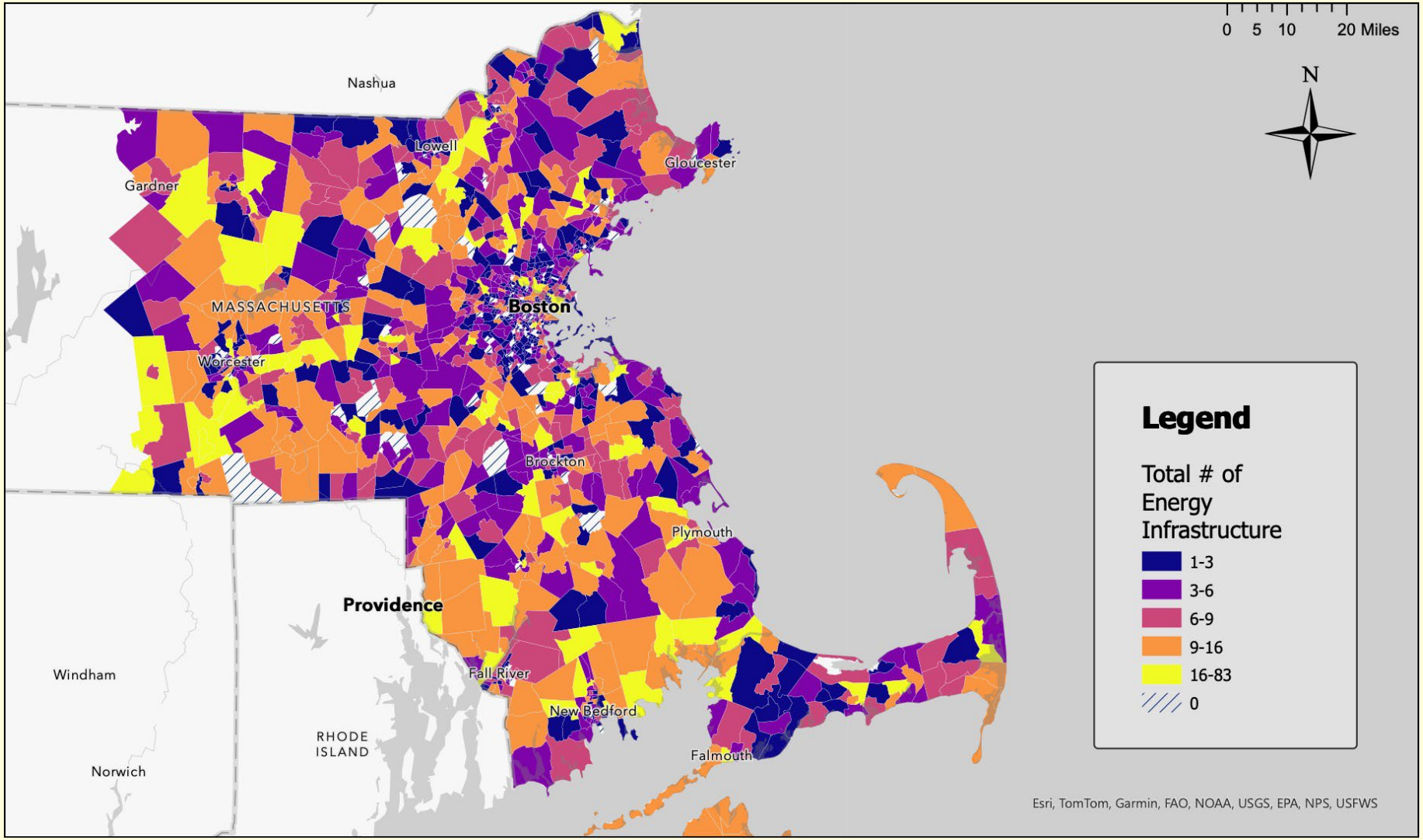
	Overall (N=41)	Natural Gas (N=11)	Natural Gas, Oil (N=7)	Oil (N=10)
Source				
Environmental Protection Agency	1 (2.4%)	0 (0%)	0 (0%)	0 (0%)
Homeland Infrastructure Foundation Level Data (HIFLD)	28 (68.3%)	9 (81.8%)	6 (85.7%)	4 (40.0%)
National Transportation Atlas Database (NTAD) from Dep. of Transportation	1 (2.4%)	0 (0%)	0 (0%)	0 (0%)
U.S. Energy Information Administration	11 (26.8%)	2 (18.2%)	1 (14.3%)	6 (60.0%)
Vintage_of_Data				
Mean (SD)	2020 (4.86)	2020 (3.57)	2020 (2.37)	2020 (1.26)
Median [Min, Max]	2020 [2000, 2020]	2020 [2010, 2020]	2020 [2020, 2020]	2020 [2020, 2020]
Missing	1 (2.4%)	0 (0%)	0 (0%)	0 (0%)
Year_Updated				
Mean (SD)	2020 (1.90)	2020 (2.30)	2020 (0.488)	2020 (1.43)
Median [Min, Max]	2020 [2020, 2020]	2020 [2020, 2020]	2020 [2020, 2020]	2020 [2020, 2020]
Missing	1 (2.4%)	0 (0%)	0 (0%)	0 (0%)
Highest_Geographic_Precision				
Third party	3 (7.3%)	1 (9.1%)	2 (28.6%)	0 (0%)
Within 166 ft	3 (7.3%)	2 (18.2%)	0 (0%)	1 (10.0%)
Within 40 ft	11 (26.8%)	3 (27.3%)	2 (28.6%)	3 (30.0%)
Missing	24 (58.5%)	5 (45.5%)	3 (42.9%)	6 (60.0%)
Intensity_Variable				
No	19 (46.3%)	3 (27.3%)	6 (85.7%)	4 (40.0%)
Yes	22 (53.7%)	8 (72.7%)	1 (14.3%)	6 (60.0%)
Number_of_Features				
Mean (SD)	74900 (264000)	56600 (172000)	316000 (575000)	503 (773)
Median [Min, Max]	993 [4.00, 1510000]	1260 [25.0, 573000]	7290 [89.0, 1510000]	196 [4.00, 2340]
Ownership_Variable				
No	17 (41.5%)	4 (36.4%)	2 (28.6%)	5 (50.0%)
Yes	24 (58.5%)	7 (63.6%)	5 (71.4%)	5 (50.0%)

	Overall (N=41)	Biodiesel (N=1)	Coal (N=3)	Electricity (N=6)	Ethanol (N=2)	Other (N=1)
Source						
Environmental Protection Agency	1 (2.4%)	0 (0%)	0 (0%)	1 (16.7%)	0 (0%)	0 (0%)
Homeland Infrastructure Foundation Level Data (HIFLD)	28 (68.3%)	1 (100%)	1 (33.3%)	4 (66.7%)	2 (100%)	1 (100%)
National Transportation Atlas Database (NTAD) from Dep. of Transportation	1 (2.4%)	0 (0%)	1 (33.3%)	0 (0%)	0 (0%)	0 (0%)
U.S. Energy Information Administration	11 (26.8%)	0 (0%)	1 (33.3%)	1 (16.7%)	0 (0%)	0 (0%)
Vintage_of_Data						
Mean (SD)	2020 (4.86)	2020 (NA)	2010 (7.51)	2020 (1.00)	2020 (2.12)	2010 (NA)
Median [Min, Max]	2020 [2000, 2020]	2020 [2020, 2020]	2000 [2000, 2010]	2020 [2020, 2020]	2020 [2020, 2020]	2010 [2010, 2010]
Missing	1 (2.4%)	0 (0%)	0 (0%)	1 (16.7%)	0 (0%)	0 (0%)
Year_Updated						
Mean (SD)	2020 (1.90)	2020 (NA)	2020 (3.46)	2020 (0.837)	2020 (1.41)	2020 (NA)
Median [Min, Max]	2020 [2020, 2020]	2020 [2020, 2020]	2020 [2020, 2020]	2020 [2020, 2020]	2020 [2020, 2020]	2020 [2020, 2020]
Missing	1 (2.4%)	0 (0%)	0 (0%)	1 (16.7%)	0 (0%)	0 (0%)
Highest_Geographic_Precision						
Third party	3 (7.3%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Within 166 ft	3 (7.3%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Within 40 ft	11 (26.8%)	1 (100%)	0 (0%)	0 (0%)	2 (100%)	0 (0%)
Missing	24 (58.5%)	0 (0%)	3 (100%)	6 (100%)	0 (0%)	1 (100%)
Intensity_Variable						
No	19 (46.3%)	0 (0%)	2 (66.7%)	2 (33.3%)	1 (50.0%)	1 (100%)
Yes	22 (53.7%)	1 (100%)	1 (33.3%)	4 (66.7%)	1 (50.0%)	0 (0%)
Number_of_Features						
Mean (SD)	74900 (264000)	312 (NA)	712 (251)	35600 (40200)	278 (50.2)	16900 (NA)
Median [Min, Max]	993 [4.00, 1510000]	312 [312, 312]	630 [512, 993]	12600 [2950, 94200]	278 [242, 313]	16900 [16900, 16900]
Ownership_Variable						
No	17 (41.5%)	0 (0%)	3 (100%)	2 (33.3%)	0 (0%)	1 (100%)
Yes	24 (58.5%)	1 (100%)	0 (0%)	4 (66.7%)	2 (100%)	0 (0%)

Infrastructure counts by census tract



Infrastructure counts by census tract (zoomed in to Boston area)



Exposure

- Is there clustering within energy types? (e.g. do gas-fired power plants get sited in the same areas or are they spread out regionally?)
- Is there clustering between energy types? (e.g. are fossil-fueled power plants and renewable electricity generation sited in similar locations?
- How many people live in close proximity* to energy infrastructure?
- How many people live in close proximity* to multiple different types of energy infrastructure?
- How many people live in close proximity* to clusters of energy infrastructure of one or many types?

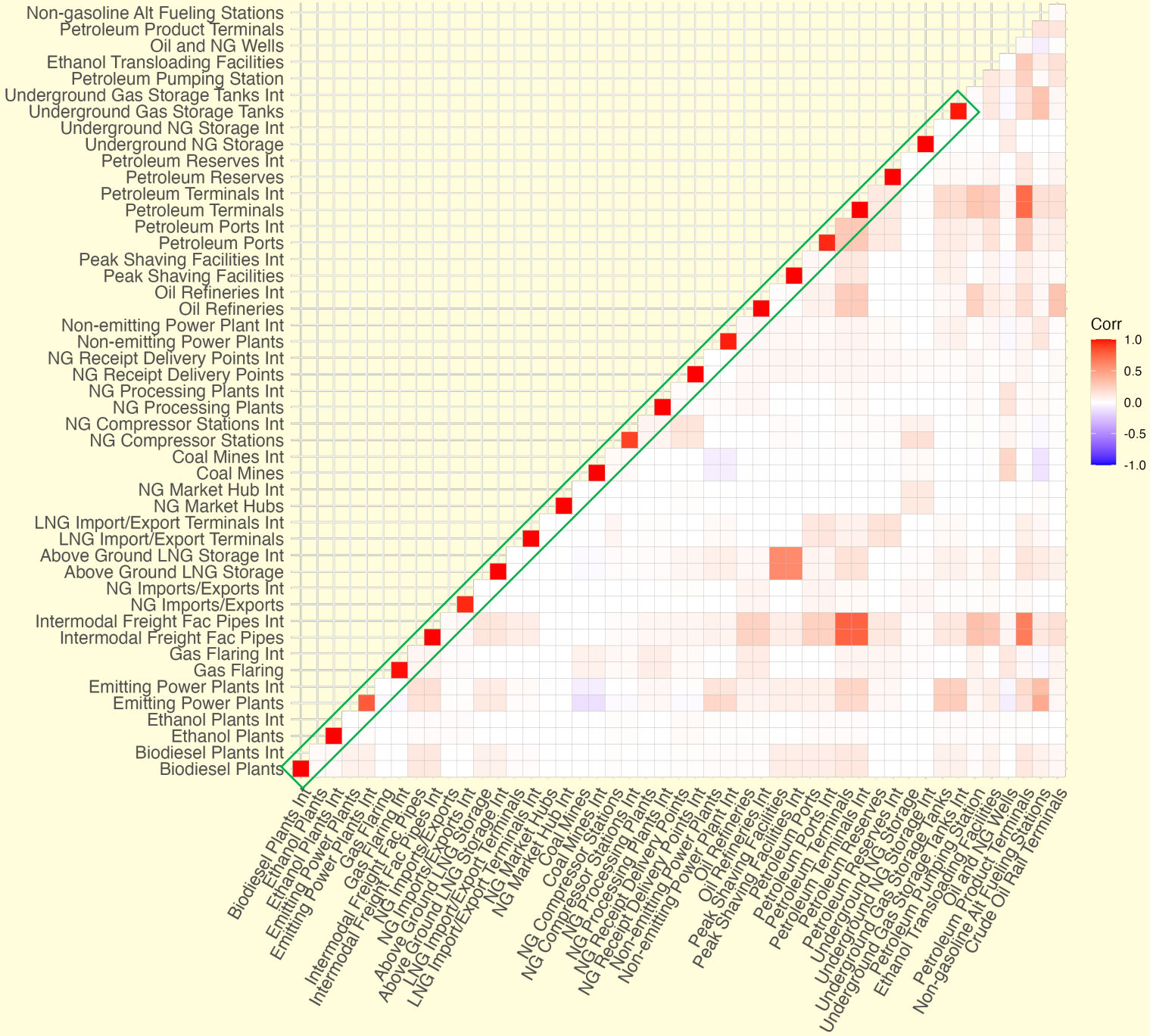
*appropriate definitions of “close proximity” is actively being debated in the literature and likely varies between different energy types; this project may be able to contribute

Data and Exposure Harmonization

- What data relevant to health and exposure is consistently available across all energy types?
- How can different types of activity and capacity data be harmonized both across supply chains and across energy types?
- How should exposure intensity to different types of energy infrastructure be harmonized, across a fuel supply chain? (e.g. is living near* 12 gas wells more or less harmful than living near* a 765-horsepower compressor station? What about twice as far from a 6000-horsepower compressor station?)
- How should exposure intensity to different types of energy infrastructure be harmonized across energy types? (e.g. is living near* a 50 MW gas-fired power plant more or less harmful than living near* a wind farm?)

Correlation Matrix

- Infrastructure counts and intensities are highly correlated
- Moderate correlations between types of petroleum infrastructure
- Low spatial correlation across the majority of infrastructure types



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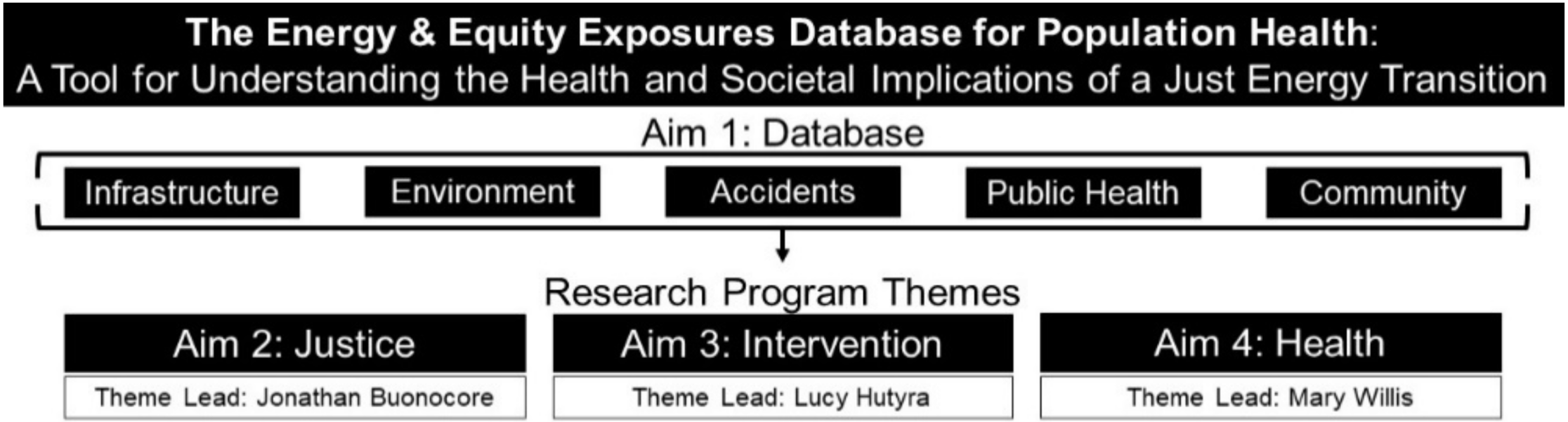
Our Main Aims



Small group discussion questions with report-back

- Are there other research issues or themes this database could be used to address that are important to pursue?
- How can this database be applied in your own work, or in the work of other stakeholders?