Nodal Protocols Risk Assessment

Phase 1: Overall Assessment, Identification of Material Risks

Presentation to the ERCOT Board
16 August 2010

MR MARKET REFORM

Outline/Agenda

1. Introduction

2. Overall Assessment of the Protocols

Assessment Criteria

Our Conclusions

3. Potential Market Design Weaknesses

Needs Fixing Now

Likely to Need Fixing Soon

Must be Fixed Over Time

Watch and Be Ready

4. Addressing the Risks

MR MARKET REFORM

Scope of the Review and of this Report

- ERCOT has contracted with Market Reform to conduct a "broad", "high-level [Phase 1] expert review and analysis of the ERCOT Nodal Protocols that:

  a. "Assesses if the Protocols will deliver … the intended improvements … vis-à-vis the current zonal market design …

  b. "… assesses potential market design weaknesses …;

  c. "Describes and suggests priorities for further analysis; and

  d. "Provides a schedule … and cost estimate for a subsequent [Phase 2] review." [1]

- This Report

  – Deals with the substantive items (a) and (b) above

  – Discusses item (c) from the perspective of risk assessment

  – Does not cover item (d), which will be dealt with separately

[1] Nodal Protocol Review Statement of Work (SoW), Exhibit A

MR MARKET REFORM

Objectives and Approach

- ERCOT has emphasized that the current Protocols have been agreed among stakeholders and that implementation is well underway, with market start scheduled for December, so the objective of Phase 1:
  - *IS NOT* to define an "ideal" market or propose changes solely for the purpose of increasing market efficiency or elegance
  - *IS* to identify issues that might pose material risk to the scheduled market start date or to successful (particularly early) market operations.

- Given this guidance, Market Reform has prepared a high-level assessment of the Protocols by:
  - Reviewing the Protocols and associated documents (e.g. NPRRs)
  - Consulting extensively with the ERCOT staff team assigned to advise the project
  - Preparing, circulating and revising the evolving analysis of these problems

This Report summarizes the most important risks identified in the Review; it is not a comprehensive list of all the problems ERCOT will face and does not prescribe solutions (other than as examples)

MARKET REFORM

Frequently Used Technical Acronyms

- AS: Ancillary Service
- CRR: Congestion Revenue Right
- DA: Day-Ahead
- DAM: Day-Ahead Market
- DR: Demand Response
- LMP: Locational Marginal Price
- LZ: Load Zone
- MCP: Market Clearing Price
- MP: Market Participant
- NOIE: Non-Opt-In Entity
- PTP: Point-to-Point
- QSE: Qualified Scheduling Entity
- RT: Real Time
- RUC: Reliability Unit Commitment
- SCED: Security-Constrained Economic Dispatch
- SWCAP: System-Wide Offer Cap
- VDI: Verbal Dispatch Instruction

MARKET REFORM

Outline/Agenda

1. **Introduction**

2. **Overall Assessment of the Protocols**

    Assessment Criteria

    Our Conclusions

3. **Potential Market Design Weaknesses**

    Needs Fixing Now

    Likely to Need Fixing Soon

    Must be Fixed Over Time

    Watch and Be Ready

4. **Addressing the Risks**

MARKET REFORM

Assessment Criteria

As criteria for assessing the Protocols, ERCOT provided the following:[1]

- "Intended Improvements of the Nodal Market vs. the current Zonal Market:
  - "Reductions in congestion costs
  - "Increased price transparency and liquidity in the marketplace
  - "Increased locational price transparency for resources; and
  - "Transparent and efficient RT dispatch"

- "Key features of the Nodal Market vs. the current Zonal Market"
  - Both DAM and RT market for energy (vs. RT-only)
  - AS in DAM to supplement self-arrangement (vs. all AS self-arranged)
  - Nodal (vs. Zonal) offers, schedules and prices for Resources
  - Resource-specific (vs. portfolio) offers and schedules
  - Thousands of Potential CRRs (vs. six Flowgate Rights)

[1] Nodal Protocol Review Statement of Work (SoW), Schedule 1 to Exhibit A

MR MARKET REFORM

Key Features and Intended Improvements

INTENDED IMPROVEMENTS of NODAL vs. ZONAL

KEY FEATURE	Transparent Prices & Liquidity	Transparent Locational Prices	Reduced Congestion Costs	Transparent & Efficient RT Dispatch
Energy DAM (vs. RT Only)	🟢	Only resources, not loads, face LMPs 🟡 🟡 🟡		
Many CRRs (vs. 6 FGRs)	🟢	CRRs do not directly affect operations or pricing, but without them LMP may be impractical		
AS in DAM (vs. Self-Arr.)	🟡	AS market is in DAM only and ignores location		
Nodal for Resources (vs. Zonal)	🟡	🟢	🟢	🟢
Resource-Specific (vs. Portfolio)	🟡	🟢	🟢	🟢

MR MARKET REFORM

Outline/Agenda

1. **Introduction**

2. **Overall Assessment of the Protocols**
   Assessment Criteria
   Our Conclusions

3. **Potential Market Design Weaknesses**
   Needs Fixing Now
   Likely to Need Fixing Soon
   Must be Fixed Over Time
   Watch and Be Ready

4. **Addressing the Risks**

MARKET REFORM

Our Summary Conclusions

- The Nodal Protocols, as these are being implemented by ERCOT:
  - Contain all the "key features" listed above
  - Will improve market performance (vs. Zonal) in the intended areas
- We have found:
  - NOTHING suggesting the existence of large-scale gaming or market manipulation opportunities (although these exist to some extent in any market)
  - ONE potential show-stopper – PTP Options in the DAM – that must be addressed before market start; and this has at least one technically easy, if politically difficult, fix: Limit PTP Options in the DAM
  - SEVERAL market design weaknesses (compromises?) that:
    - Will cause problems and create some risks unless/until they are fixed;
    - Probably cannot be fixed without changes in the Protocols and systems; but
    - Do NOT threaten market start or viability, at least in the short term

The market design weaknesses we have found are listed in the next slide, categorized by how soon they are likely to need to be fixed

Market Design Weaknesses by Category

Needs Fixing Now (before market start)

PTP Options in the DAM

Likely To Need Fixing Soon (after market start)

Load Zone Modelling/Pricing

Ancillary Services Deliverability

CRR Derating

Must Be Fixed Over Time (within a few years)

Scarcity Pricing

Watch and Be Ready (if/when fix is needed)

Settlement at Shadow Prices

RUC and RUC Clawback

SCED and 2-Step Mitigation

MARKET REFORM

Outline/Agenda

1. **Introduction**

2. **Overall Assessment of the Protocols**

   Assessment Criteria

   Our Conclusions

3. **Potential Market Design Weaknesses**

   Needs Fixing Now

   Likely to Need Fixing Soon

   Must be Fixed Over Time

   Watch and Be Ready

4. **Addressing the Risks**

MARKET REFORM

PTP Options in the DAM – Summary

- A NOIE can (in effect) bid in the DAM to buy a PTP Option settled in RT
  - If it owns the same DAM-settled PTP Option
  - For up to 110% of its forecast RT demand

- Clearing a nodal market with bids/offers for both energy and CRRs subject to Simultaneous Feasibility/Revenue Adequacy is, with modern technology:
  - Practical with PTP Obligations, because these can be modelled as linked energy bids/offers in the single calculation of network flows needed for the optimization
  - A very different matter with PTP Option Bids, because each source-sink pair in any Option Bid requires recalculating all network flows

- PTP Options in the DAM are a potential show-stopper for the Nodal Market
  - Theory, experience elsewhere and ERCOT trials suggest the DAM can take hours to solve if PTP Option Bids involve > a hundred (or so) source-sink pairs
  - If the DAM does not run, settlement can be based on RT prices – but this would surely be regarded as failure of the market if it happened more than rarely

One technically (if not politically) easy fix is to eliminate/limit PTP Options in the DAM; but other fixes may work also

MR MARKET REFORM

The General Problem of PTP Options

- The difficulty of clearing an LMP market subject to CRR revenue adequacy/ simultaneous feasibility constraints depends critically on:
  - The number and nature of integer variables – e.g., the three-part offers required for unit commitment, linked AS offers and block load bids
  - Whether and how many PTP Option bids are submitted/allowed, because (in effect) the entire security-constrained dispatch problem must be resolved for each source-sink pair in any Option bid

Representative Market-Clearing/Solution Times

	No Block Bids No Unit Commitment	Block Bids No Unit Commitment	Block Bids and Unit Commitment
Only CRR Obligation Bids	Seconds/ a Minute	Minutes	Many Minutes/ an Hour
≈ 100 CRR Option Bids	Minutes	Many Minutes	Hour(s)
Many CRR Option Bids	Many Minutes/ an Hour	Hours (12-18 in PJM)	Many Hours/ a Day

MR MARKET REFORM

Outline/Agenda

1. **Introduction**

2. **Overall Assessment of the Protocols**

   Assessment Criteria

   Our Conclusions

3. **Potential Market Design Weaknesses**

   Needs Fixing Now

   Likely to Need Fixing Soon

   Must be Fixed Over Time

   Watch and Be Ready

4. **Addressing the Risks**

MR MARKET REFORM

Load Zone Modelling/Pricing – Summary

- ERCOT is divided into a few load zones (LZs), with every load within a LZ:
    - Paying the same energy price = the average LMP within the LZ – which reduces market-driven DR and efficiency, but is probably tolerable for awhile/indefinitely
    - Distributed for DAM purposes across all LZ buses using the same load distribution factors (LDFs) – a more serious problem that may need fixing soon
- When all DAM loads are spread proportionally across all buses in a LZ:
    - A DAM load bid from a large, price-sensitive point load may be rejected due to false congestion, making the DAM unrealistic, increasing the need for RUC, etc.
    - Congestion cannot be resolved by the loads that most affect it, because all loads anywhere in the LZ are assumed to affect it equally – a particularly serious problem in load pockets with no/little generation (weighted LZ shift factors ≈ 0)
- This may be a serious (show-stopping?) problem; possible fixes include:
    - Creating "custom LZs" for large loads/load pockets – done in (e.g.) CAISO, but not allowed (at least for 3 years) under the ERCOT Nodal Protocols
    - Ignoring in the DAM constraints with resource shift factors ≤ "epsilon" ≈ 0.00 – an ad hoc fix with uncertain effects and efficacy

More/smaller LZs are better than fewer/larger LZs

MR MARKET REFORM

Ancillary Services Deliverability – Summary

- The Nodal Protocols allow QSEs to self-arrange AS as they do in the Zonal Market, but add some simple (even too-simple) AS markets

- The AS processes do not really co-optimize AS and energy
  - The location of AS is ignored in self-arrangement, in the DAM, and in any post-DAM SASM (Supplemental AS Market)
  - ERCOT may not procure more of a better/lower cost AS in place of another AS or switch capacity between energy and AS near RT (except in emergencies)

- The cost of AS reserves is low where energy LMPs are low, i.e., where energy (including reserve energy) cannot get to market, so:
  - Rational QSEs and the DAM/SASM cost minimization will put too much AS where it is undeliverable and too little in load pockets where it is most needed
  - ERCOT will often(?) have to use near-RT VDIs to get AS to high-LMP load pockets, where all capacity may already be self/DAM-scheduled for energy

  Zonal "worked" with self-arrangement and no AS market; but a market with bad incentives may be worse than no market at all

MR MARKET REFORM

CRR Derating – Summary

- A CRR is derated for settlement purposes if it turns out to have been "oversold" in a monthly CRR Auction, as determined by:
  - The difference between the ERCOT Network Model used in the Auction and the actual network capacity on the day – neither of which CRR Owners control
  - A shift-factor calculation of dubious relevance
- The effect – and presumably the intent – of derating is to impose on CRR Owners much of the cost and risk of network outages; but this:
  - Stimulates no constructive actions by MPs either in CRR Auctions or in response to network conditions on the day
  - Undercuts one of the main purposes of CRRs, which is to give MPs a way to buy insurance against the effects of network outages they cannot control
  - Reduces the value of CRRs and hence the Auction revenues distributed to loads
  - May encourage gaming of the "hedge values" that serve no purpose except to limit the risks created by the derating itself

CRR derating may "only" create unnecessary complications and games, but it is more likely (also) to create large, counterproductive risks

MR MARKET REFORM

Outline/Agenda

1. **Introduction**

2. **Overall Assessment of the Protocols**
   Assessment Criteria
   Our Conclusions

3. **Potential Market Design Weaknesses**
   Needs Fixing Now
   Likely to Need Fixing Soon
   Must be Fixed Over Time
   Watch and Be Ready

4. **Addressing the Risks**

MARKET REFORM

Scarcity Pricing – Summary

- An energy-only market like ERCOT needs energy (and AS) prices that can/will become very high (at least as high as the current SWCAP)
  - When and where there is a critical need for more supply and/or less demand
  - While allowing effective market power mitigation policies and mechanisms
- The Protocols do not provide adequate scarcity pricing
  - Generators are allowed/encouraged to bid up to SWCAP during scarcity periods
  - The Protocol's Scarcity Pricing Mechanism (SPM) is misnamed; its intent/effect is to keep prices **down** by reducing SWCAP at times
  - The SWCAP and the 2-step mitigation in SCED will tend to depress prices
  - With large LZs, load bids cannot produce congestion-driven scarcity prices
- The required "methodology for setting maximum Shadow Prices" (SPs) could be interpreted to allow SCED SP > SWCAP at times; but
  - This does not seem to be the Protocols' intent or ERCOT's plan; and
  - Even high Shadow Prices on SCED constraint violations will not produce high market prices if operators never let these constraints be violated

ERCOT needs better scarcity pricing, at least for the long run

MR MARKET REFORM

Outline/Agenda

1. **Introduction**

2. **Overall Assessment of the Protocols**
   - Assessment Criteria
   - Our Conclusions

3. **Potential Market Design Weaknesses**
   - Needs Fixing Now
   - Likely to Need Fixing Soon
   - Must be Fixed Over Time
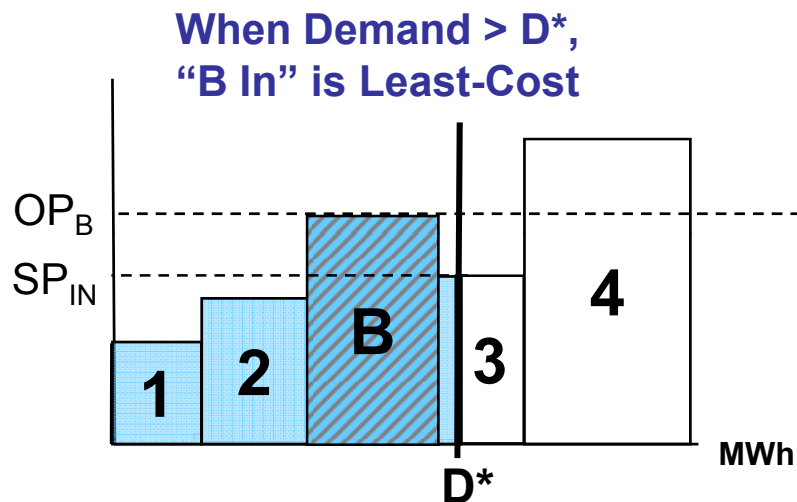   - **Watch and Be Ready**

4. **Addressing the Risks**

Settlement at Shadow Prices – Summary

- The Protocols often refer to "Shadow Prices [SPs] on constraints" or "… from the algorithm" as "Market Clearing Prices" (MCPs), and use these SPs/MCPs as settlement prices

- But the conflation of SPs with MCPs involves some implicit assumptions that are not always valid given provisions of the Protocols; in particular:

    – The Protocols allow extensive use of "integer" variables, such as three-part offers in the DAM and block bids/offers in the DAM and any SASM

    – The resulting mixed integer programming (MIP) problems are inherently difficult to solve, but modern technology can find a solution – the cleared bids and offers – that (approximately) maximizes the gains from trade

    – But the SPs from a MIP solution may not "clear the market", i.e., settling all trades at SPs may not equate demand to supply for individual MPs or overall

    – And a small change in (e.g.) network conditions or a single bid/offer can make a big difference in the SPs and the mix of cleared bids and offers

ERCOT should be aware of the potential problems here, and be prepared to (e.g.) limit bids and offers or change pricing rules if necessary

MARKET REFORM

© ERCOT & Market Reform, 2010. ERCOT Public.

With Integers/Blocks, there May Be No MCPs

B = All-or-None Block with Offer Price OP_B

**When Demand > D*,
"B In" is Least-Cost**

Demand Shadow Price = SP_{IN}

B should be IN, but cannot cover its costs @ settlement price = SP_{IN} if it is IN, so will try to stay OUT

**When Demand < D*,
"B Out" is Least-Cost**
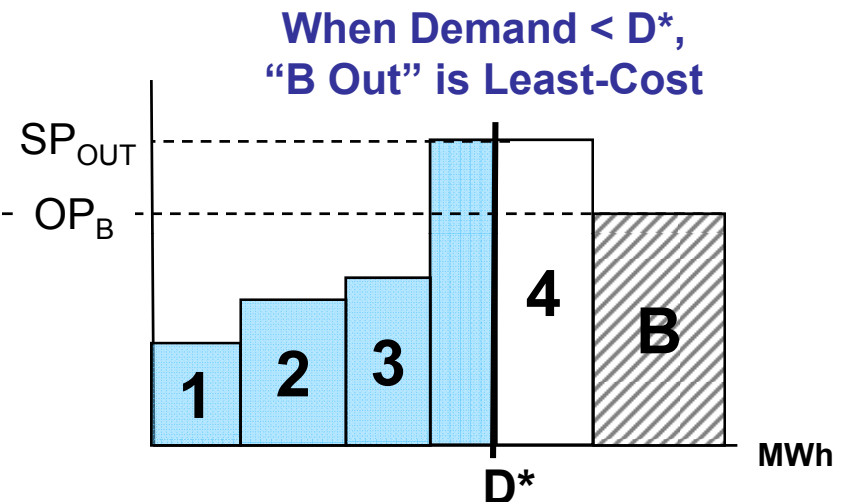
Demand Shadow Price = SP_{OUT}

B should be OUT, but can make money @ settlement price = SP_{OUT} if it is IN, so will try to avoid being OUT

*The SP does not "clear the market"; in fact, no single price does
The INs/OUTs and SPs are unstable and often inexplicable
MPs will/must use strategies (games?) to try to get what they want*

RUC and RUC Clawback – Summary

- ERCOT's Reliability Unit Commitment (RUC) process differs from, and involves more complex settlements than, RUC processes in other ISO markets. For example, the ERCOT process:
  - Runs after the DAM to minimize RUC commitment costs only (like some ISOs but unlike others that include RUC units in the final DAM pricing run)
  - "Claws back" some or all of a RUC unit's offer-based profits (which no other ISO market does), with higher claw-back for units not offered in the DAM
  - Allocates RUC costs to QSEs based on each QSE's "capacity shortage", with any final balance allocated to QSEs on a load-ratio share basis
- These complex arrangements are difficult to analyze, but they may create incentives (as examples only):
  - For loads to understate demand in the DAM and rely on RT
  - For generators to self-schedule to avoid claw-back

RUC will probably create risks and problems,[1] but we have not studied it enough to know – and only testing/experience will really tell

[1] *See presentation to ERCOT by William Hogan, "Texas Nodal Market Design", May 2, 2008, and testimony to PUC by David Patton, December 4, 2005, for discussions of RUC effects and risks.*

MR MARKET REFORM

SCED and 2-Step Mitigation – Summary

- The SCED (Security-Constrained Economic Dispatch) process that determines RT dispatch instructions and RT energy prices has some problematic features, including (as examples only):
  – Instantaneous optimization every 5 minutes based on then-committed resources, with no look-ahead (cannot commit units that will take more than 5 minutes to begin producing) or ramp rates (may call for energy that cannot be produced)
  – No optimization of AS (capacity designated for AS in earlier processes cannot be used for energy in RT or vice versa)

- The SCED also includes a 2-step offer price mitigation process that:
  – First computes LMPs with all network constraints ignored except those determined earlier to be "competitive", i.e., affected by many resources
  – Then computes final/settlement LMPs considering all constraints but capping offer prices based on the first LMPs
  – Is similar to such processes elsewhere, but also has some innovative features

The SCED (like RUC) will probably create risks and problems, but only testing/experience will really reveal what and how important they are

MR MARKET REFORM

Outline/Agenda

1. **Introduction**

2. **Overall Assessment of the Protocols**
   - Assessment Criteria
   - Our Conclusions

3. **Potential Market Design Weaknesses**
   - Needs Fixing Now
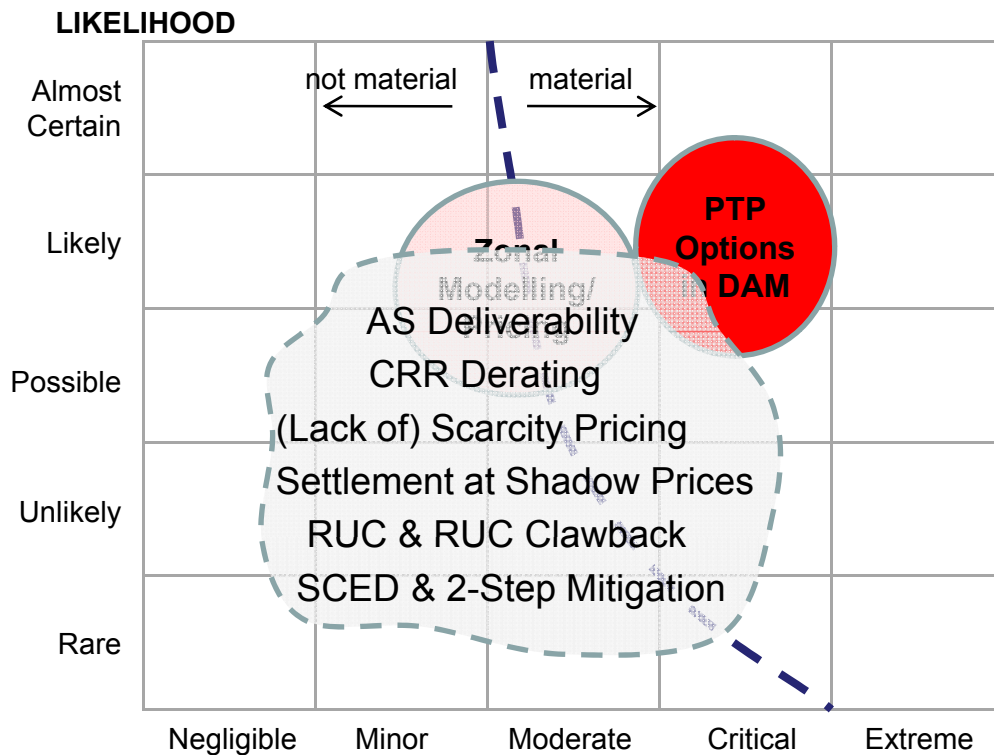   - Likely to Need Fixing Soon
   - Must be Fixed Over Time
   - Watch and Be Ready

4. **Addressing the Risks**

MARKET REFORM

Addressing the Risks

- This Review has identified some market design weaknesses that create risks; the fundamental questions for ERCOT management are now:

    1. How material are these risks?

    2. What can be done to deal with the risks judged to be material?

- Question #1 is assessed by considering (as illustrated on next slide):

    – The likelihood of each risk

    – Its impact should it occur

- Assessing question #2 above requires identification of:

    – ***Mitigation actions*** that can be taken to reduce the likelihood and/or impact of the risk, ideally bringing the risk down so that it is no longer material; and/or

    – ***Contingency plans***, for actions that can be taken should mitigation actions be insufficient (or not taken) and hence the risk becomes reality

MARKET REFORM

Risk Assessment

LIKELIHOOD

	not material ← → material

Almost Certain

Likely

Possible

Unlikely

Rare

Zonal Modelling/Pricing

PTP Options in the DAM

AS Deliverability
CRR Derating
(Lack of) Scarcity Pricing
Settlement at Shadow Prices
RUC & RUC Clawback
SCED & 2-Step Mitigation

Negligible   Minor   Moderate   Critical   Extreme   **IMPACT**

ERCOT has already begun assessing the materiality of some of these issues in its market system testing processes

- The materiality of the risks created by the problems on our list is:
  – Already apparent for PTP Options in the DAM
  – Likely for Zonal Modelling/Pricing
  – Not yet clear for the others

- Where materiality is not yet clear, it can and should be assessed:
  – Before market start, using analysis and market trials/simulation where practical; and/or
  – After market start, with a well-planned monitoring and early-warning program; and/or
  – Both before and after market start

MARKET REFORM

Assessing Materiality

Source of Risk	Questions To Be Addressed by Analysis/Trials/Simulations
PTP Options In DAM	The number of PTP Option source-sink pairs the DAM can handle; how many of these do NOIEs want/need
Load Zone Modelling/Pricing	Frequency/magnitude of load-pocket effects and DAM inefficiencies; effects of ignoring some constraints in DAM; feasibility of custom LZs
Ancillary Services	(Un)deliverability of DAM/SASM AS schedules; feasibility of SASM within an hour; robustness/effects of ERCOT's undeliverability determinations
CRR Derating	Distribution of impacts via shift factors; frequency and size of CRR de-rating; ability to influence/game "hedge values"
Lack of Scarcity Pricing	Price distributions w. scarcity; effects of 2-step mitigation; effects of SCED constraint MSPs/penalty functions now & with reserve/DR constraints
Settlement at Shadow Prices	Frequency/size of pricing inconsistencies and instabilities; market tolerance for and gaming incentives created by such inconsistencies/instabilities
RUC & RUC Clawback	Magnitude and costs of RUC commitments relative to market; likely incentive effects of RUC cost allocations and claw-back provisions
SCED & 2-Step Offer Mitigation	Inefficiencies/ anomalies created by lack of look-ahead, AS optimization, etc.; reasonableness and stability of offer price mitigation every 5 minutes

MARKET REFORM

Mitigation Actions/Contingency Plans

Source of Risk	Possible Mitigation Actions/Contingency Plans
PTP Options In DAM	Demonstrate that NOIEs do not need any/many PTP Options
Load Zone Modelling/Pricing	Create custom LZs; ignore some load-pocket constraints in DAM
Ancillary Services	Add locational constraints to AS and SASM market models
CRR Derating	Develop simpler, broader allocation of network outage costs
Lack of Scarcity Pricing	Add operating reserve and DR constraints to SCED
Settlement at Shadow Prices	Limit complexity of bids/offers; use (e.g.) "minimum uplift" pricing
RUC & RUC Clawback	Depends on problems observed in trials/reality
SCED & 2-Step Offer Mitigation	Depends on problems observed in trials/reality

ERCOT has already begun considering ways to reduce these potential risks as it implements the Protocols

ERCOT and Market Reform are now discussing what, if anything, should be included in Phase 2 of our Review of the ERCOT Nodal Protocols

MR MARKET REFORM