Tyndall°Centre
for Climate Change Research

Climate Change Policy and Canada's Oil Sand Resources: An Update and Appraisal of Canada's New Regulatory Framework for Air Emissions

Anthony Footitt

A Report for WWF

May 2007

Tyndall Centre for Climate Change Research

Contents

Part I

1. Introduction

1.1 Background

Oil sands (also known as tar sands) are mixtures of sand, water, clay and crude bitumen. Canada has a large area of these bitumen resources, with these located mainly within the province of Alberta. Minor oil sands deposits are also found on Melville Island (in Canada's Arctic Island region) and there are minor deposits of oil shale on the eastern edge of the Western Canada Sedimentary Basin.

Alberta's oil sand deposits are grouped into three principal areas: Peace River; Athabasca; and Cold Lake. The bitumen deposits in these three areas collectively cover around six million hectares (ha). Until 2002/03, the various sources of projections of World oil reserves did not include such deposits in their estimates on the basis that the mining and extraction techniques involved were unconventional (and, in simple terms, thus not conventionally 'available').

In late 2002 and early 2003 both the Oil & Gas Journal and Cambridge Energy Research Associates included Canada's oil sands in the listings of world oil reserves for the first time. On the basis of these listings Canada's resources are now ranked second in the world in terms of size.

Alberta's oil sands are currently estimated to contain an ultimately recoverable crude bitumen resource of 50 billion cubic metres (315 billion barrels), with remaining established reserves of almost 28 billion cubic metres (174 billion barrels) (Canadian National Energy Board – NEB, 2006).

The recent inclusion of Canada's oil sands in (some) estimates of World oil reserves comes after a period of rapid expansion in oil production from (and investment in) these areas, particularly the Athabasca reserve. This, in turn, has been driven, in part, by higher global oil prices, the effect of which has been to offset the relatively large extraction and recovery costs involved in the operation.

Such costs are not only associated with the mining, transport and planned renovation of extraction areas but, more significantly with the process of recovering the bitumen from the oil sands. Amongst other inputs, the process requires hot water and steam, necessitating the use of significant inputs of energy (principally from natural gas at present). In addition to recovery, there are additional processing and energy costs associated with processing of recovered bitumen into synthetic crude oil.

In the context of climate change, the use of significant inputs of energy to recover bitumen and produce synthetic crude oil from oil sands, combined with the projected future expansion of extraction and recovery (and consumption of the recovered oil) has implications for increases in greenhouse gas (GHG) emissions. There is concern from WWF (and others) that this expansion in oil sand recovery and processing may have significant implications for not only Canadian commitments, but also global emissions of greenhouse gases more generally. Accordingly, WWF has commissioned the Tyndall Centre to undertake a short independent study to explore the issue.

1.2 Objectives of the Study

The principal objective of this short study has been to explore the issue of expansion of oil sand extraction and processing in Canada, identifying any implications for the achievement of net reductions in Canada's GHG emissions in pursuance of Kyoto Protocol commitments (and, therefore, climate change more generally).

As noted in Section 1.1, expansion of the industry has been rapid in recent years; there are also various projections for future expansion, all showing sustained growth (of varying gradients). In order to achieve a balanced picture of the scale of the associated GHG emissions and any (net increase), we have drawn on published government statistics and industry data. These data have been used to develop quantitative estimates of emissions under various growth projections, where these have been compared with various emissions targets to gauge the magnitude of any 'gap' between raw unmitigated emissions and target emissions, and the extent to which mitigation measures may either address gaps (or would need to considering projected expansion).

1.3 Structure of the Report

Section 2 provides an overview of the approach taken to estimating the expansion of oil sands and the associated GHG emissions while Section 3 considers National and Provincial targets and the significance of the emissions relative to them.

In Section 4, the possible emission reductions achievable through process efficiency improvements is assessed and the residual emissions that are required to achieve the various targets set out in Section 3 is estimated.

Section 5 provides an analysis of the short and long term implications of the gap between predicted emissions and Canada's Kyoto commitments, considering the issues for Canada as a whole. Conclusions are made concerning the delivery of an optimum strategy to deliver targets and the associated issues.

2. Approach to Estimating 'Raw' Emissions

2.1 Overview

In attempting to provide estimates of greenhouse gas (GHG) emissions from future exploitation of Canada's oil sand resource the following key variables need to be considered:

- future growth and expansion of the oil sands industry itself and the associated production capacities;
- the nature of the production processes involved, the future 'share' of each extraction and processing technology;
- the GHG intensities (in terms of the quantities of GHG emitted per unit production) associated with each technology; and
- future improvements in the efficiency of these extraction and production processes or other technical measures to reduce emissions.

In terms of the latter, the approach used in this study is one that seeks to consider the magnitude of any emission reduction from improvements in efficiency, identifying any remaining gap that may exist between actual and target emissions that may need to be addressed by other measures (such as Carbon Capture and Storage – CSS) and how this may impact upon policy.

The approach to estimating efficiency improvements is described in subsequent sections. This section focuses on the approach to estimating the 'raw' (unmitigated) emissions.

2.2 Projections of Future Expansion

A quick review of the literature suggests that few attempts have been made to estimate future GHG emissions from oil sand expansion and policy implications. However, a recent attempt at such estimates has been made by the Pembina Institute[1]. The approach used can be summarised as:

- modelling future expansion of the industry on the basis of a database of planned and proposed projects;
- on the basis of the same database, predicting the share of different technologies and their future expansion; and

[1] Pembina Institute (2005): The Climate Implications of Canada's Oil Sands Development, Matthew Bramley, Derek Neabel and Dan Woynillowicz November 29, 2005

- superimposing GHG intensities on the production capacities assuming some improvement in the efficiency of technologies with time to derive annual total GHG emissions.

The approach accounts for the core variables pragmatically and, from a methodological perspective, seems reasonable given the uncertainties and information deficits. However, given the uncertainties, any approach is bound to be highly sensitive to the assumptions describing what the future entails. This is particularly the case with regard to future expansion of the industry where, all other things being equal, a doubling of expansion will result in a doubling of emissions. If there is a shortcoming in the Pembina approach, it would seem to be that assumptions on future expansion are not made absolutely explicit or, at least, it is not clear that they are consistent with the projections that have been made in the various economic and market reports. This is not so much a failing in approach as much as a problem of consistency and ease of comparison with Government projections and the authority with which (rightly or wrongly) they are viewed.

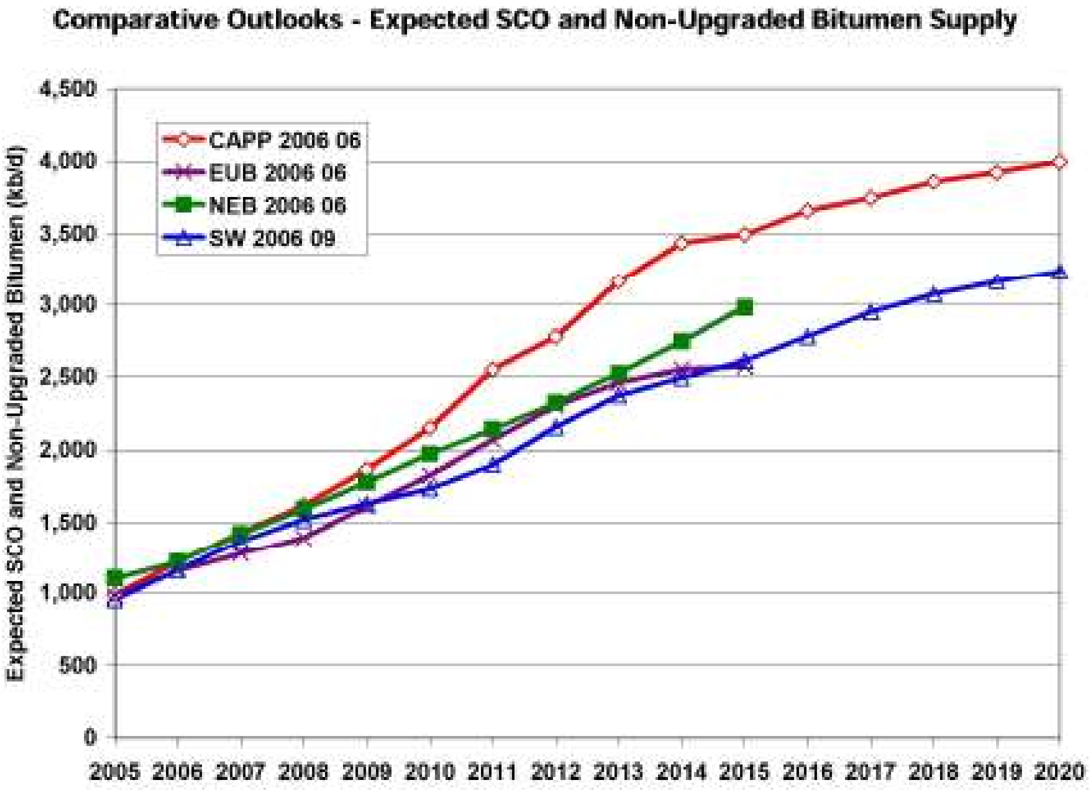
In light of these issues, in seeking to develop a new set of estimates we have sought to draw directly from official projections of oil sand expansion. There are three main sources of 'official' projections on which to base an assessment; those being from:

- Alberta Energy and Utilities Board (EUB)[2];
- Canadian Association of Petroleum Producers (CAPP)[3]; and
- the Canadian National Energy Board (NEB)[4].

Projections from these sources were summarised recently in *Canada's Oil sands industry – Production Supply and Outlooks* (RB Dunbar, Strategy West Inc. - September 2006), which also added its own assessment of the outlook for expansion. Figure 2.1 is drawn directly from the 2006 Strategy West document and provides the projections of future expansion in production from oil sands.

[2] Alberta Energy and Utilities Board (2006): Alberta's Energy Reserves 2005 and Supply /Demand Outlook 2006-2015, EUB ST98-2006, September 2006.
[3] Canadian Association of Petroleum Producers (2006): Canadian Crude Oil Production and Supply Forecast 2006-2020, May 2006.
[4] National Energy Board (2006): Canada's Oil Sands – Opportunities and Challenges to 2015: An Update – Energy Market Assessment, June 2006.

Figure 2.1: Oil Sand Expansion Projections (Source: Strategy West, 2006)



For this study we have drawn on one of these sources, namely, the industry expansion projections provided in the National Energy Board (NEB) Energy Market Assessment (EMA) *Canada's Oil Sands: Opportunities and Challenges to 2015: an Update* (Canadian NEB, June 2006). This recent EMA provides an analysis of the costs, expansion, key issues, technologies and expansion of the oil sand resource in Canada. The EMA also provides three projection scenarios based on a database of some 160 or so project specific operations, proposals, applications, announcements, approvals and disclosures. Project specific data giving type of activity, daily production capacity and start-up dates are provided in the annex to the EMA.

Based on these data and economic modelling, the EMA covers the following scenarios:

- **All Projects Case**: which assumes that all projects publicly announced to date commence operation at their name-plate volume and start date;
- **Low Case**: which the EMA notes is a projection to illustrate what might happen if the economic viability of oil sands projects is compromised, perhaps by sharply lower prices. It predicts that an outlook for sustained oil prices below US$35 per barrel would lead to marginal economics for many projects in the present business environment and would slow development; and

- **Base Case:** where the EMA notes that the projection is based on a sustained high oil price and an economically attractive environment.

Table 2.1 provides the projected oil sands production given in the 2006 NEB EMA under the various NEB scenarios. Note that the NEB (2006) data plotted by Strategy West (provided as Figure 2.1), relates to the NEB Base Case projection.

Table 2.1: Oil Sands Bitumen Production According to NEB Estimates (000 m^3/day)

	All Projects Case	Low Case	Base Case
2002	111	111	111
2003	148	148	148
2004	153	153	153
2005	152	152	152
2006	194	194	194
2007	246	225	225
2008	298	250	253
2009	344	258	282
2010	450	265	313
2011	517	273	340
2012	595	281	370
2013	645	290	402
2014	674	299	436
2015	715	307	474

The NEB also provides a breakdown of projection on production from in situ, mined and primary (cold) sources as well as Synthetic Crude Oil (SCO). These are provided in Table 2.2.

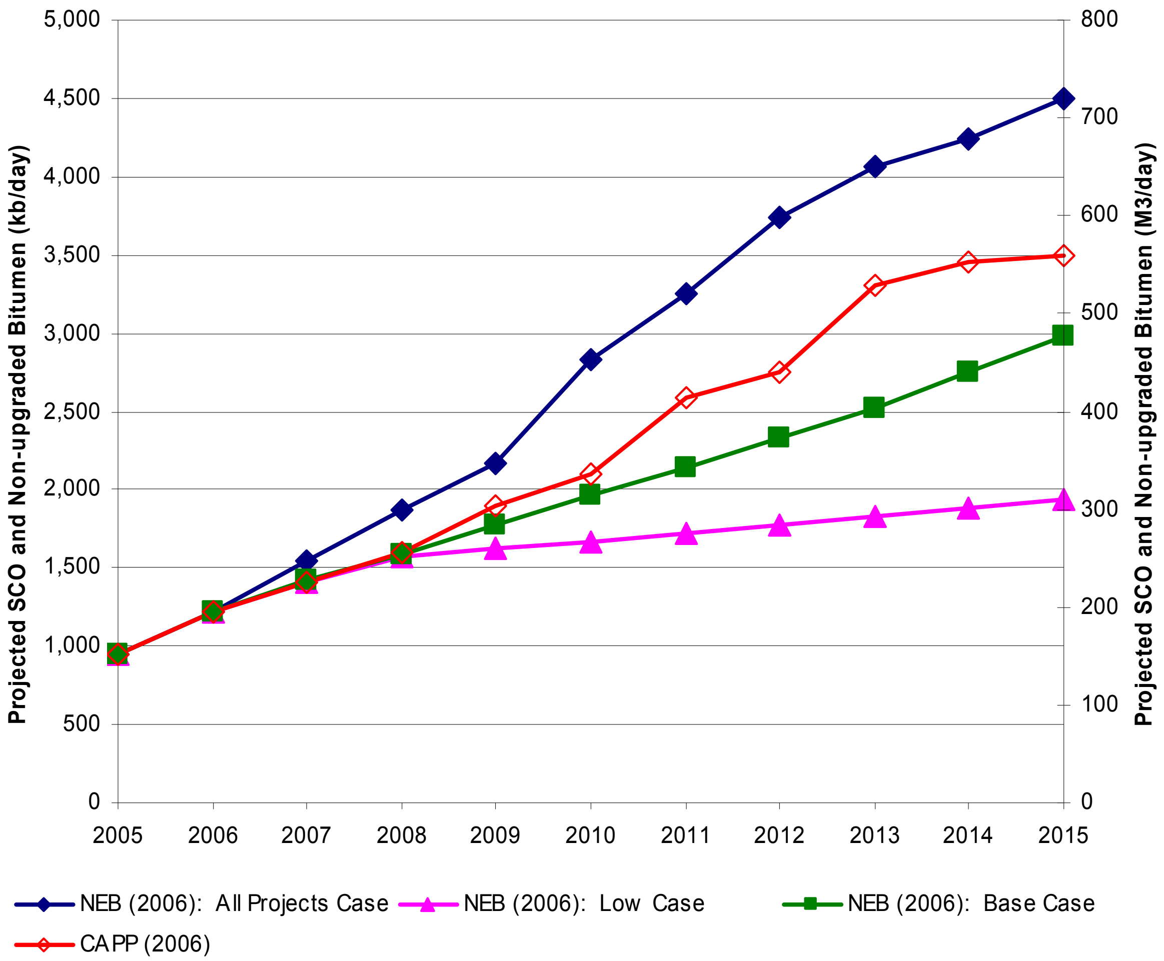
Table 2.2: NEB Estimate of Oil Sands Production and Upgrading by Type (000 m^3/day) – Base Case

	Mined	In Situ	Primary	SCO
2002	84.2	30.5	17	69.8
2003	97.7	39.9	15.5	85.5
2004	111.7	44.7	16.6	95.2
2005	113.7	44.6	16.9	92
2006	123.8	53.3	16.6	119.4
2007	131.8	76.6	16.9	144.9
2008	136.9	99	17.2	170.4
2009	146.9	118	17.5	182.5
2010	160.1	135.6	17.8	224.6
2011	174.5	147.8	18.1	239.2
2012	190.2	161	18.4	262.2
2013	207.3	175.5	18.7	278.2
2014	226	191.3	19	288.2
2015	246.3	208.6	19.3	305.9

Figure 2.2 provides NEB projected output data graphically for all three scenarios. For the purposes of comparison, the CAPP (2006) projection up to 2015 is also provided.

From the figure (and also comparison with Figure 2.1), it can be seen that the range of NEB projections used in the study covers the full range of possibilities provided by other sources. However, It is of note that the industry projections provided by CAPP (2006) tend to lie between the NEB Base case and All Projects Scenarios. This suggests actual future growth may be more likely to be higher than the NEB Base Case than it is to be lower.

Figure 2.2: Estimates of Projected Growth in Oil Sand Exploitation



2.3 Projected Breakdown by Process

Using the project specific data on 160 or so projects and proposals in the EMA we have recreated the NEB scenarios to form the basis for projections of the implied GHG emissions to different extraction processes. Base data for the NEB EMA all projects scenarios has been duplicated from the Annexes of the NEB EMA. These data include and information on the name of each of the projects, and, using information sourced from another project database (reported in the Pembina report), we have been able to cross reference and classify projects in terms of production type.

In this way we have been able to calculate a division in the NEB data for production volumes arising from:

- Steam Assisted Gravity Drainage (SAGD);
- SAGD and upgrading;
- Mining;
- Cyclic Steam Stimulation (CSS);
- Toe-Heel-Air Injection (THAI);
- Primary (Cold) Production; and
- Upgrading/Synthetic Crude Oil (SCO) production.

On the basis of these data, we have overlaid the data to provide the process divisions for both the base and low case scenarios in the EMA. These data are provided Table 2.3.

Table 2.3: NEB Scenarios and Production Volumes for Different Extraction Processes (000 m³/day)											
		2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
NEB ALL PROJECTS	**Mined**	123.8	144.1	161.2	179.2	230.2	265.3	305.9	332.6	349.4	371.5
	SAGD	30.5	49.8	80.8	106.9	154.5	183.7	213.9	236.8	252.5	267.8
	THAI/VAPEX	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	CSS	22.6	33.7	35.6	36.7	40.2	40.8	44.7	44.5	43.0	46.6
	Primary	16.6	18.5	20.3	21.3	25.6	27.5	29.6	30.0	29.4	29.1
	SCO	119.4	158.4	200.7	222.6	322.9	363.7	421.6	446.4	445.5	461.4
NEB BASE CASE	**Mined**	123.8	131.8	136.9	146.9	160.1	174.5	190.2	207.3	226.0	246.3
	SAGD	30.5	45.6	68.6	87.7	107.5	120.8	133.0	147.6	163.3	177.6
	THAI/VAPEX	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	CSS	22.6	30.8	30.2	30.1	27.9	26.8	27.8	27.7	27.8	30.9
	Primary	16.6	16.9	17.2	17.5	17.8	18.1	18.4	18.7	19.0	19.3
	SCO	119.4	144.9	170.4	182.5	224.6	239.2	262.2	278.2	288.2	305.9
NEB LOW CASE	**Mined**	123.8	131.8	135.3	134.4	135.5	140.1	144.4	149.5	155.0	159.5
	SAGD	30.5	45.6	67.8	80.2	91.0	97.0	101.0	106.5	112.0	115.0
	THAI/VAPEX	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1
	CSS	22.6	30.8	29.8	27.6	23.7	21.5	21.1	20.0	19.1	20.0
	Primary	16.6	16.9	17.0	16.0	15.1	14.5	14.0	13.5	13.0	12.5
	SCO	119.4	144.9	168.4	167.0	190.2	192.1	199.1	200.7	197.6	198.1

2.4 Conversion of Production Volumes to GHG Emissions

The next step in the approach to generating emissions estimates was to apply a series of process specific GHG intensity values to the production volumes. A review of GHG intensity values for production processes reveals only a few sources and some variation between estimates. Those most suitable and amenable to the analysis are those in the Pembina report which, itself, drew generic factors from Len Flint of LENEF Consulting. These generic factors are provided in Table 2.4 below.

Table 2.4: Generic GHG Intensity Values (Source: Pembina Report and LENEF Consulting)	
Production Type	**GHG intensity TCO_{2e}/m^3 Production**
Mining of bitumen	0.22
SAGD production of bitumen	0.35
THAI production of bitumen	0.41
Cyclic Steam production of bitumen	0.57
Upgrading of bitumen	0.28

The Pembina report also draws on a limited number of project specific intensity values from industry sustainability reports. In terms of how these generic values compare with the other values, Table 2.5 provides some industry estimates associated with oil sands projects, where these will relate to different mixes of processes (which may be the source of greatest variation between values).

Table 2.5: Industry Estimates of GHG Intensity		
	Year	**GHG intensity TCO_{2e}/m^3 Production**
Suncor	2004	0.62
Syncrude	2004	0.74
Canadian Natural resources Ltd	2002	0.57
Shell Canada	2005	0.39

Comparison of the generic intensities in Table 2.4 with these company specific values (Table 2.5) suggests that, if anything, the generic estimates may tend to underestimate emissions (these being lower than the industry values in virtually all cases).

Further cross checking of intensity values with the Canadian Association of Petroleum Producers (CAPP) Technical Report A National Inventory of Greenhouse Gas (GHG), Criteria Air Contaminant (CAC) and Hydrogen Sulphide (H2S) Emissions by the Upstream Oil and Gas Industry Volume 1, Overview of the GHG Emissions Inventory (September 2004) suggests values of 0.59 TCO_{2e}/m^3 for hot production. The generic values would seem to be broadly consistent with this or, again, even err on the side of caution (and possibly underestimate emissions). The same CAPP report provides an estimate of 0.075 TCO_{2e}/m^3 for cold (primary) production, where this has been carried through into the analysis.

Given the uncertainty in the derivation of both generic or project specific factors, for simplicity it was decided to apply generic values drawn from Table 2.4 and conduct a sensitivity analysis based on 10% error factor. The root GHG intensities applied in the analysis are summarised in Table 2.6.

Table 2.6: GHG Intensities Applied in the Analysis	
Production Type	**GHG intensity TCO_{2e}/m^3 Production**
Mining of bitumen	0.22
SAGD production of bitumen	0.35
THAI production of bitumen	0.41
Cyclic Steam production of bitumen	0.57
Primary	0.08
SCO Production	0.28

2.5 Resulting Estimates of GHG Emissions in the Absence of Mitigation

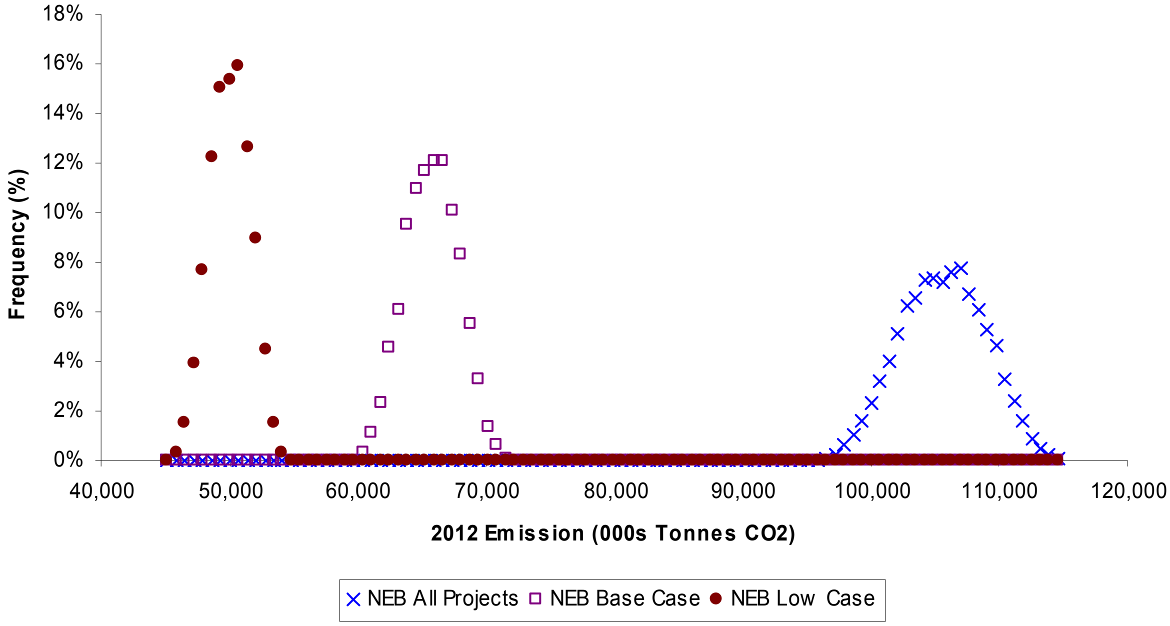
Applying these GHG intensities to the projected production capacities under the NEB scenarios up to 2015 provides the emission estimates in Table 2.7. As noted above, these emission estimates relate to ‘raw’ unmitigated emissions based on the current GHG intensities for the different processes set out in Table 2.6.

Table 2.7: Total GHG Emissions from Oil Sands - No Mitigation (000s Tonnes CO_{2e})			
	NEB All Projects	**NEB Base Case**	**NEB Low Case**
2006	31,283	31,283	31,283
2007	41,735	38,172	38,172
2008	51,831	44,004	43,482
2009	59,112	48,458	44,334
2010	80,400	55,923	47,347
2011	91,303	60,045	48,212
2012	105,229	65,436	49,696
2013	112,789	70,296	50,711
2014	115,693	74,840	51,324
2015	121,791	80,740	52,293

As noted above, these estimates reflect the use of the average intensity values set out in Table 2.6 which are likely to be subject to a degree of error. As such, we have undertaken a Monte Carlo analysis based on a +/-10% individual variation in each of the GHG intensity estimates. This provides a probabilistic distribution of emissions around for each of the scenarios set out in Figure 2.3.

As can be seen from Figure 2.3, there is a normal distribution around the average values within a relatively small range of emissions, where this suggests that no variation in any one of the GHG intensities for a given process produces markedly different results in the estimate of total emissions. That said, the analysis also suggests that, the higher the scenario for projected expansion, the greater the propensity for predicted emissions to be higher (or lower) than those predicted on the basis of the average values.

Figure 2.3: Probabilistic Distribution of Predicted Total Emission for 2012 based on 10% Error Factor in GHG Emission Intensity Values



3. Significance of GHG Emissions

3.1 Overview

Clearly, the scale of predicted future emissions from oil sands under the NEB scenarios and any policy implications is difficult to gauge without considering significance of the emissions compared with other emissions and targets.

In order to provide such contextual values, we have sought to identify a number of targets and scale these down to provide target emissions for oil sands commensurate with either Canada's commitments under Kyoto or the targets of the provincial government (Alberta). This then enables consideration of any 'gap' between the predicted emissions set out in Table 2.7 and the means to achieve any required emission reduction.

3.2 National and Provincial Total GHG Emission Targets

3.2.1 Canada's Kyoto Commitments

Canada is one of the 38 industrialised countries (Annex I countries) that has committed to cut emissions of GHGs under the Kyoto Protocol. In terms of individual country targets, Canada is required to reduce emissions to a level of 6% below 1990 emissions by 2012 (and 25% below by 2020).

Based on recent Environment Canada reports, Canadian target total emissions under Kyoto are as follows:

Canada 2012: 563,000 kt CO_{2e}
Canada 2020: 449,202 kt CO_{2e}

Further, Environment Canada notes that, in accordance with Article 3, paragraphs 7 and 8 of the Kyoto Protocol, Canada's allowable emissions for the period 2008 to 2012 is 2,815 Mt CO_{2e} (i.e. 94% of the 1990 level multiplied by five).

3.2.2 Alberta's Implied Kyoto Commitments

According to Environment Canada data, Alberta's 2004 CO_{2e} emission was 235,000 kt CO_{2e}. UNFCCC data gives Canada's emission in the same year (2004) as 780,403 kt CO_{2e}. This means that Alberta's emission was some 30% of Canada's total emission in 2004. Applying this percentage to Canada's Kyoto targets provides implied equitable Kyoto commitment targets for Alberta as follows:

Implied Kyoto Alberta 2012: 169,613 kt CO_{2e}
Implied Kyoto Alberta 2020: 135,329 kt CO_{2e}

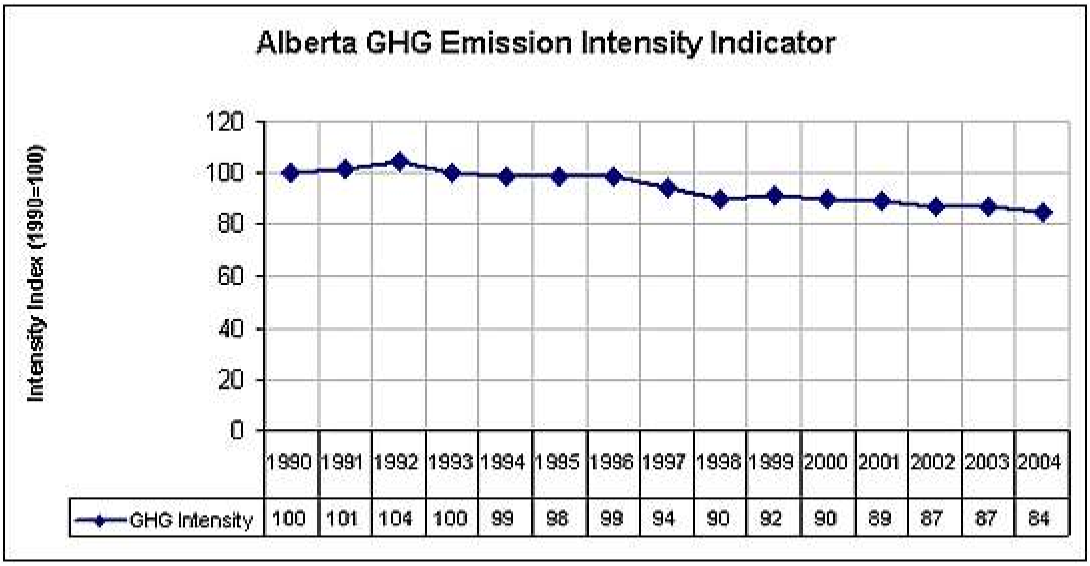
Applying this to the provisions of Article 3, paragraphs 7 and 8 of the Kyoto Protocol, Alberta's implied allowable emissions for the period 2008 to 2012 is 848 Mt CO_{2e}.

3.2.3 Government of Alberta's Target

The Government of Alberta has itself introduced a target to reduce its GHG emissions in relation to the Gross Domestic Product (GDP) by 50 per cent below 1990 levels. The objective is to reach this target by the year 2020. In addition, there is an interim target of a 30% reduction in per unit GDP intensity by 2010.

Figure 3.1 below provides the Government of Alberta's data[8] on performance on the indicator. The indexed values for the indicator are calculated by dividing the annual emissions intensity (tonnes of greenhouse gas per million dollars Gross Domestic Product) by the 1990 emissions intensity value. This gives an annual comparison to the 1990 intensity, shown as a percentage.

Figure 3.1: Government of Alberta GHG Intensity Indicator



According to the data, in 2004 the greenhouse gas emissions intensity according to the index was 84% of what it was in 1990. Based on Alberta Finance data on GDP for 2004 and emissions for the same year, it is possible to calculate the future actual CO_{2e} emissions associated with a range of scenarios for future growth in Alberta's GDP.

8 See http://www3.gov.ab.ca/env/soe/climate_indicators/15_ghg.html

Table 3.1 provides projections of the future CO_{2e} emissions up to 2009 based on GDP forecasts in the 2006 Alberta Budget and Fiscal Plan[9]. Post 2009, a number of growth scenarios are presented as follows:

- post-2009 Alberta GDP growth is equivalent to the average growth in the Fiscal Plan for the years 2006-2009 inclusive – i.e. 4.4% per annum;
- post-2009 Alberta GDP growth is equivalent to the average growth in the Fiscal Plan for the years 2003-2009 inclusive – i.e. 7.6% per annum; and
- the post 2009 Alberta GDP growth is equal to that for the Canadian economy as a whole which Environment Canada (2007)[10] notes has a growth forecast at 2.4% annually for the next 15 years (driven, in part by growth of Alberta's GDP).

9 http://www.finance.gov.ab.ca/publications/budget/budget2006/fiscal_tables_charts.pdf
10 Environment Canada (2007): The Cost of Bill C-288 to Canadian Families and Business, http://www.ec.gc.ca/doc/media/m_123/toc_eng.html

Table 3.1: GHG Emissions Implied by Alberta GDP Intensity Targets													
Year	**Alberta GHG Target Index**	**Alberta GDP ($millions)**	**Annual GDP Growth (%)**	**Implied GHG Emission 000t**	**Emission % of Can Kyoto Target**	**Alberta GDP ($millions)**	**Annual GDP Growth (%)**	**Implied GHG Emission 000t**	**Emission % of Can Kyoto Target**	**Alberta GDP ($millions)**	**Annual GDP Growth (%)**	**Implied GHG Emission 000t**	**Emission % of Can Kyoto Target**
2003		$171,175	13.5%			$171,175	13.5%			$171,175	13.5%		
2004	84%	$187,150	9.3%	235,000	42%	$187,150	9.3%	235,000	42%	$187,150	9.3%	235,000	42%
2005	81%	$211,520	13.0%	256,747	46%	$211,520	13.0%	256,747	46%	$211,520	13.0%	256,747	46%
2006	79%	$228,817	8.2%	269,762	48%	$228,817	8.2%	269,762	48%	$228,817	8.2%	269,762	48%
2007	77%	$230,477	0.7%	263,680	47%	$230,477	0.7%	263,680	47%	$230,477	0.7%	263,680	47%
2008	74%	$238,262	3.4%	264,276	47%	$238,262	3.4%	264,276	47%	$238,262	3.4%	264,276	47%
2009	72%	$251,144	5.4%	269,804	48%	$251,144	5.4%	269,804	48%	$251,144	5.4%	269,804	48%
		Projection based on Alberta Finance 2006-2009 average annual growth				**Projection based on Alberta Finance 2003-2009 average annual growth**				**Annual % Growth to Produce an Alberta Target Emission equal to 50% of Canada's Total Kyoto target (=1.7%)**			
2010	70%	$262,257	4.4%	274,425	49%	$270,339	7.6%	282,882	50%	$257,171	2.4%	269,104	48%
2011	68%	$273,862	4.4%	276,334	49%	$291,000	7.6%	293,627	52%	$263,344	2.4%	265,721	47%
2012	**66%**	**$285,980**	**4.4%**	**280,012**	50%	**$313,241**	**7.6%**	**306,703**	54%	**$269,664**	**2.4%**	**264,036**	**47%**
2013	64%	$298,635	4.4%	283,474	63%	$337,181	7.6%	320,063	71%	$276,136	2.4%	262,117	58%
2014	62%	$311,850	4.4%	286,694	64%	$362,952	7.6%	333,674	74%	$282,763	2.4%	259,954	58%
2015	60%	$325,649	4.4%	289,645	64%	$390,692	7.6%	347,496	77%	$289,549	2.4%	257,536	57%
2016	58%	$340,059	4.4%	292,295	65%	$420,552	7.6%	361,481	80%	$296,499	2.4%	254,853	57%
2017	56%	$355,107	4.4%	294,612	66%	$452,694	7.6%	375,575	84%	$303,614	2.4%	251,892	56%
2018	54%	$370,820	4.4%	296,562	66%	$487,293	7.6%	389,711	87%	$310,901	2.4%	248,642	55%
2019	52%	$387,229	4.4%	298,108	66%	$524,536	7.6%	403,814	90%	$318,363	2.4%	245,092	55%
2020	**50%**	**$404,364**	**4.4%**	**302,232**	67%	**$564,625**	**7.6%**	**422,016**	94%	**$326,004**	**2.4%**	**243,664**	**54%**

3.2.4 Comparison of Targets

Before considering the implications of the various national and provincial targets on future expansion of oil sands, it is first worth comparing the targets. In addition to deriving permissible target emissions under the Government of Alberta's provisions, Table 3.1 also compares the magnitude of these emissions with the Kyoto targets for Canada as a whole.

From the table it can be seen that, even with the smaller annual growth rate assumptions, the level of emissions permissible under the Government of Alberta target represent a substantial percentage of Canada's overall target emissions. Indeed, an average annual growth in Alberta's GDP of 1.6% per year from 2009-2020 would seem to be sufficient to produce a permissible emission equal to 50% of Canada's overall target emission for 2020 (223 Mt CO_{2e} in 2020) and only 0.6% is sufficient to produce an emission equivalent to 45% of Canada's total Kyoto target for 2020.

The data in Table 3.1 suggest that Alberta's share of Canada's overall Kyoto target emission increases to 47%, 50% and 54% by 2012 under the low, medium and high annual Alberta GDP growth scenarios respectively. In addition, this share of Canada's overall Kyoto target increases to 54%, 67% and 94% by 2020 for each of the growth scenarios (low, medium and high).

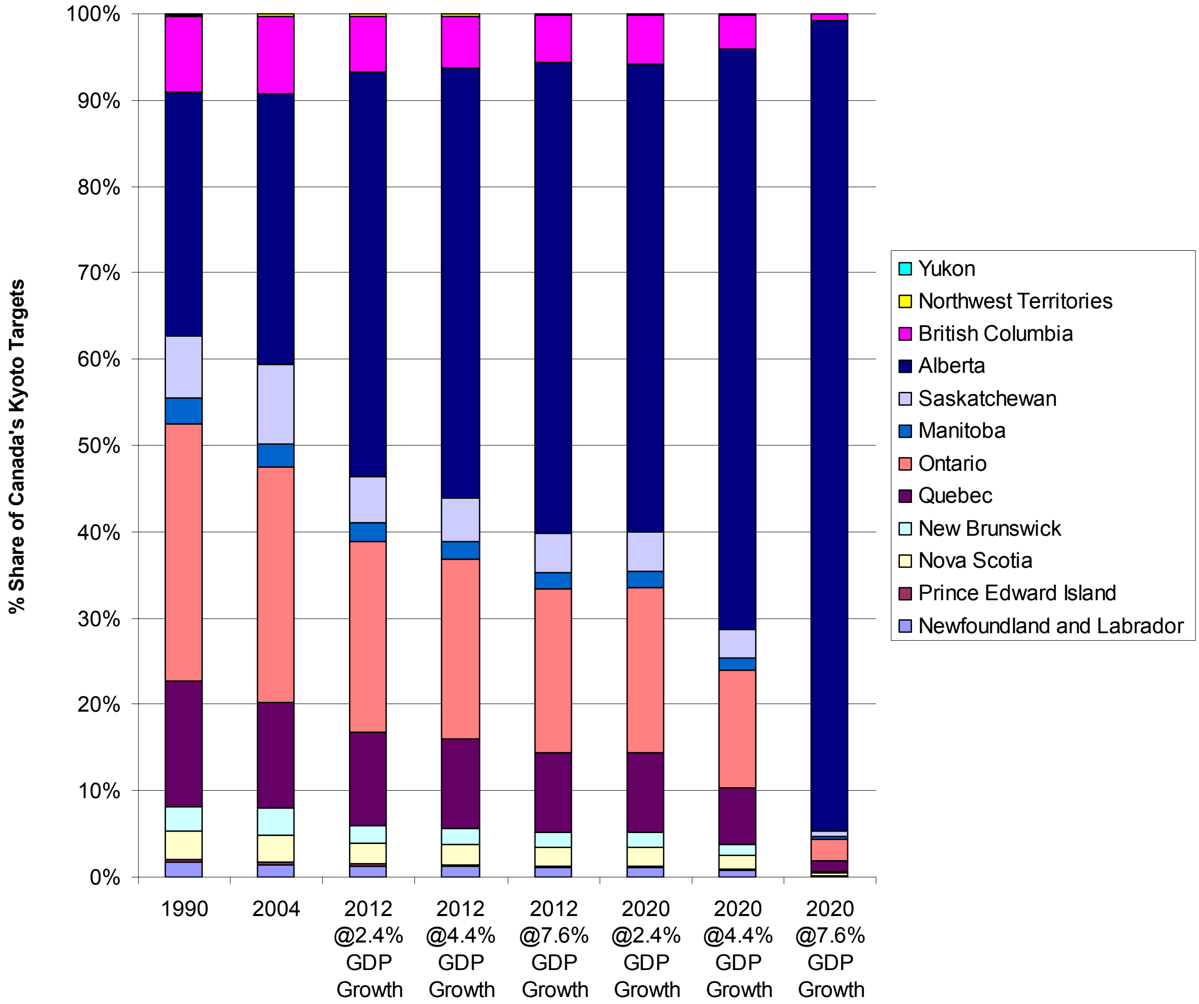
To set this in context, in 1990, Alberta's share of actual Canadian emissions was circa 28% of the total emission and around 31% in 2004. Clearly, from the perspective of the whole of Canada (and the other provinces) and its Kyoto commitments, the Government of Alberta's target would imply that very significant reductions would be required in the other provinces to enable Canada to meet its commitments under Kyoto.

Figure 3.2 provides the distribution of emissions from all provinces that would be required to remain within Canada's Kyoto targets given growth in Alberta's GDP at varying levels and the emissions implicit in the Government of Alberta's targets. As can be seen from the figure, the scale of the necessary reductions in other provinces that are implied by the Government of Alberta's targets range from the significant to the unfeasible depending on the scenario. Indeed, to remain within the bounds of the 2012 Kyoto targets for Canada as a whole (6% cut in 1990 emissions) the other provinces would have to cut their emissions by the equivalent of 30-40% of their 1990 emissions depending on the scenario (low, 30% cut; med, 34% cut; high, 40% cut).

By 2020, the other provinces would have to have cut emissions by 52-94% of their 1990 levels to achieve Canada's 2020 target of a 25% cut in 1990 emissions by 2020 (low, 52% cut; med, 66% cut; high, 94% cut).

Based on the evidence, it can be concluded that the Government of Alberta's emission targets are not consistent with achieving Canada's Kyoto targets (or certainly not in a way which is equitable).

Figure 3.2: Changes in Distribution of CO_{2e} Emissions between Provinces Implied by Comparison of Government of Alberta Target and Canada's Kyoto Commitment



3.3 Implied Target Emissions for Oil Sands

In order to compare the unmitigated emissions from future expansion of oil sands with overall target emissions (and thus examine any gap), it is necessary to attempt to translate the national and provincial targets set out in Section 3.2 into an equivalent target for oil sands.

This has been based simply on the fact that the calculated Oil sand emission for 2004 is some 12% of the total emission for Alberta for the same year. Accordingly, if one applies this 12% to both the implied equitable Kyoto target for Alberta (30% of Canada's emissions) and the Government of Alberta's targets set out in Section 3.2, one can scale down the Alberta target emissions to oil sands.

Maintaining a constant 12% would, of course, assume a constant hedging of emissions from oil sands relative to other emitters within Alberta. To this end, we have also derived target emissions that accommodate some expansion. Here we have also calculated the target emissions for oil sands based on a hedging of the emissions based on oil sands representing 20% of Alberta's emission.

Applying these percentages to both the Kyoto derived and Government of Alberta GHG intensity index target emissions (based on the average growth of 4.4% predicted growth for 2006-2009 inclusive) provides the target emissions for oil sands set out in Table 3.2.

Table 3.2: Oil Sand Emission Targets (000s t CO_{2e})

	Oil sand target to stay at 12 % of Alberta's 30% of Canada's Kyoto	Oil sand target to stay at 20 % of Alberta's 30% of Canada's Kyoto	Oil sand target to stay at 12% of Alberta GDP Target	Oil sand target to stay at 20% of Alberta GDP Target
2012	19,592	33,923	31,161	53,952
2020	15,632	27,066	33,075	57,267

In considering these target emissions, it is worth noting the complexity inherent in deriving quantitative targets for oil sand emissions in line with the Alberta Government's per unit GDP target. Here, of course, Alberta's GDP is likely to be highly influenced by the scale and speed of future development of oil sands which, inevitably, has its own effect on the emission target. Here it would be most appropriate to tie the emission target for oil sands to the GDP growth scenario assumed in the projection (in this case 4.4% after 2009), where this would require an examination of the contribution of oil sands growth to the growth in GDP for Alberta as a whole.

However, whilst this has not been possible within the budget and timescales of the study, the 12% and 20% assumptions provide some indication of the emission limits implied by the Government of Alberta's target. In addition, it should be recognised that any emission limits set for oil sands in line with the Government of Alberta's current target would not be consistent with the achievement of Canada's Kyoto commitments in any case. As such, their inclusion in this analysis becomes academic.

3.4 Significance of Unmitigated Oil Sand GHG Emissions

3.4.1 Significance Relative to Targets for All Emissions

The projected emissions from oil sands under the three NEB oil sand expansion scenarios were presented in Table 2.7, where these relate to unmitigated 'raw' emissions. For ease of reference, these projected emissions are duplicated as Table 3.3 overleaf.

Table 3.3: Total GHG Emissions from Oil Sands - No Mitigation (000s Tonnes CO_{2e})			
	NEB All Projects	**NEB Base Case**	**NEB Low Case**
2006	31,283	31,283	31,283
2007	41,735	38,172	38,172
2008	51,831	44,004	43,482
2009	59,112	48,458	44,334
2010	80,400	55,923	47,347
2011	91,303	60,045	48,212
2012	***105,229***	***65,436***	***49,696***
2013	112,789	70,296	50,711
2014	115,693	74,840	51,324
2015	121,791	80,740	52,293

A comparison of these predicted emissions with the National and Provincial targets for 2012 set out in Section 3.2 is provided in Table 3.4. This summarises the predicted emissions under the NEB scenarios and the quantitative targets for Canada and Alberta. From this comparison it can be seen that the unmitigated emissions from oil sands in 2012 would represent some 9% to 19% of Canada's overall Kyoto target for 2012. That said, as with all reference to the NEB low scenario, the lower end of the spectrum relates to adverse economics for oil sand expansion. As noted in Section 2, expected expansion is closest to the base case or between it and the all projects scenario.

On this basis, in terms of Alberta's implied 2012 Kyoto target (30% of Canada's), the unmitigated oil sand emission would be equivalent to around 39% to 62% of the target. For the Government of Alberta's target (@4.4% GDP growth), an unmitigated oil sand emission would be equivalent to between 23% and 38% of total target emissions.

Table 3.4: Predicted Unmitigated Oil Sand Emissions as a Percentage of Targets for 2012				
	Target Emission (000s t CO_{2e})	**NEB All Projects**	**NEB Base Case**	**NEB Low Case**
Oil sand Emission (No Mitigation) (000s t CO_{2e})		**105,229**	**65,436**	**49,696**
Canada Kyoto 2012	**563,000**	19%	12%	9%
Implied Alberta Kyoto 2012	**169,613**	62%	39%	29%
Alberta GDP Emissions Target (based on 4.4% growth)	**280,012**	38%	23%	18%

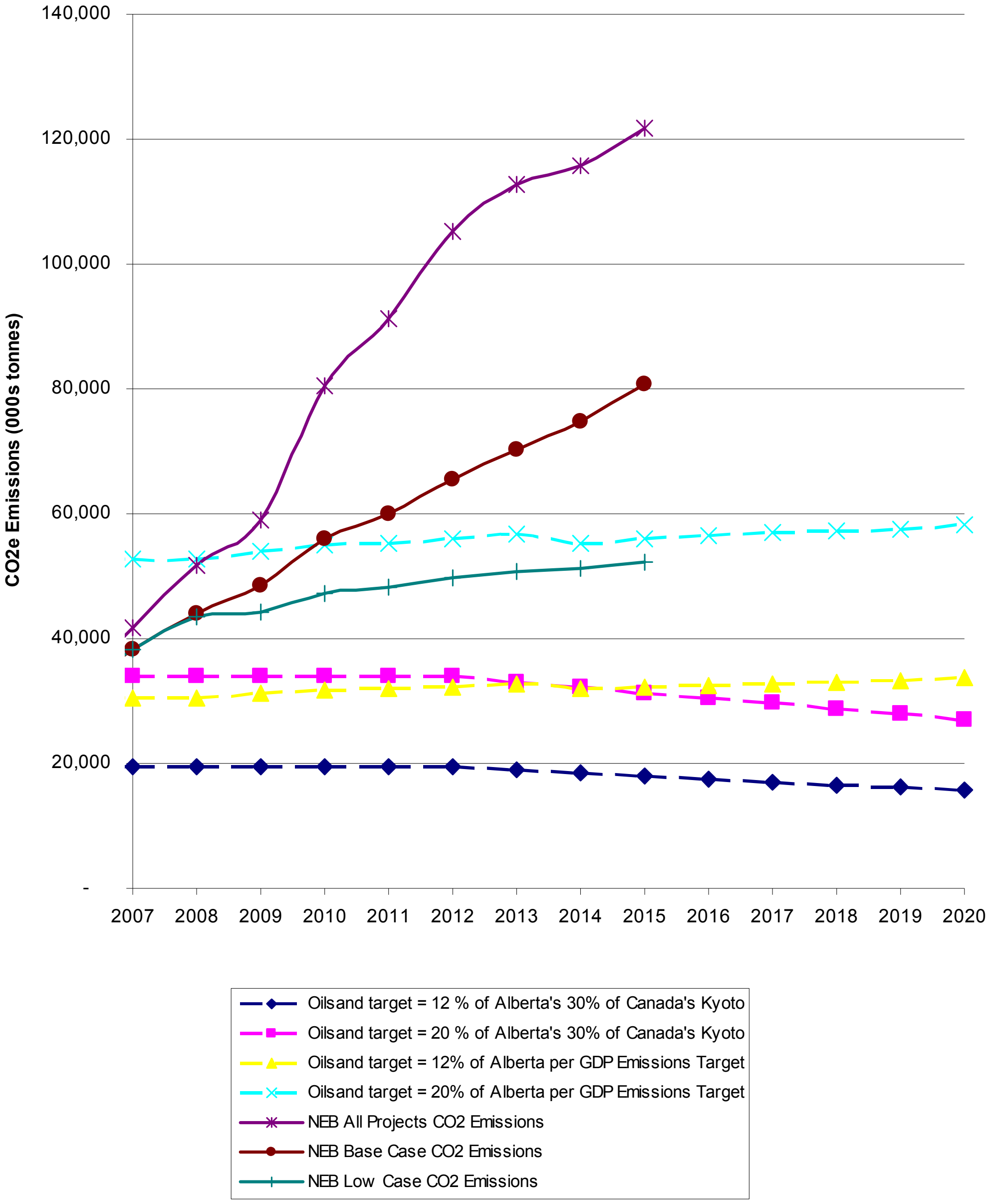
3.4.2 Significance Relative to Implied Targets for Oil Sands

In terms of trends and significance of unmitigated oil sand emissions (Table 3.3) compared with the various implied targets for oil sands (Table 3.2), Figure 3.3 shows the increase in emissions over time under all of the NEB scenarios. It also shows the implied target emissions (i.e. what the emissions would have to be to stay within the various implied targets).

In relation to the implied Kyoto targets (12% or 20% of Alberta's 30% share of Canada's emissions), emissions from oil sands are already in excess of the targets. Taking the base case NEB projection, by 2012 the unmitigated emission from oil sand would be some 3.3 times higher than the 12% of Alberta's implied Kyoto target and nearly twice in the case of the 20% implied target.

In relation to the Government of Alberta's targets (which, as noted previously are inconsistent with achieving Kyoto commitments), according to the data only the low case NEB oil sand expansion scenario (relating to adverse economics for oil sand expansion) is likely to remain within the 20% of the Government of Alberta's GDP target. The other (realistic) NEB forecasts will continue to rise significantly above all targets if left unmitigated.

Figure 3.3: Unmitigated Emissions from Oil Sands and Associated Emissions Targets by Year



4. Mitigation of GHG Emissions via Process Efficiency

41. Oil Sand Emission Reductions Required

The discussion on oil sand emissions thus far has related to the unmitigated emissions of GHG that would accompany the expansion projections provided in the NEB assessment. The reason for this is that, in considering any policy implications of this expansion it is important to identify:

- whether the unmitigated emissions would pose a problem;
- what emission reductions may be required to address the problem;
- what options are available to mitigate the emission; and, finally
- are these likely to be sufficient to address the problem - are there any residual emissions?

In terms of the former, Section 3 has provided an assessment of the expansion of oil sands and relevant emission targets which, in short, concludes that any unmitigated emissions that accompany the projected oil sand expansion do pose a significant problem, both in terms of the risk of not achieving Kyoto commitments and, more widely, the climate change implications that the Kyoto Protocol seeks to limit.

In terms of the level of emissions reduction that is required to address this problem, a simple comparison between the unmitigated emissions (Table 3.3) and the implied target emissions for oil sands under the various target scenarios (Table 3.2) provides data on the annual reduction in emission required to stay within the various targets.

Table 4.1 provides data on the gap between projected emissions and associated targets for oil sands. Data relating to all NEB projections are provided and the magnitude of the emissions reduction for each varies depending on the target used. In relation to this, it should be noted that the resulting emissions reductions required to remain within the Alberta Government target will not achieve Canada's Kyoto commitments (or at least not without significant additional cuts from the other provinces above and beyond those required under the Kyoto Protocol).

As context, Table 4.2 provides the data in terms of the percentage cut in unmitigated oil sand emissions that would be required to remain within the targets. Unfortunately, the NEB projections do not run to 2020. However, in relation to the 2012 target alone, for the base case NEB projections (which are likely to be the closest to the 'real' expansion), a cut in annual unmitigated emissions of 70% would be required for the industry to stay at 12% of Alberta's target 30% share of Canada's emission. As noted in Section 3, the 12% share relates to the fact that 12% of Alberta's 2004 CO_{2e} emission relates to oil sands.

Allowing for the oil sand share to rise to 20% of Alberta's emission, the emission reduction required under the base case is equivalent to a 48% cut in unmitigated annual emissions by 2012.

Table 4.1: Reduction in Oil sand Emission Required to fit within Targets												
	Oil sand target = 12 % of Alberta's 30% of Canada's Kyoto			Oil sand target = 20 % of Alberta's 30% of Canada's Kyoto			Oil sand target = 12% of Alberta per GDP Emissions Target			Oil sand target = 20% of Alberta per GDP Emissions Target		
	NEB All Projects	**NEB Base Case**	**NEB Low Case**	**NEB All Projects**	**NEB Base Case**	**NEB Low Case**	**NEB All Projects**	**NEB Base Case**	**NEB Low Case**	**NEB All Projects**	**NEB Base Case**	**NEB Low Case**
2007	22,143	18,580	18,580	7,812	4,249	4,249	11,277	7,714	7,714	-	-	-
2008	32,239	24,412	23,890	17,908	10,081	9,559	21,304	13,477	12,955	-	-	-
2009	39,520	28,866	24,742	25,189	14,535	10,411	27,946	17,292	13,168	5,151	-	-
2010	60,808	36,331	27,755	46,477	22,000	13,424	48,701	24,224	15,648	25,515	1,038	-
2011	71,711	40,453	28,620	57,380	26,122	14,289	59,383	28,125	16,292	36,036	4,778	-
2012	85,637	45,844	30,104	71,306	31,513	15,773	72,884	33,091	17,351	49,227	9,434	-
2013	97,157	54,664	35,079	85,723	43,230	23,645	80,044	37,551	17,966	56,094	13,601	-
2014	100,061	59,208	35,692	88,627	47,774	24,258	83,718	42,865	19,349	60,331	19,478	-
2015	106,159	65,108	36,661	94,725	53,674	25,227	89,487	48,436	19,989	65,860	24,809	-

Table 4.2: Percentage Cut in Oil sand emission required to fit within targets

	Oil sand target = 12 % of Alberta's 30% of Canada's Kyoto			Therefore Oil sand target to stay at 20 % of Alberta's 30% of Canada's Kyoto			Therefore Oil sand target to stay at 12% of Alberta GDP Target			Therefore Oil sand target to stay at 20% of Alberta GDP Target		
	NEB All Projects	**NEB Base Case**	**NEB Low Case**	**NEB All Projects**	**NEB Base Case**	**NEB Low Case**	**NEB All Projects**	**NEB Base Case**	**NEB Low Case**	**NEB All Projects**	**NEB Base Case**	**NEB Low Case**
2007	53%	49%	49%	19%	11%	11%	27%	20%	20%	0%	0%	0%
2008	62%	55%	55%	35%	23%	22%	41%	31%	30%	0%	0%	0%
2009	67%	60%	56%	43%	30%	23%	47%	36%	30%	9%	0%	0%
2010	76%	65%	59%	58%	39%	28%	61%	43%	33%	32%	2%	0%
2011	79%	67%	59%	63%	44%	30%	65%	47%	34%	39%	8%	0%
2012	81%	70%	61%	68%	48%	32%	69%	51%	35%	47%	14%	0%
2013	86%	78%	69%	76%	61%	47%	71%	53%	35%	50%	19%	0%
2014	86%	79%	70%	77%	64%	47%	72%	57%	38%	52%	26%	0%
2015	87%	81%	70%	78%	66%	48%	73%	60%	38%	54%	31%	0%

4.2 Mitigation of GHG Emissions through Process Efficiency

4.2.1 Efficiency Improvements Available

As has been noted in Section 2, unmitigated emissions associated with NEB projections for oil sand expansion have been calculated by applying per unit production intensity values for each process. A number of companies and projections predict that, as the technology improves, GHG emission per unit production will decrease. In its report, the Pembina Institute have accounted for such improvements by applying two improvement scenarios:

- **Low emission projection:** all GHG intensity factors are reduced, starting in 2004, at an annual rate of 2.3%; and
- **High emission projection:** all GHG intensity factors are reduced, starting in 2004, at an annual rate of 1%.

For reference purposes, the Pembina report notes that a target of a 50% improvement in GHG intensity over 30 years (1990–2020) is roughly equivalent to the 2.3% low emission scenario.

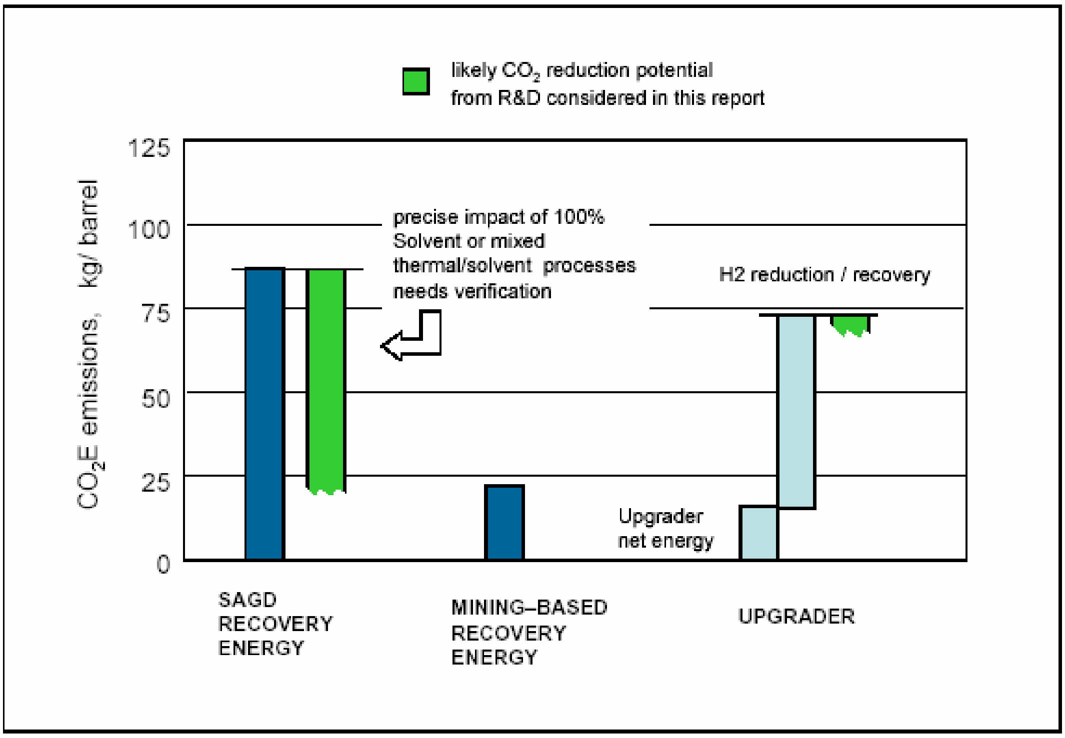
For this study, we have undertaken a review of targets and possibilities for emission reduction for each production stream with a view to developing a new scenario. In developing scenarios we have sought to develop a set of scenarios that reflect the most optimistic view on future development of the technologies reflected in industry targets and hopes for new technologies. In this way, we were seeking to develop a scenario that explored the emissions associated with 'best hopes' (and accordingly, the consequences of these best hopes not being realised).

Several industry sources and targets have been used to guide the selection of minimum and maximum values on the boundaries of this 'best hope' scenario. In terms of targets, the Suncor Energy sustainability report provides a target emission intensity of 0.56 TCO_{2e}/m^3 for 2008. With a reported intensity of 0.62 TCO_{2e}/m^3 for 2004, this is roughly equivalent to a 2.5% annual reduction in GHG intensity.

Similarly, Shell Canada has a target of 0.25 TCO_{2e}/m^3 for 2010 which, compared with the 2005 figure of 0.40 TCO_{2e}/m^3 is roughly equivalent to an annual reduction of 8.6%

In addition to these sources, the March 2004 LENEF Consulting report *Bitumen & Very Heavy Crude Upgrading Technology: A Review of Long Term R&D Opportunities* provides an analysis of the future possibilities for the application of technologies currently under development and the associated GHG intensity reductions. The results are summarised in Figure 4.1 drawn directly from that report.

Figure 4.1: Summary of CO2 Emission Reduction Potential of Processes in the Upgrading Chain



From data presented in the LENEF report, a maximum possible future reduction of 50-90% in SAGD GHG intensity and 5-10% reduction in upgrader GHG intensity can be drawn. Assuming these technologies started to provide reductions now (i.e. in the present) and in the run up to 2020 (which is clearly an over optimistic expectation), this is roughly equivalent to a reduction of 4.5% to 9% per year for SAGD and 0.4% to 0.75% per year for mining.

Based on these sources and 'best hopes', the min/max boundaries of an absolute 'best hope' scenario are presented in Table 4.3 along with the starting GHG intensities (which apply after 2006 in the model).

Table 4.3: Minimum and Maximum Annual GHG Intensity Reductions in the 'Best Hope' Scenario					
Production Type	**GHG intensity TCO_{2e}/m^3 Production in 2006**	**Minimum Assumed Annual Reduction in GHG (%)Min**		**Maximum Assumed Annual Reduction in GHG (%)**	
Mining of bitumen	0.22	0%	Default	2.50%	Suncor target reduction for 2008
SAGD production of bitumen	0.35	2.50%	Suncor target reduction for 2008	9.00%	LENEF consulting review of long-term R&D
THAI production of bitumen	0.41	2.50%	Suncor target reduction for 2008	8.60%	Shell Canada target for 2010
Cyclic Steam production of bitumen	0.57	2.50%	Suncor target reduction for 2008	8.60%	Shell Canada target for 2010
Primary	0.08	0%	Default	2.50%	Suncor target reduction for 2008
SCO Production	0.28	0.40%	LENEF consulting review of long-term R&D	0.75%	LENEF consulting review of long-term R&D

4.2.2 Generation of Associated GHG Emissions

As noted in Section 2, annual GHG Emissions are calculated by combining the sector specific production projections from the NEB Energy Market Assessment (which run to 2015) with the GHG intensity values per unit production.

In order to explore the GHG emissions generated from the 'best hope' scenario we have assumed that the maximum, minimum and average intensity reductions apply every year from 2007 onwards (which, as noted, is very optimistic not just in terms of timing but also in terms of magnitude of the reductions).

In this way, the model provides a multi-scenario case covering the following emission reduction possibilities:

- an **optimistic maximum**;
- an **optimistic minimum**; and
- an **optimistic average** emission reduction according to an industry 'best hope' emissions reduction scenarios.

As before this is applied to the NEB expansion projections to 2015 which, again, are as follows:

- **All Projects Case**: which assumes that all projects publicly announced to date commence operation at their name-plate volume and start date.
- **Low Case**: a projection to illustrate what might happen if the economic viability of oil sands projects is compromised; and
- **Base Case:** where the projection is based on a sustained high oil price and an economically attractive environment.

4.2.3 Emission Reduction Achieved in 'Best Hope' Emission Reduction Scenario

For completeness and transparency, the calculated emissions associated with all scenarios (including the unmitigated 'raw' emissions) are summarised in the Annex to this report. For clarity, the remainder of the report focuses on the emissions and emissions savings associated with the average 'best hope' emissions reduction scenario across all three NEB scenarios. As such, the emissions and emission reductions should be viewed as providing an optimistic outlook on the potential for efficiency savings, particularly since it has been assumed that the emissions reductions start in year 0, i.e. 2007 where, in fact, many of the efficiency savings are associated with longer term R&D.

The unmitigated emissions have been reported in Tables 2.7 and 3.3. Table 4.4, below, provides the level of reduction in these emissions achieved under the average 'best hope' emissions reduction scenario described above.

For ease of comparison, Table 4.5 provides the magnitude of the reduction in emissions achieved through the efficiency savings in terms of the percentage reduction achieved (i.e. relative to the unmitigated emissions). As might be expected, expressed as a percentage, all NEB scenarios represent the same level of reduction as a percentage of the starting (unmitigated emissions).

Table 4.4: Emission Reduction Average 'Best Hope' Efficiency Savings (000s Tonnes CO_{2e})

	NEB All Projects	NEB Base Case	NEB Low Case
2007	995	910	910
2008	2,510	2,131	2,106
2009	4,348	3,565	3,261
2010	7,520	5,231	4,428
2011	10,460	6,879	5,523
2012	14,095	8,765	6,657
2013	17,335	10,804	7,794
2014	20,138	13,027	8,934
2015	23,544	15,608	10,109

Table 4.5: Average 'Best Hope' Efficiency Savings as a Percentage Cut in Unmitigated Emissions			
	NEB All Projects	**NEB Base Case**	**NEB Low Case**
2007	2%	2%	2%
2008	5%	5%	5%
2009	7%	7%	7%
2010	9%	9%	9%
2011	11%	11%	11%
2012	13%	13%	13%
2013	15%	15%	15%
2014	17%	17%	17%
2015	19%	19%	19%

4.2.3 Delivery of Targets though Efficiency Savings

While Table 4.5 provides the level of emission reduction achieved, Table 4.2 has provided the level of cut in the unmitigated emissions required to meet the various implied targets. Comparison of the two suggests that a significant shortfall between the required emissions reductions and those achieved through efficiency savings alone is likely to exist.

Table 4.6 provides a simple comparison of the emissions reductions that are required to meet targets by 2012 and the emissions reductions achieved though efficiency savings in Table 4.5.

Table 4.6: Comparison of Required Reductions and those Achieved through Efficiency savings by 2012				
		Emission Reduction Achieved by 2012	**Emission Reduction Required by 2012**	**Shortfall**
12 % of Alberta's 30% of Canada's Kyoto	**NEB All Projects**	13%	81%	68%
	NEB Base Case		70%	57%
	NEB Low Case		61%	48%
20 % of Alberta's 30% of Canada's Kyoto	**NEB All Projects**		68%	55%
	NEB Base Case		48%	35%
	NEB Low Case		32%	19%
12% of Alberta GDP Target	**NEB All Projects**		69%	56%
	NEB Base Case		51%	38%
	NEB Low Case		35%	22%
20% of Alberta GDP Target	**NEB All Projects**		47%	34%
	NEB Base Case		14%	1%
	NEB Low Case		0%	0%

As can be seen from the table, the analysis suggests that the only target that is likely to be achieved by the efficiency savings alone is that of the Alberta Government's GDP intensity target in the case that 20% of Alberta's emissions are permitted from oil sands. However, as was discussed in detail in Section 3.2.4, this target implies that to remain within the bounds of the 2012 Kyoto targets for Canada as a whole (6% cut in

1990 emissions) the other provinces would have to cut their emissions by the equivalent of 30-40% of their 1990 emissions depending on the scenario (low, 30% cut; med, 34% cut; high, 40% cut). As was concluded there, this target is not consistent with achieving Canada's Kyoto targets (or certainly not in a way which is equitable) and, as such, even if met, a significant shortfall with Kyoto commitments would still exist.

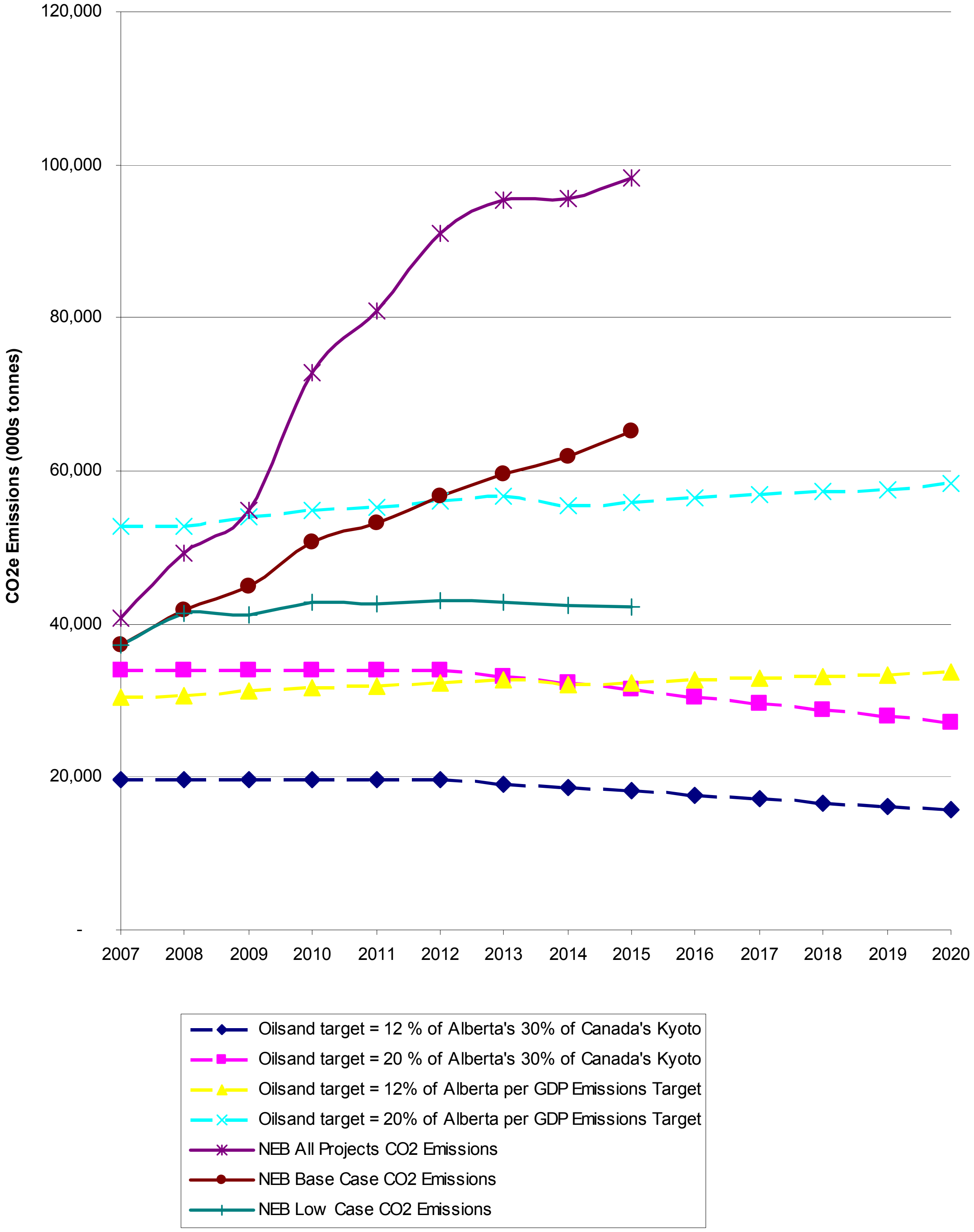
For the implied Kyoto targets for oil sands, the data suggests a shortfall equivalent to around 35-57% of the unmitigated emissions for the base case NEB projections, rising to 68% for the all projects case. As a point of note, from the Annex, the savings associated with the maximum best hope scenario in 2012 are 20% (as opposed to the 13% for the average scenario). Even looking very optimistically, then, here too a significant shortfall is likely exists.

In terms of comparison of these scenarios and targets over time, Figure 4.2 provides a version of the previously presented Figure 3.3 with emissions data adjusted to reflect the savings made through efficiency improvements. As before, the figure shows the increase in emissions over time under all of the NEB scenarios and the implied target emissions (i.e. what the emissions would have to be to stay within the various implied targets).

From the figure it can be seen that, after efficiency savings are accounted for, in relation to the implied Kyoto targets (12% or 20% of Alberta's 30% share of Canada's emissions), emissions from oil sands remain in excess of the targets and the distance only increases with time.

In relation to the NEB scenarios, only emissions under the low case scenario appear to be stabilised by the efficiency savings. As noted previously, this NEB scenario relates to what might happen if the economic viability of oil sands projects is compromised.

Figure 4.2: Oil Sand Emissions (after efficiency savings) and Associated Targets



4.3 Magnitude of Residual Emissions

The analysis in Section 4 suggests that, even applying optimistic assumptions on the scope of (and rate of introduction of) efficiency measures, these are most unlikely to produce a reduction in emissions sufficient to permit the expansion of oil sands projected by the NEB to remain within the necessary targets to reduce GHG emissions.

Tables 5.1, 5.2, 5.3, and 5.4 provide data on the calculated magnitude of the residual emission where this is the emission from oil sands that would still need to be addressed (after the efficiency savings) in order for the projected development of oil sands presented by the NEB to meet the various target scenarios for GHG reduction.

In terms of the scale of these residual emissions, it is worth making a comparison with emissions from elsewhere to gain some perspective. The reported emissions in thousands of tonnes of CO_{2e} for all provinces in Canada for 2004 are provided below for information.

- **Yukon** 418
- **Northwest Territories and Nunavut** 1,600
- **Prince Edward Island** 2,310
- **Newfoundland and Labrador** 10,500
- **Manitoba** 20,000
- **Nova Scotia** 23,000
- **New Brunswick** 24,100
- **British Columbia** 66,800
- **Saskatchewan** 69,100
- **Quebec** 91,800
- **Ontario** 203,000
- **Alberta** 235,000

From these tables, for the NEB base case projections to meet a serious target for emissions reduction consistent with Canada's commitments under Kyoto a further annual reduction of emissions from oil sands of the order of 23,000 to 38,000 thousand tonnes CO_{2e} would be required in 2012, where this is roughly equivalent to New Brunswick's total 2004 emission. This increases to 57,000 to 71,500 tonnes for the NEB all projects case which is roughly equivalent to the emission of British Columbia in 2004.

Table 4.7: Residual Emission after Average 'Best Hope' Efficiency Savings (Oil sand target = 12 % of Alberta's 30% of Canada's Kyoto)			
	NEB All Projects	**NEB Base Case**	**NEB Low Case**
2007	21,147	17,669	17,669
2008	29,728	22,281	21,784
2009	35,171	25,301	21,480
2010	53,288	31,100	23,326
2011	61,251	33,574	23,097
2012	71,542	37,079	23,447
2013	79,822	43,860	27,285
2014	79,923	46,181	26,758
2015	82,615	49,499	26,552

Table 4.8: Residual Emission after Average 'Best Hope' Efficiency Savings (Oil sand target = 20 % of Alberta's 30% of Canada's Kyoto)			
	NEB All Projects	**NEB Base Case**	**NEB Low Case**
2007	6,817	3,339	3,339
2008	15,398	7,950	7,454
2009	20,841	10,971	7,150
2010	38,957	16,770	8,996
2011	46,921	19,244	8,767
2012	**57,211**	**22,749**	**9,117**
2013	68,388	32,427	15,852
2014	68,489	34,747	15,324
2015	71,181	38,066	15,118

Table 4.9: Residual Emission after Average 'Best Hope' Efficiency Savings (Oil sand target = 12% of Alberta per GDP Emissions Target)			
	NEB All Projects	**NEB Base Case**	**NEB Low Case**
2007	10,281	6,804	6,804
2008	18,794	11,346	10,849
2009	23,598	13,727	9,907
2010	41,181	18,993	11,219
2011	48,924	21,246	10,769
2012	58,789	24,327	10,695
2013	62,709	26,747	10,172
2014	63,580	29,838	10,415
2015	65,943	32,827	9,880

Table 4.10: Residual Emission after Average 'Best Hope' Efficiency Savings (Oil sand target = 20% of Alberta per GDP Emissions Target)			
	NEB All Projects	**NEB Base Case**	**NEB Low Case**
2007	-	-	-
2008	-	-	-
2009	803	-	-
2010	17,995	-	-
2011	25,577	-	-
2012	35,132	670	-
2013	38,759	2,797	-
2014	40,193	6,451	-
2015	42,316	9,200	-

5. Residual GHG Emissions and Policy Implications

5.1 Issues for Addressing the Gap

The analysis suggests that the GHG emissions associated with a rapid and sustained growth of oil sands presents a significant and growing problem for policymakers. The evidence suggests that efficiency measures alone will not to produce a stabilisation in the emissions and so some other mechanism is required to curb emissions and/or growth. However, identifying robust solutions that provide the right balance between economic benefits and climate change commitments for both Canada and Alberta is one that requires consideration of many more factors than the issue of expansion of oil sand alone.

With respect to these wider issues, the gap between Canada's actual and target emissions as a whole has been the subject of much debate by policymakers and others in Canada. Most recently, Environment Canada's (April 2007) report *The Cost of Bill C-288 to Canadian Families and Business* has highlighted the scale of the problem and the economic costs and risks associated with addressing the gap.

5.2 Wider Issues

Drawing on the emission estimates in Natural Resources Canada's (2006) report *Canada's Energy Outlook: The Reference Case 2006*, the Environment Canada (2207) report predicts a gap of 260 Mt CO_{2e} per year on average for the years 2008-2012 for Canada as a whole.

Expansion of oil sands and related activities (upgrading) are included within these projections, although the actual contribution of the sector is buried within the data for oil and refining as a whole. However, based on a simple comparison of the emissions calculated for the NEB scenarios assuming the average 'best hope' efficiency savings from the analysis presented above suggests that oil sands are responsible for around 19-27% of this gap.

In terms of reducing the 260 Mt CO_{2e} gap, the 2007 report estimates that, solving the problem domestically would require a 33% annual reduction from business-as-usual levels for each of the five years of the Kyoto Protocol's first commitment period (2008-2012). As noted in the Environment Canada (2007) report, Canada has only one year to begin bringing about such GHG emission cuts.

The report discusses the three flexibility mechanisms in the Kyoto Protocol which are available to lower the overall costs for Annex 1 Parties in achieving their emission reduction targets. The available mechanisms identified in the Environment Canada (2007) report are:

- Clean Development Mechanism (CDM) which provides for Annex 1 Parties to implement projects that reduce emissions in developing countries;

- Joint Implementation (JI) which provides for Annex 1 Parties to implement an emission-reducing project or a project that enhances removals by sinks in the territory of another Annex I Party; and

- Emissions trading which provides for Annex I Parties to acquire assigned amount units (AAUs) from other Annex I Parties that have excess units.

The report notes that under the terms of the Kyoto Protocol, signatory countries that have not met their first compliance period targets will be required to make up the difference in the second commitment period, plus a penalty of 30%.

In terms of application of these options for Canada, the 2007 report discusses several:

- **Domestic Reductions:** the report concludes that it would not be possible to achieve the necessary emissions reductions exclusively through domestic action because of the magnitude of adjustment for Canada's economy that would be required;;

- **Clean Development Mechanism (CDM or CER):** the report identifies that project-based credits generated from the CDM represent the main option for environmentally credible international purchases. However, the report also notes the serious problem that there is considerable uncertainty about the volume of project-based credits available for purchase. Basing its estimate on preliminary information from the UNEP Risoe Centre on Energy, Climate and Sustainable Development[11], Environment Canada estimate that about 85 million CERs (i.e. 85 Mt CO_{2e}) and other project-based credits (from Joint Implementation) will potentially be available per year for purchase between 2008 and 2012[12] . This equates to less than one-third of Canada's annual reduction target. The report adds that Japan's level of reliance on international emission reductions is uncertain, with its 2005 Kyoto Achievement Plan indicating that about 13% of its 150 million tonne per year Kyoto gap would be filled through international purchase of credits (about 20 million CERs per year); and

- **Assigned Amount Units (AAUs)**: emission allowance units are granted to each Annex I country according to their respective target level of GHG emissions in the Kyoto agreement. The report identifies that some Annex I countries, including Canada, have expressed a reluctance to purchase these excess AAUs for compliance, as the excess is frequently due to economic collapse or falling production and not for reasons directly related to efforts to curb emissions (so-called "hot air").

[11] CDM Pipeline, United Nations Environment Programme (UNEP) Risoe Centre on Energy, Climate and Sustainable Development.

[12] Credits for which no buyer is currently identified or known to the United Nations – note we have not been able to confirm the validity of this Environment Canada.

As regards the mix between domestic measures and international flexibility measures, the report notes that there is uncertainty with respect to Canada's ability to rely heavily on international emissions reductions. It highlights that the Kyoto Protocol stipulates that domestic action must constitute a "significant element" of a country's effort to meet its targets[13] and thus, while there is no specific limit on the share of international credit purchases that can be counted towards any country's individual target the protocol does not foresee that countries would rely primarily on international credits to meet their commitments.

In terms of technical solutions such as Carbon Capture and Storage (CCS), the report comments that its analysis cannot credibly incorporate such long-term transformational technologies as carbon capture and storage, that could, by 2015 or so, allow many sectors of the economy, particularly the oil and gas and electric utility industries, to sequester a significant proportion of their GHG emissions at a relatively low cost.

5.3 Implications for Reducing and Offsetting Residual Emissions from Oil Sands in the Short Term (2008-2012)

In considering the options available for reducing the residual emissions from oil sands, the same general arguments would apply. Here, it should be noted that we have already accounted for efficiency savings in oil sands over the duration in the analysis and so no further savings are to be made 'in-house'.

In terms of Carbon Capture and Storage (CCS), as is noted in the Environment Canada report, an analysis cannot credibly incorporate such longer term technologies within the shorter term (2008-2015) time period. As such, based on the arguments presented by Environment Canada (2007), it would appear that the only remaining option available to permit the projected expansion of oil sands to occur within the targets would be the use of the Clean Development Mechanism.

As noted above, with respect to the Clean Development Mechanism (CDM or CER), the Environment Canada (2007) report identifies that preliminary UNEP predictions are that only 85 Mt CO_{2e} per year of credits will be available worldwide[12]. Japan is already expected to offset some 13% of its 150 Mt CO_{2e} per year (19.5 Mt CO_{2e}) emissions gap using such mechanisms (and a number of other countries are expected to do the same). In its modelling, the Environment Canada report assumes that Canadian Businesses would be eligible to purchase some 65 Mt CO_{2e} per year of CDM.

Comparing this Environment Canada assumed 65 Mt CO_{2e} with total emissions from oil sands (after efficiency savings) and also the calculated residual emissions for oil sands to meet the various targets (set out in tables 5.1 to 5.4) provides the values in Table 5.5. From the table it can be seen that, based on the arguments presented in the Environment Canada report, a substantial proportion of globally available CDM credits would be required to offset either the total or the residual emissions from oil sands to meet Kyoto targets in the period 2008-2012. Even meeting Alberta's GDP

[13] The Marrakesh Accords, Decision 15/CP.7, Article 1.

intensity target (which would only, in any case, meet a small proportion of the Kyoto target reduction) requires substantial use of these credits.

Table 5.5: Emissions versus Globally 'Available' CDM Credits							
		NEB All Projects		**NEB Base Case**		**NEB Low Case**	
Global 'available' credits 2008-2012 (kt CO_{2e}/year)		65,000		65,000		65,000	
		kt CO_{2e}	**% of CDM**	**kt CO_{2e}**	**% of CDM**	**kt CO_{2e}**	**% of CDM**
Average annual post-efficiency total oil sand emissions 2008-2012		69,788	**107%**	49,459	**76%**	42,219	**65%**
Average annual residual oil sand emissions for targets 2008-2012:	12 % of Alberta's 30% of Canada's Kyoto	50,196	**77%**	29,867	**46%**	22,627	**35%**
	20 % of Alberta's 30% of Canada's Kyoto	35,866	**55%**	15,537	**24%**	8,297	**13%**
	12% of Alberta per GDP Emissions Target	38,257	**59%**	17,928	**28%**	10,688	**16%**
	20% of Alberta per GDP Emissions Target	15,901	**24%**	134	**0%**	-	**0%**

In terms of the feasibility of the option, assuming that the projected expansion of oil sand can be supported by the use of a large percentage of globally 'available' CDM credits would seem a high risk strategy (and not one that is consistent with the spirit of the mechanism). In addition, pooling such a substantial percentage of Canada's (and perhaps the World's) available credits to 'offset' emissions from a small subset of Canadian industry would also remove the potential for other businesses and industry to use the available credits as part of their strategies. Hence, from a broader economic perspective, it is unlikely to be an option that would be attractive from the perspective of the Canadian economy as a whole.

In terms of cost, the Environment Canada report estimates the cost of CDM/JI credits at $25 Canadian per tonne. Applying these to the emissions set out in Table 5.5 provides the annual and costs of purchasing CDM credits to offset oil sand emissions in billions of $ Canada. This suggests that the cost over the period 2008-2012 alone is within the range of, say, $2 billion to $6 billion (Canadian).

Table 5.5 Cost (2008-2012) of Purchasing CDM for Oil Sand Emissions ($ Billions Canada)							
		NEB All Projects		**NEB Base Case**		**NEB Low Case**	
		Annual cost	**Cost 2008-2012)**	**Annual Cost**	**Cost 2008-2012)**	**Annual Cost**	**Cost 2008-2012**
Average annual post-efficiency total oil sand emissions 2008-2012		$1.74	**$8.72**	$1.24	**$6.18**	$1.06	**$5.28**
Average annual residual oil sand emissions for targets 2008-2012:	12 % of Alberta's 30% of Canada's Kyoto	$1.25	**$6.27**	$0.75	**$3.73**	$0.57	**$2.83**
	20 % of Alberta's 30% of Canada's Kyoto	$0.90	**$4.48**	$0.39	**$1.94**	$0.21	**$1.04**
	12% of Alberta per GDP Emissions Target	$0.96	**$4.78**	$0.45	**$2.24**	$0.27	**$1.34**
	20% of Alberta per GDP Emissions Target	$0.40	**$1.99**	$0.00	**$0.02**	$0.00	**$0.00**

Taken as a single figure, these costs would first appear large. Set against the production volumes projected in the NEB Scenarios, however, the effect on average cost expressed per barrel of oil (in $ Canadian) for the same period (2008-2012) is relatively small. These costs are provided in Table 5.7.

Table 5.7: Cost (2008-2012) of Purchasing CDM Credits for Oil Sand Emissions expressed per Barrel of oil production ($ Billions Canada)

		NEB All Projects	NEB Base Case	NEB Low Case
Average annual residual oil sand emissions for targets 2008-2012:	12 % of Alberta's 30% of Canada's Kyoto	$0.72	$0.61	$0.55
	20 % of Alberta's 30% of Canada's Kyoto	$0.50	$0.31	$0.20
	12% of Alberta per GDP Emissions Target	$0.54	$0.36	$0.26
	20% of Alberta per GDP Emissions Target	$0.19	$0.0002	

5.4 Implications for Reducing and Offsetting Residual Emissions from Oil Sands in the Longer Term

In terms of the longer term implications for Canada, in addition to the risks inherent in assuming that the projected expansion of oil sand can be supported by the use of a large percentage of globally 'available' CDM credits, there is also the question of how to address the elevated emissions in the longer term.

Clearly, if it is assumed that the expansion of oil sands projected by the NEB scenarios is supported by the Clean Development Mechanism (CDM) in the shorter term, then the increase in emissions that will result from this permitted development will have to be addressed at a later date. The larger the expansion that occurs in the interim, the larger the emission and the larger the associated problem.

In terms of how to address this elevated emission, a number of commentators suggest that a partial solution lies in Carbon Capture and Storage (CSS). For example, the Pembina Institute recently published an assessment covering the issues and opportunities of CCS for oil sands[14]. In addition, the debate about the application of the technology is presented in a number of media sources[15], in particular concerning the Federal and Provincial plans to construct of a 400km pipeline to carry CO_{2e}. In addition, CCS forms a part of the Natural Resources Canada 'roadmap'[16].

For its part, the Pembina study[14] assesses the costs of applying the technology to oil sands specifically. Here the study assumes that companies would not incorporate any

[14] Pembina (2006): Carbon Neutral 2020: A Leadership Opportunity in Canada's Oil Sands, McCulloch, M; Raynolds, M; and Wong, R, The Pembina Institute, October 2006.
[15] See for example, CBC "Piping carbon back into the ground" March 2007 http://www.cbc.ca/news/background/kyoto/capturing-carbon.html and "Alberta wants $1.5B pipeline to capture C0$_2$" March 2007 http://www.cbc.ca/canada/north/story/2007/03/06/carbon-plan.html.
[16] NRCan. March 2006. Canada's CO_{2e} Capture & Storage Technology Roadmap.

capture technologies before 2020 to allow adequate time for transportation and storage systems to be in place as well as the appropriate capture technologies to be selected and incorporated. The study bases its costs primarily on information from the Natural Resources Canada roadmap, information provided in a CCS report from the Canadian Energy Research Institute[17] which draws on information from an internal 2001 study. Cost ranges assumed in the Pembina study for the various technologies are duplicated from the Pembina report as Table 5.8 and the study uses a cost range of US $24 to $85 per tonne of CO_{2e} captured, assuming that different companies apply different technologies at different times. The study predicts that costs are likely to remain at the lower end of the spectrum ($24US).

Table 5.8: CCS Costs Applied in the Pembina Study

System	Description	Benefits	Disadvantages	Cost Range (US$/t$CO_2$)
Pre-combustion	Fuel is gasified into a 'syngas', after which it undergoes a shift reaction where it is converted to hydrogen and CO_2.	Low incremental energy penalty. CO_2 separation and compression is relatively efficient.	Some questions of suitability of using gasification on lower quality fuels (e.g., coke). Hot gas clean-up, issues related to pure H_2 turbines.	18–44
Post-combustion	Flue gas is captured after it has been combusted.	System can be fitted on to many of the existing conventional combustion systems in the oils sands. Most mature technology.	Captures up to 20% of available CO_2. Separation is limited to absorption technologies. Other technologies (membranes or cryogenics) are not yet considered commercially viable. High energy input for separation.	44–62
Oxy-fuel	Fuel is combusted in an oxygen-rich environment, creating a high-purity CO_2 stream.	CO_2 stream is easily captured. NO_x emissions are greatly reduced.	Producing oxygen is energy intensive. High temperature ranges can have adverse effects on materials used.	12–71

In contrast, the Intergovernmental Panel on Climate Change (IPCC) have also considered CCS technologies in their Special Report on Carbon Dioxide Capture and Storage[18] in considerable detail. However, comparison of the costs presented by IPCC with those used by the Pembina Institute would suggest considerable disagreement in cost estimates.

[17] CERI. June 2002. Cost for Capture and Sequestation of CO_{2e} In Western Canadian Geologic Media.
[18] IPCC (2005): Special Report on Carbon Dioxide Capture and Storage Prepared by Working Group III of the Intergovernmental Panel on Climate Change 2005.

Table 5.9 provides costs of CCS drawn directly from the IPCC report. In the IPCC report the cost ranges are not only larger, but also the IPCC report strongly notes that "*the costs of the separate components cannot simply be summed to calculate the costs of the whole CCS system in US$/$CO_{2e}$ avoided. All numbers are representative of the costs for large-scale, new installations*".

Table 5.9: IPCC Cost Ranges for the Components of a CCS system as Applied to a given type of Power Plant or Industrial Source

CCS system components	Cost range	Remarks
Capture from a coal- or gas-fired power plant	15-75 US$/t$CO_2$ net captured	Net costs of captured CO_2, compared to the same plant without capture.
Capture from hydrogen and ammonia production or gas processing	5-55 US$/t$CO_2$ net captured	Applies to high-purity sources requiring simple drying and compression.
Capture from other industrial sources	25-115 US$/t$CO_2$ net captured	Range reflects use of a number of different technologies and fuels.
Transportation	1-8 US$/t$CO_2$ transported	Per 250 km pipeline or shipping for mass flow rates of 5 (high end) to 40 (low end) MtCO_2 yr^{-1}.
Geological storage[a]	0.5-8 US$/t$CO_2$ net injected	Excluding potential revenues from EOR or ECBM.
Geological storage: monitoring and verification	0.1-0.3 US$/t$CO_2$ injected	This covers pre-injection, injection, and post-injection monitoring, and depends on the regulatory requirements.
Ocean storage	5-30 US$/t$CO_2$ net injected	Including offshore transportation of 100-500 km, excluding monitoring and verification.
Mineral carbonation	50-100 US$/t$CO_2$ net mineralized	Range for the best case studied. Includes additional energy use for carbonation.

[a] Over the long term, there may be additional costs for remediation and liabilities.

Comparison of the IPCC cost ranges with those used in the Pembina study suggests the possibility of a significant underestimate in costs in the latter. This is particularly the case given that a number of the cost components identified by the IPCC should be considered in terms of costs per installation and not of the system as a whole. As a point of note, in terms of the number of projects alone, the NEB report lists:

- 23 *in situ* projects;
- 11 mining projects; within
- 7 major primary production areas.

Drawing from the IPCC report, the largest set of costs broadly reflects the costs of capture (25-115 US$/t CO_{2e}) for a given plant. As such, even applying costs to just the major primary production areas alone would suggest a significant inflation in the costs above the US $24 to $85 per tonne of CO_{2e} captured that is used in the Pembina study.

In terms of the 'true' cost of CCS, calculation would require consideration of a large number of variables concerning, for example, nature of the source, capture technology combined with the number and geographical spread of installations and projects where such an undertaking would not be possible within a small study such as this. Clearly, however, any decision on the longer term benefits of oil sand expansion should be based on a true reflection of the likely costs of abatement where this should be a subject of further study. The best reflection of the actual costs is more likely to be achieved by examining the issue in terms of the capital expenditure (or 'one off' costs) and operational costs for each installation accounting for technical feasibility and design constraints including the magnitude of the available 'sink'. Assessing total costs in this way would be far superior to applying costs aggregated to the level of per unit CO_{2e}.

Whilst it is not possible to apply such costs at this time, the importance of gaining an accurate picture of the actual costs and benefits of oil sand expansion can be illustrated by examining the influence of costs on a proxy of the overall benefit-cost equation. Here the economics become complicated, not only because the benefits and economic multipliers involved, but also considering such issues as whether costs are borne by industry, by Federal or Provincial government or a mixture of the two, what rate of growth actually occurs and a range of other significant factors.

For the purposes of illustrating the potential significance of the issue and the importance of seriously examining the issue in more detail, a 2005 Canadian Energy Research Institute estimates that the production and development activities in the oil sands industry during the 2000 to 2020 period are expected to add a total of $634 billion (2004 dollars) to Alberta's GDP. Here, it should be noted that the level of expansion of oil sands assumed in the study is unclear, as is the distribution of this benefit with time. However, based on this value let us assume that this GDP benefit is distributed evenly such that the total benefit in the years 2015-2020 is equal to 30% ($190.2 billion Canada). Whilst the benefit is more likely to skewed towards the end of this period, to compensate, let us also assume that the modelled emissions in the period 2015-2020 are stable at the 2015 levels (which examination of the figures presented on projected emissions suggests would increase in the period).

Table 5.10 illustrates the costs of addressing the residual emissions (stabilised at 2015 levels) considering different levels of cost per tonne CO_{2e}. Note that costs per tonne simply reflect the influence of different costs on the total cost with a view to illustrating the effect on the benefit-cost ratio.

Clearly, the comparisons made in the table with the oil sand GDP impact are purely illustrative since the impact of oil sands on Alberta GDP impact will itself vary depending on the growth scenario. That said, equally the emissions will also vary significantly depending on the growth scenario. As can be seen from the table, the growth scenario has a significant impact on the emissions and the associated costs where these have a significant impact on the economic benefits expressed by the proxy indicator of Alberta GDP impact. Similarly significant is the cost of the CCS technology itself, where variation in this factor combined with the growth projection has a significant effect on the magnitude of the net benefit.

Table 5.10: Total Cost of Carbon Capture and Storage for Oil Sands 2015-2020 given Different Levels of Cost per Tonne							
Benefit to Alberta GDP in period		**$190.2**					
CCS Cost @ $US/t CO_{2e}		**$100**		**$200**		**$300**	
Total cost of CCS for Emissions under Scenarios		**Cost ($CAN Billion)**	**% of Alberta GDP Impact**	**Cost ($CAN Billion)**	**% of Alberta GDP Impact**	**Cost ($CAN Billion)**	**% of Alberta GDP Impact**
NEB All Projects	**Total emission (after savings)**	$72.4	38%	$144.8	76%	$217.2	114%
	12 % of Alberta's 30% of Canada's Kyoto	$60.9	32%	$121.7	64%	$182.6	96%
	20 % of Alberta's 30% of Canada's Kyoto	$52.4	28%	$104.9	55%	$157.3	83%
NEB Base Case	**Total emission (after savings)**	$48.0	25%	$96.0	50%	$144.0	76%
	12 % of Alberta's 30% of Canada's Kyoto	$36.5	19%	$72.9	38%	$109.4	58%
	20 % of Alberta's 30% of Canada's Kyoto	$28.0	15%	$56.1	29%	$84.1	44%

5.5 Conclusions on the Overall Policy Implications

Taken together, the magnitude of the residual emissions that will need to be reduced from oil sands given the different growth profiles and the potentially very large costs of addressing these residual emissions creates a difficult problem for policymakers in both the shorter and longer terms. It is hoped that the issues identified in this study will provide some useful insight on the selection of the most appropriate strategy.

Concerning this strategy and the interplay between the shorter and longer term implications and priorities, the attributes of the problem for the policymaker are relatively simple even if the interrelationships between the variables controlling them are not. These attributes can be summarised as follows:

11. *In the absence of climate change, the economic prospects are (were) such that growth of oil sands is facilitated, where this is reflected in the NEB projections for future growth;*

12. *Framed in the context of climate change, Canada as a whole has increased its emissions such that a large gap of 260 Mt CO_{2e} per year exists between actual emissions and target emissions;*

13. *In order to reduce the impact of addressing this gap on its economy in the 2008-2012 Kyoto period, Canada is likely to want to rely heavily on the flexibility mechanisms, in particular the Clean Development Mechanism (CDM) credits of which current UNEP predictions reported in Environment Canada suggests a maximum of 65 Mt CO_{2e} per year may be available globally (accounting for Japan alone);*

14. *The NEB base case projections for oil sand emissions, once process efficiency savings are accounted for, would require the use of 49.5 Mt CO_{2e} (76%) of global CDM credits[19] to 'offset' the total emission or around 15.5 to 29.8 Mt CO_{2e} per year (24%-46%) for calculated residual emissions in the period 2008-2012;*

15. *Carbon Capture and Storage (CCS), according to Environment Canada and others would not be available until 2015 (at the earliest);*

16. *If substantial use of CDM credits is used to support oil sand expansion within the 2008-2012 period, a significant proportion of CDM credits would not be available for other industries and emissions;*

17. *Substantial use of the CDM credits (if available) to support the growth of oil sands would obviously permit the growth of oil sands and the associated economic benefits. While enabling productivity to be increased in the short term, it would also facilitate a large increase in emissions and the potential for future emissions that would have to be addressed in the next Kyoto period;*

18. *Without other intervention, sustained use of the CDM system for oil sands, would result in the creation of a larger potential emission in the post 2012 reporting period;*

19. *Carbon Capture and Storage (CCS) may offer some potential to reduce emissions from oil sands in the future. However, this is unlikely to have developed to such a level that a significant a reduction in emissions can be produced using the technology in time for the second Kyoto period. Importantly, the technology remains young and there is significant uncertainty as to the capital expenditure and operational costs; and*

20. *In terms of these costs, funding from the 'public purse' without recourse to the oil sand industry may permit oil sands to develop according to the NEB projections. At the same time, the cost of the CCS technology may significantly reduce the net benefits of the expansion of oil sands to the Canadian economy.*

In terms of solutions to these issues, it seems sensible to suggest that a re-assessment of what constitutes optimum growth for oil sands is required. Here consideration needs to be given to the balance between the risks of increasing emissions (and longer term costs of abatement) and any economic benefits of expansion of the industry. As such, there is a need to ensure that the benefits (and costs) of oil sands expansion account for the true costs, where these would require consideration of the costs of achieving future emissions reductions as well as other social and environmental costs (and benefits) associated with the process as a whole.

[19] Increasing to 69.8 Mt CO_{2e} or 107% of available credits in the case of the NEB all projects expansion scenario.

One means of achieving this would be to plan a growth profile for oil sands that, based on analysis of costs and benefits, reflects an optimum level of sustainable growth (where the evidence suggests this is more likely to tend towards the lower NEB growth projection). An alternative is to intervene in the project economics such that development at a project level reflects the total costs of the expansion.

In the shorter term, reliance on CDM as a means of addressing emissions will not achieve either and will permit growth to continue a rate that, subsequently, will produce an even larger gap between emissions and targets. As a means of intervening in the project economics, the costs of CDM are comparatively low and would not seem to reflect the true costs of expansion described above. Per unit production costs of CDM are minimal, could be absorbed, and would only prolong and exacerbate the need to address an emission which is growing rapidly.

An economic instrument tailored to reflect the future costs of abatement in the present day may be an appropriate solution to these issues. The objective of such an instrument would be to ensure that the full costs of expansion in the longer-term are reflected in the project economics in the near term. This would help to ensure that the expansion of oil sands is more controlled in the short term and (longer-term) to the extent that it will not represent a large an ongoing social, environmental and economic cost to Canada (or the rest of the world).

Properly designed, such an instrument would help to ensure that the rate of future development of oil sands is re-profiled so that it can be accommodated within Canada's climate change commitments and can produce an optimal net social benefit. A failure to intervene in the project economics that influences that rate of growth (or more directly at a project planning level to constrain that growth to a level that is sustainable) would seem to permit the significant possibility that oil sands may, in the longer term, represent a significant and ongoing cost.

Contents

Part II

1. Introduction

1.1 Background

Oil sands (also known as tar sands) are mixtures of sand, water, clay and crude bitumen. Canada has a large area of these bitumen resources, with these located mainly within the province of Alberta.

Recovery of bitumen from oil sands is an energy intensive activity, necessitating the use of significant inputs of energy (principally from natural gas at present). In addition to recovery, there are additional processing and energy costs associated with processing of recovered bitumen into synthetic crude oil.

In the context of climate change, the use of significant inputs of energy to recover bitumen and produce synthetic crude oil from oil sands, combined with the projected future expansion of extraction and recovery (and consumption of the recovered oil) has implications for elevated emissions of greenhouse gases (GHG).

To this end, the Tyndall Centre was commissioned by WWF to undertake an independent study to explore the issue of expansion of oil sand extraction and processing in Canada, identifying any implications for the achievement of net reductions in Canada's GHG emissions in pursuance of Kyoto Protocol commitments (and, therefore, climate change more generally).

That study reported its findings and the associated policy implications in April 2007. It provided a full analysis of the core climate change issues, concluding that expansion in oil sands at the rates projected by Canadian Government publications such as the National Energy Board (NEB) Energy Market Assessment (EMA) was likely to provide a significant and sustained increase in GHG emissions in the short and longer term and that this would, in turn, present a very significant ongoing problem (and cost) for efforts to reduce total emissions in line with Canada's Kyoto commitments.

1.2 Objectives of this Study

On 26 April 2007 Canada's Government announced proposals for mandatory targets to tackle climate change and reduce air pollution in its *Regulatory Framework for Air Emissions*[2].

In light of this, we have undertaken an appraisal of this new regulatory framework to assess the effectiveness of the new framework in the context of its ability to address the increases in GHG emissions from oil sands and the other issues which we identified in our first (April 2007) report.

This report provides the appraisal in full, drawing on and complementing our initial report. As such, direct reference is made to the findings of our first report and the

[2] http://www.ec.gc.ca/doc/media/m_124/toc_eng.htm

models developed for it. Our April 2007 report should be read in conjunction with the material presented here.

1.3 Structure of the Report

Section 2 of the report summarises the provisions of Canada's new Regulatory Framework for Air Emissions as it applies to GHGs and oil sands in particular. Building on the previous (April 2007) study, Section 3 describes the effect of the new mandatory targets for oil sands on total emissions and trends in those emissions.

Section 4 discuses the suitability and sufficiency of the new framework in the context of both the targets and the net compliance costs of the regulatory framework for the oil sand industry. Section 5 draws conclusions concerning the effectiveness of the targets and associated compliance mechanisms.

2. Provisions of Canada's New Regulatory Framework for Air Emissions

2.1 General Provisions

On 26 April 2007 Canada's Government announced proposals for mandatory targets to tackle climate change and reduce air pollution in its *Regulatory Framework for Air Emissions*[2].

The essence of the new framework is the phased introduction of mandatory targets for reductions in pollutants including greenhouse gases (GHGs). In relation to GHGs, all targets are emission intensity targets designed to provide a reduction in the level of GHG emission per unit of production.

The general industry targets set out in Canada's new framework are:

- a 6% reduction in intensity (relative to a 2006 baseline) each year between 2007 and 2010, giving an enforceable 18% reduction in emission intensity (per unit production) by 2010; and

- from 2010 an annual (year on year) 2% reduction in emission intensity (per unit production) to achieve a 26% reduction in emissions intensity (per unit of production) relative to the 2006 emissions intensity baseline.

These overall targets and their cumulative effect on the 2006 emissions intensity baseline are summarised in Table 2.1.

Table 2.1: Overall Targets for Industrial Emissions Intensity Reduction

	Emissions Intensity Target Reductions by Year	Cumulative emission reduction (all relative to 2006 baseline)
2007-2008	6%*	6%
2008-2009	6%*	12%
2009-2010	6%*	18%
2010-2011	2%	20%
2011-2012	2%	21%
2012-2013	2%	23%
2013-2014	2%	24%
2014-2015	2%	26%
2015-2016	2%	27%
2016-2017	2%	29%
2017-2018	2%	30%
2018-2019	2%	32%
2019-2020	2%	33%

* These targets apply to the 2006 baseline intensity, thereafter reductions are year on year (i.e. apply to the target emissions intensity of the preceding year

The targets apply only to non-fixed process emissions from existing facilities. New facilities and fixed process emissions (where there are no known means of reducing/eliminating emissions) are treated differently under the regulations. New facilities are granted a 3 year grace period to achieve normal operating conditions before having to reach a target. Their initial target will be based on clear fuel standards but they will be required to achieve a 2% annual reduction in emissions intensity (as with existing facilities) once this is established.

The targets apply to the GHG emissions intensity per unit production and not total emissions. Emission intensity targets are distinct from emissions targets in that, where an intensity reduction target applies per unit of production, an emissions reduction target is one which applied to the magnitude of the emission itself. In this way, an intensity target will only deliver an actual emission reduction equal to its magnitude if production remains constant. For example, a 10% emissions intensity target will only deliver a 10% reduction in total emissions if production remains constant. If production increases, an equivalent (in this example, 10%) reduction in total emission will not be achieved and, depending on the rate of growth, **there is the potential for the total emission to actually increase**. Thus, if production triples over a time period, the emissions intensity needs to be reduced by two thirds just to maintain the same total emission.

A useful way of understanding the effects of intensity targets is to appreciate that an intensity reduction target of, for example, 10% will always result in total emissions that are 10% lower than they otherwise would have been in the absence of the target.

2.2 Emission Targets for Oil Sands

For the oil sands sector as a whole, the new framework of targets assumes that 6% of the oil sand emission is from the fixed process emissions that are not subject to the general targets. On the basis of this and the grace period for new processes, the framework sets out targets for the sector as a whole such that the cumulative emissions intensity reductions achieved under the targets relative to the 2006 baseline will be:

- 13% intensity reduction (relative to 2006) by 2010;
- 18% intensity reduction (relative to 2006) by 2015; and
- 23% intensity reduction (relative to 2006) by 2020.

Table 2.2 summarises the associated intensity targets for the oil sand sector provided in the new framework as cumulative reductions relative to a 2006 baseline intensity; annual reductions relative to this 2006 baseline; and as the equivalent year on year in intensity reduction by the targets.

Table 2.2: New Framework Emissions Intensity Targets for Oil sands			
	Cumulative Emission Reduction (all relative to 2006 baseline)	**Annual Emissions Intensity Target Reductions (all relative to 2006 baseline)**	**Emissions Intensity Target Reductions (all relative to year on year reduction – moving baseline)**
2007-2008	4.3%	4.3%	4.3%
2008-2009	8.7%	4.3%	4.5%
2009-2010	13.0%	4.3%	4.7%
2010-2011	14.0%	1.0%	1.1%
2011-2012	15.0%	1.0%	1.2%
2012-2013	16.0%	1.0%	1.2%
2013-2014	17.0%	1.0%	1.2%
2014-2015	18.0%	1.0%	1.2%
2015-2016	19.0%	1.0%	1.2%
2016-2017	20.0%	1.0%	1.2%
2017-2018	21.0%	1.0%	1.3%
2018-2019	22.0%	1.0%	1.3%
2019-2020	23.0%	1.0%	1.3%

Page left intentionally blank

3. Effect of Canada's New Mandatory Intensity Targets on Oil Sand Emissions

3.1 Introduction

As has been noted in Section 2, the effect of target intensity reductions (per unit production) on resulting total emissions depends upon the rate of growth of the target industry.

As part of work for our first (April 2007) report, we modelled unmitigated GHG emissions under the different oil sand growth expansion scenarios. This modelling was based on the oil sand industry expansion projections provided in the National Energy Board (NEB) Energy Market Assessment (EMA) Canada's Oil Sands: Opportunities and Challenges to 2015: an Update (Canadian NEB, June 2006) which covers the following three scenarios:

- **All Projects Case**: which assumes that all projects publicly announced to date commence operation at their name-plate volume and start date;

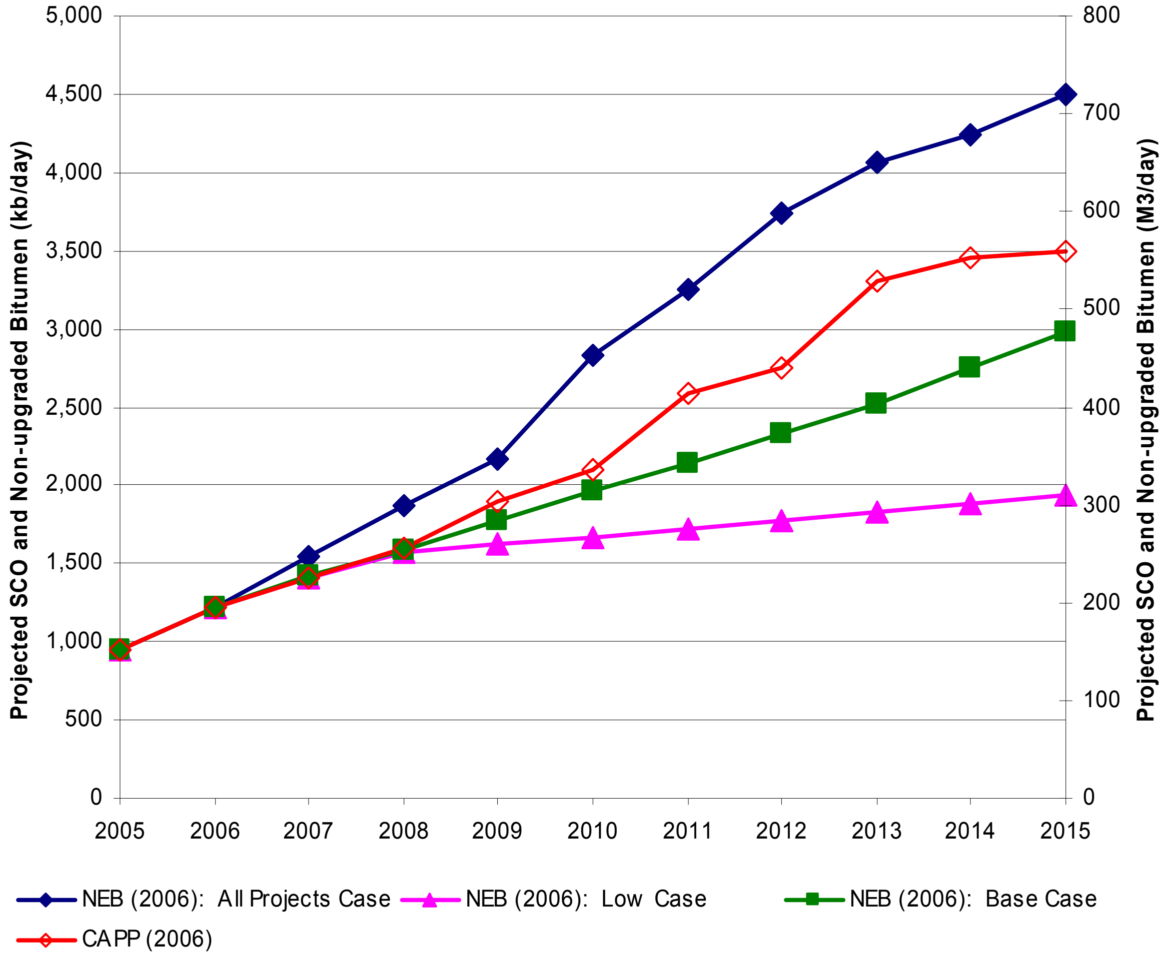
- **Low Case**: which the EMA notes is a projection to illustrate what might happen if the economic viability of oil sands projects is compromised, perhaps by sharply lower prices. It predicts that an outlook for sustained oil prices below US$35 per barrel would lead to marginal economics for many projects in the present business environment and would slow development; and

- **Base Case:** where the EMA notes that the projection is based on a sustained high oil price and an economically attractive environment.

Figure 3.1 provides the NEB projected growth in output for all three scenarios. For the purposes of comparison, the 2006 Canadian Association of Petroleum Producers (CAPP)[3] projection up to 2015 is also provided, where this lies between the NEB base case and all projects case scenarios.

[3] Canadian Association of Petroleum Producers (2006): Canadian Crude Oil Production and Supply Forecast 2006-2020, May 2006.

Figure 3.1: Estimates of Projected Growth in Oil Sand Exploitation



3.2 Effect of New Targets on Oil Sand GHG Emissions

As part of our work on the first (April 2007) report we developed a model to estimate GHG emissions associated with these scenarios. We considered the effect of a number of actions in relation to GHG emissions reduction relative to the unmitigated GHG emissions associated with the three NEB growth scenarios.

A full account of this modelling and the results is provided in our first (April 2007) report. Drawing directly from that report (and the model), Table 3.1 provides the unmitigated GHG emissions that are associated with the three NEB growth scenarios.

To assess the impact of the targets under Canada's new framework, for this report we have modelled the effect of the intensity targets on the emissions under the three NEB scenarios. The resulting (target) emissions are provided in Table 3.2 and both sets of data are plotted graphically in Figure 3.2.

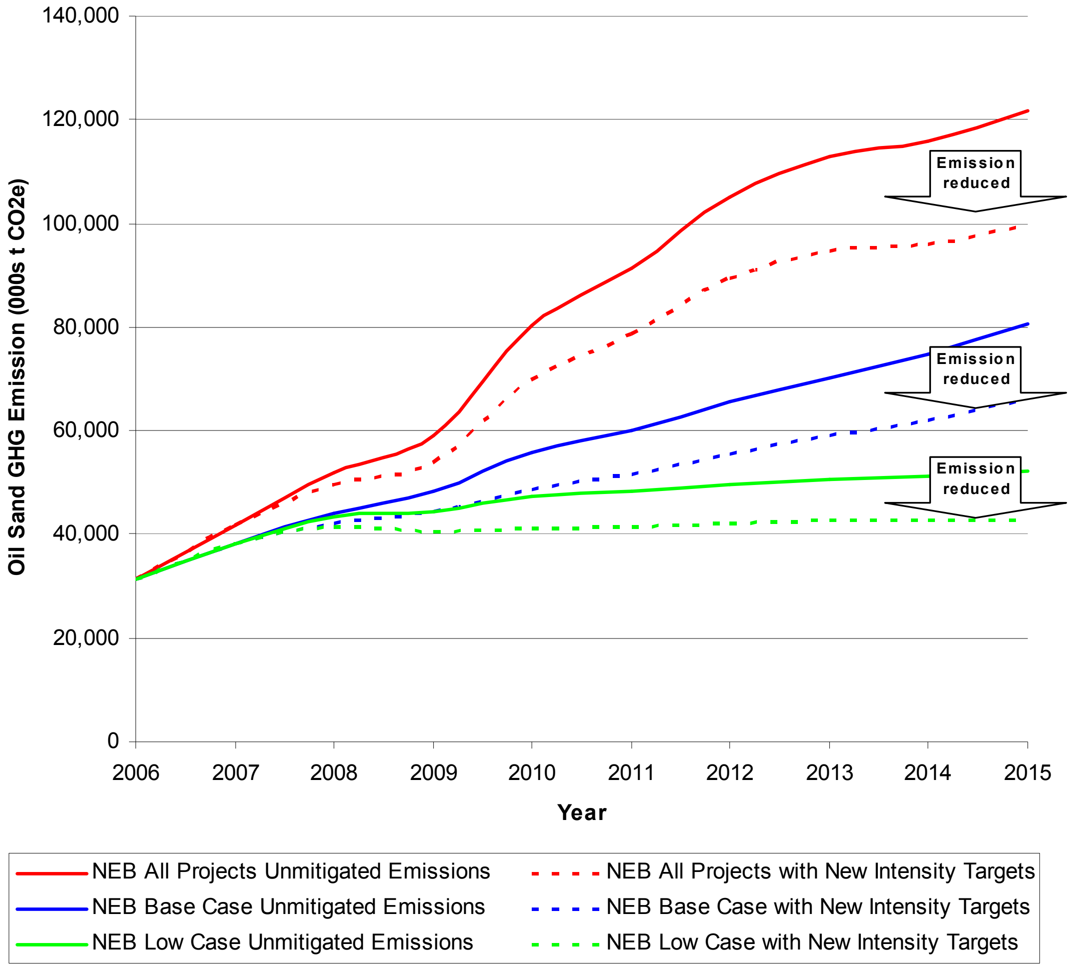
Table 3.1 Unmitigated GHG Emissions from Oil Sands (000s t CO_{2e})			
	NEB All Projects Unmitigated Emissions	NEB Base Case Unmitigated Emissions	NEB Low Case Unmitigated Emissions
2007	41,735	38,172	38,172
2008	51,831	44,004	43,482
2009	59,112	48,458	44,334
2010	80,400	55,923	47,347
2011	91,303	60,045	48,212
2012	105,229	65,436	49,696
2013	112,789	70,296	50,711
2014	115,693	74,840	51,324
2015	121,791	80,740	52,293

Table 3.2: GHG Target Emissions for Oil sands under Canada's New Framework (000s t CO_{2e})			
	NEB All Projects with New Intensity Targets	NEB Base Case with New Intensity Targets	NEB Low Case with New Intensity Targets
2007	41,735	38,172	38,172
2008	49,585	42,097	41,598
2009	53,989	44,258	40,492
2010	69,948	48,653	41,192
2011	78,521	51,638	41,463
2012	89,445	55,621	42,242
2013	94,743	59,049	42,598
2014	96,025	62,117	42,599
2015	99,868	66,206	42,881

From Figure 3.2 it can be seen that the implementation of the targets provides an accompanying reduction in what the total emissions would otherwise have been (as is the feature of intensity targets). However, it is also clear from Figure 3.2 (and the tables) that, while reducing the total emissions from what they would otherwise have been, there remains a sustained upward trend in the level of total GHG emissions under the new mandatory targets.

Clearly, the rate of increase is greater for the more rapid growth scenarios but for both scenarios reflecting healthy economics for oil sands (NEB base case and the all projects case) the rate of increase is significant. It should be noted here that industry's projection (CAPP, 2006 in Figure 3.1) lies between these two growth scenarios (i.e. with emissions between the blue and red lines in Figure 3.2).

Figure 3.2: Total Unmitigated and Target Emissions under the New Framework



3.3 Stabilisation of GHG Emissions for Oil Sands

Clearly, the new framework's targets provide a deceleration in the rate of growth in emissions from oil sands. However, even under the low expansion projection, GHG emissions from oil sands will not be stabilised in the short or longer-term under the new framework.

In terms of the scale of resulting increases in total emissions, Table 3.3 provides the percentage increase in total oil sand GHG emissions (relative to the 2006 baseline) that accompany the oil sand intensity reduction targets set out in the new regulatory framework.

From the table, for growth scenarios reflecting sustained growth in the oil sand industry (NEB base case and all projects case), the mandatory 18% intensity reduction target for 2015 still results in an increase in emissions of between 112% and 219% of the 2006 baseline.

Table 3.3: Change in Actual Oil Sand Emissions under new Intensity Targets			
	NEB All Projects	**NEB Base Case**	**NEB Low Case**
Emission intensity target by 2010 (relative to 2006)	-13%		
Resulting increase in total emission by 2010 (relative to 2006)	124%	56%	32%
Emission intensity Target by 2015 (relative to 2006)	-18%		
Resulting increase in total emission by 2015 (relative to 2006)	219%	112%	37%

The increase in total oil sand emissions is actually present within the data presented in the briefing accompanying Canada's new framework[2]. Targets and total emissions reductions for 2010, 2015 and 2020 are provided with reference to a Business As Usual Case (BAU) for all industries including oil sands. Table 3.4 provides the data on emissions reductions achieved by the targets for oil sands and published with the new framework.

Comparison with our estimates of unmitigated emissions (Table 3.1) suggests that the Environment Canada BAU is similar to the NEB base case (which has unmitigated emissions of 80.7 Mt CO_{2e} for 2015). Comparison of Environment Canada data for emissions after targets with our own (Table 3.2) suggests that our analysis predicts slightly higher emission reductions. Overall, the numbers would tend to validate the analysis presented both here (and in our first report).

Table 3.4: Oil Sand GHG Total Emission Reductions Data Published in the New Framework Documents			
	Environment Canada New Framework Business as Usual Case	**Environment Canada Estimated Reduction relative to BAU**	**Resulting Total Emission from Oil Sands**
	Million t CO_{2e}	**Million t CO_{2e}**	**Million t CO_{2e}**
2010	64	3.5	60.5
2015	80	8.9	71.1
2020	93	15.5	77.5

3.4 Comparison of Target Emission with Canada's Kyoto Targets

Canada is one of the 38 industrialised countries (Annex I countries) that has committed to cut emissions of GHGs under the Kyoto Protocol and the UN Framework Convention on Climate Change (the Convention).

The ultimate objective of the Convention is the stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Under Article 4.1(b) of the Convention, all Parties are required to undertake efforts to mitigate climate change.

The 1997 Kyoto Protocol shares the Convention's objective, principles and institutions, but significantly strengthens the Convention by committing Annex I Parties to individual, legally-binding targets to limit or reduce their greenhouse gas emissions.

Accordingly, target levels for each country cannot be regarded as nominal guidelines on desirable emission reductions but, rather, the reductions that are necessary to prevent a 'dangerous' level of climate interference. The penalty for failing to achieve the targets is not, then, limited to any infraction penalties under the Convention and Protocol, but has far wider (global) consequences.

In terms of its actual Kyoto targets, Canada is required to reduce emissions to a level of 6% below 1990 emissions by 2012 (and 25% below by 2020). Based on recent Environment Canada reports, Canadian target total emissions under Kyoto are as follows:

Canada 2012: 563,000 kt CO_{2e}
Canada 2020: 449,202 kt CO_{2e}

As noted above, the Regulatory Framework for Air Emissions notes that the Government of Canada is committed to "*reduce Canada's **total emissions** of greenhouse gases, relative to 2006 levels, by 20% by 2020 and by 60% to 70% by 2050*". Based on a total emission of 750,000 kt CO_{2e} in 2006, this target equates to a total target emission under the new framework of around 600,000 kt CO_{2e} in 2020, a shortfall of around 160,000 kt CO_{2e} from Kyoto in 2020.

Alberta's Implied Kyoto Commitments

According to the most complete data (for 2004), Environment Canada gives Alberta's 2004 CO_2 emission as 235,000 kt CO_{2e}. According to UNFCCC data, Canada's emission in the same year (2004) was 780,403 kt CO_2e. Accordingly, Alberta's emission was some 30% of Canada's total emission in 2004. Applying this percentage to Canada's Kyoto targets provides implied equitable Kyoto commitment targets for Alberta. These are as follows:

Implied Kyoto Alberta 2012: 169,613 kt CO_{2e}
Implied Kyoto Alberta 2020: 135,329 kt CO_{2e}

Oil Sand Emissions and Kyoto Commitments

The total oil sand emission for 2004 was:

- around 12% of the total emission for Alberta for the same year (235,000 kt CO_{2e}); and
- around 3.6% of the total emission for Canada for the same year (780,403 kt CO_{2e}).

As such, for the distribution of Kyoto target emissions to be equitable for all industries and sectors, it could be assumed that oil sand emissions should remain broadly within these bounds, or certainly not widely outside them.

Table 3.5 provides the Kyoto targets for Canada and those that are implied for Alberta. It also provides the 2012 modelled emissions from oil sands under the new framework of intensity targets and a comparison of emissions with targets.

As can be seen from the table, under the new framework intensity targets, emissions from oil sands will represent a significant and increasing proportion of the Kyoto target total emissions. From being equivalent to 3.6% of Canada's total GHG emission in 2004, oil sand will represent between 8% and 16% of Canada's Kyoto target emission by 2012. For Alberta's implied Kyoto target, emissions will be equivalent to between 25% and 53% of the Kyoto target emissions in 2012 where, as noted above, oil sands represented 12% of Alberta's 2004 emission.

Table 3.5: Predicted Target Oil Sand Emissions as a Percentage of Targets for 2012

	Target Emission (000s t CO_{2e})	NEB All Projects	NEB Base Case	NEB Low Case
Oil Sand Emission (with New Targets) (000s t CO_{2e})		**89,445**	**55,621**	**42,242**
Canada Kyoto 2012	**563,000**	16%	10%	8%
Implied Alberta Kyoto 2012	**169,613**	53%	33%	25%

Comparisons of 2020 targets and emission are provided in Table 3.6. In terms of the 2020 Kyoto target, the Environment Canada data on targets and emissions reduction achieved predicts an oil sand emission of 77,500 kt CO_{2e} (see Table 3.4). When compared to the 2020 Kyoto targets for Canada and implied targets for Alberta, emissions from oil sand will increase in significance and be equivalent to >20% of Canada's Kyoto target and >66% of Alberta's.

Table 3.6: Oil sand Emissions and Kyoto Targets for 2020

	Target Emission (000s t CO_{2e})	Environment Canada Projection 2020
Oil sand Emission 2020 (000s t CO_{2e})		**77,500**
Canada Kyoto 2020	**449,202**	20%
Implied Alberta Kyoto 2020	**135,329**	66%
Canada's New Framework Commitment 2020	**600,000**	15%

When compared with the Government of Canada's own target commitment set out in the new framework, the Environment Canada projections for 2020 are equivalent to 15% of their circa 600,000 kt CO_{2e} target for 2020. This suggests that the framework at present plans to permit an increase of the proportion of Canada's emission from oil sands to rise from 3.6% in 2004 to in excess of 15% in 2020.

As noted above, the Environment Canada projection in the data supporting the new regulatory framework for air emissions is closest to the NEB base case scenario. As such, if growth is more rapid and closer to the all projects scenario (which industry projections in Figure 2.1 suggest could be the case), then the proportion of target emissions (Kyoto or otherwise) given over to oil sands alone will be higher than these percentages.

4. Suitability and Sufficiency of the New Mandatory Framework Intensity

4.1 Introduction

The analysis of the new framework targets for oil sands presented thus far suggests that:

- the mandatory 18% intensity reduction target for 2015 still results in an increase in oil sand emission of between 112% and 219% relative to the 2006 baseline by 2015;

- the mandatory targets result in an increase in oil sand emission from 3.6% of Canada's total emission in 2004 to 8-16% of 2012 target emission under Kyoto and greater than 20% in 2020; and

- framed in terms of the new framework's own emission targets, oil sand emission increases from being 3.6% of Canada's emission in 2004 to >15% of by 2020.

This clearly implies that, not only are the targets inconsistent with the objective of stabilisation of emissions but they are inconsistent with the wider commitment set out in the Regulatory Framework for Air Emissions to "*reduce Canada's **total emissions** of greenhouse gases, relative to 2006 levels, by 20% by 2020 and by 60% to 70% by 2050*" (which itself is inconsistent with Canada's existing commitments under Kyoto, namely to reduce total emissions to a level of 6% below 1990 emissions by 2012 and 25% below by 2020). These facts alone suggest that the targets are insufficiently robust to address the issue of the increasing emissions that result from the sustained growth of the oil sand industry.

Our first (April 2007) report identified that a re-profiling of oil sand expansion to accommodate and balance risks and benefits is required. Further, it was identified that there would seem to be a need to ensure that the costs of expansion reflect the true costs, where these would need to account for future emissions reductions and commitments as well as other social and environmental costs (and benefits) associated with the processes as a whole.

We concluded that an economic instrument tailored to reflect the future costs of abatement in the present day may be appropriate, where such an economic instrument would ensure that the full costs of expansion in the longer-term are reflected in the project economics in the near term.

In addition to in-house reductions in the industries, Canada's new Regulatory Framework for Industrial Air Emissions provides a number of mechanisms for complying with targets designed to ease the burden and achievement of targets. In this way there is an economic component built into the new framework. As such, we have undertaken an analysis of the regulatory burden and strength of the economic 'signal' implied by the targets.

4.2 Industry Compliance Costs and the New Framework Targets

4.2.1 Additional Compliance Options

While the primary objective is to provide in-house emission reductions, the new regulatory framework sets out a number of additional mechanisms to 'offset' emissions by contributions to a Climate Change Technology fund and through an emissions trading scheme.

In terms of the Climate Technology Fund the new framework notes that firms could contribute to the fund at a rate of $15 per tonne of carbon dioxide equivalent from 2010 to 2012 and $20 per tonne in 2013. Thereafter, the rate would escalate yearly at the rate of growth of nominal GDP with the rate structure being reviewed every five years as part of the general review of the regulatory system.

It also notes that contributions to the deployment and infrastructure component would be limited to 70% of the total regulatory obligation in 2010, falling to 65% in 2011, 60% in 2012, 55% in 2013, 50% in 2014, 40% in 2015, 10% in 2016, and 10% in 2017. The contribution limit will fall to 0% by 2018.

In addition to the fund and the setting up of an emissions trading scheme, there is also limited access to the Kyoto Protocol's Clean Development Mechanism (CDM), where access is limited to 10% of each firms target emissions under the regulations. In effect then, access to emissions trading, CDM and other offsets appears limited to the achievement of Canada's new regulatory targets alone and not the achievement of targets in line with Kyoto.

4.2.2 Oil Sand In-House Emission Reductions Achievable

Clearly, the extent to which the oil sand industry will have to (and be able to) make use of these mechanisms will depend on the magnitude of emissions intensity reductions that they are able to achieve.

As part of work for our first (April 2007) report we undertook an analysis of the reductions in GHG emissions from oil sands that could reasonably be expected to be made through improvements in efficiency and technology. The objective of doing so in the first (April 2007) report was to examine the magnitude of any residual emission that would have to be addressed to meet Kyoto commitments and associated policy implications.

For that study we undertook a review of voluntary industry targets and possibilities for emission reduction for each production stream to develop a scenario that explored the emissions associated with 'best hopes' (and accordingly, the consequences of these best hopes not being realised). Several industry sources and targets were used to guide the selection of minimum and maximum values on the boundaries of this 'best hope' scenario.

For example, the Suncor Energy sustainability report provides a target emission intensity of 0.56 $tCO_{2e}m^{-3}$ for 2008. With a reported intensity of 0.62 $tCO_{2e}m^{-3}$ for 2004, this is roughly equivalent to a 2.5% annual reduction in GHG intensity. Similarly, Shell Canada has a target of 0.25 $tCO_{2e}m^{-3}$ for 2010 which, compared with the 2005 figure of 0.40 $tCO_{2e}m^{-3}$ is roughly equivalent to an annual reduction of 8.6%

In addition to these sources, the March 2004 LENEF Consulting report *Bitumen & Very Heavy Crude Upgrading Technology: A Review of Long Term R&D Opportunities* provides an analysis of the future possibilities for the application of technologies currently under development and the associated GHG intensity reductions.

Based on these sources and 'best hopes', the upper and lower boundaries of an industry emissions reduction scenario are presented in Table 4.1 along with the starting GHG intensities.

Table 4.1: Minimum and Maximum Annual GHG Intensity Reductions in the 'Best Hope' Scenario

Production Type	GHG intensity $tCO_{2e}m^{-3}$ Production in 2006	Minimum Assumed Annual Reduction in GHG (%)		Maximum Assumed Annual Reduction in GHG (%)	
Mining of bitumen	0.22	0%	Default	2.5%	Suncor target reduction for 2008
SAGD production of bitumen	0.35	2.5%	Suncor target reduction for 2008	9%	LENEF consulting review of long-term R&D
THAI production of bitumen	0.41	2.5%	Suncor target reduction for 2008	8.6%	Shell Canada target for 2010
Cyclic Steam production of bitumen	0.57	2.5%	Suncor target reduction for 2008	8.6%	Shell Canada target for 2010
Primary	0.08	0%	Default	2.5%	Suncor target reduction for 2008
SCO Production	0.28	0.4%	LENEF consulting review of long-term R&D	0.75 %	LENEF consulting review of long-term R&D

Table 4.2 provides the resulting GHG emissions from oil sands under the various NEB scenarios. As such, these emissions reflect those that are achievable through the implementation of the various technological efficiency improvements.

Table 4.2: Emissions from Oil sands after Efficiency Improvements (000s t CO_{2e})

	Minimum 'Best Hope' Efficiency Savings			Average 'Best Hope' Efficiency Savings			Maximum 'Best Hope' Efficiency Savings		
	NEB All Projects	**NEB Base Case**	**NEB Low Case**	**NEB All Projects**	**NEB Base Case**	**NEB Low Case**	**NEB All Projects**	**NEB Base Case**	**NEB Low Case**
2007	41,337	37,808	37,808	40,739	37,262	37,262	40,142	36,715	36,715
2008	50,797	43,126	42,615	49,321	41,873	41,376	47,884	40,654	40,171
2009	57,291	46,966	42,969	54,764	44,893	41,073	52,371	42,932	39,278
2010	77,187	53,688	45,455	72,880	50,692	42,918	68,912	47,932	40,581
2011	86,794	57,079	45,831	80,844	53,166	42,689	75,506	49,656	39,871
2012	99,080	61,613	46,792	91,134	56,672	43,040	84,187	52,352	39,759
2013	105,158	65,540	47,280	95,454	59,492	42,917	87,186	54,339	39,200
2014	106,761	69,062	47,361	95,555	61,813	42,390	86,247	55,792	38,261
2015	111,243	73,747	47,764	98,247	65,131	42,184	87,718	58,152	37,664

4.2.3 Delivery of Canada's New Framework Targets via In-House Reductions Alone

Comparison of these emission estimates (after efficiency savings) with the target emissions under the new framework for air emissions in Table 3.2 provides an assessment of the extent to which efficiency improvements alone are likely to achieve Canada's new targets.

Table 4.3 provides an assessment of the extent to which the new framework targets will/will not be achieved by in-house reductions under the various scenarios. In the table, the values reflect the amount that a given target has been exceeded (and would need to be offset under the new regulations). Where there is no value, the target is met.

As can be seen from the table, only in the minimum scenario are targets repeatedly missed. In the average efficiency savings scenario, short-term targets may not be achieved through efficiency savings alone, but in the longer-term the efficiency savings alone are sufficient to meet the targets. In the maximum scenario, all targets are met through efficiency savings.

4.2.4 Access to other Compliance Options

As is noted above, access to the Climate Change Technology Fund's deployment and infrastructure component would be limited to 70% of the total regulatory obligation in 2010, falling to 65% in 2011, 60% in 2012, 55% in 2013, 50% in 2014, 40% in 2015, 10% in 2016, and 10% in 2017. The contribution limit will fall to 0% by 2018.

Table 4.3: Exceedance of New Framework Targets for Oil Sands after Efficiency Savings (Exceedance in 000s t CO_{2e})									
	Minimum 'Best Hope'			Average 'Best Hope' Efficiency Savings			Maximum 'Best Hope' Efficiency Savings		
	NEB All Projects	NEB Base Case	NEB Low Case	NEB All Projects	NEB Base Case	NEB Low Case	NEB All Projects	NEB Base Case	NEB Low Case
2006	-	-	-	-	-	-	-	-	-
2007	-	-	-	-	-	-	-	-	-
2008	1,212	1,029	1,017	-	-	-	-	-	-
2009	3,303	2,707	2,477	775	635	581	-	-	-
2010	7,239	5,035	4,263	2,932	2,039	1,727	-	-	-
2011	8,273	5,441	4,368	2,323	1,528	1,227	-	-	-
2012	9,635	5,992	4,550	1,689	1,050	798	-	-	-
2013	10,415	6,491	4,683	711	443	320	-	-	-
2014	10,736	6,945	4,763	-	-	-	-	-	-
2015	11,375	7,541	4,884	-	-	-	-	-	-

Comparing the emission exceedances in Table 4.3 with the target emissions (Table 3.2) provides the percentage that targets are exceeded in any one year. Table 4.4 provides these percentages and suggests that the oil sand industry will not have to rely significantly on this mechanism, if at all.

Table 4.4: Emissions Exceedances as a Percentage of New Framework Targets for Oil Sands									
	Minimum 'Best Hope'			Average 'Best Hope' Efficiency Savings			Maximum 'Best Hope' Efficiency Savings		
	NEB All Projects	NEB Base Case	NEB Low Case	NEB All Projects	NEB Base Case	NEB Low Case	NEB All Projects	NEB Base Case	NEB Low Case
2007									
2008	2%	2%	2%						
2009	6%	6%	6%	1%	1%	1%			
2010	10%	10%	10%	4%	4%	4%			
2011	11%	11%	11%	3%	3%	3%			
2012	11%	11%	11%	2%	2%	2%			
2013	11%	11%	11%	1%	1%	1%			
2014	11%	11%	11%						
2015	11%	11%	11%						

4.2.5 Cost of Contributing to Climate Change Technology Fund

As noted above the new framework notes that firms could contribute to the Climate Change Technology fund at a rate of $15 per tonne of carbon dioxide equivalent from 2010 to 2012 and $20 per tonne from 2013 the following five years.

Applying these costs to the emissions exceedances (Table 4.3) provides the additional cost burden to the oil sand industry of meeting targets through this mechanism. These are provided as total cost in million $CAN in Table 4.5 while Table 4.6 expresses costs per barrel of production. From the tables it can be seen that the magnitude of the costs is extremely small or non-existent, only reflecting an average cost of between $0 and $0.05 per barrel. From this perspective, then, the costs of the regulation to the oil sand industry are insignificant.

Table 4.5: Oil Sand Industry Contributions to Climate Change Technology Fund (Millions $CAN - 2007)

	Minimum 'Best Hope'			Average 'Best Hope' Efficiency Savings			Maximum 'Best Hope' Efficiency Savings		
	NEB All Projects	NEB Base Case	NEB Low Case	NEB All Projects	NEB Base Case	NEB Low Case	NEB All Projects	NEB Base Case	NEB Low Case
2007									
2008	$18	$15	$15						
2009	$50	$41	$37	$12	$10	$9			
2010	$109	$76	$64	$44	$31	$26			
2011	$124	$82	$66	$35	$23	$18			
2012	$145	$90	$68	$25	$16	$12			
2013	$156	$97	$70	$11	$7	$5			
2014	$215	$139	$95						
2015	$227	$151	$98						
2010-2015	**$867**	**$559**	**$397**	**$71**	**$45**	**$35**	**$0**	**$0**	**$0**

Table 4.6: Oil Sand Industry Contributions to Climate Change Technology Fund ($ Can per Barrel)

	Minimum 'Best Hope'			Average 'Best Hope' Efficiency Savings			Maximum 'Best Hope' Efficiency Savings		
	NEB All Projects	NEB Base Case	NEB Low Case	NEB All Projects	NEB Base Case	NEB Low Case	NEB All Projects	NEB Base Case	NEB Low Case
2007									
2008	$0.02	$0.02	$0.02						
2009	$0.04	$0.04	$0.04	$0.01	$0.01	$0.01			
2010	$0.06	$0.06	$0.06	$0.02	$0.02	$0.02			
2011	$0.06	$0.06	$0.06	$0.02	$0.02	$0.02			
2012	$0.06	$0.06	$0.06	$0.01	$0.01	$0.01			
2013	$0.06	$0.06	$0.06						
2014	$0.08	$0.08	$0.08						
2015	$0.08	$0.08	$0.08						
Ave	**$0.05**	**$0.05**	**$0.05**	**$0.01**	**$0.01**	**$0.01**	**$0.00**	**$0.00**	**$0.00**

4.2.6 Emissions Trading

The analysis of target exceedances suggests that efficiency savings alone may deliver the mandatory targets with little or no need to make use of the additional compliance options set out in then new framework. However, in the average and maximum scenarios, the efficiency improvements not only meet the targets but improve on them. This creates the situation where the oil sand industry may actually have emission credits to trade within the emissions trading scheme.

Table 4.7 provides the credits that the oil sand industry may be able to trade within the emissions trading scheme under the arrangements set out in the new framework in $ktCO_{2e}$. Table 4.8 provides the value of these credits if the value of credits in the trading scheme mirrors the contributions to the Climate Change Technology fund (i.e. \$15/20 per t CO_{2e}). From the tables it can be seen that the new framework targets and arrangements may enable the oil sand industry to sell credits of significant value and in the range of between \$28 million to \$400 million for NEB base case growth projections.

Table 4.7: Oil Sand Emission Credits (000s t CO_{2e})

	Minimum 'Best Hope'			Average 'Best Hope' Efficiency Savings			Maximum 'Best Hope' Efficiency Savings		
	NEB All Projects	NEB Base Case	NEB Low Case	NEB All Projects	NEB Base Case	NEB Low Case	NEB All Projects	NEB Base Case	NEB Low Case
2006									
2007	398	364	364	995	910	910	1,593	1,457	1,457
2008	-	-	-	264	224	221	1,700	1,443	1,426
2009	-	-	-	-	-	-	1,618	1,326	1,213
2010	-	-	-	-	-	-	1,036	721	610
2011	-	-	-	-	-	-	3,015	1,983	1,592
2012	-	-	-	-	-	-	5,257	3,269	2,483
2013	-	-	-	-	-	-	7,556	4,710	3,397
2014	-	-	-	470	304	209	9,778	6,325	4,338
2015	-	-	-	1,622	1,075	696	12,150	8,055	5,217
Credits 2010-2015	**-**	**-**	**-**	**2,092**	**1,379**	**905**	**38,793**	**25,062**	**17,637**

Table 4.8: Oil Sand Emission Credits (Millions \$CAN - 2007)

	Minimum 'Best Hope'			Average 'Best Hope' Efficiency Savings			Maximum 'Best Hope' Efficiency Savings		
	NEB All Projects	NEB Base Case	NEB Low Case	NEB All Projects	NEB Base Case	NEB Low Case	NEB All Projects	NEB Base Case	NEB Low Case
2006									
2007	\$6	\$5	\$5	\$15	\$14	\$14	\$24	\$22	\$22
2008	\$0	\$0	\$0	\$4	\$3	\$3	\$26	\$22	\$21
2009	\$0	\$0	\$0	\$0	\$0	\$0	\$24	\$20	\$18
2010	\$0	\$0	\$0	\$0	\$0	\$0	\$16	\$11	\$9
2011	\$0	\$0	\$0	\$0	\$0	\$0	\$45	\$30	\$24
2012	\$0	\$0	\$0	\$0	\$0	\$0	\$79	\$49	\$37
2013	\$0	\$0	\$0	\$0	\$0	\$0	\$151	\$94	\$68
2014	\$0	\$0	\$0	\$9	\$6	\$4	\$196	\$127	\$87
2015	\$0	\$0	\$0	\$32	\$21	\$14	\$243	\$161	\$104
Credits 2010-2015	**\$0**	**\$0**	**\$0**	**\$42**	**\$28**	**\$18**	**\$714**	**\$461**	**\$320**

4.2.7 Net Cost of Industry Compliance

Comparison of the costs incurred by the oil sand industry through contribution to the Climate Change Technology Fund and the benefits from the potential to trade emission credits provides an indication of the net compliance costs of Canada's new Regulatory Framework for Air Emissions. Table 4.9 provides the costs where, in the table, a negative value reflects a net financial benefit.

It should be noted that these are the additional 'costs' once efficiency savings have been made, where the cost of these efficiency measures is not accounted for. That said, many of the efficiency savings are drawn from industry voluntary commitments to improve efficiency and, as such, a regulatory impact assessment would not normally consider these as costs of the regulation (they are existing commitments).

From the table it can be seen that the net costs of the regulation range from a total cost of $867 million between 2010 and 2015 (equivalent to an average of $0.05 per barrel of oil) through to a net financial benefit of $714 million depending on the scenario.

Taking the middle of the range scenario of NEB base case growth projections and average efficiency savings, the net costs of the regulation are around $18 million in total over the period 2010-2015 which is equivalent to a net cost of $0.002 per barrel.

Table 4.9: Net Cost of New Framework Targets for the Oil sand Industry (Millions $Can - 2007)

		Contributions to Climate Technology Fund	Emission Credits	Net Cost
Minimum 'Best Hope'	**NEB All Projects**	$867	$0	**$867**
	NEB Base Case	$559	$0	**$559**
	NEB Low Case	$397	$0	**$397**
Average 'Best Hope' Efficiency Savings	**NEB All Projects**	$71	$42	**$29**
	NEB Base Case	$45	$28	**$18**
	NEB Low Case	$35	$18	**$17**
Maximum 'Best Hope' Efficiency Savings	**NEB All Projects**	$0	$714	**-$714**
	NEB Base Case	$0	$461	**-$461**
	NEB Low Case	$0	$320	**-$320**

5. Conclusions

5.1 Effectiveness of the New Mandatory Targets in Relation to Oil Sands

Canada's new Regulatory Framework for Air Emissions notes that the Government of Canada is committed to "*reduce Canada's **total emissions** of greenhouse gases, relative to 2006 levels, by 20% by 2020 and by 60% to 70% by 2050*". It sets out a series of mandatory emissions intensity reduction targets to achieve this.

Analysis of these intensity targets for oil sands suggests that for National Energy Board (NEB) growth scenarios reflecting sustained growth in the oil sand industry (NEB base case and all projects case), the mandatory 18% intensity reduction targets for oil sands for 2015 still results in an increase in total GHG emission where this is between 112% and 219% of the 2006 baseline.

In this way, the targets will fail to stabilise emissions from (at least) this industrial source (oil sands) and GHG emissions are set to continue to rise steeply upwards. From being equivalent to 3.6% of Canada's emission in 2004, oil sand emissions will represent between 8% and 16% of Canada's Kyoto target by 2012.

For Alberta's implied Kyoto target (which is based on Alberta's 30% share of the 2004 total emission for Canada), emissions will be equivalent to between 25% and 53% of the target emissions in 2012 where, in 2004, oil sands represented 12% of Alberta's GHG emission.

In terms of the 2020 Kyoto target, the Environment Canada data supporting the new regulation predicts an oil sand emission of 77,500 kt CO_{2e}. When compared to the 2020 Kyoto targets for Canada and implied targets for Alberta, emissions from oil sand will increase in significance and be equivalent to >20% of Canada's Kyoto target and >66% of Alberta's by 2020 under the new regulation.

When compared with the Government of Canada's own target commitment set out in the new framework, the Environment Canada projections for 2020 are equivalent to 15% of their circa 600,000 kt CO_{2e} target for 2020. This suggests that the framework at present plans to permit an increase of the proportion of Canada's emission from oil sands to rise from 3.6% in 2004 to in excess of 15% in 2020 according to the figures presented in support of the new regulation.

Taken together, these facts clearly imply that, not only is the level of the target inconsistent with the objective of stabilisation of emissions and the objectives of the new regulation, but is inconsistent with the wider commitment set out in the Regulatory Framework for Air Emissions to "*reduce Canada's **total emissions** of greenhouse gases, relative to 2006 levels, by 20% by 2020 and by 60% to 70% by 2050*".

This wider target is itself is inconsistent with Canada's existing commitments under Kyoto, namely to reduce total emissions to a level of 6% below 1990 emissions by 2012 and 25% below by 2020.

It can be concluded that the targets are insufficiently robust to address the issue of the increasing emissions that result from the sustained growth of oil sand industry.

In terms of the scale of emissions reductions that are achieved by the new targets and the costs of compliance for the oil sand industry, the data suggest that the level of target set for the oil sand industry approximates broadly to reductions in line with and less than those that are reported to be feasible through efficiency savings alone and indicated in industry voluntary targets.

This implies that the new regulation mandates a target level below that which is either feasible or has been committed to voluntarily by industry. This, combined with the new mechanisms for 'offsetting' emissions in excess of the targets creates the possibility that the oil sand industry may not only incur insignificant costs from the regulation (of the order of less than five cents per barrel on average), but may actually make a net profit from trading credits within the new emissions trading scheme that will be established under the new regulations. The level of this 'profit' is of the order of tens of millions to hundreds of millions of Canadian dollars in the period 2010 to 2015.

This ability to be able to trade emission credits from having delivered on the new regulatory targets yet still be maintaining emissions at a level far in excess of the levels required to meet Canada's Kyoto commitments is a perverse effect of the new framework in its current form.

Further, this perverse effect does not seem to be limited to oil sands but would apply to all targets for all industry sectors. This is because access to 'offsetting' is limited to the achievement of the Canadian mandatory targets alone, which do not reflect Canada's commitments under Kyoto. Under the new Canadian framework, having reached the mandatory targets, any industry will be able to trade its surplus within the emissions trading scheme (while being above its implied Kyoto emissions quota).

5.2 Policy Mechanisms to Correct Targets in Relation to Oil Sands

Obviously, the first step in correcting targets in relation to oil sands is to establish what the target emission should be. In our first (April 2007) report, we derived quantitative targets for oil sands based on apportioning Canada's Kyoto targets. This was based the calculated Oil sand emission for 2004 being some 12% of the total emission for Alberta for the same year. Accordingly, this 12% was applied to an equitable Kyoto target for Alberta (30% of Canada's emissions based on 2004).

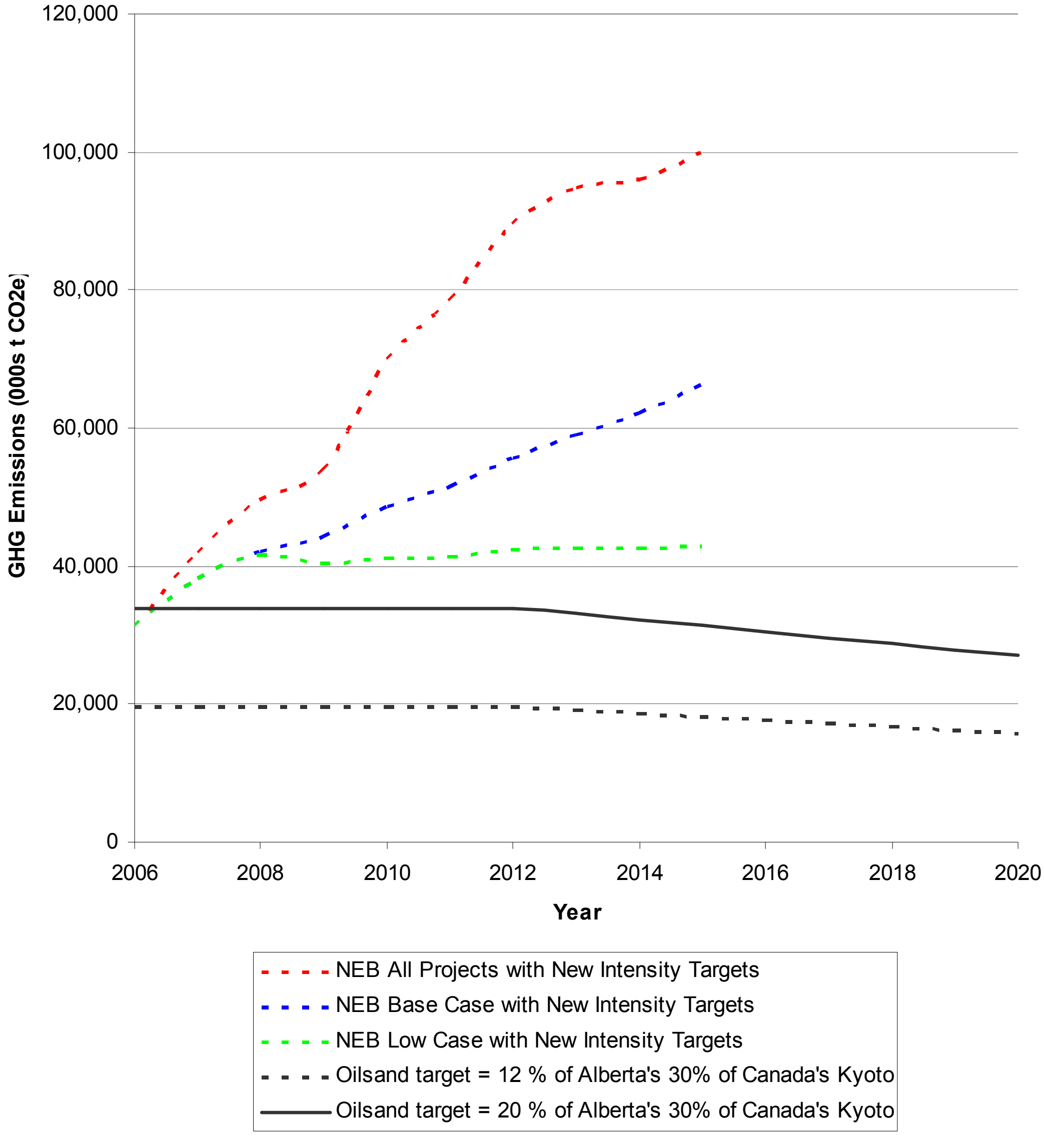
In addition to this '12% target', we also analysed a target that would permit emissions from oil sands to rise to 20% of Alberta's implied Kyoto target (20% of Alberta's 30% of Canada's total Kyoto emissions target).

The resulting target oil sand GHG emissions for 2012 and 2020 under these two '12%' and '20%' targets are provided in Table 5.1.

Table 5.1: Oil Sand Emission Targets (000s t CO_{2e})		
	Oil Sand Target to Stay at 12 % of Alberta's 30% of Canada's Kyoto	**Oil Sand Target So stay at 20 % of Alberta's 30% of Canada's Kyoto**
2006-2012	19,592	33,923
2013-2020	15,632	27,066

Figure 5.1 compares the emissions under the new regulatory framework targets with the Kyoto derived targets set pout above.

Figure 5.1: Target Oil Sand Emissions under New Regulation Compared with Kyoto Targets



As can be seen from the figure, target emissions for oil sands under the new regulatory framework are already significantly above the Kyoto targets and the large gap between the two only gets larger with time.

Our first (April 2007) report identified that, to address such an imbalance of emissions, a re-assessment of what constitutes optimum growth for oil sands is required. Here consideration needs to be given to the balance between the risks of increasing emissions (and longer term costs of abatement) and any economic benefits of expansion of the industry.

Further, it was identified that there was a need to ensure that the costs of expansion reflect the true costs, where these would need to account for future emissions reductions and commitments as well as other social and environmental costs (and benefits) associated with the processes as a whole. One means of achieving this would be to plan a growth profile for oil sands that, based on analysis of costs and benefits, reflects an optimum level of sustainable growth (where the evidence suggests this is more likely to tend towards the lower NEB growth projection). An alternative is to intervene in the project economics such that development at a project level reflects the total costs of the expansion.

We concluded that an economic instrument tailored to reflect the future costs of abatement in the present day may be an appropriate solution. The objective of such an instrument would be to ensure that the full costs of expansion in the longer-term are reflected in the project economics in the near term. This would help to ensure that the expansion of oil sands is more controlled in the short term and (longer-term) to the extent that it will not represent a large an ongoing social, environmental and economic cost to Canada (or the rest of the world). A failure to intervene in the project economics that influences that rate of growth (or more directly at a project planning level to constrain that growth to a level that is sustainable) would seem to permit the significant possibility that oil sands may, in the longer term, represent a significant and ongoing cost.

These conclusions still stand in the light of the proposals set out in Canada’s new Regulatory Framework for Air Emissions. However, the emissions trading and Climate Technology Fund established under the new regulation may provide the beginnings of such an instrument. To be effective, however, there is a need to ensure that the correct targets are selected.

In considering targets, the new regulatory framework expresses a preference for intensity targets. On a general point, for the regulator, the effectiveness of such production-linked intensity targets in the context of delivering actual emission reductions is difficult to predict. This is because there will always be uncertainty as to how production may change in the future. In this respect, quotas and targets based on actual total emissions provides both greater transparency and increased predictability of outcome.

However, in order to provide some insight into the level of an intensity based target that would be required in the regulations to deliver emissions in line with Kyoto for oil sands, we have converted the Kyoto based targets to intensity targets for all NEB scenarios. These are presented in Table 5.2 along with the existing targets set out in the new regulatory framework for air emissions.

All targets in the table reflect annual reductions in intensity (i.e. year on year reductions) starting in the period 2007-2008 as per the new framework. As can be seen from these data, there is a substantial shortfall between where the targets are set at present and where they would need to be to provide an effective GHG emissions reduction strategy consistent with Canada's Kyoto commitments. As such, they reflect the level of reduction that the International community (including Canada) has agreed is necessary to prevent a 'dangerous' level of climate interference.

The penalty for failing to achieve the targets is not, then, limited to any infraction penalties under the Convention and Protocol, but has far wider (global) consequences and associated costs that, to date, do not seem to have been accounted for in developing the new Regulatory framework for Air Emissions.

Table 5.2: Required Intensity Targets for Oil Sands to Deliver Kyoto Commitments

	New Manda-tory Targets	NEB Base Case		NEB All Projects Case		NEB Low Case	
		12 % of Alberta's 30% of Canada's Kyoto	20 % of Alberta's 30% of Canada's Kyoto	12 % of Alberta's 30% of Canada's Kyoto	20 % of Alberta's 30% of Canada's Kyoto	12 % of Alberta's 30% of Canada's Kyoto	20 % of Alberta's 30% of Canada's Kyoto
2007-2008	4.3%	21.7%	13.1%	25.2%	19.3%	19.5%	9.5%
2008-2009	4.5%	27.6%	15.1%	33.7%	23.9%	24.3%	10.4%
2009-2010	4.7%	38.2%	17.8%	50.8%	31.4%	32.1%	11.7%
2010-2011	1.1%	7.2%	7.2%	7.8%	7.8%	3.3%	3.3%
2011-2012	1.2%	7.8%	7.8%	8.5%	8.5%	3.4%	3.4%
2012-2013	1.2%	8.4%	8.4%	9.2%	9.2%	3.5%	3.5%
2013-2014	1.2%	9.2%	9.2%	10.2%	10.2%	3.6%	3.6%
2014-2015	1.2%	10.1%	10.1%	11.3%	11.3%	3.8%	3.8%

Page left intentionally blank

Annex 1: Emissions under Efficiency Scenarios

Table A1: Predicted Emissions (no Mitigation (from Table 3.4)									
	NEB All Projects CO_{2e} Emissions	NEB Base Case CO_{2e} Emissions	NEB Low Case CO_{2e} Emissions	NEB All Projects CO_{2e} Emissions	NEB Base Case CO_{2e} Emissions	NEB Low Case CO_{2e} Emissions	NEB All Projects CO_{2e} Emissions	NEB Base Case CO_{2e} Emissions	NEB Low Case CO_{2e} Emissions
2007	41,735	38,172	38,172	41,735	38,172	38,172	41,735	38,172	38,172
2008	51,831	44,004	43,482	51,831	44,004	43,482	51,831	44,004	43,482
2009	59,112	48,458	44,334	59,112	48,458	44,334	59,112	48,458	44,334
2010	80,400	55,923	47,347	80,400	55,923	47,347	80,400	55,923	47,347
2011	91,303	60,045	48,212	91,303	60,045	48,212	91,303	60,045	48,212
2012	105,229	65,436	49,696	105,229	65,436	49,696	105,229	65,436	49,696
2013	112,789	70,296	50,711	112,789	70,296	50,711	112,789	70,296	50,711
2014	115,693	74,840	51,324	115,693	74,840	51,324	115,693	74,840	51,324
2015	121,791	80,740	52,293	121,791	80,740	52,293	121,791	80,740	52,293

Table A2: Emissions after efficiency savings									
	Minimum 'Best Hope'			Average 'Best Hope' Efficiency Savings			Maximum 'Best Hope' Efficiency Savings		
	NEB All Projects	NEB Base Case	NEB Low Case	NEB All Projects	NEB Base Case	NEB Low Case	NEB All Projects	NEB Base Case	NEB Low Case
2007	41,337	37,808	37,808	40,739	37,262	37,262	40,142	36,715	36,715
2008	50,797	43,126	42,615	49,321	41,873	41,376	47,884	40,654	40,171
2009	57,291	46,966	42,969	54,764	44,893	41,073	52,371	42,932	39,278
2010	77,187	53,688	45,455	72,880	50,692	42,918	68,912	47,932	40,581
2011	86,794	57,079	45,831	80,844	53,166	42,689	75,506	49,656	39,871
2012	99,080	61,613	46,792	91,134	56,672	43,040	84,187	52,352	39,759
2013	105,158	65,540	47,280	95,454	59,492	42,917	87,186	54,339	39,200
2014	106,761	69,062	47,361	95,555	61,813	42,390	86,247	55,792	38,261
2015	111,243	73,747	47,764	98,247	65,131	42,184	87,718	58,152	37,664

Table A3: Net efficiency savings									
	Minimum 'Best Hope' Efficiency Savings			Average 'Best Hope' Efficiency Savings			Maximum 'Best Hope' Efficiency Savings		
	NEB All Projects	NEB Base Case	NEB Low Case	NEB All Projects	NEB Base Case	NEB Low Case	NEB All Projects	NEB Base Case	NEB Low Case
2007	398	364	364	995	910	910	1,593	1,457	1,457
2008	1,034	878	867	2,510	2,131	2,106	3,946	3,350	3,311
2009	1,820	1,492	1,365	4,348	3,565	3,261	6,741	5,526	5,056
2010	3,213	2,235	1,892	7,520	5,231	4,428	11,488	7,991	6,765
2011	4,510	2,966	2,381	10,460	6,879	5,523	15,797	10,389	8,342
2012	6,149	3,824	2,904	14,095	8,765	6,657	21,042	13,085	9,937
2013	7,631	4,756	3,431	17,335	10,804	7,794	25,603	15,957	11,511
2014	8,932	5,778	3,962	20,138	13,027	8,934	29,446	19,048	13,063
2015	10,548	6,992	4,529	23,544	15,608	10,109	34,073	22,588	14,630

Table A4: Net efficiency savings expressed as % Cut in emissions									
	Minimum 'Best Hope' Efficiency Savings			Average 'Best Hope' Efficiency Savings			Maximum 'Best Hope' Efficiency Savings		
	NEB All Projects	NEB Base Case	NEB Low Case	NEB All Projects	NEB Base Case	NEB Low Case	NEB All Projects	NEB Base Case	NEB Low Case
2007	1%	1%	1%	2%	2%	2%	4%	4%	4%
2008	2%	2%	2%	5%	5%	5%	8%	8%	8%
2009	3%	3%	3%	7%	7%	7%	11%	11%	11%
2010	4%	4%	4%	9%	9%	9%	14%	14%	14%
2011	5%	5%	5%	11%	11%	11%	17%	17%	17%
2012	6%	6%	6%	13%	13%	13%	20%	20%	20%
2013	7%	7%	7%	15%	15%	15%	23%	23%	23%
2014	8%	8%	8%	17%	17%	17%	25%	25%	25%
2015	9%	9%	9%	19%	19%	19%	28%	28%	28%

Table A5: Total Emission cut required to stay on target – Oil sand target = 12 % of Alberta's 30% of Canada's Kyoto									
Unmitigated Emission Reduction Required									
	NEB All Projects	NEB Base Case	NEB Low Case	NEB All Projects	NEB Base Case	NEB Low Case	NEB All Projects	NEB Base Case	NEB Low Case
2007	22,142	18,580	18,580	22,142	18,580	18,580	22,142	18,580	18,580
2008	32,238	24,411	23,890	32,238	24,411	23,890	32,238	24,411	23,890
2009	39,520	28,866	24,742	39,520	28,866	24,742	39,520	28,866	24,742
2010	60,808	36,330	27,754	60,808	36,330	27,754	60,808	36,330	27,754
2011	71,711	40,452	28,620	71,711	40,452	28,620	71,711	40,452	28,620
2012	85,637	45,844	30,104	85,637	45,844	30,104	85,637	45,844	30,104
2013	97,157	54,664	35,079	97,157	54,664	35,079	97,157	54,664	35,079
2014	100,061	59,208	35,692	100,061	59,208	35,692	100,061	59,208	35,692
2015	106,159	65,107	36,661	106,159	65,107	36,661	106,159	65,107	36,661
After Efficiency savings Residual emission to cut to stay on target									
	Minimum 'Best Hope' Efficiency Savings			Average 'Best Hope' Efficiency Savings			Maximum 'Best Hope' Efficiency Savings		
	NEB All Projects	NEB Base Case	NEB Low Case	NEB All Projects	NEB Base Case	NEB Low Case	NEB All Projects	NEB Base Case	NEB Low Case
2007	21,745	18,216	18,216	21,147	17,669	17,669	20,550	17,123	17,123
2008	31,204	23,534	23,022	29,728	22,281	21,784	28,292	21,061	20,579
2009	37,699	27,373	23,376	35,171	25,301	21,480	32,779	23,340	19,686
2010	57,595	34,096	25,862	53,288	31,100	23,326	49,319	28,340	20,989
2011	67,201	37,487	26,239	61,251	33,574	23,097	55,913	30,063	20,278
2012	79,488	42,020	27,200	71,542	37,079	23,447	64,595	32,760	20,167
2013	89,526	49,908	31,648	79,822	43,860	27,285	71,554	38,707	23,568
2014	91,129	53,430	31,729	79,923	46,181	26,758	70,615	40,160	22,629
2015	95,611	58,115	32,132	82,615	49,499	26,552	72,086	42,519	22,031

Table A6: Total Emission cut required to stay on target – Oil sand target = 20 % of Alberta's 30% of Canada's Kyoto									
Unmitigated Emission Reduction Required									
	NEB All Projects	NEB Base Case	NEB Low Case	NEB All Projects	NEB Base Case	NEB Low Case	NEB All Projects	NEB Base Case	NEB Low Case
2007	7,812	4,249	4,249	7,812	4,249	4,249	7,812	4,249	4,249
2008	17,908	10,081	9,559	17,908	10,081	9,559	17,908	10,081	9,559
2009	25,189	14,535	10,411	25,189	14,535	10,411	25,189	14,535	10,411
2010	46,477	22,000	13,424	46,477	22,000	13,424	46,477	22,000	13,424
2011	57,381	26,122	14,290	57,381	26,122	14,290	57,381	26,122	14,290
2012	71,306	31,514	15,774	71,306	31,514	15,774	71,306	31,514	15,774
2013	85,723	43,231	23,646	85,723	43,231	23,646	85,723	43,231	23,646
2014	88,627	47,774	24,258	88,627	47,774	24,258	88,627	47,774	24,258
2015	94,725	53,674	25,228	94,725	53,674	25,228	94,725	53,674	25,228
After Efficiency savings Residual emission to cut to stay on target									
	Minimum 'Best Hope' Efficiency Savings			Average 'Best Hope' Efficiency Savings			Maximum 'Best Hope' Efficiency Savings		
	NEB All Projects	NEB Base Case	NEB Low Case	NEB All Projects	NEB Base Case	NEB Low Case	NEB All Projects	NEB Base Case	NEB Low Case
2007	7,414	3,886	3,886	6,817	3,339	3,339	6,220	2,793	2,793
2008	16,874	9,204	8,692	15,398	7,950	7,454	13,962	6,731	6,249
2009	23,369	13,043	9,046	20,841	10,971	7,150	18,449	9,010	5,356
2010	43,265	19,766	11,532	38,957	16,770	8,996	34,989	14,009	6,659
2011	52,871	23,156	11,909	46,921	19,244	8,767	41,583	15,733	5,948
2012	65,157	27,690	12,870	57,211	22,749	9,117	50,265	18,429	5,837
2013	78,092	38,474	20,214	68,388	32,427	15,852	60,121	27,274	12,134
2014	79,695	41,996	20,296	68,489	34,747	15,324	59,182	28,726	11,195
2015	84,177	46,681	20,699	71,181	38,066	15,118	60,652	31,086	10,598

Table A7: Total Emission cut required to stay on target – Oil sand target = 12 % of Alberta's GDP emissions target									
Unmitigated Emission Reduction Required									
	NEB All Projects	NEB Base Case	NEB Low Case	NEB All Projects	NEB Base Case	NEB Low Case	NEB All Projects	NEB Base Case	NEB Low Case
2007	11,277	7,714	7,714	11,277	7,714	7,714	11,277	7,714	7,714
2008	21,304	13,477	12,955	21,304	13,477	12,955	21,304	13,477	12,955
2009	27,946	17,292	13,168	27,946	17,292	13,168	27,946	17,292	13,168
2010	48,701	24,224	15,648	48,701	24,224	15,648	48,701	24,224	15,648
2011	59,383	28,125	16,292	59,383	28,125	16,292	59,383	28,125	16,292
2012	72,884	33,091	17,351	72,884	33,091	17,351	72,884	33,091	17,351
2013	80,044	37,551	17,966	80,044	37,551	17,966	80,044	37,551	17,966
2014	83,718	42,865	19,349	83,718	42,865	19,349	83,718	42,865	19,349
2015	89,487	48,436	19,989	89,487	48,436	19,989	89,487	48,436	19,989
After Efficiency savings Residual emission to cut to stay on target									
	Minimum 'Best Hope' Efficiency Savings			Average 'Best Hope' Efficiency Savings			Maximum 'Best Hope' Efficiency Savings		
	NEB All Projects	NEB Base Case	NEB Low Case	NEB All Projects	NEB Base Case	NEB Low Case	NEB All Projects	NEB Base Case	NEB Low Case
2007	10,879	7,350	7,350	10,281	6,804	6,804	9,684	6,257	6,257
2008	20,270	12,599	12,088	18,794	11,346	10,849	17,357	10,127	9,644
2009	26,125	15,800	11,803	23,598	13,727	9,907	21,205	11,766	8,112
2010	45,488	21,989	13,756	41,181	18,993	11,219	37,213	16,233	8,882
2011	54,874	25,159	13,911	48,924	21,246	10,769	43,586	17,736	7,951
2012	66,735	29,268	14,447	58,789	24,327	10,695	51,842	20,007	7,414
2013	72,413	32,795	14,535	62,709	26,747	10,172	54,441	21,594	6,455
2014	74,786	37,087	15,386	63,580	29,838	10,415	54,272	23,817	6,286
2015	78,939	41,443	15,460	65,943	32,827	9,880	55,414	25,848	5,360

Table A7: Total Emission cut required to stay on target – Oil sand target = 20 % of Alberta's GDP Emissions target									
Unmitigated Emission Reduction Required									
	NEB All Projects	**NEB Base Case**	**NEB Low Case**	**NEB All Projects**	**NEB Base Case**	**NEB Low Case**	**NEB All Projects**	**NEB Base Case**	**NEB Low Case**
2007	-	-	-	-	-	-	-	-	-
2008	-	-	-	-	-	-	-	-	-
2009	5,151	-	-	5,151	-	-	5,151	-	-
2010	25,515	1,038	-	25,515	1,038	-	25,515	1,038	-
2011	36,036	4,778	-	36,036	4,778	-	36,036	4,778	-
2012	49,227	9,434	-	49,227	9,434	-	49,227	9,434	-
2013	56,094	13,601	-	56,094	13,601	-	56,094	13,601	-
2014	60,331	19,478	-	60,331	19,478	-	60,331	19,478	-
2015	65,860	24,809	-	65,860	24,809	-	65,860	24,809	-
After Efficiency savings Residual emission to cut to stay on target									
	Minimum 'Best Hope' Efficiency Savings			**Average 'Best Hope' Efficiency Savings**			**Maximum 'Best Hope' Efficiency Savings**		
	NEB All Projects	**NEB Base Case**	**NEB Low Case**	**NEB All Projects**	**NEB Base Case**	**NEB Low Case**	**NEB All Projects**	**NEB Base Case**	**NEB Low Case**
2007	-	-	-	-	-	-	-	-	-
2008	-	-	-	-	-	-	-	-	-
2009	3,330	-	-	803	-	-	-	-	-
2010	22,302	-	-	17,995	-	-	14,027	-	-
2011	31,527	1,812	-	25,577	-	-	20,239	-	-
2012	43,078	5,611	-	35,132	670	-	28,185	-	-
2013	48,463	8,845	-	38,759	2,797	-	30,491	-	-
2014	51,399	13,700	-	40,193	6,451	-	30,885	430	-
2015	55,312	17,816	-	42,316	9,200	-	31,787	2,221	-