# National Infrastructure Simulation & Analysis Center

# Interdependent Energy Infrastructure Simulation System (IEISS)

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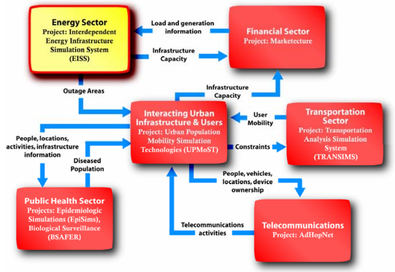


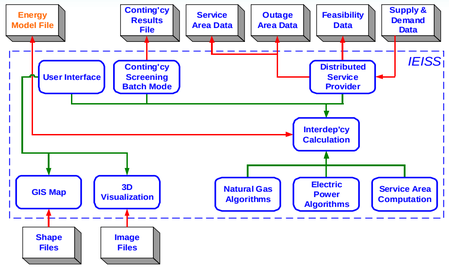

## Links to Urban Infrastructure Suite

- ***Interdependencies between electric power system and financial (energy) markets***
  - ***IEISS determines feasibility of supply and demand computed by Marketecture***
- ***Interdependencies between electric power system and transportation system***
  - ***IEISS identifies traffic controls without electric power***

## Purpose

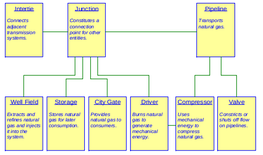
- *Research and develop a high-quality, flexible, and extendable actor - based software framework for the modeling, simulation, and analysis of interdependent energy infrastructures.*
- *Identify and understand, in depth, the infrastructure interdependencies for normal operations as well as disruptions.*
- *Provide a capability to assess, from an interdependencies perspective, the technical, economic, and national security implications of system disturbances.*
- *Assist decision makers in the areas of . . .*
  - *policy analysis,*
  - *investment & mitigation planning,*
  - *education & training*
  - *vulnerability and criticality assessments,*
  - *consequence management, and*
  - *real-time crisis assistance.*

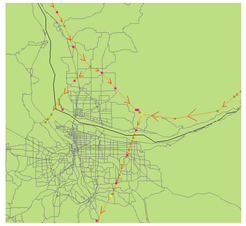
## Modules and Data Flow



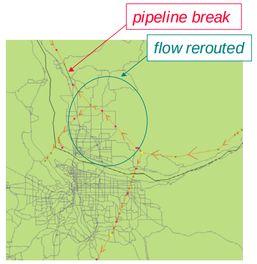

## Natural Gas Transmission Systems

- *The IEISS natural gas module represents NG transmission systems at a fidelity sufficient for determining . . .*
  - *the physical feasibility of steady-state NG flows*
  - *whether physical operating limits on NG system components are violated*
- *Several algorithms are available:*
  - *balancing production to consumption*
    - *four operating modes*
  - *physical solution*
    - *fast solver for acyclic networks*
    - *traditional iterative solver*
    - *pressure minimizing solver*
  - *dispatch of compressors*
  - *shedding of customers*



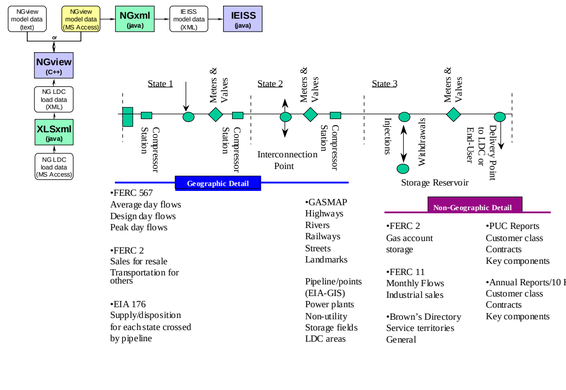



normal flow



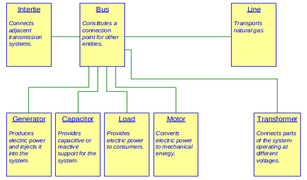

perturbed flow

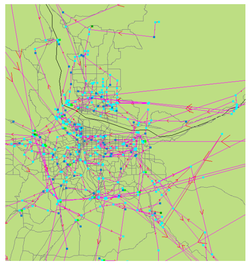
## Natural Gas Datasets Available Through NGview



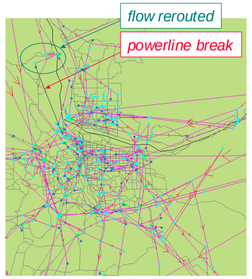

## Electric Power Transmission Systems

- *The IEISS electric power module represents EP transmission systems at a fidelity sufficient for determining . . .*
  - *the physical feasibility of steady-state EP flows*
  - *whether physical operating limits on EP components are violated*
- *Several algorithms are available:*
  - *balancing production to consumption*
  - *physical solution*
    - *linearized steady-state*
    - *non-linear steady-state*
    - *commercial solver*
    - *quasi-linear steady-state*
  - *dispatch of generation, transformers, capacitors*
    - *linear program*
    - *non-linear*
  - *shedding of customers*



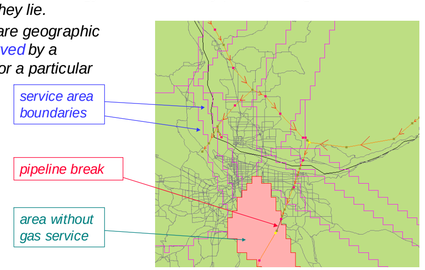
normal flow




perturbed flow

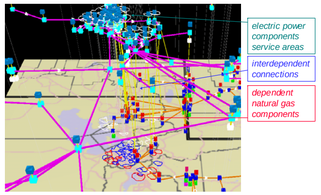
## Service & Outage Areas

- *The IEISS service/outage area module estimates the geographic area served by each energy delivery point.*
  - *City Gates serve natural gas customers.*
  - *Loads serve electric power customers.*
- *In order to continue operating, components/entities in dependent infrastructures require energy from the delivery point serving the area in which they lie.*
- *Outage areas are geographic regions not served by a delivery point for a particular infrastructure.*

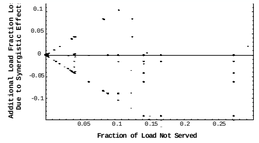


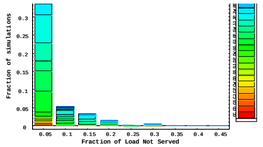

## System Interdependencies

- *The IEISS interdependency module propagates the effects of outages in one infrastructure to create further outages in other infrastructures.*
- *Interdependencies make possible feedback of events between infrastructures:*
  - *"cascading" failures may occur*
  - *substitution effects (e.g., alternate fuel types) may provide hidden robustness lessening dependencies*
- *Facilities (e.g., hospitals, fire stations) represented as points, rather than as infrastructures, may also have dependencies and loose service.*




## Synergistic & Feedback Effects



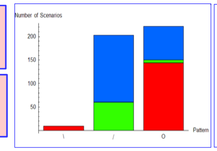



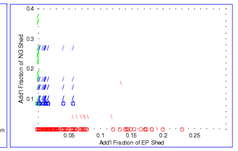

*Propagation Pattern*

*O = No propagation*
*/ = NG to EP*
*\ = EP to NG*
*X = EP to NG & NG to EP*

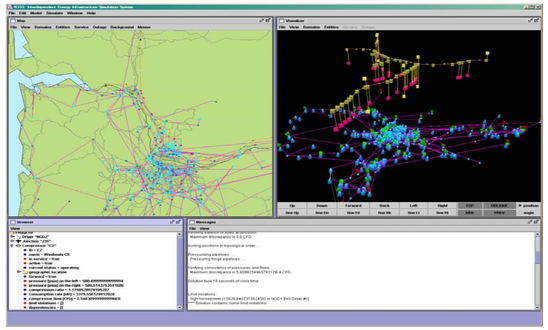
*435 Contingency Simulations*

*RED = EP-EP*
*GREEN = NG-NG*
*BLUE = EP-NG*




## User Interface



*NISAC's core partners are Sandia National Laboratories and Los Alamos National Laboratory.*
*Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under contract DE-AC04-94AL85000.*
*Los Alamos National Laboratory is operated by the University of California for the United States Department of Energy under contract W-7405 ENG-36.*