LCA Comparison of Two Aquarium Tank Systems: Fiber-Reinforced Plastic and Concrete

STANFORD
CIVIL & ENVIRONMENTAL ENGINEERING

MONTEREY BAY AQUARIUM

Agenda

- Project Introduction & Background
- LCA Methods & LCIA by Phase
- Assessment & Recommendations

Monterey Bay Aquarium: New Seawater Tank Needed

Criteria for Choosing a Tank

Performance: Lifetime of 10-20 years and withstand aquarium conditions

Cost: Lowest cost or cost-competitive

Environmental Impact: Tank with the smallest environmental "footprint" was desired

Performance

- **Service Life and Durability:** both tank systems expected to last for 20 years.

- **Functional Unit:** 20 year storage of aquatic ecosystem.

- **Maintenance:** Not a factor in this analysis. The only required maintenance is an annual cleaning by divers (similar for both tanks) to maintain tank surfaces. Use phase costs and environmental impacts cancel out, and are probably negligible regardless.

Environmental Impacts (Key Metrics)

EMISSIONS

- Carbon dioxide
- Carbon monoxide
- NOx
- SOx
- Particulates
- Volatile Organic Compounds
- Specific Process- and Material-specific waste issues

IMPACT CATEGORIES

- Total Energy Resources
- Greenhouse Gas Emissions
- Ozone Depletion
- Acidification
- Eutrofication
- Heavy Metals
- Carcinogens
- Summer Smog Formation
- Winter Smog Formation
- Solid Waste

Monterey Bay Aquarium asked Kreysler & Associates to complete an LCA as a condition of taking the contract

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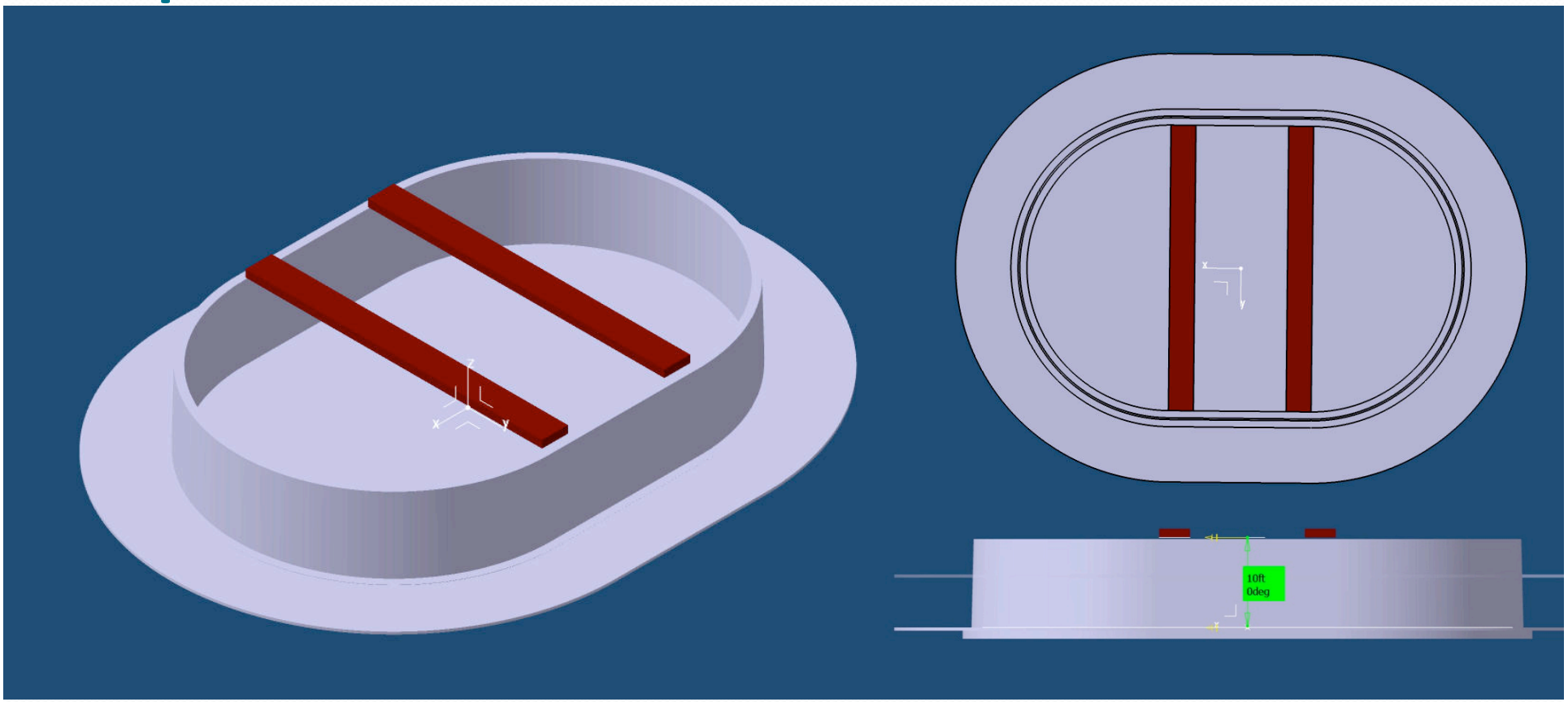
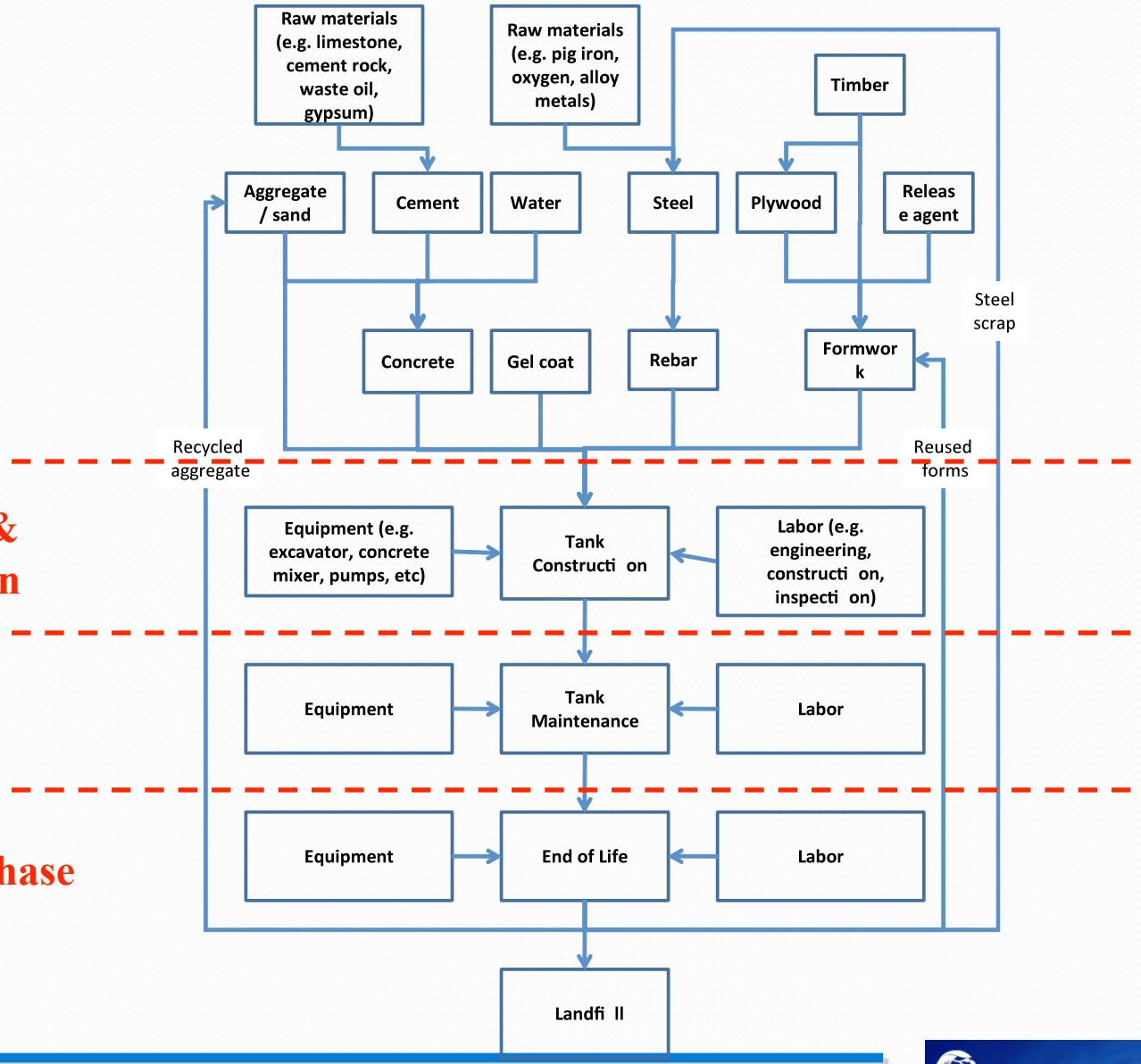
Option #1: Concrete



- Engineered and estimation by Rutherford and Chekene

Concrete Process Flow Diagram



Raw Material Production

Construction& Transportation

Use Phase

End-of-Life Phase

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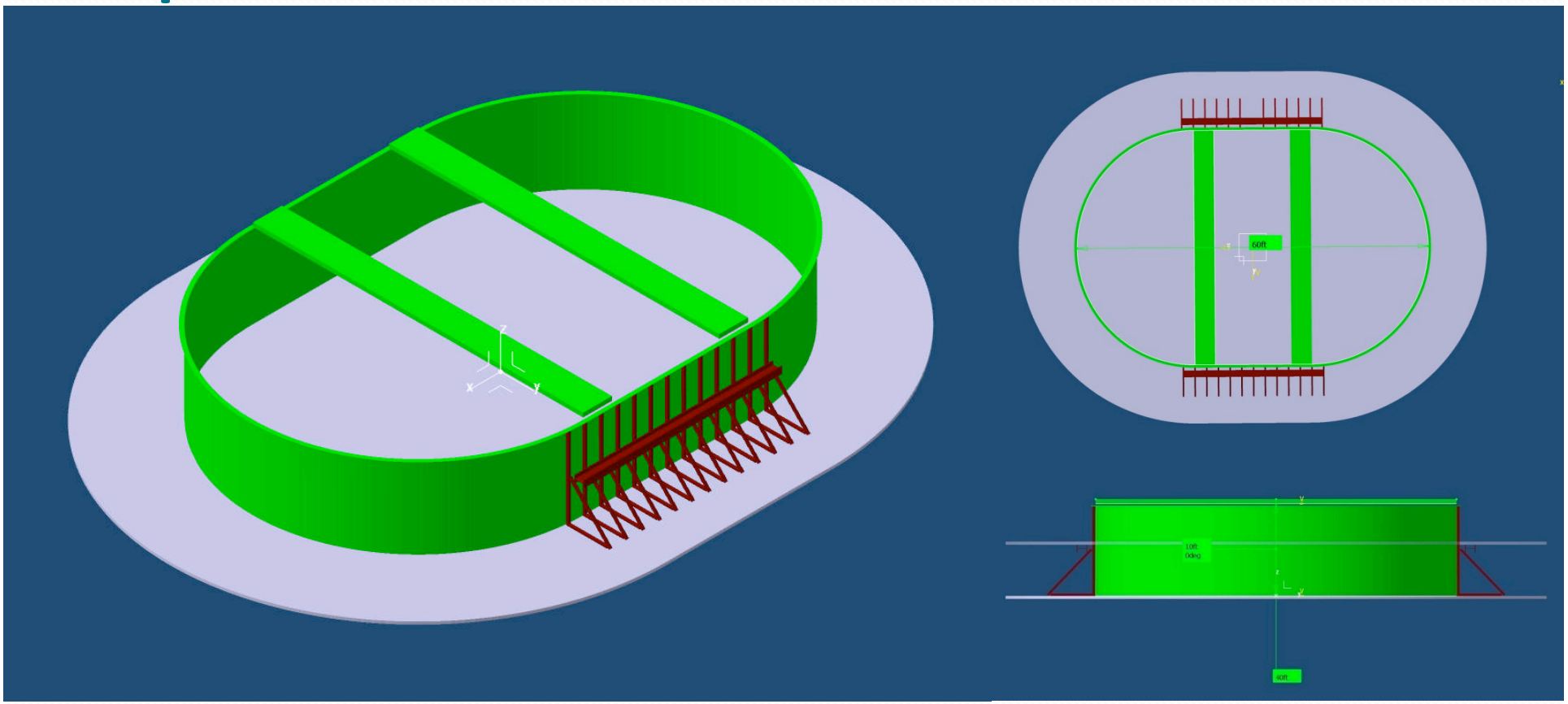
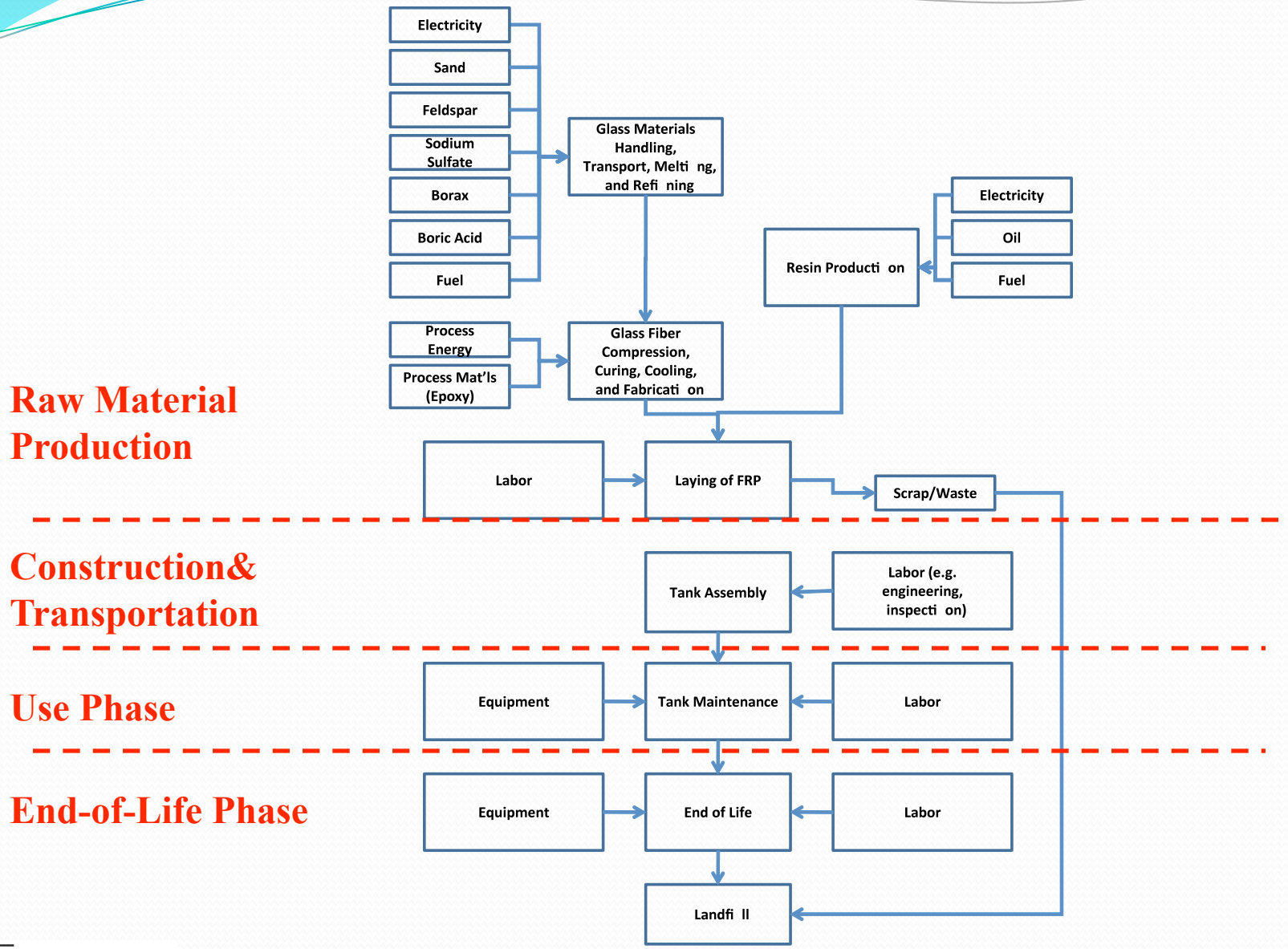
Option #2: FRP



- Kreysler & Associates (winning bid)

FRP Process Flow Diagram



Life Cycle Assessment Method and References

- **Objective:** Determine whether the FRP or Concrete tank liner has a lower overall environmental footprint

- **LCA Method:** Used a process-based rather than an EIO LCA to compare specific systems for which we had process and materials data.

- **Main References:**
  - SimaPro – Eco-Indicator 99
  - Owens-Corning Low-Energy Glass Fiber Process Data
  - Cost and fabrication data from Kreysler & Associates and MBARI
  - Ashland Resin Data

Major Assumptions

Material Production Phase

- Sandblasting: 150 hp electric LP air 3 hours
- 5% waste factor glass fiber
- 2% waste factor resin
- 3% waste factor for timber formwork

Construction Phase

- Forklift (50 hp diesel assumed)
- Concrete pump (33 hp diesel assumed)

End-of-Life Phase

- 100% Steel Salvaged
- 100% Concrete and FRP landfilled
- 75% Formwork reused

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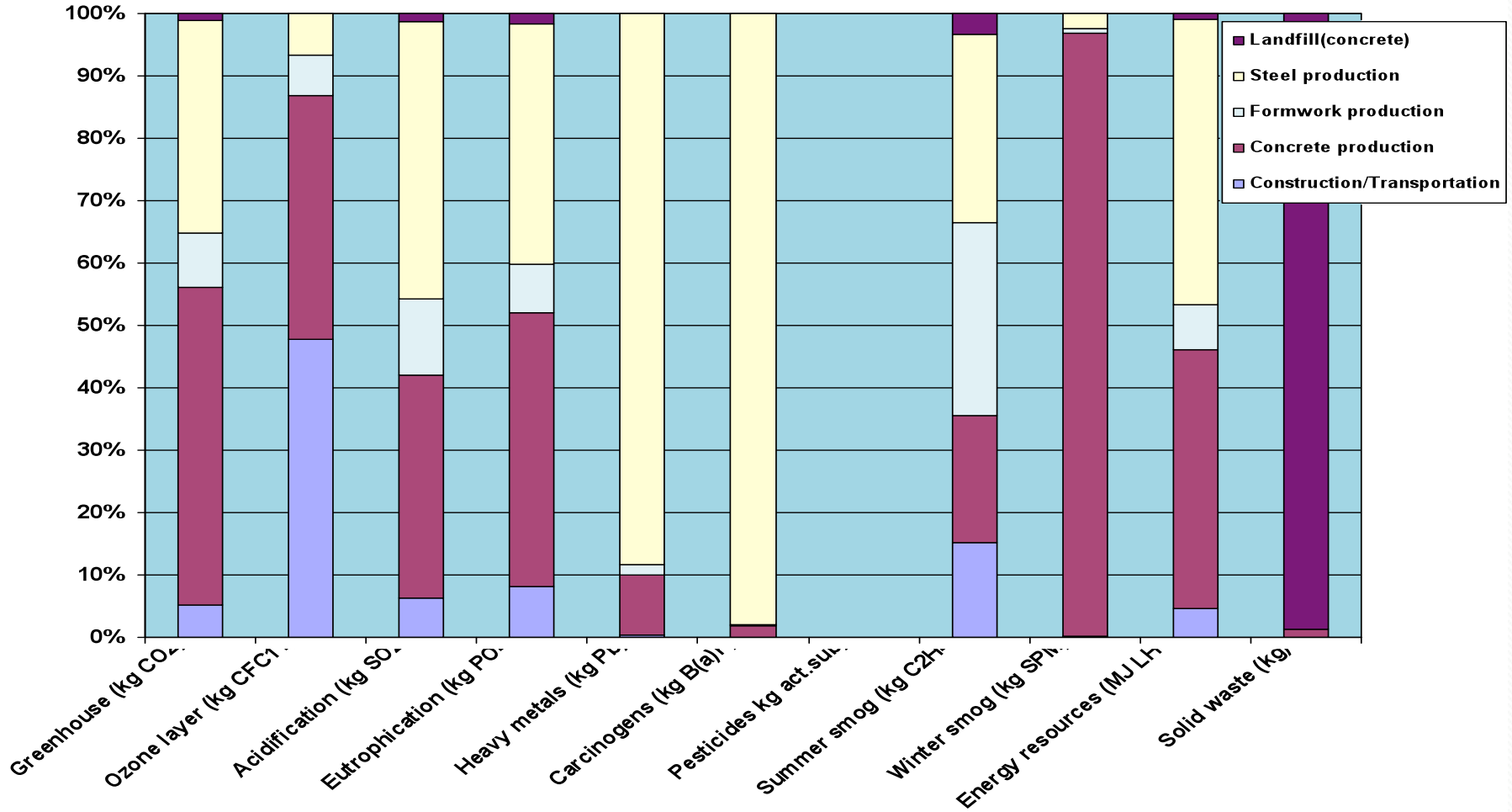
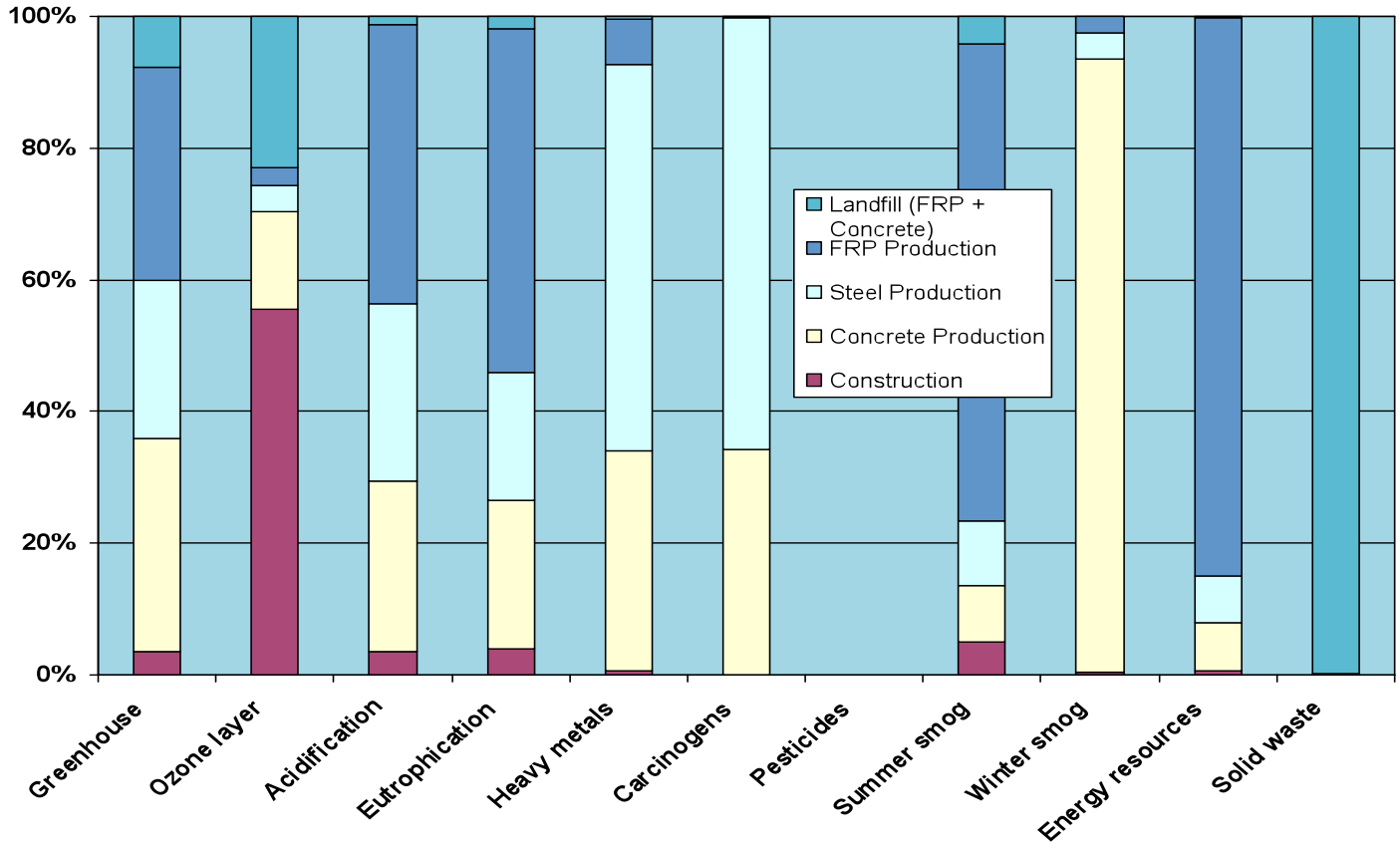
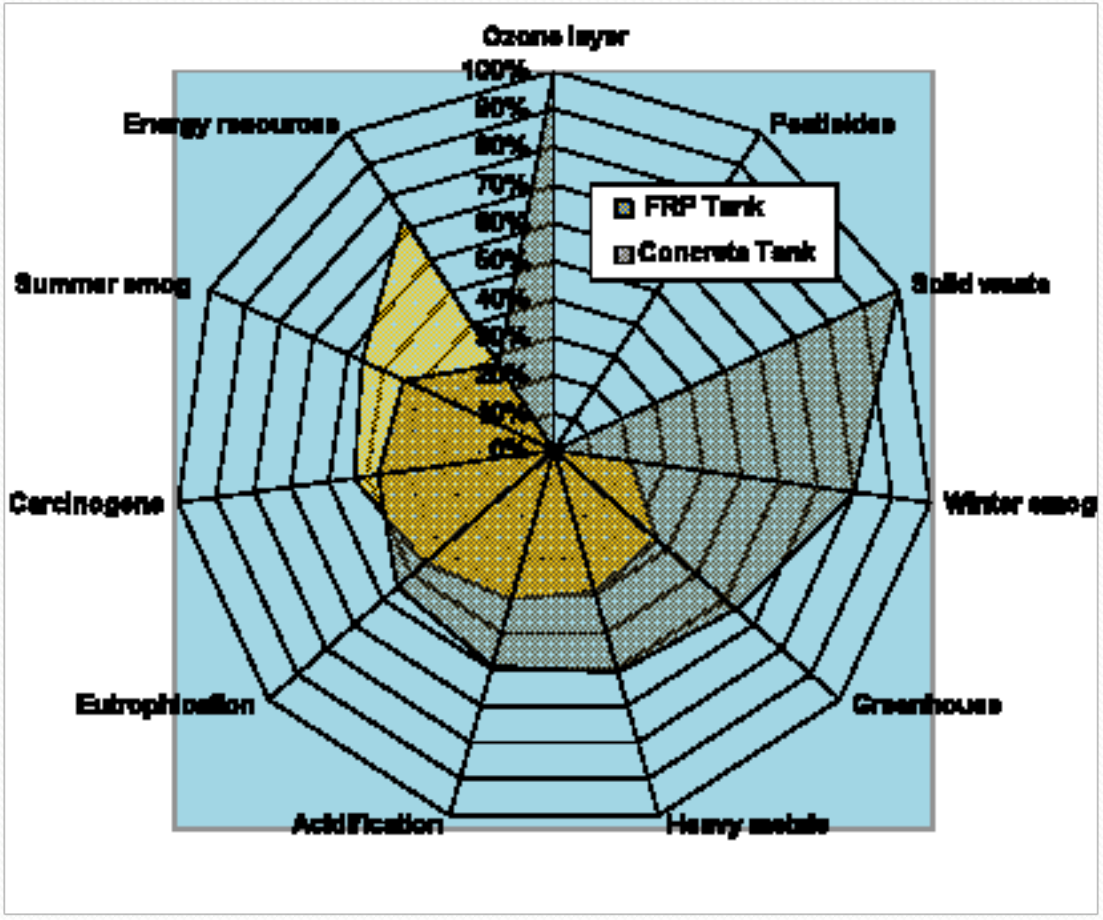
Concrete: Total Life Cycle Impact Assessment



FRP: Total Life Cycle Impact Assessment



Total Life Cycle Impacts: Concrete vs. FRP (Epoxy)



Recommendation : FRP Tank

- The FRP tank has smaller overall environmental footprint (lower solid waste, greenhouse gas emissions, and acidification)

- However, FRP consumes about three times as much energy as the concrete option. This is primarily because of the energy required to produce the resin.

- Regardless of this drawback, FRP is the superior environmental option.

Environmental Benefits of Choosing FRP comparable to:

- CO_2: Not driving 42,364 miles in a standard automobile

- Acidification: Not burning 6.14 metric tonnes of unscrubbed coal

On the other hand, the extra electricity used for the FRP tank could power 40 San Francisco households for an entire year.