Ethylene by Oxidative Dehydrogenation of Ethane
(recommended by Bruce Vrana, DuPont)

Ethylene is the largest volume organic chemical product, with world production over 50 billion pounds per year. It is normally produced by steam cracking of ethane or heavier hydrocarbons. This process is quite energy and capital intensive.

Dow Chemical has recently applied for a patent on a new process, which may require significantly less investment. In this process, ethane is passed over a catalyst at very high space velocity (100,000/hr or higher), and reacts with oxygen (exothermically!), producing ethylene in good selectivity (greater than 80% under some conditions) and high conversion. The selectivity is similar to that in the conventional steam cracking process, but the conversion is higher. Hydrogen in the feed improves the conversion while minimizing the amount of over-oxidation of the feedstock.

Because the reaction with oxygen is exothermic, the expensive furnaces of the steam cracking process should not be required. Much less coke is produced in this reactor system, according to Dow, which should result in a much more operable plant.

Dow has patented both a fixed bed supported catalyst and a fluidized bed reactor. The fluidized bed has a slightly higher selectivity, and would probably be easier to manage the heat load than the less expensive fixed bed reactor. You should use economics and technical criteria to guide your decision about which reactor technology to use in the plant design, and discuss this major decision in your report.

Your company has 1 MMM pounds per year of ethane, which is currently being produced at your Gulf Coast plant and sold for $0.07/lb in 2000. Your team has been asked to evaluate the economic viability of the Dow process for your plant, as a way of upgrading your product and increasing your sales revenue. Your job is to determine the economic optimum design, maximizing the net present value (NPV) of the project. You may consume all or part of the ethane, which is available. Based on past experience, you know that you will have to be able to defend any decisions you have made throughout the design, and the best defense is economic justification. Your plant design must be backed up with a rigorous simulation of the entire process, with all recycle loops closed.
Your marketing organization believes they can sell ethylene for $0.25/lb in 2001 dollars. Pipeline oxygen in your area costs $0.02/lb. It would be a good idea to test the sensitivity of the optimum plant design and economics to uncertainty in the selling prices of the product and the raw material.

The plant design should be as environmentally friendly as possible. Recover and recycle process materials to the maximum economic extent. Also, energy consumption should be minimized, to the extent economically justified. The plant design must also be controllable and safe to operate, an important consideration with oxygen and hydrocarbons. Remember that you will be there for the start-up and will have to live with whatever design decisions you have made.

Reference:

World Patent Applications 00/14035 and 00/14180 to Dow.