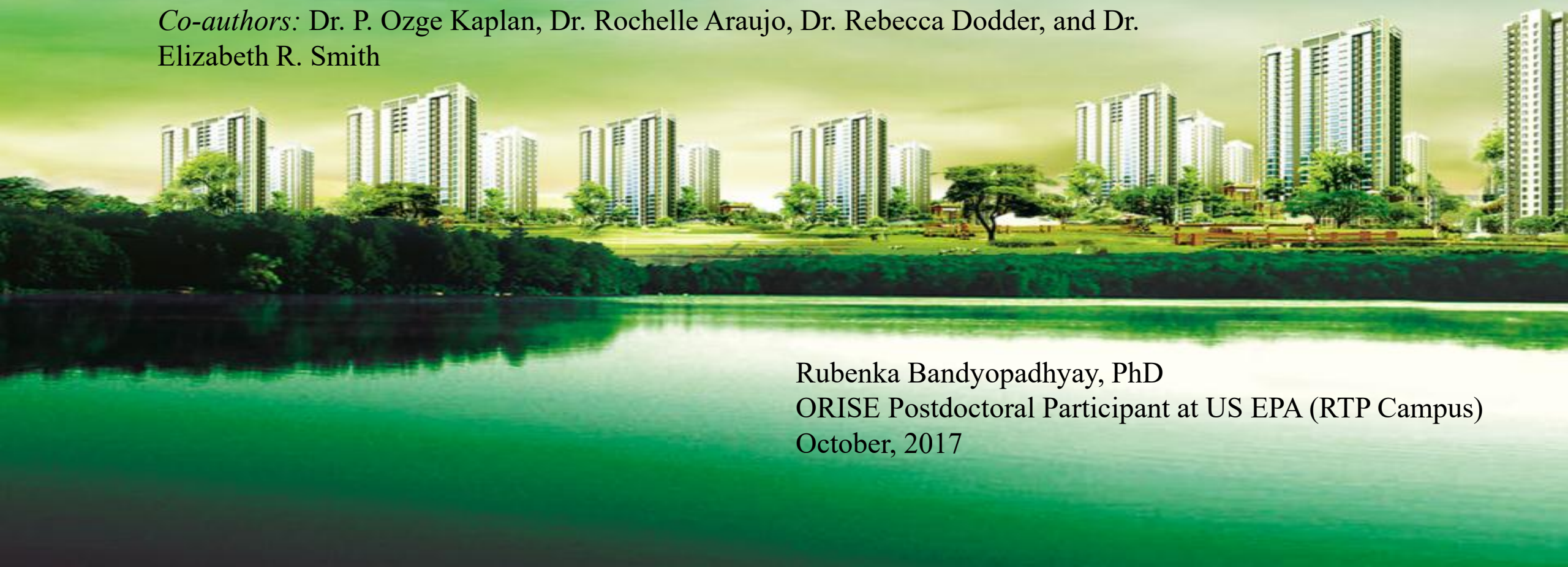
# FREIDA (Framework of Resources for modeling Energy/Environmental/Economic Impacts of Development and Advancements) in Ports

A framework for organizing data to inform coastal disaster management/pollution mitigation strategies, and an illustrative energy sector analysis

*Co-authors:* Dr. P. Ozge Kaplan, Dr. Rochelle Araujo, Dr. Rebecca Dodder, and Dr. Elizabeth R. Smith



Rubenka Bandyopadhyay, PhD
ORISE Postdoctoral Participant at US EPA (RTP Campus)
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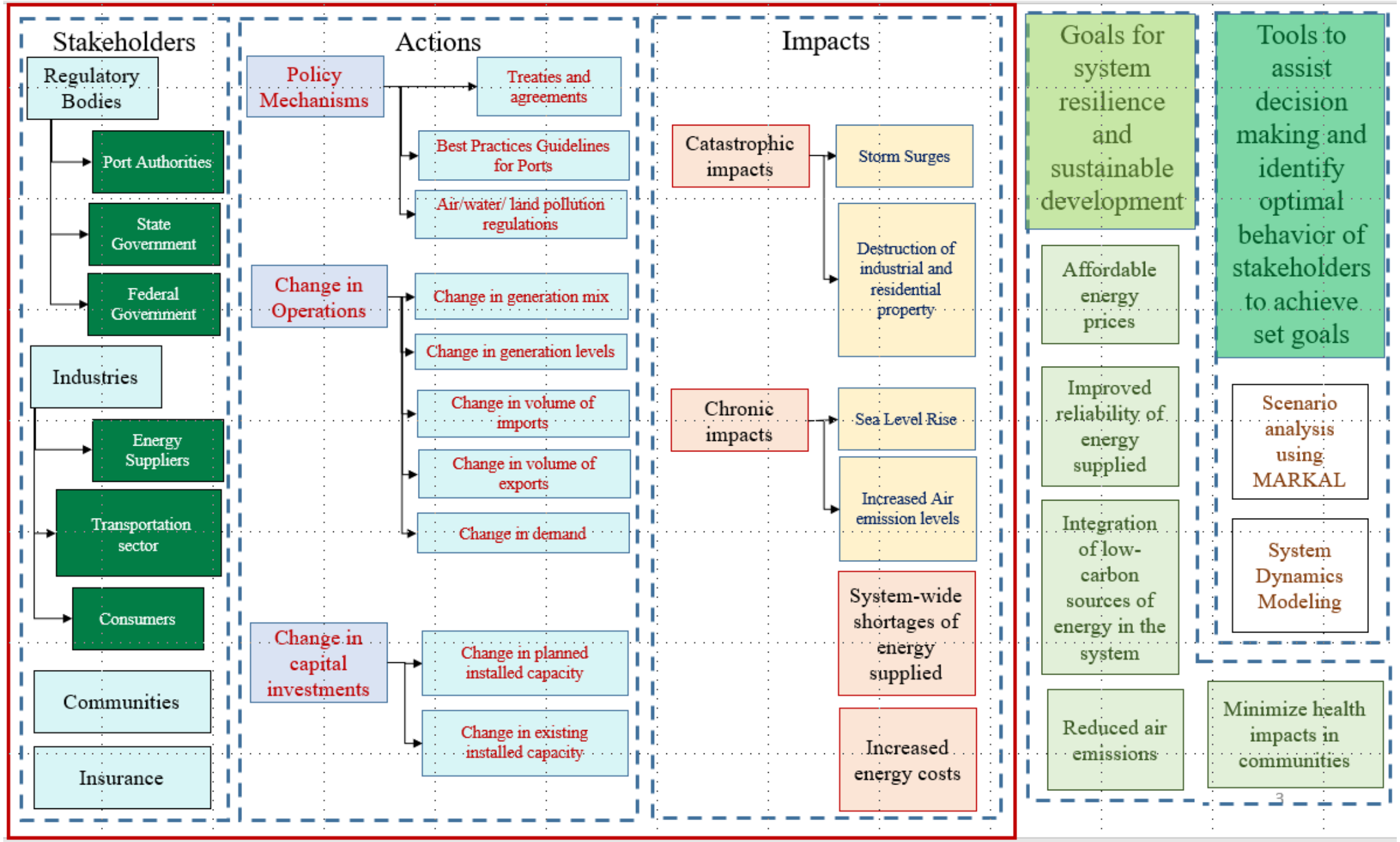
# Need for Port Related Data Frameworks

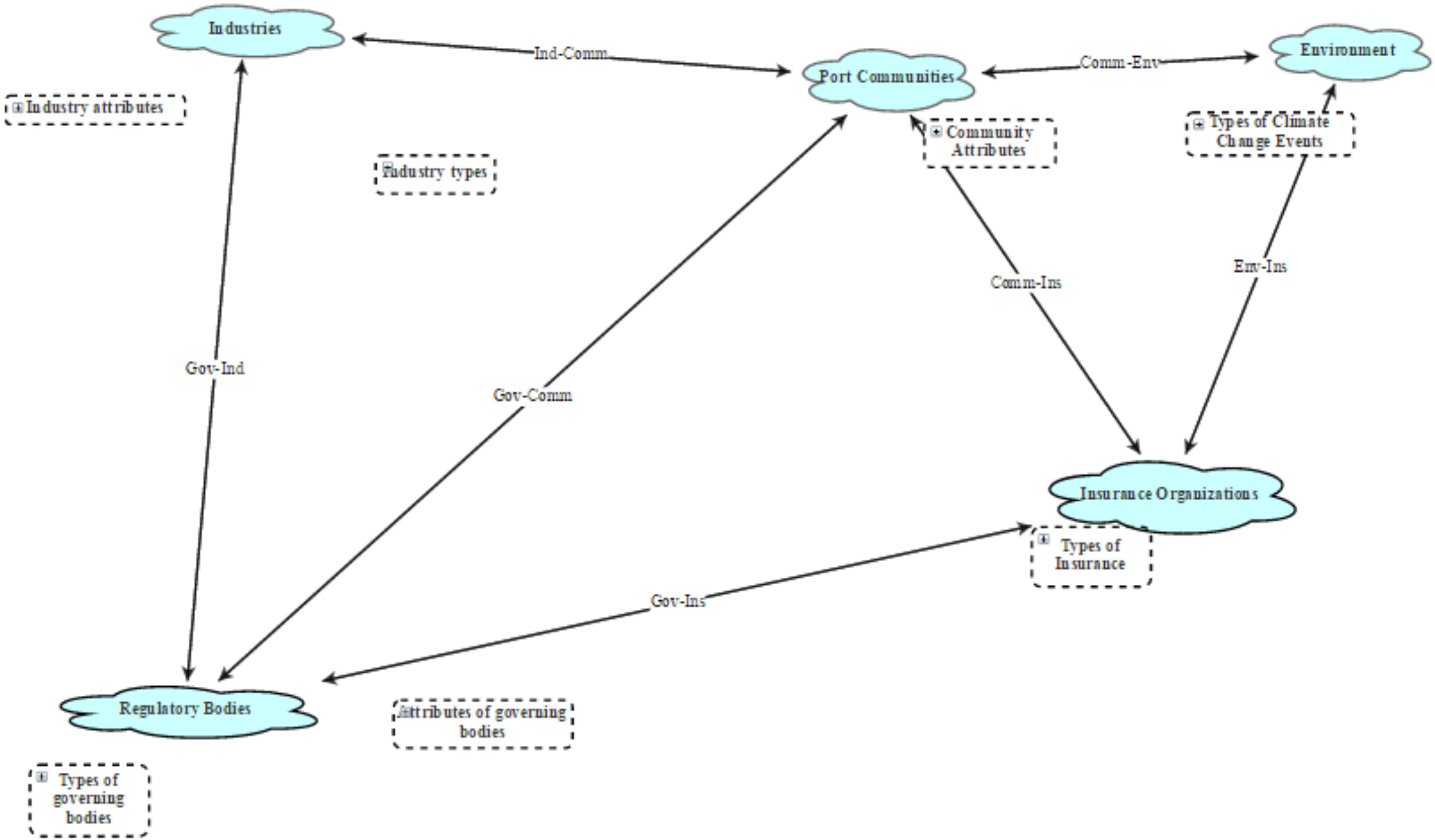
- Roughly 50% of the US national GDP is attributed to socio-economic activities in coastal regions
  - Port system operations and related industries constitute a majority of the industrial activities occurring in the US
- Port activities are complex in nature and are interconnected with the social, political, economic and environmental aspects of the coastal communities
- The ‘FREIDA in Ports’ framework is aimed to enable stakeholders to organize data resources comprehensively
  - Resilience and disaster management strategies for humanitarian applications are key areas where this framework could be used

# Building Blocks



# Opportunities for Humanitarian Applications

- Instances of opportunities for application of the 'FREIDA in Ports' framework for disaster management/pollution mitigation in ports:
  - Infrastructure and operations planning strategy to improve resilience to extreme weather events
    - Example: Investments in diversified energy system portfolio
  - Water and wastewater infrastructure management strategy following an extreme weather event
    - Example: Access to clean drinking water is a critical service that could be compromised during storm events
  - Waste and debris management strategy following an extreme weather event
    - Example: a wide variety and quantity of debris generated that could easily disrupt the waste collection network and needs to be managed effectively
  - Pollution mitigation strategy
    - Example: Investment in low carbon energy generation and transportation technologies


Industries
Ind-Comm
Port Communities
Comm-Env
Environment
Industry attributes
Industry types
Community Attributes
Types of Climate Change Events
Gov-Ind
Gov-Comm
Comm-Ins
Env-Ins
Insurance Organizations
Types of Insurance
Gov-Ins
Regulatory Bodies
Attributes of governing bodies
Types of governing bodies

# Energy System modeling with MARKAL

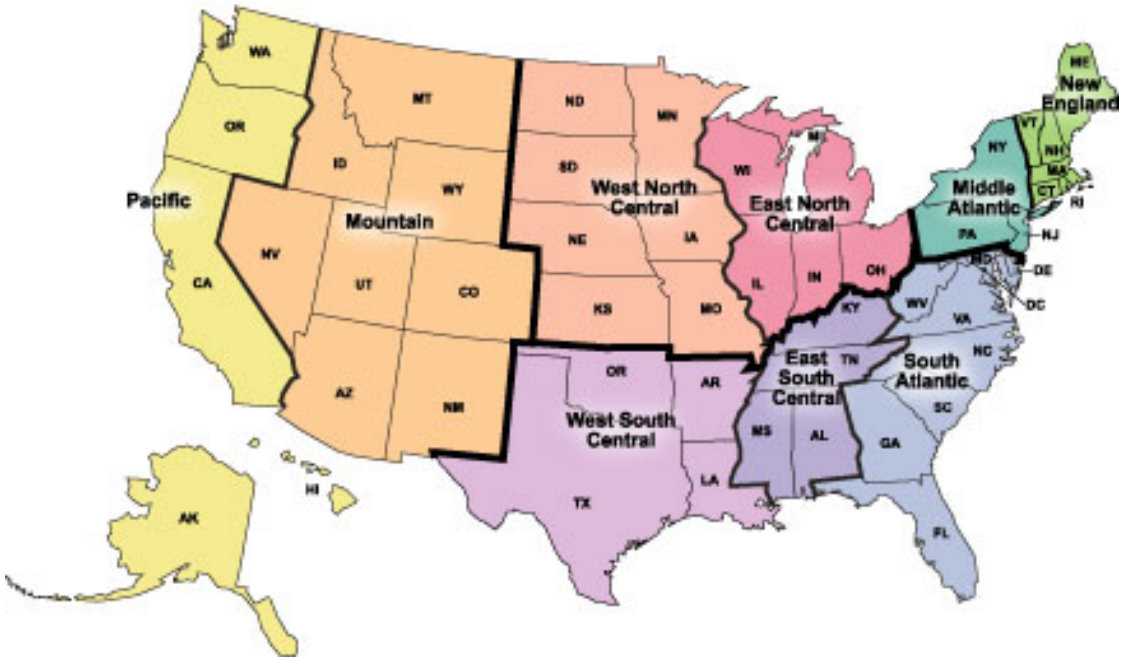
- Ports play a critical role in ensuring reliable and economic operation of US energy systems:
  - ~50% of US crude oil is imported
  - 75% of crude oil shipped via ports in South-East US
  - Ports ship majority of US natural gas exports both to international and domestic customers
  - In spite of US being a net exporter of coal, southern and eastern states still import cheap coal from South America

# Illustrative Energy Sector Analysis

- A variety of drivers including the Panama Canal expansion expected to change global and local energy market operations:
  - Change the flow of energy commodities through ports
  - Price and supply of energy inputs to ports operations and associated multimodal activities expected to change
- Unplanned port operations and expansions could result in:
  - Increased levels of pollution
  - Chronic and catastrophic impacts due to extreme weather events along the coast
  - Disruption in port activities that create a feedback loop with the Energy sector

# Energy System modeling with MARKAL

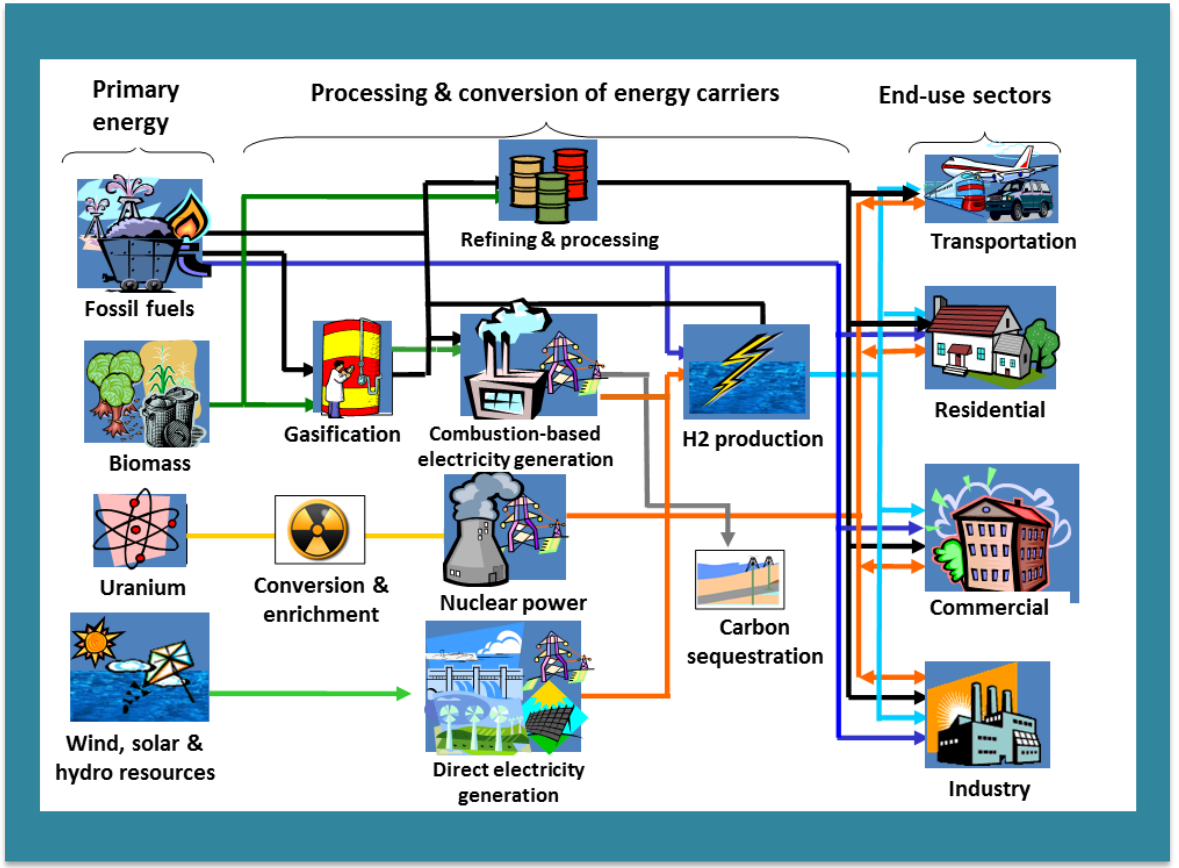
- Preliminary study:
  - Increased frequency of extreme weather events can cause fuel shortages
  - This is modeled in US EPA's MArket ALlocation (MARKAL) model by introducing **75% price spikes** to natural gas, oil and coal along the Gulf of Mexico and US East Coast




EPAUS9r – Regional resolution

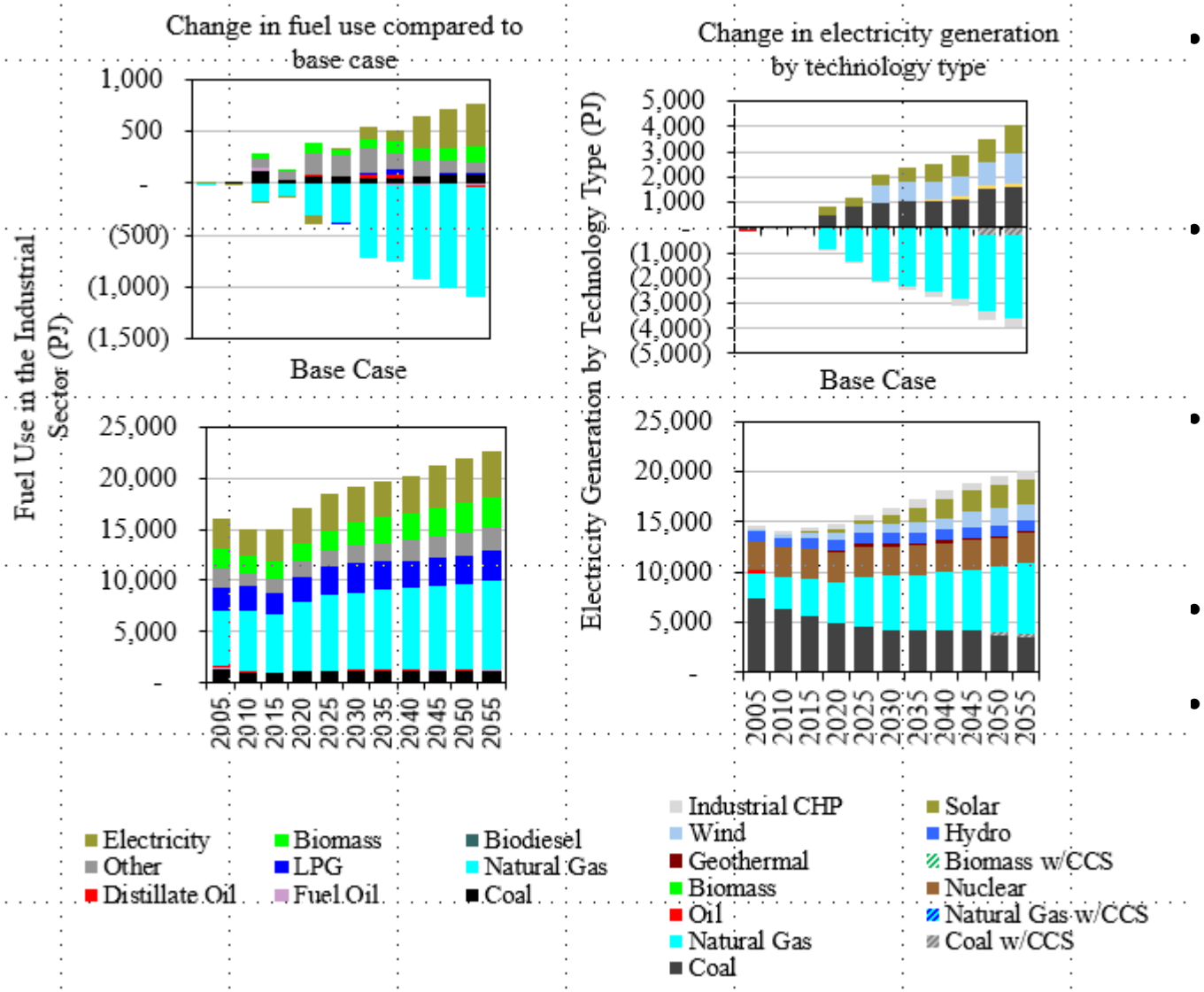
# Energy System Model: MARKAL

- **Bottom-up and technology-rich**
  - Captures the full US energy system from energy resource supply/extraction technologies to end-use technologies in all sectors
  - 9 region representation (US Census divisions)
  - Energy technologies (existing and future techs) are characterized by cost, efficiency, fuel inputs, emissions
  - Technologies are connected by energy flows
- **Optimization**
  - The model picks the "best" way (lowest system-wide cost) to meet energy demands choosing from the full "menu" of energy resources and technologies
  - The model makes these choices from 2005 to 2055, giving us a snapshot of possible future energy mixes



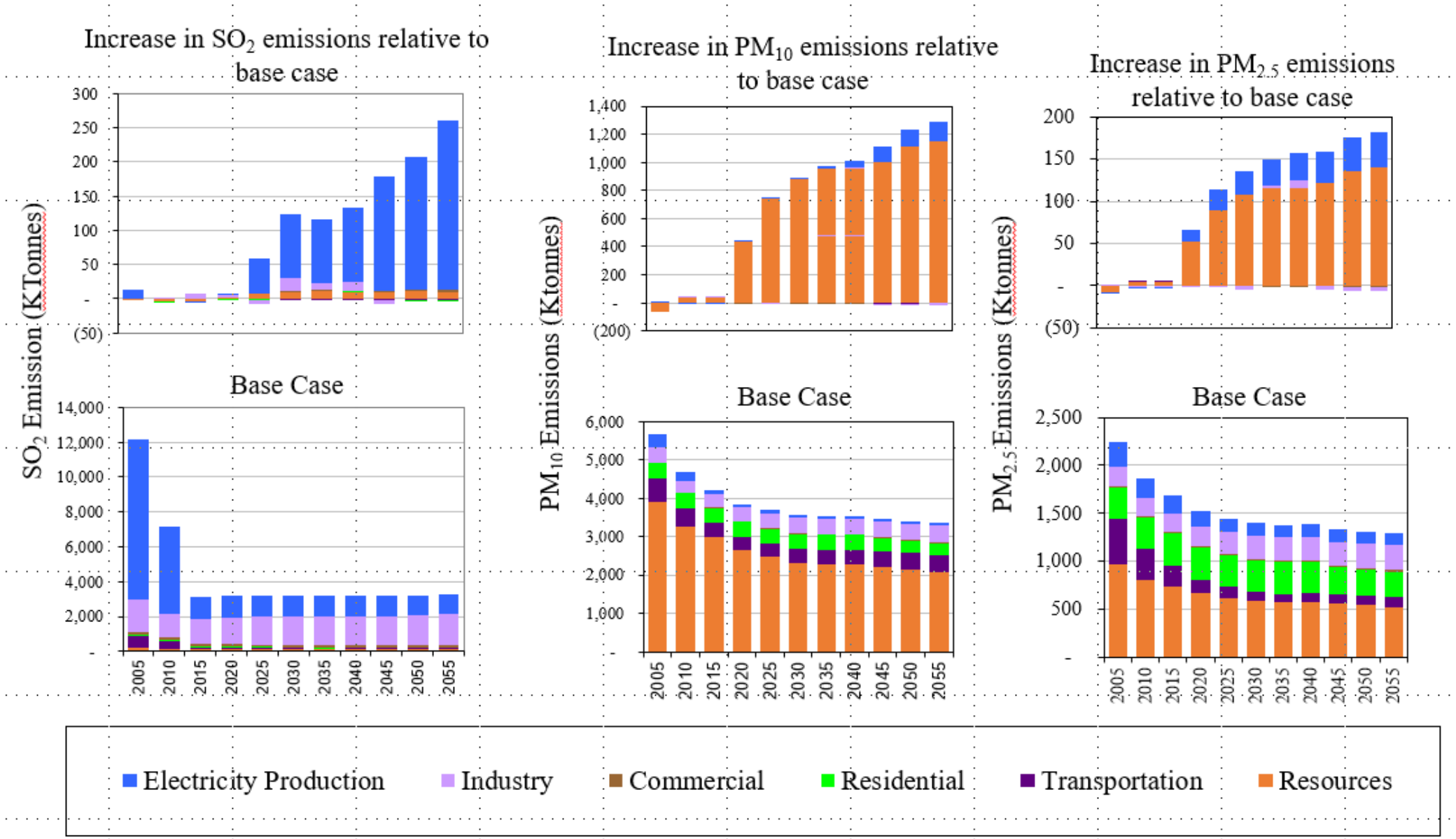

- **Emissions and impacts**
  - Full air and GHG emissions characterization: $NO_x$, $SO_2$, $PM_{10}$, $PM_{2.5}$, CO, VOC, $CO_2$, $CH_4$, $N_2O$, BC, OC, water use for electricity generation
  - Major emissions standards and regulations are included in the baseline, and additional policies can be modeled

# Fuel Use by Sector and Electricity Prices




- In the industrial sector, high fuel prices lead to switching from natural gas to electricity and biomass use
- Future electric power generation mix consists of a larger fraction of existing coal and new renewable power than new natural gas
- The commercial, residential and transportation sectors showed less than 1% change in fuel mix used
- 25-45% increase in electricity prices relative to the base case
- Increased renewable power generation results in corresponding higher investments

# Results: Emissions

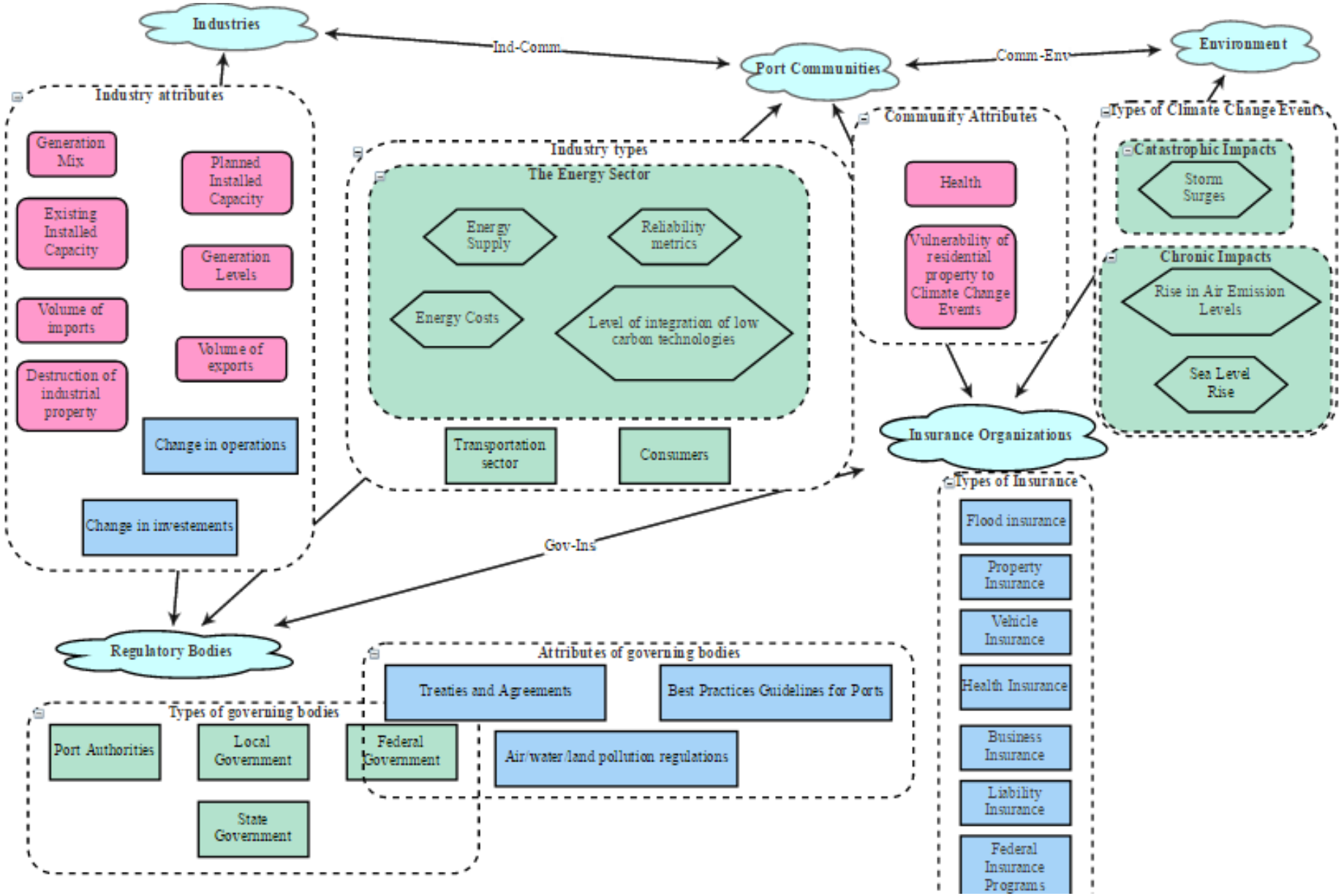


# Next Steps

- The impacts of coastal extreme weather events can be significantly impacted by
  - uncertainties around specific policies of individual port authorities
  - technical advancements and social paradigms of the future.

- MARKAL based scenario analyses to be performed for different set of energy futures

# Next Steps




Systems Dynamic modeling technique is being explored to better model stakeholder behavior under various energy futures

# Questions?

E-mail: bandyopadhyay.rubenka@epa.gov
Phone: +1 919-541-2197

# U.S. EPA MARKAL Regional Database: EPAUS9r

- **Coverage**: U.S. energy system
- **Spatial resolution**: Nine Census divisions
- **Modeling horizon**: 2005 and 2010 are calibration time periods, while 2015 through 2055 the model selects technology penetrations based on optimization
- **Sectors**: Electricity production, transportation, industrial, residential, commercial, biomass
- **Main data source:** Annual Energy Outlook (2014)
- **Pollutants**: $NO_x$, $SO_2$, $PM_{10}$, $PM_{2.5}$, CO, VOC, $CO_2$, $CH_4$, $N_2O$, BC, OC, water use for electricity generation
- **Maintenance:** Updated and calibrated to Annual Energy Outlook every two years; housed at EPA/ORD; publicly available