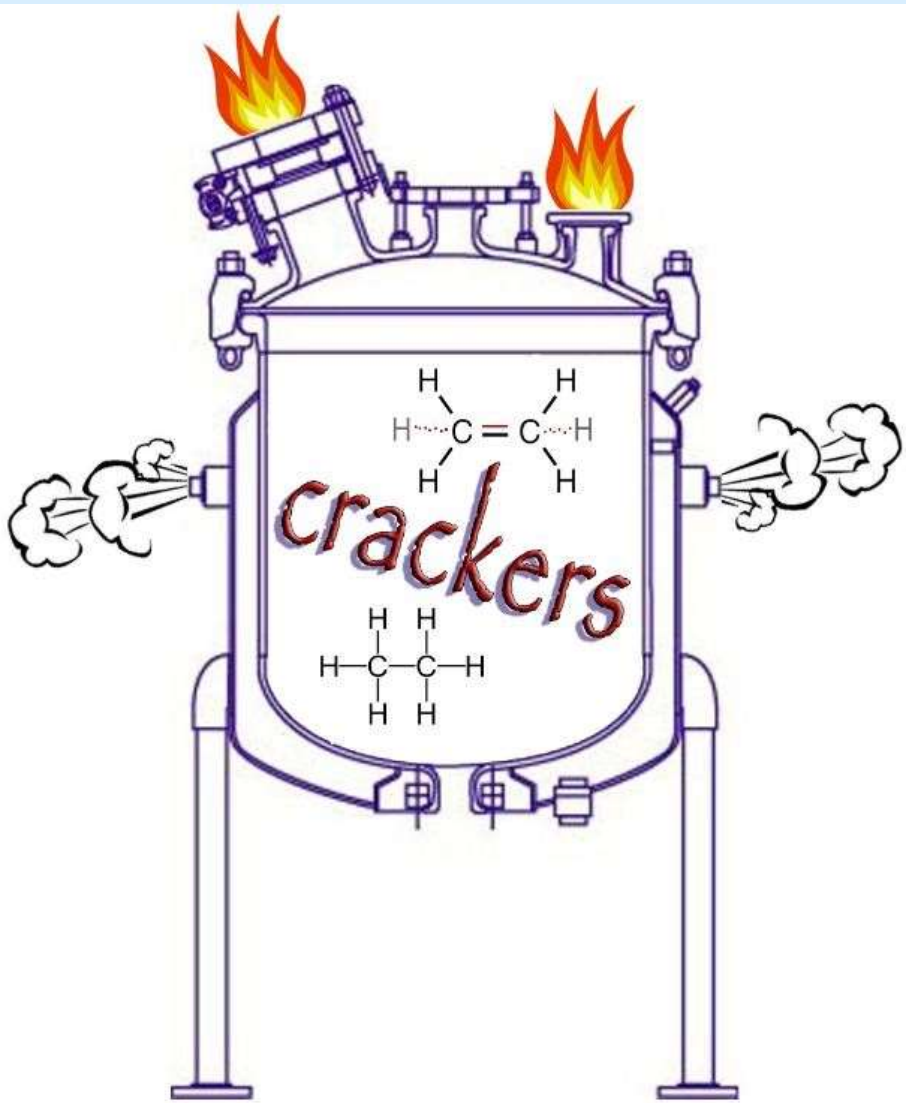


# Natural Gas Liquids to Olefins



# Crackers



Travis Wells  
Scott Chase  
Mohammed Alzain  
Salman Almutawa

# Project Definition

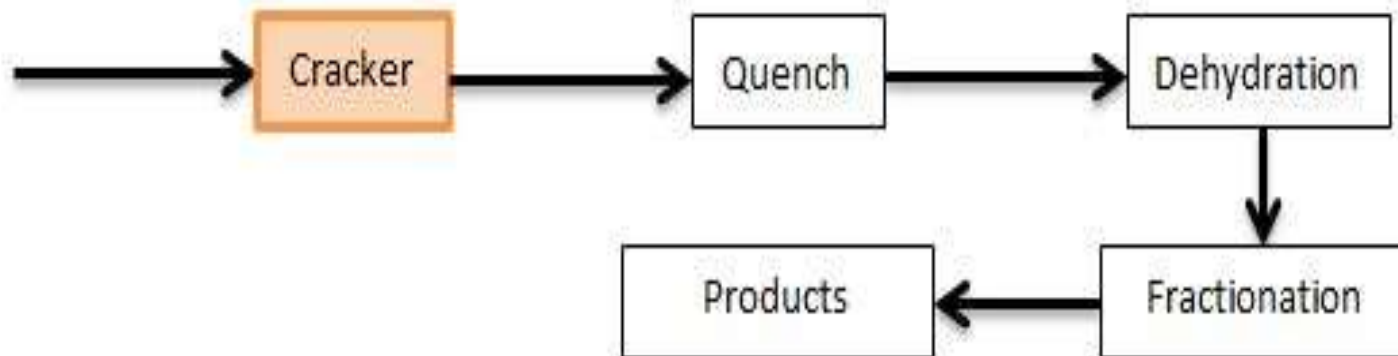
- Successfully design an olefins plant that will convert NGLs to olefins with a 1.5 billion lb/yr capacity.
- Locate the plant in an optimal area and pipeline products to nearby petrochemical plants.
- Use ethane and propane as a feedstock from the North Dakota reserves.
- Design the plant to produce high purity (99.8%) ethylene and propylene for petrochemical uses.

# Ethylene and Propylene Uses

Ethylene and propylene are the precursor components for the manufacture of many products such as polyethylene and propylene glycol



# Plant Overview



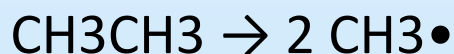
The cracker is what converts ethane and propane to ethylene and propylene through a high temperature steam diluted process.

# Thermal Vs. Catalytic Cracking

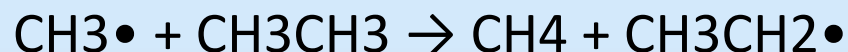
Thermal Cracker	Catalytic Cracker
No catalyst	Uses a catalyst
Higher reaction condition	Lower reaction condition
Free radical reaction	Ionic reaction
High gas yields	Low gas yields
Low octane number	High octane number
<b>High yield of C<sub>2</sub> &amp; C<sub>3</sub> olefins and low yields of gasoline and other distillates</b>	<b>High yield of C<sub>4</sub> olefins and high yields of gasoline and other distillates</b>

# Reactions

- In steam cracking, initiation usually involves breaking a chemical bond between two carbon atoms. <sup>[4]</sup>



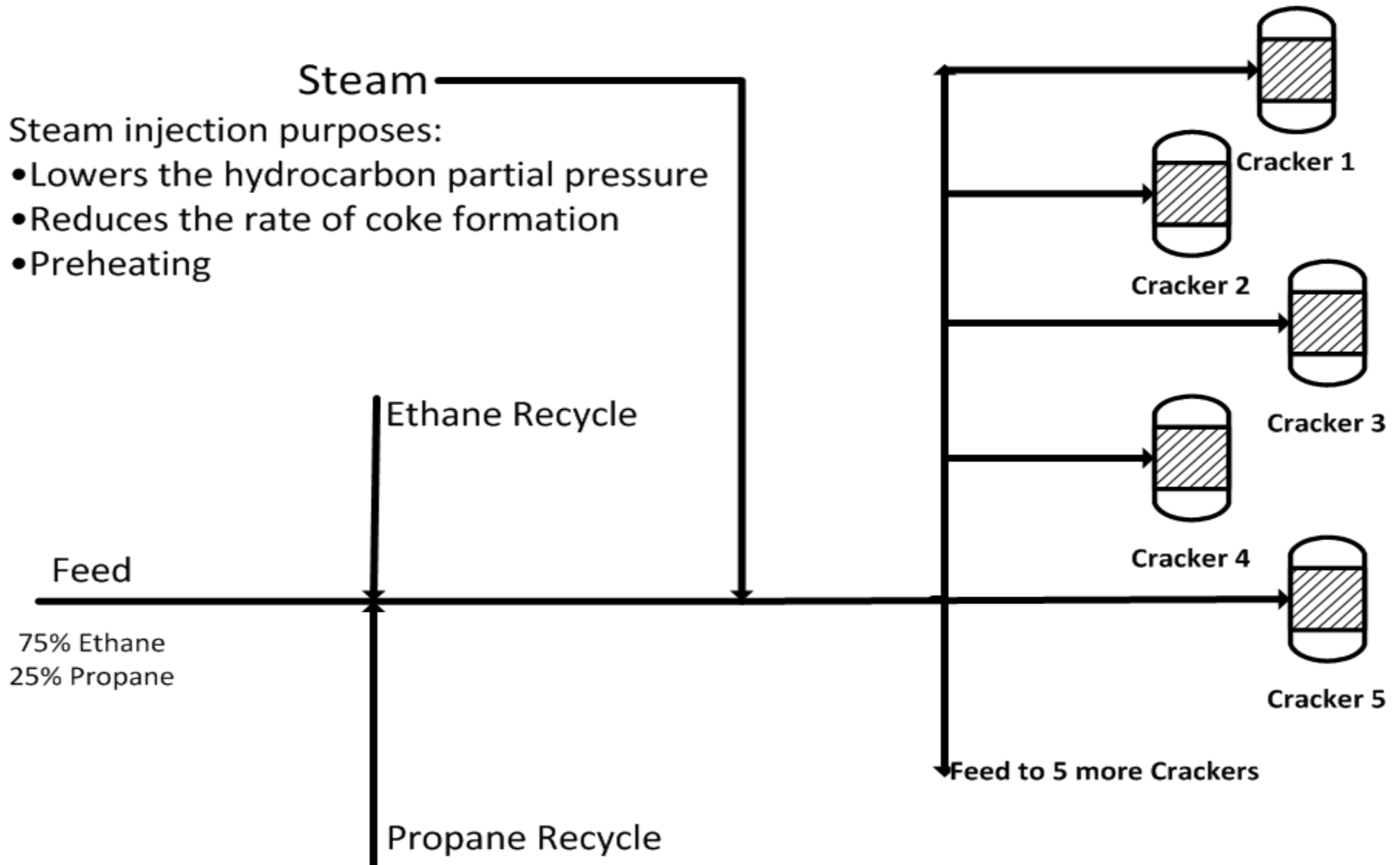
- A free radical removes a hydrogen atom from another molecule. <sup>[4]</sup>



- Radical decomposition occurs where a free radical breaks apart into two molecules, one an alkene, the other a free radical. <sup>[4]</sup>



# Cracker

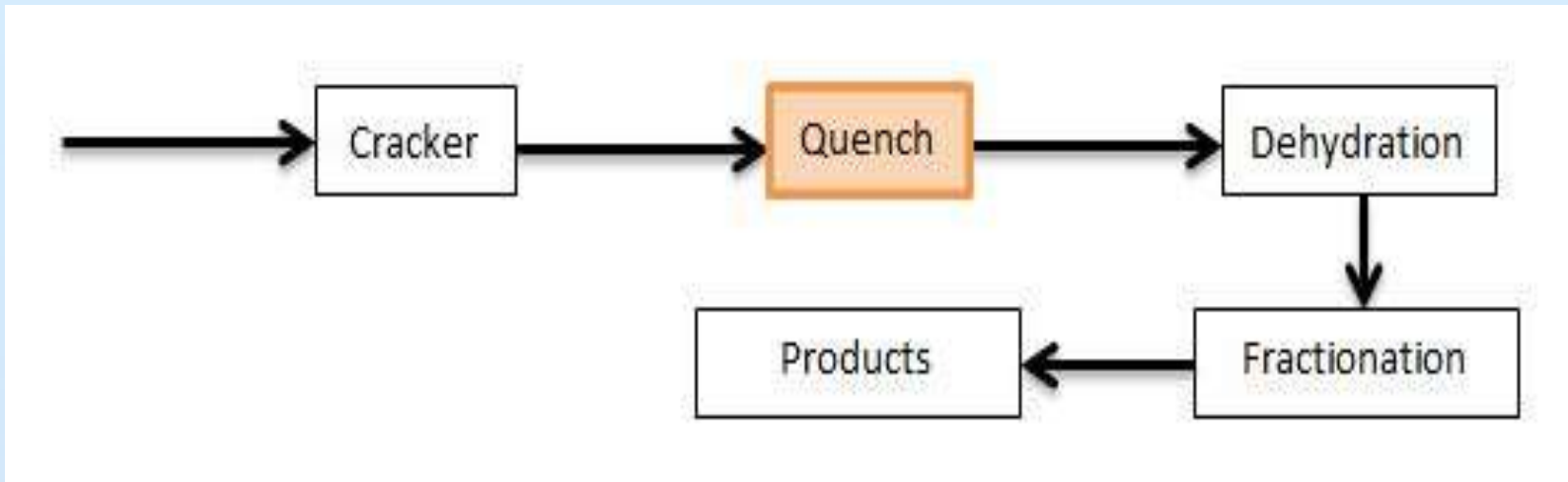


# Cracker Yields

**TABLE 10** Typical Pyrolysis Yields of Ethylene Plant Feedstocks (in mass percent): Light Paraffins<sup>a</sup>(pure compounds)

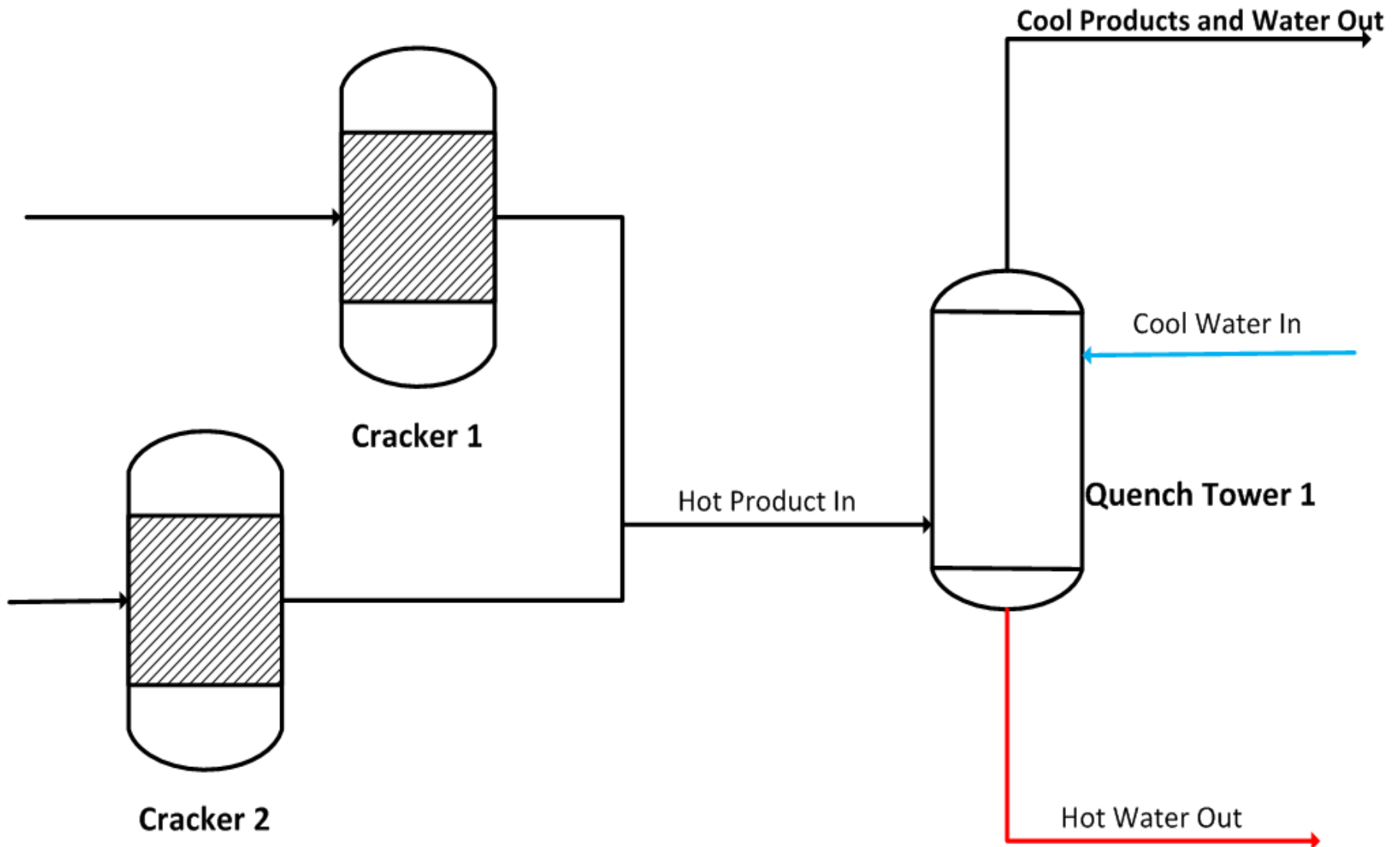
Conversion (%)	Ethane		Propane		<i>n</i> -Butane 95	Isobutane 92	<i>n</i> -Pentane 95	Isopentane 95
	50	60	75	90				
H <sub>2</sub>	3.06	3.55	1.08	1.29	1.0	1.39	0.8	0.9
CH <sub>4</sub>	2.6	4.2	18.83	24.7	21.8	23.6	17.52	20.6
C <sub>2</sub> H <sub>2</sub>	0.12	0.25	0.17	0.33	0.4	0.46	0.55	0.42
C <sub>2</sub> H <sub>4</sub>	41.65	48.2	25.0	34.5	35.8	10.3	36.5	17.95
C <sub>2</sub> H <sub>6</sub>	50.0	40.0	5.15	4.4	5.1	0.73	5.6	3.2
C <sub>3</sub> H <sub>4</sub>	0.1	0.02	0.22	0.34	0.55	2.46	0.95	1.7
C <sub>3</sub> H <sub>6</sub>	0.89	1.11	18.86	13.96	16.4	21.2	19.8	19.0
C <sub>3</sub> H <sub>8</sub>	0.14	0.17	25.0	10.0	0.15	0.33	0.55	0.55
C <sub>4</sub> H <sub>6</sub>	0.5	1.07	1.05	2.65	3.4	1.94	3.7	4.6
C <sub>4</sub> H <sub>8</sub>	0.25	0.21	1.28	1.0	1.7	16.7	2.6	14.38
C <sub>4</sub> H <sub>10</sub>	0.35	0.27	0.07	0.05	5.0	8.0	0.1	0.1
C <sub>5</sub> S	0.2	0.27	1.43	1.81	1.65	2.12	6.1	7.5
C <sub>6</sub> H <sub>6</sub>	0.2	0.48	1.09	2.2	2.58	3.42	1.8	4.1
C <sub>7</sub> H <sub>8</sub>	0.03	0.06	0.33	0.48	1.12	1.51	0.6	1.25
C <sub>8</sub> H <sub>8</sub>					0.45	0.67	0.1	0.25
C <sub>8</sub> H <sub>10</sub>							0.06	0.15
C <sub>6</sub> -C <sub>8</sub> PON		0.14	0.14	1.44	1.2	3.18	0.1	0.1
C <sub>9</sub> -200°C							1.48	1.75
Fuel oil			0.3	0.85	1.7	1.99	1.09	1.5

# Quench Tower

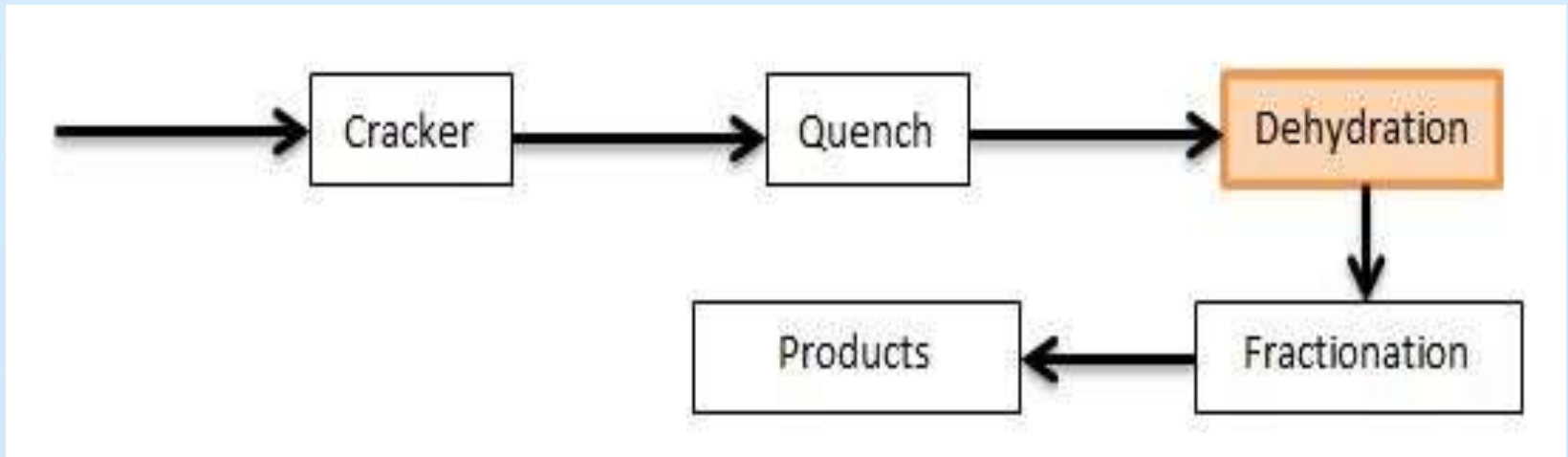


The quench system cools the products and stops the reaction to lower the yield of undesirable byproducts.

# Quench Tower

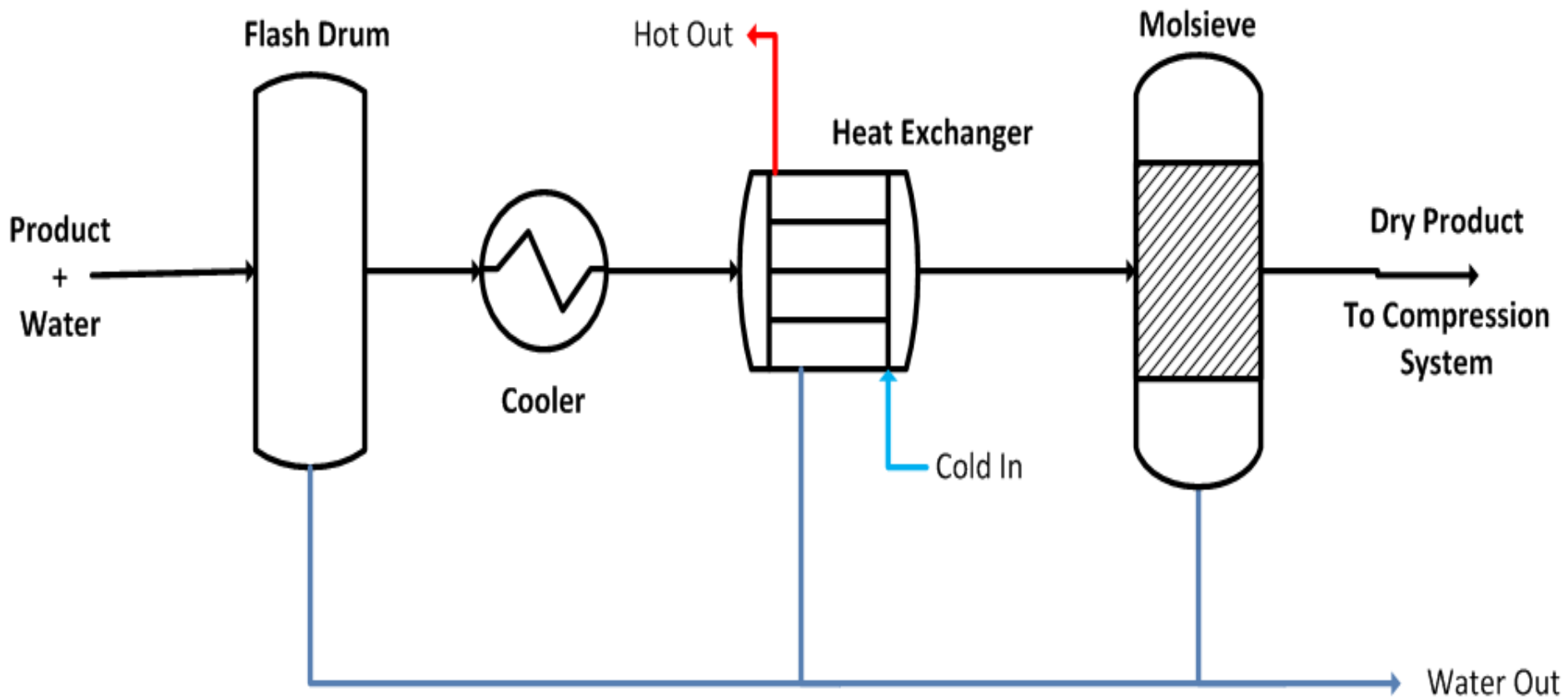


# Dehydration System

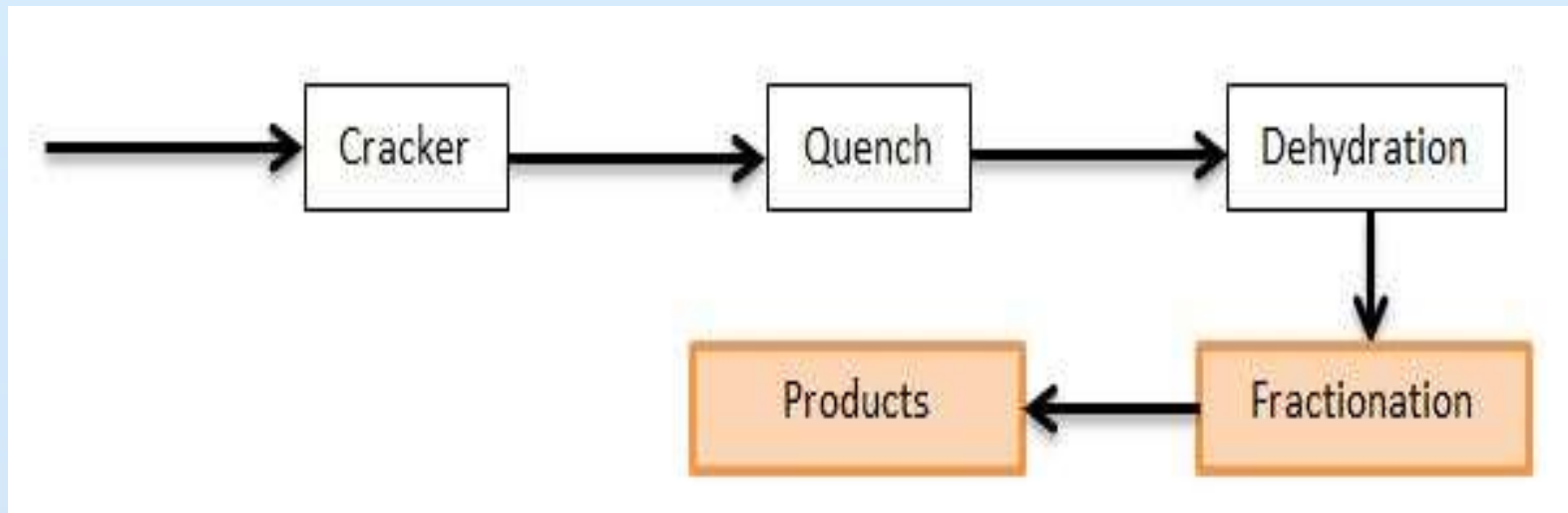


Dehydration is very important. Water levels over 100ppm in the product stream will freeze in the fraction towers and block flow.

# Dehydration System

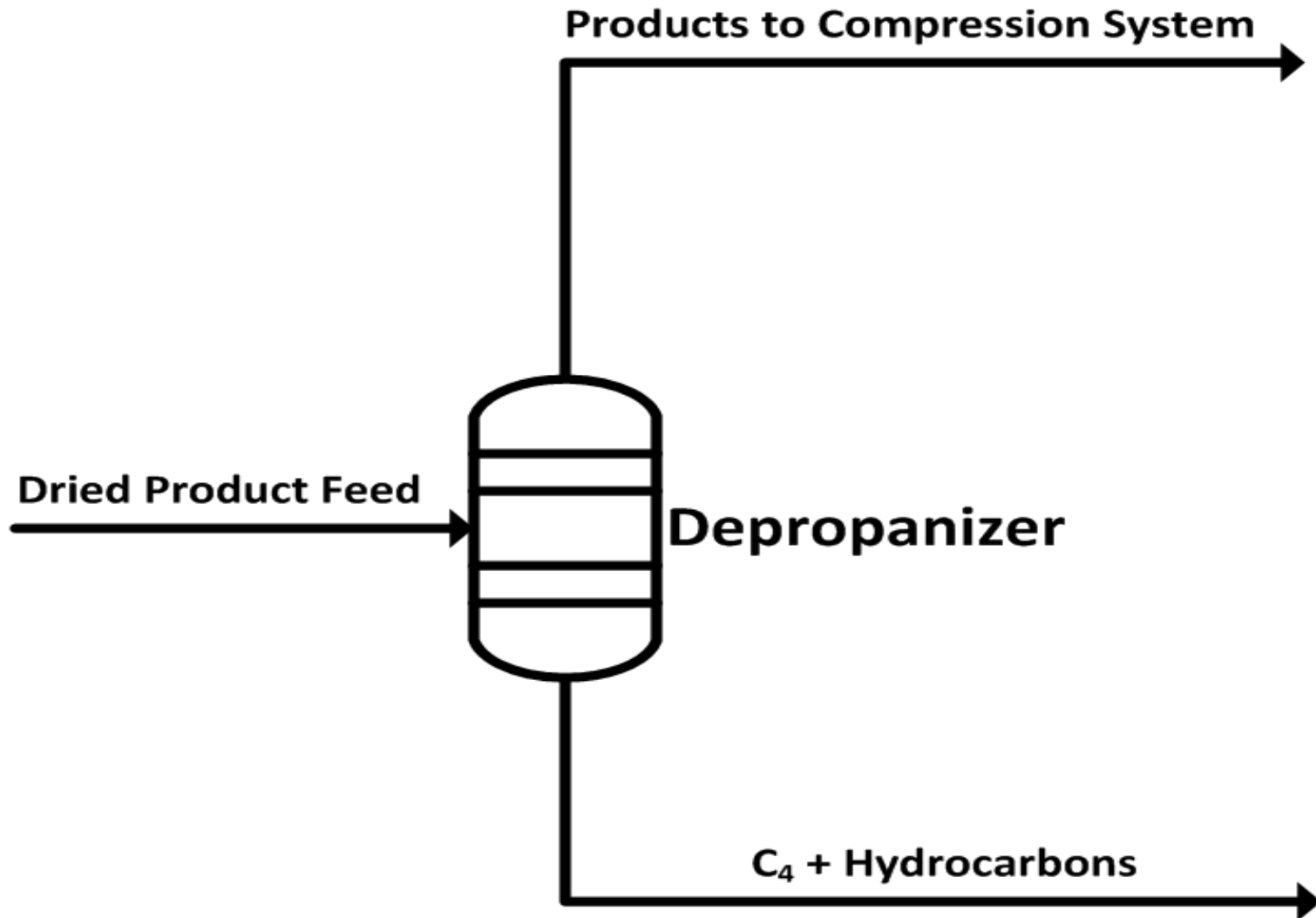


# Fractionation Towers

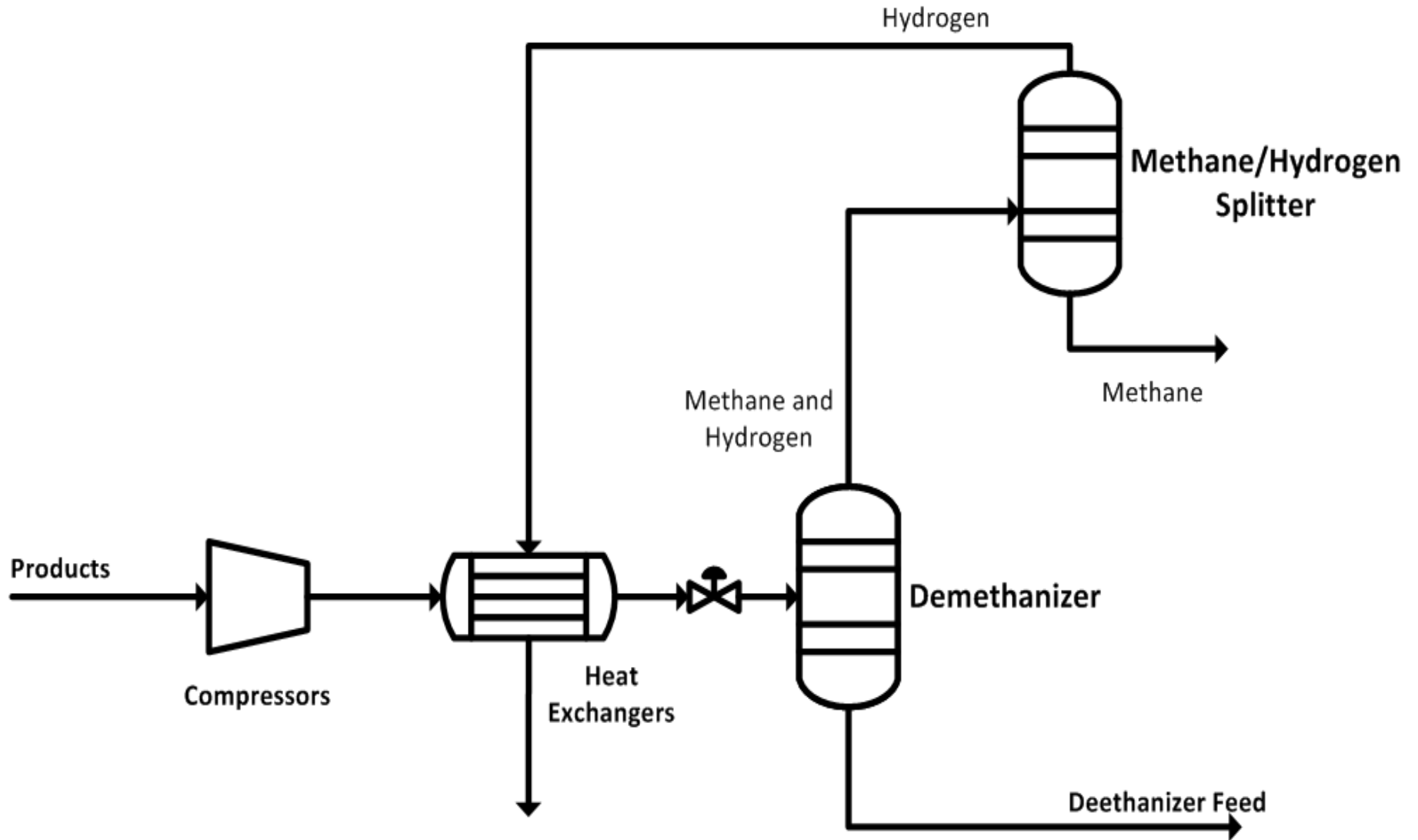


The fractionation process is a series of distillation towers that separates the products from the byproducts.

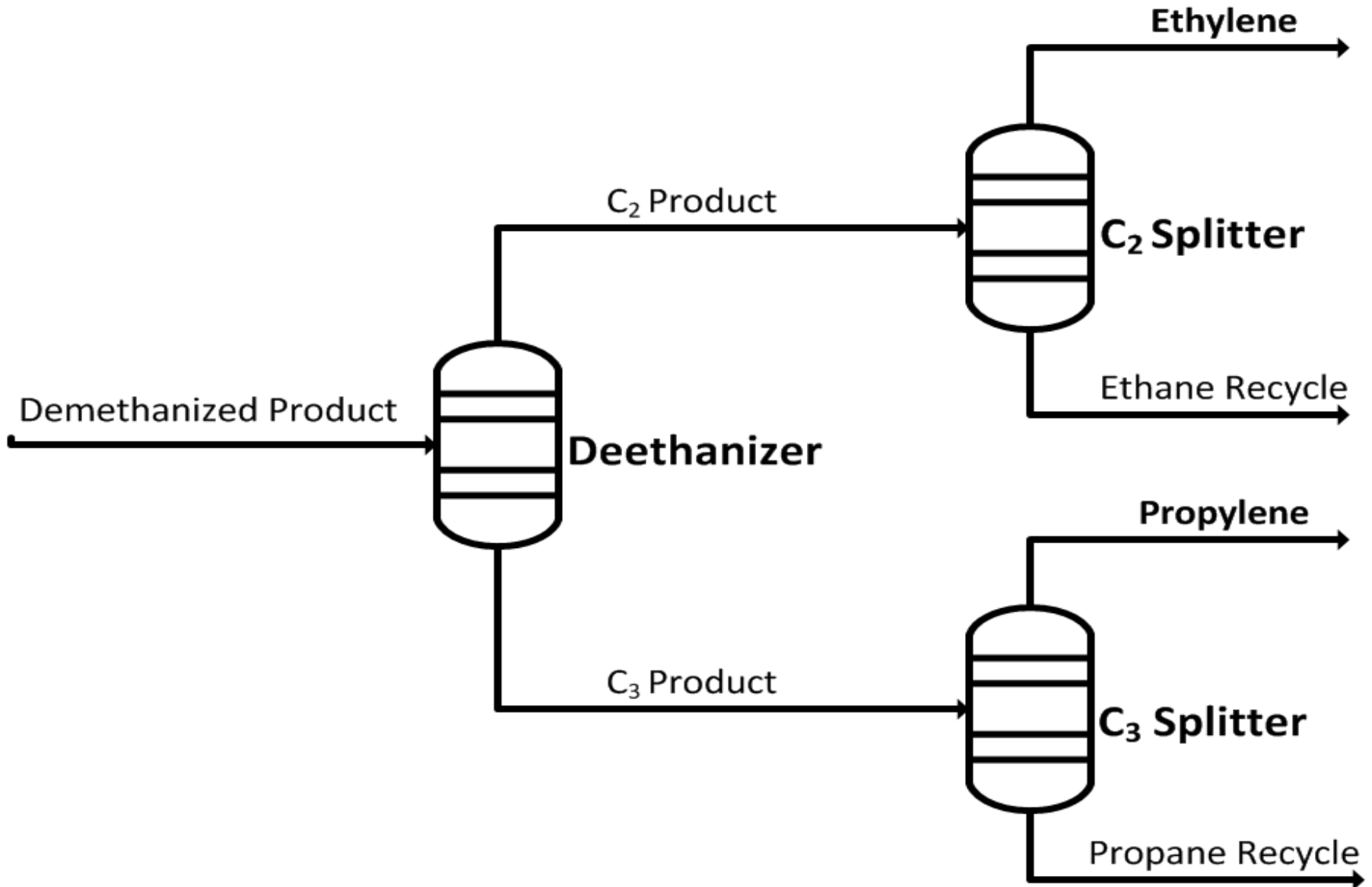
# Fractionation Towers



# Fractionation Towers



# Fractionation Towers



# Material Balance

Materials In	
Component	Lb/hr
Ethane	180000
Propane	60000
Water	2200000

Recycle	
Component	Lb/hr
Ethane	150906
Propane	30694

Materials Out	
Component	Lb/hr
Ethylene	166489
Propylene	15924
Methane	31760
Hydrogen	17255
Heavies	8572
Water	2200000

Totals	Lb/hr
Materials In	2440000
Materials Out	2440000

# Equipment Cost

MM\$	
Valves	\$0.90
Pumps	\$17.61
Compressor	\$44.81
Furnace/ Crackers	\$47.51
Heat Exchangers	\$4.17
Vessels	\$0.23
Towers & Trays	\$12.58
Mole Sieve	\$3.19
<b>TOTAL ISBL FOB</b>	<b>\$127.84</b>
Index Time	
Correction	1.53
<b>Corrected FOB</b>	<b>\$199.27</b>



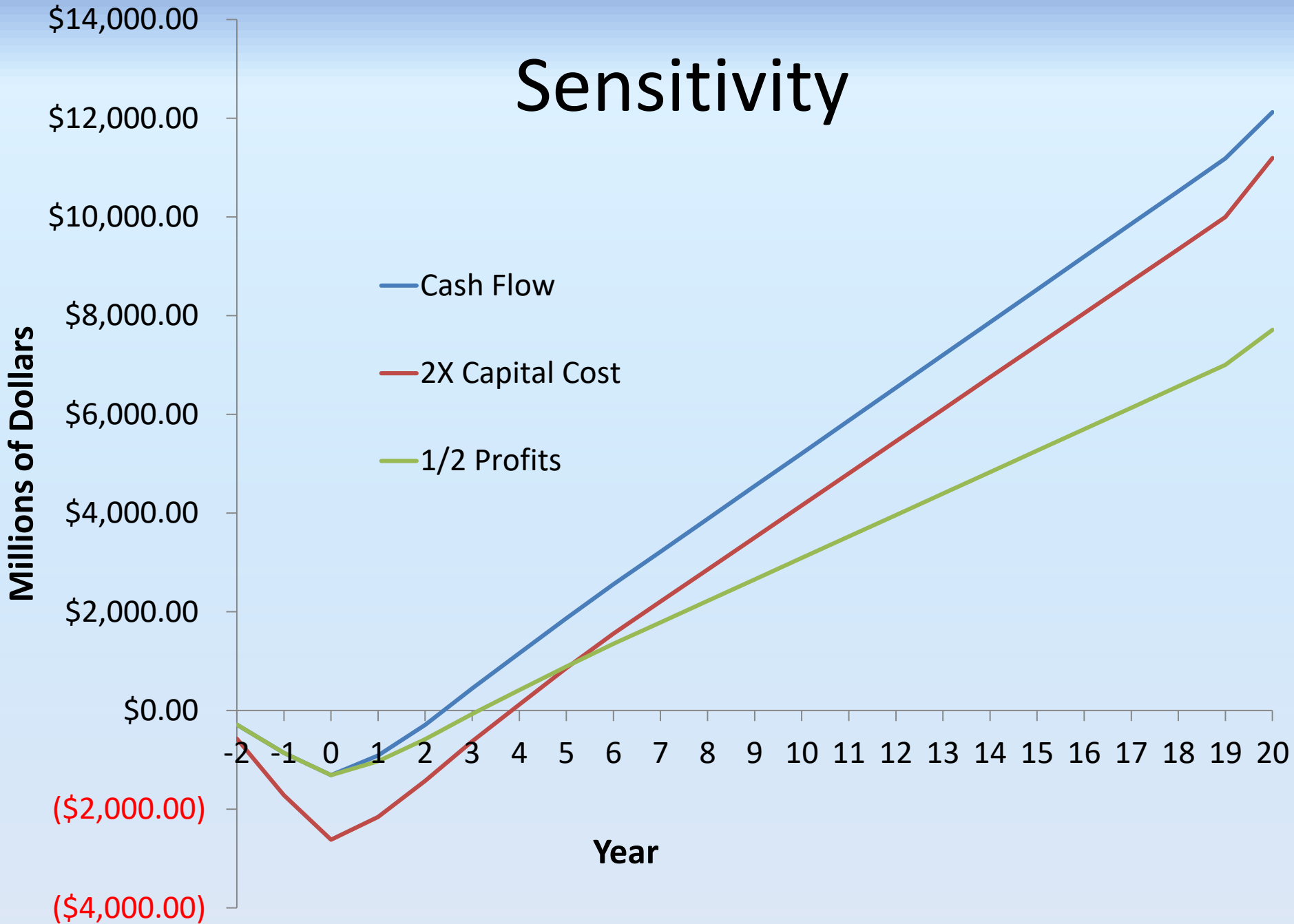
# Capital Cost Summary

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Installed ISBL	\$1,104.78
Installed OSBL	\$11.05
Working Capital	\$165.72
Property	\$28.00
Total Capital Cost	<b>\$1,309.54</b>
NPV0	<b>\$12,124.41</b>
IRR	<b>34.8%</b>
PBP (years)	<b>2.4</b>

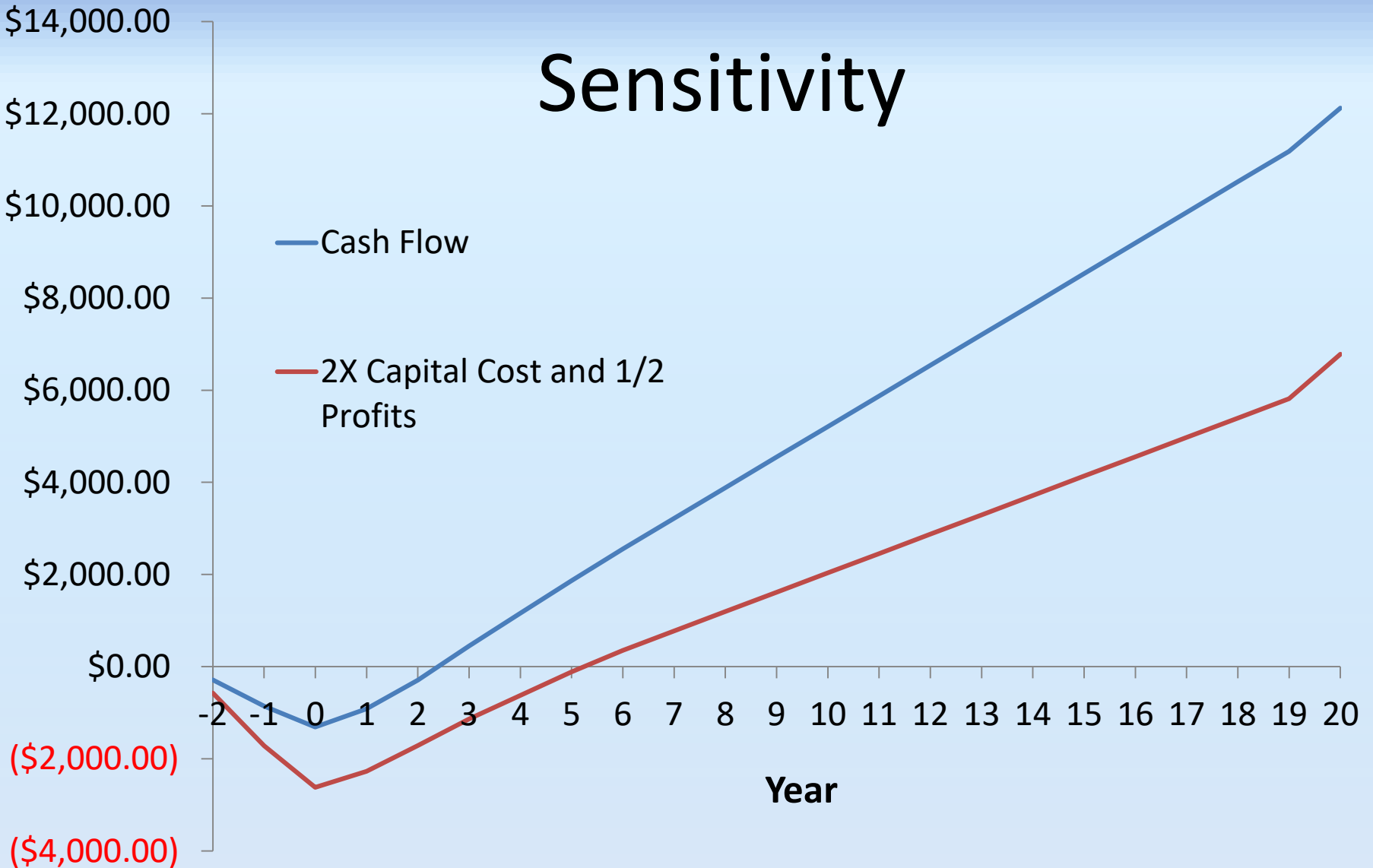
NPV, IRR, and payback period (Millions of dollars)

# Sensitivity



# Sensitivity

Millions of Dollars

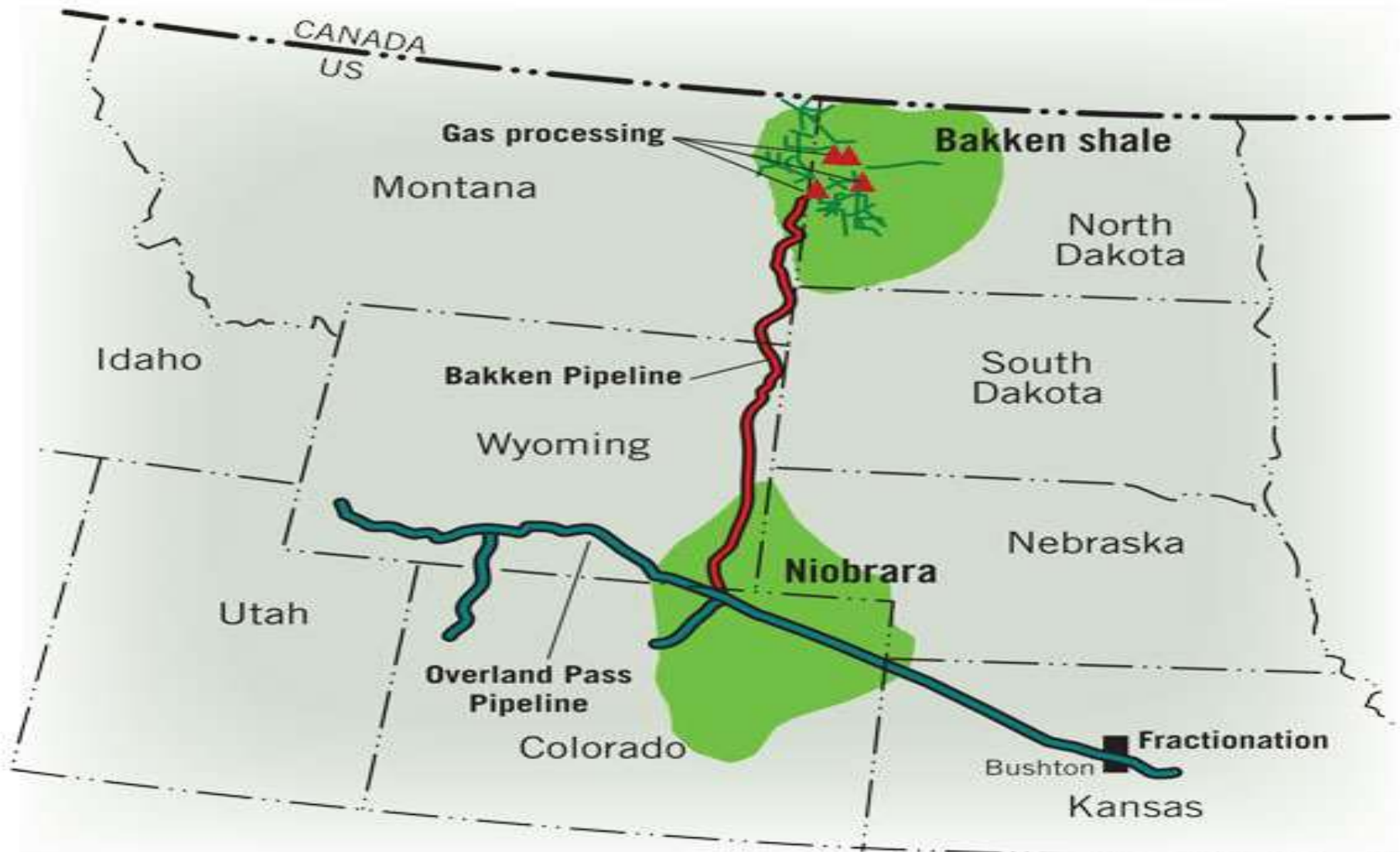


NPV0 \$6,782.5 and 14.7% IRR based on double capital cost and half the product selling price

# Feed Pipeline

## BAKKEN NGL PIPELINE

FIG. 1



# Feed Pipeline



# Feed Pipeline



# Plant Location



# Environmental Issues

- Emissions:
  - Crackers (The emission of CO<sub>2</sub> in steam cracking process is 180-200 million tons worldwide)
  - Flares
  - Turbine Compressors
- Water Treatment:
  - Quench system

# Risk Management

- Health and Safety:
  - High flammability
  - Exposure (It includes inhalation, ingestion and repeated exposure)
- Regulations:
  - Employees training
  - Operating procedures

# Accomplishments

- Built and optimized an olefin plant in Aspen+
- Decide the location of our plant
- Finished all the economic and pricing estimations on most of the equipment
- Heat integration (e.g. Heat exchanger)
- Environmental issues
- Acquired vendor information on major equipment

# References

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- [8] <http://www.ineos.com/businesses/INEOS-Olefins-Polymers-USA/Products/>



**Questions?**