WIND AND SOLAR ENERGY CONVERSION MODEL GUIDELINES CONSULTATION - ISSUES PAPER - 2016

PREPARED BY: Forecasting

VERSION: 1.0

DATE: 18 March 2016

FINAL

CONTENTS

ABBREVIATIONS

Abbreviation	Expanded name
AWEFS	Australian Wind Energy Forecasting System
ASEFS1	Australian Solar Energy Forecasting System
SDC	semi-dispatch cap
SCADA	Supervisory Control and Data Acquisition
UIGF	unconstrained intermittent generation forecast

GLOSSARY

In this document, *italicised* phrases refer to defined terms in chapter 10 of the National Electricity Rules. A list of commonly used terms and acronyms from the gas and electricity industry can be found on AEMO's website at http://www.aemo.com.au/Glossary.

1 INTRODUCTION

1.1 Matters under Consultation

AEMO is proposing changes to the Wind and Solar Energy Conversion Model Guidelines ('the ECM Guidelines') and consulting with Semi-Scheduled Generators on the changes as required by clause 2.2.7(d) of the National Electricity Rules ('the Rules').

In late 2015, AEMO identified an issue with the accuracy of the Australian Wind Energy Forecasting System ('AWEFS') dispatch forecasts. This issue had the potential to affect Semi-Scheduled Generators at times when output is constrained by a local limit not reflected in the AWEFS forecast.

AEMO discussed the issue with a number of affected participants, and has identified a proposed solution, which would require Semi-Scheduled generators (wind and solar) to provide their Local Limit to AEMO in real time. AEMO continues to investigate options for limits that do not fit within the proposed solution.

During these discussions, further improvements to the dispatch forecast were proposed. These included investigating the use of a 'Possible Power' SCADA feed provided by Semi-Scheduled Generators in real time, and allowing the 'Wind Speed' SCADA feed to be an average of several representative wind speeds.

To implement these requirements, AEMO is proposing changes to the ECM Guidelines outlined in this paper. AEMO is also proposing additional minor changes to the ECM Guidelines. All changes are summarised in Appendix A.

AEMO is seeking feedback on the issues and questions raised in this paper.

The consultation process is outlined in the accompanying "Notice of First Stage of Rules Consultation on amendments to The Energy Conversion Model Guidelines- 2016", and will be conducted in accordance with clause 8.9 of the Rules.

1.2 References

- AWEFS overview: http://www.aemo.com.au/Electricity/Market-Operations/Dispatch/AWEFS
- National Electricity Rules: http://www.aemc.gov.au/Energy-Rules/National-electricity-rules/Current-Rules
- Wind Energy Conversion Model and Guide to Data Requirements: http://www.aemo.com.au/Electricity/Market-Operations/Dispatch/Energy-Conversion-Model-for-Wind-Forecasting
- Solar Energy Conversion Model Guidelines: http://www.aemo.com.au/Consultations/National-Electricity-Market/Energy-Conversion-Model-for-Solar-Forecasting
- Generator Registration Guide: http://www.aemo.com.au/About-the-Industry/Registration/How-to-Register/Application-Forms-and-Supporting-Documentation/NEM-Generator
- Generating System Model Guidelines and Datasheets: http://www.aemo.com.au/About-the-Industry/Registration/How-to-Register/Generating-System-Model-Guidelines-and-Datasheets
- Guide to Intermittent Generation interface in the NEM Web Portal: http://www.aemo.com.au/About-the-Industry/Information-Systems/Using-Energy-Market-Information-Systems

2 OVERVIEW

The Rules require AEMO to prepare an *unconstrained intermittent generation forecast* (UIGF) of each Semi-Scheduled generating unit's *available capacity* for use in the dispatch, pre-dispatch and PASA timeframes.[1]

AEMO uses AWEFS and the Australian Solar Energy Forecasting System (ASEFS1) to produce wind and solar forecasts – the UIGF – for each timeframe.

These forecasts are used in the National Electricity Market Dispatch Engine (NEMDE) as an upper limit on the dispatch based on least cost optimisation of all available bids.

In producing an UIGF, AEMO must take into account.[2]

(1) maximum *generation* of the *semi-scheduled generating unit* provided by the Semi-Scheduled Generator as part of its *bid and offer validation data;*

(2) *plant availability* of the *semi-scheduled generating unit* submitted by the *Semi-Scheduled Generator*;

(3) information obtained for the *semi-scheduled generating unit* from remote monitoring equipment;

(4) forecasts of the *energy* available for input into the electrical power conversion process for the *semi-scheduled generating unit;*

(5) the *energy conversion model* for the *semi-scheduled generating unit*; and

(6) the assumption there are no *network constraints* otherwise affecting *generation* from the *semi-scheduled generating unit*.

Chapter 10 of the Rules defines an *energy conversion model* as:

> The model that defines how the *intermittent* input energy source (such as wind) is converted by the *Semi-Scheduled generating unit* into electrical output. That model must contain the information set out in the guidelines *published* by *AEMO* in accordance with clause 2.2.7(d).

The ECM Guidelines specify the minimum data required by AEMO to enable AWEFS/ASEFS1 to produce reliable *generation* forecasts for a *semi-scheduled generating unit*.

A Generator must submit an *energy conversion model* (ECM) for each of its *semi-scheduled generating units* before AEMO can classify it as a *semi-scheduled generating unit.*[3]

The ECM Guidelines specify two types of data:

- Static data: technical specifications provided during the registration process.
- Dynamic data: real-time generation and meteorological measurements provided via the Supervisory Control and Data Acquisition (SCADA) system.

The latest version of the Wind ECM Guidelines was published on 6 June 2013. The Solar ECM Guidelines were published on 12 April 2013.

[1] Rules clause 3.7B(a)
[2] Rules clause 3.7B(c)
[3] Rules clause 2.2.7(c)(2)

3 CHANGES TO THE ECM

The proposed changes are summarised in Appendix A. This chapter:

- Describes the proposed changes to the Wind and Solar ECM Guidelines.
- Outlines the rationale for the changes.
- Lists a series of questions, for which AEMO is seeking feedback.

3.1 New SCADA Local Limit (Wind and Solar ECM Guidelines)

AEMO proposes to add a new SCADA item "Local Limit" to the Wind and Solar ECM Guidelines. All new and existing *Semi-Scheduled Generators* will be required to provide this in respect of their *semi-scheduled generating units*.

3.1.1 What is the Local Limit?

AEMO proposes to specify the requirement for provision of an additional data item, 'Local Limit', to be provided via SCADA in megawatts (MW):

Local Limit

In MW, the lower of *plant availability* and of the limitation on capacity of connection assets on the export of energy from the wind/solar farm.

When implemented in AWEFS/ASEFS1, the Local Limit is used to cap the UIGF for the wind/solar farm in the dispatch timeframe.

The Local Limit excludes limits on a *transmission network* and *distribution network* (as required by clause 3.7B(c)(6) of the *Rules*) or limits otherwise agreed to be managed by AEMO.

The Local Limit SCADA signal complements the 'Turbines/Inverters Available' SCADA signal, which is in the existing Wind and Solar ECM Guidelines. Where 'Turbines/Inverters Available' SCADA gives information on the number of *generating units* available, 'Local Limit' SCADA gives information on limits affecting the total wind/solar farm output.

Local Limits should give regard to:

- Limits on connection assets and network connection plant, including outages.
- Limits on generating plant (plant availability), including outages.

Local Limits should not give regard to:

- Limits on the transmission network.
- Limits on the distribution network.
- Limits due to the available wind/solar energy.
- Market-related limits.
- The current dispatch level during a semi-dispatch interval.
- Limits normally managed by AEMO.
- Limits otherwise agreed by the Generator to be managed by AEMO.

3.1.2 Why is it required?

In late 2015, AEMO identified an issue with the accuracy of dispatch levels for *semi-scheduled generating units* at times when output was constrained by a limit not reflected in the dispatch UIGF and not managed by AEMO's *central dispatch* process.

The proposed SCADA 'Local Limit' provides a means for *Semi-Scheduled Generators* to prevent over-dispatch when there is a limit on the capacity of the *connection assets*. AEMO will continue to investigate

options for preventing over-dispatch when the limit is in the *distribution network* but not managed by AEMO.

Participants have raised the question of how to manage a *transformer* or other *connection asset* limitation in dispatch (including those that are dynamic). Currently, in this situation, a *Semi-Scheduled Generator* may modify its bids or contact AEMO's Control Room to invoke a temporary constraint equation. Several participants advised that neither option is practical for them, particularly when the limit is dynamic. There is also not a completely effective method of bidding such limits. The proposed SCADA 'Local Limit' would allow *Generators* to directly limit their UIGF, and hence their *dispatch* level, in these circumstances.

A *Scheduled Generator* bids 'Maximum Availability' in NEMDE (along with *network constraints*) as an upper limit on *dispatch*. For *Semi-Scheduled Generators*, the 'Maximum Availability' bid is ignored and substituted with the UIGF. Bidding unavailable capacity into a higher price band is a workaround, but that capacity can be dispatched at times of supply scarcity.

For the pre-dispatch and PASA timeframes, a *Semi-Scheduled Generator* submits half-hourly "Upper MW Limit" and "Elements Unavailable" profiles via the Intermittent Generation Portal. The UIGF is calculated based on the *plant availability* indicated by the number of "Elements Unavailable"[4], and "Upper MW Limit" is then used to cap the UIGF. These limits are not applied in the dispatch timeframe.

For *dispatch*, AWEFS uses "SCADA Turbines Available" data provided in real time[5] when calculating the *dispatch* UIGF, analogous to the use of "Elements Available" in Pre-dispatch and PASA. However, AWEFS does not apply any cap in *dispatch* on that UIGF, other than at the Nameplate Capacity. This may result in NEMDE calculating a higher dispatch level than can be physically achieved if there is a limit on the wind/solar farm's production that is not managed by AEMO's constraint equations in NEMDE. There is no analogous signal to "Upper MW Limit" for dispatch. This is the gap that the SCADA Local Limit intends to fill.

The over-dispatch due to not capping the dispatch UIGF can result in:

- Distorted and inefficient dispatch and pricing outcomes.
- Potential suppression of the spot price.
- Increased use of the regulating lower service.[6]

AEMO is proposing that it be mandatory for *Semi-Scheduled Generators* to provide the SCADA 'Local Limit' given the benefit to the *market* of improved *dispatch* accuracy.

3.1.3 What about distribution network constraints?

The definition of UIGF in the Rules means that *distribution network constraints* must be excluded from the SCADA 'Local Limit' signal, but there are *distribution network constraints* that AEMO does not manage in NEMDE.

AEMO acknowledges that there may be limits on *semi-scheduled generating units* that are not covered by either an AEMO-managed constraint equation or the proposed SCADA 'Local Limit', so these are not addressed by the proposed changes to the Wind and Solar ECM Guidelines.

AEMO invites comment on the likelihood and impact of this kind of limitation, and intends to further investigate potential options to improve the accuracy of *dispatch* where the *distribution network constraints* are not managed by AEMO. Two options under consideration are:

- AEMO to manage additional *distribution network constraints* where this is a practical and efficient way to improve *dispatch* outcomes, noting that this may put additional data requirements on *distribution network service* providers.
- A change to the Rules to amend the definition of UIGF to allow consideration of *network constraints* not managed by AEMO.

[4] For AWEFS, wind turbines unavailable; for ASEFS1, inverters unavailable.
[5] This data is a mandatory provision under the ECM Guidelines.
[6] For more information refer to AEMO's *Guide to Ancillary Services in the National Electricity Market* located at http://www.aemo.com.au/en/Electricity/Market-and-Power-Systems/Ancillary-Services/~/media/Files/Other/electricityops/0160-0048%20pdf.ashx

3.1.4 Benefits and costs of SCADA Local Limit

The benefits and costs of the proposed SCADA Local Limit are summarised in Table 1.

Table 1 - Benefits and Costs of Proposed SCADA Local Limit

Benefits for Wind/Solar farms	Benefits for Market
FCAS regulation causer pays factors more closely aligned with generator performance	More efficient *dispatch* and pricing outcomes, with calculated *dispatch* more closely aligned with actual output when local limits apply
Less manual intervention	Reduced over-dispatch error and frequency lower regulation
Reduced risk of premature binding or violating of network constraint equations involving that *generating unit*	

Costs for Wind/Solar farms	Costs for AEMO
Implementation and maintenance of the new SCADA Local Limit	ECM Consultation and update process
Additional compliance costs to ensure it meets the Rules and ECM Guidelines requirements	AWEFS/ASEFS1 system changes

3.1.5 What alternatives did AEMO consider?

AEMO considered a number of other options (outlined below) to improve the accuracy of dispatch where *Semi-Scheduled Generators* have local limits.

1. Generator manages by bidding capacity into high price bands

Under this option, the Semi-Scheduled Generator manages dispatch of its *generating unit* to within the local limit by bidding any band capacity above that limit to a high price band, hence making it uneconomic to *dispatch*. AEMO understands this is one of the current approaches.

AEMO does not consider this option to be viable because:

- That capacity might still be dispatched during supply scarcity.
- Frequent rebidding to match a dynamic local limit would be problematic, with an increased risk of human error.

2. Generator manages by bidding inflexible

Under this option, the *Semi-Scheduled Generator* manages *dispatch* of its *generating unit* to within the local limit by bidding a maximum loading level at that limit in accordance with clause 3.8.19(a1) of the Rules.

AEMO does not consider this option to be viable because:

- The AER has advised AEMO that it is not compliant with Rule clause 3.8.19(a1) – a lower local limit due to a planned outage would not prevent a *Generator* from being able to "operate in accordance with *dispatch instructions*", as its dispatch level is always treated as a cap and it could choose to operate at that lower level and still comply.

3. AEMO applies an ad-hoc constraint equation in NEMDE upon request

Under this option, the Semi-Scheduled Generator would make an ad hoc request that AEMO applies a generic constraint equation in NEMDE to manage the dispatch of its generating unit to the local limit advised by Generator. AEMO understands this is one of the current approaches.

AEMO does not consider this option to be viable because:

- Frequent changes to the constraint equation to match a dynamic local limit would be problematic for AEMO, with an increased risk of human error.
- Significant manual intervention is required.

5. Changes to cap the Dispatch UIGF at existing "Upper MW Limit" submitted via Intermittent Generation Portal

Under this option, AWEFS/ASEFS1 would be modified to automatically cap the Dispatch UIGF at the "Upper MW Limit" submitted by the *Semi-Scheduled Generator* via the Intermittent Generation Portal.

AEMO does not consider this option to be viable because:

- Frequent changes to the "Upper MW Limit" to match a dynamic local limit would be problematic, with an increased risk of human error.
- The half-hourly resolution of "Upper MW Limit" might not suit dynamic local limits.
- It is inconsistent with the current design of UIGF, because the 'Dispatch UIGF' uses the existing real-time "SCADA Turbines/Inverters Available" rather than the Intermittent Generation Portal equivalent "Elements Unavailable" (which is only used in Pre-dispatch and PASA).

6. Changes to cap the Dispatch UIGF at existing "SCADA Control System Set-Point"

Under this option, AWEFS/ASEFS1 would be modified to automatically cap the Dispatch UIGF at the existing SCADA MW Set-point (control system set-point, which is mandatory under the ECM Guidelines), rather than at the new SCADA Local Limit separately provided.

AEMO does not consider this option to be viable because:

- It is not compliant with Rule clause 3.7B(c)(6), which requires the calculation of the UIGF to assume that there are no *network constraints*. The control system set-point may reflect distribution and transmission network constraints, so is not suitable for capping the UIGF.
- The SCADA MW Set-point signal is required by AWEFS/ASEFS1 to determine when *generation* output is limited, so AWEFS/ASEFS1 can correctly calculate the dispatch UIGF and for correct model tuning.

3.1.6 What is the proposed implementation?

AEMO proposes the following:

- Change to the Wind and Solar ECM Guidelines, to mandate the provision of a real-time SCADA 'Local Limit' for existing and future *semi-scheduled generating units*; **and**
- Changes to AWEFS/ASEFS1 to:
  - Apply the SCADA 'Local Limit' as a cap on the 'Dispatch UIGF', if the incoming quality of SCADA 'Local Limit' is "Good" AND its value is greater or equal to zero AND its value is below a *generating system's nameplate rating*
    Else
  - Ignore the SCADA 'Local Limit'

Figure 1 overleaf shows the AWEFS calculation of UIGF and the various caps applied, including the proposed SCADA 'Local Limit'.

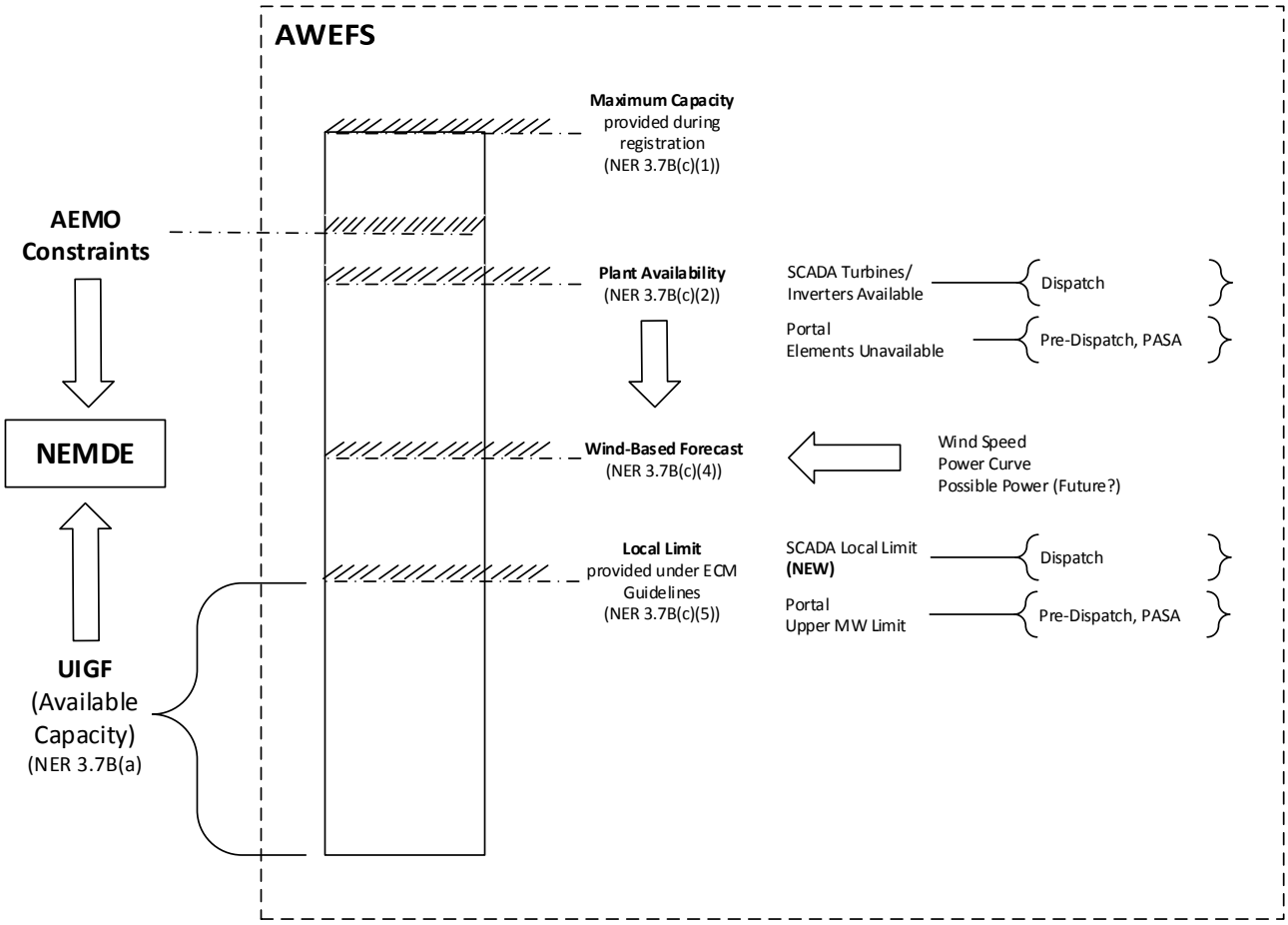

Figure 1: Calculation of AWEFS UIGF

3.1.7 Consultation questions

AEMO seeks feedback on these questions relating to the provision and use of a SCADA Local Limit:

1. **Do you agree that the requirement for a SCADA Local Limit will improve your dispatch outcomes?**
2. **Do you agree with the proposed validation of the SCADA Local Limit, and the proposed validation range (see Section 3.1.6)? If not, how should quality be handled?**
3. **What types of limits affect your *semi-scheduled generating unit*? Who is responsible for determining those limits, how dynamic are they, how often do they occur, and how they are applied?**
4. **Please quantify for your wind/solar farm(s) the likely impact of the exclusion of *distribution network constraints* not managed by AEMO from the SCADA 'Local Limit' definition (see Section 3.1.1).**
5. **What do you estimate are your upfront and ongoing costs in providing and maintaining a SCADA 'Local Limit'?**
6. **Are there other options available to manage the local limit issue not canvassed in this paper?**
7. **Are there any other related matters you wish to raise?**

3.2 Changes to SCADA Wind Speed (Wind ECM Guidelines)

SCADA Wind Speed is a key input to the Dispatch UIGF calculation in AWEFS, and is a mandatory provision in the Wind ECM Guidelines.

3.2.1 What is the proposed change?

AEMO proposes changes to the current definition to clarify that:

- Instantaneous measurements are required. Instantaneous means values updated at least every 10 seconds. If only averages are available, maximum 15-second average update.
- Wind speed may be an average of several representative locations in the wind farm or cluster.

Wind Speed

Measurements from turbine nacelle anemometers are much preferred over measurements from meteorological mast(s).

A single wind speed measurement must be representative of wind conditions across the site for calculation of dispatch UIGF. For large wind farms an average of several turbine nacelle wind speed measurements may be used to achieve this.

3.2.2 Why are the changes required?

The vendor of AWEFS requested these changes to improve the accuracy of AWEFS dispatch forecasts, which are based on the wind speed SCADA measurement. It is their view is that an average of wind speed measurements from nacelle-top anemometry provides a more representative characterisation of wind conditions across the site than a single meteorological mast.

3.2.3 Consultation questions

AEMO seeks feedback on these questions relating to changes to SCADA Wind Speed:

1. **Do you agree that the proposed changes will improve your dispatch outcomes?**
2. **What do you estimate are your upfront and ongoing costs in applying this proposed definition?**
3. **The vendor of AWEFS prefers wind speed measurements from turbine nacelle anemometers over meteorological mast measurements. Do you agree, and what information can you give about the suitability and relative accuracy of the two measurement types for your wind farm(s)?**

3.3 Optional: New SCADA Possible Power (Wind and Solar ECM Guidelines)

As a part of the current review informing the proposed changes to the Wind and Solar ECM Guidelines, AEMO has considered a variety of mechanisms for improving AWEFS/ASEFS1 forecast accuracy.

For clarity, this section only describes Possible Power as it relates to wind farms. An equivalent definition incorporating solar irradiance and inverters available is proposed for the Solar ECM Guidelines and shown in the table of changes in Appendix A.

In response to feedback from AWEFS stakeholders, AEMO is proposing to include an optional additional SCADA item called “Possible Power” that is intended to provide an estimate of the theoretical power available according to each wind farm’s internal control system.

3.3.1 What is Possible Power?

AEMO proposes that Possible Power act as a measure of the active power that each wind farm can deliver to the network based only on wind conditions at the site and available wind turbines. Possible Power should not give regard to transmission and distribution *network constraints* – it is intended to act as the plant control system’s best estimate of theoretical power generation available in the current dispatch period.

The proposed definition of Possible Power in the ECM Guidelines is:

Possible Power

The estimate by the wind farm's control system of active power (in MW) available from the current wind and available turbines.

Possible Power should give regard to:

- Turbines available in the current *dispatch* period.
- Wind conditions in the current *dispatch* period.

Possible Power should not give regard to:

- Limits on network connection plant, including outages.
- Limits on the *transmission network.*
- Limits on the *distribution network.*
- *Market*-related limits.
- Limits normally managed by AEMO.
- Limits otherwise agreed by the *Generator* to be managed by AEMO.

3.3.2 Why is it required?

Currently, when AWEFS calculates a *dispatch* UIGF based on wind conditions, it applies the single Wind Speed SCADA value provided to a power curve tuned to correlate wind speed to power output for each individual wind farm. The provision of SCADA Possible Power will allow development of a dataset that can be used to further explore further for optimisation of AWEFS and additional improvements in system forecast accuracy. Stakeholders advised that many wind farm control systems are able to provide an estimate that may be superior to that determined by AWEFS.

Based on further investigation, AEMO may undertake additional work to integrate the Possible Power forecasts into the AWEFS Dispatch UIGF.

3.3.3 Benefits and Costs

Table 2 summarises the benefits and costs of including SCADA Possible Power as optional provisions in the ECM Guidelines.

Table 2 - Benefits and Costs of Proposed SCADA Possible Power

Benefits for Wind farms	Benefits for Market
Inform AEMO's investigation into potential improvements to forecast accuracy.	Inform AEMO's investigation into potential improvements to forecast accuracy
	Following AEMO's investigation, potential for reduced dispatch error and frequency regulation

Costs for Wind farms	Costs for AEMO
Implementation and maintenance of the new SCADA Possible Power	ECM Consultation and update process
	AWEFS/ASEFS1 system changes

3.3.4 Consultation questions

AEMO is seeking feedback on the following questions relating to the provision and use of a SCADA Possible Power:

1. **Do you agree with the definition of SCADA Possible Power?**
2. **Does your wind farm control system currently produce an estimate of Possible Power, or an equivalent? If not equivalent, what can it produce?**
3. **How is this estimate calculated?**
4. **If the control system does not currently produce a suitable Possible Power estimate, what would be the implementation costs of doing so?**
5. **How should data quality, validation and update frequency issues be handled for Possible Power?**

3.4 New Maximum Capacity (Wind and Solar ECM Guidelines Static Data)

AEMO proposes to add a new item “Maximum Capacity” to the Wind and Solar ECM Static Data as a mandatory provision for Semi-Scheduled Generators.

Semi-Scheduled Generators are required to provide both Maximum Capacity and Nameplate Rating (also referred to as Registered Capacity) to AEMO as part of the registration process, but only Registered Capacity is referred to in the Wind and Solar ECM Guidelines.

Note that AEMO proposes to rename the “Registered Capacity” item in the Wind and Solar ECM Guidelines to “Nameplate Rating” for consistency with the terms used in the registration process. This is one of the minor changes listed in Appendix A.

3.4.1 What is Maximum Capacity?

The proposed definition of Maximum Capacity in the Wind and Solar ECM Guidelines is:

Maximum Capacity

Maximum generation to which the *semi-scheduled generating unit* may be dispatched. This definition can be found in sections C, I.4 and I.5 of "Application for Registration as a Generator in the NEM".

3.4.2 Why is it required?

At registration, all Generators are required to provide AEMO with the Nameplate Rating[7] (also referred to as Registered Capacity) and Maximum Capacity of their generating units. Generally, the Nameplate Rating of a *generating unit* is less than or equal to its Maximum Capacity.

AWEFS/ASEFS1 currently caps the calculated UIGF for a *semi-scheduled generating unit* at its Registered Capacity as supplied in the Wind and Solar ECM Guidelines. The Maximum Capacity is not currently communicated to AWEFS/ASEFS1.

However, AEMO is also required to cap the UIGF to the Maximum Capacity under clause 3.7B(c)(1) of the Rules.[8] There are cases where the Maximum Capacity is less than the Registered Capacity, and this has resulted in a scheduling error.[9]

[7] Defined in the NER as “The maximum continuous output or consumption in MW of an item of equipment as specified by the manufacturer, or as subsequently modified.”

[8] When preparing a UIGF, AEMO must take into account (among other things) the maximum generation of the *semi-scheduled generating unit* provided by the *Semi-Scheduled Generator* as part of its *bid and offer validation data*. This is represented in the market systems as Maximum Capacity.

[9] http://www.aemo.com.au/Electricity/Resources/Reports-and-Documents/Market-Event-Reports/Scheduling-Error-Report-Incorrect-Unconstrained-Intermittent-Generation-Forecasts-UIGF-2012-to-2016

AEMO is proposing a solution involving changes to AWEFS/ASEFS1 to cap the UIGF for a *semi–scheduled generating unit* at its Maximum Capacity. To achieve this, AEMO proposes to include Maximum Capacity as part of the Wind and Solar ECM Static data. This is an administrative change to provide the Maximum Capacity value to AWEFS/ASEFS1.

3.4.3 Consultation questions

No consultation is required, as Maximum Capacity is already provided as part of the registration process and there are no proposed changes to that definition.

3.5 Slope Tracking Direction (Solar ECM Static Data)

AEMO proposes to add a new item, “Slope Tracking Direction”, to the Solar ECM Static Data as a mandatory provision for solar farms using active solar tracking.

3.5.1 What is Slope Tracking Direction?

Slope Tracking Direction

Direction in which slope tracking is done. Specify "north-south" if panels are tilted in the north/south direction over an east-west axis. Specify "east-west" if panels are tilted from east to west over a north-south axis. For any other angles/cases, specify the compass orientation of the tracking (see "azimuth", perpendicular to axis' compass orientation) and attach additional information on the tracking.

3.5.2 Why is it required?

The existing Solar ECM Static Data does not capture adequate detail to allow modelling of tracking array equipped solar farms.

3.5.3 Consultation Questions

AEMO is seeking feedback on the following questions relating to the proposed Slope Tracking Direction:

1. **Are there other types of tracking that are not covered by the proposed Solar ECM Guidelines?**
2. **For a given generating system, are multiple tracking axes with different orientation likely to be used at the same site?**

3.6 Other Minor Changes

AEMO is proposing various other minor changes to the ECM Guidelines to:

- Clarify existing data item definitions.
- Remove unused data items.
- Correct grammatical and typographical errors.
- Improve the overall format.

These changes and their rationale are summarised in Appendix A.

4 Appendices

The following document is incorporated as an Appendix to this discussion paper.

- **Appendix A:** *Proposed Amended Energy Conversion Model Guidelines*, March 2016.

APPENDIX A – Proposed Amended Energy Conversion Model Guidelines, March 2016

The following tables detail the proposed changes to the Wind and Solar ECM Guidelines:

- Table 3 shows proposed changes to the Wind ECM Guidelines
- Table 4 shows proposed changes to the Solar ECM Guidelines

Table 3. Changes made to Energy Conversion Model for Wind Farms

Data type	Original	New	Comment
	Cluster definition guide		
N/A	i. no more than 50 wind turbines (with some degree of flexibility) (this would correspond to clusters of approximately 100 MW each).	Item deleted	This is not needed, the important constraints are the regional one and the technical one.
N/A	ii. no more than 7 km x 7 km (with some degree of flexibility)	i. no more than 7 km x 7 km (with some degree of flexibility)	Due to deletion of item i. item ii becomes item i.
N/A	iii. only identical turbines are included in a cluster	ii. only identical turbines are included in a cluster	Due to deletion of item i. item iii. becomes item ii.
N/A	NOTE: Identical turbines means turbines supplied by same manufacturer, having the same model and characteristic power curve.	NOTE: Identical turbines means turbines supplied by same manufacturer, having the same model, hub height and characteristic power curve.	Sometimes a model is available in different hub heights.
N/A	Different types of wind turbines in the wind farm	Different types of wind turbines in the wind farm (model, hub height)	Sometimes a model is available in different hub heights.
N/A	Wake effects. Presence of wake effects among clusters would increase complexity in the modelling process.	Item Deleted	Wake effects also exist within a cluster and are part of the modelling, removed to avoid confusion.
	ECM Data template		
Cluster ID	N/A	N/A	Section deleted as it is repeated at the cluster level.
Nameplate Rating	Data Type: Registered Capacity Description: The total installed capacity of the Wind Farm (MW).	Data Type: Nameplate Rating Description: The total installed capacity of the Wind Farm (MW). This equals turbine nameplate rating x total number of turbines installed. This Item corresponds to "Nameplate Rating" in Sections C and I.5 of "Application for Registration as a Generator in the NEM."	Changed the name of data type and added reference for consistency with supplementary documentation.
Maximum Capacity	N/A	New data type. Added Description: Maximum generation to which the semi-scheduled generating unit may be dispatched. This definition can be found in sections C, I.4 and I.5 of "Application for Registration as a Generator in the NEM".	Added new data type for cases where maximum capacity is different to nameplate rating. Reference for consistency with supplementary documentation. This is a required item.

Data type	Original	New	Comment
Met Mast Measuring Height	Description: If a met mast available, indicate the height(s). (repeat line if several). Please provide measuring heights for both the SCADA wind speed data and also wind Farm Historical measurements.	Description: If a met mast available, indicate the measuring height(s) above ground level. Example - Met mast (SCADA wind speed data) height: met mast A=80m, met mast B=85m, met mast C=92m	Input to have multiple data points entered into the one cell to create standardised sheet. Example added to assist participant in populating cell.
Met Mast Geographical Coordinates	Description: If a met mast available, indicate the geographical coordinates. (repeat line if several). Please provide geographical coordinates for both the SCADA wind speed data and also wind Farm Historical measurements.	Description: If a met mast available, indicate the geographical coordinates. Example - Met mast (SCADA wind speed data) coordinates = met mast A: (-81.15611,122.47823) met mast B: (-81.15984,122.47159)	Input to have multiple data points entered into the one cell to create standardised sheet. Example added to assist participant in populating cell.
Air Density	Description: The typical air density at the level of this Wind Farm. In case of multiple power curves the one that corresponds to this density is considered.	Description: The typical air density at the level of this Wind Farm (yearly average). In case of multiple power curves the one that corresponds to this density is considered.	"(yearly average)" added for clarification.
Wind Farm SCADA to AEMO	Description: Unless otherwise stated, instantaneous measurements are required. Instantaneous means values sent every 2 seconds to AEMO, or more often.	Description: Unless otherwise stated, instantaneous measurements are required. Instantaneous means values updated every 4-10 seconds. If only averages are available, maximum 15-second average update is required.	SCADA values can now be updated up to every 10 seconds to AEMO, otherwise maximum 15 second average update is required.
Wind Farm Active Power	Data Type: Wind Power Data Description: Total wind farm power.	Data Type: Wind farm Active Power Description: Total wind farm active power.	Changed the name of data type and description for clarity.
Number of Wind Turbines Actively Generating	Description: As number of turbines in operation, i.e. generating	Description: number of turbines actively generating power.	Change of definition.
Local Limit	N/A	New Data Type In MW, the lower of plant availability and of the limitation on capacity of connection assets on the export of energy from the wind farm. When implemented in AWEFS, the Local Limit is used to cap the UIGF for the wind farm in the dispatch timeframe. The Local Limit excludes limits on a transmission network and distribution network (as required by clause 3.7B(c)(6) of the Rules) or limits otherwise agreed to be managed by AEMO.	New required SCADA item to deal with local limitations
Possible Power	N/A	New Data Type The estimate by the wind farm's control system of active power (in MW) available from the current wind and available turbines.	New optional SCADA item to take into account farms control system 'possible power' output.

Data type	Original	New	Comment
Wind Speed Data	Description: Measurements from turbine nacelle anemometers much preferred over measurements from meteorological mast(s).	Description: Measurements from turbine nacelle anemometers are much preferred over measurements from meteorological mast(s). A single wind speed measurement, which must be representative of wind conditions across the site for calculation of dispatch UIGF. For large wind farms an average of several turbine nacelle wind speed measurements may be used to achieve this	More information added.
Wind Direction Data	Description: Measurements from turbine nacelle anemometers much preferred over measurements from meteorological mast(s).	Description: Wind direction measurements from turbine nacelle anemometers much preferred over measurements from meteorological mast(s). Wind direction from selected single representative nacelle (no averaging for direction).	More information added.
Temperature Data	Description: Also provide the height at which this is measured. Instantaneous value required.	Description: Ambient temperature. Also provide the height at which this is measured.	Added ambient temperature. Removed instantaneous value required as it is specified in “Wind farm SCADA to AEMO”.
Provide Historical SCADA measurements since the beginning of operation of the wind farm	Description: Only applicable if an operational wind farm is registered as a scheduled or semi-scheduled generator or a Non-scheduled wind farm expanding to >= 30MW registered capacity and thereby creating a need for their output to be forecast. Time resolution should be same as SCADA.	Description: Only applicable if an operational wind farm is registered as a scheduled or semi-scheduled generator or a Non-scheduled generating unit expanding to >= 30MW Nameplate Rating and thereby creating a need for their output to be forecast. Time resolution should be same as current SCADA. If this time resolution is not available, 1 minute averages will suffice.	Clarifying required time resolution.
Wind Farm Control System Set-Point	Description: MW set-point applied in the wind farm's control system to limit (down regulate) its output to at or below the level required by AEMO or the NSP. At other times when no limit applies, the set-point to be set to above the wind farm's registered maximum capacity, but below 250% of it. Control system set-point quality flag and control system operation status (On/Off) is also to be provided via SCADA.	Description: MW set-point applied in the wind farm's control system to limit (down regulate) its output. At other times when no limit applies, the set-point to be set to above the wind farm's Nameplate Rating, but below 250% of it.	Removes any confusion regarding AEMO or NSP limits. AWEFS wants to know if the farm is limiting its output, not why. Quality flag is not provided by the participant, so it has been removed to avoid any confusion. Control system operation status (On/Off) is not used by AWEFS and has been removed from description.
SCADA data available from this windfarm	Description: SCADA readings as per Rules S5.2.6 to be provided	Description: SCADA readings not listed above, if any, to be provided as per National Electricity Rules S5.2.6.	Clarified in addition to those not mentioned above. This item has been moved to the bottom of Wind farm SCADA to AEMO section for greater readability.

Data type	Original	New	Comment
If the wind farm is not in operation yet, provide historical wind measurements from the site	Data Type deleted		Mostly not supplied and not used by AWEFS.
ECM Data Template Cluster			
Data pertaining to a particular cluster has been moved from the ECM data template into a separate tab. If there is more than one cluster, repeat the sheet into a separate tab.			
ID of this Wind Turbines Cluster	Unique ID(s) of the cluster(s) of wind turbines in the farm to be provided by the participant. Maximum 10 characters allowed. Example- SYDWND_CL1, SYDWND_CL2. Cluster ID(s) to be same as specified in the Registration process	Unique ID of the cluster of wind turbines in the farm to be provided by the participant. Maximum 10 characters allowed. Example- SYDWND_CL1. Cluster ID to be same as specified in the Registration process	Cluster information has been separated into a tab. For multiple clusters the table can be repeated into a separate tab. Therefore, plural to singular language changes have been made and the example has been changed accordingly.
Manufactures' power vs. wind speed characteristic curve	Description: Provide the characteristic curve of the type of wind turbines in this cluster using the turbine curves table attached. This is the basic power curve provided by the manufacturer. Curve of id 6, in the template provided, is estimated for the wind farm taking into account wake effects.	Description: Provide the characteristic curve of the type of wind turbines in this cluster using the turbine curves table attached. This is the basic power curve provided by the manufacturer.	Delete outdated reference
Directional Power Curve	Description: These are characteristic curves that give the power output of the wind farm cluster as a function of wind speed and wind direction. Such curves are dependent on the specific wind farm cluster as they account for wake effects. Please provide in separate file (e.g. WASP format). This should be consistent with information provided in Generating System Design Data Sheets section 12.4.1 page 59 - power curve	Description: These are characteristic curves that give the power output of the wind farm cluster as a function of wind speed and wind direction. Such curves are dependent on the specific wind farm cluster as they account for wake effects. Please provide in separate file (e.g. WASP format). This should be consistent with information provided in Generating System Design Data Sheets section 12.4.1 page 58 - power curve	Corrected reference from pg. 59 to pg.58
Turbine Nameplate rating	Data type: Nominal power Description: The nominal power of that type of turbine (kW). This should be consistent with information provided in Generating System Design Data Sheets section 7.1.1, page 21	Data type: Turbine nameplate rating Description: The nameplate rating of that type of turbine (kW). This should be consistent with information provided in Generating System Design Data Sheets section 7.1.1, page 21	Changed data type and description for consistency with supplementary documentation.
Maximum Power	Data Type: Maximal Power. Units: W Description: The maximal power a turbine of that type can produce (kW). This should be consistent with information provided in Generating System Design Data Sheets section 7.1.1, page 21	Data Type: Maximum Power. Units: kW Description: The maximum power a turbine of that type can produce (kW). This should be consistent with information provided in Generating System Design Data Sheets section 7.1.1, page 21	Changed 'maximal' to 'maximum' for consistency with supplemental data. Changed units to kW so that the units matched those described in the description and that of data type: Nominal Power.

Data type	Original	New	Comment
Rated Speed	N/A	Corrected reference from pg. 58 to pg. 57.	Incorrect reference provided.
Cut-in speed	N/A	Corrected reference from pg. 58 to pg. 57	Incorrect reference provided.
Cut-out speed	N/A	Corrected reference from pg. 58 to pg. 57.	Incorrect reference provided.
Restart after cut-out wind speed	Reference deleted: “This should be consistent with information provided in Generating System Design Data Sheets section 12.4.1, page 58 and 59”	N/A	Reference to “restart after cut-out wind speed” does not exist.
Cluster SCADA		Description: Unless otherwise stated, instantaneous measurements are required. Instantaneous means values updated at least every 4-10 seconds. If only averages are available, maximum 15-second average update is required.	Description added for clarification in instantaneous vales.
Cluster active power	Data Type: Wind power data. Description: Total cluster power	Data Type: Cluster active power. Description: Total cluster active power	Changed data type and term in description for consistency.
Number of wind turbines available for generation data	Data Type: Number of wind turbines in operation data. Description: As number of turbines available for generation	Data Type: Number of wind turbines available for generation data. Description: number of turbines available for generation. This definition is the summation of: • Turbines operating • Turbines available to operate, but not operating due to ambient conditions (very low / high wind speeds, ambient temperature) • Turbines available to operate, but paused due to down regulation. This definition excludes all the following cases: • Turbines under maintenance or repair • Turbines with a fault or damage • Turbines not yet built • Transmission/distribution network not available	Same description as for farm level.
Number of wind turbines actively generating	Description: As number of turbines in operation, i.e. generating	Description: As number of turbines actively generating power.	Clarification that this section only refers to turbines actively generating power.
Wind Farm Control System Set-Point at cluster level (if any)	item deleted	N/A	Not used by AWEFS.

Data type	Original	New	Comment
Wind Speed Data	Description: Also provide the height at which this is measured. 10 min averages acceptable.	Description: Wind speed measurements from turbine nacelle anemometers much preferred over measurements from meteorological mast(s). Also provide the height at which this is measured.	10 minute averages are not acceptable, refer to "Cluster SCADA" for acceptable sampling. Changed description to be similar to wind speed data at farm level.
Wind Direction Data	Description: Also provide the height at which this is measured.10 min averages acceptable. Units: Decimal Degrees Lat/Lon	Description: Wind direction measurements from turbine nacelle anemometers much preferred over measurements from meteorological mast(s) Also provide the height at which this is measured. Units: degrees true (º)	10 minute averages are not acceptable, refer to "Cluster SCADA" for acceptable sampling. Changed description to be similar to wind direction data at farm level. Corrected units from lat/lon to degrees true.
Temperature Data	Row Deleted	N/A	A single temperature measurement for the whole farm is sufficient, therefore temperature data at cluster level is not required.
	Turbine Curves table		
Wind Turbine Characteristic curves	N/A	Added second wind speed column	Thrust curves don't always have same wind speed steps.

Table 4 Changes made to Energy Conversion Model for Solar Farms

Parameter	Original	New	Comment
	Introduction tab		
Cluster definition	The same number of modules connected to each inverter, if any inverters.	The same combination and number of modules connected to each inverter, if any inverters.	Added as was already defined in PV tab
Cluster definition example 1	Solar PV without tracking, one module type and one inverter type for the entire facility.	Solar PV without tracking, one module type and one inverter type for the entire facility, same number of modules connected to each inverter	Further clarification
Cluster definition example 2	The combination of module types must be identical for all inverters in that cluster. If this occurs, then all parameters related to modules must be specified for each module type. For example, one cluster has 3 modules of Type A and 4 modules of Type B connected to all inverters in the cluster. If other module configurations exist (e.g. 8 modules of Type A and 2 modules of Type B), they should be listed in a different cluster.	The combination of module types must be identical for all inverters in that cluster. All parameters related to modules must be specified for each module type. For example, one cluster has 3000 modules of Type A and 4000 modules of Type B connected to each inverter in the cluster. If other module configurations exist (e.g. 8000 modules of Type A and 2000 modules of Type B), they must be in a different cluster.	Further clarification and more realistic numbers.
ECM PV, ECM CPV & ECM CST tabs			
The following changes apply to all of non-concentrating, concentrating, and concentrating solar thermal farms unless otherwise stated.			
Columns F and H have been removed as the discussion paper is no longer relevant and the accuracy considerations are empty.			
The required column previously had required/not required in cells. For consistency with wind ECM, these cells have been changed to yes/no.			

Parameter	Original	New	Comment
N/A	Subheading: Facility	Subheading: Solar farm identification	More descriptive subheading
DUID	Parameter name: Facility ID Description: The MMS ID provides access to station data held in the MMS. MMS-specific data is not repeated here.	Parameter name: DUID Description: DUID of the solar farm to be proposed by the participant. Maximum 8 characters allowed. Example - SYDNSLR. NOTE: DUID to be same as specified in the Registration process.	N/A
Facility Name	N/A	Description: Name of the Solar farm. To be same as specified in the registration process.	Description added
Region	Description: Name of NEM region of the facility.	Description: Name of NEM region of the facility. To be same as specified in the registration process.	
N/A	N/A	Subheading: Solar farm nominal data	Subheading added
Nameplate rating	Parameter type: Registered capacity Description: Total installed capacity of the facility.	Parameter type: Nameplate rating Description: This Item corresponds to "Nameplate Rating" in Sections C and I.5 of "Application for Registration as a Generator in the NEM."	Clarification of what is being asked. Reference provided.
Maximum Capacity	N/A	Description: Maximum generation to which the semi-scheduled generating unit may be dispatched. This definition can be found in sections C, I.4 and I.5 of "Application for Registration as a Generator in the NEM",	Added new data type for cases where maximum capacity is different to nameplate rating. Reference for consistency with supplementary documentation. This is a required item.
N/A	N/A	Subheading: Solar farm status	Subheading added
Status of the solar farm	Parameter type: Facility status Description: Allows non-operational data to be filtered from operational data for historical analysis.	Parameter type: Status of the solar farm Description: Status of the solar farm.	Parameter type changed for consistency with wind ECM. Removed remark regarding filtering data as it is not accurate.
Facility connection date	Parameter deleted.	N/A	Due to addition of the two items below, facility connection date has been deleted.
From which date is or will the solar farm be fully operational?	N/A	Description: Provide the plan for progressive commissioning of the solar farm with expected dates of commissioning	New required parameter to replace ‘facility connection date’
From which date will the solar farm be first connected to the grid or energised?	N/A	Description: Provide the date when the solar farm is expected to commence generation.	New required parameter to replace ‘facility connection date’
N/A	N/A	Subheading: Solar farm location and terrain data	Subheading added
Facility Altitude	Units: m	Units: m ASL	Units relevant to altitude measurement
Facility time zone	Description: Calculable from latitude and longitude	Description: Facility time zone	Not really “calculable”, description is not important and not required

Parameter	Original	New	Comment
N/A	N/A	Subheading: Solar farm miscellaneous	Subheading added
Solar farm SCADA to AEMO	heading: Dynamic parameters Description: Parameters that continually update Interval periods specified here denote sampling intervals of measurements. Aggregation of the measured data will be done by MMS or the ECM.	Heading: Solar farm SCADA to AEMO Description: Unless otherwise stated, instantaneous measurements are required. Instantaneous means values updated at least every 4-10 seconds. If only averages are available, maximum 15-second average update is required	Description added to specify instantaneous values are required along with a definition of instantaneous.
This change applies to the following parameters: Ambient temperature Wind speed Wind direction Relative humidity Barometric pressure	Description: Per facility	Description: To be representative of the whole solar farm	Description changed for transparency that the measurement will be used as a representation for the entire facility.
Solar farm control system set-point	Data type: Active power control set point Description: Per facility	Data type: Solar farm control system set-point Description: MW set-point applied in the solar farm's control system to limit (down regulate) its output. At other time when no limit applies, the set-point to be set to above the solar farm's nameplate rating, but below 250% of it.	Improved definition of solar farm control system set-point.
Local limit	N/A	Description: In MW, the lower of plant availability and of the limitation on capacity of connection assets on the export of energy from the solar farm. When implemented in ASEFS1, the Local Limit is used to cap the UIGF for the solar farm in the dispatch timeframe. The Local Limit excludes limits on a transmission network and distribution network (as required by clause 3.7B(c)(6) of the Rules) or limits otherwise agreed to be managed by AEMO.	New required SCADA item to deal with local limitations
Possible power	N/A	Description: The estimate by the solar farm's control system of active power (in MW) available from the current solar resource and available generation plant.	New optional SCADA item to take into account farms control system 'possible power' output.
Reactive power generation	N/A	Description: Per facility	Description added
Number of inverters available	Description: Per cluster The number of inverters that are available to deliver power if sufficient sunlight is available	Description: Per cluster The number of inverters that are available to deliver active power if sufficient sunlight is available	Added "active" for clarification

Parameter	Original	New	Comment
Number of turbines available (ECM CST only)	Description: Per cluster	Description: Per cluster The number of turbines that are available to deliver active power if sufficient sunlight is available	Added similiar description as PV and CPV.
Trackers online	N/A	Description: Per cluster	Added description.
Cluster specific details have been moved to separate tabs. The following changes apply to all ECM PV Cluster, ECM CPV cluster & ECM CST cluster tabs unless otherwise stated.			
N/A	N/A	Subheading: cluster identification	New subheading
Cluster ID	Description: Unique ID of cluster.	Description: Unique ID of the cluster in the farm to be provided by the participant. Maximum 10 characters allowed. Example- SYDSLR_CL1. NOTE: to be same as specified in registration process	Added for consistency with wind ECM Guidelines.
N/A	N/A	Subheading: Cluster Characteristics	New subheading
Technology type (PV only)	Data type: Descriptive string. E.g. {PV static, PV single axis azimuth, PV single axis altitude, PV dual axis}	Data type: Descriptive string. E.g. {PV static, PV single axis azimuth tracking, PV single axis slope tracking, PV dual axis tracking}	Data type changed to wording used elsewhere
Technology type (CPV only)	Data type: Descriptive string. E.g. {CPV static, CPV single axis azimuth, CPV single axis altitude, CPV dual axis}	Data type: Descriptive string.	Left open for the possibility of other technology types.
Inverter manufacturer (Not CST)	N/A	Required: Yes	Yes was missing
Inverter model ID (Not CST)	N/A	Required: Yes	Yes was missing
Total DC power of modules in cluster (Not CST)	N/A	Description: The total sum DC nameplate rating of all modules in this cluster, used for cross-checking and documenting overprovisioning ratio	New required parameter.
Total DC power of inverters in cluster (Not CST)	N/A	Description: The total sum DC nameplate rating of all inverters in this cluster, used for cross-checking and documenting overprovisioning ratio	New required parameter.
Total AC power of inverters in cluster (Not CST)	N/A	Description: The total sum AC nameplate rating of all inverters in this cluster, used for cross-checking and documenting overprovisioning ratio	New required parameter.

Parameter	Original	New	Comment
Slope tracking direction	N/A	Description: Direction in which slope tracking is done. Specify "north-south" if panels are tilted in the north/south direction over an east-west axis. Specify "east-west" if panels are tilted from east to west over a north-south axis. For any other angles/cases, specify the compass orientation of the tracking (see "azimuth", perpendicular to axis' compass orientation) and attach additional information on the tracking	New required parameter. Allow further descriptive detail for slope tracking
Inverter (Not CST)	Description: Parameters that apply to an inverter Please copy this section of the sheet for each inverter of the cluster.	Description: Parameters that apply to an individual inverter Please copy this section of the sheet for each inverter of the cluster.	This is not about inverter type, but the individual inverter.
Centre altitude of modules connected to inverter (Not CST)	Units: metres	Units: m ASL	Changed units so that they are appropriate for altitude.