SLURRY HYDROCRACKER PROJECT

Appendix F - Environmental Assessment

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F.1 SUMMARY

This appendix shows the environmental analysis of the emissions during the conversion of the slurry bitumen and sample calculation.

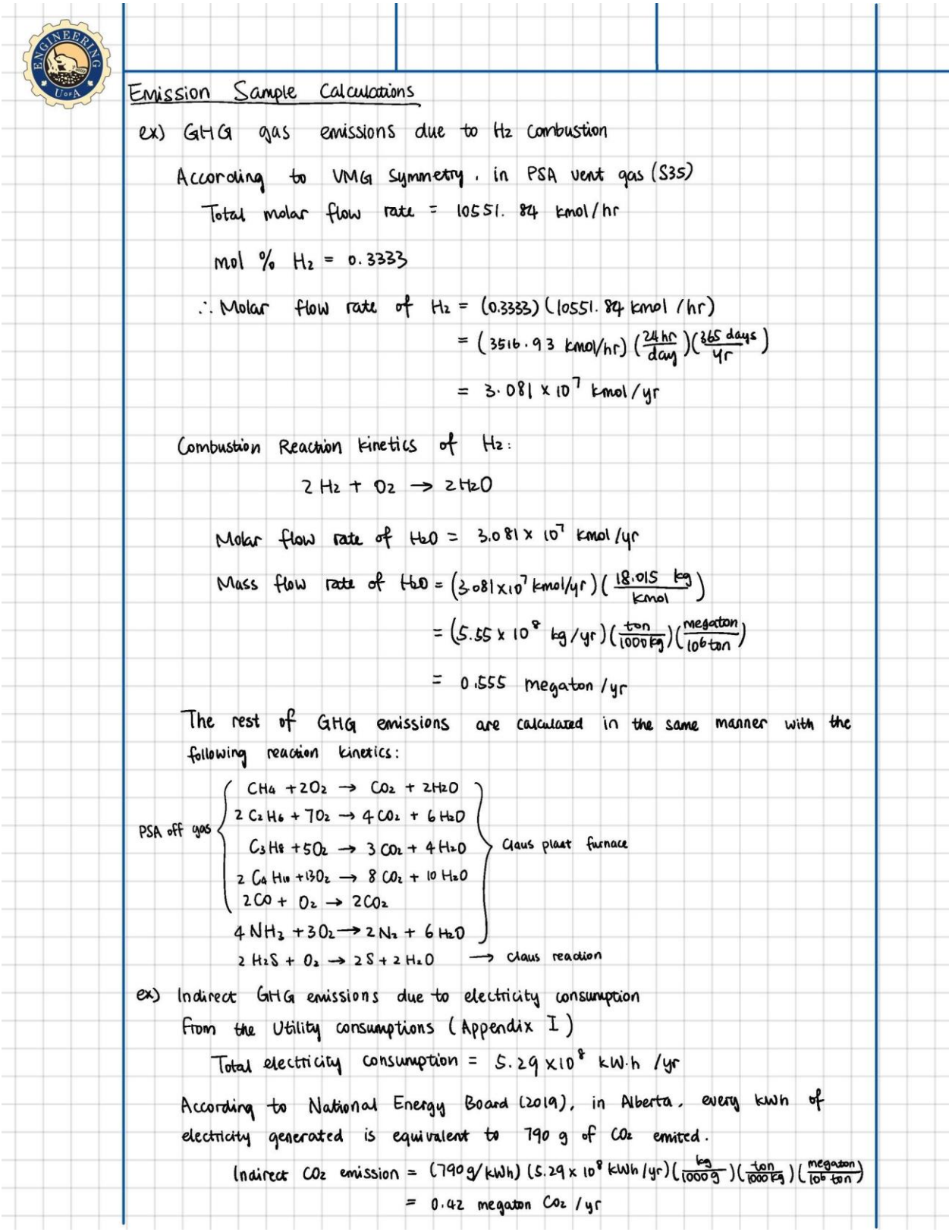
F.2 ENVIRONMENTAL ANALYSIS

Due to the combustion of the PSA off-gas, the Claus plant operation, and natural gas burning, this project emits a total amount of 4.77 megatons of greenhouse gases (GHG) annually. Indirect GHG associated with electricity consumption due to electric motors of the pumps, compressors, and expander is 0.52 megatons per year. In summation, this project results in 5.29 megatons of annual carbon footprint. The detailed break-down is illustrated in Table F1.

Table F 1: Annual Emission from different sources.

Annual Emissions				
Direct	PSA Vent Gas Combustion	CO_2	2.43	megatons
		H_2O	0.75	megatons
	Claus Plant	CO_2	0.0015	megatons
		H_2O	0.12	megatons
	Natural Gas Fuel	CO_2	0.81	megatons
		H_2O	0.66	megatons
		NO_2	<7.8E-04	ppb in ambient air
		SO_2	<8.5E-06	ppb in ambient air
		Particulates	<1.2E-13	µg/m3 ambient air
Indirect	Electricity Consumption	CO_2	0.52	megatons

F.2.1 Emission Sample Calculations



Emission Sample Calculations

ex) GHG gas emissions due to H_2 combustion

According to UMG symmetry, in PSA vent gas (S35)

Total molar flow rate = 10551.84 kmol/hr

mol % H_2 = 0.3333

∴ Molar flow rate of H_2 = (0.3333)(10551.84 kmol/hr)

$= (3516.93 \text{ kmol/hr})\left(\frac{24 \text{ hr}}{\text{day}}\right)\left(\frac{365 \text{ days}}{\text{yr}}\right)$

$= 3.081 \times 10^7 \text{ kmol/yr}$

Combustion Reaction kinetics of H_2:

$$2H_2 + O_2 \rightarrow 2H_2O$$

Molar flow rate of H_2O = 3.081×10^7 kmol/yr

Mass flow rate of H_2O = $\left(3.081 \times 10^7 \text{ kmol/yr}\right)\left(\frac{18.015 \text{ kg}}{\text{kmol}}\right)$

$= \left(5.55 \times 10^8 \text{ kg/yr}\right)\left(\frac{\text{ton}}{1000 \text{ kg}}\right)\left(\frac{\text{megaton}}{10^6 \text{ ton}}\right)$

$= 0.555$ megaton/yr

The rest of GHG emissions are calculated in the same manner with the following reaction kinetics:

PSA off gas → Claus plant furnace:

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$
$$2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$$
$$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$$
$$2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$$
$$2CO + O_2 \rightarrow 2CO_2$$
$$4NH_3 + 3O_2 \rightarrow 2N_2 + 6H_2O$$

Claus plant furnace →

$$2H_2S + O_2 \rightarrow 2S + 2H_2O$$

→ Claus reaction

ex) Indirect GHG emissions due to electricity consumption

From the Utility consumptions (Appendix I)

Total electricity consumption = 5.29×10^8 kW·h/yr

According to National Energy Board (2019), in Alberta, every kWh of electricity generated is equivalent to 790 g of CO_2 emited.

Indirect CO_2 emission = $(790 \text{ g/kWh})(5.29 \times 10^8 \text{ kWh/yr})\left(\frac{\text{kg}}{1000 \text{ g}}\right)\left(\frac{\text{ton}}{1000 \text{ kg}}\right)\left(\frac{\text{megaton}}{10^6 \text{ ton}}\right)$

$= 0.42$ megaton CO_2/yr

F.3 REFERENCES

[1] National Energy Board. (2019, August 28). Canada's Renewable Power Landscape 2017 – Energy Market Analysis. Retrieved from https://www.cer-rec.gc.ca/nrg/sttstc/lctrct/rprt/2017cndrnwblpwr/ghgmssn-eng.htmlt

[2] "Canadian Ambient Air Quality Standards." *NaturalGasorg*, naturalgas.org/environment/naturalgas/.