Natural Gas to Oxygenated Gasoline

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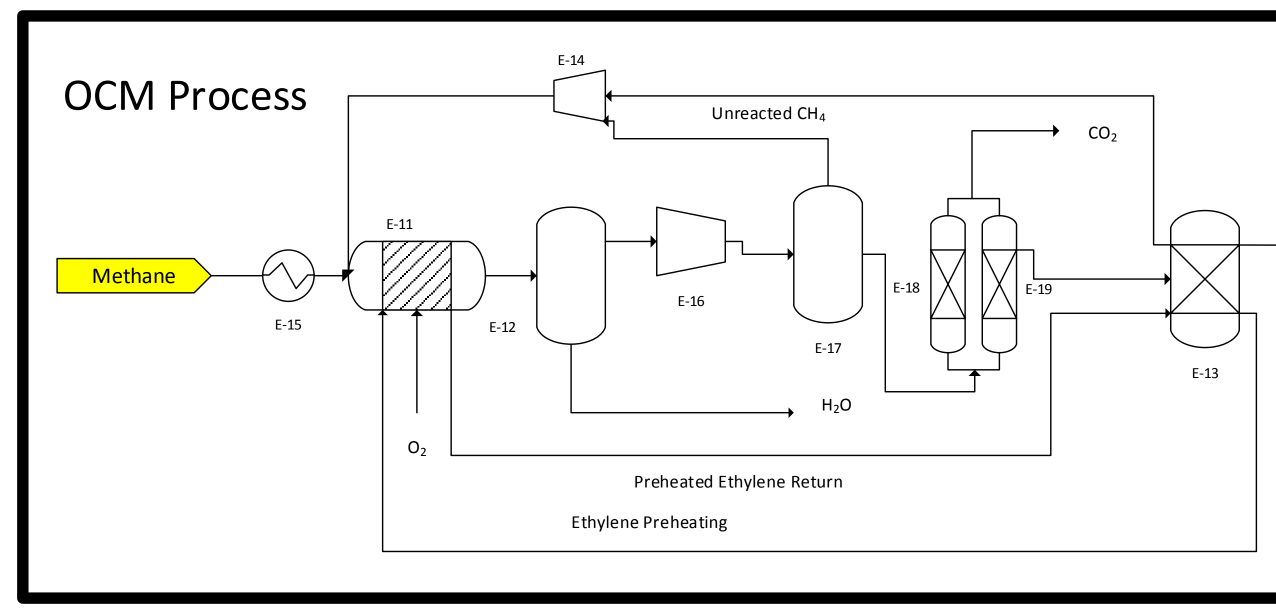
Abstract

Methane is taken from a variety of sources including landfill, drilling flare, or standard pipeline and converted to gasoline and ethanol. This is accomplished by utilizing rapid prototype inorganic nanowire catalysts in conjunction with oxidative coupling of methane (OCM) to ethylene. This ethylene is converted to gasoline and ethanol by an ethylene to liquid fuel (ETL) process and an ethylene hydration (EH) process respectively. The result is a clean, oxygenated fuel for transportation.

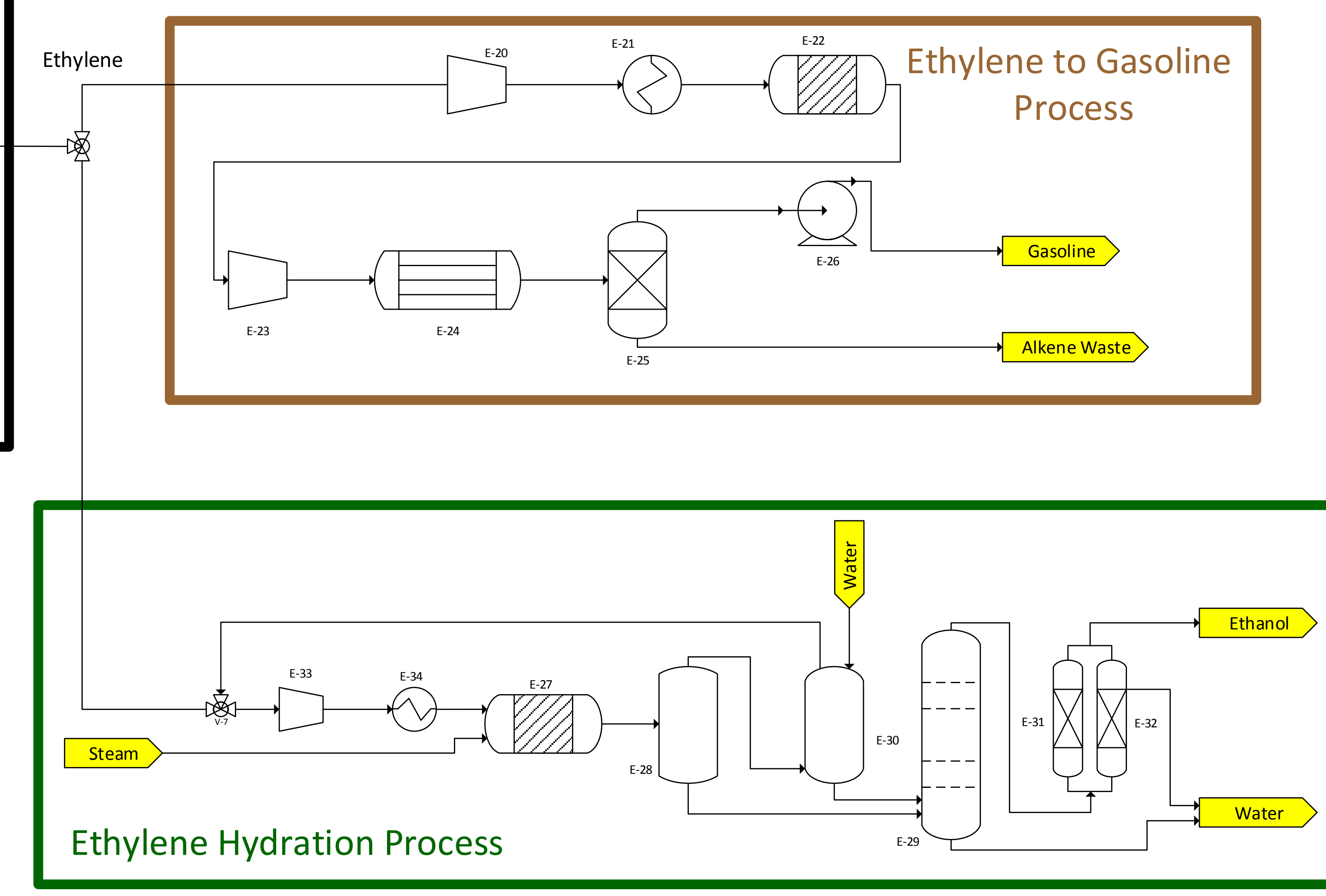
Novelty

- Production of gasoline in situ for remote locations
- Goal is to produce fuel for a town 10,000 people
- Utilizes waste methane from oil wells as feed
- Eliminates need to import fuel
- Uses enhanced nanowire catalysts for ethylene
- Reduced production cost when compared to current methods (Fisher Tropsch)

Process Flow Diagram



Equipment List Description			
Equipment Label	**Description**	**Equipment Label**	**Description**
E-11	OCM Reactor	E-23	Compressor E
E-12	Flash Separator 1	E-24	Condenser
E-13	Ethylene Recovery	E-25	Flash Separator
E-14	Compressor C	E-26	Pump A
E-15	Methane Preheater	E-27	Ethylene Hydration Reactor
E-16	Ethylene Compressor	E-28	Flash Separator
E-17	Flash Separator 2	E-29	Ethanol-Water Distillation
E-18	OCM Adsorption Column 1	E-30	Ethanol Absorber
E-19	OCM Adsorption Column 2	E-31	EH Adsorption Column 1
E-20	Compressor D	E-32	EH Adsorption Column 2
E-21	Heater A	E-33	EH Inlet Compressor
E-22	ETL Reactor	E-34	EH Reactor Preheater



Reactions

Oxidative Coupling of Methane (OCM):

$$2CH_4 + O_2 \rightarrow C_2H_4 + 2H_2O$$
$$\Delta H_R = -67 \text{ kCal/Gmol}$$

Ethylene to Liquid Fuels:

$$C_2H_4 \rightarrow \text{gasoline}^{**}$$

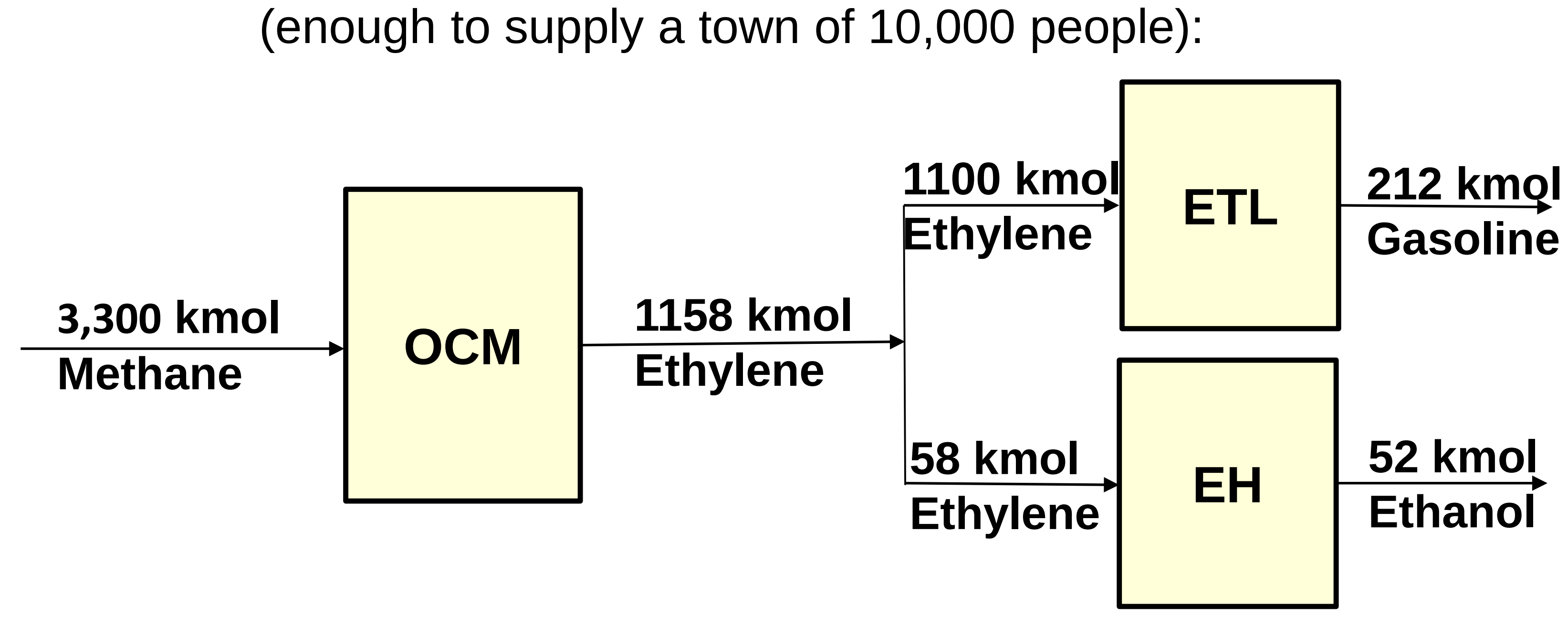
Ethylene Hydration

$$C_2H_4 + H_2O \rightarrow CH_3CH_2OH$$
$$\Delta H_R = -10.8 \text{ kCal/Gmol}$$

**Gasoline produced was assumed to consist of approximately 71% alkanes (modelled as octane), 3% alkene impurities, and 26% aromatics (modelled as 13 aromatic classes, mainly toluene).

Overall Production Rates

The following diagram contains the overall process mass balance. The gasoline and ethanol streams are combined to produce an approximately 90% gasoline, 10% ethanol mixture totaling 7,260 gallons per day (enough to supply a town of 10,000 people):



Simulation and Methods

- Simulations were primarily run in Aspen Plus and custom Microsoft Excel VBA programs.
- ETL and OCM reactor models were based on reaction stoichiometry and conversion rates from Synfuels and Siluria-designed catalysts.
- The EH reactor model utilized conversion data and Langmuir-Hinshelwood-Hougen-Watson (LHHW) rate kinetics for a zirconium tungstate catalyst.
- Simulations were completed for each the OCM process, the ETL process, and the EH process independently. The processes were then combined to simulate from methane to oxygenated fuel.
- The predicted mass balance aligned very well with the simulations that were run in Aspen Plus, validating the methods that were used.