AESO Recommendation Paper

Implementation of Market & Operational Framework For Wind Integration in Alberta

March 2009

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EXECUTIVE SUMMARY

Alberta has excellent wind resources with over 500 MW of wind generation currently on the Alberta Integrated Electric System (AIES) and continued strong interest in wind development.[1] Integration of large-scale wind power, however, is still relatively new and presents new operational opportunities and challenges.

Power system planners and operators are already familiar with a certain amount of variability and uncertainty on the AIES. However, integrating wind generation presents unique challenges for system operators because wind power is variable, can increase (ramp up) or decrease (ramp down) rapidly and may be in opposite direction to load patterns, all of which make predicting wind power and maintaining the reliability of the power system more challenging. When wind suddenly ramps up or down, conventional generation such as coal, gas or hydro-electricity must be immediately dispatched or power exchanged with other provinces to offset the imbalance. There are limits to how much generation can be held in reserve, how fast it can be dispatched and how much power can be imported or exported to accommodate wind variability.

The AESO recognized that it was important, both to system reliability and to the successful development of renewable resources in Alberta, that the impact on power system operations and the obligations of market participants were understood as Alberta reached higher levels of wind penetration.

In concert with stakeholders, the AESO has produced some of the first wind interconnection standards in North America, delivered several groundbreaking wind specific integration studies that identified operational impacts and necessary mitigation measures, launched the wind power forecasting project, and created the Market & Operational Framework for Wind Integration (MOF) in Alberta in September 2007. The basic premise of the MOF is that if the System Operator has access to a reasonable forecast of wind power, they can establish operating plans using the following measures; (1) Energy Market Merit Order (EMMO), (2) Regulating Reserves (3) Load/Supply Following Services and (4) Wind Power Management (WPM).

In this respect, the MOF forms the foundation for initiatives required to further refine and define rules, AESO operating policies and procedures (OPPs) and tools needed to integrate as much wind power into the Alberta system as is feasible without compromising system reliability or the fair, efficient and openly competitive operation of the market. In addition, the MOF described the need for improved understanding of wind power diversity, changes to interconnection processes, generation scenario development and in turn transmission development.

Alberta's Provincial Energy Strategy, announced in December 2008 is also an important consideration as it sets the context for the development of long term transmission plans including the need for upgrades to the transmission system to areas of renewable energy and the development of additional interties to other markets. These initiatives

[1] There is currently over 11,500 MW of wind generation in the AESO interconnection queue.

are advancing under related consultations, regulatory processes and ongoing work and are described in this paper.

This recommendation paper is the next major step in the implementation of the Market and Operational Framework (MOF) and represents the culmination of valuable work done through industry work groups. This paper provides an overview of the MOF, describes current system resources and mechanisms used to manage variability and ramps (load and supply) on the power system. In addition, the paper provides the following set of recommendations regarding enhancements to rules, practices and procedures and requirements needed to implement the MOF:

Wind power forecasting requirements;

(1) Procurement of a centralized wind forecasting service
(2) Rules, procedures, standards and technical requirements regarding wind generator forecast data/information, communication protocols, and data quality
(3) Establishment of data management functions for wind forecasting information.
(4) How to make wind power forecasts available to market participants

Wind power curtailment protocol:

(1) How to allocate system wind power limits to individual facilities
(2) How to apply wind power limits at each wind facility (potential MW capacity)
(3) How to re-assess and re-allocate curtailments to wind facilities (time and magnitude)

Supply surplus protocol:

(1) Including wind and cogeneration facilities in operating procedure OPP 103
(2) Developing a Minimum Operating Level (MOL) for all generating units
(3) Modifying the order of steps in OPP 103
(4) Providing the market with notifications of supply surplus conditions as a way to encourage voluntary rather than involuntary action

The following near term steps are planned; (1) the AESO will conduct a stakeholder consultation session to ensure that the concepts and recommendations in the recommendation paper are fully understood, (2) Stakeholders will be provided an opportunity to provide formal/written feedback to the AESO, (3) the AESO will finalize recommendations based on stakeholder feedback, and (4) the AESO will proceed to develop the rules, procedures, and standards through the established ISO Rules process.

It is expected that implementation of the MOF will occur over a number of years as system and market conditions are expected to evolve as will the requirements necessary to operate both the system and the market. Advances will be realized through concerted effort, experience, continuous improvement and collaboration with industry.

1.0 INTRODUCTION

Alberta's electricity market was established in January 1996 and it has evolved considerably since then and will continue to develop over time with changes to the social, economic, and technological landscape. It is imperative that the electricity market remains successful and sustainable. The Government of Alberta's 2005 Electricity Policy Framework (Policy Framework) reinforced that system reliability and a fair, efficient and openly competitive are essential to the success of the electricity market and that the market will determine the technology, timing and location of generation without preference for one form of generation over another.

Wind generation is a technology that has developed relatively rapidly over the last decade throughout the world. Alberta has excellent wind resources with over 500 MW of wind generation currently on the Alberta Integrated Electric System (AIES) and continued strong interest in wind development.[2] Integration of large-scale wind power, however, is still relatively new and presents new operational opportunities and challenges. The AESO recognized that it was important, both to system reliability and to the successful development of renewable resources in Alberta, that the impact on power system operations was understood as Alberta reaches higher levels of wind penetration.

The AESO has been working closely for several years with stakeholders, developers and technical experts in other jurisdictions to better understand the impacts of integrating wind power on the AIES. These consultative efforts produced some of the first wind interconnection standards in North America, delivered several groundbreaking wind specific integration studies that identified operational impacts and necessary mitigation measures, initiated and conducted the wind power forecasting project, and created the Market & Operational Framework (MOF) for Wind Integrating in Alberta in September 2007. This recommendation paper is the next major step in the implementation of the Market and Operational Framework (MOF) and represents the culmination of valuable work done through the industry work groups.

The AESO remains proactively engaged in initiatives respecting wind power integration through its Alberta-wide stakeholder activities and broader industry initiatives such as leading the NERC Integration of Variable Generation Task Force (IVGTF), contributing to the Independent System Operator and Regional Transmission Organization Council (IRC) Operation and Markets Wind Studies, and participating in the Utility Wind Integration Group (UWIG). In addition to receiving awards from CanWEA and UWIG in 2008, the AESO continues to work with technical experts from other jurisdictions to leverage international knowledge, experience and best practices regarding wind integration. This continued consultation and collaboration will help form future plans for advancing wind integration and enabling wind generation development in Alberta.

[2] There is currently over 11,500 MW of wind generation in the AESO interconnection queue.

2.0 PURPOSE

In September 2007, the AESO issued its Market & Operational Framework for Wind Integration in Alberta (MOF)[3]. This recommendation paper provides an overview of the MOF, describes current system resources and mechanisms used to manage variability and ramps (load and supply) on the power system. In addition, the paper provides a set of recommendations regarding enhancements to rules, practices and procedures and requirements needed to implement the MOF.

The AESO held a stakeholder Information Session[4] in October, 2007 to review the key elements of the MOF and present a multi-year implementation plan. The AESO extended an open invitation for stakeholders to participate in industry working groups created to assist the AESO in developing options and recommendations for broader industry consultation. A series of industry working groups were formed to advise the AESO on:

(1) Wind power forecasting requirements
(2) Supply surplus protocols
(3) Wind power management protocols, and
(4) Wind power management technical requirements.

Led by the AESO, the working groups were comprised of a broad cross section of stakeholders who committed to exploring the issues in greater detail and developing a report and specific recommendations for the AESO to consider. The mandate of each working group, associated documentation and the work group findings and recommendations are posted on the AESO website.

In addition to outlining the need for change to operating procedures, practices, and market rules, the MOF also described the need for changes to other areas, such as the interconnection processes, generation scenario development and in turn transmission development. Improving the understanding of wind power diversity is also an important piece of information as geographic distribution of wind power facilities may assist in reducing aggregate wind power variability and ramping impacts on the system.

Alberta's Provincial Energy Strategy, announced in December 2008, must also be considered as it sets the context for the development of long term transmission plans including the need for upgrades to the transmission system to areas of renewable energy and the development of additional interties to other markets.

Work has progressed on these initiatives through existing industry consultations, regulatory processes and ongoing operations and further information can be found in sections 4.8, 4.9, and 4.10 of this report.

[3] AESO Market & Operation Framework for Wind Integration in Alberta
[4] http://www.aeso.ca/gridoperations/13030.html

The AESO has completed its review of the work group findings and recommendations and related industry consultations (i.e. transmission plans/applications) and has incorporated much of this information into this overarching recommendation paper. The intent of this recommendation paper is to initiate broad industry consultation on recommendations regarding implementation of the MOF rather than to conduct further consultation on the structure or content of the MOF.

The AESO appreciates the input and efforts of those stakeholders that participated in the working groups and in the preparation of the recommendation papers and recommendations. Such collaborative and consultative efforts help deliver more complete and robust results and, as such, the AESO encourages stakeholders to participate in this next stage and solicits feedback from all stakeholders on the proposed recommendations and next steps described to implement the MOF.

3.0 BACKGROUND

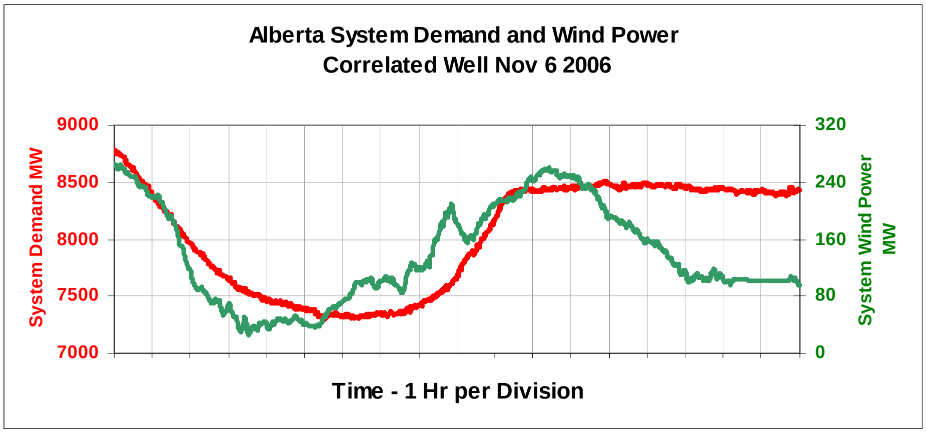
Alberta operates under a competitive electricity market structure where competitive forces determine the volume and timing of generation production; price responsive load reduction and inter regional exchanges of electric energy, all of which impact the volume and pace of wind development in Alberta. To facilitate fair, efficient and openly competitive market outcomes, the AESO provides for open access to transmission and markets and consistent application of rules and requirements to the extent workable in practice.

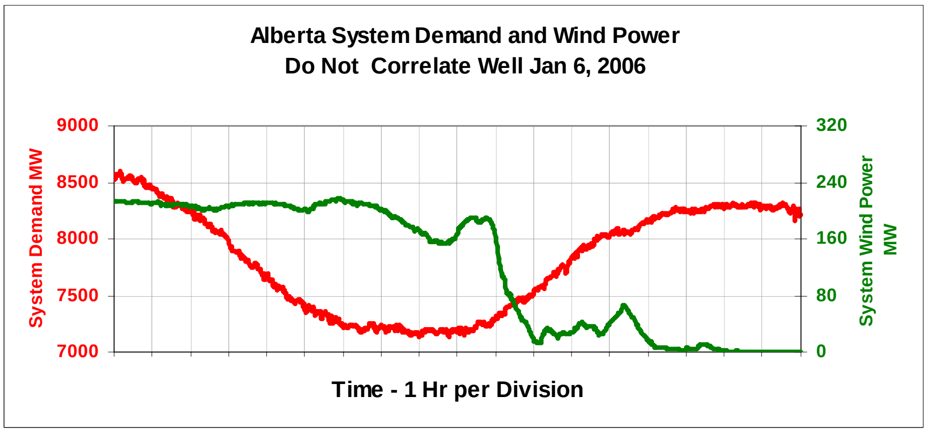
Integration of large-scale wind generation is still relatively new and presents significant new operational opportunities and challenges. Power system planners and operators are already familiar with a certain amount of variability and uncertainty on the AIES. However, integrating wind generation presents unique challenges for system operators because wind power is variable, can increase (ramp up) or decrease (ramp down) rapidly and may be in opposite direction to load patterns, all of which make predicting wind power and maintaining the reliability of the power system more challenging. The AESO own studies (Phase I Studies 2005) indicated that:

- Increasing wind power development increases operational uncertainty;
- Wind power variability in aggregate can create persistent ramping effects where, in some instances, a significant portion of the total wind power capacity is ramped over a 3-5 hour time period; and,
- In the 20-minute and less time frame, wind power variability increases as wind generation increases, but not proportionally[5].

The following diagrams illustrate actual conditions where wind power is following or opposing typical AIES load patterns.

[5] Wind penetration levels increased about 6 times and the amount of wind power inter-hour variability increased by about by 3 times; (Reference Table 9 in the Appendix of Phase I Study)



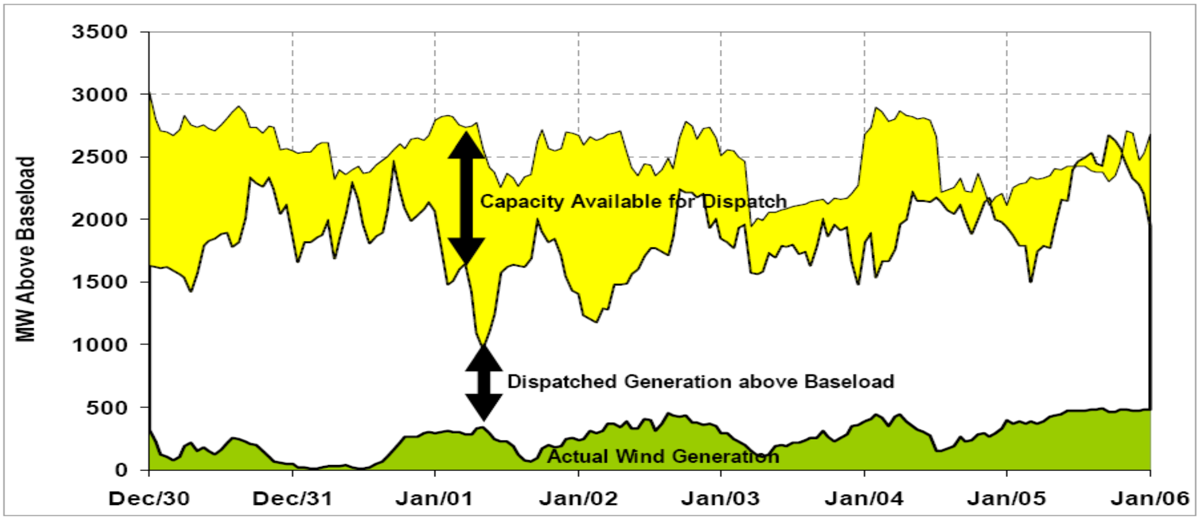


At the extreme, wind power may be at full capacity during light load periods just as other generating units approach their minimum stable operating levels. These studies also illustrated how ramping (20 minute to hours) of wind generation rather than intra-hour variability presented the greatest operational challenges.

Reliable power system operation requires ongoing precise balancing of supply and demand in accordance with minimum operating criteria. The AESO system operator manages supply-demand balance on a minute-to-minute basis considering load forecasts, operating uncertainties (i.e. unit de-rates and outages) and using current resources, rules and procedures. When wind suddenly ramps up or down, generating resources (predominantly coal, gas or hydro-electric) must be immediately dispatched to offset the imbalance. In practical terms, energy from wind generation is accepted as delivered and any resulting imbalances will be offset with intra Alberta resources or potentially with power exchanged from other provinces.

In this respect, the current size and composition of generation resources in Alberta (predominantly thermal and a large amount of cogeneration) in combination with the limited interconnection capability affect the capability of the system to accommodate wind power variability in the near term.

The following diagram from the AESO weekly wind report illustrates the amount of dispatchable capability (up and down) that is currently available in the Alberta market to accommodate wind.



This diagram illustrates that the amount of capacity above base-load generation[6] and available for dispatch on the AIES is limited and may vary from 1,000 to 3,000 MW in the span of a one-week period. Also during hours where the amount of base-load generation plus actual wind generation approaches the system demand curve, there is very little room available to accommodate additional wind generation without curtailment of base-load and/or wind generation (i.e. supply surplus conditions).

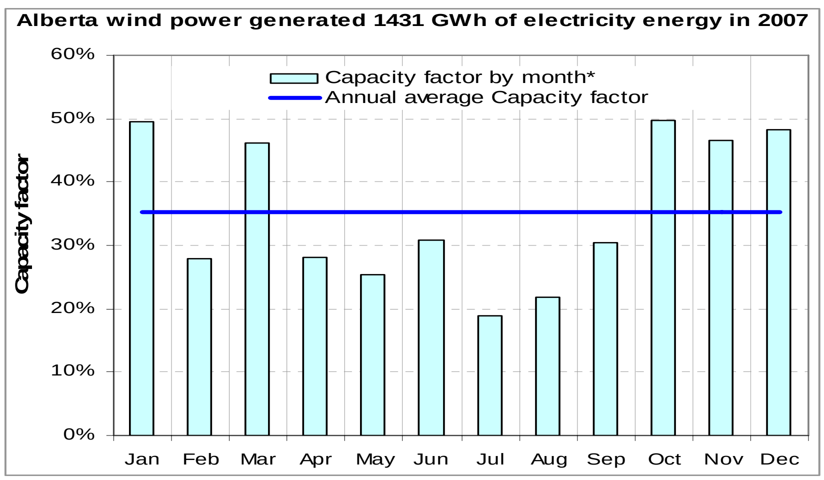
Presently, as a non-dispatchable resource, wind power does not submit offer into the electricity market but rather supplies its energy to the market at $0 and is a price taker. Accordingly, as the volume of non-dispatchable resources (base load, cogeneration and wind) increase on the AIES relative to the existing portfolio of resources, the frequency and risk of supply surplus conditions occurring will also increase. Increased amounts of non-dispatchable resources on the AIES may also place downward pressure on market prices which could impact long term adequacy and the ability to attract fast ramping resources required to complement wind generation.

Wind facilities are “fuelled” by the wind, which blows steadily at times and not at all at other times. Depending upon its location, a modern wind turbine may produce electricity 70-85% of the time, but it generates different outputs dependent on wind

[6] Base-load generation is comprised of generation from coal, gas or hydro that is at zero dollar offers, TMR, small non-dispatchable or behind-the-fence industrial co-generation (may vary between 4,500 MW and 6,000 MW on the AIES). Dispatched generation above base-load represents the head room before supply surplus conditions occur and includes generation produced from regulating and contingency reserves as well as the amount of non-zero dollar generation dispatched from the EMMO. Capacity Available for Dispatch includes unloaded capacity from regulating reserves as well as the amount of offered generation capacity that is not dispatched into the electricity markets.

speed and direction and can often run at less than full capacity. The proportion of the actual output out of their total capability (full turbine rating) is their capacity factor. System wide capacity factors are simply a sumation of all facility data.

In 2007, wind power contributed over 1,400 GWh of electric energy to the AIES with an overall annual capacity factor of about 35 %. The wind generation capacity factor may exceed 50 % during some periods or it may have minimal or no capacity on some days during peak load periods (summer and winter peaks) due to prevailing weather conditions (i.e. cold temperature limitations or no wind during high pressure weather patterns). For example, on January 28, 2008 when the system winter peak was established (9,711 MW), wind generation varied from between 0 to 270 MW throughout the day and over the peak load hour, the hourly average wind generation was 1 MW. On August 18, 2008 when the summer peak was established (9,541 MW), wind generation was about 100 MW over that hour. The following graph shows monthly capacity factors for 2007 and how they change month to month.



Facility specific or system wide capacity factors show how much of the total amount of wind power on the system is operating at a point in time. Historical monthly or seasonal capacity factors therefore could be useful information for AESO system and market operations, system planning and resource adequacy assessments. In addition, market participants may find capacity factors useful.

Accommodating higher levels of wind generation on the AIES will create operational and market impacts and drive the need for new or refined rules, tools, procedures and standards as well as the need for new fast ramping/responding resources to maintain supply-demand balance and system reliability. Both the AESO and market participants need to become more familiar with the characteristics of wind generation and factor it into day-day operating practices, decision making processes and offer strategies. In this respect, the AESO will continue to enhance market monitoring and metrics and determine appropriate reports for communication with industry including reports regarding wind variability and system performance (see Appendix IV, Weekly Wind Reports).

4.0 MARKET & OPERATIONAL FRAMEWORK (MOF)

In consideration of these challenges with wind generation and the probability of large scale wind penetration in Alberta, the AESO developed and issued the Market and Operational Framework (MOF) September 2007[7] and continues to advance its implementation.

The MOF provides guidance to the AESO and stakeholders regarding the necessary mitigating measures, obligations, and cost allocation associated with wind integration. The MOF also informs transmission planning and supports the development of much needed transmission infrastructure. The transmission plans in turn influence the pace of wind project development and the AESO continues to monitor this to anticipate and prepare for operational and market conditions and develop the necessary rules, procedures and tools to meet the AESO's commitment to integrate as much wind power into the Alberta system as is feasible without compromising system reliability or the fair, efficient and openly competitive operation of the market.

The basic premise of the MOF for adding wind power to the AIES is as follows:

> ***If*** the System Operator receives a reasonable forecast of wind power generation, ***then*** the System Operator can establish operating plans to accommodate the forecast wind energy by using the following measures or tools:
>
> - The Energy Market Merit Order (EMMO)
> - Regulating Reserves
> - Load / Supply Following Services
> - Wind Power Management (WPM)

In addition, the MOF noted that "geographic diversity of the wind generation resources will tend to reduce the need to use these tools, or conversely increase the amount of wind generation that the AIES will be able to absorb."[8]

The MOF prescribed the following resources and measures be used by the system controller to manage wind power variability; (1) energy market merit order (EMMO), (2) operating reserves, (3) load supply following services, and (4) wind power management (WPM) where the energy market plus operating reserves are insufficient. The following diagram illustrates the associated challenges and the solutions prescribed in the MOF.

[7] Market & Operational Framework for Wind Integration in Alberta
[8] The Market & Operational Framework for Wind Integration in Alberta – September 2007; page 3

CHALLENGES	MOF SOLUTIONS
Predictability of wind power	Wind power forecasting rules and requirements
Flexible Resources for wind power	EMO, AS, load products and Load-Supply following
Wind variability, supply surplus, ramping events	Wind power management, forecasting & OPPs
Transmission development	Transmission plans, NID's and forecasts of wind projects
Wind interconnection projects	Queue management
Cost Allocation	Load Transmission & Ancillary Services Wind Facility Owners Forecasting and Power management

The following sections provide an overview of the Market and Operational Framework and further describe the system resources, practices and mechanisms that are currently used to manage variability and ramps (load and supply) and ensure supply-demand balance on the power system.

4.1 Wind Forecasting

As noted previously, the basic premise of the Market and Operational Framework is that if the operator has a reasonable wind generation forecast they can use this forecast to prepare an operating plan therefore enhanced wind forecasting is a foundational piece of the MOF.

The AESO's own studies, as well as studies conducted in other jurisdictions, have shown that increased accuracy in forecasting wind power can reduce operational issues associated with wind integration. Wind power forecasts can also lessen the need for, and cost of, other mitigating measures.

In Alberta, the AESO currently uses relatively unsophisticated practices to forecast wind power. Wind generation facilities have been operating for several years however the AESO has not and does not have access to historical records of wind turbine availability or to historical meteorological data. During the wind forecasting pilot project, the importance of historical data became evident as this data can be used to determine trends, anomalies and can be used to improve forecasting abilities. More recommendation respecting wind forecasting data can be found in section 6.1.2.

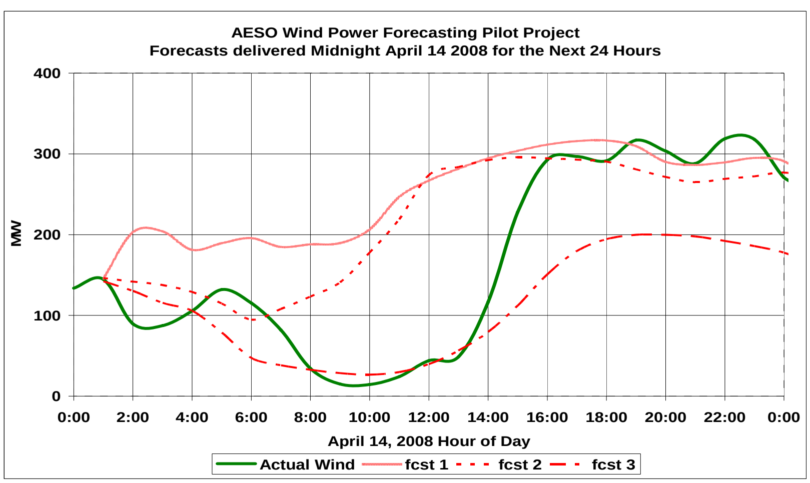
To various degrees, actual wind power or estimates of wind power are currently used to help manage market and system operations including; forecasting and procuring ancillary services, evaluating short term adequacy (STA), assessing available transmission capacity (ATC), dispatching the energy market merit order (EMMO) and curtailing wind generation if required (i.e. transmission constraints).

System operators are very familiar with demand forecasting and while there are similarities with forecasting wind generation there are fundamental differences. Wind generation forecasting is significantly different in that the forecast is very sensitive to time horizon with error in the forecast growing the further in advance the forecast is made As illustrated below, deviations between forecasted and actual demand are typically small (in the order of 1-2%) and generally does not vary over time horizons (i.e. day-ahead, hours ahead, or real time).

> Demand Example: On a system with a 10,000 MW peak demand, a load forecast 12 hours in advance of actual operating conditions could be in error by 300 MW (3%).
>
> Wind Example: For a system with 2,000 MW forecast of wind power, a wind forecast 12 hours in advance of actual operating conditions could be in error by 400 MW (20%) and has some chance of being out by 2,000 MW (100%).

As the amount of wind generation increases on the system, wind forecasting practices will become increasingly important to manage the associated supply variability and uncertainty. As the “first line of defense,” wind power forecasts will play a critical role in system operations and planning. The forecasts will provide additional information about how much, how fast and when the aggregate wind power will change and therefore assist the operator in the preparation of a viable and reliable operating plan.

In May 2008, the AESO completed a year long wind forecasting pilot project using international vendors to compare and contrast wind forecasting methodologies. As can be seen from the following figure, there can be significant differences (i.e. phase/timing and amplitude) between the actual wind power and the wind power forecast.



In the future, wind power forecasts will be used to determine reserve requirements, operational assessments and limits such as STA, ATC, and others. It is expected that a comprehensive assessment of wind power forecast and forecast uncertainty (probability the forecast is incorrect) will improve the accuracy of assessment of resource needs, the efficiency of procurement and minimize costs including the use of WPM.

In this respect, wind forecasting techniques used to support real time operation must be put in place to provide the system operator with forecasting tools and approaches which can predict the magnitude and timing of wind generation plant output (including ramps) and also provide information regarding the uncertainty of these forecasts. Accordingly, advances in wind forecasting techniques will need to become fully integrated into existing and future tools, practices and procedures.

4.2 Energy Market Merit Order (EMMO):

The energy market merit order (EMMO) is the list of all offers and bids for energy assets submitted by pool participants, sorted in order of offer and bid price blocks. The energy assets are dispatched in relative economic order to maintain a balance between energy supply and demand. As per the MOF, the EMMO is the primary mechanism for system operators to ensure system reliability and fair, efficient and openly competitive operation of the electricity market.

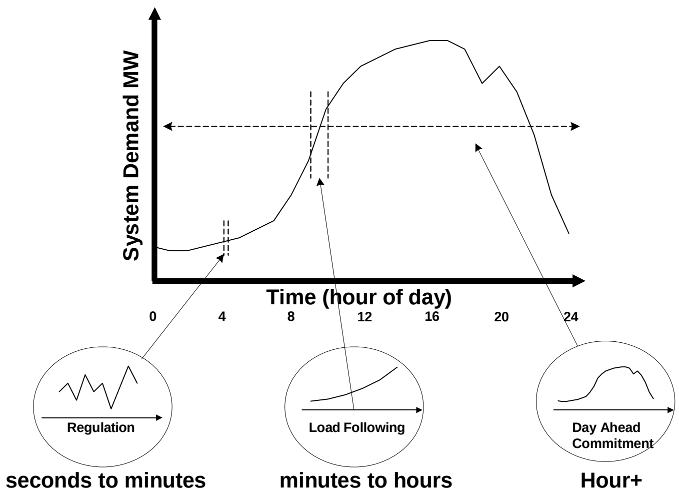
Wind generation is not dispatchable and does not submit offer into the market, however its energy capacity is considered in supply adequacy assessments. Wind output will be accepted as delivered unless there are reliability concerns in which case the supply surplus protocols will guide the curtailment process. In practical terms, the output of wind facilities is monitored by the system controller via SCADA telemetry and the metered output is accepted as delivered, to the market and the AIES. Wind generation is a price taker in the market and receives market price for the MW generated/supplied. In this respect, its variable output can contribute to supply demand imbalance. The AESO considers that wind generation will continue to participate in the market as a price-taker for the foreseeable future.

AESO ‘Must Offer and Must Comply’ (MOMC) rules effectively freeze the Energy Market Merit Order (EMMO) at T-2 except for Acceptable Operating Reasons (AOR)[9]. The current operational practice is to dispatch the EMMO assuming that wind power will remain at the same MW output[10] until the next dispatch decision (on average about every 20 minutes). Actual operating experience has shown that persistence forecasting is quite effective however in future advanced wind power forecasting techniques may be employed.

The system operator dispatches resources up or down the EMMO supplemented with regulating reserves as necessary, to keep supply and demand in balance and to ensure compliance with reliability standards and prevent reliability events. The diagram below

[9] AOR as defined in ISO Rules
[10] This is a rudimentary form of persistence forecasting

shows how the EMMO, regulation and load following resources are currently used to maintain supply demand balance. The regulation and a small component of the load following requirements are currently provided by the regulating reserve services with the remainder of load following and scheduling provided from dispatching the EMMO.



In the Alberta market today, Regulating Reserves provide the seconds to minute balancing and a small component of Load Following. Today the majority of Load Following comes from the units offered/ committed into the EMMO. In the future, with large scale wind integration, it is anticipated that Regulating Reserves may carry a larger Load Following component, thus the need to develop a separate service for load/wind following as discussed in section 4.4.

4.3 Regulating Reserves

Operating Reserves is the generation capability above system demand required to provide for regulation, load-forecasting error, equipment forced and scheduled outages and local area protection. Western Electricity Coordinating Council (WECC) standards require Balancing Authorities (i.e. AESO) to maintain sufficient regulating reserve to meet NERC's control performance criteria described in BAL-001 and provide for sufficient contingency reserves[11] consisting of spinning and supplemental reserves to meet the North American Reliability Council (NERC) control performance standard BAL-002.
Included in these services are regulating reserves, spinning reserves and supplemental reserves (non-spinning) which are procured competitively in the Alberta Operating Reserve Market.

Regulating Reserves are fast responding resources that are used in real time to help maintain supply demand balance typically within a 20-minute timeframe. They are controlled directly by the AESO Automatic Generation Control (AGC) System.

[11] Current WECC standard is the Contingency reserves are primarily based on 5% of the firm load served by hydro and wind generation and 7% of the firm load served by thermal and that a minimum of 50% of the contingency reserves must be spinning reserves.

Regulating Reserves are fast responding and, at a minimum, must be capable of ramping through the regulation range within 10 minutes to be a qualified resource.

AESO studies found that Regulating Reserves are an effective measure to mitigate the effects of short-term wind power variability (i.e. within 20 minutes). AESO analysis also indicated that the intra-20 minute variability of net demand (wind plus load variability) only increased marginally with increasing wind penetration levels suggesting that it could be reasonably managed with existing or relatively small increases in regulating reserves. The MOF concluded that the AESO would plan for and procure sufficient regulating reserves to manage real-time and forecasted variability to the extent qualified resources are offered and available in the Operating Reserves market. When the Regulating reserves are insufficient, then wind power management would be used. In the future, additional balancing resources supplied through load/wind following services (see next section 4.4).

Day-ahead load and supply forecasts are currently used to estimate the hourly volume of Operating Reserves needed for next day(s) real time operations. Due to confidentiality concerns respecting operating and forecast data, day-ahead wind power forecasts/estimates are not currently used in the calculation of required operating reserves or the procurement of those operating reserves. However, during real time operation, the actual amount of wind generation is included in the calculation of required reserves[12].

Once implemented, wind power forecasts will be integrated into the existing forecast for next day(s) operating reserves and the procurement processes. AS procurement will use the wind power forecast to ensure sufficient supply ramp rate (EMMO and AS) is available to operate the system and market in a reliable and appropriate manner. The forecasts, together with associated accuracy or uncertainty information, are extremely important because they will improve the efficiency of AS procurement and will serve to minimize the use of WPM.

It is expected that advances in wind power forecasting techniques will increase the accuracy and predictability of the wind forecasts and these improvements will be reflected in the supply forecasts. Ultimately, improvements to wind forecasting should lead to a more precise match of procured operating reserve volumes to real time operating requirements and in turn result in more efficient procurement of resources. It is also possible that different types of forecasts may be developed (i.e. optimized to forecast ramping events) and that processes may change to utilize new information/forecasts.

4.4 Load/Supply Following Services

Wind ramping events that occur from 20 minutes to several hours may present a critical reliability risk, particularly when the ramps are in opposition to the system load patterns.

[12] The "Contingency Reserve Required" field on the AESO's CSD page is the real-time calculation which includes wind actual wind generation. http://ets.aeso.ca/ets_web/ip/Market/Reports/CSDReportServlet.

AESO studies[13] concluded that regulating reserves assist in managing wind power ramps but that a new load/supply following service may be required in future to respond to larger increases or decreases in wind power (ramps). It is also expected that this less stringent ramping requirement should widen the potential for suppliers along with available resources such as demand side services, storage facilities, inter-control area dynamic schedules and others.

The use of regulating reserves as opposed to load/supply following services would depend on which service would best meet technical operating or reliability requirements in the most efficient (i.e. cost effective) manner within established market rules. The MOF indicated that load/supply following services are similar to regulating reserves and that up to certain penetration levels, wind ramping could be managed with additional regulating reserves, a new load/supply following service or both. In this respect, it is expected that load/supply following services would be created and procured based on wind forecasts, once more experience is gained with wind forecasting and accuracy standards have been established.

In those cases where regulating reserves and load/supply following services are not adequate to balance supply with demand, WPM techniques will need to be employed.

4.5 Wind Power Management (WPM)

The MOF clarified that the system operator may 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.[14] Market participants are required 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.

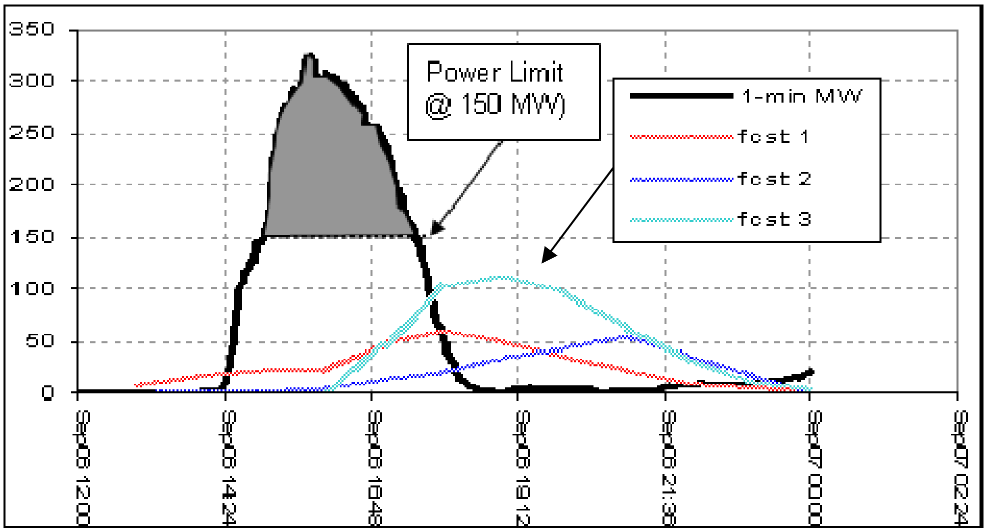
To the extent that the energy market and available regulating reserves are insufficient to maintain reliability, out of market actions including curtailments (supply and/or load) are used by the system operator to ensure compliance with industry reliability standards and/or to restore reliable system operation. These actions may be exercised in real time or in advance (if required) to meet reliability standards and/or maintain system reliability.

Accordingly, wind generators face risk of wind power management due to insufficient resources on the AIES to accommodate either the actual or forecasted wind generation or due to these and potentially other conditions:

a. Forecast loss of wind power and insufficient ancillary services or ramping services;
b. Supply surplus conditions ($ 0 offer dispatch) – thermal units will not be dispatched below the minimum stable operating limits;

[13] http://www.aeso.ca/gridoperations/13843.html
[14] ISO Rule 6.7.

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



The diagram above uses actual wind power data from the recent wind power forecasting pilot to illustrate how WPM may be used. In this case, using actual data and the forecasts, a ramping event was not forecast. If inadequate AS or ramping resources were available to the system operator to accommodate the actual wind ramp (shown in black) the only means available to the system operator to maintain system reliability would be to apply a system wind power limit (i.e. 150 MW). This example is for illustrative purposes and it is unlikely that use of WPM would be required for a 350 MW ramping event. However, as the amount wind generation increases on the AIES, this type of operator intervention to control or limit the aggregate wind power output on the system may be necessary to maintain system reliability when ramping events may be several hundreds of MW's over a few hours.

Since wind is a non-dispatchable $0 resource, wind generation will generally be accepted as delivered except when price hits $0 and Supply Surplus procedures are initiated. Currently, wind generators and co-generation are exempt from the established operating procedures for managing supply surplus operating conditions (i.e. OPP 103). Accordingly, wind generation is currently only curtailed to manage transmission constraints and other reliability events but not for market situations/dispatches. The MOF clearly indicated that higher levels of wind generation will make the noted exemption unsustainable requiring revisions to Operating Policy and Procedures (OPP) including OPP 103 for Supply Surplus $ 0 offers. Further details regarding necessary modifications to OPP 103 are provided in section 5.4.

The actual duty, frequency and magnitude of power management will depend on a number of factors including; actual wind penetration and production, diversity of wind production, forecasting accuracies, system response and supply portfolio and offer (price) strategies. The design, implementation and use of wind power management rules and tools and use of these in combination with EMMO and AS are of great interest to wind power facilities and developers as well as other market participants and stakeholders. The AESO expects that over time through operating experience, these approaches will be refined and improved.

4.6 Compliance (MOMC and WPM)

The MOF also clarified how wind generators would be affected by government market policy direction which created a series of supply obligations designed to ensure the visibility and availability of generation supply and also provide the AESO with the authority to direct units to ensure supply adequacy. Accordingly, the ISO Must Offer and Must Comply (MOMC) rules are designed to meet this intent and provide the system operator with greater certainty regarding available supply.

Wind generation, however, is considerably more variable and uncertain and clearly cannot operationally comply with these requirements (i.e. it is semi-dispatchable and may only be dispatched when there is fuel). Imposing these requirements on wind generators would be unworkable in practice and hinder participation in the market. However, as clarified in the MOF, a 'must forecast' provision for wind generators would be an appropriate substitute for the must offer requirement, given that wind power forecasts have the potential to reduce operational uncertainty.

Although wind forecasting will greatly assist the operator, as previously noted, there are some weather/wind events that may not be predicted and the system operator must be able to reduce or limit wind generation output when it cannot be accommodated on the grid. At the very least, wind facilities can be taken off-line. However new technology is now available that enables more refined approaches such as wind power or ramp rate limiting. Wind Power Management (WPM),[15] was therefore considered to be a fair and reasonable obligation for wind generators in lieu of the must comply requirement for other generators in the market.

In the interim the AESO issued a letter[16] to stakeholders that confirmed that wind generators are exempt from MOMC until appropriate comparable rules can be implemented. The specific requirements and recommended approaches respecting must forecast will be formalized through market participant and system operator rules, tools, practices and procedures and is described further in section 5.3.2. Necessary refinements in these capabilities will continue to be advanced over time through consultation on rules and procedures.

[15] Market and Operational Framework for Wind Integration in Alberta – **p. 10 Section 4.4**
[16] http://www.aeso.ca/downloads/Wind_momc_letter.pdf

4.7 Cost Allocation

Consistent with the policy and legislative framework in Alberta, the MOF also established that wind generators will assume responsibility and costs for wind power forecasting and wind power management equipment and lost opportunity costs (ie. lost production due to curtailment).

Respecting the implementation of wind forecasting, there are a number of cost elements for which the total costs and cost recovery mechanisms are yet to be determined and these will become more clearly defined as wind forecasting is implemented. The key elements include: (1) procurement of a wind forecasting service (2) acquisition/delivery of data from wind power facilities to the forecasting service provider and (3) costs incurred by the AESO to receive and use forecasting or wind power related information.

It is expected that the AESO will contract with a forecasting service (may also include data collection, verification and quality control) to provide a series of daily and hourly wind power forecasts to the AESO. The costs associated with the wind power forecasting service would be collected directly from individual wind generators through market fees or tariff charges.

It is expected that each wind power facility will be required to collect and provide certain data to the forecasting provider in the form, timeframe and quality defined by an AESO standard. It is expected that the costs (infrastructure and operating) associated with the collection and provision of this data to the forecasting service provider will be the responsibility of each wind power facility. These costs will be allocated according to existing policy and tariff principles for similar costs.

Finally, as noted in the MOF, costs incurred by the AESO to receive and use forecasting or wind power related information (real time information) are considered system (shared) costs necessary to maintain system reliability and the associated costs will be allocated according to existing policy and tariff principles for similar costs.

As per current policy and regulation, load assumes the costs associated with increased ancillary services and transmission upgrades and the AESO will continue to ensure that these costs are allocated consistent with policy and legislation, are reasonable and are prudently incurred.

4.8 Diversity

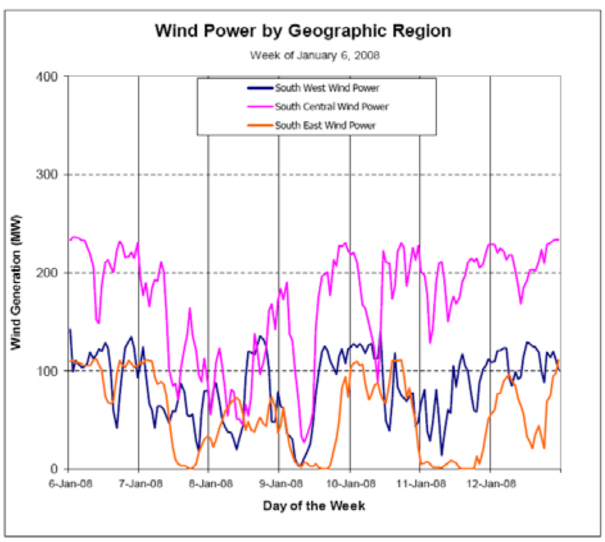
The ISO expressly does not have a role in the centralized planning of generation investments. Nonetheless, it is responsible to ensure that the costs of ancillary services and transmission are prudently incurred. As noted in the MOF[17], geographic diversity of wind generation resources will tend to reduce the need to use mitigation measures and therefore increase the amount of wind generation the AIES will be able to

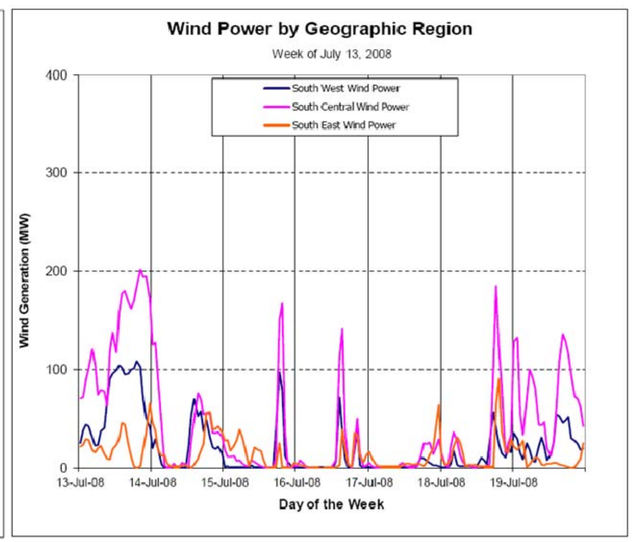
[17] Market and Operational Framework for Wind Integration in Alberta – p. 6 Section 3.1.6 Wind Power Diversification

accommodate. Diversity effects associated with wind generation is therefore an area of interest to the AESO. At the October 2007 stakeholder session, the AESO committed to monitoring operating conditions and has produced and published weekly reports that illustrate actual wind power diversity on the AIES.

At the same time, the AESO also indicated that it would consider updating the system impact studies using more recent data (i.e. post 2004) and that additional findings would be published. However, based on actual operations and evidence to date, there is general consensus that the weekly reports and forecasting project results have provided valuable information about system impacts including ramping effects and diversity and that it is not necessary to refresh the system impact studies at this time.

In this respect, the following two figures from the AESO Weekly Reports (2008) illustrate some of the findings respecting wind power diversity. During the week of January 6, there were periods of time when there appeared to be some amount of diversity between the different wind regions in Alberta. Whereas, during the week of July 13, the wind patterns of the 3 regions were very similar indicating little to no diversity. From experience to date, little or no diversity has been observed between wind regions in southern Alberta during major wind ramping events (i.e. all existing wind facilities are ramping in the same direction). Similar findings have also been noted in other jurisdictions (i.e. CAISO).





There is still much to be learned about wind power diversity and the AESO remains committed to monitoring this aspect and working with industry to better understand diversity and its impact on operations, reliability, market outcomes and the development and integration of wind in general.

4.9 Interconnection & Queue Management

The MOF and its implementation plan recognized that there were challenges with both the Interconnection process and rules and how to plan and advance necessary transmission to integrate wind generation on a large scale. Given the large number of interconnection proposals received for wind development projects, it was recognized that improvements were required to the interconnection and queue management processes.

Effectively, an interested generator (including wind) could pay the nominal application fee and be placed in line (the queue) for; application processing, interconnection studies and an interconnection proposal. This work is conducted on a first come first serve basis and the nominal application fee (i.e. $ 50,000) is effectively a payment for a call option[18] on their project. Without milestones (checks and balance) to ensure that projects are actually proceeding, developers could hold up other projects later in the queue. There was general consensus on the necessary improvements to several important aspects of interconnection management:

- Milestones, with consequences for non-compliance, were required to ensure appropriate allocation of resources and advancement of projects in the queue,
- AESO should continue to accept new interconnection applications, and
- Increased transparency and visibility of the interconnection queue was needed.

On September 26, 2007, the AESO published a discussion paper entitled “Interconnection Queue Business Practices” which outlined the proposed milestones that a project would be required to meet in order to maintain its queue position. The paper was followed by a stakeholder consultation session on October 19, 2007. The AESO received overall positive feedback with regards to the proposed practices. Since the rollout of the MOF implementation plan in October 2007, the AESO has completed the following activities to improve the interconnection and queue management processes and advance transmission:

- Published Project Milestones Obligations on the AESO website in January 2008.
- Published a revised zonal interconnection queue: wind applications were sorted into different geographical zones and within each zone the projects were arranged according to their respective queue positions.
- Completed interconnection proposals for zones not requiring system upgrades were prepared first. These proposals included load flow studies, +/- 50% cost estimates and a high level assessment of required remedial action scheme.
- Over 25 interconnection proposals have been issued. A few projects have accepted their interconnection proposals and have moved on to the next stage. Two need applications for interconnection have also been submitted to the AUC since October 2007.

[18] Provides the right to proceed with the project.

- Transmission system planning activities for the southern and central regions including preliminary consultation on need.

4.10 Generation Scenarios & Transmission Planning

When the MOF was issued, it was noted that a new approach for establishing and advancing transmission plans (i.e. multiple generation scenarios and associated transmission plans), would need to be explored and developed to accommodate new wind generation. It is also clear that transmission and intertie capacity are critical enablers for the development of wind generation resources in order to:

1. Interconnect variable energy resources located in remote regions of the province;
2. Deliver ramping and ancillary services from inside and outside Alberta to balance supply and demand; and,
3. Exchange any surplus energy with other jurisdictions.

Alberta's Provincial Energy Strategy, announced in December 2008, must also be considered as it sets the context for the development of long term transmission plans including the need for upgrades to the transmission system to areas of renewable energy and the development of additional interties to other markets. The Provincial Energy Strategy (2008) outlines the following specific transmission development objectives:

- The requirement for urgent comprehensive upgrades to the transmission system to relieve congestion and reduce the significant losses associated with the existing transmission infrastructure.
- The development of transmission to areas of renewable and low-emission energy within Alberta.
- The development of additional interties to other markets to ensure access to adequate electricity supply and to provide greater export opportunities for producers.

Accordingly, the AESO has advanced plans for the south region of the province to accommodate the large scale development of wind generation. The south region of the province is currently Alberta's primary wind power generation area and over 7,500 MW of applications for new wind generation have been received by the AESO in this region. It is expected that not all wind generation that has requested connection to the system will be constructed, and there is uncertainty about where the projects will ultimately be located.

Regardless of the location of future wind generation development, there is limited capability in the south region transmission system to meet the needs of this new generation. Given the significant system constraints, the south region transmission system will require substantial improvements, including multiple new 240 kV and/or 500 kV transmission system loops and substations and upgrading of existing facilities to accommodate the generation interconnections. In this respect, the proposed transmission plan, which was filed with the Alberta Utilities Commission (AUC) at the end of 2008, is flexible to accommodate various possible futures of wind development.

Regarding intertie capacity, it is recognized that Alberta is one of the least interconnected jurisdictions in Canada with limited capacity to import or export electricity. Increasing wind generation increases the probability and frequency of supply surplus situations due to the non-dispatchable nature of wind generation. Consequently, there is the potential of more frequent occurrences of supply surplus as the level of wind penetration increases. Under the current market design, frequent and/or sustained supply surplus ($ 0 prices) could lead to reliability and adequacy concerns (inability to keep thermal units on-line without utilizing out-of-market directives) unless there is sufficient intertie capacity to efficiently clear the market.

Within the next 10 year timeframe, there are two key areas of focus for the AESO regarding Alberta's interties; restoring the capacity of existing interties and developing new intertie capacity. Given the benefits of accessing other markets and the controllability of HVDC technology (particularly as it may assist in managing the variability of large amounts of new wind generation), this aspect will be explored further in the context of developing new intertie capacity.

In addition, the potential benefits of more dynamic and frequent scheduling intervals for interties may also assist in wind integration and this will be considered as future enhancements to the Alberta market rules and practices.

5.0 RECOMMENDATIONS

The MOF was an important first step which established the overall framework for wind integration in Alberta. The MOF forms the foundation for initiatives required to further refine and define AESO rules, operating policies and procedures (OPPs) and tools needed to integrate as much wind power into the Alberta system as is feasible without compromising system reliability or the fair, efficient and openly competitive operation of the market. It is also intended to achieve a reasonable balance between the use of and costs for forecasting, ancillary services and wind power management to mitigate wind power variability and uncertainty.

It is expected that the current system and operating practices used to manage system reliability and facilitate market operations will not fundamentally change as a result of implementation of the MOF. However, wind power variability and ramps will create a dramatically altered environment for system operators and market participants. Therefore, further refinements will be required to rules, tools, procedures and standards and system operators will need access to new fast ramping/responding resources to maintain supply-demand balance and reliable system operation.

In order to advance the implementation of the MOF and wind integration in Alberta, the AESO formed several industry work groups to provide the AESO input and assistance respecting various aspects of the MOF including the protocol for using resources such as Forecasting, EMMO, AS and WPM. The AESO recommendations are based on those findings and are explained in more detail in the following sections of this paper.

5.1 Industry Working Groups

Following the release of the MOF in September 2007, the AESO hosted an information session on October 19, 2007. At this session, the AESO reviewed the MOF and summarized the work needed to move forward on wind integration and specifically shared a high level implementation plan for the first phases of MOF work for the next 2 years (2008/09). The plan described a set of work streams, deliverables, a schedule[19] and information on how stakeholders could participate.

In November 2007, the AESO formed working groups to assist the AESO in the development of recommendations on how to implement the Market and Operational Framework, in order of priority based on the urgent need to have practices in place prior to reaching critical wind penetration levels on the AIES[20]:

1. Wind Power Forecasting[21],
2. Wind Power Management (WPM) Curtailment Protocol,
3. Wind Power Management Supply Surplus Protocol, and,
4. Wind Power Management Technical Requirements/Standards

Valuable information was acquired through the work group process and members and, work group findings are summarized in subsequent sections of this paper along with AESO recommendations regarding necessary next steps respecting implementation of each key work stream.

5.2 Use of Forecasting, AS and WPM

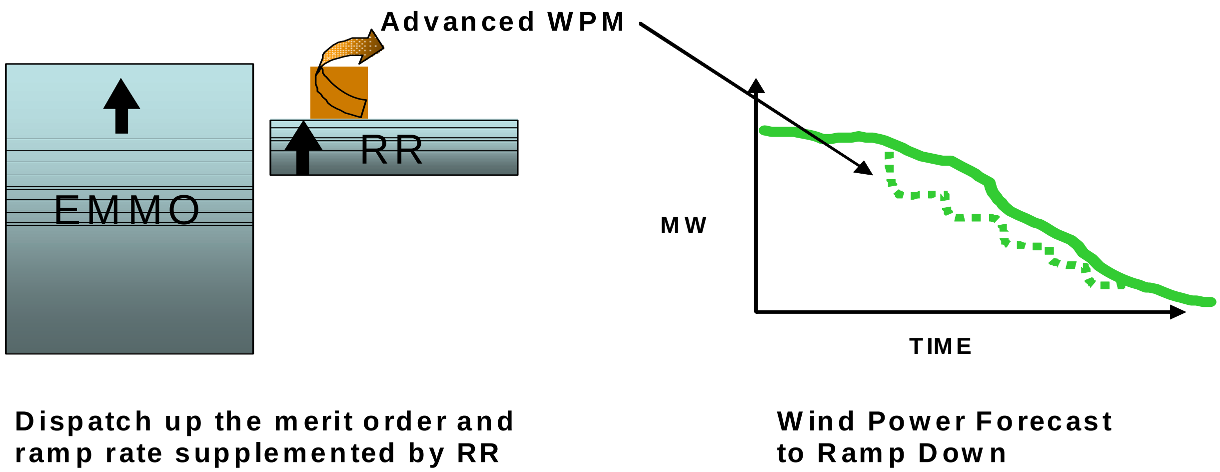
One of the most significant and dramatic changes to day-day operations of AESO and market participants will be the introduction and use of wind power forecasting techniques and how they will be used together with the EMMO, AS and WPM to accommodate wind generation on the AIES.

With the large scale integration of wind generation, the system controller will become increasingly reliant upon the wind forecast (and certainty of that forecast) to ensure that adequate resources and ramping capability is available on the system. Wind power forecasts and forecast accuracy/uncertainty are expected to be central to balancing the use and cost of AS and WPM and will be instrumental to achieving the reasonable balance of resources and costs envisioned in the MOF.

[19] http://www.aeso.ca/downloads/MOF_Implementation_Plan-Schedule.pdf
[20] AESO studies indicated a critical reliability threshold of 900 MW.
[21] Wind Forecasting Pilot was initiated in Spring 2007

As described previously, the MOF established that the following measures will be used for managing wind variability; (1) wind power forecasts, (2) EMMO, (3) AS, and (4) wind power management. The following diagrams illustrate how these mechanisms and resources may be used by the system controller to manage a forecast wind power ramp down (i.e. Scenario 1) and a forecast wind power ramp up (i.e. Scenario 2).

Scenario #1: Forecasted Wind Power Ramp Down

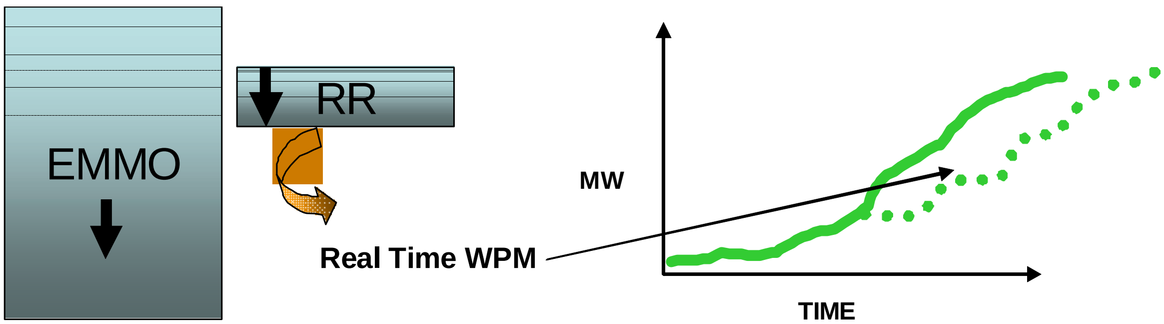


When wind power is forecast to ramp down, the system operator will plan to dispatch up the merit order (EMMO) and supplement this by dispatching up Regulating Reserves. Should the system ramp rate[22] of the EMMO plus Regulating Reserves be insufficient to accommodate the total wind and load ramp rate, the system operator may need to slow down the system ramp rate by curtailing or limiting wind power output[23].

Conversely, when wind power is forecast to ramp up, the system operator will plan to dispatch down the merit order (EMMO) and supplement this by dispatching down Regulating Reserves. Should the ramp rate of EMMO plus Regulating Reserves be insufficient to keep up with forecast wind and forecast load, the system operator will need to slow down the up ramp of wind by limiting wind power increases to match the ramp rate capability of the market.

[22] The AIES ramp rate capability used in the Phase 1 and Phase 2 studies was 300 - 600 MW per hour, a typical system rate at the time. Ramp rates are a reflection of the rates of generation units. For instance we have more ramp rate today due to the added generators since the studies.
[23] A demand side option (i.e. new AS product) may also provide the capability to counter wind down ramps.

Scenario #2: Forecasted Wind Power Ramp Up



Dispatch down the merit order and ramp rate supplemented by RR

Wind Power Forecast to Ramp Up

When the actual wind power and wind power forecast match, or are closely correlated (i.e. timing and magnitude) the operational plans will be sufficient. For events where the forecast amount of wind generation is inaccurate (i.e. more or less) or if the wind ramps occurs a few hours earlier or later, the system operator will be required to re-adjust their operating plans.

While in its infancy in Alberta, wind power forecasting is not a new capability in the industry. Many European countries such as Germany, Spain and Denmark have well developed wind resources and years of experience with wind power development and system integration. AESO is well positioned to leverage technological advances elsewhere to build forecasting capability that is well suited for Alberta.

5.3 Wind Forecasting

The Alberta Department of Energy, Alberta Energy Research Institute and the AESO, in collaboration with an Industry Work Group, conducted a wind power forecasting pilot project which was completed May 31, 2008. The purpose of the pilot project was to:

- Trial wind power forecasting methods and providers
- Identify the most effective method(s) to forecast wind power in Alberta
- Identify the most effective providers of wind power forecasts
- Inform the AESO and industry on the capabilities of wind power forecasting in Alberta

A Wind Power Forecasting Work Group was formed to assist the AESO in completing the pilot project and provide recommendations to the AESO respecting; forecast accuracy, data requirements, centralized versus decentralized forecasting, methodologies, Environment Canada's role, and areas for research. As part of the project, each forecaster was required to complete and submit reports. These reports are extensive and summarize key findings and recommendations are posted on the AESO website along with the Industry Work Group Report findings and recommendations[24] on how best to advance wind power forecasting in Alberta. The reports, together with AESO event analysis, shaped the following discussion and recommendations.

The forecasting pilot project confirmed the AESO's initial views that wind generation ramps present one of the greatest operational challenges. Although the forecasts in the pilot project were not tuned for ramps, it was clear that a forecast tuned to predicting ramp direction, timing, magnitude and rate of change would definitely be valuable to the AESO and the electricity market as a whole. In this respect, the forecasting work group recommended that the AESO research how to customize forecasts for ramps as well as how to best use ramp forecasts.

It was also recognized that in the future, the use of uncertainty information for specific purposes/forecasts may be valuable. In the forecasting pilot, most forecasters ran many (sometimes several hundred) forecasts for each hour based on varying input conditions into the forecasting model. The forecasts can be plotted and from this range of information, the degree of uncertainty of the forecast can be determined. This type of information may be used by the system operator to procure additional resources (e.g. stand-by regulating reserves) where the uncertainty is high due to a potentially volatile weather system.

Wind power forecasting is expected to be an important tool for managing the variable nature of wind power and key to reliably increasing wind penetration in an efficient and reliable manner, however, there are still many details yet to be determined. In this section, the wind forecasting work group findings are discussed and the AESO's recommendations regarding wind forecasting are provided.

5.3.1 Wind Power Forecasting Recommendations

There are two widely accepted models for wind power forecasting; (1) centralized and (2) decentralized. Centralized forecasting is where a single forecast supplier provides the AESO with a single aggregated forecast for all wind power facilities according to AESO specifications and requirements. A centralized forecast system implies that the AESO facilitates and manages the forecasting process. The AESO would specify requirements, clarify accountabilities for wind facilities and for the forecaster and these formalized in service contract, market rules, technical standards, and/or operating procedures as appropriate.

Decentralized forecasting, on the other hand, would entail one or more forecaster providing the AESO distinct forecasts for individual and independent wind facilities. Decentralized forecasts would be generated and submitted to the AESO (or by a third party) by the forecasters not the wind facility. Wind facilities would be required to comply with AESO market rules, operating procedures or technical standards. Wind

[24] http://www.aeso.ca/downloads/Work_Group_Paper_Final_(3).pdf

facilities and forecasters would help the AESO define performance and accuracy requirements.

Forecasters unanimously recommended a centralized model citing efficiency, economics, uniform quality and accuracy. The work group recommended a centralized forecasting model based on a number of benefits including the ability to develop a focused relationship with one vendor to facilitate learning, continuous improvement and customization of forecasts. The AESO agrees with this recommendation and solicits stakeholder input on this approach.

> ***Recommendation 1 – Forecasting*: The AESO recommends that a centralized forecasting approach be implemented in Alberta.**

One of the most important findings by forecasters and the Work Group was that wind forecasting in Alberta is relatively difficult in comparison to other jurisdictions. Accordingly, it was recommended that the AESO should implement forecasting as soon as possible in order to continue valuable learning and begin customizing forecasts for Alberta. Specifically, there was general agreement that the AESO should, as soon as possible, initiate solicitation (RFP), evaluation and selection of a centralized forecasting provider. The AESO agrees with this recommendation and solicits stakeholder input on this approach.

> ***Recommendation 2 – Forecasting:* The AESO recommends that solicitation (RFP), evaluation and selection of a centralized forecasting service provider should proceed as soon as practicable.**

5.3.2 Data Requirements Recommendation

Specific data requirements for wind facilities remain to be developed and forecasters generally recommended that meteorological conditions and facility design details such as turbine locations, type, and height be included. The following data from the wind power facilities were recommended:

- Turbine availability data (real time and planned) is submitted hourly. This would be similar to available capacity of the conventional generators.
- On-site meteorological data were recommended or acknowledge for potential value - differences about specifics for on-site meteorological data. Met tower data from hub height and one other height including wind speed, wind direction, ambient temperature and pressure based on 10 minute averages delivered every 10 minutes.
- Facility power curves

A common theme from the forecasters was that incentives or minimum requirements should be established to ensure that data provided from wind power facilities is accurate, good quality, and has high availability. The development of the specific data requirements will require input from forecasters, turbine manufacturers and wind generators and these requirements will be specified in AESO rules, procedures, practices and/or standards. The AESO therefore recommends that consultation commence on the development of forecasting data requirements and obligations for wind power facilities through the established ISO rules process.

> ***<u>Recommendation 3 – Forecasting:</u> The AESO will commence consultation on rules, procedures, standards and technical requirements regarding submission of wind generator forecast data/information including; data requirement such as turbine availability and on-site meteorological data as described above, communication protocols, and data quality required from wind generation facilities (or individual forecasters) to deliver forecasts to the AESO.***

5.3.3 Data Management Recommendation

Experience gained in the Wind Power Forecasting Pilot project clearly illustrated the large challenge and significant resources needed to obtain quality data necessary for forecasting. There is a significant volume and range of data to be collected, validated and managed and data quality issues such as wind speed and direction devices that may become inoperable during cold weather. Monitoring the quality of the data is a key consideration. There are three principal approaches to manage and monitor the quality of forecasting data:

1. <u>Third party</u> collects data directly from wind facilities, stores, organizes and manages that data, performs quality control and data management before forwarding/sending data/information to a Forecaster. The Forecaster will use it to produce the wind power forecasts for the AESO to use in operations. This method was used in the pilot project primarily due to the data sensitivity of the future wind facilities that participated in the project.
2. <u>AESO</u> collects data directly from wind facilities, stores, organizes and manages that data, performs quality control and data management before forwarding/sending data/information to a Forecaster. The Forecaster will use it to produce the wind power forecasts for the AESO to use in operations.
3. <u>Forecaster(s)</u> collect data directly from wind facilities, stores, organizes and manages that data, performs quality control and data management before using that data/information to produce the wind power forecasts.

Common to all options is the need for data quality and accuracy at each stage of the process. All data/information will be retrieved from wind facilities and provided to the forecaster(s) to prepare a forecast and the interface between data acquisition and forecasts is equally important. Any inaccuracies along the process will contribute to forecast accuracy and errors and in the future this may be the basis for monitoring compliance and penalties.

It is recognized that considerable skills, expertise and infrastructure are required to collect, store, organize, manage massive amounts of data and provide the necessary flexibility and reporting capability needed for a range of purposes and timeframes including real time. Significant effort will be required to analyze and determine what data is needed, how frequent, its format and communication mechanisms. While the AESO has considerable experience tracking and storing very large amounts of operating and market data, the AESO would need to make significant enhancements to its systems and processes to enable the necessary manipulation, analysis and reporting of data.

For various reasons including concerns respecting confidentiality[25] of future wind facilities, a third party provider responsible for data management was used successfully used in the pilot project but not without significant effort and cost for up-front "learning".

It is expected that the forecaster would likely possess the necessary skills and capabilities to manage data and this would reduce the volume of data available and the complexity and cost of the interface between the AESO and the Forecaster. Notwithstanding, the AESO will need access to certain data for compliance, settlement and market monitoring.

All three options are feasible, however, experience from the wind forecasting pilot indicated that it takes considerable work and effort to establish data requirements, to upgrade systems and data architecture, enhance processing capability and ensure adequate communication protocols and performance. This experience is not a reflection of the specific provider but rather illustrated the complexity and difficulty with this operating and business model. In this respect, the AESO concluded that the use of a separate third party data management service provider would not be more efficient or effective than the other identified options (i.e. AESO or forecaster) and therefore this approach will not be pursued.

Accordingly, the AESO will conduct further analysis and research to determine the capability, resources, systems and time required to perform the data management function. In parallel, the AESO will include data management as an optional requirement in the wind forecasting RFP.

> ***Recommendation 4 – Forecasting Data Management:* As part of its forecasting research and development work, the AESO will continue work to determine the capability, resources, systems and time required to perform the data management function. In parallel, the AESO will include data management as an optional requirement in the wind forecasting RFP.**

5.3.4 Forecasting Accuracy Recommendation

Wind power forecasting in Alberta is in its infancy, and as such, it appears too soon to establish forecasting accuracy requirements and certainly premature to establish an

[25] Past concerns (confidentiality) have prevented the AESO from obtaining facility data or meteorological data needed to monitor and ensure data quality.

associated compliance framework and penalties. However, in the longer term, accuracy of forecasts will be essential to achieving the full benefits of the MOF and some form of compliance to accuracy standards will be required.

Establishment of accuracy standards will be crucial to advancing wind power forecasting, managing overall costs and ensuring that there is an appropriate balance between the AS costs to load and the opportunity cost to wind facilities. Greater accuracy of wind forecasts will contribute to a more efficient and stable operating environment and reduce the incidence and impact of reliability events and decreased AS costs and the degree of wind power management needed. Conversely, inaccuracies or errors in the forecasts will increase operational risks and may result in more use of wind power management.

In this respect, the work group recommended that further consultation (i.e. wind developers, forecasters, load customers and conventional generators) is required to develop accuracy targets and mechanisms to encourage ongoing accuracy improvements and innovation including; incentives when accuracy is improved or targets met and/or disincentives (penalties) when accuracy is not achieved. At this time, more work is required to understand, develop, implement and measure forecasting accuracy and it would be premature to develop specific accuracy standards at this time. It was also considered that the development of accuracy standards, associated mechanisms, and any associated compliance obligations should proceed following operating experience with the wind forecasting service.

> ***Recommendation 5 – Forecasting Accuracy:*** ***The AESO will monitor forecasting, market and operational results and develop measures of forecasting accuracy. The AESO intends to leverage available data and forecasting resources toward this end.***

5.3.5 Forecast Market Information & Transparency Recommendation

As a general principle, it is generally accepted that for a market to function efficiently and effectively, an information-rich environment is necessary to inform market participants and investors of the risks and opportunities. In addition, without a common market forecast, and the potential for wide swings in wind generation, market participants will be left to guess or estimate the aggregate wind generation output resulting in increased market volatility. Ensuring comparable requirements for wind generators in relation to other generating sources is also an important consideration. Therefore, the AESO recommends that wind forecasts should be transparent and made broadly available to all market participants. As noted by the industry work group, this can also motivate and encourage accuracy and innovation in the industry at large.

The MOF stated that the AESO would “explore methods to improve service to the market including increased market data/information transparency” and therefore suggested that wind power forecasts should be as transparent as possible and made available as market information particularly near term to real time. The AESO would like to solicit further stakeholder feedback on this matter.

***<u>Recommendation 6 – Forecasting:</u>* The AESO considers that system or aggregate wind forecasts should be transparent and made available to all market participants, particularly near term to real time.**

5.4 WPM Curtailment Protocol

Wind power management was recognized in the MOF as a necessary mitigation measure to manage wind power variability. As noted previously, the AESO formed three industry working groups to ensure that WPM is available to the AESO prior to reaching critical wind penetration levels on the AIES. The WPM Curtailment Protocol Working Group was therefore tasked with developing a procedure that can be used by the system operator to effect system wide reductions to wind power on the AIES needed to maintain supply demand balance and/or restore reliability.

It is expected that operational assessments and plans will incorporate wind power forecast(s) and will be used to determine the total or system wind power limit (SWPL) needed to ensure supply demand balance or to maintain or restore system reliability. This working group did not address the procedures or calculations for determining the SWPL but rather focused on how to allocate the required wind reduction among wind facilities. In other words, a protocol would be developed to allocate the SWPL among wind facilities. It was recognized that procedures for allocating system wind power limits (SWPL) are interdependent with a number of other activities including wind power forecasting, forecasting accuracy, AS procurement, ramp rates and will require further consideration and refinements in future.

Given that conditions that prompt or require wind power management such as supply surplus may span several hours resulting in limits being placed on wind facilities during that period, the industry work group highlighted the need for a fair, efficient and effective protocol. The working group also recognized that system operating conditions are dynamic and the capability of each wind facility will likely change during the effective timeframe. Therefore the protocol needs to consider changes in overall SWPL, changes in system conditions (including WPF) and do so in a manner that is fair among wind generators as well as with other generators and market participants. Since other generators are curtailed based on their offers, it is reasonable to apply a similar curtailment protocol to wind facilities.

Guided by reliability requirements and market principles, the work group developed two options for allocating and dispatching a SWPL; Option 1 is based on what the wind power facility is capable of producing using real-time turbine availability and wind conditions at the wind power facility and Option 2 is based on the wind power facility nameplate rating. Pro rata allocation of curtailments was considered fair and consistent with existing practices used with other generators. Both curtailment options allocate curtailments on a pro rata basis however, the basis for the calculation of the pro rata share differs between Option 1 and Option 2 as described below. Appendix III provides sample calculations for both methodologies.

5.4.1 Potential MW Capability

Option 1 prescribes that curtailment be allocated based on the Potential MW Capability of each WPF. The Potential MW Capability is the amount of wind power that the wind facility would have produced without any reduction or limit to that wind power facility output. Without power limiting the potential MW and actual MW are equal. When power limited a WPF is required to curtail (i.e. spilling wind) making actual MW produced less than that facility's potential MW.

The Potential MW Capability would be calculated using turbine availability and other wind facility operating data and would be telemetered from the wind facility to the AESO. Wind turbine manufacturers have confirmed that the potential MW capability can be provided but they also noted that there could be a 10-15% error in the data. The AESO will monitor performance including data accuracy/quality.

Wind power output may vary due to many factors including; wind speed, wind direction, turbine height, etc. Because the Potential MW Capability protocol calculations are based on actual capability from all wind facilities in a wind farm, this approach to calculating and allocating wind power curtailments will take advantage of any associated diversity benefits.

Utilizing the most up to date wind power output capability in the Potential MW Capability calculation ensures the highest degree of fairness and overall efficiency (i.e. minimize spilled wind). The frequency for calculating and re-allocating limits was also considered key to achieving a high degree of "fairness". However, there are practical reasons that must be considered in establishing frequency and the protocol must balance the need for accurate operating conditions and curtailments with implementation complexity and cost.

5.4.2 Maximum Continuous Rating (MCR)

Option 2 specifies that curtailment be allocated based on Maximum Continuous Rating (MCR). All generating assets have a Maximum Continuous Rating or MCR. It is the maximum MW capability that a generating asset can continuously maintain (and supply). The MCR for a wind facility is turbine availability and the net-to-grid MW capability for each available turbine operating at full MW. A simple MCR would be based on all turbines being available. A more complex MCR could use a real-time determination of WPF MW based on the real-time availability of the turbines and would be the MW that can be produced at the facility with all turbines available at top/potential of the asset.

This approach was considered to be fair, understandable and relatively simple to implement. However, it doesn't realistically reflect actual wind facility operation or capability since the MCR can be inaccurate and wind turbines rarely operate at their rated capability. By using a static factor to allocate wind power limits regardless of plant location or production, this option also does not capture any diversity benefits or consider any regional variations in WPF output. Another deficiency with this protocol was that a wind facility not producing (0 MW) would be allocated a capacity reduction based on its MCR resulting in ‘unfair’ distribution of the curtailment and missed diversity benefits.

The market requires generating assets to offer their full capability into the market but can price those offers as they wish. The full potential of a wind power asset is the maximum output with the available fuel supply at that moment. With conventional generation fuel supply and other operating conditions are rather constant and predictable whereas wind generator output will fluctuate and is much less predictable even in the near term or real-time. Since traditional generation offers are day ahead and become fixed at T-2 (MOMC) a comparable requirement is required.

5.4.3 WPM Curtailment Protocol Recommendations

The publication of the work group report/paper on the AESO website represented the completion of the efforts of the WPM Curtailment Protocol working group. The working group concluded that allocating curtailment or limits based on the facility MCR rating could lead to inefficient operation, as any limits placed on a wind power facility may have little bearing on what the wind facility was actually producing or could produce. Option 1, the Potential MW Capability approach, offers a number of positive attributes including taking advantage of any diversity across wind power facilities and allowing reallocation of limits over time. The Work Group therefore recommended;

(1) Pro-rata allocation of system wide wind curtailments;
(2) Use of Potential MW Capability to allocate wind power curtailments; and,
(3) Curtailments should be re-assessed and re-allocated every 20 minutes if the limit for any one WPF has changed by greater than 5 MW

The AESO has reviewed the working group proposal and considers that conceptually the approach is sound and reasonable. However, the impacts of implementing and operating the proposed protocol have not been fully evaluated and further work will be required to determine to what extent this functionality and capability can be implemented and in what timeframe. Regardless, the AESO solicits feedback on the work group recommendation to use a Potential MW Protocol.

> ***<u>Recommendation 7 – WPM Protocol:</u> The AESO seeks stakeholder feedback on the work group recommendations to use a Potential MW Protocol and specifically would like input from stakeholders regarding practicality and risks associated with this option.***

5.5 Supply Surplus

In late 2007, the AESO formed an industry work group to investigate and review existing Operating Policies and Procedures for Dispatch (OPP 103) respecting management of supply surplus situations. OPP 103 was established to provide a set of operating procedures for the system controller to be used regarding dispatch of generating units offered in at zero dollars (i.e. dispatching of equal priced offers) in a Supply Surplus situation.

Wind generators and co-generation are currently exempt from OPP 103. The wind exemption was granted when there was a relatively small amount of wind generation on the AIES and consequently a relatively low risk of Supply Surplus conditions occurring. However, with increasing wind penetration on the AIES, it will be necessary to revise OPP 103 to include wind generators.

Following extensive discussion and analysis the Supply Surplus work group developed a set of recommendations regarding the supply surplus protocol. The overall objectives were to develop a protocol that was fair and efficient and to address technical/operating and market issues such as intertie capacity, import or export scheduling and inflexible or flexible $0 offers. As a foundation principle, the work group concluded that all generation facilities should reduce their MW output during supply surplus conditions.. The working group recommendations are summarized below:

(1) Include wind power facilities and co-generation facilities in OPP 103 procedures with co-generation to be subject to Minimum Operating Level (MOL) requirements

(2) Establish a Minimum Operating Level (MOL) for each asset and, where possible, assets should not be dispatched below their MOL.

(3) Refine MOL definition to include new constraints not included in Minimum Stable Generation[26] (MSG) but that affect the asset's ability to operate at or below a threshold. MOL is a physical operating limit (not an economic limit) for an asset constrained by legal/regulatory, environmental, health and safety, equipment reliability, operating level required to serve dispatched ancillary services, or operating level required to prevent damages to third party equipment. Examples of physical operating constraints for types of generation and import/export are included in the WG paper (Appendix A).

(4) Develop a mechanism for pool participants to declare and submit the MOL. It is expected that the need for, approach and frequency of declaration may vary among generators and will need to be defined.

(5) Revise the current "inflexible block" definition. The definition of "inflexible block" will need to be amended as follows:

> "inflexible block" means a block of energy that may be dispatched on or dispatched off, but not partially dispatched on, <u>except for a $0 offer block it may be dispatched to the asset's MOL.</u>

Definition of "flexible block" does not require any changes since it accommodates the proposed $0 SMP management protocol.

(6) Provide market indication of supply surplus conditions (similar to supply adequacy situations) to provide market participants an opportunity to take voluntary actions in the face of potential $0 SMP conditions and also become

[26] ISO Rule definition for MSG is “minimum stable generation” which means the minimum generation level that an asset can be continuously operated at without becoming unstable.

aware that an out-of-market dispatch to clear the energy imbalance could be forthcoming.

The Supply Surplus work group also developed the following protocol respecting OPP 103:

Step 1: Curtail opportunity services including import transactions.

Step 2: Take the following actions, taking into account the transmission system operating and reliability constraints and an objective of rotating the curtailments amongst market participants where possible:

a. Curtail flexible $0 blocks, by pro-rata assignment,

b. Where wind generation is required to be curtailed pursuant to (a), assign the curtailment amongst each individual wind power facility using the wind power management protocol,

c. Curtail inflexible $0 blocks to the asset's MOL.

Step 3: Curtail an asset to 0 MW (go off line), considering the asset's minimum off time.

A potential consequence of this Supply Surplus protocol on cogeneration could be increases in DTS tariff (that apply to load supplied from the AIES) since they may require additional capacity from the AIES if their own on-site generation is curtailed. This requires further evaluation, and if there are inappropriate consequences in this regard, the AESO may consider amendments to the AESO Tariff.

5.5.1 Supply Surplus Recommendations

The AESO appreciates the efforts of the Supply Surplus working group to develop a set of recommendations regarding an effective supply surplus protocol and related amendments to OPP 103. The AESO also recognizes that this protocol and OPP 103 will impact a range of market participants and in different ways. Given the range of interests, the work group could not possibly capture or reflect all points of views. The work group contributions on this initiative were constructive, substantial, and appreciated however the proposal must now be considered and tested by a broader audience. Therefore the AESO solicits further comments from stakeholders on these conclusions.

***Recommendation 8 – Supply Surplus Protocol:* The AESO solicits input from all stakeholders on the proposed supply surplus protocol and proposed modifications to OPP 103.**

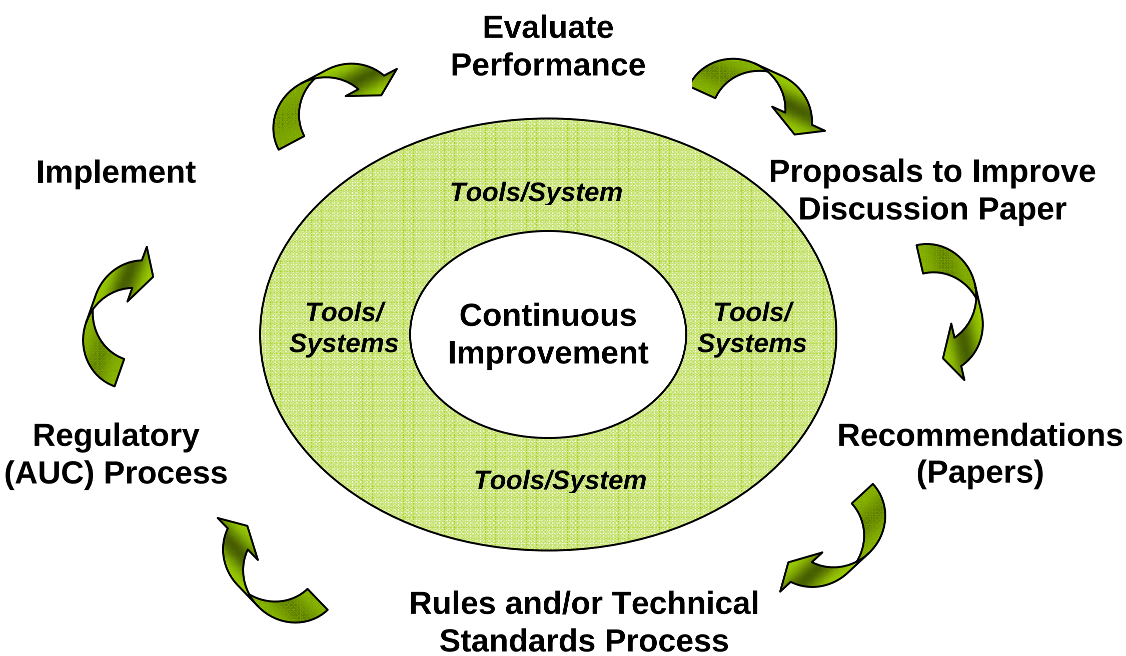
6.0 IMPLEMENTATION CONSIDERATIONS

This paper contains contain several recommendations regarding enhancements to rules, practices and procedures and requirements needed to implement the MOF including improvements to; (1) wind forecasting (2) wind power management and (3) supply surplus operating protocols. These recommendations and discussions have increased our combined (i.e. AESO and industry) understanding of the issues with wind integration and have advanced AESO's efforts toward wind integration. There is now considerable work to implement the MOF, realize benefits and continuously learn and improve the rules, practices and procedures and requirements to integrate wind.

This section provides an overview of some of the key implementation considerations including (1) the need to continuously improve rules, practices and procedures, (2) necessary changes to technical requirements and standards, (3) advancements in system operator tools, (4) compliance to forecasting requirements and (5) contingency plans if implementation is delayed.

6.1 Change Management and Continuous Improvement

The MOF was advanced with a clear policy and legislative framework in place in Alberta recognizing that the necessary enhancements to rules, practices and procedures and requirements needed to implement the MOF would take several years. In this respect, the tools and practices and must be constantly evaluated and improved in the light of their efficiency, effectiveness and flexibility and changing system and market conditions (see following diagram).



Wind penetration is expected to increase to approximately 1,200 MW on the AIES by 2010 with completion of the SW transmission upgrade emphasizing the urgent need for new rules and enhanced tools and technical requirements. As the amount of wind increases on the AIES, the AESO will continue to monitor and evaluate system performance, operating experience, use of resources (i.e. EMMO, AS, WPM) to manage ramping and supply surplus events and share these findings with stakeholders (i.e. post on AESO website).

One of the overall objectives of the MOF is to achieve a reasonable balance between the amount and cost of ancillary services and the amount and cost of wind power management (lost opportunity from curtailment of wind power output). The solutions, costs and benefits are however inversely correlated as the amount of AS procured may result in less use of WPM. Conversely, if AS procurement is minimized this will result in increased use of WPM. In addition, under-stating AS requirements will also result in insufficient system ramp rate and an increased reliability risk, which may require involuntary load curtailment. Alternatively, if excess supply from EMMO and AS is more than required to supply demand, then reduction of supply must be achieved with out-of-market actions, such as Supply Surplus and more use of WPM. This complex relationship is one example of an area that needs to be closely monitored, analyzed and reported.

As noted previously, for a market to function efficiently, an information-rich environment is necessary to inform market participants and investors of the risks and opportunities. In this respect, the AESO has been publishing a weekly wind report to provide industry with information regarding correlation of wind generation to system load, pool price impacts, regional diversity of wind generation, amount of wind generation in the energy market and other factors. A sample weekly wind report can be found in Appendix IV and similar reports may be accessed at the AESO website[27]. The AESO intends to continue to post these reports and to enhance its monitoring processes respecting wind integration on an ongoing basis.

The AESO also intends to continue to utilize industry work groups and/or consultation to produce discussion papers with proposals to improve practices and procedures. This will continue through the established consultation cycles including; discussion papers, rules and/or technical standards process, regulatory process and implementation. Including recent and upcoming experience with wind power forecasting, ongoing performance monitoring will help deliver continuous improvement over time.

The most urgent and important functions to advance at this time to further wind integration are forecasting, supply surplus procedures and wind power management. It is recognized that each function and capability varies in complexity and the degree and range of impact and the development process takes considerable time and effort from market participants, stakeholders and the AESO.

Given the urgency respecting these functions, the AESO will continue to explore avenues to accelerate the overall schedule without compromising the integrity of the consultation process. To the extent possible, the AESO will advance activities in parallel and provide regular updates to stakeholders on progress made in each work stream.

[27] http://www.aeso.ca/gridoperations/14246.html

6.2 Technical Requirements and Standards

The AESO developed the Wind Power Facility Technical Requirements (WPFTR), effective November 2004. The WPTR also highlighted a number of areas where further requirements or upgrades would likely be needed for larger scale wind integration but these would be determined after wind power variability studies had been assessed.

These requirements included but were not limited to; power limiting, ramp rate limiting and supplemental over-frequency control. This wording was intended to clearly indicate to wind power developers that further upgrades to the WPFTR would be forthcoming in order to minimize unexpected outcomes. The wind power management curtailment protocol work group considered power limiting and ramp rate limiting in their work and supplemental over frequency control (virtual governor for wind facilities) technical requirements.

Decisions regarding wind curtailment, supply surplus and wind power forecasting will determine to a large extent, the implementation details respecting rules, practices, procedures as well as technical requirements. Given the current stage of development and consultation regarding the overarching rules and procedures, the AESO considers it premature to consult on specific technical requirements. For example, wind power forecasting will be in development and evaluation for some time and Wind Power management is further along and will be more straightforward.

Similar to the other work groups discussed earlier, the AESO felt it was prudent to form a WPM Technical Requirements team to determine whether and what standards will be needed - removed, added or revised, in order to implement wind power management. Working with non-wind generators, wind generators, wind developers, and wind turbine manufacturers technical requirements and associated standards for the proposed wind power management curtailment protocol have been drafted.

In addition, advanced control features on wind plants (voltage regulation, low voltage ride through, curtailment, frequency regulation, etc.) will become increasingly important to maintaining balanced, stable and reliable operation of the power system at higher wind levels. Even though some of these control features may not be necessary to achieve adequate grid performance in the near term, they will be critical in the future.

Therefore, it will be necessary for all new and some existing wind facilities to be equipped with these features now, so that they will be available to perform the required functions when the power system requires this performance at higher levels of wind penetration. Given the expected difficulty and expense in modifying and/or retrofitting some existing wind power facilities, the WPFTR (s 1.2 g) provided an exemption from the 2004 requirements for any facilities that interconnected under the technical requirements that were in effect prior to November 15, 2004 but specified that these facilities would be required to comply with the WPFTR if the facilities underwent a refurbishment or major upgrade. The AESO considers that this approach is reasonable and prudent but expects that the issue of applicability should be discussed in the rules and standards development and consultation phase. This will include a discussion of the potential grandfathering of certain wind facilities based on the terms and conditions of interconnection agreements and other relevant information.

Once the foundational elements of the MOF (i.e. forecasting, WPM protocol, etc.) have been determined and finalized through this consultation process, the technical requirements team is positioned to move forward quickly through the standards consultation process.

6.3 System Operator Tools

System operator tools are critical to implementation of rules, practices and procedures and are, of course, essential to successful MOF implementation and wind integration as a whole. The Alberta electricity market is conceptually quite straightforward, however, the operational aspects, number of interrelated steps and associated details regarding operation of the system and market is extremely complex.

The system operators rely on a complex arrangement of systems, tools and procedures to ensure that appropriate steps are taken to operate the market and ensure reliable operation and that this is executed in a transparent and consistent manner. There are a suite of systems, tools and mechanisms currently used by the system operators. These systems must be leveraged, modifed and supplemented to provide the operator with displays/tools that will allow them to incorporate wind curtailment, supply surplus and wind power management into day-to-day operating practices. It is critical that operating tools are available prior to the large scale integration of wind. Accordingly, the AESO is proceeding with the preliminary design of necessary systems and tools in parallel with this consultation process.

This will include wind power forecasting for different time horizons and for different purposes, and will require substantial changes to operations practices and the tools used to dispatch the EMMO and regulating reserves. System operator tools are not limited to wind power forecasting but are also required to assist the system controllers in their assessment of the need for and use of wind power curtailment. Regardless of the details of the final WPM protocol, many parties are affected and impacted. The processes and systems used to manage reliability and market operations must be responsive and reliable.

In this respect, the AESO has made significant progress on the development of a prototype of operator tools related to wind integration. The AESO had developed a working prototype which has been demonstrated to some of the industry working groups and continues to be tested and validated in system operations. The design, implementation and use of system tools for system operators is complex and will take considerable effort but it is critical to accommodating the large-scale wind integration on the AIES.

6.4 Compliance to Forecasting Requirements

As noted previously, wind power forecasting in Alberta is in its infancy, and as such, it appears too soon to establish an associated compliance framework and penalties.

However, in the longer term, accuracy of forecasts will be essential to achieving the full benefits of the MOF and some form of compliance will be required. In this respect, compliance monitoring is an important activity which will support continuous improvement and learning.

As was discussed in the Data Management section of this paper (5.3.3), this function could be performed by the AESO or the forecaster depending on data requirements, which entity performs data management and the actual AESO rules. The mechanism to monitor compliance similarly depends on the forecasting model to the extent it influences data requirements and access to data. For example, if centralized wind forecasting is performed by a forecasting service provider, the AESO would need more information than an aggregate forecast to perform compliance monitoring of individual wind farms. In this respect, more work is required to specify the roles, obligations, rules, standards (data quality, accuracy) and mechanisms respecting wind forecasting and the associated measures and details respecting compliance monitoring can then be determined.

6.5 Contingency Plans

For all major projects, contingency plans are necessary to define strategies and actions to deal with specific variances to basic assumptions which may result in a particular problem or emergency. This usually includes a monitoring process and “triggers” for initiating planned actions.

From the outset, it was recognized that the work plan outlined for implementing the MOF was ambitious and that certain elements may need to be refined as we go, based on operating experience. In addition, the consultation and regulatory[28] process associated with AESO rules may also impact resources and timelines.

These and other relevant changes have the potential to delay implementation of some operational components of the MOF by several months. However, the AESO still anticipates significant growth in wind power development by as early as June 2009 which means that it is imperative to be prepared to operate reliably until such time that the key elements of the MOF are fully implemented. 2009 is also forecast to be a busy year with continued growth in load and generation including wind and planned upgrades to core AESO operational systems, including the commissioning of a new EMS system and upgrades to the Dispatch Tool.

Accordingly, the AESO will develop a set of contingency plans in case the rules development and or regulatory approval cycles are delayed. In general, in the event of any delays to the implementation of new or revised rules, OPPs or tools, the AESO will continue to operate with what exists today and ensure reliable operations with existing rules, OPP’s, and practices while implementing the MOF.

[28] Rules/complaint process adjudicated by the AUC

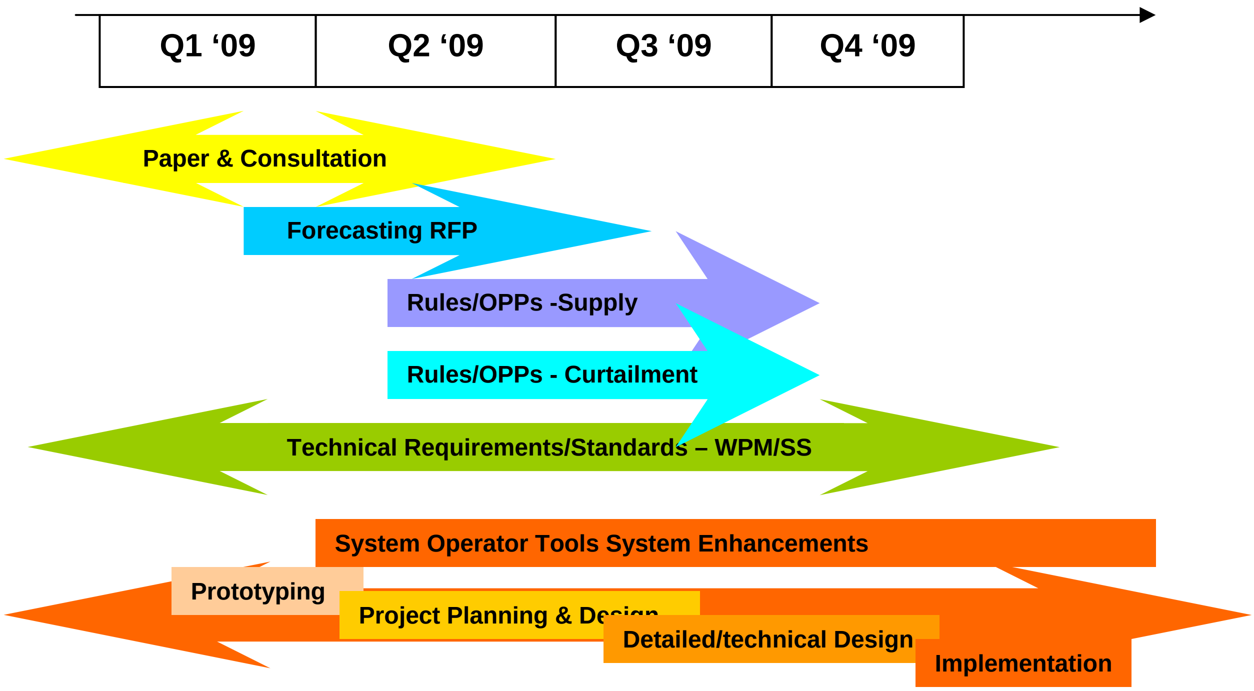
7.0 NEXT STEPS

Through our wind integration efforts with stakeholders, other jurisdictions and interested parties including vendors and forecasters, we have a clearer understanding of the attributes of wind generation and the necessary measures, functions and capabilities to accommodate large scale integration on the AIES. However, much work is still left to be done.

The MOF identified several areas of work which need to advance in order to facilitate wind integration in Alberta including; Wind Power Forecasting, Wind Power Management, Market & Operating Rules (i.e. , Curtailment Protocol, Supply Surplus OPP 103, etc.), System Operator Tools, Technical Requirements, Interconnection Standards & Queue Management; Generation Scenario Development, Transmission Planning; Ancillary Services; and Diversity. The different work streams were initiated at different times and have advanced at various rates. Implementation of some initiatives are subject to feedback through this consultation, some are ready to proceed through the established rules or OPP change processes and others are still in the early exploratory stages.

The AESO is pleased with the continued progress respecting wind integration but seeks to advance the initiative even more in the coming year and subsequent years. Given the high level of interdependence, continued coordination will be needed to move these initiatives forward in a complementary manner. Given the complexity and broad scope of this work, a range of expertise, knowledge and skills as well as familiarity with the evolving nature and direction of the market and operating environment will also be required.

The following chart provides a high level schedule for MOF implementation over the next few years. The assessment is based on the most current available information and reflects our current assessment however delays in the order of 3-6 months delays or potentially more are possible if the key underlying assumptions shift.



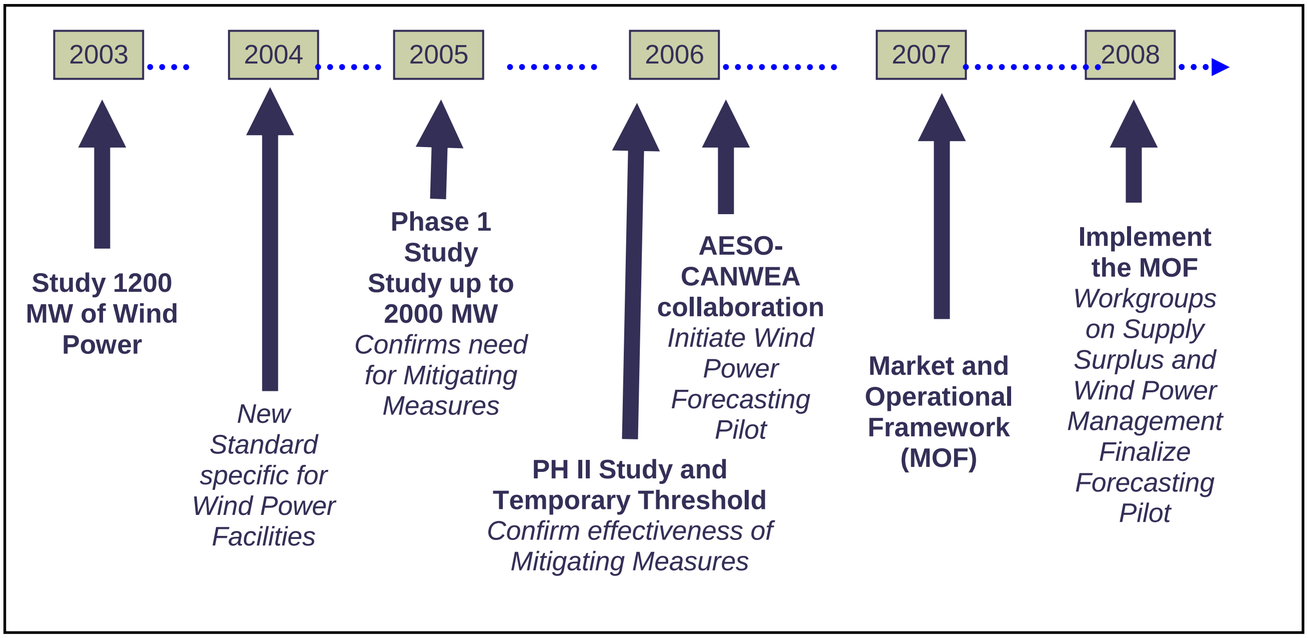
In summary, the near term steps/plan are as follows:

- Issue this overarching MOF recommendation paper
- Conduct a stakeholder consultation session to ensure concepts in the recommendation paper are fully understood before stakeholders provide feedback to the AESO
- Stakeholders to provide formal/written feedback to the AESO
- AESO to complete and publish AESO Comment and Response Matrix
- AESO to incorporate stakeholder feedback to finalize recommendations and proceed to development of rules, practices, procedures, requirements, standards and system design planning and implementation.

The success of the wind integration initiative so far is primarily due to inclusive and open consultation and collaborative problem solving by the AESO and its stakeholders. The individuals who participated in the original MOF consultative process or subsequently on any of the working groups committed a great deal of time and effort and contributed positively to advancing solutions. Just as much collaboration, discipline and assistance will be required on an ongoing basis in order to implement the MOF and accommodate more wind on the AIES. The AESO encourages stakeholders to participate in the overall MOF implementation or specific areas of interest.

Appendix I: Wind Integration History

The AESO's collaborative efforts with industry over the last several years regarding wind integration are illustrated below.



The following list summarizes the consultation and collaborative work the AESO has undertaken with industry stakeholders

- Stakeholder Sessions
  - Wind Integration Information Session – December 2006
  - MOF Implementation Consultation/Information Session – Oct 19 2007
  - Forecasting Pilot Session (Project Completion) – June 2008

- Stakeholder Information
  - MOF – Sept 2007
  - MOMC for wind –Nov 2007
  - Project Milestone Obligation – Jan 2008
  - Weekly Wind reports –started Nov 2007
  - Pilot project progress review – Feb 2008
  - Pilot project presentation – Jun 2008
  - Pilot project reports – Aug 2008
  - WPM WG Report – Aug 2008
  - Supply Surplus WG report – Aug 2008

- Industry Work Group Activity
  - Pilot project: July 2006 to Aug 2008
  - WPM: Nov 2007 to Aug 2008
  - Supply Surplus: Nov 2007 to Aug 2008

Appendix II: Current use of wind generation in STA & ATC

Short Term Adequacy – STA (T- 6 to real time)

Short-term adequacy (STA) is the ability of a power system with a given set of resources to meet the load over the short term (can be anywhere from 7 days to 1 hour in advance of real time). Supply adequacy assessments compare forecasts of supply with forecasted load and provide system operators with sufficient information to develop a plan to manage supply and demand balance and create operational plans.

Near term assessments of load and supply are used to assess STA which is used to create operation plans to ensure sufficient generation is on line to meet the forecasted demand and have sufficient reserves to deal with contingencies. Short Term Adequacy (STA) currently uses both load and supply forecasts and it is generally assessed at about T-6 however the timeframe for these calculations and assessments may range from 7 days in advance to T-1.

A fixed estimate of 80 MW[29] of wind generation is currently used to calculate perform STA assessments for all hours. When it is known that wind capacity will be zero due to weather conditions (i.e. high pressure patterns or cold temperature cut out) the 80 MW estimate is modified accordingly. In future, wind power forecasts will be integrated into the STA assessments and as forecasting accuracy improves the value of STA assessments and the quality and efficiency of the resulting operating plans will also improve.

Available Transmission Capacity – ATC (T- 6 to real time)

Available Transmission Capacity (ATC) is the amount of transmission capacity available for the exchange of electricity between jurisdictions/markets (import/export transactions). The ATC is forecast a day ahead and as conditions change, the system controller may revise the ATC. The amount of southern generation on line (including wind generation) has a significant impact on the amount of available ATC but the current day ahead forecast does not consider wind generation.

However, the AESO has developed a tool that considers the current level of wind generation on the system and forecasts a MW level that can be reasonably counted on in the T-2 timeframe. If the ATC can be improved near real time, the system controller will repost a new ATC limit. In the future, as wind power forecasts become more robust they can be considered in day-ahead calculations of ATC and further refinements to the ATC calculations (i.e. improved accuracy) may be possible.

[29] Based on AESO experience and judgment

Appendix III: Curtailment Protocol Options & Calculations

Potential MW Capability

Option 1 prescribes that curtailment be allocated based on the Potential MW Capability of each WPF. The Potential MW Capability is the amount of wind power that the wind facility would have produced without any reduction or limit to that wind power facility output. Without power limiting the potential MW and actual MW are equal. When power limited a WPF is required to curtail (i.e. spilling wind) making actual MW produced less than that facility's potential MW.

The Potential MW Capability would be calculated using turbine availability and other wind facility operating data and would be telemetered from the wind facility to the AESO. Wind turbine manufacturers have confirmed that the potential MW capability can be provided but they also noted that there could be a 10-15% error in the data. The AESO will monitor performance including data accuracy/quality.

Wind power at facilities vary from many factors that impact output; wind speed, wind direction, turbine height, etc. Because the Potential MW Capability calculations are based on actual output from all the wind facilities and these facilities are not generally correlated this approach to calculating and allocating wind power curtailments takes advantage of any benefits from diversity of the wind generation.

Utilizing the most up to date wind power output the Potential MW Capability calculation ensures the highest degree of fairness. The frequency for calculating and re-allocating affects "fairness". More frequent calculation/reallocation more accurate and fair.

The following example illustrates the curtailment for a system wide power limit (SWPL) for two wind facilities: WPF_A has a 60 MW maximum capability and is currently operating at 50 MW and WPF_B has a 90 MW maximum capability and is currently operating at 10 MW. The Potential MW Protocol, the initial pro-rata allocation would be:

$$\text{Power Limit}_{WPF}{}^{A} = SWPL * 50MW / (50MW+10MW)$$
$$= SWPL * 83.3\%$$
$$\text{Power Limit}_{WPF}{}^{B} = SWPL * 10MW / (50MW+10MW)$$
$$= SWPL * 16.7\%$$

If the SWPL remains the same however the Potential MW for the 60 MW facilities has increased from 50 to 60 MW and the Potential MW for the 90 MW facility has increased from 10 to 80 MW, then the curtailment protocol should be re-calculated and re-allocated. The next iteration of the allocation would be;

$$\text{Power Limit}_{WPF}{}^{A} = SWPL * 60MW / (60MW+80MW)$$
$$= SWPL * 42.8\%$$
$$\text{Power Limit}_{WPF}{}^{B} = SWPL * 80MW / (60MW+80MW)$$
$$= SWPL * 57.2\%$$

Maximum Continuous Rating (MCR)

All generating assets have a Maximum Continuous Rating or MCR. It is the maximum MW capability that a generating asset can continuously maintain (and supply). The true MCR for a wind facility would be the MW that can be produced at the facility with all turbines available at top/potential of the asset. The market requires generating assets to offer their full capability into the market but can price those offers as they wish. The full potential of a wind power asset is the maximum output with the available fuel supply at that moment. With conventional generation fuel supply and other operating conditions are rather constant and predictable whereas wind generators will fluctuate and are not predictable even in the near term or real-time. Since traditional generation offers are day ahead and become fixed at T-2 (MOMC) a comparable requirement is required. The work group developed and evaluated the following curtailment protocol options.

A simple MCR would be based on all turbines being available. A more complex MCR could use a real-time determination of WPF MW based on the real-time availability of the turbines. The allocation is pro-rata with the share of a facility based on MCR. For example, if there are 2 WPFs, with WPF $_{A}$ has a 60 MW maximum capability and WPF $_{B}$ has a 90 MW maximum capability, the pro-rata allocation would be:

$$\text{Power Limit}_{\text{WPF A}} = \text{SWPL} * 60\text{MW} / (60\text{MW}+90\text{MW})$$
$$= \text{SWPL} * 40\%$$
$$\text{Power Limit}_{\text{WPF B}} = \text{SWPL} * 90\text{MW} / (60\text{MW}+90\text{MW})$$
$$= \text{SWPL} * 60\%$$

The MCR protocol allocates SWPL among WPFs based on each facility's. This approach was considered to be fair, understandable and relatively simple to implement. However, it doesn't realistically reflect actual wind facility operation or capability since the MCR can be inaccurate and wind turbines rarely operate at their rated capability. By using a static factor to allocate wind power limits regardless of plant location or production, this option also does not capture any diversity benefits or consider any regional variations in WPF output. This approach was considered to be an inherently less efficient approach.

Appendix IV: Weekly Wind Report

Daily Alberta Wind Generation Statistics										
497MW of Wind Power Currently Operational										
	Wind Generation (MWh/MW) Statistics								Curtailment Statistics	
Date	Average Off-Peak Wind Gen (MWh)	Off-Peak Capacity Factor	Average On-Peak Wind Gen (MWh)	On-Peak Capacity Factor	Average Daily Wind Gen (MWh)	Minimum Wind Generation	Maximum Wind Generation	Average Wind Gen During High Load Hour (MWh)	Number of Hours	Number of Affected Wind Power Facilities
27-Jan-08	226	45.40%	267	53.78%	253	30	416	295	0	0
28-Jan-08	171	34.33%	21	4.30%	71	0	270	1	0	0
29-Jan-08	0	0.00%	2	0.34%	1	0	16	7	0	0
30-Jan-08	28	5.62%	204	40.95%	145	0	345	205	0	0
31-Jan-08	195	39.34%	247	49.71%	230	0	453	196	0	0
1-Feb-08	49	9.94%	112	22.57%	91	0	219	106	0	0
2-Feb-08	193	38.82%	11	2.23%	72	0	315	0	0	0