

Comparative LCA of Fiber Reinforced Polymer and Glass Fiber Reinforced Concrete Façade Panels

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Life Cycle Assessment for Complex Systems | Autumn 2020
CEE 226 | Professor Michael Lepech | Stanford University

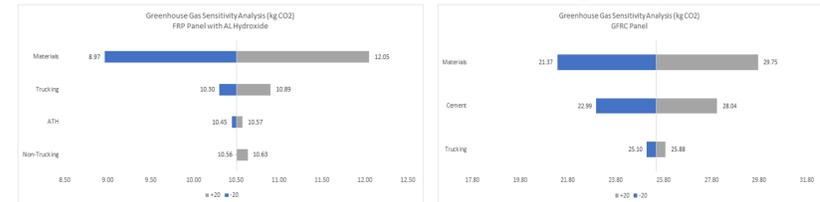


Objectives

- Perform life cycle cost and impact analysis of Kreysler & Associates' fiber reinforced polymer (FRP) panels [1m x 1m x .635cm] to glass-fiber reinforced concrete panels (GFRC) [1m x 1m x 1.905cm]
- Compare material production energy of Kreysler's Alumina Trihydrate (ATH) supply chain to proxy materials in SimaPro
- Analyze life cycle impact sensitivity to FRP and GFRC panel inputs

Sensitivity Analysis

- Sensitivity analyses were conducted for: (1) greenhouse gases, (2) energy resources, (3) acidification, and (4) winter smog
- Among the four panels, FRP with ATH modeled as aluminum hydroxide has the least environmental impact.
- All four panels were most sensitive to changes in the amount of materials and least sensitive to the non-trucking transportation.



Life Cycle Cost & Impact Comparisons

Life Cycle Impact Assessment

- GFRC's impacts were close to double those of FRP in many single score categories
- FRP has higher carcinogen and summer smog impacts than GFRC
- GFRC energy resources were approximately 60% higher than FRP
- Heavy metals made up over 70% of the total single score impact for both panels

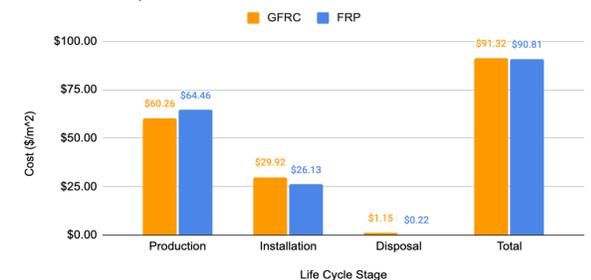


Life Cycle Cost

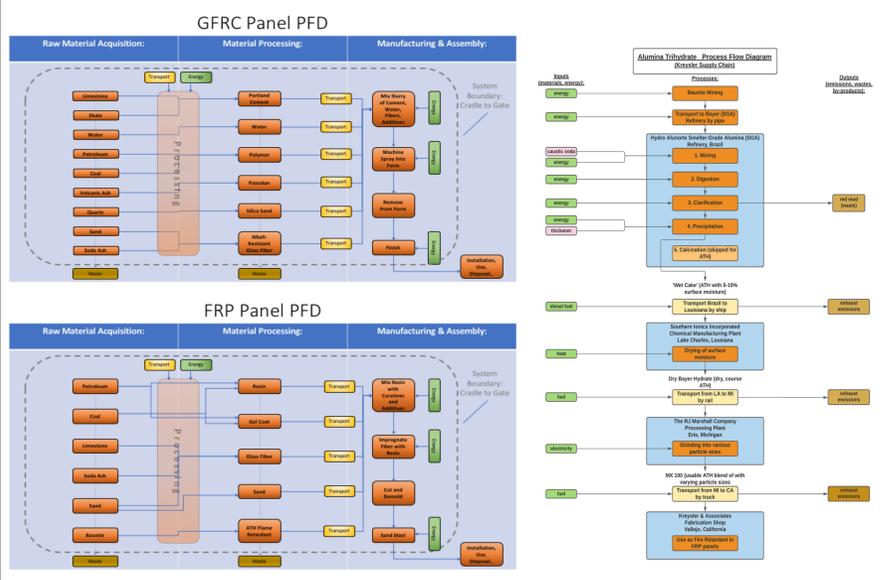
- Kreysler & Associates provided materials, labor, and manufacturing costs for FRP
- Corresponding costs for the GFRC panel were estimated using typical industry prices
- Labor and overhead costs were assumed to be similar for both panels
- Higher materials cost for FRP and higher transportation, installation, and disposal costs for GFRC

	FRP	GFRC
Total LCC	\$ 165.06	\$ 201.95
LCC Excluding Maintenance	\$ 91.32	\$ 90.81

FRP and GFRC Life Cycle Cost Comparison (Excluding Maintenance)

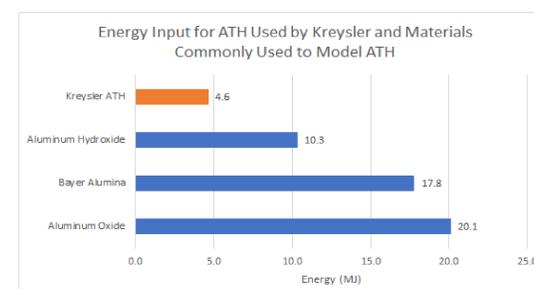
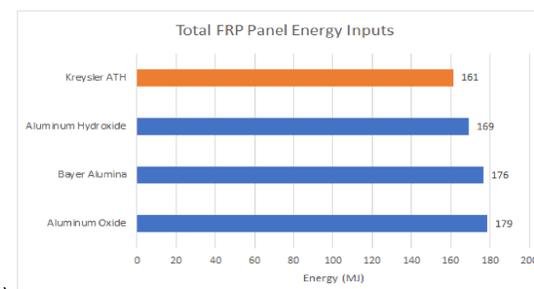


Process Flow Diagrams



ATH Energy Modeling

- ATH is a fire-retardant additive in FRP
- ATH is not an available material in Simapro. Through a review of other LCAs and refining processes, we chose Aluminum Hydroxide as well as Aluminum Oxide and Bayer Alumina (both Al₂O₃ but different supply chains) as proxies with similar impacts
- Kreysler's supply chain is significantly more efficient than supply chains for SimaPro proxy materials.
- FRP w. Kreysler ATH yields a ~5-10% reduction in panel material process energy compared to FRP w. proxies



Conclusions

- Over a 50-year period FRP façade panels are significantly cheaper than a GFRC alternative.
- Slightly higher cradle-to-gate costs are offset by lower transport, installation, and lifetime maintenance costs.
- Environmental impacts are similarly lower for FRP panels – GFRC production results in notably higher energy use, heavy metals, and greenhouse gas emissions.