**March 11, 2015**

**ERCOT Proposal for Synchronous Inertial Response Service (SIR Service) Market**

**Introduction**

Synchronous Inertial Response (SIR) is an instantaneous response that is continuously self-deployed from synchronous machines following disturbances — a key determinant of the strength and stability of the power system. SIR is defined as stored kinetic energy (at nominal frequency) that is extracted from the rotating mass of a synchronous machine following an imbalance in a power system. Stored kinetic energy is based on the commissioned design capability of the plant. It can be determined through appropriate validation procedures based on the following relationship:

Stored kinetic energy = Jω02/2=H·MVA,

Where:

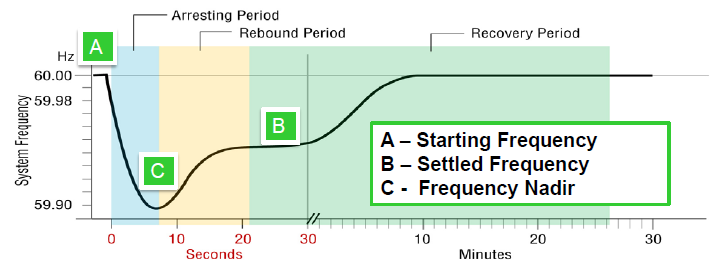
* The stored kinetic energy is in Mega Watt – Seconds;
* J is the combined moment of inertia of a synchronous machine and turbine prime mover in kg·m2, based on their size and weight;
* ω0 is the nominal rotor speed in rad/s, and
* MVA is the machines rated capacity in Mega Volt – Amperes.
* H is the figure of merit used to analyze the synchronous machine’s inertial response and is referred to as the machine’s inertia constant in seconds.

Solving for H the above equation results in H = Jω02/(2·MVA) seconds.

The inertial response that a synchronous machine can provide is independent of the machine’s power output and the total system response to an initiating event is determined by the summation of the contributions from each of the online synchronous machines. ERCOT will determine by analysis the desired response of the system under the largest generator trip event. The level of SIR required by ERCOT will be based on fnadir>59.3 Hz. — which is more than the prevailing initial threshold of UFLS and RoCoF limitations implied by RoCoF protection settings of synchronous generators in ERCOT system.

A key point to note is that any On-Line machine that is synchronously connected to the grid provides its entire SIR to the power system, regardless of its output power level. Thus, SIR is unlike Primary Frequency Response or other Ancillary Services in which a capacity reservation (in MW or MVA) is required. The amount of SIR provided is a property of the synchronous machine and whether the machine is synchronously connected to the power system (i.e., On-Line).

An Off-Line synchronous machine does not provide SIR to the power system.

Figure 1 Typical frequency response following a generator trip.

**Proposed Market Construct for SIR Service (SIRS)**

The key element is to allow the SIRS awarded quantity to be anywhere from 0 MW-sec to the full offered SIRS MW-sec (limited by the actual Resource SIRS capability – based on Inertia constant H and its MVA rating). Under this concept, the amount of SIRS awarded to any Resource would depend on its offer price, and could be less than the actual SIR the Resource would provide when On-Line.

The concept is as follows:

1. ERCOT will publish the amounts of hourly SIRS (in MW-sec) required by the ERCOT system as part of the daily AS Plan.
2. QSEs representing Load Serving Entities, on a Load Ratio Share basis, are assigned their respective SIR Service obligations.
3. These LSE QSEs have the option of self-arranging their assigned SIR Service obligations.
4. The DAM will procure SIRS to cover the difference between the SIRS required as published in the AS plan less the sum of all self-arranged SIRS by the LSE QSEs.
   1. DAM is voluntary
   2. New Resource Specific Submission Item: SIR Offer
      1. Resource Name
      2. SIRS Quantity is MW-Sec
      3. SIRS Offer Price in $/MW-Sec
   3. QSE can submit SIRS Offers for each Resource in its portfolio, independent of whether these same Resources have a corresponding 3PO or EOC or nothing submitted.
   4. Presence of SIRS Offer represents the willingness of the QSE to sell SIRS from this Resource
   5. The Awards for each SIRS Offer may range from 0 MW-sec to the full offered amount in the SIRS Offer subject to the maximum qualified amount (SIRS awarded quantity cannot be more than what the Resource is capable of based on H and MVA rating as certified in RARF).
5. COP will be modified to include an additional field - SIRS Responsibility in MW-sec. This is required for AS Responsibility Check to monitor the provision of SIRS and alarm if QSE/Resources are not providing their share of SIRS Responsibility.
6. After DAM,
   1. LSE QSEs are to submit Trades for SIRS that was self-arranged
   2. QSE with SIRS Awards and SIR Trades where they are designated as Sellers, are to update Resource COP with SIRS responsibilities
7. In Real Time, the telemetry status of qualified Resources will enable ERCOT to measure total amount of SIR present
   1. As this concept is developed, stakeholders may need to determine whether additional telemetry data is needed to ensure SIRS awards are being properly provided. Do we need telemetry for SIRS Responsibility?

**Equations in the optimization**

**Objective:** (yellow highlights are changes from current)

Note: Submission of SIRS Offer is voluntary. i.e. QSE does not have to submit SIRS Offer.

**Resources with 3PO and/or AS offer:**

(StartupCost\*Status + MinEnergyCost\*LSL\*Status + EOC\*MWAward\*Status + ASOffer\*ASAward\*Status + SIRSOfferPrice\*SIRSAward\*Status)

Note: Status = 1, Resource is On-Line; otherwise if Status =0, then Resource is Off-Line

**Self-Committed Resources with EOC and/or AS Offer :**

(EOC\*MWAward + ASOffer\*ASAward + SIRSOfferPrice\*SIRSAward)

**Resources that otherwise did not submit 3PO or AS Offer:**

(SIRSOfferPrice\*SIRSAward)

**New Constraints:**

1. SIRS Procurement Constraint (Shadow Price = SPsir)

Sum(SIRSAward) >= ERCOT\_SIRRequirement – Total\_SIRSSelf-Arrangement

1. Resource Specific Maximum SIRS Award Constraint: (Shadow Price = SPMaxSir). One constraint for each SIR Offer

H\*MVA >= SIRSAward

**MCPC for SIRS = Shadow Price of SIRS Procurement Constraint = SPsir**

**Further considerations**

1. Request feedback on proposal for market construct for Synchronous Inertial Response Service
2. Methodology to determine SIRS requirements (AS Plan)
   1. Coordination of SIRS, PFRS and FFRS requirements
3. Others?