Dossier : R-3848-2013

HQD - DEMANDE D'APPROBATION DES CARACTÉRISTIQUES DU SERVICE D'INTÉGRATION ÉOLIENNE ET DE LA GRILLE D'ANALYSE EN VUE DE L'ACQUISITION D'UN SERVICE D'INTÉGRATION ÉOLIENNE

Evidence of

William K Marshall

Review of HQD Application

WKM Energy

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Personal Background

- ***Electrical Engineer with MSc in Power Systems***
- ***37 years in the electric power business***
- ***Director of Strategic Planning for NB Power (8 years)***
  - Transmission and generation planning
  - Open access transmission tariff (OATT) development
- ***President and CEO of NB System Operator (4 years)***
  - Completed wind integration studies under my direction
  - Reliability Coordinator for Maritimes Area
  - Administration of the NB OATT
  - Member of Reliability Coordinating Committee of NPCC
  - Similar responsibilities to HQT system operating centre (CCR)
- ***Independent consultant (5.5 years)***
  - NRCan, ACOA, NB, PEI, NS, Emera, EBM and others

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Objectives of WKM Evidence

- ***Review the reliability requirements for wind integration***
- ***Analyse the Application***
  - Relative to reliability requirements
  - Relative to EIÉ, EGM and CFQ
  - Relative to isolated wind balancing requirements
  - Relative to FERC Order 764
  - Relative to utility industry studies on wind integration
- ***Comment on Mr. Hanser's evidence***
- ***Provide conclusions and recommendations***

Reliability Requirements For Wind Integration?

- ***The nature of electricity drives the requirements and must be understood***
  - Electricity can not be stored
  - It travels at the speed of light
  - It has to be produced at the same time that it is consumed
- ***Production must be continuously balanced with consumption***
- ***Reliability has two components***
  - Adequacy – Are there enough resources? (Planning)
    - Requirement is an amount of physical transmission/generation capacity
  - Security - Can the physical resources be continuously operated? (Operating)
    - Requirement is operating flexibility to provide ancillary services
      - Frequency control, Balancing, Reserves, etc
    - Physical capacity provides ancillary services rather than energy

Reliability Requirements

- ***Resource Adequacy* – *Sufficient capacity to reliably supply the forecast load***
  - Criteria – "disconnect firm load not more than 1 day in 10 years"
  - HQD file "Review of Adequacy" with NPCC every year
  - Wind generation accepted as 30% of nameplate capacity
  - 5% supplemental capacity is not required for integration
  - Capacity accepted from any accredited resource
- ***Security* – *Continuously balance load and generation***
  - NERC Control Performance Standards CPS-1 and CPS-2 measure the actual performance of CCR in controlling frequency.
    - Regulating Reserve that can increase or decrease its output via Automatic Generation Control (AGC) within 10 minutes.
      - Studies indicate 6 to 30 MW needed for 3000 MW of wind
    - Load Following capacity that can increase or decrease its output between 10 to 60 minutes
      - Studies indicate 82 to 150 MW needed for 3000 MW of wind

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Reliability Requirements

- ***Security (continued)***
  - NERC Disturbance Control Standard (DCS) requires that HQT Area recover to its pre disturbance schedule within 15 minutes and restore its operating reserves within 105 minutes following a contingency greater than 500 MW
    - HQT carries 1000 MW 10 Minute Operating Reserve of which 250 MW is spinning
    - Failure penalty is an increase in spinning reserve amount
    - No indication of increased requirement for 3000 MW of wind
    - But likely increased activation with wind
  - Regulation capacity for Frequency Control is not additive to operating reserve but is included as the initial component
    - Each shorter time requirement contributes to longer time need
      - Regulating reserve counts as spinning reserve and load following
      - Spinning reserve counts as 10 minute reserve
      - 10 minute reserve counts as 30 minute reserve
      - Total current requirement under "*Entente de services complémentaires*" (ESC) is 1500 MW

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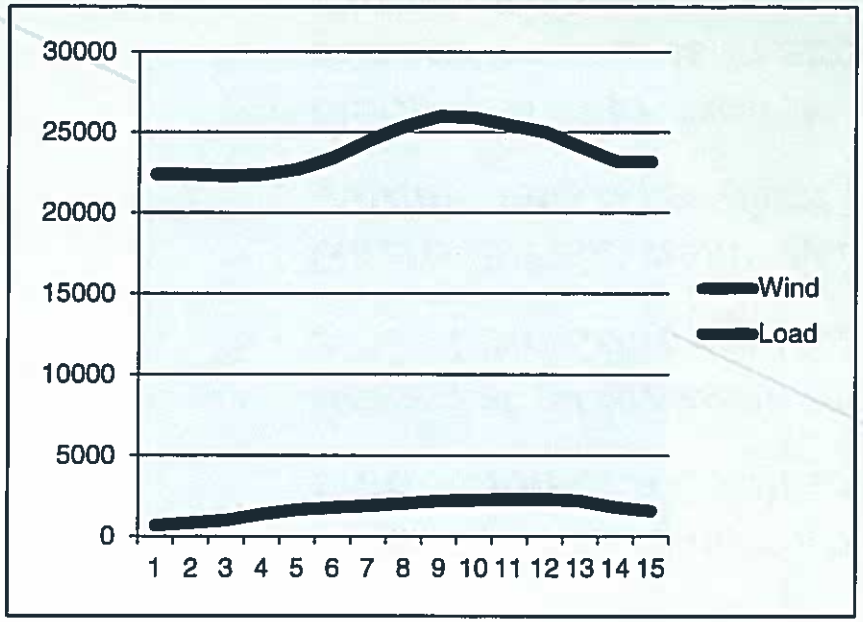
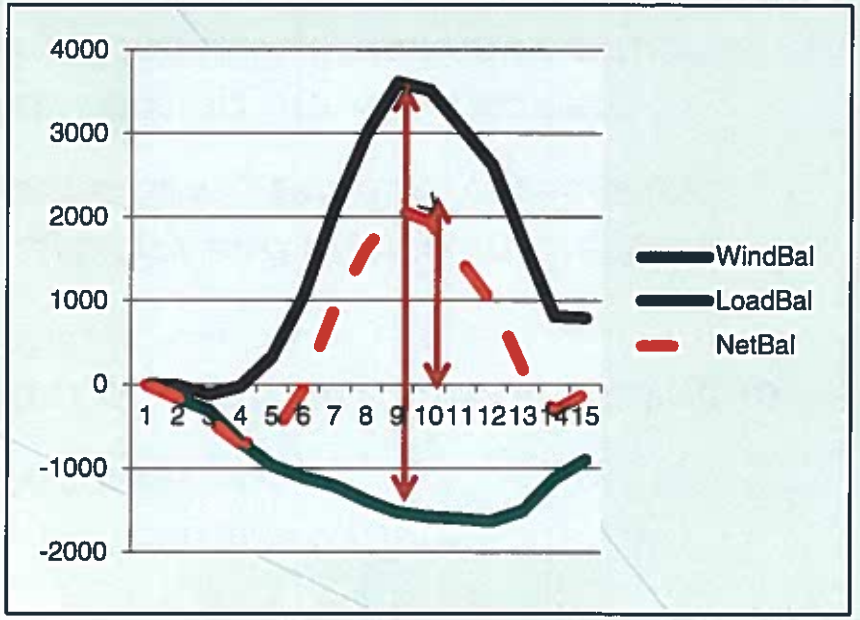
Net Load vs Isolated Balancing

- *North American standard is "net load balancing"*
- *Consider actual wind data for Jan 20, 2013 prorated for 3139 MW in 2015 and typical mild winter day hourly load*

Load and Wind MW



Balancing Requirements



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- *Net Load Balancing - fewer resources - more efficient*
  - 2000 MW versus 5000 MW
- *HQD used net load balancing for Wind Studies and EGM*

HQD Application

Wind power integration service requires the supplier to:

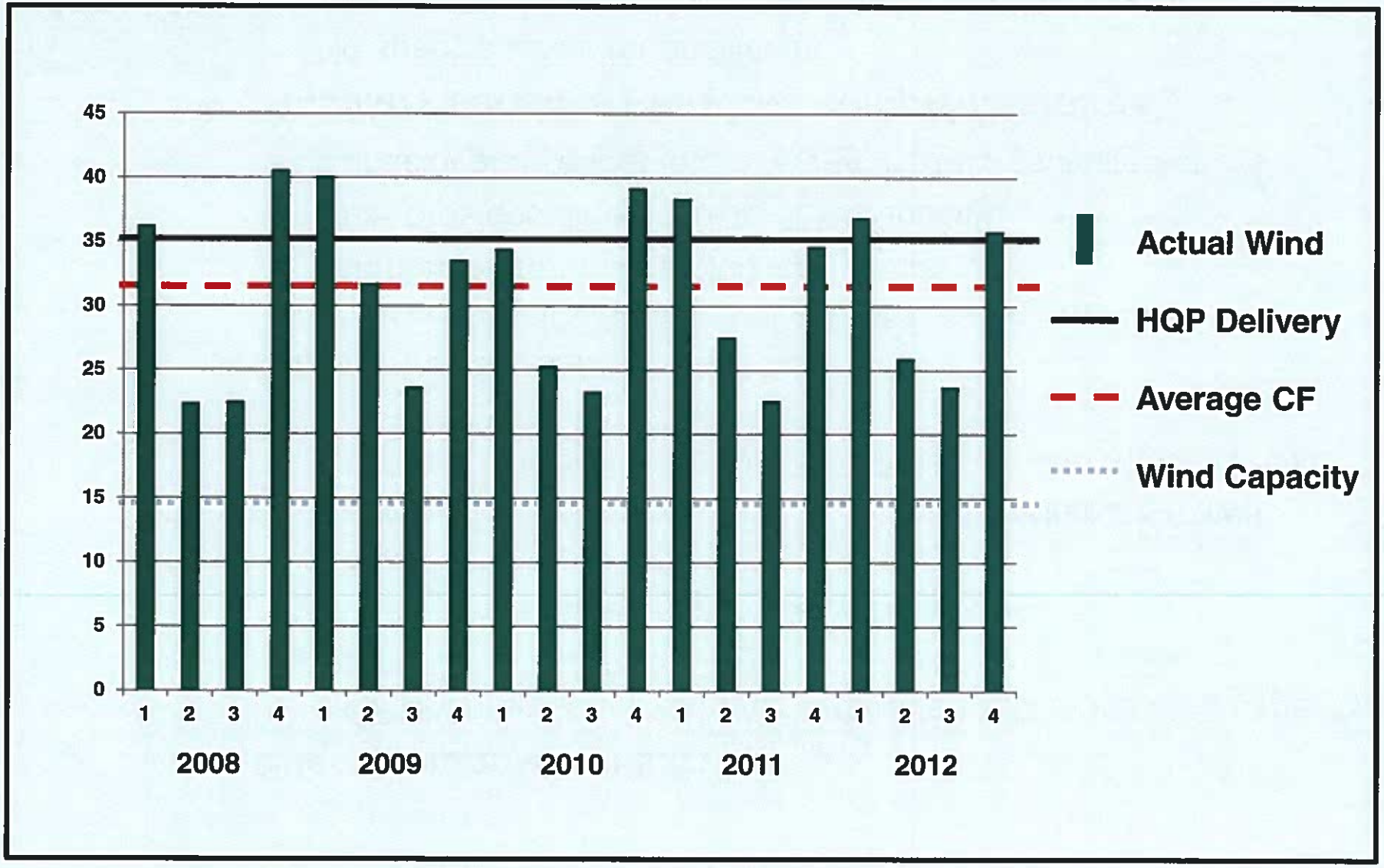
- ***Absorb in real time with a firm load the variable energy production of a Contract Quantity.***
- ***Return at all times an amount of electricity corresponding to 35% of the Contract Quantity***
- ***Guarantee the delivery of capacity and energy in the winter months and be subject to penalties if the delivery is short.***
- ***Mobilize a load capable of absorbing the wind power generation that is in excess of the 35% required to return to the Distributor.***

There are several issues with the service as proposed that are similar to the Entente d'Intégration Éolienne (ElÉ) currently in effect

Entente d'Intégration Éolienne ("EIÉ") 2005

- ***Energy modulation service***
  - HQP absorbs actual wind and return to HQD at flat 35% capacity factor (CF or FU) rate
  - Hourly measurements of actual versus forecast
  - Annual settlement for
    - Absolute value of wind forecast errors from actual at $1/MWh
    - Actual wind differential from 35%CF delivery at $75/MWh in 2005 escalated at 2.5%
- ***Supplemental winter capacity***
  - Wind contribution equal to higher of 15% or lowest wind contribution for highest 300 load hours
  - HQP provides differential to 35% capacity
  - Capacity price equal to $80/kW-yr in 2006 escalated at 2%
- ***Ancillary services (Services complémentaires")***
  - No specific terms for ancillaries
  - Assumed to be negligible and/or imbedded in modulation

Historical EIÉ Capacity Factor by Quarter



Source - Marshall report Figure 4-1

EIÉ is still in Force

Outstanding issues disadvantage HQD customers

- ***Bundling different services into one amalgamated service***
  - Supplemental capacity is separate and should be procured via RFP
- ***Mismatch of modulated energy delivery versus HQD load***
  - Actual performance has been 30.96%CF not intended 35%CF
    - HQD insistence on 35% in future is an issue
  - Seasonal wind generation is highest in winter similar to load
    - Winter surplus above 35%CF goes to HQP
  - Winter surplus plus 4% shortfall below 35% is returned in spring/summer
- ***Annual settlement energy pricing***
  - Settlement price is $75/MWh in 2005 escalated at 2.5%
  - Returned summer energy displaces much lower priced market or Heritage Pool energy
    - $75.6 million/year cost to HQD versus Heritage Pool
- ***Supplemental winter capacity overpayment***
  - 30% wind capacity recognized by NPCC is not accounted for
  - Winter capacity under EIÉ for 300 hours is only 15%
  - HQD has paid HQP for 20% capacity not the incremental 5%
    - $45 million/year cost to HQD without NPCC adjustment

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Lessons Learned From the EIÉ

The following points should apply to any new agreement for wind integration

- ***30% wind capacity accepted by NPCC must be considered;***
- ***The supplemental capacity is not required for reliable integration of wind generation***
  - It is for adequacy and not security
  - It is a separate product that should be procured by a separate RFP if and when required as per Régie decision D-2011-193
- ***Wind modulation is a commercial product that is not required for reliability;***
  - It could be eliminated or,
  - It could be a banking service as in the EGM or,
  - If the Régie wishes to have fixed returns, it should be monthly at historical monthly capacity factors rather than a yearly fixed return; and
  - As a separate service modulation should be procured via a separate RFP.

Issues with the HQD Application

The service is proposed as a single service

- But in reality includes several distinct services
  - Modulation
  - Supplemental capacity
  - Ancillary services (Frequency Regulation and Load Following)
- They all should be procured via separate RFP's, if and when required by the Régie

Each separate service has additional issues

- Modulation of a contract quantity of variable wind into a constant 35% CF delivery is a commercial service not required for reliability
  - Modulation if needed should be monthly or EGM banking
- Supplemental capacity deemed as 5% of contract in winter actually requires 35% capacity be provided at all times
  - The 30% NPCC capacity credit is for seasonal adequacy
  - Providing wind backup to 35% in real time needs 35% capacity available
- One (1) minute control by CCR provides ancillary services for wind integration equal to 100% of the contract quantity

Issues with the HQD Application

Each separate service has additional issues (Continued)

- No attempt by HQD to determine the correct quantity of ancillary services
  - Either as an increment to those in the "*Entente de services complémentaires*" in order to balance the net load combination of wind and Heritage resources
  - Or as needed for isolated balancing of wind independently
- HQD has challenged my understanding of the Application that 100% capacity under 1 minute control is 100% ancillary services capacity (HQD-02-01.2 Régie IR- #7.1)

  « La compréhension du service d'intégration éolienne de monsieur Marshall, citée en préambule, est inexacte ».
- My understanding of the Application is
  - 100% of the capacity is under 1 minute control of CCR
  - The capacity must be controlable both up and down
  - There are no restrictions on its use
  - It is capacity able to provide ancillary services (Regulation, Load Following, Spinning Reserve, etc)

Examples of CCR Dispatch Requirements as per the HQD Application

Contract Quantity (MW)	100							
	Scenario 1				**Scenario 2**			
	High Wind Forecast				**Low Wind Forecast**			
	Low Actual Production				**High Actual Production**			
HQD Wind forecast	100%				0%			
Actual HQD Wind Production		80%	50%	10%		20%	50%	90%
	Planned Hourly Schedule	**CCR Five (5) Minute Schedules**			**Planned Hourly Schedule**	**CCR Five (5) Minute Schedules**		
Firm Supplier Commitment (MW)								
HQD load (35%)	35				35			
System losses (5.4%)	5				5			
Load at HQT or Interconnection	60				60			
Total Supply Required	100				100			
Generation Dispatch (MW)								
HQD Wind Generation	100	80	50	10	0	20	50	90
Initial Supplier Dispatch	0				100			
CCR Instruction to Supplier		20	50	90		80	50	10
Dispatch Change Required	0	20	50	90	0	-20	-50	-90

Source - Marshall report Figure 6-1

Reliability Requirements vs Application

(For 3139 MW of Wind Capacity)

		Minimum Requirement For Reliability		Implicitly Required in the Application	
		Winter	Summer	Winter	Summer
Adequacy (Year,Month,Day ahead)					
Supplemental Capacity(%CF)		0%	0%	35%	35%
	(MW)	0	0	1099	1099
Forecast Risk Capacity	(MW)	47	47	1099	1099
Security (Real Time)					
Ancillary Service Capacity					
Regulating Reserve (0-10 min)	(MW)	6-31	6-31	3139	3139
Load Following (<60 min)	(MW)	86-157	86-157	3139	3139
Incremental LF (10-60 min)	(MW)	80-126	80-126	0	0
Required Reliability Services Capacity	(MW)	86-157	86-157	3139	3139

Error Correction

Source - Marshall report Figure 5-1

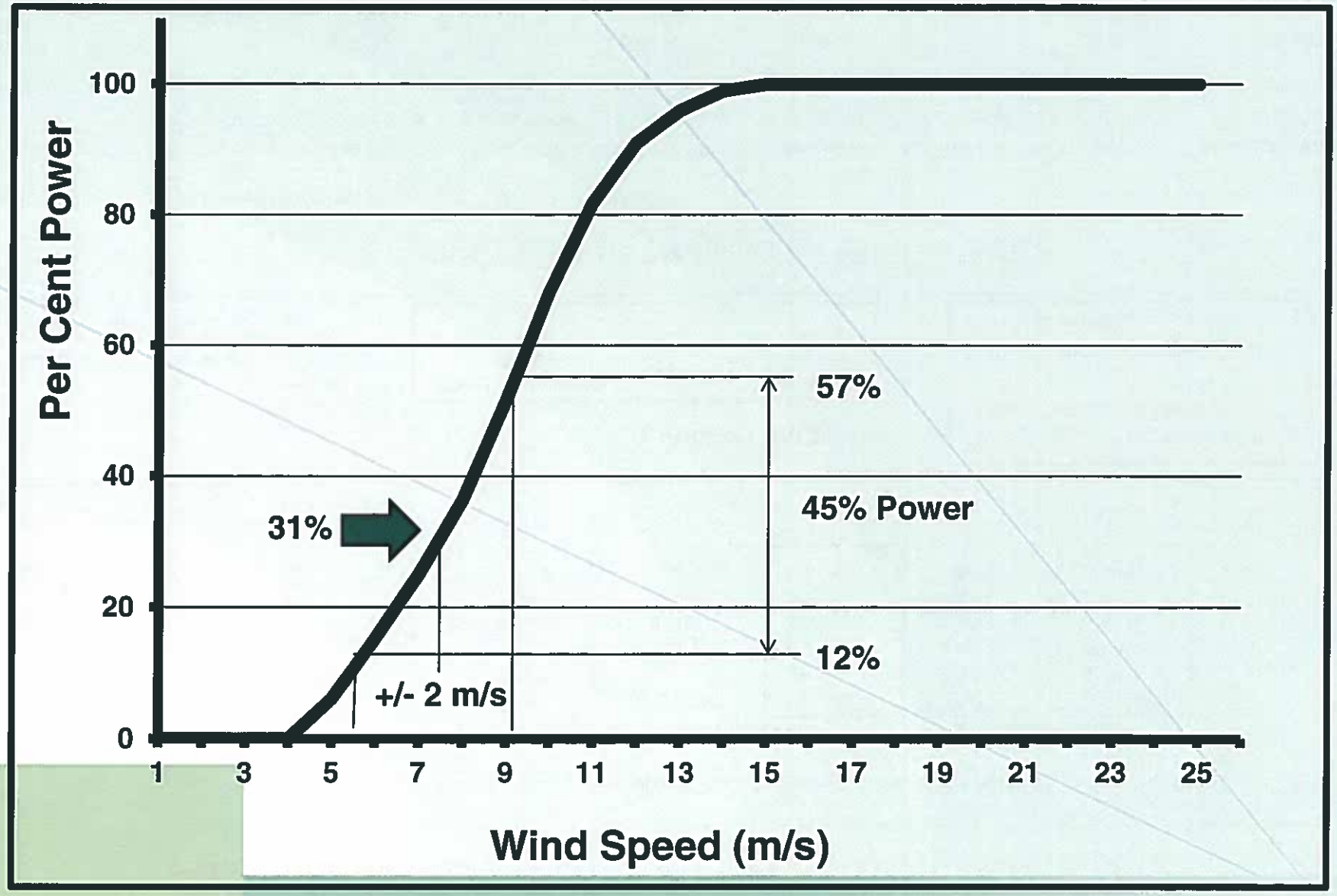
Order in Council Regulations

- ***Issue is interpretation of the requirement***
  - The energy block(s) are "*subject to a balancing service and supplementary capacity in the form of a wind energy integration agreement.*"
    - Objective is to reliably integrate wind for system security,
    - NPCC already recognizes 30% capacity for resource adequacy
- ***HQD view is***
    - 5% supplemental capacity for adequacy, plus
    - energy modulation with a uniform 35% capacity return, and
    - 100 % contract under 1 minute control
- ***An alternative view could be***
  - "*Balancing service and supplementary capacity*" means
    - The incremental Regulation and Load Following capacity needed for integration
  - Surely the government did not intend to force the isolated (and inefficient) balancing of wind and load separately
  - In any event, in addition to the ancillary services to be obtained through a separate RFP, if necessary or required, the modulation service and any additional supplemental capacity should also be obtained via separate RFPs

Isolated Operation of Wind Generation

- ***Application requires 100% of "contract quantity" be under 1 minute CCR control***
  - If wind output is zero, the 100% capacity must be available to increase
  - If wind output is 100%, the 100% capacity must be able to decrease
  - 100% of contract quantity is effectively "Regulating Reserve"
- ***But how much does wind actually vary? How much ancillary service capacity (Regulation and Load Following) is actually required to balance these variations?***
- ***Answers require***
  - Understanding of wind generation characteristics
  - Analysis of actual historical wind generation data
- ***HQD has not provided 1 minute data so hourly and 5 minute data was analysed***

Typical Wind Generator Power Curve



Source - Marshall report Figure 6-2

Actual HQD Wind Production for 2012

Range of Hourly Wind Production - Maximum to Minimum For Single Hours

Installation Period	Installed Cap MW	Maximum Hour MWh/hr	Maximum Hour % Capacity	Minimum Hour MWh/hr	Minimum Hour % Capacity
Jan 1 - Mar 27	706.5	679.6	96.2%	0.01	0.00%
Mar 28 - Oct 10	845.1	781.6	92.5%	0.02	0.00%
Oct 11 - Nov 05	925.1	911.4	98.5%	0.40	0.04%
Nov 06 - Dec 11	1036.1	952.0	91.9%	0.11	0.01%
Dec 12 - Dec 31	1137.3	964.6	84.8%	2.05	0.18%
Weighted Average Installed Capacity (IC) =	852.1				

Production Variations

	Annual Average	Maximum
Hour to Hour Variation (% of Capacity)	3.2%	26.9%
Applied to 3139 MW in 2015 (MW)	100.3	844.1

Only 3.9% of hourly variations exceeded 10% of capacity

100% capacity control via AGC is excessive

Analysis of Wind Production for All Hours in 2012

Number of hours in year 2012 (HRS) = 8784 Hours

	Actual Production a	Potential Production b=IC*HRS	35% CF Production c=b*0.35	Annual Differential d=a-c	Hourly +ve Deviations e=Sum(a-c)+	Hourly -ve Deviations f=Sum(a-c)-	Absolute Value Modulation g=e-f
Energy (MWh)	2,317,270	7,485,041	2,619,764	-302494	632,036	-934530	1,566,566
Average Energy (MWh/h)	263.8	852.1	298.2	-34.4	187.0	-172.9	178.3
Average Cap Fac (%)	31.0%	100.0%	35.0%	-4.0%	21.9%	-20.3%	20.9%
Expected Dispatch (%Cap)					56.9%	14.7%	

Source - Marshall report Figure 6-3

Persistence Forecast for 2012

Persistence forecast assumes past generation from previous hour "persists" through the current hour to the next hour

- allows time for CCR analysis and communication to balancing agent

	Production level considered (% of Capacity)					
	<100%	<15%	>15%	<60%	>60%	15% to 60%
Average Error (% of Capacity)	5.6%	3.4%	6.7%	5.5%	5.9%	6.9%
Applicable Hours (% Time)	100%	33.3%	66.7%	84.7%	15.3%	51.4%
Hours Excluded (% Time)	0%	66.7%	33.3%	15.3%	84.7%	48.6%
Maximum Single Error (% Cap)	44.9%	33.6%	44.9%	38.9%	44.9%	38.9%
2015 Wind Capacity (MW)	3139					
Average 2015 Error (MW)	175	107	210	174	185	217

Source - Marshall report Figure 6-4

Forecast errors are significantly smaller than 100% of capacity
The Application requirement for 100% control is excessive

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HQD Wind Forecasts vs Actual Generation

Wind Forecast Errors Jan 20-26, 2013

Installed capacity = 1437 MW	Average Absolute Error		Maximum +ve Error		Maximum -ve Error	
	(MW)	(%Capacity)	(MW)	(%Capacity)	(MW)	(%Capacity)
HQD 4 Hr Forecast *	79.9	5.56%	613.9	42.7%	-286.7	-19.9%
HQD 1 Hr Forecast *	72.1	5.02%	580.9	40.4%	-267.7	-18.6%
2 Hr Persistence Forecast **	63.3	4.40%	277.2	19.3%	-299.3	-20.8%
Slope Adjusted 2 Hr Persistence Forecast **	52.2	3.63%	246.4	17.1%	-323.6	-22.5%

Note - +ve error is forecast higher than actual
-ve error is forecast lower than actual

* Regie IR-2 #5.1. 5.2
** WKM analysis

HQD forecast could be better

Forecast errors are only about 5% of capacity or less

Requirement for 100% capacity control on AGC is excessive

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Analysis of HQD 5 Minute Data

Operation of 1437 MW of Wind Capacity for Jan 20-26, 2013

Hourly Intervals

	Hourly Wind Production	% Installed Capacity	Hourly Deviations	% Installed Capacity	Amount for 3139 MW in 2015
Average MW	868.7	60.4%	36.5	2.5%	80
Maximum MW	1,116.9	77.7%	314.0	21.8%	686
Minimum MW	314.0	21.8%	-174.9	12.2%	382

Five (5) Minute Intervals

	5 Minute Wind Production	% Installed Capacity	5 Minute Deviations	% Installed Capacity	Amount for 3139 MW in 2015
Average MW	868.7	60.4%	6.1	0.4%	13
Maximum MW	1,133.1	78.8%	52.1	3.6%	114
Minimum MW	279.4	19.4%	-71.5	-5.0%	-156

Source – Marshall report Figure 6.5

Corrects Error in report

5 Minute variations are 5% of capacity or less
Only 2.3% of variations exceeded 1.5% of capacity
100% capacity control via AGC is excessive

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Isolated Wind Operation Conclusions

- ***HQD assumes that wind must be balanced separately from load***
- ***Under this assumption, I conclude that for 3139 MW of wind generation in 2015***
  - about **300MW of intra-hour Load Following** capacity is sufficient
    - hourly deviations are less than 10% of capacity for 96.1% of time
  - about **50MW of Regulating Reserve** capacity is sufficient
    - 5 minute deviations are less than 1.5% of capacity for 97.7% of time
- ***The Application requirement for 100% (3139 MW) control via AGC (or in 1 minute) is excessive even for isolated balancing of wind generation.***
- ***But isolated balancing of wind is counter to standard industry practice in North America.***
- ***The accepted approach requires balancing the net variations of the load, wind production and other generation which minimizes the total balancing requirements and the associated costs.***

FERC Order 764

Integration of Variable Generation Resources (VERs)

- *Transmission providers must offer intra-hourly transmission scheduling*
  - NYISO is implementing 15 minute scheduling available to HQD
  - ISO-NE is exploring 15 minute scheduling
- *Wind plants and other VERs must provide meteorological and forced outage data to the transmission provider*
  - Purpose is to improve power production forecasting
- *Schedule 10 - Generator Regulation & Frequency Response*
  - Not compulsory in the *proforma OATT*
  - Consider on case by case basis like examples in the Evidence of Mr. Hanser
- *Provide guiding principles for VER integration*

Intention is *"efficient utilization of transmission and generation resources to the benefit of all customers"*

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FERC Order 764

Guiding principles for VER Integration

- *Approach for proper design of generator regulation and frequency response service charges*
  - *"Find the least cost methods of **balancing the system as a whole**"*
  - *"acquire the **appropriate amount** of reserves needed **to integrate VERs reliably**"*
  - Include diversity benefits by *"**aggregating the variations of all resources**"*
  - Account *"for diversity benefits **among all resources and loads**"*
  - Determine *"**overall generation regulating reserve** needs and **allocate those costs accordingly**"*
  - Allocations of *"**proportionate share is based on the operational characteristics** of such customers (or customer classes)"*
- *Mr. Hanser agrees*

*"Additional ancillary service needs are always considered for the **entire pool of resources**, rather than just for VERs"*

(Red underlines added for emphasis)

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Wind Integration Studies - Regulation

Study	Peak Load MW	Wind MW	Penetration %Peak	Regulation MW	Regulation %Wind
GE-ERCOT 2008	65,000	15,000	23.1%	102	0.7%
NYISO 2010	37,130	8,000	21.5%	116	1.5%
UVIG #1	10,000	1,500	15.0%	8	0.5%
UVIG #2	33,000	3,300	10.0%	36	1.1%
HQ Regulation	39,000	3,000	7.7%	6	0.2%
IEA HQ Regulation	39,000	3,000	7.7%	30	1.0%
HQ Application	38,972	3,139	8.1%	3139	100.0%

Source – Marshall report Figure 9-1

Note HQD Application -

It has relatively low wind penetration (8%) but excessive regulation request (100%)

Wind Integration Studies – Load Following

Study		Peak Load MW	Wind MW	Penetration %Peak	Load Following MW 1 StDev	Load Following %Wind 3StDev	Load Following %Wind
NBSO 2005 #1	NB Area	3,300	400	12.1%	3.7	11.1	2.8%
#2	NB Area	3,300	600	18.2%	8.1	24.3	4.1%
#3	NS Area	2,100	400	19.0%	7.7	23.1	5.8%
#4	Maritimes	5,400	1000	18.5%	10.3	30.9	3.1%
GE-NS Power 2013 #1		2,100	335	16.0%		21	6.3%
#2		2,100	488	23.2%		29	5.9%
#3		2,100	551	26.2%		32	5.8%
#4		2,100	916	43.6%		45	4.9%
Idaho 2013 #1		3,400	800	23.5%		50	6.3%
#2		3,400	1,000	29.4%		130	13.0%
#3		3,400	1,200	35.3%		195	16.3%
HQ Following #1		39,000	3,000	7.7%		82	2.7%
IEA HQ Following		39,000	3,000	7.7%		150	5.0%
HQ Application		38,972	3,139	8.1%		3139	100.0%

Source – Marshall report Figure 9-2

Note HQD Application – Low penetration, excessive Load Following

Wind Integration Costs

	Peak Load MW	Wind MW	Penetration %Peak	Cost $/MWh
Studies				
NBSO 2007 #1	3,300	400	12.1%	4.39
#2	3,300	600	18.2%	4.71
#3	3,300	800	24.2%	7.36
EXCEL Energy #1	7,148	720	10.1%	3.51
#2	7,148	1,075	15.0%	4.77
#3	6,922	1,400	20.2%	5.13
Idaho 2013 #1	3,400	800	23.5%	6.51
#2	3,400	1,000	29.4%	11.03
#3	3,400	1,200	35.3%	16.38
UVIG			20.0%	5.00
Hanser				
BPA	11,300	4,711	42%	$4.81
PSE	4,900	773	16%	$6.07
Idaho	3,245	678	21%	$5.01
Westar	5,000	614	12%	$0.58
NWE	1,784	141	8%	$6.18

Source – Marshall report Figures 9-3 and 9-4

HQ is most similar to BPA – mainly hydro with large interties

Wind Integration Costs

- ***Hanser evidence "provides Indicative costs for HQD"***
  - IR response to HQD-02-01 Régie IR 4.4
- ***US Utility characteristiCS are very different than HQ***
  - Predominantly thermal systems
    - Higher costs because of unit commitment requirements
  - Integration challenge is much greater than HQD
    - Thermal plus higher wind penetration rates
  - Integration costs will be higher than in Québec
    - Lowest cost is BPA with extremely high penetration (Westar is not full service)
- ***BPA is most similar to HQ***
  - Mainly hydro with large interconnections
  - Cost is $5/MWh with 42% penetration
  - HQD with more hydro and 8% penetration should be much less
  - Reasonable cost is likely $2 to 3/MWh not $5/MWh
  - Indicative costs only without RFP or detailed study

Mr. Hanser's Evidence

Wind integration in HQD

- ***Four "unique" characteristics***
  - Contract duration
    - Needs both intra-hourly and long term
  - Type of services sought
    - *"intra-hour, hourly and longer-term integration services, including capacity firming"*
    - HQD desire services to be bundled
  - Location of the service providers
    - Need to be inside Quebec area
    - Transmission from NYISO not available
  - Ownership
    - HQD can not own generation
- ***Many utility companies face similar challenges***
  - The issue is not the "unique" obligations of HQD but rather how HQD chooses to address them

Conclusions

- ***The separate services bundled into the Application should***
  - be unbundled and
  - procured via separate RFP's if deemed necessary or economic
- ***Modulation and Supplemental adequacy capacity are not required for reliable wind integration***
- ***100% contract under 1 minute control by CCR is excessive***
- ***Isolated balancing of wind separate from other resources is***
  - Inconsistent with North American industry practice, as well as
  - Inefficient, costly and counter to a mandate to supply at least cost
- ***The required services to balance 3139 MW of wind in the HQ system in 2015 based on existing studies is***
  - 6 to 31 MW of Regulating Reserve (AGC)
  - plus 80 to 126 MW of Load Following
  - which taken together is a total balancing capacity of 86 to 157 MW
- ***Regulating Reserve and Load Following are separate capacity services which should be procured via separate RFPs in order to achieve a minimum cost of supply***

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Evidence of

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Review of HQD Application

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