

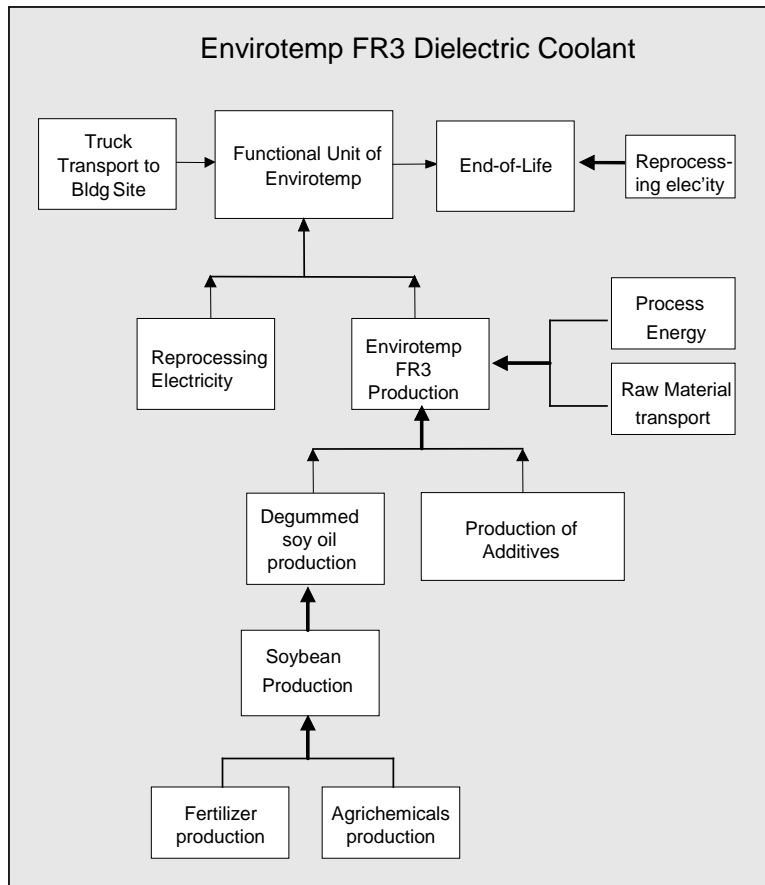
# Cooper Envirotemp FR3

## Product Selection and Description

Envirotemp FR3 Dielectric Coolant is a soy oil-based transformer fluid. A relatively small-sized (1 000 kV·A) transformer is assumed for BEES, which requires about 1.89 m<sup>3</sup> (500 gal) of fluid to cool. The functional unit for Envirotemp FR3, as for all BEES transformer oils, is the use of 1.89 m<sup>3</sup> (500 gal) of transformer fluid to cool a 1 000 kV·A transformer for a period of 30 years.

## Flow Diagram

The flow diagram below shows the major elements of the production of this product, as it is currently modeled for BEES.



*Figure 1: Envirotemp FR3 Dielectric Coolant System Boundaries*

## Raw Materials

The main constituent of Envirotemp FR3 is degummed soybean oil, and it contains small amounts of other additives, shown in the Table below.

*Table 1: Envirotemp FR3 Constituents*

<i>Constituent</i>	<i>Mass Fraction (%)</i>
Degummed soybean oil	95
Additives	5

Data for soybean production comes from the U.S. LCI Database. Production data for soybean oil comes from

the National Renewable Energy Laboratory LCA study on biodiesel use in an urban bus,<sup>1</sup> in which degummed soy oil is modeled as the precursor to soy-based biodiesel. Additives used in Envirotemp FR3 include a blend of natural esters and methacrylate resins, phenol compounds, and coloring. These additives are not specified due to confidentiality concerns, but they are included in the model and life cycle data for their production comes from the general contents of the SimaPro LCA database.

## Manufacturing

**Energy Requirements and Emissions.** Steam from natural gas and electricity are used to heat and blend a 22.71 m<sup>3</sup> (6 000 gal) batch of Envirotemp FR3. The Table below presents the quantities of each type of energy per gal of product (1 gal weighs 3.2 kg).

**Table 2: Envirotemp FR3 Manufacturing Energy**

<b><u>Energy Carrier</u></b>	<b><u>Quantity per gal</u></b>
Electricity	0.216 MJ (0.06 kWh)
Natural gas	4.43 MJ (4 200 Btu)

Electricity and natural gas are modeled using the U.S. average electric grid from the U.S. LCI Database.

**Transportation.** Soybean oil is assumed to be transported 322 km (200 mi) to the production site. Transportation of additives is assumed to cover 800 km (500 mi) by truck to the Envirotemp facility. Transportation data is based on the U.S. LCI Database.

## Transportation

Heavy-duty truck transportation is used to represent transportation from the Envirotemp facility to the transformer to be filled at the point of use. The distance traveled is modeled as a variable of the BEES system.

## Use

For BEES, Envirotemp FR3 Dielectric Fluid is used in a transformer with a capacity of 1.89 m<sup>3</sup> (500 gal). Any type of transformer oil needs to be reconditioned or reclaimed over the life of the transformer: transformer aging, thermal problems, or electrical problems can generate dissolved gas, which results in deterioration or contamination of the fluid. Included in the BEES use phase modeling is the electricity required to recondition the oil when dissolved gas analysis tests indicate the need. Reconditioning is assumed to occur every five years.<sup>2</sup> The transformer itself is assumed to have a lifetime of 30 years.

## End of Life

At the end of the 30-year life of the transformer, Envirotemp FR3 is modeled the same as most all other transformer oils in BEES: at year 30, Envirotemp is assumed to be further reconditioned and reused in another transformer. Included in the end-of-life modeling is the electricity required to recondition the oil.

## References

### Life Cycle Data

National Renewable Energy Laboratory (NREL): *U.S. Life-Cycle Inventory Database*. 2005. Golden, CO.

Found at: <http://www.nrel.gov/lci/database>.

PRé Consultants: *SimaPro 6.0 LCA Software*. 2005. The Netherlands.

Sheehan, J. et al., *Life Cycle Inventory of Biodiesel and Petroleum Diesel for Use in an Urban Bus*,

---

<sup>1</sup> Sheehan, J. et al., NREL/SR-580-24089 (Washington, DC: US Department of Agriculture and US Department of Energy, May 1998).

<sup>2</sup> Information on dissolved gas analysis testing can be found in the U.S. Bureau of Reclamation (USBR) website's Facilities Instructions Standards and Techniques (FIST) document, <http://www.usbr.gov/power/data/fist/fist3-30>. Energy information on reconditioning was provided during telephone conversations with S.D. Myers, a transformer and transformer fluid contractor, November 2001.

NREL/SR-580-24089 (Washington, DC: U.S. Department of Agriculture and U.S. Department of Energy, May 1998).

**Industry Contacts**

Patrick McShane, Cooper Power Systems (February 2005)