Supply chain network design to support biofuel production: A case study

Note: Use this case if your team consists of graduate students.

The company XYZ has decided to produce bioethanol in the state of Texas. The company needs to design a supply chain consisting of suppliers, hubs and biorefineries for the conversion of raw material (i.e., biomass) into biofuel. The suppliers of biomass are represented by the counties in the state of Texas; it is assumed that the centroid of the county is the county seat. A total of 254 counties (see Table 1) are available to supply the necessary feedstock for the production process. The supply information is provided in the file TX_suppliers.csv.

Table 1. Network definition

Definition	Value
Counties	254
Potential locations for hubs	1303
Potential locations for biorefineries	167
Conversion technologies	1 (thermochemical conversion)
Network demand	1,476,310,602 liters

Hubs are needed to consolidate and preprocess biomass to reduce the transportation cost and, therefore, the delivery cost as well as to meet the biomass quality characteristics. The potential locations to open hubs correspond to train stations (see file TX_hubs.csv for locations and capacities) because the transportation mode utilized to move the raw material from the hubs to the biorefineries is train. The distances (km) and transportation costs ($/Mg) are included in file TX_railroads.csv. The cost of loading/unloading a train is $3,066,792 USD and its capacity is 338,000 Mg. The hubs serve as transshipment and preprocessing node, no storage of material is allowed.

Table 2. Hub parameters

Parameter	Value
Hub investment cost	$ 3,476,219 USD
Preprocessing capacity	300,000 Mg

Truck is the transportation mode utilized to move the biomass from the counties to the hubs. The distances (km) and transportation costs ($/Mg) are presented in file TX_roads.csv. The investment cost to build a hub is shown in Table 2. The set of potential locations to open the hubs has several locations too close to each other; thus, a reduction in the number of potential locations is appropriate.

The potential locations to open the biorefineries are obtained from feasibility studies conducted by government agencies. The potential biorefineries' coordinates are in file TX_plants.csv. Different biomass conversion technologies can be implemented in the biorefineries. The technology considered for the conversion process in this case study is the thermochemical conversion. The data on this technology is also presented in the file TX_plants.csv. The cost to open a biorefinery is presented in Table 3.

Table 3. Biorefinery parameters

Parameters	**Value**
Investment cost (Equivalent Annualized Cost)	$ 130,956,797 USD
Annual conversion capacity	152,063,705 liters
Conversion yield	232 liters/Mg

The bioethanol demand for the state must be satisfied either with the production of the company or with a third-party supply. When the company is not able to supply the required demand of biofuel at a competitive price (i.e., at a price below the third-party price), then, the biofuel is bought from the vendor. The third-party price needs to be estimated with a market analysis since there is no information available for Texas. Several scenarios can be defined from a probability distribution so uncertainty about the third-party can be tackle and reflected in the model output. The demand is assumed deterministic.

The purpose of the problem is to minimize the investment and transportation costs by finding the optimal number of hubs and biorefineries that the company needs to install as well as the flows between suppliers-hubs and hubs-biorefineries. The company asks IEs to propose the modeling approach, data preprocessing, heuristics and algorithms for solving this problem.