



Coordinating the Gas and Electric Power Interface

EUCI Workshop

Charlotte, North Carolina
May 5th and 6th, 2014

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Topics

- Gas Electric Planning Process
- Short term vs. long-term optimization scenarios
- Co-optimizing gas and electric expansion
- Co-optimization of gas and electric production cost
- Gas Electric Adequacy



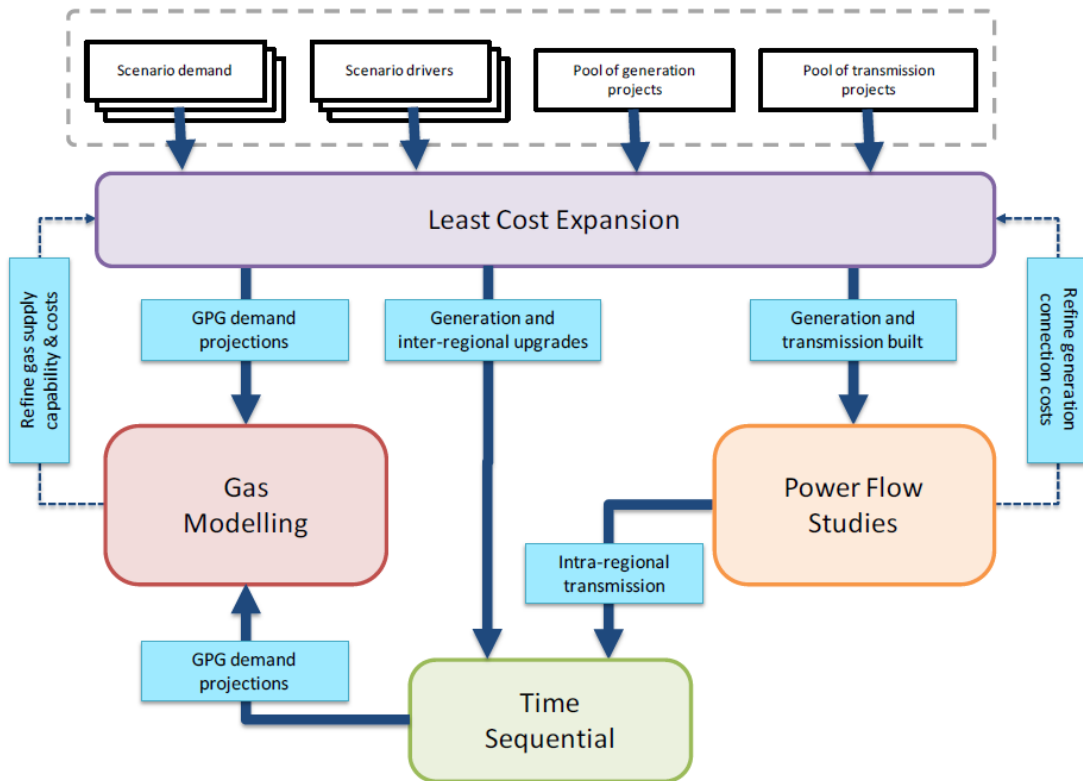
Natural Gas and Electric Planning Process

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Australian AEMO Co-Optimization of Generation and Transmission in planning and Gas Planning



Least-cost expansion modelling delivers a co-optimized set of new generation developments, inter-regional transmission network augmentations, and generation retirements across the NEM over a given period. This provides an indication of the optimal combination of technology, location, timing, and capacity of future generation and inter-regional transmission developments.

The least-cost expansion algorithm invests in and retires generation to minimize combined capital and operating-cost expenses across the NEM system.

This optimization is subject to satisfying:

- The energy balance constraint, ensuring supply matches demand for electricity at any time,
- The capacity constraint, ensuring sufficient generation is built to meet peak demand with the largest generating unit out of service, and
- The Large-Scale Renewable Energy Target (LRET) constraint, which mandates an annual level of generation to be sourced from renewable resources.



Planning Process in US

Power Sector

- 10 Year Plans
- Stakeholder Process
- Planning Coordinators
- Integrated Resource Plans
- Modeling Workgroups
- Regional Reliability Standards
- Planning Process Cost Recovery

Natural Gas Sector

- No 10 year plans
- Stakeholder Process Pipeline to LDC
- No Planning Coordinators
- No Integrated Resource Plans
- No modeling workgroups
- No Regional Reliability Standards
- No shared cost allocation for planning pipelines
- Proposed project with open season



Strategic Planning Gas Electric

PLEXOS[®]
Integrated Energy Model

- Cost Recovery Mechanism
- Gas Electric Planning Coordinator Function
- Stakeholder Process
- 10 year plans
- Reliability Standards
- Least Cost Multi Sector Co-Optimized Planning
- Regional vs. National





Co-Optimizations for Electricity and Natural Gas Sectors

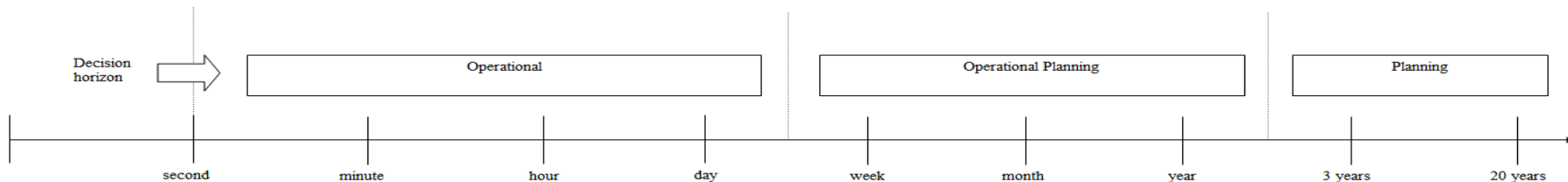
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Gas Electric Coordination

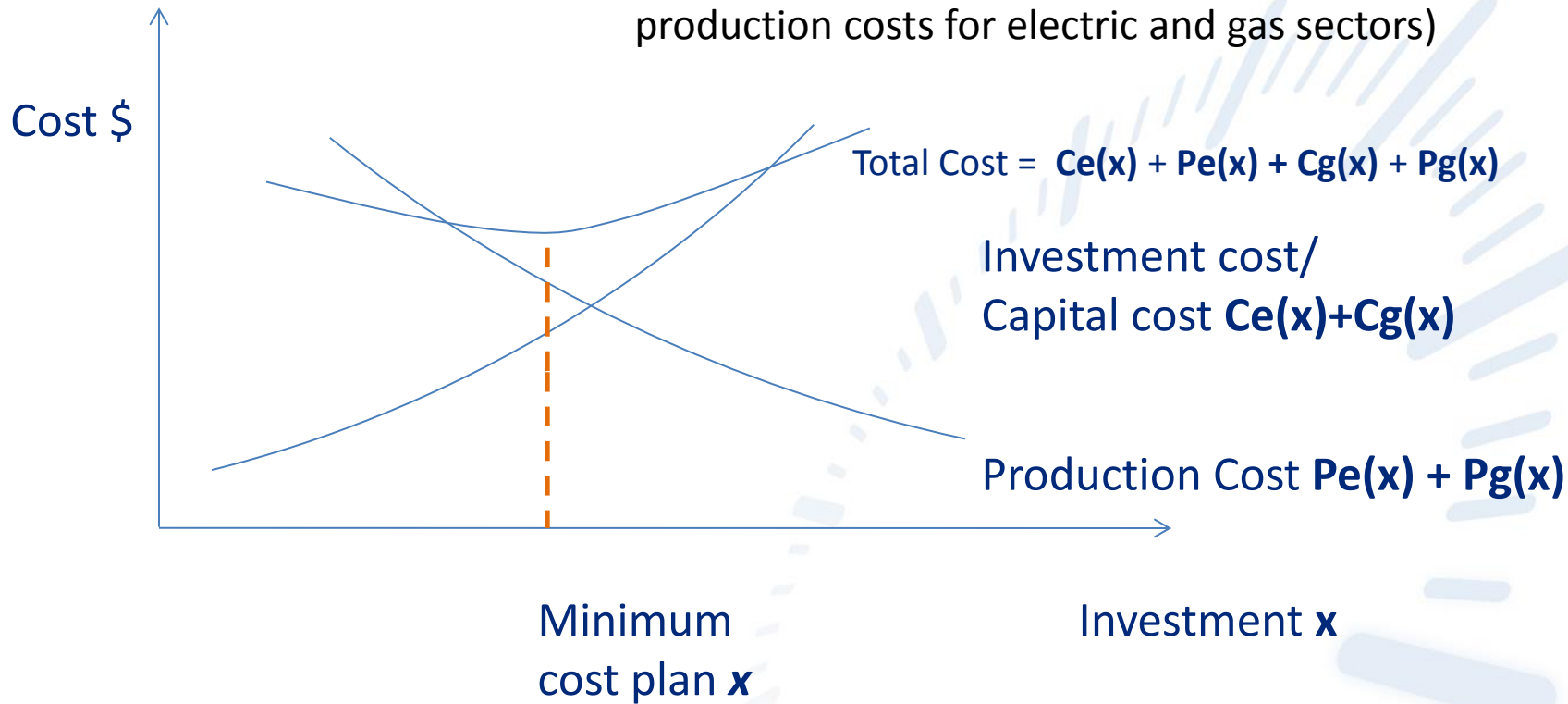


- Focus on long-term studies with decision variables spanning many years:
- Co-optimize generation new builds and retirements with:
 - Transmission line builds *e.g.* AC or DC lines; and
 - Transmission interface upgrades;
 - Power Plants, Storage, Demand Response
 - Natural gas pipeline and storage expansion
 - And others such as ancillary services



Optimization

Objective: Minimize net present value of forward-looking costs (*i.e.* capital and production costs for electric and gas sectors)



$$\text{Minimize } \sum_{y=1}^Y \sum_{i=1}^I (BuildCost_i \times Build_{i,y}) + \sum_{t=1}^T \left(\sum_{i=1}^I ProdCost_i \times Prod_{i,t} \right) + ShortCost \times Shortage_t$$

subject to

$$\text{Supply and Demand Balance: } \sum_{i=1}^I Prod_{i,t} + Shortage_t = Demand_t \quad \forall t$$

$$\text{Production Feasible: } Prod_{i,t} \leq ProdMax_i \quad \forall i, t$$

$$\text{Expansion Feasible: } Build_{i,y} \leq BuildMax_{i,y} \quad \forall i, y$$

$$\text{Integrity: } Build_{i,y} \text{ integer}$$

$$\text{Reliability: } LOLP(Build_{i,y}) \leq LOLPTarget \quad \forall y$$

This simplified illustration shows the essential elements of the mixed integer programming formulation. Build decisions cover generation, transmission and gas elements, as does supply and demand balance and shortage terms. The entire problem is solved simultaneously, yielding a true co-optimized solution.



Co-Optimization of Electric and Natural Gas Production Cost



Illustrative Formulation of Co-Optimization of Natural Gas and Electric Markets with Co-Optimizations of Ancillary Services

PLEXOS®
Integrated Energy Model

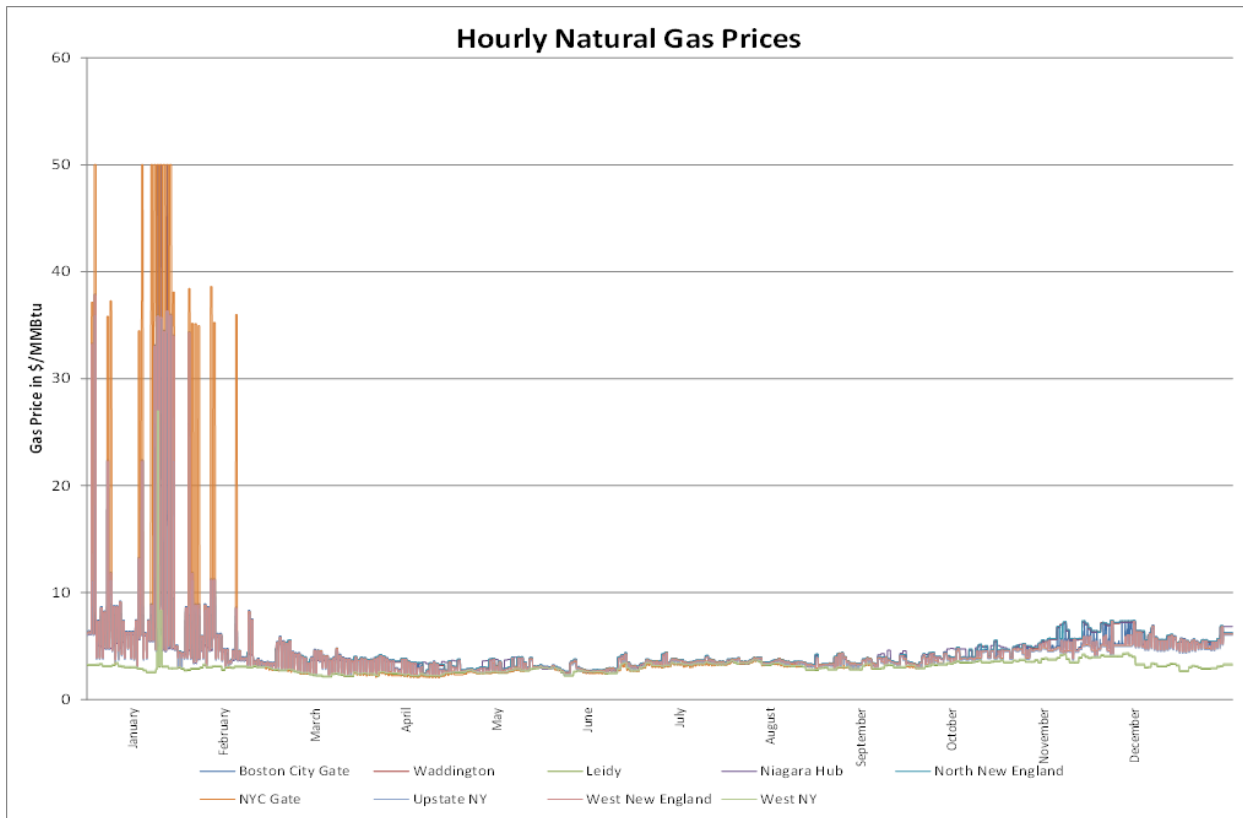
- Objective:
 - Co-Optimization of Gas Electric Markets with Co-Optimization of Ancillary Services
- Minimize:
 - Electric Production Cost + Gas Production Cost + Electric Demand Shortage Cost + Natural Gas Demand Shortage Cost + Ancillary Services Shortage Cost
- Subject to:
 - [Electric Production] + [Electric Shortage] = [Electric Demand] + [Electric Losses]
 - [Ancillary Service Provision] \geq [Ancillary Services Requirements]
 - [Transmission Constraints]
 - [Electric Production] and [Ancillary Services Provision] feasible
 - [Gas Production] + [Gas Demand Shortage] = [Gas Demand] + [Gas Generator Demand]
 - [Gas Production] feasible
 - [Pipeline Constraints]
 - others



Simplified Model Inputs/Results

Northeast Natural Gas Prices

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Integrated Energy Model



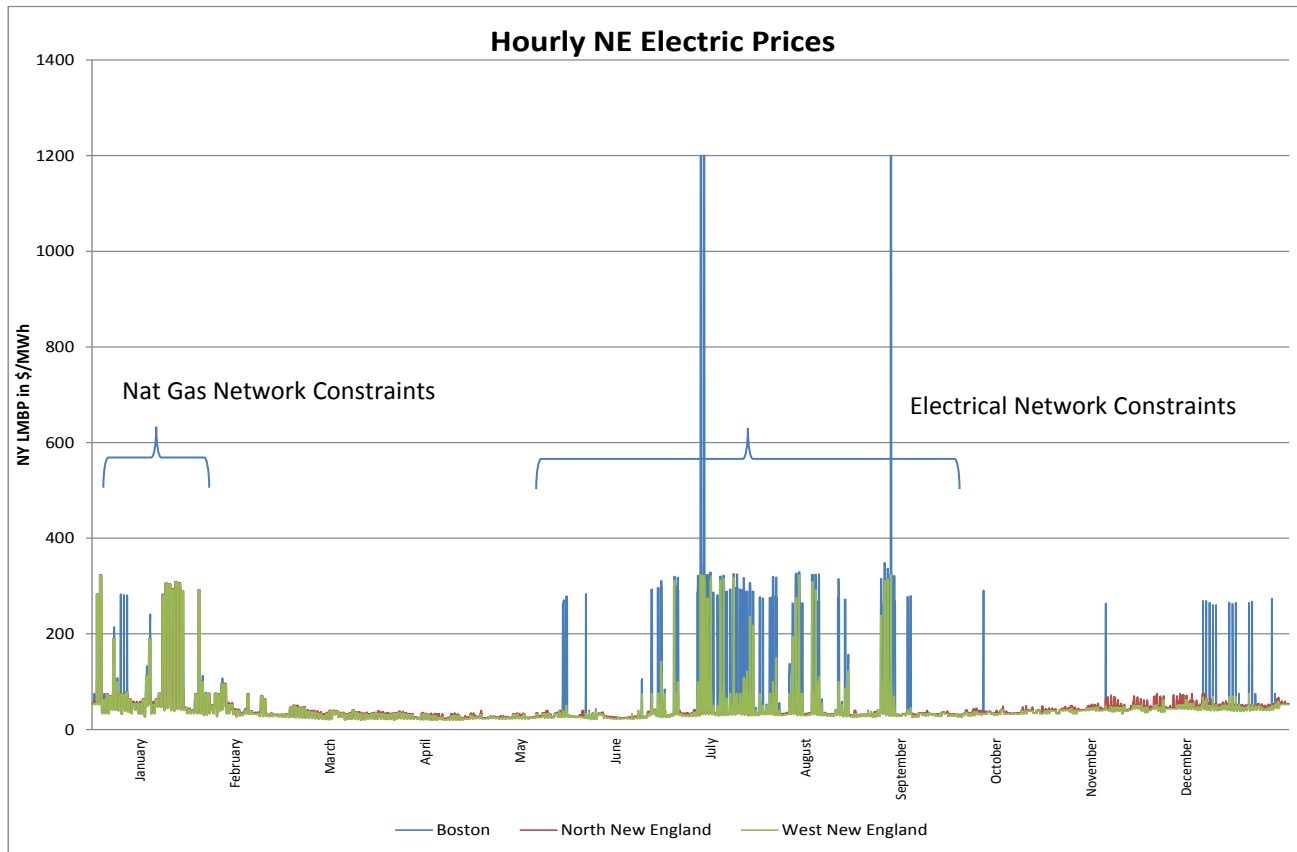
Natural Gas prices at Leidy, Niagara Hub and Transco Z6 are used as the production costs for the natural gas into NY and New England. Citygate prices are calculated by PLEXOS.



Simplified Model Results

ISONE LMP

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Electric Prices for ISONE.

Prices in Winter influenced by natural gas shortages. Summer prices reflect shortages calculated by PLEXOS.



Gas Electric System Adequacy

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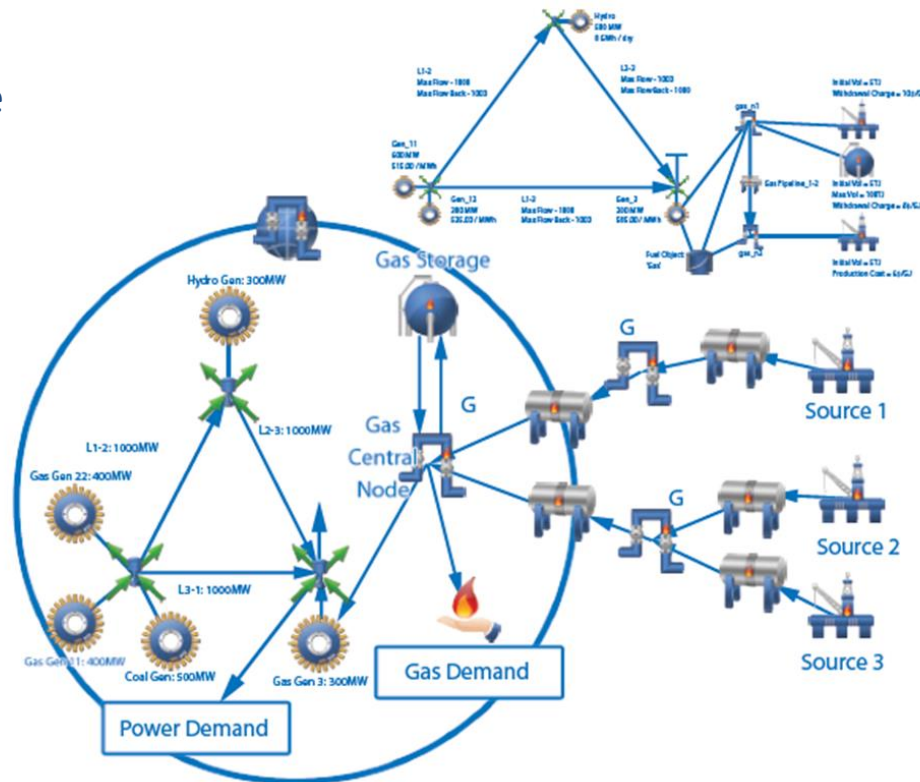
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Gas Electric System Adequacy

- Supply and Demand Balance
- Planned Outages or Maintenance Rate
- Forced Outage Rate
- Mean Time To Repair
- Repair Time Distributions
- Reliability Metrics - Convolution
- Contingencies
- Monte Carlo
- Derating
- VOLL
- USE
- Dump
- Stored Fuel and Electricity





Outages

- Planned vs. Forced Outages
 - Maintenance Outage Rate
 - Forced Outage Rate
 - Repair Time Characteristics
- Equipment
 - Generators, Transmission Lines, Transformers
 - Pipeline, Compressors (derates)

Gas and Electric Contingencies



Reliability Metrics

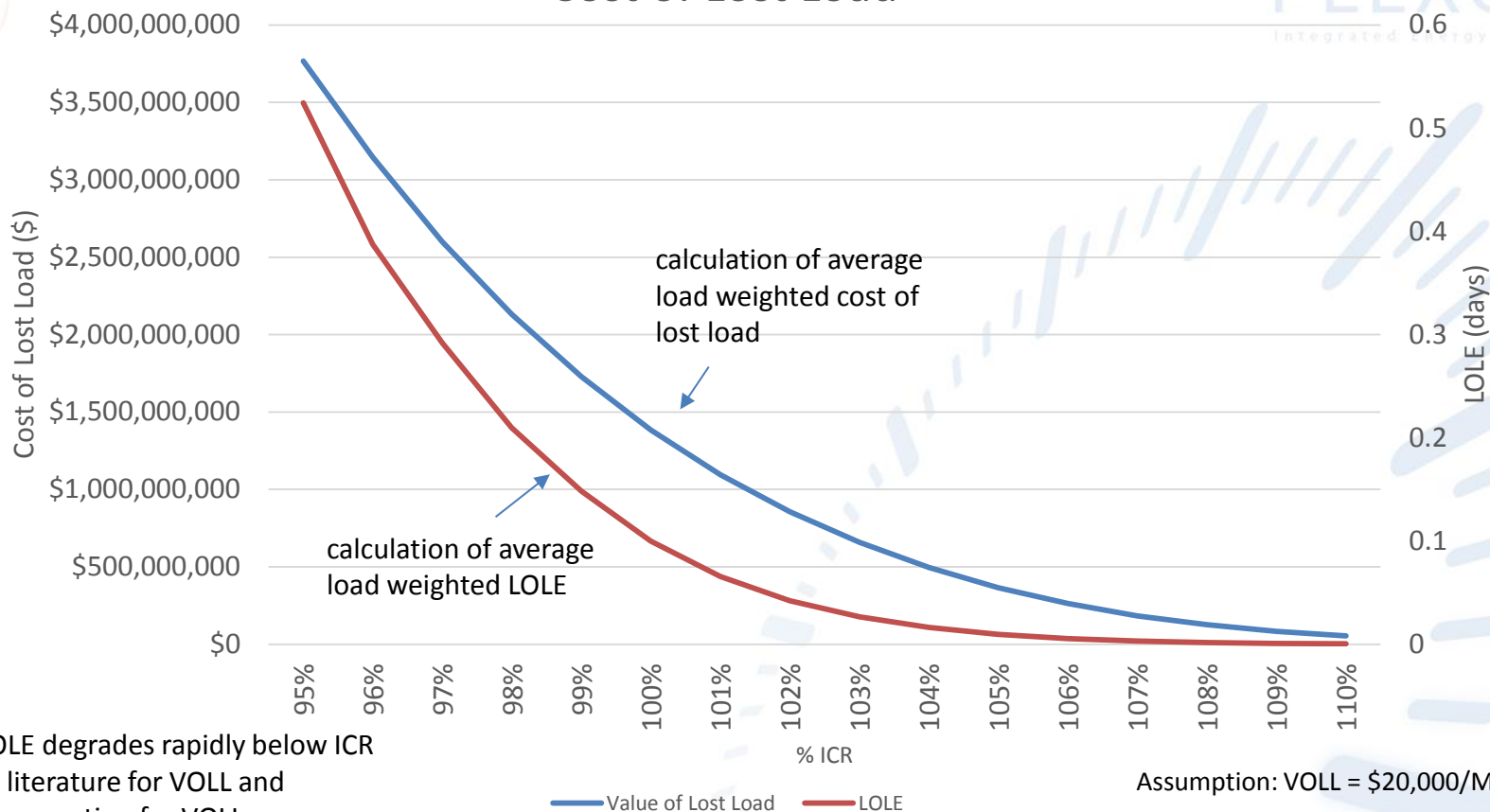
- LOLP – Loss of load probability
- LOLE – Loss of load expectation
- EENS – Expected energy not served
- EDNS – Expected demand not served



Case Example: Unserved Demand



Cost of Lost Load



- System LOLE degrades rapidly below ICR
- Reviewed literature for VOLL and picked a assumption for VOLL