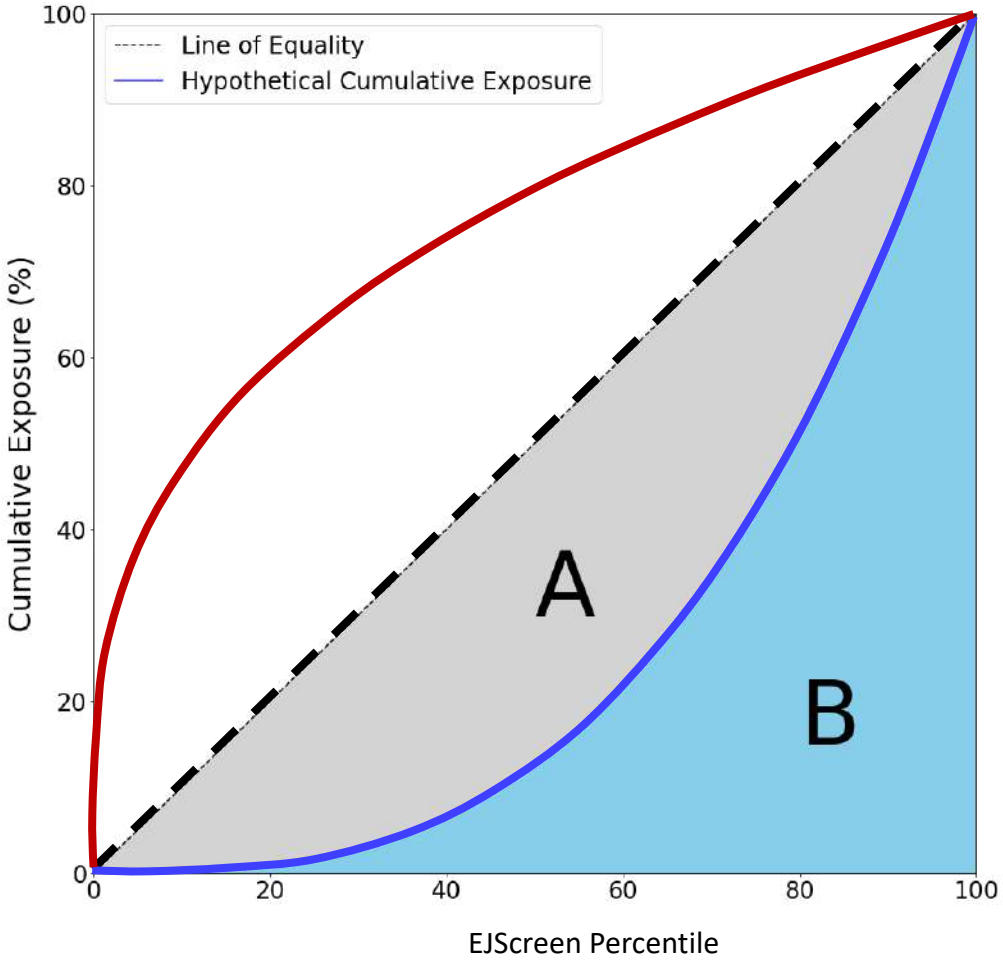
Defining Egalitarian Metric for $PM_{2.5}$ Distribution



$$Suits = \frac{A}{A + B}$$

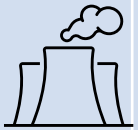
Suits = 0: Equal Exposure

Suits > 0: Inequitable Exposure

Suits < 0: Greater burden on less vulnerable communities

Zhu et al. (2022)

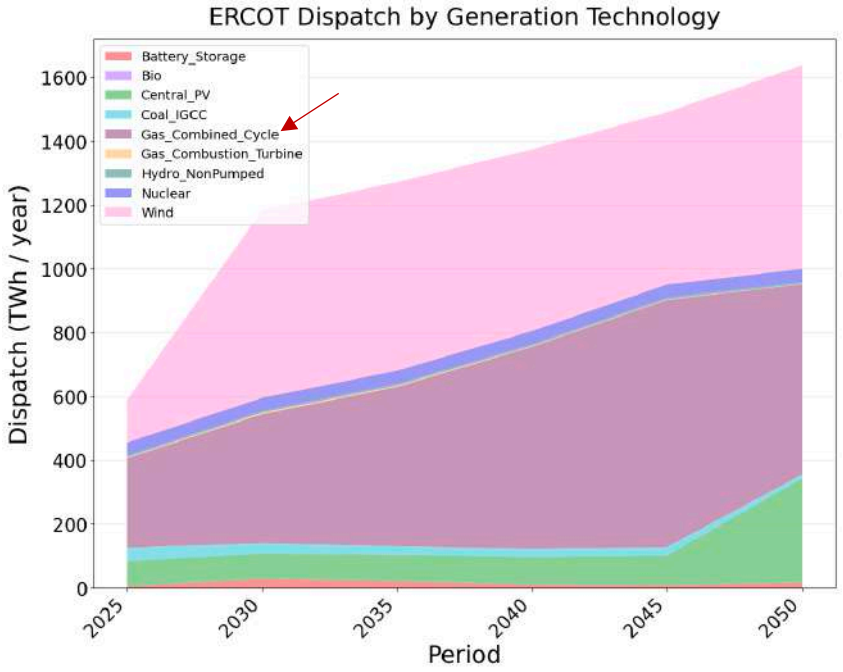
Environmental and *Equity* Constraints

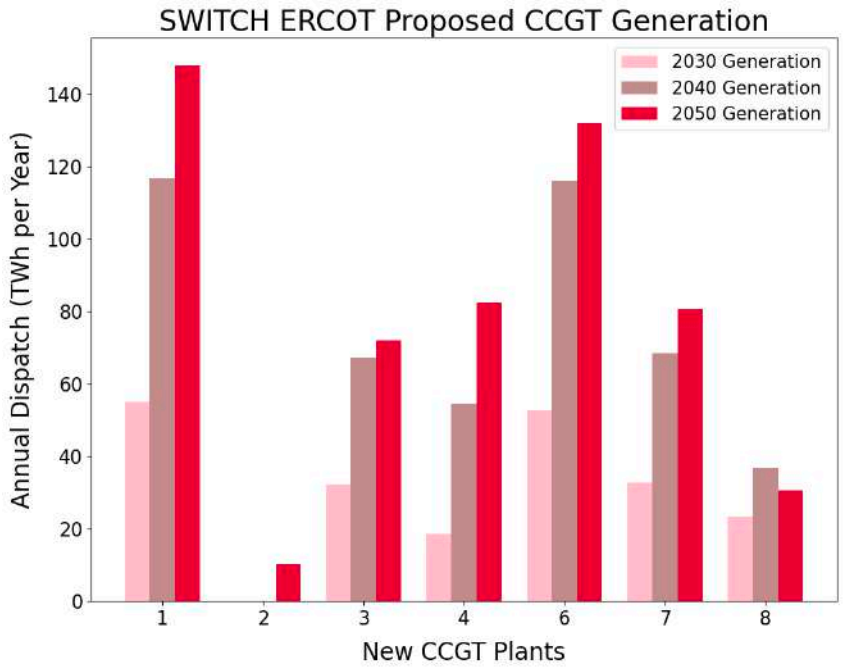
Facility Constraint	Equity of Impacts *Give me equity…*	Scale of Impacts *…or give me a death constraint*
Dispatch 	Restrict inequitable plant	Restrict harmful plant
Siting 	Site away from EJ communities	Site away from population centers

…or just build less Fossil Fuel Infrastructure

SWITCH ERCOT Proposes New CCGT

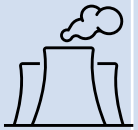
- Most of SWITCH ERCOT's new fossil fuel facilities are Combined Cycle Gas Turbines (CCGT)



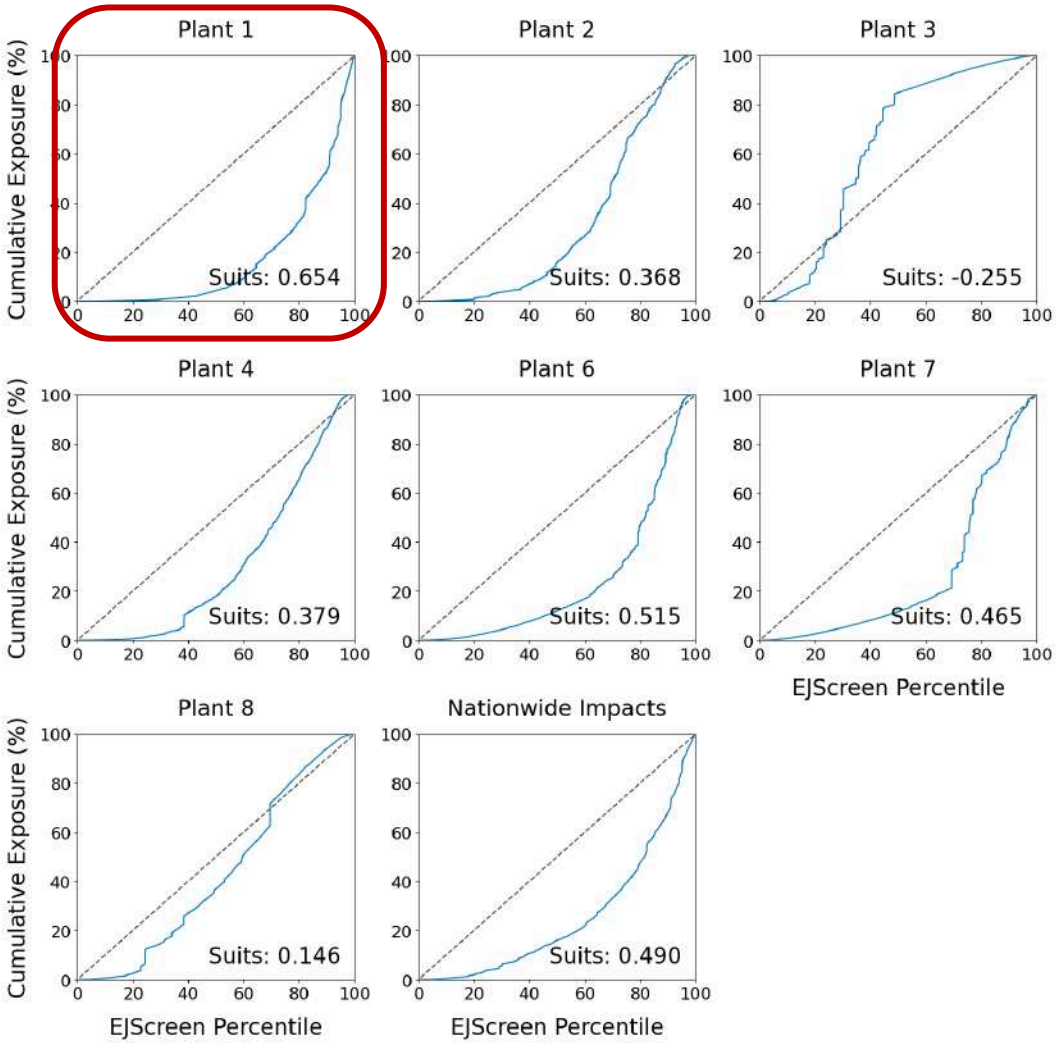


French, J., Potts, J., Castellanos, S. (2025) (*In Preparation*)

Constraint 1: Equitable Dispatch

Facility Constraint	Equity of Impacts *(U.S. Scope)*	Scale of Impacts *(International Scope)*
Dispatch 	**Restrict inequitable plant**	Restrict harmful plant
Siting 	Site away from EJ communities	Site away from population centers

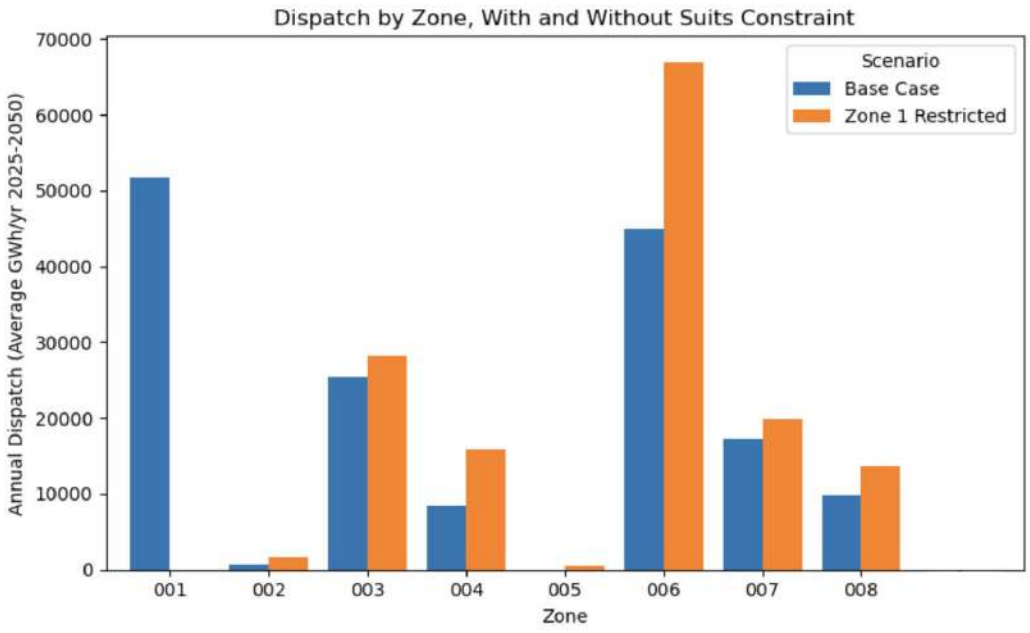
Constraint 1: Restrict Facility with Greatest $PM_{2.5}$ Suits Index

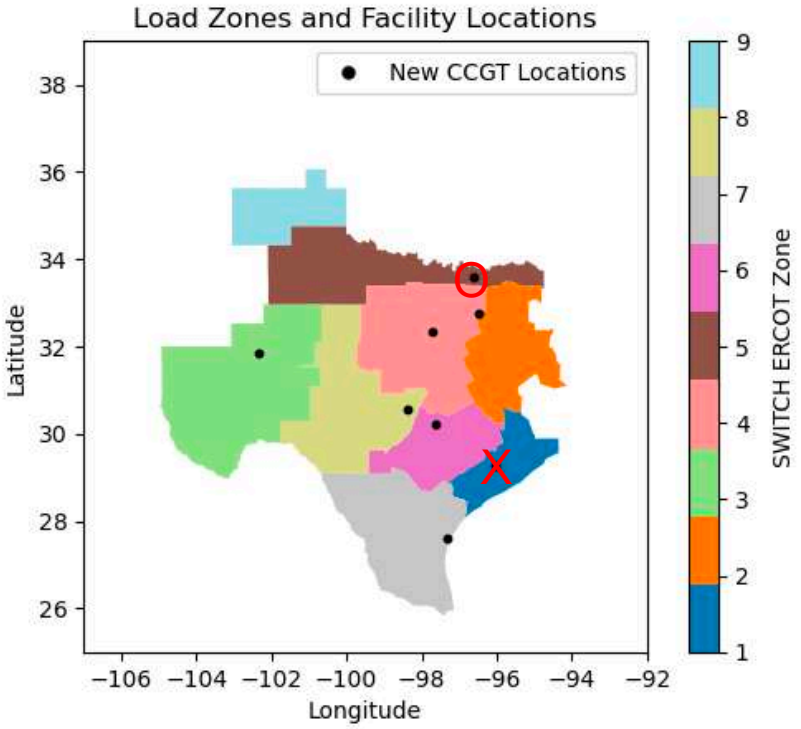


The University of Texas at Austin
Maseeh Department of Civil, Architectural and Environmental Engineering
Cockrell School of Engineering

French, J., Potts, J., Castellanos, S. (2025) (*In Preparation*)

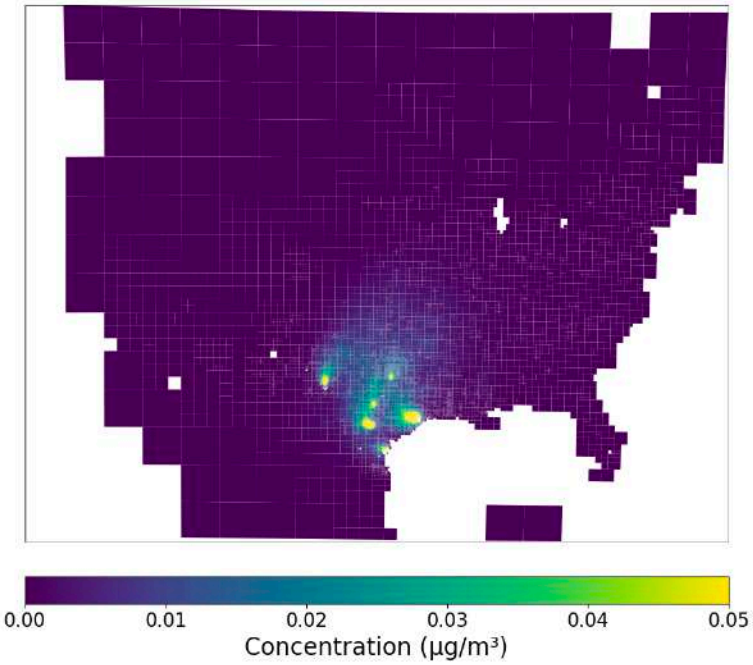
Restricting Plant 1 Increases Other Load Zones' Dispatch





Constraint 1 Mitigates Inequities and PWEL

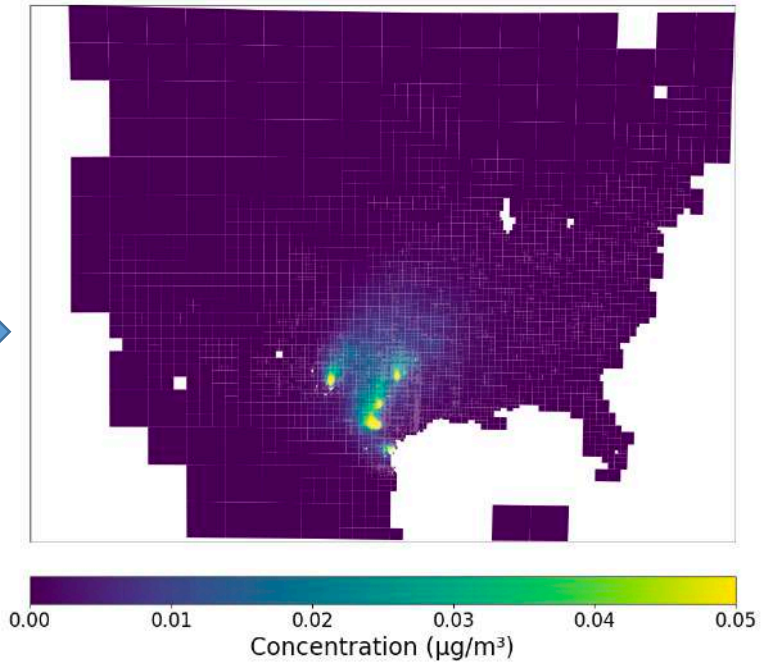
2030-2050 $PM_{2.5}$ (µg/m³), Base Case



PWEL: 2.34 ng/m³
Suits: 0.490

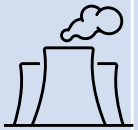
Restrict Zone 1

2030-2050 $PM_{2.5}$ (µg/m³), Plant 1 Restricted

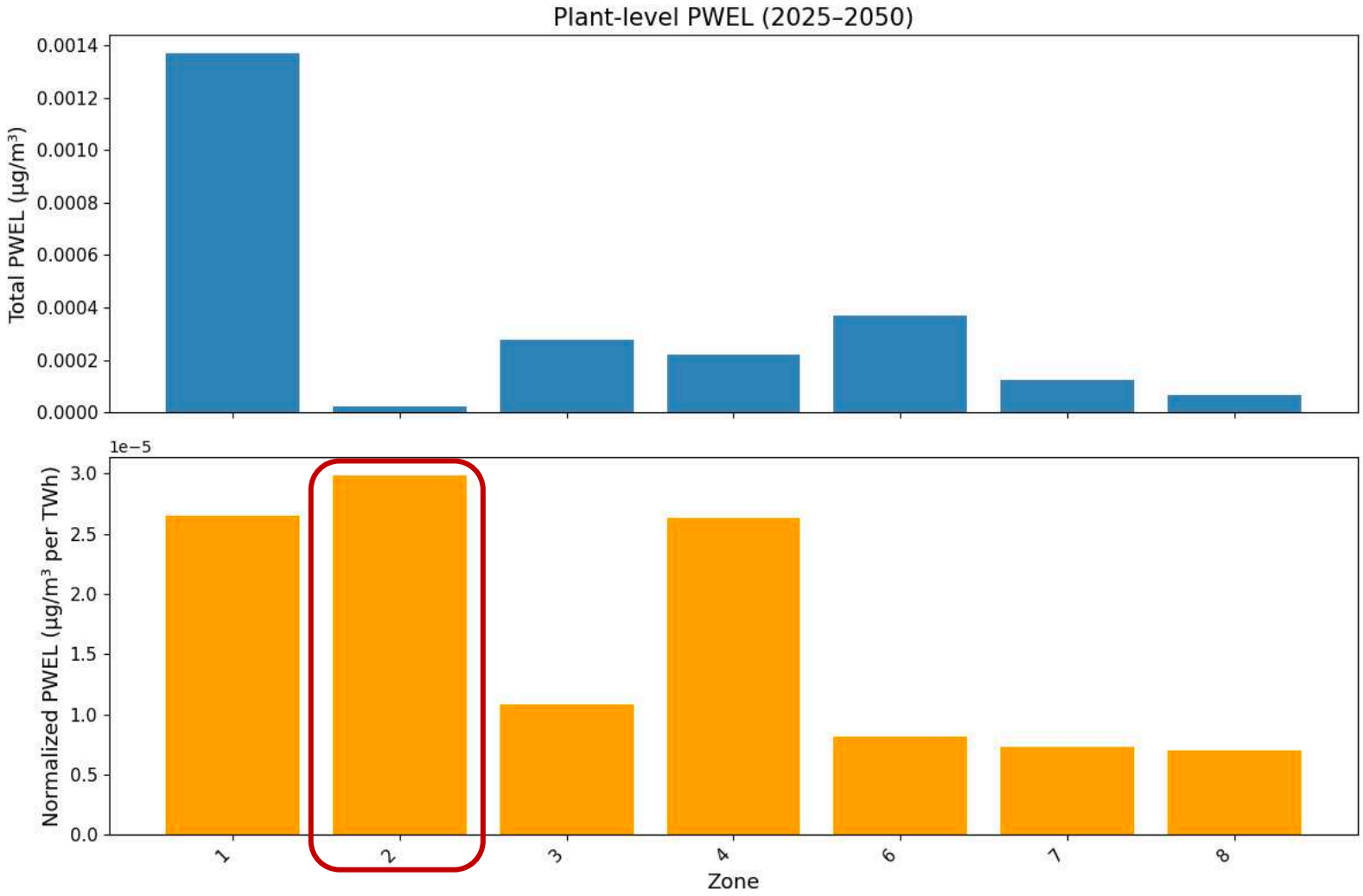


PWEL: 1.44 ng/m³
Suits: 0.322

Constraint 2: Restrict Harmful Facility

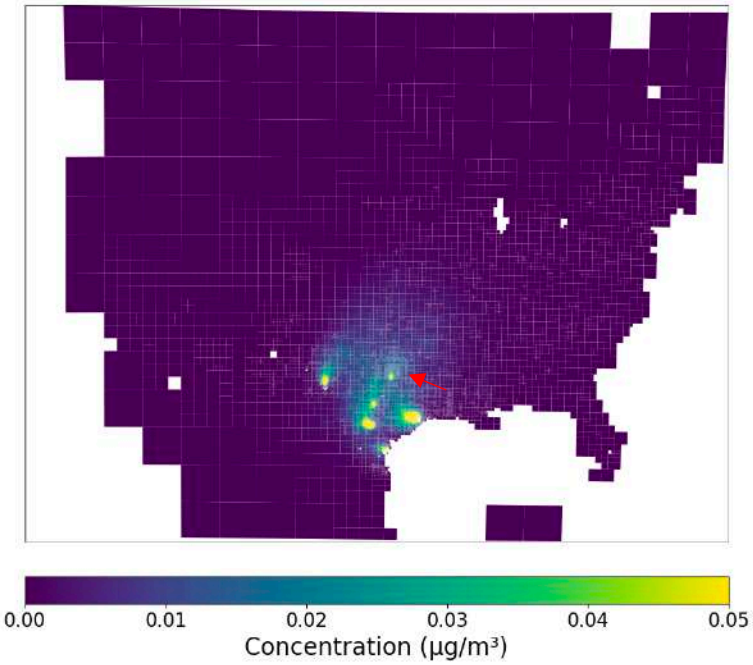
Facility Constraint	Equity of Impacts *(U.S. Scope)*	Scale of Impacts *(International Scope)*
Dispatch 	Restrict inequitable plant	**Restrict harmful plant**
Siting 	Site away from EJ communities	Site away from population centers

Overall Health Constraint: Target Facility with Highest PWEL / TWh



Constraint 2 Marginally Reduces PWEL and Inequities

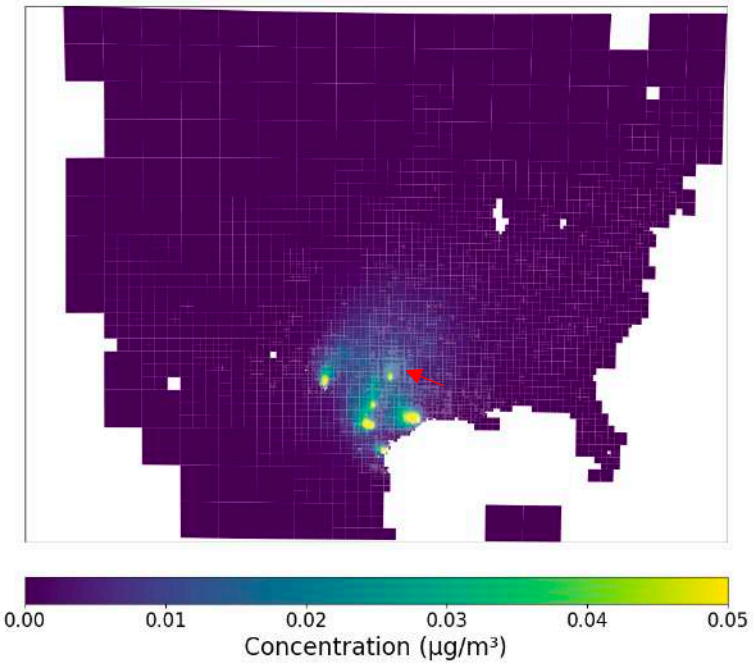
2030-2050 $PM_{2.5}$ (µg/m³), Base Case



PWEL: 2.34 ng/m³
Suits: 0.490

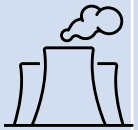
Restrict Zone 2

2030-2050 $PM_{2.5}$ (µg/m³), Plant 2 Restricted



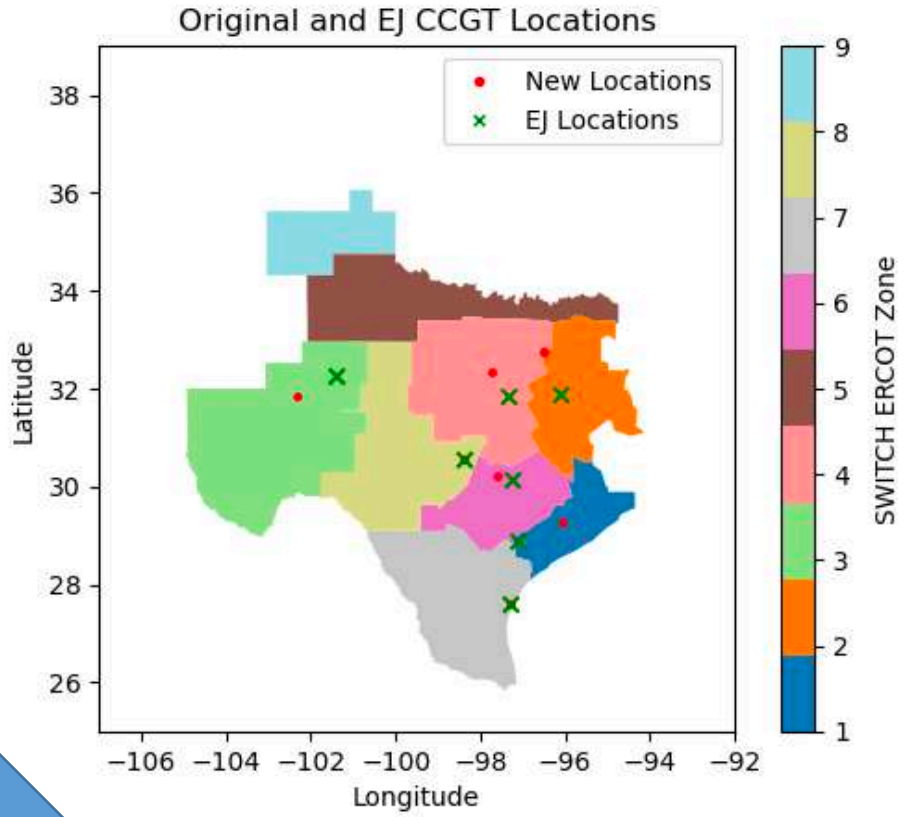
PWEL: 2.26 ng/m³
Suits: 0.488

Constraint 3: Equitable Siting

Facility Constraint	Equity of Impacts *(U.S. Scope)*	Scale of Impacts *(International Scope)*
Dispatch 	Restrict inequitable plant	Restrict harmful plant
Siting 	**Site away from EJ communities**	Site away from population centers

Equitable Siting Constraint utilizes EJScreen Metric

Identify CCGT locations in the lowest EJScreen percentile tract for each load zone

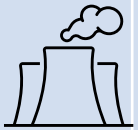
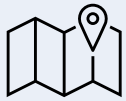


PWEL: 1.78 ng/m³
Suits: 0.490

EJ siting constraint

PWEL: 0.79 ng/m³
Suits: 0.251

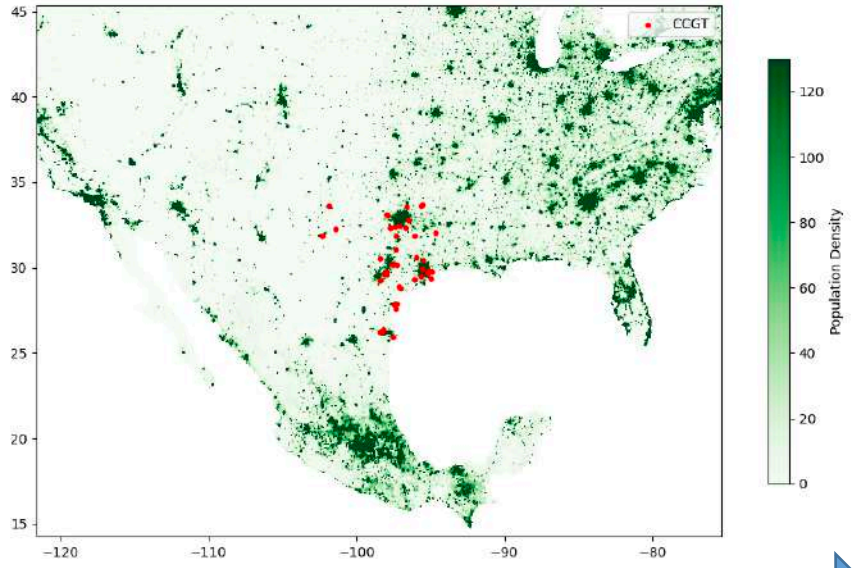
Constraint 4: Population-based Siting

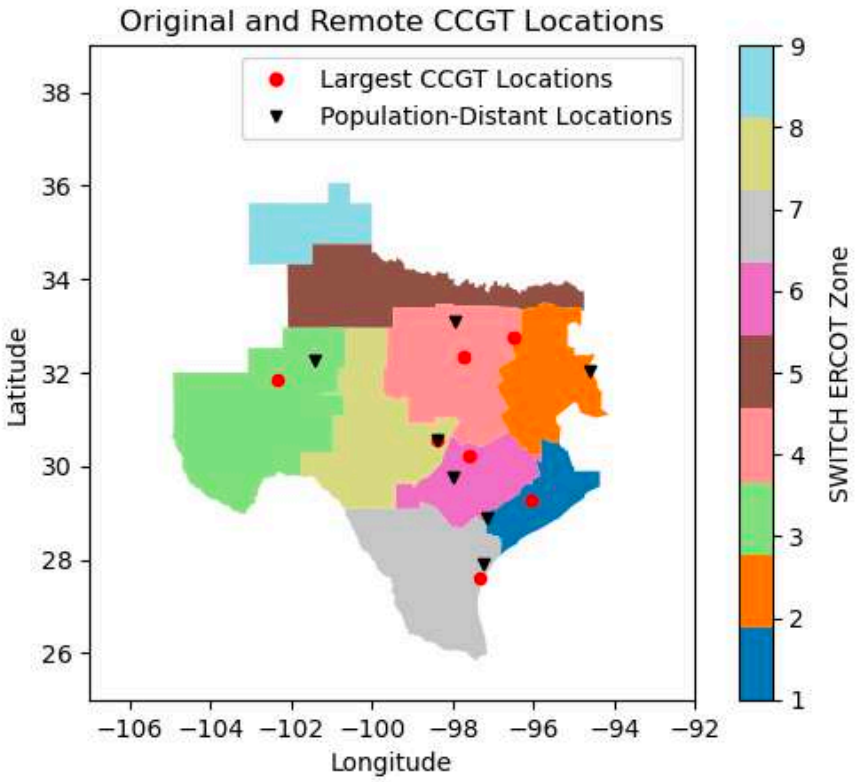
Facility Constraint	Equity of Impacts *(U.S. Scope)*	Scale of Impacts *(International Scope)*
Dispatch 	Restrict inequitable plant	Restrict harmful plant
Siting 	Site away from EJ communities	**Site away from population centers**

Siting Away from Population Centers

- Maximize distance from populations
  - Assume a Gaussian plume:

    Minimize $\sum \frac{Population}{(Distance)^2}$





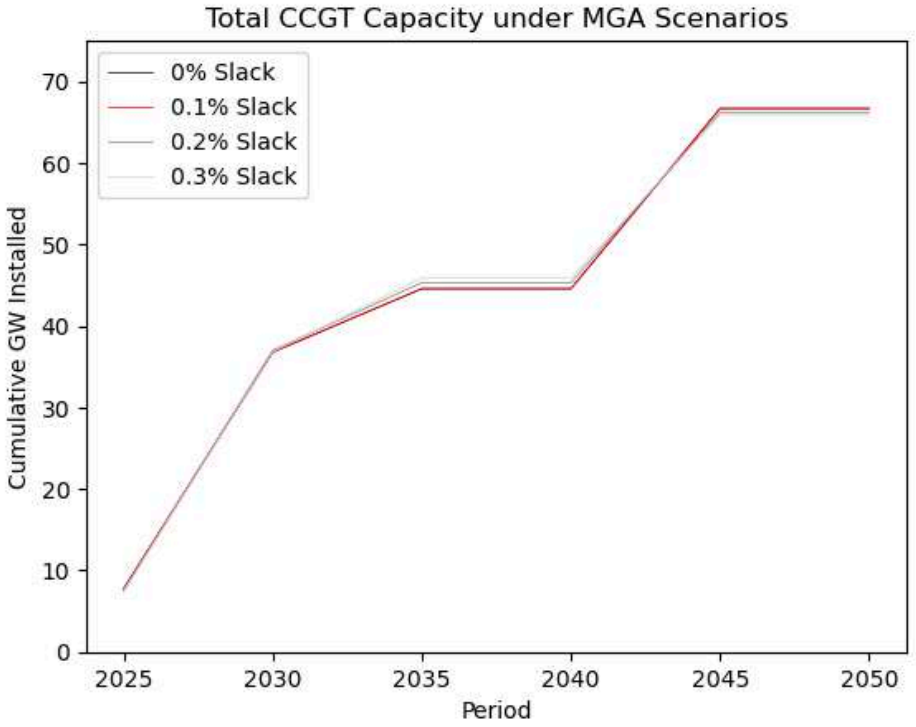
PWEL: 2.30 ng/m³
Suits: 0.490

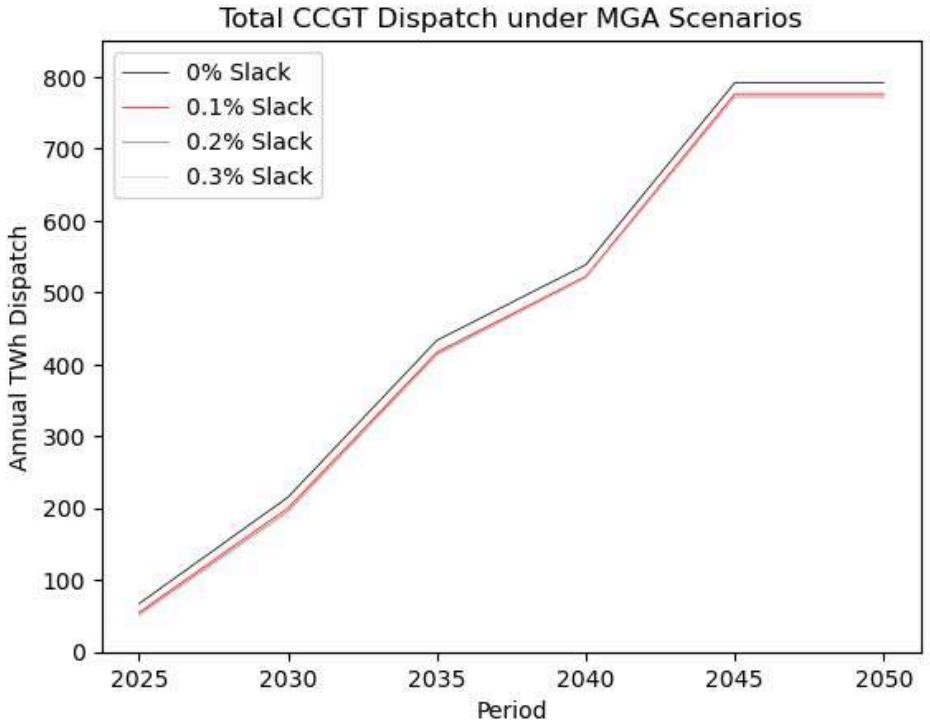
PWEL siting constraint

PWEL: 0.60 ng/m³
Suits: 0.222

…or just build less CCGT

- Modeling to Generate Alternatives: Minimize natural gas capacity, constrain costs by a “slack value”





Most Constraints have Unintended Benefits

(but Emissions Factors can Play a Confounding Role)

	Regional $PM_{2.5}$ PWEL (ng/m^3)	Nationwide Suits Index	ERCOT System Cost (2020-2050, NPV)
Unconstrained	2.34	0.490	$448B

Key takeaways

- Large load growth in Texas can have a wide range of impacts, but there are opportunities to mitigate them.
- A strategy for modeling and constraining emissions impacts of future facilities was developed.
- Differences in priorities and constraint mechanisms drive differences in constraints, with unanticipated outcomes.
- Opportunities to rethink the planning of the future grid.

Research Questions

What is the potential for generation technologies to meet large load growth? What are the impacts of these technologies on a system's cost and emissions?

What are some ways to reflect **opposition**, **people** and the impacts of the power sector on people's **well-being**?

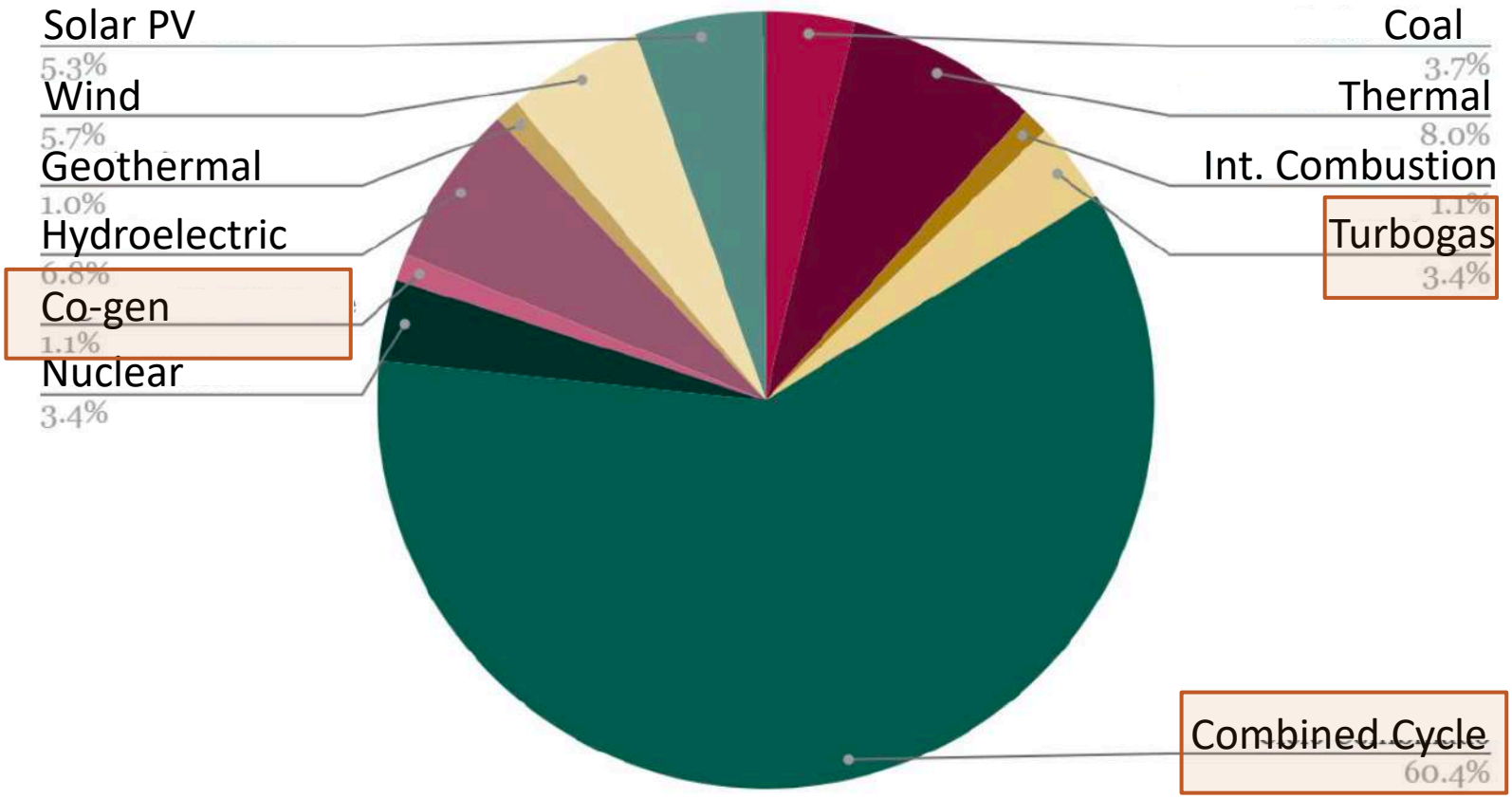
Beyond the border: How might these large load growth dynamics impact Mexico's power sector?

U.S.–Mexico Natural Gas Trade

- In 2024, U.S. pipeline exports to Mexico **averaged 6.4 Bcf/d**, supplying **~ 72% of Mexico's total gas demand** (8.9 Bcf/d).
- In **May 2025**, exports to Mexico reached a record high of **7.5 Bcf/d**.
- U.S. natural gas enters Mexico through four main corridors: South Texas, West Texas, Arizona, California.
- Natural gas fuels **~65% of Mexico's electricity generation**

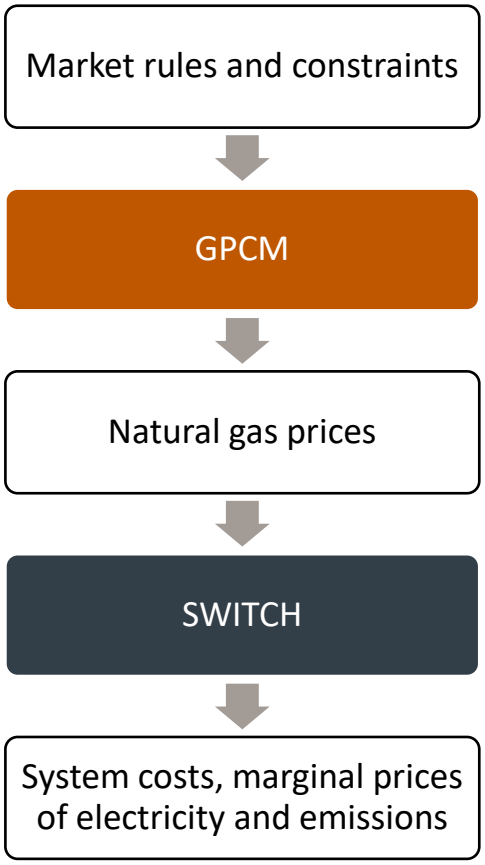
Mexico's electricity generation mix

Electricity generation by technology (2024)



Integrated Modeling: SWITCH + GPCM

- Different scenarios will be mapped out:
  1. Natural Gas Import Ceiling Scenarios
  2. Clean Energy Scenarios
  3. Data Center Growth Scenarios
  4. Public Sector Ownership Scenarios



Integrated Modeling: SWITCH + GPCM

- Different scenarios will be mapped out:
  1. **Natural Gas Import Ceiling Scenarios**
  2. Clean Energy Scenarios
  3. Data Center Growth Scenarios
  4. Public Sector Ownership Scenarios

NG Import Ceiling

- The four main corridors make a combined capacity of ~14.8 Bcf/d.
- Political and trade conditions define import limits.
- Scenarios:
  1. 6.0 Bcf/d
  2. 7.5 Bcf/d
  3. 8.5 Bcf/d
  4. No restrictions
  5. 0 imports

Integrated Modeling: SWITCH + GPCM

- Different scenarios will be mapped out:
  1. Natural Gas Import Ceiling Scenarios
  2. **Clean Energy Scenarios**
  3. Data Center Growth Scenarios
  4. Public Sector Ownership Scenarios

Clean Energy

- Mexico has failed to meet its 35% clean energy goal by 2024.
- No 2050 target.
- PROSENER 2025 implies new 2030 target: 38-45%
- Scenarios:
  1. 38% by 2030
  2. 45% by 2030
  3. None

Integrated Modeling: SWITCH + GPCM

- Different scenarios will be mapped out:
  1. Natural Gas Import Ceiling Scenarios
  2. Clean Energy Scenarios
  3. **Data Center Growth Scenarios**
  4. Public Sector Ownership Scenarios

Data Center Growth

- EPRI's US data-center electricity demand report (2030).
- Focus on fastest growing hubs. (VA, TX, AZ)
- Growth scenarios

1. Low (3.7%)
2. Moderate (5%)
3. High growth (10%)
4. Higher growth (15%)

Integrated Modeling: SWITCH + GPCM

- Different scenarios will be mapped out:
  1. Natural Gas Import Ceiling Scenarios
  2. Clean Energy Scenarios
  3. Data Center Growth Scenarios
  4. **Public Sector Ownership Scenarios**

Public Sector Ownership

- CFE is guaranteed a minimum **54%** share of electricity generation. Private sector maximum of **46%.**
- Scenarios
  1. CFE: 54% share through 2050
  2. Liberalization after 2030

RESET

RAPID, EQUITABLE, & SUSTAINABLE ENERGY TRANSITIONS LAB

Sergio Castellanos
sergioc@utexas.edu