



# Independent Assessment of Midwest ISO Operational Benefits

*Prepared for:*  
Midwest ISO Stakeholders

*Prepared by:*  
**ICF Consulting**

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# Outline

- Introduction and Study Background
- Cases Examined and Study Methodology
- Model and Data Source Overview
- Summary Results
- Supporting Analyses
- Conclusions

*Introduction and Study  
Background*

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# Origin & Timeline of the ICF Study



- The Department of Energy conducted initial cost/benefit on Midwest ISO market in August 2005 based on a 1-hour period. ICF performed a similar study for the Midwest ISO in October 2005 covering a single day.
- The Midwest ISO hired ICF International in November 2005 to conduct an independent evaluation utilizing a 10 month period.
- ICF Study Chronology
  - Feb 06: data gathering for model development initiated
  - Apr 06: first model preliminary estimates completed
  - May – Aug 06: generators requested to review, revise and approve data
  - Sep 06: revised discrete flowgate data
  - Oct 06: preliminary estimates from second model runs completed
  - Nov 06: modeling to evaluate potential benefits largely complete, showing estimated production cost savings of 3% to 5%
  - Nov – Dec 06: Midwest ISO worked with ICF, the Independent Market Monitor and SAIC to identify assumption variables that should be reflected in preliminary results from third model run to better reflect actual study period results
  - Feb 07: ICF releases the full report.

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# ICF Study – What it is



- Focuses on subset of operational benefits and reflection on performance
  - Regional unit commitment and security-constrained economic dispatch
  - Improved utilization of transmission assets
  - Tool to evaluate trends in market outcomes; “high-level” indication of market benefits
- Highlights differences between realized and potential benefits
  - Potential benefits reflect optimization of regulation and reserves
  - Inefficiencies in actual operations due primarily to conservative operating decisions during market start-up reflected in gap between potential and realized benefits
    - Unit commitment (level and type of capacity)
    - Generation offer flexibility (EcoMin, EcoMax, ramp)

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# ICF Study – What it is not



- What the ICF Study Is Not:
  - Precise indication of how Midwest ISO market actually performed
  - A “rate case-quality” tool for states in the Midwest ISO footprint
  - Tool that can be utilized to answer questions for individual generation units or the corresponding Balancing Authority
  
- Areas not Covered by the ICF Study:
  - Transmission access, expanded markets & reduced barriers to trade
  - Improved reliability through regional power flow visibility and dispatch
  - Improved generator availability and efficiency in peak price periods
  - Opportunities for greater participation of price responsive demand

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# Stakeholder Participation



- This study was driven by an open and interactive Stakeholder process designed to ensure the accurate representation of the Midwest ISO system and to benefit from the feedback of all Stakeholders.
- Stakeholder activities included:
  - Access to a centralized stakeholder website
  - Review of study assumptions
  - Review of all generating unit and demand
  - Several stakeholder meetings

*Cases Examined and Study  
Methodology*

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# Cases Examined



- ICF prepared and analyzed four primary cases in order to develop the study results. Each case involved a ten month study period between June 1, 2005 and March 31, 2006. These cases are:
  - **Day-1 Case**: This case estimated the production cost of the Midwest ISO market assuming continued Day-1 operation.
  - **Day-2 Optimal Case**: This case was designed to estimate the theoretical maximum benefits from centralized operations in a Day-2 market as compared to the Day-1 Case.
  - **Day-2 Actual Case**: This case was designed to estimate the benefits achieved by the Midwest ISO's Actual Day-2 operation over the study period. ICF used actual hourly dispatch data from the Midwest ISO's Day-2 market operations to estimate actual production costs during this historical period.
  - **No-ASM (Ancillary Services Market) Case**: This sensitivity case was designed to simulate achievable benefits from centralized dispatch given the fact that current Midwest ISO operations do not include centralized dispatch and commitment of regulation and operating reserves.

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# Methodology



- Benefits (both positive and negative) were assessed as the change in production costs across the four cases described above which were designed to reflect varying market structures in the Midwest ISO territory.
- Production costs include fuel costs, non-fuel VO&M, and emission allowance costs.
- Production cost savings are the industry accepted measure of benefits achieved through centralized system operations under market restructuring.
- Three cases were performed using the GE-MAPS simulation software (Day-1, Day-2 Optimal, and No-ASM). The remaining case was developed using actual hourly operation for each facility in the Midwest ISO.

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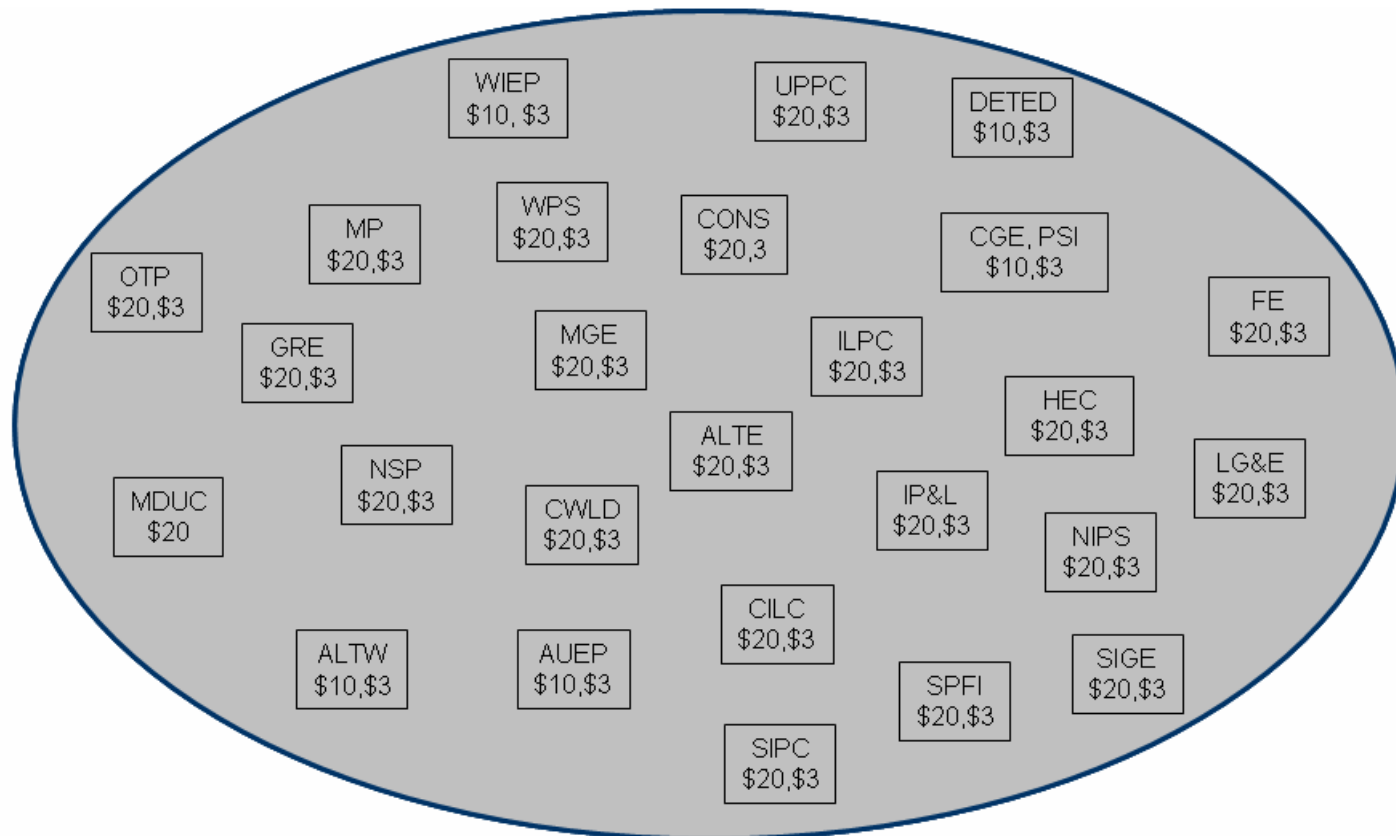
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# Methodology – Hurdle Rates



- A key element of the approach to estimating RTO benefits involves the use of “hurdle rates” to capture inefficiencies associated with decentralized markets. Two hurdles were used, a commitment hurdle and a dispatch hurdle.
  - Commitment hurdles capture company operation (decentralized operation)
  - Dispatch hurdles capture non-tariff related dispatch inefficiencies associated with scheduling and dispatching practices across multiple transmission providers.
- The determination of the appropriate level of hurdle rates is achieved through calibration. Hurdle rates are introduced in the model to calibrate the simulated model outcome to historical (2004) market outcomes.
- ICF calibrated to four primary parameter during this exercise, namely
  - Midwest ISO net interchange,
  - Generation by Balancing Authorities,
  - Generation by unit type, and
  - Generation by unit

# Calibrated Hurdle Rates



Control Area Name ( Commitment Hurdle (\$), Dispatch Hurdle (\$))

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# Methodology – Day-2 Actual Case



- There are two broad production cost components that are considered in estimating the total system production costs. Namely,
  - Costs from local generation and
  - Costs from generation outside the Midwest ISO footprint.
- In the Day-1, Day-2 Optimal, and No-ASM Cases both of these values are direct outputs of the GE-MAPS model.
- In the Day-2 Actual Case, the comparison to Day-1 system production costs is not directly possible because we can only directly measure production costs within the Midwest ISO.

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# Methodology – Day-2 Actual Case



- The approach used to estimate each of these two cost components for the Day-2 Actual Case is discussed below.
  
- Costs from Local Generation
  - Each local generation unit has four main sub-components of costs associated with generation dispatch. These costs are fuel, non-fuel variable operating and maintenance costs (VOM), NOX emission costs and SO2 emission costs.
  
  - Each of these costs were calculated on an hourly basis using parameters consistent with the GE-MAPS model inputs and methodology.

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# Methodology – Day-2 Actual Case



- Non-Midwest ISO Unit Production Costs
  - Non-Midwest ISO region unit production costs are assumed to be consistent with model costs realized in the Day-2 Optimal Case.
  - These hourly fuel, VOM, and emissions costs are aggregated to a monthly total and adjusted to account for any differences in net interchange in that month between simulated Day-2 Optimal model results and actual operations.

# *Model and Data Source Overview*

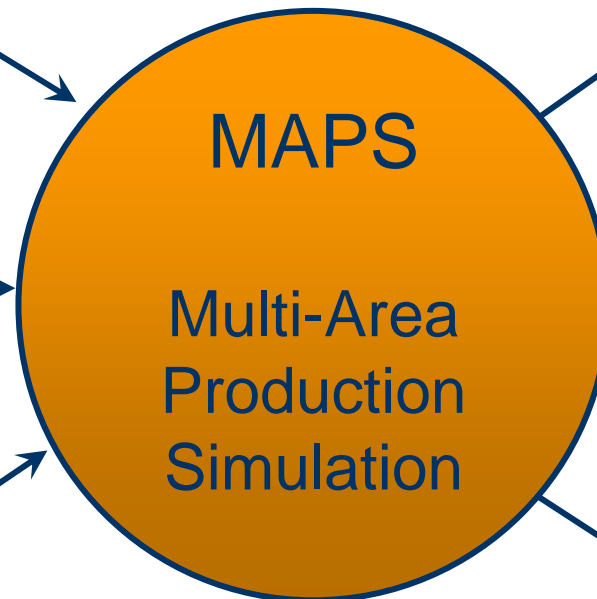
# MAPS Model Overview

## MAPS Input

**Load Data**  
up to  
- 175 load areas

**Transmission Data**  
up to  
- 60,000 lines  
- 7,500 constraints

**Unit Data**  
up to  
- 7,500 units



## MAPS Output

**Unit Dispatch**  
Hourly Dispatch Profile  
Number of Starts  
Capacity Factor by Intervals  
Hourly Emission Profile  
Duration Curve by Intervals

**Location Based  
Marginal Prices at  
Generator & Load  
Buses**

**Transmission Flows**  
-Hourly Flow Profile  
- Identification of Limiting Lines  
- Congestion Costs on  
Constraining Lines

Source: GE Power Systems Energy Consulting

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# Key Features of the GE-MAPS Modeling Tool



- Model Structure
  - Performs security constrained unit commitment (SCUC) and security constrained economic dispatch (SCED);
  - Models hour-by-hour production costs while honoring transmission constraints;
  - Determines hourly spot prices at individual buses and flows on individual transmission lines;
  - Models thousands of generation units, external contracts, multiple fuel types, thousands of transmission nodes and transmission facilities, phase-angle regulators, companies/pools/RTOs;
  - Operating reserves simultaneously modeled with the energy markets.

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# Key Features of the GE-MAPS Modeling Tool



- Pricing:
  - Hourly LMP by node or zone.
- Unit Commitment:
  - Commitment using priority order of costs;
  - Endogenously incorporates unit operating characteristics;
  - Commitment and dispatch by company, area, pool, or system.
- Transmission Modeling:
  - Models all transmission lines and transmission interfaces;
  - Applies appropriate overload costs (hurdles) to enforce limits;
  - Models operating nomograms and phase-angle regulators.

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# Key Features of the GE-MAPS Modeling Tool



- Load Modeling:
  - 8760 hourly loads;
  - Peak and load shape by area.
- Unit data:
  - Seasonal, maximum and continuous MW ratings;
  - Up to 7 power points per unit with incremental heat rates; between power points;
  - Maintenance and forced outage rates;
  - Downtime/uptime, must run, emission characteristics;
  - Fuel costs, fixed and variable O&M, emission costs, startup cost.

# Comparison of Model and Midwest ISO Market Operation



Parameter	MAPS	Midwest ISO Day- Ahead
Optimize Production Cost	Yes	Yes
Security Constrained Unit Commitment (SCUC)	Yes	Yes
Security Constrained Unit Commitment (SCED)	Yes	Yes
Locational Marginal Pricing (LMP)	Yes	Yes
Hourly Dispatch	Yes	Yes
Day 1 Commitment by Company	Yes	Yes
Day 2 Commitment by RTO	Yes	Yes
RTO-wide Dispatch	Yes	Yes
Operating Reserve Market	Yes	Forthcoming

# Most Data was Provided by Stakeholders or the Midwest ISO



Data Element	Source
Unit heat rates	Stakeholders/Midwest ISO
Unit primary fuel	Stakeholders/Midwest ISO
Unit secondary fuel	Stakeholders/Midwest ISO
Unit ramp rates	Stakeholders/Midwest ISO
Unit NOx emission rates	Stakeholders/Midwest ISO/ICF
Unit interconnection nodes	Stakeholders/Midwest ISO
Must-run requirements	Stakeholders/Midwest ISO
Hourly unit dispatch (2004,2005 and 2006)	Midwest ISO
Zonal Definitions	Midwest ISO
Hourly Demand by Zone (2004, 2005 and 2006)	Midwest ISO
Midwest ISO internal and external interfaces and flowgates	Midwest ISO
Tariff detail; firm and non-firm 2004	Midwest ISO
Hourly Imports from Canada	Midwest ISO
Power flow cases	Midwest ISO
Spinning reserve requirements	Midwest ISO
Fuel prices	ICF; based on historical data
Midwest ISO Members	Midwest ISO
Emissions costs	ICF; based on historical data

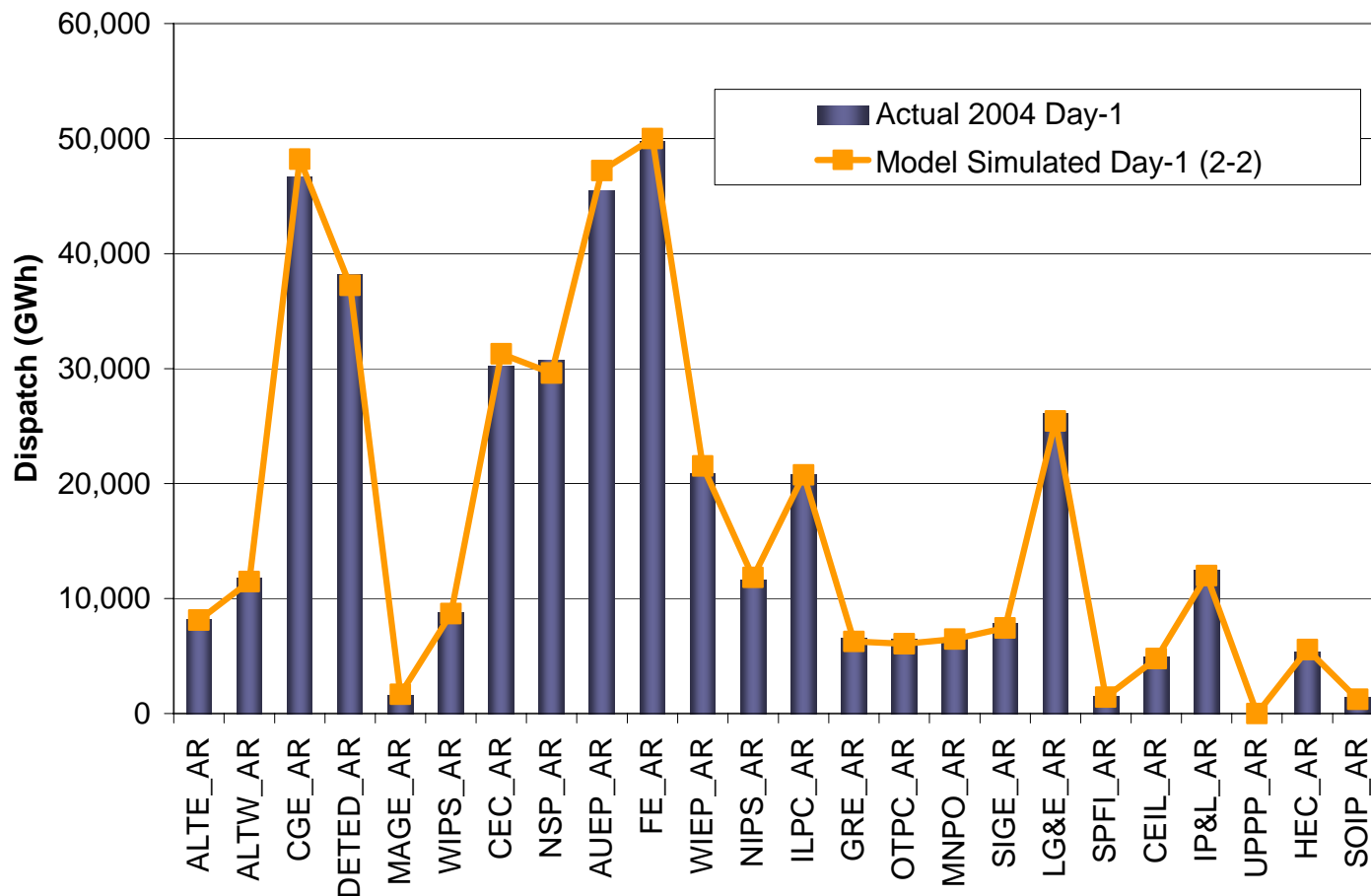
# *Study Results*

# Summary Calibration Results

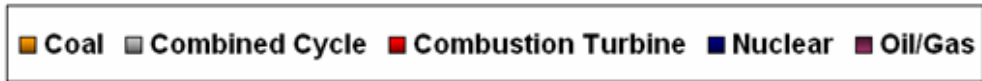
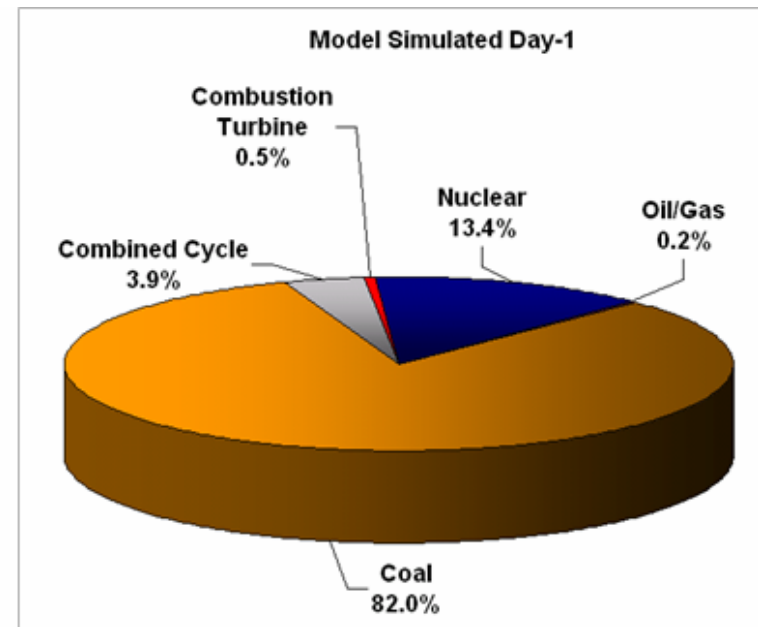
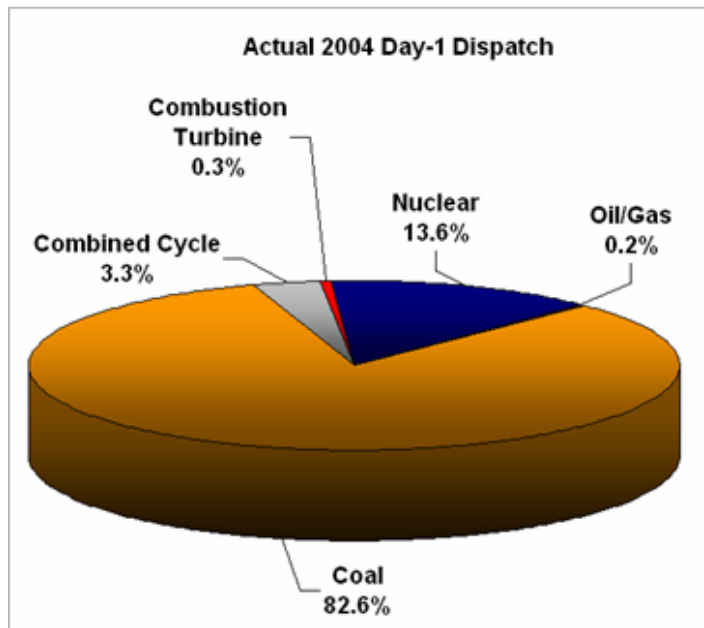


Calibration Parameter	Correlation	R-Squared
Dispatch by Area	0.999	0.999
Dispatch by Unit Type	1.000	0.999
Dispatch by Unit	0.995	0.990

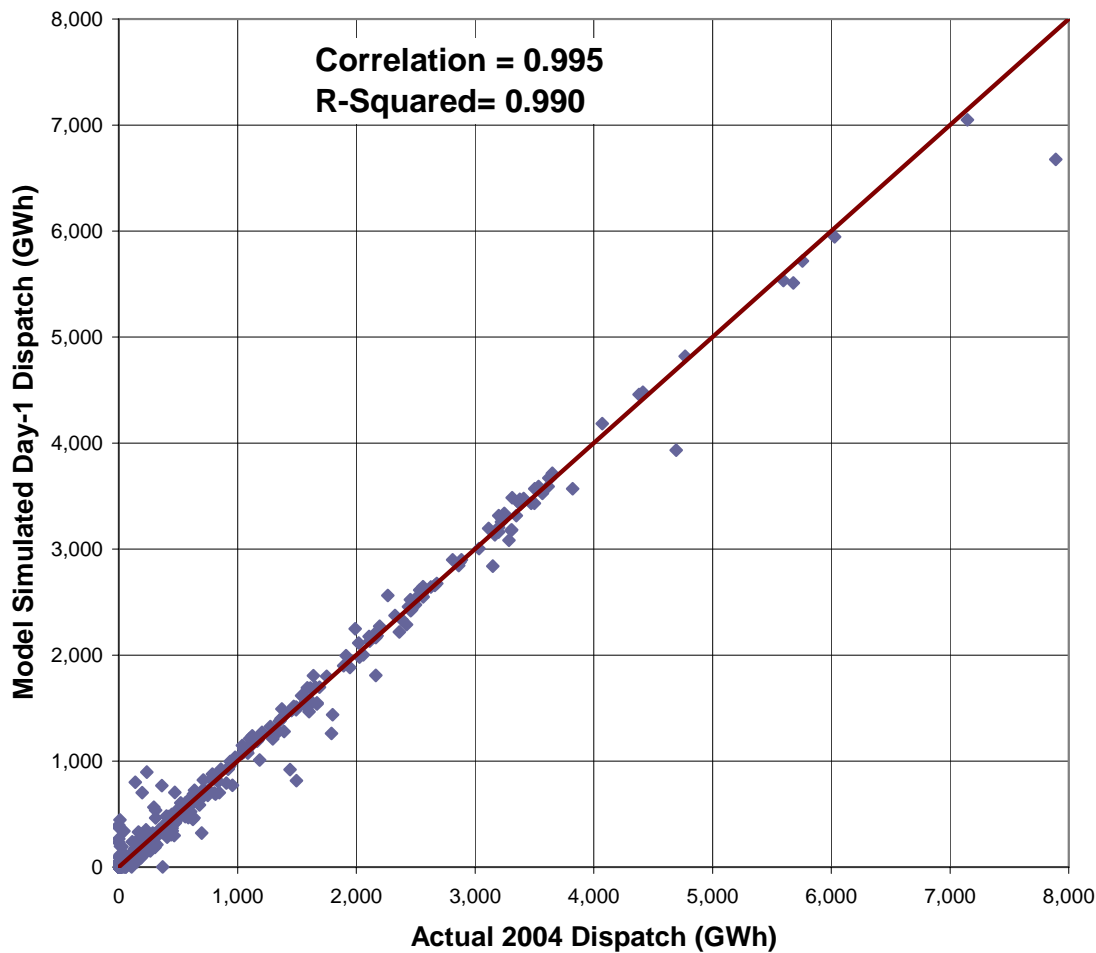
# Calibration Results - Total Dispatch by Balancing Authority – 2004 Actual vs. ICF Calibration



# Calibration Results - Total Dispatch by Capacity Type – 2004 Actual vs. ICF Calibration

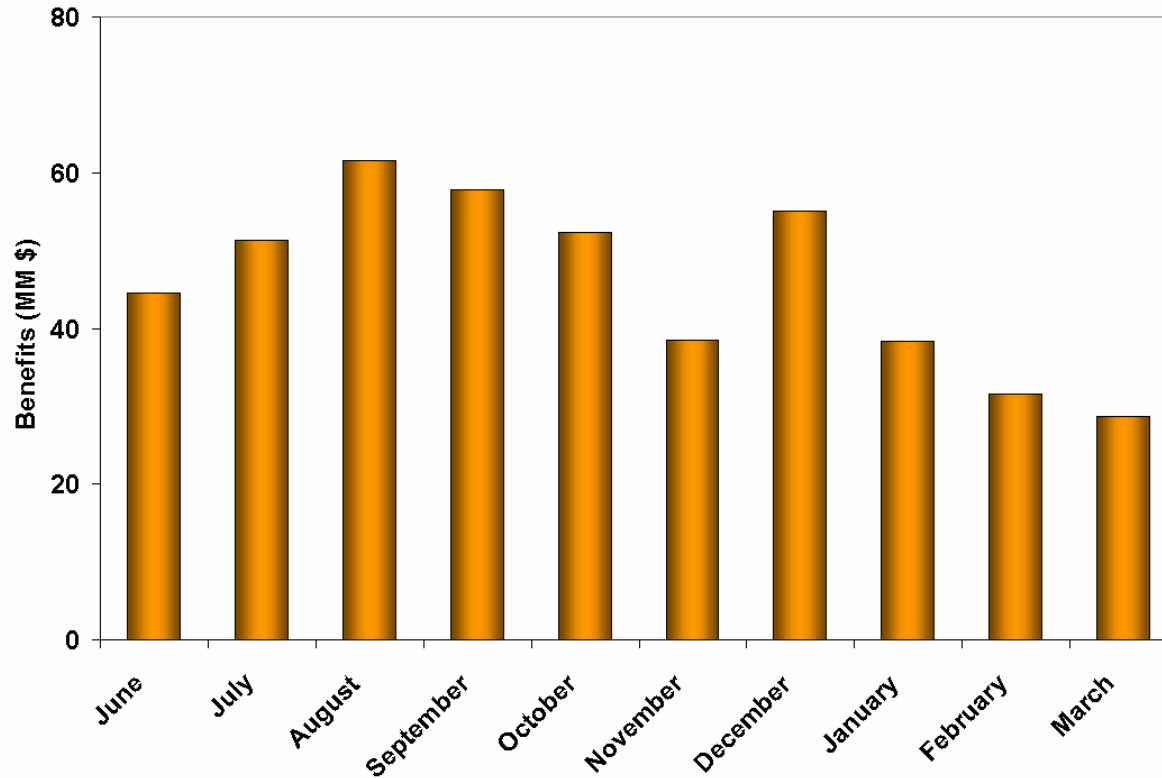


# Calibration Results - Total Dispatch by Generator – 2004 Actual vs. ICF Calibration



# ICF Benefit Study – Summary Results

## June 2005 – March 2006



**Summary (MM\$):**  
Theoretical Max - \$460

Note: Reflects theoretical maximum benefit including benefits associated with ASM.

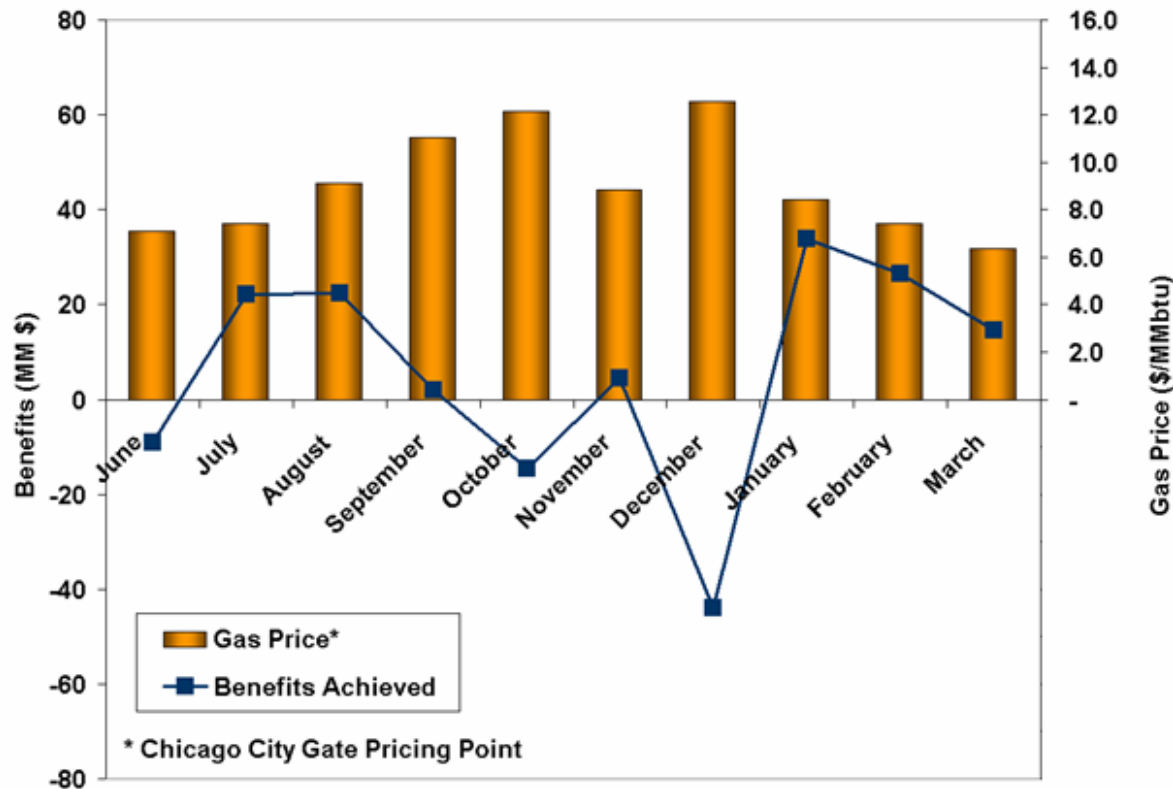
# Summary of Midwest ISO Benefits – June 2005 through March 2006



Category	Benefits (\$million)	Annualized Benefits (\$million)
Theoretical Maximum Potential Benefits	460	552
Estimated Achievable Benefits Given Current Market Structure	271	325
Actual Benefits Achieved	58	70

- Our analysis yields the following three primary results:
  - Up to \$460 million in benefits were potentially achievable through optimal operation of the Midwest ISO grid during the study period.
  - Of the \$460 million in maximum potential benefits we estimate that approximately \$271 million was actually achievable during the study horizon given the existing treatment of ancillary services.
  - Of the \$271 million achievable benefits, \$58 million was realized through Midwest ISO operation of the grid.

# Monthly Benefits Achieved and Historical Natural Gas Prices



<b>Summary (MM\$):</b>	
Theoretical Max	\$460
ASM <sup>1</sup>	<u>(\$189)</u>
Achievable	
Theoretical	\$271
<b>Actual</b>	<b>\$ 58</b>

<sup>1</sup> Ancillary Services Market (ASM) Theoretical Value calculated by ICF. Given that the Midwest ISO has not launched the ASM initiative, these should not be included in actual achievable results. Note that the ASM theoretical value generated by ICF is within the range of the Midwest ISO value estimates generated and shown in the April 3, 2006 Filing to FERC (EL06-\_\_\_-00). The ASM Market Potential Benefits are shown as \$113 to 208m.

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# Monthly Potential and Achieved Benefits



- This monthly analysis yields the following secondary results:
  - While benefits were lower during initial start up, significant improvement was demonstrated towards the end of the period. In fact, benefits in the 2006 period were close to the maximum achievable absent optimization of ancillary services.
  - The unprecedented period of high natural gas, coal, and emission allowance prices between September and December 2005 correlate with periods of lower achieved benefits, and in some cases increased costs, for Midwest ISO.
  - Even as operations appear to have been improving (as seen in other data), the costs of sub-optimal commitment and dispatch were increasing due to rising generation input costs.
  - In this environment, the cost impacts of even small incremental deviations from Day-1 optimization between gas and coal generation are economically magnified.

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# Monthly Potential and Achieved Benefits

- October and December 2005 were especially challenging periods for Midwest ISO operations due to record high fuel prices. For example, natural gas prices peaked at an average of \$12.60/MMBtu in December 2005<sup>1</sup>.
- We note that had actual benefits achieved in December and October been at the average level for all other months in the study period total achieved benefits would have exceeded \$146 million<sup>2</sup> or up to 54 percent of the total achievable benefits.

<sup>1</sup> Source: Gas Daily; Chicago City Gate price

<sup>2</sup> This illustrative back-of-the-envelope calculation assumes that losses of \$14 and \$43 million in October and December are replaced with savings of \$14.5 million, the average achieved in the remaining months of the study.

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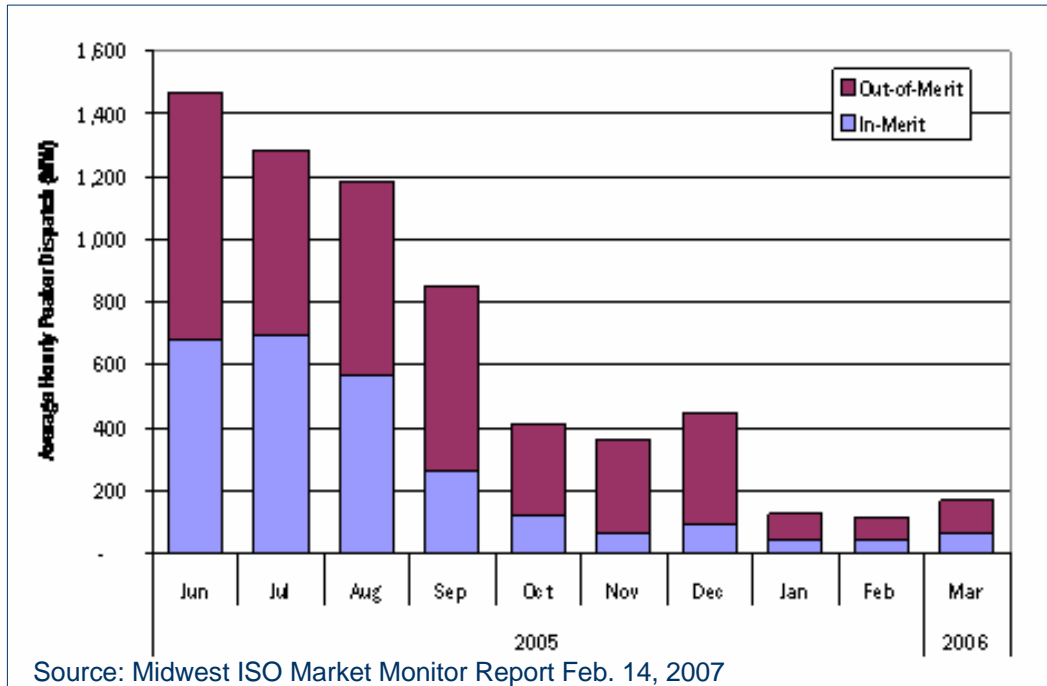
# Potentially Conservative Factors Vis-à-vis the Benefits Achieved and Achievable



- Because this analysis compares the results of three MAPS model analyses with a detailed review of actual market operations during the study period, significant efforts were made to incorporate as many “real-world” phenomena as possible directly into the model.
- While we believe that the majority of these issues are captured in our modeling, several variables could not be fully modeled within the MAPS framework or within the context of this study. Thus, there may be some features of the modeling that may have resulted in a conservatively low estimate of actual benefits achieved and/or a high estimate of achievable benefits. These items include:
  - Choice of Calibration Year
  - Day-Ahead vs. Real-Time Commitment
  - Bid Inflexibility
  - Offered Capacity

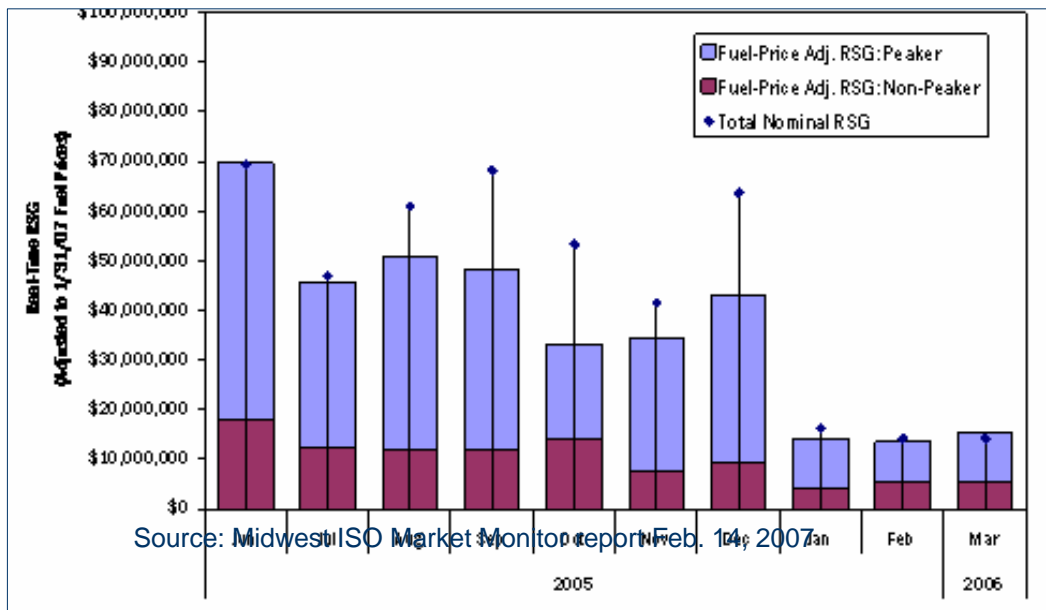
# *Supporting Analyses*

# Supporting Analyses



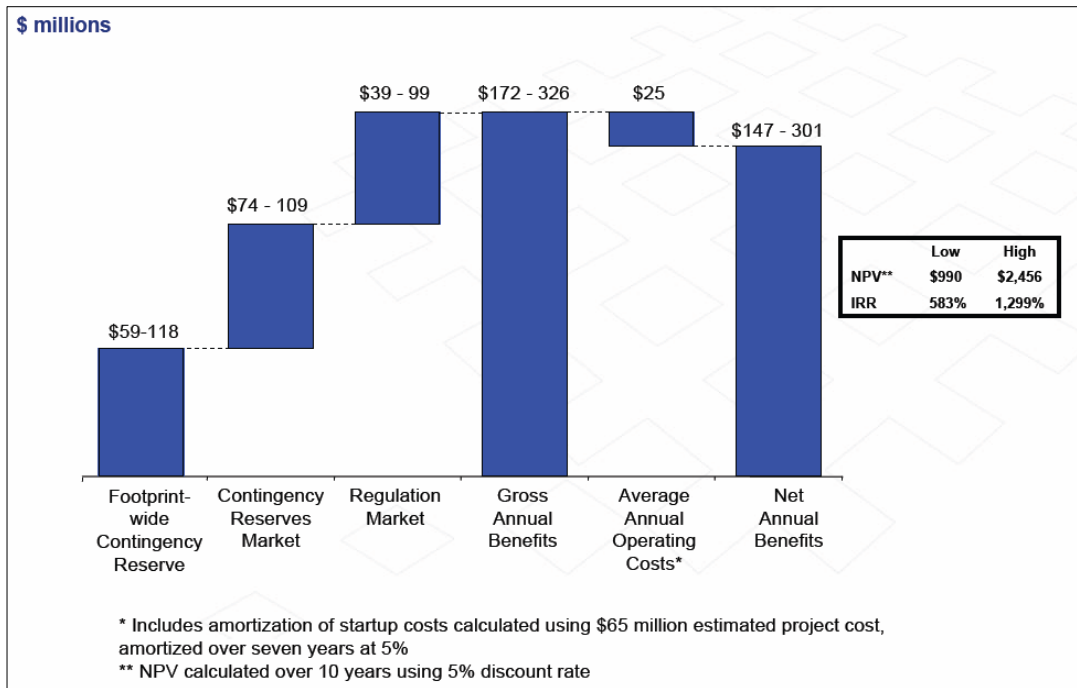
- ICF's findings in this study are consistent with previous analyses. This graphic is an excerpt from the Market Monitor report highlighting economic and non-economic peaking unit dispatch in the Midwest ISO.
  - Summer 2005 shows large amounts of out-of-merit peaking dispatch. While there is less in October and December, it is still above 2006 levels. The lower 2006 levels support our findings of an improving trend.
- The combination of out-of-merit dispatch and extremely high fuel prices is consistent with the study results indicating negative benefits achieved during the months of October and December 2005. Note, that the definition of out-of-merit dispatch does not precisely correspond to the definition of "economic dispatch" in the ICF study associated with market rules, and hence, care needs to be exercised in comparing the two analyses.

# Supporting Analyses



- Our study results are also similar to a Midwest ISO review of Revenue Sufficiency Guarantee (RSG) trends.
- RSG payments by month are high in 2005 compared to 2006. Since these are payments for units not otherwise recovering their costs, the trend also supports our conclusion of improving performance.

# Supporting Analyses



Source: Midwest Contingency Reserve Sharing and Midwest ISO Ancillary Services Market – Project Update, October 10, 2006

- While the ICF study of the proposed Midwest ISO ASM market is not as detailed regarding reserves as that contained in a recent Midwest ISO filing, the theoretical value generated by ICF is within the range of the Midwest ISO value estimates generated and shown in the April 3, 2006 Filing to FERC.
- The comparable potential benefits in the Midwest ISO study are shown as \$113 to \$208 million (see “contingency reserves” and “regulation market” bars in graphic).

# *Conclusions*

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# Conclusions



- Centralized unit commitment is a key driver for market benefits
- RTO operational benefits are largely associated with improved ability to displace gas with coal, more efficient use of coal, better use of import potential.
  - Growing reliance on natural gas generation within MISO footprint associated with powerplant additions over the last ten years and ongoing load growth could increase the scope for savings from central dispatch in future years.
  - Tightening environmental controls and resulting greater diversity in coal plant fleet could also make optimization of coal plant utilization more important in future years.
- A confluence of Factors led to 100% theoretical benefits not being realized
  - Improved operations especially crucial during periods of extremely high gas prices since even small deviations can have large effects
  - Overall optimization may be assisted by optimization of operating reserves
- While benefits were small during initial start up, significant improvement demonstrated towards the end of the period
  - In addition to general start up, MISO also faced record natural gas, emission allowance and coal prices which exacerbated shortcomings