System Management

System Management Standard

System Restart Services

(System Restart Standard)

This Standard is a guide to the acquisition of

***System Restart Service*s.**

1 October 2014

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1. Introduction

Section 3.9 of the WEM Rules states that the standard for the *System Restart Service* (SRS) must be a level which is sufficient to meet the operational plans developed by *System Management* (SM) in accordance with Clause 3.7.1

The operational plans for the restarting of *South West Interconnected System (SWIS)* are based on the formation of a number of separate islanded parts of the *SWIS* network referred to as Electrical Sub-networks. For each Electrical Sub-network generating units with black start capability may be contracted by SM to be available to be restarted without the need for an external electricity supply. These generating units with black start capability will provide a *System Restart Service* (SRS) and will be used to restart other non-black start generating units and assist in the restoration of electrical supply to the load.

This document details the elements of a standard for the *System Restart Service*s that SM considers necessary to ensure that the requirements of the operational plans can be met. It is based on a similar standard developed by the Australian Energy Market Commission (AEMC)[1] with appropriate changes to account for the different legislation and characteristics of the *SWIS.*

In developing a System Restart Standard SM needs to give consideration to the following matters:

1. the application of a standard for SRS across the *SWIS;*
2. the amount of time within which SRS are required to restore supply to a specified level;
3. the SRS and its reliability requirements;
4. the number of electrical sub-networks and factors to be taken into account in determining the boundaries of the sub-networks;
5. the diversity and strategic location of SRS;

[1] http://www.aemc.gov.au/getattachment/e871fd0a-3f4b-4fc9-ae6b-aedce3053932/System-Restart-Standard-Reliability-Panel.aspx

In implementing this standard to the *SWIS* SM must develop the following documents to provide the specific requirements;

a. The SRS Boundaries of the Electrical Sub-networks,

b. The SRS Quantity Guidelines

2 SRS Objective

The Market Rule Objectives can be found in section 1.2 of those rules. The following is SM's summary of these objectives as they pertain for the purposes of System Restart Services. The objective is similar to that defined in the National Electricity Market.

"The objective for *System Restart Service*s is to minimise the expected economic costs to the WEM in the long term and in the short term, of a major supply disruption, taking into account the cost of supplying *System Restart Service*s."

3 Recommendations for elements of the SRS standard

3.1 Application of the restart standard across the *SWIS*

SM considers that any standard for *System Restart Service*s should be applied equally across all electrical sub-networks of the *SWIS*, to the extent that it is practicable and reasonable to do so.

SM would not consider this necessary if it was inconsistent with the System Restart Objective.

3.2 Restoration of supply to a specified level

A key aspect of the provision of a *System Restart Service* is the specification of the maximum amount of time within which the *System Restart Service*s are required to restore supply to a specified level.

The System Restart Plan would enable the restoration of the whole SWIS from any of the System Restart Service.

The standard for each electrical sub-network is defined to give SM the guideline it must follow for its procurement, training and operational processes.

3.2.1 Timing Element of the standard

*System restart service*s should be procured for each electrical sub-network sufficient to:

a. Re-supply and energise the auxiliaries of power stations within 1½ hours of SM initiating system restoration after a major supply disruption occurring such that there would be sufficient capacity to meet 40% of the peak load demand in the affected electrical sub-network or the capacity installed within that electrical sub-network which ever is the lesser; and

b. restore generation and transmission within the affected electrical sub-network such that 40% of the peak load demand of the electrical sub-network or the capacity installed within that electrical sub-network which ever is the lesser could be supplied within four hours of SM initiating system restoration after a major supply disruption occurring and 100% within 10 hours provided all generating capacity to supply the peak load demand is available

c. restore supply to all substations within 5 hours of SM initiating system restoration after major supply disruption occurring to ensure that substation battery capacity is not exhausted to the point where it is no longer possible to operate the equipment at the substation

This is shown graphically in Figure 1, which displays a schematic of the System Restart Standard showing restoration milestones as the percentage supply capability to be achieved at specified times.

Certain assumptions have been made in developing the System Restart Standard and these are included in section 3 of this paper. Key restoration parameters/milestones are;

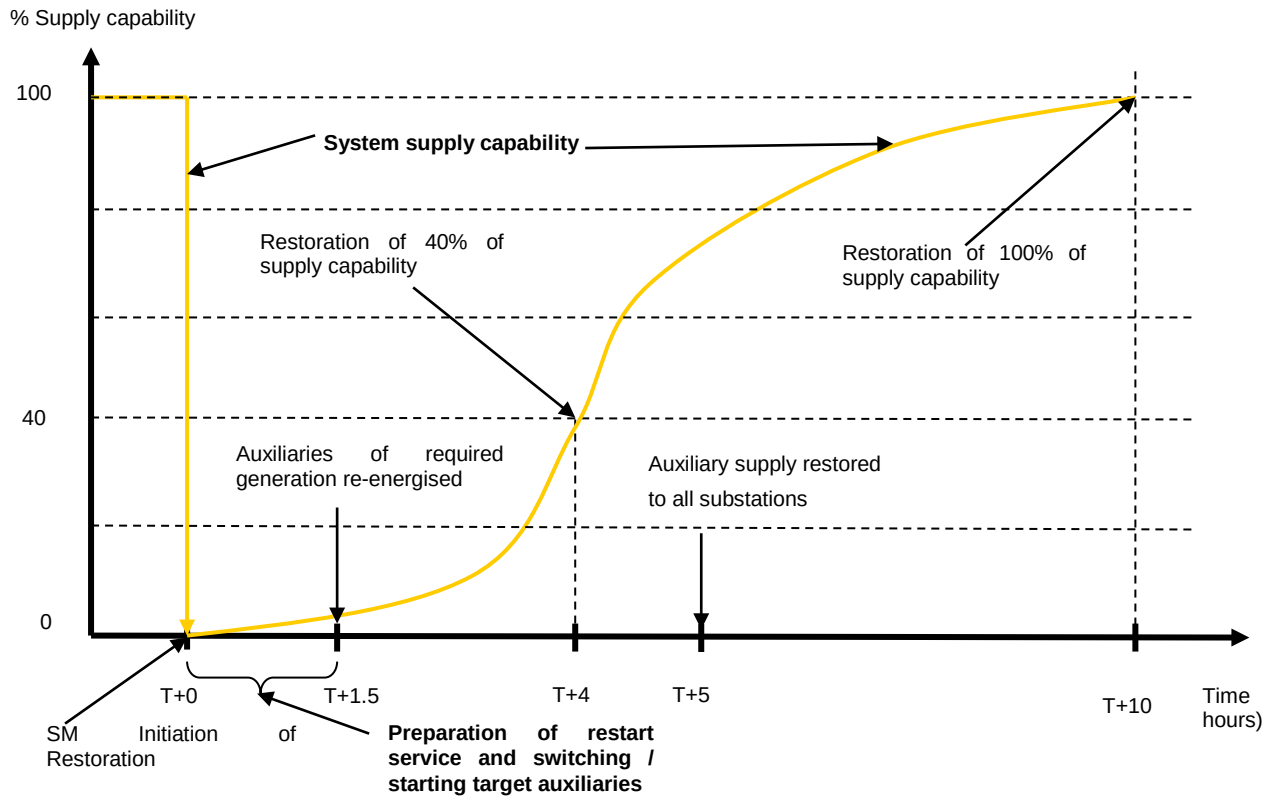
a. an intermediate milestone relating to the re-energising of generating unit auxiliaries, and

b. the final restoration milestone relating to customer supply capability is expressed in terms of peak demand in order to provide a more stable and consistently defined target.

c. that substation batteries have sufficient capacity to operate the substation equipment for 12 hours at Terminal substations and 8 hours at Zone substations

Given that there can be no guarantees as to the exact nature of power system conditions when a major supply disruption occurs, time frames for restoration of supply must be capable of being met under certain system conditions.

Figure 1: Schematic of the system restart standard



3.2.2 Rationale

Timeframes required for restoring the supply capability in the market and the extent of the network restored following the occurrence of a major supply disruption are affected by a number of factors:

a. location (electrical distance from load and other generation) of *System Restart Services*;
b. technology of units supplying *System Restart Services*;

c. technology of units that are targets for *System Restart Service*s; and
d. the condition and status of power system infrastructure immediately following the occurrence of a major supply disruption.

Each of these factors creates unknowns. Although restoring customer supply capability is important, SM believes that benchmarking performance against such a parameter alone in the early phase of recovery might give a misleading impression of the potential for success (or otherwise) of restoration efforts. As a consequence the System Restart Standard focuses on the resupply and energisation of the auxiliaries of available generating capacity and the resupply and energisation of substation auxiliaries as two of the required criteria.

It is also noted that the *System Restart Service* is the capability of restarting large generating units following a major supply disruption. These large generating units shall be known as Specified Generating Units, and shall have a nameplate rating of at least 20% of the peak load in the electrical sub-network in which they have their connection point. Therefore, inclusion of the requirement to re-supply and energise the auxiliaries of power stations and substations auxiliaries in the System Restart Standard is consistent with the objective of procuring the *System Restart Service*s.

SM believes that a target of 1.5 hours to restore supply to the specified level of the auxiliaries of large generating units is broadly achievable with the current technologies and processes available, subject to adequate services available.

The latter phases of the restoration process focus on the outcome of resupplying the substation auxiliaries and the bulk of consumers in a sufficiently timely manner. SM believes that a target to restore 40% of an affected electrical sub-network's peak load demand supply capability from the transmission network within 4 hours would represent an effective benchmark because achieving 40% restoration marks a point at which most of the available network paths would need to have been restored. SM also believes that a target of restoring the auxiliary supplies to all substations within 5 hours is consistent with the stated design time of 6 hours for substation battery capacity. The remaining restoration would generally depend upon providing time for large generating units to come back up to the level of output required to achieve 100% supply capability and the need for extensive preparations to be made in the distribution system.

A conservative assessment of the timeframes achievable in a sample electrical sub-network, with a single system restart source capable of supplying auxiliaries of only one large generating unit or is shown in Table 1 for demonstration of the current practice.

Preliminary studies indicate that under certain conditions, a suitably tested and located *System Restart Service* should:

a. provide auxiliary supplies to start an initial large generating unit and subsequently further extend to supply the auxiliaries of the next large generating unit, possibly at another power station, within an indicative time of 1.5 hours of a major supply disruption occurring.

b. restart at least four large generating units within four hours of a major supply disruption with sufficient time for two of these generating units to reach their full generating capacity and for two other generating units to reach 25% of their generation capacities, subject to generator startup times.

c. provide auxiliary supplies to all substations within 5 hours

Table 1: Indicative times

Indicative times since SM iniates the restoration after a major supply disruption /black system condition occurring	Progression of providing aux supplies of large generating units	Progression of restoring generating unit or/transmission capability	Progression of restoring supply to loads
0.5 hour	• Start SRS source • Extend SRS supply to a power station with large generating unit(s)		
1.0 hour	• First large generating unit starting		
1.5 hours	• First large generating unit started and loading • SRS now available to start other large generating units	First large generating unit loading. Auxiliary supplies restored to major terminal substations and selected zone substation	Some load being re-connected as generating unit output capability increases
3.0 hours	• First large generating unit stable, providing auxiliary supplies of third and fourth large generating units • Second large generating unit now started from the generator auxiliary supply from SRS	First large generating unit on 60%+ load with second large generating unit synchronised. Supply to other sub-networks being restored	More load connected to match output capability of the generating units
4.0 hours		First generating unit on ~100% load. Second generating unit on ~100% load. Third and fourth generating units started and on ~25% load. If multiple sub-networks startedsub-networks re- synchronised	A significant portion (40% or more) of sub-network load connected to match output capability of the generating units
5.0 hours		Auxiliary supplies restored to all substations	
10.0 hours		All generating units dispatched to normal load levels and all	100% of sub-network load connected

		available transmission elements in service. All sub-networks re – synchronised and the *SWIS* operating in normal state	

3.3 Reliability of System Restart Services

The reliability of generating units that may be used to provide SRS shall be as follows.

3.3.1 Reliability of restart services

Overall a target of at least 99% is required across the SWIS at all times.

The System Restart Services must be highly reliable and likely to perform in the manner intended if and when called upon to do so. Such services are those assessed by SM to be likely to perform on more than 90% of the occasions the service is called upon to deliver the service.

The reliability of System Restart Services must be demonstrated by the following:

a. an appropriate level of testing to be determined by SM, and
b. engineering analysis undertaken by each prospective tenderer and assessed and approved by SM, in its reasonable opinion.

3.3.3 Combination of services to deliver higher level of reliability

Certain technologies may be more reliable than others in terms of the probability of successfully delivering a restart service when called upon to deliver the service. However a combination of individual restart services with lower reliability than required for a System Restart Service due to their technologies would, in combination, be able to meet the required level of reliability for a System Restart Service.

The following example is intended to illustrate this concept:

Assume the notional reliability requirement for a System Restart Service is, say, 90% – that is, if subjected to repeated random tests of its restart capability, any given restart service would be expected to fail to deliver on less than 10% of the occasions it was called on.

There are two restart technologies, A and B.

a. ‘Technology A’ is considered highly reliable, and if subjected to repeated random tests of its restart capability, any given unit would be expected to fail to deliver on less than 10% of the occasions it was called on.

b. ‘Technology B’ is considered only moderately reliable and if subjected to repeated random tests of its restart capability, any given unit would be expected to fail to deliver on, say, 40% of the occasions it was called on.

If assessment of the reliability of a restart services were on the basis of the likely capability of any individual unit, only ‘technology A’ would be considered worthy of contracting as a System Restart Service. However, if a group of three

'technology B' units could be established and offered collectively as a restart service, the probability of all three units failing at the same time is only 6.4% (40% x 40% x 40%).

Hence, a group of three or more 'technology B' units, all of the same unit capacity as the 'technology A' unit, would meet the notional reliability requirement for a System Restart Service of 90%..

3.3.2 Rationale

There is no evidence that SM is aware of that would lead it to believe it is practicable to commission a study that would determine a "correct" System Restart Service reliability threshold. Accordingly, if numerical thresholds are to be established for the (probable) reliability of restart services, it must be done in a deterministic manner, with the long term interests of consumers of electricity adequately served if the community could be reasonably certain that the restart services procured on its behalf would work if and when required.

SM believes that a threshold of 90% expected reliability for System Restart Services meets the presumed community expectations and should be reasonably achievable with current technology and processes.

Having set the required reliability threshold, there is a further challenge in applying this threshold to the assessment of tendered restart services. In the absence of a large number of repeated experiments, say 1,000, it is impossible to assign any objectively accurate measure of the reliability of a given restart service. In the absence of statistical information, an appropriate way of assigning a numerical measure to the reliability of a particular restart service is to apply world's best practice to the facilities in question, taking account of the technologies in use and the general condition of the plant involved. Engineering experience applied in this way will allow "approximately correct" assessments of reliability to be made.

3.4 Determining electrical sub-networks

SM considers that the configuration of the *SWIS* is such that it is necessary to restart at least one of electrical sub-networks in order to meet the times within which the *System Restart Service*s are required to restore supply to a specified level that are specified in section 2.2. The number to be restarted will depend on the remaining infrastructure available during the black start event.

3.4.1 Sub-Network Element of the standard

The electrical sub-networks will be determined by taking into account, but not limited by, the following factors:

a. the number and strength of transmission corridors connecting an area to the remainder of the power system;
b. the electrical distance (length of transmission lines) between generation centres;
c. a significant quantity of generation in an area, of the order of 100 MW or more;
d. a significant quantity of load in an area, of the order of 100 MW or more;
e. the location of synchronising facilities to re-synchronise the areas

In view of the physical nature of these criteria, it should be expected that electrical sub-network boundaries would not necessarily coincide with regional network boundaries.

Once the boundaries of the electrical sub-networks have been determined, SM will publish this information on its website prior to commencing a process to procure *System Restart Service*s.

3.4.2 Rationale

SM's review of the *System Restart Service* arrangements concluded that SM must take the following factors into account and described the relevance of these factors:

a. The number and strength of transmission corridors connecting an area to the remainder of the system;
b. The electrical distance between groups of generation;
c. The amount of generation in an area;
d. The amount of load in an area.
e. The location of synchronising facilities

SM must develop and publish the SRS Boundaries of Electrical Sub-networks to provide the requirements be followed by SM in determining electrical sub-networks, including the determination of the appropriate number of electrical sub-networks and the characteristics required within an electrical sub-network (such as the amount of generation or load, or electrical distance between generation centres, or the location of synchronising points between the electrical sub-networks)

3.5 Diversity and strategic location of restart services

SM considers that it is essential that SRS providers are strategically located and provide sufficient diversity to ensure that generating unit and network element failures do not result in the inability to restart the SWIS

3.5.1 Diversity Element of the standard

The following guidelines will apply in specifying the diversity of System Restart Services:

a. Electrical

It is important that there is an appropriate degree of independence between the services, particularly in regard to any reasonably foreseeable potential single points of electrical or physical failure. Consideration should be given to the potential for a major power system disturbance to adversely affect more than one service.

b. Technological

Diversity of technologies should also be considered to minimise the reliance of services on a common attribute. For example, a restoration strategy may be less robust if the services all relied on gas supplies or all services were trip-to-house load.

c. Geographic

Where there is potential for a natural disaster such as a severe bad weather event or earthquake or other event to adversely effect services that are closely located by geography, consideration should be given to achieving geographic diversity.

For the purpose of this standard, the failure of a power station is a level of failure that should be reasonably catered for. Therefore a limitation is to be imposed of only one *System Restart Service* for any power station.

The following guidelines apply to specifying the strategic location of System Restart Services

a. The services require a range of capabilities to be effective in restoring the power system following a major supply disruption. Key capabilities include energising parts of the network and assisting other generating units to restart. Any strategic location would be well placed both geographically and electrically to facilitate power system restoration.

b. The following factors should be taken into account when considering the strategic locations of System Restart Services:

   (i) complexity of the relevant parts of the network,
   (ii) flexibility in re-configuring the relevant parts of the network,
   (iii) simplicity in establishing a path between the System Restart Services and large generating units.

In some cases there may be trade-offs between these factors. For example, a clear path may be faster to establish but it may be characterised by less flexibility.

Subject to a consideration of the above factors, a strategic location may be either within or outside an electrical sub-network where the service is required.

3.5.2 Rationale

Independence of *System Restart Service*s is considered important to avoid the restart process from being exposed to a reasonably foreseeable single point of failure (where 'single point of failure' is broadly interpreted) that could disable all *System Restart Service*s for an electrical sub-network. This independence is sought through several forms of diversity, including electrical, technical and geographical, as well as the limitation on a power station to provide only one restart service.

The effect of an adverse event may be minimized through diversity, in circumstances such as where at least either one *System Restart Service* or one transmission corridor was not available. If there were two (or more) independent restart services available to each electrical sub-network, then infrastructure non-availability would not leave the electrical sub-network without an effective service.

SM must develop and publish the SRS Quantity Guidelines to provide the requirements for the number and location of *System Restart Service*s for each electrical sub-network. This will be presented in the Ancillary Service Report developed in accordance with the Wholesale Electricity Market Rules.

4 Demonstration of compliance with the Rules

It is recognised that the economic aim of providing the services is not that they should be provided in such a way as to only minimise the cost of provision in the short term but to be delivered in an economically efficient manner that minimises the overall economic cost of a major supply disruption.

In developing the System Restart Standard, SM notes that the objectives require balancing the cost (as distinct from price) of service provision with the community benefits of the service level procured to meet the standard. However, SM also notes that the level of benefit the community actually derives from setting the standard at a particular level is extraordinarily difficult or impossible to measure and is practically set by comparing with industry standards.

System shutdown is a rare event with high economic impact and preparation for such an event has many characteristics of insurance (paid for but possibly never used). Accordingly, the System Restart Standard effectively specifies the level of insurance to be procured at a baseline level, for the vast majority of consumers and producers. The System Restart Standard effectively caps or limits the economic and commercial impact of a major supply disruption on industry participants and the broad community.

The proposed elements of the System Restart Standard are comprehensively discussed in Sections 2.1 through 2.5 above. Through the discussion in Section 2, SM believes it has presented a sound rationale for each element of the System Restart Standard, demonstrating that each makes a contribution to minimising the likely impact on the community of any major supply disruption:

a. The proposals for time frames within which the power system must be restored to a given level (Section 2.2), establish realistic targets for competently delivered effective restart services.

b. The targets for the reliability of restart services (Section 2.3) represents thresholds that should meet reasonable community expectations regarding the probability of timely successful recovery from a major supply disruption. The specification of service reliability levels with provision for assessment and testing of claimed reliability ensures value for money.

c. Proposed guidelines for establishment of electrical sub-network boundaries (Section 2.4) incorporate thresholds for ensuring the size of the electrical sub-networks are neither so small that an unreasonable number of restart services need to be found nor so large as to give discomfort to a community that it risks being inadequately covered by restart services.

d. Guidelines with respect to diversity and strategic location of restart services (Section 2.5) adequately control for plausible modes of system failure that might otherwise prevent multiple restart services being simultaneously disabled.

On the basis of this System Restart Standard, SM believes the proposed arrangements represent a considerable improvement in the level of regulatory certainty offered by *System Restart Service* arrangements, providing a rational balance between cost and service level. The System Restart Standard allows fair rewards to investors in *System*

*Restart Service*s, which in turn provides an environment for delivery of both short term and longer term protection to the industry, including the vast majority of consumers, against prolonged power system shutdowns.

On balance, SM considers the proposed System Restart Standard promotes efficient use of and investment in electricity services in a way that advances the long-term interests of consumers of electricity.

5 Glossary

In this System Restart Standard:

a) a word or phrase in this style has the same meaning as given to that term in the WEM Rules

b) a reference to a "MR" followed by a number refers to a provision of the WEM Rules

c) a word or phrase appearing in this document has the meaning set out opposite that word or phrase in the table below; and

d) the singular includes the plural and vice versa

Word or Phrase	Meaning
black start capability	Following disconnection of a generating unit and all its auxiliary supplies from the power system it is subsequently able to deliver electricity to its connection point without having taken supply from any part of the power system since disconnection
black system condition	The absence of voltage on all or a significant part of the transmission network or within a region following a major supply disruption, affecting one or more power stations and a significant number of customers – formal declaration of a black system condition requires loss of 60% of forecast supply
credible contingency event	An event as defined in the *Technical Code*
electrical sub-network	Geographically defined area of the network for which restart services are to be contracted, with boundaries based on the physical characteristics of the system and system security
Facility	Has the meaning given to the expression "Facility" in the WEM Rules
generating unit	The actual generator of electricity and all related equipment essential to it functioning as a single entity
Generation	The production of electrical power by converting another form of energy in a generating unit
Load	A connection point (or points) in an electrical network at which electrical power is delivered from a distribution network or transmission network to a Rule Participant
major supply disruption	The unplanned absence of voltage on a part of the *SWIS* affecting one or more power stations
network	The apparatus, equipment, plant and buildings used to convey, and control the conveyance of, electricity to customers (whether whole sale or retail) excluding any asset used to provide a connection that is part of a transmission system or distribution system, which is registered as a Network according to the WEM Rules.

Word or Phrase	Meaning
non-credible contingency event	Any event other than a credible contingency event
peak load demand	maximum load demand
power system	The electrical power system of the *SWIS* grid including associated generating units and transmission networks and distribution networks for the supply of electricity, operated as an integrated arrangement
restart service	The process of supplying sufficient energy and establishing a connection via the transmission system to restart other (large) generating units
SM	Has the meaning given to the term "System Management" in the WEM Rules
Specified Generating Unit	Generating units within the same power station: (a) whose nameplate ratings collectively are at least 20% of the peak load in the electrical sub-network in which they have their connection point; and (b) are capable of having all their auxiliary supplies provided by a *system restart service* alone within 60 minutes of a major supply disruption, unless otherwise specified by SM.
SRS	*System Restart Service*
SRS Boundaries of Electrical Sub-networks	The document of that name published by SM and any alteration or revision to that document
SRS Description of Service	The document with that name published by SM and any alteration or revision to that document
SRS Quantity Guidelines	The document with that name published by SM and any alteration or revision to that document
System Restart Service	A contracted system restart service that meets the technical, the performance, and the combined reliability and availability requirements specified in Section 5 of the SRS Description of Service, and is highly likely to perform in the manner intended if and when called upon to do so.
System Restart Standard	This document and any alteration or revision to it
system restart plan	A plan developed by SM specifying the strategies and procedures to be used in recovering from black system conditions
system shutdown	Widespread failure of supply that may (or may not) qualify as a black system condition

Word or Phrase	Meaning
transmission line	A power line that is part of a transmission network
transmission network	Any network operating at nominal voltages of 132 kV and above plus any part of a network operating at nominal voltage between 66 kV and 132 kV that operates in parallel to and provides support to the higher voltage networks
WEM Rules	Wholesale Electricity Market Rules

DOCUMENT APPROVAL

Approved

Head of System Management