**Introduction**

Why Styrene? Key building block in the creation of many consumer and industrial products

- **Location:** Edmonton, AB
- **Plant Capacity:** 105 kilotonnes per year
- **Market Growth:** CAGR of 5.64% from 2021 to 2030

**Innovation**

- Multi-tube, isothermal reactor
  - Better conversion compared to conventional adiabatic design
  - Reduced utility and separation load compared to steam injection

- Compressor-based heat integration
  - Better heat transfer, lower capital cost, lower carbon emissions
  - More energy and cost efficient than vacuum steam generation proposed in literature

**Process Description**

- **Feed Preparation**
  - Water and ethylbenzene are mixed and heated to 640°C via a furnace. The water to ethylbenzene ratio is maintained using a ratio controller
  - The recycled water from the three phase separator and recycled ethylbenzene from the third distillation column are mixed with the fresh feed before entering the process again

- **Catalytic Reactor**
  - Mixed feed is fed into a multi-tube, fixed bed, catalytic reactor, within a furnace to operate isothermally
  - The main reaction will be endothermic dehydrogenation of ethylbenzene producing styrene, along with side reactions producing benzene, toluene, methane, hydrogen, and ethylene
  - The reactor effluent is compressed and fed to the heat exchanger

- **Three Phase Separation**
  - The product stream from the heat exchanger is fed to the three phase separator
  - The bottom stream mostly consisting of water is recycled back into the process
  - The middle stream contains aromatics and most of our valuable products and by-products and is sent to the first distillation column
  - The top stream is mostly composed of light gases and is sent to the flash drum

- **Distillation**
  - The first column separates benzene and toluene from ethylbenzene and styrene
  - The second column separates benzene from toluene which are both temporarily stored and sold
  - The third column separates ethylbenzene from styrene. Ethanylene is recycled back into the process and the styrene will be temporarily stored and sold

**Environmental**

- **Process Aromatics:** Styrene, ethylbenzene, toluene, benzene

- **Environmental Impact**
  - Toxic, volatile, and flammable
  - All aromatics are recycled or sold
  - In case of spill, may contaminate soil and sediment

- **Impactful Units:** Heat exchangers, furnace, and compressor

- **Environmental Assessment**
  - Cooling water is not contaminated
  - Steam in reaction recycled
  - SOx and NOx are 2.4 and 2.8 ppm
  - \( \text{eCO}_2 \) is 33 kilotonne/year, within 100 kilotonne/year regulation of Alberta’s TIER

**Economics**

- **Revenue:** $327.98 MM
- **Payback Period:** 16 years
- **Selling Price:** $2.95/kg
- **Interest Rate:** 9.7%
- **Plant Lifetime:** 30 years
- **ROROI:** 17.5%

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