ERM

180 Admiral Cochrane Drive
Suite 400
Annapolis, MD
21401

Telephone: +1 410 266 0006
Fax: +1 443 458 6609

www.erm.com

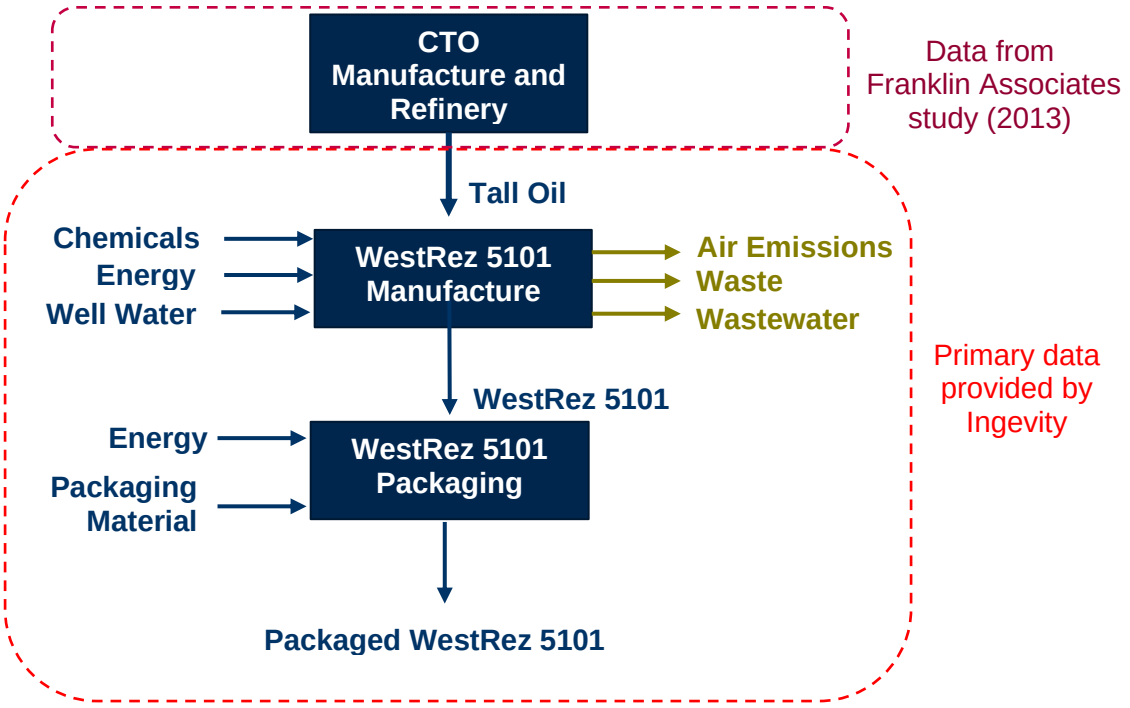
Project Summary – Carbon Footprint for Ingevity of WestRez® 5101 and its Substitute

ERM

Methodology

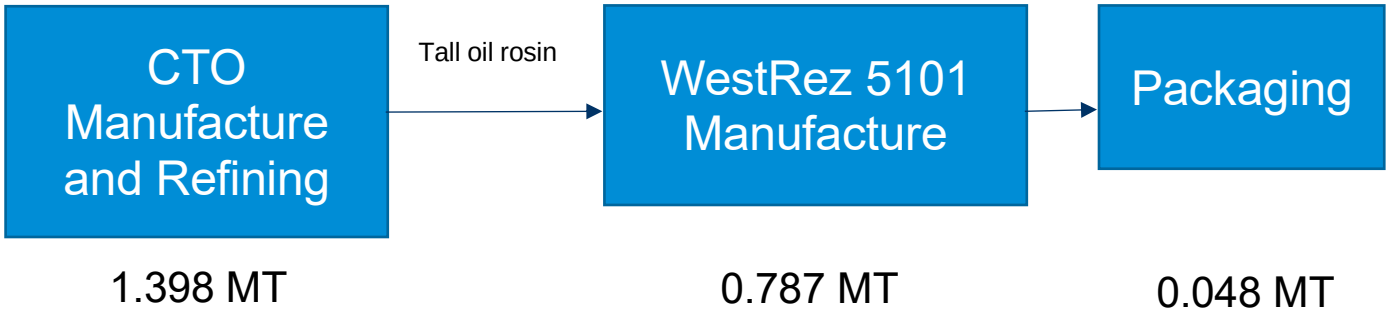
ERM conducted a carbon footprint study of the product WestRez® 5101, manufactured by Ingevity. WestRez 5101 is a tackifier resin chemical product made from the primary raw material tall oil rosin (TOR), which is derived from wet crude tall oil (CTO), a by-product of the kraft pulping process. The objective of this study was to determine the cradle-to-gate carbon footprint associated with the WestRez® 5101 product manufactured by Ingevity.

In a model developed in the SimaPro software, we considered the life cycle carbon footprint of raw material and energy inputs to the manufacture of WestRez 5101. The carbon footprint of TOR is based on the Franklin Associates study for the American Chemistry Council Pine Chemistry Panel, an industry-wide study published in 2013 to which Ingevity contributed data. ERM used production data from Ingevity, and inventory data from the ecoinvent 3.6 database, as inputs to the SimaPro model to calculate life cycle greenhouse gas (GHG) impacts in units of metric tons of carbon dioxide equivalent (CO_2e) per 1 metric ton (MT) of WestRez 5101 or its substitute. The study also compared the carbon footprint of WestRez 5101 to a typical hydrocarbon-based substitute, assumed to be functionally equivalent as a 1:1 substitution. The system boundary is shown below.



WestRez 5101 Carbon Footprint

The results of the WestRez 5101 study are summarized in graphic form below, illustrating the contribution of each major stage to the total carbon footprint of the packaged product.



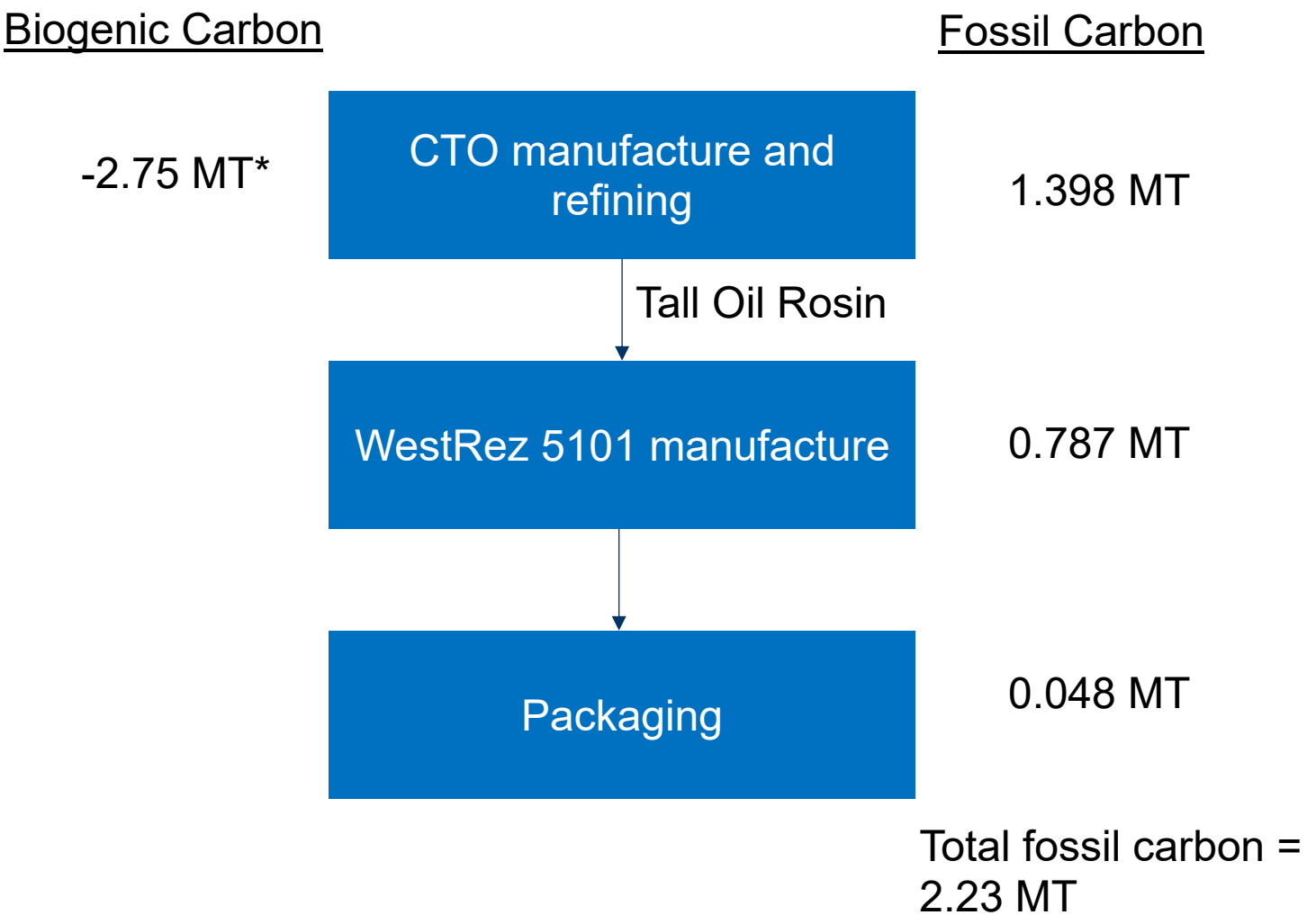
This figure represents the carbon footprint for 1 MT of WestRez 5101, calculated using the "IPCC 2013 GWP 100a" impact method. The most significant contributors to the footprint include the TOR obtained from paper and pulping, and the other chemicals involved in Ingevity's manufacturing process. These base case results consider fossil carbon only and do not incorporate storage of biogenic carbon in the raw material derived from a by-product of paper mills. This approach is consistent with the assumptions of the LCA study conducted by Franklin Associates for the ACC Pine Chemistry Panel. ERM used the Franklin Associates study as the source of carbon footprint data on the TOR raw material input.

In comparison to the hydrocarbon-based alternative, WestRez has an estimated 12% lower carbon footprint per 1 MT of product:

Base Case	**WestRez® 5101**	**Hydrocarbon-based Substitute**
GHG Impact (MT CO_2e per MT product)	2.23	2.54

Biogenic Carbon Considerations

Because CTO is derived from bio-based materials, the biogenic carbon contained within the CTO represents carbon that has been taken up from the atmosphere and stored during the lifetime of the WestRez product.

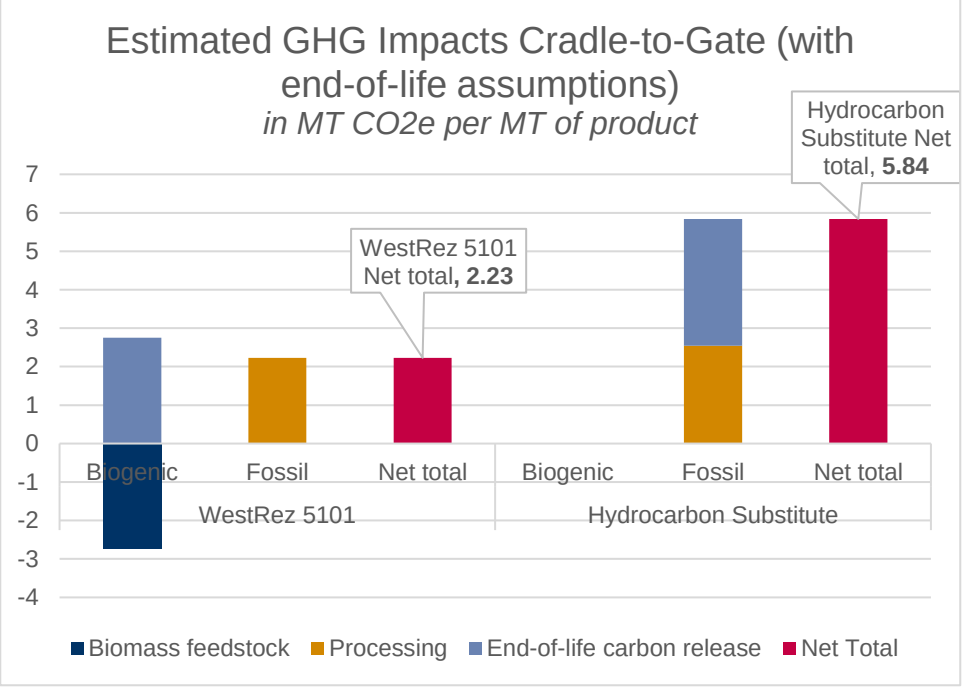


*2.75 MT represents the estimated carbon storage associated with the TOR input to the WestRez manufacturing process. ERM calculated this based on a sensitivity analysis in the Franklin Associates study that estimated carbon storage credits in the CTO distillation process. There will also be biogenic carbon associated with paper used in product packaging.

End-of-Life Benefits

As a cradle-to-gate carbon footprint, ERM's study did not address the final disposition of the WestRez product in detail; however, the potential comparative benefits have been estimated and are discussed below. WestRez is derived from a biogenic carbon source, so if the carbon stored in the product is oxidized at the end of its life this will be released back into the atmosphere as CO_2 – balancing the uptake of CO_2 that occurred at the start of the product's life cycle during tree growth. As such, this oxidation will result in no net change in CO_2 concentrations in the atmosphere and therefore would not represent an increase in global warming impact.

After its use – typically in cardboard adhesive applications – the product containing WestRez or its substitute would be expected to be disposed of by incineration or landfilling, or to be recycled. Regardless of disposal or recycling method, the biogenic carbon in WestRez would not add to global warming impact.[1] By contrast, if the hydrocarbon-based substitute is incinerated at the end of product life and its carbon content is 100% oxidized, without any capture or storage of emissions, this would add an estimated 3.3 metric tons CO_2e per metric ton of the substitute product, for a total carbon footprint of 5.84 metric tons CO_2e per metric ton of product.



[1] ERM's estimates of end-of-life impacts assume that WestRez would be inert in landfill conditions and would not break down to create methane emissions that would add to global warming impact. This assumption is based on information provided by Ingevity and is consistent with information cited in the Franklin Associates study.

Conclusions

- The base case study is a cradle to gate assessment that accounts for fossil carbon emissions only. In this conservative base case, WestRez 5101 shows a carbon footprint of 2.23 MT CO2e per MT of product: **12% lower compared to the hydrocarbon-based alternative**. This is based on the energy use, materials, packaging and wastes associated with the WestRez 5101 manufacturing process, without taking into account any potential carbon benefits from the bio-based feedstock.

- The primary raw material for WestRez 5101 is a bio-based material (by-product of the pulp and paper industry). By accounting for uptake of carbon in the forest growth, and storage of that biogenic carbon in crude tall oil, the carbon footprint becomes negative: -0.52 MT. This means that the amount of CO2e that the trees removed from the atmosphere during growth (-2.75 MT of biogenic carbon) outbalances the amount of carbon associated with the raw materials, energy use, packaging and wastes associated with WestRez production (2.23 MT). **This sequestered carbon will be released at the end of product life and represents only temporary storage.**

- At the end of product life, the carbon in the WestRez material (biogenic and fossil carbon) and in the hydrocarbon-based alternative (fossil carbon only) will eventually be released to the atmosphere again, through aerobic degradation or incineration. The biogenic carbon in WestRez balances out the amount of carbon stored as a result of tree growth in the raw material stage of the product life cycle. The WestRez 5101 carbon footprint, with end-of-life impacts included, is **62% lower compared to the hydrocarbon-based alternative**.