# Ethoxene Process

(Production of Chemicals from Ethane Derived from Marcellus Shale)

## I. Introduction

Mountaineer Engineering Solutions (MES), Inc., was contacted by MGTek, Inc. on August 5th, 2011, to identify viable technologies for Marcellus Shale gas processing. During the first two phases of this project, MES, Inc. and MGTek, Inc., narrowed the technologies to the integrated ethoxene-vinyl acetate monomer (IEVAM) process.

For Phase 3, MGTek, Inc., requested the design of an IEVAM plant to produce 100,000 tonne/y of ethylene, 200,000 tonne/y of acetic acid, and 200,000 tonne/y of VAM at a purity of 99.5 mol%, 99.9 wt%, and 99.85 wt% respectively. The design for this plant is based on a 6% internal hurdle rate and a 10 year plant life. Prices for ethylene, acetic acid, and VAM used for this design were $1.22/kg, $0.66/kg, and $1.31/kg, respectively.

In addition, MES, Inc., prepared an environmental impact statement for the plant. Finally, MES, Inc., completed a detailed design and economic analysis for the IEVAM process and conducted a HAZOP analysis for the reactor section of the plant.

## II. Background

In August 2011, Mountaineer Engineering Solutions, Inc., was approached by MGTek, Inc., to design a plant for the processing of the heavy components of Marcellus Shale gas for non-fuel uses.

The Marcellus shale formation was chosen for this project due to its high ethane content and its location. The formation contains 7-15% ethane content and spans the states of West Virginia, eastern Ohio, Pennsylvania, and southern New York and is approximately 54,000 square miles.[1] Extraction of the gas prior to processing requires large amounts of water for drilling and hydraulic fracturing. Although there is local controversy over possible health and environmental issues of these processes, wells are still being established throughout the region. On average, these wells produce 14 million $ft^3$/day of wet gas containing a mixture of gaseous hydrocarbons.[2,3,4] The two most abundant gases are methane and ethane, which account for 75-85% and 7-15% of the gas in the formation, respectively.[5,6]

The investigations of MES, Inc., consisted of three phases. During Phase 1, MES, Inc., investigated possible chemical processes and plant locations for the project. Based on the legislative and environmental policies researched in Phase 1, West Virginia was recommended as the best state to construct the plant. The location was narrowed further to the Northern Panhandle or the Charleston area because of existing chemical industry. The Charleston area was the recommended based on its proximity to potential ethylene customers, its proximty to major transportation routes, and its high ranked school systems that would potentially provide high-quality employees.[4,5]

In Phase 2, MES, Inc., conducted further research for possible technologies for ethane processing. The integrated ethoxene-vinyl acetate monomer (IEVAM) process was chosen as the best candidate because multiple products could be produced. The selection of the IEVAM process was based on the information available on the processes, the global and local demand, and the ease of simulation.

In Phase 3, MES, Inc., began modeling the IEVAM process. It was requested that the plant produce 100,000 tonne/y of ethylene, 200,000 tonne/y of acetic acid, 200,000 tonne/y of vinyl acetate monomer; however during Phase 3, the required acetic acid production for the plant was a determined to be a flexible amount and could be reduced at the discretion of MES, Inc. and MGTek, Inc.

## III. Results

Based on an economic analysis of Unit 100, the break-even price for ethane is $0.257/kg for the process. Figure 1 shows the cash-flow diagram for Unit 100 assuming an ethane price of $0.257/kg. The best-case scenario break-even price for ethane is $0.445/kg. Figure 2 shows the BFD for Unit 100, and Figures 3, 4, and 5 show the PFD for each section of the BFD.

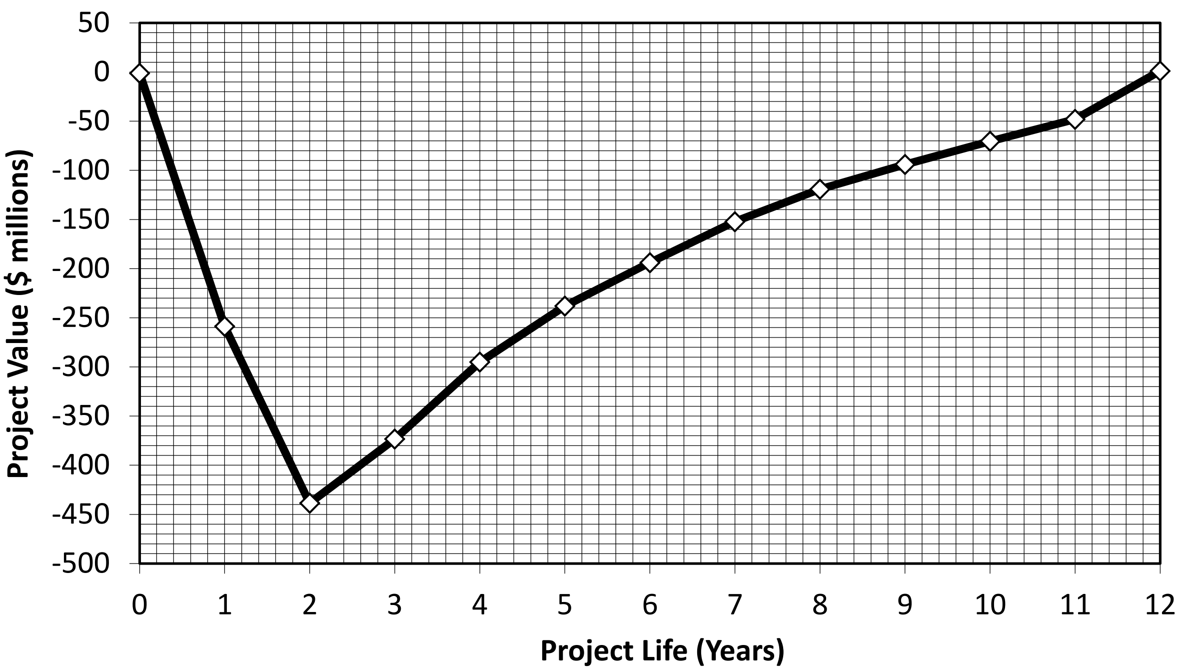


Figure 1: Cash flow diagram for Unit 100 with an ethane feed price of $0.257/kg

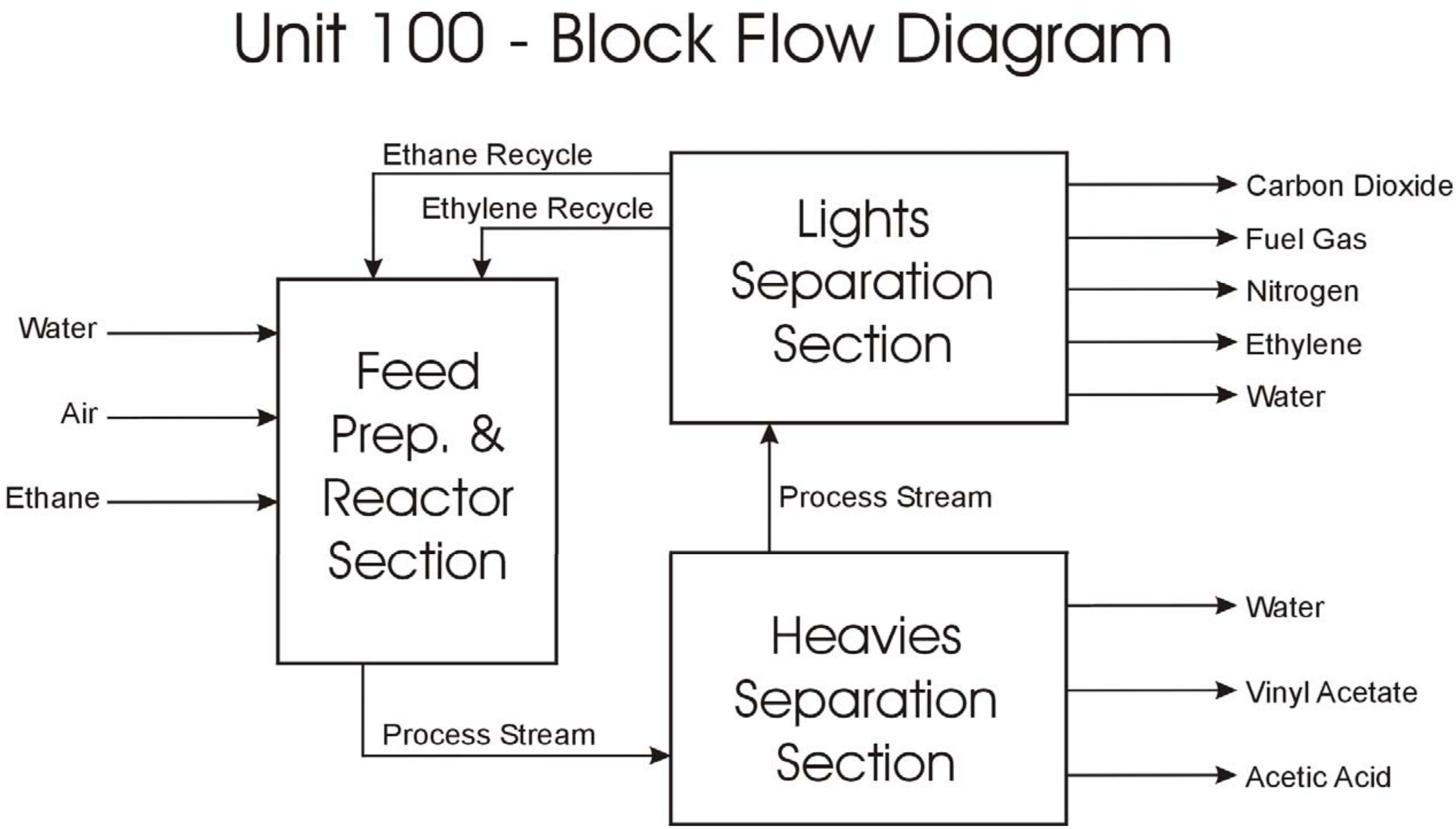


Figure 2: BFD for IEVAM Unit 100

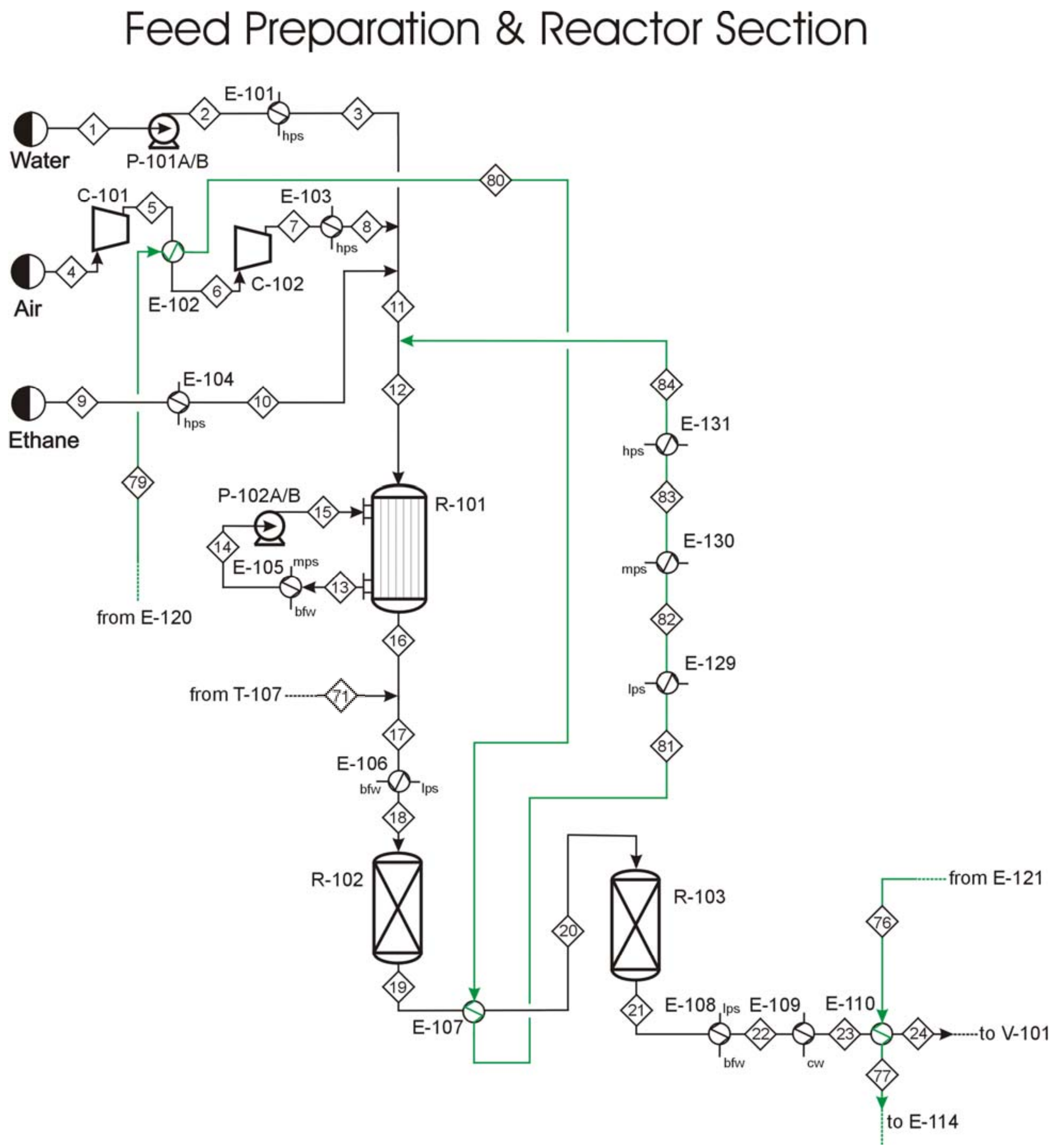


Figure 3: Feed preparation and reactor section PFD

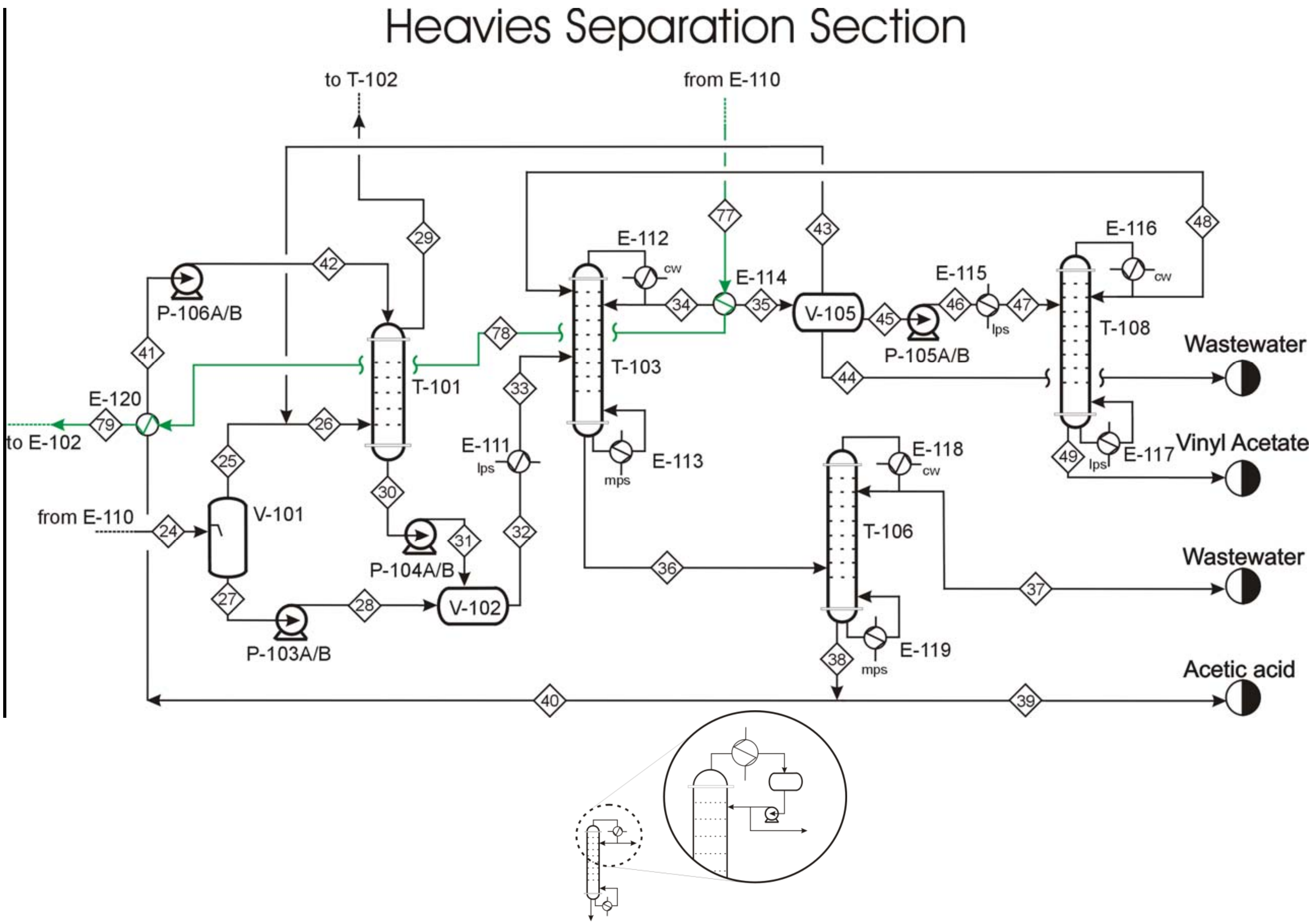


Figure 4: Heavies separation section PFD and typical tower condenser layout

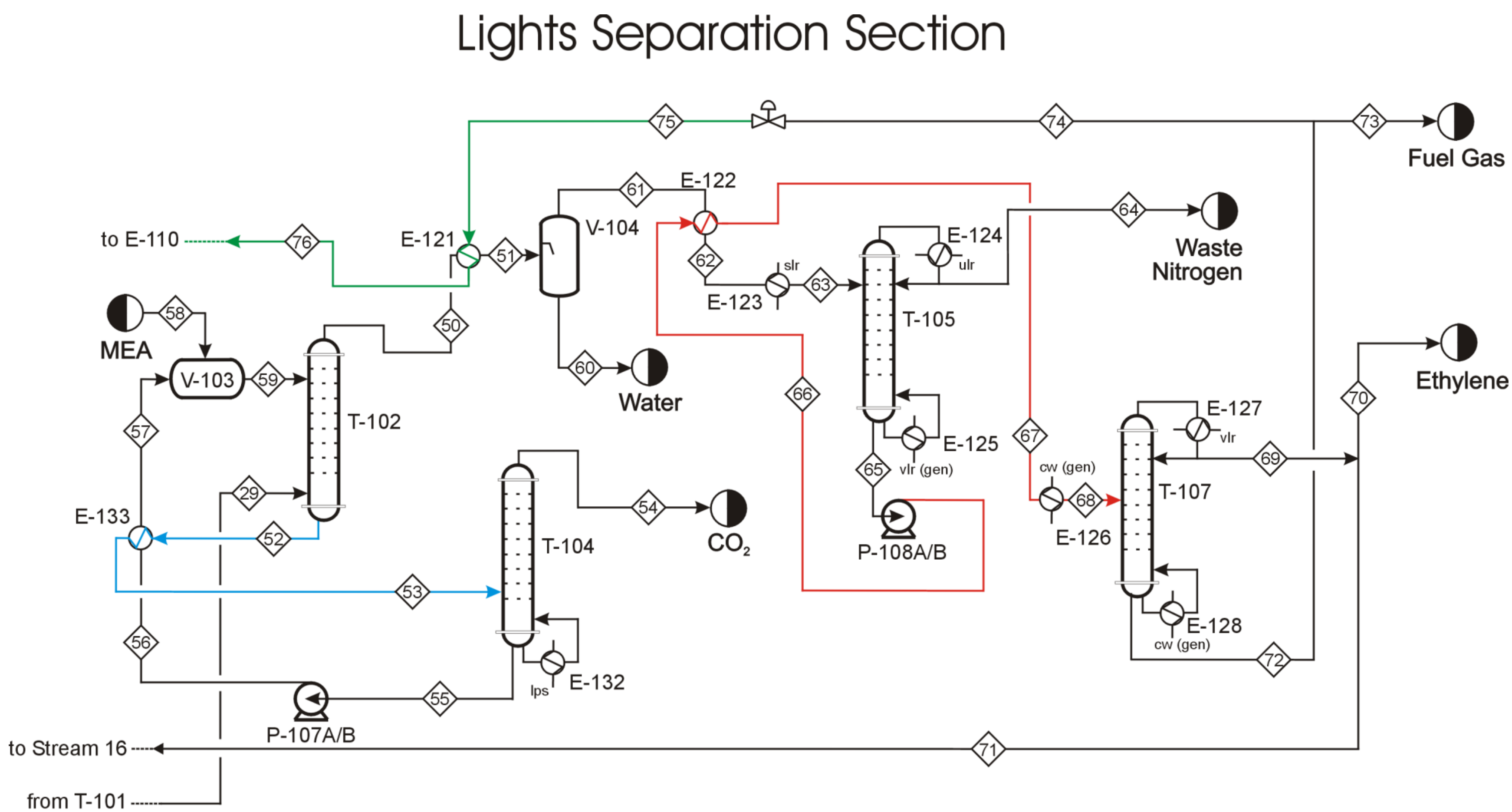


Figure 5: Lights separation section PFD

# IV. References


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