Letter of Findings - Reviewing Net GHG Impacts of KMMEF

Kevin Tempest, R&D Scientist, *Low Carbon Prosperity Institute*

This **Low Carbon Prosperity Institute (LCPI)** *Letter of Findings* reviews the latest Draft Second Supplemental Environmental Impact Statement (DSSEIS) published by the Department of Ecology to explore scenarios and sensitivities regarding the life-cycle GHG impacts of methanol produced from the proposed facility in Kalama, WA. *Time for research and writing was commissioned under contract between LCPI and Northwest Innovation Works (NWIW). The content of this letter is solely the work of the author.*

A. Key Findings

- The Ecology-led DSSEIS sensitivity analysis indicates a high likelihood of between 2 and 9 MtCO2e/year more emissions in the absence of KMMEF, including "extremely limited" potential for emissions to be higher with KMMEF methanol. These results are similar to the December 2018 analysis from LCPI (likely range of 2.3 to 7.2 MtCO_2e/year) despite using a distinct and independent methodology. Consistent results across different methodologies lend increased confidence to the forecast and likelihood of net avoided emissions.

- Inclusion of in-state emissions mitigation would increase the high-end range of net avoided emissions. This likelihood would be more certain if Ecology made it a formal permitting condition. In addition, the most accurate projections of the power grid under the Clean Energy Transformation Act would increase confidence in and the likeliest range of net avoided emissions.

- Under much faster emissions intensity decline of global methanol substitutes than Ecology's analysis considers, the general findings remain consistent: It is very likely that net cumulative GHG benefits will accrue with KMMEF methanol compared to without it. This finding, based on new analysis for this letter, holds even with conservative assumptions that in-state emissions mitigation is ineffective and KMMEF methanol emissions intensity does not improve while competing methanol does rapidly. The additional stress and boundary testing indicate net global benefits through at least 2049, and very likely through end of facility life, even against a benchmark of a deeply decarbonized global industry. Nonetheless, it would likely be inconsistent to assume a major movement across the global industry while KMMEF emissions intensity remained static. This is not a given, and efforts should be made to ensure that KMMEF methanol remains well ahead of the curve;

- A preliminary analysis finds it highly unlikely that substituting KMMEF methanol for gasoline end-use would be prevalent enough to lead to a net emissions increase. The combination of conditions required for there to be a net emissions increase represent an extreme outlier scenario. Even so, methanol availability as a fuel should not be used as a justification to stop pushing forward on primary solutions to meeting the global climate challenge, such as electrification of transport and building end-uses. If fuel-use impacts are a concern, mitigation strategies that include accelerating electrification of transport and buildings should be considered under the proposed voluntary mitigation plan.

B. Project Background and Status

The Kalama Manufacturing and Marine Export Facility (KMMEF) would produce and export up to 3.6 million tonnes of methanol (Mt-MeOH) annually from the Port of Kalama in Cowlitz County. Through methane gas consumption, on-site and purchased power, transport, and end-of-life methanol use, the project would generate greenhouse gas (GHG) emissions. These GHG emissions would occur within Washington state as well as globally, both upstream and downstream of Washington state. The predominant pathway for methanol from KMMEF is end-use in China where methanol is an intermediary for other higher value chemicals, most notably olefins that are used in plastics manufacturing, and as a fuel.

The Draft Second Supplemental Environmental Impact Statement (DSSEIS) analysis was completed under Department of Ecology (DOE) guidance and the draft was authored and released by DOE on September 2, 2020.[1] The DSSEIS followed a determination in the Fall of 2019 that the 1st SEIS lacked sufficient sensitivity and detail in order to receive Ecology approval for a Shoreline Conditional Use Permit (CUP). The DSSEIS was undertaken in order to conduct a wider sensitivity analysis covering emissions impacts from a range of possible assumptions, as well as a more detailed proposal for the voluntary mitigation of all in-state emissions related to KMMEF, a probable but not yet definite requirement for the CUP.[2] The DSSEIS is primarily focused on sensitivity analysis of the GHG impacts of the facility and the likeliest substitution for other competitive alternatives, most notably other methanol sources, but also olefins from crude oil naphtha.

The ***net emissions impact*** or ***net avoided emissions*** from KMMEF methanol's entry into global markets is the full life-cycle emissions of KMMEF methanol production and end-use, less those from what would have been produced and used from other manufacturers. Substitution of other methanol is the predominant mechanism determining the net emissions impact of KMMEF methanol, although secondary impacts could include substituting for naphtha-derived olefins or through induced additional demand from a marginal increase in lower cost supply.

Net impacts analysis and life-cycle analysis are both commonly accepted best practices to determine a best estimate of the full GHG implications of a project. An example of life-cycle analysis is the treatment of fuels under a Low Carbon Fuel Standard (LCFS) including upstream emissions and transport, through to combustion. Net impacts are commonly used, such as in Sound Transit's estimated GHG benefits due to displacement of cars from roads or in electric vehicles displacing gasoline consuming vehicles.

C. Overview of Findings

The Low Carbon Prosperity Institute reviewed the First DSEIS in December 2018 based on my research and writing. That LCPI analysis determined that the *net emissions impact* would fall very likely within a range of 2.3 to 7.2 million metric tons of avoided carbon dioxide equivalents ($MtCO_2e$).[3] Expanding to technically possible though highly unlikely scenarios presented a boundary of net impacts from a 1.7 $MtCO_2e$ *increase* to a 13.6 $MtCO_2e$ decrease in net emissions impact each year. That analysis determined that these emissions savings are extremely likely through the 2030s, but decrease in certainty later in the projection.

To conduct a sensitivity analysis, an *Emissions Sensitivity Model* (ESM) was developed for Ecology's DSSEIS. Based on the full range of sensitivity explored, the DSSEIS use of the ESM "demonstrates that the potential for global GHG emissions from the project to exceed any other case is extremely limited" (DSSEIS p. 86), while "All ESM results using plausible input values demonstrate that the KMMEF is expected to result in less GHG emissions increases than the alternate cases." (DSSEIS p. 105).

The DSSEIS determined that, given dynamic market conditions and ample spare global capacity, KMMEF methanol would not influence the total global volumes of methanol or allocation to various end-uses, most

[1] In consultation with TRC Environmental, Keramida, Greene Economics, Cowlitz County, the Port of Kalama, and other relevant agencies.

[2] The DSSEIS almost exclusively considers methanol substitution with the exception of a higher oil price scenario in which methanol-to-olefin (MTO) substitutes for some naphtha-to-olefin production. See page 53 of the DSSEIS for more information.

[3] Kevin Tempest. *Kalama Methanol Plant – Review of Greenhouse Gas Impact Assessments*. December 2018.

notably the ratio of used for olefins versus fuels. Within the DSSEIS, 47 separate scenarios evaluated with the ESM are presented. Of these, 39 scenarios fall within the likeliest range of impacts. Eight additional scenarios were also presented, consisting of two "outlier scenarios" and six scenarios developed "to explore the boundaries of results that can be produced, even if under somewhat unrealistic combinations of input assumptions."

The 39 most likely scenarios each assume an end-use mix of 60% olefins and 40% fuel while covering a range of sensitivities including different combinations of methanol substitution (from 20% coal and 80% natural gas pathways to 80% coal and 20% natural gas pathways), global warming potentials, methane leakage rates, emission rate intensities for key life-cycle steps (referred to as "input values"), demand growth based on pace of COVID-19 related recession recovery, and oil prices.

Across the 39 most likely scenarios, the *net emissions impact* ranges from 2.2 to 8.8 MtCO_2e/year greater in the absence of KMMEF than with it. This is the average, over 40-years with no discounting for impacts further out in time with KMMEF methanol emission intensity assumed unchanged over time, and includes modest decreases in the GHG intensity of the alternative methanol production over time. The *net emissions impact* includes a range of 4.2 to 5.8 MtCO_2e/year from the life-cycle of KMMEF methanol versus avoided emissions of 6.5 to 14.5 MtCO_2e/year.

The additional eight scenarios, testing less likely boundary conditions, such as outlier scenarios with 100% olefin or 100% fuel end-use, expand the range of *net avoided emissions* to 0.25 to 9.5 MtCO_2e per year with KMMEF methanol in the global market. This includes annual life-cycle emissions from KMMEF of 2.8 to 9.4 MtCO_2e and avoided emissions of 6.5 to 14.5 MtCO_2e.

High confidence in net avoided GHG emissions with KMMEF methanol is due, in large part, to the lack of lower-carbon production pathways which KMMEF methanol could displace, along with the high likelihood that a substantial portion of the substituted methanol would have been produced starting from coal.

In the DSSEIS, nearly 80% of global methanol capacity was considered as potential substitution. The KMMEF methanol, due to novel Ultra Low Emissions technology, was determined to be lower emitting than every other potential source of methanol considered. This includes 29 manufacturing facilities importing to China, meaning KMMEF methanol would very likely be the lowest emissions intensity methanol available to the Chinese market. This is reinforced if, as the DSSEIS indicates, KMMEF pathways to olefins are less emission intensive than naphtha-to-olefin pathways (Table 3.5-10), although that finding appears to less certain and not fully resolved.

Nonetheless, in order for there to be a net emission increase from KMMEF methanol, the LCPI 2018 analysis previously determined that no more than 20% of the methanol could substitute for coal based-methanol if the remainder directly displaced naphtha-derived olefins or petroleum-based transportation fuels.[4] That ratio is extremely unlikely, as also indicated by the DSSEIS range of likely substitution impacts.

The Ecology-led DSSEIS sensitivity analysis indicates a high likelihood of between 2 and 9 MtCO2e/year more emissions in the absence of KMMEF, including "extremely limited" potential for emissions to be higher with KMMEF methanol. These results are similar to the December 2018 analysis from LCPI (likely range of 2.3 to 7.2 MtCO2e/year) despite using a distinct and independent methodology. Consistent results across different methodologies lend increased confidence to the forecast and likelihood of net avoided emissions.

While both the initial LCPI analysis from late 2018 and the DSSEIS offer high confidence in net emissions benefits associated with KMMEF, there are additional factors that the ESM could consider. I consider the general implications of several of those factors here.

[4] Kevin Tempest. *Kalama Methanol Plant – Review of Greenhouse Gas Impact Assessments*. December 2018.

D. Extending the sensitivity analysis

While the sensitivity analysis covers a wide array of important parameters, there are some additional parameters worth mentioning. The main motivation for enhancing the sensitivity analysis is to both account for all of the most likely sources of emissions sensitivity and, critically, to assess whether the long-term lifetime facility GHG impacts are likely beneficial even under collective global action to rapidly decarbonize.

1. *In-state Emissions Mitigation:*

The most readily assessable of these is the mitigation of all in-state emissions related to KMMEF. Details of the voluntary mitigation approach were one major determinant for requiring a second SEIS. This plan for mitigation is taking shape and is perhaps a likely, though not yet formal, requirement of permitting.

Given this, a range of mitigation effectiveness from none up to 100% of in-state emissions should be considered. This represents roughly up to 1 $MtCO_2e$/year of net emissions impact – although would be lower or higher depending on the scenario.

Inclusion of in-state emissions mitigation would increase the high-end range of net avoided emissions. This likelihood would be more certain if Ecology made it a formal permitting condition.

2. *Purchased Power*

The regulated transition to 100% carbon-free in-state electricity was established by the legislature in 2019 (net zero including offsets by 2030 and zero-carbon without offsets by 2045, known as the Clean Energy Transformation Act or CETA).[5] The DSSEIS includes a medium estimate of 0.19 $MtCO_2e$/year from power purchases and a high estimate of 0.37 $MtCO_2e$/year (DSSEIS Table 3.5-2).

The medium estimate attempts to account for CETA using a ratio of 80% renewable and 20% natural gas from 2030 to 2045. This overlooks two important factors: (1) The 20% of the mix from natural gas is required to be offset by mitigation of emissions elsewhere which, if done effectively enough to meet CETA requirements, would reduce the GHG impact of that power to zero; (2) The requirement of no more than 20% of the mix as natural gas is applied to each utility and not the statewide mix. Since many utilities are already below the 20% fossil fuel generation threshold, the statewide mix by 2030 is very likely to have less natural gas, roughly only 10% - half as much natural gas as is being assumed.[6]

As a result of these two factors, the current high case should use the value of the medium case – which should also likely be corrected to half as much natural gas input for 2030 to 2045, while the medium case should assume zero-carbon purchased power between 2030 to 2045 as a result of the carbon-neutral requirement of CETA.

Updating to more accurately reflect CETA requirements would increase confidence in and the likeliest range of net emissions reductions.

3. *Long-term emissions intensity of avoided methanol*

The DSSEIS applied some level of evolving production trends, but acknowledges that it does not capture potential technological improvements (p. 75) and "new policies or market shifts to occur in the markets for fossil fuels or plastics" (p. 105). Ultimately, the DSEIS settles on a "best current estimate of future emissions" for methanol production absent KMMEF that shows marginal improvements over time (Figure 3.5-10) of around a 20% decrease

[5] https://www.commerce.wa.gov/wp-content/uploads/2020/02/CETA-Overview.pdf

[6] *UPDATED: Effect of GHG Emissions and Rates from 100% Clean Power*. LCPI. March 5, 2019.

in emissions intensity over 40 years.[7]

There is legitimate concern that such modest decreases in emissions intensity are inconsistent with any deep decarbonization pathways and, therefore, could underestimate the production and technological improvements against which KMMEF would compete over the longer term.

While this is tricky to forecast, there are modelled pathways published for faster rates of improvement, such as the International Energy Agencies (IEA) *Future of Petrochemicals* report which was referenced often in the original LCPI report.

The IEA report includes a "reference technology scenario" or RTS with a 10% average emission intensity improvement through the end of the forecast window in 2050, a "clean technology scenario" or CTS with a nearly 60% decrease in average emissions intensity through 2050, and two lightly explored scenarios where the industry completely decarbonizes through bioenergy or electrolysis pathways. A couple of notes about these pathways:

The CTS forecasts a 45% decline in petrochemical CO2 emissions from 2017 to 2050, halves ocean-bound plastics by 2030 over present levels and nearly eliminates them by 2050, and increases plastics recycling globally to beyond levels seen in Europe today.

Under fully decarbonized petrochemical scenarios, methanol production greatly increases as the only viable pathway to certain end-products that are currently supplied by other fuel sources. The more likely pathway, through bioenergy, sees global methanol demand more than double in 2050 versus the CTS while demand actually increases five-fold relative to the CTS in an electricity-pathway scenario.

A possible approach to stress-test the effects of more rapidly evolving GHG reductions from the sector is to compare the net impacts of a substitution pathway in which the emissions intensity of the alternative methanol declines consistent with the CTS: 22% by 2030 and 58% by 2050.

Boundary conditions can also be queried against a scenario in which alternative methanol production shifts over time completely away from GHG emissions, reaching zero by the last year of the KMMEF lifespan in 2060.

For a first pass at such a stress-test and expanded boundary conditions, I evaluated 21 of the 39 most likely scenarios. This includes those for which the net avoided emissions were the lowest for KMMEF.[8] I summarize my rough findings here, and provide some additional detail in an addendum to this Letter.

In comparison to the CTS-derived pathway, 18 out of the 21 scenarios show net cumulative emissions benefits from KMMEF methanol through end of facility life:

- In the reference case (RC), under all scenarios the net cumulative emissions savings over the life of KMMEF are **between 68 and 102 MtCO_2e.**
- In the lower coal case (LCC), net cumulative emissions savings range from **-17 to 6 MtCO_2e**.
- In the higher coal case (HCC), net cumulative emissions savings range from **111 to 152 MtCO_2e**.

None of these scenarios consider improvements over time in KMMEF emission intensity or credit any in-state mitigation, which could reach roughly 40 MtCO_2e of cumulative impact. Therefore, these ranges are likely conservative, and are best viewed as a stress test.

Notably, with effective in-state mitigation the

[7] This is shown for the Reference Case using the central estimates, but may be different for other ESM scenarios.

[8] Including the he lower coal case (LCC) with 3% methane leakage or fast economic recovery, which have the lowest net benefits for KMMEF.

cumulative net impact of KMMEF would be a reduction in emissions under all scenarios compared to a "Clean Technology Scenario" pathway for global methanol production.

Of the 3 scenarios out of 21 that show a slightly higher cumulative emission with KMMEF than without, the cumulative emissions become greater in 2055 (under a 3% methane leakage scenario) or 2060 (under the "high" inputs case or using the highest GWP option, the AR5 20-year values).

These findings, a range of -17 to +152 $MtCO_2e$ net benefit under a CTS pathway, without any in-state mitigation crediting or improvement of the carbon intensity of KMMEF production, are consistent with the main conclusion of the DSSEIS that it is highly unlikely that KMMEF methanol would result in a net increase in global GHG emissions.

Under a less likely, but more optimistic, scenario of a global mobilization to a zero emissions global industry by 2060, cumulative emissions are lower with KMMEF than without it in all of the RC and HCC scenarios. Under the LCC pathway for methanol substitution, KMMEF cumulative emission would surpass the alternative between 2049 and 2054 – reaching 25 to 50 $MtCO_2e$ net emissions *added* by 2060. In all but one scenario (3% methane leakage), effective in-state emissions would push KMMEF methanol back into a cumulative net benefit.

A boundary condition of a rapidly decarbonizing global industry, to net-zero emissions by 2060, does show the possibility of a net addition to cumulative, global GHG emissions from the KMMEF, a threshold that in the worst-case conditions would be crossed between 2049 and 2054. As discussed in the next section, the concept that global methanol production would rapidly drop in emissions intensity but KMMEF methanol emissions intensity would remain static does not appear at all likely. There would be substantial pressure on KMMEF to improve its' emissions intensity, and it would be well positioned to on-board newer feedstocks than most other methanol facilities. Viewing the evolution of the global market as completely independent of KMMEF processes is, in my opinion, not realistic.

As one final note for this section, all scenarios tested included substantial net avoided emissions into the 2040s. Certainty in emissions reduction through these critical decades can slow climate change and buy vital time to ramp up global decarbonization solutions. The impacts in these earlier decades should not be underestimated.

Under much faster emissions intensity decline of global methanol substitutes than Ecology's analysis considers, the general findings remain consistent: It is very likely that net cumulative GHG benefits will accrue with KMMEF methanol compared to without it. This finding, based on new analysis for this letter, holds even with conservative assumptions that in-state emissions mitigation is ineffective and KMMEF methanol emissions intensity does not improve while competing methanol does rapidly. The additional stress and boundary testing indicate net global benefits through at least 2049, and very likely through end of facility life, even against a benchmark of a deeply decarbonized global industry.

4. *Long-term emissions intensity of KMMEF methanol*

A static emissions intensity from KMMEF, particularly if in-state mitigation were deemed ineffective, does indicate higher risk of contribution a net increase to global GHG emissions under scenarios in which global production drives towards zero emissions over the lifespan of KMMEF.

Assuming that KMMEF production remains static while global markets rapidly shift, however, raises the question of how KMMEF fits into the evolution of lowest carbon pathways. The plastics and chemicals industries are noted as amongst the most difficult to eliminate GHG emissions from. Governor Inslee's *Evergreen Plan* states that "eliminating climate pollution from industrial sources is an enormous challenge" and notes that "the federal government has a role to play exploring opportunities for industrial-sector carbon capture technologies".[9]

A key report referenced by the *Evergreen Plan* is the Energy Transitions Commission's *Mission Possible: Reaching Net-Zero Carbon Emissions from Harder to Abate Sectors by Mid-Century*. The report notes that plastics are likely to require the costliest supply-side measures of any of the sectors examined, at \$265-\$295/tCO_2e (see Exhibit 5 of *Mission Possible*). Even pushing as aggressively as possible for demand reductions, advanced recycling, substitution, and materials circulation measures, emissions from plastics are expected to increase 25% in 2050 over current emissions levels without additional supply-side measures (see Exhibit 5.3 of *Mission Possible*). This is a realistic best-case scenario for global consumption habits (demand-side measures).

Coal to natural gas switching is a highlighted approach, with continued applicability through 2040 (figure on Page 42 of the report). However, the biggest and most likely supply-side measures to reach net-zero for plastics over the long-term are very clearly bioenergy for chemical feedstocks and carbon capture.

Chemicals for feedstocks are the single largest demand sector for bioenergy in the decarbonization pathways shown in *Mission Possible* (Exhibit 6.11), with 28 EJ/year of demand (and another 6 EJ/year for chemical industry energy inputs). All other industrial sectors (steel, cement, and other industry) demand 22 EJ/year in the *Mission Possible* supply-side decarbonization pathway. Even this amount of bioenergy for feedstocks, 28 EJ/year, would cover only a fraction of feedstock needs, leading the report authors to state that

> "The strategy for plastics decarbonization must therefore combine an as complete as possible shift towards a circular model, with carbon sequestration – in the form of solid plastics placed in permanent, secure and leak-proof storage – and an as limited as possible use of bio-feedstock to compensate for inevitable losses in the value chain."

The limited supply of available bioenergy and the lack of additional approaches to net-zero in many industries – but notably plastics and aviation – merits that, in the words of the *Mission Possible* authors, "public support to biomass development should transition away from nonpriority sectors to high-priority sectors."

In addition to bioenergy, chemical production is projected in the *Mission Possible* deep decarbonization pathway to be the largest sector for carbon capture, including 1.9 billion metric tons of CO_2e per year (GtCO_2e) from carbon capture on the incineration of plastics and 1.4 GtCO_2e for energy of which natural gas is a primary input (Exhibit 6.12). This is about one-third of the total demand with the remaining two-thirds spread across 10 other sectors.

One other valuable resource for perspective is the IEA *Petrochemical Outlook* (IEA Outlook). The CTS scenario of the IEA Outlook does include a small amount of carbon capture for methanol, although requiring far less investment than is saved with capital savings from natural gas rather than coal investments (Figure 5.15 of the IEA Outlook). However, it is the two "Beyond the CTS" scenarios that are the most pertinent for this discussion.

These two pathways are for bioenergy and electricity. While methanol demand in 2050 is in the CTS is 179Mt, this demand jumps under lower carbon pathways to 380Mt in the bioenergy and 1000Mt in the electricity case. This is because methanol takes on increased prominence as the primary pathway to

[9] *Jay Inslee's Evergreen Economy Plan.* Page 24.

additional end-products once petroleum-based feedstocks are off the table.

The bioenergy case, the more likely of the two to scale cost-effectively for methanol according to the *Mission Possible* report, would demand half of the global sustainable biomass supply to shift fully to bio-based routes for primary chemical production (Figure 5.18 of the IEA Outlook).

Given the likelihood that both bio-based methanol and carbon capture are needed to deeply decarbonize the industry, *even after circular economy and demand reduction approaches are leveraged*, it is reasonable to return to the question of how KMMEF fits into the lowest carbon pathways. The very likely answer is that KMMEF would fit into the lowest carbon pathways relative to other methanol production routes.

It would be very unlikely for major movement across the global industry to occur while KMMEF emissions intensity remained static. It is likely a better assumption, given the regulatory setting and the technological suitability for biogas as a feedstock along with regional biomass availability, that KMMEF would stay ahead of the curve.

Of course, assuming that KMMEF methanol would inevitably remain ahead of the curve as deeper decarbonization strategies are deployed should not be taken for granted. However, it is illustrative that KMMEF methanol appears to be much lower risk of "carbon lock-in", or becoming a stranded asset left behind by a rapid and deep global decarbonization, than has been speculated.

E. The Question of Fuel-Use

The DSSEIS addresses the question of methanol being used as a fuel, assigning a 40% share of KMMEF methanol to eventual fuel use for the full 40 years, also noting that there is no direct influence of KMMEF on the share of global methanol consumption for fuel versus olefins or other chemicals, due to a competitive global market and KMMEF as "price taker". According to the DSSEIS, even if 100% of KMMEF methanol were to go directly for olefins, as required by the dock leasing agreement with the Port of Kalama, alternative uses of methanol would fill any fuel demand. The end result of these predicted market dynamics is that the *net emissions impact* is the same whether 100% of KMMEF methanol winds up as fuel or olefins.

It is the expressed intention of the KMMEF manufacturers to ensure that KMMEF methanol is used for olefin production. The merit of that intention was questioned in Spring of 2019 when internal documents from Spring of 2018 targeted at potential investors promoted methanol as a clean transportation option.[10] Subsequently, the intent was reinforced by a dock lease agreement dictating that no methanol from KMMEF can be sold as a fuel, subject to penalties.[11]

Shortly after the DSSEIS was released, NWIW announced a $10 million investment from a Hafnia Limited, a major oil product shipping group.[12] Hafnia Limited has agreed to ship one-third of the methanol to market and intends to use "next-generation methanol dual-fueled ships" as part of a 19-year charter with NWIW. This follows an agreement with MOL in June to carry the other two-thirds of the methanol volume with an emphasis on natural gas derived fuels, including methanol, as a replacement for traditional bunker fuel and the use of natural gas fueled ships.[13] NWIW representatives indicated that these ships would not be allowed to bunker fuel from KMMEF as part of the dock lease agreement.

[10] Molly Soloman. *Controversial Kalama Methanol Plant May Be Misleading Public, Regulators*. OPB. April 29, 2019.
[11] Molly Soloman. *Port Of Kalama: Methanol Refinery Can't Export For Fuel*. OPB. June 13, 2019.
[12] Mallory Gruben. *Major oil product shipping group invests $10M in Kalama methanol plant.* TDN. September 16, 2020
[13] *Giant Japanese shipping firm to invest in $2B Kalama methanol project*. The Daily News. June 18, 2020.

The efficacy of this intent in combination with the dock lease requirements on the eventual downstream market remains to be seen, and could likely be bolstered though additional purchasing agreement or even mitigation approaches that promote shifts in transport away from liquid fuels. The DSSEIS finds that there is likely to be limited to no impact on global methanol end-uses in either case.

Therefore, the primary impact of fuel end-use of KMMEF methanol is not the net emissions impact, but the gross emission impact. The combustion of methanol to provide energy – including transport or heat – releases GHGs, whereas those greenhouse gases are primarily sequestered into plastics via the olefin pathway. Emissions directly attributable to KMMEF methanol are higher if the methanol is combusted. However, the net impact of substituting KMMEF methanol for more emissions intensive methanol is the equivalent no matter the end-use. The difference is in the production pathway to the methanol, with the methanol through end-product effects being equivalent no matter the initial source of methanol.

Demand as a fuel, be it for transportation or heat, does raise concerns. Induced demand may occur through the addition of cheaper fuel to the market, such as in the case that KMMEF as a lower cost supplier could shift prices lower. The DSSEIS considers this scenario unlikely and/or small enough to not include as part of the sensitivity.

Nonetheless, added demand that materializes would lead to additional emissions, while cheaper fuel supply could also contribute to stifling competing technologies that are much lower carbon, such as electrification of transport or heating. Although, according to the IEA Outlook, methanol as a fuel may provide capacity to reduce local air pollutants and, through blending, improve combustion performance of various fuels (page 70), it is certainly not a low-GHG fuel if derived from fossil fuel resources.

Testing this legitimate concern, that direct displacement of transportation gasoline plus induced additional fuel demand will lead to net *added* emission from KMMEF, merits a short analysis. To do so, I start by referencing previous analysis regarding the original EIS.[14] That analysis pointed to prior research which indicated a 37% higher GHG emissions from 85% methanol blending with gasoline (M85) than from gasoline alone and it estimated that each gallon of methanol fuel could induce new demand of another 0.6 gallons of liquid fuel demand.[15] Combining these impacts gives a worst-case scenario of a 120% increase in emissions per gallon-equivalent of M85.[16]

As in the 2018 LCPI analysis, I now pose the question: Given the very likely GHG benefits of methanol for methanol substitution, what ratio of methanol for gasoline-displacement would negate any net climate benefits? To do this, I compare the added emissions per tonne of methanol used as a gasoline substitute (as M85) with the avoided emissions of methanol substitution based on the DSSEIS. The steps are outlined below:

- **STEP 1:** Based on Figure 5.4 of the First SEIS in August 2019, the life-cycle gasoline emissions to substitute for the equivalent

[14] Erickson, P. and Lazarus, M. (2018). *Towards a Climate Test for Industry: Assessing a Gas-Based Methanol Plant.* Discussion brief. Stockholm Environment Institute

[15] Assumes 2% methane leakage and 20-year GWP. The 37% higher GHG emissions does not assume lower emissions intensity ULE methanol production which would likely reduce the impacts to around 26%. However, worst-case leakage rates of 3% would essentially counteract that reduction. Regarding the 0.6 gallons of induced demand, Erickson & Lazarus in a 2013 analysis of the Keystone XL pipeline (*Greenhouse gas emissions implications of the Keystone XL pipeline*) found that additional transport fuel demand could rise by as much as 60% beyond each barrel of fuel supplied. This assumed per barrel oil prices in the $100 range where the supply curve is steep relative to lower prices, however oil prices in 2019 averaged in the $50 to $60 range and long-term forecasts typically do not envision $100 per barrel prices in the 2020s or 2030s. At lower oil-prices, given a flatter supply curve (small change in price for a given change in production), induced demand would be relatively muted compared to the Keystone XL analysis. A more recent analysis published in Nature by Erickson, Lazarus, and Piggot (2018, *Limiting fossil fuel production as the next big step in climate policy*) suggest a range of elasticities ranging from 0.2 to 0.6.)

[16] 1.37 x 1.60 give 2.2, which is a 120% increase. Note that multiplying these two values assumes that the additional induced demand is for higher-emitting M85, rather than gasoline, which is another worst-case assumption.

methanol as a transport fuel are around 7 MtCO2e per year, or about 1.9 tCO2e per t-MeOH equivalent. A 120% increase works out to 2.3 tCO2e additional emissions per t-MeOH;

- **STEP 2:** For the three reference cases, the avoided emissions per t-MeOH from KMMEF are 0.61 (for the LCC case with 20% coal-based methanol), 1.65 (for the RC case with 60% coal-based methanol), and 2.11 (for the HCC case with 80% coal-based methanol).[17]

- **STEP 3:** Comparing the result of step 1 with the range of results in step 2 provides the relative ratio of substitution in order to have a breakeven, net GHG impact:
  - LCC: 21% as M85 that displaces gasoline plus induces demand versus 79% that substitutes for other methanol for any end-use;
  - RC: 41% for gasoline displacement versus 59% for methanol substitution;
  - HCC: 47% for gasoline displacement versus 53% for methanol substitution;

This presents another boundary-condition: *gasoline displacement would need to be at least one-quarter of the overall methanol displacement, and very likely at least twice as high, in order to negate the net benefits of methanol substitution.*[18] Each of the three assumptions (worst-case gasoline substitution impacts, KMMEF methanol creating significant new fuel demand, and new fuel demand displacing gasoline rather than other methanol sources) is not likely. The DSSEIS did not view even two of these three conditions (new fuel demand and that fuel demand displacing gasoline rather than methanol) as likely enough to include as a sensitivity test. While possible, the extremely unlikely combination of these three conditions represents an outlier, or another boundary condition.

This short and preliminary analysis concludes that it is highly unlikely that substituting KMMEF methanol for gasoline end-use would be prevalent enough to lead to a net emissions increase. The combination of conditions required for there to be a net emissions increase represent an outlier scenario.

It is clear that methanol as a fuel is a sub-optimal outcome for global GHG emissions. The question remains whether KMMEF exerts any net influence on methanol volumes used as a fuel and if that influence is material to the overall net emissions impact. Without greater knowledge of the complex dynamics and interaction between the fuels market and chemicals market alongside technological and policy developments that could alter those markets, I am left to defer to the economic analysis of the DSSEIS.

That economic analysis finds that KMMEF methanol will not influence the eventual end-use markets for methanol in any significant way, with the exception of a small shift in naphtha olefin substitution under high oil price conditions. Given that, it is a safe assumption that these effects of induced demand or any potential delay of competing technologies are likely to be secondary to the substitution impacts, as concluded in the 2018 LCPI Analysis.

Evan so, ***methanol availability as a fuel should not be used as a justification to stop pushing forward on primary solutions to meeting the global climate challenge, such as electrification of transport and building end-uses. If fuel-use impacts are a concern, mitigation strategies that include accelerating electrification of transport and buildings should be considered.***

[17] This includes an estimated impact of induced demand for coal in other sectors of the Chinese economy from the First SEIS. This was estimated, given 10% price elasticity, to be 0.057 tCO2e per tonne of KMMEF methanol. Including this lowers the net avoided emissions attributed to KMMEF methanol.)

[18] The other most likely pathway, substitution for naphtha-derived olefins, is small (on the order of 0.1 tCO2e per tonne of MeOH in either direction) compared to the impacts of gasoline or methanol substitution. To the extent that naphtha displacement does occur, it would not greatly impact the ratio of gasoline displacement versus methanol displacement determined here.)

F. **Thought Exercise**: Does KMMEF ensure global emissions will rise, just less slowly?

In the DSSEIS, it is repeatedly noted that despite very likely net avoided emissions with KMMEF methanol production, that this will likely only “slow the global increase in emissions arising from methanol production and use” and should not be viewed as a means to decrease methanol related emissions.

This concept has been highlighted elsewhere as indicative that KMMEF is inconsistent with decreasing overall emissions from the sector. This is not accurate. *Net avoided emissions* analysis indicates that each ton of KMMEF methanol added to the market decreases global emissions. The overall impact can be seen in the IEA Outlook scenarios. Despite an 80% growth in methanol production from 2017 to 2050, annual emissions decline due to decreased emissions intensity between the RTS and the CTS. This is predominantly from coal to gas switching, with a small contribution from carbon capture.

To illustrate this point, I offer the following thought exercise. Assume that growth in methanol demand reaches the highest levels forecast in the DSSEIS (Figure 3.5-8) of 250 Mt of methanol per year by 2059, or 2.5 times current levels. Of the roughly 100 Mt of methanol produced annual at current rates, of which roughly 45 Mt is made from coal.

According to the DSSEIS (Table 3.5-10), coal-based methanol creates 3.8 tCO_2e/t-MeOH whereas KMMEF creates 0.64 tCO_2e/t-MeOH. Each coal-based t-MeOH substituted by a KMMEF-equivalent t-MeOH results in 3.16 tCO_2e avoided. Replacing 45Mt of methanol made from coal would reduce global emissions from current levels by 142 $MtCO_2e$. Increasing global production by 150 Mt of methanol (from 100 to 250) by 2059 through ULE technology would add back about 96 $MtCO_2e$, leaving a net decrease in emissions of 46 $MtCO_2e$ relative to current levels.

Some of that 46 $MtCO_2e$ would be released through additional end-uses of methanol – and would certainly be exceeded by combustion of a substantial share of that methanol as a fuel. However, olefin production from methanol adds about 0.10 to 0.15 tCO_2e/t-methanol based on data taken from the DSSEIS. An additional 150 Mt of olefins would add another 15 to 23 $MtCO_2e$, leaving a net decrease in emissions of 23 to 31 $MtCO_2e$.

Presumably some, if not all, of that net decrease in emissions would be taken for eventual end-uses in plastics and end-of-life disposal of those plastics. This thought exercise is certainly not trying to suggest that our goal as a global society should be to consume 150 Mt of methanol more each year by 2059 for olefin and plastics production, which would be extremely unsustainable and carry many associated harmful impacts.

However, it does illustrate the following concept is incorrect: that committing to KMMEF emissions-intensity levels of methanol means accepting that increasing global demand inevitably leads to annual global emissions increases from the sector. From a GHG perspective, there is ample current coal-based methanol production to technically allow for a substantial expansion of the global methanol industry while decreasing net global emissions. This expansion of demand is theoretical and a pathway forward that should absolutely be avoided, but this exercise illustrates how KMMEF methanol can be viewed as compatible with a future in which all sectors play a role in decarbonizing.

Concluding thoughts

The DSSEIS presents a wide-ranging view of the GHG impacts of KMMEF methanol production through ESM scenarios. Life-cycle analysis and the net impact on alternative or reference consumption habits are common practice, and essential for ascertaining a full, best estimate of the total impacts from any investment decision. Prominent examples are the use of marginal emissions rates for purchased power associated with the KMMEF as well as the substitution impacts of major public transportation infrastructure over long life-times. Life-cycle analysis is embedded in Low Carbon Fuel Standard being considered in Washington as well.

The DSSEIS findings are consistent with LCPI findings from late 2018, with a high likelihood of at least 2 $MtCO_2e$/year avoided global emissions from KMMEF's projected annual methanol production. An upside of 9 $MtCO_2e$ per year is also within the highly likely range – which is slightly higher than LCPI's original findings.

Some of this benefit hinges on KMMEF methanol not inducing additional demand, particularly for fuel use, or going in any significant share to naphtha-olefin substitution, for which net emissions impacts are marginal in either direction. That is supported, although not guaranteed, by economic analysis presented in the DSSEIS. Even if this may, if anything, underestimate the market demand influence of KMMEF, such influence is unlikely to be large enough to alter the high likelihood of net avoided emissions.

In reviewing the DSSEIS, there are a few areas of sensitivity that could additionally be considered. In general, these would have some impact on broadening the likeliest range of outcomes as well as the outlying boundary conditions. In doing so, this added sensitivity does not materially alter the main conclusions of the DSSEIS that global emissions are very likely to be lower with KMMEF methanol than without over the lifetime of the facility, or that the chances that emissions would be greater with the facility than without it are extremely low.

The perspective offered by including a dynamic and more rapidly improving emissions intensity of methanol likely to be consumed absent KMMEF production reinforces that the net emissions benefits are almost certain to be positive into the 2050s and very likely to remain positive through end of facility life. This is true even if KMMEF does not improve emissions intensity in the face of rapid global improvement – an unlikely combination – and if the in-state emissions mitigation is deemed to be fully ineffective.

To reinforce a near certain global emissions benefit over the full lifetime, I conclude with the same set of recommendations offered in late 2018, some of which have seen forward movement already. Over the life of KMMEF, steps should be taken towards the following, many of which could fit into a voluntary mitigation strategy that is made a formal requirement;

- Playing a leading role in actively sourcing and promoting industry best practices for low-leakage natural gas;

- Ensuring a robust voluntary mitigation program to annually offset the in-state share of emissions, one that relies on highest-standard markets and methodologies with regards to permanence and additionality of emissions reductions;

- To the extent they exist, executing on purchasing agreements and setting clear regulatory frameworks that prioritize the displacement of coal to methanol production; and

- With an eye to long-term industry evolution, research and consider opportunities through grants and partnerships, to further improve the global GHG impact of KMMEF. Such approaches could include adding alternative low-carbon feedstocks such as biogas or renewable natural gas to the mix;

Addendum 1: Methodology and Sensitivity around rapid GHG decline scenarios

In section D.4 of the report, I discuss some initial calculations for an extended scope of GHG emissions pathways for the most likely methanol KMMEF methanol would substitute out. In this section, I expand on the methodology and results. This methodology has been put together on a rapid timeframe, so these findings should be considered preliminary.

The context for this analysis is the DSSEIS best estimate that reference case scenario methanol against which KMMEF would enter the market is forecast to decline by approximately 20% between 2020 and 2059 (see DSSEIS Figure 3.5-10, copied here):

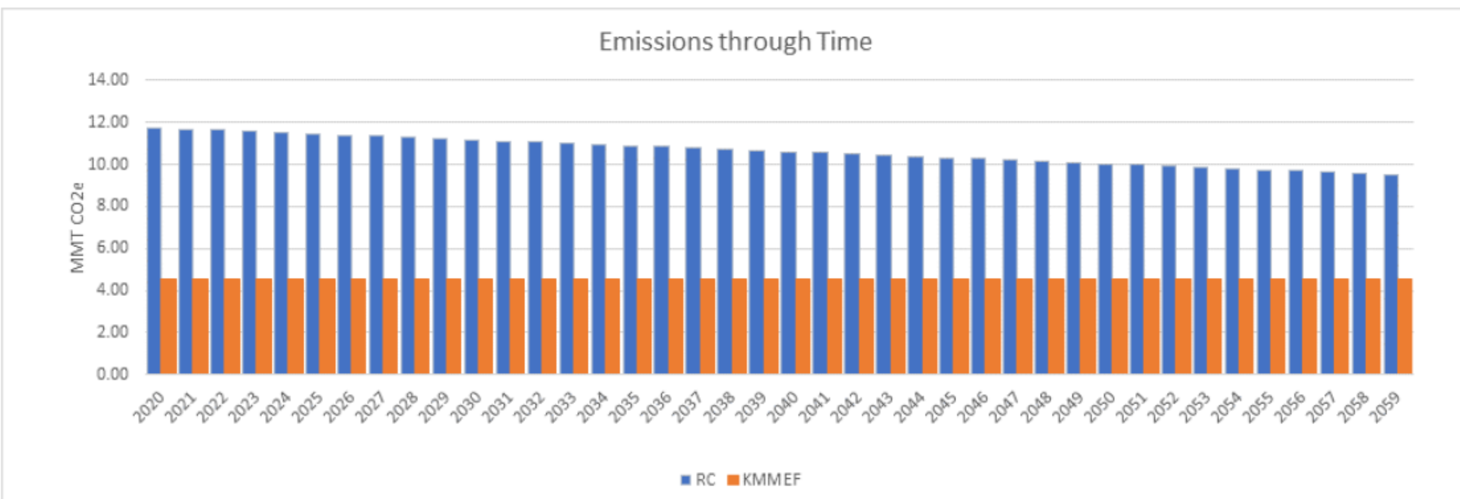


Figure 3.5-10. 20-Year Annual Expected Emissions, 2020 through 2059, RC and KMMEF

By comparison, the KMMEF methanol emissions are constant and static over the 40-year window for each scenario, although with variance for that emissions intensity between scenarios. In the scenario shown above, which is the best estimate presented in the DSSEIS, cumulative emissions through 2059 are 243 $MtCO_2e$ lower with KMMEF than without it, a 57% decrease in net emissions versus the reference case.

Assuming a relatively slow rate of decline in emissions intensity makes it difficult to view the project through the lens of a climate litmus test. In part to address this, the DSSEIS compares KMMEF methanol to a "lower coal-based production case" (LCC) and finds emissions forecast to be 103 $MtCO_2e$ lower, or roughly 36%, with KMMEF methanol than without it.

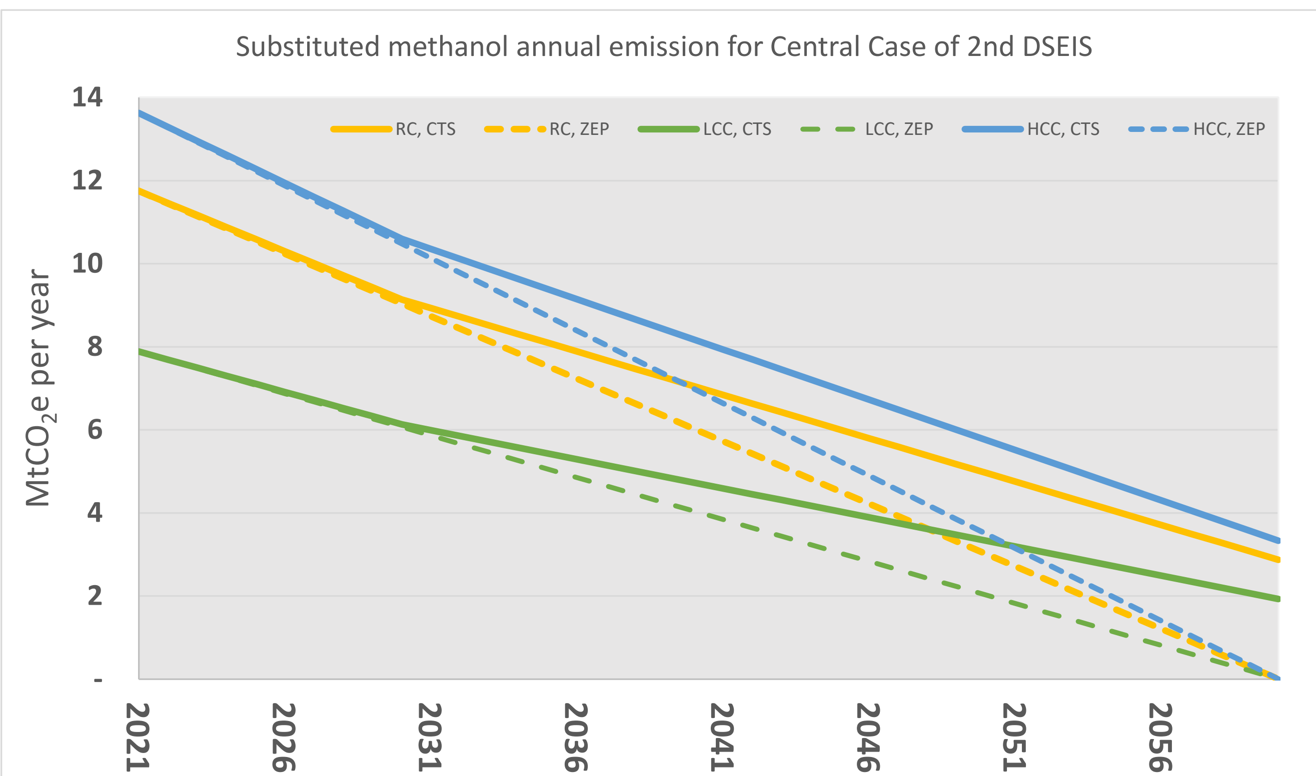
These comparisons present limited insights into an important question: Is KMMEF methanol compatible with ambitious low carbon pathways. In an attempt to answer this question, I looked at 21 of the 39 scenarios that the DSSEIS finds as within the highly likely range of outcomes. This range includes the worst performing KMMEF scenario on a net impacts basis – the LCC substitution mix with 3% methane leakage rates – as well as one of the best-performing KMMEF scenarios – the "high coal-based production case" or HCC using 20-year Global Warming Potentials from the IPCC 5th Assessment Report (AR5 20-year GWP).

To assess sensitivity around a more rapidly improving emissions intensity from the methanol sources most likely to be substituted with KMMEF, I developed two trajectories:

- One based on the IEA *Petrochemical Outlook* rate of decline under a "Clean Technology Scenario" (CTS) of 22% by 2030, 58% by 2050, extrapolated out through 2050 to a 76% decrease in emissions intensity. This represents an additional stress or sensitivity test around a scenario that would fall within the highly range of highly likely outcomes;
- And another based on a steady, linear decline in emissions intensity to zero by 2060, a fully "zero emissions pathway" (ZEP). This represents an extended boundary condition;

In both cases, to isolate the impact to changes of the methanol most likely to be substituted by KMMEF, I assume no change over time in KMMEF methanol emissions intensity, but hold it constant at the levels estimated for each scenario by the ESM approach of the DSSEIS.

The annual emissions intensities, including beginning and end year, are only shown for the central, reference case. For all other cases, only the 40-year average emissions intensity is presented. In order to turn all scenarios into annual averages, I scaled the initial emissions intensity for the year 2021 (I assume a first operational year of 2021 and a final operational year of 2060) for each scenario based on the ratio of first year emissions to average 40-year emissions in the reference case. From there, the rate of decline for each of the CTS and ZEP are applied. The graph below shows the annual emissions over time for the two scenarios and three substitution cases for the central set of cases presented in the DSSEIS.



To get a clear picture of the long-term global GHG emissions impacts, I present two measures, shown in the two tables below (the first for comparison to the CTS and the second for the boundary test using the ZEP). Those are the cumulative net emissions (CNE) benefits (substituted methanol *minus* KMMEF with no crediting for in-state emissions, consistent with the DSSEIS) as well as the year in which the CNE benefits from KMMEF would exceed the case without KMMEF, if any. The year CNE threshold would be crossed is presented both for zero in-state emissions mitigation and the crediting of total of 1 $MtCO_2e$/year mitigation every year for 40 years.

			Clean Technology Scenario Comparison	
Case	**Scenario**	**KMMEF Emissions (MtCO2e)**	**Cumulative Net Emissions (CNE) Impact of KMMEF (change in MtCO2e)**	**Year CNE alternative scenario (w/ or w/out in-state mitigation)**
Reference Case (RC)	Central	183	-99	NA / NA
	High	216	-90	NA / NA
	Low	167	-89	NA / NA
	3% Leakage	225	-68	NA / NA
	AR5 20-YR GWP	233	-102	NA / NA
	High Oil Price	183	-97	NA / NA
	Fast Econ Growth	183	-84	NA / NA
	AVERAGE	**198**	**-90**	**31% to 45% average decrease**
Lower Coal Production (LCC)	Central	183	-6	NA / NA
	High	216	3	2060 / NA
	Low	167	-6	NA / NA
	3% Leakage	225	17	2055 / NA
	AR5 20-YR GWP	233	1	2060 / NA
	High Oil Price	183	-4	NA / NA
	Fast Econ Growth	183	-1	NA / NA
	AVERAGE	**198**	**1**	**0.3% average increase to 20% average decrease**
Higher Coal Production (HCC)	Central	183	-144	NA / NA
	High	216	-137	NA / NA
	Low	167	-129	NA / NA
	3% Leakage	225	-111	NA / NA
	AR5 20-YR GWP	233	-152	NA / NA
	High Oil Price	183	-142	NA / NA
	Fast Econ Growth	183	-125	NA / NA
	AVERAGE	**198**	**-134**	**40% to 52% average decrease**

Across all scenarios modeled using a static KMMEF emissions rate and a CTS rate of emissions intensity decline, the overall cumulative net emissions impact is from 17 $MtCO_2e$ increase to an avoided 152 $MtCO_2e$. By scenario averages, this works out to be a 0 to 52% average decrease in emissions. Even with 18 $MtCO_2e$ of effective mitigation (an effectiveness of 45% out of a proposed 40 $MtCO_2e$), the net cumulative global impact would be lower emissions with KMMEF methanol than without it in all scenarios. In the worst-case scenario, KMMEF methanol would lead to a CNE reduction in every year until at least 2055, and would never lead to a CNE increase in 18 out of 21 scenarios.

For this sensitivity test, the results are consistent with the DSSEIS findings of an extremely limited likelihood that KMMEF would lead to a net emissions increase and, if it did, this threshold would not be crossed until well into the 2050s in the worst-case scenario.

			Zero Emissions Pathway Scenario Comparison	
Case	Scenario	KMMEF Emissions (MtCO2e)	Cumulative Net Emissions (CNE) Impact of KMMEF (change in MtCO2e)	Year CNE alternative scenario (w/ or w/out in-state mitigation)
Reference Case (RC)	Central	183	-52	NA / NA
	High	216	-40	NA / NA
	Low	167	-47	NA / NA
	3% Leakage	225	-20	NA / NA
	AR5 20-YR GWP	233	-47	NA / NA
	High Oil Price	183	-51	NA / NA
	Fast Econ Growth	183	-40	NA / NA
	AVERAGE	**198**	**-42**	**18% to 34% average decrease**
Lower Coal Production (LCC)	Central	183	25	2054 / NA
	High	216	38	2052 / NA
	Low	167	22	2054 / NA
	3% Leakage	225	51	2049 / 2058
	AR5 20-YR GWP	233	39	2053 / NA
	High Oil Price	183	27	2053 / NA
	Fast Econ Growth	183	29	2054 / NA
	AVERAGE	**198**	**33**	**20% average increase to 4% average decrease**
Higher Coal Production (HCC)	Central	183	-90	NA / NA
	High	216	-79	NA / NA
	Low	167	-80	NA / NA
	3% Leakage	225	-55	NA / NA
	AR5 20-YR GWP	233	-88	NA / NA
	High Oil Price	183	-88	NA / NA
	Fast Econ Growth	183	-74	NA / NA
	AVERAGE	**198**	**-79**	**29% to 43% average decrease**

The more stringent comparison to a boundary condition of the ZEP shows an increased likelihood that KMMEF methanol production could lead to a global emissions increase – although this would only occur against a LCC alternative. Given effective in-state mitigation, only 1 out of the 21 scenarios analyzed would project a net cumulative emissions increase. The full range projects anywhere from a 51 $MtCO_2e$ increase in emission (crossing the net increase threshold in 2049) to a 90 $MtCO_2e$ decrease in emissions.

This exercise provides boundary conditions under a low plausibility combination of assumptions: Optimistically, global industry moves rapidly to zero emissions. At the same time, KMMEF methanol does not improve emissions intensity at all despite being well positioned to do so (see section D.4 of the Letter of Findings). Even in this low plausibility case, the likeliest outcome would be a net global reduction in emissions. ***This indicates with high confidence that KMMEF methanol production is consistent with low carbon and even zero carbon pathways, strengthened by avoided emissions over at least the first two to three decades: an absolutely critical period of deployment and development of low and zero-carbon technology.*** I would also speculate that in a scenario where one, if not the most, expensive sector to decarbonize reaches zero emissions, it is highly likely that global transport and building fuel use is fully decarbonized and methanol is not in use, at least in significant volumes, in those sectors.

Addendum 2: Text of Public Comment

Public comment offered during the September 22nd, 10AM public hearing – with one factual correction:

Thank you for the opportunity to speak today on this important and complex topic. My name is Kevin Tempest, and I work as the R&D Scientist for the Low Carbon Prosperity Institute. The rapidly dwindling greenhouse gas budget demands resource allocation only with high confidence that long-term benefits outweigh costs. Other Pacific Northwest export proposals have merited rejection on GHG grounds. This one looks different.

According to analysis I completed in late 2018, global GHG emissions are likely to be 2 to 7 million tons per year lower with this facility than in its absence.

The draft analysis arrives at similar conclusions through its own, separate methods, providing increased confidence.

Across a wide range of assumptions, such as methane leakage, global warming potentials, and methanol end-uses, 47 different scenarios forecast a very likely range of 2 to 9 million net emissions avoided per year and an extremely likely range of 0.25 to ~~12 million~~ 9.6 net avoided emissions per year. That is before consideration of in-state emissions mitigation that is much more ambitious than Ecology's own Clean Air Rule.

While Kalama methanol is likely to remain lower emitting than prevailing alternatives, confidence diminishes farther out in time. In a sector that Governor Inslee's ambitious *Evergreen Plan* found as the costliest to decarbonize, demand for methanol and plastics is forecast to continue to grow through at least mid-century even under low carbon scenarios that maximize recycling and the circular economy such as those from the *Energy Transitions Commission* and the *International Energy Agency*.

Longer-term, prioritization of carbon capture and finite biogas resources are the clear leading candidates to drive emissions towards zero. Combined, these technologies are actually *carbon-negative*. This facility can -and should be ready - to adapt to these technologies and trends in order to minimize the risk of becoming a net emissions source, and increasing the odds of compatibility with a net-zero emissions future.

Thank you for your time.