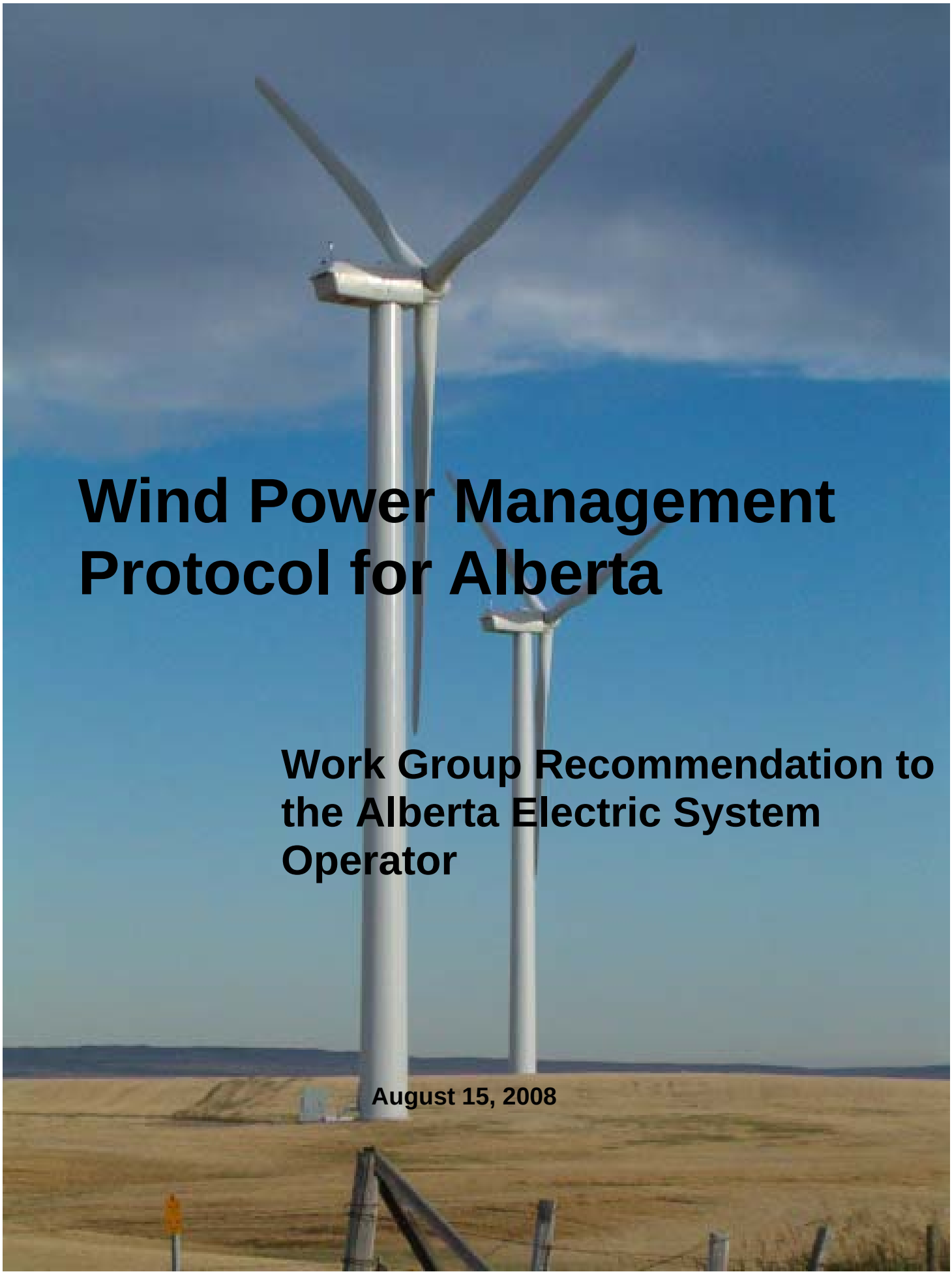

Wind Power Management Protocol for Alberta

Work Group Recommendation to the Alberta Electric System Operator

August 15, 2008

Executive Summary

Around the world the interest in, and development of, wind power continues to grow. As a power source, wind power holds great potential for Alberta. Alberta has adopted a leadership position in wind power development in Canada reaching approximately 545 MW or 5.6 %[1] of 2007 peak load.

There are some key wind power attributes that make managing the system reliably more challenging. These attributes include:

- potential for extremely fast ramps (increases or decreases)
- potential for unpredictable wind (fuel source uncertainty)
- potential for output variability and
- potential for production uncorrelated with load.

The AESO developed and finalized its Market & Operational Framework for Wind Integration in Alberta (MOF) to address these challenges in September of 2007. A key component of the MOF was that, after other mitigation tools have been used to the extent they are available, the system operator will use wind power management to maintain supply-demand balance and/or restore system reliability.

The AESO indicated at that time that it intended to use work groups, where it made sense, and that the purpose for those groups was to gain insight and input to assist the AESO in developing recommendations for full industry consultation. A Wind Power Management Protocol work group was formed and their recommendations follow.

Work Group Recommendation to the AESO

After examining different protocols, most work group members recommend that when wind power management is required the AESO should use pro-rata allocation protocol based on the Potential MW Capability[2] of the wind power facilities. Based on manufacturer feedback, the Potential MW Capability at this time could be out by ten (10) to fifteen percent (15%) of the real time WPF MW output. However, the Potential MW Capability is still representative of changing wind conditions and would lead to a more equitable allocation of the System Wind Power Limit (SWPL). Wind turbine manufacturers have also indicated that they can calculate the Potential MW Capability and telemeter this to the system operator giving a high degree of confidence in the ability to implement this option. Finally, the Potential MW Capability at this time requires only the use of the power limiting control feature at the WPFs.

[1] 5.6 percent determined as 545 MW of wind power capacity serving a peak system load of 9710 MW.
[2] The Potential MW Capability is the wind power that would have been produced at the point of interconnection without wind power facility curtailment

The work group recommends that once WPM is activated on the WPFs that the SC should re-assess and re-allocate, where required, every twenty (20) minutes if any one of the WPFs limits has changed by five (5) MW or more.

The work group concluded that the recommended protocol would limit the wind generation as to not exceed the system controller's system wind power limit and based on manufacturer feedback, the telemetered Potential MW Capability is reasonable for operational use.

- and, therefore, supports reliable operations,
- With the appropriate tools, this protocol is efficient in limiting wind generation to the required SWPL,
- The recommended protocol efficiently delivers the required SWPL while minimizing lost production from the wind power facilities,
- A pro rata based allocation methodology is fair and consistent with in market pro rata allocations. The allocation of lost opportunity (wind power curtailment) amongst the WPFs is fair.
- Continuous assessment and re-allocation of the power limits to the wind power facilities addresses and leverages diversity to the extent it exists.

TABLE OF CONTENTS

List of Figures

1.0 INTRODUCTION

Around the world the interest in, and development of, wind power continues to grow. As a power source, wind power holds great potential for Alberta. Alberta has adopted a leadership position in wind power development in Canada reaching approximately 545 MW or 5.6 %[3] of 2007 peak load.

There are some key wind power attributes that make managing the system reliably more challenging. These attributes include:

- potential for extremely fast ramps (increases or decreases)
- potential for unpredictable wind (fuel source uncertainty)
- potential for output variability and
- potential for production uncorrelated with load.

These operational challenges may appear across all time frames, from seconds to minutes to hours. Limited interconnections and a predominant thermal supply portfolio limit Alberta's ability to 'share' or dampen the wind power variability and, in turn, limit resources and practices used to maintain supply-demand balance. The variability of wind power increases supply uncertainty. As such, faster responding resources and new policies and procedures are needed to maintain supply-demand balance.

The AESO developed its Market & Operational Framework for Wind Integration in Alberta (MOF) to address these challenges. The MOF established the mitigation tools that the AESO will use to manage wind power reliably and in a fair, efficient and openly competitive manner as well as how associated costs will be allocated.

A key component of the MOF was that, after other mitigation tools have been used to the extent they are available, the system operator will use wind power management to maintain supply-demand balance and/or restore system reliability. Specifically the MOF stated:

> *"ISO Rule 6.7 requires the system controller to "issue directives to market participants as required to prevent a threat to system security or to return the AIES to a safe and reliable state"[7] and requires market participants to "use reasonable efforts to comply with directives from the system controller to prevent a threat to system security or to assist in the recovery from or return the AIES to a safe and reliable state."[8]*
>
> *In situations where the system cannot absorb all the forecasted or actual wind power generated, maintaining system security will call for wind power to be dispatched down, ramp rate limited or dispatched off. To do this, wind power facilities will be required to have power management capabilities, including Power Limiting and/or Ramp Rate Limiting. Power Limiting is the capability to limit power at the facility to a specified level*

[3] 545 MW serving a peak system load of 9710 MW.

while Ramp Rate Limiting is the capability to control the rate at which wind power increases or decreases. Both are designed to control real time wind production levels."

The MOF was finalized in September 2007 at which time the AESO also introduced to stakeholders a plan which identified a series of work streams necessary to implement the MOF. The AESO indicated at that time that it intended to use work groups, where it made sense, and that the purpose for those groups was to gain insight and input to assist the AESO in developing recommendations for full industry consultation.

One of the work streams was Wind Power Management (WPM) established to develop requirements for WPM. That work stream has three "sub" groups focused on:

1. Wind Power Management Protocol (WPMP) – how to allocate wind power reductions once they have been identified as needed

2. Supply Surplus - $0 curtailment (OPP 103) – one of the triggers for wind power reduction – when – allocation of power reduction among all $0 offers.

3. Technical Standards – what technical requirements are needed for wind power facilities (WPF) to meet power management requirement.

The contents of this document are related to the first initiative, Wind Power Management Protocol.

2.0 WPM Protocol Work Group

2.1 Background & Scope:

The work group for WPMP was formed in November 2007 to assist the AESO in developing technically feasible and reasonable protocols for use of ramp rate limiting and/or power limiting among wind power facilities and to do so using the AESO's ADaMs[4] (Automated Dispatch and Messaging System). The protocol will determine the allocation of overall wind power reduction or restoration among wind facilities. In other words, the protocol will determine and communicate the MW level each facility is being dispatched on (or activated) or dispatched off (de-activated).

Automatic control of WPFs by the AESO and use of the protocol to deal with local congestion management were deemed out of scope. In addition, it was decided that the work group should not debate and discuss the systems conditions that would result in the activation of WPM or in the determination of the System Wind Power Limit (SWPL). Instead the focus was on, once WPM is activated, what is the most reliable, fair, efficient and openly competitive protocol to bring total wind power production down to the SWPL and to maintain the SWPL until it is removed by the System Controller.

[4] Currently ADaMS requires a ten (10) minute compliance timeframe

Grandfathering and potential exemptions were considered by the Work Group who decided, while it is important to deal with grandfathering or exemptions somewhere at some time, development of the best protocol should not be materially impacted by the amount of wind power.

A “parking lot” concept was used to capture items raised for consideration by the AESO. The following are the items captured in the “parking lot”, however they are not part of this paper.

- Negative pool price to manage supply surplus
- Compensation for dispatch down to manage as a reciprocal to buying Ancillary Services to supplement needed supply
- Allowing wind facilities to price offers and set price

Terms of Reference including representation on the work group can be found in Appendix A.

2.2 Objectives:

System Wind Power Limit (SWPL) is the maximum amount of wind power than can be reliably accommodated based on the capability of the Energy Market Merit Order (EMMO) and Ancillary Services (AS). The SWPL will be a specific number which will then be allocated to the individual wind power facilities. The SWPL will be determined with software tools that monitor and evaluate the Energy Market Merit Order (EMMO), Ancillary Services (AS), interconnections and load and wind power forecasts. These conditions are used to determine the SWPL.

The objective of the protocol is to take the SWPL and determine what each WPF needs to contribute. Once the SWPL is determined, wind power curtailments and the associated allocation are communicated.

At a minimum, the protocol must be able to be used in the following conditions:

- Forecast loss of wind and insufficient flexibility of the energy market
- Forecast loss of wind and insufficient ancillary services or ramping services
- Insufficient ancillary services due to market conditions or emergency conditions (e.g. SCADA failure)
- Unforeseen (i.e. not forecasted) wind conditions such as a microburst
- Disturbance and emergency conditions – wind may be dispatched off during islanding conditions or system emergencies where wind variability cannot be tolerated”

- The AESO is also developing a transmission congestion protocol where WPM might be used.

For example, supply surplus conditions could develop from conditions such as wind power ramping up when load ramps down. In addition, wind power forecasts could require the AESO to dispatch the energy market merit order up in advance of a predicted loss of wind power to ensure there are sufficient resources available in time. Advanced curtailment of wind power is to accommodate the flexibility and ramping speed of dispatched generation and ancillary services available.

The conditions used to determine SWPL will change over time and will need to be managed until such time that the EMMO and AS are sufficient to restore system conditions to normal Wind power curtailment may be required for a number of reasons.

2.3 Evaluation Criteria:

Some key considerations in the development of this recommendation include the following:

- This recommendation is for wind power management for system wide conditions such as supply surplus and wind power ramping conditions. However, this protocol could be used to allocate and re-allocate wind power facility limits to two or more WPFs during a constrained period of more the twenty (20) minutes.

- Subject to any considerations regarding grandfathering or exempting certain WPF, all remaining WPFs are treated the same through pro-rata dispatch with no regional or grouping constraints to address regional problems.

- The Work Group discussed examples such as the south west ramping up first and the EMMO and ancillary services able to accommodate this ramp and change in MW, then the south central and south east start to ramp up and the EMMO and AS are unable to accommodate these MW. This type of consideration could penalize wind power facilities that are more often the last to ramp up.

The criteria the work group used to evaluate options were:

1. Reliability: ability to ensure wind generation does not exceed the system controller's SWPL

2. Fairness**:** ability to consistently share the lost opportunity (wind power curtailment) amongst WPFs and avoid non complying WPFs generating less than their share causing other WPFs to exceed their share of the required curtailment.

3. Efficiency: ability to meet the SWPL with the least amount of lost production to the wind power facilities.

4. Diversity**:** ability to manage changing wind generation conditions that can occur from geographic dispersion of WPFs.

In addition, the following were considered in the work group's evaluation:

- Minimum stable operation of a WPF,
- Safety and environmental hazards,
- Conditions for dispatch versus directive,
- Capability to comply, and
- Duration and amount

The duration and level of wind power curtailments are important to wind power facilities and developers as well as system operators. The following circumstances and uncertainties, outside anyone's control, affect the requirement for WPM:

- Weather and wind conditions, weather predictions and wind power forecasts
- market participants' offer strategies - market participants establish the flexibility, ramp rate capability and the offers including $0 offers for their generating units,
- real-time characteristics of generation facilities.

2.4 Alternatives Considered:

The Work Group (WG) considered and evaluated two protocols to implement power limiting and allocate among individual wind power facilities (WPFs):

- Potential MW Capability Based Curtailment Protocol
- Maximum Continuous Rating (MCR) Based Curtailment Protocol.

Potential MW Capability:

The Potential MW Capability is the wind power that would have been produced at the point of interconnection without wind power facility curtailment. The Potential MW Capability of a WPF can also be considered the energy 'offered' by the WPF. Curtailment protocols such as transmission congestion management are often based on energy offers. Thus when no power limiting is in effect, the potential MW and actual MW would be the same, when a WPF is curtailed (the WPF spilling wind), the actual MW will be less than the potential MW.

The Potential MW Capability is a telemetered quantity from the WPF to the AESO and is based on current meteorological data and turbine availability at the WPF, thus it is not a forecast.

This protocol allocates SWPL pro-rata based on each WPF's Potential MW Capability. For example, there are two WPFs, WPF_A has a 60 MW maximum capability operating at 50 MW and WPF_B has a 90 MW maximum capability operating at 10MW. The initial pro-rata allocation would be:

Power Limit $_{WPF}{}^{A}$ = SWPL * 50MW / (50MW+10MW)

= SWPL * 83.3%

Power Limit $_{WPF}{}^{B}$ = SWPL * 10MW / (50MW+10MW)

= SWPL * 16.7%

Once WPM is invoked the actual MW will not exceed the WPF Power Limit. The Potential MW will be determined for each WPF and should any change, particularly when the Potential MW is greater than the WPF Power Limit, the allocation could be re-calculated and re-allocated.

For example, assume that the SWPL remains the same however the Potential MW for the 60 MW MCR facilities increased from 50 to 60 MW and the Potential MW for the 90 MW MCR facility increased from 10 to 80 MW.

The next iteration of the allocation would be;

Power Limit $_{WPF}{}^{A}$ = SWPL * 60MW / (60MW+80MW)

= SWPL * 42.8%

Power Limit $_{WPF}{}^{B}$ = SWPL * 80MW / (60MW+80MW)

= SWPL * 57.2%

Appendix C includes a summary of observations and the pros and cons with this protocol. In general, the work group felt that this protocol could deal with changing wind conditions assuming re-dispatching of the WPF limits. It was also seen as more consistent with curtailment based on offers. Finally, the work group felt this protocol caused the least amount curtailment from the WPFs.

.

Protocol #2: MCR Capability: All generating assets have a Maximum Continuous Rating or MCR. For wind power assets the MCR is a 'virtual' energy 'offer' from a WPF the turbine availability and the net-to-grid MW capability should each available turbine operate at full MW. A simple MCR is the based on all turbines being available. A more complex MCR would be a real-time determination based on real-time availability of the turbines.

Protocol #2 allocates SWPL among WPFs based on each facility's MCR, energy 'offered' and used in transmission congestion management. The allocation is pro-rata with the "share" of a facility is based on MCR. For example, there are 2 WPFs, WPF $_{A}$ has a 60 MW maximum capability and WPF $_{B}$ has a 90 MW maximum capability. The pro-rata allocation would be:

Power Limit $_{WPF\ A}$ = SWPL * 60MW / (60MW+90MW)

= SWPL * 40%

Power Limit $_{WPF\ B}$ = SWPL * 90MW / (60MW+90MW)

= SWPL * 60%

Appendix C includes a summary of observations and the pros and cons with this protocol. In general it was felt that this protocol was simple and easier to implement. The protocol did not deal with changing wind conditions and could result with uneven loss of curtailment amongst the WPFs.

3.0 RECOMMENDATIONS

After examining different protocols, most work group members recommend that when WPM is required the AESO should use pro-rata allocation protocol based on the Potential MW Capability of the wind power facilities. Based on manufacturer feedback, the Potential MW Capability at this time could be out by ten (10) to fifteen percent (15%) of the WPF MW output. However, the Potential MW Capability is still representative of changing wind conditions and would lead to a more equitable allocation of the SWPL. Wind turbine manufacturers have also indicated that they can calculate the potential MW capability and telemeter this to a system operation giving a high degree of confidence in the ability to implement this option. Finally, the Potential MW Capability at this time requires only the use of the power limiting control feature at the WPFs.

The following figure is used to illustrate the concepts of Potential MW Capability, actual MW production and lost opportunity production.

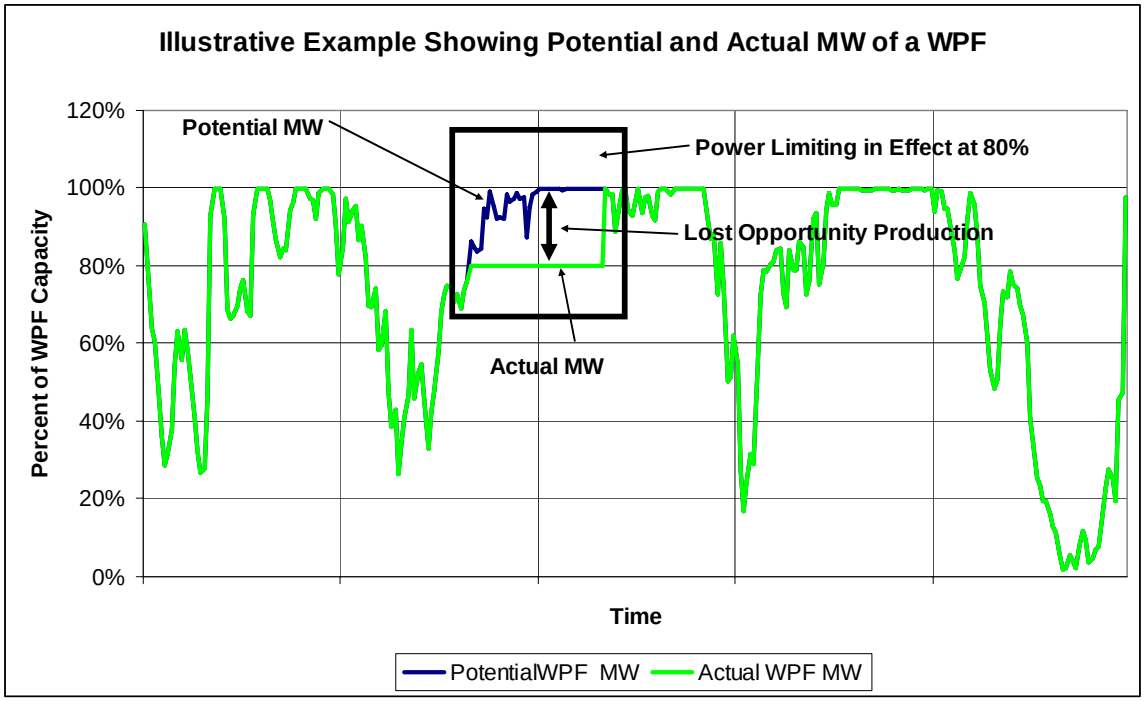

Figure 1 – Illustrative Example of Potential and Actual MW

The work group recommends that once WPM is activated on the WPFs that the SC should re-assess and re-allocated, where required, every twenty (20) minutes if any one of the WPFs limits has changed by five (5) MW or more.

The work group concluded that the recommended protocol best met the evaluation criteria:

Wind generation would not exceed the system controller SWPL and based on manufacturer feedback, the telemetered Potential MW Capability is reasonable for operational use[5].

- and, therefore, supports reliable operations,
- With the appropriate tools, this protocol is efficient in limiting wind generation to the required SWPL,
- The recommended protocol efficiently delivers the required SMPL while minimizing lost production from the wind power facilities,

[5] Based on manufacturer feedback, the Potential MW Capability at this time could be out by ten (10) to fifteen percent (15%) of the WPF MW output. However, the Potential MW Capability is still representative of changing wind conditions and would lead to a more equitable allocation of the SWPL.

- A pro rata based allocation methodology is fair and consistent with in market pro rata allocations. The allocation of lost opportunity (wind power curtailment) amongst the WPFs is fair.

- Continuous assessment and re-allocation of the power limits to the wind power facilities addresses and leverages diversity to the extent it exists.

4.0 POTENTIAL MW CAPABILITY PROTOCOL DETAILS

The AESO will have tools (such as the Dispatch Decision Support Tool) that will examine the system and market conditions and consider an appropriate SWPL for wind generation as necessary. The SWPL will be activated or deactivated and the tool will allocate the curtailment or restoration to the wind power facilities, according to established wind power management protocol. The procedures that caused the need for a limit on wind power are the same procedures that would be reversed to restore the SWPL.

More specifically, if the SWPL is used to manage Supply Surplus, the SC will release or increase the SWPL by reversing out of the supply surplus procedures as able to do so reliably. Similarly, if the SWPL was used to manage an unforeseen ramping event, the SC will dispatch the EMMO until such time that the SWPL can be removed, subject that no other procedures such as Supply Surplus come into affect.

However, the restoration of SWPL used to manage disturbances or emergencies, will be gradual once the disturbance or emergencies conditions subside and wind power can be accommodated and wind power management used for local conditions will be addressed in the specific policies dealing with such conditions.

Each WPF's allocation will be issued to the wind power operators using the AESO's Automatic Dispatch and Messaging System (ADaMs). The WPFs will be required to comply with the power limits to their facilities within ten (10) minutes of an ADaMs directive (activate or deactivate) and as required by OPPs.

SCADA system between the WPF and the AESO will provide a status indication to the AESO that the Power Limiting is in effect and a telemetered value of the power limit. The "tools" at the AESO's System Coordination Centre will receive data and monitor the Potential MW Capability and Actual MW on the WPFs based on that SCADA data.

The following figure illustrates the proposed implementation of the wind power management protocol.

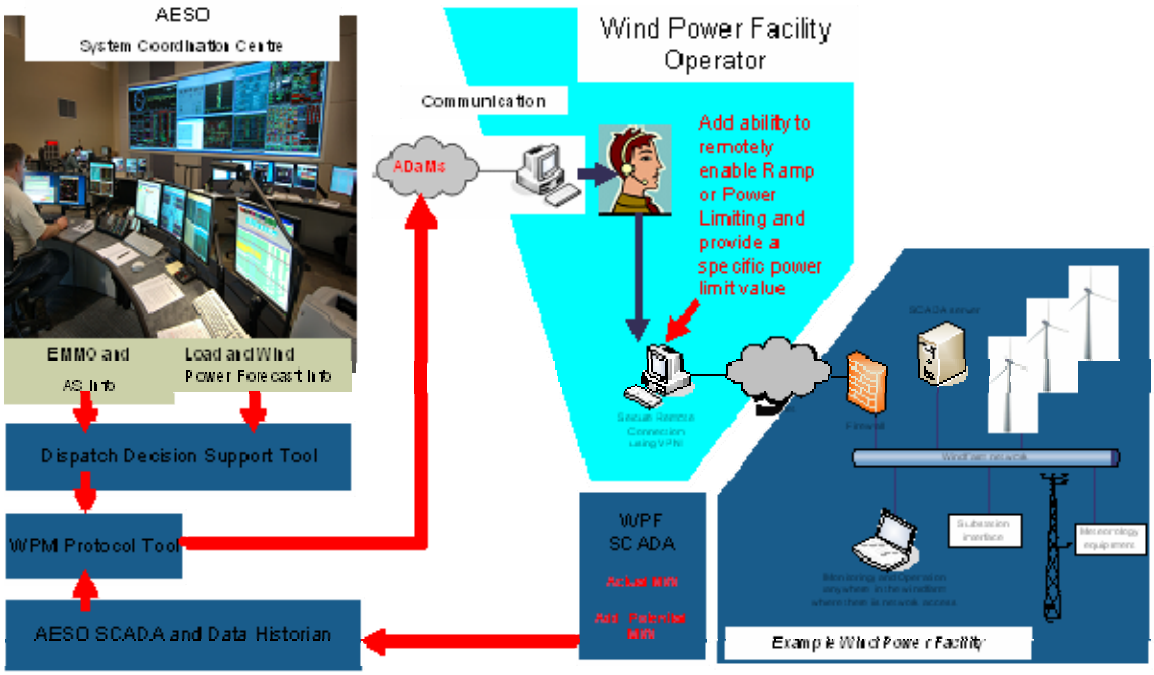

Figure 2 – Pictorial View of Implementing Wind Power Management

If the SWPL is in effect for twenty (20) minutes the "tools" will re-calculate WPF limits based on the new Potential MW Capability and determine any changes to WPF limits if outside a reasonable tolerance. A WPF limit must change by more than five (5) MW to result in a re-allocation. Under these conditions, the tools will automatically issue a message to the SC to re-allocate the updated WPF limits.

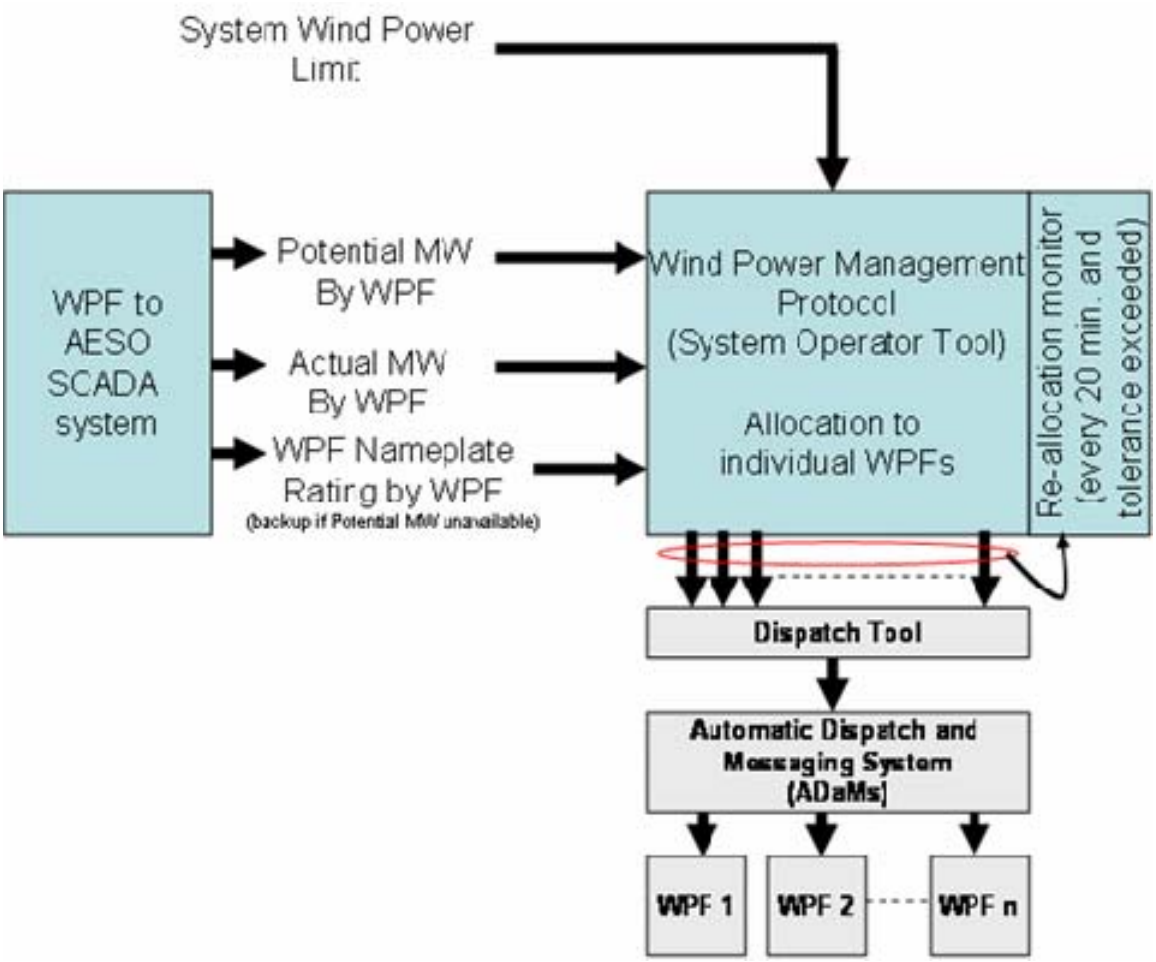

Figure 3 – Re-Allocation

When wind power management is activated and wind power is curtailed, the ability to determine a facility's current real-power capability is lost to the AESO. However, there is a way to determine what the real-power would have been if wind power management had been de-activated. This is calculated using the wind power facility turbine capacity availability and appropriate meteorological conditions to the wind power facility. This calculation is referred to as the Potential MW Capability (or Available MWs / Possible MWs as described by some wind turbine manufacturers).

It is common practice to have backup plans for any protocol as telemetry and SCADA problems can occur. The backup plan is to re-allocate based on MW output of the facility in the event the Potential MW is unavailable or erroneous[6].

[6] Erroneous can be assessed from the SCADA data quality flags or when the Potential MW and actual MW are different by more than 15% during unconstrained conditions.

Appendix A

Definitions and Descriptions of Terminology

- Activated: control of the wind power management system being used in the AIES to control the MW output of the wind turbines to its allocated limit.
- Alberta Interconnected Electric System (AIES): as per AESO rules.
- Automated Dispatch and Messaging System (ADaMS): as per AESO rules.
- De-activated: control of the wind power management system being used in the AIES to control the MW output of the wind turbines to its restored limit.
- Energy Market Merit Order (EMMO): This represents the offer blocks bids greater than $0 from the dispatchable generators.
- Market and Operational Framework (MOF): as found on the AESO website http://www.aeso.ca/downloads/MOF_Final__Sept26.pdf.
- Maximum Continuous Rating (MCR): as per AESO rules.
- Operating Policies and Procedures (OPP): as per AESO rules.
- Potential MW Capability: the real-time, real-power capability of the WPF if no power limiting was in effect at the WPFs.
- Supervisory Control and Data Acquisition (SCADA): as per AESO rules.
- System Controller (SC): as defined in the AESO rules.
- System Wind Power Limit (SWPL): the value expressed in MW that the System Controller (SC) is able to accommodate the AIES.
- Transmission facility owner (TFO): as per AESO rules.
- Wind Power Management (WPM): equipment at a WPF used for ramp rate limiting, power limiting or power reductions to over frequency conditions.
- Wind Power Facility (WPF): any wind turbine generators that connects to the AIES and includes all equipment from turbines to the point of interconnection.
- Wind Power Facility limit (WPF Limit): means the value expressed in MW's that the SC directs an individual WPF to not exceed during a SWPL event.

Appendix B

Terms of Reference

PURPOSE

The Work Group will assist the AESO's MOF implementation by developing technically feasible and reasonable recommendations to the AESO for a protocol on the use of the ramp rate limiting and/or power limiting for wind power facilities from the AESO's ADaMs7 (Automated Dispatch and Messaging System). The protocol is to determine when, to which facilities and to what MW level will power limiting and/or ramp rate limiting be dispatched on (or activated) at wind power facilities and when the power limiting and/or ramp rate limiting can be dispatched off (de-activated). The protocol at minimum will consider:

- Forecast loss of wind and insufficient ancillary services or ramping services
- Insufficient ancillary services due to market conditions or emergency conditions (e.g. SCADA failure)
- Unforeseen (i.e. not forecasted) wind conditions such as a microburst
- Disturbance and emergency conditions – wind may be dispatched off during islanding conditions or system emergencies where wind variability cannot be tolerated

SCOPE OF WORK FOR THE WORK GROUP

The Scope of the "Work Group" includes:

- Dispatch/directive to the wind power facility operator using the AESO's Automatic Dispatch and Messaging system (ADaMs) where the wind power facility operator shall within 10 minutes (activate/de-activate) power limiting and/or ramp rate limiting.
- Consideration of which Wind Power Facilities (WPF) are exempt are per the Technical Requirements Work Group
- Consideration of minimum stable operation of a WPF
- Consideration of safety and environmental hazards
- Consideration as to whether this will be a dispatch or a directive

[7] Currently ADaMs requires a 10 minute compliance timeframe

- Consideration of periods of time where a facility is unable to comply

Out of Scope for the “Work Group” includes:

- Automatic control of WPFs from the AESO
- Protocol for wind power facilities to deal with local congestion management. This will fall under the Congestion Management protocol.

RESPONSIBILITIES

Responsibilities of the AESO

The AESO’s responsibilities include:

- Coordination of the Work Group to its timely completion. The AESO will determine when the Work Group is to be concluded.
- Chairing the Work Group, which will be comprised of a cross section of industry participants in the technical, operational and market domains.
- The AESO Chair shall make reasonable efforts to ensure that there is “balance” on industry representation and balance on the recommendations or options provided to industry.
- While consensus on some issues may not be possible, the AESO will encourage full discussion in order to ensure that all views are understood and to allow the development of balanced and reasonable recommendations.
- The AESO Chair will ensure that meeting notes are recorded and circulated to all members Power Management work groups (Supply Surplus Work Group, Wind Power Management Protocol Work Group and Wind Power Management Technical Requirements Work Group).
- Points of concern raised that are outside the Scope of the Work Group will be logged by the AESO Chair and provided to the AESO to be addressed in a timely manner.
- Provide and request logistical support and resources as necessary.
- Ensure Work Group recommendations align with other AESO initiatives and protocols.
- Coordinate Work Group communication with the rest of industry.
- Review recommendations and determine inclusion of same in AESO industry consultation.

Responsibilities of the Work Group members

The Work Group member's responsibilities include:

- Attendance at and constructive participation in all meetings.
- Providing reasonable and competent input to Work Group activities and communications.
- Providing logistical support and resources as necessary.
- Promoting the Purpose of the Work Group.
- Advise and assist the AESO by developing technically feasible and reasonable recommendations in accordance with these Terms of Reference.
- Provision of input as requested and in a timely manner and will most likely represent the views of their industry sector8.

In addition:

- In order to be acceptable to the AESO, all Work Group recommendations must be reasonable and must consider the AESO's mandate as per the Electric Utilities Act and its regulations, as well as other AESO initiatives and protocols. In addition, all Work Group recommendations must be consistent with the MOF.
- The Work Group is not a forum to debate the implementation of the MOF or develop recommendations that amend the intent of the MOF9.
- Participation as a Work Group member does not imply agreement to recommendations produced by the Work Group.
- Work Group members are not precluded from participating in any AESO industry consultation.

WIND POWER MANAGEMENT PROTOCOL STRATEGY

Process

[8] For example, a Work Group member from a coal fired generation facility is assumed to not only represents the views of their facility but other coal fired generation facilities.
[9] I.e. the MOF indicates that wind power facilities are not eligible to set a non-zero pool price, thus a Work Group recommendation where wind power can set price will not be accepted by the AESO.

The Work Group shall meet as required by the AESO to achieve the following target dates.

Target Dates

Terms of Reference	Complete by Dec 31, 2007
Work Group recommendations	Complete by March 31, 2008

Communication of Documents and Information

All Work Group communication to the industry will be through the AESO. As documents are approved by the AESO they will be posted onto the AESO website. The AESO will take reasonable efforts to ensure that Work Group members' comments and submissions will remain confidential to the Work Group and will not be posted or otherwise distributed, except as otherwise contemplated in these Terms of Reference. Work Group members must treat all documentation and information provided to them as confidential information.

Work Group Members

- Alberta Electric System Operator
- Airtricity
- Alberta Consumer Advocate
- Creststreet
- ENMAX
- Natural Power Consulting
- Naturener
- TransAlta Wind
- TransCanada
- Shell Canada Limited

The final terms of reference for the working group can be found on the AESO website at the following link.

http://www.aeso.ca/downloads/Terms_Of_Reference_Wind_Power_Management__Protocol_Final_feb4_2008.pdf

APPENDIX C: SUMMARY and COMPARISON of PROTOCOLS

The following table summarizes the 2 protocols with various considerations such as; assumption on the virtual offer from a WPF, effectiveness, efficiency fairness, application to other protocols and diversity.

Protocol Type	Assumption on the Offer	Effectiveness	Efficiency	Fairness	Application to other Protocols	Diversity
Pro-rata on MCR	The assumed offer of a WPF is MCR. PRO: The protocol is "simple" as the power limit for a wind power facility is established at the beginning of an event and only changes when the SWPL is changed or removed. It also does not need other real time information such as wind power output potential.	It will prevent aggregate wind power output to exceed the limit determined by what the system can accommodate.	**Pro:** Effective when a WPF that is producing MW less than the power limit is operating unconstrained and will experience no lost opportunity. This would leave some room for that specific WPF to further ramp up (WPF-based). Effective when there is no diversification effect among the outputs of all wind farms. **Con:** A WPF that is producing MW more than the power limit will be constrained and will experience	**Pro:** The protocol is "fair" in term of contribution to the system based on MCR. And should be fair for less diversification situation when all wind power facilities are affected in similar way. The real time MCR of all WPFs is accurate (real-time update from WPF SCADA or WPF operator. The default MCR can be the WPF maximum and is thus a fail safe value. **Con:** -MCR based contribution is not	Pro-rata based on "offer". The protocol could be applied during supply surplus conditions, large system ramping conditions and transmission congestion.	**Pro:** When all WPFs are behaving the same (all at full, all ramping) there is no diversity and the protocol accommodated the diversity or lack of diversity. **Con:** When all WPFs are not behaving the same there is diversity and the protocol does not accommodate the diversity well.

Protocol Type	Assumption on the Offer	Effectiveness	Efficiency	Fairness	Application to other Protocols	Diversity
	CON: A WPF offer of MCR is not realistic as WPFs operate at full MCR only some of the time. No coordination among different wind farms.		lost opportunity. A WPF that is producing MW less than the power limit will have un-used room and can not be shared by others that may need it. It is less efficient and results into more lost opportunity.	necessary the same as energy-based contribution, but could be close in long run. -No difference or incentive for different wind farm ramping behaviors. -depends on accurate MCR.		
Pro-rata on Potential MW	The assumed offer of a WPF is Potential MW. If the Potential MW have changed and WPF Power Limits are 're-calculated and re-allocated'. **Pro:** This might be considered more consistent in principle to other generators in the market.	It will prevent aggregate wind power output to exceed the limit determined by what the system can accommodate.	**Pro:** The protocol is equally effective as above when there is no diversification effect among the outputs of all wind farms. The protocol is more efficient when there is diversification effect as it allow un-used room from some wind farms to be shared by others, it results into more lost opportunity (Aggregate-based).	**Pro:** -The protocol is "fair" in term of contribution to the system based on energy. - introduce some more lost opportunity for fast ramping up behaviors. **Con:** -Energy based contribution is not necessary the same as MCR-based contribution, but could be close in long run.	Pro-rata based on "offer". The protocol could be applied during supply surplus conditions, large system ramping conditions and transmission congestion.	**Pro:** Diversity is naturally considered in the protocol as it is based on current wind power conditions and as wind power conditions change at the WPFs the updated allocation would consider any effects of diversity. **Con:** More complex calculation, needed additional real-time data such as Potential MW.

Protocol Type	Assumption on the Offer	Effectiveness	Efficiency	Fairness	Application to other Protocols	Diversity
	There is some coordination among wind farms. **Con:** Once the WPF Power Limiting goes into effect, the Potential MW is a determination based on WPF meteorological data and turbine available and capability.		**Con:** As this protocol need real time 're-calculated and re-allocated' based on real-time information, its efficiency is impacted by real-time measurement, algorithm and update interval.			

Table 1 – Comparison of Potential MW Capability and MCR Protocols

Appendix D: Potential MW Capability Example

The following figure illustrates an example of re-allocating power limits based on Potential MW Capability. This illustrates the curtailment of three WPFs using the proposed protocol. The current actual capabilities of the three WPFs are 50, 100 and 500 MW respectively and prior to SWPL being activated their actual capability MW outputs are currently 5, 50, and 500 MW respectively. Prior to any SWPL, the three WPFs actual MW outputs were at 5, 50 and 500 MW. The Potential MW Capability was also equal to the 5, 50 and 500 MW. The example illustrates that activity in any of these facilities can trigger change in WPF Limits.

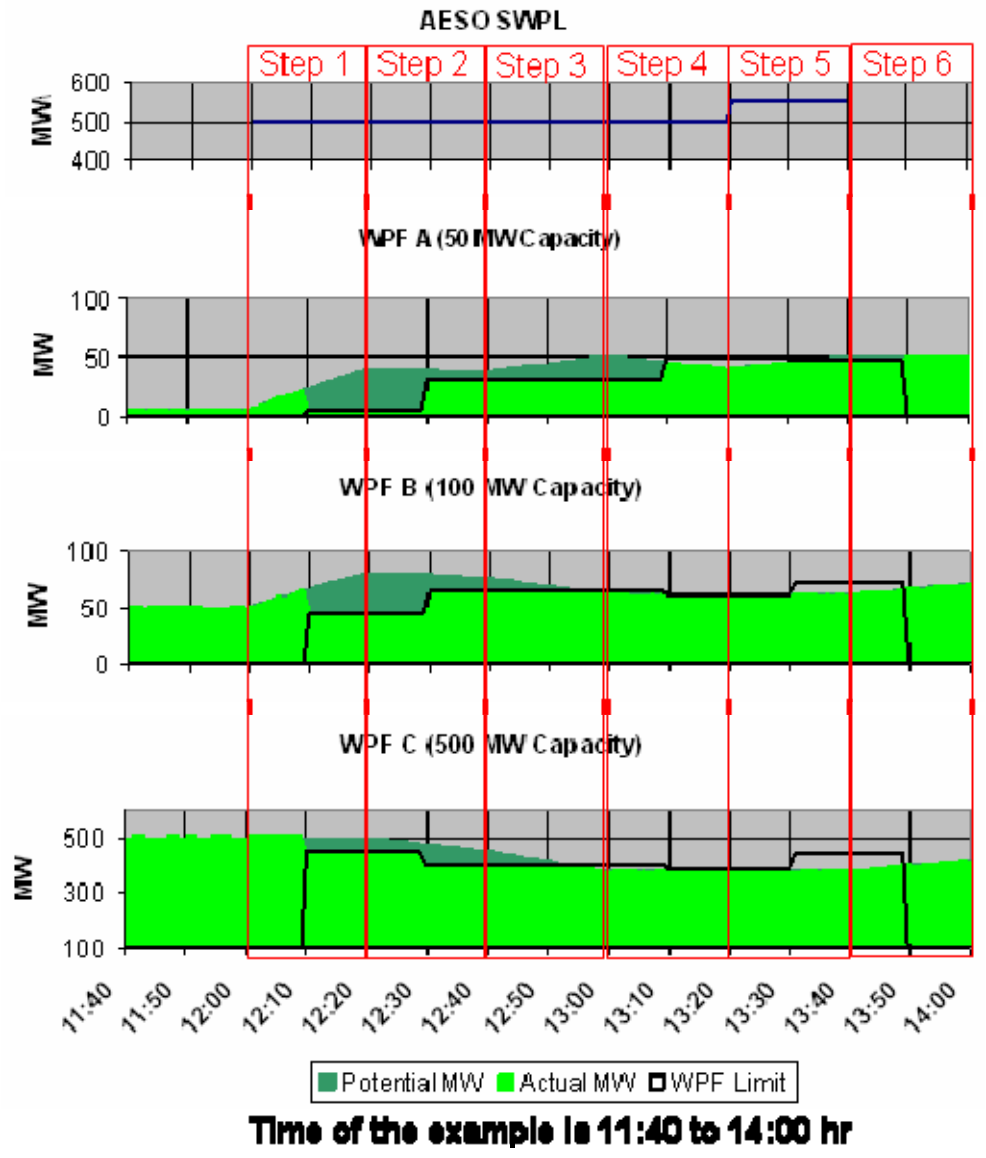

Figure 4 – Illustrative Example of the WPM Protocol

In Step 1, the SC through the use of tools and system conditions determined that a 500 MW SWPL needs to be directed. The “tool” calculated each WPF Limit based on the actual MW output at the time, the WPF Limits were rounded to issue a reasonable directive to each WPF limit at 5, 45, 450 MW.

In Step 2, twenty (20) minutes has elapsed, the 500 MW SWPL is still in effect and the tool re-calculated limits based on the potential MW. Note that the real MW are never greater than the WPF Limit in effect from the previous step and if the Potential MW Capability has dropped less than the WPF Limit, the real MW would be equal to the Potential MW Capability. In this step, there were significant changes in wind power conditions at the facilities that triggered all the WPF limits to change by 5 MW or more. The new rounded WPF Limits were dispatched to 32, 65 and 403 MW.

In Step 3, the wind power condition changes as determined by the measured Potential MW Capability changed, however the new WPF Limits have not changed by five (5) MW or more, thus no new WPF Limits are directed.

In Step 4, wind power conditions continue to change as determined by the measured Potential MW Capability. The calculated limits indicated at least one WPF has changed by five (5) MW or more and thus updated new limits to the WPFs were directed by the SC. Note however, that the WPF Limits were greater than the Potential MW Capability and thus no curtailment of wind power was occurring. The new rounded WPF Limits were directed to 50, 62 and 388 MW.

In Step 5, the system controller has determined that the SWPL can increase to 550 MW. Notice that the sum of the Potential MW Capability is less than 550 MW. Thus the new WPF Limits will be greater than the Potential MW and no wind power curtailment would occur. The new rounded WPF Limits were directed to 47, 71, and 444 MW.

In Step 6, the SWPL is removed through an SC directive via the ADaMs..