Carbon Footprint of Geomembrane HDPE vs Traditional Waterproofing Barrier

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ABSTRACT
Lowering the Carbon Footprint is one of the strongest advantages by using HDPE geomembrane instead of traditional way for waterproofing as compacted clays.
A HDPE liner 1.5 mm could give similar watertight as 0,60 m compacted of high quality and homogeneous clay with lower permeability than 1 x 10-11 m/sec (ASTM D 5887). Based on several scientist survey, considering all resources and energy to become either products as a waterproofing barrier, the geosynthetics (geomembrane HDPE 1.5 mm) takes up lower carbon dioxide equivalent, therefore it is more environmentally friendly solution.

1. INTRODUCTION

Features of HDPE Geomembrane and its Carbon Footprint.
The main component of HDPE is the monomer ethylene, which is polymerized to form polyethylene. The main catalysts are aluminum trialkylitatanium tetrachloride and chromium oxide
The polymerization of ethylene and co-monomers into HDPE occurs in a reactor in the presence of hydrogen at a temperature of up to 110 º Celsius degrees (230 degrees Fahrenheit). The resulting HDPE powder is then fed into a pelletizer to make pellets.
Then, SOTRAFA, as a manufacturer with latest technology in calandred system (flat die), makes geomembrane ALVATECH HDPE from these pellets. The Geomembrane ALVATECH HDPE keeps its outstanding features constantly either dry season or wet season.

2. GHG IDENTIFICATION AND CO2 EQUIVALENTS

The GHGs (**G**reen**h**ouse **G**as protocol) included in the calculation were the three (3) primary GHGs, namely carbon dioxide, methane, and nitrous oxide. Each of these gases has a different Global Warming Potential (GWP), which is a measure of how much a given mass of a greenhouse gas contributes to global warming or climate change.

Carbon dioxide is by definition issued a GWP of 1.0. To quantitatively include the contributions of methane and nitrous oxide to the overall impact, the mass of the methane and nitrous oxide emissions are multiplied by their respective GWP factors and then added to the mass emissions of carbon dioxide to calculate a “carbon dioxide equivalent” mass emission. For purposes of this paper, the GWPs were taken from the values listed in the USEPA regulations “Mandatory Reporting of Greenhouse Gas Emissions” (USEPA, 2010). The GWPs for the GHGs considered in this analysis are:

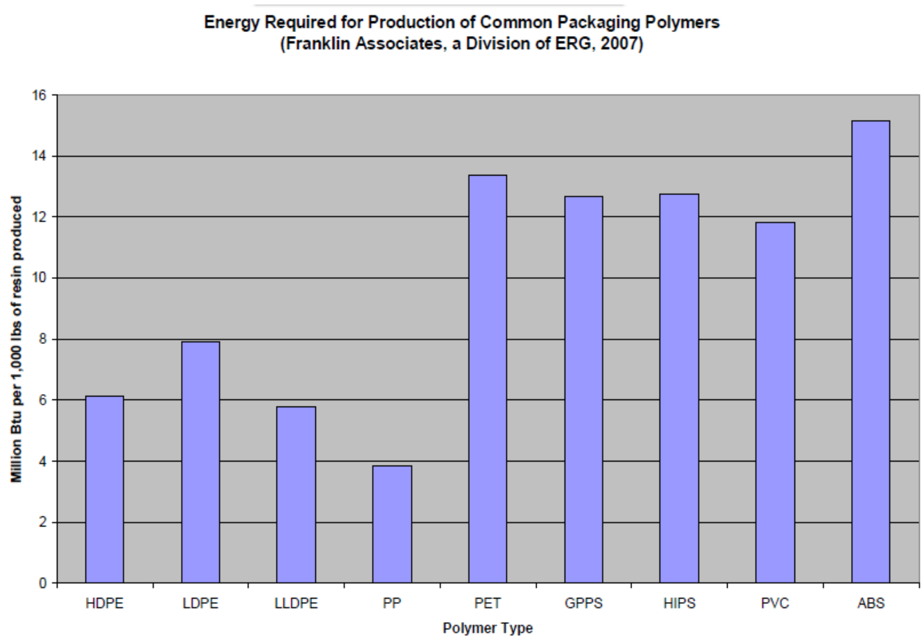
- ✓ Carbon Dioxide = 1.0 — GWP 1 kg CO_2 eq/Kg CO_2
- ✓ Methane = 21.0 — GWP 21 Kg CO_2 eq/Kg CH_4
- ✓ Nitrous Oxide = 310.0 — GWP 310 kg CO_2 eq/kg N_2O

Using the relative GWPs of the GHGs, the mass of carbon dioxide equivalents (CO_2eq) was calculated as follows:

“Eq.(1)”

$$\text{kg } CO_2 + (21.0 \times \text{kg } CH_4) + (310.0 \times \text{kg } N_2O) = \text{kg } CO_2 \text{ eq} \quad (1)$$

Figure 1.



6 million Btu = 156 liters fuel equivalent = 1,758 KW*hour
FIG. 1. Energy Required for Production of Common Packaging Polymers
(Franklin Associates, a Division of ERG, 2007)

Figure 2.

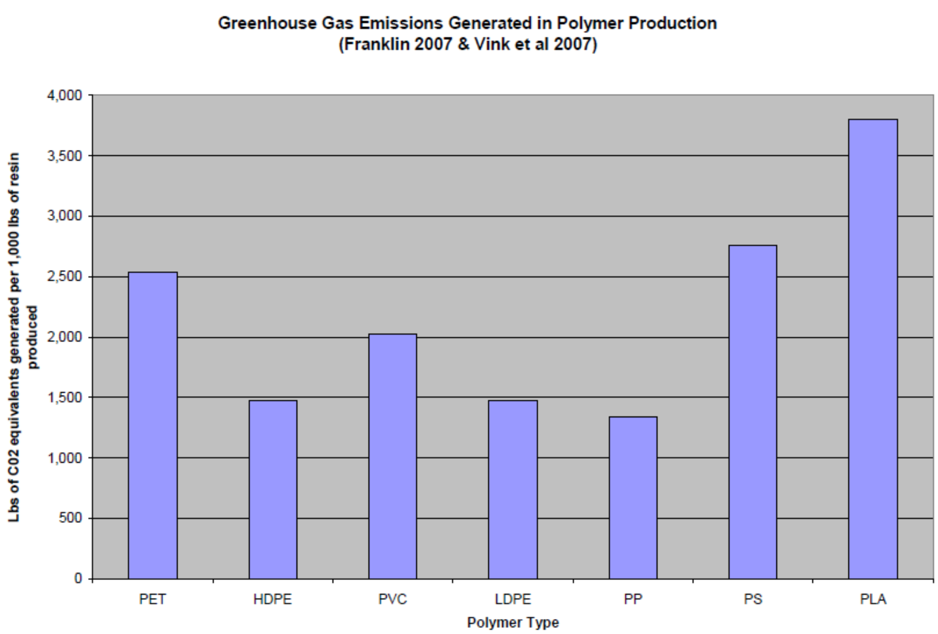


FIG. 2. Greenhouse Gas Emissions Generated in Polymer Production
(Franklin 2007 & Vink et al 2007)

Assumption

The energy, water, and waste information from the extraction of the raw materials (oil or natural gas) through production of HDPE pellets and then manufacturing geomembrane HDPE:

- ✓ 1,5 mm thick HDPE geomembrane, with density 940 Kg/m^3
- ✓ HDPE carbon footprint is 1.60 Kg CO_2/kg polyethylene (ICE, 2008).

(2) 940 Kg/m3 x 0,0015 m x 10,000 m2/hectare x 1.15 (scrap and overlaps) = 16,215 Kgr HDPE/hectare
(3) E = 16,215 Kg HDPE/Ha x 1.60 Kg CO2/kg HDPE => 25.944 Kg CO2 eq/hectare

Assumption Transport: 15.600 squm/truck, 1000 km from manufacturing plant to jobsite

- 10.15 kg CO_2/ gal diesel x gal/3,785 liters = 2.68 Kg CO_2 /liter diesel
- 0.26 g N_2O/gal diesel x gal/3,785 liters x 0,31 kg CO_2 eq/g N2O = 0,021 kg CO_2 eq/liter diesel
- 1.44 g CH_4/gal diesel x gal/3,785 liters x 0,021 kg CO_2 eq/g CH4 = 0,008 kg CO_2 eq/liter diesel

On-Road truck product transport emissions:

(4) E = TMT x (EF CO2 + 0.021·EF CH4 + 0.310·EF N2O)
(5) E = TMT x (0.972 + (0.021 x 0.0035) + (0.310 x 0.0027)) = TM x 0.298 Kg CO2 eq/ton-mile

Where:
E = Total CO_2 equivalent emissions (kg)
TMT = Ton Miles Traveled
EF CO_2 = CO_2 emission factor (0.297 kg CO_2/ton-mile)
EF CH_4 = CH_4 emission factor (0.0035 gr CH_4/ton-mile)
EF N_2O = N_2O emission factor (0.0027 g N_2O/ton-mile)

Converting to Metric Units:

(6) 0.298 kg CO2/ton-mile x 1.102 tons/tonne x mile/1.61 km = 0,204 kg CO2/tonne-km
(7) E = TKT x 0,204 kg CO2 eq/tonne-km

Where:
E = Total CO_2 equivalent emissions (kg)
TKT = tonne – kilometers Traveled

Distance from Manufacturing Plant (Sotrafa) to Job Site (Hypothetical) = 1000 km

- Typical Loaded truck weight: 15,455 kg/truck + 15.6000 sqm x 1.5 x 0.94/truck = 37,451 kg/truck
- 0.641 truck/hectare

(8) E = (1000 km x 37,451 kg/truck x tonne/1000 kg x 0.641 truck/hectare) x 0.204 kg CO2 eq/tonne-km
(9) E = 4,897.24 Kg CO2 eq/hectare

Table 1. Summary of Geomembrane HDPE 1.5mm Carbon Footprint

Process Step	Kg CO_2 eq/Ha	Assumptions
Manufacturing Geomembrane HDPE 1,5mm	25,944	From ICE 1.6a (polyethylene) = 1.6 tonnes CO_2/tonne PE
Transport to Job site	4,897	1,000km form Manufacturing Plant to Job site
TOTAL	**30,841**	**Kg CO_2 eq/10.000 sqm**

3. FEATURES OF COMPACTED CLAY LINERS AND ITS CARBON FOOTPRINT

Compacted clay liners have been historically used as barrier layers in water lagoons and waste containment facilities. Common regulatory requirements for compacted clay liners are a minimum thickness of 0.6 meters, with a maximum hydraulic conductivity of 1 x 10^{-11} m/sec.

The process

Clay at the borrow source is excavated using standard construction equipment, which also loads the material onto tri-axle dump trucks for transport to the job site. Each truck is assumed to have a capacity of 15 m^3 of loose soil. Using a compaction factor of 1.38, it is estimated that over 550 truckloads of soil would be needed to construct a 0.6-meter thick compacted clay liner over a one-hectare area.

The distance from the borrow source to the job site is, of course, site-specific and can vary greatly. For the purposes of this analysis, a distance of 16 km (10 miles) was assumed. Since transport from the clay borrow source and the job site is such a large component of the overall carbon emissions, the sensitivity of the overall carbon footprint to changes in this site-specific variable is investigated later in this study.

Table 2. Summary of Compacted Clay Liner Carbon Footprint

Process Step	Kg CO_2 eq/Ha	Assumptions
Excavate Soil at Borrow Source	2,656	CAT 329 Excavator, Operation 40 hours/ha. Assume 24,5 liters/hr fuel consumption, based on medium work application and medium engine load factor (CAT performance handbook)
Haul Clay to Job Site	93,527	Assume site is 16km from borrow source, and 552 truckloads (each carrying 15m^3 of clay) are needed to cover 1 hectare.
Construct Clay liner CAT D6 Bulldozer	2,789	Operation 40 hours/ha. Assume 25,7 liters/hr diesel fuel consumption
Construct Clay liner CAT 815 Sheepsfoot compactor	4,553	Operation 40 hours/ha. Assume 42 liters/hr diesel fuel consumption
Construct Clay liner CAT 815 Smooth drum compactor	4,553	Operation 40 hours/ha. Assume 42 liters/hr diesel fuel consumption
38.000 liters water truck	1,518	Operation 40 hours/ha. Assume 14 liters/hr diesel fuel consumption
TOTAL	**109,593**	**Kg CO_2 eq/10.000 sqm lined area with compacted clay**

4. CONCLUSIONS

Considering all above mentioned, once again it is being showed the huge advantage to use geosynthetics instead traditional materials. When it comes down to waterproofing the Geomembrane ALVATECH HDPE 1,5 mm is by far the best choice because not only ensure the outstanding features in the long term (high chemical resistance and strong mechanical properties) but also is much more environmentally friendly solution.

It has 3 times less carbon footprint, not even have good quality clay at 16 km from borrow source to job site, comparing with geomembrane HDPE supplied by truck at 1.000 km from manufacturing plant.

In the end that is why, the geomembrane ALVATECH HDPE is being installed in wide range application for covering and ground protection in high demanding industries as mining, oil, landfills, waste water treatment and irrigation lagoons.