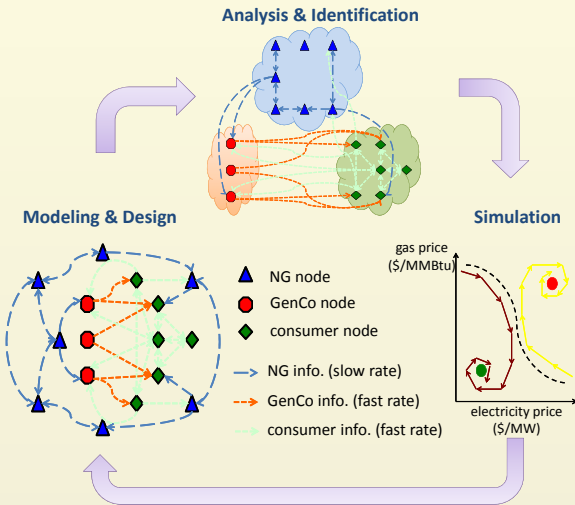# Computational Modeling for Resilient Electricity-Gas Infrastructures (CMREX)*

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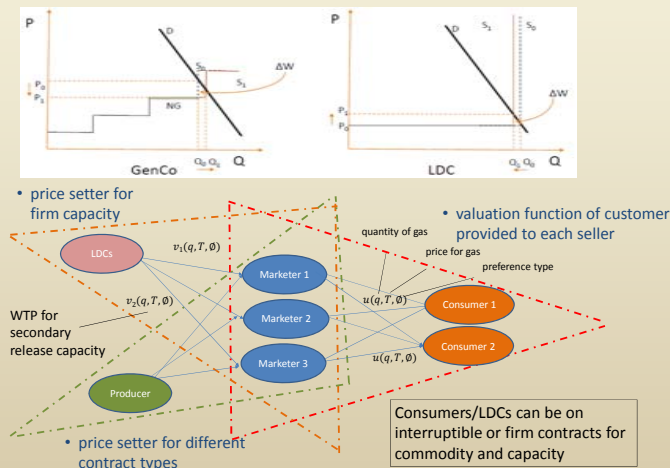
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**University of Southern California**

## CMREX

Develop multi-timescale ING-EI models
Analyze contingency scenarios
Define resiliency metrics
Perform resiliency assessment
Create evaluation environments
Verify and validate the models

**natural gas** ⟷ **electricity**

Interdependent Natural Gas-Electric Infrastructure (ING-EI)

**Key characteristics:**
- Mostly bilateral transactions
- Prioritized market participants
- Speed of sound energy transmission

**Key characteristics:**
- Periodic, transparent, regulated markets
- Speed of light energy transmission

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### Goal #1 — Develop novel solutions for efficient ING-EI operation

**Analysis & Identification**

**Modeling & Design**

gas price ($/MMBtu)

electricity price ($/MW)

- ▲ NG node
- ● GenCo node
- ◆ consumer node
- → NG info. (slow rate)
- → GenCo info. (fast rate)
- → consumer info. (fast rate)

**Simulation**

*Challenges:*
- Develop tools to investigate how the dynamics of hybrid networks are affected by the topology of the interconnections between idem-temporal subcomponents
- Determine efficient controls for operation of underlying physical + economic infrastructure
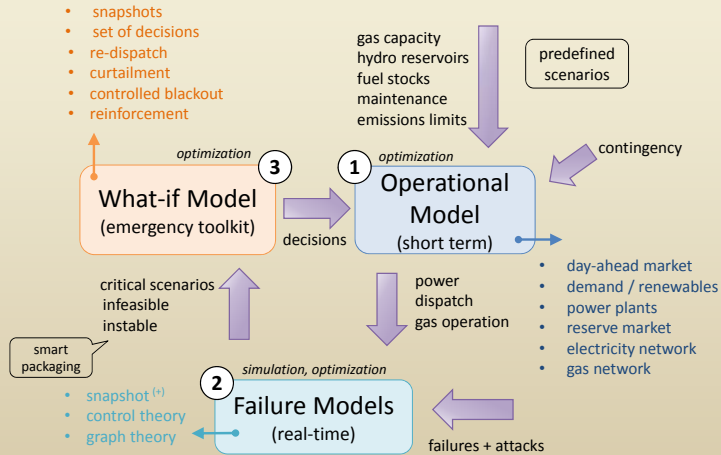
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### Goal #5 — Evaluate resiliency algorithms for ING-EI operations, control and monitoring using DETER testbed

Natural Disasters, Terrorism, Hackers Attacks, SECURITY

Power Systems, Smart Cities, Energy Generation, Smart Grid

DETERLab — Application / Cyber / Physical

*Challenges:*
- Evaluate combined models with scenarios requiring resiliency management
- Develop an information substrate that allows decentralized operation while sharing information between interested entities
- Integrate natural gas and electric models correctly at scale and complexity

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### Goal #2 — Develop natural gas spot market models including demand response

GenCo — P, Q

LDC — P, Q

$v_1(q,T,\emptyset)$
$v_2(q,T,\emptyset)$
$u(q,T,\emptyset)$

quantity of gas
price for gas
preference type

- LDCs
- Marketer 1
- Marketer 2
- Marketer 3
- Producer
- Consumer 1
- Consumer 2

WTP for secondary release capacity

valuation function of customer provided to each seller

- price setter for firm capacity
- price setter for different contract types

Consumers/LDCs can be on interruptible or firm contracts for commodity and capacity

*Challenges:*
- Evaluate current state of the natural gas infrastructure
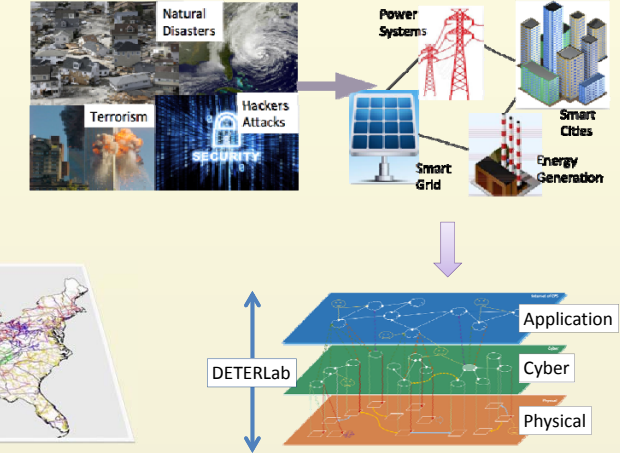- Integrate natural gas constraints with dynamic market mechanism correctly at scale and complexity

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### Goal #3 — Develop ING-EI operational scenarios for improving resiliency at market level

- snapshots
- set of decisions
- re-dispatch
- curtailment
- controlled blackout
- reinforcement

gas capacity
hydro reservoirs
fuel stocks
maintenance
emissions limits

predefined scenarios

**What-if Model** (emergency toolkit) — *optimization* ③

**① Operational Model** (short term) — *optimization*

contingency

decisions

- day-ahead market
- demand / renewables
- power plants
- reserve market
- electricity network
- gas network

power dispatch
gas operation

critical scenarios
infeasible
instable

smart packaging

- snapshot (+)
- control theory
- graph theory

**② Failure Models** (real-time) — *simulation, optimization*

failures + attacks

*Challenges:*
- Identify key what-if models for resiliency improvement
- Incorporate the impact of close-to-real-time scale decisions and events

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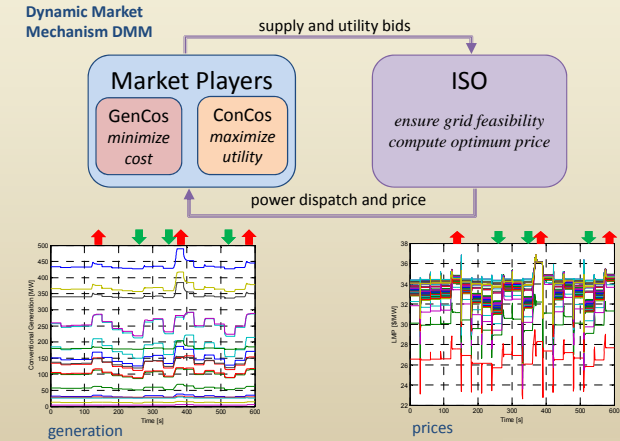### Goal #4 — Develop real-time dynamic ING-EI operational models and controls for improving resiliency at fast time scales

**Dynamic Market Mechanism DMM**

supply and utility bids

**Market Players**
- GenCos — *minimize cost*
- ConCos — *maximize utility*

**ISO**
- *ensure grid feasibility*
- *compute optimum price*

power dispatch and price

generation

prices

*Challenges:*
- Improve convergence rate of DMM as complexity and size increase
- Identify key resilience metrics and methods for improvement

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