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Techno-economic Analysis for the Integration of Advanced Nuclear Power with a Reference Methanol-Synthesis Plant

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IES
Integrated Energy Systems

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EXECUTIVE SUMMARY

Efforts continue to identify the most-economic methods to decarbonize several sectors of the United States (U.S.) economy. Industrial processes such as synfuel synthesis and high-value commodity chemicals rely heavily on energy-dense and easily stored and transported fossil fuels, which power and feed their operations. The steam methane reformer (SMR) is a widely used pathway for producing methanol (CH_3OH). In this process, methane (CH_4) from natural gas (NG) reacts with steam produced from water (H_2O) over a catalyst at high temperatures (700–1,000°C) to produce syngas, a mixture of hydrogen (H_2) and carbon monoxide (CO). The syngas is then converted into CH_3OH through a second catalytic reaction. This method is known for being an efficient and commonly employed pathway for industrial CH_3OH production. The high-temperature heat needed for SMR, which is currently used in the NG-to-CH_3OH process, cannot be supplied by small modular nuclear reactor (SMNR) direct heating; the temperatures required for the SMR process exceed those of the main steam produced by near-market high-temperature gas reactors (HTGRs).

For the conventional process of producing CH_3OH, this leaves possible nuclear-integration opportunities that include: (1) blending nuclear H_2 into the SMR NG fuel, or (2) assessing alternative synthesis routes leveraging nuclear capabilities and steam electrolysis outputs. In the reference CH_3OH plant, SMR provides the methanol-synthesis reactor with H_2 and CO. In Case 2, the state-of-the-art reverse water gas shift (RWGS) pathway achieves the same, sourcing carbon from an industrial carbon dioxide (CO_2) source.

If the NG import for the SMR furnace is eliminated so the only carbon-containing fuels are the recycled light gases from the separation portion of the plant, whether by electrical heating or instead blending high-temperature steam electrolysis (HTSE)-H_2 into the fuel gas, the emissions from the reference CH_3OH plant would be reduced by 64%. On the national-scale, this would reduce total greenhouse gas (GHG) emissions by nearly 1 million metric tons per year (MMT/yr.). Because of the promising opportunity for further nuclear decarbonization, the RWGS pathway for the front-end of the CH_3OH process was investigated. Nuclear H_2 and CO_2 from an industrial source would react in an RWGS reactor to produce syngas, which would then go into the methanol-synthesis reactor. Replacing the 1 MMT/yr. reference methanol plant with this state-of-the-art plant would require the H_2 production of a 1 gigawatt electrical (GWe) nuclear power plant (NPP) and would defer 1.4 MMT/yr. of CO_2 emissions from another source into a feedstock for liquid fuels or chemical manufacturing.

Nuclear power is a viable and energy-dense source of clean electricity, heat, and H_2 that could provide the large, sustainable energy supply demanded by the synfuels and chemicals synthesis industry. The U.S. Department of Energy's (DOE's) Integrated Energy Systems (IES) program is working to perform research and development, design, economic siting, and risk analysis to show how advanced nuclear reactors can be integrated with the existing industry to provide clean energy, thereby reducing CO_2 and other emissions. This state-of-the-art effort seeks to enable the first onsite demonstrations and commercial deployments of advanced SMNRs integrated with industries such as chemical production, refining, iron- and steel-making, and more. The DOE IES seeks to demonstrate the ability of advanced nuclear reactors to meet the heat and power demands of these industries while reducing CO_2 emissions in a sustainable and cost-competitive way.

The primary objective of the current research work documented in this report is to design, analyze, and document industrial-scale SMNR integration with a reference methanol-synthesis plant. The foreseen outcome is the provision of reliable, cost-competitive, and sustainable clean energy, alongside a reduction of CO_2 emissions. Specifically, the focus of this work lies on meeting the heat and electricity demands of the reference facilities with nuclear power while also supplying clean H_2 via integrated HTSE. This report presents a comprehensive techno-economic assessment of the integration of advanced nuclear reactors into a reference methanol-synthesis plant, as well as considering financial incentives from the Inflation Reduction Act (IRA) of 2022. The evaluation aims to explore the potential economic benefits and

challenges associated with incorporating advanced nuclear reactors into methanol-synthesis plant operations, particularly in terms of energy efficiency, economic implications, and environmental impact. By examining both the technical feasibility and economic viability, this analysis seeks to identify existing gaps and propose solutions for successful nuclear-integration implementation. The findings are intended to provide valuable insights for stakeholders considering the adoption of advanced nuclear reactors in the synfuels and chemicals synthesis sectors.

A CH_3OH reference plant for the SMR-based methanol-synthesis process was modeled in Aspen Plus V12 to serve as a base case for comparison with various nuclear-integration options. The capacity used for this study stands at 1 MMT/yr. of NG to CH_3OH, and all the estimations and assumptions followed accordingly are based on this reference capacity. It is important to note the total nationwide methanol-production capacity estimations indicate the nine operative methanol facilities currently functional in the U.S. collectively produce an average of 967,800 metric tons per year (MT/yr.). A summary of all cases considered in this study is shown in Table 1 based on the assumption that SMNRs are available with rated thermal power in increments of 200 megawatt thermal (MWth).

Table 1. Study cases for advanced nuclear reactor integration. Inputs and outputs relative to business-as-usual (BAU) case. Delta and percent change from BAU shown in parenthesis.

Case Number	**Description**	**Methanol production (MT/yr.)**	**NG Fed Usage (MT/day)**	**CO_2 emissions (kMT/yr.)**	**CO_2 feedstock (MT/day)**	**SMNR energy use (MWth)**	**Electricity export sales (MWe)**
BAU	Reference CH_3OH plant	1,000,000	1605	483	-	-	-
1 - Nuclear hydrogen and NG fuel blend	1a- Nuclear hydrogen from 200 MWth HTGR/HTSE – Backs out 38.4% of NG from fuel-gas blend	1,000,000	1488 (-117, -7.3%)	365 (-118, -24.4%)	-	200	2
	1b - Nuclear hydrogen from 400 MWth HTGR/HTSE – Backs out 76.7% of NG from fuel-gas blend	1,000,000	1371 (-234, -14.6%)	247 (-236, -48.9%)	-	400	2
	1c - Nuclear hydrogen from 600 MWth HTGR/HTSE – Backs out 100% of NG from fuel-gas blend and puts surplus electricity onto the grid	1,000,000	1300 (-305, -19.0%)	175 (-308, -63.8%)	-	600	33.4
2 - SMR replacement by RWGS pathway that sources carbon from an industrial CO_2 source	Nuclear electricity + HTSE-H_2 + RWGS	1,000,000	0 (-1605, -100%)	286 (-197, 40.1%)	4855	2800	52

A summary of the main findings of the technical analysis of SMNR integration with this reference methanol-synthesis plant includes:

- The reference methanol plant, before integration with SMNRs in the BAU Case, emits approximately 483k metric tons per year (kMT/yr.) of CO_2.
- Nuclear H_2 from a 200 MWth HTGR/HTSE to the SMR furnace reduces 118 kMT/yr. of CO_2 by backing-out about 38.4% of the NG from the fuel-gas blend, as described in Case 1a. Doubling the thermal power of the HTGR to 400 MWth doubles the emission reduction to 236 kMT/yr. and increases the hydrogen input such that the total NG back-out to 76.7%.
- A 600 MWth HTGR can produce enough H_2 to completely eliminate the NG burned in the SMR furnace to satisfy the required heat combustion of the reference plant and bring the total emissions in the plant down to 175 kMT/yr., as observed in Case 1c.
- By fully replacing the SMR with a RWGS reactor type, an overall deeper decarbonization is possible. Industrial CO_2, rather than NG, is converted to methanol with nuclear-integrated H_2 production via HTSE. A total of 197 kMT/yr. of SMR reactor-derived CO_2 emissions are avoided, and 1605 tons per day of NG fuel usage can be eliminated. This is a reduction of 40.1% of the overall CO_2 emissions and 100% of the fossil fuel sources, as defined in Case 2. This configuration also led to an electricity surplus of 52 MWe from the 2800 MWth HTGR/HTSE system.

The gap analysis and techno-economic results of the above-mentioned integrations evaluated in this report show advanced nuclear power SMNRs can have an impact on reducing the CO_2 emissions in CH_3OH-synthesis plants. SMNRs need to efficiently handle energy requirements fluctuations without compromising the operational stability of the CH_3OH-synthesis plant or reactor safety. These safety evaluations are being considered within the IES program in separate research. The proposed integrations involve upfront investments for reactor construction, as well as operating and maintenance (O&M) costs that are evaluated against the economic benefits. Implementing SMNRs in CH_3OH-synthesis facilities has the potential for substantial long-term economic, resilience, and environmental advantages.

The economic analysis on each of the case studies provided in Table 1 was conducted with a variety of assumptions, including low, medium, and high SMNR cost-estimates and tax incentives from the IRA. A detailed summary of the economic results over a project lifetime of 40 years are shown in Table 2.

Table 2. Techno-economic analysis (TEA) results summary of advanced nuclear reactor integrations in CH_3OH-synthesis plants.

40-Year Project Lifetime					
Case Study		**Case 1a**	**Case 1b**	**Case 1c**	**Case 2**
High-Level Reactor Cost		**Capital Expenditures (CAPEX) for an HTGR = $8,000/kilowatt electrical (kWe)**			
IRA Benefits	Tax Credits	ITC-48E + PTC-45V	ITC-48E + PTC-45V	ITC-48E + PTC-45V	ITC-48E + PTC-45V
Financial Metrics	Net Present Value (NPV)	$590M	$291M	-$251M	-$6908M
	Avoided Cost of Carbon (ACC) (\$/mtCO_2) w/o credits	$123.9	$121.6	$139.4	$1,087.0
	Avoided Net Cost of Carbon (ANCC) (\$/mtCO_2) w/credits	$25.0	$22.8	$35.1	$282.1
	Internal Rate of Return (IRR)	42.0%	22.0%	-2.0%	-
Medium-Level Reactor Cost		**CAPEX HTGR = $5,500/kWe**			
IRA Benefits	Tax Credits	ITC-48E + PTC-45V	ITC-48E + PTC-45V	ITC-48E + PTC-45V	ITC-48E + PTC-45V
Financial Metrics	NPV	$793M	$832M	$560M	-$2963M
	ACC (\$/mtCO_2)w/o credits	$87.3	$85.0	$97.3	$780.0
	ANCC (\$/mtCO_2) w/credits	$0.0	-$2.3	$6.3	$72.0
	IRR	60.0%	43.0%	29.0%	-
Low-Level Reactor Cost		**CAPEX HTGR = $3,000/kWe**			
IRA Benefits	Tax Credits	ITC-48E + PTC-45V	ITC-48E + PTC-45V	ITC-48E + PTC-45V	ITC-48E + PTC-45V
Financial Metrics	NPV	$928M	$1171M	$1089M	$199M
	ACC (\$/mtCO_2) w/o credits	$60.1	$57.9	$66.1	$552.3
	ANCC (\$/mtCO_2) w/credits	-$22.4	-$17.9	-$17.8	-$58.8
	IRR	90.0%	69.0%	54.0%	16.0%

ITC-48E: clean electricity investment tax credit, **PTC-45V:** clean hydrogen production tax credit

The main outcomes of the TEA for SMNR integration with the reference CH_3OH-synthesis plant for all evaluated case studies over a 40-year project lifetime are as follows:

- The CAPEX for the SMNR is the main cost driver that impacts the difference in potential profits between all case studies.
- Tax credits (e.g., ITC, PTC) are the main revenue drivers:
    - The ITC-48E credit, which subsidizes the installation costs for the SMNR, is more advantageous than the PTC-45Y credit, which only provides revenue for clean electricity production.
    - PTC-45V provides revenue for the case studies where clean H_2 is produced onsite.
- For the nuclear H_2 and NG fuel blend cases, the ACC can go below \$147.7/ton CO_2 without considering the IRA tax credits, as described in Case 1c. For the low-level reactor cost scenario, where ACC is expressed as a negative value in Table 2, this can be considered as revenue. In those cases where the ACC is influenced by the IRA tax credits with ITC-48E and PTC-45V applied to the clean electricity investment and nuclear H_2 HTSE production process, the ACC (as revenue) can go up to \$20.7/ton CO_2 abated, as seen with Case 1a.
- When an advanced nuclear reactor is built and integrated into CH_3OH-synthesis operations, the case with the common highest absolute NPV among all three nuclear cost levels is Case 1b, where the NPVs, including the tax credits, reach \$1168M, \$829M, and \$288M, respectively, for the low-, medium-, and high-reactor capital cost levels assumed in this study. This assumption includes the ITC-48E credit for the SMNR and the PTC-45V credit for the H_2 used in the process.
- Case 2 presents the highest total costs since the SMNR required to cover these scenarios also has the highest-rated thermal power of 2800 MWth, which increases the total investment and considerably impacts the ACC and NPV at the end of the project lifetime. Case 2 includes a different CH_3OH-synthesis pathway approach—RWGS—requiring massive quantities of H_2; however, these technologies have not been fully industrially scaled at the time of this investigation:
    - Replacing NG with H_2 in the SMR furnace fuel gas makes the Case 1 variants more cost-competitive relative to Case 2. Case 1 requires minimal retrofits to the process, while the high-costs associated with Case 2 are due to the major modifications and changes in the process, including the requirement of more SMNR capacity, these factors led to higher NPVs in Case 1 than in Case 2.
- When the IRA ITCs and PTCs are excluded, higher levels of decarbonization have less annual revenue after tax. However, in the cases where the IRA ITCs and PTCs are included, a proportional relationship between the quantity of CO_2 emissions that were avoided and the avoidance costs was shown:
    - For the nuclear H_2 and NG fuel blend in Cases 1a, 1b, and 1c, which are eligible for the ITC-48E and PTC-45V credits, the potential exists to achieve increased levels of CO_2 emissions reduction with minimal or negative ACC.
    - Cases 1a, 1b, 1c, and 2 provide significant cost-savings associated with the SMNR-based CH_3OH-synthesis decarbonization for the lowest reactor cost case, including the IRA credits.
    - Cases 1b, 1c, and 2 are the most impactful cases in that they provide a 49–64% reduction in CO_2 emissions, while resulting in a significant reduction in CO_2 avoidance costs, when tax credits are considered.
- Case 2 has a higher decarbonization potential by using CO_2 industrial sources. While TEA results have shown high costs and less profits associated with, because it can’t take advantage of carbon credits and requires larger SMNR capacity. The conventional 1a through 1c cases seem more profitable because they need a smaller SMNR and require less changes.

CONTENTS

FIGURES

TABLES

ACRONYMS

ACC	avoided cost of carbon
ANCC	avoided ne cost of carbon
ANL	Argonne National Laboratory
BAU	business-as-usual
BFD	block-flow diagram
BMT	billion metric tons
BOAK	best-of-a-kind
BTL	biomass-to-liquid
CAPEX	capital expenditures
CFPP	coal-fired power plant
CH_3OH	methanol
CH_4	methane
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
DCC	direct capital cost
DCF	discounted cash flow
DF	discount factor
DME	dimethyl ether
DOE	U.S. Department of Energy
EBITDA	earnings before interest, taxes, depreciation, and amortization
EBT	earnings before taxes
EPA	U.S. Environmental Protection Agency
EtOH	ethanol
FLIGHT	Facility Level Information on Greenhouse Gases Tool
FOAK	first-of-a-kind
GAIN	Gateway for Accelerated Innovation in Nuclear
GHG	greenhouse gas
GHGRP	Greenhouse Gas Reporting Program
GWe	gigawatt electrical
H_2	hydrogen
H_2O	water
HP	high-pressure

HTGR	high-temperature gas reactor
HTSE	high-temperature steam electrolysis
ICC	indirect capital cost
IES	Integrated Energy Systems
INL	Idaho National Laboratory
IP	intermediate pressure
IPCC	Intergovernmental Panel on Climate Change
IRA	Inflation Reduction Act of 2022
IRR	internal rate of return
ITC	investment tax credit
kMT/yr.	k metric tons per year
kWe	kilowatt electrical
LHV	lower heating value
LP	low pressure
LWR	light water reactor
MACRS	Modified Accelerated Cost Recovery System
MMT	million metric tons
MMT/yr.	million metric tons per year
MP	medium pressure
MT/yr.	metric tons per year
MW	megawatts
MWe	megawatt electrical
MWth	megawatt thermal
NG	natural gas
NIHPA	nuclear-integrated hydrogen production analysis
NOAK	nth-of-a-kind
NPP	nuclear power plant
NPV	net present value
NRC	U.S. Nuclear Regulatory Commission
O	oxygen
O&M	operating and maintenance
OCC	overnight capital cost
PFD	process-flow diagram
PTC	production tax credit
RE	renewable energy

RWGS	reverse water gas shift
SET	Standard Economic Tool
SMNR	small modular nuclear reactor
SMR	steam methane reformer
SOEC	solid oxide electrolyzer cell
TEA	techno-economic analysis
U.S.	United States
WACC	weighted average capital cost

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Preliminary Technical and Economic Assessment and Gap Analysis of Advance Nuclear Reactor Integration with a Reference Methanol Plant

1. INTRODUCTION

Despite significant efforts to reduce carbon dioxide (CO_2) emissions focused primarily on electricity generation, electric-power generation only accounts for 25% of the total greenhouse gas (GHG) emissions in the United States (U.S.) [1]. As of 2021, the industrial sector was ranked as the third-largest contributor of direct GHG emissions in the U.S., producing around 23% of the total national emissions, trailing closely behind the transportation sector at 28% [1]. Furthermore, when considering electric-power emissions by end-use, the industrial sector owns approximately 30% of lifecycle emissions [2]. In a 2022 study conducted by the Intergovernmental Panel on Climate Change (IPCC), the industrial sector's GHG emissions totaled about 1,393 million metric tons per year (MMT/yr.), with forecasts predicting a 7% reduction to 1,282 MMT/yr. by 2050 [3].

According to the Greenhouse Gas Reporting Program (GHGRP) report in 2021 [1], the chemicals sector (non-fluorinated) is the third-largest GHG-emitting industrial sector among stationary sources behind coal-fired power plants (CFPPs) and petroleum and natural gas (NG) systems. While emissions from this sector increased by 1.1% from 2020 to 2021, the number of those reporting also increased. Here, it is seen that a total of 186 million metric tons (MMT) of carbon dioxide equivalent (CO_2e) was emitted by the chemicals industry in 2022, according to public data available in the U.S. Environmental Protection Agency's (EPA) Facility Level Information on Greenhouse Gases Tool (FLIGHT) [4].

Facilities producing methanol (CH_3OH) are located around the world, including in Asia, North and South America, Europe, Africa, and the Middle East. The industry has over 90 plants with a combined production capacity of around 110 MMT, or 36.6 billion gallons yearly [5]. The U.S. has a total of nine operational CH_3OH-synthesis plants, according to the latest available data from the EPA reported as of June 2023 [6] (see Appendix A), which illustrated that the nation's production of CH_3OH is predominantly located in the Gulf Coast region, primarily in Texas and Louisiana, and collectively contributes over 96% of the total production from seven of nine companies across the country. The remaining production, approximately 4%, is distributed between two companies located in Tennessee.

Accounting for the fact that these CH_3OH-synthesis plants vary in size, configuration, technologies, and capacity, the distribution of these facilities and emissions data in the three states are summarized as follows:

- Texas has the largest number of methanol plants in the U.S. at five sites producing a total of 4.4 MM/yr. of CH_3OH, with facilities in cities such as Pasadena, Pampa, and Beaumont, generating around a total of 1.2 MMT CO_2e/yr.
- Louisiana hosts two major CH_3OH-synthesis plants, in Geismar and St. James Parish, accounting for about 4.4 MMT of CH_3OH yearly and producing a total 1.6 MMT CO_2e/yr.
- Tennessee has two small CH_3OH plants accounting for a total of 0.89 MMT of CH_3OH produced, but their actual emissions are not publicly available at the time of this investigation.

Methanol, considered to be the simplest aliphatic molecule (one-carbon) of the alcohol family, which serves as a building-block molecule for the synthesis of other chemicals and solvents (e.g., acetic acid, formaldehyde, dimethyl ether, methylamine, methyl tertiary butyl ether) [7]. Further, methanol is regarded as a potential alternative to petroleum-based fuels because of its high oxygen (O) content, which leads to clean combustion, and reduced GHG emissions [8]. On the global scale, a GHGs emissions from various anthropogenic sources have increased; energy is the primary contributor, responsible for the release of 36.8 billion metric tons (BMT) of CO_2 and 135 MMT of methane (CH_4) into the atmosphere [9,10] annually. Therefore, there are important ongoing efforts to study different carbon sources and capture processes to sequester these gases and later convert them into value-added products like CH_3OH.

Today, CH_3OH production mostly relies on fossil feedstocks—e.g., NG and coal [7,11]—accounting for 85% from NG and coal feedstocks, where 65% of that ratio comes from NG and the remainder from coal. There are conventional chemical routes for CH_3OH production, such as the steam methane reformer (SMR) process of converting NG to form syngas, followed by catalytic conversion into methanol, as indicated in Figure 1, direct catalytic oxidation of CH_4, or CO_2 hydrogenation. Despite advancements in alternative production routes, such as biomass gasification and CO_2 hydrogenation, SMR remains a primary method to generate syngas due to its efficiency and scalability.

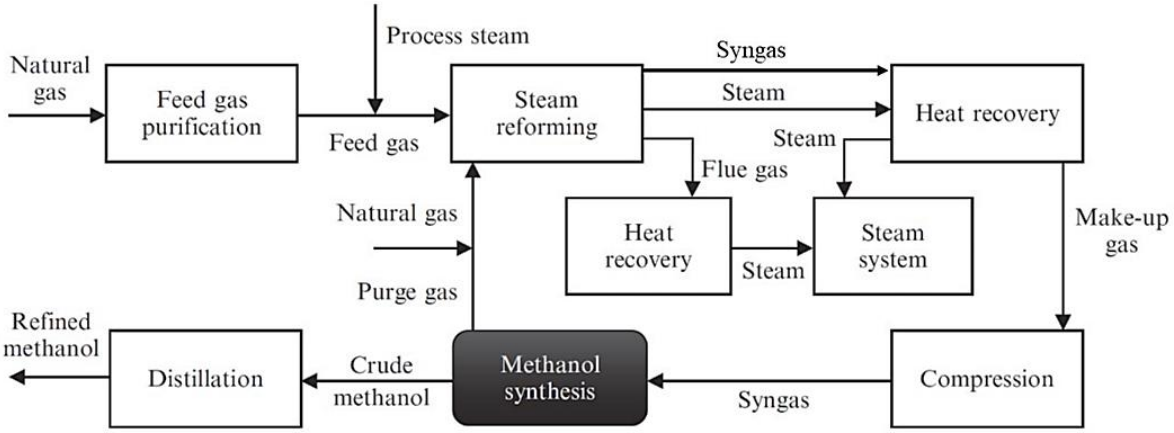
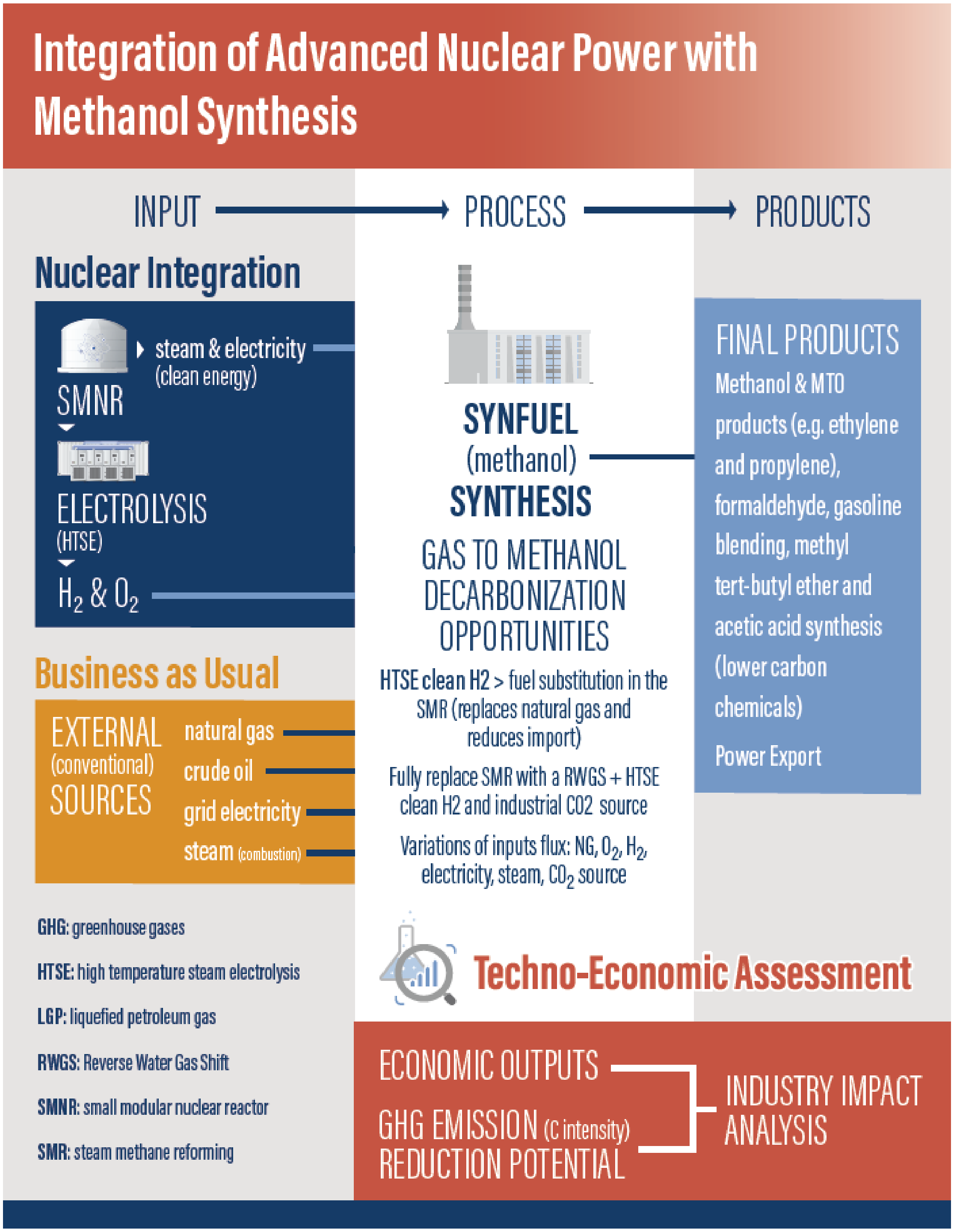


Figure 1. Methanol-synthesis process via SMR [12].

While numerous low-carbon technologies are available for electricity generation, innovative solutions are imperative to decarbonize sectors beyond electricity. Integrating nuclear power with the industry offers a distinct advantage, given the capability of nuclear energy to provide low-carbon heat and electricity. Achieving net-zero emissions in the U.S. by 2050 will require an additional 550–770 gigawatt electrical (GWe) of clean, reliable power, necessitating over 200 GWe of new nuclear capacity, as outlined in the 2023 report, “Pathways to Commercial Liftoff: Advanced Nuclear” [13].

Since synfuels are used frequently in the generation of nuclear power [14], this technical report aims to assess the integration of small modular nuclear reactors (SMNRs) at an industrial scale to decarbonize synfuels and chemical facilities and deliver reliable, competitive, and sustainable clean energy while reducing CO_2 emissions. Additionally, this report compares various integration options on a technical and economic basis, evaluating their CO_2-reduction potential. The focus is on a reference CH_3OH-synthesis process using the NG feed from an SMR unit to further convert hydrogen (H_2) and co-rich syngas into CH_3OH. The reference methanol plant could be potentially located in the cluster region (e.g., Gulf Coast) mentioned above. A reference-plant capacity of 1,000,000 metric tons per year (MT/yr.) was selected for process economics and nuclear-integration cost estimations performed on this analysis.

The study examines the potential of nuclear power to meet the energy needs of the reference methanol plant by producing clean H_2 via high-temperature steam electrolysis (HTSE) for fuel-gas blending. A second approach of fully eliminating the SMR unit replaced with a reverse water gas shift (RWGS) reactor fed with an industrial CO_2 source and electrolysis-H_2 is also assessed. The H_2 fuel blending and SMR substitution aim to partially or fully eliminate the need for NG imports, reducing this source of CO_2 emissions. Figure 2 illustrates the nuclear-integration opportunities assessed in this study and their impact on the overall process economics for the methanol-synthesis industries.



Integration of Advanced Nuclear Power with Methanol Synthesis

INPUT → PROCESS → PRODUCTS

Nuclear Integration

SMNR
steam & electricity
(clean energy)

ELECTROLYSIS
(HTSE)

H_2 & O_2

Business as Usual

EXTERNAL
(conventional)
SOURCES

natural gas
crude oil
grid electricity
steam (combustion)

GHG: greenhouse gases

HTSE: high temperature steam electrolysis

LGP: liquefied petroleum gas

RWGS: Reverse Water Gas Shift

SMNR: small modular nuclear reactor

SMR: steam methane reforming

SYNFUEL
(methanol)
SYNTHESIS

GAS TO METHANOL
DECARBONIZATION
OPPORTUNITIES

HTSE clean H2 > fuel substitution in the SMR (replaces natural gas and reduces import)

Fully replace SMR with a RWGS + HTSE clean H2 and industrial C02 source

Variations of inputs flux: NG, O_2, H_2, electricity, steam, CO_2 source

FINAL PRODUCTS

Methanol & MTO products (e.g. ethylene and propylene), formaldehyde, gasoline blending, methyl tert-butyl ether and acetic acid synthesis (lower carbon chemicals)

Power Export

Techno-Economic Assessment

ECONOMIC OUTPUTS

GHG EMISSION (C intensity)
REDUCTION POTENTIAL

INDUSTRY IMPACT
ANALYSIS

Figure 2. Methods and expected outcomes for nuclear power integration in methanol-synthesis processes.

This study leverages the reference plants and conceptual engineering designs for nuclear integration into the methanol industries developed in previous studies at Idaho National Laboratory (INL) [15] for a generic methanol plant based on existing U.S. facilities. Specific integration opportunities are identified and compared on a technical and economic basis, evaluating their CO_2-reduction potential for electricity, heat, and H_2 using SMNRs. The techno-economic analysis (TEA) described in Figure 3 provides insights for future project investments for the SMNR deployment in U.S. industries sectors.

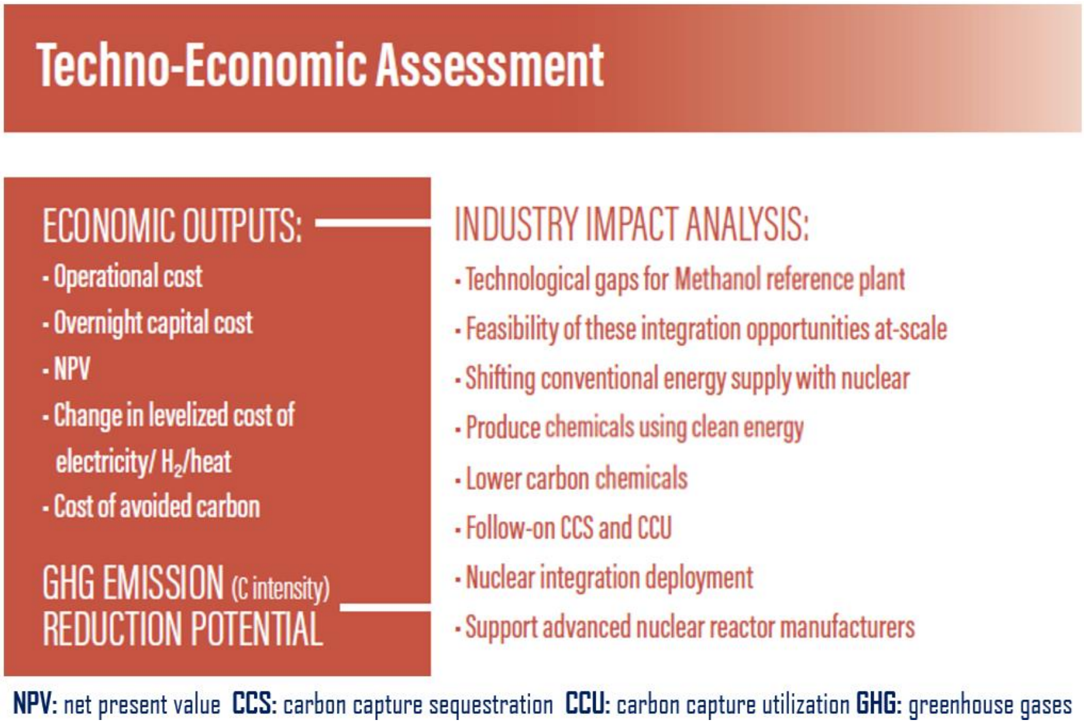


Figure 3. TEA considerations and methanol sector impact analysis.

This work supports the U.S. Department of Energy (DOE) Office of Nuclear Energy's Integrated Energy Systems (IES) Program by providing a preliminary technical and economic assessment and gap analysis of advanced nuclear reactor integration across the synfuels and chemicals industry.

To thoroughly understand the potential for decarbonization and nuclear integration in process economics, this report compiles comprehensive information from previous INL studies [15] and original assessments for the petroleum refining industry, including:

- Nationwide plant-level production capacities, distributions, and emissions.
- Process-flow diagrams (PFDs) and block-flow diagrams (BFDs) of the reference methanol plant and corresponding nuclear-integrated configurations, detailing main process-unit operations and conditions, including energy and material flows.
- Overall balance datasheets for each main process-unit operation, including electric-power consumption, heat demand from fuel combustion, steam consumption, steam generation, steam quality, heat loss, H_2 demand, heating value of byproducts, and CO_2 emissions.
- An evaluation of advanced nuclear reactor integration opportunities considering the overall process requirements.
- A consideration of each nuclear-integration case and its own variations, to conduct a TEA with a reference methanol plant by using the standard economic tool (SET), including:
    - The substitution of nuclear energy for a conventional energy supply
    - A reduction in the avoided cost of carbon (ACC) dioxide emissions
    - An advanced reactor construction and implementation schedule
    - Capital costs, engineering costs, etc.
    - Gaps in technology development and demonstration
    - Concepts of operations (including labor).

2. REFERENCE METHANOL PLANT

Currently, the nationwide methanol plant system configurations encompass a variety of technologies and feedstock-processing methods, as previously investigated at INL [15]. Table 3 shows a breakdown of the overall configurations, technologies, and feedstocks of these systems at the commercial and pilot scale

Table 3. Methanol-synthesis plant configurations and feedstock-processing systems at the commercial and pilot scale.

Facility	Technology	Feedstock	Processing
NG-based Plants	Steam Reforming	NG as the primary feedstock	NG undergoes steam reforming to produce syngas, which is primarily composed of H_2 and carbon monoxide (CO). Syngas is then converted into methanol through catalytic processes.
Coal-based Plants	Coal Gasification	Coal	Coal is gasified to produce syngas. Similar to NG-based plants, the syngas is then converted into methanol through catalytic processes.
Biomass-based Plants	Biomass Gasification or Fermentation	Biomass: woody and agricultural residues, or organic waste	Biomass can be converted into syngas through gasification processes or directly fermented into methanol using specialized enzymatic processes.
Renewable Methanol Plants	Electrolysis or Biomass-to-Liquid (BTL) Processes	Renewable electricity to produce H_2	Clean H_2 is then combined with CO_2 from various sources (e.g., industrial emissions, atmospheric capture) to produce methanol via catalytic processing.
Integrated Plants	Combines Multiple Technologies	Multiple feedstocks can be combined	For example, some plants may integrate NG with captured CO_2 from industrial processes or direct air capture to produce methanol, thus reducing CO_2 emissions.

Most methanol plants in the U.S. use NG, while the others still rely on coal gasification. This number might fluctuate in future years due to emerging commercial developments to incorporate newer configurations and technologies aimed at decarbonizing this industrial sector by incorporating carbon-capture technologies, proposing the adoption of more efficient catalytic processes, and promoting renewable energy to power plant operations. By transitioning towards cleaner and greener processing, NG-based methanol plants would have the potential to significantly reduce their environmental footprint while maintaining their role as key contributors to the methanol-production landscape in the U.S. Each configuration offers distinct advantages and considerations in terms of efficiency, feedstock availability, environmental impact, and technological complexity, contributing to the diverse landscape of methanol-production systems across the U.S.

The standard methanol-synthesis process around which the reference methanol plant is designed is depicted in Figure 4, this process configuration relies on the standard NG to methanol-synthesis process via SMR modeled in a previous investigation in INL using Aspen Plus [16].

NG is mostly comprised of CH_4 with a non-negligible portion of higher hydrocarbons. In this study, NG is assumed to have a molar composition of 95% methane, 3% ethane, and 2% propane. NG used as a raw material is introduced into the NG stream at a pressure of 35 bar (500 psi), which is the pressure of gas in NG pipelines. The energy required for preheating and the SMR reaction is supplied from the furnace by burning NG as a fuel. The NG fuel and ambient air then are introduced into the furnace along with the light ends from the fractionation section, where complete combustion occurs. The pressures and temperatures of the fuel and air stream are specified as 1.01 bar and 25°C, respectively.

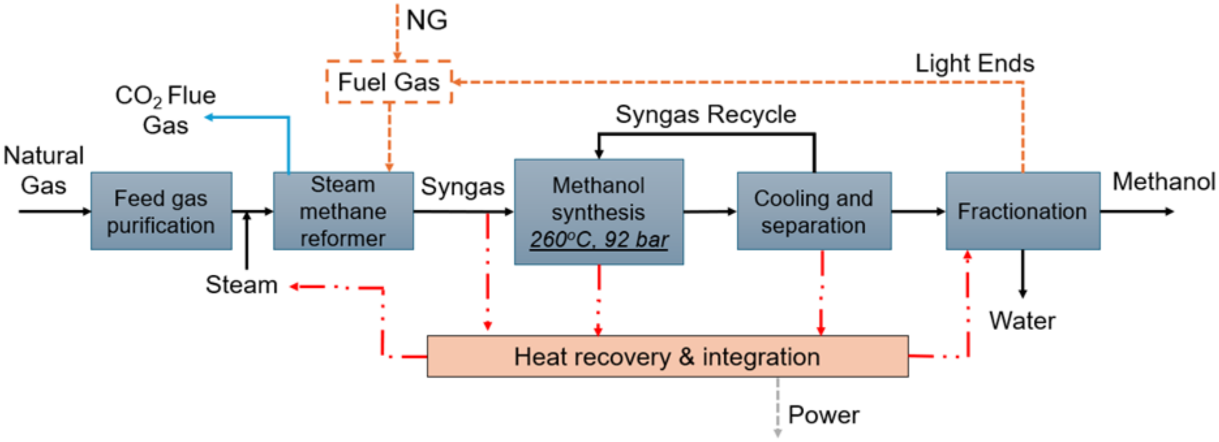


Figure 4. Standard methanol-synthesis via SMR [12].

The syngas stream exiting the SMR is then cooled, and the water (H_2O) is removed. Some of the heat from cooling the syngas is used to preheat feedstock streams, water and steam used in the chemical reactions. The methanol-synthesis process used in this model is based on Lurgi's Mega Methanol design (92 bar and Temp >290°C) [12] using two methanol reactors in series, producing CH_3OH as the target product and ethanol (EtOH) and dimethyl ether (DME) as byproducts, where the heat generated for the reactions is recovered for steam production. These condensate byproducts are then sent over a fractionation block for further separation and removal, achieving levels higher than 99.9% CH_3OH purity. A descriptive BFD of the process can be seen in Figure 4. A rationale for the conceptual basis of the chosen model is presented in Appendix A.

2.1 Configuration, Size, Assumptions

In the methanol industry, the production capacities of various U.S. facilities also experience dynamic changes over time due to various factors such as upgrades, complete shutdowns, expansions, and ownership changes. To simplify reference and energy estimations for the methanol-synthesis process models using Aspen Plus, the total nationwide production capacities shown in Figure 5 have been simplified to annual averages. These estimations indicate the nine methanol facilities in the U.S. collectively produce an average capacity of 967,800 MT/yr., with a median capacity of 800,000 MT/yr. Both the median and average capacities of nationwide methanol facilities fall under approximately 56% of the nationwide site capacities, as seen in Figure 5. The reference plant capacity used for this study stands at 1 MMT/yr of NG to methanol, while all the estimations and assumptions followed accordingly are based on this reference-plant capacity. A rationale for the conceptual basis of the chosen model is presented in Appendix A.

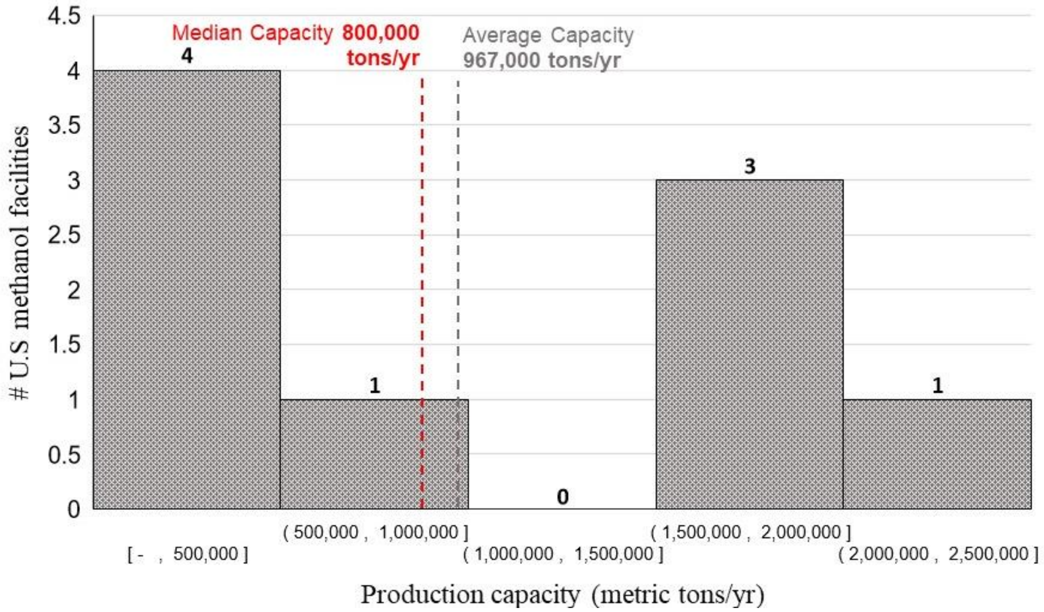


Figure 5. Nationwide methanol plant capacity distribution.

Emissions from six U.S. methanol plants were reported on the EPA FLIGHT website [4]. Figure 6 shows the relationship between GHG emissions and production capacity. The chosen reference-plant capacity for Aspen Plus corresponds to emissions totaling 476,066 tons per year.

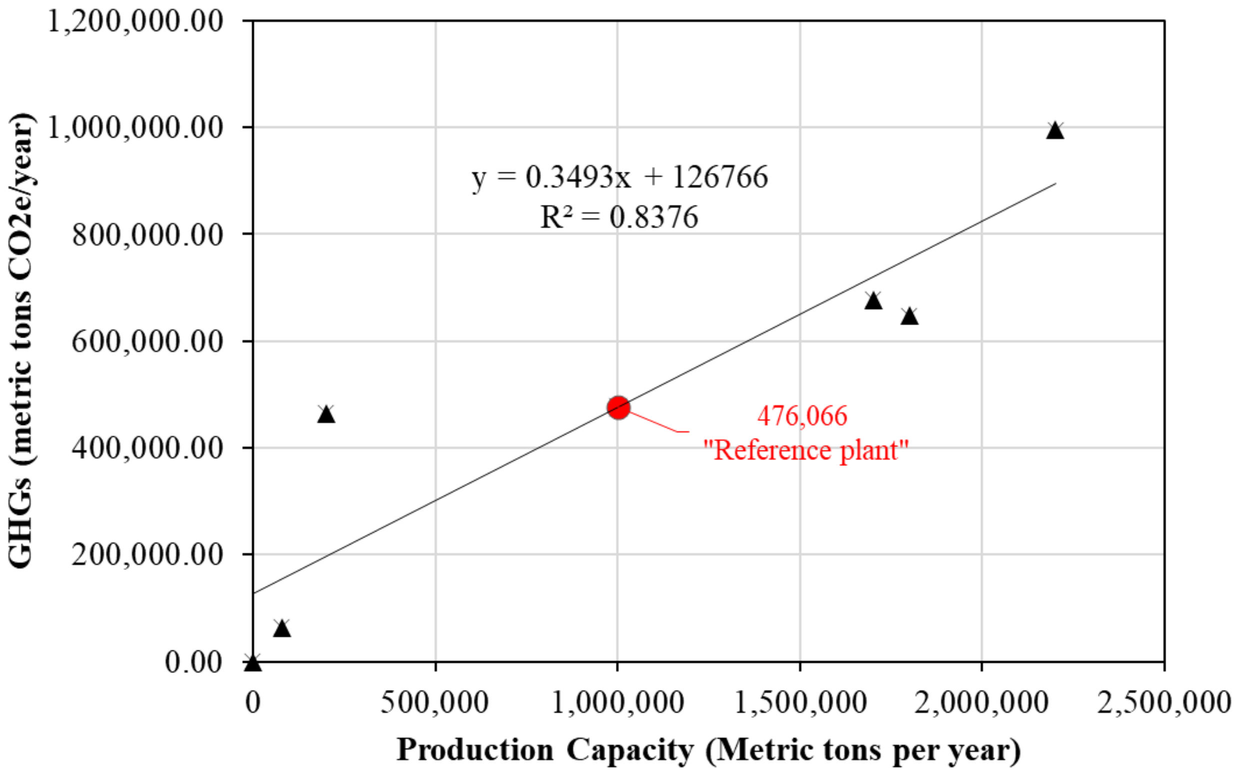


Figure 6. GHG emissions vs. production capacity correlation for U.S. methanol production.

2.2 Reference Methanol-Synthesis Plant Process Modeling Details

This section summarizes the Aspen Plus model that was developed at INL to represent SMR methanol-synthesis reference plant. The function of each block and its simulation settings are described in this section. PFDs for syngas production, methanol-synthesis, and distillation are presented in Appendix B, while details of the process model can be seen in Appendix F.

The NG is mostly comprised of CH_4, where the NG typical molar composition is about 95% CH_4, 3% ethane, and 2% propane. The NG pressure used in this configuration was the usual one managed for pipeline transportation, 34 bar (500 psi).

The energy required for preheating and SMR is supplied from the furnace by burning NG as the fuel. NG fuel and ambient air are introduced into the furnace block (FNC-1) along with the light ends from the fractionation section, where complete combustion proceeds. The pressures and temperatures of the fuel and air stream are specified as 1.01 bar and 25°C, respectively. The RGibbs reactor model was employed for the furnace block.

NG contains sulfur in the form of hydrogen sulfide and methyl/ethyl mercaptan, which might damage the reformer catalyst. The mercaptans in NG are additives that give NG its odor. A desulfurization unit (DESULFUR) with a zinc oxide adsorbent was introduced to remove the sulfur compounds. The preferred operating temperature of desulfurization reactions ranges from 350–400°C, so NG is preheated by the heat exchanger connected to the downstream furnace (HX6). The Ryield reactor model was employed for this purpose.

The PRE-RFM block represents the pre-reformer, which converts higher hydrocarbons from the NG into carbon oxides and H_2 to increase the efficiency of syngas production during SMR. The raw-material stream (e.g., NG-steam mixing gas) is preheated to 600°C by another heat exchanger connected to the furnace (HX4) to meet the operating temperature of the pre-reformer (~500–600°C).

The RFM-1 block represents the primary SMR. To fulfill the highly endothermic SMR reaction, the stream of NG-steam mixing gas is preheated to 900°C by a third heat exchanger connected to the furnace (HX3) to supply an additional 75 megawatts (MW) of heat from the furnace to the SMR. An RGibbs model was selected for this reactor.

The syngas stream exiting the SMR is then cooled, and the H_2O is removed. Some of the heat from cooling the syngas is used to preheat the steam used in the chemical reactions (HX8). A CO_2 makeup stream mixes with the syngas to match the stoichiometry of the synthesis reaction and is compressed.

The methanol-synthesis process used in this model is based on Lurgi’s Mega Methanol design [12], as well as the reference methanol-synthesis model included in Aspen Plus v11. A series of compressors (K201-S1 and K201-S2) increases the pressure of the crude syngas stream to 92 bar, which is favorable for the methanol reaction. The modeled process uses two methanol reactors in series (R201-A and R201-B) to produce CH_3OH as the target product and EtOH and DME as byproducts. Both reactors were simulated by a kinetic-based reactor model that considers the four reactions listed in Table 4.

Table 4. Methanol-synthesis reactions.

Number	Label	Reaction Equations	Ref
1	Methanol-Synthesis	$CO_2 + 3H_2 \rightleftharpoons CH_3OH + H_2O$	Target Product
2	RWGS Reaction	$CO_2 + H_2 \rightleftharpoons CO + H_2O$	Intermediate
3	Ethanol Formation	$2CO + 4H_2 \rightleftharpoons EtOH + H_2O$	Byproduct
4	DME Formation	$2CH_3OH \rightleftharpoons DME + H_2O$	Byproduct

To remove the heat produced by these reactions, the syngas feed cools the second reactor, while boiler feedwater cools the first reactor to generate steam. The configuration of the methanol-synthesis reactor simulated for this process is illustrated in Figure 7. Details of the process arrangement can be seen in Appendix B.

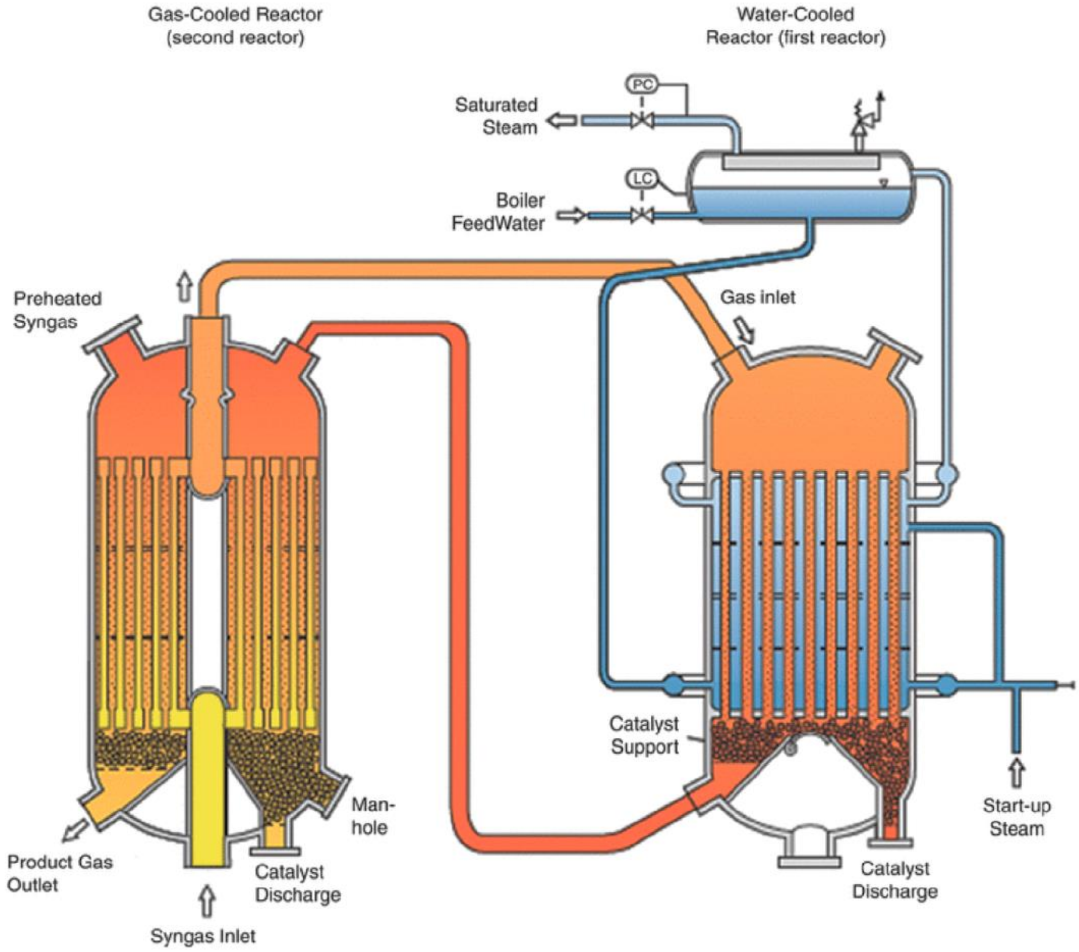


Figure 7. Detailed diagram of Lurgi's two-stage reactor [12].

The stream exiting the synthesis reactor is cooled down using a process-heat exchanger, along with air or water coolers to condense and cool the CH_3OH, H_2O, and byproducts. A flash drum block (V201) separates the unreacted light gases (L13) from the condensed liquid mixture of crude methanol (L14A). Most of the light gases obtained post-condensation are recycled back to the methanol reactor.

The purpose of the water scrubber (C201) is to remove DME from the light gas. Hydrophobic DME, which is not dissolved in the water scrubber, exits the tower with the light gases, whereas hydrophilic CH_3OH and EtOH are captured in the H_2O and sent to the distillation tower along with the crude CH_3OH.

Some light gas remains dissolved in the crude CH_3OH following the water scrubber. The first distillation tower (C301) separates light ends from the crude CH_3OH. The tower has three theoretical stages, and the feed stream is introduced at the third stage. Light gases separated from the crude CH_3OH exit the top of the column, while the H_2O and CH_3OH mixture exit the bottom and are pumped to the next distillation tower. Here, a RadFrac distillation model, including a partial-vapor condenser and a kettle reboiler, is used. To match the target temperature of the first stage of the distillation tower (or condenser) at 45.5°C, the distillate rate is adjusted to 20.249 tons per day. The reboiler duty was 6 MW. After the first distillation tower, the crude CH_3OH had less than a 1 × 10-11 mass fraction of light gas.

The second distillation tower (C302) separates the H_2O and impurities from the CH_3OH to meet the Grade A product specifications. Thirty-five stages are required for distillation, and the feed stream is introduced on the 15th. Methanol exits the top of the distillation tower, a byproduct containing EtOH exits the 30th stage, and H_2O exits the bottom. Here, a RadFrac distillation model, including a partial-vapor condenser and kettle reboiler, is used. The molar reflux ratio for the separation was 1.5, while the mass flowrate of the liquid-side stream at the 30th stage was 27.4 tons per day. To match the target water purity of the bottom stage to 0.999999, the reboiler duty is modified to 93 MW. In the end, methanol purity at the top of the tower is achievable at a mass fraction of 0.999.

2.3 Energy-Balance and Heat-Recovery System

This section describes the auxiliary systems of the model's energy-consuming components and the approach to minimizing the external energy demands within the system. The system was optimized for energy use to decrease the size required for an integrated nuclear plant. Decreasing the required capacity of a nuclear power plant (NPP) is expected to also reduce the capital costs involved.

The furnace supplying heat to the SMR provides heat for both the reformer and the NG preheat and generates high-pressure steam for power and heat delivery using a backpressure turbine configuration. Steam generated in the furnace could also be used for system startup. The furnace uses an air preheater with a fuel-gas outlet temperature of 117°C, which is reasonably low for decent boiler efficiency but sufficiently higher than the fuel-gas dew point.

A large amount of high-temperature heat can be recovered from syngas following the reformer. The reformer outlet gas is at 875°C, and it must be cooled to 35°C to condense the H_2O it contains. However, only a portion of this heat can be used because a significant amount of the heat, mostly latent heat from water condensation, is removed at relatively low temperatures. Other opportunities for heat recovery are the cooling system for the CH_3OH reactor, which must remain at a constant temperature near 265°C, and the partial cooling of the raw-methanol product. Heat in the raw product of the first reactor stage is recuperated in the second reactor stage. Heat from the raw product of the second stage is used to preheat the syngas feed. Recovery of the available heat suing cycle tempo modeling software is illustrated by the PFD in Figure 27 in Appendix C, as well as the heat-transfer-temperature (Q-T) diagram shown in Figure 8. Starting from the left side, at the syngas inlet, injection-steam superheaters are followed by an injection-steam evaporator (illustrated as a drum type) and a preheater. This injection steam, which primarily consists of recycled water effluents, is injected into the NG prior to the reformer. This lower quality water stream is not introduced into the main process steam system; however, a dedicated backpressure turbine is used to assist with system power demands, the outlet of which is only slightly superheated. Next on the syngas-cooling line is an evaporator that generates low pressure (LP) steam for the reboiler duty of column C-301. The last heat recovery taking place is a dirty-water preheater, which preheats the syngas before it is introduced into its own deaerator.

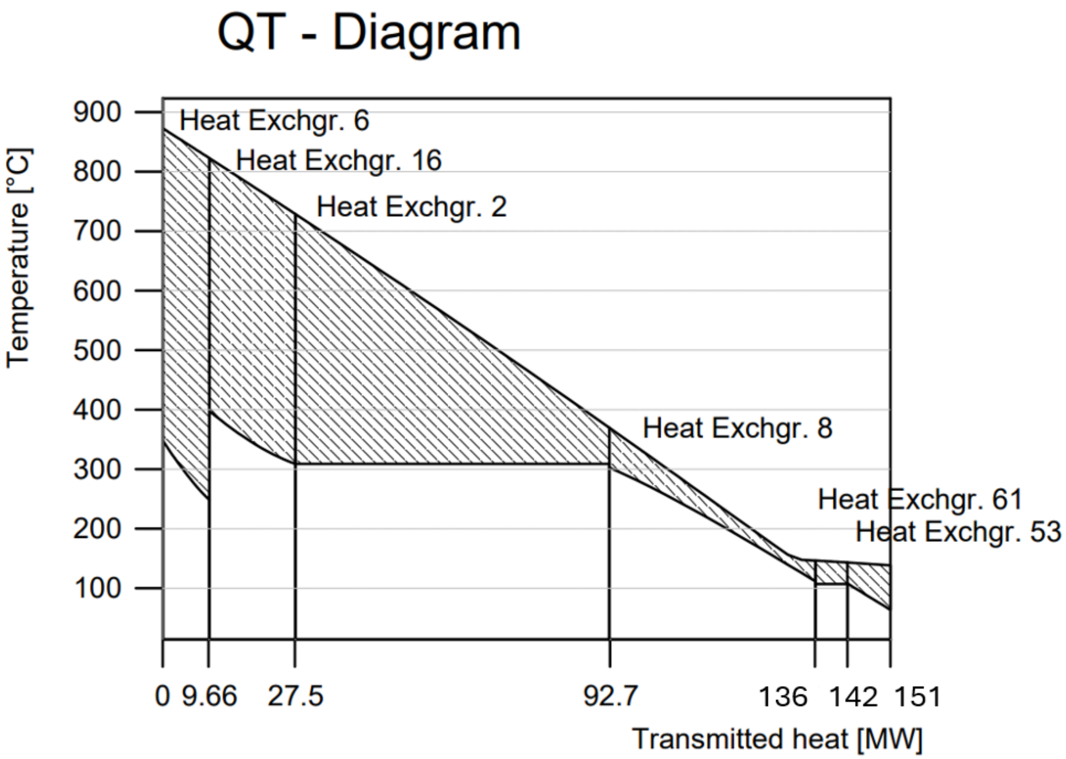


Figure 8. Heat-transfer temperature (Q-T) diagram of waste-heat recovery from syngas-cooling.

High-pressure (HP) steam is generated in the furnace, which contains the preheater, evaporator, and superheater . The HP steam then expands in the first turbine section to intermediate pressure (IP), where additional steam is added. The IP steam comes from feedwater, preheated in the raw-methanol cooler, evaporated while cooling the methanol reactor (part of the steam is then routed for the light-end gas heater) and superheated, before being introduced into the turbine. A final turbine section exhausts all the steam at 2.5 bar through a backpressure turbine, where all the condensation heat is used to provide the reboiler duty of a C-302 column. Condensate from this system is then split into separate HP and IP streams.

The Q-T diagram in Figure 8 illustrates the heat exchange that occurs during the syngas-cooling. Figure 8 shows that at the onset of condensation, heat can be supplied for low-temperature waste-heat recovery or for boiling water at 1 atm to supply the column C301 reboiler. Making steam only at 2.5 bar to supply the column C302 reboiler would simplify the process steam system, but its saturation temperature is too high for this abundant low-temperature heat to be utilized.

Heat is not recuperated directly from the syngas to final heated processes due to the complex piping necessary to deliver the syngas to multiple points in the plant. A steam system of this type would require bypasses and an auxiliary heat source to remain flexible in the case of off-design operation. Process steam solves these issues and is a standard approach used in many industries.

2.4 Mass, Energy, and CO_2 Balance

Table 5 summarizes the megawatt electrical (MWe) and megawatt thermal (MWth) energy requirements for methanol production. The energy demands of the reference methanol plant are based on the Aspen Plus model with heat integration (see Section 2.3). Electricity and steam consumption, heating duty from fuel combustion, steam generation, and heat rejection to the ambient condition are summarized for each process unit. A negative number for power and steam consumption signifies that the steam or power is produced in the specific unit operation.

Table 5. Overall energy requirements for reference methanol plant.

Process Unit	Power Consumption	Heat from Fuel Combustion	Steam Consumption	Steam Generation	Steam Quality (Production)	Steam Quality (Consumption)	Heat Released to Ambient
	MWe	**MWth**	**MWth**	**MWth**			**MWth**
Steam Methane and Autothermal Reforming + Cooling	0	327	135* (48 kg/s)	151	LP, MP, HP	MP	64
Lurgi's Two-Stage Reactor and Methanol Cooling	32	—	—	78	MP	—	80
Methanol Distillation	-3	—	102	—	—	LP	94
Process Steam and Power System	-32	—	-237	—	—	MP, LP	0
Total	**-2**	**327**	**0**	**229**	**—**	**—**	**238**

Steam is generated during SMR, syngas-cooling, and methanol-cooling. Additional steam is generated in the furnace by combusting additional fuel. Some steam is injected into the SMR process, while the rest is used by the process steam and power system, providing power and heat duties to other unit operations. Additional steam from the furnace is generated because implementing only a waste-heat-recovery system to produce steam is not sufficient to meet all power and heat-duty demands internally. Implementation of this additional steam production is sized to meet all heat-duty, and resultant power production comes out at a very small excess. Water generated as part of a chemical reaction is not considered in the mass- or energy-balance because it is not used in the energy-system streams. The energy demand of the cooling system to reject heat to the ambient condition was not included in the model, meaning the actual net electricity export may be smaller by up to several megawatts. Considering that the only energy supplied to the system comes from fuel combustion, the energy required for methanol production is 5.535 GJ/T CH_3OH. This value does not include energy generated from the feedstock.

NG introduced as feedstock contains 750 MW (23.79 GJ/T methanol), and the CH_3OH product contains 631 MW based on the lower heating value (LHV). Thus, the total energy requirement for CH_3OH production, as calculated in the model, is 29.33 GJ/T CH_3OH. This highlights the potential of integrating low-carbon sources when considering an alternative feedstock.

Table 6 summarizes the direct carbon emissions for each process unit, in terms of both the reference plant and the national-scale. The total national emissions for 2023 are reported based on the data contained in EPA FLIGHT, and the reference-plant emissions are from the Aspen Plus results, including heat integration [4]. Emissions are produced during combustion of NG in the furnace and are released in the exhaust stream during SMR and in the light ends during distillation. The national-scale emissions are used to calculate process-unit emissions by estimating the relative contribution of emissions from each unit. The linear correlation in Figure 6 estimates CO_2 emissions generated by the reference plant at 476,066 T/yr. using national data. This value aligns with the emissions calculated in the Aspen Plus model, with heat integration shown in Table 6. The amount of CO_2 emissions associated with methanol production is 0.487 kg CO_2 per kg of methanol.

Table 6. Direct CO_2 emissions for the reference methanol plant and at the national-scale.

Process Unit	Reference Plant CO_2 Emissions MT/yr.	National-Scale CO_2 Emissions MT/yr.
SMR + Cooling	422,925	2,596,379
Lurgi's Two-Stage Reactor and Methanol Cooling	—	—
Methanol Distillation	41,147*	252,608
Process Steam and Power System	—	—
Total	464,072	2,848,987
* The light gases from the methanol-synthesis and distillation sections are recovered and used as fuel in the reforming furnace. Combustion of the light gases reduces the amount of NG required by the reforming furnace.		

3. NUCLEAR INTEGRATION IN METHANOL SYNTHESIS

Methanol plants are large point-source of GHG emissions, the majority of which consume a large amount of energy to convert CH_4 to CH_3OH. Intermittent operation of methanol plants is not practical due to high-temperature operation and economic incentives towards continuous production, as such, the energy source must be highly reliable, which makes SMNR integration an attractive option for decarbonization in the methanol industry.

The reference methanol plant burns the non-condensable gases (light ends) from the fractionation section of the plant, supplemented by NG, to supply the combustion-grade heat for the SMR. All the lower-grade heat (steam) and electricity demands are satisfied by robust heat-recovery systems, involving process steam generators and backpressure turbines. There are several potential pathways to integrate SMNRs into the reference methanol plant, with a range of viability. One possible option is to use nuclear steam or electricity to preheat the SMR feedstocks, reducing the need for additional NG combustion. However, the most direct pathway is to blend nuclear hydrogen, generated by HTSE, into the fuel gas, as depicted by Figure 9. In this scenario, nuclear hydrogen backs out NG from the fuel-gas system, yielding a modified fuel gas with lower carbon intensity that is burned in the existing furnaces.

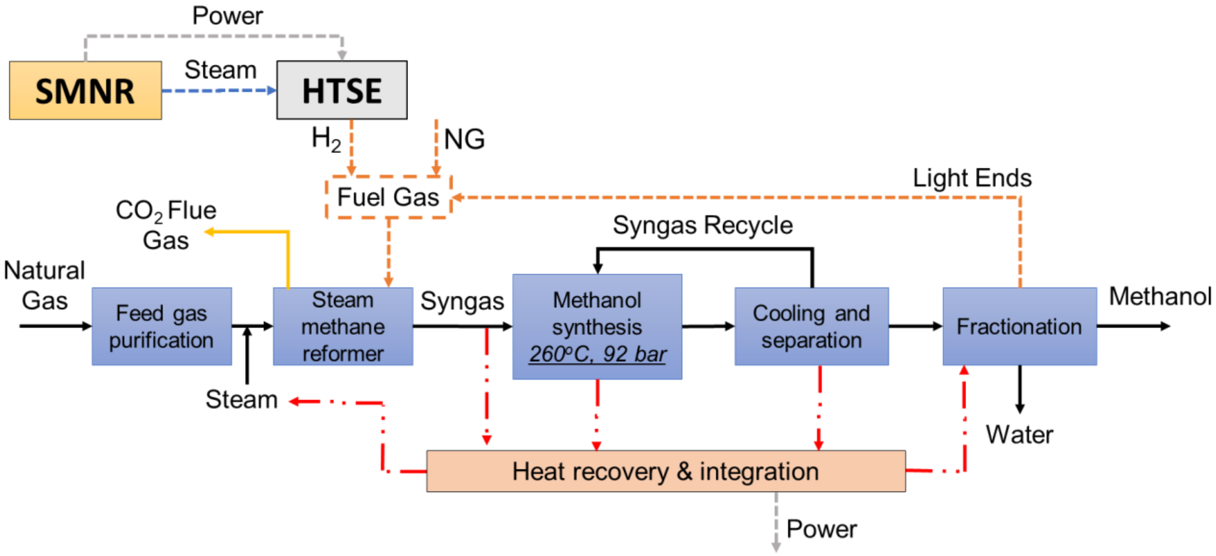


Figure 9. Standard methanol-synthesis via SMR with HTSE and H_2 used for fuel substitution.

The CO_2 reduction potential from this pathway is limited due to the method by which syngas is produced. Over one-third of the emissions from the reference plant come indirectly from feedstock NG, which forms the light ends that are recycled to the SMR furnace. Without significantly modifying the methanol-synthesis pathway, deeper decarbonization is predicated on post-combustion fuel-gas CO_2 capture. With more significant modifications, syngas can be produced using the RWGS, thus allowing an industrial CO_2 source that would otherwise be emitted from another facility. This process would require a large amount of H_2 from an SMNR; a schematic of the RWGS-based methanol-synthesis process is indicated in Figure 10.

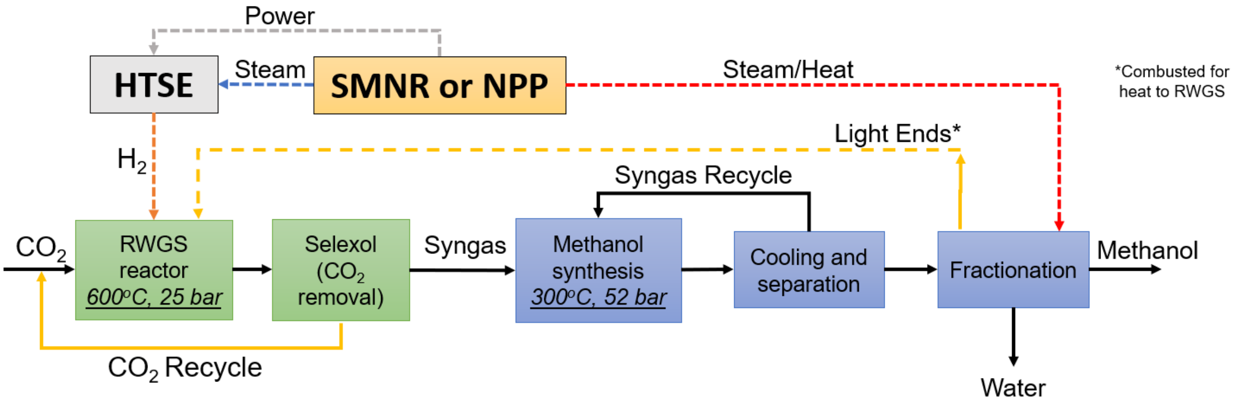


Figure 10. Methanol-synthesis via RWGS with SMNR and HTSE.

Through the RWGS pathway, nuclear power produces clean H_2 to reduce CO_2 to CH_3OH through a multistep process. Similar to the conventional process, light ends are burned to provide heat for the RWGS reactor. These emissions are the expense of fixing CO_2 as methanol, a useful precursor in the petrochemical industry. Depending on the end-use of the methanol, the life cycle emissions for the RWGS synthesis may be close to carbon neutral or net-negative.

This analysis is focused on high-temperature gas reactor (HTGR)-type SMNRs. A generic HTGR was modeled in Aspen HYSYS using the conditions listed in Table 7. Although high-temperature gas-gas heat exchangers are being developed, it is assumed that the steam generator may not be bypassed. In other words, the highest quality heat accessible from the generic HTGR is the main steam, which has a saturation temperature of approximately 350°C and is superheated to 565°C. The generic HTGR is assumed to be available in increments of 200 MWth. Attached to a typical Rankine cycle with a thermal efficiency of about 40%, electrical production may be 80 MW. Cogeneration, particularly the generation of utility steam for HTSE, will lower the electricity production of the power cycle according to the total amount and grade of heat extracted.

Table 7. Thermodynamic properties of HTGR coolants.

Coolant		Temperature (°C)	Pressure (bar)	Phase	Flow Rate (kg/s)
Primary Helium	Core Inlet	260	60	Supercritical	80.4
	Core Outlet	750			
Secondary Steam	Steam Gen. Inlet	220	165	Subcooled liquid	81.1
	Steam Gen. Outlet	565		Gas	

Other types of advanced SMNRs could be suitable for integration with the reference methanol plant. Notable varieties include liquid metal, molten salt, and light-water cooled reactors. Each type has its own advantages. Light water reactors (LWRs) operate at lower temperatures than the other types. Each reactor type produces electricity, which can be used to produce H_2 by HTSE, which is the key energy input for either nuclear-integration approach.

To calculate the GHG emission reductions that could potentially result from SMNR integration, it is assumed that NG is the reference methanol plant's source of supplemental combustion heat (beyond what can be supplied by the light ends) and syngas. Each nuclear-integration case study, described in detail in Section 4.1, backs out NG usage to avoid the CO_2 emissions.

4. CONCEPTUAL DESIGNS

This section outlines potential changes to the reference plant to reduce GHG emissions through various nuclear integration pathways. Section 4.1 establishes the key metrics for the TEA conducted in Section 7, while Section 4.2 discusses other potential opportunities for emission reduction that are not considered in the present work.

4.1 Delta Case Studies for TEA

The delta cases detailed in this section calculate key TEA inputs, such as the size of the SMNR and HTSE plant required for integration, as well as the input and outputs of the plant. The model described in Section 2 was used to establish the natural gas usage and CO_2 emissions from the BAU case (Section 4.1.1). In Section 4.1.2, a supplemental furnace model showed the incremental emission reductions from blending hydrogen in place of natural gas fuel, and an integrated HTGR-HTSE model showed the capital investment requirements for each case. Finally, a model for using an industrial CO_2 source, rather than natural gas as a feedstock is established in Section 4.1.3, which determines the emissions and nuclear hydrogen requirements.

4.1.1 Business-as-Usual (BAU)

The reference methanol plant converts NG to methanol through a two-step process, reforming to syngas and catalytic conversion to methanol. As the BFD in Figure 11 demonstrates, the BAU scenario only takes in combustion-grade heating. The rest of the energy inputs, such as the HP and LP steam and electricity, are satisfied through energy integration, specifically in cooling the syngas and crude methanol. Nearly all the emissions result from burning light gases, which are recirculated and mixed with additional NG to burn in the SMR furnace. These emissions and total NG consumption are as follows:

- NG consumption: 1605 MT/day
- CO_2 emissions: 483 k metric tons per year (kMT/yr.)
- Electricity export: 2 MW.

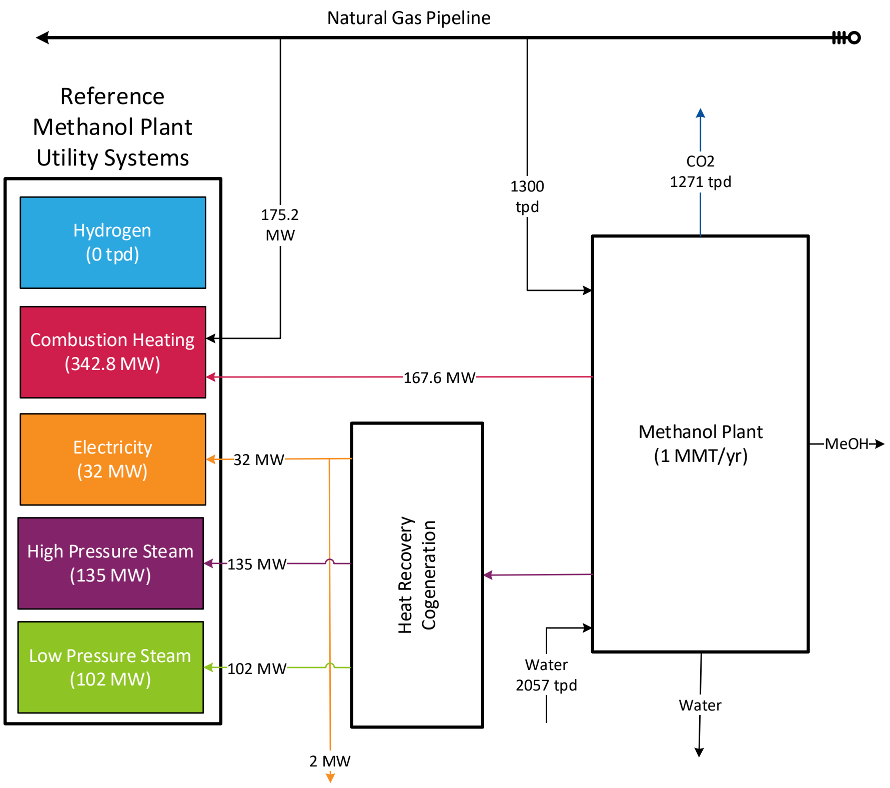


Figure 11. Utility system BFD for BAU reference methanol plant.

4.1.2 Case 1: Use Nuclear Hydrogen to Back-out Extra NG from Fuel Gas

The energy recovery system at the reference methanol plant has been tuned to be steam-neutral (e.g., all steam used is also generated within plant boundaries, recovering waste heat primarily from hot effluent streams) and electricity-positive. As such, blending HTSE-derived H_2 into the fuel-gas system is the main "minimum retrofit" scenario for nuclear-integrated decarbonization. In the BAU Case, nearly half of the combustion duty is satisfied by burning unreacted syngas and incondensable light gases from the fractionation section of the plant. These gases are blended with NG, yielding a fuel gas with a high H_2 content. In Cases 1a through 1c, the NG is incrementally backed-out, to be replaced with more HTSE-derived H_2. Table 8 shows the molar composition of the reference fuel gas used in the BAU Case, as well as that of the modified fuel gas used in Case 1c.

Table 8. Molar composition of the SMR fuel gas at the reference and modified methanol plant.

Molar Composition	Light Ends	NG	Reference Fuel Gas	Modified Fuel Gas
Hydrogen	0.7492	–	0.5321	0.8967
Methane	0.1776	0.9500	0.4014	0.0732
Ethane	Trace	0.0300	0.0087	–
Propane	Trace	0.0200	0.0058	–
Methanol	0.0068	–	0.0048	0.0028
Carbon Monoxide	0.0079	–	0.0056	0.0032
Carbon Dioxide	0.0567	–	0.0402	0.0233
Nitrogen	0.0007	–	0.0005	0.0003

Molar Composition	Light Ends	NG	Reference Fuel Gas	Modified Fuel Gas
Flow Rates (kg/s)				
Light Ends	–	–	3.72	3.72
NG	–	–	3.52	0
HTSE Hydrogen	–	–	0	1.46

Cases 1a and 1b demonstrate the potential carbon abatement from incrementally adding 200 MWth of HTGR/HTSE capacity to the reference methanol plant. Figure 12 depicts how the emissions from the plant are reduced by adding clean H_2 and backing-out the NG from the fuel gas. Four points are highlighted, corresponding to the reference-plant fuel gas (BAU Case), a fuel gas with the H_2 produced by a 200 MWth and 400 MWth HTGR added (Cases 1a and 1b), and the modified fuel gas, where a 600 MWth HTGR blends enough H_2 into the fuel gas to eliminate the NG import entirely, and also put electricity on the grid (Case 1c). The model that produces the hydrogen required for Case 1c is detailed in Appendix D. The significant increase in H_2 content in the fuel gas may require alterations to the furnace. It is assumed that the CH_4 and CO_2 in the light-ends dilute the modified fuel gas (90 vol% H_2) enough that the alterations are feasible. The reference plant furnace would already be considered a high H_2 burner, so the system would likely be able to handle the increase by adjusting the combustion air and flue gas recirculation rates.

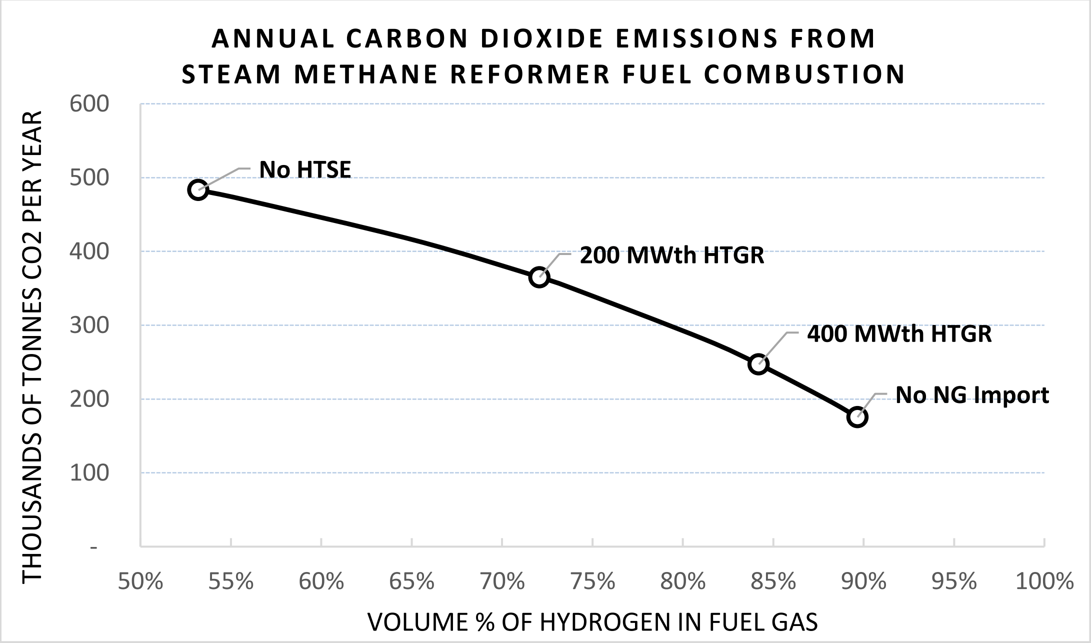


Figure 12. CO_2 emissions vs. H_2 content of SMR fuel gas.

It is assumed that the change to the composition of the fuel gas does not impact the heat-recovery/cogeneration system. The implementation of these H_2 fuel-gas blending cases will require additional calculations, considering in the future:

- Impacts on the combustion air supply requirements.
- Heat exchanger performance resulting from changes to the fuel-gas composition and flowrate.
- Retrofitting fuel injectors designed for the different volumetric energy density.

4.1.2.1 Case 1a: Use Nuclear Hydrogen from 200 MWth SMNR Backing-out 38.4% NG

A 200 MWth HTGR-type SMNR produces 48.4 MT/day of H_2, which is enough to back-out 67.2 MWth of NG and yields a fuel gas that is 72.1 vol.% H_2. This schematic is depicted by Figure 13, with key TEA inputs below:

- NG consumption: 1488 tpd
- CO_2 emissions: 365 kMT/yr.
- Electricity export: 2 MW.

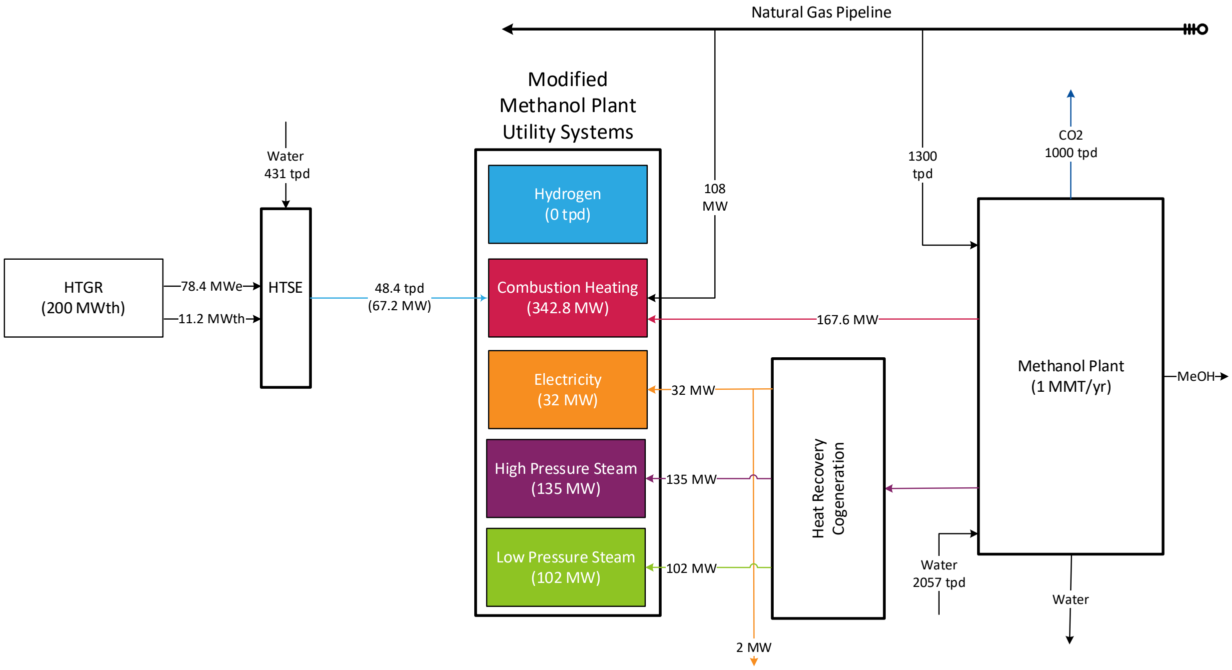


Figure 13. Utility system BFD for reference methanol plant delta Case 1a.

4.1.2.2 Case 1b: Use Nuclear Hydrogen from 400 MWth SMNR Backing-out 76.7% NG

A 400 MWth HTGR-type SMNR produces 96.8 MT/day of H_2, which is enough to back-out 134.4 MWth of NG and yields a fuel gas that is 84.2 vol.% H_2. This schematic is depicted by Figure 14, with key TEA inputs below:

- NG consumption: 1371 tpd
- CO_2 emissions: 247 kMT/yr.
- Electricity export: 2 MW.

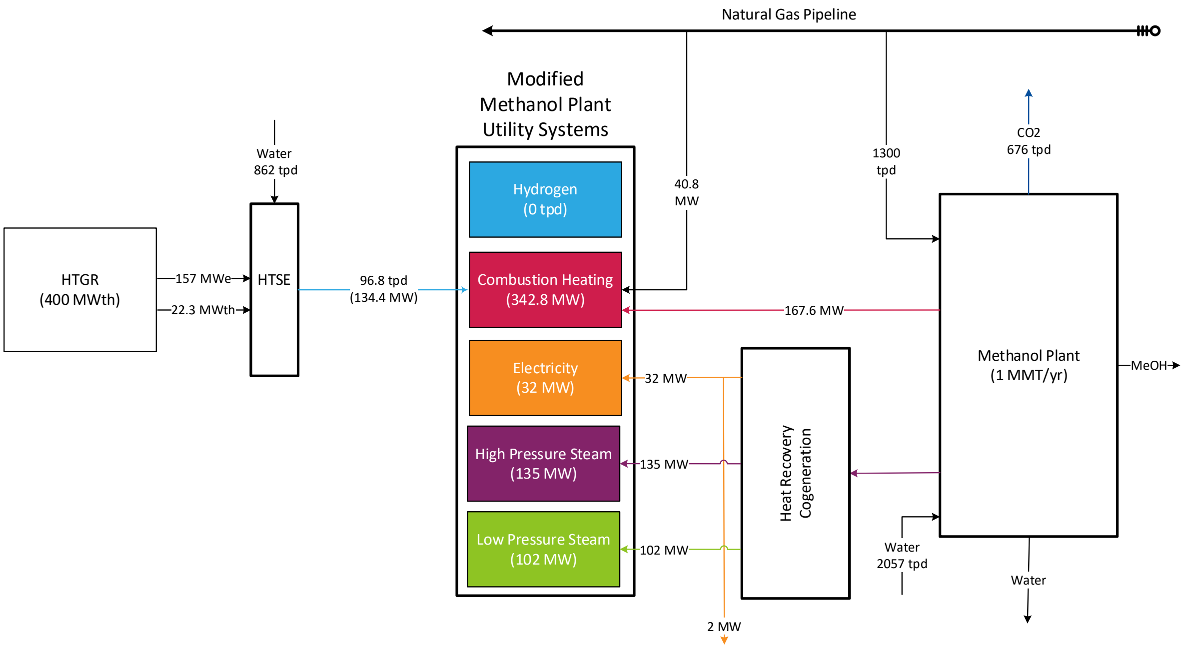


Figure 14. Utility system BFD for reference methanol plant delta Case 1b.

4.1.2.3 Case 1c: Use Nuclear Hydrogen from 600 MWth SMNR Backing-out 100% NG

A 600 MWth HTGR-type SMNR can produce more H_2 than can be consumed by the reference methanol plant's SMR furnace. The HTSE system in this case is therefore undersized, resulting in the production of 126.1 MT/day of H_2, which is enough to back-out all 175.2 MWth of the NG and yields a fuel gas that is 89.7 vol.% H_2. The remaining electricity produced by the SMNR that is not consumed by the HTSE plant is assumed to be sold to the electrical grid. This schematic is depicted in Figure 15, with key TEA inputs below:

- NG consumption: 1300 tpd
- CO_2 emissions: 175 kMT/yr.
- Electricity export: 33.4 MW.

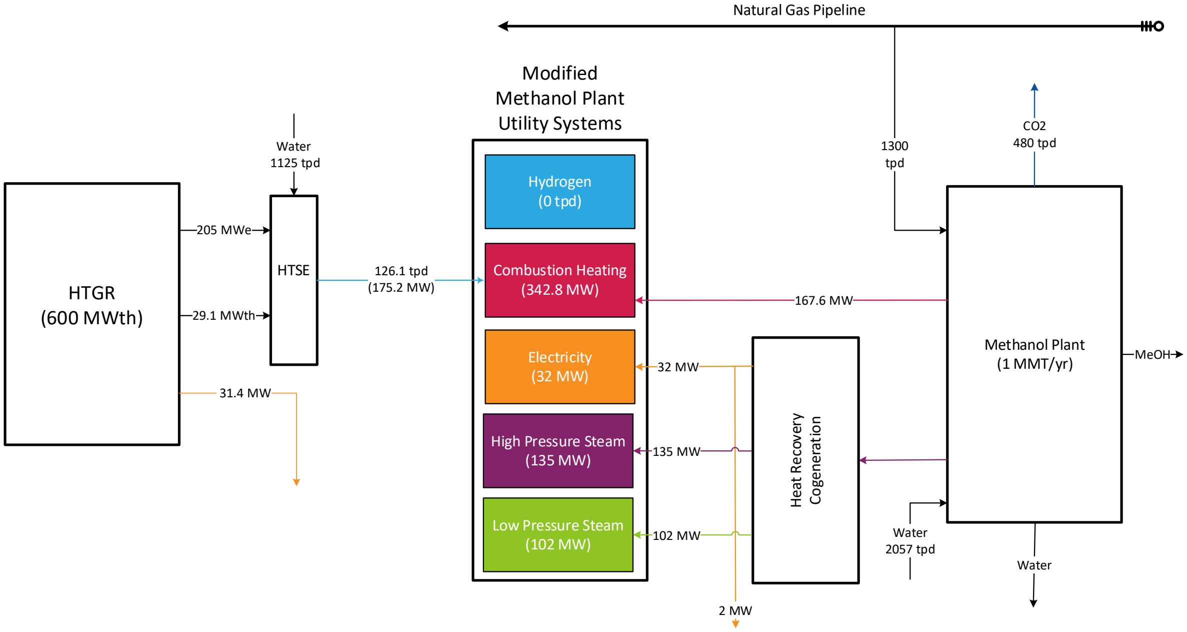


Figure 15. Utility system BFD for reference methanol plant delta Case 1c.

4.1.3 Case 2: SMR Replaced with RGWS, SMNR Generates Hydrogen For Syngas Production

Case 2 is a more aggressive means of nuclear integration for methanol production. Instead of reforming NG into syngas, an industrial CO_2 source is reduced to CO with HTSE-derived H_2, which reacts with additional H_2 to produce the crude methanol product. The RWGS reactor, methanol-synthesis, hydrogen, and CO_2 compression blocks were modeled based on a previous model developed at Argonne National Laboratory (ANL) [17]. The ANL baseline Aspen Plus model was modified by the INL chemical process modeling group to expand and improve the model and match the reference-plant capacity of 1 MMT/yr. In addition, its heat integration modeling and optimization was developed using Cycle Tempo software by INL staff. The details of the RWGS process model can be seen in Appendix F. Figure 16 demonstrates that a 2800 MWth HTGR-type SMNR can be configured to produce the 650 tpd of H_2 required to convert CO_2 to 1 MMT/yr. of methanol while also satisfying the electricity demand of the RWGS-based plant. For this case, the H_2 product is only compressed to 26.2 bar, which better matches the inlet pressure of the RWGS reactor and slightly reduces the specific electricity consumption of the HTSE system. This plant has the following TEA inputs:

- NG usage: 0 tpd
- CO_2 feedstock: 4855 tpd
- CO_2 emissions: 286 kMT/yr.
- Electricity export: 52 MW.

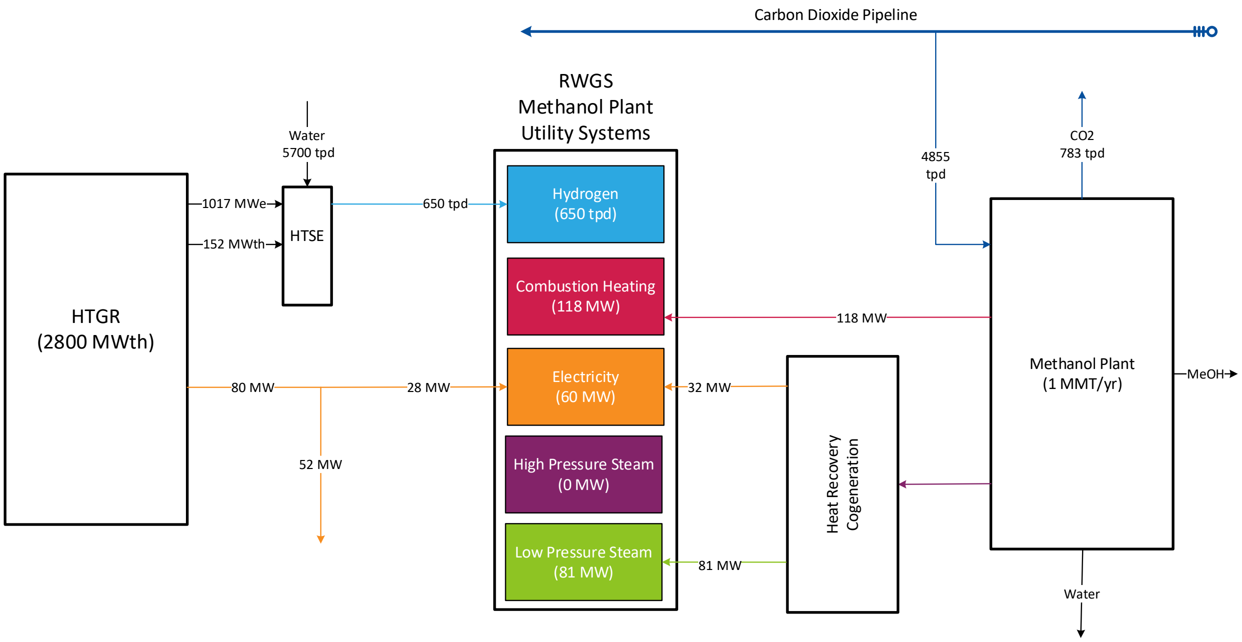


Figure 16. Utility system BFD for RWGS methanol plant.

Case 2 has higher Scope 1 emissions (GHGs emitted directly at the plant) than Case 1c, because the fractional conversion of the RWGS reactor is lower than that of the SMR. These emissions are originally sourced from another facility, and simply pass through the RWGS plant, while the majority is fixed as methanol. A lifecycle analysis of emissions, depending on a variety of initial carbon sources, as well as the end uses for the product methanol, is recommended for future work. In the case where the industrial CO_2 source is fossil fuel-derived and the methanol goes to synthetic fuel production, the RWGS plant may be considered to be close to net-zero; if the CO_2 feedstock is biogenic or sourced from direct air capture, and the methanol goes to petrochemicals, the RWGS methanol plant may be carbon-negative.

4.2 Opportunities Identified for Further Emission Reduction

The study has identified several CO_2 emission sources from the methanol plant that may be reduced by utilizing clean power supplied from an SMNR. In particular, the H_2 produced from an SMR of NG and the combustion of NG and waste gas in the SMR furnaces contribute >30% of CO_2 emissions. The conventional SMR H_2 process produces syngas that contains H_2 and CO in the reforming reaction of NG to H_2. This reaction requires heat to complete the reaction at a temperature range of –800-1000°C. This heat is supplied through the combustion of NG in the reforming furnace, which emits CO_2 into the atmosphere in the fuel gas. In addition, the byproduct CO_2 in the syngas stream is removed to purify the H_2 product and typically released to the atmosphere.

New technological alternatives are being explored to replace the fossil fuel-based heat supply for the SMR with an electrified SMR. Aarhus University and Haldor Topsoe have explored this novel concept through process modeling and laboratory experiments and determined the decarbonization process is feasible [18]. This concept requires pilot plant testing, scale-up, and demonstration to validate the system. With the integration and energy supply from an SMNR, clean electricity and steam could be supplied to the electric SMR process to significantly reduce the associated CO_2 emissions. This scheme would be another low-carbon H_2 production alternative from the aforementioned high-temperature electrolysis process integrated with an SMNR.

Waste gas (light ends) is produced from the methanol-synthesis process and combusted in the SMR furnaces. Alternative processes to convert the waste gas to H_2 and co-products of coke and CO_2 emissions can also be considered. In this process configuration, the conversion of waste gas through the novel electric SMR could provide a low-carbon H_2 production pathway. In addition, the waste gas could be converted into H_2 and CO_2 through the electric plasma process, which utilizes electricity as the primary energy source [19]. The use of clean electricity from an SMNR for the pyrolysis process would yield a decarbonized H_2 product. This process has been modeled and demonstrated on the pilot plant scale. The electricity demand for the process is high, which has limited the commercialization of the process.

Also, a more traditional approach to addressing the carbon emissions of a SMR process would be to apply stack gas scrubbing to the SMR furnace effluent to remove the CO_2 from this stream. The SMNR could provide heat and power for the scrubbing process and CO_2 compression. Commercial CO_2 removal processes are available, therefore this could provide a near-term solution for decarbonization.

5. CO_2 EMISSIONS REDUCTION FOR NUCLEAR-INTEGRATED METHANOL-SYNTHESIS PLANT

Figure 17 shows a waterfall chart that depicts incremental SMR decarbonization where each incremental 200 MWth HTGR-HTSE eliminates 118 kMT/yr. of CO_2 emissions by backing-out 67.2 MWth of NG. The right blue bar depicts the emissions from the reference methanol plant with a 600 MWth HTGR, which produces enough hydrogen to completely eliminate the need for NG combustion and generates surplus electricity. This is the maximum amount of emission reduction that is achievable without reconfiguring the front-end of the methanol plant. By replacing the SMR with a RWGS reactor, an overall deeper decarbonization is possible. While Figure 18 does show an increase in CO_2 flow exiting the stack when compared to Case 1c, Figure 19 shows this is a result of converting 1.77 MMT/yr. of CO_2 that would have been emitted from another source into methanol with 84% efficiency, yielding net-negative emissions of 1.49 MMT/yr. This is shown by the net emissions bar in Figure 18 going into the negative, representing a 408% emission reduction. It must be stressed that these emission reductions likely necessitate CO_2 capture at another site, and care must be taken to ensure that both entities do not take credit for the same abatement.

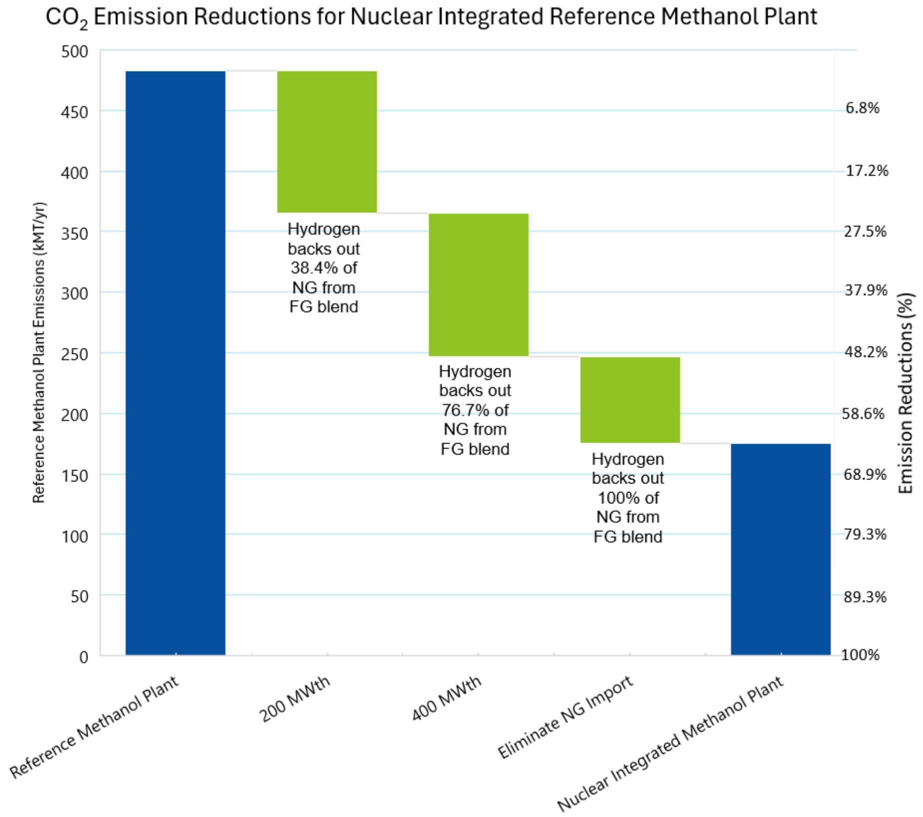


Figure 17. Reduction of CO_2 emissions for Cases 1a through 1c.

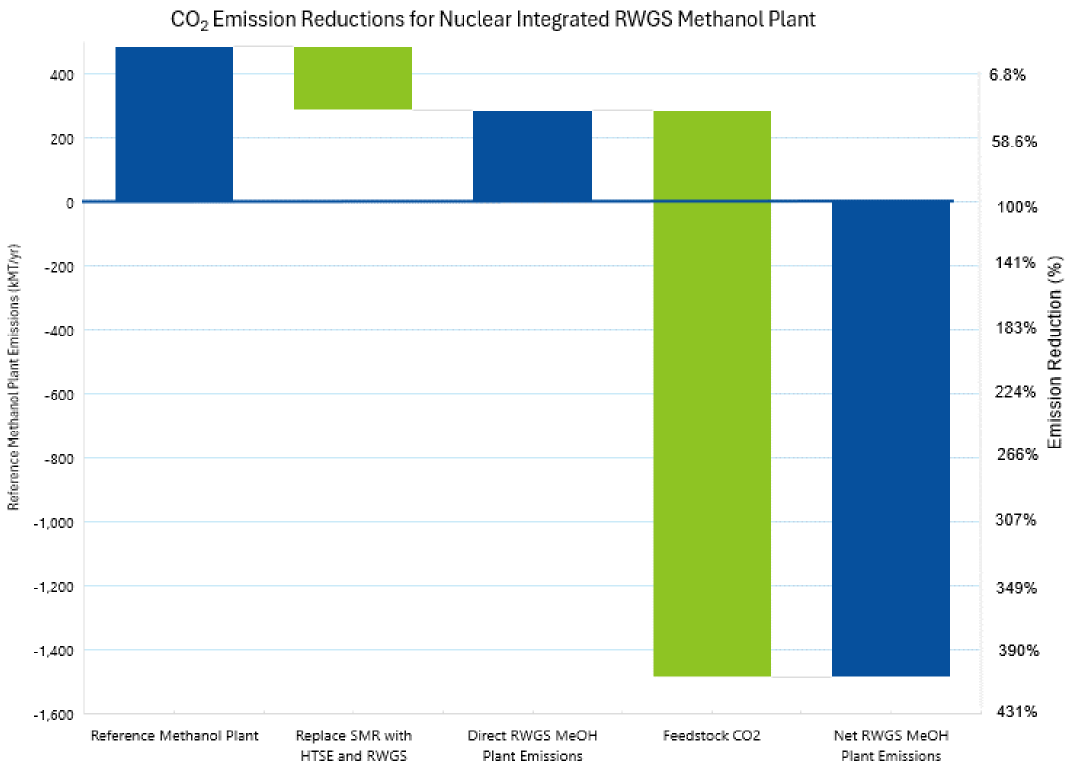


Figure 18. Reduction of CO_2 emissions for Case 2.

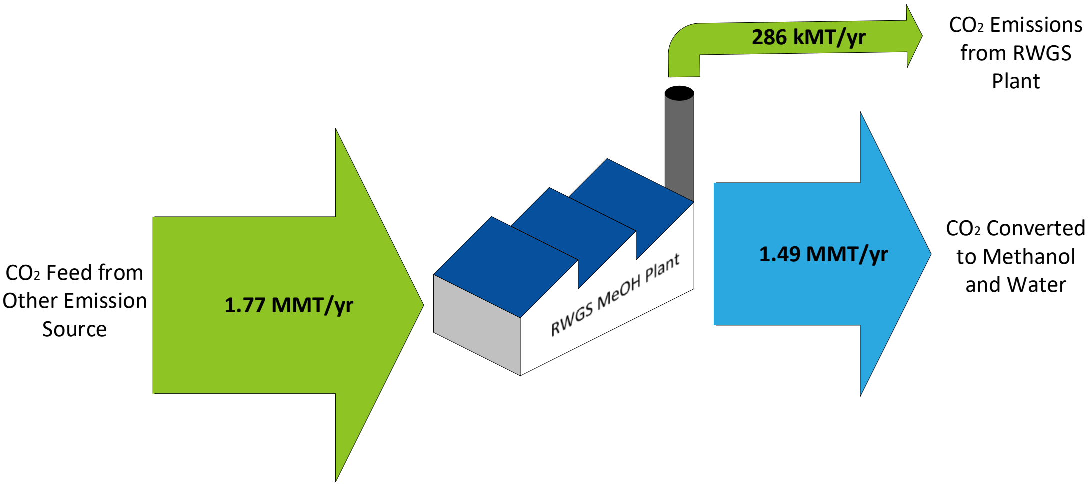


Figure 19. Comparison of CO_2 emissions and conversion from the RWGS methanol plant.

The RWGS plant discussed in Case 2 has zero NG usage; the only energy inputs to the plant are clean electricity and H_2 from the SMNR. While the smokestack emissions from the RWGS plant are higher than those from the conventional SMR-based process with the lowest possible carbon intensity fuel gas (Case 1c), it is important to note that the key distinction between the two processes is the carbon source from which the methanol product is derived. The RWGS plant requires more nuclear power and a larger investment than the reference plant, but also has a benefit that goes well beyond what is portrayed by Figure 18. As a matter of perspective, the RWGS plant diverts the equivalent CO_2 of three SMR-based reference methanol plants from the atmosphere and into the chemical and synthetic fuel industries. In doing so, the RWGS plant emits less than 60% of the CO_2 of each reference plant—with all of it being unconverted feedstock rather than new emissions from the on-site combustion of fossil fuels. It may be feasible to capture and purify CO_2 from this flue gas and recirculate it to the methanol feedstock stream. This was not considered in the present work as it likely presents diminishing returns, but should be investigated more fully in future work.

It would be infeasible to consider the RWGS plant to be a standalone decarbonization project. Producing 1 MMT/yr. of methanol by this method requires an enormous amount of industrial CO_2, which must be sourced nearby to be economical. The reference refinery studied concurrently to this investigation emits 1.59 MMT/yr. of CO_2 [20]; thus, if instead of the nuclear integration discussed in that work, the emissions from the reference refinery were captured and sent over the fence to the RWGS plant, further CO_2 capture would be needed on the RWGS plant's fuel gas just to operate at full capacity. Emission inventory and accounting, particularly as it pertains to tax credits, would need to be conducted very carefully in such a joint venture. In this report, it is considered that the refinery would enjoy the benefits and incentives of capturing emissions and sending them to utilization, while the RWGS plant shoulders the burden of investment in the CO_2 utilization technology. This is not an equitable partnership, nor is it likely to be how such a joint venture would be implemented, but it depicts a conservative estimate for the ACC.

6. TECHNO-ECONOMIC ANALYSIS METHODOLOGY

The Standard Economic Tool (SET) is used in TEA. The incorporation of critical inputs such as capital expenditure (CAPEX), operating and maintenance (O&M) costs, yearly revenue, and tax credits is calculated by leveraging existing features from the nuclear-integrated H_2 production analysis (NIHPA) tool [21]. To connect the SET and NIHPA tools, all the assumptions, including the financial and technical parameters related to the SMNR, HTSE, and methanol-synthesis plant, are documented in Section 6.1.1. The integration between the SET and NIHPA tools is introduced in Section 6.2.

6.1 Assumptions

In this TEA study, it is assumed that the facility owns the developing SMNR, HTSE, and existing methanol-synthesis facilities. Therefore, only one set of financial inputs are used and clarified in Section 6.1.1. The technical assumptions related to each facility, including the SMNR, HTSE, and methanol-synthesis plant, are discussed in Section 6.1.2.

6.1.1 Financial Assumptions

- A Cost of Equity: 10% is assumed for all cases, as well as their respective variations as defined in the previous section.
- Depreciation refers to all depreciable capital costs, including direct capital costs (DCCs) and indirect capital costs (ICCs) for the SMNR and the HTSE, which are considered with a depreciation period of 15 years using the Modified Accelerated Cost Recovery System (MACRS).
- The project time is assumed to have a startup date of January 1, 2030. For this project, it is assumed the length of the construction would be one year for the HTSE and the SMNR, suggesting construction occurs overnight. The project lifetime is assumed to be 40 years considering the SMNR license. The debt term is assumed to be 30 years starting from January 1, 2031.
- The Nth-of-a-kind (NOAK) plant type design was assumed for the SMNR and the HTSE. The resulting values represent a commercial build between the second and fourth unit deployed of a given type assuming demonstrations by 2030, which are termed best-of-a-kind (BOAK).
- No inflation rate is considered in this TEA for verification purposes.
- The tax credits provided by the Inflation Reduction Act (IRA) of 2022 are utilized in this assumption. The IRA-45V tax credit is applied for clean H_2 production for the HTSE, while the IRA-48E tax credit is applied for the SMNR investment tax credits [22].

6.1.2 Technical Assumptions

- It is assumed that all ICCs and DCCs contributing to the CAPEX for the SMNR can be represented as the total capital investment in the unit of dollar per kilowatt of electricity generated from the SMNR. The thermal efficiency is assumed to be 40% for each unit of the SMNR. No land cost is considered in the scope of this TEA.
- The HTSE solid oxide electrolyzer cell (SOEC) stack costs, process water, coolant water, and labor costs, as well as a percentage of the ICCs, are based on the studies done by INL [9]. Only H_2 is produced and used entirely in the methanol-synthesis plant. No additional H_2 is generated to sell to the market, and the O is exhausted unrecoverably as enriched air.
- It is assumed the existing methanol-synthesis plant is fully depreciated and no additional CAPEX costs are considered for Cases 1a, 1b, and 1c. No additional annual tax and insurance, as well as the maintenance and repair of the methanol-synthesis plant, are assumed for Cases 1a, 1b, and 1c. For Case 2, additional CAPEX and fixed O&M are considered for the RWGS case.

6.2 Integration of SET and NIHPA

The SET was developed as a generic TEA tool that can perform cash flow analysis to estimate levelized costs for a specific product (LCOx), the net present value (NPV) of an investment, and the internal rate of return (IRR) for an investment. SET requires inputs, such as financial parameters and cost contributors, including revenue stream, CAPEX, annual variable O&M, annual fixed O&M, and annual received tax credits. NIHPA has built-in formulas for estimating the annual revenue stream, CAPEX, annual variable O&M, annual fixed O&M, and annual received tax credits for nuclear-integrated H_2 production. In this study, the features in the NIHPA tool are expanded to integrate the SMNR and the

HTSE with the methanol-synthesis plant by adding the feedstock and product unit costs of the entire facility, including the SMNR, HTSE, and methanol-synthesis plant. The outputs of the NIHPA tool are fed to the SET to perform a cash flow analysis. A description of the calculations developed in each tool is described in the following sections.

6.2.1 SET Tool

The SET tool discounts future cash flows back to the same dollar year. A discounted cash flow (DCF) method allows one to compare project investments against revenues in a consistent manner. This is necessary because a quantity of money today does not have the same value as the same quantity next year due to its potential to earn interest. For instance, $100 invested today at a hypothetical risk-free rate of 10% would be worth $110 next year. Conversely, $100 received a year from now is worth about $90 today when considering the time value of money. The discount factor (DF) for year “t” depends on the discount rate “r” and t. As t increases, future cash flows are worth less in present terms due to heavier discounting, as given by Equation (1):

$$DF_t = \frac{1}{(1+r)^t} \qquad \text{Equation (1)}$$

Equation (2) is applied to a series of cash flows to calculate their present value, determining profitability through NPV. Mathematically, this is expressed as:

$$NPV = \sum_{t=1}^{T} \frac{CF_t}{(1+r)^t} \qquad \text{Equation (2)}$$

Where:

NPV is the net present value

t is a specific year

T is the project's total length (80 years is the maximum amount of the time available)

CF_t is the cash flow in year *t* (positive for returns, negative for investments or losses)

r is the project’s discount rate, equal to the cost of equity.

The DF in this case is assumed to be equal to the cost of the equity rate given that the cashflow developed in SET is the net of the debt principal payments, as observed in Table 9. Furthermore, to discount the estimated cashflow, the cost of equity rate is preferred rather than the weighted average capital cost (WACC), which also includes a cost of debt.

Table 9. Simplified model calculation methodology.

+ Revenue
- Variable O&M
- Fixed O&M
= EBITDA
- Tax Depreciation
- Interest Expense
= EBT
- Taxes
+ Tax Credits
= Net Income

+ Tax Depreciation
- Debt Principal Payment
= cashflow

Where:

O&M is operating and maintenance costs

EBITDA is Earnings Before Interest, Taxes, Depreciation, and Amortization

EBT is Earnings Before Taxes.

Another key metric is the IRR, calculated similarly to NPV but with NPV set to zero to solve for r. The IRR represents the discount rate at which the project breaks even. If the IRR exceeds the cost of equity, the project is considered profitable, meeting the required returns for equity and debt holders.

Cash flows for each year are calculated based on revenues, costs, and taxes. In this model, a simplified version of the calculation highlights direct additions and subtractions from revenue to cash flow, though the underlying comprehensive method is represented in Table 9.

Additionally, the SET tool can estimate the Levelized Cost of a product "X" following Equation (3):

$$LCO_x = \sum_{t}^{T} \frac{\left(\frac{1}{(1+r)^t}\right) * TotalCosts_t}{\left(\frac{1}{(1+r)^t}\right) * Production_t} \qquad \text{Equation (3)}$$

Where:

$TotalCosts_t$ includes:

- Variable O&M
- Fixed O&M
- Tax Payment
- Loan Interest Expense
- Loan Principal Payments
- Cash Payments for Capital Costs from Equity.

This study considers debt principal payments as an extra cost needing to be subtracted from the flow of revenue generated for the IES investment project; furthermore, the final mass of profits obtained by all the IES is smaller than the case where the principal payments are not considered as an extra cost.

Finally, in this model, inflation can be applied at the cash flow level, adjusting the final step to reflect the overall impact of price changes.

6.2.2 NIHPA Tool

While NIHPA was developed for nuclear-integrated H_2 production through HTSE, the existing formula in NIHPA for estimating the CAPEX, annual variable O&M, and annual fixed O&M are generalized to be used for the SMNR, HTSE, and methanol-synthesis plants.

The formulas for the SMNR CAPEX, annual variable O&M, and annual fixed O&M are shown in Equation (4), Equation (5), and Equation (6), respectively.

$$CAPEX_{SMNR} = C_{OC} * 1000 * Cap_{th} * E_{th} \qquad \text{Equation (4)}$$

Where:

$CAPEX_{SMNR}$ is the CAPEX for SMNR in the unit of U.S. dollars.

C_{OC} is the overnight capital costs (OCC) in the units of $/kilowatt electrical (kWe).

Cap_{th} is the thermal capacity for a SMNR in the unit of MWth.

E_{th} is the thermal efficiency for a SMNR converting thermal energy to electricity in percentage units.

$$AnnVarO\&M_{SMNR} = \left(O\&M_{nonfuel} + O\&M_{fuel}\right) * Cap_{th} * E_{th} * F_{cp} * 8760 \qquad \text{Equation (5)}$$

Where:

$AnnVarO\&M_{SMNR}$ is the annual variable O&M costs for SMNR in the unit of U.S. dollars.

$O\&M_{nonfuel}$ is the non-fuel O&M costs in the unit of $/MWh.

$O\&M_{fuel}$ is the nuclear fuel O&M costs in the unit of $/MWh.

F_{cp} is the capacity factor of an NPP in percentage units.

$$AnnFixedO\&M_{SMNR} = O\&M_{fixed} * Cap_{th} * E_{th} * F_{cp} * 8760 \qquad \text{Equation (6)}$$

Where:

$AnnFixedO\&M_{SMNR}$ is the annual fixed O&M costs for SMNR in the unit of U.S. dollars.

$O\&M_{fixed}$ is the fixed O&M costs in $/MWh units.

The formula for HTSE CAPEX, annual variable O&M, and annual fixed O&M are shown in Equation (7), Equation (8), and Equation (9), respectively.

$$CAPEX_{HTSE} = (C_{dir} + C_{indir}) * E_{HTSE} * 1000 + C_{land} \qquad \text{Equation (7)}$$

Where:

$CAPEX_{HTSE}$ is the CAPEX for HTSE in the unit of U.S. dollars

C_{dir} is the DCCs, including the installed stack manufacturing costs and the balance of plant costs, in the units of $/kW-dc

C_{indir} is the ICCs, including site preparation, engineering and design, process and project contingency, and upfront permitting costs, in the units of $/kW-dc

E_{HTSE} is the electricity required for HTSE operation in the units of MW-dc

C_{land} is the land costs that are not depreciable in the unit of U.S. dollars.

$$AnnVarO\&M_{HTSE} = \left(C_{cw} * U_{cw} + C_{pw} * U_{pw}\right) * F_{cp} * 365 * F_p \qquad \text{Equation (8)}$$

Where:

$AnnVarO\&M_{HTSE}$ is the annual variable O&M costs for HTSE in the unit of U.S. dollars

C_{cw} is the cooling water cost in the unit of $/gallon

C_{pw} is the process water cost in the unit of $/gallon

U_{cw} is the cooling water usage in the unit of gallon/day

U_{pw} is the process water usage in the unit of gallon/day

F_p is the performance factor of the HTSE plant considering the degradation factors.

$$AnnFixedO\&M_{HTSE} = C_{labor,HTSE} + C_{GA,HTSE} + C_{ins} + C_{main} + (C_{dec} - C_{sal}) * H(T - t) \quad \text{Equation (9)}$$

Where:

$AnnFixedO\&M_{HTSE}$ is the annual fixed O&M costs for HTSE in the unit of U.S. dollars

$C_{labor,HTSE}$ is the annual labor costs for HTSE plants in the unit of U.S. dollars

$C_{GA,HTSE}$ is the annual general and administrative costs for HTSE plants in the unit of U.S. dollars

C_{ins} is the annual property tax and insurance costs in the unit of U.S. dollars

C_{main} is the annual maintenance and repair costs in the unit of U.S. dollars

C_{dec} is the decomposing costs in the unit of U.S. dollars that would appear at the end of the project

C_{sal} is the salvage value in the unit of U.S. dollars that would appear at the end of the project

$H(T - t)$ is a Heaviside step function where $H(T - t)$ is one only when $T \geq t$; otherwise, $H(T - t)$ is zero.

The formulas for the annual variable O&M and annual fixed O&M for the methanol-synthesis plant are shown in Equation (10) and Equation (11), respectively.

$$AnnVarO\&M_{Meth} = (C_{CO2} * U_{CO2} + C_{NG} * U_{NG} * F_{cv}) * 365 \quad \text{Equation (10)}$$

Where:

C_{CO2} is the carbon dioxide price in the unit of \$/MT

U_{CO2} is the carbon dioxide usage in the unit of MT/day (only required for Case 2)

C_{NG} is the NG price in the unit of \$/Million British Thermal Unit (MMBtu)

U_{NG} is the NG usage in the unit of MT/day

F_{cv} is the transformation coefficient from MMBtu to equivalent MT.

$$AnnFixedO\&M_{Meth} = C_{labor,Meth} + C_{GA,Meth} \quad \text{Equation (11)}$$

Where:

$AnnFixedO\&M_{Meth}$ is the annual fixed O&M costs for Methanol plants in the unit of U.S. dollars

$C_{labor,Meth}$ is the annual labor costs for Methanol plants in the unit of U.S. dollars

$C_{GA,Meth}$ is the annual general and administrative costs for Methanol plants in the unit of U.S. dollars.

6.2.3 Discounted Cash Flow Model

A DCF model is used to estimate the revenue generated from the methanol-synthesis plant under different scenarios. For this purpose, variable and fixed O&M costs are subtracted from total revenue to obtain earnings before interest, taxes, depreciation, and amortization (EBITDA). Depreciation and interest expenses are then deducted from EBITDA to determine earnings before taxes (EBT). After accounting for taxes and applying any available tax credits, net income is calculated. Depreciation, a non-cash expense, is added back to the net income to adjust for its impact on actual cash levels. Payments toward debt principal are subtracted to arrive at the final cash flow. To estimate the NPV of these cash flows, the annual cash flows are discounted back to their present value using an appropriate cost of equity. Finally, the cash flows are summed to find the total NPV.

6.2.4 Avoided Cost of Carbon

The reduction of emissions resulting from the integration of clean energy systems into an existing industrial facility incurs additional costs. These extra costs to build cleaner IES can thus be viewed as the cost of avoiding carbon emissions. In mathematical terms, this is described in Equation (12).

$$acc_{MeOH\ plant} = \frac{C_{add}}{CO_{2,avoid}} \qquad \text{Equation (12)}$$

Where:

acc_{MeOH} is the methanol-synthesis plant onsite CO_2 avoided costs in the units of U.S. dollars per metric ton of CO_2 production during the project lifetime

C_{add} is the methanol-synthesis plant additional discounted cost, which is calculated as the difference between the total cost (CAPEX + O&M costs) in scenario “i” and the total cost in the BAU Case in the units of U.S. dollars during the project lifetime

$CO_{2,avoid}$ is the avoided CO_2 that is the difference between the total CO_2 emissions from the methanol-synthesis plant in scenario “i” and the total CO_2 emissions from the methanol-synthesis plant in scenario BAU in the units of metric ton CO_2 production during the project lifetime.

Additionally, the avoided net cost of carbon (ANCC) is estimated according to Equation (13).

$$acc_{MeOH\ plant,net} = \frac{C_{add} - [PTC + ITC]}{CO_{2,avoid}} \qquad \text{Equation (13)}$$

Where:

$acc_{ref,net}$ is the methanol-synthesis plant onsite CO_2 net avoided costs in the units of U.S. dollars per metric ton of CO_2 production

PTC is the amount of dollars per day received from the IRA-45V tax credit during the total period the credit is available

ITC is the amount of dollars per day received as a percentage of the CAPEX according to the IRA-48E tax credit.

7. CASE STUDIES: TEA

As inputs to SET, NIHPA can provide the annual revenue stream, CAPEX, variable O&M, fixed O&M, and annual received tax credits for each case defined in Section 4.1. The CAPEX, variable O&M, and fixed O&M are documented in Section 7.1. The product prices contributing to the annual revenue stream and the annual received tax credits are discussed in Section 7.2. Section 7.3 reports the TEA results for each individual case comparing with BAU represented as delta cases. Section 7.4 considers the impacts of the ACC for each delta case. Section 7.5 discusses the risk associated with the financial and technical implementations that may impact the TEA results.

7.1 Cost Analysis

The cost contributors of each case defined in Section 4.1 include the CAPEX, variable O&M, fixed O&M for the SMNR and HTSE, and the variable O&M for the methanol-synthesis plant. The costs analysis for the SMNR, HTSE, and methanol-synthesis plant are discussed in Sections 7.1.1, 7.1.2, and 7.1.3, respectively.

7.1.1 Small Modular Nuclear Reactors

This study uses the data estimated by the Gateway for Accelerated Innovation in Nuclear (GAIN) [23], which identified reference overnight capital costs (OCCs) and O&M costs and trends for large and small advanced nuclear reactors, focusing on cost projections for 2030–2050. In GAIN [23], a methodology was developed to estimate these costs using a comprehensive, extensive, and public set of detailed cost-estimates from the literature that were mapped, escalated, and processed.

The data were normalized to a common baseline, and cost ranges were derived by analyzing quartiles within data groupings. This approach was selected to provide a statistically neutral determination of cost ranges, decreasing the outlier effect. The result was cost ranges between different estimators, rather than selecting single data points.

The analysis does not estimate first-of-a-kind (FOAK) or NOAK costs since the included data were both FOAK and NOAK costs. Furthermore, the resulting quartile values were termed BOAK, which means the next commercial offering, typically between the second and fourth units deployed of a given type, assuming that demonstrations would occur by 2030 through DOE's Advanced Reactor Demonstration Program (ARDP) or other commercial efforts.

For the TEA, three scenarios are created to be consistent with GAIN [23]: (1) advanced, (2) moderate, and (3) conservative. Those scenarios follow the NREL Annual Technology Baseline (ATB) [24] definitions. "Advanced" represents data points with minimal cost-overruns, indicating a very well-executed build, own, and operate project. This scenario could occur if lessons-learned from previous demonstrations are thoroughly applied or if there is substantial government investment in de-risking the technology before execution, ensuring cost-overruns are avoided. The "moderate" scenario corresponds to data points that fall in the middle range of the dataset estimates compiled. This is considered the baseline scenario and is most likely to occur. Significant cost-overruns and inefficiencies still happen here but are less severe than in the conservative scenario. The "conservative" scenario represents the data points with substantial cost-overruns. In this scenario, there has been very limited learning between the initial demonstration and the BOAK estimate. Many of the challenges faced with the FOAK project remain unresolved before developing the next commercial offering [23].

It is vital to note that this report assumes an accelerated built rate of SMNR compared to the GAIN report [23]. The learning rates and units built that are reached in 2040 in the GAIN report are assumed to be reached in 2030 in the following analysis. The reason for this is that learning rates and units deployed are not attached to a calendar year. In other words, the capital costs are not dependent on a calendar year but on the numbers of unit deployed and the learning rates achieved.

The O&M costs are divided into two main categories: (1) fixed O&M costs, and (2) variable O&M costs. Variable O&M costs represent the marginal cost of producing power, influencing the bid price for market clearance. These costs include natural uranium, enrichment, fabrication, and other front-end expenses incurred long before the fuel is loaded into the reactor. The fuel remains in the reactor for years before significant back-end costs for spent nuclear fuel management arise, assuming direct disposal.

The OCCs, variable O&M, and fixed O&M costs were estimated using data from GAIN [23], as shown in Table 10.

Table 10. SMNR cost structure. Adapted from GAIN [23].

Cost contributors for SMNR	Advanced	Moderate	Conservative
BOAK OCC ($/kWe)	3,000	5,500	8,000
Non-fuel costs for variable O&M ($/MWh)	2.2	2.6	2.8

Fuel costs for variable O&M ($/MWh)	10.0	11.0	12.1
Fixed O&M costs ($/MWh) @93% capacity factor	14.5	16.6	26.5
Construction periods (months)	60	82	125

Given the high uncertainty in cost-overruns and construction time, the construction period was set within the range for large reactors.

To quantify the total CAPEX, annual variable O&M, and annual fixed O&M, the thermal capacity, thermal efficiency, and capacity factor used for each case defined in Section 4.1 are shown in Table 11. Note that the thermal efficiency here is the nominal thermal efficiency to convert a 200 MWth of SMNR to 80 MWe.

Table 11. Thermal capacity, thermal efficiency, and capacity factor. Adapted from GAIN [23].

Parameters	Case 1a	Case 1b	Case 1c	Case 2
Thermal capacity (MWth)	200	400	600	2800
Nominal thermal efficiency (%)	40	40	40	40
Capacity factor (%)	93	93	93	93

7.1.2 High-Temperature Steam Electrolysis

The CAPEX for HTSE includes DCCs, ICCs, and the non-depreciable land costs. The DCC for constructing the HTSE facilities includes the installed stacks, as well as the balance of plant costs that are the function of the HTSE capacity. A linear regression is performed to fit the DCC data ranging from 10 MW-dc to 1600 MW-dc, as shown in Figure 20. The NOAK HTSE design is assumed in this study.

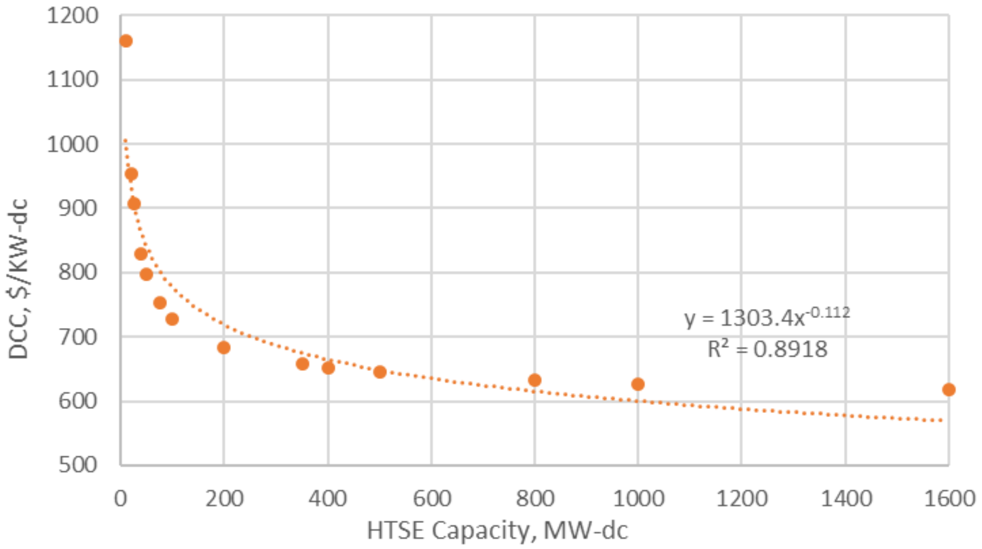


Figure 20. DCCs for an HTSE facility as a function of NOAK HTSE capacity.

In this study, since each case propose different amounts of hydrogen demands, there are various sizes of HTSE capacities for Cases 1a, 1b, 1c and 2. Therefore, their HTSE capacities and cost's structure are reported in Table 12.

Table 12. HTSE cost structure. Adapted from [9].

Cost contributors for HTSE	Case 1a	Case 1b	Case 1c	Case 2
HTSE capacity (MW-dc)	74	149	194	994
DCCs ($/kW-dc)	803	743	721	600
ICCs ($/kW-dc)	332	307	298	248
Land costs ($ Million)	17	31	40	169
Cooling water costs ($/gallon)	2.79E-5	2.79E-5	2.79E-5	2.79E-5
Process water costs ($/gallon)	2.79E-3	2.79E-3	2.79E-3	2.79E-3
Cooling water usage (gallon/day)	5,971,410	11,946,768	15,575,229	79,764,426
Process water usage (gallon/day)	132,647	265,382	345,984	1,771,864
Performance factor at the 1st, 6th, 11th, 16th, 21st, 26th, 31st, and 36th year (%)	100%	100%	100%	100%
Performance factor at the 2nd, 7th, 12th, 17th, 22nd, 27th, 32nd, and 37th year (%)	98%	98%	98%	98%
Performance factor at the 3rd, 8th, 13th, 18th, 23rd, 28th, 33rd, and 38th year (%)	96%	96%	96%	96%
Performance factor at the 4th, 9th, 14th, 19th, 24th, 29th, 34th, and 39th year (%)	94%	94%	94%	94%
Performance factor at the 5th, 10th, 15th, 20th, 25th, 30th, 35th, and 40th year (%)	92%	92%	92%	92%
Additional staffs in HTEF	8	9	10	15
Annual labor costs ($)	$990,233	$1,177,690	$1,258,424	$1,893,087
Annual general and administrative costs ($)	$9,902	$11,777	$12,584	$18,931
Annual property tax and insurance costs ($)	$2,028,550	$3,754,346	$4,750,966	$20,252,851
Annual maintenance and repair costs ($)	$1,793,930	$3,320,122	$4,201,473	$17,910.426
Decomposing costs ($ Million)	8	16	20	84
Salvage value (($ Million)	10	19	24	101

7.1.3 Methanol-Synthesis Plant

It is assumed that the methanol-synthesis plant has been fully depreciated and that no additional CAPEX is necessary to integrate the methanol-synthesis plant with the HTSE and SMNR. No integration costs are considered within the scope of the TEA since the order of the magnitude for the integration costs is significantly smaller than the SMNR CAPEX. The cost structure of the reference methanol-synthesis plant is documented in Table 13. The NG usage for each case, along with the CO_2 reduction and electricity sales, are calculated by leveraging the HYSYS model in Appendix D.

Table 13. Cost structure of reference methanol plant.

Cost Contributors for Methanol-Synthesis Plant	BAU	Case 1a	Case 1b	Case 1c	Case 2	Notes
Methanol price ($/MT)	366	366	366	366	366	Ref. [25]
Methanol production (MT/yr.)-Cases 1a, 1b, and 1c	995,555	995,555	995,555	995,555	1,075,649	Ref. [16]
Industrial CO_2 price ($/MT) @2021	-	-	-	-	13.10	Ref. [26]

NG price ($/MMBtu)	6.4	6.4	6.4	6.4	6.4	Ref. [27]
NG usage (MT/day)	1488	1371	1300	0	1488	-
Annual labor costs ($ for 50 staff-members)	$7,367,360					Ref. [43]
Annual general and administrative costs ($)	$1,473,472					Ref. [43]
Property tax and insurance ($)	$11,566,718					Ref. [43]

7.2 Market Analysis

7.2.1 Methanol Production/Projections Within U.S. Context - Price in the U.S.

According to the EPA [6], the U.S. has nine operating methanol plants as of 2023. Figure 21 illustrates the location of these methanol-production facilities, which are predominantly located in the Gulf Coast region. For a complete breakdown of these U.S. methanol-production facilities, including their names, locations, and capacities, refer to Table 14. The total U.S. methanol production in 2023 was approximately 8.7 MMT/yr. In 2020, North America accounted for 5% of the total global methanol demand and 4% of the supply [15].

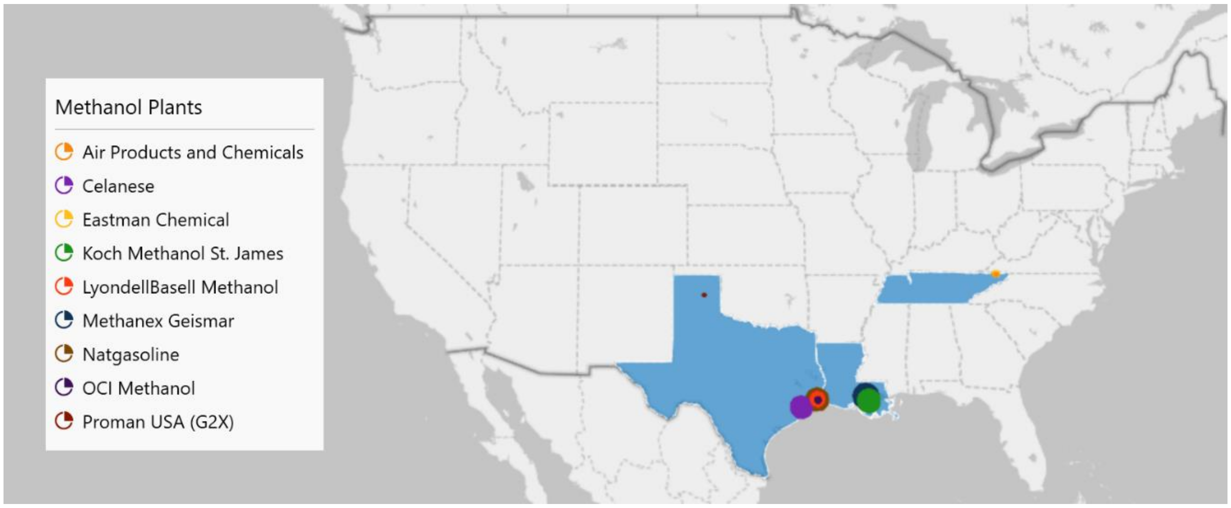


Figure 21. Methanol producers in the U.S.

Table 14. Distribution of U.S. methanol-production facilities.

Company	State	Site	Capacity (Tons Per Year)
Celanese [28]	Texas	Pasadena	1,620,000
Proman USA (G2x) [29]	Texas	Pampa	78,750
OCI Methanol [30]	Texas	Beaumont	200,000
Lyondellbasell [31]	Texas	Beaumont	800,000
Natgasoline [31]	Texas	Beaumont	1,700,000

Company	State	Site	Capacity (Tons Per Year)
Methanex [32]	Louisiana	Geismar	2,200,000
Koch Methanol [33]	Louisiana	St. James Parish	1,800,000
Eastman Chemical [31]	Tennessee	Kingsport	215,420
Air Products & Chemicals [31]	Tennessee	Kingsport	96,000
			Total Capacity: 8,710,170

The methanol price was taken from the Methanol Institute (MI) [26]. Figure 22 shows historic methanol market global pricing. The price used as a reference was set at $366 per metric ton, which represents the average price of methanol in the U.S. according to MMSA Spot Barge data for the year 2022 [25,34].

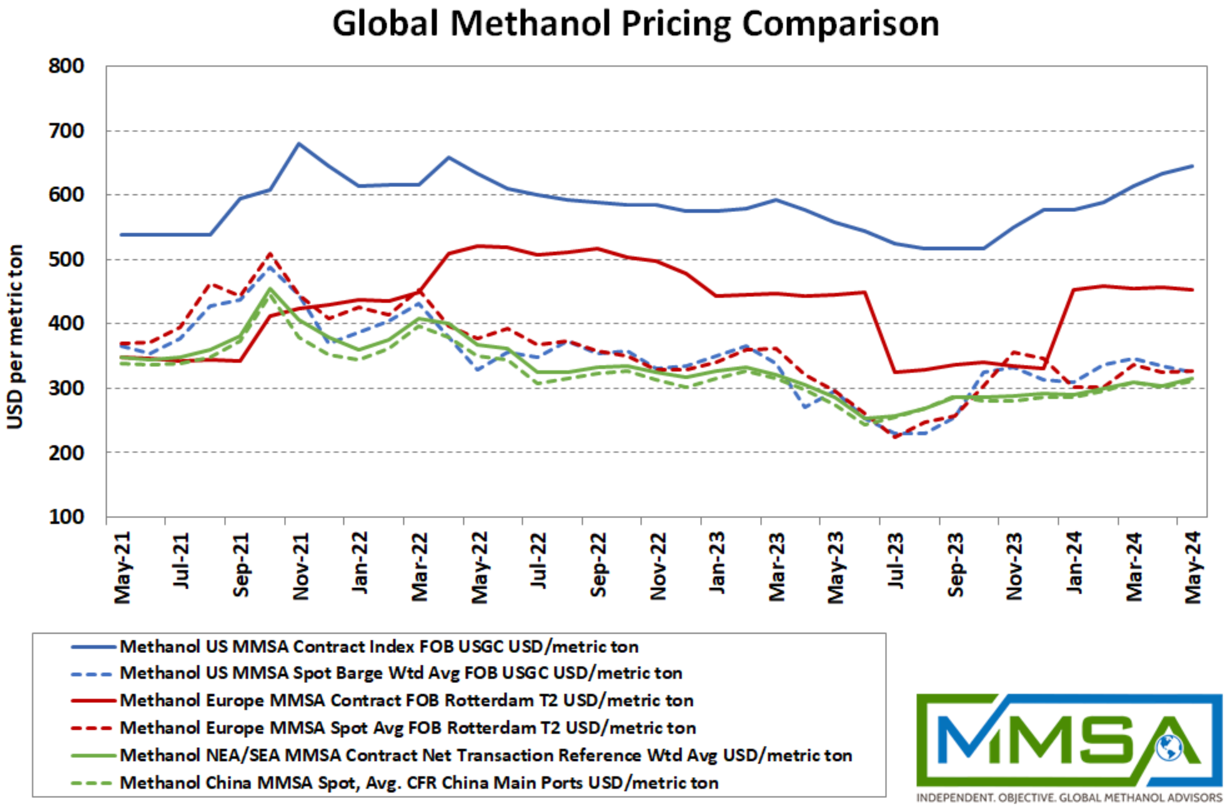


Figure 22. Methanol pricing in key regional markets (U.S. Gulf Coast, Rotterdam, Coastal China) [25,34].

7.2.2 Inflation Reduction Act Tax Credits

The IRA offers a vast set of financial incentives to promote clean energy technology investments and decarbonize energy production, featuring over 20 new or revised tax incentives and funding for grants and loans. These measures are aimed at stimulating investments in clean energy technology and transitioning to a net-zero energy economy [35]. Additionally, the IRA includes grants and loans for clean energy projects that reduce GHG emissions and other pollutants, with bonuses for projects in disadvantaged and energy-challenged communities, and those meeting labor requirements [36].

For the past two decades, federal tax credits have been a primary financial incentive for renewable energy (RE) deployment in the U.S. The production tax credit (PTC), introduced in the Energy Policy Act of 1992, primarily supported wind energy projects, while a 30% investment tax credit (ITC) was established for solar projects [12]. These federal tax credits have undergone numerous expirations, extensions, modifications, and renewals [37,38]. The new IRA extends and modifies the PTCs and ITCs for RE, making them technology-neutral, emissions-based credits. The current PTC from the IRA is based on the electricity produced by a system and is received annually, whereas the ITC is based on the CAPEX of building the system and is received once as a portion of the total CAPEX [39].

Overall, these tax credit extensions and modifications have been crucial in shaping the U.S. RE landscape, driving significant investment and growth in the sector. The IRA tax credits also apply to advanced nuclear energy, allowing taxpayers to choose between the PTC for ten years after a facility is built in 2025 or later, or the entire ITC at once. These new tax credits are available from 2025 until 2032, or until annual GHG emissions from electricity production are 25% or less of 2022 levels. Taxpayers must choose between the PTC or ITC, as they cannot receive both. Credits may be extended if CO_2 emissions do not meet the 2022 threshold [39].

The IRA also promotes investments in disadvantaged communities by offering bonus credits for projects meeting specific criteria, including wage and apprenticeship requirements, domestic content standards, and locations in energy communities. Aiming for 100% CO_2 pollution-free electricity by 2035, the IRA recognizes the climate crisis, particularly in the electric-power sector. Achieving these climate goals requires substantial investments to accelerate clean energy deployment and foster innovation in new technologies to reduce CO_2 emissions. The IRA expands the Loan Authority for Innovative Clean Energy Projects, providing the DOE Loan Programs Office with $40 billion in loan authority, supported by $3.6 billion in credit subsidies. This funding is intended to provide loan guarantees under Section 1703 of the Energy Policy Act, targeting innovative clean energy technologies, including RE systems, carbon-capture, nuclear energy, and critical minerals processing, manufacturing, and recycling. Additionally, the IRA introduces measures to ensure broader accessibility to these tax incentives for state, local, and tribal governments, and tax-exempt organizations, allowing them to receive certain tax credits as direct payments or transfer credits to unrelated parties in exchange for cash [40,41].

7.3 Nuclear-Integration Case Studies – Deltas

7.3.1 Financial Performance

Using NIHPA and SET, the two scenarios described previously are modeled to obtain the present value of cash flows for the two potential methanol plant integrations with an SMNR. Cash flow growth is calculated according to Equation (14):

$$Cash\ Flow\ Growth = \frac{NPV_{case_i} - NPV_{BAU}}{NPV_{BAU}} \qquad \text{Equation (14)}$$

The results for each scenario under three different CAPEX levels, with and without tax credits, are summarized in Figure 23.

The results show that CAPEX is critical to obtaining positive cash flow NPV when the reactor size increases. The tax credits selected (e.g., ITC-48E and/or PTC-45V) are the main revenue drivers in each scenario. When an advanced nuclear reactor is built and further integrated into methanol-synthesis plant operations, the most-profitable scenario is Case 1b, which uses nuclear hydrogen from 400 MWth SMNR backing-out 76.7% NG. Case 1b includes ITC-48E for the SMNR and PTC-45V for the H_2 used in the process. It is important to note that ITC-48E and PTC-45V reduce the net investment costs and make all nuclear-integration scenarios (e.g., Cases 1a, 1b, 1c, and 2) more cost-competitive than the BAU when the CAPEX is low ($5,500/kWe).

Note that the size of the reactor of Case 2 (e.g., SMR replaced with RGWS, SMNR Generates Hydrogen for Syngas Production) always makes the cash flow NPV negative and only when the CAPEX is lower does the cash flow become positive. In other words, nuclear integration for Case 2 presents the highest total costs, the NPV becomes positive when the tax credits are present, and the CAPEX is not higher than $3,000/kWe. These results are summarized in Table 15, Table 16, and Table 17, respectively.

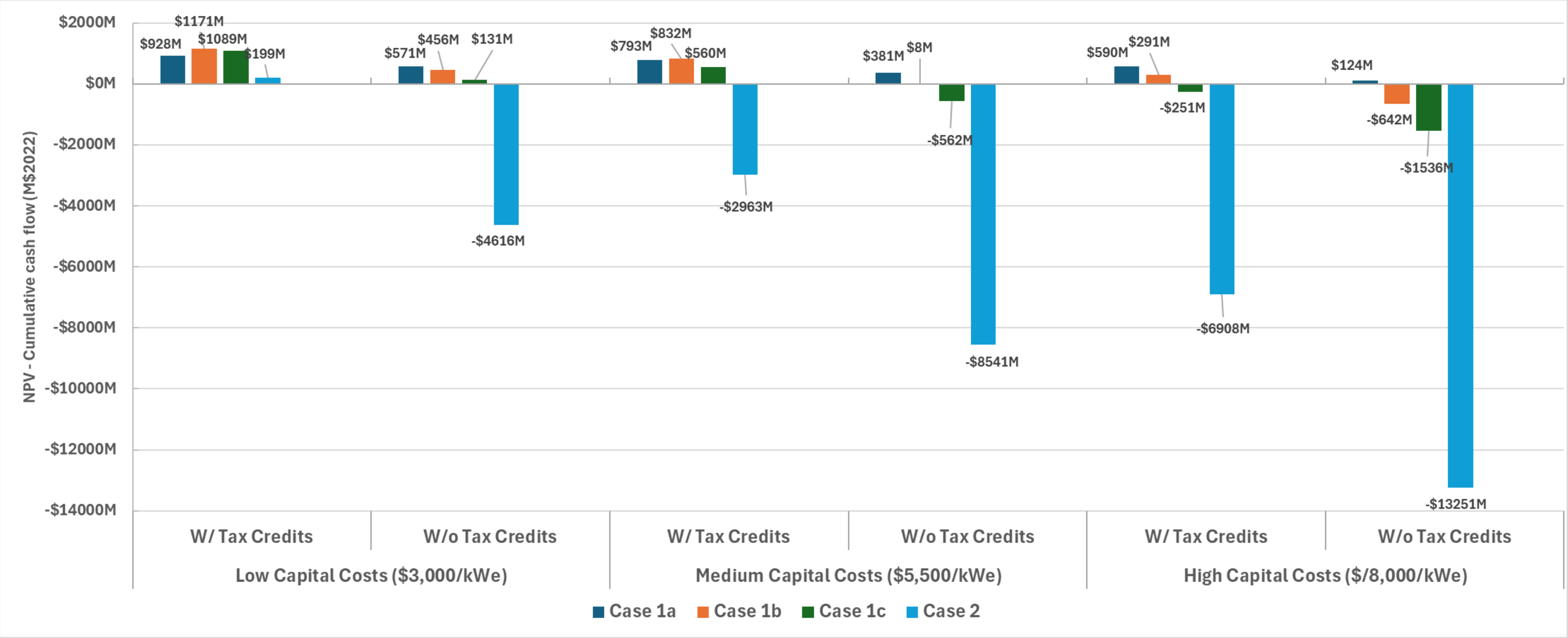


Figure 23. NPV cumulative cash flow (2022 USD).

Table 15. Summary of key results of financial performance for high CAPEX ($8,000/kWe).

40 Years Project Lifetime					
CAPEX HTGR = $8,000/kWe		**Case 1a**	**Case 1b**	**Case 1c**	**Case 2**
Feedstocks	NG Consumption	1488 tpd	137 tpd	1300 tpd	0 tpd
	CO_2	0 kMT/yr.	0 kMT/yr.	0 kMT/yr.	4855 kMT/yr.
Products	CO_2 Emissions Savings (MMT of CO_2/yr.)	118 MMT/yr.	236 MMT/yr.	308 MMT/yr.	197 MMT/yr.
	Electricity Sales	2.0MW	2.0MW	33.4MW	52.0MW
IRA Benefits	Tax Credits	ITC 48E + PTC 45V	ITC 48E + PTC 45V	ITC 48E + PTC 45V	ITC 48E + PTC 45V
Finance	NPV Cash Flow	$590M	$291M	-$251M	-$6908M
	Delta NPV of Total Costs w/ITC48E and PTC 45V (Relative to BAU)	-$464M	-$763M	-$1305M	-$7962M
	ACC ($/mt$CO_2$)	$123.9	$121.6	$139.4	$1,087.0
	ANCC ($/mt$CO_2$) w/credits	$25.0	$22.8	$35.1	$282.1
	IRR	42.0%	22.0%	-2.0%	0.0%

Table 16. Summary of key results of financial performance for medium CAPEX ($5,500/kWe).

40 Years Project Lifetime					
CAPEX HTGR = $5,500/kWe		**Case 1a**	**Case 1b**	**Case 1c**	**Case 2**
Feedstocks	NG Consumption	1488 tpd	1371 tpd	1300 tpd	0 tpd
	CO_2	0 kMT/yr.	0 kMT/yr.	0 kMT/yr.	4855 kMT/yr.
Products	CO_2 Emissions Savings (MMT of CO_2/yr.)	118 MMT/yr.	236 MMT/yr.	308 MMT/yr.	197 MMT/yr.
	Electricity Sales	2.0 MW	2.0 MW	33.4 MW	52.0MW
IRA Benefits	Tax Credits	ITC 48E + PTC 45V	ITC 48E + PTC 45V	ITC 48E + PTC 45V	ITC 48E + PTC 45V
Finance	NPV Cash Flow	$793M	$832M	$560M	-$2963M
	Delta NPV of Total Costs w/ITC48E and PTC 45V (Relative to BAU)	-$261M	-$222M	-$494M	-$4017M
	ACC ($/mt$CO_2$)	$87.3	$85.0	$97.3	$780.0
	ANCC ($/mt$CO_2$) w/credits	$0.0	-$2.3	$6.3	$72.0
	IRR	60.0%	43.0%	29.0%	0.0%

Table 17. Summary of key results of financial performance for low CAPEX ($3,000/kWe).

40 Years Project Lifetime					
CAPEX HTGR = $3,000/kWe		**Case 1a**	**Case 1b**	**Case 1c**	**Case 2**
Feedstocks	NG Consumption	1488 tpd	1371 tpd	1300 tpd	0 tpd
	CO_2	0 kMT/yr.	0 kMT/yr.	0 kMT/yr.	4855 kMT/yr.
Products	CO_2 Emissions Savings (MMT of CO_2/yr.)	118 MMT/yr.	236 MMT/yr.	308 MMT/yr.	197 MMT/yr.
	Electricity Sales	2.0MW	2.0MW	33.4MW	52.0MW
IRA Benefits	Tax Credits	ITC 48E + PTC 45V	ITC 48E + PTC 45V	ITC 48E + PTC 45V	ITC 48E + PTC 45V
Finance	NPV Cash Flow	$928M	$1171M	$1089M	$199M
	Delta NPV of Total Costs w/ITC48E and PTC 45V (Relative to BAU)	-$126M	$117M	$35M	-$855M
	ACC ($/mt$CO_2$)	$60.1	$57.9	$66.1	$552.29
	ANCC ($/mt$CO_2$) w/credits	-$22.4	-$17.9	-$17.8	-$58.8
	IRR	90.0%	69.0%	54.0%	16.0%

7.3.2 Future Prospects and Developments

This study has pinpointed multiple CO_2 emission sources within a reference methanol-synthesis plant via SMR that could potentially be mitigated by integrating clean power from a HTGR-type SMNR. Key contributors identified to be major CO_2 emissions contributors include H_2 production from NG SMR and the combustion of NG and waste gas in SMR furnaces, which together account for over 30% of emissions.

The traditional SMR process generates syngas containing both H_2 and CO_2 by NG SMR, a reaction that requires high temperatures (1,500–1,800°F) mainly supplied by burning NG, leading to CO_2 emissions in the fuel gas. Additionally, the CO_2 byproduct from the syngas is typically released into the atmosphere after the purification of the H_2 product. Some options identified as future prospects for decarbonization and nuclear-integration developments into the methanol-synthesis processes are described as follows.

7.3.3 Emerging Technological Alternatives

7.3.3.1 Stack Gas Scrubbing

Traditional Approach: Another method to mitigate CO_2 emissions is applying stack gas scrubbing to the SMR furnace effluent. This involves removing CO_2 from the stack gas, with the SMNR providing the necessary heat and power for the scrubbing and CO_2 compression processes.

7.3.3.2 Electrified SMR (eSMR)

Research and Feasibility: Aarhus University and Haldor Topsoe have demonstrated through process modeling and laboratory experiments that replacing fossil fuel-based heat with electrified SMR is feasible. This technology requires further validation through pilot plant testing, scale-up, and demonstration.

Integration with SMNR: Utilizing clean electricity and steam from an SMNR could significantly reduce CO_2 emissions by supplying the necessary heat and power for the electric SMR process. This approach could complement low-carbon H_2 production from HTSE integrated with an SMNR.

7.3.3.3 Waste Gas Utilization

Conversion Processes: Light-end gases from the methanol-synthesis process can be combusted in eSMR furnaces or converted into H_2 and co-products like coke and CO_2.

Electric Plasma Process: Waste gas can also be converted into H_2 and CO_2 using an electric plasma process, which primarily relies on electricity. While this method has been modeled and scaled on pilot plants, its high electricity demand has hindered widespread commercialization. However, clean electricity from an SMNR could make this process viable and yield a decarbonized H_2 product.

Integrating SMNRs with methanol plants presents a promising pathway for significant CO_2 emission reductions. The electrification of SMR processes, innovative waste gas conversion methods, and traditional stack gas scrubbing are all viable strategies that require further development and demonstration. As these technologies mature, they could transform the methanol-production industry into a more sustainable and environmentally friendly sector.

7.4 ACC Estimations

The ACC is the total cost incurred for CO_2 abatement along these nuclear-integration scenarios. The results from CO_2 emissions reductions at various scopes, along with the price of power, heat, and H_2 for each of the cases serve as the basis for this calculation. Scope 1 emissions are estimated on a yearly basis along with all ACC calculations. The calculations assume a 40-year project life. A sensitivity analysis for the ACC cases was conducted for a project life of 20 years and is exhibited in Appendix E.

Using Equation (12) and Equation (13), ACC for cases without tax credits and with tax credits are shown in Figure 24 and Figure 25, respectively.

Figure 24 presents the annual CO_2 avoidance cost as a function of the total onsite CO_2 avoidance for scenarios, respectively, excluding and including the IRA ITCs and PTCs. The ACC was examined for three SMNR costs of \$8000/kWe, \$5,500/kWe, and \$3,000/kWe, respectively. The total onsite CO_2 avoidance is listed in terms of MT CO_2 per year, based on the 476k MT/year of CO_2 emissions associated with the referenced 1,000,000 MT/yr. methanol-synthesis plant.

Figure 24 and Figure 25 also present decarbonization cost as a function of the quantity of CO_2 emissions avoided for scenarios excluding and including the IRA ITCs and PTCs, respectively, but in this figure, the ACC is presented on a normalized basis. Therefore, the normalized ACC presented in terms of \$/ton-CO_2 for each case can be compared while also maintaining perspective on which cases provide the highest level of methanol-synthesis plant decarbonization.

When the IRA ITCs and PTCs are excluded, Figure 24 illustrates that higher decarbonization levels are generally associated with higher annual costs. Cases on the lower-right side of the dataset provide higher levels of decarbonization at a relatively lower cost than for the other cases. These cases could be viewed as providing greater value than the other cases that were considered.

Figure 25 shows the proportional relationship that forms between the quantity of CO_2 emissions that were avoided and the avoidance costs when the IRA ITCs and PTCs are included. The electrolysis-based Cases 1a, 1b, 1c, and 2, which are eligible for clean electricity ITC and clean H_2 PTC investments, illustrate the potential to achieve increased levels of reductions of CO_2 emissions with minimal or, in most cases, negative CO_2 avoidance costs. In addition, Figure 25 illustrates the impact of reactor costs on the decrease in ACC, when it is compared with Case 2 where the reactor size is much larger—especially on Case 2—with the application of the tax credits. Cases 1b and 1c provide significant cost-savings associated with SMNR-based methanol-synthesis plant decarbonization. Cases 1b, 1c, and 2 are the most impactful cases in that they provide 49–64% reduction in CO_2 emissions while resulting in a significant reduction in the CO_2 avoidance cost.

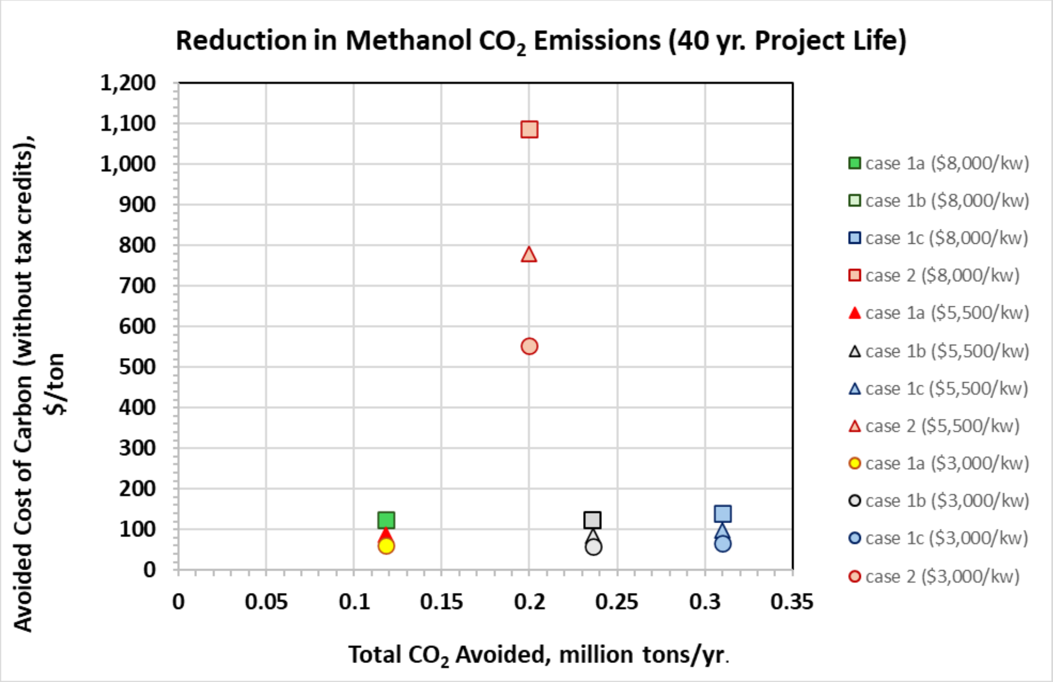


Figure 24. HTGR-type SMNR methanol-synthesis plant decarbonization total onsite CO_2 avoidance and annual cost by case **without** IRA ITCs and PTCs.

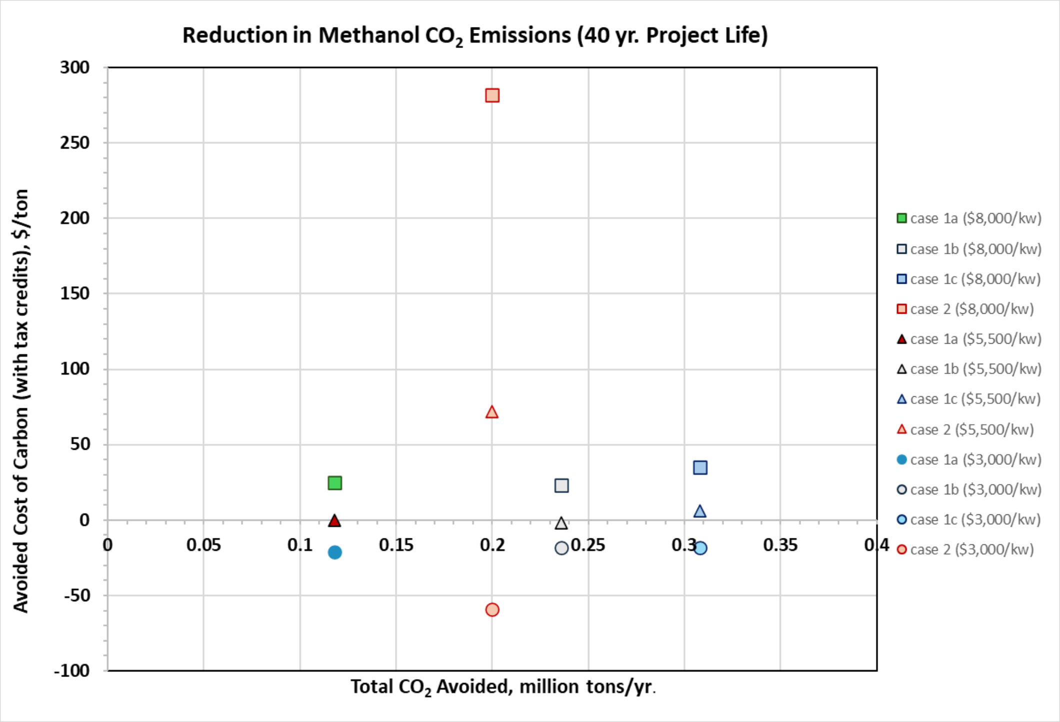


Figure 25. HTGR-type SMNR methanol-synthesis plant decarbonization total onsite CO_2 avoidance and annual cost by case **including** IRA ITCs and PTCs.

Figure 24 also presents the decarbonization cost as a function of the quantity of CO_2 emissions avoided for scenarios excluding the IRA ITCs and PTCs, while Figure 25 depicts the same estimations including the IRA ITCs and PTCs, respectively. Note that in these figures, the ACC is presented on a normalized basis. Therefore, the normalized ACC (presented in terms of \$/ton-CO_2) for each case can be compared, while also maintaining perspective on which cases provide the highest level of methanol-synthesis plant decarbonization.

7.5 Risk Assessment and Management

7.5.1 Financial and Reinvestment Risks

There are many different risks associated with investment projects, but financial and reinvestment risks are relevant for this study. Gonçalves [42] states that reinvestment risk is the risk that cash flows generated by the investment will need to be reinvested at a lower rate of return. He notes that this risk is particularly relevant for long-term projects, where reinvestment opportunities might not yield the same returns.

Financial risk is affected by different factors, such as market fluctuations, the state of the economy, regulations, credit defaults, liquidity shortages, operational failures, economic downturns, etc. It involves potential losses due to changes in market conditions, impacting interest rates, equity prices, and commodity prices. For instance, interest rate risk can affect borrowing costs, while equity and commodity price risks can impact the value of investments and profitability. The possibility of a borrower or counterparty defaulting on obligations can cause financial losses. Changes in the spread between interest rates for different credit ratings can affect financing costs. Funding risk involves the risk that necessary funding may not be available when needed or may come at higher costs.

Liquidity risk might result in not meeting short-term financial obligations due to insufficient cash or the inability to sell assets quickly without affecting their price. The DCF model allows us to identify and estimate the cash reserves that the project will generate over a period of time, and furthermore, it can be used to make better decisions and manage risk.

Also, environmental risk includes potential financial impacts from environmental factors and natural disasters. Climate change and natural disasters can disrupt project operations. Finally, economic risk encompasses broader economic factors that can negatively impact a project, such as a recession that can reduce sales and inflation that can affect the costs of the company. In other words, purchasing power and cost structures can be affected.

7.5.2 Technical Risks

The technical risks will include the integration of the SMNR and methanol-synthesis plant operations. The methanol-synthesis plant operates on a continuous basis but could incur variations in operating rates. These changes could alter the normal/system design electricity, heat/steam, and H_2 demands from the integrated HTSE system, which are outlined below:

- Normal methanol-synthesis plant operating conditions change
- Unit emergency shutdowns
- Planned methanol unit startup and shutdowns
- SMNR emergence shutdown
- SMNR refueling, maintenance, and inspection.

The magnitude of these changes and their ultimate impact on the SMNR operation require an assessment.

The methanol-synthesis plant operation could change due to weather-related impacts, feedstock availability, and other variables that could impact the energy and H_2 demand from the SMNR. Normally, these operational alterations are planned and executed to minimize the impact on energy demand.

However, methanol plants do experience infrequent major changes or disruptions to operation that would have a direct impact on SMNR operation. These changes could range from a single unit shutdown to an entire methanol-synthesis plant outage due to fires, equipment failure, power outages, and other circumstances. As a result, major dynamic changes would occur in the integrated SMNR and methanol-synthesis plant operations. This type of situation would have to be assessed in a probabilistic risk assessment (PRA).

The methanol-synthesis plant and SMNR require planned shutdowns to inspect, refuel, clean, and repair equipment. These outages are planned and executed over 1–2 months. Prior to these shutdowns, the methanol-synthesis plant and SMNRs will decrease operating rates to the ultimate shutdown condition. Upon completion of the shutdown work, the system will return to full operation in an orderly manner. A clear understanding of the hazards, limitations, requirements, and system dynamics is required.

Also, the integration scheme includes an SMNR, which will be regulated by the U.S. Nuclear Regulatory Commission (NRC). The technical risks will include the governance and requirements of the NRC as a factor for the operational changes. Also, an understanding of the NRC’s regulations concerning nuclear reactor operation will be needed in the integration operation.

8. CONCLUSIONS

The TEA and gap analysis for advanced nuclear reactor integration into a 1 MMT/yr. reference methanol-synthesis plant considered in this report reveals significant potential for profitably decarbonizing chemical production by leveraging energy-efficient processes, such as HTSE and combined heat-power. Nuclear-integrated H_2 production via HTSE appears to be a cost-effective means of lowering the CO_2 intensity of the conventional SMR fuel gas, particularly when the nuclear ITC and clean hydrogen PTC from the IRA apply. In the case of the state-of-the-art RWGS pathway, the overall economics are highly impacted by SMNR size and the capital cost associated with this technology. The economic viability of this pathway likely requires SMNR capital costs to reach average-to-low estimates.

Initially, the BAU reference methanol plant emits 483,000 tons of CO_2 annually. Replacing some or all of the NG required for combustion heat with clean hydrogen in the SMR unit can significantly reduce these emissions. For instance, in Case 1a, where NG is reduced about 38.4% by using electrolysis-based hydrogen, the fuel-gas blend eliminates 118,000 tons of CO_2 emissions per year—or 24.4% CO_2 less relative to BAU—selling 2 MW of electricity to the grid as export sales, this surplus power comes from the heat-recovery cogeneration system. Further nuclear hydrogen-NG blending decreases CO_2 emissions even more, as seen in Case 1b. Clean hydrogen backing-out 76.7% of NG can double CO_2 abatement to 236,000 tons CO_2 per year (48.9% CO_2 less relative to BAU) exporting the same power to the grid as in Case 1a. The most extreme nuclear-integrated scenario is described in Case 1c, where the supplemental NG required for combustion heat demands in the SMR unit is completely replaced by 100% clean hydrogen combustion, resulting in a reduction of 308,000 tons of CO_2 per year—or 63.8% CO_2 less relative to BAU—and an additional 31.4 MW of power sold to the grid that comes from the HTGR on top of the surplus electricity gotten in the heat-recovery cogeneration system for a total of 33.4 MW of electricity sales.

Ultimately, for Case 1c it was demonstrated that a 600 MWth HTGR-HTSE system can satisfy the reference methanol plant's entire supplemental combustion heating demand when 100% of the NG required for combustion heat is replaced for hydrogen, while the process electricity, high-pressure steam, and low-pressure steam demands are fully covered by the internal heat-recovery system. Cases 1a and 1b are incremental integrations building towards Case 1c, where 200 and 400 MWth HTGRs, respectively, are dedicated to produce hydrogen for fuel-gas blending.

For Case 2, where the SMR unit is replaced by the RWGS pathway that sources carbon from an industrial CO_2 source, the proposed technology requires a 2800 MWth HTGR-HTSE system to fully satisfy the process hydrogen, electricity, and heat demands. A total of 197,000 tons of CO_2 emissions would be abated per year—or 40.1% CO_2 less relative to BAU—and 52 MW of clean electricity would be sold to the grid. The analysis assumed various reactor costs and evaluated financial metrics, such as NPV, IRR, and ACC over a 40-year project lifespan, including a detailed estimation both with and without the current tax credit incentives as of 2024. Results indicate the advanced nuclear reactor CAPEX is the main cost driver for all nuclear-integration pathways.

Tax credits—particularly ITC-48E and PTC-45V—significantly influence the revenue in all case studies, showing the ACC can be as low as \$139.4/ton CO_2 without tax credits, as revealed in Case 1c at high-reactor cost levels for the clean hydrogen-NG fuel-gas blend cases, but can be decreased to the point of creating a revenue of \$22.4/ton CO_2 as depicted in Case 1a for the same proposed technology. For the fuel-gas blend scenario, the highest NPV is observed in Case 1b at low and medium reactor cost levels, which is influenced by the high amount of hydrogen produced and the tax credits associated (PTC 45V). Although Case 1c generates more hydrogen the CAPEX associated with this case are significant, which reduces its profitability in comparison with Case 1b. Even though both Cases 1b and 1c incur higher total costs due to larger thermal power requirements, they remain cost-competitive. In addition, Case 1a also reveals that only backing-out 38.4% of NG into the SMR unit, the process economics for Case 1a are profitable, even though are smaller than the other options suggested for fuel blending in Cases 1b and 1c.

In Case 2, where a full replacement of the SMR unit by the RWGS pathway is suggested, the outcomes of this study conveyed that the proposed scenario does not seem profitable in the lifetime period studied in this analysis. This is because the larger thermal power requirements incur greater total costs due to the HTGR-HTSE system size, not remaining cost-competitive at all three reactor cost levels. This is in large part due to calculating the ACC using only the delta in emissions between the reference plant and the RWGS plant, when RWGS is an overall deeper decarbonization effort due to the conversion of industrial CO_2 instead of CH_4 to CH_3OH.

Overall, deeper decarbonization correlates with higher annual costs when tax credits are excluded. However, with the inclusion of tax credits, a proportional relationship between CO_2 emissions avoided and ACC emerges. Cases 1a, 1b, and 1c show a high-potential for achieving high-levels of CO_2-emission reductions with minimal or negative additional CO_2 avoidance costs, making SMNR-based methanol-synthesis decarbonization profitable and environmentally impactful. While the ACC associated with Case 2 are higher than the above-mentioned scenarios due to the high-capital costs associated with this technology, even though a negative CO_2 emissions balance can be achieved as described in Section 5.

The estimations calculated in this report are not absent from limitations. The economic analysis used the most updated SMNR cost-estimates, and they should be seen as a first intent to estimate the profitability of an investment project that integrated a methanol-synthesis plant with an HTGR. The analysis depends on the cost structure and IRA tax credits assumed. Increasing the certainty on these key variables would add more fidelity to the analysis.

The results of this study highlight the significant impact that the IRA tax credits will have on the economics of SMNR investment projects—especially when factoring in cost uncertainties associated with a developing technology that has not initiated construction. Investors may initially plan to use the ITC based on cost and capacity factor forecasts but might need to stack others, such as the H_2 tax credit, as actual costs are incurred.

The main cost driver explaining the difference in profits between scenarios is the CAPEX of the SMNR, while the tax credits serve as the primary revenue driver. Despite the total high CAPEX amount, the integration of an HTGR-HTSE system with the methanol-synthesis plant can save future costs of carbon and increase the revenues of the projects through the IRA tax credits. When a nuclear reactor is built and integrated into methanol-synthesis operations, the most-profitable scenarios are those with a CAPEX of $3,000/kWe where all available tax credits are captured, including ITC-48E for the construction of the HTGR and PTC-45V for the production of internally used H_2.

A new SMNR cannot capture the benefits from both the PTC and ITC. Therefore, the most valuable credit for a project depends on the capital costs of the SMNR. In theory, a shift from the ITC to the PTC could occur if the SMNR projects face low capital costs. Thus, the ITC becomes valuable and attractive in discounted monetary terms, relative to the PTC, as capital costs rise. Finally, a discussion of a potential tax credit for clean steam production could be beneficial for the processes needing to use steam internally.

9. ACKNOWLEDGEMENTS

This work was supported by the DOE-NE IES Program, with work being conducted at INL under DOE Operations Contract No. DEAC0705ID14517. ANL is acknowledged for providing the baseline RWGS Aspen Plus model. INL created the modified Aspen Plus version of the baseline RWGS model and made changes to expand and improve the model. INL developed heat integration models using Cycle-Tempo and added that into the modified Aspen Plus RWGS. INL is recognized for developing the original SMR Aspen Plus model.

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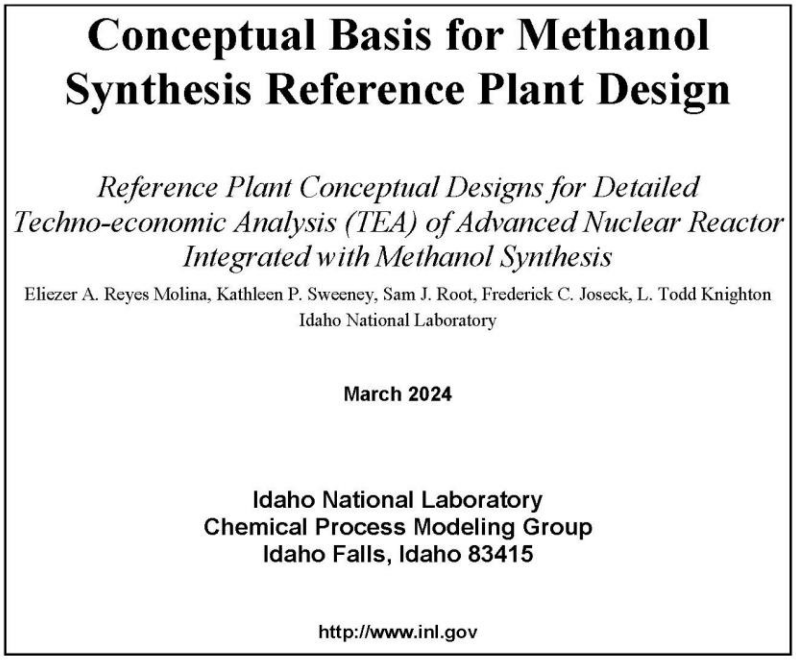
Appendix A

Conceptual Basis for Methanol-Synthesis Reference Plant Design



Conceptual Basis for Methanol Synthesis Reference Plant Design

Reference Plant Conceptual Designs for Detailed Techno-economic Analysis (TEA) of Advanced Nuclear Reactor Integrated with Methanol Synthesis

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OVERVIEW

The U.S. Department of Energy's (DOE) Integrated Energy Systems (IES) program is intensively working to identify opportunities to substitute conventional energy sources with nuclear energy. This document outlines the foundational principles and design criteria used for establishing the reference generic methanol plant that can effectively incorporate advanced nuclear reactors within the methanol synthesis sector. The conceptual design emphasizes the operation units considered to be part of a reference methanol plant for the integration of cutting-edge nuclear reactor technology into existing synfuels infrastructure to enhance efficiency, reduce emissions, and optimize resource utilization.

This initiative aims to provide a comprehensive framework for conducting a thorough techno-economic analysis to assess the feasibility and viability of such integrated systems. Key considerations include the methanol synthesis demand for electricity, high and low-pressure steam, and hydrogen. The goal is to establish a robust reference model that can serve as a benchmark for evaluating the potential benefits and challenges of deploying advanced nuclear reactors in the synfuels industry.

ACRONYMS

ATR	autothermal reformer
BLT	biomass to liquid
FY24	fiscal year 2024
IES	Integrated Energy Systems
MMT	million metric tonne
MTG	methanol to gasoline
NG	natural gas
SMR	steam methane reforming
U.S.	United States

1. REFERENCE METHANOL SYNTHESIS BASIS

The purpose of this document is to communicate the specification for the reference methanol synthesis plant design that will be used within the IES program, Nuclear Applications pillar, in FY24 work to perform technoeconomic analysis of advanced nuclear reactor heat and power integrated with U.S. methanol synthesis operations. This design is generic and does not represent a single methanol production facility. Instead, it represents an average capacity and the variety of process unit operations that would be included in a fully capable conversion type U.S. methanol synthesis site.

The specification that will be use in analysis is for an average capacity methanol synthesis plant via steam methane reforming (SMR) with Lurgi two-stage reactor followed by methanol cooling and with a capacity of 1 million metric tonne (MMT) of high purity methanol (> 99.8%) produced. Other process units assumed included in the specification are as specified below in Table 1.

Table 1. Process unit operations assumed to be in the reference methanol synthesis plant.

Process Unit
Steam Methane Reforming
Lurgi's Two-Stage Reactor & methanol cooling
Methanol Distillation
Air separation unit
Process steam and power system

The remainder of this specification document discusses the rationale for this baseline choice.

2. CAPACITY AND DISTRIBUTION OF U.S. METHANOL PLANTS

The United States has a total of nine operating methanol plants, as per the most recent publicly available information from each company [1]. As shown in Figure 1, methanol production in the United States is concentrated in the Gulf Coast region, due to the logistical benefits it affords. Specifically, Texas and Louisiana account for over 96% of all production (seven out of nine companies), with the remaining 4% or so (two companies) being produced in Tennessee. Table 2 gives a comprehensive distribution of the U.S. methanol production facilities, including their names, locations, and capacities.

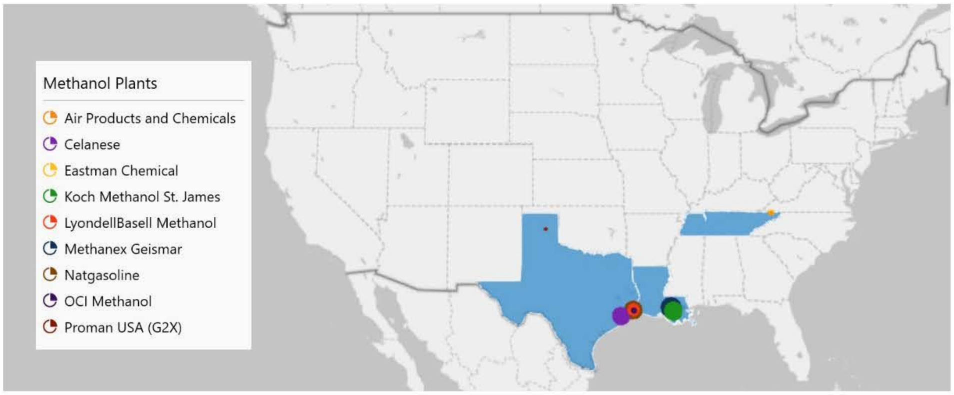

Figure 1. Methanol producers in the United States.

Table 2. Distribution of U.S. methanol production facilities [2].

Company	State	Site	Capacity (Metric Tons Per Year)
Celanese	Texas	Pasadena	1,620,000
Proman USA (G2x)	Texas	Pampa	78,750
OCI Methanol	Texas	Beaumont	200,000
Lyondellbasell	Texas	Beaumont	800,000
Natgasoline	Texas	Beaumont	1,700,000
Methanex	Louisiana	Geismar	2,200,000
Koch Methanol	Louisiana	St. James Parish	1,800,000
Eastman Chemical	Tennessee	Kingsport	215,420
Air Products & Chemicals	Tennessee	Kingsport	96,000
			Total capacity: 8,710,170

Regarding those states that have a significant concentration of methanol facilities:

Texas has most of the methanol production facilities in the U.S, due to the number of refineries located in the Beaumont area, and it reports about 4.4 MMT of methanol produced yearly—50% of the nation's production.

Louisiana only has two facilities, but these facilities, Methanex and Koch, located in Donaldsville are the largest in the country, with annual production capacities of 2.2 and 1.8 MMT, respectively.

Tennessee—specifically, Kingsport—features the nation's smallest production capacity, accounting for an annual production of just 311,420 metric tons.

Capacities may change over time due to upgrades, closures, expansions, or changes in ownership.

To obtain a reference plant capacity and estimate heat and energy duties, average capacity values are used. The average and median capacities for the total number of methanol facilities in the U.S. were calculated to be 967,300 and 800,000 metric tonne per year, respectively. The median is over 56% of all the methanol facilities capacity, and 44% of the nationwide methanol facilities are below the average capacity. Figure 2 shows the distribution of the U.S. methanol plants capacities. The reference plant capacity was chosen to be 1 million metric tonne per year.

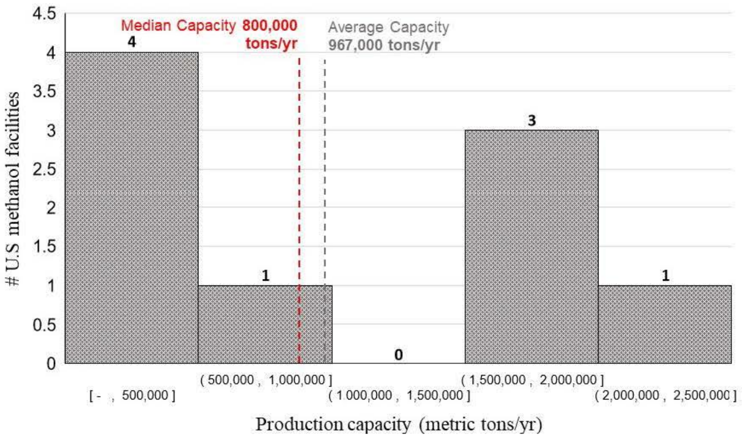

Figure 2. Nationwide methanol plant capacities distribution chart.

CONFIGURATION OF U.S. METHANOL PLANT SYSTEMS

Currently, nationwide methanol plant systems configurations encompass a variety of technologies and feedstock processing methods as previously investigated in Idaho National Laboratory [2]. Table 3 shows a breakdown of the overall systems configurations, technologies, and feedstocks at commercial and pilot scale:

Table 3. Methanol synthesis plant configurations and feedstock processing at commercial and pilot scale.

Facility	Technology	Feedstock	Processing
Natural Gas-Based Plants	Steam Reforming	Natural gas (NG) as the primary feedstock	NG undergoes steam reforming to produce syngas, primarily composed of hydrogen and carbon monoxide. Syngas is then converted into methanol through catalytic processes.
Coal-Based Plants	Coal Gasification	Relies on coal	Coal is gasified to produce syngas. Similarly, to NG-based plants, the syngas is then converted into methanol through catalytic processes.
Biomass-Based Plants	Biomass Gasification or Fermentation	Biomass: woody and agricultural residues, or organic waste	Biomass can be converted into syngas through gasification processes or directly fermented into methanol using specialized enzymatic processes.
Renewable Methanol Plants	Electrolysis or Biomass-to-Liquid (BTL) Processes	Renewable electricity to produce hydrogen	Clean hydrogen is then combined with CO_2 from various sources (e.g., industrial emissions, atmospheric capture) to produce methanol via catalytic processing.
Integrated Plants	Combines multiple technologies	Multiple feedstocks can be combined	For example, some plants may integrate NG with captured CO_2 from industrial processes or direct air capture to produce methanol, reducing carbon emissions.

It is know that the majority of methanol plants in the United States utilize natural gas steam reforming, while others still relies on coal gasification, this number might fluctuate over the upcoming years due to emerging commercial developments to incorporate newer configurations and technologies aimed at decarbonizing this industrial sector by incorporating carbon capture technologies, proposing the adoption of more efficient catalytic processes, also promoting renewable energies for powering the plant operations. By transitioning towards these cleaner and greener processing, natural gas-based methanol plant would have the potential to significantly reduce their environmental footprint while maintaining their role as key contributors to the methanol production landscape in the U.S. Each configuration offers distinct advantages and considerations in terms of efficiency, feedstock availability, environmental impact, and technological complexity, contributing to the diverse landscape of methanol production systems across the United States. The reference methanol plant was chosen to be Natural Gas-Based with Steam Methane Reformer (not including autothermal reformer unit) and Lurgi two-stage reactor followed by methanol cooling.

A rationale for the baseline chosen is presented in the following section.

3. BENCHMARK METRICS COMPARISON BETWEEN DIFFERENT METHANOL SYNTHESIS PROCESSES AND THE AVAILABLE INL PROCESS SIMULATION MODELS

For the process simulation of the methanol synthesis using natural gas through steam methane reforming conversion, two different models from Idaho National Laboratory (INL) database repository were thoroughly assessed. The natural gas to methanol to gasoline (MTG) used in the TEV-667 in 2010 was compared to the most recent model developed in the INL/RPT-23-03731 2024 report. Table 4 discloses the benchmark metrics and the model results considered for the baseline chosen in the methanol synthesis reference plant.

Both models were developed to generate around 10,000 tonnes of methanol a day, which closely matches the national average capacity of methanol production mentioned in section 2. Even though the methanol purity achieved in both models reached 99.8%, the light ends recycled in the INL/RPT-23-03731 model highly impacts the total CO2 emissions accounted for the overall process for about a half of the MTG. In addition, the presence of an autothermal reformer (ATR) in the NG to MTG model requires an additional heat consumption than the one used in INL/RPT-23-03731, because of the fact that ATRs are very heat intensives. While the MeOH synthesis int the NG to MTG considers REqui and RStoic reactors for MeOH production the INL/RPT-23-03731 model is based upon the two steps Lurgi reactors which are reported to be used at-scale which requires a high fuel to methanol ratio of 0.76 compared with 0.5 in the latter case, due to the Lurgi's high yields and selectivity towards methanol production, this estimations might led to additional feedstock cost for the same product amount.

Therefore, for process modeling purposes the methanol synthesis design selected for the reference plant was the process developed in the INL/RPT-23-03731 report. That excludes an ATR unit, utilize a two stages Lurgi reactor, recycling the light ends to the furnace, without partial condenser or reboilers specified and a lower fuel to product ratio.

Table 4. Benchmark metrics are used for process model selection.

Parameter / observation	NGNP - NG to MTG baseline	INL's 2024 model from INL/RPT-23-03731 (scaled down to 10,105 tonnes/day)
Similarity	~10K/day = 3.2-3.5 million tons/year	~10K/day = 3.2-3.5 million tons/year
Similarity	over 99.8% purity	99.99%
Similarity	Light ends burned in the furnace + fuel	Light ends burned in the furnace + fuel
Discrepancy	Industry validated	Has not been validated
Discrepancy	Reformer stream feed P and T (31 bar, 540C)	Reformer stream feed P and T (16.5 bar, 600C)
Discrepancy	NG Reforming relies on ATR (NG+STEAM+O2) for syngas production	INL's Model just used SMR (No ATR as done in the latest model modification modification)
Discrepancy	There is no CO2 make-up or H2 purge off	CO2 make up was used
Discrepancy	MeOH synthesis NGNP considers REqui and RStoic reactors for MeOH production	Based upon the two steps Lurgi reactors.
Discrepancy	Fractionation units feed stream is about 87% MeOH mass fraction	Fractionation block feed has 76% MeOH mass fraction
Discrepancy	Equilibrium stages in distillation columns 8 (1st column) and 18 (2nd column), respectively	Equilibrium stages in distillation columns is 27 (1st column) and 50 (2nd column), respectively
Discrepancy	Partial condenser and Kettle reboiler used	No partial condenser or reboilers specified
Discrepancy	Propanol and Ethanol by products	DME and EtOH was considered as by product
	Fractionation Feed Comp (mass fraction)	
O2	9.86E-17	0
H2	0.000117374	1.10E-08
N2	0.000238145	3.00E-10
CO	1.33E-05	1.00E-08
CO2	0.006771696	0.003926743
NH3	1.96E-05	0
H_2O	0.120355517	0.234901064
CH4	0.001838366	7.48E-06
C2H6	2.39E-07	2.23E-08
C3H8	2.04E-11	7.27E-12
I-C4	0	0

Parameter / observation	NGNP - NG to MTG baseline	INL's 2024 model from INL/RPT-23-03731 (scaled down to 10,105 tonnes/day)
N-C4	0	0
MEOH	0.869784406	0.760614995
EtOH	0	0.000534463
DME	0.000304619	1.52E-05
AR	0.000262735	0
H2S	0	0
NO	1.79E-14	0
NO2	0	0
C3-OH	0.000294004	
	CO2 Emissions (ton/day CO2)	
	2,755	Initially 1321.64 tons a day and then reduced to 29.99 ton a day when light ends are recycled to the furnace
	Single Pass Synthesis MeOH Yield	
	In first pass 0.253211 then to 0.252658 (mass fraction)	In first stage 0.0138, then to 0.1605 and exits the two stages at 0.1997 (mass fraction)
	Syngas Feed Comp (mass fraction)	
O2	4.01E-16	0
H_2	0.125561791	0.130629961
N2	0.008507976	0.000213607
CO	0.562560183	0.395321189
CO2	0.285230836	0.42805967
NH3	1.94E-05	0
H_2O	0.003260008	0.004435354
CH4	0.01242937	0.041338435
C2H6	4.64E-07	1.76E-06
C3H8	3.02E-11	2.00E-10
I-C4	0	8.99E-15
N-C4	0	2.05E-14
MEOH	0	2.79E-08
EtOH	0	1.30E-11
DME	0	7.80E-14
AR	0.002429933	0
H2S	0	0
NO	0	0
NO2	0	0
SO2	0	0
COS	0	
H2S	0	0

Parameter / observation	NGNP - NG to MTG baseline	INL's 2024 model from INL/RPT-23-03731 (scaled down to 10,105 tonnes/day)
	Fuel to Product Ratio	
	7603.2 ton/day NG per 10001 ton a day of MeOH at (99.8%) = 0.76	5000 ton/day NG per 10105.8 tonne a day of MEOH at (99.9%) = 0.5

4. METHANOL SYNTHESIS VIA STEAM METHANE REFORMING

4.1. ASPEN PLUS CHEMICAL PROCESS MODEL

The generic reference plant for methanol synthesis process via steam methane reforming was modeled in Aspen Plus V12. This section summarizes the Aspen Plus model built to represent SMR and methanol synthesis. The function of each block and its simulation settings are described in this section. PFDs for syngas production, methanol synthesis, and distillation are presented in Appendix A of the INL RPT-24-76930 report.

NG is mostly comprised of methane, but higher hydrocarbons do account for a non-negligible portion. NG is assumed to have a molar composition of 95% methane, 3% ethane, and 2% propane. NG used as raw material is introduced into the stream (NG) at a pressure of 35 bar (500 psi), which is the pressure of gas in NG pipelines.

The energy required for preheating and SMR is supplied from the furnace by burning NG as fuel. NG fuel and ambient air are introduced into the furnace block (FNC-1) along with the light-ends from the fractionation section, where complete combustion proceeds. The pressures and temperatures of the fuel and air stream are specified as 1.01 bar and 25°C, respectively. The RGibbs reactor model was employed for the furnace block.

NG contains sulfur in the form of hydrogen sulfide and methyl/ethyl mercaptan, which might damage the reformer catalyst. The mercaptans in NG are additives that give NG its odor. A desulfurization unit (DESULFUR) with a zinc oxide adsorbent was introduced to remove the sulfur compounds. The preferred operating temperature of desulfurization reactions ranges from 350°C to 400°C, so NG is preheated by the heat exchanger connected to the downstream furnace (HX6). The Ryield reactor model was employed for this purpose.

The PRE-RFM block represents the pre-reformer, which converts higher hydrocarbons from the NG into carbon oxides and hydrogen to increase efficiency of syngas production during SMR. The raw material stream (NG-steam mixing gas) is preheated to 600°C by a heat exchanger (HX4) connected to the furnace to meet the operating temperature of the pre-reformer (500°C~600°C).

The RFM-1 block represents the primary SMR. To fulfill the highly endothermic reaction of SMR, the stream of NG-steam mixing gas is preheated to 900°C by a heat exchanger (HX3) connected to the furnace to supply an additional 75 MW of heat from the furnace to the steam methane reformer. An RGibbs model was selected for this reactor.

The syngas stream exiting the SMR is then cooled, and water is removed. Some of the heat from cooling the syngas is used for pre-heating the steam used in chemical reactions (HX8). A carbon dioxide makeup stream mixes with the syngas to match the stoichiometry of the synthesis reaction, and is compressed.

The methanol synthesis process used in this model is based on Lurgi's Mega Methanol design, as well as the reference methanol synthesis model included in Aspen Plus v11. A series of compressors (K201-S1 and K201-S2) increases the pressure of the crude syngas stream to 92 bar, which is favorable for the methanol reaction. The modeled process utilizes two methanol reactors in series (R201-A and R201-B) to produce methanol (MeOH) as the target product and ethanol (EtOH) and dimethyl ether (DME) as byproducts. Both reactors were simulated by a kinetic-based reactor model that considers the four reactions listed in Table 5.

Table 5. Methanol synthesis reactions.

#	Label	Reaction Equations	Ref
1	Methanol Synthesis	$CO_2 + 3H_2 \rightleftharpoons MeOH + H_2O$	Target Product
2	Reverse WGS Reaction	$CO_2 + H_2 \rightleftharpoons CO + H_2O$	Intermediate
3	Ethanol Formation	$2CO + 4H_2 \rightleftharpoons EtOH + H_2O$	Byproduct
4	DME Formation	$2CH_3OH \rightleftharpoons DME + H2O$	Byproduct

To remove the heat produced by these reactions, the syngas feed cools the second reactor, and boiler feedwater cools the first reactor to generate steam. The configurations of the methanol synthesis reactors simulated for the process are illustrated in Figure 3.

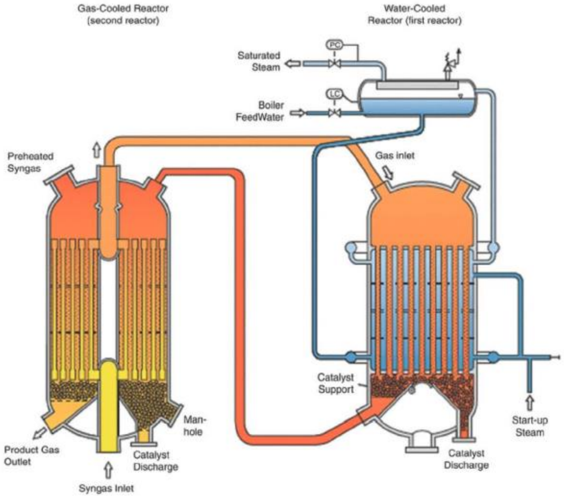

Figure 3. Detailed diagram of Lurgi's two-stage reactor.

The stream exiting the synthesis reactors is cooled down using a process-heat exchanger, along with air or water coolers to condense and cool the methanol, water, and byproducts. A flash drum block (V201) separates the unreacted light gases (L13) from the condensed liquid mixture of crude methanol (L14A). Most of the light gases obtained post-condensation are recycled back to the methanol reactor.

The purpose of the water scrubber (C201) is to remove DME from the light gas. Hydrophobic DME, which is not dissolved in the water scrubber, exits the tower with the light gases, whereas hydrophilic methanol and ethanol are captured in the water and sent to the distillation tower along with the crude methanol.

Some light gas remains dissolved in the crude methanol following the water scrubber. The first distillation tower (C301) separates light-ends from crude methanol. It has three theoretical stages, and the feed stream is introduced at the 3rd stage. Light gases separated from crude methanol exit the top of the column, whereas water and methanol mixture exit the bottom and are pumped to the next distillation tower. Here, a RadFrac distillation model, including a partial-vapor condenser and a kettle reboiler, was used. To match the target temperature of first stage of the distillation tower (or condenser) to 45.5°C, the distillate rate was adjusted to 20.249 ton/day. The reboiler duty was 6 MW. After the first distillation tower, the crude methanol had less than a 1×10^{-11} mass fraction of light gas.

The second distillation tower (C302) separates the water and impurities from the methanol to meet Grade A product specifications. Thirty-five (35) stages are required for the distillation, and the feed stream is introduced on the fifteen (15) stage. Methanol exits the top of the distillation tower, a byproduct containing ethanol exits at the thirty (30) stage, and water exits the bottom (stage one). Here, a RadFrac distillation model, including a partial-vapor condenser and a kettle reboiler, was used. The molar reflux ratio for the separation was 1.5, and the mass flowrate of the liquid side stream at the thirteenth stage was 27.4 ton/day. To match the target water purity of the bottom stage to 0.999999, the reboiler duty was modified to 93 MW. In the end, methanol purity at the top of the tower is achievable at a mass fraction of 0.999.

5. REFERENCES

1. EPA. 2022. "2022 Greenhouse Gas Emissions from Large Facilities." Environmental Protection Agency. Accessed October 13, 2023. https://ghgdata.epa.gov/ghgp/main.do?site_preference=normal.
2. Thermal Integration of Advanced Nuclear Reactors with a Reference Refinery, Methanol Synthesis, and a Wood Pulp Plant. INL/RPT-23-03951, Idaho National Laboratory, Idaho Falls, ID.

Appendix B

Generic Methanol-Synthesis Plant Overall BFD and Energy Requirements

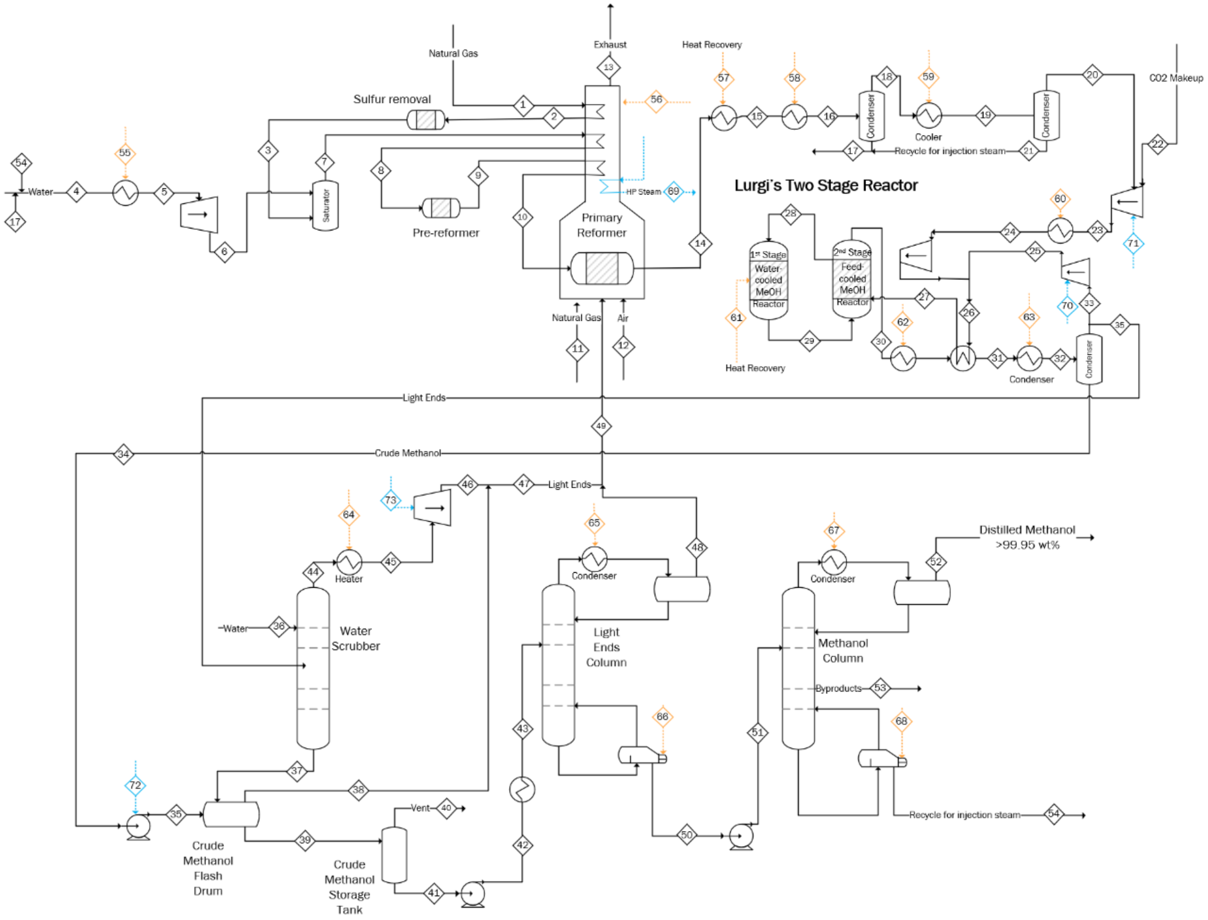

Figure 26. Reference methanol plant via SMR.

Appendix C

Heat Integration PFDs

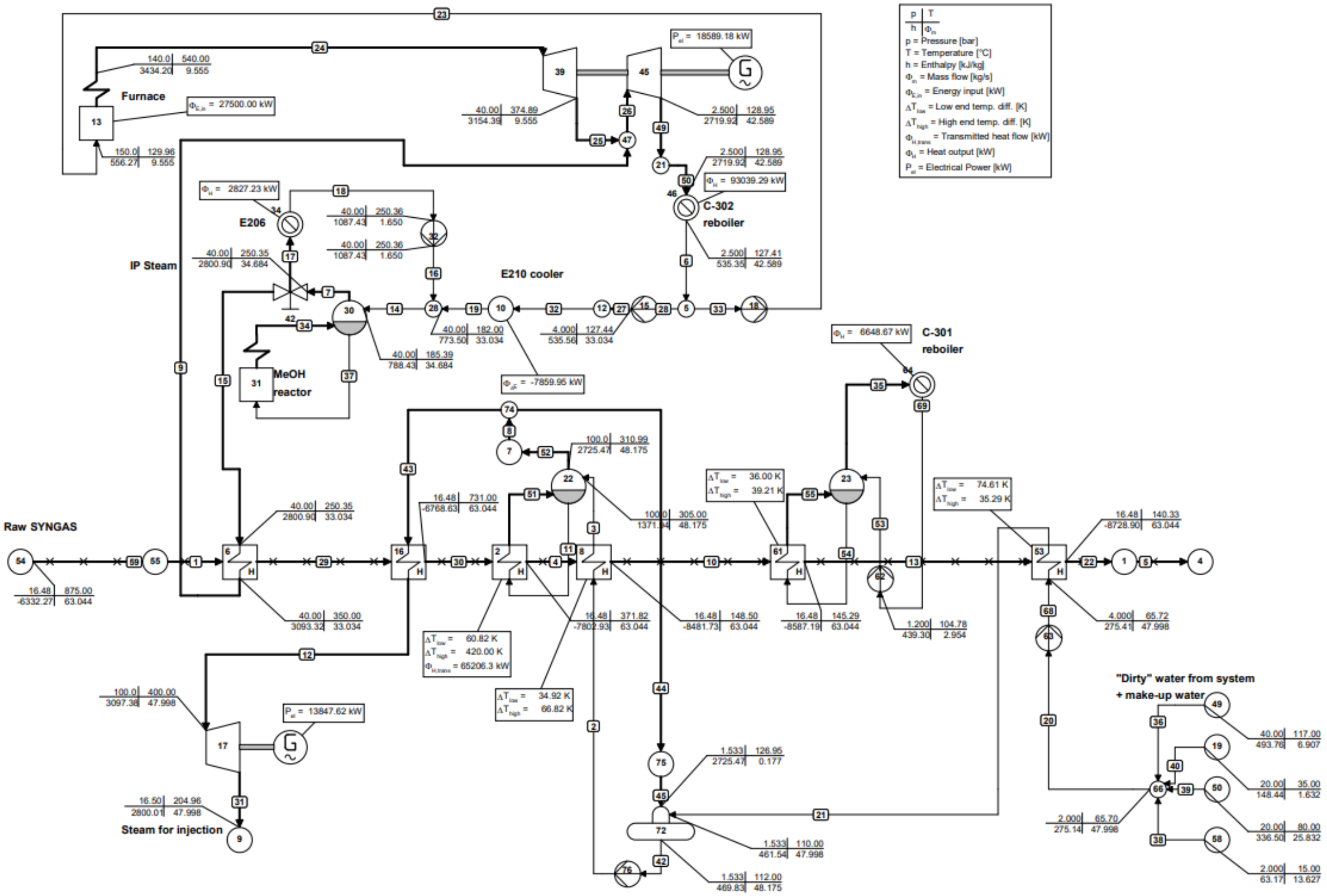

Figure 27. Cycle Tempo PFD of heat recovery from syngas-cooling for the SMR methanol plant.

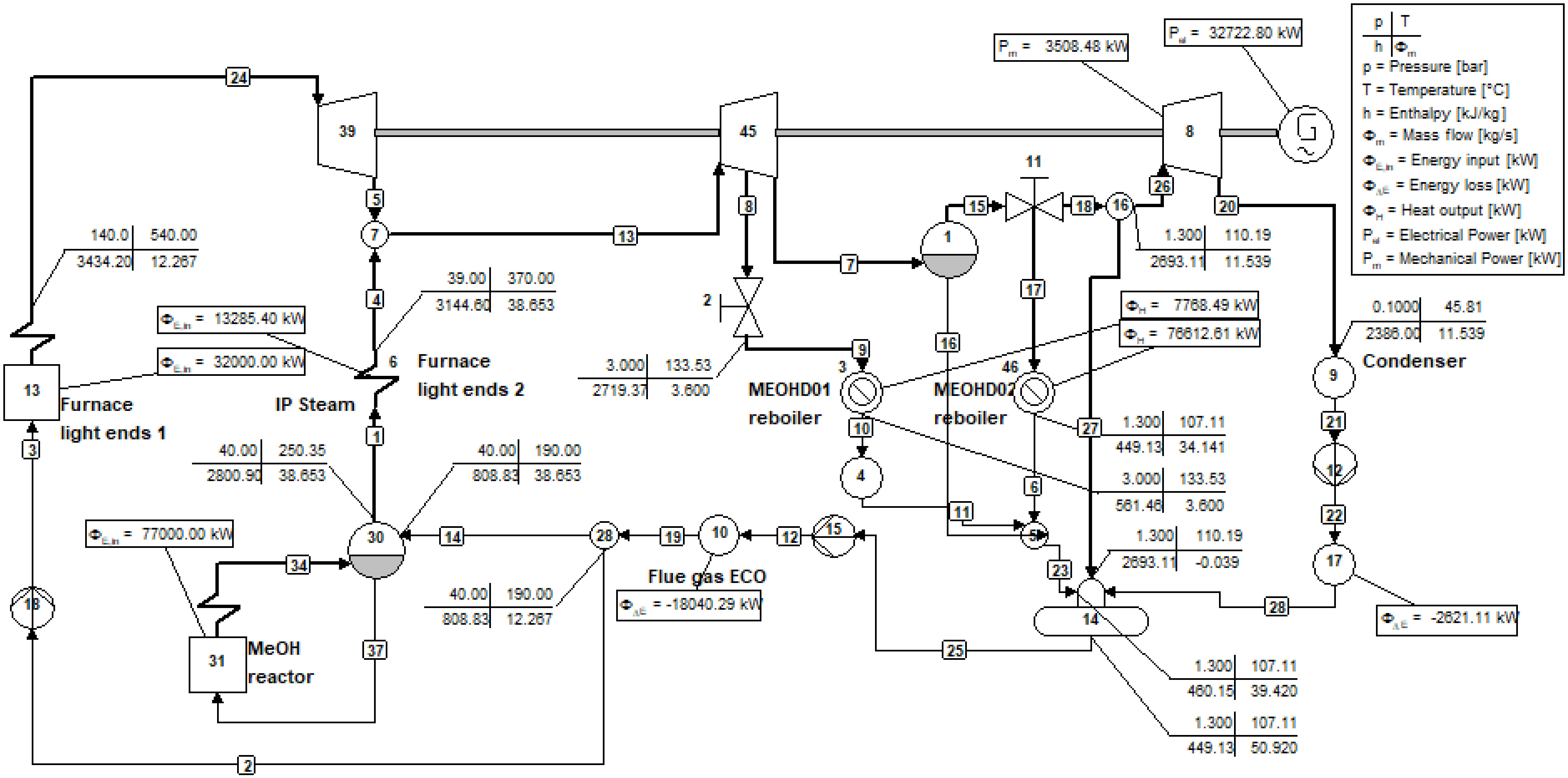

Figure 28. Cycle Tempo PFD of heat recovery for the RWGS methanol plant.

Appendix D

HTGR Rankine Cycle with Integrated HTSE System for Hydrogen Production

HTSE uses low-grade heat to boil water before it is split into H_2 and O. HTSE is more efficient than electrolysis completed on liquid H_2O because the latent heat of vaporization is provided by heat rather than electricity. The Rankine cycle depicted in Figure 29 has an ideal extraction point for boiling this ambient pressure water: between the two stages of the condensing turbine. The model is scaled such that the electricity produced by the integrated Rankine cycle is used to power the electrolyzer or the balance of plant with excess being sold, with the following assumptions:

- Nominal pressure drop in all heat exchangers is 2%
- Isentropic turbine efficiency is 90%
- Isentropic pump efficiency is 75%
- About 27% of IP dry steam is de-superheated to re-superheat the interstage wet steam in the condensing turbine
- Roughly 8% of interstage wet steam is condensed and subcooled by 4°C to vaporize and preheat the HTSE feedwater
- The condenser provides 4°C of subcooling at 0.1 bar absolute pressure
- Rectification efficiency is 95%.

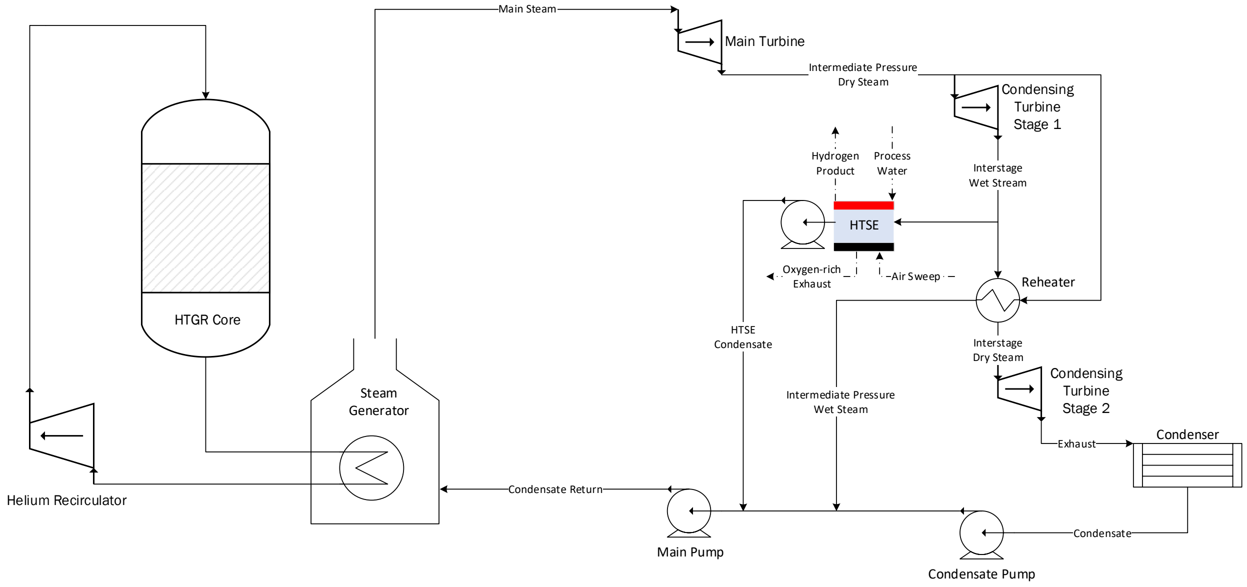

Figure 29. Schematic of an HTGR Rankine cycle with integrated HTSE with O recovery.

Table 18 shows the energy-balance for the model, which produces product hydrogen at 20°C, 66.9 bar, and 0.05 mole percent moisture content. Table 19 details the mass balance for the HTSE system. The thermodynamic properties for the Rankine cycle steam streams are listed in Table 20.

Table 18. Energy-balance – HTSE-integrated-HTGR Rankine cycle for reference methanol plant.

Equipment	Heat/Work (MW)
Core	600
HTSE Steam Generator	29.13
Condenser	334.9
Main Turbine	120.9
Condensing Turbine Stage 1	36.9
Condensing Turbine Stage 2	98.8
Primary Helium Recirculator	14.5
Main Pump	5.5
Condensate Pump	0.5
HTSE Condensate Pump	0.03
HTSE Electricity Consumption	204.6
Electrolysis (AC to Rectifier)	*188.7*
Compression and Pumping	*12.8*
Resistive Trim Heating	*3.1*
Electricity Sales	31.4

Table 19. Mass balance – HTSE-integrated-HTGR Rankine cycle for reference methanol plant.

Equipment	Mass Flow (kg/s)
Water to be Split	15.1
Air Sweep	31.3
H_2 Product	1.46
O-Rich Exhaust	42.8
Water Blowdown	2.0

Table 20. Thermodynamic properties of Rankine cycle steam for reference methanol plant integration.

Stream	Temperature (°C)	Pressure (bar)	Phase	Flow Rate (kg/s)
Condensate Return	220	165	Subcooled liquid	243.3
Main Steam	565		Gas	
IP Dry Steam	285.6	23.65	Superheated vapor	66.5
IP Wet Steam	220		Saturated vapor	
Interstage Wet Steam	170.2	7.95	Saturated vapor	176.8
Interstage Dry Steam	200.1		Superheated vapor	162.7
HTSE Condensate	165.7		Subcooled liquid	14.1
Exhaust	46.2	0.1	Two-phase (0.85)	162.7
Condensate	41.8		Subcooled liquid	

Appendix E

TEA Results and ACC for A Project Life of 20 Years Using the Same Advanced Nuclear Reactor Cost

Table 21. Summary of key data outputs for high CAPEX ($8,000/kWe) at 20 years project lifetime.

20 years Project Lifetime					
CAPEX HTGR = $8,000/kWe		**Case 1a**	**Case 1b**	**Case 1c**	**Case 2**
Feedstocks	NG Consumption	1488 tpd	1371 tpd	1300 tpd	0 tpd
	CO_2	0 kMT/yr.	0 kMT/yr.	0 kMT/yr.	4855 kMT/yr.
Products	CO_2 Emissions Savings (MMT of CO_2/yr.)	118 MMT/yr.	236 MMT/yr.	308 MMT/yr.	197 MMT/yr.
	Electricity Sales	2.0MW	2.0MW	33.4MW	52.0MW
IRA Benefits	Tax Credits	ITC 48E + PTC 45V	ITC 48E + PTC 45V	ITC 48E + PTC 45V	ITC 48E + PTC 45V
Finance	NPV Cash Flow	$558M	$243M	-$251M	-$7144M
	Delta NPV of Total Costs w/ITC48E and PTC 45V (Relative to BAU)	-$360M	-$674M	-$1169M	-$8061M
	ACC ($/mt$CO_2$)	$281.3	$276.8	$316.1	$2,466.9
	ANCC ($/mt$CO_2$) w/credits	$32.8	$28.7	$50.5	$410.5
	IRR	39.0%	17.0%	-	-

Table 22. Summary of key data outputs for high CAPEX ($5,500/kWe) at 20 years project lifetime.

20 years Project Lifetime					
CAPEX HTGR = $5,500/kWe		**Case 1a**	**Case 1b**	**Case 1c**	**Case 2**
Feedstocks	NG Consumption	1488 tpd	1371 tpd	1300 tpd	0 tpd
	CO_2	0 kMT/yr.	0 kMT/yr.	0 kMT/yr.	4855 kMT/yr.
Products	CO_2 Emissions Savings (MMT of CO_2/yr.)	118 MMT/yr.	236 MMT/yr.	308 MMT/yr.	197 MMT/yr.
	Electricity Sales	2.0MW	2.0MW	33.4MW	52.0MW
IRA Benefits	Tax Credits	ITC 48E + PTC 45V	ITC 48E + PTC 45V	ITC 48E + PTC 45V	ITC 48E + PTC 45V
Finance	NPV Cash Flow	$772M	$800M	$515M	-$3116M
	Delta NPV of Total Costs w/ITC48E and PTC 45V (Relative to BAU)	-$145M	-$117M	-$403M	-$4034M
	ACC ($/mt$CO_2$)	$193.8	$189.3	$215.7	$1,729.6
	ANCC ($/mt$CO_2$) w/ credits	-$11.8	-$15.9	-$0.7	$36.8
	IRR	58.0%	40.0%	26.0%	-

Table 23. Summary of key data outputs for high CAPEX ($3,000/kWe) at 20 years project lifetime.

20 years Project Lifetime					
CAPEX HTGR = $3,000/kWe		**Case 1a**	**Case 1b**	**Case 1c**	**Case 2**
Feedstocks	NG Consumption	1488 tpd	1371 tpd	1300 tpd	0 tpd
	CO_2	0 kMT/yr.	0 kMT/yr.	0 kMT/yr.	4855 kMT/yr.
Products	CO_2 Emissions Savings (MMT of CO_2/yr.)	118 MMT/yr.	236 MMT/yr.	308 MMT/yr.	197 MMT/yr.
	Electricity Sales	2.0MW	2.0MW	33.4MW	52.0MW
IRA Benefits	Tax Credits	ITC 48E + PTC 45V	ITC 48E + PTC 45V	ITC 48E + PTC 45V	ITC 48E + PTC 45V
Finance	NPV Cash Flow	$916M	$1151M	$1057M	-$3116M
	Delta NPV of Total Costs w/ITC48E and PTC 45V (Relative to BAU)	-$1M	$233M	$139M	-$793M
	ACC ($/mt$CO_2$)	$128.6	$124.2	$140.9	$1,139.0
	ANCC ($/mt$CO_2$) w/ credits	-$53.5	-$44.0	-$45.3	-$199.0
	IRR	89.0%	67.0%	52.0%	13.0%

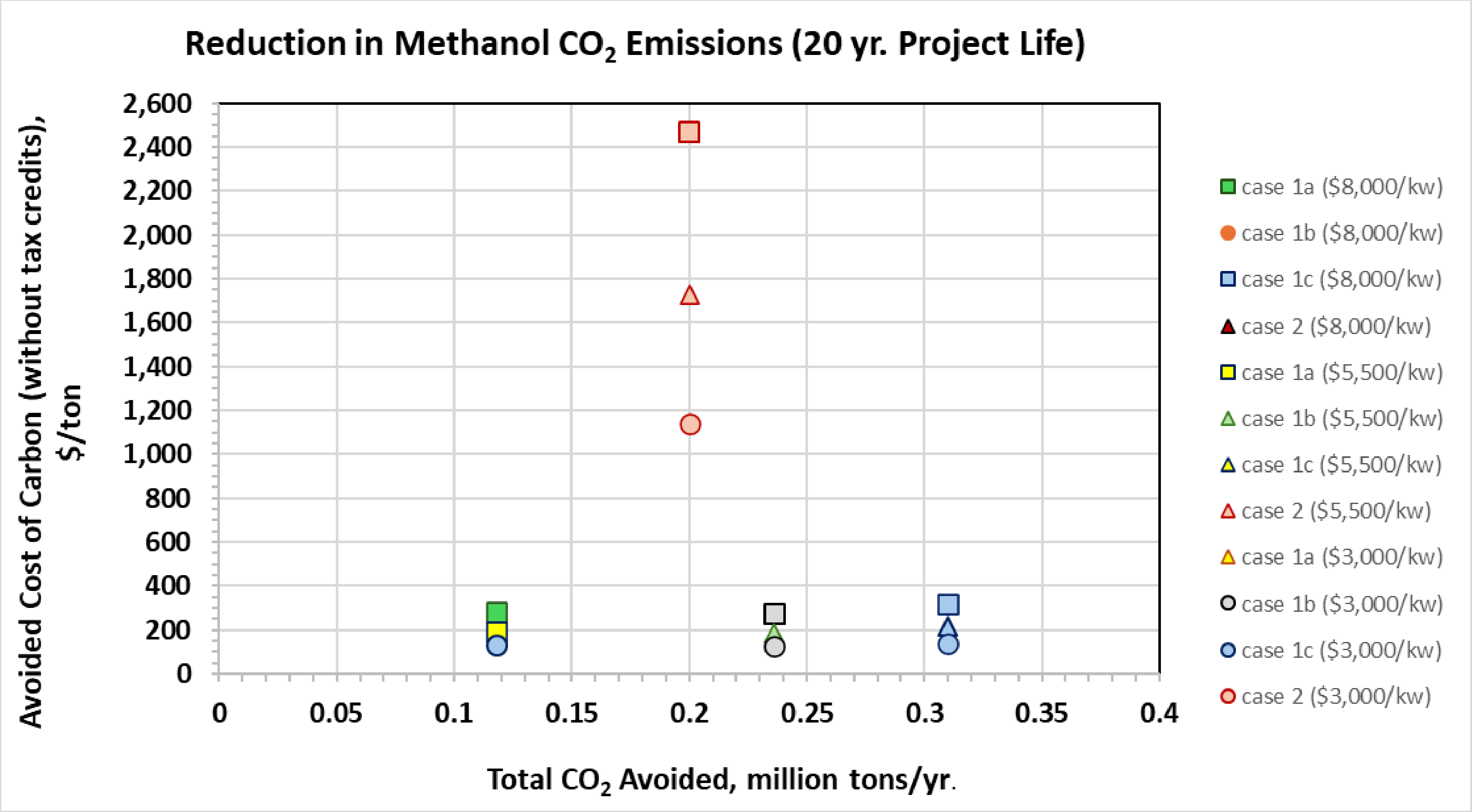

Figure 30. HTGR-type SMNR methanol-synthesis plant decarbonization total onsite CO_2 avoidance and annual cost by case **without** IRA ITCs and PTCs.

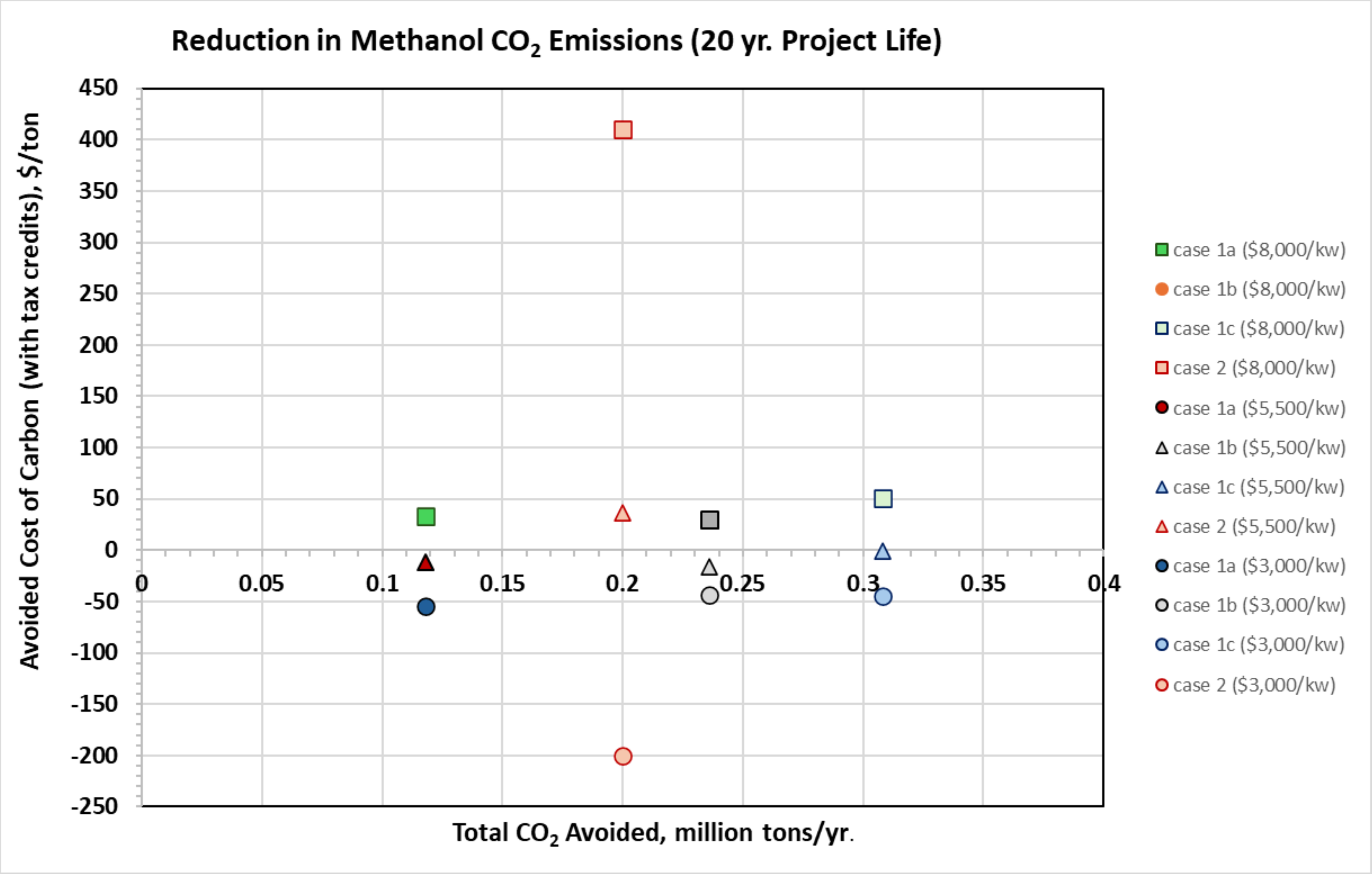

Figure 31. HTGR-type SMNR methanol-synthesis plant decarbonization total onsite CO_2 avoidance and annual cost by case **with** IRA ITCs and PTCs.

Appendix F

Aspen Plus Model Flowsheets, Heat and Mass Balances

F.1.- SMR Methanol Model Flowsheets

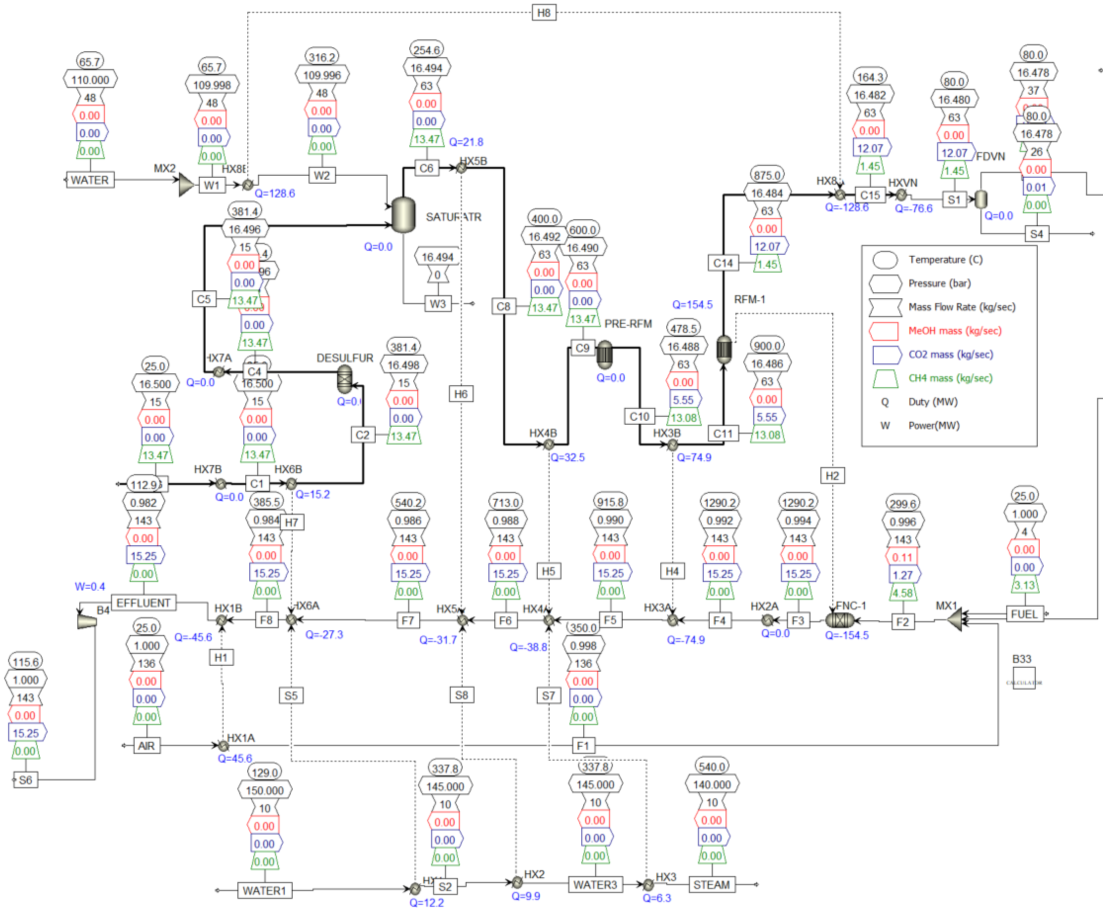

Figure 32. Aspen Plus SMR model reforming section and furnace.

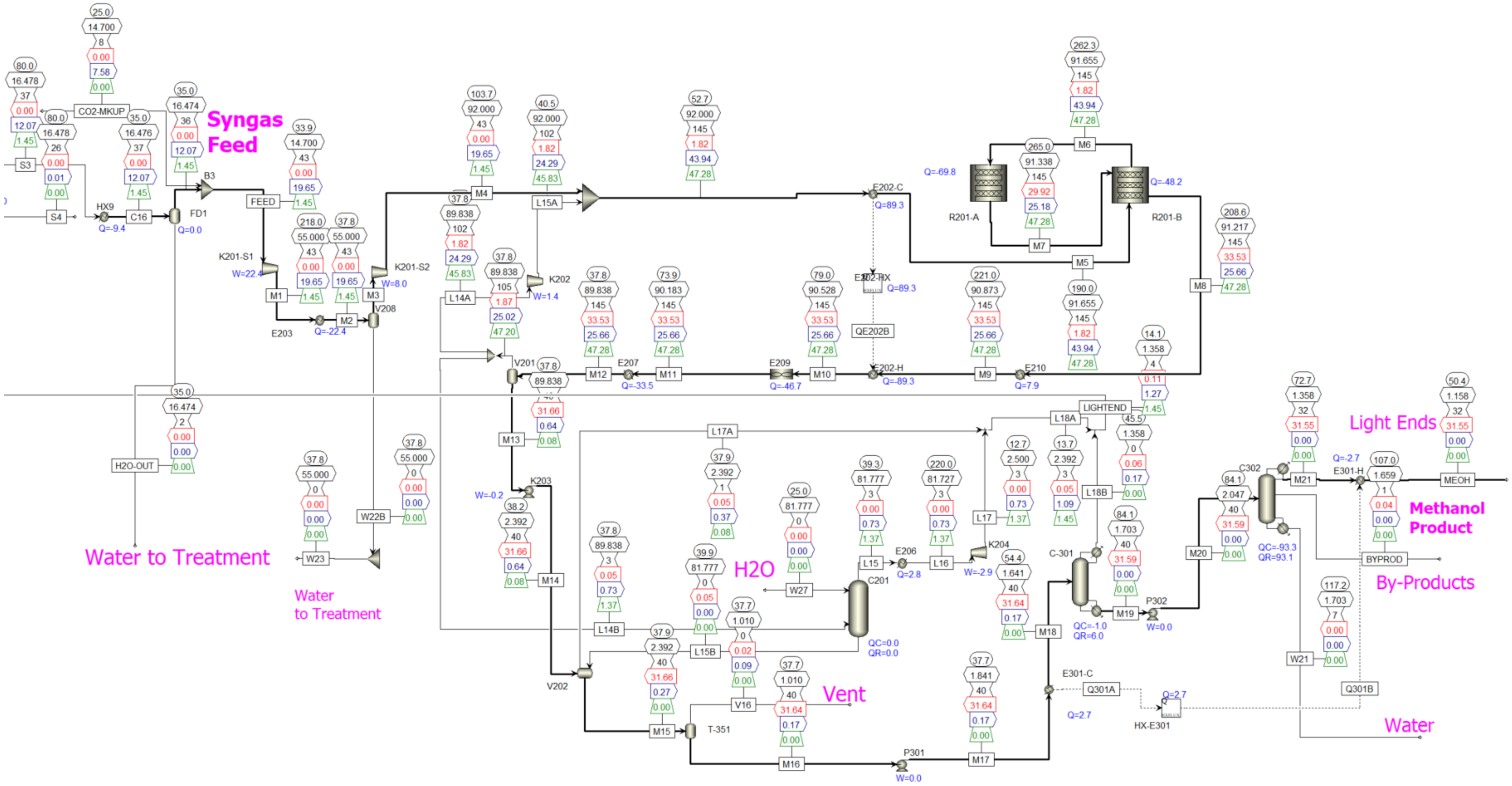

Figure 33. Aspen Plus SMR model methanol-synthesis and distillation sections.

F.2. -SMR Model Material and Heat Balance

Table 24 Material balance for SMR methanol model

Stream Name	**Units**	**AIR**	**BYPROD**	**C1**	**C2**	**C4**	**C5**	**C6**	**C8**	**C9**	**C10**	**C11**	**C14**	**C15**	**C16**	**C17**	**CO2-MKUP**	**EFFLUENT**	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**FEED**	**FUEL**
From			C302	HX7B	HX6B	DESULFUR	HX7A	SATURATR	HX5B	HX4B	PRE-RFM	HX3B	RFM-1	HX8A	HX9	FD1		HX1B	HX1A	MX1	FNC-1	HX2A	HX3A	HX4A	HX5A	HX6A	B3	
To		HX1A		HX6B	DESULFUR	HX7A	SATURATR	HX5B	HX4B	PRE-RFM	HX3B	RFM-1	HX8A	HXVN	FD1	B3	B3	B4	MX1	FNC-1	HX2A	HX3A	HX4A	HX5A	HX6A	HX1B	K201-S1	MX1
Temperature	C	25	107.0222996	25	381.4	381.3999181	381.3999181	254.5561719	400	600	478.481007	900	875	164.2829814	35	34.99959303	25	112.9435245	350	299.6301267	1290.180115	1290.180257	915.8169462	713.0021209	540.2492838	385.4764242	33.85632655	25
Pressure	bar	1	1.658528568	16.5	16.498	16.496	16.496	16.494	16.492	16.49	16.488	16.486	16.484	16.482	16.476	16.474	14.7	0.982	0.998	0.996	0.994	0.992	0.99	0.988	0.986	0.984	14.7	1
Mass Vapor Fraction		1	0	1	1	1	1	1	1	1	1	1	1	1	0.956135188	1	1	1	1	1	1	1	1	1	1	1	1	1
Mass Flows	kg/hr	489600.00	2916.67	54166.67	54166.67	54166.67	54166.67	226958.33	226958.33	226958.33	226958.33	226958.33	226958.33	226958.33	133963.07	128086.87	27333.33	515621.05	489600.00	515621.05	515621.05	515621.05	515621.05	515621.05	515621.05	515621.05	155420.20	12600.00
O2	kg/hr	114036	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20437	114036	114036	20437	20437	20437	20437	20437	20437	0	0
H2	kg/hr	0	0	0	0	0	0	0	0	0	3298	3298	20164	20164	20163	20163	16	0	0	2760	0	0	0	0	0	0	20180	0
N2	kg/hr	375564	0	0	0	0	0	0	0	0	0	0	0	0	0	0	35	375420	375564	375599	375420	375420	375420	375420	375420	375420	35	0
CO	kg/hr	0	0	0	0	0	0	0	0	0	399	399	58581	58581	58581	58581	0	2	0	403	2	2	2	2	2	2	58581	0
CO2	kg/hr	0	0	0	0	0	0	0	0	0	19979	19979	43468	43468	43445	43444	27282	54906	0	4558	54906	54906	54906	54906	54906	54906	70726	0
NH3	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H2O	kg/hr	0	2689	0	0	0	0	172792	172792	172792	156179	156179	99527	99527	6555	680	0	64472	0	41	64472	64472	64472	64472	64472	64472	680	0
CH4	kg/hr	0	0	48491	48491	48491	48491	48491	48491	48491	47103	47103	5218	5218	5218	5218	0	0	0	16486	0	0	0	0	0	0	5218	11280
C2H6	kg/hr	0	0	2870	2870	2870	2870	2870	2870	2870	2	2	0	0	0	0	0	0	0	668	0	0	0	0	0	0	0	668
C3H8	kg/hr	0	0	2806	2806	2806	2806	2806	2806	2806	0	0	0	0	0	0	0	0	0	653	0	0	0	0	0	0	0	653
I-C4	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-C4	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MEOH	kg/hr	0	141	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	396	0	0	0	0	0	0	0	0
ETOH	kg/hr	0	87	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DME	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21	0	0	0	0	0	0	0	0
AR	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H2S	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NO	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	382	0	0	382	382	382	382	382	382	0	0
NO2	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	1	1	1	1	0	0
Mole Flows	kmol/hr	16970.30	155.54	3181.66	3181.66	3181.66	3181.66	12773.06	12773.06	12773.06	13709.44	13709.44	18931.30	18931.30	13769.96	13443.82	629.34	18879.34	16970.30	19538.58	18879.34	18879.34	18879.34	18879.34	18879.34	18879.34	14073.15	740.10
O2	kmol/hr	3564	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	639	3564	3564	639	639	639	639	639	639	0	0
H2	kmol/hr	0	0	0	0	0	0	0	0	0	1636	1636	10002	10002	10002	10002	8	0	0	1369	0	0	0	0	0	0	10010	0
N2	kmol/hr	13407	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	13401	13407	13408	13401	13401	13401	13401	13401	13401	1	0
CO	kmol/hr	0	0	0	0	0	0	0	0	0	14	14	2091	2091	2091	2091	0	0	0	14	0	0	0	0	0	0	2091	0
CO2	kmol/hr	0	0	0	0	0	0	0	0	0	454	454	988	988	987	987	620	1248	0	104	1248	1248	1248	1248	1248	1248	1607	0
NH3	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H2O	kmol/hr	0	149	0	0	0	0	9591	9591	9591	8669	8669	5525	5525	364	38	0	3579	0	2	3579	3579	3579	3579	3579	3579	38	0
CH4	kmol/hr	0	0	3023	3023	3023	3023	3023	3023	3023	2936	2936	325	325	325	325	0	0	0	1028	0	0	0	0	0	0	325	703
C2H6	kmol/hr	0	0	95	95	95	95	95	95	95	0	0	0	0	0	0	0	0	0	22	0	0	0	0	0	0	0	22
C3H8	kmol/hr	0	0	64	64	64	64	64	64	64	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	15
I-C4	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-C4	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MEOH	kmol/hr	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0
ETOH	kmol/hr	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DME	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AR	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H2S	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NO	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0	13	13	13	13	13	13	0	0
NO2	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mass fraction																												
O2		0.232917001	0	0	0	0	0	0	0	0	7.14381E-29	7.14381E-29	8.40567E-19	8.40567E-19	0	0	0	0.039635781	0.232917001	0.221162739	0.039635781	0.039635781	0.039635781	0.039635781	0.039635781	0.039635781	0	0
H2		0	0	0	0	0	0	0	0	0	0.014530024	0.014530024	0.088842445	0.088842445	0.150514158	0.157419226	0.000603392	3.27305E-07	0	0.005353563	3.27305E-07	3.27305E-07	3.27305E-07	3.27305E-07	3.27305E-07	3.27305E-07	0.129840447	0
N2		0.767082999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.001289996	0.728093528	0.767082999	0.7284403	0.728093528	0.728093528	0.728093528	0.728093528	0.728093528	0.728093528	0.000226868	0
CO		0	0	0	0	0	0	0	0	0	0.00175679	0.00175679	0.258115616	0.258115616	0.437294376	0.457355983	0	4.46755E-06	0	0.000780708	4.46755E-06	4.46755E-06	4.46755E-06	4.46755E-06	4.46755E-06	4.46755E-06	0.376922015	0
CO2		0	0	0	0	0	0	0	0	0	0.088027257	0.088027257	0.191526237	0.191526237	0.324306315	0.3391757	0.998106612	0.106485534	0	0.008840003	0.106485534	0.106485534	0.106485534	0.106485534	0.106485534	0.106485534	0.455060108	0
NH3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.55585E-13	0	0	2.55585E-13	2.55585E-13	2.55585E-13	2.55585E-13	2.55585E-13	2.55585E-13	0	0
H2O		0	0.921978299	0	0	0	0	0.761336515	0.761336515	0.761336515	0.688139214	0.688139214	0.438524394	0.438524394	0.048934471	0.005311532	0	0.125036818	0	7.96284E-05	0.125036818	0.125036818	0.125036818	0.125036818	0.125036818	0.125036818	0.004377407	0
CH4		0	0	0.895209565	0.895209565	0.895209565	0.895209565	0.213653834	0.213653834	0.213653834	0.20753955	0.20753955	0.02299038	0.02299038	0.038949215	0.040736063	0	2.40964E-27	0	0.031973324	2.40964E-27	2.40964E-27	2.40964E-27	2.40964E-27	2.40964E-27	2.40964E-27	0.033571921	0.895209565
C2H6		0	0	0.052987265	0.052987265	0.052987265	0.052987265	0.012646125	0.012646125	0.012646125	7.14826E-06	7.14826E-06	7.9778E-07	7.9778E-07	1.35155E-06	1.41356E-06	0	0	0	0.001295167	0	0	0	0	0	0	1.16496E-06	0.052987265
C3H8		0	0	0.05180317	0.05180317	0.05180317	0.05180317	0.012363525	0.012363525	0.012363525	1.1301E-09	1.1301E-09	7.42526E-11	7.42526E-11	1.25797E-10	1.31568E-10	0	0	0	0.001265891	0	0	0	0	0	0	1.0843E-10	0.05180317
I-C4		0	0	0	0	0	0	0	0	0	1.10655E-13	1.10655E-13	2.72885E-15	2.72885E-15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-C4		0	0	0	0	0	0	0	0	0	1.55434E-13	1.55434E-13	6.2294E-15	6.2294E-15	1.05537E-14	1.10379E-14	0	0	0	0	0	0	0	0	0	0	9.0967E-15	0
MEOH		0	0.048222477	0	0	0	0	0	0	0	1.51985E-08	1.51985E-08	1.31149E-07	1.31149E-07	1.13045E-07	8.21788E-08	0	3.1339E-26	0	0.000767772	3.1339E-26	3.1339E-26	3.1339E-26	3.1339E-26	3.1339E-26	3.1339E-26	6.77262E-08	0
ETOH		0	0.029799224	0	0	0	0	0	0	0	1.95511E-11	1.95511E-11	5.03431E-11	5.03431E-11	4.39652E-11	3.18048E-11	0	0	0	6.33374E-07	0	0	0	0	0	0	2.62114E-11	0
DME		0	0	0	0	0	0	0	0	0	9.80406E-16	9.80406E-16	3.95649E-14	3.95649E-14	6.70192E-14	7.00936E-14	0	0	0	4.02705E-05	0	0	0	0	0	0	5.77664E-14	0
AR		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H2S		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NO		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000741628	0	0	0.000741628	0.000741628	0.000741628	0.000741628	0.000741628	0.000741628	0	0
NO2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.91509E-06	0	0	1.91509E-06	1.91509E-06	1.91509E-06	1.91509E-06	1.91509E-06	1.91509E-06	0	0
Mole fraction																												
O2		0.21	0	0	0	0	0	0	0	0	3.69592E-29	3.69592E-29	3.14923E-19	3.14923E-19	0	0	0	0.033829656	0.21	0.182396279	0.033829656	0.033829656	0.033829656	0.033829656	0.033829656	0.033829656	0	0
H2		0	0	0	0	0	0	0	0	0	0.11932408	0.11932408	0.52834988	0.52834988	0.726382046	0.744003768	0.013	4.43437E-06	0	0.070083529	4.43437E-06	4.43437E-06	4.43437E-06	4.43437E-06	4.43437E-06	4.43437E-06	0.711313983	0
N2		0.79	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.002	0.709845703	0.79	0.686221956	0.709845703	0.709845703	0.709845703	0.709845703	0.709845703	0.709845703	8.94381E-05	0
CO		0	0	0	0	0	0	0	0	0	0.00103831	0.00103831	0.110474172	0.110474172	0.151882244	0.155566862	0	4.35606E-06	0	0.000735541	4.35606E-06	4.35606E-06	4.35606E-06	4.35606E-06	4.35606E-06	4.35606E-06	0.148610062	0
CO2		0	0	0	0	0	0	0	0	0	0.033112671	0.033112671	0.052172863	0.052172863	0.071689976	0.073427269	0.985	0.066082288	0	0.005300792	0.066082288	0.066082288	0.066082288	0.066082288	0.066082288	0.066082288	0.114191924	0
NH3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.09874E-13	0	0	4.09874E-13	4.09874E-13	4.09874E-13	4.09874E-13	4.09874E-13	4.09874E-13	0	0
H2O		0	0.959650609	0	0	0	0	0.750908298	0.750908298	0.750908298	0.632356129	0.632356129	0.291822335	0.291822335	0.026425688	0.002809059	0	0.189557401	0	0.000116645	0.189557401	0.189557401	0.189557401	0.189557401	0.189557401	0.189557401	0.00268344	0
CH4		0	0	0.95	0.95	0.95	0.95	0.236637116	0.236637116	0.236637116	0.214164866	0.214164866	0.017180383	0.017180383	0.023619573	0.02419257	0	4.10221E-27	0	0.052595237	4.10221E-27	4.10221E-27	4.10221E-27	4.10221E-27	4.10221E-27	4.10221E-27	0.023110702	0.95
C2H6		0	0	0.03	0.03	0.03	0.03	0.007472751	0.007472751	0.007472751	3.93549E-06	3.93549E-06	3.18068E-07	3.18068E-07	4.37277E-07	4.47885E-07	0	0	0	0.001136673	0	0	0	0	0	0	4.27856E-07	0.03
C3H8		0	0	0.02	0.02	0.02	0.02	0.004981834	0.004981834	0.004981834	4.24266E-10	4.24266E-10	2.01871E-11	2.01871E-11	2.77535E-11	2.84268E-11	0	0	0	0.000757582	0	0	0	0	0	0	2.71556E-11	0.02
I-C4		0	0	0	0	0	0	0	0	0	3.15172E-14	3.15172E-14	5.62852E-16	5.62852E-16	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-C4		0	0	0	0	0	0	0	0	0	4.42711E-14	4.42711E-14	1.28487E-15	1.28487E-15	1.76648E-15	1.80933E-15	0	0	0	0	0	0	0	0	0	0	1.72842E-15	0
MEOH		0	0.028220272	0	0	0	0	0	0	0	7.85246E-09	7.85246E-09	4.90693E-08	4.90693E-08	3.43227E-08	2.44354E-08	0	2.67121E-26	0	0.000632336	2.67121E-26	2.67121E-26	2.67121E-26	2.67121E-26	2.67121E-26	2.67121E-26	2.33427E-08	0
ETOH		0	0.012129119	0	0	0	0	0	0	0	7.0257E-12	7.0257E-12	1.31008E-11	1.31008E-11	9.28436E-12	6.57757E-12	0	0	0	3.62818E-07	0	0	0	0	0	0	6.28342E-12	0
DME		0	0	0	0	0	0	0	0	0	3.52308E-16	3.52308E-16	1.02959E-14	1.02959E-14	1.41528E-14	1.44961E-14	0	0	0	2.30683E-05	0	0	0	0	0	0	1.38478E-14	0
AR		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H2S		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NO		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000675025	0	0	0.000675025	0.000675025	0.000675025	0.000675025	0.000675025	0.000675025	0	0
NO2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.1369E-06	0	0	1.1369E-06	1.1369E-06	1.1369E-06	1.1369E-06	1.1369E-06	1.1369E-06	0	0
Enthalpy, mixture	MJ/kmol	-0.01	-280.08	-75.71	-58.56	-58.56	-58.56	-192.46	-186.30	-177.15	-165.05	-145.38	-75.89	-100.35	-53.96	-48.29	-388.21	-69.09	9.68	1.95	-27.45	-27.45	-41.74	-49.13	-55.18	-60.39	-63.49	-75.42

Stream Name	**Units**	**H2O-OUT**	**L13**	**L14A**	**L14B**	**L15**	**L15A**	**L15B**	**L16**	**L17**	**L17A**	**L18A**	**L18B**	**LIGHTEND**	**M1**	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M10**	**M11**	**M12**	**M13**	**M14**	**M15**	**M16**	**M17**
From		FD1	V201	B2	B2	C201	K202	C201	E206	K204	V202	B7	C-301	B10	K201-S1	E203	V208	K201-S2	E202-C	R201-B	R201-A	R201-B	E210	E202-H	E209	E207	V201	K203	V202	T-351	P301
To		HX1A	B2	K202	C201	E206	B5	V202	K204	B7	B7	B10	B10	MX1	E203	V208	K201-S2	B5	R201-B	R201-A	R201-B	E210	E202-H	E209	E207	V201	K203	V202	T-351	P301	E301-C
Temperature	C	34.99959303	37.77777778	37.77777778	37.77777778	39.33688568	40.52087267	39.92198778	220	12.67042988	37.9139599	13.71248062	45.5	14.1155872	217.9765015	37.77777778	37.77777778	103.6504294	190	262.3085583	265.0163593	208.6285246	221	78.99017066	73.88888889	37.77777778	37.77777778	38.19589938	37.9139599	37.68329998	37.69791516
Pressure	bar	16.474	89.83843645	89.83843645	89.83843645	81.777	92	81.777	81.727	2.5	2.392201459	2.392201459	1.357987865	1.357987865	55	55	55	92	91.65526214	91.65526214	91.33759609	91.21738607	90.87265004	90.52791218	90.18317431	89.83843645	89.83843645	2.392201459	2.392201459	1.01	1.840620875
Mass Vapor Fraction		0	1	1	1	1	1	0	1	1	1	1	1	1	1	0.997525027	1	1	1	1	1	1	1.000003548	1	0.772764513	0.723257983	0	0	0	0	0
Mass Flows	kg/hr	5876.20	376632.23	365709.90	10922.33	10750.32	365709.90	1422.02	10750.32	10750.32	1826.93	12577.25	843.80	13421.05	155420.20	155420.20	155035.54	155035.54	520745.44	520745.44	520745.44	520745.44	520743.97	520743.97	520743.97	520743.97	144111.74	144111.74	143706.82	143276.60	143276.60
O2	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H2	kg/hr	0	94395	91657	2737	2737	91657	0	2737	2737	23	2760	0	2760	20180	20180	20180	20180	111837	111837	95990	94417	94418	94418	94418	94418	23	23	0	0	0
N2	kg/hr	0	1204	1169	35	35	1169	0	35	35	0	35	0	35	35	35	35	35	1204	1204	1204	1204	1204	1204	1204	1204	0	0	0	0	0
CO	kg/hr	0	13709	13311	398	398	13311	0	398	398	5	403	0	403	58581	58581	58581	58581	71892	71892	26271	13714	13714	13714	13714	13714	5	5	0	0	0
CO2	kg/hr	1	90072	87460	2612	2611	87460	1	2611	2611	1321	3931	627	4558	70726	70726	70725	70725	158185	158185	90649	92361	92359	92359	92359	92359	2287	2287	967	627	627
NH3	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H2O	kg/hr	5875	382	371	11	29	371	1232	29	29	12	40	1	41	680	680	296	296	667	667	28364	27696	27696	27696	27696	27696	27314	27314	28535	28530	28530
CH4	kg/hr	0	169916	164989	4928	4928	164989	0	4928	4928	278	5205	1	5206	5218	5218	5218	5218	170207	170207	170207	170207	170207	170207	170207	170207	290	290	13	1	1
C2H6	kg/hr	0	5	5	0	0	5	0	0	0	0	0	0	0	0	0	0	0	5	5	5	5	5	5	5	5	0	0	0	0	0
C3H8	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
I-C4	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-C4	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MEOH	kg/hr	0	6731	6536	195	7	6536	188	7	7	184	191	205	396	0	0	0	0	6536	6536	107714	120714	120714	120714	120714	120714	113983	113983	113987	113916	113916
ETOH	kg/hr	0	9	9	0	0	9	0	0	0	0	0	0	0	0	0	0	0	9	9	129	202	202	202	202	202	193	193	193	193	193
DME	kg/hr	0	209	203	6	6	203	0	6	6	5	11	10	21	0	0	0	0	203	203	213	225	225	225	225	225	16	16	12	10	10
AR	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H2S	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NO	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NO2	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mole Flows	kmol/hr	326.14	60232.15	58485.41	1746.73	1741.80	58485.41	74.32	1741.80	1741.80	65.39	1807.19	20.98	1828.17	14073.15	14073.15	14051.81	14051.81	72537.23	72537.23	66210.61	65391.80	65391.84	65391.84	65391.84	65391.84	5159.70	5159.70	5168.62	5157.58	5157.58
O2	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H2	kmol/hr	0	46825	45468	1358	1358	45468	0	1358	1358	11	1369	0	1369	10010	10010	10010	10010	55478	55478	47617	46837	46837	46837	46837	46837	11	11	0	0	0
N2	kmol/hr	0	43	42	1	1	42	0	1	1	0	1	0	1	1	1	1	1	43	43	43	43	43	43	43	43	0	0	0	0	0
CO	kmol/hr	0	489	475	14	14	475	0	14	14	0	14	0	14	2091	2091	2091	2091	2567	2567	938	490	490	490	490	490	0	0	0	0	0
CO2	kmol/hr	0	2047	1987	59	59	1987	0	59	59	30	89	14	104	1607	1607	1607	1607	3594	3594	2060	2099	2099	2099	2099	2099	52	52	22	14	14
NH3	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H2O	kmol/hr	326	21	21	1	2	21	68	2	2	1	2	0	2	38	38	16	16	37	37	1574	1537	1537	1537	1537	1537	1516	1516	1584	1584	1584
CH4	kmol/hr	0	10591	10284	307	307	10284	0	307	307	17	324	0	325	325	325	325	325	10610	10610	10610	10610	10610	10610	10610	10610	18	18	1	0	0
C2H6	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C3H8	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
I-C4	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-C4	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MEOH	kmol/hr	0	210	204	6	0	204	6	0	0	6	6	6	12	0	0	0	0	204	204	3362	3767	3767	3767	3767	3767	3557	3557	3557	3555	3555
ETOH	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	4	4	4	4	4	4	4	4	4	4
DME	kmol/hr	0	5	4	0	0	4	0	0	0	0	0	0	0	0	0	0	0	4	4	5	5	5	5	5	5	0	0	0	0	0
AR	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H2S	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NO	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NO2	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mass fraction																															
O2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H2		5.52163E-07	0.250627814	0.250627814	0.250627814	0.254637167	0.250627814	7.10305E-06	0.254637167	0.254637167	0.012576888	0.219476245	2.31083E-06	0.205677615	0.129840447	0.129840447	0.130162591	0.130162591	0.21476309	0.21476309	0.184331263	0.181312107	0.181312932	0.181312932	0.181312932	0.181312932	0.000160311	0.000160311	9.43836E-07	1.36092E-08	1.36092E-08
N2		0	0.003196584	0.003196584	0.003196584	0.003247728	0.003196584	3.14867E-08	0.003247728	0.003247728	0.000220712	0.002808033	8.46334E-08	0.002631493	0.000226868	0.000226868	0.000227431	0.000227431	0.002312612	0.002312612	0.002312612	0.002312612	0.002312735	0.002312735	0.002312735	0.002312735	2.82162E-06	2.82162E-06	2.39846E-08	4.98432E-10	4.98432E-10
CO		4.03019E-07	0.036398214	0.036398214	0.036398214	0.036980572	0.036398214	3.75452E-07	0.036980572	0.036980572	0.002734244	0.032006057	1.25174E-06	0.02999387	0.376922015	0.376922015	0.377857198	0.377857198	0.138056865	0.138056865	0.050449514	0.026335054	0.02633498	0.02633498	0.02633498	0.02633498	3.49829E-05	3.49829E-05	3.24924E-07	7.37186E-09	7.37186E-09
CO2		0.000190082	0.239151952	0.239151952	0.239151952	0.242866113	0.239151952	0.000850546	0.242866113	0.242866113	0.72285583	0.312587923	0.742586987	0.339622561	0.455060108	0.455060108	0.456186911	0.456186911	0.303767271	0.303767271	0.174074698	0.177362751	0.177360017	0.177360017	0.177360017	0.177360017	0.015868418	0.015868418	0.006731943	0.004373324	0.004373324
NH3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H2O		0.99980789	0.001014321	0.001014321	0.001014321	0.002662345	0.001014321	0.86669765	0.002662345	0.002662345	0.006375567	0.003201716	0.000935377	0.003059228	0.004377407	0.004377407	0.001909422	0.001909422	0.001280809	0.001280809	0.054468068	0.053185724	0.053185812	0.053185812	0.053185812	0.053185812	0.189534634	0.189534634	0.198563821	0.199128433	0.199128433
CH4		2.86327E-07	0.451146798	0.451146798	0.451146798	0.458361363	0.451146798	3.19691E-05	0.458361363	0.458361363	0.151975401	0.413856693	0.001539424	0.387933735	0.033571921	0.033571921	0.033655215	0.033655215	0.326851837	0.326851837	0.326851837	0.326851837	0.326853019	0.326853019	0.326853019	0.326853019	0.002014498	0.002014498	8.84407E-05	9.06614E-06	9.06614E-06
C2H6		1.19421E-11	1.28296E-05	1.28296E-05	1.28296E-05	1.30347E-05	1.28296E-05	1.43114E-09	1.30347E-05	1.30347E-05	1.79458E-05	1.3748E-05	3.70337E-06	1.31165E-05	1.16496E-06	1.16496E-06	1.16785E-06	1.16785E-06	9.35767E-06	9.35767E-06	9.35767E-06	9.35767E-06	9.3577E-06	9.3577E-06	9.3577E-06	9.3577E-06	2.84053E-07	2.84053E-07	5.67241E-08	2.18103E-08	2.18103E-08
C3H8		1.55796E-16	1.04238E-09	1.04238E-09	1.04238E-09	1.05905E-09	1.04238E-09	2.79295E-14	1.05905E-09	1.05905E-09	2.08978E-09	1.20878E-09	1.01617E-09	1.19667E-09	1.0843E-10	1.0843E-10	1.08699E-10	1.08699E-10	7.64405E-10	7.64405E-10	7.64405E-10	7.64405E-10	7.64409E-10	7.64409E-10	7.64409E-10	7.64409E-10	3.79399E-11	3.79399E-11	1.14798E-11	5.98457E-12	5.98457E-12
I-C4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-C4		1.60119E-21	0	0	0	0	0	0	0	0	0	0	0	0	9.0967E-15	9.0967E-15	9.11927E-15	9.11927E-15	2.71498E-15	2.71498E-15	2.71498E-15	2.71498E-15	2.71498E-15	2.71498E-15	2.71498E-15	2.71498E-15	0	0	0	0	0
MEOH		7.85852E-07	0.017872549	0.017872549	0.017872549	0.000667837	0.017872549	0.132228146	0.000667837	0.000667837	0.100569417	0.015179229	0.242908803	0.029496903	6.77262E-08	6.77262E-08	6.38376E-08	6.38376E-08	0.01255158	0.01255158	0.206845483	0.231810726	0.231811293	0.231811293	0.231811293	0.231811293	0.790934576	0.790934576	0.793193059	0.795075246	0.795075246
ETOH		3.09032E-10	2.49825E-05	2.49825E-05	2.49825E-05	1.09197E-06	2.49825E-05	0.000183633	1.09197E-06	1.09197E-06	0.000132684	2.02067E-05	8.58453E-05	2.43335E-05	2.62114E-11	2.62114E-11	2.47503E-11	2.47503E-11	1.75448E-05	1.75448E-05	0.000248074	0.000387867	0.000387887	0.000387887	0.000387887	0.000387887	0.001336329	0.001336329	0.001340224	0.00134359	0.00134359
DME		5.61037E-18	0.000553956	0.000553956	0.000553956	0.000562748	0.000553956	5.44097E-07	0.000562748	0.000562748	0.002541308	0.000850147	0.011936213	0.001547143	5.77664E-14	5.77664E-14	5.79097E-14	5.79097E-14	0.000389033	0.000389033	0.000409092	0.000431964	0.000431965	0.000431965	0.000431965	0.000431965	0.000113146	0.000113146	8.1163E-05	7.02973E-05	7.02973E-05
AR		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H2S		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NO		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NO2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mole fraction																															
O2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H2		4.93504E-06	0.777416455	0.777416455	0.777416455	0.779616444	0.777416455	6.74175E-05	0.779616444	0.779616444	0.174302175	0.757713352	4.61029E-05	0.749018193	0.711313983	0.711313983	0.712394243	0.712394243	0.76482044	0.76482044	0.719171021	0.716249518	0.716250235	0.716250235	0.716250235	0.716250235	0.002221126	0.002221126	1.30177E-05	1.87542E-07	1.87542E-07
N2		0	0.000713523	0.000713523	0.000713523	0.000715544	0.000713523	2.15057E-08	0.000715544	0.000715544	0.000220117	0.000697617	1.21506E-07	0.000689613	8.94381E-05	8.94381E-05	8.95739E-05	8.95739E-05	0.000592653	0.000592653	0.000649282	0.000657412	0.000657445	0.000657445	0.000657445	0.000657445	2.81324E-06	2.81324E-06	2.3805E-08	4.94275E-10	4.94275E-10
CO		2.59236E-07	0.008125496	0.008125496	0.008125496	0.00814851	0.008125496	2.56465E-07	0.00814851	0.00814851	0.002727171	0.00795234	1.79729E-06	0.007861098	0.148610062	0.148610062	0.148835757	0.148835757	0.035383697	0.035383697	0.014165618	0.00748716	0.007487112	0.007487112	0.007487112	0.007487112	3.48828E-05	3.48828E-05	3.22527E-07	7.31118E-09	7.31118E-09
CO2		7.78179E-05	0.033979241	0.033979241	0.033979241	0.034059746	0.033979241	0.000369778	0.034059746	0.034059746	0.458877313	0.049431626	0.678612683	0.056652249	0.114191924	0.114191924	0.114364785	0.114364785	0.04955142	0.04955142	0.031108861	0.032093363	0.032092755	0.032092755	0.032092755	0.032092755	0.010070697	0.010070697	0.004252981	0.002760525	0.002760525
NH3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H2O		0.999916224	0.000352065	0.000352065	0.000352065	0.00091211	0.000352065	0.920490171	0.00091211	0.00091211	0.009887172	0.00123687	0.002088188	0.00124664	0.00268344	0.00268344	0.001169391	0.001169391	0.000510397	0.000510397	0.023779286	0.023510197	0.023510153	0.023510153	0.023510153	0.023510153	0.29384807	0.29384807	0.306451351	0.307058907	0.307058907
CH4		3.21567E-07	0.175844153	0.175844153	0.175844153	0.176340793	0.175844153	3.8128E-05	0.176340793	0.176340793	0.26466012	0.179536598	0.003859252	0.177520485	0.023110702	0.023110702	0.023145799	0.023145799	0.146263634	0.146263634	0.160239543	0.162246022	0.162246033	0.162246033	0.162246033	0.162246033	0.003507221	0.003507221	0.000153276	1.5699E-05	1.5699E-05
C2H6		7.15553E-12	2.66792E-06	2.66792E-06	2.66792E-06	2.67544E-06	2.66792E-06	9.10641E-10	2.67544E-06	2.67544E-06	1.66736E-05	3.18196E-06	4.95328E-06	3.20229E-06	4.27856E-07	4.27856E-07	4.28506E-07	4.28506E-07	2.23411E-06	2.23411E-06	2.44758E-06	2.47823E-06	2.47823E-06	2.47823E-06	2.47823E-06	2.47823E-06	2.63843E-07	2.63843E-07	5.24495E-08	2.01494E-08	2.01494E-08
C3H8		6.36561E-17	1.47812E-10	1.47812E-10	1.47812E-10	1.48231E-10	1.47812E-10	1.21186E-14	1.48231E-10	1.48231E-10	1.32401E-09	1.90776E-10	9.26805E-10	1.99223E-10	2.71556E-11	2.71556E-11	2.71968E-11	2.71968E-11	1.24447E-10	1.24447E-10	1.36338E-10	1.38045E-10	1.38045E-10	1.38045E-10	1.38045E-10	1.38045E-10	2.40307E-11	2.40307E-11	7.23825E-12	3.77014E-12	3.77014E-12
I-C4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-C4		4.96342E-22	0	0	0	0	0	0	0	0	0	0	0	0	1.72842E-15	1.72842E-15	1.73104E-15	1.73104E-15	3.35335E-16	3.35335E-16	3.67378E-16	3.71978E-16	3.71978E-16	3.71978E-16	3.71978E-16	3.71978E-16	0	0	0	0	0
MEOH		4.41883E-07	0.003487818	0.003487818	0.003487818	0.000128639	0.003487818	0.078957734	0.000128639	0.000128639	0.087687652	0.003296932	0.304891629	0.006758101	2.33427E-08	2.33427E-08	2.19813E-08	2.19813E-08	0.002812167	0.002812167	0.050771748	0.057612133	0.05761207	0.05761207	0.05761207	0.05761207	0.689436154	0.689436154	0.688271136	0.689312074	0.689312074
ETOH		1.2086E-10	3.39091E-06	3.39091E-06	3.39091E-06	1.46294E-07	3.39091E-06	7.62665E-05	1.46294E-07	1.46294E-07	8.04647E-05	3.05259E-06	7.49431E-05	3.87762E-06	6.28342E-12	6.28342E-12	5.92749E-12	5.92749E-12	2.73403E-06	2.73403E-06	4.23515E-05	6.70465E-05	6.70497E-05	6.70497E-05	6.70497E-05	6.70497E-05	0.000810176	0.000810176	0.000808855	0.00081019	0.00081019
DME		2.19417E-18	7.51891E-05	7.51891E-05	7.51891E-05	7.53925E-05	7.51891E-05	2.25975E-07	7.53925E-05	7.53925E-05	0.001541141	0.00012843	0.010420329	0.000246542	1.38478E-14	1.38478E-14	1.38689E-14	1.38689E-14	6.06236E-05	6.06236E-05	6.98409E-05	7.46691E-05	7.4669E-05	7.4669E-05	7.4669E-05	7.4669E-05	6.85972E-05	6.85972E-05	4.89837E-05	4.23896E-05	4.23896E-05
AR		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H2S		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NO		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NO2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Enthalpy, mixture	MJ/kmol	-287.97	-27.84	-27.84	-27.84	-27.31	-27.75	-283.77	-21.47	-28.08	-220.51	-35.04	-330.30	-38.43	-57.75	-63.49	-63.15	-61.09	-29.78	-27.39	-33.80	-36.88	-36.44	-41.36	-43.93	-45.77	-255.10	-255.31	-256.16	-256.01	-256.01

Stream Name	Units	M18	M19	M20	M21	MEOH	NG	S1	S2	S3	S4	S6	S24	STEAM	V16	W1	W2	W3	W21	W22B	W23	W27	WATER	WATER1	WATER3
From		E301-C	C-301	P302	C302	E301-H		HXVN	HX1	FDVN	FDVN	B4	B5	HX3	T-351	MX2	HX8B	SATURATR	C302	V208	B9				HX2
To		C-301	P302	C302	E301-H		HX7B	FDVN	HX2	HX9			E202-C			HX8B	SATURATR			B9		C201	MX2	HX1	HX3
Temperature	C	54.44444444	84.11266765	84.12165238	72.66345351	50.35115058	25	80	337.8247279	79.99878607	79.99878607	115.6389551	52.69559345	540	37.68329998	65.7000412	316.1649631		117.1766204	37.77777778	37.77777778	25	65.7	129	337.8247279
Pressure	bar	1.640620875	1.70272573	2.047463594	1.357987865	1.157987865	16.5	16.48	145	16.478	16.478	1	92	140	1.01	109.998	109.996		1.70272573	55	55	81.777	110	150	145
Mass Vapor Fraction		0	0	0	0	0	1	0.590252113	0.0001	1	0	1	1	1	1	0	1		0	0	0	0	0	0	1
Mass Flows	kg/hr	143276.60	142432.80	142432.80	113676.98	113676.98	54166.67	226958.33	34398.00	133963.07	92995.26	515621.05	520745.44	34398.00	430.22	172791.67	172791.67		25839.15	384.66	384.66	1250.00	172791.67	34398.00	34398.00
O2	kg/hr	0	0	0	0	0	0	0	0	0	0	20437	0	0	0	0	0		0	0	0	0	0	0	0
H2	kg/hr	0	0	0	0	0	0	20164	0	20163	0	0	111837	0	0	0	0		0	0	0	0	0	0	0
N2	kg/hr	0	0	0	0	0	0	0	0	0	0	375420	1204	0	0	0	0		0	0	0	0	0	0	0
CO	kg/hr	0	0	0	0	0	0	58581	0	58581	0	2	71892	0	0	0	0		0	0	0	0	0	0	0
CO2	kg/hr	627	0	0	0	0	0	43468	0	43445	23	54906	158185	0	341	0	0		0	0	0	0	0	0	0
NH3	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0
H2O	kg/hr	28530	28530	28530	1	1	0	99527	34398	6555	92971	64472	667	34398	5	172792	172792		25839	384	384	1250	172792	34398	34398
CH4	kg/hr	1	0	0	0	0	48491	5218	0	5218	0	0	170207	0	11	0	0		0	0	0	0	0	0	0
C2H6	kg/hr	0	0	0	0	0	2870	0	0	0	0	0	5	0	0	0	0		0	0	0	0	0	0	0
C3H8	kg/hr	0	0	0	0	0	2806	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0
I-C4	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0
N-C4	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0
MEOH	kg/hr	113916	113711	113711	113570	113570	0	0	0	0	0	0	6536	0	72	0	0		0	0	0	0	0	0	0
ETOH	kg/hr	193	192	192	106	106	0	0	0	0	0	0	9	0	0	0	0		0	0	0	0	0	0	0
DME	kg/hr	10	0	0	0	0	0	0	0	0	0	0	203	0	2	0	0		0	0	0	0	0	0	0
AR	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0
H2S	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0
NO	kg/hr	0	0	0	0	0	0	0	0	0	0	382	0	0	0	0	0		0	0	0	0	0	0	0
NO2	kg/hr	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0		0	0	0	0	0	0	0
Mole Flows	kmol/hr	5157.58	5136.60	5136.60	3546.76	3546.76	3181.66	18931.30	1909.38	13769.96	5161.34	18879.34	72537.23	1909.38	11.05	9591.40	9591.40	0.00	1434.29	21.34	21.34	69.39	9591.40	1909.38	1909.38
O2	kmol/hr	0	0	0	0	0	0	0	0	0	0	639	0	0	0	0	0	0	0	0	0	0	0	0	0
H2	kmol/hr	0	0	0	0	0	0	10002	0	10002	0	0	55478	0	0	0	0	0	0	0	0	0	0	0	0
N2	kmol/hr	0	0	0	0	0	0	0	0	0	0	13401	43	0	0	0	0	0	0	0	0	0	0	0	0
CO	kmol/hr	0	0	0	0	0	0	2091	0	2091	0	0	2567	0	0	0	0	0	0	0	0	0	0	0	0
CO2	kmol/hr	14	0	0	0	0	0	988	0	987	1	1248	3594	0	8	0	0	0	0	0	0	0	0	0	0
NH3	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H2O	kmol/hr	1584	1584	1584	0	0	0	5525	1909	364	5161	3579	37	1909	0	9591	9591	0	1434	21	21	69	9591	1909	1909
CH4	kmol/hr	0	0	0	0	0	3023	325	0	325	0	0	10610	0	1	0	0	0	0	0	0	0	0	0	0
C2H6	kmol/hr	0	0	0	0	0	95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C3H8	kmol/hr	0	0	0	0	0	64	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
I-C4	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-C4	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MEOH	kmol/hr	3555	3549	3549	3544	3544	0	0	0	0	0	0	204	0	2	0	0	0	0	0	0	0	0	0	0
ETOH	kmol/hr	4	4	4	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DME	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0
AR	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H2S	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NO	kmol/hr	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0
NO2	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mass fraction																									
O2		0	0	0	0	0	0	8.40567E-19	0	0	0	0.039635781	0	0	0	0	0	0	0	0	0	0	0	0	0
H2		1.36092E-08	1.79695E-28	1.79695E-28	0	0	0	0.088842445	0	0.150514158	2.08666E-06	3.27305E-07	0.21476309	0	0.000310738	0	0	0	0	1.93327E-06	1.93327E-06	0	0	0	0
N2		4.98432E-10	6.5745E-29	6.5745E-29	0	0	0	0	0	0	0	0.728093528	0.002312612	0	7.84561E-06	0	0	0	0	8.0303E-10	8.0303E-10	0	0	0	0
CO		7.37186E-09	1.59076E-27	1.59076E-27	0	0	0	0.258115616	0	0.437294376	2.05726E-06	4.46755E-06	0.138056865	0	0.00010608	0	0	0	0	1.38244E-06	1.38244E-06	0	0	0	0
CO2		0.004373324	1.58422E-11	1.58422E-11	1.98496E-11	1.98496E-11	0	0.191526237	0	0.324306315	0.000251677	0.106485534	0.303767271	0	0.792223753	0	0	0	0	0.000908406	0.000908406	0	0	0	0
NH3		0	0	0	0	0	0	0	0	0	0	2.55585E-13	0	0	0	0	0	0	0	0	0	0	0	0	0
H2O		0.199128433	0.200302568	0.200302568	1.25416E-05	1.25416E-05	0	0.438524394	1	0.048934471	0.999742928	0.125036818	0.001280809	1	0.010530546	1	1	0	0.999999	0.999085704	0.999085704	1	1	1	1
CH4		9.06614E-06	1.98595E-20	1.98595E-20	0	0	0.895209565	0.02299038	0	0.038949215	1.09362E-06	2.40964E-27	0.326851837	0	0.026522588	0	0	0	0	9.37936E-07	9.37936E-07	0	0	0	0
C2H6		2.18103E-08	1.14791E-18	1.14791E-18	0	0	0.052987265	7.9778E-07	0	1.35155E-06	5.1339E-11	0	9.35767E-06	0	1.16841E-05	0	0	0	0	3.71322E-11	3.71322E-11	0	0	0	0
C3H8		5.98457E-12	1.83399E-20	1.83399E-20	0	0	0.05180317	7.42526E-11	0	1.25797E-10	1.20395E-15	0	7.64405E-10	0	1.84157E-09	0	0	0	0	4.80678E-16	4.80678E-16	0	0	0	0
I-C4		0	0	0	0	0	0	2.72885E-15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-C4		0	0	0	0	0	0	6.2294E-15	0	1.05537E-14	2.29561E-20	0	2.71498E-15	0	0	0	0	0	0	4.97688E-21	4.97688E-21	0	0	0	0
MEOH		0.795075246	0.798346389	0.798346389	0.999059308	0.999059308	0	1.31149E-07	0	1.13045E-07	1.57229E-07	3.1339E-26	0.01255158	0	0.166367661	0	0	0	6.51656E-07	1.63501E-06	1.63501E-06	0	0	0	0
ETOH		0.00134359	0.001351041	0.001351041	0.000928149	0.000928149	0	5.03431E-11	0	4.39652E-11	5.95307E-11	0	1.75448E-05	0	0.000219337	0	0	0	3.48344E-07	6.15067E-10	6.15067E-10	0	0	0	0
DME		7.02973E-05	1.27052E-09	1.27052E-09	1.59191E-09	1.59191E-09	0	3.95649E-14	0	6.70192E-14	1.58551E-17	0	0.000389033	0	0.003699767	0	0	0	0	1.60772E-17	1.60772E-17	0	0	0	0
AR		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H2S		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NO		0	0	0	0	0	0	0	0	0	0	0.000741628	0	0	0	0	0	0	0	0	0	0	0	0	0
NO2		0	0	0	0	0	0	0	0	0	0	1.91509E-06	0	0	0	0	0	0	0	0	0	0	0	0	0
Mole fraction																									
O2		0	0	0	0	0	0	3.14923E-19	0	0	0	0.033829656	0	0	0	0	0	0	0	0	0	0	0	0	0
H2		1.87542E-07	2.47176E-27	2.47176E-27	0	0	0	0.52834988	0	0.726382046	1.86503E-05	4.43437E-06	0.76482044	0	0.006003776	0	0	0	0	1.7286E-05	1.7286E-05	0	0	0	0
N2		4.94275E-10	6.50774E-29	6.50774E-29	0	0	0	0	0	0	0	0.709845703	0.000592653	0	1.09082E-05	0	0	0	0	5.16693E-10	5.16693E-10	0	0	0	0
CO		7.31118E-09	1.57478E-27	1.57478E-27	0	0	0	0.110474172	0	0.151882244	1.32333E-06	4.35606E-06	0.035383697	0	0.000147505	0	0	0	0	8.89601E-07	8.89601E-07	0	0	0	0
CO2		0.002760525	9.98159E-12	9.98159E-12	1.44558E-11	1.44558E-11	0	0.052172863	0	0.071689976	0.000103037	0.066082288	0.04955142	0	0.701121909	0	0	0	0	0.000372047	0.000372047	0	0	0	0
NH3		0	0	0	0	0	0	0	0	0	0	4.09874E-13	0	0	0	0	0	0	0	0	0	0	0	0	0
H2O		0.307058907	0.308304563	0.308304563	2.23127E-05	2.23127E-05	0	0.291822335	1	0.026425688	0.999875673	0.189557401	0.000510397	1	0.022766954	1	1	0	0.999999497	0.999607803	0.999607803	1	1	1	1
CH4		1.5699E-05	3.4326E-20	3.4326E-20	0	0	0.95	0.017180383	0	0.023619573	1.22825E-06	4.10221E-27	0.146263634	0	0.064391995	0	0	0	0	1.05381E-06	1.05381E-06	0	0	0	0
C2H6		2.01494E-08	1.05855E-18	1.05855E-18	0	0	0.03	3.18068E-07	0	4.37277E-07	3.07622E-11	0	2.23411E-06	0	1.51343E-05	0	0	0	0	2.22582E-11	2.22582E-11	0	0	0	0
C3H8		3.77014E-12	1.15326E-20	1.15326E-20	0	0	0.02	2.01871E-11	0	2.77535E-11	4.9193E-16	0	1.24447E-10	0	1.62659E-09	0	0	0	0	1.9648E-16	1.9648E-16	0	0	0	0
I-C4		0	0	0	0	0	0	5.62852E-16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N-C4		0	0	0	0	0	0	1.28487E-15	0	1.76648E-15	7.11616E-21	0	3.35335E-16	0	0	0	0	0	0	1.54338E-21	1.54338E-21	0	0	0	0
MEOH		0.689312074	0.690882243	0.690882243	0.99933196	0.99933196	0	4.90693E-08	0	3.43227E-08	8.84118E-08	2.67121E-26	0.002812167	0	0.202228425	0	0	0	3.66385E-07	9.19743E-07	9.19743E-07	0	0	0	0
ETOH		0.00081019	0.000813193	0.000813193	0.000645727	0.000645727	0	1.31008E-11	0	9.28436E-12	2.32826E-11	0	2.73403E-06	0	0.000185438	0	0	0	1.3622E-07	2.40647E-10	2.40647E-10	0	0	0	0
DME		4.23896E-05	7.64727E-10	7.64727E-10	1.10751E-09	1.10751E-09	0	1.02959E-14	0	1.41528E-14	6.20094E-18	0	6.06236E-05	0	0.003127954	0	0	0	0	6.29028E-18	6.29028E-18	0	0	0	0
AR		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H2S		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NO		0	0	0	0	0	0	0	0	0	0	0.000675025	0	0	0	0	0	0	0	0	0	0	0	0	0
NO2		0	0	0	0	0	0	0	0	0	0	1.1369E-06	0	0	0	0	0	0	0	0	0	0	0	0	0
Enthalpy, mixture	MJ/kmol	-254.10	-250.27	-250.27	-236.87	-239.64	-75.71	-114.91	-256.64	-51.51	-284.07	-69.01	-34.21	-226.09	-327.04	-285.14	-236.87		-280.83	-287.68	-287.68	-288.71	-285.14	-279.56	-237.98

Table 25 Heat Balance for SMR methanol model

Stream Name	H1	H2	H4	H5	H6	H7	H8	Q301A	Q301B	QE202A	QE202B	S5	S7	S8
QCALC MW	-45.6428709	-154.532206	-74.9268135	-32.456924	-21.8372328	-15.1594531	-128.595832	-2.73051039	-2.73051035	-89.2843715	-89.2843715	-12.1579325	-6.30451515	-9.89725984
TBEGIN C	25		478.481007	400	254.556172	25	65.7000412	37.6979152		52.6955935		129	337.824728	337.824728
TEND C	350		900	600	400	381.4	316.164963	54.4444444		190		337.824728	540	337.824728

F.3. - RWGS Methanol Model Flowsheets

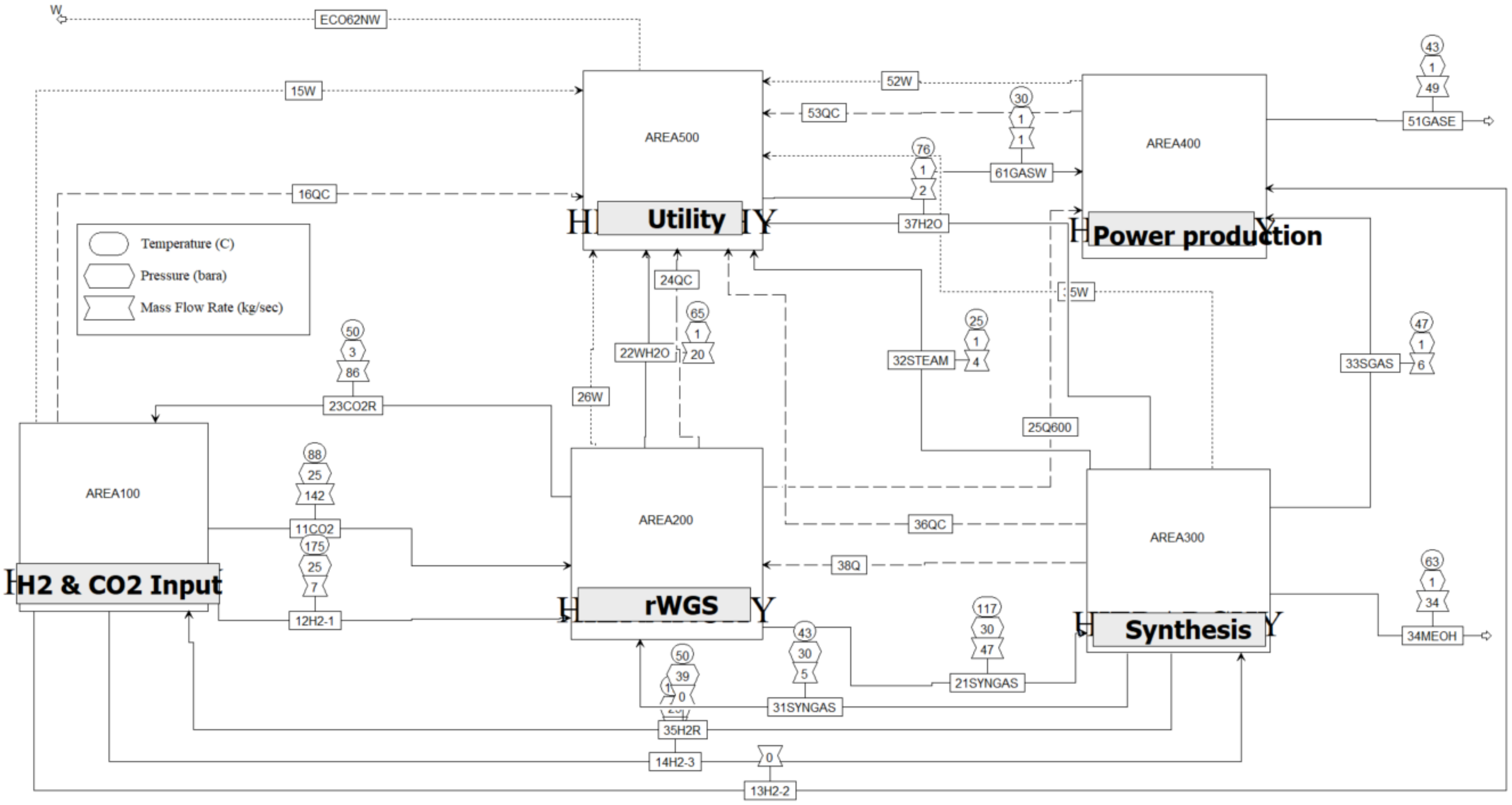

Figure 34. Aspen Plus RWGS methanol model blocks (1 MMT/yr.).

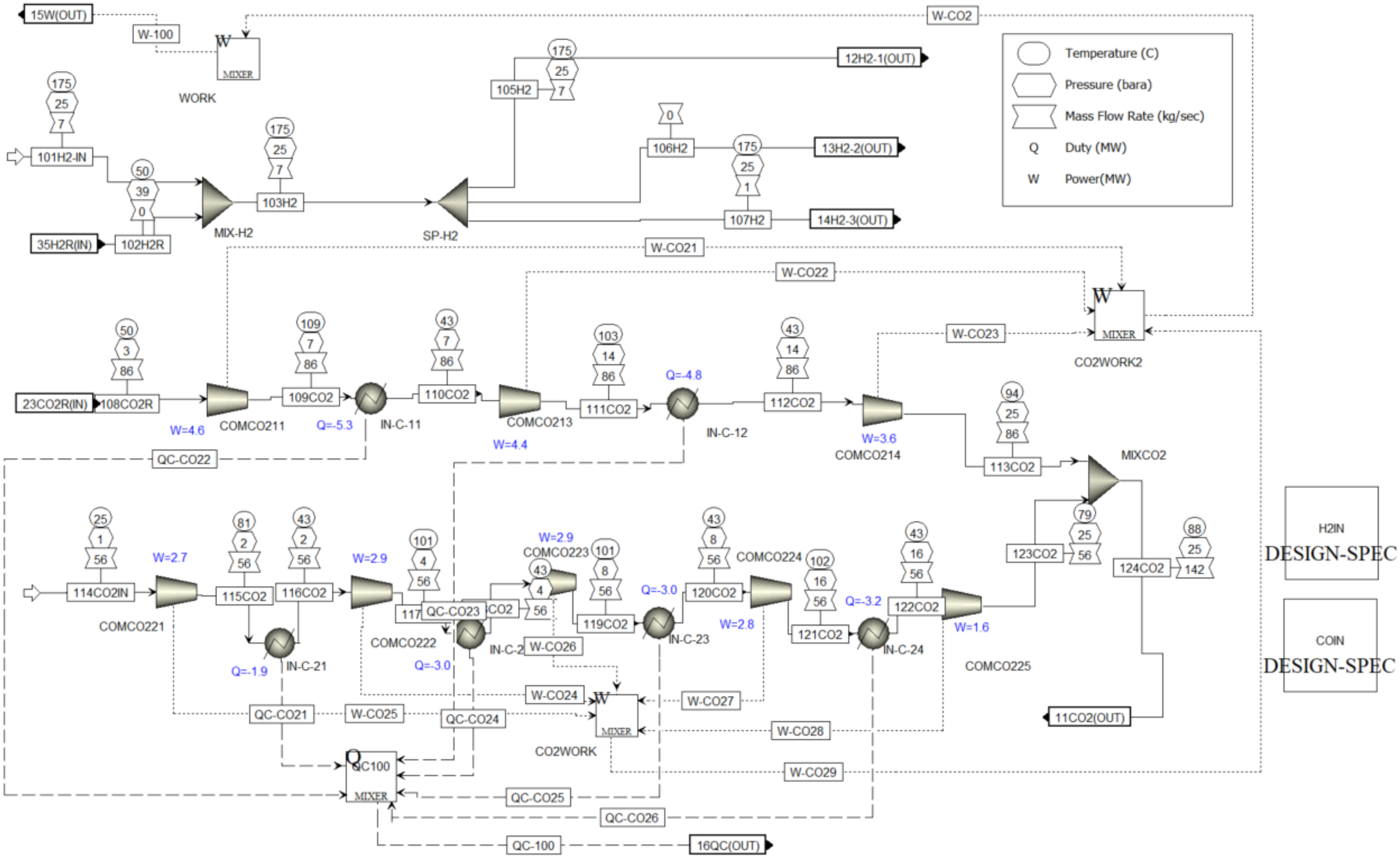

Figure 35. Aspen Plus A100 H_2 and CO_2 compression block.

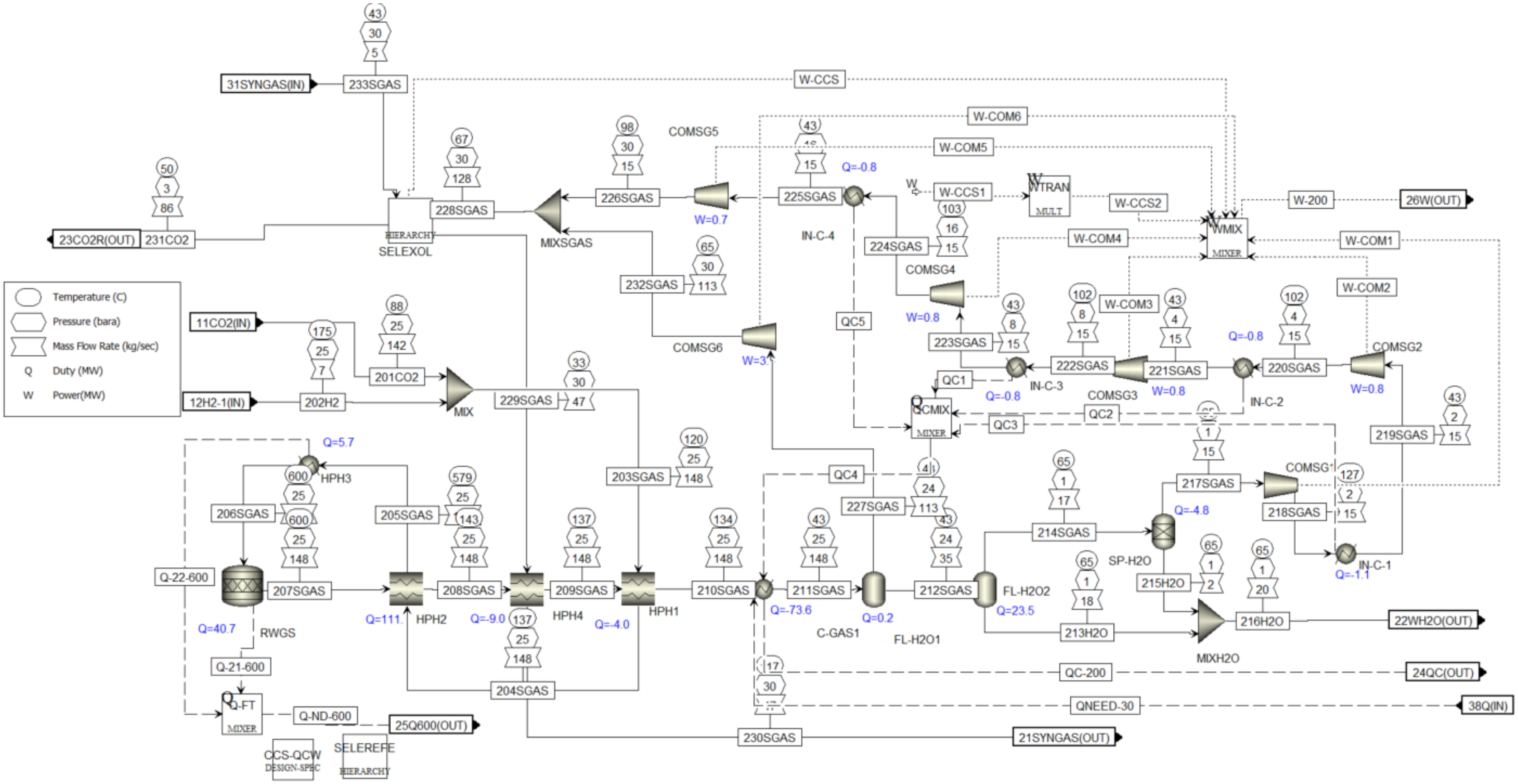

Figure 36. Aspen Plus Area 200 RWGS reaction block.

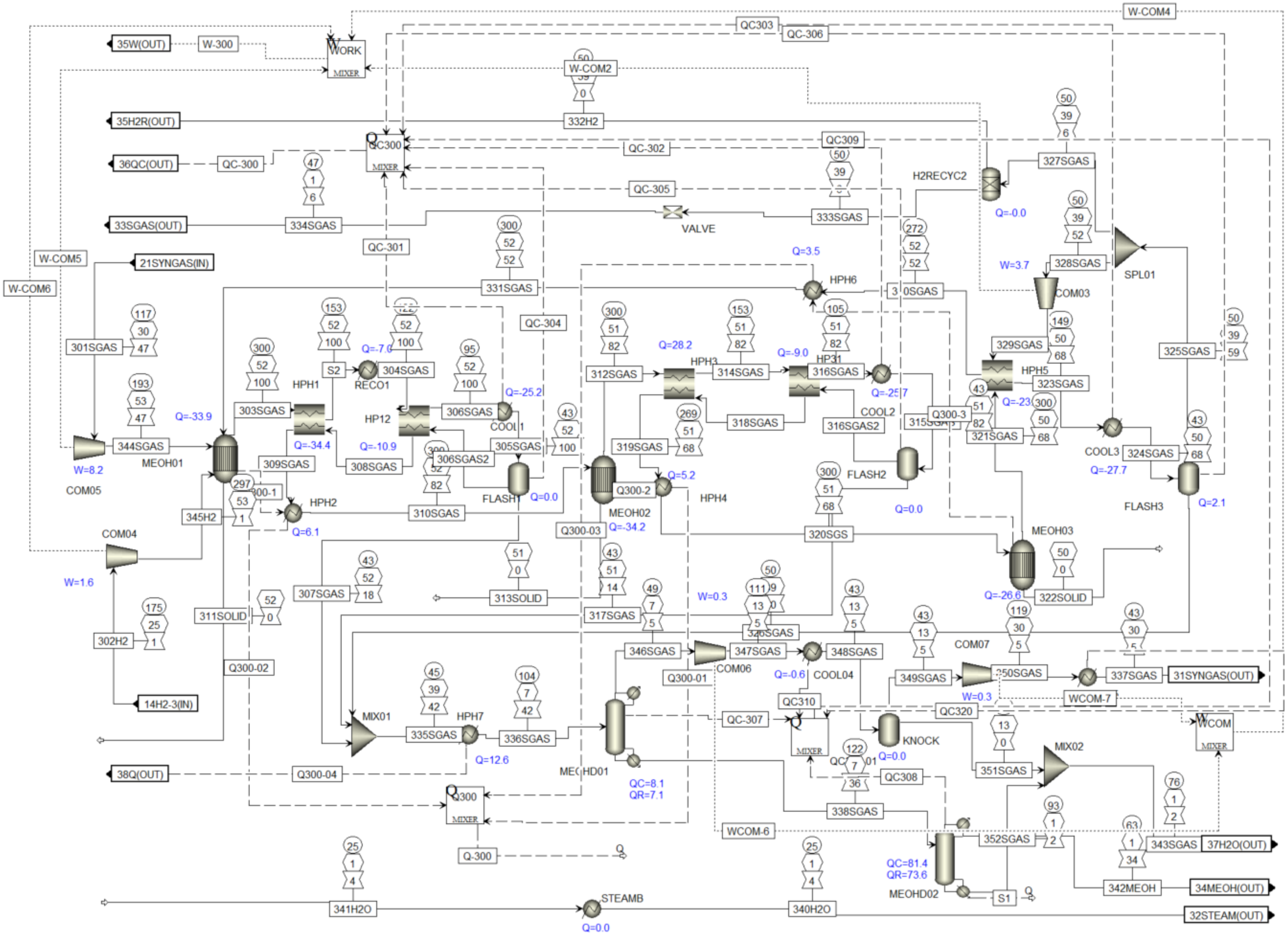

Figure 37. Aspen Plus Area 300 methanol-synthesis.

F.4. - RWGS Methanol Model Material & Heat Balance

Table 26 RWGS Overall BFD methanol material balance

	Units	11CO2	12H2-1	13H2-2	14H2-3	21SYNGAS	22WH2O	23CO2R	31SYNGAS	32STEAM	33SGAS	34MEOH	35H2R	37H2O	51GASE	61GASW
From		AREA100	AREA100	AREA100	AREA100	AREA200	AREA200	AREA200	AREA300	AREA300	AREA300	AREA300	AREA300	AREA300	AREA400	AREA500
To		AREA200	AREA200	AREA400	AREA300	AREA300	AREA500	AREA100	AREA200	AREA500	AREA400		AREA100	AREA500		AREA400
Stream Class		CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN
Phase		Vapor Phase	Vapor Phase		Vapor Phase	Vapor Phase	Liquid Phase	Vapor Phase		Liquid Phase	Vapor Phase	Liquid Phase	Vapor Phase			
Temperature	C	88.01	175.00		175.00	117.00	65.00	49.55	43.00	25.00	47.37	63.01	49.50	76.07	43.00	30.00
Pressure	bara	24.70	25.00		25.00	30.00	1.00	3.45	30.00	1.20	1.23	1.00	39.23	1.00	1.00	1.00
Molar Vapor Fraction		1.00	1.00		1.00	1.00	0.00	1.00	0.97	0.00	1.00	0.00	1.00	0.04	0.87	0.40
Molar Liquid Fraction		0.00	0.00		0.00	0.00	1.00	0.00	0.03	1.00	0.00	1.00	0.00	0.96	0.13	0.60
Molar Solid Fraction		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Vapor Fraction		1.00	1.00		1.00	1.00	0.00	1.00	0.97	0.00	1.00	0.00	1.00	0.06	0.92	0.46
Mass Liquid Fraction		0.00	0.00		0.00	0.00	1.00	0.00	0.03	1.00	0.00	1.00	0.00	0.94	0.08	0.54
Mass Solid Fraction		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Molar Enthalpy	kJ/kmol	-382047.23	4399.12		4399.12	-59207.66	-283808.58	-376804.00	-328528.86	-285828.38	-67881.58	-234881.63	750.61	-274771.77	-100003.54	-284669.84
Mass Enthalpy	kJ/kg	-8790.28	2182.23		2182.23	-4457.05	-15616.92	-8740.38	-8161.40	-15865.89	-5145.08	-7330.40	372.35	-13147.97	-3573.05	-7926.13
Molar Entropy	J/kmol-K	-13318.92	-14816.88		-14816.88	16234.14	-153766.13	2092.53	-7202.62	-163237.78	30195.98	-228656.93	-28172.22	-154513.88	-15693.92	-147997.69
Mass Entropy	kJ/kg-K	-0.31	-7.35		-7.35	1.22	-8.46	0.05	-0.18	-9.06	2.29	-7.14	-13.98	-7.39	-0.56	-4.12
Molar Density	kmol/cum	0.88	0.66		0.66	0.91	53.08	0.13	1.31	55.35	0.05	23.29	1.43	0.83	0.04	0.10
Mass Density	kg/cum	38.33	1.34		1.34	12.15	964.61	5.61	52.61	997.18	0.61	746.23	2.88	17.31	1.22	3.57
Enthalpy Flow	MW	-1246.81	14.44		1.88	-209.69	-319.55	-748.62	-42.22	-61.06	-32.81	-250.47	0.00	-28.78	-175.34	-7.63
Average MW		43.46	2.02		2.02	13.28	18.17	43.11	40.25	18.02	13.19	32.04	2.02	20.90	27.99	35.92
Mole Flows	kmol/hr	11748.63	11819.50	0.00	1538.12	12749.59	4053.32	7152.35	462.59	769.02	1739.82	3838.87	0.00	377.08	6311.89	96.48
H2O	kmol/hr	0.333953356	0	0	0	0.034012081	4028.419681	0.333953356	0	769.0231108	0.502288103	3.08582645	0	305.4968186	1274.510191	0
CO	kmol/hr	401.0447736	0	0	0	4183.227986	0.153011087	401.0447736	98.58148702	0	458.6131339	4.19E-05	0	0.174662804	0	0.327673891
H2	kmol/hr	1.74E-09	11819.5	0	1538.117116	7734.700667	4.73E-12	1.74E-09	0.00066855	0	1094.633612	0	1.09E-07	3.07E-12	0	7.80E-12
CO2	kmol/hr	11346.66667	0	0	0	831.5673129	24.19695679	6750.388078	350.6280626	0	161.3079015	3.61212479	0	6.972291583	741.1051032	31.16924838
O2	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	182.2635856	0
N2	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	4113.949504	0
CH4	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H6	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H4	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H2	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C3	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C4	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H2S	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NH3	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SULFUR	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CARBON	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STEAM	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SO2	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NO2	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MEA	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WAXES	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C5	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C6	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C7	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C8	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C9	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C10	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C11	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C12	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C13	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C14	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C15	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C16	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C17	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C18	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C19	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COS	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AR	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GLYCOL	kmol/hr	0.055869971	0	0	0	0.010718524	0.055796846	0.055869971	0	0	0	1.14E-07	0	0.010719537	0.066516384	0.066516384
METHANOL	kmol/hr	0.530421192	0	0	0	0.051354634	0.492121763	0.530421192	13.3809908	0	24.76745284	3832.169412	0	64.42757088	0	64.91969265
Mole Fractions																
H2O		2.84E-05	0	0	0	2.67E-06	0.993857405	4.67E-05	0	1	0.0002887	0.000803838	0	0.810160037	0.20192196	0
CO		0.034135445	0	0	0	0.328106811	3.77E-05	0.056071725	0.213107135	0	0.263597371	1.09E-08	0	0.000463196	0	0.003396178
H2		1.48E-13	1	0	1	0.6066626	1.17E-15	2.43E-13	1.45E-06	0	0.629163276	0	1	8.14E-15	0	8.08E-14
CO2		0.965786227	0	0	0	0.065223053	0.005969667	0.943799612	0.757965253	0	0.092715048	0.000940935	0	0.018490117	0.117414044	0.323053864
O2		0	0	0	0	0	0	0	0	0	0	0	0	0	0.028876207	0
N2		0	0	0	0	0	0	0	0	0	0	0	0	0	0.651777251	0
CH4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H6		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H2S		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NH3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SULFUR		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CARBON		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STEAM		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SO2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NO2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MEA		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WAXES		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C5		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C6		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C7		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C8		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C9		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C10		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C11		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C12		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C13		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C14		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C15		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C16		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C17		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C18		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C19		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COS		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AR		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GLYCOL		4.76E-06	0	0	0	8.41E-07	1.38E-05	7.81E-06	0	0	0	2.96E-11	0	2.84E-05	1.05E-05	0.000689409
METHANOL		4.51E-05	0	0	0	4.03E-06	0.000121412	7.42E-05	0.028926168	0	0.014235605	0.998255216	0	0.170858222	0	0.672860549

	Units	**11CO2**	**12H2-1**	**13H2-2**	**14H2-3**	**21SYNGAS**	**22WH2O**	**23CO2R**	**31SYNGAS**	**32STEAM**	**33SGAS**	**34MEOH**	**35H2R**	**37H2O**	**51GASE**	**61GASW**
From		AREA100	AREA100	AREA100	AREA100	AREA200	AREA200	AREA200	AREA300	AREA300	AREA300	AREA300	AREA300	AREA300	AREA400	AREA500
To		AREA200	AREA200	AREA400	AREA300	AREA300	AREA500	AREA100	AREA200	AREA500	AREA400		AREA100	AREA500		AREA400
Stream Class		CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN
Phase		Vapor Phase	Vapor Phase		Vapor Phase	Vapor Phase	Liquid Phase	Vapor Phase		Liquid Phase	Vapor Phase	Liquid Phase	Vapor Phase			
Mass Flows	kg/hr	510624.4351	23826.69366		3100.659533	169366.1522	73661.52952	308343.1336	18621.13499	13854.16667	22954.36736	123005.5476	2.21E-07	7880.416138	176658.9321	3465.226411
H2O	kg/hr	6.01626322	0		0	0.612737164	72573.10852	6.01626322	0	13854.16667	9.048860822	55.59202753	0	5503.610725	22960.65796	0
CO	kg/hr	11233.42453	0		0	117173.8892	4.285901758	11233.42453	2761.306884	0	12845.93733	0.001174543	0	4.892375004	0	9.178276763
H2	kg/hr	3.51E-09	23826.69366		3100.659533	15592.22838	9.54E-12	3.51E-09	0.001347717	0	2206.650006	0	2.21E-07	6.19E-12	0	1.57E-11
CO2	kg/hr	499364.5307	0		0	36597.11113	1064.903229	297083.2292	15431.07091	0	7099.128482	158.9688896	0	306.8491581	32615.88737	1371.752387
O2	kg/hr	0	0		0	0	0	0	0	0	0	0	0	0	5832.216024	0
N2	kg/hr	0	0		0	0	0	0	0	0	0	0	0	0	115246.0422	0
CH4	kg/hr	0	0		0	0	0	0	0	0	0	0	0	0	0	0
C2H6	kg/hr	0	0		0	0	0	0	0	0	0	0	0	0	0	0
C2H4	kg/hr	0	0		0	0	0	0	0	0	0	0	0	0	0	0
C2H2	kg/hr	0	0		0	0	0	0	0	0	0	0	0	0	0	0
C3	kg/hr	0	0		0	0	0	0	0	0	0	0	0	0	0	0
C4	kg/hr	0	0		0	0	0	0	0	0	0	0	0	0	0	0
H2S	kg/hr	0	0		0	0	0	0	0	0	0	0	0	0	0	0
NH3	kg/hr	0	0		0	0	0	0	0	0	0	0	0	0	0	0
SULFUR	kg/hr	0	0		0	0	0	0	0	0	0	0	0	0	0	0
CARBON	kg/hr	0	0		0	0	0	0	0	0	0	0	0	0	0	0
STEAM	kg/hr	0	0		0	0	0	0	0	0	0	0	0	0	0	0
SO2	kg/hr	0	0		0	0	0	0	0	0	0	0	0	0	0	0
NO2	kg/hr	0	0		0	0	0	0	0	0	0	0	0	0	0	0
MEA	kg/hr	0	0		0	0	0	0	0	0	0	0	0	0	0	0
WAXES	kg/hr	0	0		0	0	0	0	0	0	0	0	0	0	0	0
C5	kg/hr	0	0		0	0	0	0	0	0	0	0	0	0	0	0
C6	kg/hr	0	0		0	0	0	0	0	0	0	0	0	0	0	0
C7	kg/hr	0	0		0	0	0	0	0	0	0	0	0	0	0	0
C8	kg/hr	0	0		0	0	0	0	0	0	0	0	0	0	0	0
C9	kg/hr	0	0		0	0	0	0	0	0	0	0	0	0	0	0
C10	kg/hr	0	0		0	0	0	0	0	0	0	0	0	0	0	0
C11	kg/hr	0	0		0	0	0	0	0	0	0	0	0	0	0	0
C12	kg/hr	0	0		0	0	0	0	0	0	0	0	0	0	0	0
C13	kg/hr	0	0		0	0	0	0	0	0	0	0	0	0	0	0
C14	kg/hr	0	0		0	0	0	0	0	0	0	0	0	0	0	0
C15	kg/hr	0	0		0	0	0	0	0	0	0	0	0	0	0	0
C16	kg/hr	0	0		0	0	0	0	0	0	0	0	0	0	0	0
C17	kg/hr	0	0		0	0	0	0	0	0	0	0	0	0	0	0
C18	kg/hr	0	0		0	0	0	0	0	0	0	0	0	0	0	0
C19	kg/hr	0	0		0	0	0	0	0	0	0	0	0	0	0	0
C20	kg/hr	0	0		0	0	0	0	0	0	0	0	0	0	0	0
COS	kg/hr	0	0		0	0	0	0	0	0	0	0	0	0	0	0
AR	kg/hr	0	0		0	0	0	0	0	0	0	0	0	0	0	0
GLYCOL	kg/hr	3.467761959	0		0	0.665282077	3.463223219	3.467761959	0	0	0	7.05E-06	0	0.665344953	4.128568172	4.128568172
METHANOL	kg/hr	16.99584069	0		0	1.645513406	15.76864427	16.99584069	428.7558482	0	793.6026867	122790.9855	0	2064.398535	0	2080.167179
Mass Fractions																
H2O		1.18E-05	0	0	0	3.62E-06	0.985224024	1.95E-05	0	1	0.000394211	0.000451947	0	0.698390875	0.129971679	0
CO		0.021999387	0	0	0	0.6918377	5.82E-05	0.03643157	0.14828886	0	0.559629334	9.55E-09	0	0.000620827	0	0.00264868
H2		6.87E-15	1	0	1	0.092062246	1.29E-16	1.14E-14	7.24E-08	0	0.096132033	0	1	7.85E-16	0	4.54E-15
CO2		0.977948755	0	0	0	0.216082792	0.014456708	0.963482552	0.828685841	0	0.309271363	0.001292372	0	0.038938192	0.184626313	0.395862268
O2		0	0	0	0	0	0	0	0	0	0	0	0	0	0.033013989	0
N2		0	0	0	0	0	0	0	0	0	0	0	0	0	0.652364649	0
CH4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H6		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H2S		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NH3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SULFUR		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CARBON		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STEAM		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SO2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NO2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MEA		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WAXES		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C5		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C6		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C7		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C8		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C9		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C10		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C11		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C12		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C13		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C14		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C15		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C16		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C17		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C18		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C19		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COS		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AR		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GLYCOL		6.79E-06	0	0	0	3.93E-06	4.70E-05	1.12E-05	0	0	0	5.73E-11	0	8.44E-05	2.34E-05	0.001191428
METHANOL		3.33E-05	0	0	0	9.72E-06	0.000214069	5.51E-05	0.023025226	0	0.034573059	0.998255671	0	0.261965675	0	0.600297623
Volume Flow	cum/sec	3.700389118	4.947405468		0.643824953	3.871399478	0.02121224	15.26804389	0.098311113	0.003859277	10.47362374	0.045787888	2.13E-11	0.126479275	40.17691483	0.269878918

Table 27 RWGS Overall BFD heat balance

Stream Name	**16QC**	**24QC**	**25Q600**	**36QC**	**38Q**	**53QC**
QCALC MW	21.18	64.55	-46.46	167.03	-12.64	17.27
TBEGIN C	109.34	134.28	578.50		44.89	180.00
TEND C	43.00	43.00	600.00		104.00	43.00

Table 28 RWGS A100 material balance

	Units	101H2-IN	102H2R	103H2	105H2	106H2	107H2	108CO2R	109CO2	110CO2	111CO2	112CO2	113CO2	114CO2IN	115CO2	116CO2	117CO2	118CO2	119CO2	120CO2	121CO2	122CO2	123CO2	124CO2
From				MIX-H2	SP-H2	SP-H2	SP-H2		COMCO211	IN-C-11	COMCO213	IN-C-12	COMCO214		COMCO221	IN-C-21	COMCO222	IN-C-22	COMCO223	IN-C-23	COMCO224	IN-C-24	COMCO225	MIXCO2
To		MIX-H2	MIX-H2	SP-H2				COMCO211	IN-C-11	COMCO213	IN-C-12	COMCO214	MIXCO2	COMCO221	IN-C-21	COMCO222	IN-C-22	COMCO22	IN-C-23	COMCO224	IN-C-24	COMCO225	MIXCO2	
Stream Class		CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN
Maximum Relative Error																								
MIXED Substream																								
Phase		Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase		Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Pha	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase
Temperature	C	175	49.5	175	175		175	49.55105234	109.3424096	43	102.7273821	43	93.80053424	25	80.77901203	43	101.1725415	43	101.477474	43	102.0892917	43	79.17137777	88.01021769
Pressure	bara	25	39.23	25	25		25	3.44737865	6.88	6.88	13.76	13.76	24.7	1.01325	2.02	2.02	4.04	4.04	8.08	8.08	16.16	16.16	24.7	24.7
Molar Vapor Fraction		1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Molar Liquid Fraction		0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Molar Solid Fraction		0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mass Vapor Fraction		1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Mass Liquid Fraction		0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mass Solid Fraction		0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Molar Enthalpy	kJ/kmol	4399.119284	750.6138192	4399.119284	4399.119284		4399.119284	-376803.9992	-374510.7103	-377160.4367	-374939.3891	-377378.5421	-375580.2188	-393545.366	-391410.2086	-392895.633	-390632.5213	-392961	-390718.1558	-393093.5154	-390892.5152	-393370.9339	-392110.654	-382047.226
Mass Enthalpy	kJ/kg	2182.232714	372.350447	2182.232714	2182.232714		2182.232714	-8740.377054	-8687.181735	-8748.64501	-8697.125402	-8753.704201	-8711.990143	-8942.221186	-8893.705688	-8927.457817	-8876.034912	-8928.94	-8877.980718	-8931.954142	-8881.942549	-8938.257704	-8909.621357	-8790.280754
Molar Entropy	J/kmol-K	-14816.88103	-28172.21743	-14816.88103	-14816.88103		-14816.88103	2092.526324	2940.633871	-4660.8215	-3825.217208	-10888.31098	-10196.65566	2807.108965	3660.731373	-775.8207252	79.45495273	-6674.83	-5828.205102	-12717.18522	-11887.97967	-19071.65251	-18567.96377	-13318.92471
Mass Entropy	kJ/kg-K	-7.350080873	-13.97514605	-7.350080873	-7.350080873		-7.350080873	0.048538415	0.068211189	-0.108112805	-0.088730058	-0.252566171	-0.236522477	0.063783725	0.083179914	-0.017628363	0.001805392	-0.15167	-0.132429711	-0.288962577	-0.270121193	-0.433350129	-0.421905207	-0.306446637
Molar Density	kmol/cum	0.66361944	1.4300509	0.66361944	0.66361944		0.66361944	0.13012569	0.219618304	0.268976068	0.454695589	0.553743582	0.862997065	0.041078939	0.069058414	0.07749732	0.131135505	0.156329	0.264765092	0.318223543	0.539843317	0.660753571	0.913151715	0.881936655
Mass Density	kg/cum	1.337777156	2.882811008	1.337777156	1.337777156		1.337777156	5.609812959	9.467904483	11.59575352	19.6022569	23.87228775	37.20442987	1.807875881	3.039246973	3.410641557	5.771247361	6.880019	11.65225873	14.00495447	23.75839639	29.0796325	40.18762435	38.33113663
Enthalpy Flow	MW	16.32270862	2.28E-11	16.32270862	14.44316399		1.87954463	-748.6209028	-744.0646774	-749.3290604	-744.9163612	-749.7623845	-746.1895391	-502.4567054	-499.7306559	-501.6271627	-498.7377482	-501.71	-498.8470816	-501.8798078	-499.0696939	-502.2340003	-500.6249454	-1246.814484
Average MW		2.01588	2.01588	2.01588	2.01588		2.01588	43.11072587	43.11072587	43.11072587	43.11072587	43.11072587	43.11072587	44.0098	44.0098	44.0098	44.0098	44.0098	44.0098	44.0098	44.0098	44.0098	44.0098	43.46246003
Mole Flows	kmol/hr	13357.61711	1.09E-07	13357.61711	11819.5	0	1538.117116	7152.353096	7152.353096	7152.353096	7152.353096	7152.353096	7152.353096	4596.278589	4596.278589	4596.278589	4596.278589	4596.279	4596.278589	4596.278589	4596.278589	4596.278589	4596.278589	11748.63168
H2O	kmol/hr	0	0	0	0	0	0	0.333953356	0.333953356	0.333953356	0.333953356	0.333953356	0.333953356	0	0	0	0	0	0	0	0	0	0	0.333953356
CO	kmol/hr	0	0	0	0	0	0	401.0447736	401.0447736	401.0447736	401.0447736	401.0447736	401.0447736	0	0	0	0	0	0	0	0	0	0	401.0447736
H2	kmol/hr	13357.61711	1.09E-07	13357.61711	11819.5	0	1538.117116	1.74E-09	1.74E-09	1.74E-09	1.74E-09	1.74E-09	1.74E-09	0	0	0	0	0	0	0	0	0	0	1.74E-09
CO2	kmol/hr	0	0	0	0	0	0	6750.388078	6750.388078	6750.388078	6750.388078	6750.388078	6750.388078	4596.278589	4596.278589	4596.278589	4596.278589	4596.279	4596.278589	4596.278589	4596.278589	4596.278589	4596.278589	11346.66667
O2	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N2	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CH4	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H6	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H4	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H2	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C3	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C4	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H2S	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NH3	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SULFUR	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CARBON	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STEAM	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SO2	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NO2	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MEA	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WAXES	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C5	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C6	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C7	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C8	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C9	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C10	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C11	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C12	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C13	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C14	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C15	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C16	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C17	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C18	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C19	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COS	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AR	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GLYCOL	kmol/hr	0	0	0	0	0	0	0.055869971	0.055869971	0.055869971	0.055869971	0.055869971	0.055869971	0	0	0	0	0	0	0	0	0	0	0.055869971
METHANOL	kmol/hr	0	0	0	0	0	0	0.530421192	0.530421192	0.530421192	0.530421192	0.530421192	0.530421192	0	0	0	0	0	0	0	0	0	0	0.530421192
Mole Fractions																								
H2O		0	0	0	0	0	0	4.67E-05	4.67E-05	4.67E-05	4.67E-05	4.67E-05	4.67E-05	0	0	0	0	0	0	0	0	0	0	2.84E-05
CO		0	0	0	0	0	0	0.056071725	0.056071725	0.056071725	0.056071725	0.056071725	0.056071725	0	0	0	0	0	0	0	0	0	0	0.034135445
H2		1	1	1	1	0	1	2.43E-13	2.43E-13	2.43E-13	2.43E-13	2.43E-13	2.43E-13	0	0	0	0	0	0	0	0	0	0	1.48E-13
CO2		0	0	0	0	0	0	0.943799612	0.943799612	0.943799612	0.943799612	0.943799612	0.943799612	1	1	1	1	1	1	1	1	1	1	0.965786227
O2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CH4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H6		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H2S		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NH3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SULFUR		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CARBON		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STEAM		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SO2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NO2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MEA		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WAXES		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C5		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C6		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C7		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C8		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C9		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C10		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C11		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C12		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C13		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C14		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C15		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C16		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C17		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C18		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C19		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COS		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AR		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GLYCOL		0	0	0	0	0	0	7.81E-06	7.81E-06	7.81E-06	7.81E-06	7.81E-06	7.81E-06	0	0	0	0	0	0	0	0	0	0	4.76E-06
METHANOL		0	0	0	0	0	0	7.42E-05	7.42E-05	7.42E-05	7.42E-05	7.42E-05	7.42E-05	0	0	0	0	0	0	0	0	0	0	4.51E-05

	Units	101H2-IN	102H2R	103H2	105H2	106H2	107H2	108CO2R	109CO2	110CO2	111CO2	112CO2	113CO2	114CO2IN	115CO2	116CO2	117CO2	118CO2	119CO2	120CO2	121CO2	122CO2	123CO2	124CO2
From				MIX-H2	SP-H2	SP-H2	SP-H2		COMCO211	IN-C-11	COMCO213	IN-C-12	COMCO214		COMCO221	IN-C-21	COMCO222	IN-C-22	COMCO223	IN-C-23	COMCO224	IN-C-24	COMCO225	MIXCO2
To		MIX-H2	MIX-H2	SP-H2				COMCO211	IN-C-11	COMCO213	IN-C-12	COMCO214	MIXCO2	COMCO221	IN-C-21	COMCO222	IN-C-22	COMCO22	IN-C-23	COMCO224	IN-C-24	COMCO225	MIXCO2	
Mass Flows	kg/hr	26927.35319	2.21E-07	26927.35319	23826.69366		3100.659533	308343.1336	308343.1336	308343.1336	308343.1336	308343.1336	308343.1336	202281.3014	202281.3014	202281.3014	202281.3014	202281.3	202281.3014	202281.3014	202281.3014	202281.3014	202281.3014	510624.4351
H2O	kg/hr	0	0	0	0		0	6.01626322	6.01626322	6.01626322	6.01626322	6.01626322	6.01626322	0	0	0	0	0	0	0	0	0	0	6.01626322
CO	kg/hr	0	0	0	0		0	11233.42453	11233.42453	11233.42453	11233.42453	11233.42453	11233.42453	0	0	0	0	0	0	0	0	0	0	11233.42453
H2	kg/hr	26927.35319	2.21E-07	26927.35319	23826.69366		3100.659533	3.51E-09	3.51E-09	3.51E-09	3.51E-09	3.51E-09	3.51E-09	0	0	0	0	0	0	0	0	0	0	3.51E-09
CO2	kg/hr	0	0	0	0		0	297083.2292	297083.2292	297083.2292	297083.2292	297083.2292	297083.2292	202281.3014	202281.3014	202281.3014	202281.3014	202281.3	202281.3014	202281.3014	202281.3014	202281.3014	202281.3014	499364.5307
O2	kg/hr	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N2	kg/hr	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CH4	kg/hr	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H6	kg/hr	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H4	kg/hr	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H2	kg/hr	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C3	kg/hr	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C4	kg/hr	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H2S	kg/hr	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NH3	kg/hr	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SULFUR	kg/hr	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CARBON	kg/hr	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STEAM	kg/hr	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SO2	kg/hr	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NO2	kg/hr	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MEA	kg/hr	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WAXES	kg/hr	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C5	kg/hr	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C6	kg/hr	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C7	kg/hr	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C8	kg/hr	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C9	kg/hr	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C10	kg/hr	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C11	kg/hr	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C12	kg/hr	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C13	kg/hr	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C14	kg/hr	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C15	kg/hr	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C16	kg/hr	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C17	kg/hr	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C18	kg/hr	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C19	kg/hr	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20	kg/hr	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COS	kg/hr	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AR	kg/hr	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GLYCOL	kg/hr	0	0	0	0		0	3.467761959	3.467761959	3.467761959	3.467761959	3.467761959	3.467761959	0	0	0	0	0	0	0	0	0	0	3.467761959
METHANOL	kg/hr	0	0	0	0		0	16.99584069	16.99584069	16.99584069	16.99584069	16.99584069	16.99584069	0	0	0	0	0	0	0	0	0	0	16.99584069
Mass Fractions																								
H2O		0	0	0	0	0	0	1.95E-05	1.95E-05	1.95E-05	1.95E-05	1.95E-05	1.95E-05	0	0	0	0	0	0	0	0	0	0	1.18E-05
CO		0	0	0	0	0	0	0.03643157	0.03643157	0.03643157	0.03643157	0.03643157	0.03643157	0	0	0	0	0	0	0	0	0	0	0.021999387
H2		1	1	1	1	0	1	1.14E-14	1.14E-14	1.14E-14	1.14E-14	1.14E-14	1.14E-14	0	0	0	0	0	0	0	0	0	0	6.87E-15
CO2		0	0	0	0	0	0	0.963482552	0.963482552	0.963482552	0.963482552	0.963482552	0.963482552	1	1	1	1	1	1	1	1	1	1	0.977948755
O2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CH4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H6		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H2S		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NH3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SULFUR		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CARBON		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STEAM		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SO2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NO2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MEA		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WAXES		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C5		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C6		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C7		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C8		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C9		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C10		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C11		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C12		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C13		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C14		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C15		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C16		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C17		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C18		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C19		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COS		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AR		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GLYCOL		0	0	0	0	0	0	1.12E-05	1.12E-05	1.12E-05	1.12E-05	1.12E-05	1.12E-05	0	0	0	0	0	0	0	0	0	0	6.79E-06
METHANOL		0	0	0	0	0	0	5.51E-05	5.51E-05	5.51E-05	5.51E-05	5.51E-05	5.51E-05	0	0	0	0	0	0	0	0	0	0	3.33E-05
Volume Flow	cum/sec	5.591230421	2.13E-11	5.591230421	4.947405468		0.643824953	15.26804389	9.046444291	7.386399714	4.369439239	3.587878604	2.302168606	31.08025887	18.48788562	16.47468649	9.7360669	8.16702	4.822176688	4.01209804	2.365027061	1.932254488	1.398172977	3.700389118
Vapor Phase																								
Molar Enthalpy	kJ/kmol	4399.119284	750.6138192	4399.119284	4399.119284		4399.119284	-376803.9977	-374510.7104	-377160.4367	-374939.3891	-377378.5421	-375580.2188	-393545.366	-391410.2086	-392895.633	-390632.5213	-392961	-390718.1555	-393093.5154	-390892.5152	-393370.9339	-392110.6554	-382047.226
Mass Enthalpy	kJ/kg	2182.232714	372.350447	2182.232714	2182.232714		2182.232714	-8740.37702	-8687.181736	-8748.64501	-8697.125403	-8753.704201	-8711.990143	-8942.221186	-8893.705688	-8927.457817	-8876.034912	-8928.94	-8877.980711	-8931.954142	-8881.942549	-8938.257704	-8909.621389	-8790.280754
Molar Entropy	J/kmol-K	-14816.88103	-28172.21743	-14816.88103	-14816.88103		-14816.88103	2092.526324	2940.633871	-4660.8215	-3825.217208	-10888.31098	-10196.65566	2807.108965	3660.731373	-775.8207252	79.45495273	-6674.83	-5828.205102	-12717.18522	-11887.97967	-19071.65251	-18567.96377	-13318.92471
Mass Entropy	kJ/kg-K	-7.350080873	-13.97514605	-7.350080873	-7.350080873		-7.350080873	0.048538415	0.068211189	-0.108112805	-0.088730058	-0.252566171	-0.236522477	0.063783725	0.083179914	-0.017628363	0.001805392	-0.15167	-0.132429711	-0.288962577	-0.270121193	-0.433350129	-0.421905207	-0.306446637
Molar Density	kmol/cum	0.66361944	1.4300509	0.66361944	0.66361944		0.66361944	0.13012569	0.219618304	0.268976068	0.454695589	0.553743582	0.862997065	0.041078939	0.069058414	0.07749732	0.131135505	0.156329	0.264765092	0.318223543	0.539843317	0.660753571	0.913151715	0.881936655
Mass Density	kg/cum	1.337777156	2.882811008	1.337777156	1.337777156		1.337777156	5.609812959	9.467904483	11.59575352	19.6022569	23.87228775	37.20442987	1.807875881	3.039246973	3.410641557	5.771247361	6.880019	11.65225873	14.00495447	23.75839639	29.0796325	40.18762435	38.33113663
Enthalpy Flow	MW	16.32270862	2.28E-11	16.32270862	14.44316399		1.87954463	-748.6208999	-744.0646775	-749.3290604	-744.9163612	-749.7623845	-746.1895391	-502.4567054	-499.7306559	-501.6271627	-498.7377482	-501.71	-498.8470812	-501.8798078	-499.0696939	-502.2340003	-500.6249472	-1246.814484
Average MW		2.01588	2.01588	2.01588	2.01588		2.01588	43.11072587	43.11072587	43.11072587	43.11072587	43.11072587	43.11072587	44.0098	44.0098	44.0098	44.0098	44.0098	44.0098	44.0098	44.0098	44.0098	44.0098	43.46246003

Table 29 RWGS A100 heat balance

	QC-100	QC-CO21	QC-CO22	QC-CO23	QC-CO24	QC-CO25	QC-CO26
QCALC MW	21.17644	1.896507	5.264383	4.846023	2.972491	3.032726	3.164306
TBEGIN C	109.3424	80.77901	109.3424	102.7274	101.1725	101.4775	102.0893
TEND C	43	43	43	43	43	43	43

Table 30 RWGS A200 material balance

	Units	201CO2	202H2	203SGAS	204SGAS	205SGAS	206SGAS	207SGAS	208SGAS	209SGAS	210SGAS	211SGAS	212SGAS	213H2O	214SGAS	215H2O	216H2O	217SGAS	218SGAS	219SGAS	220SGAS	221SGAS	222SGAS	223SGAS	224SGAS	225SGAS	226SGAS	227SGAS	228SGAS	229SGAS	230SGAS	231CO2	232SGAS	233SGAS
Description																																		
From				MIX	HPH1	HPH2	HPH3	RWGS	HPH2	HPH4	HPH1	C-GAS1	FL-H2O1	FL-H2O2	FL-H2O2	SP-H2O	MIXH2O	SP-H2O	COMSG1	IN-C-1	COMSG2	IN-C-2	COMSG3	IN-C-3	COMSG4	IN-C-4	COMSG5	FL-H2O1	MIXSGAS	SELEXOL	HPH4	SELEXOL	COMSG6	
To		MIX	MIX	HPH1	HPH2	HPH3	RWGS	HPH2	HPH4	HPH1	C-GAS1	FL-H2O1	FL-H2O2	MIXH2O	SP-H2O	MIXH2O		COMSG1	IN-C-1	COMSG2	IN-C-2	COMSG3	IN-C-3	COMSG4	IN-C-4	COMSG5	MIXSGAS	COMSG6	SELEXOL	HPH4			MIXSGAS	SELEXOL
Stream Class		CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN
Maximum Relative Error																																		
Cost Flow	$/sec																																	
MIXED Substream																																		
Phase		Vapor Phase	Vapor Phase	Vapor Phase	Vapor Pha	Vapor Phase	Vapor Phase	Vapor Phase					Liquid Phase	Liquid Phase	Vapor Phase	Liquid Phase	Liquid Phase	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase	
Temperature	C	88.01021769	175	119.9784142	137	578.5019497	600	600	143	137.1753293	134.2775947	43	43	65	65	65	65.00258686	65	127.074882	43	101.8153224	43	102.1050233	43	102.6836693	43	97.88675634	43	67.29115807	33	117	49.55105234	65.09354	43
Pressure	bara	24.7	25	24.7	24.7	24.7	24.7	24.51	24.51	24.51	24.51	24.51	24.21	1	1	1	1	1	2.02	2.02	4.04	4.04	8.08	8.08	16.16	16.16	30.3	24.21	30.3	30	30	3.44737865	30.3	30
Molar Vapor Fraction		1	1	1	1	1	1	1	0.999250179	0.968899985	0.955765757	0.77533	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0.967315
Molar Liquid Fraction		0	0	0	0	0	0	0	0.000749821	0.031100015	0.044234243	0.22467	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.032685
Molar Solid Fraction		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mass Vapor Fraction		1	1	1	1	1	1	1	0.999401119	0.975151125	0.96463972	0.76151	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0.969797
Mass Liquid Fraction		0	0	0	0	0	0	0	0.000598881	0.024848875	0.03536028	0.23849	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.030203
Mass Solid Fraction		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Molar Enthalpy	kJ/kmol	-382047.226	4399.119284	-188243.0399	-187631	-170654.6822	-169779.652	-163558	-180534.2297	-181905.3621	-182517.0776	-193760	-318971.5111	-283921.9315	-345284.3179	-282801.5048	-283808.5783	-380274.9152	-377805.9321	-381151.2699	-378885.2633	-381213.4445	-378966.8631	-381340.1659	-379132.7602	-381603.9796	-379687.2834	-157569.4206	-170889.631	-61742.24378	-59207.65731	-376803.9992	-156871	-328529
Mass Enthalpy	kJ/kg	-8790.280754	2182.232714	-8301.1084	-8274.13	-7525.500101	-7486.913172	-7212.53	-7961.166644	-8021.630601	-8048.605921	-8544.41	-13276.34685	-15608.41019	-9330.725461	-15693.24778	-15616.92113	-8773.095557	-8716.135123	-8793.313413	-8741.035728	-8794.747807	-8742.918269	-8797.671321	-8746.745581	-8803.757609	-8759.538655	-7069.8994	-7237.314795	-4647.849704	-4457.050403	-8740.377054	-7038.54	-8161.4
Molar Entropy	J/kmol-K	-13318.92471	-14816.88103	-8161.892664	-6638.65	21257.26532	22271.95217	32871.28	5498.772674	2181.379158	685.476675	-30391.5	-157770.9952	-153770.1652	4155.848622	-153784.6909	-153766.1314	12726.83779	13599.67427	4231.766135	5086.767229	-1661.609099	-814.7769081	-7691.904141	-6861.48322	-14018.43029	-13289.20375	6594.533845	6077.038099	8919.653441	16234.14173	2092.526324	6885.063	-7202.62
Mass Entropy	kJ/kg-K	-0.306446637	-7.350080873	-0.359921704	-0.29275	0.93739914	0.982144622	1.449552	0.242483908	0.096194074	0.03022803	-1.3402	-6.566801054	-8.453407601	0.112304789	-8.533834577	-8.461173233	0.293613277	0.313749967	0.09762855	0.11735377	-0.038333992	-0.018797232	-0.177455329	-0.158297183	-0.323410837	-0.306587287	0.295886668	0.257367504	0.671456139	1.222078211	0.048538415	0.308922	-0.17893
Molar Density	kmol/cum	0.881936655	0.66361944	0.759662685	0.726971	0.34711457	0.338568411	0.336598	0.719892736	0.751545302	0.766650422	1.20482	27.80644461	52.94482158	0.035728383	54.39912233	53.07886045	0.035683232	0.060939755	0.077464433	0.130831246	0.156193572	0.263994714	0.31764512	0.537596221	0.658101756	1.061886914	0.931730859	1.084057279	1.168177277	0.914799252	0.13012569	1.087508	1.30705
Mass Density	kg/cum	38.33113663	1.337777156	17.22676132	16.48541	7.871467119	7.677667108	7.632991	16.32490393	17.04268461	17.38522122	27.3215	668.0650752	963.0830955	1.322131976	980.304005	964.6098487	1.546710394	2.641469019	3.357740788	5.670956251	6.770300949	11.44300401	13.76851195	23.30242001	28.52580229	46.02810416	20.7658247	25.59708313	15.51811931	12.15223427	5.609812959	24.23768	52.61397
Enthalpy Flow	MW	-1246.814484	14.44316399	-1232.37132	-1228.37	-1117.225562	-1111.496999	-1070.76	-1181.904027	-1190.880425	-1194.885144	-1268.49	-467.9262514	-287.3325437	-157.0946844	-32.21364981	-319.5461935	-129.6976721	-128.8555936	-129.9965642	-129.2237134	-130.0177697	-129.2515441	-130.0609897	-129.3081254	-130.1509667	-129.4972527	-800.4083449	-926.3553843	-218.6634501	-209.687077	-748.6209028	-796.858	-42.2152
Average MW		43.46246003	2.01588	22.67685601	22.67686	22.67685601	22.67685601	22.67686	22.67685601	22.67685601	22.67685601	22.6769	24.0255482	18.19031714	37.00508812	18.02058495	18.1731454	43.34557999	43.34557999	43.34557999	43.34557999	43.34557999	43.34557999	43.34557999	43.34557999	43.34557999	43.34557999	22.28736389	23.61229764	13.28404482	13.28404482	43.11072587	22.28736	40.25398
Mole Flows	kmol/hr	11748.63168	11819.5	23568.13168	23568.13	23568.13168	23568.13168	23568.13	23568.13168	23568.13168	23568.13168	23568.1	5281.144072	3643.245	1637.899072	410.072568	4053.317568	1227.826504	1227.826504	1227.826504	1227.826504	1227.826504	1227.826504	1227.826504	1227.826504	1227.826504	1227.826504	18286.98761	19514.81412	12749.59205	12749.59205	7152.353096	18286.99	462.5912
H2O	kmol/hr	0.333953356	0	0.333953356	0.333953	0.333953356	0.333953356	4085.134	4085.133953	4085.133953	4085.133953	4085.13	4028.419681	3618.502202	409.9174791	409.9174791	4028.419681	0	0	0	0	0	0	0	0	0	0	56.71427188	56.71427188	0.034012081	0.034012081	0.333953356	56.71427	0
CO	kmol/hr	401.0447736	0	401.0447736	401.0448	401.0447736	401.0447736	4485.845	4485.844774	4485.844774	4485.844774	4485.84	51.12606899	0.153011087	50.9730579	0	0.153011087	50.9730579	50.9730579	50.9730579	50.9730579	50.9730579	50.9730579	50.9730579	50.9730579	50.9730579	50.9730579	4434.718705	4485.691762	4183.227986	4183.227986	401.0447736	4434.719	98.58149
H2	kmol/hr	1.74E-09	11819.5	11819.5	11819.5	11819.5	11819.5	7734.7	7734.699998	7734.699998	7734.699998	7734.7	0.000233338	4.73E-12	0.000233338	0	4.73E-12	0.000233338	0.000233338	0.000233338	0.000233338	0.000233338	0.000233338	0.000233338	0.000233338	0.000233338	0.000233338	7734.699765	7734.699998	7734.700667	7734.700667	1.74E-09	7734.7	0.000669
CO2	kmol/hr	11346.66667	0	11346.66667	11346.67	11346.66667	11346.66667	7261.867	7261.866667	7261.866667	7261.866667	7261.87	1201.050103	24.19695679	1176.853146	0	24.19695679	1176.853146	1176.853146	1176.853146	1176.853146	1176.853146	1176.853146	1176.853146	1176.853146	1176.853146	1176.853146	6060.816564	7237.66971	831.5673129	831.5673129	6750.388078	6060.817	350.6281
O2	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N2	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CH4	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H6	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H4	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H2	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C3	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C4	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H2S	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NH3	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SULFUR	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CARBON	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STEAM	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SO2	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NO2	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MEA	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WAXES	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C5	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C6	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C7	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C8	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C9	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C10	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C11	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C12	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C13	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C14	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C15	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C16	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C17	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C18	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C19	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COS	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AR	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GLYCOL	kmol/hr	0.055869971	0	0.055869971	0.05587	0.055869971	0.055869971	0.05587	0.055869971	0.055869971	0.055869971	0.05587	0.055863483	0.055796846	6.66E-05	0	0.055796846	6.66E-05	6.66E-05	6.66E-05	6.66E-05	6.66E-05	6.66E-05	6.66E-05	6.66E-05	6.66E-05	6.66E-05	6.49E-06	7.31E-05	0.010718524	0.010718524	0.055869971	6.49E-06	0
METHANOL	kmol/hr	0.530421192	0	0.530421192	0.530421	0.530421192	0.530421192	0.530421	0.530421192	0.530421192	0.530421192	0.53042	0.492121763	0.337032867	0.155088896	0.155088896	0.492121763	0	0	0	0	0	0	0	0	0	0	0.038299429	0.038299429	0.051354634	0.051354634	0.530421192	0.038299	13.38099

	Units	201CO2	202H2	203SGAS	204SGAS	205SGAS	206SGAS	207SGAS	208SGAS	209SGAS	210SGAS	211SGAS	212SGAS	213H2O	214SGAS	215H2O
Mole Flows	kmol/hr	11748.63168	11819.5	23568.13168	23568.13	23568.13168	23568.13168	23568.13	23568.13168	23568.13168	23568.13168	23568.1	5281.144072	3643.245	1637.899072	410.072568
H2O	kmol/hr	0.333953356	0	0.333953356	0.333953	0.333953356	0.333953356	4085.134	4085.133953	4085.133953	4085.133953	4085.13	4028.419681	3618.502202	409.9174791	409.9174791
CO	kmol/hr	401.0447736	0	401.0447736	401.0448	401.0447736	401.0447736	4485.845	4485.844774	4485.844774	4485.844774	4485.84	51.12606899	0.153011087	50.9730579	0
H2	kmol/hr	1.74E-09	11819.5	11819.5	11819.5	11819.5	11819.5	7734.7	7734.699998	7734.699998	7734.699998	7734.7	0.000233338	4.73E-12	0.000233338	0
CO2	kmol/hr	11346.66667	0	11346.66667	11346.67	11346.66667	11346.66667	7261.867	7261.866667	7261.866667	7261.866667	7261.87	1201.050103	24.19695679	1176.853146	0
O2	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N2	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CH4	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mole Fractions																
H2O		2.84E-05	0	1.42E-05	1.42E-05	1.42E-05	1.42E-05	0.173333	0.173332957	0.173332957	0.173332957	0.17333	0.762792991	0.993208583	0.250270292	0.999621801
CO		0.034135445	0	0.017016401	0.017016	0.017016401	0.017016401	0.190335	0.190335188	0.190335188	0.190335188	0.19034	0.00968087	4.20E-05	0.031121001	0
H2		1.48E-13	1	0.501503478	0.501503	0.501503478	0.501503478	0.328185	0.32818469	0.32818469	0.32818469	0.32818	4.42E-08	1.30E-15	1.42E-07	0
CO2		0.965786227	0	0.481441076	0.481441	0.481441076	0.481441076	0.308122	0.308122288	0.308122288	0.308122288	0.30812	0.227422332	0.006641595	0.718513837	0
O2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CH4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H6		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H2S		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NH3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SULFUR		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CARBON		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STEAM		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SO2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NO2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MEA		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WAXES		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C5		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C6		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C7		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C8		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C9		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C10		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C11		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C12		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C13		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C14		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C15		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C16		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C17		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C18		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C19		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COS		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AR		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GLYCOL		4.76E-06	0	2.37E-06	2.37E-06	2.37E-06	2.37E-06	2.37E-06	2.37E-06	2.37E-06	2.37E-06	2.37E-06	1.06E-05	1.53E-05	4.07E-08	0
METHANOL		4.51E-05	0	2.25E-05	2.25E-05	2.25E-05	2.25E-05	2.25E-05	2.25E-05	2.25E-05	2.25E-05	2.25E-05	9.32E-05	9.25E-05	9.47E-05	0.000378199

	Units	216H2O	217SGAS	218SGAS	219SGAS	220SGAS	221SGAS	222SGAS	223SGAS	224SGAS	225SGAS	226SGAS	227SGAS	228SGAS	229SGAS	230SGAS
Mole Flows	kmol/hr	4053.317568	1227.826504	1227.826504	1227.826504	1227.826504	1227.826504	1227.826504	1227.826504	1227.826504	1227.826504	1227.826504	18286.98761	19514.81412	12749.59205	12749.59205
H2O	kmol/hr	4028.419681	0	0	0	0	0	0	0	0	0	0	56.71427188	56.71427188	0.034012081	0.034012081
CO	kmol/hr	0.153011087	50.9730579	50.9730579	50.9730579	50.9730579	50.9730579	50.9730579	50.9730579	50.9730579	50.9730579	50.9730579	4434.718705	4485.691762	4183.227986	4183.227986
H2	kmol/hr	4.73E-12	0.000233338	0.000233338	0.000233338	0.000233338	0.000233338	0.000233338	0.000233338	0.000233338	0.000233338	0.000233338	7734.699765	7734.699998	7734.700667	7734.700667
CO2	kmol/hr	24.19695679	1176.853146	1176.853146	1176.853146	1176.853146	1176.853146	1176.853146	1176.853146	1176.853146	1176.853146	1176.853146	6060.816564	7237.66971	831.5673129	831.5673129
O2	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N2	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CH4	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mole Fractions																
H2O		0.993857405	0	0	0	0	0	0	0	0	0	0	0.003101346	0.002906216	2.67E-06	2.67E-06
CO		3.77E-05	0.04151487	0.04151487	0.04151487	0.04151487	0.04151487	0.04151487	0.04151487	0.04151487	0.04151487	0.04151487	0.242506792	0.22986085	0.328106811	0.328106811
H2		1.17E-15	1.90E-07	1.90E-07	1.90E-07	1.90E-07	1.90E-07	1.90E-07	1.90E-07	1.90E-07	1.90E-07	1.90E-07	0.42296194	0.396350175	0.6066626	0.6066626
CO2		0.005969667	0.958484886	0.958484886	0.958484886	0.958484886	0.958484886	0.958484886	0.958484886	0.958484886	0.958484886	0.958484886	0.331427827	0.370880792	0.065223053	0.065223053
O2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CH4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H6		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H2S		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NH3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SULFUR		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CARBON		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STEAM		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SO2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NO2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MEA		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WAXES		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C5		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C6		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C7		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C8		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C9		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C10		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C11		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C12		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C13		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C14		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C15		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C16		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C17		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C18		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C19		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COS		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AR		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GLYCOL		1.38E-05	5.43E-08	5.43E-08	5.43E-08	5.43E-08	5.43E-08	5.43E-08	5.43E-08	5.43E-08	5.43E-08	5.43E-08	3.55E-10	3.75E-09	8.41E-07	8.41E-07
METHANOL		0.000121412	0	0	0	0	0	0	0	0	0	0	2.09E-06	1.96E-06	4.03E-06	4.03E-06

	Units	201CO2	202H2	203SGAS	204SGAS	205SGAS	206SGAS	207SGAS	208SGAS	209SGAS	210SGAS	211SGAS	212SGAS	213H2O	214SGAS	215H2O	216H2O	217SGAS	218SGAS	219SGAS	220SGAS	221SGAS	222SGAS	223SGAS	224SGAS	225SGAS	226SGAS	227SGAS	228SGAS	229SGAS	230SGAS	231CO2	232SGAS	233SGAS
Mass Flows	kg/hr	510624.4351	23826.69366	534451.1287	534451.1	534451.1287	534451.1287	534451.1	534451.1287	534451.1287	534451.1287	534451	126882.3815	66271.78197	60610.59949	7389.747546	73661.52952	53220.85194	53220.85194	53220.85194	53220.85194	53220.85194	53220.85194	53220.85194	53220.85194	53220.85194	53220.85194	407568.7473	460789.5992	169366.1522	169366.1522	308343.1336	407568.7	18621.13
H2O	kg/hr	6.01626322	0	6.01626322	6.016263	6.01626322	6.01626322	73594.83	73594.83201	73594.83201	73594.83201	73594.8	72573.10852	65188.33036	7384.778163	7384.778163	72573.10852	0	0	0	0	0	0	0	0	0	0	1021.723488	1021.723488	0.612737164	0.612737164	6.01626322	1021.723	0
CO	kg/hr	11233.42453	0	11233.42453	11233.42	11233.42453	11233.42453	125650.3	125650.3064	125650.3064	125650.3064	125650	1432.061643	4.285901758	1427.775741	0	4.285901758	1427.775741	1427.775741	1427.775741	1427.775741	1427.775741	1427.775741	1427.775741	1427.775741	1427.775741	1427.775741	124218.2448	125646.0205	117173.8892	117173.8892	11233.42453	124218.2	2761.307
H2	kg/hr	3.51E-09	23826.69366	23826.69366	23826.69	23826.69366	23826.69366	15592.23	15592.22703	15592.22703	15592.22703	15592.2	0.000470381	9.54E-12	0.000470381	0	9.54E-12	0.000470381	0.000470381	0.000470381	0.000470381	0.000470381	0.000470381	0.000470381	0.000470381	0.000470381	0.000470381	15592.22656	15592.22703	15592.22838	15592.22838	3.51E-09	15592.23	0.001348
CO2	kg/hr	499364.5307	0	499364.5307	499364.5	499364.5307	499364.5307	319593.3	319593.2996	319593.2996	319593.2996	319593	52857.97482	1064.903229	51793.07159	0	1064.903229	51793.07159	51793.07159	51793.07159	51793.07159	51793.07159	51793.07159	51793.07159	51793.07159	51793.07159	51793.07159	266735.3248	318528.3964	36597.11113	36597.11113	297083.2292	266735.3	15431.07
O2	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N2	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CH4	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H6	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H4	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H2	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C3	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C4	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H2S	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NH3	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SULFUR	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CARBON	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STEAM	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SO2	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NO2	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MEA	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WAXES	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C5	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C6	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C7	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C8	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C9	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C10	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C11	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C12	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C13	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C14	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C15	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C16	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C17	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C18	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C19	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COS	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AR	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GLYCOL	kg/hr	3.467761959	0	3.467761959	3.467762	3.467761959	3.467761959	3.467762	3.467761959	3.467761959	3.467761959	3.46776	3.467359233	3.463223219	0.004136014	0	3.463223219	0.004136014	0.004136014	0.004136014	0.004136014	0.004136014	0.004136014	0.004136014	0.004136014	0.004136014	0.004136014	0.000402726	0.00453874	0.665282077	0.665282077	3.467761959	0.000403	0
METHANOL	kg/hr	16.99584069	0	16.99584069	16.99584	16.99584069	16.99584069	16.99584	16.99584069	16.99584069	16.99584069	16.9958	15.76864427	10.79926105	4.969383222	4.969383222	15.76864427	0	0	0	0	0	0	0	0	0	0	1.227196418	1.227196418	1.645513406	1.645513406	16.99584069	1.227196	428.7558
Mass Fractions																																		
H2O		1.18E-05	0	1.13E-05	1.13E-05	1.13E-05	1.13E-05	0.137702	0.137701706	0.137701706	0.137701706	0.1377	0.571971519	0.983651389	0.121839715	0.99932753	0.985224024	0	0	0	0	0	0	0	0	0	0	0.002506874	0.002217332	3.62E-06	3.62E-06	1.95E-05	0.002507	0
CO		0.021999387	0	0.021018619	0.021019	0.021018619	0.021018619	0.235102	0.235101583	0.235101583	0.235101583	0.2351	0.011286529	6.47E-05	0.023556536	0	5.82E-05	0.026827375	0.026827375	0.026827375	0.026827375	0.026827375	0.026827375	0.026827375	0.026827375	0.026827375	0.026827375	0.304778631	0.27267547	0.6918377	0.6918377	0.03643157	0.304779	0.148289
H2		6.87E-15	1	0.044581614	0.044582	0.044581614	0.044581614	0.029174	0.02917428	0.02917428	0.02917428	0.02917	3.71E-09	1.44E-16	7.76E-09	0	1.29E-16	8.84E-09	8.84E-09	8.84E-09	8.84E-09	8.84E-09	8.84E-09	8.84E-09	8.84E-09	8.84E-09	8.84E-09	0.038256679	0.033838062	0.092062246	0.092062246	1.14E-14	0.038257	7.24E-08
CO2		0.977948755	0	0.934350222	0.93435	0.934350222	0.934350222	0.597984	0.597984142	0.597984142	0.597984142	0.59798	0.416590343	0.016068728	0.854521685	0	0.014456708	0.973172539	0.973172539	0.973172539	0.973172539	0.973172539	0.973172539	0.973172539	0.973172539	0.973172539	0.973172539	0.654454804	0.691266463	0.216082792	0.216082792	0.963482552	0.654455	0.828686
O2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CH4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H6		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H2S		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NH3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SULFUR		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CARBON		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STEAM		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SO2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NO2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MEA		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WAXES		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C5		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C6		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C7		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C8		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C9		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C10		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C11		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C12		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C13		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C14		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C15		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C16		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C17		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C18		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C19		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COS		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AR		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GLYCOL		6.79E-06	0	6.49E-06	6.49E-06	6.49E-06	6.49E-06	6.49E-06	6.49E-06	6.49E-06	6.49E-06	6.49E-06	2.73E-05	5.23E-05	6.82E-08	0	4.70E-05	7.77E-08	7.77E-08	7.77E-08	7.77E-08	7.77E-08	7.77E-08	7.77E-08	7.77E-08	7.77E-08	7.77E-08	9.88E-10	9.85E-09	3.93E-06	3.93E-06	1.12E-05	9.88E-10	0
METHANOL		3.33E-05	0	3.18E-05	3.18E-05	3.18E-05	3.18E-05	3.18E-05	3.18E-05	3.18E-05	3.18E-05	3.18E-05	0.000124278	0.000162954	8.20E-05	0.00067247	0.000214069	0	0	0	0	0	0	0	0	0	0	3.01E-06	2.66E-06	9.72E-06	9.72E-06	5.51E-05	3.01E-06	0.023025
Volume Flow	cum/sec	3.700389118	4.947405468	8.617908154	9.005456	18.86035279	19.33642665	19.4496	9.093998194	8.710989511	8.539359088	5.43376	0.052756995	0.019114476	12.73418837	0.00209395	0.02121224	9.558072438	5.596722838	4.402832415	2.606891912	2.18359126	1.291930857	1.073723147	0.634422089	0.518252557	0.321185725	5.451916432	5.000456898	3.031691693	3.871399478	15.26804389	4.670972	0.098311
Vapor Phase																																		
Molar Enthalpy	kJ/kmol	-382047.226	4399.119284	-188243.0399	-187631	-170654.6822	-169779.652	-163558	-180461.8391	-178837.7693	-178110.5384	-157410			-345284.3179			-380274.9152	-377805.9321	-381151.2699	-378885.2633	-381213.4445	-378966.8631	-381340.1659	-379132.7602	-381603.9796	-379687.2834	-157569.4206	-170889.631	-61742.24378	-59207.65731	-376803.9977	-156871	-329289
Mass Enthalpy	kJ/kg	-8790.280754	2182.232714	-8301.1084	-8274.13	-7525.500101	-7486.913172	-7212.53	-7956.772479	-7835.801476	-7782.033569	-7067.42			-9330.725461			-8773.095557	-8716.135123	-8793.313413	-8741.035728	-8794.747807	-8742.918269	-8797.671321	-8746.745581	-8803.757609	-8759.538655	-7069.8994	-7237.314796	-4647.849704	-4457.050403	-8740.37702	-7038.54	-8159.36
Molar Entropy	J/kmol-K	-13318.92471	-14816.88103	-8161.892664	-6638.65	21257.26532	22271.95217	32871.28	5606.274402	6705.058687	7162.451104	6498.92			4155.848622			12726.83779	13599.67427	4231.766135	5086.767229	-1661.609099	-814.7769081	-7691.904141	-6861.48322	-14018.43029	-13289.20375	6594.533845	6077.038099	8919.653441	16234.14173	2092.526324	6885.063	-2562.99
Mass Entropy	kJ/kg-K	-0.306446637	-7.350080873	-0.359921704	-0.29275	0.93739914	0.982144622	1.449552	0.247187162	0.293783069	0.312942937	0.29179			0.112304789			0.293613277	0.313749967	0.09762855	0.11735377	-0.038333992	-0.018797232	-0.177455329	-0.158297183	-0.323410837	-0.306587287	0.295886668	0.257367504	0.671456139	1.222078211	0.048538415	0.308922	-0.06351
Molar Density	kmol/cum	0.881936655	0.66361944	0.759662685	0.726971	0.34711457	0.338568411	0.336598	0.719360661	0.728509032	0.733229481	0.94335			0.035728383			0.035683232	0.060939755	0.077464433	0.130831246	0.156193572	0.263994714	0.31764512	0.537596221	0.658101756	1.061886914	0.931730859	1.084057279	1.168177277	0.914799252	0.13012569	1.087508	1.266738
Mass Density	kg/cum	38.33113663	1.337777156	17.22676132	16.48541	7.871467119	7.677667108	7.632991	16.31530225	16.62687991	16.78171862	21.011			1.322131976			1.546710394	2.641469019	3.357740788	5.670956251	6.770300949	11.44300401	13.76851195	23.30242001	28.52580229	46.02810416	20.7658247	25.59708313	15.51811931	12.15223427	5.609812959	24.23768	51.12207
Enthalpy Flow	MW	-1246.814484	14.44316399	-1232.37132	-1228.37	-1117.225562	-1111.496999	-1070.76	-1180.544246	-1134.385975	-1114.458083	-798.993			-157.0946844			-129.6976721	-128.8555936	-129.9965642	-129.2237134	-130.0177697	-129.2515441	-130.0609897	-129.3081254	-130.1509667	-129.4972527	-800.4083449	-926.3553845	-218.6634501	-209.687077	-748.6208999	-796.858	-40.9299
Average MW		43.46246003	2.01588	22.67685601	22.67686	22.67685601	22.67685601	22.67686	22.68028143	22.82316235	22.88740299	22.2726			37.00508812			43.34557999	43.34557999	43.34557999	43.34557999	43.34557999	43.34557999	43.34557999	43.34557999	43.34557999	43.34557999	22.28736389	23.61229764	13.28404482	13.28404482	43.11072587	22.28736	40.35725

Table 31 RWGS A200 heat balance

	Q-21-600	Q-22-600	Q-ND-600	QC-200	QC1	QC2	QC3	QC4	QC5	QNEED-30
QCALC MW	-40.734	-5.72856	-46.4626	64.54924	0.809446	0.794056	1.140971	3.587314	0.842841	-12.64427
TBEGIN C	600	578.502	578.502	134.2776	102.105	101.8153	127.0749	127.0749	102.6837	44.89136
TEND C	600	600	600	43	43	43	43	43	43	104

Table 32 RWGS A300 material balance

	Units	301SGAS	302H2	303SGAS	304SGAS	305SGAS	306SGAS	306SGAS2	307SGAS	308SGAS	309SGAS	310SGAS	311SOLID	312SGAS	313SOLID	314SGAS	315SGAS	316SGAS	316SGAS2	317SGAS	318SGAS	319SGAS	320SGS	321SGAS	322SOLID	323SGAS	324SGAS	325SGAS	326SGAS
From				MEOH01	RECO1	COOL1	HP12	FLASH1	FLASH1	HP12	HPH1	HPH2	MEOH01	MEOH02	MEOH02	HPH3	COOL2	HP31	FLASH2	FLASH2	HP31	HPH3	HPH4	MEOH03	MEOH03	HPH5	COOL3	FLASH3	FLASH3
To		COM05	COM04	HPH1	HP12	FLASH1	COOL1	HP12	MIX01	HPH1	HPH2	MEOH02		HPH3		HP31	FLASH2	COOL2	HP31	MIX01	HPH3	HPH4	MEOH03	HPH5		COOL3	FLASH3	SPL01	MIX01
Stream Class		CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN
MIXED Substream																													
Phase		Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase			Vapor Phase	Liquid Phase	Vapor Phase	Vapor Phase	Vapor Phase		Vapor Phase		Vapor Phase		Vapor Pha	Vapor Pha	Liquid Pha	Vapor Pha	Vapor Pha	Vapor Pha	Vapor Phase		Vapor Phase		Vapor Phase	Liquid Phase
Temperature	C	117	175	300	122.498807	43	95.0657	43	43	98	270	300		300		153	43	105.2397	43	43	98	268.6728	300	300		149.3775983	43	49.5	49.5
Pressure	bara	30	25	52	52	52	52	51.5	51.5	51.5	51.5	51.5		51		51	51	51	50.5	50.5	50.5	50.5	50.5	50		50	50	39.23	39.23
Molar Vapor Fraction		1	1	1	1	0.920427091	0.979006	1	0	1	1	1		1		1	0.923839	1	1	0	1	1	1	1		1	0.927148457	1	0
Molar Liquid Fraction		0	0	0	0	0.079572909	0.020994	0	1	0	0	0		0		0	0.076161	0	0	1	0	0	0	0		0	0.072851543	0	1
Molar Solid Fraction		0	0	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	0	0	0	0		0	0	0	0
Mass Vapor Fraction		1	1	1	1	0.821737078	0.954637	1	0	1	1	1		1		1	0.830065	1	1	0	1	1	1	1		1	0.838205814	1	0
Mass Liquid Fraction		0	0	0	0	0.178262922	0.045363	0	1	0	0	0		0		0	0.169935	0	0	1	0	0	0	0		0	0.161794186	0	1
Mass Solid Fraction		0	0	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	0	0	0	0		0	0	0	0
Molar Enthalpy	kJ/kmol	-59207.65731	4399.119284	-67135.16859	-73061.48273	-78228.2611	-74619.8	-63422.99157	-249752.9302	-61730.22527	-56380.28714	-55437.36652		-68210.90159		-73127.38199	-79185.9	-74694.3	-65053.5	-250904	-63357.7	-58036.7	-57049.4	-69266.9		-74296.30599	-80127.43481	-67881.57849	-249363.5146
Mass Enthalpy	kJ/kg	-4457.050403	2182.232714	-4689.316827	-5103.263276	-5464.259372	-5212.11	-4960.942385	-7788.033039	-4828.534313	-4410.062491	-4336.307299		-4752.239012		-5094.769156	-5516.86	-5203.93	-5042.92	-7836.17	-4911.46	-4498.98	-4422.44	-4812.17		-5161.575462	-5566.680548	-5145.078665	-7875.29532
Molar Entropy	J/kmol-K	16234.14173	-14816.88103	10063.9059	-2296.191626	-16859.86462	-6416.64	-405.4674863	-206467.6053	4530.654438	16368.1537	18057.90277		10428.26189		524.0277774	-16188.3	-3375.31	-536.634	-205255	4408.382	16196.99	17968.38	10802.55		629.8986949	-15517.18578	1333.855141	-206956.2459
Mass Entropy	kJ/kg-K	1.222078211	-7.350080873	0.702952629	-0.16038643	-1.177664848	-0.4482	-0.031715641	-6.438268934	0.354387503	1.280315946	1.412488011		0.726534789		0.036508904	-1.12783	-0.23516	-0.0416	-6.41045	0.341736	1.255583	1.392901	0.750484		0.043760852	-1.078022982	0.101099441	-6.536006511
Molar Density	kmol/cum	0.914799252	0.66361944	1.075819431	1.566676561	2.101173039	1.715441	1.92893494	24.40999753	1.639167378	1.120581497	1.062357631		1.055386554		1.423848646	2.055723	1.609109	1.892995	24.50677	1.608416	1.101992	1.042174	1.034949		1.408328878	2.010680472	1.447709957	24.55636658
Mass Density	kg/cum	12.15223427	1.337777156	15.40209833	22.4295135	30.08113304	24.55932	24.66040017	782.7995051	20.95587708	14.32603432	13.58167337		15.14841072		20.43710336	29.50667	23.09623	24.41958	784.676	20.74851	14.21567	13.444	14.89717		20.27164651	28.94196408	19.10035657	777.5533012
Enthalpy Flow	MW	-209.687077	1.87954463	-469.3177052	-510.7464259	-546.867636	-521.64	-408.1491065	-138.6919354	-397.2555641	-362.8268433	-356.7588197		-390.9785604		-419.15937	-453.886	-428.141	-344.533	-109.332	-335.552	-307.371	-302.142	-328.768		-352.6399257	-380.3167907	-301.2499382	-76.93475389
Average MW		13.28404482	2.01588	14.31662032	14.31662032	14.31635209	14.31662	12.78446445	32.06880723	12.78446445	12.78446445	12.78446445		14.35342402		14.35342402	14.35342	14.35342	12.89997	32.01875	12.89997	12.89997	12.89997	14.39411		14.39411407	14.39411407	13.19349672	31.66402077
Mole Flows	kmol/hr	12749.59205	1538.117116	25166.29919	25166.29919	25166.39718	25166.3	23167.2576	1999.139577	23167.2576	23167.2576	23167.2576	0	20634.86605	0	20634.86605	20634.87	20634.87	19066.15	1568.713	19066.15	19066.15	19066.15	17087.04	0	17087.03704	17087.03704	15976.34884	1110.688204
H2O	kmol/hr	0.034012081	0	119.4307271	119.4307271	119.4396949	119.4307	2.720825801	116.7188691	2.720825801	2.720825801	2.720825801	0	105.5423645	0	105.5423645	105.5424	105.5424	2.557087	102.9853	2.557087	2.557087	2.557087	93.49088	0	93.4908777	93.4908777	4.612379278	88.87849842
CO	kmol/hr	4183.227986	0	6372.257804	6372.257804	6372.078228	6372.258	6325.945736	46.13249175	6325.945736	6325.945736	6325.945736	0	5162.571503	0	5162.571503	5162.572	5162.572	5127.509	35.06298	5127.509	5127.509	5127.509	4228.884	0	4228.884261	4228.884261	4211.323544	17.56071666
H2	kmol/hr	7734.700667	1538.117116	14756.69509	14756.69509	14756.99569	14756.7	14756.9954	0.000292159	14756.9954	14756.9954	14756.9954	0	12121.78228	0	12121.78228	12121.78	12121.78	12121.78	0.000225	12121.78	12121.78	12121.78	10051.73	0	10051.73213	10051.73213	10051.73198	0.00015167
CO2	kmol/hr	831.5673129	0	2036.220735	2036.220735	2036.215752	2036.221	1879.446732	156.7690195	1879.446732	1879.446732	1879.446732	0	1776.625195	0	1776.625195	1776.625	1776.625	1647.176	129.4497	1647.176	1647.176	1647.176	1556.242	0	1556.241714	1556.241714	1481.247947	74.99376628
O2	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N2	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CH4	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H6	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H4	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H2	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C3	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C4	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H2S	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NH3	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SULFUR	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CARBON	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STEAM	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SO2	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NO2	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MEA	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WAXES	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C5	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C6	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C7	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C8	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C9	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C10	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C11	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C12	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C13	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C14	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C15	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C16	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C17	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C18	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C19	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COS	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AR	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GLYCOL	kmol/hr	0.010718524	0	0.010718524	0.010718524	0.010719651	0.010719	1.99E-06	0.010717657	1.99E-06	1.99E-06	1.99E-06	0	1.99E-06	0	1.99E-06	1.99E-06	1.99E-06	3.95E-10	1.99E-06	3.95E-10	3.95E-10	3.95E-10	3.95E-10	0	3.95E-10	3.95E-10	1.77E-13	3.95E-10
METHANOL	kmol/hr	0.051354634	0	1881.68411	1881.68411	1881.657091	1881.684	202.1489043	1679.508187	202.1489043	202.1489043	202.1489043	0	1468.344701	0	1468.344701	1468.345	1468.345	167.13	1301.215	167.13	167.13	167.13	1156.688	0	1156.688063	1156.688063	227.4329921	929.2550705

	Units	326SGAS	327SGAS	328SGAS	329SGAS	330SGAS	331SGAS	332H2	333SGAS	334SGAS	335SGAS	336SGAS	337SGAS	338SGAS	340H2O	341H2O	342MEOH	343SGAS	344SGAS	345H2	346SGAS	347SGAS	348SGAS	349SGAS	350SGAS	351SGAS	352SGAS	S2
From		FLASH3	SPL01	SPL01	COM03	HPH5	HPH6	H2RECYC2	H2RECYC2	VALVE	MIX01	HPH7	COOL05	MEOHD01	STEAMB		MEOHD02	MIX02	COM05	COM04	MEOHD01	COM06	COOL04	KNOCK	COM07	KNOCK	MEOHD02	HPH1
To		MIX01	H2RECYC2	COM03	HPH5	HPH6	MEOH01		VALVE		HPH7	MEOHD01		MEOHD02		STEAMB			MEOH01	MEOH01	COM06	COOL04	KNOCK	COM07	COOL05	MIX02	MIX02	RECO1
Stream Class		CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN
MIXED Substream																												
Phase		Liquid Phase	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase				Liquid Phase	Liquid Phase	Liquid Phase	Liquid Phase		Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase		Vapor Phase	Vapor Phase	Liquid Phase	Liquid Phase	Vapor Phase
Temperature	C	49.5	49.5	49.5	79.9179038	272	300	49.5	49.5	47.37277139	44.89135894	104	43	122.2586389	25.00000001	25	63.00957121	76.07392129	192.9595948	297.3748585	48.93332295	110.648594	43	43	119.37269	43	92.80307138	152.9392533
Pressure	bara	39.23	39.23	39.23	52	52	52	39.23	39.23	1.23	39.23	6.76	30	6.5	1.2	1.2	1	1	52.5	52.5	6.5	13	13	13	30	13	1	52
Molar Vapor Fraction		0	1	1	1	1	1	1	1	1	6.49E-08	0.168305683	0.967315328	0	0	0	0	0.041109012	1	1	1	1	0.933665794	1	1	0	0	1
Molar Liquid Fraction		1	0	0	0	0	0	0	0	0	0.999999935	0.831694317	0.032684672	1	1	1	1	0.958890988	0	0	0	0	0.066334206	0	0	1	1	0
Molar Solid Fraction		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mass Vapor Fraction		0	1	1	1	1	1	1	1	1	3.06E-08	0.185395995	0.969797051	0	0	0	0	0.062900736	1	1	1	1	0.942510034	1	1	0	0	1
Mass Liquid Fraction		1	0	0	0	0	0	0	0	0	0.999999969	0.814604005	0.030202949	1	1	1	1	0.937099264	0	0	0	0	0.057489966	0	0	1	1	0
Mass Solid Fraction		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Molar Enthalpy	kJ/kmol	-249363.5146	-67881.57849	-67881.57849	-66955.39325	-60918.70502	-60027.2267	750.6138192	-67881.57849	-67881.57849	-250046.5753	-240317.1803	-328528.8637	-231537.4835	-285828.3776	-285828.3776	-234881.6282	-274771.7689	-56889.84991	8030.878494	-321219.1893	-318945.0915	-323574.3145	-327338.1793	-324656.1429	-270597.2447	-275170.3521	-72060.14361
Mass Enthalpy	kJ/kg	-7875.29532	-5145.078665	-5145.078665	-5074.878531	-4617.328243	-4549.758716	372.350447	-5145.078665	-5145.078665	-7824.732632	-7520.269697	-8161.40178	-7464.660189	-15865.88594	-15865.88594	-7330.39643	-13147.97388	-4282.569856	3983.807813	-8055.402444	-7998.373555	-8114.463303	-8131.82248	-8065.194615	-7829.871044	-14043.57259	-5033.320852
Molar Entropy	J/kmol-K	-206956.2459	1333.855141	1333.855141	1703.295976	15344.79505	16939.4501	-28172.21743	1333.855142	30195.97951	-206040.4785	-178463.1666	-7202.624388	-203230.049	-163237.7792	-163237.7792	-228656.9304	-154513.8844	16938.34205	-13911.88458	2937.602076	3775.705676	-9807.380454	2948.099208	3915.803747	-189343.0356	-153013.6703	141.9667528
Mass Entropy	kJ/kg-K	-6.536006511	0.101099441	0.101099441	0.129101179	1.16305748	1.283924229	-13.97514605	0.101099441	2.288701786	-6.447645419	-5.584665823	-0.178929519	-6.552041737	-9.061073668	-9.061073669	-7.136130481	-7.393570762	1.275089198	-6.901147181	0.073667974	0.094685591	-0.245945445	0.073237468	0.097277443	-5.478738532	-7.809193722	0.00991622
Molar Density	kmol/cum	24.55636658	1.447709957	1.447709957	1.743328643	1.127679472	1.072925191	1.4300509	1.447709957	0.046143013	24.46102374	1.268260508	1.307050184	21.66089639	55.35169629	55.35169629	23.28895489	0.828159538	1.328733138	1.086307402	0.248575535	0.418794265	0.553311302	0.517418962	0.967819154	23.41321508	46.07590397	1.451825962
Mass Density	kg/cum	777.5533012	19.10035657	19.10035657	23.00060073	14.87803541	14.15563499	2.882811008	19.10035657	0.608787686	781.6746594	40.52843866	52.61396549	671.8737778	997.1763071	997.1763071	746.2280787	17.30721883	17.65095055	2.189865365	9.912258565	16.69994209	22.0639762	20.82817	38.95856807	809.1514479	902.8132006	20.78524107
Enthalpy Flow	MW	-76.93475389	-32.80611827	-268.44382	-264.781137	-240.9085093	-237.3830779	2.28E-11	-32.80611827	-32.80611827	-324.9591872	-312.3149177	-42.21515674	-269.0390776	-61.05795226	-61.05795226	-250.4665074	-28.78097377	-201.4784384	3.43123102	-44.20841127	-43.89543416	-44.53253992	-42.0621567	-41.71752157	-2.47038322	-26.31059055	-503.7464259
Average MW		31.66402077	13.19349672	13.19349672	13.19349672	13.19349672	13.19349672	2.01588	13.19349672	13.19349672	31.95592578	31.95592578	40.25397506	31.01781966	18.01528	18.01528	32.04214539	20.89841152	13.28404482	2.01588	39.8762435	39.8762435	39.8762435	40.25397506	40.25397506	34.55960427	19.59404207	14.31662032
Mole Flows	kmol/hr	1110.688204	1739.824389	14236.52445	14236.52445	14236.52445	14236.52445	1.09E-07	1739.824388	1739.824388	4678.540678	4678.540678	462.591209	4183.083726	769.0231108	769.0231108	3838.867406	377.0820634	12749.59205	1538.117116	495.4569523	495.4569523	495.4569523	462.591209	462.591209	32.86574333	344.21632	25166.29919
H2O	kmol/hr	88.87849842	0.502288103	4.110091174	4.110091174	4.110091174	4.110091174	0	0.502288103	0.502288103	308.582645	308.582645	0	308.582645	769.0231108	769.0231108	3.08582645	305.4968186	0.034012081	0	0	0	0	0	0	0	305.4968186	119.4307271
CO	kmol/hr	17.56071666	458.6131339	3752.71041	3752.71041	3752.71041	3752.71041	0	458.6131339	458.6131339	98.75619176	98.75619176	98.58148702	4.19E-05	0	0	4.19E-05	0.174662804	4183.227986	0	98.75614982	98.75614982	98.75614982	98.58148702	98.58148702	0.174662804	6.63E-26	6372.257804
H2	kmol/hr	0.00015167	1094.633612	8957.098364	8957.098364	8957.098364	8957.098364	1.09E-07	1094.633612	1094.633612	0.00066855	0.00066855	0.00066855	3.14E-25	0	0	0	3.07E-12	7734.700667	1538.117116	0.00066855	0.00066855	0.00066855	0.00066855	0.00066855	3.07E-12	0	14756.69509
CO2	kmol/hr	74.99376628	161.3079015	1319.940046	1319.940046	1319.940046	1319.940046	0	161.3079015	161.3079015	361.212479	361.212479	350.6280626	3.61212479	0	0	3.61212479	6.972291583	831.5673129	0	357.6003542	357.6003542	357.6003542	350.6280626	350.6280626	6.972291583	1.02E-14	2036.220735
O2	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N2	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CH4	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H6	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H4	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H2	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C3	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C4	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H2S	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NH3	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SULFUR	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CARBON	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STEAM	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SO2	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NO2	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MEA	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WAXES	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C5	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C6	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C7	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C8	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C9	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C10	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C11	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C12	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C13	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C14	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C15	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C16	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C17	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C18	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C19	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COS	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AR	kmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GLYCOL	kmol/hr	3.95E-10	1.93E-14	1.58E-13	1.58E-13	1.58E-13	1.58E-13	0	0	0	0.010719651	0.010719651	0	0.010719651	0	0	1.14E-07	0.010719537	0.010718524	0	0	0	0	0	0	0	0.010719537	0.010718524
METHANOL	kmol/hr	929.2550705	24.76745284	202.6655393	202.6655393	202.6655393	202.6655393	0	24.76745284	24.76745284	3909.977974	3909.977974	13.3809908	3870.878194	0	0	3832.169412	64.42757088	0.051354634	0	39.09977974	39.09977974	39.09977974	13.3809908	13.3809908	25.71878894	38.70878194	1881.68411

	Units	301SGAS	302H2	303SGAS	304SGAS	305SGAS	306SGAS	306SGAS2	307SGAS	308SGAS	309SGAS	310SGAS	311SOLID	312SGAS	313SOLID	314SGAS	315SGAS	316SGAS	316SGAS2	317SGAS	318SGAS	319SGAS	320SGS	321SGAS	322SOLID	323SGAS	324SGAS	325SGAS	326SGAS
Mole Fractions																													
H2O		2.67E-06	0	0.004745661	0.004745661	0.004745999	0.004746	0.000117443	0.058384552	0.000117443	0.000117443	0.000117443	0	0.005114759	0	0.005114759	0.005115	0.005115	0.000134	0.06565	0.000134	0.000134	0.000134	0.005471	0	0.005471451	0.005471451	0.0002887	0.080021106
CO		0.328106811	0	0.253205994	0.253205994	0.253197873	0.253206	0.273055441	0.023076174	0.273055441	0.273055441	0.273055441	0	0.250186819	0	0.250186819	0.250187	0.250187	0.268933	0.022351	0.268933	0.268933	0.268933	0.247491	0	0.247490788	0.247490788	0.26359737	0.015810663
H2		0.6066626	1	0.586367307	0.586367307	0.586376969	0.586367	0.636976359	1.46E-07	0.636976359	0.636976359	0.636976359	0	0.587441772	0	0.587441772	0.587442	0.587442	0.635775	1.43E-07	0.635775	0.635775	0.635775	0.588267	0	0.588266538	0.588266538	0.629163276	1.37E-07
CO2		0.065223053	0	0.080910615	0.080910615	0.080910102	0.080911	0.081125128	0.078418246	0.081125128	0.081125128	0.081125128	0	0.086098218	0	0.086098218	0.086098	0.086098	0.086393	0.08252	0.086393	0.086393	0.086393	0.091077	0	0.09107733	0.09107733	0.092715048	0.067520089
O2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CH4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H6		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H2S		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NH3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SULFUR		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CARBON		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STEAM		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SO2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NO2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MEA		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WAXES		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C5		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C6		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C7		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C8		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C9		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C10		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C11		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C12		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C13		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C14		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C15		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C16		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C17		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C18		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C19		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COS		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AR		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GLYCOL		8.41E-07	0	4.26E-07	4.26E-07	4.26E-07	4.26E-07	8.61E-11	5.36E-06	8.61E-11	8.61E-11	8.61E-11	0	9.66E-11	0	9.66E-11	9.66E-11	9.66E-11	2.07E-14	1.27E-09	2.07E-14	2.07E-14	2.07E-14	2.31E-14	0	2.31E-14	2.31E-14	1.11E-17	3.56E-13
METHANOL		4.03E-06	0	0.074769997	0.074769997	0.074768632	0.07477	0.008725629	0.840115521	0.008725629	0.008725629	0.008725629	0	0.071158431	0	0.071158431	0.071158	0.071158	0.008766	0.829479	0.008766	0.008766	0.008766	0.067694	0	0.067693893	0.067693893	0.014235605	0.836648006
Mass Flows	kg/hr	169366.1522	3100.659533	360296.3504	360296.3504	360291.0029	360296.4	296180.9812	64110.02172	296180.9812	296180.9812	296180.9812		296180.982		296180.982	296181	296181	245952.8	50228.22	245952.8	245952.8	245952.8	245952.8		245952.7603	245952.7603	210783.906	35168.85434
H2O	kg/hr	0.612737164	0	2151.57799	2151.57799	2151.739546	2151.578	49.01643864	2102.723107	49.01643864	49.01643864	49.01643864		1901.375248		1901.375248	1901.375	1901.375	46.06664	1855.309	46.06664	46.06664	46.06664	1684.264		1684.264339	1684.264339	83.09330415	1601.171035
CO	kg/hr	117173.8892	0	178489.49	178489.49	178484.46	178489.5	177192.2704	1292.189547	177192.2704	177192.2704	177192.2704		144605.6928		144605.6928	144605.7	144605.7	143623.6	982.1282	143623.6	143623.6	143623.6	118452.7		118452.7397	118452.7397	117960.857	491.8826978
H2	kg/hr	15592.22838	3100.659533	29747.7265	29747.7265	29748.33248	29747.73	29748.33189	0.000588958	29748.33189	29748.33189	29748.33189		24436.05847		24436.05847	24436.06	24436.06	24436.06	0.000453	24436.06	24436.06	24436.06	20263.09		20263.08576	20263.08576	20263.08546	0.000305749
CO2	kg/hr	36597.11113	0	89613.6673	89613.6673	89613.448	89613.67	82714.0748	6899.373196	82714.0748	82714.0748	82714.0748		78188.91952		78188.91952	78188.92	78188.92	72491.86	5697.055	72491.86	72491.86	72491.86	68489.89		68489.88657	68489.88657	65189.42591	3300.460655
O2	kg/hr	0	0	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	0	0	0	0		0	0	0	0
N2	kg/hr	0	0	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	0	0	0	0		0	0	0	0
CH4	kg/hr	0	0	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	0	0	0	0		0	0	0	0
C2H6	kg/hr	0	0	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	0	0	0	0		0	0	0	0
C2H4	kg/hr	0	0	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	0	0	0	0		0	0	0	0
C2H2	kg/hr	0	0	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	0	0	0	0		0	0	0	0
C3	kg/hr	0	0	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	0	0	0	0		0	0	0	0
C4	kg/hr	0	0	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	0	0	0	0		0	0	0	0
H2S	kg/hr	0	0	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	0	0	0	0		0	0	0	0
NH3	kg/hr	0	0	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	0	0	0	0		0	0	0	0
SULFUR	kg/hr	0	0	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	0	0	0	0		0	0	0	0
CARBON	kg/hr	0	0	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	0	0	0	0		0	0	0	0
STEAM	kg/hr	0	0	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	0	0	0	0		0	0	0	0
SO2	kg/hr	0	0	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	0	0	0	0		0	0	0	0
NO2	kg/hr	0	0	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	0	0	0	0		0	0	0	0
MEA	kg/hr	0	0	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	0	0	0	0		0	0	0	0
WAXES	kg/hr	0	0	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	0	0	0	0		0	0	0	0
C5	kg/hr	0	0	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	0	0	0	0		0	0	0	0
C6	kg/hr	0	0	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	0	0	0	0		0	0	0	0
C7	kg/hr	0	0	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	0	0	0	0		0	0	0	0
C8	kg/hr	0	0	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	0	0	0	0		0	0	0	0
C9	kg/hr	0	0	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	0	0	0	0		0	0	0	0
C10	kg/hr	0	0	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	0	0	0	0		0	0	0	0
C11	kg/hr	0	0	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	0	0	0	0		0	0	0	0
C12	kg/hr	0	0	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	0	0	0	0		0	0	0	0
C13	kg/hr	0	0	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	0	0	0	0		0	0	0	0
C14	kg/hr	0	0	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	0	0	0	0		0	0	0	0
C15	kg/hr	0	0	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	0	0	0	0		0	0	0	0
C16	kg/hr	0	0	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	0	0	0	0		0	0	0	0
C17	kg/hr	0	0	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	0	0	0	0		0	0	0	0
C18	kg/hr	0	0	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	0	0	0	0		0	0	0	0
C19	kg/hr	0	0	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	0	0	0	0		0	0	0	0
C20	kg/hr	0	0	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	0	0	0	0		0	0	0	0
COS	kg/hr	0	0	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	0	0	0	0		0	0	0	0
AR	kg/hr	0	0	0	0	0	0	0	0	0	0	0		0		0	0	0	0	0	0	0	0	0		0	0	0	0
GLYCOL	kg/hr	0.665282077	0	0.665282077	0.665282077	0.665352002	0.665282	0.000123779	0.665228222	0.000123779	0.000123779	0.000123779		0.000123779		0.000123779	0.000124	0.000124	2.45E-08	0.000124	2.45E-08	2.45E-08	2.45E-08	2.45E-08		2.45E-08	2.45E-08	1.10E-11	2.45E-08
METHANOL	kg/hr	1.645513406	0	60293.22331	60293.22331	60292.35759	60293.22	6477.287535	53815.07005	6477.287535	6477.287535	6477.287535		47048.93584		47048.93584	47048.94	47048.94	5355.206	41693.73	5355.206	5355.206	5355.206	37062.78		37062.78397	37062.78397	7287.444322	29775.33965
Mass Fractions																													
H2O		3.62E-06	0	0.00597169	0.00597169	0.005972227	0.005972	0.000165495	0.032798665	0.000165495	0.000165495	0.000165495	0	0.00641964	0	0.00641964	0.00642	0.00642	0.000187	0.036938	0.000187	0.000187	0.000187	0.006848	0	0.006847918	0.006847918	0.000394211	0.045528098
CO		0.6918377	0	0.495396331	0.495396331	0.495389723	0.495396	0.598256747	0.020155812	0.598256747	0.598256747	0.598256747	0	0.488234227	0	0.488234227	0.488234	0.488234	0.583948	0.019553	0.583948	0.583948	0.583948	0.481608	0	0.481607686	0.481607686	0.559629334	0.013986316
H2		0.092062246	1	0.082564607	0.082564607	0.082567514	0.082565	0.10043971	9.19E-09	0.10043971	0.10043971	0.10043971	0	0.082503807	0	0.082503807	0.082504	0.082504	0.099353	9.02E-09	0.099353	0.099353	0.099353	0.082386	0	0.082386088	0.082386088	0.096132033	8.69E-09
CO2		0.216082792	0	0.248722107	0.248722107	0.24872519	0.248722	0.279268691	0.107617702	0.279268691	0.279268691	0.279268691	0	0.263990345	0	0.263990345	0.26399	0.26399	0.294739	0.113423	0.294739	0.294739	0.294739	0.278468	0	0.278467648	0.278467648	0.309271363	0.093846124
O2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CH4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H6		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H2S		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NH3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SULFUR		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CARBON		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STEAM		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SO2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NO2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MEA		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WAXES		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C5		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C6		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C7		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C8		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C9		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C10		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C11		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C12		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C13		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C14		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C15		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C16		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C17		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C18		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C19		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COS		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AR		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GLYCOL		3.93E-06	0	1.85E-06	1.85E-06	1.85E-06	1.85E-06	4.18E-10	1.04E-05	4.18E-10	4.18E-10	4.18E-10	0	4.18E-10	0	4.18E-10	4.18E-10	4.18E-10	9.98E-14	2.46E-09	9.98E-14	9.98E-14	9.98E-14	9.98E-14	0	9.98E-14	9.98E-14	5.22E-17	6.97E-13
METHANOL		9.72E-06	0	0.16734342	0.16734342	0.1673435	0.167343	0.021869357	0.839417436	0.021869357	0.021869357	0.021869357	0	0.158851981	0	0.158851981	0.158852	0.158852	0.021773	0.830086	0.021773	0.021773	0.021773	0.150691	0	0.150690661	0.150690661	0.034573059	0.846639454
Volume Flow	cum/sec	3.871399478	0.643824953	6.497966537	4.462081603	3.327030069	4.075126	3.336218967	0.022749554	3.925986704	5.742865957	6.057611059		5.431097463		4.025643633	2.788268	3.562162	2.797764	0.017781	3.292777	4.80598	5.081835	4.586119		3.370234932	2.360593463	3.065444604	0.012563931

	Units	327SGAS	328SGAS	329SGAS	330SGAS	331SGAS	332H2	333SGAS	334SGAS	335SGAS	336SGAS	337SGAS	338SGAS	340H2O	341H2O	342MEOH	343SGAS	344SGAS	345H2	346SGAS	347SGAS	348SGAS	349SGAS	350SGAS	351SGAS	352SGAS	S2
Mole Fractions																											
H2O		0.0002887	0.0002887	0.0002887	0.0002887	0.0002887	0	0.0002887	0.0002887	0.065957029	0.065957029	0	0.073769177	1	1	0.000803838	0.810160037	2.67E-06	0	0	0	0	0	0	0	0.887514045	0.004745661
CO		0.26359737	0.26359737	0.26359737	0.26359737	0.26359737	0	0.263597371	0.263597371	0.021108332	0.021108332	0.213107135	1.00E-08	0	0	1.09E-08	0.000463196	0.328106811	0	0.199323371	0.199323371	0.199323371	0.213107135	0.213107135	0.005314433	1.93E-28	0.253205994
H2		0.629163276	0.629163276	0.629163276	0.629163276	0.629163276	1	0.629163276	0.629163276	1.43E-07	1.43E-07	1.45E-06	7.50E-29	0	0	0	8.14E-15	0.6066626	1	1.35E-06	1.35E-06	1.35E-06	1.45E-06	1.45E-06	9.34E-14	0	0.586367307
CO2		0.092715048	0.092715048	0.092715048	0.092715048	0.092715048	0	0.092715048	0.092715048	0.077206228	0.077206228	0.757965253	0.000863508	0	0	0.000940935	0.018490117	0.065223053	0	0.721758677	0.721758677	0.721758677	0.757965253	0.757965253	0.212144649	2.96E-17	0.080910615
O2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CH4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H6		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H2S		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NH3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SULFUR		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CARBON		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STEAM		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SO2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NO2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MEA		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WAXES		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C5		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C6		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C7		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C8		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C9		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C10		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C11		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C12		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C13		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C14		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C15		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C16		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C17		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C18		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C19		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COS		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AR		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GLYCOL		1.11E-17	1.11E-17	1.11E-17	1.11E-17	1.11E-17	0	0	0	2.29E-06	2.29E-06	0	2.56E-06	0	0	2.96E-11	2.84E-05	8.41E-07	0	0	0	0	0	0	0	3.11E-05	4.26E-07
METHANOL		0.014235605	0.014235605	0.014235605	0.014235605	0.014235605	0	0.014235605	0.014235605	0.835725976	0.835725976	0.028926168	0.925364742	0	0	0.998255216	0.170858222	4.03E-06	0	0.078916603	0.078916603	0.078916603	0.028926168	0.028926168	0.782540918	0.112454813	0.074769997
Mass Flows	kg/hr	22954.36736	187829.5386	187829.5386	187829.5386	187829.5386	2.21E-07	22954.36736	22954.36736	149507.0987	149507.0987	18621.13499	129750.1366	13854.16667	13854.16667	123005.5476	7880.416138	169366.1522	3100.659533	19756.96207	19756.96207	19756.96207	18621.13499	18621.13499	1135.827083	6744.589055	360296.3504
H2O	kg/hr	9.048860822	74.04444333	74.04444333	74.04444333	74.04444333	0	9.048860822	9.048860822	5559.202753	5559.202753	0	5559.202753	13854.16667	13854.16667	55.59202753	5503.610725	0.612737164	0	0	0	0	0	0	0	5503.610725	2151.57799
CO	kg/hr	12845.93733	105114.9197	105114.9197	105114.9197	105114.9197	0	12845.93733	12845.93733	2766.200434	2766.200434	2761.306884	0.001174543	0	0	0.001174543	4.892375004	117173.8892	0	2766.199259	2766.199259	2766.199259	2761.306884	2761.306884	4.892375004	1.86E-24	178489.49
H2	kg/hr	2206.650006	18056.43545	18056.43545	18056.43545	18056.43545	2.21E-07	2206.650006	2206.650006	0.001347717	0.001347717	0.001347717	6.32E-25	0	0	0	6.19E-12	15592.22838	3100.659533	0.001347717	0.001347717	0.001347717	0.001347717	0.001347717	6.19E-12	0	29747.7265
CO2	kg/hr	7099.128482	58090.29743	58090.29743	58090.29743	58090.29743	0	7099.128482	7099.128482	15896.88896	15896.88896	15431.07091	158.9688896	0	0	158.9688896	306.8491581	36597.11113	0	15737.92007	15737.92007	15737.92007	15431.07091	15431.07091	306.8491581	4.48E-13	89613.6673
O2	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N2	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CH4	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H6	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H4	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H2	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C3	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C4	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H2S	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NH3	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SULFUR	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CARBON	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STEAM	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SO2	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NO2	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MEA	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WAXES	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C5	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C6	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C7	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C8	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C9	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C10	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C11	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C12	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C13	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C14	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C15	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C16	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C17	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C18	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C19	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COS	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AR	kg/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GLYCOL	kg/hr	1.20E-12	9.81E-12	9.81E-12	9.81E-12	9.81E-12	0	0	0	0.665352002	0.665352002	0	0.665352002	0	0	7.05E-06	0.665344953	0.665282077	0	0	0	0	0	0	0	0.665344953	0.665282077
METHANOL	kg/hr	793.6026867	6493.841635	6493.841635	6493.841635	6493.841635	0	793.6026867	793.6026867	125284.1398	125284.1398	428.7558482	124031.2984	0	0	122790.9855	2064.398535	1.645513406	0	1252.841398	1252.841398	1252.841398	428.7558482	428.7558482	824.0855502	1240.312984	60293.22331
Mass Fractions																											
H2O		0.000394211	0.000394211	0.000394211	0.000394211	0.000394211	0	0.000394211	0.000394211	0.037183537	0.037183537	0	0.042845448	1	1	0.000451947	0.698390875	3.62E-06	0	0	0	0	0	0	0	0.816003863	0.00597169
CO		0.559629334	0.559629334	0.559629334	0.559629334	0.559629334	0	0.559629334	0.559629334	0.018502134	0.018502134	0.14828886	9.05E-09	0	0	9.55E-09	0.000620827	0.6918377	0	0.140011367	0.140011367	0.140011367	0.14828886	0.14828886	0.004307324	2.75E-28	0.495396331
H2		0.096132033	0.096132033	0.096132033	0.096132033	0.096132033	1	0.096132033	0.096132033	9.01E-09	9.01E-09	7.24E-08	4.87E-30	0	0	0	7.85E-16	0.092062246	1	6.82E-08	6.82E-08	6.82E-08	7.24E-08	7.24E-08	5.45E-15	0	0.082564607
CO2		0.309271363	0.309271363	0.309271363	0.309271363	0.309271363	0	0.309271363	0.309271363	0.106328657	0.106328657	0.828685841	0.001225192	0	0	0.001292372	0.038938192	0.216082792	0	0.796575911	0.796575911	0.796575911	0.828685841	0.828685841	0.270154817	6.65E-17	0.248722107
O2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CH4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H6		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2H2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H2S		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NH3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SULFUR		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CARBON		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STEAM		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SO2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NO2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MEA		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WAXES		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C5		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C6		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C7		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C8		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C9		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C10		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C11		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C12		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C13		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C14		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C15		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C16		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C17		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C18		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C19		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C20		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COS		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AR		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GLYCOL		5.22E-17	5.22E-17	5.22E-17	5.22E-17	5.22E-17	0	0	0	4.45E-06	4.45E-06	0	5.13E-06	0	0	5.73E-11	8.44E-05	3.93E-06	0	0	0	0	0	0	0	9.86E-05	1.85E-06
METHANOL		0.034573059	0.034573059	0.034573059	0.034573059	0.034573059	0	0.034573059	0.034573059	0.837981213	0.837981213	0.023025226	0.955924222	0	0	0.998255671	0.261965675	9.72E-06	0	0.063412654	0.063412654	0.063412654	0.023025226	0.023025226	0.725537859	0.183897488	0.16734342
Volume Flow	cum/sec	0.333826917	2.731617687	2.268413441	3.506838799	3.685802288	2.13E-11	0.333826917	10.47362374	0.0531292	1.024706379	0.098311113	0.053643565	0.003859277	0.003859277	0.045787888	0.126479275	2.665360897	0.393309255	0.553662416	0.32862659	0.248733273	0.248343349	0.132770216	0.000389924	0.002075177	4.815066575

Table 33 RWGS A300 heat balance

	Q-300	Q300-01	Q300-1	Q300-02	Q300-2	Q300-03	Q300-3	Q300-04	QC-300	QC-301	QC-302	QC-304	QC-305	QC-306	QC-307	QC303	QC308	QC309	QC310	QC320	S1
QCALC MW	79.90998	28.99093	33.88672	27.81869	34.21974	23.10036	26.62579	-12.6443	167.0337	25.23175	25.74549	-0.02659	-0.02018	-2.1321	8.064697	27.67687	81.35899	90.55843	0.637106	0.497635	-73.621
TBEGIN C	300	300		300		300		44.89136		95.0657	105.2397	42.99105	43	43		149.3776			110.6486	119.3727	
TEND C	268.6728	268.6728		270		272		104		43	43	43	43	49.5		43			43	43	