WPTF WESTERN POWER TRADING FORUM

# Day-Ahead Market Enhancements

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# Outline

**Topic 1:** Separate, benchmark, compare framework

**Topic 2:** "Separate"

- Downward imbalance product need
- Connection to resource sufficiency tests in EDAM and EIM
- Settlements and VER participation
- Mosaic quantile regression approach

**Topic 3:** Level-set on WPTF position

**Topic 4:** "Benchmark"

**Topic 5:** "Compare"

- Procurement and deliverability implications
- Pricing implications
- Market process timing
- Secondary design issue considerations

# Topic 1

## OVERVIEW OF SEPARATE, BENCHMARK, COMPARE

# WPTF path forward proposal

1. Separate general DAME design decisions from IRP framework decisions and impact
2. Benchmark framework ability to achieve DAME goals
   - How well does each framework address the problem statement and improve EDAM footprint efficiencies?
3. Compare each framework's market, reliability, and regulatory impacts
   - Real-time deliverability
   - Cross-product impacts; LMP price formation, ancillary service deliverability
   - Need for local market power mitigation and CRR shortfall mitigation rules
   - Implementation risk and optimization integrity and timeliness
   - Transparency
   - FERC risk – benchmark against other ISO designs

# Topic 2

SEPARATE

# Observations on the need for downward imbalance reserves

- Does the market still have a need for downward products?
- Observations:
  - Only 0.25% of renewable generation self-scheduled was cut in 2022, indicating ample downward dispatchability
  - Operators rarely bias RUC for downward, so this is not needed to reduce operator bias
  - Rarely see WEIM BAAs fail downward tests and never by a significant amount
  - Flexible RS test form RT must-offer requirements for EDAM entities
  - Downward product adds significant number of constraints to day-ahead market process
- Can downward imbalance product be added later if needed?

# Connection to Resource Sufficiency tests

- Would like more discussion on WRAP and RSE tests
- What happens if 100% of IRP requirement is not procured in IFM due to demand curve
  - Increase likelihood of failing WEIM RSE tests?
- Is IRD used in any of the RSE tests?
- What is the impact on RSE test if resources awarded IRU are converted to energy and fully used in real-time?
  - Do they not have any upward ramping capability left, so BAA has to get upward flex from other resources? Or is economic offer sufficient to meet ramping test.
- Is the IR requirement the same as the uncertainty requirement used in the WEIM RSE flex test?
  - Both use mosaic quantile regression approach

# Settlements and VER participation

- Additional transparency on IRP to FRP settlements is needed at policy level
- Additional transparency on how virtuals and load are settled today compared to how they will be settled after DAME
- VER participation and must-offer rules need to be clarified for RA and non-RA resources
  - Final paper indicates a must-offer obligation, but VERs do not have a day-ahead RA must-offer obligation
  - Consider whether it makes sense to pay a VER to meet its own contribution to uncertainty, especially in downward direction

# Mosaic quantile regression methodology

- Allows the CAISO to create a more accurate IRP requirement based on weather conditions and forecasts for solar, wind, and load
- Consequence of methodology is that in real-time it can highly variable between intervals – can see wide swings from 0 MW to closer to 99$^{th}$ percentile histogram cap
  - Discussed in FRP WEIM methodology paper
  - Because real-time requirement is typically very low, this impact may be muted
- Worthwhile discussion on whether to smooth forecast for day-ahead to reduce ramp jumps between hours

Note: it seems like mosaic approach is well suited to adjusting BAA level requirement into zones using output for zonal solar and wind

# Topic 3

## LEVEL SET

# Level-set

- WPTF supports an evaluation of a zonal framework and separate issues, and believes there is plenty of time given EDAM 2025 implementation date
  - "Zonal framework" is short-hard for frameworks that reflects constraints somewhere between a BAA level and nodal framework
  - Vistra presented on one option, MSC will present on other options
- "Uncertainty requirement" is short-hand for the outcome of the CAISO's statistical function based on system forecast
  - Any feasible proposal for zonal maintains this "uncertainty requirement" calculated at BAA level and includes diversity benefit
  - Uncertainty would be allocated to "active zones" based on estimated uncertainty patterns
- IRP **is not** a "successor to RUC" under any active proposal
  - RUC core functionality will be maintained, and out-of-market action to address uncertainty will be moved in-market via IRP

# Initiative history

- The CAISO's original design for the day-ahead products was a zonal framework for the first two years of initiative
  - Using sub-regional constraints to ensure deliverability with the option of creating more granular zones if needed
  - Contemplated a deliverability assessment tool for operators to see if new sub-regions needed to be enforced
- CAISO switched to nodal framework based on issues identified with flexible ramping product (FRP)
- While there may be some similarities between FRP and IR products, they are not entirely the same
  - FRP was a system wide (BAA level) requirement
  - FRP is priced based on opportunity cost and procured in real-time to meet real-time conditions (same transmission constraints enforced and similar outage patterns)
  - The trade-offs for FRP are not the same trade-offs for IRP

# Nodal Flexible Ramping Product

- Flexible Ramping Product was initially implemented using a system (BAA level) wide approach
  - One requirement for the entire BAA and one uniform price
  - **Goal was to reduce HASP operator bias**
- Opportunity cost-based pricing, meaning resources did not submit offer prices
  - If a resource did not have an opportunity cost with energy, then cheapest resource to award FRP
  - No opportunity cost when energy offer was high or behind a constraint and unable to provide energy
- CAISO deployed nodal FRP Feb 1, 2023
  - DAME discussions always point to nodal FRP as a way to test and get comfortable with nodal design performances
  - No indication yet whether nodal FRP has reduced HASP operator bias

# Connection between IRP and FRP

- "Procured in the same way for the same reasons" and "no difference between biddable or not biddable" (or DA/RT)
  - May be true from an engineering perspective, but this is not true from a market perspective
- Market perspective:
  - Procurement from VERs behind a constraint is less likely if they have ability to bid a high IRP price compared to being evaluated on its opportunity cost
  - Day-ahead price signal drives investment in generation and transmission in a way real-time prices do not
  - Accuracy of nodal price signal changes based on how well uncertainty materializes in real-time compared to day-ahead forecast
  - Virtual participation and financial products meaningfully changes day-ahead market considerations compared to real-time market considerations

# Topic 3

## BENCHMARK

# Benchmark

| | Nodal Framework | Zonal Framework | Considerations |
|---|---|---|---|
| Increases real-time economic offers | ☑ | ☑ | Only to extent it requires more economic offers than current bidding practices or other existing requirements in real-time |
| Improve day-ahead price formation | ☑ | ☑ | Both improve if additional Pmin energy within IFM and not RUC; price signal varies based on framework |
| Improve operator confidence and decrease operator intervention | ☑ | ☑ | To extent AS and IRU are both deliverable in real-time AND net load uncertainty is why operators are biasing |
| Captures EDAM diversity benefits | ☑ | ☑ | Diversity benefits reduced in different ways in Vistra zonal versus CAISO nodal proposal |
| Creates equivalent risk profiles between EDAM entities | ☑ | ☑ | Zonal: uncertainty function will be applied to system forecast, include diversity benefit, and allocated to active zones |

# Topic 5

## COMPARE

# High-level framework comparison

- The more nodal design, the more granular and precise the distribution methodology needs to be, otherwise it creates market inefficiencies
  - If accurate, and IFM system conditions remain the same in real-time, then less likely to have stranded capacity
  - If not accurate, or IFM system conditions change in real-time, create inefficient procurement, pricing issues, stranded capacity, and continued operator bias
- The more zonal/system design, the higher loss in visibility to day-ahead transmission constraints
  - How accurate is it to consider IFM transmission constraints (assuming 95% of uncertainty materializes) as a proxy for real-time conditions?
- What granularity appropriately balances the likelihood of capacity being accessible in real-time while mitigating inefficient procurement and other adverse impacts?

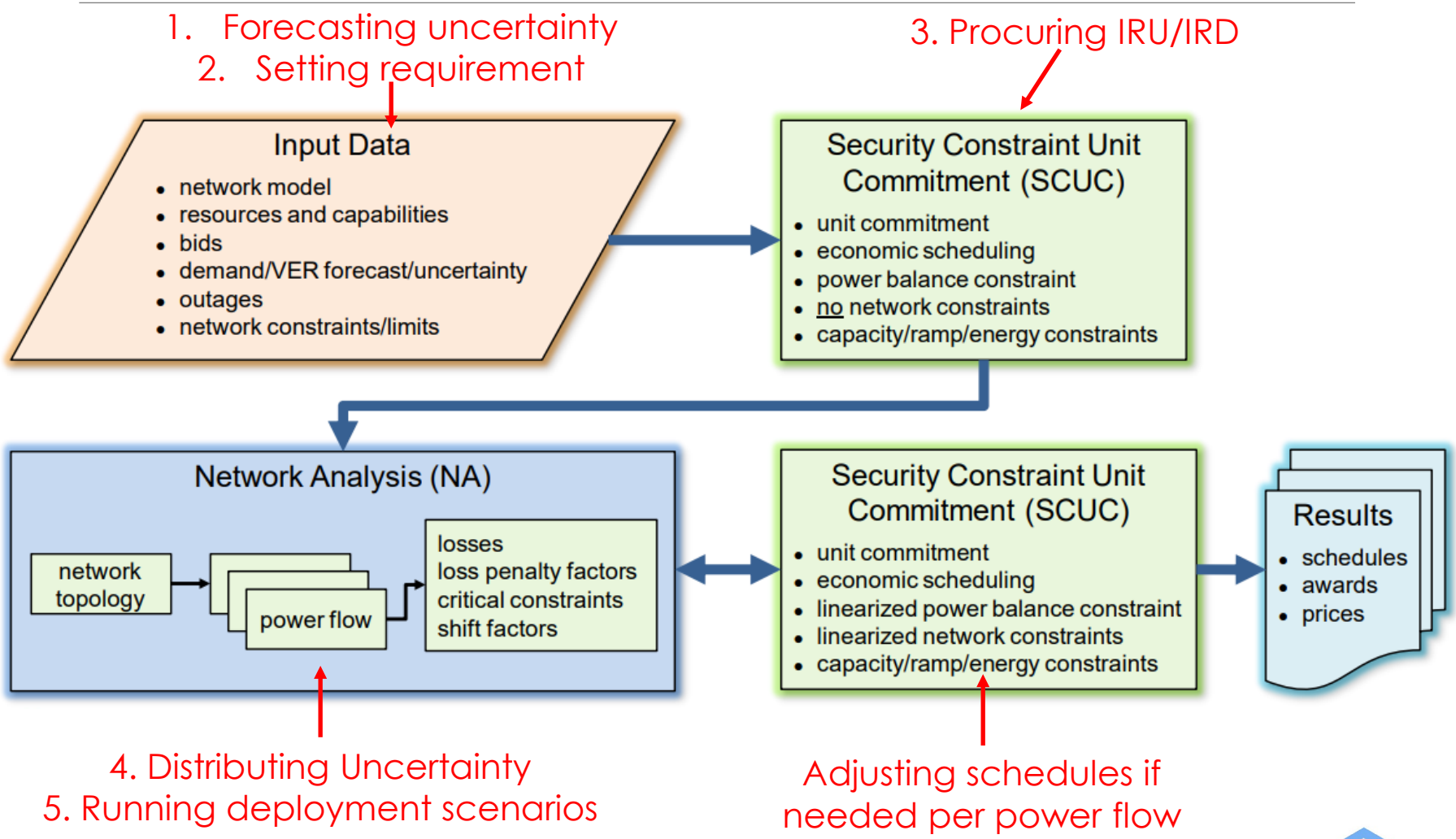
# Framework comparison outline

1. Uncertainty distribution
2. Real-time deliverability risk
3. Price impacts
4. Interaction with ancillary services
5. Complexity and market process timing
6. Secondary design impacts
   - Storage state-of-charge constraint
   - Market Power Mitigation
   - CRR market

# Overview of uncertainty distribution under nodal framework

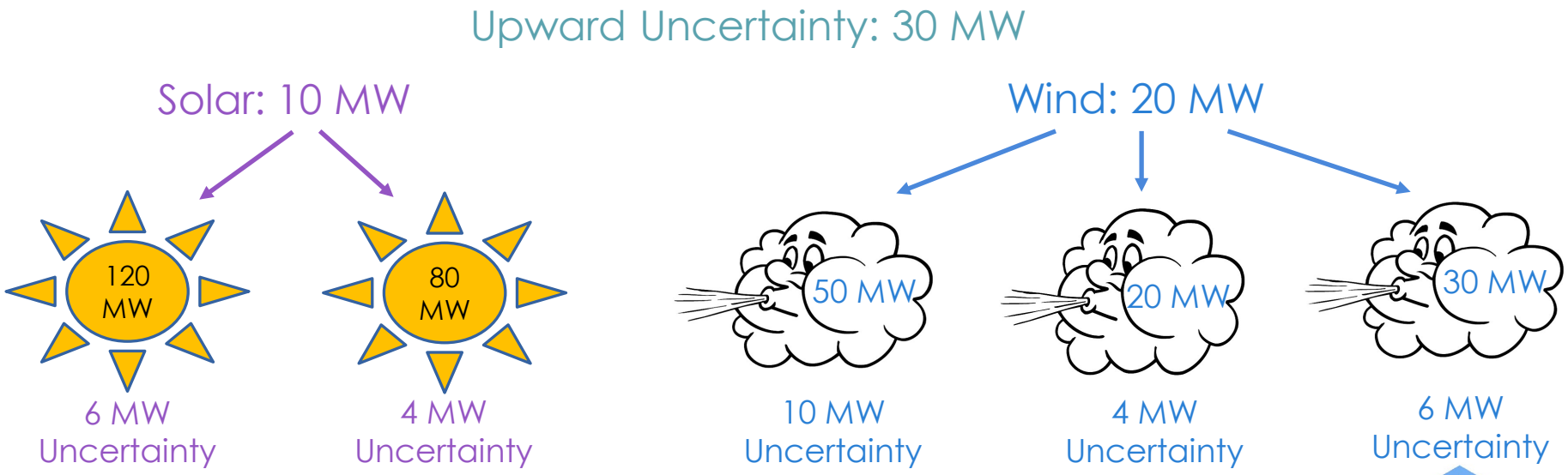
- Nodal framework requires what is referred to as deployment scenarios
  - Test that all the procured imbalance reserve product can be "delivered" to where the uncertainty is forecasted to materialize, considering transmission constraints
- Zonal framework could also use deployment scenarios
- Uncertainty Distribution under nodal framework involves five steps
  - Forecast uncertainty
  - Use forecasted uncertainty to set requirement for IRU and IRD
  - Procure sufficient IRU/IRD to meet requirement
  - **Distribute the uncertainty for nodal deployment scenarios**
  - **Test to see if the procured IRU/IRD can be "delivered" to meet the uncertainty where it's been distributed (i.e., running deployment scenarios)**

# Five steps in procuring imbalance reserves under nodal design

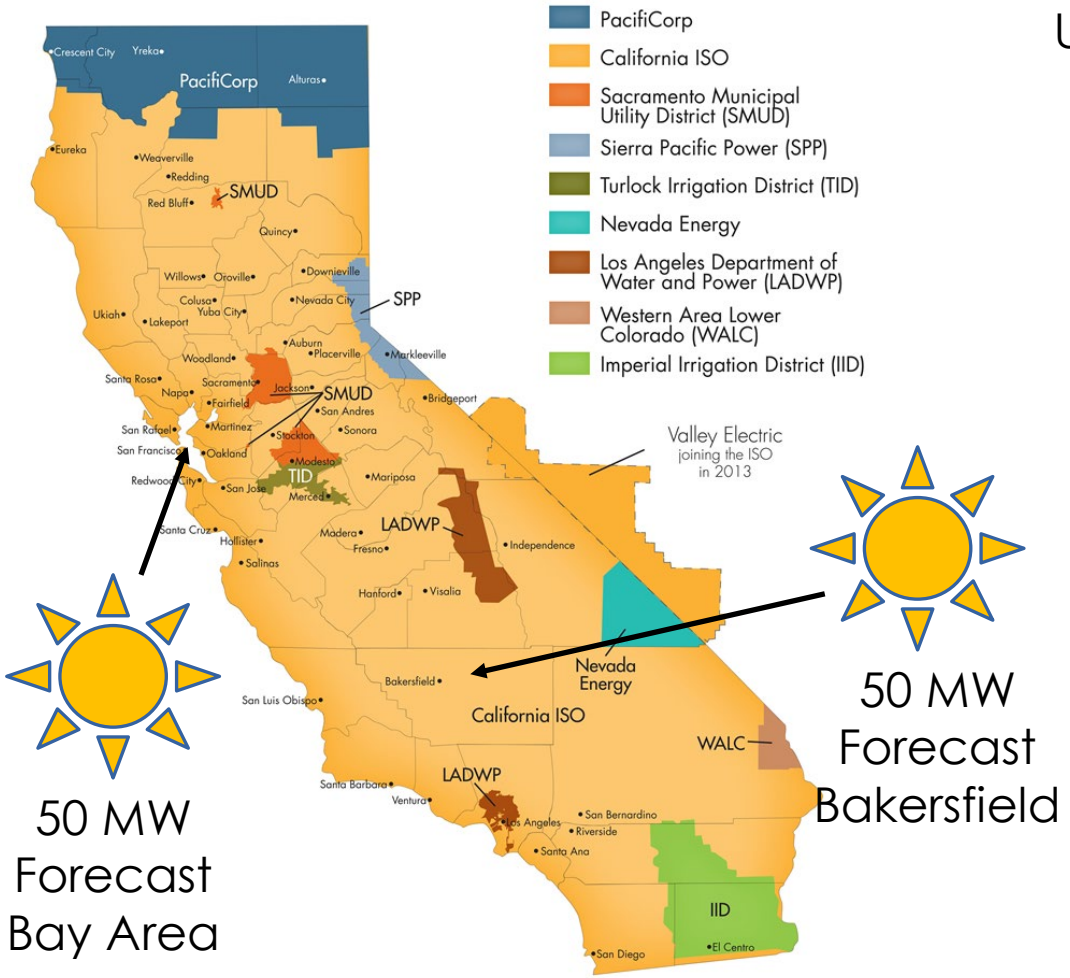


# Distributing uncertainty

- Each BAA's uncertainty will be separated into class – solar, wind, and load – based on historical contribution to uncertainty
- The uncertainty by class will then be distributed pro-rata to the nodes associated with that resource type
  - Forecasted output for wind and solar
  - Load distribution factors for load



# Distributing uncertainty




Upward Uncertainty: 20 MW Solar

Distributed uncertainty:
Bakersfield: 10 MW upward
Bay Area: 10 MW upward

Actual uncertainty:
Bakersfield: 4 MW upward
Bay Area: 16 MW upward

Can the capacity procured to meet Bakersfield uncertainty be deliverable to Bay Area?

# Distributing uncertainty in a zonal

- Under a zonal framework there are multiple ways the uncertainty can be distributed to the "active zones"
  - Follows a "top down" approach, not a "bottom up
- All zonal approaches would start with the BAA level uncertainty requirement as calculated by the CAISO's quantile regression approach and adjusted for diversity benefit (same as nodal approach)
- The BAA level uncertainty requirement is then separated and allocated to the "active zones" within the BAA
  - Could allocate based on various factors, such as location or differences in uncertainty between zones
  - Sets a minimum amount of IR that has to be procured within that zone (or that can be delivered to that zone depending on how constraints are reflected
- There is no need to distribute the uncertainty first to the nodal level to set zonal requirements

# Real-time deliverability risk comparison

- We don't see much difference in real-time deliverability risk between frameworks
  - The nodal framework could still result in stranded capacity in real-time
- The distribution of uncertainty does not consider any variation of uncertainty relative to location
- Inaccurate distribution will result in inefficient procurement
  - There will be too much imbalance procured to meet areas with over estimated uncertainty (e.g., Valley) and not enough procured to meet areas with under-estimated uncertainty (e.g., coast)
- The capacity procured to meet uncertainty in areas that were over-estimated may not be deliverable to actual uncertainty that materializes in the under-estimated areas
  - Operators may still take action (e.g., bias RUC) because they are not confident in where capacity is procured

# Price impact comparison

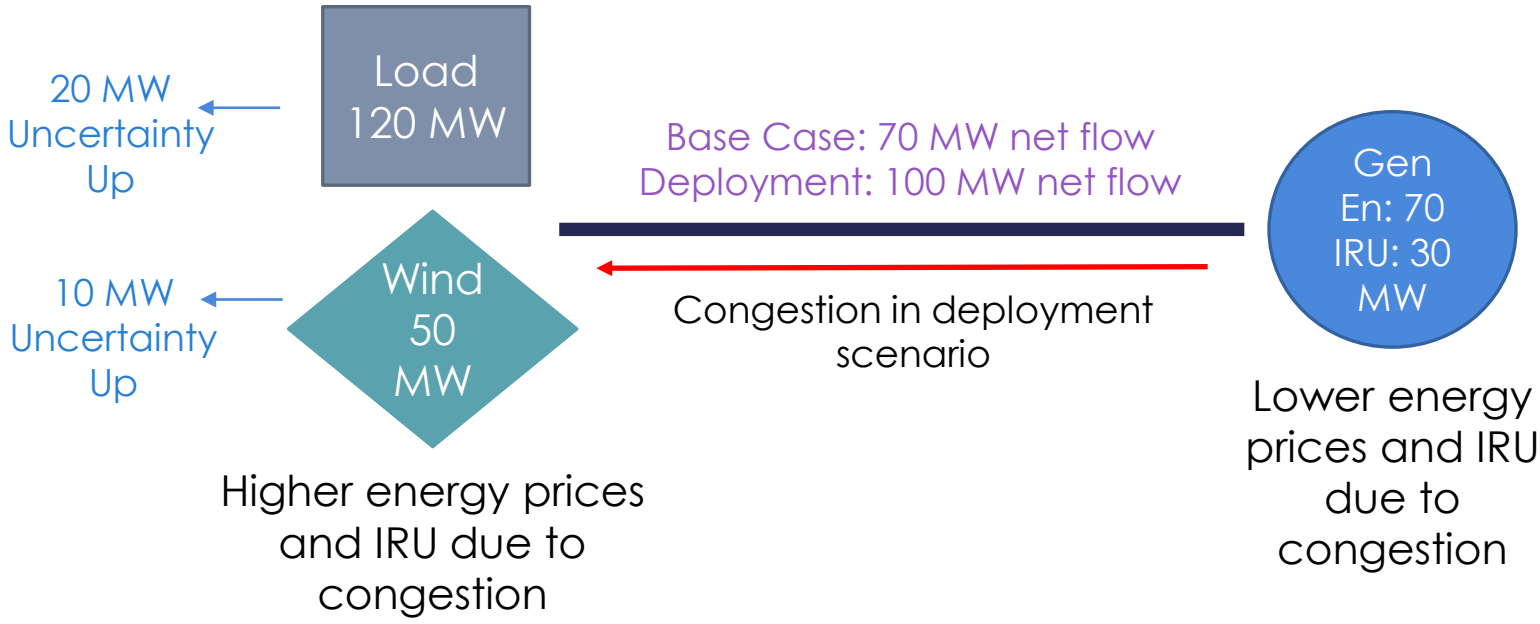
- As you move along the spectrum from nodal to system, the make up of IR prices and its impact on energy prices change
- Nodal IR prices will have two (three?)cost components
  - System marginal cost for IRU/IRD will be the same at all locations
  - Congestion component creates the price differences among nodes
  - Congestion in deployment scenarios reflected in energy prices
- Zonal prices could have different prices by defined region
  - Differences in regional/zonal prices reflect differences in marginal cost by constrained area
- System wide price has one price across entire footprint
  - No congestion differences reflected

# Nodal Imbalance Reserve prices

- Accurate price signals are key to a well-functioning competitive market
  - Provide signal to participants as to where energy, flexibility, and/or capacity, is valued most
- The more nodal the design, the more granular the prices become
- If nodal prices provide accurate and meaningful economic signals, the added transparency is beneficial
- If nodal prices do not provide accurate economic signals, then added transparency is not effective and may cause additional market inefficiencies
  - Mathematically correct prices and accurate economic price signals are not always the same

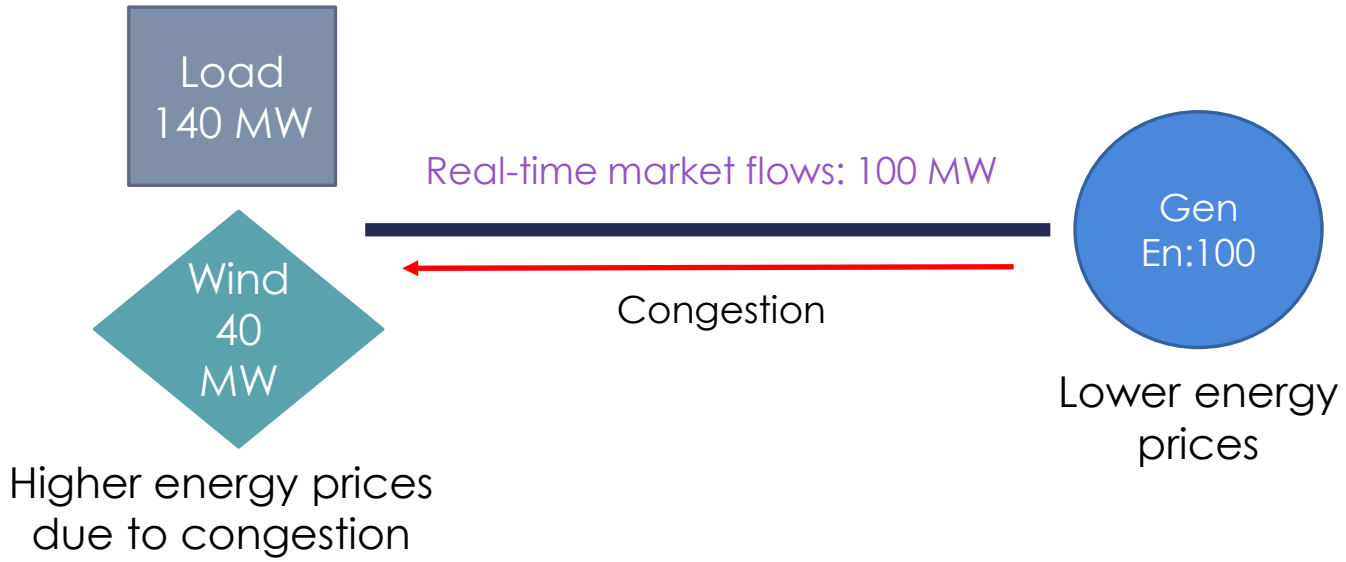
# Congestion pricing scenario: Day-ahead

- Assume 20 MW upward uncertainty allocated to load node and 10 MW upward uncertainty allocation to wind resource
  - Wind is bidding at its forecast (50 MW)
- Transmission line has 100 MW limit



# Congestion pricing Scenario 1a: Real-time

- If in real-time the uncertainty materializes, the generation on other side of constraint will be dispatched 100 MW for energy
- Pricing and congestion signal is consistent between day-ahead and real-time pricing
  - Assume same energy offer prices as day-ahead
- Consistent pricing only occurs if 95% of uncertainty actually materializes in real-time



# Congestion pricing Scenario 1b: Real-time

- If in real-time the uncertainty does not fully materialize (more likely), then congestion does not materialize
- Pricing and congestion signal is now inconsistent between day-ahead and real-time pricing
- Market design has created a systematic price divergence between the day-ahead and real-time markets

# Interaction with virtual bidding (1 of 2)

- Virtual bidders are sophisticated and will react to systematic price differences between the day-ahead and real-time prices
  - Submit virtual supply/demand offers at locations with congestion created by upward/downward deployment
- Virtuals will start to converge the prices, but for a cost to the market that provides no additional benefit
- Not the same as when virtual supply fills in for under scheduled renewables or virtual demand fills in for under scheduled load the day-ahead
  - For under-scheduled renewables or load, the virtuals are aligning the day-ahead market supply and demand levels with real-time expectations

# Interaction with virtual bidding (2 of 2)

- Virtuals may allow for additional IRU/IRD to be procured from resources if virtuals provide counterflow on transmission constraints originally constraining IRU/IRD awards to certain resources
  - Counterflow from virtuals allows more IRU/IRD awards to "flow" on constraint in deployment scenarios
- If in real-time *some* of the uncertainty does materialize, the awarded IRU/IRD is now undeliverable because the counterflow provided by the virtuals is no longer there
  - Back to a market with inconsistent price signals between the day-ahead and real-time markets due to deployment scenarios not aligning with reality
  - End up with undeliverable IRU/IRD in real-time
- Creates a volatile cycle of price divergence/convergence all based on virtuals reacting to the inconsistent price signals

# Congestion price signal

- Inaccurate congestion price signals may result in over-investment in transmission or generation
  - Using price signals assuming 95% uncertainty materializes can result in inefficient transmission investment
  - May build transmission when its not actually needed
- Inaccurate congestion price signals may result in transmission and generation being built in the wrong areas
  - Inaccurate distribution of uncertainty will create inaccurate price signals at nodal level
  - Market may see congestion due to deployment scenarios in an area where uncertainty was over-estimated to occur
- Transparency of nodal IR pricing can be meaningful if day-ahead congestion due to uncertainty materializes in real-time in the same location and provides consistent signal between markets

# Congestion component transparency

- Assuming congestion components are providing meaningful price signals, market will need to know cost due to energy and cost due to uncertainty
  - Consider breaking out congestion component by base case and deployment costs
- When congestion occurs in both the base case and deployment scenario, there is no way to know what cost is congestion from energy and what cost is due to assumed level of uncertainty
  - Congestion component of energy reflects shadow prices of both base case and deployment
  - Congestion component of IRU only reflects shadow prices of deployment scenario
  - May need to consider indicating congestion from upward and downward uncertainty separately

# Zonal price formulation

- Zonal framework would have one price for imbalance reserves (up/down) for each defined region
- Price differences between the region reflect inability to access cheaper capacity from other regions due to deliverability conditions
  - Assuming regions are defined based on identified transmission constrained areas
- Price differences would also reflect higher need for uncertainty capacity in some areas over others
  - Different balance of supply and demand

# Zonal and nodal price formulation trade-offs

- Nodal prices are beneficial if uncertainty distribution is accurate, and all assumed uncertainty materializes
  - Otherwise, nodal prices are not meaningful and create adverse market impacts
- If uncertainty does not materialize, nodal prices have the potential to create price divergence between day-ahead and real-time prices
- Inaccurate uncertainty distribution assumptions will lead to inaccurate price signals and inefficient transmission investment
  - Create false congestion patterns due to inaccurate assumptions
  - The market will signal the need for more energy and imbalance reserves in areas its not needed
  - The market will have diluted price signals for energy and imbalance reserves in areas it is needed

# Ancillary Services Zonal procurement

- AS are a capacity product procured in the IFM market and will compete alongside energy and IRU/IRD
- Procured zonally with ancillary services that come in from intertie locations competing for transmission capacity into the CAISO BAA
- If zonal AS procurement results in capacity stranded behind constraint, operators can block resources from providing the AS
  - We can use AS procurement data to assess magnitude of potential issue with zonal IR procurement
- CAISO reports show that stranded AS is not an issue
  - Operators have created a tool to help address (has rarely been used per report)
  - Enforce new zones when operators foresee transmission constrained areas

# Nodal IR and Zonal AS risks reliability

- Nodal procurement of IR in a market with zonal procurement of AS will inappropriately prioritize accessibility of IR over AS
  - AS are a high priority product protected in real-time
  - WECC/NERC requirement
- When the market is deciding which resources to award what products, it will first procure IRU/IRD capacity from resources not stranded behind a constraint
  - This in turn will push more AS being procured from resources that are stranded behind constraints and less accessible in real-time
- AS is not re-optimized in real-time whereas IRU/IRD show up as energy offers the market can use to meet real-time conditions
  - Market may redispatch energy offers from IRU/IRD but does not have the ability to re-optimize AS

# Risking reliability is not a reason to move forward

- "The nodal imbalance reserves may technically make it more likely (all else equal) for AS to be procured from undeliverable capacity is a better argument for nodal AS than against nodal IR"
  - WPTF strongly disagrees and cautions the CAISO to have this perspective
- If undeliverable AS is a concern today, then we should be prioritizing that discussion over nodal IR procurement
  - Or at a minimum having the conversation together
- Initiatives put in the CAISO catalog does not mean it will be on a policy roadmap or ever begins
  - Even if the initiative is kicked off at some point, we should not presume it will result in a nodal AS design
  - Stakeholder process should identify the problem statement, evaluate options, and compare costs and benefits

# AS scarcity events by cause

| Issue impacting A/S procurement | Year | | |
|---|---|---|---|
| | 2017 | 2018 | 2019 |
| Telemetered limits reduce resource capacity | | 116 | 77 |
| Resource outage or Pmin re-rate | 18 | 43 | 72 |
| Transmission issues block A/S delivery | 8 | 2 | 34 |
| MSG transition issue | 2 | 16 | 4 |
| System conditions where energy is needed over A/S capacity | 20 | | 9 |
| Increase in A/S requirements in RTM | 4 | 5 | 12 |
| Resource issues: shutdown, ramp, or exceptional dispatch | 2 | 7 | |
| **Totals** | **54** | **189** | **208** |

# Complexity considerations

- What added complexity balances the cost with benefits and minimizes risk to market inefficiencies?
  - Implementation, market transactability and transparency risk
- Complexity of market power mitigation design
  - Need to develop novel default "competitive offer"
  - Competitive LMP used in the mitigation method will be directly impacted by energy offers
- Adverse impact to CRR market
  - Shifting costs and harming CRR holders for a market design decision that is independent of CRR market
- What are the risks starting with a more simplified approach and enhancing as gained experience informs that decision making process?

# Market Process timing considerations

- Market process timing is a key concern with any significant changes to the market design
  - There are several enhancements being proposed simultaneously but being discussed in parallel environments that all add to market processing time
  - EDAM includes multiple new day-ahead market runs
- Prioritize what market design features we are willing to increase market processing time for and which we are comfortable foregoing at this point
  - Nodal procurement may be more feasible from a market processing time perspective if downward products are removed
  - Accurately reflecting storage resource's state-of-charge may be feasible if we remove downward products
- WPTF supports evaluating these tradeoffs

# Secondary design impacts

- CAISO removed the constraint that was going to reflect the impact providing IRU/IRD has on a storage resources' state-of-charge
  - Our understanding mainly due to added market processing time needed
  - Without the constraint, will result in infeasible schedules for storage resources
  - Zonal approach may allow for the constraint to be included the market design without foregoing other trade-offs



# Secondary design impacts cont.

- Nodal framework includes use of local market power mitigation (LMPM) approach
  - Requires coming up with a novel construct to determine what a competitive IR offer should be
  - Uses a "competitive LMP" as a floor for mitigation which is based on inaccurate day-ahead price signals
  - Zonal framework could leverage same bid cap as A/S
- CRR impact
  - Look forward to hearing CAISO's proposed solution



# Proposed comparison table

| Market Design Element* | Nodal | Zonal | Trade-offs | Support |
|---|---|---|---|---|
| **Uncertainty Requirement** | Mosaic Quantile Regression approach adjusted for diversity benefit | | Can consider more granular renewable forecasts in zonal | Ask Hong Zhou |
| **Distributing uncertainty requirement for procurement** | Nodal distribution based on LDFs and VER forecasts | Zonal distribution based on observed/forecasted uncertainty differences between zones | More simplified approach that captures zonal uncertainty differences but do not have a proxy to test for transmission feasibility | How accurate of a proxy is the day-ahead deployment scenarios for real-time deliverability? |
| **Price Formulation** | Nodal pricing granularity; only accurate signal when all uncertainty materializes | Zonal pricing granularity; lose some visibility | Less visibility in pricing differences with zonal, but no concerns with inaccurate congestion pricing signals and virtual offers | |
| **Market Power Mitigation Approach** | Dynamic local market power mitigation triggered based on congestion | Bid cap set at same level as AS bid cap | | |

*There are likely additional market design elements to include. This is just an initial list for discussion purposes.


Thank you! Questions?

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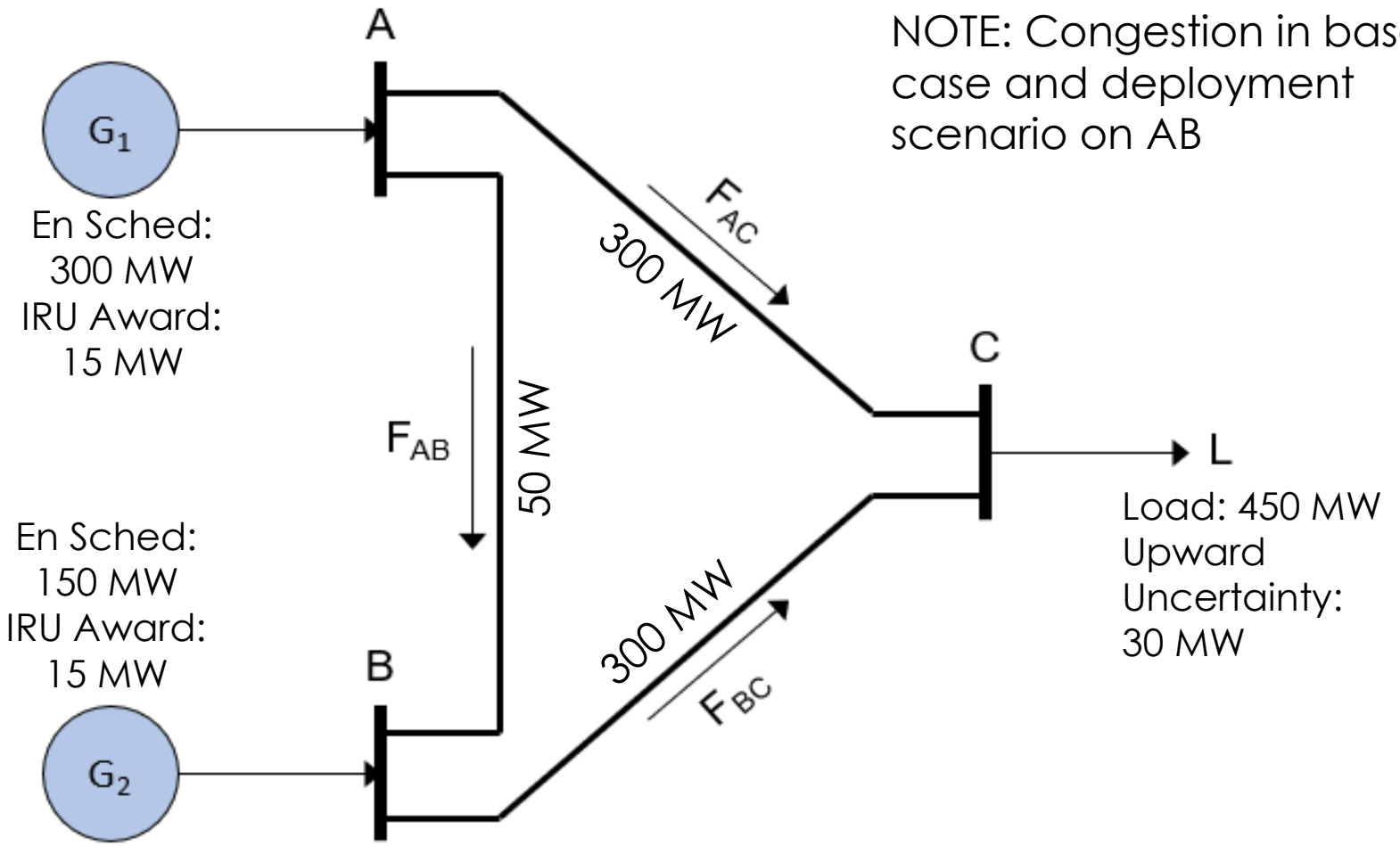
# Appendix

# Why did the CAISO add software issues as reason for AS blocking?

| Version | Change | Date |
|---|---|---|
| 3.4 | Converted from Word SharePoint to Centric | 3/09/16 |
| 3.5 | Minor updates to clean up formatting; no content changes | 9/30/16 |
| 3.6 | Added consideration to add continuing real-time AS blocking into tomorrow's Day-Ahead.<br>Minor format and grammar updates.<br>Replaced A/S with AS. | 3/22/18 |
| 4.0 | Periodic Review:<br>Section 1.4: Updated by adding instances when the "RESOURCE" constraint type drop down should be used. Section 1.3, Steps 2 & 4: Updated second bullet to include "as necessary."<br>Replaced instances of ISO with CAISO. | 10/21/21 |
| 4.1 | Section 1.4: Added consideration for real-time AS blocking ("system condition, unit issue, or software issue"). | 2/01/23 |



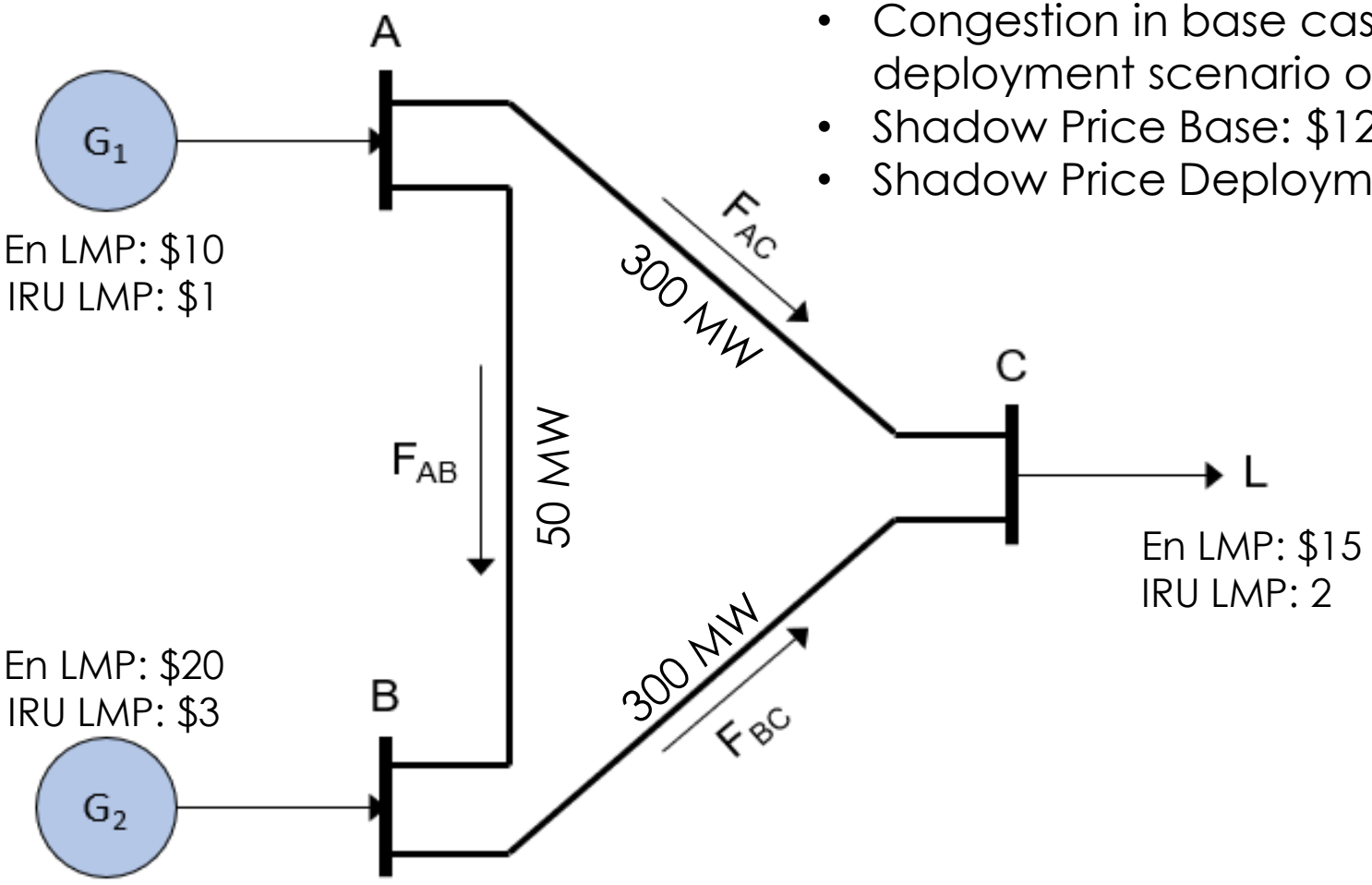
# Price example from solver with congestion: Schedules




NOTE: Congestion in base case and deployment scenario on AB

# Price example from solver with congestion

- Congestion in base case and deployment scenario on AB
- Shadow Price Base: $12
- Shadow Price Deployment: $3



# Outstanding Questions

- Does the distribution methodology ensure that the total amount of uncertainty distributed to a resource's location, plus that resource's energy schedule, does not exceed total capability of resource?
  - Is there something like the IFM awards capacity constraint applied to the amount of uncertainty distributed?
- Confirm if the deployment scenarios assume all upward uncertainty materializes and then all downward uncertainty materializes?
  - Is that an accurate assumption and what impact does that have on congestion pricing?
- Does it make sense to allocate diversity benefit based on uncertainty level?