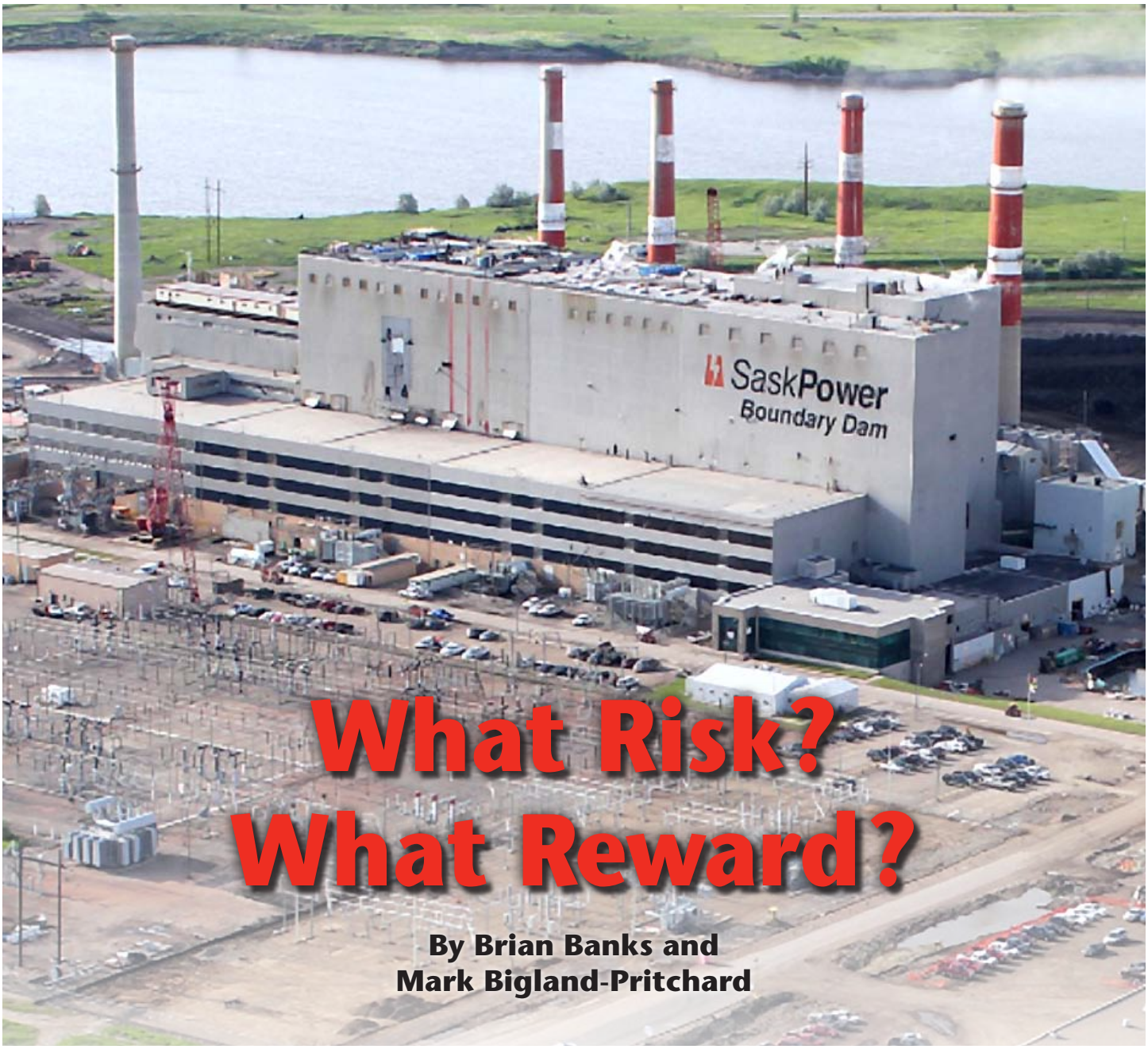
SaskPower's
Carbon Capture Project



What Risk? What Reward?

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Contents

Introduction

On April 26, 2011, the Minister responsible for SaskPower, Rob Norris, announced approval of the construction of the Boundary Dam Integrated Carbon Capture and Storage (CCS) Demonstration Project. It would be among the first commercial-scale carbon capture and storage facilities in the world and would cost an estimated $1.24 billion. The news release claimed the project would transform an aging generating unit at Boundary Dam Power Station near Estevan into a producer of reliable, "clean" electricity while reducing greenhouse gas emissions by approximately one million tonnes per year — the equivalent of taking more than 250,000 vehicles off Saskatchewan roads each year — in addition to capturing carbon dioxide (CO_2) for enhanced oil recovery. "SaskPower and its private-sector partners are leading the world in the development of a technology that will help to address climate change while ensuring that we can continue to use coal as an energy source for many years to come," Norris said.[1]

Three years later on October 2, 2014, SaskPower stated that it "will officially start the $1.35 billion Boundary Dam power plant…The 110 megawatt (MW) project will cut carbon dioxide emissions by about a million metric tons annually, by trapping it before it enters the atmosphere and pumping it underground."[2]

On October 4, 2014, the Leader Post reported SaskPower CEO Robert Watson's excited reaction that the $1.4 billion CCS technology "works". The story went on to assert that the world's first commercial-scale, post combustion CCS project was operating and would remove 90 per cent of the carbon dioxide emitted from the new plant. The story repeated that the original budget was $1.24 billion, but the unexpected costs of refurbishing Unit 3 (including removing lead paint and asbestos from the 45 year-old power unit) inflated the cost by $115 million to $1.36 billion. SaskPower admitted that the final bills will not come in for another six months and will put the project $150 million to $200 million over budget. Mike Monea, the project leader, also said "we'll be capturing at our target levels — 99.9 per cent." And SaskPower once again stated that the plant will remove one million tonnes of CO_2 emissions — equivalent to taking 250,000 cars off the road annually. The plant is expected to produce 110 MW of electricity, enough to power 100,000 homes for a year.[3] Although, it does appear that there was some confusion in the Leader Post report as Monea was likely referring to the proportion of flue gases diverted into the capture facility, not the proportion of CO_2 captured from those gases in that facility.

The announcements made by SaskPower raise many questions regarding the cost and cost overruns of the project, the amount of CO_2 it will actually remove on a long term basis, and the amount of electricity it will generate annually. Final costs will exceed $1.4 billion. The corporation attributed the budget overruns to increased costs of asbestos and lead removal from the old plant. This explanation is perplexing, particularly given that SaskPower has a long history of removing asbestos and lead from refurbishing old plants and should have had precise knowledge of these costs prior to the project start. Cost overruns may be more attributable to cost plus contracts awarded part way through construction and a desire to complete the project before the end of 2014. How much CO_2 will be removed annually is also in question. (A capture rate of 90 per cent is considered to be at the high end.) Will there be ongoing monitoring of CO_2

capture — including downstream losses — and will these measurements be reported regularly to the government and the public? Is it certain that SaskPower will run this plant year-round? For instance, during the lower-demand periods of spring and fall it might make financial sense to prioritize hydro plants, whose running costs are much lower. And even more telling: CCS units reduce the power output of coal-fired plants by 20 to 30 per cent (hence the reduction of Boundary Dam 3's rated capacity from 139 MW to 110 MW); however there is no experience as to whether this parasitic load will change over time. Given this long-term uncertainty, will the plant continuously generate 110 MW of electricity for the extent of its operational life? Answering these questions to the satisfaction of the Saskatchewan public is the responsibility of SaskPower and the government.

It is the intention of this paper, however, to address the more crucial issues respecting this project which are: assessments of the financial, environmental and technical risks of SaskPower's CCS project versus the potential rewards/benefits of expenditures exceeding $1.4 billion. Several primary issues will be addressed regarding the value proposition of this project. What are the current and future impacts on SaskPower's finances? How will project costs affect electrical rates and ratepayers in years to come? Are the publicized environmental benefits as positive as claimed? Who is the major benefactor of the CCS facility? However, before analyzing the risk/reward balance it is first necessary to provide a brief overview of the CCS process itself and outline of the current climate regarding CCS and its adoption as a technology.

The most developed technique for capturing carbon from emissions in a coal-fired plant is known as amine scrubbing. It involves bubbling the exhaust from burning coal through a solution of water and monoethanolamine (MEA). MEA

Boundary Dam CO_2 capture plant

is toxic and caustic, with an acrid, ammoniacal smell. SaskPower is using an unspecified amine product that apparently is less toxic than MEA, having adopted Shell Oil's CanSolv process.[4] The amine bonds to carbon dioxide separating it from the other gases in the exhaust. The process creates a new chemical compound, an amine carbonate (a weak acid).[5] The amine carbonate and water are pumped into a "stripper" where the solution is boiled and the pressure is lowered. Heat and expansion reverses the earlier reaction, breaking up the carbonate into CO_2 and leftover amine. The carbon dioxide is then pumped into underground storage or into a temporary facility, and the amine returned to combine with the next batch of coal exhaust. A small percentage of the amine is not recovered, and over time some of it decomposes or reacts: hence some new amine must be added during the process. To minimize loses, it is important to maintain the amines and exhaust in a self-contained system: this is one of the reasons why CCS is "breathtakingly expensive".[6]

The Global CCS Institute, an organization funded by governments and energy companies to promote carbon capture and storage, states there are 55 CCS projects currently in various stages of planning or construction world-wide. Only one project, Boundary Dam, is a CCS post combustion coal-fired plant: other such projects have been abandoned or postponed for cost reasons. The vast majority are smaller pipeline/refining facilities, which are much cheaper to construct. Most of the US projects intend to use the CO_2 for enhanced oil recovery; whereas the Chinese, European and Korean projects (23 of 55) the primary storage option is in geological saline formations,[7] often financed through carbon trading schemes.

The Massachusetts Institute of Technology (MIT) maintains a database of CCS projects. It identifies 26 CCS power plant projects currently under construction or in the planning phase. Almost all are using natural gas as fuel or alternatively gasifying coal. In the US only two projects are under construction and in the European Union all 11 projects are still in the planning phase. This site also lists eighteen cancelled and inactive CCS projects as of September 30, 2014.[8]

What are some of the obstacles with respect to the construction of coal-fired CCS plants? *Scientific American* describes the difficulties facing Kemper County Energy Facility, owned by Southern Company, one of the few US CCS coal projects actually under construction. Kemper envisions stripping 65 per cent of the CO_2 from a 582 MW gasification power plan and plans to convert coal to a synthetic gas as the fuel for its plant. The facility requires piping to extend across much of the state, construction of conveyor belts as tall as buildings, and an operating coal mine, where massive trucks ferry unearthed lignite coal to a storage dome. But Kemper has been plagued by cost overruns, rising from "less than $3 billion to $5.5 billion today", and putting pressure on the company's stock. UBS bank released a financial assessment, for instance, downgrading Southern to "sell," noting ongoing discussions with Mississippi regulators on whether the plant's spending was prudent.[9] Analysts have concluded that the more carbon Kemper captures the more money it will lose, a situation that actually encourages reduced levels of CO_2 capture. When the value of the CO_2 is much less than the incremental operating costs, shareholders will not support such losses for long. The latest cost forecast for Kemper has now reached $6 billion.[10]

Are the first generation CCS projects, like the Kemper project, merely high-cost demonstrations, or is it feasible that additional Kemper-style power plant will be built? The necessary preconditions to take CCS in North America to the next stage of development are: high North American natural gas prices (low natural gas prices make it more desirable as a fuel); continued

logistical or policy barriers to low-cost renewables such as wind power; available indigenous low-rank coals; a desire to control or lower CO_2 emissions; either a serious carbon pricing regime or nearby oil fields that would purchase the CO_2 for enhanced oil recovery projects; and suitable geological formations for CO_2 disposal. Without these conditions being present, second generation CCS coal-fired plants are highly unlikely. Today, however, natural gas prices are far too low, often making coal less competitive as a fuel, especially when GHG emission levels are considered. Many countries and companies that have similar quantities of coal may not have the billions of dollars to invest in Kemper's gasification technology and CCS. A country that does have large quantities of both low grade coal and money is China, where first generation CCS post combustion projects are under construction (as reported by Wired magazine) and whose 1.3 billion people can arguably absorb the cost of CCS experimentation. Although Saskatchewan has sufficient quantities of relatively cheap low grade coal, and obstacles remain to large-scale wind power, the other conditions are not present. Hence additional CCS projects in Saskatchewan beyond Boundary Dam 3 would present a substantial challenge. Apart from Boundary Dam 3, remaining coal-fired capacity in Saskatchewan amounts to 1285 MW: 427 MW at Boundary Dam 5 and 6, 582 MW at Poplar River and 276 MW at Shand. Canadian regulations (see below) exclude renewal of these plants after their retirement dates if CCS is not installed: hence the choice will be between permanent shutdown and a problematic CCS conversion process.

In 2014, the United States Environmental Protection Agency (EPA) proposed new carbon emission standards for new coal and natural gas fired plants. To reach the standards the new plants will have to install CCS, as the limit is 1,100 pounds (500 kg) of carbon dioxide per megawatt hour for coal fired plants. The Canadian federal regulations are similar: they specify that a new unit — i.e. one commissioned from July 2015 onwards — must emit less than 420 tonnes/GWh, which will rule out new coal plants unless CCS is installed. A unit which has reached its retirement date but is still operating is subject to the same emissions limit: thus they will also have to be either refitted with CCS or closed permanently.[11] These regulations could enable CCS in the USA and in coal-dependent Canadian provinces (principally Alberta and Saskatchewan); but whether it will generate new out-of-province revenue streams for SaskPower depends on whether the corporation has any significant intellectual property rights over the technology. The US situation is, however, still uncertain: pushback by the US utility industry has been strong. In comments on the EPA's proposed regulations, the National Mining Association, the US Chamber of Commerce, and others urged the EPA to withdraw and write new "achievable" standards that do not rely on CCS technology:

> *The National Mining Association stated, 'While EPA cites several major projects in determining that CCS is 'adequately demonstrated,' these projects are either under construction and not yet operational, in the planning phase and facing difficulties, or not designed to function primarily as a power plant. The lack of commercially operating facilities with real world performance data belies the demonstrated nature of these projects.*[12]

The main reason the utility industry is resisting the new standards and CCS is that it forces coal to compete with natural gas and could raise wholesale electricity prices by as much as 80 per cent. The US Energy Department admits that first generation CCS technologies have a captured cost of carbon dioxide of between $70 and $90 per tonne for wholesale electricity.[13] Given the current absence of serious carbon-pricing schemes in the jurisdictions concerned, this is not good news for those wishing to sell CCS technology.

Financial Risks of the Boundary Dam CCS Project

How financially risky is the Boundary Dam CCS project? And who will ultimately be responsible for this costly gamble? SaskPower is fully aware of the level of risk it has taken on with this project. "The project involves complex emerging technology, critical partnerships, and **significant financial exposure**" (our emphasis).[14] SaskPower proceeded with Boundary Dam CCS without obtaining any partners who would contribute financially to its capital costs. The $240 million contributed by the federal government covers only about one sixth of the costs. Investing $1.5 billion in experimental technology involves a high level of risk, especially for a company of SaskPower's size.

A snapshot of SaskPower's financial metrics reveals just how much financial exposure the CCS project created — as well as considerable financial stress. In 2013 the value of SaskPower's assets was about $8.6 billion, its total debt $5.5 billion and its annual revenue about $2.0 billion with a net income (profit) of $114 million. The company claimed that its 2013 return on equity was 8.2 per cent, but its projected return for 2014 will be 1.3 per cent, a very sharp decline that will lead to an estimated net income of only $27 million in 2014. This suggests that SaskPower will be operating very close to a break even position in 2014. In 2010, prior to the CCS project, its capital expenditures were just under $200 million, $310 million in 2011, rising to $500 million in 2012 and then to $710 million in 2013, when the CCS project was in its penultimate year. This rapid increase in capital expenditure coincides closely with the large expenditures on the CCS project: in fact 39 per cent of the total 2013 capital expenditure was dedicated to the CCS project. SaskPower's debt-equity ratio was 69.8 per cent in 2013 and is forecast to be 77 per cent in 2016, a significant increase. Finance charges in 2013 were $262 million, ten times net income, and up from $57 million in 2012. The spike in interest costs no doubt added to the increase in corporate debt which was $588 million in 2013, mostly as a result of CCS spending. The above financial indicators make it obvious that without a significant increase in electrical rates SaskPower would be in a difficult financial situation by 2015.[15]

Dating back to at least the 1970s SaskPower has vociferously claimed that its ageing infrastructure was a serious issue and that without significant new capital expenditures the system would become increasingly fragile leading to more outages and unhappy customers. Ageing infrastructure is SaskPower's mantra, oft repeated in its rate increase submissions and in its annual reports. The need to upgrade ageing infrastructure has been the corporation's historic go to position when seeking rate increases. It is a given that whichever energy path SaskPower embarks on its infrastructure will have to be upgraded, preferably with smart grid technology — and that its demand projections indicate a need for new capacity. But what is ironic is that SaskPower decided to rebuild (at reduced capacity) one of its oldest coal-fired plants, Boundary Dam 3, rather than mothball it and build new, less expensive, less polluting electrical generation. It is also interesting to note that in the 2013 Annual Report the corporation predicts that it will need to invest one billion annually in capital expenditures to update its system as a normal practice. One billion just happens to be the

approximate cost of the CCS part of the Boundary Dam project. SaskPower closed Boundary Dam 4 in 2014 and it would have to be retrofitted with CCS in order to reopen. Such investment levels are not possible without significant additional rate increases. Can a corporation with a current debt of $5.5 billion responsibly take on annual investments of $1 billion annually?[16]

At this point the bills for the Boundary Dam CCS project are not all yet in. The related Carbon Capture Test Facility at Shand is not yet complete: thus further expenditures beyond the approximate $60 million invested so far will be forthcoming.[17] As stated in the corporation's Rate Review Panel submission, this facility is being built with Hitachi as a partner and will be used to test new carbon capture technologies that could benefit SaskPower as the corporation looks to keep coal as a long term generation option. The pipeline to transport CO_2 to the Weyburn oil fields was completed by Cenovus, but some of the costs of completing the Aquistore CO_2 deep injection site are still outstanding. Pipeline News reports in an interview with PTRC that Aquistore costs are about $30 million, not including future operating costs.[18] Also, in its submission to the Rate Review Panel SaskPower admits the price for coal will increase in 2014 as contracts with producers expire and that was one of the additional reasons it applied for a three year rate increase. By sticking with coal fired plants SaskPower will continue to face long term fuel input costs at a time when wind power, for example, is becoming more competitive.

Aquistore injection well

The CCS project is also creating financial risks for all classes of electrical energy purchasers. Early in 2014, SaskPower's application to the Rate Review Panel requested rate increases of 15.5 per cent over a three year period, beginning January 1, 2014, the first multi-year application ever made to the Panel. The Panel approved a 10.5 per cent increase taking effect January 1, 2014, and a second rate hike of five per cent was approved for January 1, 2015, but the 2016 increase was rejected. Cabinet later approved the first 5.5 per cent rate hike, but scaled back the 2015 increase from five to three per cent. Minister Bill Boyd said "the utility was now forecasting a better financial outlook for 2015." How this is possible was not made clear.[19] SaskPower has ten customer classes, and according to its submission to the Panel each class would be charged a different rate hike — the 5.5 per cent increase approved by Cabinet is actually an average increase across all the classes. For 2014, SaskPower requested in its application the following: a 5.3 per cent increase for urban residential customers; oilfields 3.6 per cent; contract customers 6.4 per cent; farm customers 3.5 per cent and rural commercial 4.8 per cent. Urban commercial would pay the highest rate at seven per cent. The application concluded that if the rates were approved the 2015 net income would be $39.9 million and $40.4 million in 2016 and its return on equity would be about two per cent, a far cry from its target of eight per cent. Given that Cabinet has approved only a 3.5 per cent increase for 2015, net income is expected to be much less than the $39.9 million requested.

The future financial outlook for SaskPower is shaky. In 2016, the corporation will need much greater than a five per cent increase to get its books back to a healthy condition. One hundred SaskPower customers account for 40 per cent of the corporation's electrical demand. A series of six or seven per cent increases could seriously impair the competitive advantage of some of these businesses and have damaging effects on the provincial economy. (However, potash and oil account for a very large proportion of electrical demand, and these corporations would have little choice but to pass on higher operating costs — the risk to the provincial economy from this quarter could come from their lobbying for compensatory lower taxes.) On the other hand urban commercial customers such as electrically heated senior citizen condominiums, for example, cannot afford such high rate increases and have to absorb higher prices. The reason why SaskPower is willing to apply for much lower increases for those living in rural Saskatchewan and to its oilfield customers is not explained in its submission.[20]

A further financial risk to SaskPower is the long term operating costs of Boundary Dam 3 and the CCS plant. A cost versus return analysis of the business case shows how enormous the operating losses will be — as much as $1 billion over twenty years. The CCS plant will have a parasitic effect on SaskPower's financial position for the next twenty years. (See below James Glennie's 20 year cash flow analysis for Boundary Dam Capital Investment and Operations).[21]

Potential Rewards from the Boundary Dam CCS Project

The balance sheet, *Boundary Dam Capital Investment and Operations*, provides a very rough estimate of the revenues and expenditures of the Boundary Dam plant incurred over a 20 year period and compares them to the investment, revenues and expenditures to operate the CCS plant. It also shows Cenovus's potential revenues versus Saskatchewan governments royalty revenues. There are a large number of unknowns and costs that have not been included in this balance sheet; however, it does provide enough basic data to draw conclusions about the fiscal responsibility of the CCS project.

BOUNDARY DAM CAPITAL INVESTMENT & OPERATIONS 20-YEAR CASH FLOWS ($-MILLION)					
SASKPOWER/SK RATEPAYERS				**WEYBURN CONSORTIUM**	
COAL FIRED POWER STATION		CARBON/SULPHUR CAPTURE FACILITY		(HEADED BY CENOVUS ENERGY)	
Investment		**Investment**		**Investment**	
Feds	(85.0)	Feds	(155.0)	Unknown	N/A
SaskPower	(395.0)	SaskPower	(720.0)		
TOTAL	**(480.0)**	**TOTAL**	**(875.0)**		
Operations		**Operations**		**Operations**	
Revenue		**Revenue**		**Revenue**	
Electricity sales	1,307.1	CO_2 sales to Cenovus	450.0	Crude sales	4,500.0
		H_2SO_4 sales	30.0		
		Fly ash sales	25.0		
Expense		**Expense**		**Expenses**	
O&M (inc. fuel)	(697.0)	Parasitic load	(400.0)	SK Oil Royalties	(600.0)
		O&M	(400.0)	CO_2 purchase	(450.0)
NET REVENUE	610.1	NET REVENUE	(295.0)	GROSS REVENUE	3,450.0
Total Investment	(480.0)	Total Investment	(875.0)	Total Investment	N/A
Total Operations	610.1	Total Operations	(295.0)	Total Operations	3,450.0
NET PROFIT	**130.1**	**NET PROFIT**	**(1,170.0)**		
PROJECT TOTAL			**(1,039.9)**	**GROSS MARGIN**	**3,450.0**

Revenues from the Boundary Dam Station and CCS Facility

The following is an assessment of the accuracy of Glennie's cash flow estimate:

1. Sale of CO_2, estimated to be $450 million, may be too high. SaskPower has agreed to provide Cenovus Energy a million tonnes of CO_2 per year for ten years, but the actual price per tonne has not been made public and it is not known whether Cenovus is able to lower the amount purchased at any time. Estimates range in the neighborhood of $20 to $25 per tonne over 20 years: thus total revenues could be $400-$500 million. But it is also questionable whether the Weyburn field will have an additional twenty year life span even with enhanced oil recovery technologies are applied. Will Cenovus continue to operate its enhanced oil recovery operation should the price of oil drop below $70 per barrel for extended periods of time as low prices negatively affect profit margins? With West Texas Intermediate oil dipping below $50/barrel in early 2015 Cenovus may not purchase the contracted amounts of CO_2, and as a result SaskPower will forego revenues and be required to inject the CO_2 in its Aquistore site and take on additional operating costs. Many risk factors are at play regarding the sale of CO_2.

2. Sale of sulfuric acid and fly ash over the next twenty years has been roughly estimated to be about $60 million. This figure may be relatively accurate. However, the revenues from fly ash could instead be applied to the revenues on the coal-fired plant side of the ledger as fly ash segregation and sale has been a normal part of Boundary Dam operations for many years.

3. This balance sheet does not consider the possible revenues earned from the Shand Test Facility. Additionally, it does not estimate any future sales of the CCS technology that SaskPower is bringing on stream. Does SaskPower have patents or any other intellectual property that it may be able to sell to other utilities in the future? Apparently it does not have patents on the amine stripper or the CanSolv process. Pipeline News confirms this, and further states that the Shand CCS Facility will test a wide variety of vendor-specific technologies to validate performance of their equipment and systems.[22] But there is no estimate of revenues from this, as SaskPower's partner in this venture, Hitachi/Mitsubishi will be conducting most of the testing (8,000 – 12,000 hours) in the first year of operation. Mike Monea in Pipeline News claims that Boundary Dam 3 CCS has created knowledge that SaskPower can monetize: *"Right now we are waiting for some direction from our government on how to do that. … SaskPower has gained knowledge on construction and integration that nobody really has. … The next plant will be 20-30% less expensive."*[23] This is a very ambitious and optimistic prediction — is it rooted in reality or in sales talk?

4. What is the likelihood of utilities purchasing SaskPower's CCS technology? SaskPower admits they do not own the "technology of capture."[24] As in the Kemper case discussed above, scalable CCS projects seem unlikely for decades, especially for profit driven privately owned utilities. SaskPower's partners in the Shand Facility Shell, Hitachi/Mitsubishi, and SNC Lavalin own the technical applications and will mainly benefit from future sales of amine strippers. Again many potential revenues and expenditures are undisclosed or difficult to estimate accurately as the market for future CCS projects is highly suspect.

5. Net loss in revenues from the CCS facility as estimated in the cash flow analysis above at $295 million may be underestimated.

Shand Carbon Capture Test Facility

Expenditures of Boundary Dam CCS Facility

1. Not all aspects of the project are complete, and CCS expenditures are not consistently reported in our sources: hence a total cost picture is also not possible. SaskPower's submission to the Rate Review Panel states a total investment in CCS of $878 million from 2012 to 2014 and no capital invested in 2015.[25] No Shand Test Facility would likely exist without the initial investment in Boundary Dam CCS, so its costs need to be applied to the CCS Facility. SaskPower will pay for ongoing Aquistore CO_2 injectivity, containment and capacity costs. Operating and monitoring costs of storing additional CO_2 in the Aquistore underground facility during the life span of Boundary Dam 3 have not been estimated. It is not known how much CO_2 will actually be produced and captured by this plant. Aquistore will be used as a storage buffer when Cenovus cannot accept CO_2. These costs are not included in the profit/loss estimate above. (Petroleum Technology Research Centre posted on its website that SaskPower was feeding CO_2 into a dedicated pipeline on October 1, 2014. The exact pipeline is not identified).[26] More importantly, the cost of borrowing is absent from the balance sheet. Over a twenty year period interest costs of borrowing hundreds of millions

would be considerable. SaskPower's Annual Report 2014 states financial charges increased to $262 million from $57 million in 2012. Imagine the cost of additional borrowing for Boundary Dam 4 CCS.

2. The operating and maintenance expenditures of $400 million over 20 years are therefore too low.

3. The bottom line loss of $1,039 million then is much higher than stated on the balance sheet.

4. Calculations of the sale of Boundary Dam electricity are estimated in the above balance sheet to be $1,307 million. It is not entirely clear how this figure was arrived at, but it is possible to replicate it with a simple calculation:

   Income = years of operation x 8760hrs/yr x rated capacity (in MW) x capacity factor x price charged per MWh.

   If the plant operates for 20 years, the capacity factor is 80% and the average price charged is $85/MWh (i.e. 8.5 cents per kWh), then:

   Income = 20yrs x 8760hrs/yr x 110 MW x 0.8 x $85/MWh

   = $1310 million.

Financial Rewards Gained by Third Parties

Cenovus will purchase one million tonnes of CO_2 annually for enhanced oil recovery in the Weyburn oil field. Each tonne of CO_2 increases Cenovus's oil production in Weyburn by two or three barrels. In 2013 WTI oil was valued at approximately $90/barrel: thus each tonne of CO_2 would have provided $180 to $270 of increased revenues. In January 2015 that number is 50 per cent less. If Cenovus pays $25/tonne for CO_2, then Cenovus still earns on average $100 to $150 in additional revenues from increased productivity occurring as a result of CO_2 injection. PTRC reports that "The Weyburn oilfield was producing only 8,000 barrels per day by 1990. CO_2 began to be injected in 2000, and within 5 years oil production had grown to nearly 30,000 barrels per day" and remained at those levels until 2010.[27] If injection maintains production levels at 30,000 barrels per day for the next five years, Cenovus will produce an additional 10.9 million barrels per year and about 50 million additional barrels in only five years. The balance sheet below estimates that over 20 years a potential gross revenue gain of $3.45 billion for Cenovus, which is a conservative estimate of the value of the oil produced (even with WTI oil at $50/barrel).[28] SaskPower has taken on almost all of the financial risk but Cenovus will reap the greatest rewards.

BOUNDARY DAM CAPITAL INVESTMENT & OPERATIONS
20-YEAR CASH FLOWS ($-MILLION)

SASKPOWER/SK RATEPAYERS			WEYBURN CONSORTIUM (HEADED BY CENOVUS ENERGY)	
Coal-fired power station profit	130.1			
Carbon capture loss	(1,170.0)			
NET LOSS	**(1,039.9)**		**GROSS PROFIT**	**3,450.0**

Environmental Risks Resulting from Boundary Dam CCS

The pollution effects of coal mining, burning coal, venting coal gases, and disposing of ash and other residues are well known. Burning coal releases more GHGs than any other fossil fuel per unit, twice that of burning natural gas. With a 90 per cent capture rate coal plants with CCS emit CO_2 at a rate 1/10 that of a conventional plant, but this is still a significant amount, perhaps as much as 140 tonnes of CO_2 per GWh of power. Coal is responsible for the greatest percentage of CO_2 emissions world-wide, billions of tonnes annually.[29] It has been known for several years that a majority of the world's fossil fuel reserves need to stay in the ground in order for the internationally-agreed target of keeping average global temperature rise below 2°C is to be achieved.[30] A January 2015 landmark study by Christophe McGlade and Paul Ekins, published in Nature, found that, in order to stay below 2°C in an economically-optimum way, 88 per cent of the world's coal reserves (i.e. of the known resources which are accessible with current technology and under current economic conditions) must stay in the ground. With widespread introduction of CCS technology, this figure reduces only slightly, to 82%. (The equivalent figures for Canada's coal reserves are 82% and 75% respectively.)[31]

Critics of coal-fired plants list the following further negative impacts:

1. Significant reduction of air quality, plus serious impacts on human health, due to emissions of heavy metals, (arsenic, cadmium, mercury, uranium and chromium to name a few) sulfur dioxide, nitrogen oxides, and particulates. CCS does not remove heavy metals, particulates or radiation from emissions.
2. Water contamination resulting from coal washing and disposal of fly ash in unlined landfills, allows toxins to leach into the environment.
3. Land degradation from strip mining.
4. Occupational risks such as respiratory hazards, cave-ins and explosions.
5. Community health risks such as increased asthma, cancers and pulmonary disorders.[32]

The health impact of these toxic substances has not been documented for Saskatchewan, but is most likely significant. The financial cost — in medical treatment, environmental impact, insurance, etc. — may also be expected to be high. In a study of these "externalities" in the case of Alberta's coal-fired power stations, a 2013 report co-authored by the Asthma Society of Canada, the Canadian Association of Physicians for the Environment, The Lung Association for Alberta and the North-West Territories and the Pembina Institute calculated the costs to society to be between $36 and $137 per megawatt-hour.[33]

Many experts agree that to believe coal can be clean is self-delusionary. And yet SaskPower proposes to continue coal combustion at Boundary Dam for at least another 20 years.

SaskPower and Greenhouse Gas Emissions

Let's examine the GHG emissions SaskPower is responsible for. SaskPower reports its GHG emissions annually to Environment Canada, which publishes a report of the nation's heavy emitters, including the top 40 GHG emitters in Saskatchewan. The latest figures available are for 2012 and the table below summarizes the total emissions by facility. The GHGs emitted from the three coal-fired plants is 12,933,647 tonnes, with an additional 162,550 tonnes from the two coal mines that supply SaskPower.[34] If the GHGs from natural gas plants are added in, then SaskPower's total emissions in 2012 was 14,058,288 tonnes. The CCS Boundary Dam project is slated to reduce GHGs by one million tonnes annually which amounts to only seven per cent of the corporation's emissions, not a major decrease given the $1.5 billion dollar investment. When we add the emissions created by the co-generation plants to SaskPower's emissions, then the CCS facility reduces total GHG emissions by only a little more than six per cent of emissions produced from electrical generation. See tables below.[35]

Greenhouse Gas Emissions 2012 Selected (1) (2)

SaskPower Boundary Dam	6,935,649	Coal-fired
Poplar River	4,378,466	Coal-fired
Shand	1,660,532	Coal-fired
Queen Elizabeth	653,318	Natural gas
Yellow Head	138,979	Natural gas
Ermine Generation	128,694	Natural gas
Bienfait Mine	113,162	Coal mining
Boundary Dam Mine	49,488	Coal mining
Total	**14,058,288**	

(1) All gases including HFC, NO2, etc. CO_2 is by far the largest amount emitted.
(2) Total provincial emissions from all sources 2012 – 74.8 million tonnes, increased from 43.5 in 1990.

Greenhouse Gas Emissions CoGen Plants 2012 (1) (2)

Meridian	885,549
Cory Potash	675,495
Northland	67,876
Total	**1,628,920**

(1) All gases
(2) Cogeneration plants produce electricity for sale to SaskPower

What is even more concerning is the continuous increase in GHG emissions in Saskatchewan. Since 1990, even with slow population growth, Saskatchewan's emissions grew from 43.5 million tonnes to 74.8 million tonnes.[36]

Therefore, SaskPower, which is the largest single corporate emitter by far, has a greater responsibility to reduce its emissions.

A further environmental risk will occur as a result of the additional GHGs Cenovus will emit as it increases its oil supply from the injection of one million tonnes of CO_2 in the Weyburn oilfield. A rough calculation shows that the quantity of CO_2 injected underground is substantially less than the quantity of CO_2 generated by burning the extra oil produced. In the well-monitored Weyburn-Midale project, carbon dioxide from a Beulah, North Dakota coal gasification plant is pumped into Saskatchewan's Weyburn and Midale oilfields. 34.5 million tonnes (net) of injected carbon dioxide had enabled recovery of an extra 222 million barrels of oil by 2008, according to the Regina-based Petroleum Technology Research Centre.[37] When that oil was burnt, it will have resulted in the emission of about 95 million tonnes of carbon dioxide. Hence, for each tonne of carbon dioxide injected

into the oilfield, about 2.7 tonnes of carbon dioxide are eventually emitted from combustion of the oil recovered. This calculation does not even account for carbon dioxide losses in the course of the injection process: a substantial proportion returns to the surface with the oil.

In 2012, Environment Canada reported that Cenovus was responsible for 94,088 tonnes of GHG emissions. This amount may well increase as SaskPower's CO_2 is used in its enhanced oil recovery operations and this oil is refined and burned. The additional amount of GHGs expended and CO_2 losses by Cenovus must be subtracted from the one million tonnes of CO_2 SaskPower will capture.[38] Another factor that should be considered is the CO_2 that is lost to the atmosphere during the injection process. As PTRC explains, because the CO_2 blends with oil and becomes part of the oil mixture, a certain amount of CO_2 will return to the surface during oil production. The oil company separates this CO_2 from the oil mixture at the surface, compresses it and re-injects it. Some will necessarily be lost during these points in the overall process.[39] When all GHG emissions are considered the one million tonnes captured annually is not a significant reduction in the province's contribution to climate change.

Weyburn oil field

Conclusion

In 2011, SaskPower's decision to rebuild Boundary Dam 3 and construct a CCS facility is an important turning point in the corporation's history. At a time when utilities and grid management corporations around the world are shifting decisively towards renewables as costs fall, SaskPower appears willing to lock the province into fossil fuel electrical generation for decades. SaskPower missed an opportunity to shut down its oldest and dirtiest plant and instead spent $1.5 billion on a very financially risky new technology, CCS. In future CCS may become lower cost and technical issues may be resolved, but in 2011 it was an extremely poor fit for SaskPower and the purchasers of electrical power. When corporations take high risks, then the potential for high rewards should be the result, not so for Boundary Dam 3 CCS. The financial losses for Boundary Dam 3 are high and the future rewards are far from proven.

What alternatives did SaskPower have? The cleanest and cheapest alternative was to move forward the plan to construct the 177 MW Chaplin wind farm and pursue additional wind power opportunities spread throughout the province. The cost estimates for this project were not provided in the Rate Review Report. James Glennie's table below shows the cost benefit comparison of wind power versus Boundary Dam CCS.[40]

		WIND	COAL
	Units		
Capacity	MW	288.2	160.1
Capital cost	$-mln	576.5	519.8
Generation	GWh p.a.	1,010.0	1,010.0
20 year expenses			
Capital repayment	$-mln	1,222.3	1,212.0
Fixed O&M	$-mln	247.9	84.8
Variable O&M	$-mln	0.0	612.1
Transmission & Balancing	$-mln	337.7	200.0
TOTAL		**1,807.9**	**2,108.9**
20 year expense difference			**301.0**

Coal when compared to wind is about $300 million more expensive over 20 years. When factoring in the capital cost of CCS, coal is even more uncompetitive. Wind is affordable. Twenty-six per cent of North Dakota's power is generated by wind; Denmark almost 40 per cent, and Spain over 20 per cent.[41] Wind could become a much more significant part of Saskatchewan's electrical generation. A frequent criticism of wind power is that it would reduce grid reliability. The reality is that Denmark and Germany, the pioneers in integrating wind power into the grid, have the best grid reliability figures in Europe, substantially better than is achieved in North American jurisdictions.[42] In order to integrate variable renewables like wind and solar photovoltaics, it is necessary to organize the grid somewhat differently from the traditional framework of "baseload", "intermediate" and "peaking" power sources. In what has become known as the "Kombikraftwerk" approach, variable sources are put on to the grid first, and dispatchable (quick-response) sources used to "plug the gaps".[43] Further flexibility is permitted by trading (for example, Denmark sells excess wind power to Norway and Sweden, and purchases hydro power from those countries at times of low wind production and high demand) and by smart grid technology, which enables the time of consumption to be more closely matched with the time of production without loss of convenience.[44]

A second — though less climate-friendly — possibility was to upgrade the Queen Elizabeth plant at an estimated cost of $488 million as noted in the Rate Review Panel submission.

The advantage of this choice was the additional power generated when compared to Boundary Dam — 205 MW versus 110.[45] The cost, in fact, would have been one-third and for almost double the output. Upgrading to a combined cycle natural gas generation would also have lowered GHG emissions by about 40 per cent less than comparable coal-fired generation.

(However, those who, following the findings of climate science, believe that we must move to a low carbon economy much faster, put the emphasis on shifting to renewables such as wind, solar, hydro and biomass, and seek to minimize the degree to which natural gas is used as a "bridge" fuel. No fossil fuel can ever be carbon-neutral; and there is evidence that emissions associated with natural gas are increasing as a result of methane leaks (especially from fracked wells)[46], venting and flaring.[47])

As demonstrated above, SaskPower's CCS decision has led to several financially damaging outcomes:

- SaskPower's financial health has been severely impaired for several years.
- All Saskatchewan purchasers of electricity will be saddled with higher cost electricity.
- With the cost of electricity at 12-14 cents per kilowatt-hour and rising, the province's economic competitive position will be weaker. Saskatchewan no longer has affordable electricity and it is likely to get more expensive in future, especially if Boundary Dam 4 CCS is built.
- The financial rewards from future sales of CCS technology are highly questionable making the return on the CCS investment nearly impossible to attain.

On the environmental side the CCS decision has brought about very small rewards. Shutting down Boundary Dam permanently would have resulted in no future GHG emissions. The one million tonnes captured amounts to only about seven per cent of all GHG's created by SaskPower's coal-fired generation, and less than two per cent of the province's total emissions. SaskPower could have made the decision to begin moving away from coal just as Ontario has successfully done.

The decision to build a $1.5 billion CCS facility was ultimately a political decision approved and then promoted by the provincial government. Premier Wall has stated that he had to convince a SaskPower board committee to support the CCS project.[48] In the past several years Saskatchewan's energy/environmental policy has been to maintain the status quo. Saskatchewan government has seemed to willfully ignore the shift to renewables as their efficiencies have improved and costs have dropped.[49] Adopting CCS allows Saskatchewan to appear to favour

an environmentally sound policy. Even though both British Columbia and Alberta have a carbon compliance scheme in place, Saskatchewan has never proclaimed regulations to the 2009 *Management and Reduction of Greenhouse Gases Act*, which has been rewritten along Alberta lines to set emission targets and allow corporations to make compliance payments. New environmental regulations and a phased-in Saskatchewan carbon tax would have allowed the government to put in place a 21st century environmental regime. The government fully understands that at a time, perhaps as early as 2018, SaskPower will have to phase out Boundary Dam 4 plant when federal GHG regulations are enforced. Yet Premier Wall as recently as mid-September 2014 touted so-called "clean coal" as an important provincial objective and justified paying a Washington lobbyist to promote it. Wall's interview in Pipeline News sheds light on his views regarding CCS.

> *The beauty of this technology is there's no contrivance. There's no artificer of moving the CO_2 around, cap and trading it, shifting it. The companies are buying it. … There's an underlying economic case beyond coal and heading towards enhanced oil recovery. … We had more than one company who wanted to buy the million tonnes of CO_2. … We had a lot of due diligence. We looked carefully. There was still risk. … The new technology came in on time and on budget.*[50]

Answering the question "Does the project equate to having an ace up your sleeve when dealing with the US?", Wall replied

> *It does. They [US] want some environmental elbow room from the different NGOs that hate, that don't like Keystone. They need some environmental room to quote — unquote, "deal with the Canadians" … But also look at it [CCS] as validation that we're serious about the environment, and tell those worried about Canada in general, they ought not to. In Canada, this is the largest per-capita project related to CO_2 mitigation.*[51]

Premier Wall's statements reveal the political nature of the CCS decision. To increase SaskPower's debt so substantially in order to garner US support for the Keystone Pipeline demonstrates the government's commitment to the development of fossil fuels over any other alternatives.

CCS may well become an appropriate technology in future for pipelines, some refineries and gasification plants. Biomass energy with carbon capture and storage may become an important carbon-negative technology in the future. But at this time it is far too expensive for coal-fired plants to adopt, and a completely inappropriate technology for Saskatchewan and SaskPower to adopt. The risks greatly outweigh the rewards.

> *There's little question that the high hopes of [CCS] a half-decade ago are badly faded today, leaving a gaping hole in the arsenal of measures identified to reverse the tide of greenhouse-gas emissions. Even optimistic estimates by Bloomberg New Energy Finance for [CCS] expanding its footprint have it offsetting just 1/1,565th of current global emissions in the coming years.*[52]

The predominant reason for the CCS to go ahead appears to be to recover more oil from south east Saskatchewan and reward the oil producing companies rather than adopting appropriate carbon pricing, and moving forward more rapidly on a menu of renewable energy options.

Endnotes

1 *www.saskpower.com/wpcontent/uploads/2013saskpowerannualreport.pdf*

2 Leader Post, October 2, 2014, p. D4.

3 Leader Post Oct. 3, 2014, p.D1. The original plant was rated at 139 MW according to SaskPower's 2011 document *Powering a Sustainable Energy Future*.

4 See *www.shell.com/global/products-services/solutions-for-businesses/globalsolutions/shell-cansolv/shell-cansolv-solutions/co2-capture.html* and *www.shell.com/global/products-services/solutions-for-businesses/globalsolutions/shell-cansolv/shell-cansolv-solutions/co2-capture.html*

5 The chemistry of the process is outlined at *https://en.wikipedia.org/wiki/Amine_gas_treating*

6 *www.wired.com/2014/03/clean coal*. The article is provocatively titled *Renewables Aren't Enough*.

7 *www.globalccsinstitute.com/*

8 *http://sequestration.mit.edu/tools/projects*

9 *www.scientificamerican.com/article/can=1=power-plant-clean-up-coal-and-make-money*

10 Bloomberg, Oct. 29, 2014. It is certain that most US utilities generating electricity from coal are resisting the application of CCS. Examples of stalled and cancelled CCS projects attest to that.

11 The Canadian federal greenhouse gas emissions from electricity generation regulations are found at *http://laws-lois.justice.gc.ca/eng/regulations/SOR-2012-167/FullText.html*

12 *www.bloomberg.com/news.2014-15-13/coal-pushback-carbon-limits-for-new-power-plants-must-be-grounded-in-reality-html*

13 *www.bloomberg.com/news/2014-02-12/CO2-capture*

14 *www.saskpower.com/wp-content/uploads/2014-15-16-rate-application*

15 SaskPower (2014), 2013 Annual Report, p71: *www.saskpower.com/wpcontent/uploads/2013saskpowerannualreport.pdf*

16 Ibid

17 Pipeline News p. A25 *http://pipelinenews.ca/Newspaper/2014_10_section_ a.pdf*

18 Ibid, p. A.29

19 *www.leaderpost.com/Government+trims+SaskPower+rate+hike/102111432/story/html*

20 *www.saskpower.com/wp-content/uploads/2014-15-16-rate-application*. See table p. 50.

21 *www.saskwind.ca/blogbackend2014/10/1CO2* Balance sheet created from data from, Project Sequesters Tax Dollars, Murray Mandryk, Leader Post October 4, 2014, SaskPower Annual Report & Accounts, U.S Energy Information Administration, and Canadian Association of Petroleum Producers. Compiled by James Glennie, Sask Wind Power Association.

22 *Pipeline News, P. A25*

23 *Ibid., P. A18*

24 *Ibid., P. A18-19*

25 *www.saskpower.com/wp-content/uploads/2014-15-16-rate-application*

26 *http://aquistore.ca* It is estimated that 25 million tonnes of CO_2 are already stored in south east Saskatchewan. 6550 tonnes/day are currently injected in the Weyburn oil field. The million additional tonnes purchased by Cenovus will add to that. What is the limit that can be stored? In 2012 Saskatchewan produced 172.9 million barrels of oil worth $12.3 billion (Saskatchewan Department of the Economy Annual Report, 2013).

27 *http://ptrc.ca/projects/Weyburn-Midale* What Happens When CO_2 is Stored Underground? p.17

28 *www.saskwind.ca/blogbackend2014/10/1CO2*

29 Heinberg, Richard. (2009). *Blackout: Coal, climate and the last energy crisis*. New Society Publishers: Heinberg quotes the MIT study, "The Future of Coal" that if 60 per cent of CO_2 produced from US coal-based power generation were to be captured and compressed to a liquid for geological sequestration, its volume would be about equal the total US oil consumption of 20 million barrels per day.

30 See, for example, Carbon Tracker Initiative & Grantham Research Institute on Climate Change and the Environment (2013), Unburnable Carbon 2013: Wasted Capital and Stranded Assets, available at *www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2014/02/PB-unburnable-carbon-2013-wasted-capital-stranded-assets.pdf*. Also the Carbon Tracker's basic information page at *www.carbontracker.org/resources/*

31 Christophe McGlade & Paul Ekins (2015:Jan:08), The geographical distribution of fossil fuels unused when limiting global warming to 2degC, *Nature*, vol 517, pp187-190

32 Zehner, Ozzie. (2012). *Green Illusions: The Dirty Secrets of Clean Energy and the Future of Environmentalism*. Lincoln: University of Nebraska Press

33 Kristi Andersen, Tim Weis, Ben Thibault, Farrah Khan, Beth Nanni & Noel Farber (2013), A Costly Diagnosis: subsidizing coal power with Albertans' health, Asthma Society of Canada / Canadian Association of Physicians for the Environment / Lung Association, Alberta & NW Territories / Pembina Institute / Pembina Foundation

34 *www.ec.gc.ca/gc.ca/ges-ghg/default.asp?lang=En&=8044859A-1* This is Environment Canada's link to its annual report on GHG emissions.

35 Ibid

36 *Ibid*. Environment Canada's National Inventory Report, Greenhouse Gas Sources and Sinks in Canada also provides total GHG emissions by province. Saskatchewan's GHG emissions from coal-fired plants are stated to be 15,800,000 tonnes, a slightly higher figure than quoted above.

37 Steve Whittaker for Petroleum Technology Research Centre (2008:Nov:16), Update on the IEA GHG Weyburn-Midale CO_2 Monitoring and Storage Project and PTRC's New Aquistore Project: presentation to Carbon Sequestration Leadership Forum, Washington DC

38 Environment Canada, ibid

39 Wong, R., Goehner, A., and McCulloch M. (2013). *Net greenhouse gas impact of storing CO_2 through enhanced oil recovery (EOR)* Pembina Institute: Drayton Valley, AB.

40 *www.saskwind.ca/blogbackend2014/10/1CO2*

41 Weis, Tim. Leader Post. October 1, 2014 (Weis is director of the Alberta chapter of the Canadian Wind Energy Association); see also *http://www.sunwindenergy.com/wind-energy/denmark-breaks-own-wind-record*

42 *http://energytransition.de/2014/08/german-grid-more-stable-in-2013/* , *http://energytransition.de/2012/10/747/*, *www.energinet.dk/EN/OM-OS/Nyheder/Sider/Dansk-forsyningssikkerhed-er-nummer-et-i-EU.aspx*

43 A useful introduction to the Kombikraftwerk concept is provided in a short video on "the Combined Power Plant" at *www.youtube.com/watch?v=aNZgjEDPe24*, produced by Berlin-based Renewable Energy Agency. A slightly longer video outlining the Danish strategy for conversion to 100 per cent renewable energy may be found at *www.energinet.dk/EN/KLIMA-OG-MILJOE/the-Danish-windcase/Sider/Den-danske-vindcase.aspx*

44 This is also explained in the video at *www.energinet.dk/EN/KLIMA-OG-MILJOE/the-Danish-windcase/Sider/Den-danske-vindcase.aspx*

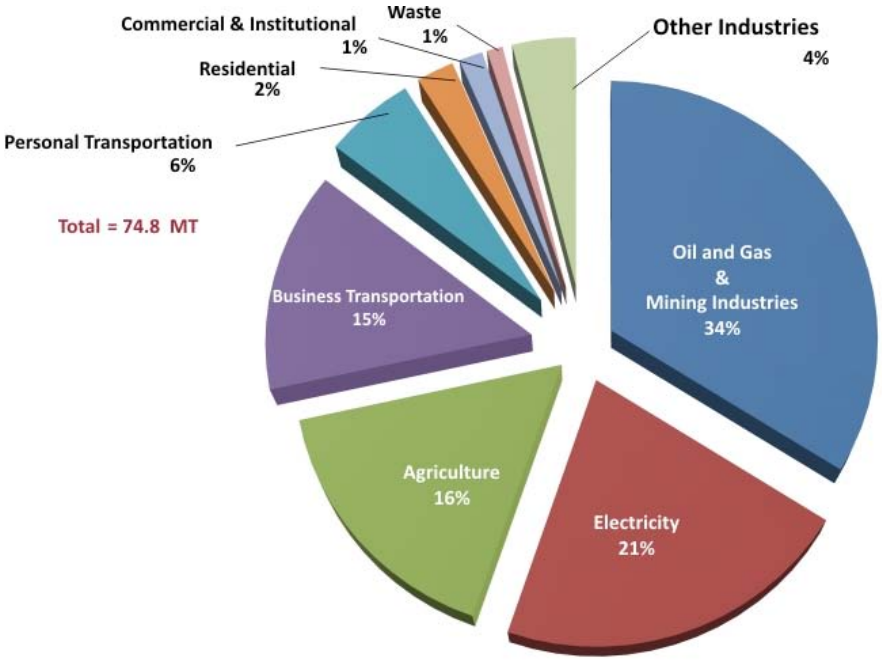
45 SaskPower Rate Review Panel Submission pp 27 and 28. Readers may wonder why SaskPower ignored the high risks associated with CCS. Psychologists have studied risk assessment extensively. Daniel Kahneman, a Nobel prize winner, concludes, "When people were favourably disposed toward a technology, they rated it as offering large benefits and imposing little risk; when they disliked a technology, they could think of only its disadvantages, and few advantages came to mind. Because the technologies lined up neatly from good to bad, no painful trade-offs needed to be faced." …

"as the psychologist Johnathan Heidt said in another context, 'The emotional tail wags the rational dog.' The affect heuristic simplifies our lives by creating a world that is much tidier than reality. Good technologies have few costs in the imaginary world we inhabit, bad technologies have no benefits, and all decisions are easy. In the real world, of course we often face painful trade-offs between benefits and costs." Kahneman, Daniel. (2011). *Thinking fast and slow*. Doubleday Canada, pp 139-140. SaskPower is very favorably disposed to coal generation as it has been the corporation's primary fuel source for a half century. It is ingrained in the corporate culture.

46 A useful summary of research into methane emissions from fracked wells was published in *Nature* in 2013: Jeff Tollefson (2013:Jan:03), Methane leaks erode green credentials of natural gas, Nature, vol. 493, p.12

47 *www.environment.gov.sk.ca/climatechange*

The pie chart shows total GHG emissions in Saskatchewan by industry sector. The 34% from the oil and gas and mining industries is made up of 13% from direct fuel combustion for process heating and 21% from venting, flaring and leaks:



48 Pipeline News, P. A14-15.

49 *http://nytimes.com/2014/11/19/business/economy A carbon tax could bolster green energy*. Nov. 19, 2014. The United States Energy Information administration projects that the levelized costs of wind energy coming onstream in 2019 (including everything from capital costs to operational outlays) could be as little as $71 per MW hour measured in 2012 dollars. European costs for wind power are typically somewhat lower than this.

50 Pipeline News, P. A14-15.

51 Ibid.

52 *www.bloomberg.com/news/2014-12-04/this-process-averts-climate-change-now-the-bad-news.html*. Bloomberg estimates CCS would cost $17.6 trillion worldwide.