SUMMARY of LCA COMPARISON of CSP with RCP – 3rd PARTY REVIEW

Groupe AGĒCO completed the Life Cycle Assessment (LCA) study on behalf of the commissioning organization, the Corrugated Steel Pipe Institute (CSPI).

The independent third-party verification was conducted by an external panel of experts per ISO 14044 Section 6.2: Critical review by internal or external expert:

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BACKGROUND

- In 2018, CSPI produced an EPD (Environmental Product Declaration), which is a snapshot in time of CSP's carbon footprint. This EPD is good for 5 years. It was based upon data from 2016.

- It was based upon 1 metric ton of steel and produced results in GHG emissions, Ozone depletion, Smog, Acid Rain, Eutrophication (induces excessive green algae) & depletion of fossil fuels.

- Purpose of this project - Compare "Cradle to Grave" environmental impact of CSP to RCP, using an 1800mm diameter pipe, 125m x 25m profile, 75-year service life sensitized for regional water and soil disparities. This can be extrapolated to produce any other diameter.

- "Cradle to Grave" includes 1) raw material supply, 2) transport to the manufacturer, 3) manufacturing, 4) construction, 5) use, 6) end-of-life and 7) benefits and loads from recycling.

LIFE CYCLE STAGES

Production stage			Construction stage		Use stage							End-of-life stage				Benefits and loads from recycling
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
Raw material supply	Transport	Manufacturing	Transport	Construction - Installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy	Operational water use	Deconstruction,	Transport	Waste processing	Disposal	Potential net benefits from recycling beyond the system boundary
Included			Included		Inclu-ded	Excluded						Included				Included

IMPACT ASSESSMENT METHOD AND INDICATORS

Global warming: The **global warming potential** refers to the impact of a temperature increase on the global climate patterns due to the release of greenhouse gases (GHG) (e.g. carbon dioxide and methane from fossil fuel combustion). (kg CO2 equivalent)

Ozone depletion: The **ozone depletion potential** indicator measures the potential of stratospheric ozone level reduction due to the release of some molecules such as refrigerants used in cooling systems (e.g. chlorofluorocarbons). (kg CFC-11 equivalent)

Acidification: The **acidification potential** refers to the change in acidity (i.e. reduction in pH) in soil and water due to human activity. (kg N equivalent).

Eutrophication: The **eutrophication potential** measures the enrichment of an aquatic or terrestrial ecosystem due to the release of nutrients (e.g. nitrates, phosphates) resulting from natural or human activity (e.g. the discharge of wastewater into watercourses). (kg N equivalent)

Smog: The **formation of tropospheric ozone** indicator covers the emissions of pollutants such as nitrogen oxides and volatile organic compounds (VOCs) into the atmosphere. (kg O3 equivalent).

Fossil fuel: The depletion of **fossil fuels** refers to the use of energy from non-renewable resources (e.g., natural gas, coal, petroleum). (MJ surplus)

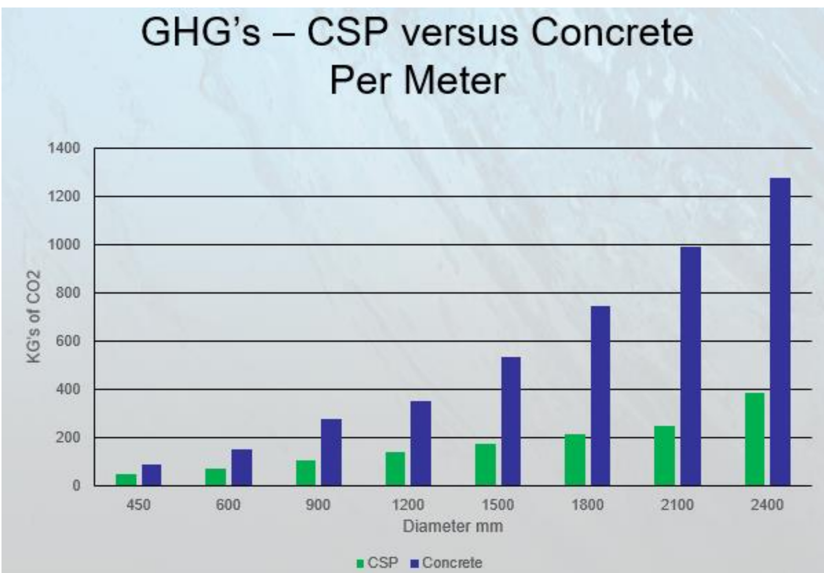
RESULTS

Table 6-1: Results per UF (one metric tonne) of corruragted steel pipe

Indicators[1]	Units	Production (A1-A3)	Construction (A4-A5)	End-of-life (C1-C4)	Net benefits or loads from recycling (D)	Total
Global warming	kg CO_2 eq.	2.4E+03	3.1E+02	1.6E+01	-7.6E+02	2.0E+03
Ozone depletion	kg CFC-11 eq.	1.7E-05	7.4E-05	3.9E-06	5.3E-06	1.0E-04
Smog	kg O_3 eq.	1.9E+02	7.6E+01	4.1E+00	-2.1E+01	2.5E+02
Acidification	kg SO_2 eq.	1.1E+01	2.6E+00	1.4E-01	-1.5E+00	1.2E+01
Eutrophication	kg N eq.	6.6E-01	4.6E-01	2.1E-02	-6.1E-02	1.1E+00
Fossil fuel depletion	MJ surplus	1.7E+03	6.7E+02	3.5E+01	-3.5E+02	2.1E+03

Indicator	**CSP**	**Concrete**	**Difference**	**Advantage**
Global Warming	2,001 kg	8,755 kg	-77%	4.3 times
Ozone Depletion	.0001 kg	.0007 kg	-85%	7.0 times
Smog	253 kg	800 kg	-68%	3.1 times
Acidification	12 kg	48 kg	-74%	4.0 times
Eutrophication	1.1 kg	15 kg	-93%	13.6 times
Fossil fuels	2,096 MJ	8,237 MJ	-75%	3.9 times

Extrapolating this out to a number of diameters, we get the following results on Global Warming;



SENSITIVITY ANALYSIS

As a result of variations in the literature on durability and service life, scenarios were run to determine the impact on the results.

1st. CSP needs to be replaced after 75 years and RCP is given the high-end service life of 120 years. Results were as follows;

Table 6-10: Life cycle results of the sensitivity analysis on the reference service life (RSL)

Indicator	Unit	RCP	CSP	Difference with new RSL[1] (%)	Difference with current RSL[1] (%)
		Per FU			
Global warming	kg CO_2 eq.	8.8E+03	3.2E+03	-63%	-77%
Ozone depletion	kg CFC-11 eq.	6.9E-04	1.6E-04	-76%	-85%
Smog	kg O_3 eq.	8.0E+02	4.0E+02	-49%	-68%
Acidification	kg SO_2 eq.	4.8E+01	2.0E+01	-59%	-74%
Eutrophication	kg N eq.	1.5E+01	1.7E+00	-88%	-93%
Fossil fuel depletion	MJ surplus	8.2E+03	3.4E+03	-59%	-75%

[1] *A negative result means that CSPI's pipe has a lower result.*

2nd. Wall thickness of CSP changed when a deeper installation is required;

Table 6-11: Life cycle results of the sensitivity analysis on the wall thickness of the CSP

Indicator	Unit	RCP	CSP	Difference with new FU (%)	Difference with current FU (%)
		Per new FU			
Global warming	kg CO_2 eq.	8.8E+03	3.5E+03	-60%	-77%
Ozone depletion	kg CFC-11 eq.	6.9E-04	1.8E-04	-74%	-85%
Smog	kg O_3 eq.	8.0E+02	4.4E+02	-45%	-68%
Acidification	kg SO_2 eq.	4.8E+01	2.2E+01	-55%	-74%
Eutrophication	kg N eq.	1.5E+01	1.9E+00	-87%	-93%
Fossil fuel depletion	MJ surplus	8.2E+03	3.7E+03	-56%	-75%

CONCLUSION

Overall, when compared to reinforced concrete pipe manufactured in North America, CSP 1800 mm diameter corrugated steel pipe has lower potential impacts on all studied indicators.

The main advantage of CSP over the RCP is the lower mass of the product.

The stages contributing the most to the potential impacts of CSP are HDG coil production and construction. The net recycling benefits, which acknowledge the value of steel scrap, enable the corrugated steel pipes to significantly reduce its impacts.

RECOMMENDATIONS

- **Promote the use of coatings improving durability.** Results highly depend on the difference of durability between the two products. As long as CSPI can maintain the durability of its pipe, CSP 1800 mm diameter steel pipes will remain competitive.
- **Increase CSPI's members participation in data collection.** Practices vary from one plant to another depending on the suppliers, loss and energy use. By improving the sample representativeness, CSPI can have a better understanding of its members' plants performance and work to improve it.
- **Work with HDG suppliers to improve HDG environmental performance.** Since HDG coil production is responsible for most of the CSP potential impacts, this will help CSPI keep their competitive position on the long term.