

# Steps Toward Connecting Model- based Impact Assessments with Integrated Assessment Modeling

Tom Wilbanks  
Oak Ridge National Laboratory

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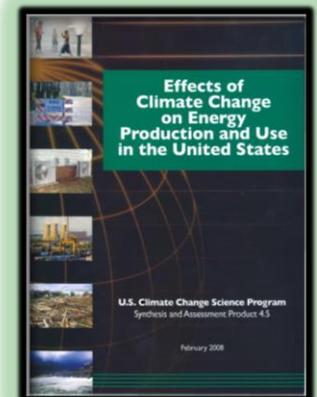
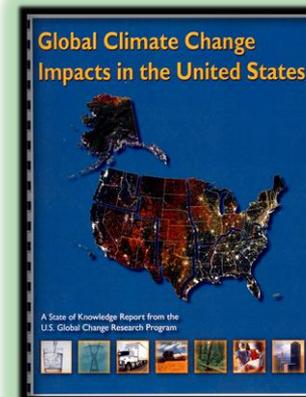
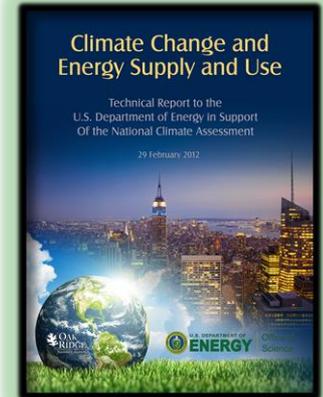
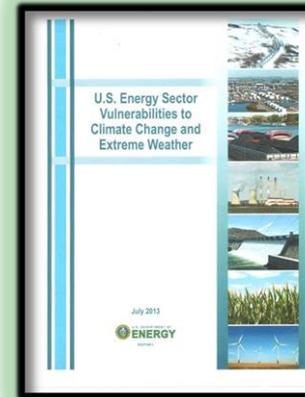
# For years, the DOE Integrated Assessment Research Program Has Been Working to Improve Model-based Capacities for Climate Change IAV Analysis, Linked with IAMs (I):

- Faced initially with a number of challenges, e.g.:
  - Most IAV research was not model-based -- often case-study-based rather than generic, samples not necessarily representative, often qualitative
  - Most of the knowledge indicated that impacts and adaptation potentials were very context specific: varied widely according to location, scale, threat, and affected systems – difficult to generalize about drivers and sensitivities
  - Very little of the knowledge was based on observations of impacts that could be attributed to climate change or of adaptations that had paid off in reducing risks of climate change – treatment of effects necessarily speculative
  - Most of its model-based research was focused on “natural” or human-managed environmental systems, not on built infrastructures such as energy supply and demand systems – especially limited knowledge of sensitivities and effects for human systems

# For years, the DOE Integrated Assessment Research Program Has Been Working to Improve Model-based Capacities for Climate Change IAV Analysis, Linked with IAMs (II):

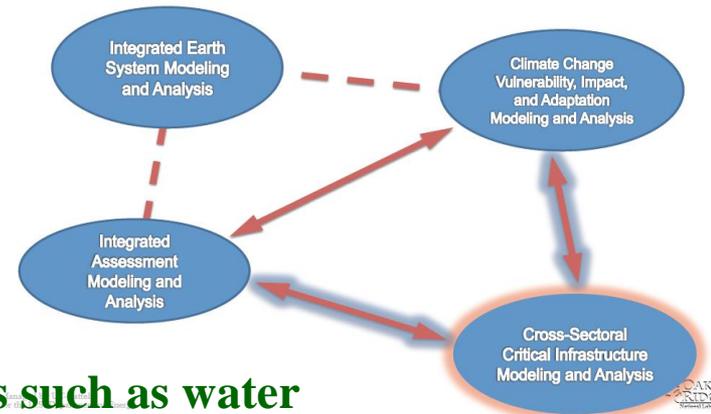
- A number of developments since then have been helpful:

- Four general assessments of implications of climate change for energy supply and demand, all supported by DOE
- Participation in IPCC, NAS/NRC, and other opportunities to stay informed about the latest developments in energy impact and adaptation research
- Progress in applying modeling approaches to climate change related impacts and adaptation issues, e.g.:
  - AgMIP
  - Water resource management
  - Critical infrastructures



# Most Recently, a Focus Has Been on Incorporating the Critical Infrastructure Modeling and Data Capabilities in Integrated Assessment Research (I):

- A particularly good fit with energy impact assessment needs, e.g.:
  - Concerned with impacts of disruptive events on built infrastructures
  - Concerned with cross-sectoral linkages, including linkages of energy infrastructures with other infrastructures such as water
  - Including very detailed geo-coded data bases for asset-specific energy infrastructures across the entire country – a unique national resource
- Labeled by DOE “Connected Infrastructure Dynamics Models” (CIDM), we are:
  - Adding detail to the energy infrastructure layers of the “system of systems” approach
  - Working to strengthen the water layers of the approach
  - Working to add capacities to project changes in infrastructures through time, including technological change and demographic change



# Most Recently, a Focus Has Been on Incorporating the Critical Infrastructure Modeling and Data Capabilities in Integrated Assessment Research (II):

- We have also examined the CIDM impact modeling tools to evaluate the science and data on which their calculations are built (largely inherited from the DHS NISAC program)
- We have found a number of components that we believe are not up to the standards of DOE's Office of Science, and we are upgrading the tools to strengthen their science base, e.g.:
  - Estimating sensitivities of infrastructures to changes in climate parameters: oversimplified "fragility curves"
  - Estimating energy demands at a granular local scale: over-reliance on Landscan population data, which underrepresents non-residential energy demands
  - Estimating population migration effects of exposures to extreme weather events: differences between evacuation data and net migration, multi-dimensional nature of environmental migration

# Most Recently, a Focus Has Been on Incorporating the Critical Infrastructure Modeling and Data Capabilities in Integrated Assessment Research (III):

- Led to the development of a “white paper” by the IAM and IAV/CIDM communities, working together (January 2013)
- Which considered:
  - Science questions that might be answered through connections between IAM and CIDM
  - Challenges that would have to be met in connecting IAM and CIDM
  - Experiences so far in exploring connections – and lessons learned so far
  - Possible targeted experiments with connecting IAM and CIDM, initially through “soft coupling”

**EXPANDING TOOLS FOR INTEGRATED ASSESSMENT RESEARCH: TOWARD CONNECTIONS BETWEEN INTEGRATED ASSESSMENT MODELS AND CRITICAL INFRASTRUCTURE PROTECTION MODELS**

Oak Ridge National Laboratory  
Electric Power Research Institute  
Los Alamos National Laboratory  
Massachusetts Institute of Technology  
Pacific Northwest National Laboratory  
Sandia National Laboratories

January 2013

# A Brief Glimpse at Three Examples in the Past Year (I):

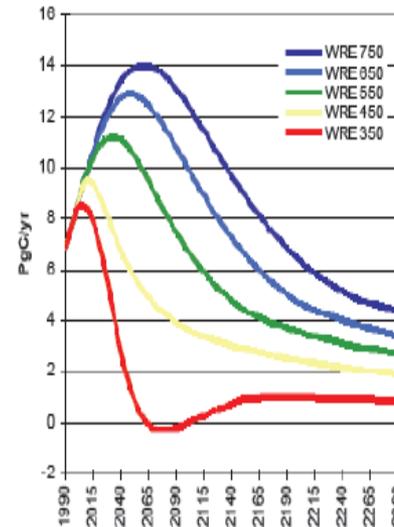
- **There have been other experiments as well, such as a collaboration between MIT and Sandia on relationships between macroeconomic issues and water availability issues**
- **The three examples:**
  - **Implications of the nation's growing appetite for natural gas for the regional energy economy in the Gulf Coast region (RIAM: GCAM-US/CIDM)**
  - **Energy/water infrastructure interactions in a small-region case study of climate change implications in 2050, incorporating technological changes over that period (three-lab CIDM consortium, linked to IAM and CMIP-5 framing)**
  - **Assistance to the current Quadrennial Energy Review (QER) – CIDM impact scenarios as contributions to an integrated multi-institutional perspective**

# A Brief Glimpse at Several Examples in the Past Year (II):

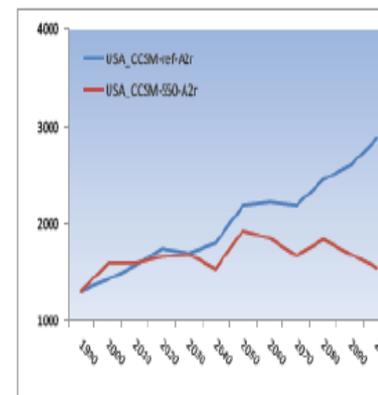
- **Other connections have included use of CIDM data bases in assessing effects of climate change-related temperature increases on regional (Southeastern) thermal electricity generation capacity (RIAM)**

# RIAM Experiment in Linking GCAM with CIDM: Assessing Opportunities and Vulnerabilities in a Rapidly Evolving U.S. Natural Gas Industry (Clark, Fernandez, et al.)(I):

- Loosely couples GCAM-USA and CIDM to anticipate energy and economic implications of increased natural gas demand and increased domestic natural gas production, along with emerging challenges to the current NG infrastructure
- GCAM models shifts in the US domestic energy system: final demand and energy production over the century across technology, policy, and economic scenarios



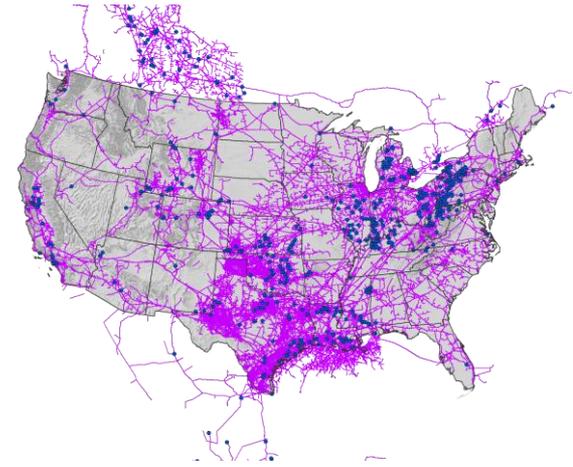
Future climate and energy policy will play a large role in shaping how the US energy system evolves.



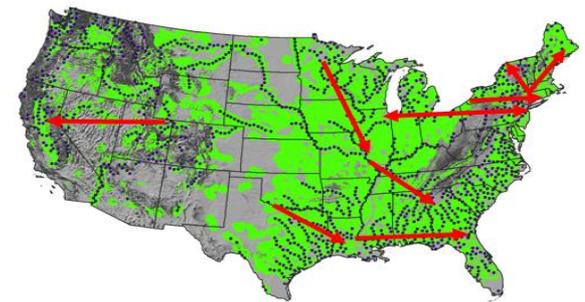
Changes in the number of US cooling degree days (CDD) will drive major changes in US energy system.

# RIAM Experiment in Linking GCAM with CIDM: Assessing Opportunities and Vulnerabilities in a Rapidly Evolving U.S. Natural Gas Industry (Clark, Fernandez, et al.)(II):

- **CIDM downscales energy demand projections to granular scale, identifies siting criteria for new NG infrastructures reflecting changed demand and supply conditions, and offers a simulated future NG pipeline and storage infrastructure more suited to these conditions than the current infrastructure**



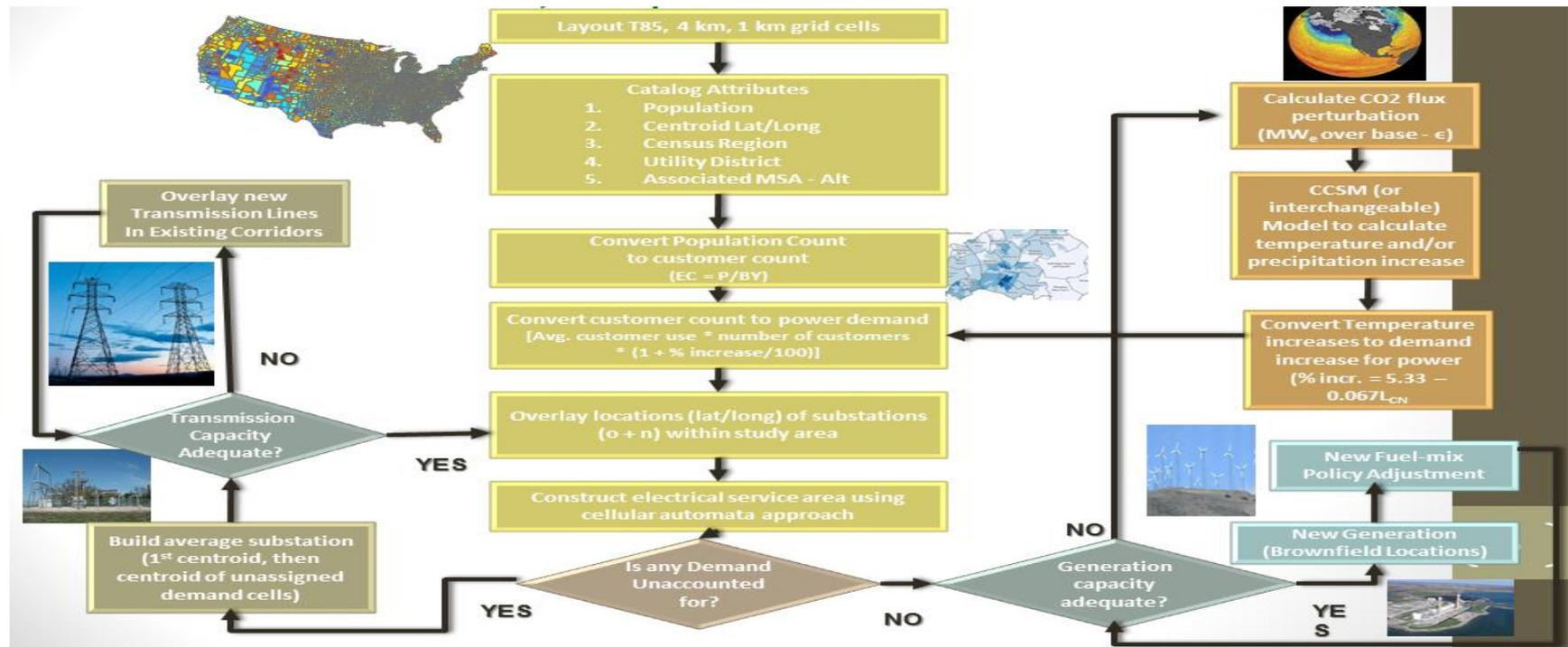
Existing 2013 Natural Gas Pipeline system with existing storage sites



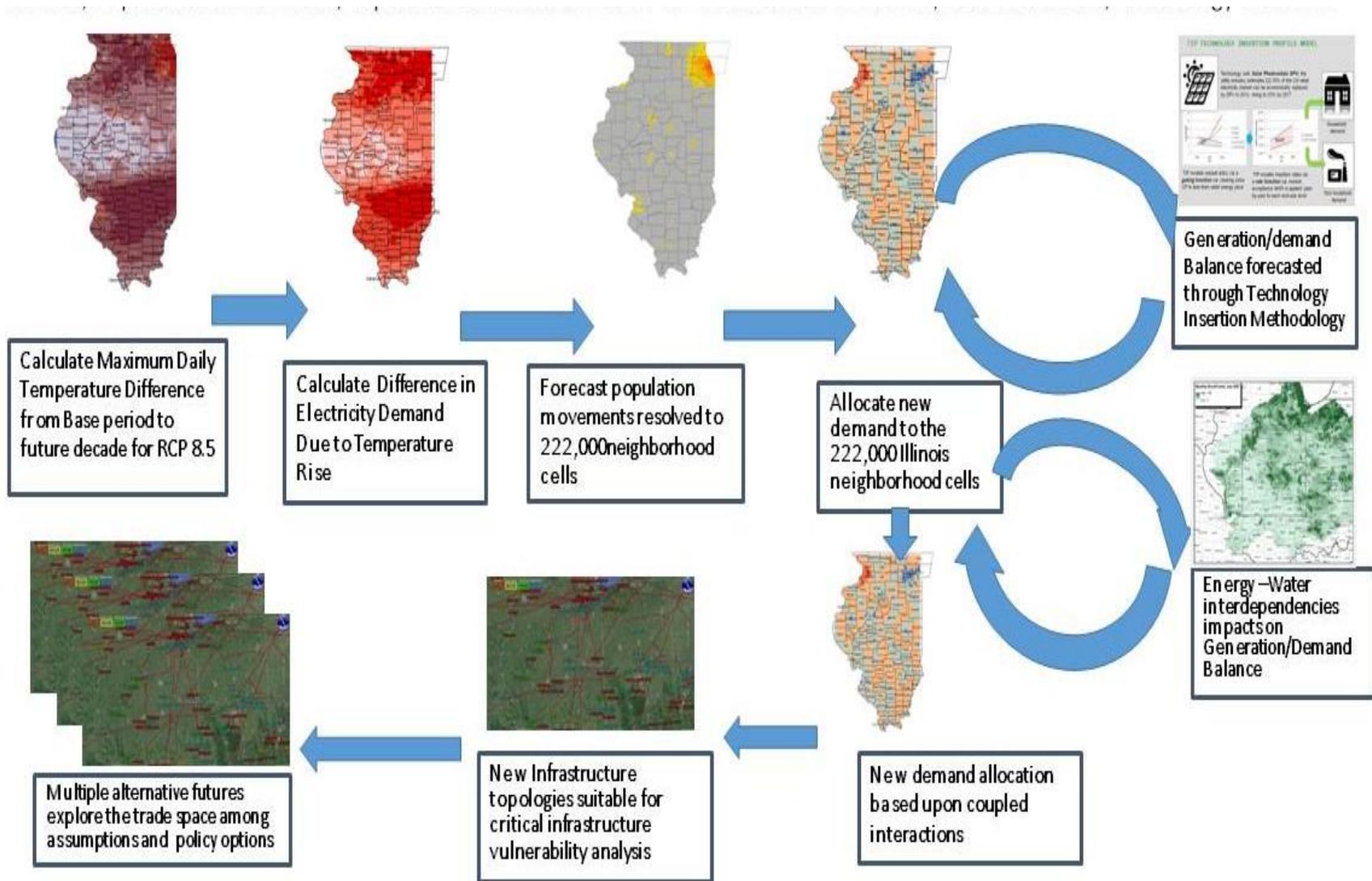
Possible site permitted storage sites overlaid with new required pipelines

# Small-scale Case Study of Energy-Water Infrastructure Interactions, under Climate Change, Population Movements, and Technological Change (Fernandez, Tidwell, Toole, et al.)(I):

- Taking the Champaign, IL, small region as a case in point: one of several localities projected to face electricity distribution stresses – the one with the best hydrological records and projections (under RCP 8.5 2057 conditions of moderate temperature change and seasonal changes in water availability, along with projections of moderate urbanization of the population distribution and potentials for technological change in electricity use efficiency and enhanced renewable energy supply contributions)



# Small-scale Case Study of Energy-Water Infrastructure Interactions, under Climate Change, Population Movements, and Technological Change (Fernandez, Tidwell, Toole, et al.)(II):





# Model-based Climate Change Impact Assessment as a Part of the Quadrennial Energy Review (QER):

- **Mandated by a Presidential Memorandum in January 2014 as fulfilling a commitment in the Climate Change Action Plan**
- **Focused initially on America's infrastructure for transmitting, storing, and delivering energy, especially electricity transmission and distribution, oil and gas pipelines, and natural gas storage**
- **Intended to provide recommendations on how to transform these infrastructures and systems to meet the challenges of the 21<sup>st</sup> century**
- **Report due January 15, 2015**
- **Engaging a host of institutions, but relying heavily on DOE national laboratories – rather hectic last-minute process**

# Model-based Climate Change Impact Assessment as a Part of the Quadrennial Energy Review (QER):

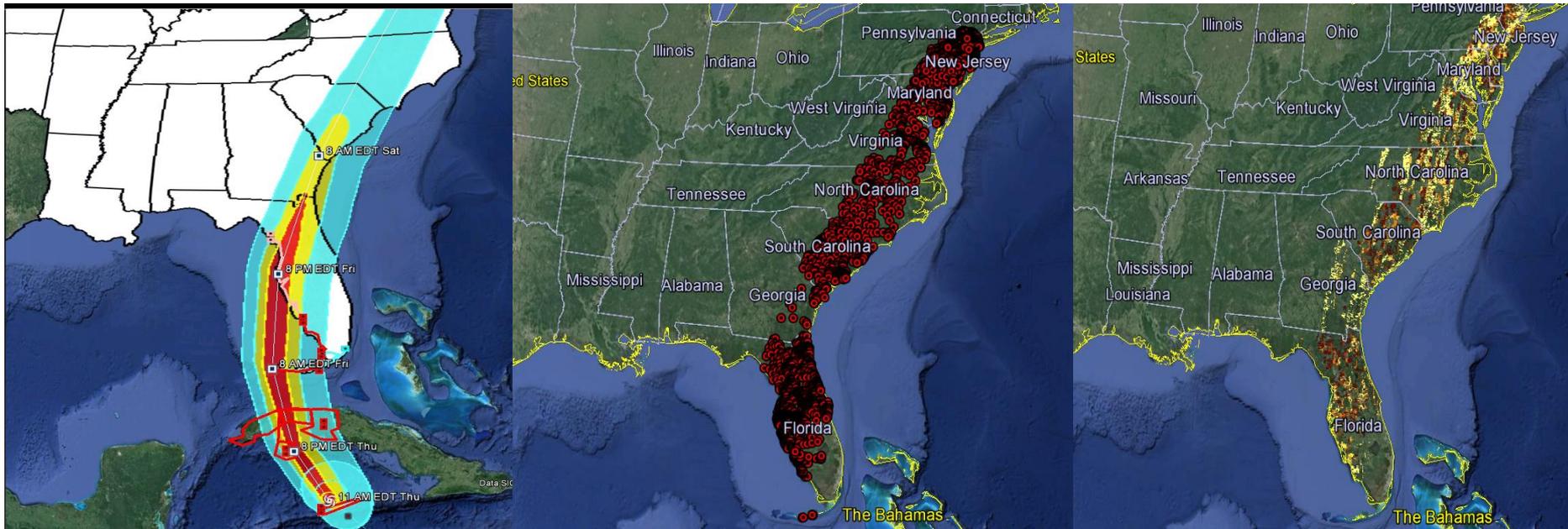
- **A bit hard to talk about at this moment, because the process is taking place as we speak**
- **Many fingers in the pie, with DOE project managers greatly challenged to bring order to what is happening**
- **Ian Kraucunas is coordinating DOE lab assistance to QER analysis and assessment, filling a critically important need**
- **Ambitious aspirations confronting daunting time pressures:**
  - **The January 15 deadline for submitting QER-1**
  - **Means a target of September 15 for a first draft report, to allow extensive reviews and revisions**
  - **Most new analysis and packaging of existing information to be completed by the end of August**

# Model-based Climate Change Impact Assessment as a Part of the Quadrennial Energy Review (QER):

- **Among many inputs, we expect that CIDM tools and data sets – including applications such as VERDE and EARSS – will be used to explore implications of two (+) climate change scenarios for energy transmission, storage, and delivery infrastructures in the US:**
  - **Increased risks of severe droughts and extreme heat events:**
    - **More frequent/severe/longer-lasting heat waves: e.g., reduced efficiency in electricity transmission lines, electricity outages in US cities during the August 2006 heat wave**
    - **Indirect effects of droughts on TS&D systems: e.g., increased risks of wildfires, possible seasonal effects on electricity supply for natural gas compression for pipeline transmission**
  - **Severe coastal storms on top of sea-level rise (and, in the Gulf Coast land subsidence): storm surges and impacts, wind impacts, flooding reflecting inland rainfall as well as storm surges, etc.**
- **Modeling results being embedded in a larger framework of knowledge, data, and tools**
- **Plus the RIAM IAM/CIDM examination of natural gas infrastructure futures**

# Energy infrastructure impact simulation capacities are impressive, if threats can be projected (or postulated), e.g.:

## Hypothetical Hurricane Charley impacts on the electric grid

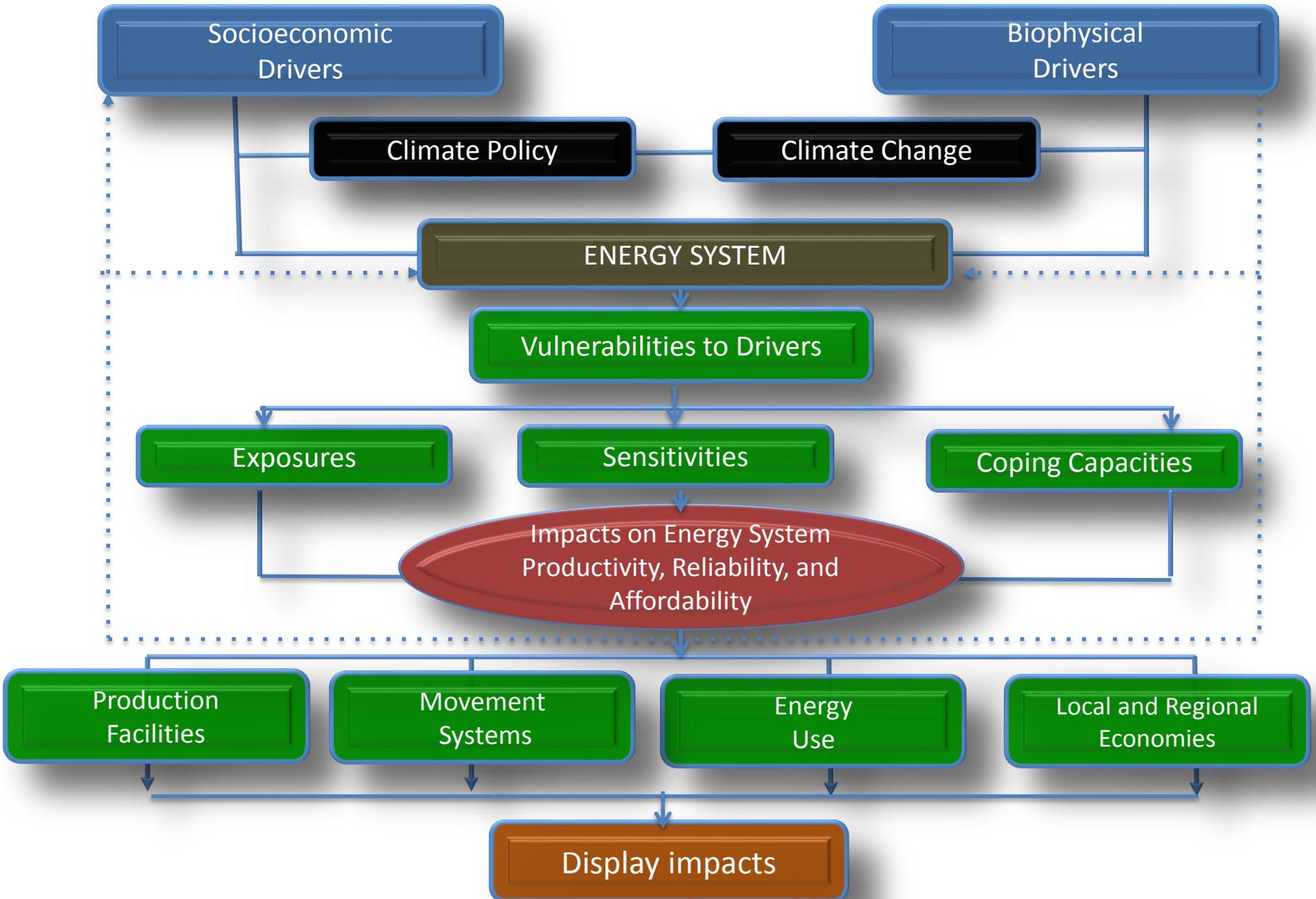


Charley-Category 4  
Advisory 13

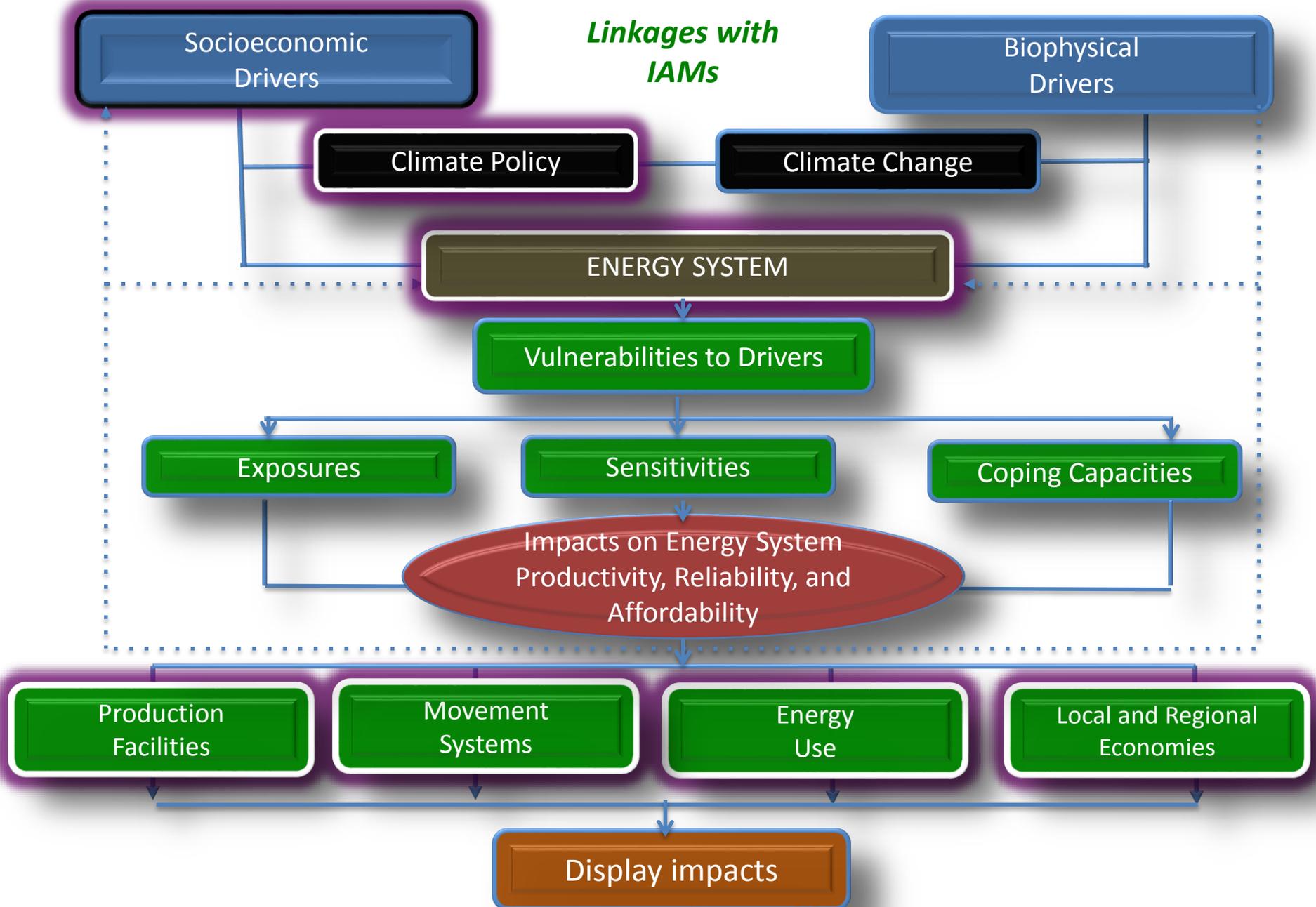
Sub Stations Affected

Service Areas  
Recovery Estimates

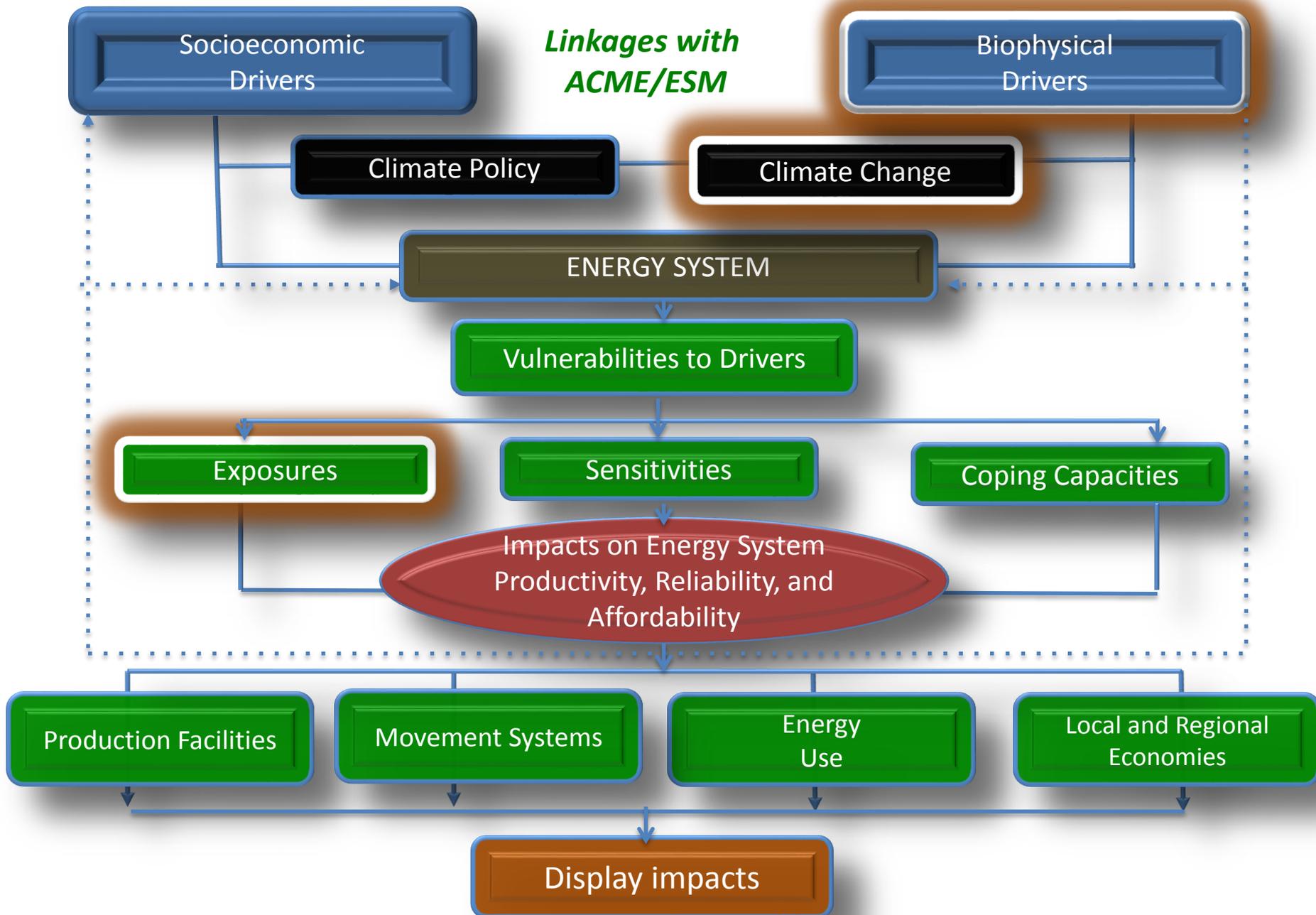
# THE OAK RIDGE IMPACTS OF CLIMATE CHANGE ON ENERGY SYSTEMS TOOL (ORIENT)



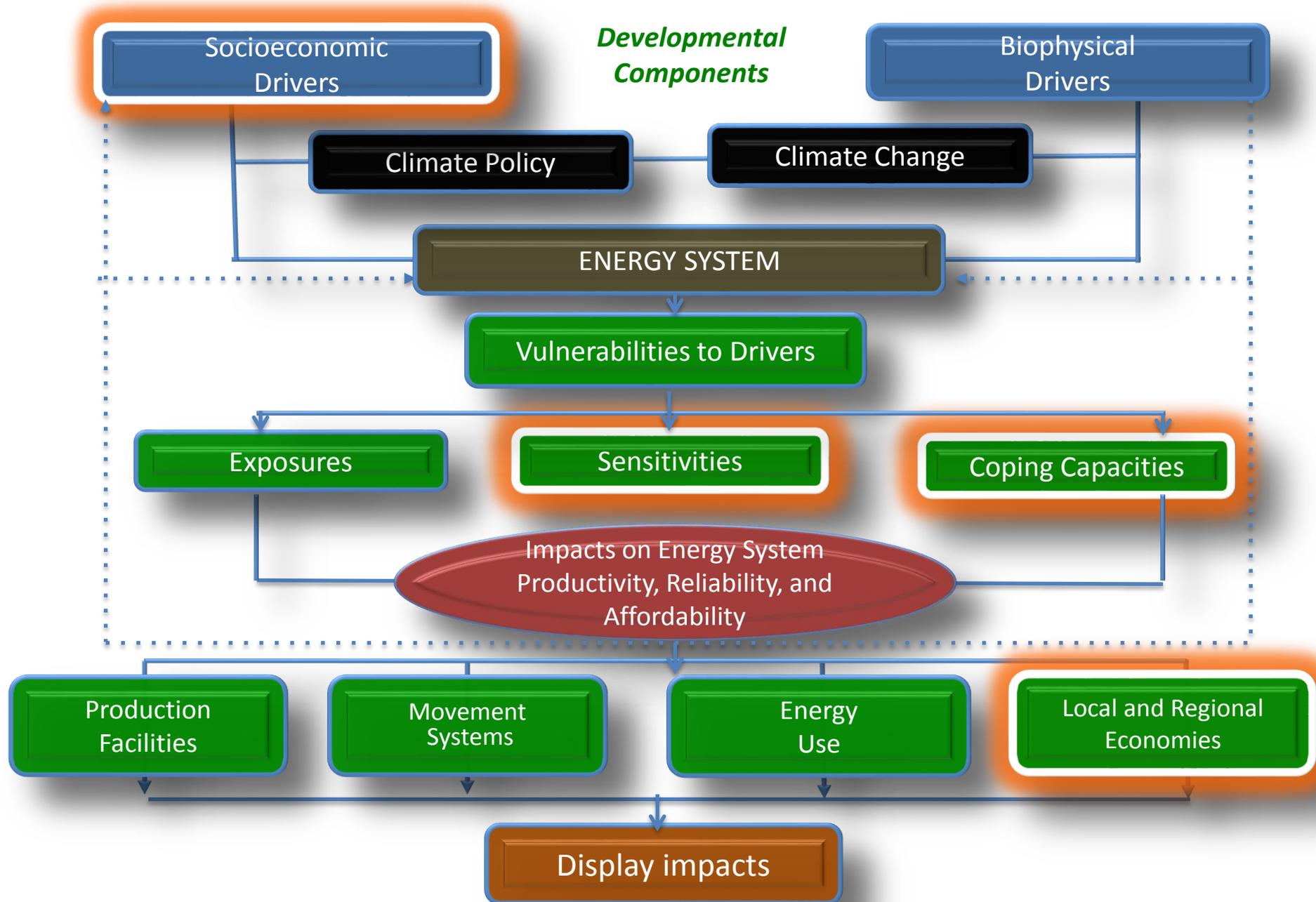
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## **In Summary:**

- **Years of investment by the DOE Integrated Assessment Research Program are paying off in the development of tools for model-based impact assessment, linked with Integrated Assessment Modeling**
- **The CIDM ensemble of asset-specific data bases and analytical structures is an invaluable resource for assessing implications of climate change and climate-related extreme events for energy infrastructures, both supply and use oriented**
- **This set of capabilities is especially well-suited for examining interconnections between energy infrastructures and other built infrastructures**
- **The science base on which CIDM rests needs further development; but priority needs have been identified, and the tools are being nested in a more general framework for impact assessment**
- **Meanwhile, this model-based approach to impact assessment is already proving useful for informing discussions of sectoral and regional vulnerabilities to climate-change-related disruptions of energy supply and demand**

# THANK YOU !

**Thomas J. Wilbanks**

Phone: (865) 574-5515

E-mail: [wilbankstj@ornl.gov](mailto:wilbankstj@ornl.gov)