

# **Testing the reliability of FERC's Wholesale Power Market Platform: An Agent-Based Computational Economics Approach**

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(Work in Progress)

# Key Issues for Wholesale Power Markets

- ***Short-Run:*** Efficient production of electricity from existing generation capacity
- ***Short-Run:*** Efficient transmission of electricity to existing load-serving entities
- ***Longer-Run:*** Efficient planning and investment for *new* generation and *new* transmission capacity

# Wholesale Power Market Platform -- WPMP (FERC, White Paper, April 2003)

## WPMP Objectives

- Customer-based competitive wholesale power markets providing reliable service
- Fair and open access to the transmission grid at reasonable prices
- Good price signals to encourage appropriate investment in new generation and new transmission
- Market power mitigation

## Key WPMP Features

- Independent operation of the transmission system by RTO/ISO
- Day-ahead electricity market (financial contracts)
- Real-time electricity market to supplement longer-term contracts
- Ancillary services (e.g., reserves adequacy,...)
- Congestion management, preferably through Locational Marginal Pricing (LMP) and financial transmission rights
- Market monitoring and market power mitigation

## FERC's Basic WPMP Proposal Adopted?

- **Mid-Atlantic states** (PJM) implement similar plan (1998)
- **New York** (NY-ISO) implements similar plan (1999)
- **New England** (NE-ISO) implements similar plan (2003)
- **California** (CAISO) files to adopt similar plan (2003)
- **Midwest** (MISO) **files to adopt** similar plan (7/2003) and **withdraws** filing (10/2003)
- **Opposition** from states in Southeast and Northwest

# Economic Electricity Research

([www.econ.iastate.edu/tesfatsi/epres.htm](http://www.econ.iastate.edu/tesfatsi/epres.htm))

- *Analytical/Empirical:*
  - Berkeley (Borenstein, Bushnell, Oren,...); Cambridge (Green, Newbery,...); EPRI (Chao, Peck,...); Harvard (Hogan,...); MIT (Joskow,...); U of Oslo (Halseth, von der Fehr,...); Stanford (Wilson, Wolak,...); ...
- *Human-Subject Experiments:*
  - Cornell (Mount,...); George Mason U (Rassenti, Smith, Wilson,...); ...

## **DOE's Quantitative Assessment of WPMP (DOE/S-0138, 4/03)**

- **GE's Multi-Area Production Simulation (MAPS) Model:** Transmission issues on a short-run regional basis
- **DOE's Policy Office Electricity Modeling System (POEMS) Model:** Mid-term and longer-run projections of usage of generation infrastructure

## Key Aspects of DOE's Quantitative Assessment

- **Comparison** of Non-WPMP case (projected continuation of existing conditions) to WPMP case (seamless U.S. implementation assumed)
- **Many cautions about model limitations** (e.g., equilibrium assumed, no strategic bidding, demand held constant across tested cases...)
- Estimated average long-run net consumer cost savings (2016-2020) = \$225Million/Year (regional variability)

# Potential Contributions of Agent-Based Computational Economics (ACE) Approach

- Key market participants (generators, load-serving entities, ISO,...) modeled as **autonomous interacting agents**
- **Agent learning** can be calibrated to data (empirical, human-subject experimental)
- Behaviors and interaction networks **evolve over time**
- Easier to include and test **detailed structural market features** for individual and/or joint effects

## **ACE Electricity Research:** **( [www.econ.iastate.edu/tesfatsi/aelect.htm](http://www.econ.iastate.edu/tesfatsi/aelect.htm) )**

- Argonne National Lab (Macal, North,...)
- CSIRO-Australia (Batten,...)
- Helsinki University (Hamalainen,...)
- Iowa State University (Sheble, Tesfatsion,...)
- London Business School (Bunn, Day,...)
- Los Alamos National Lab (Barrett, Marathe,...)
- Pacific Northwest National Lab (Roop,...)
- Others (see website above)

# Our ACE Wholesale Power Market Model

- Based on **Standard Market Design (SMD)** implemented by New England (ISO-NE) on March 1, 2003
- **SMD meets basic WPMP structural requirements:**
  - Independent System Operator (ISO)
  - Day-ahead and real-time electricity markets
  - Congestion managed via LMP
  - Financial transmission rights
  - Planned reserve/capacity markets and enhanced demand response

# Initial Core Model

## ➤ Traders

- Sellers and Buyers
- Follow market rules
- Learning abilities

## ➤ ISO roles

- Assessment of systems reliability
- Optimal power flow calculation
- Settlement procedures

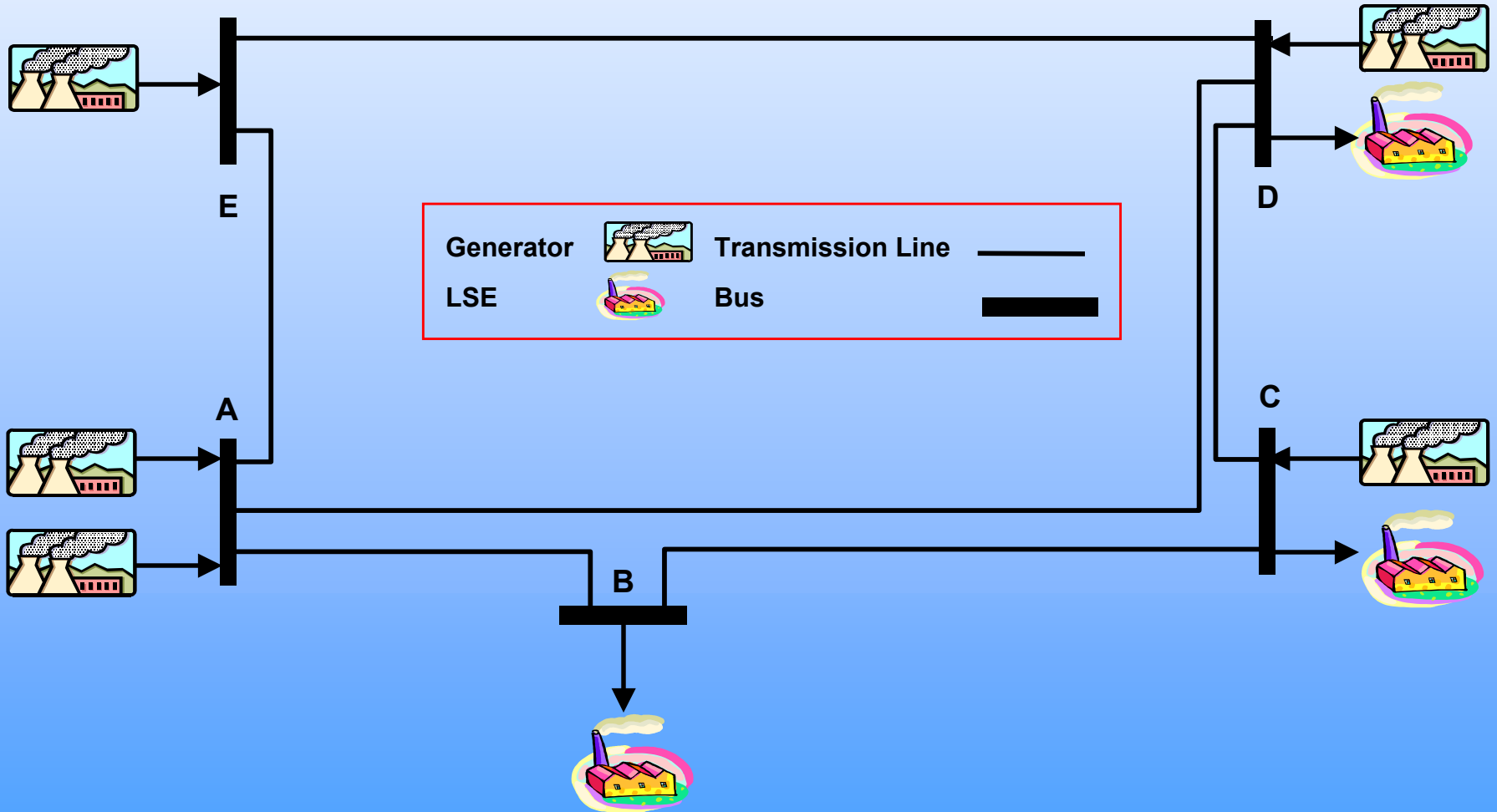
## ➤ Multi-settlement process

- Day-ahead electricity market
- Real-time electricity market
- Supply re-offer period

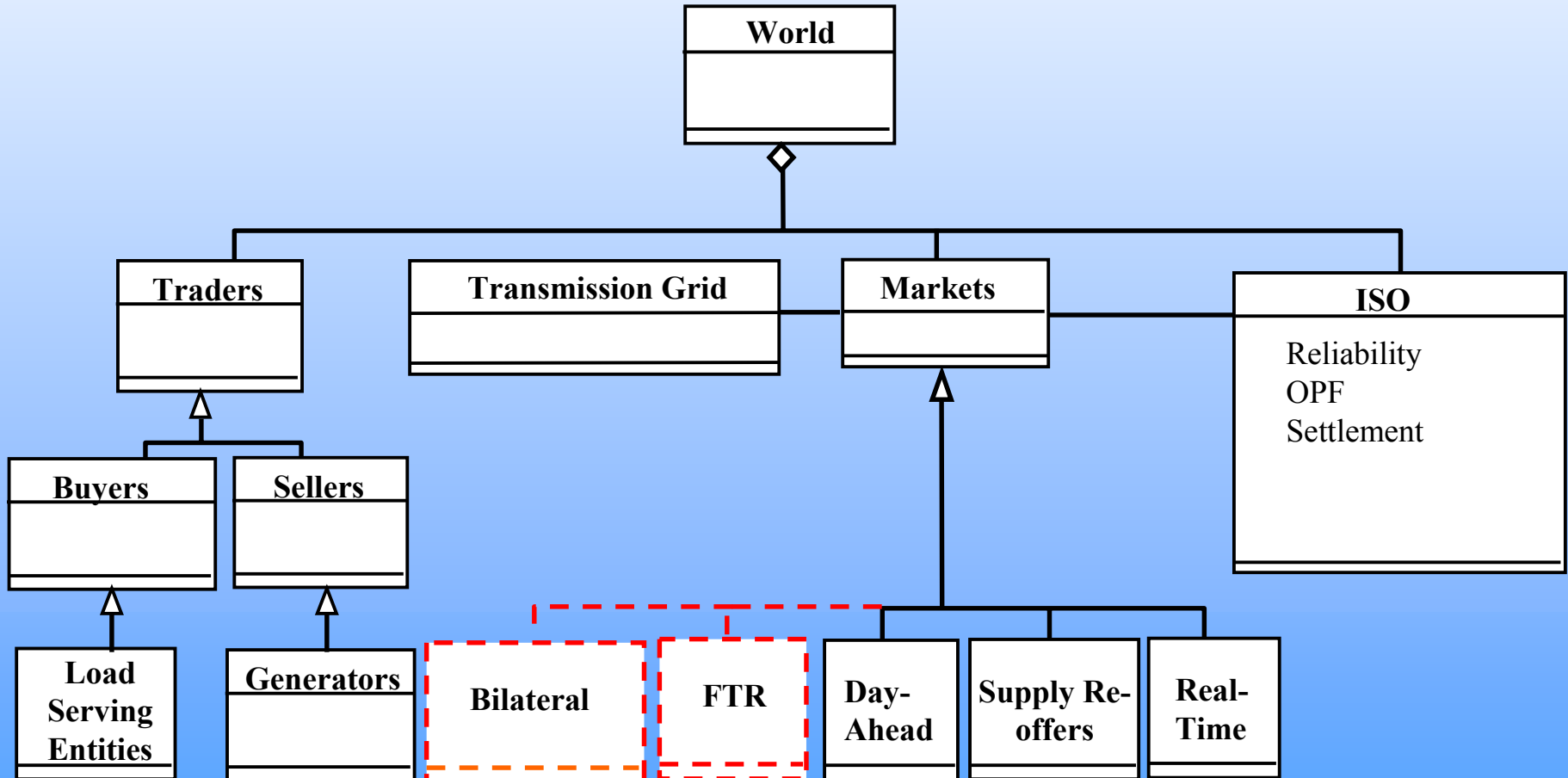
## ➤ AC transmission grid

- Congestion managed via LMP
- 5-bus demo model (scalable to a more complex grid)

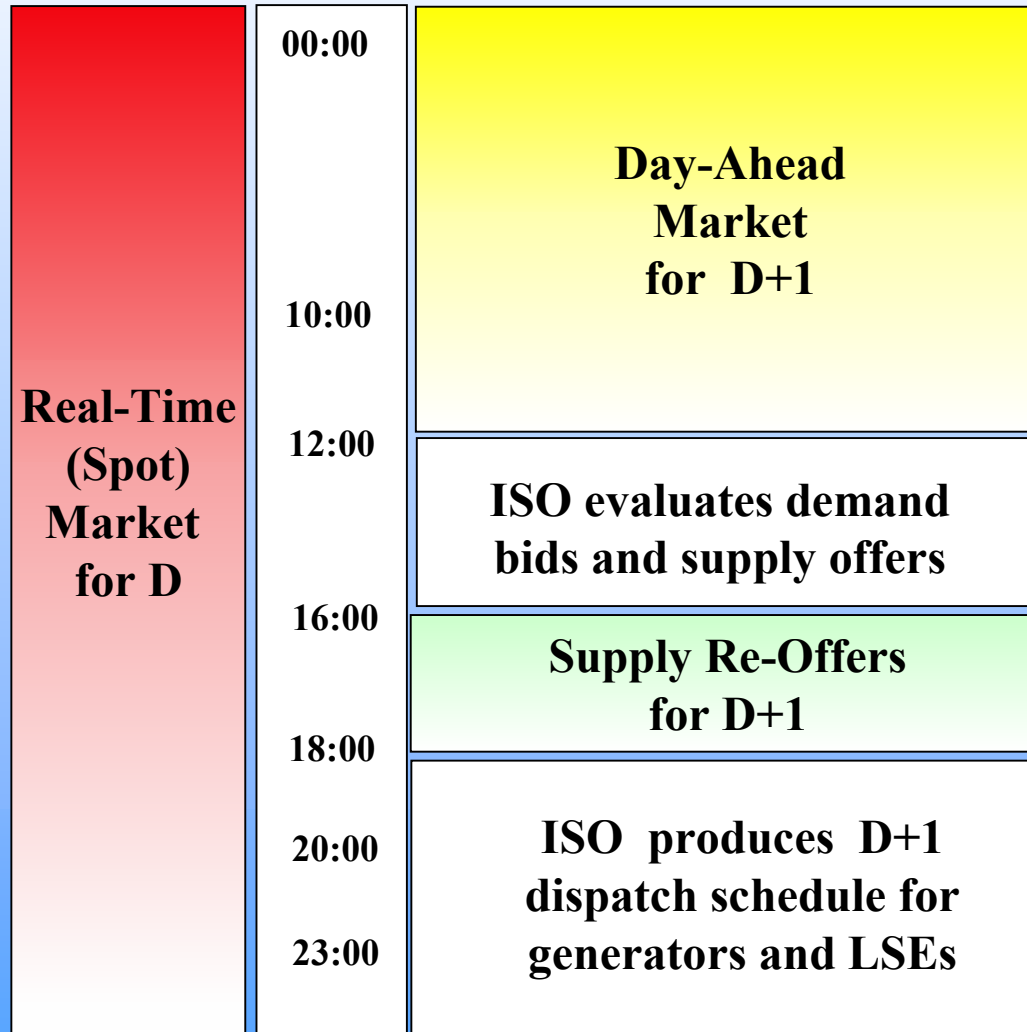
# 5-Bus Demo Model



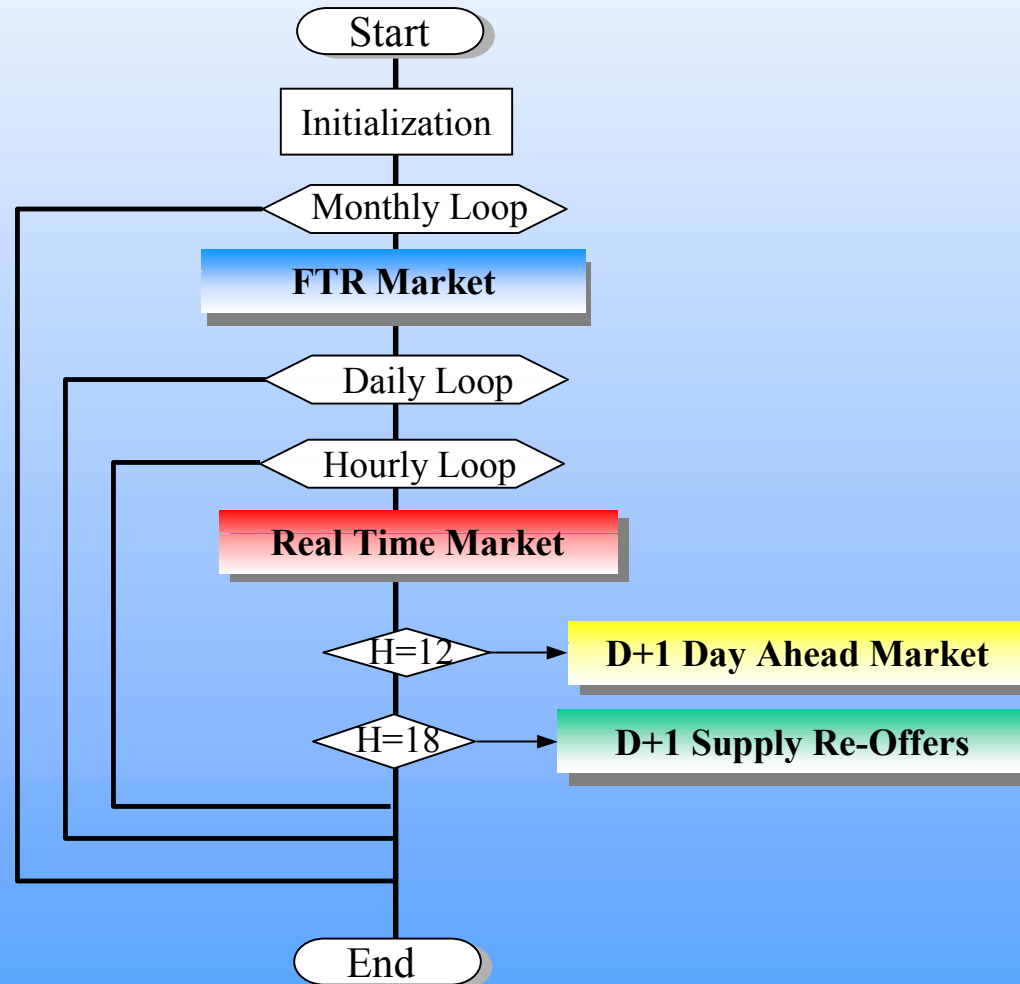
# ACE WPM Model: Class Hierarchy



# ISO Market Operation (Day D)



# ACE WPM Model: Activity Flow



## Measures of Market Performance (Economic Reliability)

- **Market Efficiency:** the ratio of *actual* profits to *maximum possible* profits for buyers and sellers
- **Market Power:** the ability to *profitably* alter prices away from competitive levels

## Market Performance: Key Considerations

- **Learning Effects:** “Sellers intend to make as much money as possible and will use all available strategies to achieve this goal.”

(Frank Wolak, Senate Hearing, 5/15/03)

- **Role of Demand Responsiveness:** “The symmetrical nature of the *double* auction (electricity market)...appears to prevent either buyers or sellers from successfully learning to gain market power advantages through strategic pricing.”

(Nicolaisen, Petrov, Tesfatsion, *IEEE-TEC*, 2001)

## Market Performance: Key Considerations ...

- **Importance of FTR Design for LR Management of Congestion:**

“We can make all the reliability standards in the world (but they won’t do much good) if we don’t have people willing to invest in transmission and other technologies.”

(Pat Wood III, FERC Chair, Senate Hearing, 9/10/03)

## Initial Experimental Design: Treatment Factor Ranges

- Simple reinforcement learning → Learning to learn
- Passive demand → Active demand bidding
- No transmission rights → Point-to-point financial transmission rights

# Longer-Run Research Plans

- Collaboration with Los Alamos National Lab energy researchers (Dr. Achla Marathe,...)
- **Objectives:**
  - To scale up ACE wholesale power market model to more realistic dimensions
  - To incorporate ACE wholesale power market model into the LANL Marketecture Model for U.S. Energy Infrastructure