Managing El Nino Events in Colombia's Hydro-Dominated Electricity Market

Frank A. Wolak
Department of Economics
Stanford University
wolak@zia.stanford.edu
http://www.stanford.edu/~wolak
Chairman, Market Surveillance Committee California ISO

Outline of Talk

- The challenges of El Nino Events
- How recent El Nino event was dealt with
  - Thermal units forced on
  - Natural gas rationing and forced switch to liquid fuels
  - Purchase and storage of hydro energy
- How can future El Nino events be handled using market mechanisms?
  - Benefits of market mechanisms
  - Electricity and natural gas market interactions
- Purpose of current study
  - Analyze performance of market over past five years, including El Nino event
  - Identify market rule changes necessary to allow market mechanisms to manage El Nino events

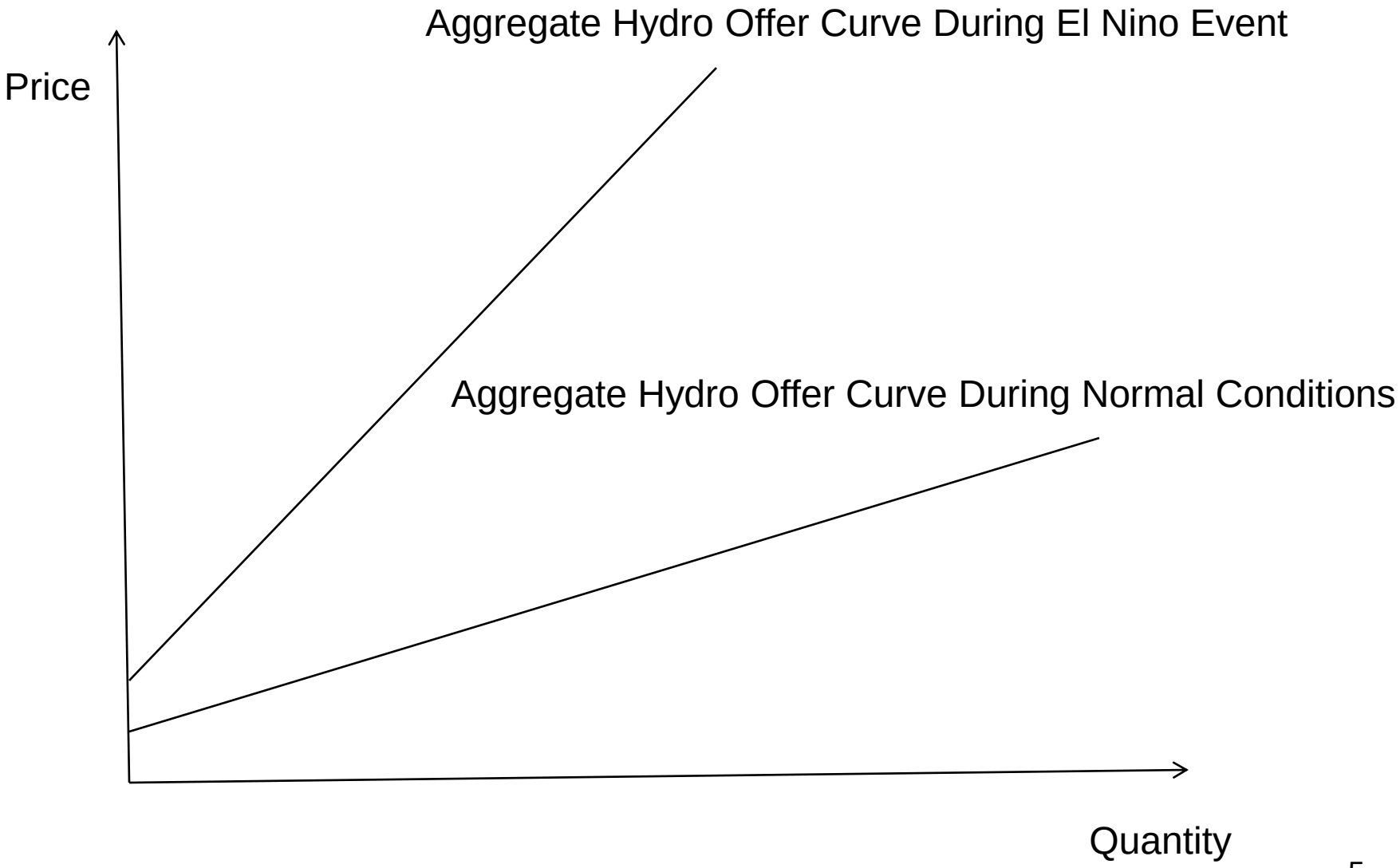
The Challenges of El Nino Events

- Low hydro conditions for sustained period of time
  - Risk of insufficient energy to meet hourly demand during El Nino event
  - If water levels become too low, generation unit owners cannot meet all hourly demands for energy during El Nino event even if all thermal units run at full capacity
- Key decision facing market participants and regulator is how much to run thermal units during early stages of El Nino event
  - If produce enough thermal energy early enough can conserve enough water to meet all hourly demands during El Nino event
  - Difficult to determine when thermal units should be used more intensively because future water inflows are uncertain
  - Different financial and political risks faced by hydro generation unit owners versus regulator and government
    - Different decision about when to run thermal units more intensively

The Challenges of El Nino Events

- El Nino events can also enhance the ability and alter the incentive of suppliers to exercise unilateral market power
- Low hydro conditions cause hydroelectric suppliers to submit steeper offer curves in order to conserve water
  - Occurs even if no hydro supplier has the ability to exercise unilateral market power

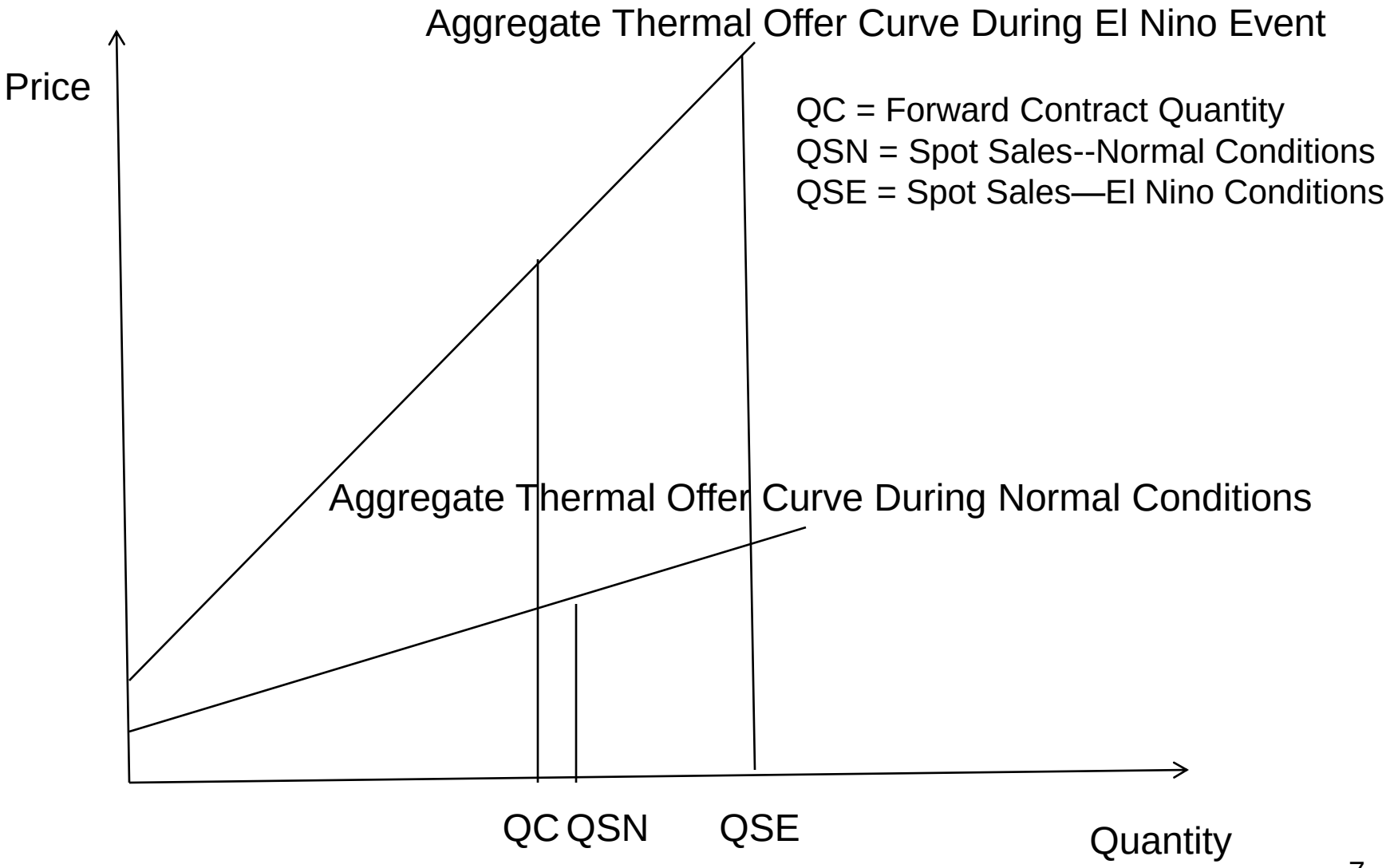
The Challenges of El Nino Events



The Challenges of El Nino Events

- Steeper offer curves by hydro supplier cause thermal suppliers to face steeper residual demand curves
  - Thermal suppliers residual demand curve = Market Demand minus willingness-to-supply curve of all hydro suppliers
    - For more information on properties of residual demand curve see, Wolak, F.A., “Report on Market Performance and Market Monitoring in Colombian Electricity Supply Industry,” July 30, 2009, SSPD document.
- If a thermal supplier has the ability to exercise unilateral market power, steeper residual demand curve enhances this ability
  - Thermal supplier are also likely to have a greater incentive to exercise unilateral market power because they are now more exposed to short-term prices
    - (Q(short-term market) – Q(forward contract)) is larger because they sell more energy in short-term market under El Nino event

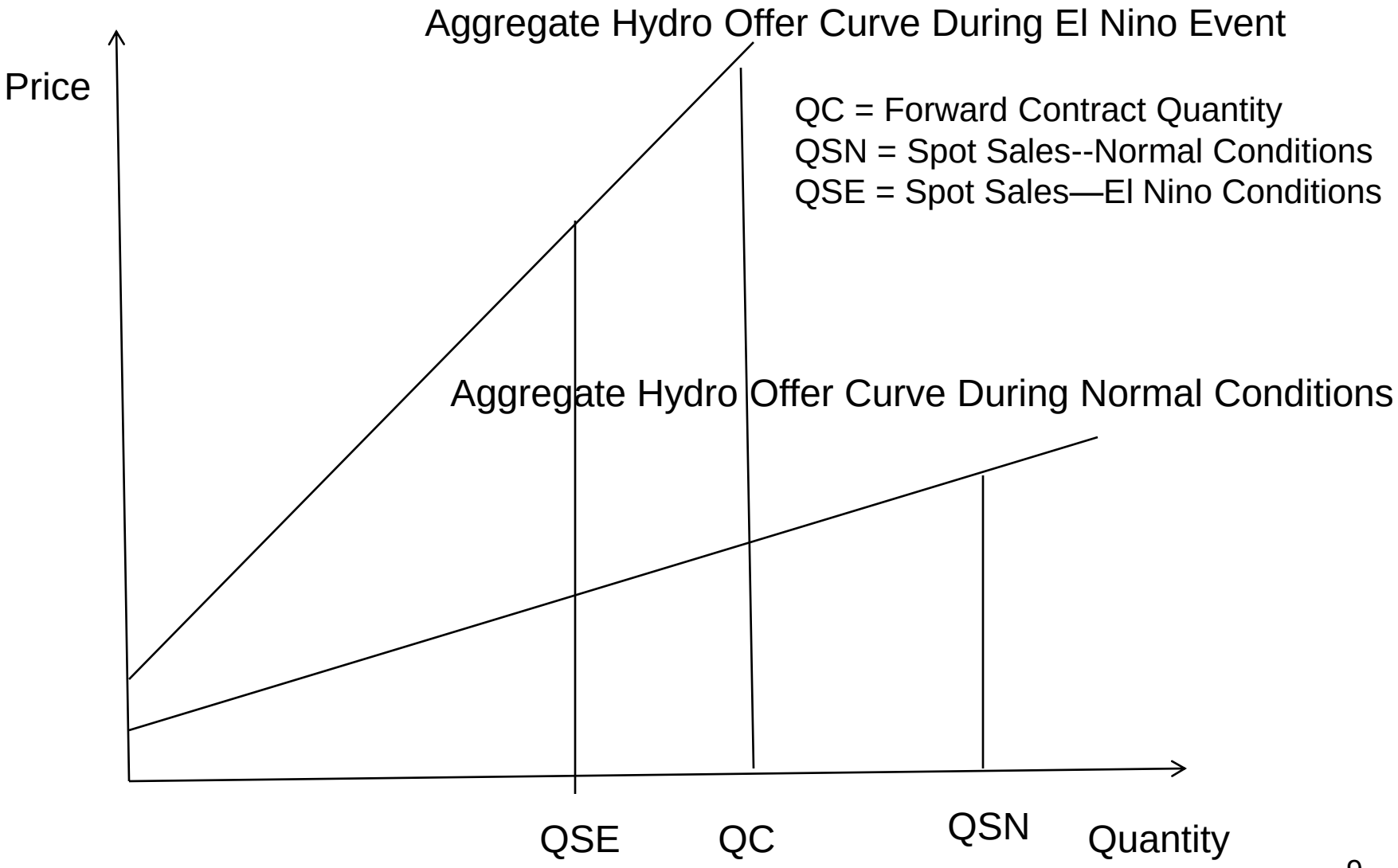
The Challenges of El Nino Events



The Challenges of El Nino Events

- Thermal suppliers with incentive to exercise unilateral market power submit steeper offer curves, which implies hydro suppliers face a steeper residual demand curve
- Hydro suppliers with ability to exercise unilateral market power now face a steeper residual demand curve
  - Hydro suppliers have greater *ability* to exercise unilateral market power
  - However, fixed-price forward contract position of hydro suppliers may reduce their *incentive* to exercise unilateral market power because hydro suppliers are now less exposed to short term prices
    - (Q(short-term market) – Q(forward contract)) is smaller because they sell less energy in short-term market
    - (Q(short-term market) – Q(forward contract)) may even become negative—Hydro supplier is net buyer of short-term energy

The Challenges of El Nino Events



The Challenges of El Nino Events

- For thermal supplier both ability and incentive to exercise unilateral market power in short-term market power is enhanced by El Nino event
  - Strong incentive to submit steeper offer curve into short-term market
- For hydro suppliers, ability to exercise market power is increased, but depending on value of QC relative to QSE, supplier may have incentive to use this ability exercise unilateral market power to drive prices down
  - Strong incentive to submit offer curve to limit short-term prices if supplier expects to sell less than QC in short-term market
- These divergent incentives may explain differences in hydro supplier and thermal supplier behavior during initial stages of recent El Nino event in Colombia

The Challenges of El Nino Events

- Increased opportunities to exercise unilateral market power in electricity sector during El Nino events can impact upstream fossil fuel markets
- Input fossil fuel suppliers can capture a portion of the increased profits in electricity sector by raising input fossil fuel prices
- Extent to which this occurs depends on ability of fossil fuel suppliers to exercise unilateral market power
  - Colombian coal suppliers compete in an international market, which limits their ability to raise domestic coal prices
  - Natural gas market is primarily for Colombia and neighboring countries
    - No export or import terminals for natural gas in Colombia
- Conclusion--Market performance problems more likely to arise in natural gas market rather in coal market during El Nino event

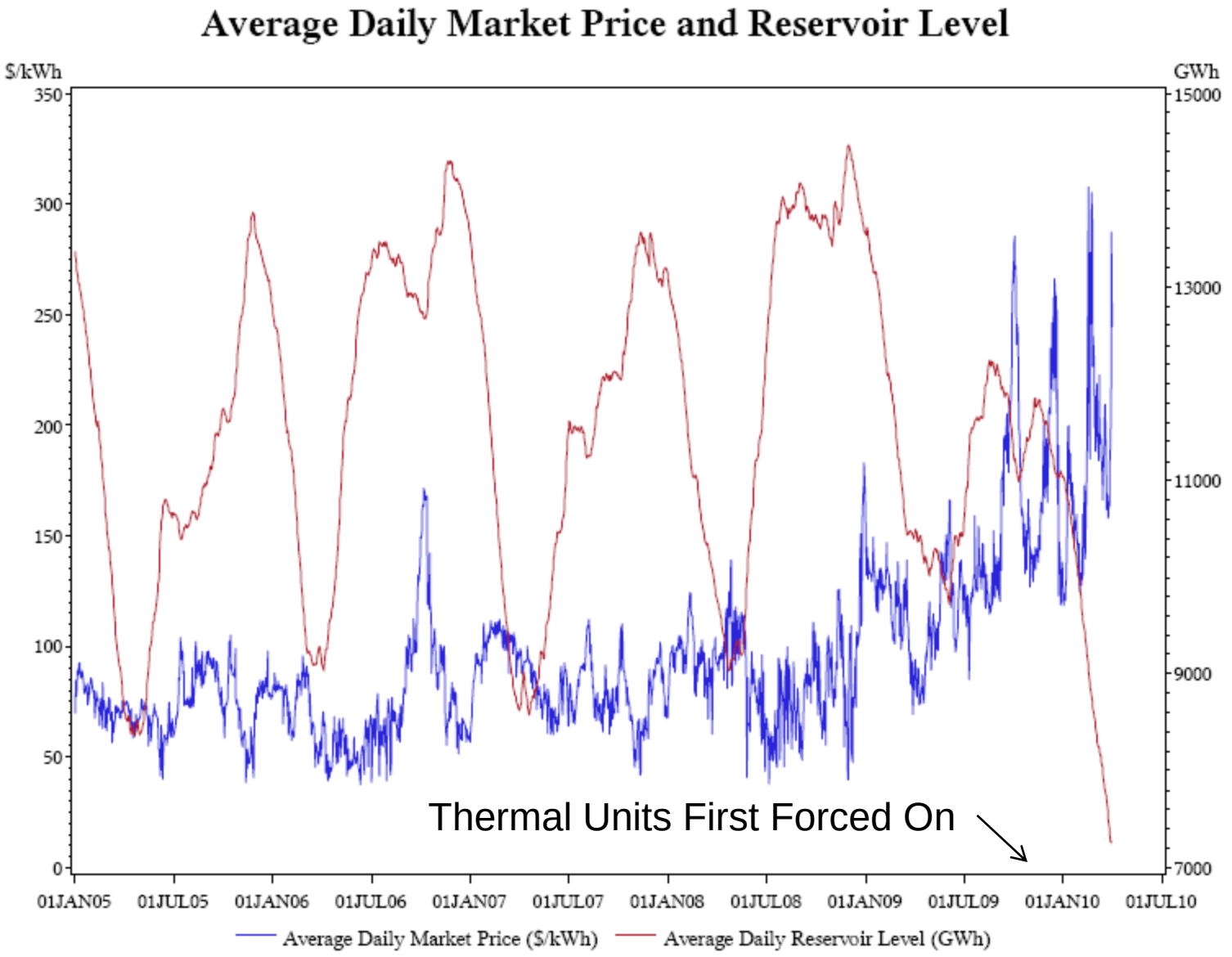
The Challenges of El Nino Events

- El Nino events also provide greater opportunities for suppliers to exploit the negative and positive reconciliation payment mechanisms
- Operating constraints and transmission constraints are typically made more severe by El Nino events
  - Suppliers that know when these operating constraints will bind can submit offers into energy market to receive positive and negative reconciliation payments
- Incentives created by Positive and Negative Reconciliation Mechanisms discussed in
  - Wolak, F.A., “Report on Market Performance and Market Monitoring in Colombian Electricity Supply Industry,” July 30, 2009, SSPD document.
- Another reason for hydro suppliers to submit low offer prices during initial stages of El Nino event is to receive negative reconciliation payments
  - Q(Ideal) > Q(real) for hydroelectric suppliers

Recent El Nino Event

- Summary of recent El Nino event
  - Thermal units forced to operate under CREG Resolution 137/09 to achieve required daily output level
    - Offers into short-term market set at regulated variable cost
  - Natural gas rationing in center of Colombia because of insufficient pipeline capacity to transport all contracted natural gas to these consumers
    - Forced switch to liquid fuels for thermal generation units located in center of Colombia that technically able to do so
  - Purchase of hydro energy not generated for later sale during scarcity conditions under CREG Resolution 010/10
- Recently, required amount of thermal production and purchased hydro energy reduced as a result of increased water inflows
  - Reduced level of natural gas rationing and forced use of liquid fuels
- Amount of generation capacity off-line was very low during first two months of 2010
  - Large increase in last February and early March of 2010

Recent El Nino Event



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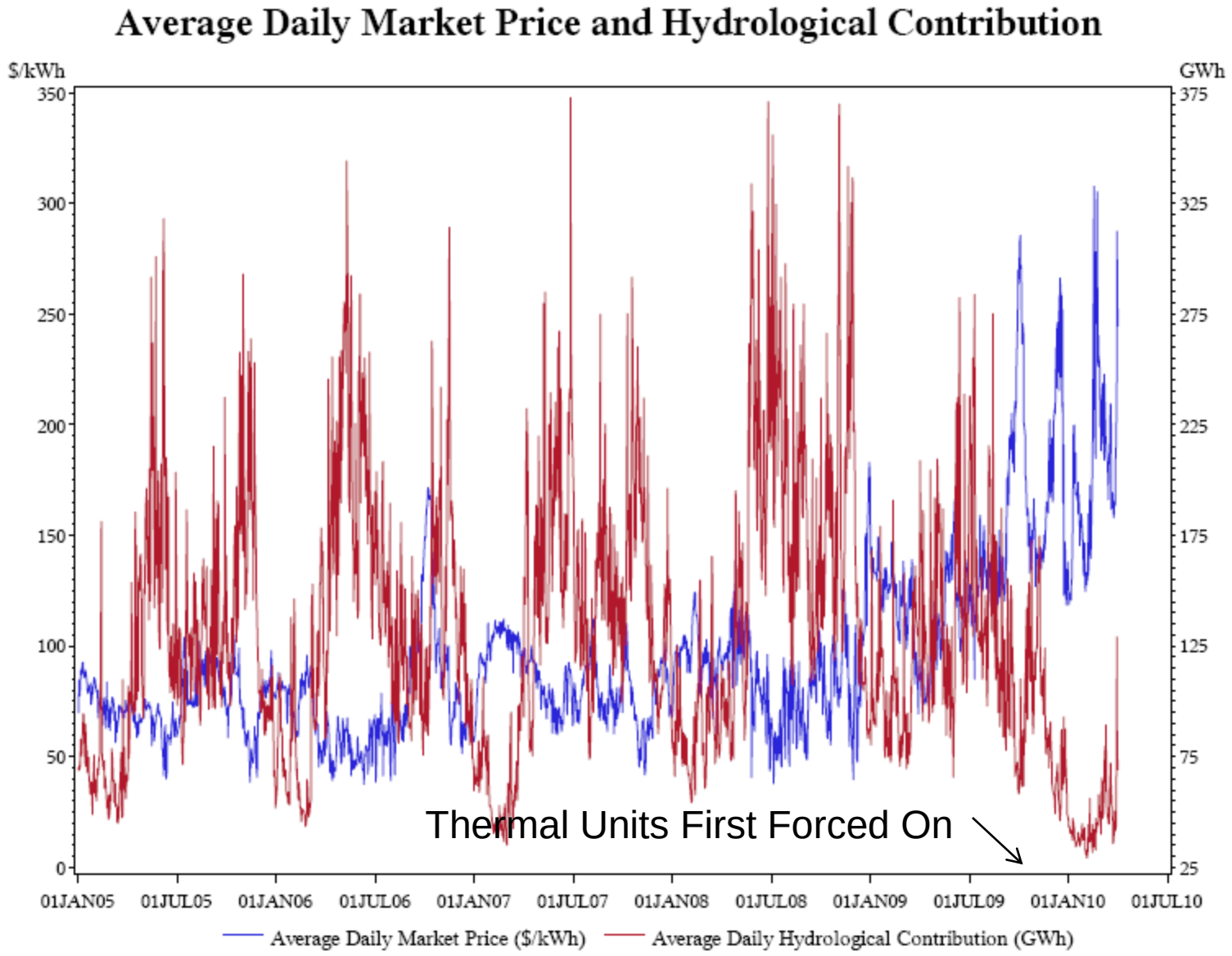

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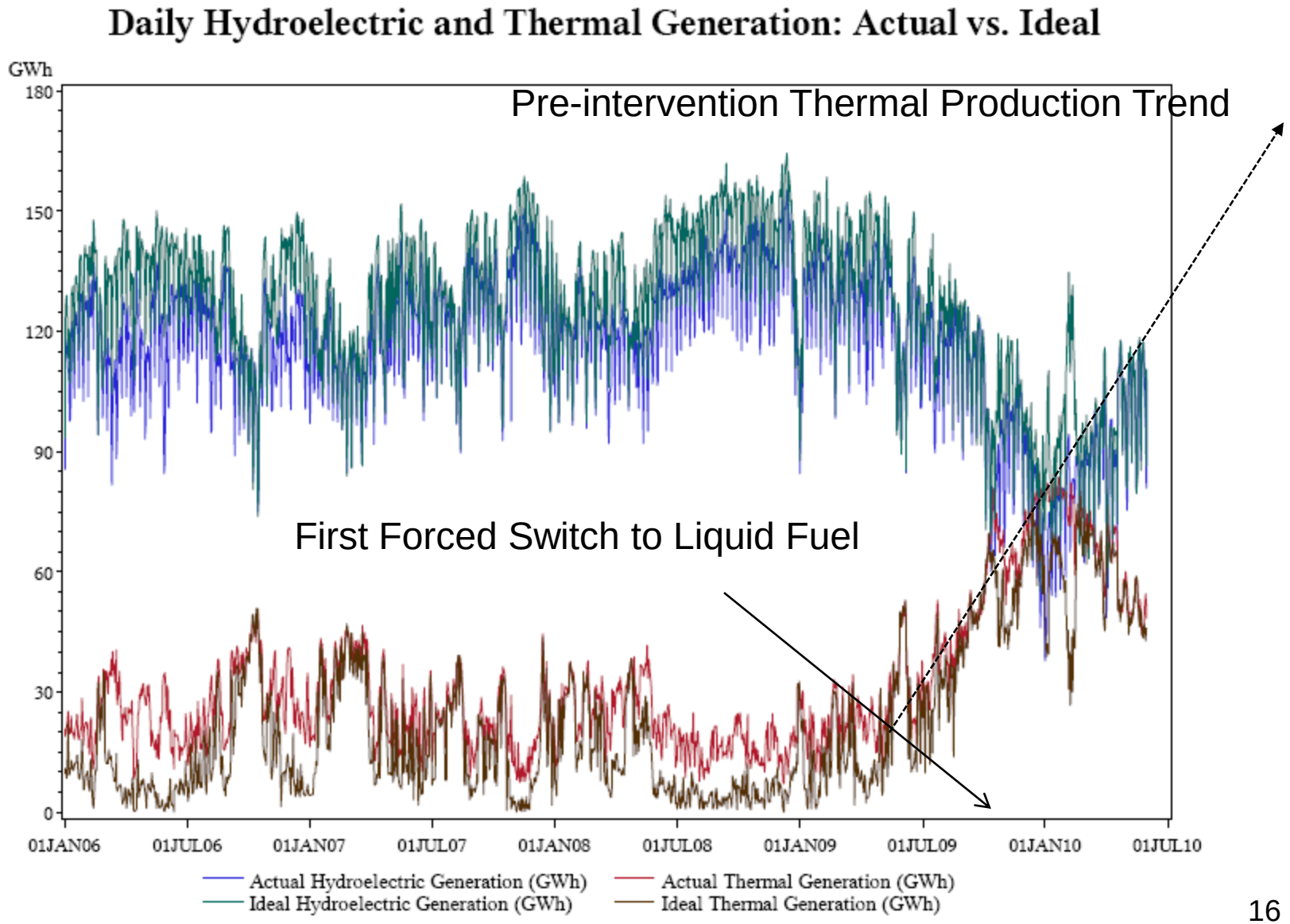

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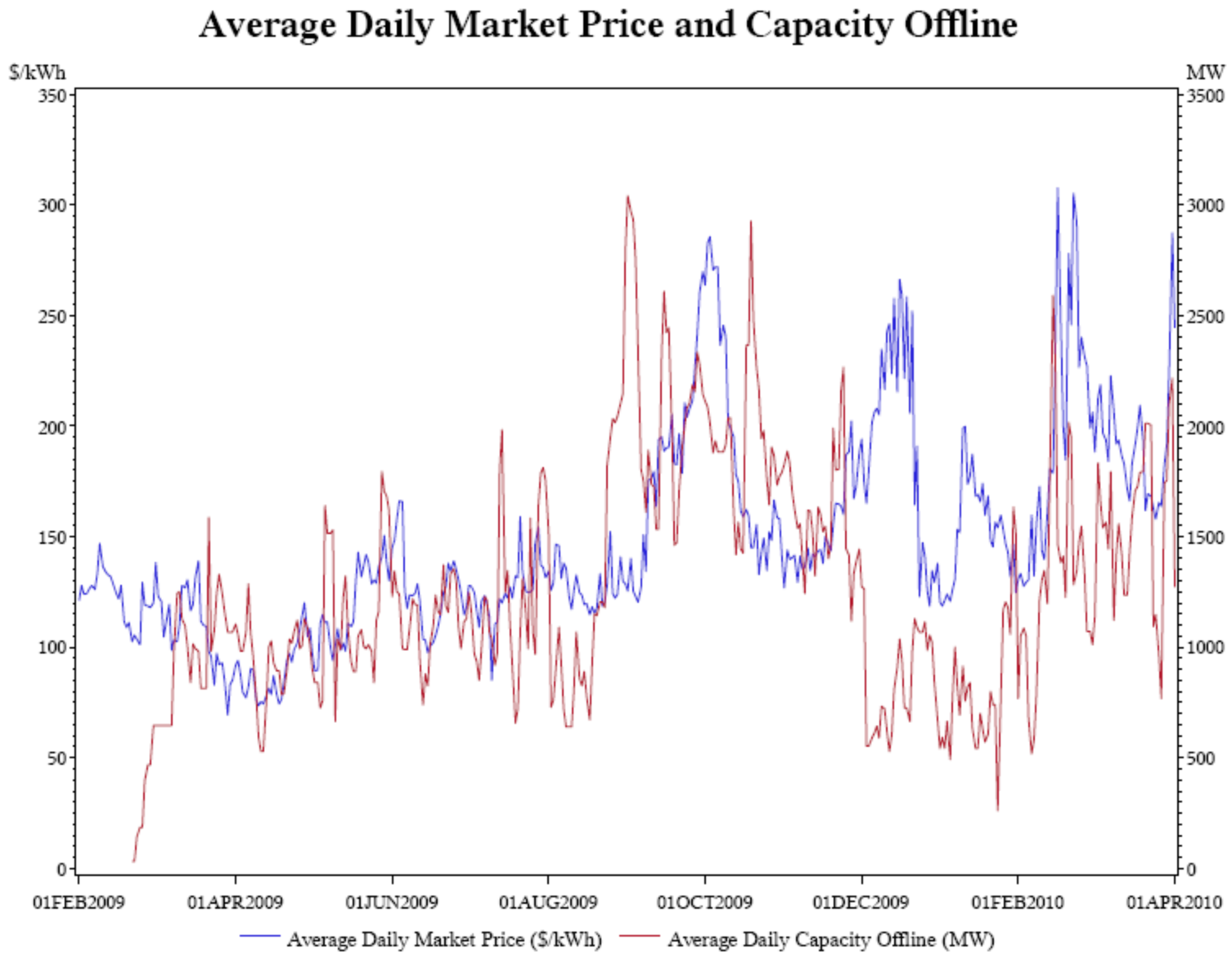
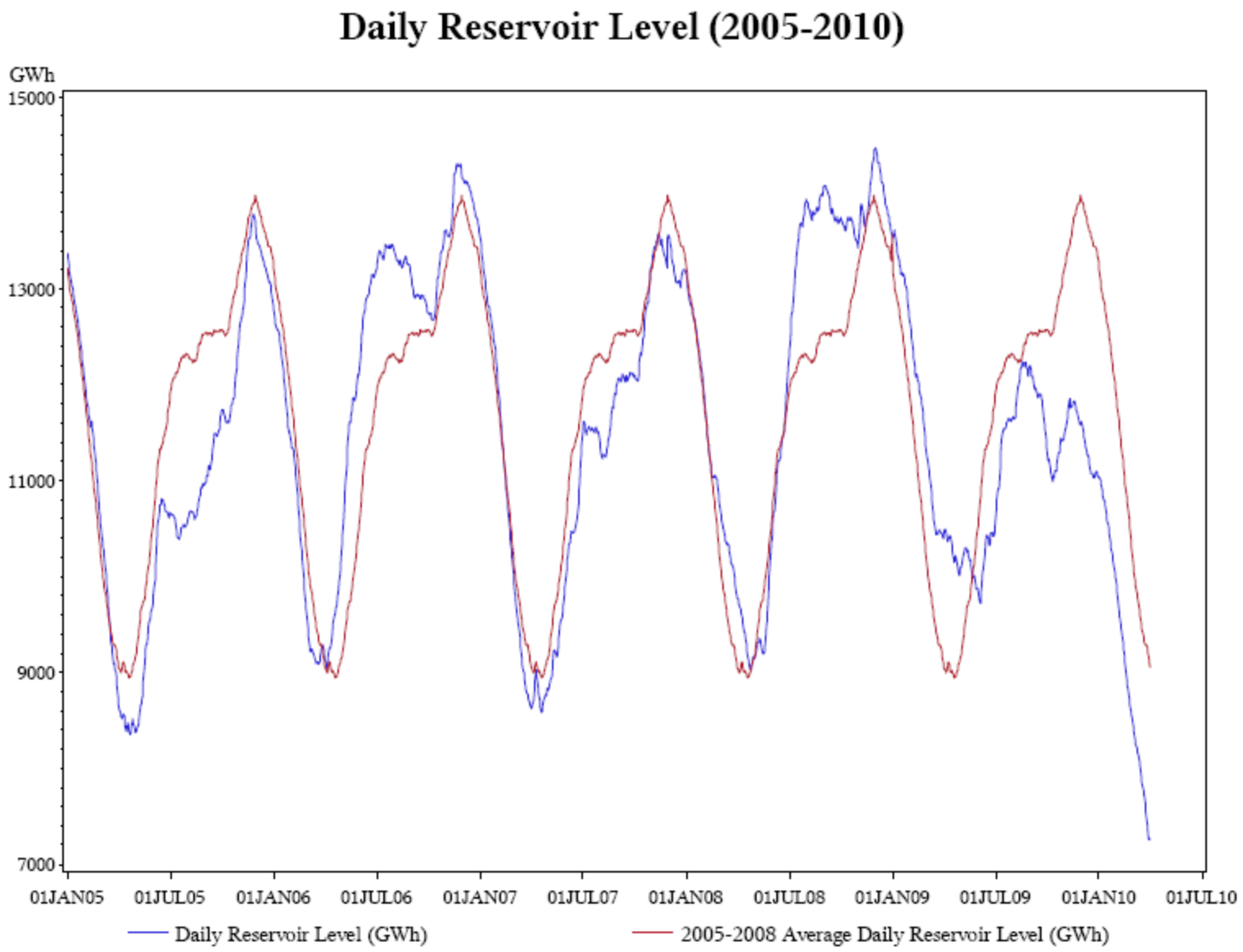


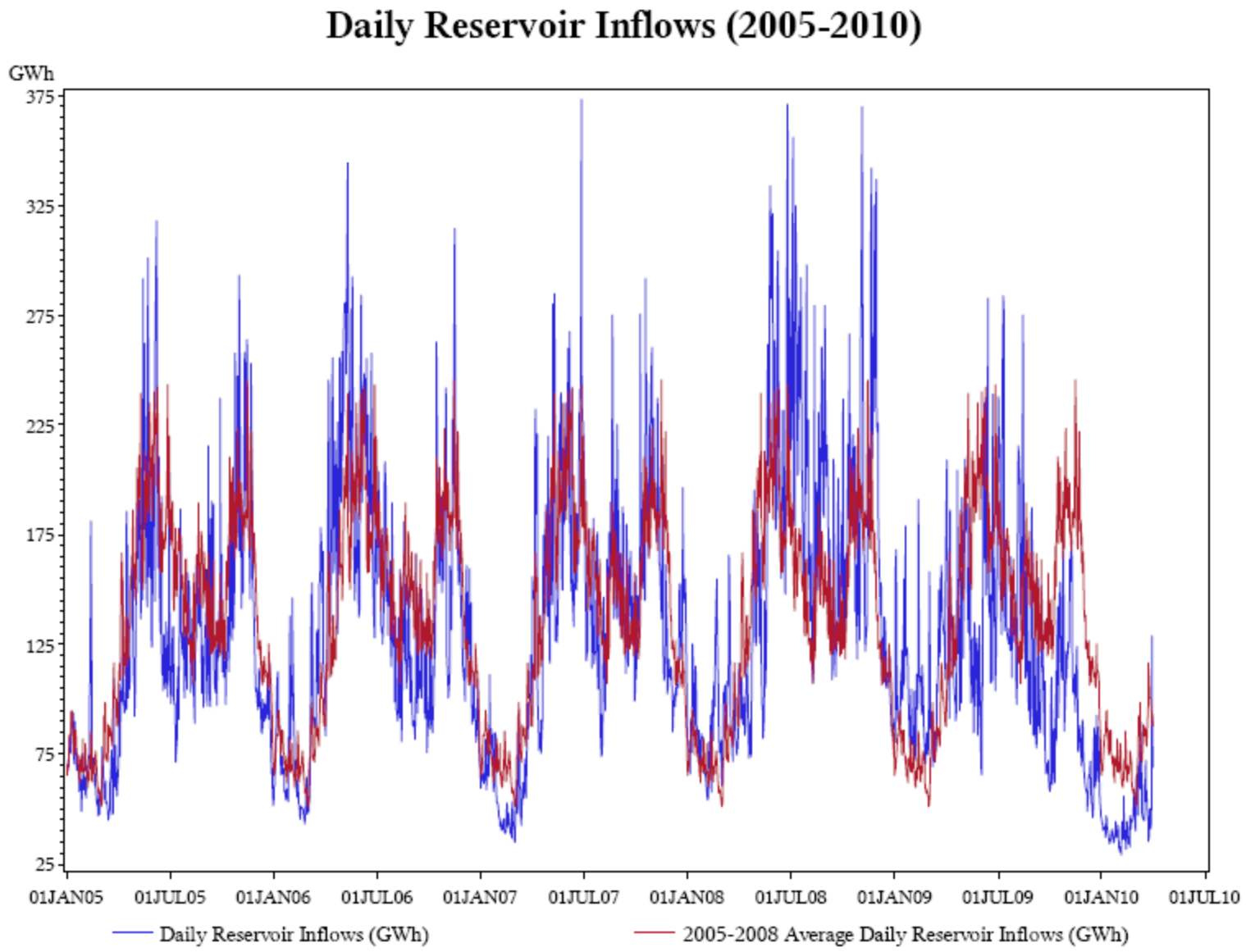
Key Outstanding Questions

- Did large thermal suppliers have a greater ability and incentive to exercise unilateral market power?
- Did large hydro suppliers have a greater ability, but no incentive to raise market prices?
- Was market performance degraded by these actions?
  - Compare actual prices to competitive benchmark prices before, during, and after period
- Did positive and negative reconciliation payment mechanism further degrade market performance during El Nino event?
- Was intervention necessary to cause thermal units to operate at the level needed to prevent a shortage period?
- Was early purchase of hydroelectric energy necessary to cause thermal units to operate?
- Was natural gas rationing necessary to achieve fuel switching?

Was Intervention Necessary?



Was Intervention Necessary?



Market Mechanisms and El Nino

- Why are market mechanisms preferable to regulatory interventions for handling El Nino events?
  - Reward thermal suppliers for being able to produce energy when water levels are low
    - Rather than require them to submit price offers equal to regulated variable cost of production
  - Limit payoff to hydro suppliers for selling energy early too during El Nino event
  - Limits costs to consumers from buying hydro electricity at high price early in El Nino event and selling it back later at a lower price
  - Eliminates need for all gas consumers in central Colombia to pay for difference between price of liquid fuels and contractual price of natural gas
    - Thermal suppliers were allowed to buy liquid fuels at contractual natural gas price because of natural gas rationing

Market Mechanisms and El Nino

- Why current market mechanisms in electricity and natural gas may be inadequate to manage El Nino event
- Current Reliability Charge mechanism may be not make shortage periods sufficiently costly to hydroelectric suppliers
  - Water shortage price may be too high to deter hydro suppliers from selling energy too early during El Nino event
  - Expected increase in Bolsa price during shortage period may be insufficient to deter early energy sales
  - Final consumers do not have sufficient flexibility to express their willingness to pay to avoid shortage periods
- Natural gas market has both regulated and unregulated forward contract prices
  - Market inefficiencies caused by natural gas pricing discussed in
    - Wolak, F.A., “Report on Market Performance and Market Monitoring in Colombian Electricity Supply Industry,” July 30, 2009, SSPD document.
  - Currently no short-term market trading of natural gas
    - Makes it difficult to manage short-term locational supply and demand imbalances as occurred during recent El Nino event

Making Market Mechanisms Work

- Market mechanism must achieve two goals
  - Reward thermal suppliers for supplying more energy throughout El Nino periods
    - Particularly early in period in order to avoid a future shortage period
  - Make cost to hydro suppliers of having insufficient energy during El Nino periods high enough to make it profitable for them to take early action to avoid shortage conditions
- Current Reliability Charge Payment mechanism has suppliers of Firm Energy (FE) pay
  - max(0,P(spot)-P(scarcity)*FE
  - Mechanism was designed to provide incentives to hydro suppliers to conserve water to avoid making this payment
  - If P(scarcity) set too high, supplier may instead choose to sell now at high price, instead of saving water to avoid paying
  - If P(spot) in future is not expected to rise very far above P(scarcity), then hydro suppliers may sell water now instead of saving water for the future
    - Both of above problems appear to be relevant to recent El Nino event

Making Market Mechanisms Work

- If expected cost of shortage period to hydro suppliers is sufficiently high, they should insure risk of supply shortfall during El Nino period with thermal supplier
  - Hydro supplier sells 100 MWh fixed-price forward contract, but can only deliver 60 MWh during El Nino period, so it will buy 40 MWh of spot price insurance from thermal supplier
- Must make E[max(0,P(spot)-P(scarcity)*FE] sufficiently large so that hydro supplier would prefer to pay for this price insurance from thermal supplier in current period rather than produce to limit short-term prices
- Thermal supplier provides shortage insurance to hydro supplier by running intensively early during El Nino event
  - Rewarded with higher prices early in El Nino event
  - Fossil fuel supplier has Incentive to sign spot insurance contract to avoid paying [max(0,P(spot)-P(scarcity)*FE]

Making Market Mechanisms Work

- Encourage trading of natural gas on short-term market
  - Allow short-term price to rise to reflect local scarcity conditions
  - During recent El Nino event, price in central Colombia would rise
  - Least cost fuel switching would occur in response
- Allocate priority for use of pipeline capacity, but allow trading of pipeline capcity allocations among users
  - Retailer serving residential and commercial gas customers could pay some customers to reduce their demand and sell part of pipeline allocation to a thermal generator
- Long-term gas contract prices can remain regulated because of small number of gas suppliers in Colombia, but short-term market transactions could occur at market prices
  - Forward contract holders can compete against suppliers to sell short-term natural gas and increase efficiency of use of pipeline capacity
  - Natural gas consumed by user with higher value because supplier always has option to sell in long-term gas in short-term market or consume it to produce electricity or other energy services

Making Market Mechanisms Work

- Encourage active participation of final demand in wholesale market
  - Final consumers can facilitate purchase of insurance against hydroelectric energy shortages
  - When El Nino conditions are likely to arise, buy additional forward contracts from thermal suppliers
    - Sell forward contracts purchased from hydro suppliers
- Express willingness to pay to avoid shortage periods in forward and short-term market
- Information release of market outcomes and other market data will facilitate active participation of larger consumers and retailers in managing El Nino events
- Information release also facilitates new entry in generation and retailing segments of industry

Questions to Be Addressed in Report

- Will recently implemented rule changes improve market performance during future El Nino events?
  - Water purchase and future sale
  - Cost-based thermal offers
  - Proposed markets for standardized forward contract for energy
- What additional market rule changes should be implemented to improve market performance during El Nino events?
  - Reliability Charge Mechanism
  - Reconciliation Payment

For More Information On

- Lessons from international market monitoring
- Electricity market design
- Market performance measurement
- http://www.stanford.edu/~wolak

Questions to Be Addressed in Report

- Did large thermal and hydro suppliers have a greater ability to exercise unilateral market power?
- Did large thermal and hydro suppliers have a greater incentive to exercise unilateral market power?
- Was market performance degraded by these actions?
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- Did positive and negative reconciliation payment mechanism further degrade market performance during El Nino event?
- Was intervention necessary to cause thermal units to operate?
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Reconciliation Mechanisms

- According to the Colombian market rules the positive reconciliation payment (if Q(Actual) > Q(Ideal)) is equal to

$REC^{Pos} = (PR^{Pos})x(q^{Actual} – q^{Ideal})$ where

$PR^{Pos} = \min([CSC + CTC + COM + OCV] + CAP/GSA , P^{Offer})$
CSC = the input fuel cost,
CTC = the fuel transportation cost,
COM = variable operating and maintenance cost
OCV = other variable costs for thermal plants,
CAP = Start-up costs,
GSA = total security generation for the start-up day,
P^{Offer} = offer price of generation unit.
Note: That suppliers are guaranteed start-up cost recovery

These suppliers also receive P_{spot} for their Ideal Generation.

Reconciliation Mechanisms

According to the Colombia market rules for negative reconciliation (Q(Ideal) > Q(Actual)) payments, the supplier would pay

$REC^{Neg} = (PR^{Neg})x(q^{Ideal} – q^{Actual})$,

where $PR^{Neg} = ½ x (P^{Offer} + P_{spot})$, but it would also receive P_{spot} for Q(Ideal).

Another way to view this payment stream is that the supplier receives P_{spot} for Q(Actual) and $½ x (P_{spot} – P^{Off})$ for the difference between q^{Ideal} and q^{Actual}

Design of reconciliation payment mechanisms can enhance ability of suppliers to exercise unilateral market power