Supplemental Information to the
Testimony to Canadian Senate
Standing Committee on Energy, Environment
And Natural Resources
March 15, 2017

During his testimony to the above Committee on January 31, 2017, Jeff Erikson, Americas General Manager for the Global CCS Institute, offered additional information in response to three questions from Committee Members, as reflected below.

1. **Senator Massicotte:** Let's say $125 a tonne. How big is that network? In other words, let's say you had a coal plant. Coal is obviously one of the cheapest sources of energy today. What impact would it have on our coal price if you assumed $125 or $150?

   Mr. Erikson: I don't have those numbers. I'm happy to get back to you to provide those numbers.

   Supplemental Information: It is difficult to apply a single number in response to this question. One study estimates that for a new coal-fired power plant (i.e. for supercritical pulverized coal), addition of post-combustion CCS system could increase the cost of electricity by 48% (lower end) per Mwh. However, other studies show that CCS adds 50-100% to the levelized cost (lifecycle cost) of electricity (LCOE) for a single generator, but the LCOE increase might have no impact on consumers (in other words, consumers might not experience an increase in their electricity bill), because wholesale prices tend to be set by generators with much higher marginal costs (e.g. open cycle gas turbines).

   Source: Edward Rubin, John Davison, Howard Herzog. "The cost of carbon capture and storage," International Journal of Greenhouse Gas Control (2015), http://www.cmu.edu/epp/iecm/rubin/PDF%20files/2015/Rubin_et_al_ThecostofCCS_IJGGC_2015.pdf

2. **Senator Massicotte:** Just explain how you get there, because you seem to be pricing the costs of not getting there. Obviously, when you say it's going to be higher, that means you have made a calculation. How much would it cost civilization to meet or not meet our target? Can you describe a bit more how you get that number and what it means?

   Mr. Erikson: I'll first say it's not our number. It's calculated by the International Energy Agency, the IEA. They run numerous economic models with different variables. They ran 11 models to optimize the low-carbon mix to get to a 2 degree scenario, and what they have determined is auto is 11, and I believe it was at eight that you could not get to 2 degrees without CCS. The other three implied a 138 per cent increase in the cost.

   How they do the modelling is beyond my expertise, but I do know that the model is intended to optimize what I'll call the CO2 intensity. As you take options off the table, then the price of the other options increases just based on supply and demand, and I'd be happy to provide you with additional information for the record.

   Supplemental Information: The Intergovernmental Panel on Climate Change, or IPCC ran multiple models that analyzed various technology portfolios that can help mitigate climate change by 2100. IPCC concluded that to prevent the global temperatures from rising beyond 2 degrees,

GLOBALCCSINSTITUTE.COM
5335 WISCONSIN AVE, NW,
SUITE 305
WASHINGTON, DC 20015
T +1 202 895 2788
E THEAMERICASOFFICE@GLOBALCCSINSTITUTE.COM

ABN 92 136 814 465

global greenhouse gas concentrations in the atmosphere should be stabilized at 450 parts per million (ppm) by 2100.

- Scenarios in which all countries of the world begin mitigation immediately, there is a single global carbon price, and all key technologies are available, have been used as a cost-effective benchmark for estimating macroeconomic mitigation costs. Under the absence or limited availability of technologies, mitigation costs can increase substantially depending on the technology considered.
- Estimates of the aggregate economic costs of mitigation vary widely and are highly sensitive to model design and assumptions as well as the specification of scenarios. In a scenario with no CCS, less than 50% of models (4 out of 11) were able to produce results reaching 450 ppm concentrations. Of the four models that did achieve 450 ppm, the average cost of meeting the 2DS increased by 138% compared to the benchmark level.
- The lack of availability of CCS is associated with the most significant cost increase. One fundamental reason for this is that the combination of biomass with CCS can serve as a CDR technology in the form of BECCS. In addition to the ability to produce negative emissions when coupled with bioenergy, CCS is a versatile technology that can be combined with electricity, synthetic fuel, and hydrogen production from several feedstocks and in energy-intensive industries such as cement and steel. 85% of IPCC scenarios (101 of 116) consistent with 2°C requirements require global net negative emissions before 2100, typically through BECCS and afforestation.
- Note that this information also corrects two mis-statements in Mr. Erikson's original testimony. Mr. Erikson indicated that the modelling was conducted by the IEA, when in fact it was the IPCC. And Mr. Erikson stated that three of eleven models were successful in achieving a 450 ppm outcome, when it was actually four models. Neither of these mis-statements change the essence of his response.

  For more information, see the full IPCC report: http://www.ipcc.ch/report/ar5/wg3/

3. **Senator Seidman:** You have a policy brief on your website that's titled Challenges related to carbon transportation and storage — showstoppers for CCS? The brief concludes that there are common market failures and barriers in the U.S. and European experiences. I'm sure it's very complicated, but could I just ask you if you would be able to give us some insight of what those common market failures and barriers are?

   Mr. Erikson: Sure. First, I would say that that particular report you were referring to is not actually written by the institute, but by an academic partner of ours. We felt it was important for us to publish the results.

   The market failures that the authors were referring to were primarily with respect to appropriately pricing the cost of what I'll call the externalities. Externalities occur where we're not appropriately pricing the impact that various industrial processes in power generation have on the environment, which ultimately results in larger mitigation and adaptation costs down the road. That key market failure is similar to what Al Gore has

GLOBALCCSINSTITUTE.COM
5335 WISCONSIN AVE, NW,
SUITE 305
WASHINGTON, DC 20015
T +1 202 895 2788
E THEAMERICASOFFICE@GLOBALCCSINSTITUTE.COM

ABN 92 136 814 465

been talking about for the last 15 years. It's not appropriately pricing the externalities that are shared commonly across all stakeholders.

That one didn't do it for you, did it. I see the look on your face.

Senator Seidman: No. What might some of those externalities be?

Mr. Erikson: As I mentioned earlier, there is a difference in the way electricity markets value dispatchable power as opposed to intermittent power. Let me rephrase that. There is no difference and there ought to be, because dispatchable power, which is power that you can dial up on demand, has additional value for the grid itself. That's one example of the externalities that aren't appropriately priced.

Again, I think it's best if I have a reference to the report itself and get back to you at a later date.

Supplemental Information: The referenced policy brief identifies several barriers (both market failures and regulatory gaps) that impede CO2 transportation and storage infrastructure development. The most significant that exist in the United States (some of which are presumably shared by Canada) are noted below.

- **Comprehensive policy.** There is no comprehensive policy in place at the federal level to address infrastructure, and legal and regulatory risks. In effect, there is a market failure around who will pay for – and who will build – the infrastructure, and the legal and regulatory framework to support the required infrastructure development is not in place. There is no overarching federal regulatory framework governing CO2 pipelines regarding rates, access, or siting authority, and these gaps will affect project development and economics. For example, rates may be set differently for existing pipelines carrying CO2 as a commodity for use in EOR as opposed to new pipelines dedicated for CO2 disposal. As the pipeline network expands to accommodate more movement of CO2 across states, it will be important to ensure that rules governing non-discriminatory access and eminent domain are in place.
- **Long-term Responsibility.** Long-term geologic storage is the crux of the CCS challenge. There are no entities who will take CO2 and store it. Oil companies will use CO2 for EOR but are not interested in long-term storage and assuming the responsibilities and steps that go along with that, including monitoring and verification…In the words of one expert: “Until there is an entity that will take CO2 for long-term storage, or unless the federal government steps in and handles all costs of storage and takes on all liabilities, CCS will not move forward.”
- **Front-loaded Costs.** The large up-front cost for site appraisal and characterization – with no guarantee of success –constitutes a barrier to entry for storage. A utility considering a capture project will want to know there is sufficient storage capacity for a number of years, but will not want to pay the cost of appraising a storage site prior to a final investment decision.
- **Operating and counterparty risk.** Private companies also want some mechanism or policy approach that addresses or shares the risks involved if they invest in a capture project and there is no way to dispose of the CO2, e.g., a storage site does not get built, the storage site

GLOBALCCSINSTITUTE.COM
5335 WISCONSIN AVE, NW,
SUITE 305
WASHINGTON, DC 20015
T +1 202 895 2788
E THEAMERICASOFFICE@GLOBALCCSINSTITUTE.COM

ABN 92 136 814 465

gets shut in, or there is some other commercial or infrastructure related issue that interrupts or precludes the company from providing the CO2 to an off-taker. In addition, there is the risk that over the life of a storage project, the CO2 source becomes uneconomic.

- **Long-term Liability.** Gaps in federal legislation for CO2 storage, especially with regard to access to pore space and long-term liabilities, need to be addressed to support the commercialization of CCS. For the former, "the injecting party must either own the pore space, have permission from the owner, or have statutory or common law right to use the pore space." There are several categories of long-term liabilities to be addressed: tort (defining responsibility and obligations to pay damages if injected CO2 causes injuries); climate (requirements to pay compensation if CO2 leaks into atmosphere); and regulatory (requirements involved in maintaining a CO2 storage site).
- **CO2 Accounting.** While EPA has developed mandatory reporting rules for facilities injecting CO2 for EOR or long-term sequestration, the rules do not create an accounting system to verify storage, monitor leakage throughout the infrastructure, or establish specific protocols to match the performance of steps in the CCS chain with the specific low carbon policy approach in place.

GLOBALCCSINSTITUTE.COM
5335 WISCONSIN AVE, NW,
SUITE 305
WASHINGTON, DC 20015
T +1 202 895 2788
E THEAMERICASOFFICE@GLOBALCCSINSTITUTE.COM

ABN 92 136 814 465