**Procurement and pricing of the proposed future set of Ancillary Services – Working Document (5/6/2014)**

**Revisions Description:**

5/6/2014:

1. Added to the Assumptions section, two items that are NOT being considered at present:
   1. Pay for performance
   2. Real-Time energy and AS co-optimization
2. Removed sentence that implied that Load Resource (UFR-TYPE) qualified for FFR1 are not eligible to provide other AS. A Resource can provide any Ancillary Service that it has been qualified for
3. MCPC for FFR1 & FFR2 is capped at VOLL
4. Changed formatting of document orientation to portrait
   1. Split the AS Plan table into three tables for better readability in portrait mode
   2. Minor format changes

5/2/2014:

1. Added RegUp, FRRS-Up, RegDn, FRRS-Dn Ancillary Services. This changed the following sections:
   1. Set of Constraints for AS procurement
   2. AS Plan
   3. Resource Limits
   4. AS MCPCs
2. Other edits for clarification
   1. Added description of high level rules for self-arrangement of AS in the table of constraints for AS procurement

4/25/2014:

1. Modified the consensus item questions and recorded the consensus from the 4/18/2014 FAST work session meeting
   1. Modified constraint for procurement of CR by removing term for contribution of FFR2 to CR.
   2. Crossed out all MCPC pricing options **except for Option 1** for FFR1, FFR2, & CR2 – based on answer to question 1 in list of consensus items
2. Corrected the label for the ratio of FFR/PFR ratio to PFR/FFR i.e. this ratio defines how many MW of PFR is equivalent to 1 MW of FFR

4/11/2014:

1. Incorporated the ratio that equivalences 1 MW of FFR with R MW of PFR. This change removed the minimum FFR procurement constraint – impacts constraint table and AS MCPCs. This also resulted in modifications to the handling of DAM AS insufficiency process
2. Section on Transition Plan introduced
3. Other edits to improve description

**Assumptions:**

* RATF addresses pricing impacts of “blocky” MW (Load Resource – UFR Type) deployments
  + This has direct impacts on the deployment of the proposed future AS (FFR1,FFR2,CR2,SR2)
* All AS Offer prices are greater than equal to zero. i.e. no negative offer prices for AS
* For now, SIR & EIR is out of scope as further discussions are required
* The AS obligations will be determined on a Load Ratio Share basis
* For now, incorporating ORDC into DAM is not considered
* PFR & FFR services under consideration from a market procurement perspective are “upward” services, i.e. inject energy or reduce energy consumption when deployed. From a market procurement perspective, PFR “Down” and FFR “Down” services will be discussed when there is concern of over frequency (trip of a DC tie when it is carrying significant exports). The system will be built with sufficient flexibility to accommodate future addition of these “Down” services.
* For now, pay for performance for AS is not considered
* For now, Real-Time energy and AS co-optimization is not considered

**Transition Plan**

The transition to the proposed future set of Ancillary Service products needs to consider the following

1. Implementation: In the building of the software system, instead of replacing current AS products, add the new AS products to the set of existing AS products
   1. Allows flexibility of rolling in the future AS products in phases rather than “big bang” approach
   2. Allows option of rolling back if issues encountered
2. Ensure sufficient advance notice to the market before “go-live”. Allow enough time for hedging/forward contracting.

**Example AS Offer from Load Resource (UFR-Type)**

|  |  |  |  |
| --- | --- | --- | --- |
| Capacity (MW) | FFR Offer Price ($/MW) | CR Offer Price ($/MW) | SR Offer Price ($/MW) |
| 100 | 5 | 3 | 2 |

**Note 1:** Offers are Resource specific. Offers from Resources for services they are not qualified to provide will be rejected.

**Note 2:** The offer submittals may not specify the subgroup of the service. The system will determine which subgroup of AS (e.g. FFR1 or FFR2, CR1 or CR2, etc.) based on the qualification status within the ERCOT registration system.

Clearing process:

1. The example AS offer above is only for Resources qualified for FFR2.
2. The clearing process will award only ONE type of AS to this Resource as the deployment is blocky. i.e. the AS offers in the above example are treated as mutually exclusive.
3. The optimization process will attempt to maximize the revenue for this Resource for a given set of AS MCPCs as opportunity costs for the different AS products are incorporated into the AS MCPCs
   1. Ongoing analysis on how to deal with the binary variables introduced (mutually exclusive AS offer modelling) so that the revenue to Resource is maximized

**Note 3:** For Generation Resources (or other types that can submit offers to sell energy and AS offers), the clearing process with energy and AS co-optimization, has the effect of producing LMP (energy price) and AS MCPCs (AS prices) that will maximize the Resource total revenue from sales of energy and Ancillary Services. This is because opportunity costs for the different products are incorporated into the prices.

For example, if a Generation Resource offers 100 MW for sale of energy and Ancillary Service(s), then the result of the clearing process will be such that the sum of the energy and AS sales (awards) will be 100 MW (no overlapping of services) and the total revenue to the Generation Resource will be maximized.

**Note 4:** AS offers from SCED Dispatchable Resources (Generation and Controllable Load Resources) will not be treated as mutually exclusive. i.e. for the example AS Offer above, if offered from a Generation Resource or a Controllable Load Resource, then that Resource’s AS MW capacity offer can be awarded multiple AS such that the sum of the AS awards do not exceed the total MW offered for AS and the sum of the AS awards is less than or equal to HSL-LSL (or MPC-LPC for Controllable Load Resource).

**AS Substitution**

Current design provides the QSE submitting Resource specific AS Offers to specify for a given AS MW offer separate prices for each of the AS the Resource is qualified for (the absence of a price for a AS is taken as not offering for that AS). This allows the procurement process to optimally allocate the AS MW among the different AS. This form of AS substitution is different than the practice at other ISOs. The ERCOT form of AS substitution has the following features:

1. Provides more flexibility to QSE in letting them decide which AS to offer with a price
2. Does not ensure AS MCPC hierarchy where, higher quality AS are guaranteed to get a higher MCPC than lower quality AS

**Procurement process**

1. The system wide minimum AS MW requirements on an hourly basis are posted in advance. In addition, in certain cases, the maximum AS MW allowed is also posted. The DAM 6:00 A.M. posting for AS plan will incorporate any updates to the AS MW requirements. An example is shown below:

**Regulation Up and Down:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Hour | RegUpRequirement*\** | FRRS-UpMaxRequirement*\** | RegDnRequirement*\** | FRRS-DnMaxRequirement*\** |
| 1 | A1 | B1 | C1 | D1 |
| 2 | A2 | B2 | C2 | D2 |
| : |  |  |  |  |
| 24 | A24 | B24 | C24 | D24 |

\* The AS plan requirements that can be self-arranged

**Primary Frequency Response and Fast Frequency Response:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Hour | PFRRequirement**\*** | FFRMinRequirement**\*** | FFRMaxRequirement | FFR1MaxRequirement**\*** | PFR/FFR Ratio  1 MW FFR = R MW of PFR |
| 1 | X1 | Y1 | Z1 > Y1 | S1 <= Y1 | R1 |
| 2 | X2 | Y2 | Z2 > Y2 | S2 <= Y2 | R2 |
| : |  |  |  |  |  |
| 24 | X24 | Y24 | Z24 > Y24 | S24 <= Y24 | R24 |

\* The AS plan requirements that can be self-arranged

**Contingency Reserve and Supplemental Reserve:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Hour | CRRequirement**\*** | CR1MinRequirement**\*** | SRRequirement**\*** | SR1MinRequirement**\*** |
| 1 | T1 | U1 | V1 | W1 |
| 2 | T2 | U2 | V2 | W2 |
| : |  |  |  |  |
| 24 | T24 | U24 | V24 | W24 |

\* The AS plan requirements that can be self-arranged

1. If DAM cannot procure the required amounts of AS ( PFR or FFR or CR or SR or minimum FFR or minimum CR1 or minimum SR1), then
2. Declare DAM AS insufficiency
3. Re-Open DAM AS offer submittal window
4. Change AS requirements plan if applicable:
   1. if sufficient AS offers are not available with respect to the original AS requirements, reduce the AS requirements
      1. **Alternative for consideration**: do not reduce AS requirements, setup AS demand curves (approved by TAC) and let the AS demand curve set the price if the rerun of DAM does not procure the AS requirements
         1. Is this a better way to send appropriate price signals to the market?
5. Rerun DAM
6. Ultimately, if sufficient AS cannot be procured through the DAM process, then RUC process will be used to commit Resources to provide required AS.
   1. **Alternative for consideration**: A Real-Time energy and AS co-optimization (including near term commitment) could be utilized to procure required AS.
      1. Market Participants can reconfigure their portfolio closer to Real-Time
      2. Resources that cannot fulfil their AS responsibilities due to Real-Time operational conditions, can buy out their AS responsibilities. (e.g. Forced Outages, Duration Limited Resources running out of stored energy, etc.)
      3. Adds complexity in handling changing AS responsibilities

**Other Questions**

1. Do we need ability to self-arrange Ancillary Services?
2. What impact does the ability to negatively self-arrange Ancillary Services on the future AS procurement process?

**Ancillary Service Constraints and corresponding MCPCs**

This section is to start discussion on the constraints to be enforced and pricing of Ancillary Services (MCPCs). ERCOT has provided as an example, a set of constraints and the resultant MCPCs (multiple options) as a **starting point for discussion**.

Objective for the optimization engine is to **minimize** offer based costs (supply: energy & AS) minus bid based revenue (demand: energy & PTP) subject to constraints for power balance, AS procurement, transmission flow, etc. (This is the same as stating the objective to be the maximization of bid based revenue (demand: energy & PTP) minus offer based costs (supply: energy & AS). The objective for the engine is the same as what we have today in DAM.

Example Resource Limit Constraints in DAM:

Generation Resource:

LSL <= Energy + SR1 + CR1 + PFR (or FFR1) + RegUp (or FRRS-Up) <= HSL

LSL <= Energy – RegDn (or FRRS-Dn)

Controllable Load Resource:

LPC <= RegUp (or FRRS-Up) + PFR + CR1 + SR1 + RegDn (or FRRS-Dn) <= MPC

Load Resource (UFR-Type qualified for FFR2):

LPC <= SR2 <= MPC; or LPC <= CR2 <= MPC; or LPC <= FFR2 <= MPC

Load Resource (UFR-Type qualified for FFR1): LPC <= FFR1<= MPC

**Note 1**: Resource can only be awarded a given type of AS if they have been qualified for providing that AS.

**Note 2**: If applicable, there will be a limit on the maximum amount of a given type of AS that a Resource can be awarded.

Note that the Load Resources cannot submit Resource specific demand bids (bid to buy) and hence the Load Resource Limit Constraints do not have an energy consumed portion between their lower and upper limits.

1. In the current ERCOT market, all demand (load) is bought at the Load Zone (except for Wholesale Load). Load Resources cannot submit Resource Specific (locational) demand bids (bid to buy energy). Load Resources can only submit Resource specific Offers to sell Ancillary Services.
2. Generation Resources, however, can submit Resource specific Offers to sell energy and Ancillary Services.
3. Due to the above two features of our market design, in the DAM optimization:
   1. For Generation Resources, the energy and AS co-optimization process allocates the offered MW capacity (constrained between LSL and HSL) between energy and Ancillary Services taking into account opportunity costs for energy and Ancillary Services. i.e. the prices (LMP-energy and MCPC-AS) incorporate opportunity costs
   2. For Load Resources, as there is no energy component (demand), the energy and AS co-optimization process only allocates the offered MW capacity considering only AS offer(s)
4. If AS offers from Load Resources were cleared against the AS requirement from Load Resources, as there is no consideration of energy, then the corresponding AS MCPC will be determined solely by the marginal AS Offer from Load Resources – there is no opportunity cost for energy incorporated.

**Consensus Item:**

|  |  |  |  |
| --- | --- | --- | --- |
| # | Question | Comments | Consensus from 4/18/2014 FAST Work Session |
| 1 | Should the MCPC for FFR (FFR1 & FFR2), CR2, SR2 reflect opportunity costs for energy and other Ancillary Services? | YES- There is precedence as can be seen in setting the MCPC for RRS from Zonal and Nodal Markets  YES- Liquidity concerns in terms of sufficient AS offers from Load Resources to meet FFR,CR2,SR2 are mitigated  NO- These are different AS products and should be cleared against the specific requirements of that AS | Answer is YES |
| 2 | Should FFR2 be provided additional compensation as this product can be considered as ALSO providing CR (or a portion of it) | YES- Note if FFR2 is compensated for its contribution to CR, the recall of this FFR2 **may** be delayed.  NO – ERCOT’s AS Methodology should be such that it takes into account the deployed FFR2 when determining the CR Target amounts in the AS Plan.  NO – In case of SCED headroom shortage, there may be instances where all of the CR needs to be deployed. In this scenario, ERCOT would NOT want to use FFR2 as part of CR deployment to protect against Firm Load Shed due to G-2 (BAL-003)  No – This will lead to the same MW being compensated for two AS  Conditional NO – If the answer to 1 is YES, then as FFR2 AND CR2 has opportunity costs for energy and other AS incorporated into AS MCPCs, there is no need for this additional compensation – (double counting of opportunity costs may occur depending on how constraints are defined?) | Answer is NO |

The table below is an example of one way to setup the constraints for the procurement of AS. There are other ways to setup the required constraints for the procurement of AS. For example instead of a constraint to enforce a minimum amount of CR procurement from SCED dispatchable Resources (CR1), the constraint could be replaced with another constraint that enforces a maximum amount of CR procurement for non-SCED dispatchable Resources (CR2).

More discussion is required - **both** for the selection of constraints and the setup of the MCPCs for the different AS.

Note 1: As an illustration, the table below shows how the constraints need to be setup to have a limit on the maximum procurement of AS from demand side **or** a minimum amount of AS that needs to be procured from supply side:

1. PFR and FFR constraints are setup so that
   1. Ratio that equivalences 1 MW of FFR with R MW of PFR is incorporated
   2. Limit on the maximum procurement from FFR1, FFR2
2. CR and SR constraints are setup so that there is a minimum procurement target of CR and SR from Generation Resources
3. FRRS-Up and FRRS-Dn constraints are setup so there is a limit on the maximum procurement of these AS

| ID | Constraints to procure AS | Equation | ShadowPrice | Comments |
| --- | --- | --- | --- | --- |
| 1 | Combined PFR + FFR procurement | PFR+R\*(FFR1+FFR2) >= (PFR+FFR)TotalTarget  (PFR+FFR)TotalTarget  = Requirement (X+R\*Y) minus (PFR+R\*FFR) Self Arrangement | SPPFR+FFR | 1. Combined procurement allows opportunity cost of energy to be incorporated the resulting MCPCs. Also helps in mitigating liquidity concerns in FFR by combining the clearing with PFR offers 2. Constraint incorporates the Ratio that equivalences 1 MW of FFR with R MW of PFR 3. A QSE can self-arrange its PFR and FFR obligations separately or can substitute PFR for FFR using the applicable ratio R. 4. The maximum amount of FFR that can be self-arranged cannot exceed the Load Ratio Share multiplied by the minimum FFR requirement (Y). 5. In addition, the maximum amount of FFR1 that can be self-arranged cannot exceed the Load Ratio Share multiplied by the maximum FFR1 requirement (S) |
| 2 | Maximum FFR procurement | FFR1 + FFR2 <= FFRMAX-Target  FFRMAX-Target  = Max FFR (Z) minus FFR Self Arrangement | SPFFR-MAX | 1. Sets a maximum FFR (FFR1+FFR2) procurement target 2. This shadow price is less than or equal to zero 3. The maximum amount of FFR that can be self-arranged cannot exceed the Load Ratio Share multiplied by the minimum FFR requirement (Y). |
| 3 | Maximum FFR1 procurement | FFR1 <= FFR1MAX-Target  FFR1MAX-Target  =Max FFR1 (S) minus FFR1 Self Arrangement | SPFFR1-MAX | 1. Sets a maximum FFR1 procurement target 2. This shadow price is less than or equal to zero 3. In addition, the maximum amount of FFR1 that can be self-arranged cannot exceed the Load Ratio Share multiplied by the maximum FFR1 requirement (S) |
| 4 | CR procurement | CR1+CR2 >= CRTarget  CRTarget  = Requirement (T) minus (CR) Self Arrangement | SPCR | 1. A QSE can self-arrange its entire CR obligation using CR1. If the QSE decides to self-arrange a portion of its CR obligation using CR2, then the self-arrangement of CR2 cannot exceed the QSEs Load Ratio Share multiplied by the difference between CR Requirement and CR1 Min Requirement |
| 5 | Minimum CR1 procurement | CR1>= CR1Target  CR1Target  = Requirement (U) minus (CR1) Self Arrangement | SPCR1 | 1. Sets a minimum SCED dispatchable CR1 procurement target 2. Not a strong constraint (penalty cost for violating this constraint is relatively low) – or can use CR1 Demand curve to set the shadow price for this constraint. 3. The opportunity cost for energy is incorporated into this shadow price (SPCR1). If this constraint was redefined to be a maximum procurement target for CR2, then the previous constraint (ID# 4) would incorporate the opportunity costs for energy in its shadow price (SPCR) |
| 6 | SR procurement | SR1+SR2>= SRTarget  SRTarget  = Requirement (V) minus (SR) Self Arrangement | SPSR | 1. A QSE can self-arrange its entire SR obligation using SR1. If the QSE decides to self-arrange a portion of its SR obligation using SR2, then the self-arrangement of SR2 cannot exceed the QSEs Load Ratio Share multiplied by the difference between SR Requirement and SR1 Min Requirement |
| 7 | Minimum SR1 procurement | SR1>= SR1Target  SR1Target  = Requirement (W) minus (SR1) Self Arrangement | SPSR1 | 1. Sets a minimum SCED dispatchable SR1 procurement target 2. Not a strong constraint (penalty cost for violating this constraint is relatively low) – or can use SR1 Demand curve to set the shadow price for this constraint. 3. The opportunity cost for energy is incorporated into this shadow price (SPSR1). If this constraint was redefined to be a maximum procurement target for SR2, then the previous constraint (ID# 6) would incorporate the opportunity costs for energy in its shadow price (SPSR) |
| 8 | Regulation UP procurement | RegUp + FFRS-Up >= RegUpTarget  RegUpTarget  = Requirement (A) minus (RegUp + FRRS-Up) Self Arrangement | SPRegUp | 1. A QSE can self-arrange its entire RegUp obligation using RegUp. If the QSE decides to self-arrange a portion of its RegUp obligation using FRRS-Up, then the self-arrangement of FRRS-Up cannot exceed the QSEs Load Ratio Share multiplied by the FRRS-Up Max Requirement. |
| 9 | Maximum FRRS-Up procurement | FRRS-Up <= FRRS-UpMaxTarget  FRRS-UpMaxTarget  = Max FRRS-Up (B) minus (FRRS-Up) Self Arrangement | SPFRRSUp-MAX |  |
| 10 | Regulation DOWN procurement | RegDn + FRRS-Dn >= RegDnTarget  RegDnTarget  = Requirement (C) minus (RegDn + FRRS-Dn) Self Arrangement | SPRegDn | 1. A QSE can self-arrange its entire RegDn obligation using RegDn. If the QSE decides to self-arrange a portion of its RegDn obligation using FRRS-Dn, then the self-arrangement of FRRS-Dn cannot exceed the QSEs Load Ratio Share multiplied by the FRRS-Dn Max Requirement. |
| 11 | Maximum FRRS-Down procurement | FRRS-Dn <= FRRS-DnMaxTarget  FRRS-DnMaxTarget  = Max FRRS-Dn (D) minus (FRRS-Dn) Self Arrangement | SPFRRSDn-MAX |  |

|  |  |  |
| --- | --- | --- |
| AS MCPC | Equation | Comments |
| PFR | SPPFR+FFR |  |
| FFR1 | Minimum of R\*SPPFR+FFR, or VOLL | Value of FFR is R multiplied by the value of PFR  Note: The MCPC of FFR1 is capped at VOLL |
| FFR2 | Minimum of R\*SPPFR+FFR, or VOLL | Value of FFR is R multiplied by the value of PFR  Note: The MCPC of FFR2 is capped at VOLL |
| CR1 | SPCR+ SPCR1 |  |
| CR2 | SPCR+ SPCR1 | CR2 is valued the same as CR1 |
| SR1 | SPSR+ SPSR1 |  |
| SR2 | SPSR+ SPSR1 | SR2 is valued the same as SR1 |
| RegUp | SPRegUp |  |
| FRRS-Up | SPRegUp | FRRS-Up is valued the same as RegUp |
| RegDn | SPRegDn |  |
| FRRS-Dn | SPRegDn | FRRS-Down is valued the same as RegDn |