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Title: Renewable Energy Generation Working Group – Summary of Process and Outcomes

Date: 14 February 2011

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DOCUMENT DETAILS

Report Title:	Renewable Energy Generation Working Group – Summary of Processes and Outcomes
Release Status:	Public
Confidentiality Status:	Public domain

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1. INTRODUCTION

The Renewable Energy Generation Working Group (REGWG) was convened by the Market Advisory Committee (MAC) at its meeting on 12 March 2008. The REGWG's scope was to consider and assess system and market issues arising from the increase in the national Mandatory Renewable Energy Target (MRET) to 20% by 2020. In particular, the REGWG was tasked to focus on issues related to:

- the treatment of intermittent generators in the Reserve Capacity Mechanism;
- the allocation of ancillary service charges; and
- system security at times of low load.

The REGWG was initially chaired by the Office of Energy with four meetings held between April 2008 and April 2009. At its meeting on 29 April 2009, the MAC approved the IMO's proposal to chair and provide administrative support for the REGWG. After the IMO received funding approval in July 2009, twelve further meetings were held between August 2009 and September 2010.

Membership of the REGWG varied during its operation, but included representatives from:

- IMO
- Office of Energy
- Alinta
- Carnegie Wave Energy
- Collgar Wind Farm
- Department of Premier and Cabinet
- Department of Treasury and Finance
- DMTenergy
- Economic Regulation Authority (ERA)
- Energy Response
- Griffin Energy
- Investec
- Landfill Gas & Power
- Mid West Energy
- New World Energy
- Pacific Hydro
- Skyfarming
- SunPower
- System Management
- Synergy
- Tenet Consulting
- Verve Energy
- WA Solar
- Western Power

It should be noted that the work undertaken by the REGWG included the most comprehensive technical review completed since the commencement of the Wholesale Electricity Market (WEM) in Western Australia.

This report, prepared by the IMO, details the process undertaken and outcomes of the REGWG.

2. REVIEW OF CERTIFIED RESERVE CAPACITY CALCULATION METHODOLOGIES FOR INTERMITTENT GENERATORS (SENERGY ECONNECT)

The REGWG review started with work undertaken by Senergy Econnect on behalf of the Office of Energy. This work was established to consider Capacity Credit allocation methods for intermittent generators. Senergy Econnect combined historical weather and generation data series from REGWG members and the Bureau of Meteorology with historical electricity load series to quantify interactions between electricity demand and wind, solar and landfill gas energy resources in the South West interconnected system (SWIS). Likely Capacity Credit allocations based on a number of allocation methods were compared with the existing method.

Fleet reliability, wind generation during peak load-inducing weather events and variations in wind and solar regimes across the SWIS were also investigated. Probabilistic, whole-of-system analysis is required to evaluate the contribution intermittent generators make to system reliability and was not undertaken as part of this exercise. Instead, it has been addressed through subsequent work.

The Senergy Econnect report[1] and a summary of findings were presented to the REGWG in August 2009.

3. SCOPING DOCUMENT TO ASSESS THE IMPACTS OF INTERMITTENT GENERATION

The IMO commissioned Sinclair Knight Merz (SKM) to develop a work programme to ensure that the various policy, system and market issues related to increasing intermittent generation were adequately considered.

SKM developed a work programme consisting of the following four Work Packages:

- Work Package 1: Scenarios for Modelling Renewable Generation in the SWIS
- Work Package 2: Reserve Capacity and Reliability Impacts
- Work Package 3: Frequency Control Services
- Work Package 4: Technical Rules

This work programme was endorsed by the REGWG and presented to the MAC at Meeting 22 (9 September 2009). The four Work Packages are explained in further detail below.

[1] This report is available at http://www.imowa.com.au/f3086,790514/Meeting_5_papers.zip.

4. WORK PACKAGE 1: SCENARIOS FOR MODELLING RENEWABLE GENERATION IN THE SWIS

4.1. Background

The SKM scoping study recognised the need to understand the likely development of the generation mix in the market in order to set the priority and timing of developments that will accommodate any increase in intermittent generation levels.

ROAM Consulting was subsequently appointed to undertake Work Package 1 and was required to:

- identify existing policies or regulations that may promote or impede intermittent generators or dispatchable renewable energy generators locating in the SWIS as a precursor to scenario development;
- determine the likely scenarios for the future generation mix in the SWIS as a result of State and Federal Government policies and regulations; and
- identify the key drivers and constraints that determine these scenarios and how changes in those drivers would change the scenario outcomes.

4.2. Outcome

ROAM considered the key drivers that would likely affect the future mix of renewable generation and developed four possible scenarios that explored a range of potential outcomes for the SWIS. The table below lists the variables in the four scenarios[2].

Summary of Scenarios and Assumptions						
	Scenario Name	**CPRS[3]**	**Demand growth**	**Gas price**	**CCS[4]**	**Renewable technologies**
1	Strained network	CPRS -15%	Low	High	*Not available*	Wind
2	Minimal change	CPRS -5%	Medium	Moderate	*Not available*	Wind
3	Low emissions	CPRS -25%	Low	Moderate	*Available*	Mix
4	Coal development	CPRS -5%	High	High	*Available late*	Wind

ROAM then produced generation development planting schedules for each of the four possible scenarios above, aligning future generator developments (known and theoretical) with forecast demand growth. ROAM also developed an estimate of the likely level of greenhouse gas emissions resulting from each scenario.

[2] From Executive Summary of ROAM report "Scenarios for Modelling Renewable Generation in the SWIS" (25 August 2010), http://www.imowa.com.au/f139,628433/FINAL_WP1_Report_Imo00015_to_IMO_2010-08-25.pdf
[3] CPRS: Carbon Pollution Reduction Scheme
[4] CCS: Carbon Capture and Storage

The scenarios and planting schedules developed as part of Work Package 1 were utilised in the modelling for Work Package 3.

5. WORK PACKAGE 2: RESERVE CAPACITY AND RELIABILITY IMPACTS

5.1. Background

SKM noted, in its scoping study, the need to reassess the contribution of intermittent generators towards system security and capacity and the appropriate method for remunerating the capacity that they provide. It has been widely acknowledged that the current valuation methodology is unsuitable for solar generation, due to its inclusion of overnight periods, and there are doubts as to whether the 3-year average provides an accurate representation of the value of wind generators at peak demand times.

McLennan Magasanik Associates (MMA) was subsequently appointed to undertake Work Package 2 and was required to:

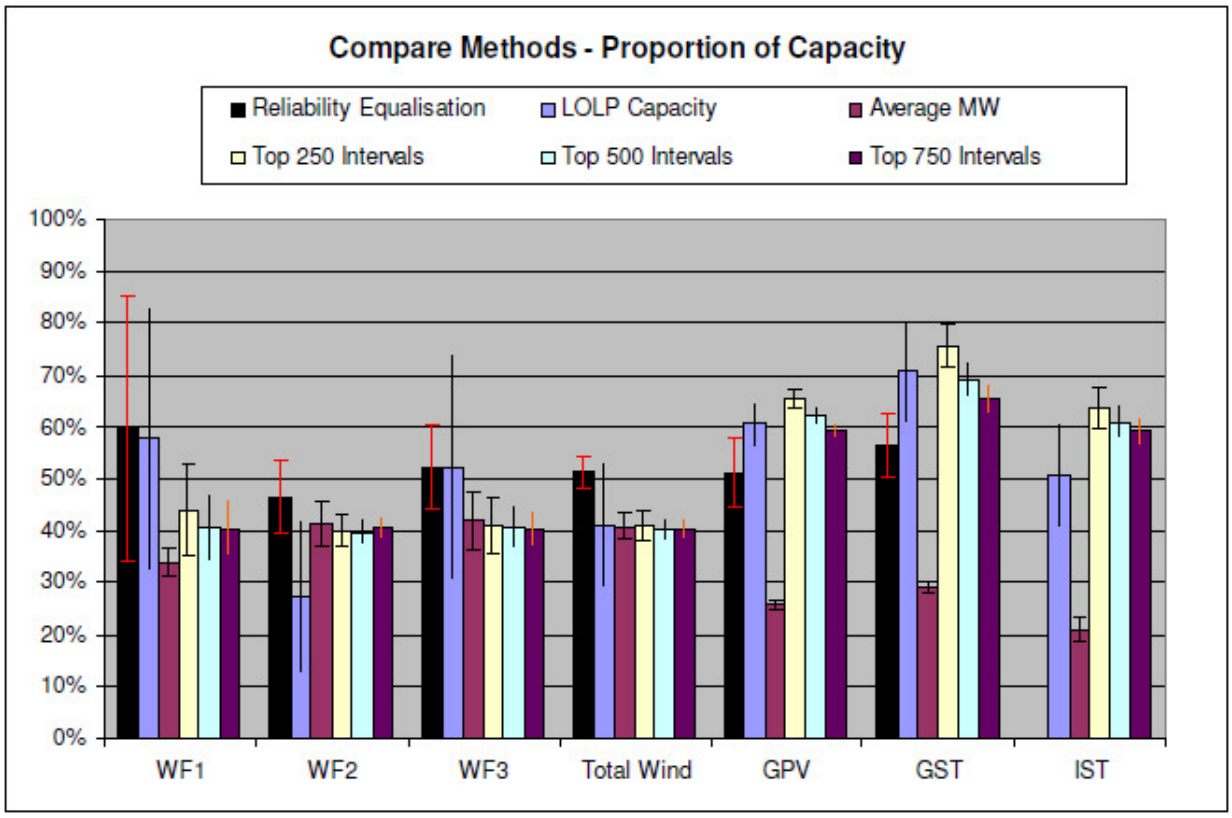
- review whether capacity based on average output is a reasonable approximation to the capacity value of intermittent generation sources; and
- if not, identify and review other available measures that:
    - reflect the impact on system reliability;
    - are robust with acceptable volatility of measure; and
    - are easy to understand and apply without detailed system modelling.

5.2. MMA Review

MMA tested a reliability-based Loss of Load Probability approach (LOLP) as its starting point[5]. Other valuation methods were also examined by MMA and compared in the graph below[6]. The LOLP method was found to be highly volatile as heavy weighting is applied to 0%-20% PoE (Probability of Exceedance) conditions, for which limited data is available (primarily 2002/03). A method using the average output of the top 750 trading intervals from selected high demand years, scaled to future load forecasts, was recommended by MMA as an interim measure due to similar valuation to LOLP but with reduced volatility. MMA recommended to progress to the LOLP method once data availability improved, noting the limitations of the LOLP method as a result of the lack of historical data.

[5] For more information on the LOLP technique, see MMA report "Valuing the Capacity of Intermittent Generation in the South-west Interconnected System of Western Australia" (29 January 2010), http://www.imowa.com.au/f139,628386/04._WP_2_Initial_Report.pdf

[6] Exec Figure 2 from MMA report "Valuing the Capacity of Intermittent Generation in the South-west Interconnected System of Western Australia" (29 January 2010), http://www.imowa.com.au/f139,628386/04._WP_2_Initial_Report.pdf



WFx = actual Wind Farm x (not identified due to data confidentiality)
GPV = simulated Geraldton Photo-Voltaic solar farm
GST = simulated Geraldton Solar Thermal plant
IST = simulated Inland Solar Thermal plant

Consultation on MMA's report with the Office of Energy, Verve Energy, System Management and the Oates Implementation Committee led to MMA issuing a supplementary report. The key issues considered were:

- questions about the basis of modelled/simulated data, used in the absence of measured wind farm outputs;
- questions about the relationship of the capacity valuation to the reliability criterion;
- evaluation of the use of lower numbers of Trading Intervals (the 12 intervals used for Individual Reserve Capacity Requirement determination, 60 intervals, 160 intervals) on capacity valuations and volatility;
- analysis of the effect of increasing wind penetration on valuation (the resulting analysis showed a reducing valuation with increasing penetration of wind, and also suggested that 1,200 MW to 1,500 MW of wind could exist on the SWIS without jeopardising reliability of the system);

- the development of a method of selecting critical peak demand Trading Intervals based on Load for Scheduled Generation (LSG)[7] rather than total system demand; and
- consideration of an alternative methodology proposed by the Office of Energy.

The supplementary report will be compiled into one comprehensive study report.

MMA continued to recommend that the 750 trading interval method be adopted (Proposal 2A below) using LSG for interval selection, with consideration for a moving average approach to reduce volatility. MMA also proposed an alternative method, denoted as Proposal 2B, using 750 trading intervals from the last three years.

In the supplementary report, MMA concluded that LSG would provide a more accurate assessment of the reliability impacts of intermittent generators. LSG is calculated using the load that remains after removing the level of intermittent generation in the market. The use of LSG can change the timing of critical system reliability conditions towards those times where the demand on Scheduled Generators is highest. This technique accounts for increasing penetration of Intermittent Generation and promotes diversity of technology types and location. The REGWG agreed that LSG provided a reasonable basis for assessing system risk in any particular trading interval. LSG was used in each of the valuation methods considered subsequently.

Continued concerns were raised by System Management through this process about the confidence in reliability of intermittent generation from an operational perspective under extreme weather events. System Management developed an alternative approach to valuing the Capacity Credits assigned to intermittent generation facilities. This is denoted as Proposal 3 in the table below.

In light of concerns raised about the use of modelled data and system reliability, an individual member of the REGWG also proposed an alternative methodology for capacity valuation, denoted as Proposal 1 in the table below.

It must be acknowledged that a lack of available data about the likely performance of intermittent generation facilities during extreme hot weather events has contributed to uncertainty and the concerns raised by System Management.

The operational realities of maintaining power system security must be balanced with accepting an approach which supports longer term investment in intermittent generation in the SWIS through the appropriate assignment of Capacity Credits to all facilities. There is no clear answer to this tradeoff.

The table below summarises and compares the various methods proposed for the Capacity Credit valuation of intermittent generation facilities as presented to the REGWG[8].

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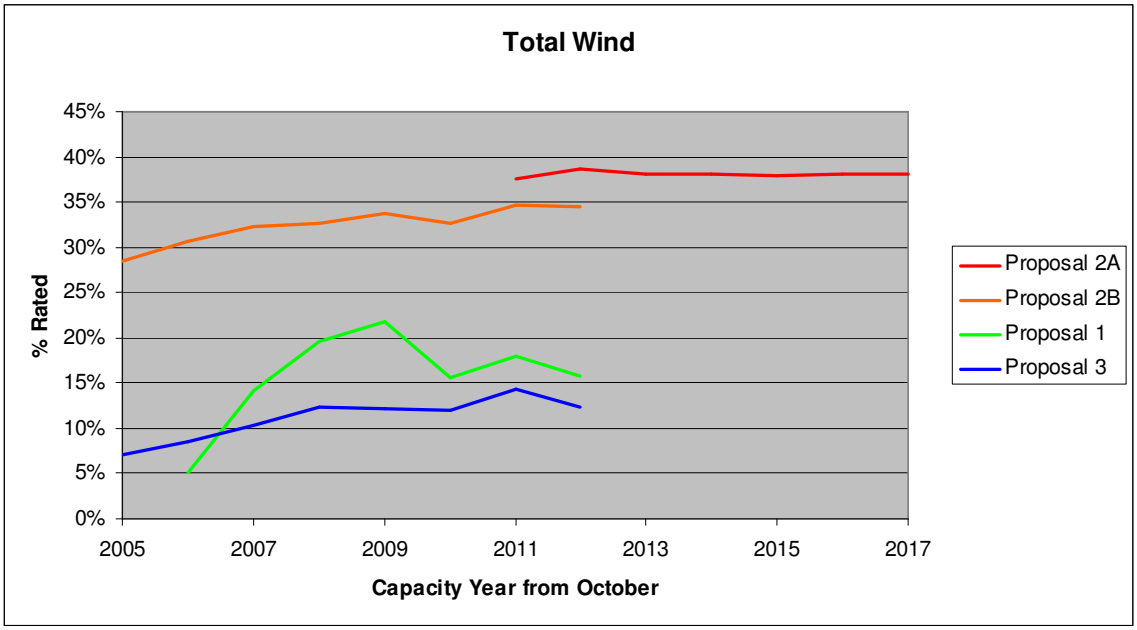
[7] Load for Scheduled Generation (LSG) = (Total system load) – (Total intermittent generation)

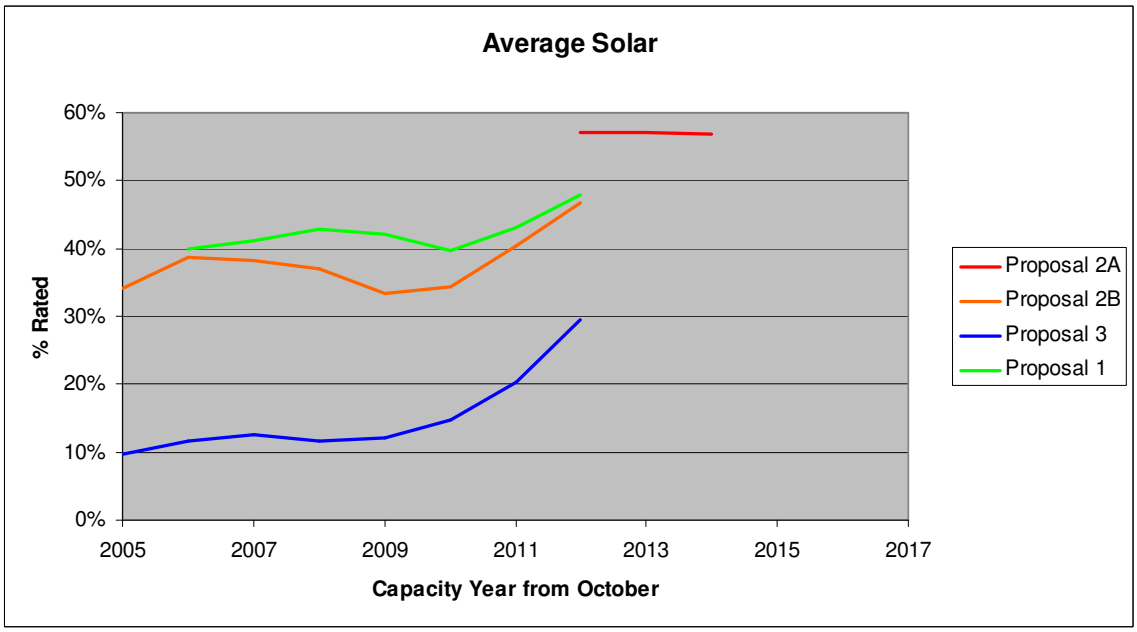
[8] Table 3-3 from MMA report "Analysis of Procedures for Assessing the Capacity Value of Intermittent Generation in the Wholesale Electricity Market" (2 August 2010), found at http://www.imowa.com.au/f139,732955/Agenda_Item_8b_-_MMA_Report_Capacity_Valuation_Methods.pdf

Proposal ► Criteria ▼	1	2A	2B	3
Basis	Fleet POE for 12 TI, shared on last three years 250 TI	750 TI for selected high demand years scaled to forecast	750 TI based on last three years	Fleet POE on 175 TI, shared on 250 TI over last three years
Transparency	Moderate – complex interactions but based on history	Moderate – some interactions and forecasting uncertainty	High – based on history	Moderate – some interactions
Simplicity	Moderate	Moderate	High	Moderate
Fleet POE	95%			90%
Accuracy and Robustness	Low (Conservative)	High –best represents reliability impact	Moderate (Conservative)	Low (Conservative)
Continuity of valuation	Low due to significant interactions among resources	High – changes infrequently, but then substantially	Moderate due to year to year variations	Moderate with significant interactions among resources

The table and graphs below provide estimates of the capacity valuation that would result from the various methodologies.

Proposal	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Total Wind													
P1		0.05	0.14	0.20	0.22	0.16	0.18	0.16					
P2A							0.38	0.39	0.38	0.38	0.38	0.38	0.38
P2B	0.28	0.31	0.32	0.33	0.34	0.33	0.35	0.34					
P3	0.07	0.08	0.10	0.12	0.12	0.12	0.14	0.12					
Wind + GPV													
P1		0.39	0.39	0.41	0.41	0.35	0.35	0.36					
P2A								0.45	0.44	0.44			
P2B	0.31	0.34	0.35	0.35	0.34	0.34	0.37	0.39					
P3	0.09	0.10	0.11	0.11	0.13	0.15	0.20	0.25					
Wind + GST													
P1		0.38	0.38	0.40	0.42	0.40	0.40	0.41					
P2A								0.45	0.44	0.44			
P2B	0.31	0.34	0.35	0.35	0.34	0.34	0.37	0.39					
P3	0.09	0.10	0.11	0.11	0.13	0.15	0.20	0.25					
Wind + IST													
P1		0.14	0.22	0.26	0.29	0.26	0.28	0.29					
P2A								0.44	0.44	0.44			
P2B	0.29	0.32	0.33	0.33	0.32	0.32	0.35	0.38					
P3	0.06	0.08	0.10	0.09	0.09	0.10	0.15	0.23					





5.3. REGWG Resolution

The REGWG discussed the merits of the proposals at length during the 12 August 2010 and 2 September 2010 meetings. The REGWG was unable to reach a consensus decision for a valuation methodology.

Throughout the debate, System Management maintained that higher valuations could compromise the reliability of the power system. System Management made reference to the capacity allocations to wind farms in the National Electricity Market (NEM), in the order of 5% of nameplate capacity, while noting that the NEM has no capacity market and the lower

valuation does not affect the income of individual wind farms. They expressed reservations with the use of modelled data, as well as the limited quantity of data that was available for assessment. System Management also pointed out that the performance of wind farms in peak periods exhibits large variability. System Management stated its preference for Proposal 3 as it focuses on intervals when the capacity is most needed. System Management also indicated that it could only support methodologies that would result in valuations up to 20% of nameplate capacity for wind farms.

System Management's view was countered by various REGWG members, including Market Participants with existing intermittent generation facilities (Alinta and Griffin Energy), proponents of new intermittent generation facilities (Pacific Hydro and Mid West Energy) and Synergy. These members supported Proposal 2A, suggesting that this proposal, developed and recommended by an expert consultant, has the strongest scientific basis and strongest link to system reliability. They also indicated that any reduction in the capacity valuation for intermittent generators would harm investment in the renewable energy sector in the SWIS, and suggested that grandfathering provisions should be considered for existing facilities.

The IMO suggested Proposal 1 at the 2 September 2010 meeting, which was supported by LGP on the basis that it is a compromise between the other proposals. System Management indicated that, while not its preferred proposal, it could accept Proposal 1 on the grounds that the valuation did not exceed 20% of nameplate capacity. This was not supported by the other parties who continued to advocate Proposal 2A.

While failing to reach a consensus position on the matter of valuing Capacity Credits for intermittent generation, the REGWG supported the proposal that the IMO would nominate the valuation methodology that it felt best served the Market Objectives and would recommend a solution to the MAC.

6. WORK PACKAGE 3: FREQUENCY CONTROL SERVICES

6.1. Background

In its scoping review, SKM recommended a thorough assessment of Frequency Control Services in the SWIS, noting that increasing intermittent generation would lead to uncertainty in the type, quantity and costs for these services.

ROAM Consulting was subsequently appointed to undertake Work Package 3 and was required to:

- determine whether the existing spinning reserve, load following, curtailment and demand response criteria in the SWIS are adequate for the forecast levels of intermittent generation, and the projected scenarios for the overall generation mix;
- determine whether intermittent generators can be used to provide the frequency control services required including load following for overnight load troughs; and
- determine the cost and the method of allocating of these costs associated with the provision of frequency control services for the forecast penetration levels of intermittent generation.

6.2. ROAM Recommendations and REGWG Resolutions

A summary of the ROAM recommendations and the IMO's response is shown in the table below. This summary was reviewed at the 2 September 2010 meeting of the REGWG and has been updated subsequent to the meeting. The IMO intends to proceed as outlined in the IMO Response column of the table.

Summary of ROAM Consulting recommendations and IMO response

	No.	Executive Summary Subheading	ROAM Recommendation	IMO Response
Competitive Procurement of Ancillary Services	1	**Projected load following requirements can be technically provided under the existing rules and with existing infrastructure (Section 7.3)**	Introduce a competitive market for the provision of ancillary services	This recommendation will be progressed. System Management is developing a proposal for a competitive ancillary services market, which will be provided to the new Rules Development Implementation Working Group (RDIWG).
	4	**Equations in the Rules for determination of costs of load following are flawed (Section 14)**	An efficient market for frequency control ancillary services should be established	
	5	**Cost projections are sensitive to changes in assumptions (Section 14.9) (Section 14.8.2)**	Introduce a competitive market for the provision of ancillary services	
	6	**Cost projections are sensitive to changes in assumptions (Section 14.9) (Section 14.8.2)**	Actively seek opportunities to minimise load following costs.	
Ancillary Services Cost Allocation	3	**Equations in the Rules for determination of costs of load following are flawed (Section 14)**	The methodology in the Rules for the determination of the costs of load following and spinning reserve (clause 9.9.2 of WEM Rules) should be updated as a priority (suggested equations proposed in section 14.4).	This recommendation will be progressed, subject to the further review requested by the REGWG.
	7	**The division of cost between load following and spinning reserve needs review (section 14.9)**	Review the methodology in the Rules for allocating the costs of spinning reserve and load following (clause 9.9.2).	
	8	**Intermittent generators should pay the marginal cost of load following (Section 14.10)**	Intermittent generators should pay the marginal cost of the provision of the load following service, above that required for load variability	
Dispatch Merit Order	9	**Dispatch priorities at time of minimum load will become important (Section 12)**	Implement transparent dispatch merit order priorities in the SWIS	The issue of the dispatch merit order and potential wind curtailment will not be reviewed further by the REGWG. This issue will be highlighted to MAC – potential for review by the RDIWG.
	10	**Facilities for wind curtailment are likely to be necessary (Section 12)**	Intermittent generators must be able to curtail if necessary	

Technical Rules	**2**	**Inertia and governor response are not limiting factors (Section 11.3)**	Arduous requirements for wind farms to provide system inertia should not be applied. Clause 3.10.1 of the WEM Rules is a sufficient standard for the Load Following service.	Agreed. No action to be taken.
	11	**Ramping limits on intermittent generators are ineffective at reducing variability (Section 15)**	Ramp limits should not be applied to intermittent generators individually for the purpose of reducing Load Following requirements and therefore the 15% limit should be removed from the Technical Rules if only for this purpose	Recommendation to be referred to ERA's Technical Rules Committee.
	12	**Intermittent generation is unlikely to be an attractive provider of load following service (Section 16)**	Facilitating intermittent generators to provide load following services should not be an immediate priority.	Agreed. No action to be taken.
Wind Correl	**13**	**Wind exhibits correlation within three distinct zones in the SWIS (Section 6.1.2)**	Consider commissioning a detailed wind correlation study	Not recommended to be progressed. It was determined that this would not add value to the REGWG process.

At the 2 September 2010 meeting, the REGWG requested that further review be undertaken in relation to the allocation of Load Following and Spinning Reserve costs, prior to the development of a Rule Change Proposal. Specifically, the IMO was asked to instruct ROAM to:

- Consider how the impact of Scheduled Generator deviations from dispatch targets can be reflected in the allocation of Load Following costs;
- Consider the suggestions made by Verve Energy for the simplification and staged implementation of the proposed changes to the Market Rules; and
- Investigate the use of a proportioning approach and prepare a comparison of this approach and the difference-based approach.

The initial work of this further review was presented to the MAC at the 10 November 2010 meeting.

7. WORK PACKAGE 4: TECHNICAL RULES

SKM concluded that increasing penetration of intermittent generators would require evaluation of the current requirements of the Technical Rules and Power System Operating Procedures and consideration of potential revisions. SKM noted that mechanisms were required to ensure that Power System Security is not compromised due to plausible contingency events, while avoiding overly stringent requirements that may be prohibitively expensive for new generators.

SKM was subsequently appointed to undertake Work Package 4 and was required to:

- evaluate the appropriateness of the existing Technical Rules and Power System Operating Procedures as applied to intermittent generators; and
- recommend changes resulting from increased penetration of intermittent generators in the SWIS.

While the Technical Rules and Power System Operating Procedures are generally outside the scope of the REGWG, this Work Package was undertaken to complete the analysis into the issues arising from increasing penetration of intermittent generation. The Final Report was generally accepted by the REGWG at the 12 August 2010 meeting. The REGWG also agreed that the Final Report will be passed to the ERA's Technical Rules Committee for further consideration. This will be issued to the ERA by the end of November 2010.

8. INFORMATION PROVISION OF AGGREGATE INTERMITTENT GENERATION OUTPUT

One of the issues discussed through the course of the review process is the lack of information available on intermittent generation facility outputs. At the 12 August 2010 Meeting of the REGWG, it was agreed that the IMO would develop and progress a Rule Change Proposal to publish aggregated information about the output levels of intermittent generation facilities. It was the IMO's preference at the time for the information to be made available to the WEM in, or as close to, real time as is possible. This action item will be undertaken by the

IMO. The publication of this information will be required in any case should a LSG method be proposed by the IMO.

9. CONCLUSION

This report has been prepared by the IMO to detail part of the history and outworkings of the REGWG process. While it took a significant amount of time and effort to reach the outcomes, the issues are of significant strategic importance to the continued investment in, and delivery of, renewable energy within the Western Australian WEM.