MH/NCN Undertakings 35, 36, 37 (Transcript pages 1562, 1563, 1568)
Requested by CNF
Re: 450 MW Wind Sensitivity Analysis

Manitoba Hydro has completed sensitivity analyses with respect to the economics of wind generation, specifically sensitivities to capacity factor and to wind turbine generator equipment life.

The analyses are:

1. The long term economics of wind in 2009.
2. The expected economic benefit of Wuskwatim instead of wind.
3. The Social Net benefit of Wuskwatim instead of wind.

450 MW of wind generation at 35% capacity factor would produce approximately the same energy as Wuskwatim. At 40% capacity factor only about 400 MW of wind generation would be needed to produce this same amount of energy, while at 30% capacity factor 525 MW of wind generation would be required. The analyses to the sensitivity of capacity factor made these wind capacity adjustments accordingly.

The capacity factor for a limited amount of wind generation in Manitoba could potentially reach as high as 40%. However it is considered unlikely that after the development of 250 MW of wind currently in Manitoba Hydro's Power Resource Plan that there would be sufficient sites that would be capable of providing a further 400 MW of wind at 40% capacity factor. Also it is possible after the initial 250 MW development that the remaining sites may be capable of only 30% capacity factor. For this reason both capacity factors have been considered in the sensitivity analyses.

The long term economics of wind in 2009 is comparable to Table 6 in the Manitoba Hydro/NCN rebuttal evidence submitted to CEC on February 27, 2004. This analysis is provided on the attached table titled "450 MW Wind Power Internal Rate of Return

Sensitivity". Whereas the analysis in the rebuttal showed at expected export prices that the for the long term economics of wind the IRR was 6.1% for expected wind resource at 35% capacity factor, for 40% capacity factor the IRR would be 7.9%, while for 30% capacity factor the IRR would be 4.2%.

Extending the turbine generator equipment life from 20 years to 25 years would increase the IRR from 6.1% to 6.4%. On the basis of information from Manitoba Hydro's consultant, Helimax, in providing this analysis it is assumed that the operation and maintenance cost for the last five years of its life would increase from $41/kW/year to $90/kw/year.

Also for the same sensitivities to capacity factor and equipment life an analysis is provided on the expected benefit of Wuskwatim instead of wind on an attached figure comparable to Figure 1 of the rebuttal. Information in the sensitivity figure was used as input for a sensitivity analysis for the social benefit study comparing Wuskwatim to wind. This sensitivity analysis is titled "Social Net Benefits of Wuskwatim vs. Wind Development – Sensitivity to Capacity Factor and Turbine Life" and is comparable to the study provided as Attachment 1 in the rebuttal evidence.

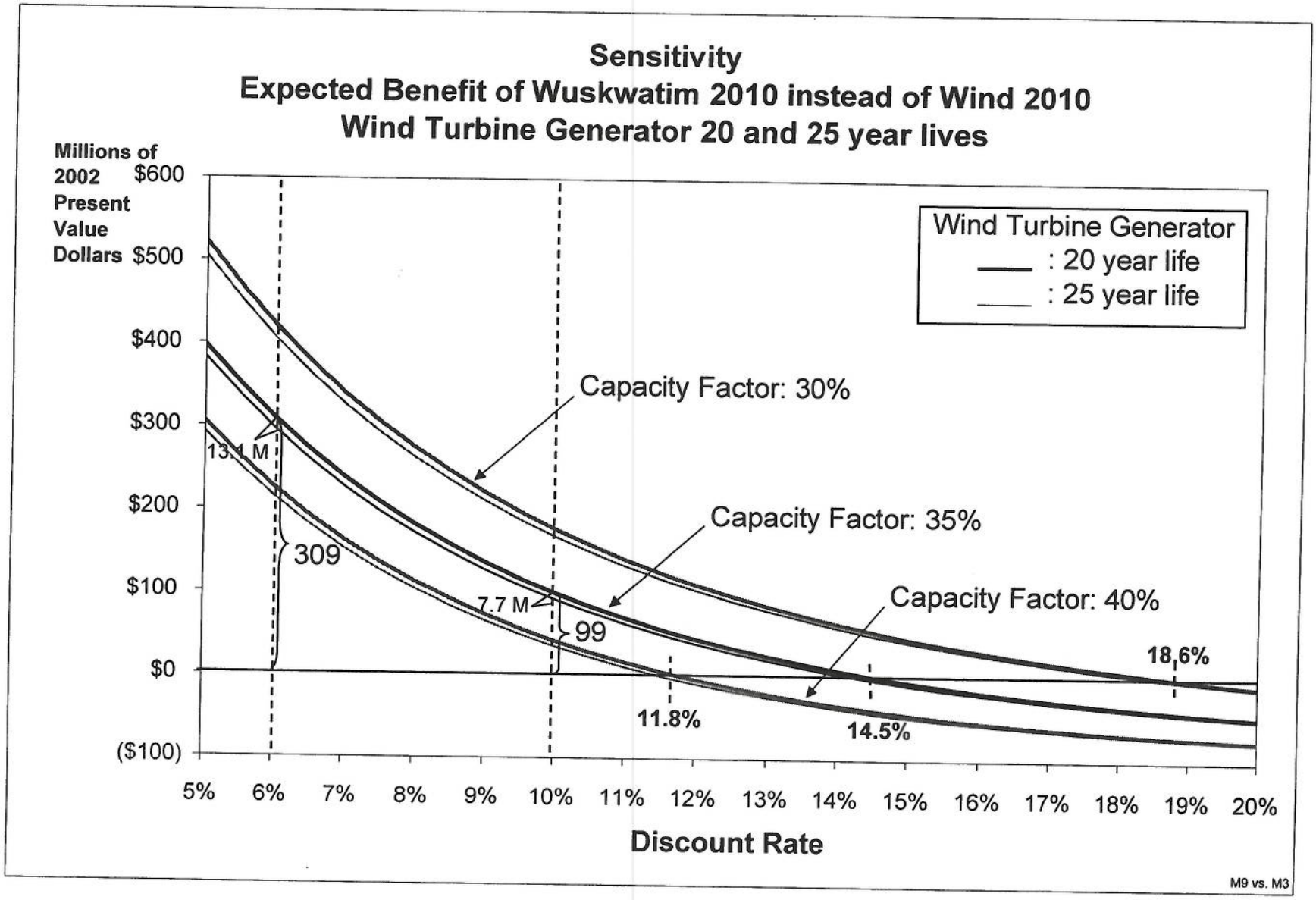
The analysis shows at expected export prices that the for the 6% real discount rate, the net benefit of Wuskwatim over wind is $ 376 million at the expected 35% capacity factor. At 40% capacity factor the net benefit decreases to $ 299 million while at 30% capacity factor the net benefit increases to $ 480 million.

The analysis is less sensitive to the equipment life of the wind turbine generator. At a 6% real discount rate, the net benefit of Wuskwatim over wind for a 25 year equipment life decreases to $ 226 million as compared to $ 237 million for a 20 year equipment life.

450 MW Wind Power Internal Rate of Return Sensitivity

ISD - 2009, based on Long-Term Economics and Expected Export Prices

Capacity Factor:	30%	35%	40%
20 year life	4.2%	6.1%	7.9%
25 year life	4.4%	6.4%	8.1%


Sensitivity
Expected Benefit of Wuskwatim 2010 instead of Wind 2010
Wind Turbine Generator 20 and 25 year lives
Millions of 2002 Present Value Dollars
$600
$500
$400
$300
$200
$100
$0
($100)
Wind Turbine Generator
: 20 year life
: 25 year life
Capacity Factor: 30%
Capacity Factor: 35%
Capacity Factor: 40%
13.1 M
309
7.7 M
99
18.6%
11.8%
14.5%
5% 6% 7% 8% 9% 10% 11% 12% 13% 14% 15% 16% 17% 18% 19% 20%
Discount Rate
M9 vs. M3

SOCIAL NET BENEFITS
OF
WUSKWATIM VS WIND DEVELOPMENT

Sensitivity to Capacity Factor and Turbine Life

Prepared for Manitoba Hydro

by

Marvin Shaffer & Associates Ltd.

March 19, 2004

1.0 Sensitivity to Capacity Factor

Tables 1 and 2 summarize the social net benefits of Wuskwatim relative to wind at 30%, 35% and 40% capacity factors. Table 1 provides the results at a 6% real discount rate; Table 2 at an 8% real discount rate. All of these cases assume a 20 year turbine life.

As shown in the tables, the social net benefits of Wuskwatim are smaller the higher the assumed capacity factor for wind. This is because of reduced number of wind turbines and consequently less capital and O&M required to provide the same average energy as Wuskwatim. Even at a 40% capacity factor, however, the social net benefits of Wuskwatim are still almost $300 million greater than wind at a 6% real discount rate and just over $170 million greater at an 8% real discount rate.

In terms of the different accounts, the higher capacity factor reduces the difference in the project net return between Wuskwatim and wind. However it does increase somewhat the social adjustments—the taxpayer, other transfer and employment advantages of Wuskwatim. That is because of the reduced capital taxes, land lease payments and employment benefits of wind at the higher capacity factor. There would be somewhat less environmental impact of wind the higher the capacity factor, but the differences between the two projects would not significantly change. They remain low for both projects.

2.0 Sensitivity to Turbine Life

Tables 3 and 4 summarize the social net benefits of Wuskwatim relative to wind at 20 and 25 year economic lives for the wind turbines. Table 3 provides the results at a 6% real discount rate; Table 4 at an 8% real discount rate. Both turbine life cases assume a 35% capacity factor.

As shown in the tables, the social net benefits of Wuskwatim are smaller the longer the economic life of the wind turbines. However, the differences are not great. At a 6% real discount rate the social net benefits of Wuskwatim fall from $376 million to $362 million with a 25 year turbine life. At an 8% real discount rate they fall from $237 million to $226 million. The longer economic life does delay the investment in replacement turbines, but the impact in present value terms is relatively small and is offset by higher fixed O&M costs in the later years of the turbine operations.

3.0 Combined Capacity Factor and Turbine Life Sensitivities

Tables 5 and 6 show the social net benefits for all capacity factor and turbine life sensitivities. The most favourable case for wind is the 40% capacity factor and 25 year economic life for the turbines. Even in that case the social net benefits for Wuskwatim are $287 million greater than wind at a 6% real discount rate; $163 million greater at an 8% real discount rate.

Table 1

Sensitivity of Social Net Benefits to Wind Capacity Factor

(2002 NPV at 6% real, $million Cdn)

	30% Capacity Factor	35% Capacity Factor	40% Capacity Factor
Project Net Return (at expected export prices)	421.2	309.5	225.9
Taxpayer Net Benefit	44.2	49.3	53.1
Other Transfers -Trans fund net benefits -Land lease net benefits	5.9 (15.8)	5.9 (13.6)	5.9 (11.9)
Employment Net Benefit	24.2	25	25.6
Overall Social Net Benefit	***479.8***	***376.1***	***298.7***

Table 2

Sensitivity of Social Net Benefits to Wind Capacity Factor

(2002 NPV at 8% real, $million Cdn)

	30% Capacity Factor	35% Capacity Factor	40% Capacity Factor
Project Net Return (at expected export prices)	274.5	182.4	113.3
Taxpayer Net Benefit	32.4	36.2	39.0
Other Transfers -Trans fund net benefits -Land lease net benefits	5.5 (11.4)	5.5 (9.8)	5.5 (8.6)
Employment Net Benefit	22.3	22.9	23.4
Overall Social Net Benefit	***323.2***	***237.1***	***172.6***

Table 3

Sensitivity of Social Net Benefits to Wind Turbine Life

(2002 NPV at 6% real, $million Cdn)

	20 Year Life	25 Year Life
Project Net Return (at expected export prices)	309.5	296.3
Taxpayer Net Benefit	49.3	48.6
Other Transfers -Trans fund net benefits -Land lease net benefits	 5.9 (13.6)	 5.9 (13.6)
Employment Net Benefit	25.0	25.2
Overall Social Net Benefit	***376.1***	***362.5***

Table 4

Sensitivity of Social Net Benefits to Wind Turbine Life

(2002 NPV at 8% real, $million Cdn)

	20 Year Life	25 Year Life
Project Net Return (at expected export prices)	182.4	171.9
Taxpayer Net Benefit	36.2	35.8
Other Transfers -Trans fund net benefits -Land lease net benefits	 5.5 (9.8)	 5.5 (9.8)
Employment Net Benefit	22.9	23.1
Overall Social Net Benefit	***237.1***	***226.4***

Table 5

Social Net Benefits of Wuskwatim Relative to Wind

by Capacity Factor and Turbine Life

(2002 NPV at 6% real, $million Cdn)

	30% Capacity Factor	35% Capacity Factor	40% Capacity Factor
20 Year Turbine Life	479.8	376.1	298.7
25 Year Turbine Life	464.0	362.5	286.9

Table 6

Social Net Benefits of Wuskwatim Relative to Wind

by Capacity Factor and Turbine Life

(2002 NPV at 8% real, $million Cdn)

	30% Capacity Factor	35% Capacity Factor	40% Capacity Factor
20 Year Turbine Life	323.2	237.1	172.6
25 Year Turbine Life	310.9	226.4	163.2