# **EMISSIONS REGULATION** APPLICABLE TO COAL-FIRED POWER GENERATION

SaskPower began its clean coal power generation in the absence of regulatory direction. The Boundary Dam Unit 3 (BD3) retrofit was completed and operational by October 2014. The *Reduction of Carbon Dioxide Emissions from Coal-Fired Generation of Electricity Regulations ("Regulations") were enacted in* Canada in September 2012 pursuant to *The Canadian Environmental Protection Act*<sup>4</sup> (*CEPA*). The Regulations came into effect on July 1, 2015. However this was well after the decision had been taken to proceed with the BD3 retrofit, and construction was in full swing.

The **performance standard** under the

Regulations for all coal-fired power generation is a CO<sub>2</sub> emissions limit of 420 tonnes per GWh, which is equivalent to the emissions intensity level of a modern, high efficiency, base loaded Natural Gas Combined Cycle ("NGCC") power plant. This standard applies to new power plants constructed after July 2015 and End-of-life units constructed before July 2015.

Under the Regulations, *Cumulative CO*<sub>2</sub> *Reduction* from coal-fired power generation is estimated at 214 million tonnes of  $CO_2$  across Canada by July 2036. As a point of reference, the GHG emissions for the energy sector in Canada in 2012 is shown in Figure 5. The electricity generation by fuel type in Canada for 2013 is shown in Figure 6.



# FIGURES 5-7

### FIGURE 5 | GREENHOUSE GAS (GHG) EMISSIONS IN CANADA FOR THE ENERGY SECTOR (2012)



TOTAL GHG EMISSIONS IN CANADA, 2012 = 699 MEGA TONNES CO<sub>2</sub> EQUIVALENT



### FIGURE 6 | ELECTRICITY GENERATION IN CANADA BY FUEL TYPE (2013)

TOTAL ELECTRICITY GENERATED IN CANADA, 2013 = 611.31 TWh Courtesy of the Canadian Electricity Association



#### FIGURE 7 | ANTICIPATED CANADIAN COAL FLEET REDUCTION FROM 2007 ONWARD

\*Retirement age 45–50 years as per the 2012 Reduction of Carbon Dioxide Emissions from Coal-Fired Generation of Electricity Regulations. Includes Ontario voluntary coal shutdown by 2014.

**BY COMPARISON**, the UK carbon emissions performance standard for coal-fired power units was legislated in December 2013 at 450 tonnes per GWh. Although the EU has not set a performance standard for power plants, the European Investment Bank has adopted a policy that it will no longer fund any power plant that is designed to emit more than 550 tonnes per GWh. The EC has recommended a limit of 450 tonnes per GWh following the UK's lead. In the USA, while a target reduction in power-generation-related carbon emissions was set at 30% in 2013, the Environmental Protection Agency (EPA) is still working out the details of the impact on existing coal-fired power plants. Compliance in the USA will not be required until 2020.

# In Canada, under CEPA, End-of-life Coal Units are defined as follows:

Units commissioned before 1975\*, will reach their End-oflife on December 31, 2019, or on December 31 of the 50th year following commissioning, whichever comes first Units commissioned after 1974 but before 1986<sup>+</sup> will reach their End-of-life on December 31, 2029 or on December 31 of the 50th year following commissioning, whichever comes first Units commissioned in or after 1986<sup>‡</sup> will reach their End-of-life on December 31 of the 50th year following commissioning

Under the Regulations, **Carbon Capture and Storage (CCS)** for new and Endof-life coal units incorporating CCS technology can apply to receive a temporary exemption from the performance standard until December 31, 2024 and must have documented evidence of the following construction milestones:

by January 1 2020

Complete Front End Engineering and Design (FEED). by January 1

Purchase all major carbon capture equipment. by JANUARY 1

Obtain regulatory approvals for carbon capture. 2022 All contracts for

BY JANUARY 1

All contracts for transportation and storage of  $CO_2$  in place.

BY JANUARY 1 2024 Begin commissioning

of  $CO_2$  capture, transportation and storage elements of the CCS system.

**Substitution** of a power plant to meet its performance standard compliance obligation at another power unit can only take place under the Regulations if the two power units have the same owner and they are of similar size (e.g. nominally 300 MW). The substitution will only last until the substituted unit reaches its own End-of-life. After June 30, 2015, a unit that is permanently shut down ahead of its End-of-life date may swap any leftover operating time to one or many other units with the same owner, in the same province, and with equivalent total potential power production over the period of the swap.

It may be possible for each province to negotiate a federal-provincial **Equivalency Agreement** with the Government of Canada to enable each provincial jurisdiction to regulate the reduction of carbon emissions by coal-fired power generation (i.e. possibly a different approach to meeting the overall targeted reduction in CO<sub>2</sub> emissions associated with coal-fired power generation for a province).

The Regulations that came into effect on July 1, 2015 are also expected to result in significant **reductions in SO<sub>2</sub> and NO<sub>X</sub> emissions** as shown in Figure 8.

\*Including Units 1 through 5 at SaskPower's Boundary Dam Power Station

<sup>†</sup>Including Unit 6 at SaskPower's Boundary Dam Power Station and Units 1 and 2 at SaskPower's Poplar River Power Station

### FIGURE 8 | ANTICIPATED NO<sub>X</sub> AND SO<sub>2</sub> REDUCTIONS DUE TO CO<sub>2</sub> REGULATION IN CANADA



Courtesy of the Canadian Electricity Association

Canada's GHG Regulations came into effect on July 1, 2015



Source and assumptions: NPRI data was used for existing unit emissions, forecast based on 2009–2011 operation, coal unit retirement from 45–50 years as outlined in the 2012 Reduction of Carbon Dioxide Emissions from Coal-Fired Generation of Electricity Regulations

# **Other air emissions regulations** pertaining to coal-fired power generation plants apply across Canada as follows:

Mercury (Hg) emissions standards were set for the year 2010 to ensure a reduction of 60% of the 2695 kg of Hg emitted in the baseline year of 2003. The Council of Canadian Ministers of Environment (CCME) is monitoring Hg emissions reductions to ensure the target is reached. Proposed changes to CEPA as of July 2015 apply to other emissions as follows:

- Sulphur dioxide (SO<sub>2</sub>) at 0.47 4.91 kg per MWh\*
- Nitrogen oxides (NO<sub>X</sub>) at 0.47 0.66 kg per MWh<sup>†</sup>
- Particulates (PM<sub>10</sub> + PM<sub>2.5</sub>) at 7.5 12 g per MWh<sup>†</sup>

\*The precise limit imposed on a power plant depends upon the thermal output anticipated for the coal fuel used and its sulphur content.

<sup>†</sup>Regulatory harmonization with the USA is sought. The low end of the range is the current US EPA regulation. The higher end of the range is anticipated new US EPA regulation.

# **ABBREVIATIONS**

This is not a comprehensive list.

BD3 - Boundary Power Plant Station Unit 3

CCS - Carbon Capture, Transportation and Storage

**CCPC** – Canadian Clean Power Coalition

**CCTF** – SaskPower's Carbon Capture Test Facility (at Shand Power Station)

**CEPA** – The Canadian Environmental Protection Act

**CIC** – Crown Investments Corporation of the Government of Saskatchewan (owner of all Crown corporations such as SaskPower)

**CO<sub>2</sub>e** – The climate forcing factor associated with a greenhouse gas expressed as "carbon dioxide equivalents". For example, the climate forcing factor of methane (CH4) is 21 times the factor for CO<sub>2</sub>. Hence, one methane molecule is equivalent to 21 carbon dioxide molecules in terms of greenhouse impact on the climate.

C\$ - Canadian Dollars

EC - European Commission

**ECRF** - SaskPower's Emissions Control Research Facility (at Poplar River Power Station)

EOR - Enhanced Oil Recovery

**EU** – European Union

**GHG** – Greenhouse Gas

**GWh** – Giga-Watt-Hour, the energy unit of total power generation

**ICCS** – Integrated Carbon Capture and Storage, which is the name of the combined BD3 power plant retrofit project and the geological storage of its captured CO<sub>2</sub>.

IEAGHG - IEA Greenhouse Gas R&D Programme

**MW** – Mega-Watt, the energy unit used for powergenerating capacity

PCC - Post-Combustion Capture

**PM<sub>2.5</sub>** – Fine Particulate Matter found in the air that is less than or equal to 2.5 mm (micrometres) in diameter and normally only observed by electron microscope. This material is often associated with energy combustion and the fine particulate matter is believed to cause serious health issues upon entering lungs of air-breathing animals.

**PM<sub>10</sub>** – Coarse Particulate Matter found in the air that is less than or equal to 10 (mm) micrometres in diameter. It can be seen with the human eye in the air as soot, dust, dirt and liquid droplets. This material is often associated with energy combustion.

**PTRC** – Petroleum Technology Research Centre, a non-profit R&D corporation located in Regina, Saskatchewan

**R&D** – Research and Development

QA/QC - Quality Assurance and Quality Control

SE - Southeast

SaskPower – Saskatchewan Power Corporation

# REFERENCES

<sup>1</sup>2014 SaskPower Annual Report

<sup>2</sup>SaskPower's fiscal year runs from January 1 to December 31.

<sup>3</sup>From 2010-2014, SaskPower invested C\$4.7 billion in capital assets (upgrades, new construction)

<sup>4</sup>Canada Gazette, Vol. 146, No. 19 – September 12, 2012 (Government of Canada)

<sup>5</sup> Provided by SaskPower

#### <sup>6</sup>http://www.ir.gov.sk.ca/coal

<sup>7</sup>The Encyclopedia of Saskatchewan. The Oil and Gas Industry. http://esask.uregina.ca/entry/oil\_and\_gas\_industry.html

<sup>8</sup>Melzer, Stephen, 2012. Report for the National Enhanced Oil Recovery Initiative, Center for Climate and Energy Solutions Carbon Dioxide Enhanced Oil Recovery (CO<sub>2</sub> EOR): Factors Involved in Adding Carbon Capture, Utilization and Storage (CCUS) to Enhanced Oil Recovery

<sup>9</sup>From Leasing Mineral Rights: "Unitization of a producing field: The purpose of unitization is to produce oil or gas more efficiently and effectively by bringing together an area involving a large number of sections. Unitization is used where the industry feels that a large portion of the oil and gas can be produced with fewer wells. Upon unitization, an owner within the boundaries of the unitized field is entitled to participate in production, even though no well is located on his land. The provisions of a lease may therefore permit "pooling," in which case you receive a portion of the royalty, based on the number of acres you put in the pool. The lease may permit "unitization," which converts your royalty into a "tract factor," based on a complex formula. Even though unitization in the vast majority of cases provides a better total income for the mineral owner, an owner should not grant the right to unitize automatically; nor should he leave it up to the company's discretion. Because participation in a unit is not based on the number of acres you have in the unit but is determined by the company, based on geological factors, you should very carefully assess your position. For example, while you may hold five per cent of the area in a unit, you may be allocated only two per cent of the production."

#### <sup>10</sup> http://www.economy.gov.sk.ca/PR-IC11

<sup>11</sup>Pan Canadian was a subsidiary company of Canadian Pacific Railway until it merged with Alberta Energy Company in 2002 to form EnCana Corporation, an independent oil and gas corporation. In December 2009, Cenovus Corporation split from EnCana to operate as an independent integrated oil company, including all of the oil assets from the original firm. EnCana continues to operate the natural gas assets of the original firm and is a leading independent Canadian natural gas producer.

<sup>12</sup>Numac Energy Inc. was incorporated in Alberta in 1971 and was an independent oil producing company until it was purchased by Anderson Exploration Inc. in early 2010. Anderson was subsequently purchased by Devon Energy (USA) to form Devon Canada Corporation in late 2010. Numac, in partnership with Nexen Inc., operated a  $CO_2$ -EOR pilot at its Elswick Midale oil leases in 2001 using trucked  $CO_2$  from the Air Liquide plant in Medicine Hat, Alberta. It ultimately decided not to proceed with full-scale operation of  $CO_2$ -EOR due to various technical issues it encountered during the pilot as well as poor economics due, in part, to the lack of a pipelined source of  $CO_2$ . The Elswick oil field is one of many potential  $CO_2$ -EOR targets in SE Saskatchewan.

### <sup>13</sup> http://www.economy.gov.sk.ca/adx/aspx/adxGetMedia. aspx?DocID=10290,10289,3384,5460,2936,Documents&MediaID=26122&Filename=SPRI+CO<sub>2</sub>+Pilot+Injection+Test.pdf

<sup>14</sup> http://www.ucsusa.org/global\_warming/science\_and\_impacts/impacts/early-warning-signs-of-global-1.html#. Va6YMnnbKTM <sup>15</sup> http://unfccc.int/kyoto\_protocol/items/2830.php ; The agreement came into force in 2005 upon ratification by 55 signatory parties belonging to the UNFCCC. Those signatories include Canada but notably exclude the USA as of mid-2015.

<sup>16</sup>Clift, R. and J. Seville (Editors), 1993. Proceedings of the Second International Symposium on Gas Cleaning at High Temperatures. University of Surrey, UK. Springer Science and Business Media. P. 129.

#### <sup>17</sup> https://en.wikipedia.org/wiki/Integrated\_gasification\_combined\_cycle

<sup>18</sup> http://www.nrcan.gc.ca/energy/coal/carbon-capture-storage/4307

<sup>19</sup> http://www.nrcan.gc.ca/energy/coal/carbon-capture-storage/4333

#### <sup>20</sup> http://cornerstonemag.net/exploring-the-status-of-oxy-fuel-technology-globally-and-in-china/

<sup>21</sup> Tanner, C. S., Baxley, P. T., Crump, J. G., & Miller, W. C. (1992, January 1). Production Performance of the Wasson Denver Unit CO<sub>2</sub> Flood. Society of Petroleum Engineers. doi:10.2118/24156-MS

<sup>22</sup> Beliveau, D. A. (1987, November 1). Midale CO<sub>2</sub> Flood Pilot. Petroleum Society of Canada. doi:10.2118/87-06-05

<sup>23</sup> The Midale and Weyburn oil fields are operated in the same geological formation, along with several surrounding oil leases/ operations. Each of the two oil fields is owned by approximately 30 owners but each field was "unitized" in the 1960s to support water flooding infrastructure investment. Each unitized oil field is operated by one major oil company on behalf of the owners. Pan Canadian was an owner of part of the Midale oil field and consequently had access to the CO<sub>2</sub>-EOR pilot program undertaken by Shell Canada.

#### <sup>24</sup> http://www.dakotagas.com/CO2\_Capture\_and\_Storage/Pipeline\_Information/index.html

 $^{25}$  Apache Canada began a commercial CO<sub>2</sub>-EOR flood at Midale in 2006 using approx. 1800 tonnes per day of CO<sub>2</sub> supplied by DGC. At that time Apache Canada contributed data and sponsorship to the renamed IEAGHG Weyburn-Midale CO<sub>2</sub> Monitoring and Storage Project.

<sup>26</sup> Hitchon, Brian (Editor), 2012. Best Practices for Validating CO<sub>2</sub> Geological Storage: Observations and Guidance from the IEAGHG Weyburn Midale CO<sub>2</sub> Monitoring and Storage Project. Chapter 1. Updated data from Cenovus and PTRC as of 2014.

<sup>27</sup> Approximately one-third of the CO<sub>2</sub> injected in a given oil production cycle is "lost" to the reservoir. The uncertainty prior to the IEAGHG Weyburn CO<sub>2</sub> Monitoring Project beginning its work was, "Where does the CO<sub>2</sub> go?"

#### <sup>28</sup> http://ptrc.ca/projects/weyburn-midale

#### <sup>29</sup> http://www.canadiancleanpowercoalition.com/

 $^{
m 30}$  http://www.SaskPower.com/our-power-future/our-electricity/our-electrical-system/cory-cogeneration-station/

#### <sup>31</sup> http://www.canadiancleanpowercoalition.com/index.php/ccpc-materials/ccpc-reports-phase/phase-i/

<sup>32</sup>Wilson, M. and M. Monea (Editors), 2004. IEAGHG Weyburn CO<sub>2</sub> Monitoring and Storage Project Summary Report 2000– 2004. From the Proceedings of the 7th International Conference on Greenhouse Gas Control Technologies, September 5–9, 2004, Vancouver, Canada. Petroleum Technology Research Centre, Regina.

## <sup>33</sup> http://hub.globalccsinstitute.com/sites/default/files/publications/151303/co2-stored-underground-ieaghg-weyburnmidale-co2-monitoring-storage-project.pdf

### <sup>34</sup> http://www.environment.gov.sk.ca/adx/aspx/adxGetMedia. aspx?DocID=1273,1272,929,928,926,240,94,88,Documents&MediaID=619&Filename=2007-052\_project\_description.pdf

<sup>35</sup> By this time, CO<sub>2</sub> sequestration in deep saline aquifers associated with "acid gas reinjection" at natural gas producing operations was an accepted practice, e.g. StatOil's Sleipner field. See Tore A. Torp and John Gale, Proceedings of the 6th Conference on Greenhouse Gas Control Technologies, 2003, Volume 1, p. 311–316.

<sup>36</sup> http://www.pm.gc.ca/eng/news/2008/03/25/pm-and-saskatchewan-premier-announce-major-carbon-capture-and-storage-project

<sup>37</sup> http://www.publications.gov.sk.ca/details.cfm?p=56895

<sup>38</sup> http://www.SaskPower.com/our-power-future/our-electricity/our-electrical-system/boundary-dam-power-station/

<sup>39</sup> http://www.shell.com/global/products-services/solutions-for-businesses/globalsolutions/shell-cansolv/shell-cansolv-solutions/co2-capture.html

# <sup>40</sup> http://www.shell.com/global/products-services/solutions-for-businesses/globalsolutions/shell-cansolv/shell-cansolv-solutions/so2-co2.html

<sup>41</sup> Johnstone, Bruce, 2012. From Regina Leader-Post and Saskatoon StarPhoenix newspapers. "SaskPower, Cenovus sign CO<sub>2</sub> supply deal". December 20, 2012.

<sup>42</sup> There are many sources of ENGO criticism of the BD3 ICCS Project. One example from the Sierra Club of Canada is embedded in the newspaper article noted in reference 51.

<sup>43</sup> Zinchuk, B., 2015. Pipeline News. "Report critical of Boundary Dam suggests the answer is wind". April 1, 2015.

#### <sup>44</sup> http://large.stanford.edu/courses/2010/ph240/vasudev1/

<sup>45</sup>See for example: Lefebvre, R., Elena Simonova, and Liang Wang. July 2012. Issue in Focus. Certified General Accountants (Canada). "Labour Shortages in Skilled Trades – The Best Guestimate?" http://ppm.cga-canada.org/en-ca/Documents/ca\_rep\_2012-07\_labour-shortage.pdf

<sup>46</sup> https://en.wikipedia.org/wiki/R.\_W.\_Beck,\_Inc. Due to various acquisitions since 2009, R.W. Beck is now part of Leidos Engineering LLC, www.leidos.com/engineering

<sup>47</sup> http://www.babcock.com/products/Pages/Subcritical-Radiant-Boilers.aspx

<sup>48</sup> http://www.snclavalin.com/en/

<sup>49</sup> http://www.mhps.com/en/products/generator/

<sup>50</sup> http://www.stantec.com/

<sup>51</sup> http://www.cenovus.com/operations/oil/docs/rafferty-landowner.pdf

<sup>52</sup> Johnstone, B., 2014. Regina Leader-Post. "CCS best bet to stop climate change." October 4, 2014.

<sup>53</sup>Wu, Ying and John J. Carroll (editors), Acid Gas Injection and Related Technologies, Advances in Natural Gas Engineering, 2011. John Wiley & Sons. P. 170.

#### <sup>54</sup> http://www.tcmda.com/en/

<sup>55</sup> http://www.oilsandsken.com/huge-challenge-facing-oil-and-gas-companies/

<sup>56</sup> http://www.ferc.gov/industries/gas/indus-act/lng.asp

<sup>57</sup> http://www.nrcan.gc.ca/energy/coal/carbon-capture-storage/4333

<sup>58</sup> http://SaskPowerccs.com/2015-symposium/symposium/

<sup>59</sup> http://www.co2-research.ca/index.php/about-us/

60 https://ukccsrc.ac.uk/

<sup>61</sup> Hitchon, Brian (Editor), 2012. Best Practices for Validating CO<sub>2</sub> Geological Storage: Observations and Guidance from the IEAGHG Weyburn Midale CO<sub>2</sub> Monitoring and Storage Project.

<sup>62</sup> Private communication with the PTRC.