Expert Opinion on the climate implications of development and operation of the Yggdrasil oil and gas fields

Date: 18 June 2024

To: Law firm Simonsen Vogt Wiig, attorney Jenny Sandvig

From: Michael Lazarus, Senior Scientist, Stockholm Environment Institute US

1. Background

The law firm Simonsen Vogt Wiig, representing Greenpeace Nordic and Nature and Youth Norway has asked me to provide an expert opinion on the following questions:

- Is the Government's methodology for estimating the climate effect of a new oil and gas field appropriate and is it implemented in a robust manner?
- Does the Government's estimate that Yggdrasil (gross 365 MtCO2e) may reduce global GHG emissions by 52 MtCO2e reflect a reasonable and robust application of net emissions analysis methodology? If not, what might a more likely estimate look like?
- What are the broader climate implications of developing the Yggdrasil oil and gas fields? Would its development be consistent with meeting global climate goals?

2. About Stockholm Environment Institute US and the author

The Stockholm Environment Institute US Center (SEI US) is a nonprofit research organization affiliated with the Stockholm Environment Institute in Sweden. With offices in Somerville, MA; Davis, CA; and Seattle, WA, SEI US combines expertise from various fields—environmental science, economics, policy analysis, and the social sciences—to provide evidence-based insights and solutions to support sustainable development and address environmental challenges. By adopting a multidisciplinary, international lens, SEI US leverages a global network to allow for insights and experiences from around the world to both inform and enrich its work in the US. Courts in the US and Europe have relied on the opinions and testimony of SEI US staff in several high-profile cases related to the climate implications of oil and gas development.[i]

I am a Senior Scientist at SEI US, where I have worked in over thirty countries on climate policy, energy planning, and carbon markets. I have co-led SEI's work on fossil fuel supply and climate change, the development of the Production Gap Report, have published widely in peer-reviewed literature, including

[i] See e.g. *Juliana v. United States*, No. 6:15-CV-01517-AA (D. Or.); *Columbia Riverkeeper et al. v. Cowlitz County et al.*, SHB No. 17-010c (Shoreline Hearings Board for the State of Washington); *Advocates for a Cleaner Tacoma et al. v. Puget Sound Clean Air Agency, Puget Sound Energy*, PCHB No. P19-087c (Pollution Control Hearings Board for the State of Washington); *Verenigung Mileiudefensie et al. v. Royal Dutch Shell,* C/09/571932 / HA ZA 19-379 (District Court of the Hague, Netherlands)
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many on the impact of projects and policies on greenhouse gas emissions.[1–12] Among other duties, I have served as advisor to the World Bank Partnership for Market Readiness and the Western Climate Initiative, as member of the Methodology Panel of the Clean Development Mechanism. I am on the editorial board of the Climate Policy journal and a regular reviewer for leading energy and climate journals. I am also adjunct faculty at the Evans School of Public Administration at the University of Washington, where I teach Climate Policy. I hold a B.A. in Chemistry from Wesleyan University and an M.S. in Energy and Resources from the University of California, Berkeley.

The opinions expressed here are my own and are based on the data and facts available to me at the time of writing, as well as based upon my own professional experience and expertise. Should additional relevant or pertinent information become available, I reserve the right to supplement the discussion and findings in this document. In preparation of this opinion, I have not discussed content or collaborated with any other expert witness in this case.

3. Is the Government's methodology for estimating the climate effect of a new oil and gas field appropriate? And if so, is it implemented in a robust and consistent manner?

There are several ways to assess the climate effect of a new oil and gas field. One is net emissions analysis, which is used to estimate the incremental impact of a project in contrast with a counterfactual baseline. This is the approach that the Government has relied upon here, drawing on a report by Rystad Energy[13]. It is widely used for project assessment, though with limitations in scope and certainty, as described below[14].

The specific methodology used by Rystad Energy to estimate net emissions impact is similar to what other analysts have used for fossil fuel development projects[4,15]. It seeks to capture three important dynamics: 1) how increased oil and gas supply would translate, through market (price) effects, to increased energy consumption; 2) what other energy sources would be displaced by added oil and gas consumption; and 3) the upstream emissions impacts of substituting for other oil and gas production.

While Rystad Energy's methodology for net emissions analysis is appropriate, its implementation is problematic. Their analysis makes a number of assumptions and arguments that are inconsistent with other literature, inappropriate for its own counterfactual scenario (Gradual Energy Transition), or not well matched with the time frame of the project. They are systematically biased towards a result that shows new Norwegian oil and gas production would reduce rather than increase emissions (see Question 2 below).

Other approaches to assessing the climate effects of the Yggdrasil development include examining its consistency with national and global climate targets, and its lock-in, equity, and climate leadership implications. These elements are equally important to consider. However, to my knowledge the Government has not addressed them. I touch briefly on these considerations in response to the last question.

4. **Does the Government's estimate that Yggdrasil (gross 365 MtCO2e) may reduce global GHG emissions by 52 MtCO2e reflect a reasonable and robust application of net emissions analysis methodology? If not, what might be a more likely estimate?**

The Government's estimate of emissions benefit draws on the Rystad Energy report noted above, which looked at "Net greenhouse gas emissions from increased oil and gas production on the Norwegian continental shelf"[13,16]. The Rystad Energy report did not look specifically at the Yggdrasil project, but rather at average production characteristics on the continental shelf and its net emissions implications.

The written submission from the Office of the Attorney General of Norway (dated 18/10/20230) suggests that the Government derived its estimate of 52 $MtCO_2e$ reduction over the lifetime of field development by applying the average greenhouse gas (GHG) emissions impact per barrel of oil equivalent (BOE) energy produced, as estimated in the Rystad Energy report (-26 and -123 $kgCO_2$ equivalent/BOE for oil and gas, respectively) to the lifetime production amounts listed in that communication[17]. These GHG emissions impact estimates are based on the results of Rystad Energy's main "Gradual Transition" scenario, which Rystad Energy states is "in line" with the Announced Pledges Scenario (APS) of the International Energy Agency (IEA) 2022 World Energy Outlook (WEO)[18].

The following elements of the Rystad Energy analysis are problematic and biased in favor of the finding of emissions benefits for new Norwegian oil and gas production. For each an alternative assumption is offered that is more consistent with widely cited, peer-reviewed literature or with the APS upon which the Rystad Energy analysis is based:

a) Analysis timeframe. Ideally, the net emissions analysis would be conducted on an annual basis based on expected Yggdrasil oil and gas production, accounting for the evolution of economies and energy systems and the implementation of climate and other policies over time. Using a midyear that represents the midpoint of expected production can be a reasonable surrogate. Aker BP has recently provided an estimated annual production profile for the field, but this only covers expected recoverable resources (plus one additional recently discovered resource) and not the full "risked resource potential" that the government has used to estimate total emissions[16]. The midpoint of production for this profile is 2030; but considering that the timing of the remaining 22% of total (risked) production is likely to be considerably later, and that other resources may well be discovered in coming years, the midpoint could be considerably later. Assuming a start date of 2027 for Yggdrasil and production profile similar to the giant Ula oil field, which Höök et al (2009) characterize as "quite representative" of other giant offshore North Sea fields, one could expect a midpoint of cumulative production closer to 2034.[19] Considering the long tail of production well into the 2040s, 2035 would be a reasonable midpoint to use. However, the Rystad Energy analysis uses assumptions for current (e.g., upstream CO2 emissions) or year 2030 performance, which systematically overestimates the emissions associated with oil and gas production and other energy sources that Yggdrasil production would substitute for.
   - Government (Rystad) assumption for analysis midyear: today or 2030
   - Alternative assumption: 2035

b) Oil price elasticities. Rystad Energy's oil price elasticity assumptions are out of sync with widely-cited, peer-reviewed literature[4,20–24], and minimize the market impacts of increased production, relative to findings of other studies and reports. Due to relatively low demand and high supply elasticity assumptions (-0.1 and 1, respectively), Rystad Energy estimates that global oil consumption increases by only a tenth of a barrel for every barrel produced. By comparison, the US Government found in their analysis of the market effects that it would result in an increase in consumption of 0.22 for every barrel produced by the Willow oil project in Alaska[25]. Several years ago, Erickson and Lazarus found that oil consumption would increase by 0.5 barrels for every barrel produced, at a time when oil prices were expected to remain higher over the long run (with less elastic supply), conditions that the market could return to in the future[4]. Several other researchers have found ratios close to 0.5[20,22–24]. Most recently, Prest et al[15] conducted a comprehensive and transparent assessment which found a best estimate of demand and supply elasticities (-0.35 and 0.42, respectively) that results in oil consumption increasing by 0.45 barrels for every barrel produced.

- Government (Rystad) assumption for increase in BOE oil consumed per BOE produced: 0.1.
- Alternative assumption: 0.45.

c) Increase in energy demand. The Government's estimate fails to account for the increase in global energy consumption that would result from decreased energy prices. Without explanation, Rystad Energy assumes that every unit of increased oil and gas consumption as a result of market effects leads to a corresponding unit of decrease in the consumption of substitute fuels, and global energy demand is unaffected. This is contrary to economic theory and real-world experience. Consumers take advantage of lower fuel prices to drive more, turn up their thermostats, and purchase more, often long-lived, oil- and gas-based equipment. One way to determine the extent and type of substitution is to use cross-price elasticities. Another is to look to long-term energy scenarios, as in Erickson and Lazarus (2018), which found that that price-induced changes in oil consumption would lead to changes in overall energy use and switching to substitute fuels in roughly equal proportions[4,26].

- Government (Rystad) assumption: no effect on total energy demand.
- Alternative assumption: half of increased oil and gas consumption reflects increased energy demand.[ii]

d) Displaced energy. The Rystad Energy analysis overstates the extent to which gas production will displace coal use in the power sector. Rystad Energy makes a series of arguments to arrive at a conclusion that increased gas consumption (due to added Norwegian production) would occur wholly in the power sector of LNG importing countries (in Asia). Without much justification, they make an admittedly simplified assumption that this increase in gas-fired power would largely displace electricity from coal (70%) with the remaining displacing renewables. While such an outcome is conceivable, especially in the near term, it is not in sync with the IEA APS scenario on which Rystad Energy bases its analysis and does not adequately take into account how the global gas market could evolve by the middle of the 2030s. Under the APS scenarios in IEA's 2022 WEO[18], gas is in decline globally in the power as well as buildings sectors by 2030, coal power is on the way out in most countries, and the vast majority of new power generation is coming from renewables, as well as some nuclear and fossil power with carbon capture and storage (CCS). In IEA's more recent 2023 WEO, the projected decline in Asia Pacific demand for natural gas is even steeper under its APS scenario, while the transition away from coal to renewable electricity is significantly faster.[27] Consequently, increasing gas supply (owing to Yggdrasil) could well have the effect of slowing the transition away from gas in buildings as well as in the power sector, and displacing renewables (and nuclear and fossil CCS) far more than coal. Furthermore, Rystad Energy argues that Norwegian gas would be used only in existing gas fired plants with available capacity, an assumption reasonable in the short-term effects but not in the long-term, especially

[ii] The 50% assumption is extended from oil to gas, and 100% substitution is an implausible assumption.

for regions where decisions are still being made on whether to construct new gas-fired plants. This is the case for Asia, where gas power in still on the rise in 2030 in the APS[18].

- Government (Rystad) assumption: largely power sector displacement (fraction not indicated); 70% of which is coal power; 30% renewable energy.
- Alternative assumption based on IEA 2022 WEO APS: 60% power sector displacement / 40% buildings (in rough proportion to changes in demand 2021-2030); 60% of added gas in buildings substituting for electricity, 40% for renewables[iii]; and 35% displacement of coal / 65% displacement of renewables in the power sector.[iv]

e) Upstream emissions. Rystad Energy assumes that oil and gas producers in the rest of the world take limited steps to reduce methane (CH_4) emissions and none to reduce the carbon dioxide (CO_2) emissions associated with their oil and gas production. This assumption does not appropriately account for countries' commitments under the Global Methane Pledge (GMP) and their broader net zero and related pledges. Rystad Energy assumes a 30% reduction in upstream methane (CH_4) emissions by 2030, which matches the GMP goal *for all sectors.* However, agriculture accounts for the largest share of global methane emissions and reducing methane emissions from agriculture (predominantly from livestock) is far more difficult and costly than reducing them in the energy sector. Furthermore, the Rystad Energy analysis appears to assume no reductions in CO_2 emissions from oil and gas operations, even though CO_2 emissions from oil and gas operations are significantly greater than methane emissions on a CO2 equivalent basis, and many producing countries have pledged to reduce these emissions as well. Under IEA 2022 WEO Net Zero by 2050 Scenario, for example, average upstream combined CO_2 and CH_4 emissions intensity from oil and gas operations declines by 50% and 55%, respectively, from 2020 to 2030[28]. IEA does not report upstream emissions intensity declines for their Announced Pledges Scenario, but one could make the simplifying assumption that these intensities decline at the same pace as overall emissions reductions across both the NZE and APS (IEA only reports total CO_2 emissions).

- Government (Rystad) assumption: reduction in emissions intensity of average global oil and gas production of 30% for CH_4 and 0% for CO_2 from current levels.
- Alternative assumption: reduction in CH_4 and CO_2 emissions intensity of average global production of 38% for oil and 41% for gas. (The APS achieves roughly 75% of the emissions reductions by 2035 as the NZE does by 2030).

When combined, these adjusted assumptions suggest that a more likely estimate is that the development of Yggdrasil will *increase* global GHG emissions by roughly 80 $MtCO_2e$ over its lifetime.

This simple, adjusted estimate was assembled from available published studies and the limited information provided in the Government and Rystad Energy reports, and only examined some of the assumptions, not all. It points to the value of conducting a more robust and comprehensive analysis, including under a net zero scenario, which could also consider issues not addressed here. Among those

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[iii] Estimates of drawn from changes out to 2030 shown Table 8.1 and Figure 5.6 of IEA's 2022 WEO for the APS, as rough indicator of marginal effects for power/buildings share of added gas demand and electricity/renewables share of marginal building energy sources.

[iv] This is half of the Rystad coal share, a simplified assumption taking into account that while there is still some potential for added coal-to-gas switching in Asia, by 2035 it is no longer likely to be the predominant effect, as gas power begins to decline in Asia in the IEA APS after 2030, and in other regions.

issues is the assumption that the added electricity demand from the project will result in no emissions[v] as well as concerns identified by Vista Economics[29], whose report I am aware of but have not reviewed.

f) What are the broader climate implications of developing the Yggdrasil oil and gas fields? Would its development be consistent on meeting global climate goals?

It is important to consider the climate effects of oil and gas development in a broader context than net emissions analysis alone, especially in light of its limitations in scope and certainty. This broader context includes assessing whether the development of the Yggdrasil oil and gas fields is consistent with national and global climate targets. Such an assessment can involve looking to modelling studies to assess whether a project such as Yggdrasil would be developed in a scenario that is consistent with climate targets, specifically the goal of the Paris Agreement to which Norway is a Party of "holding the increase in global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels"[30]. One such widely-regarded assessment is the IEA's Net Zero Emissions (NZE) roadmap, first issued in 2021, found that that no new oil and gas fields need to be developed beyond 2021[19,29]. In its update released last fall, the IEA reiterated that "no new long-lead time upstream oil and gas projects are needed in the NZE Scenario"[31]. These findings would suggest that development of Yggdrasil is therefore inconsistent with meeting global climate targets.

Other broader aspects of examining a fossil fuel project's climate implications are its lock-in, equity and leadership effects. An assessment of lock-in effects would consider the extent to which this project would lead to long-lived investments in new, fossil fuel using-infrastructure, including new gas-fired power plants or petroleum-fueled vehicle fleets that the additional supply and lower prices could lead to. The Rystad Energy analysis avoids addressing lock-in effects, by assuming all the added Norwegian gas will be used in existing facilities. However, this assumption ignores the dynamics by which greater gas availability and lower prices will influence decisions on new natural gas power plants or building equipment.[vi]

The Government should consider the signals that approval and development of this project sends to other oil and gas producing countries that have fewer resources with which to develop alternative sources of employment and revenue. As this last's Production Gap Report underscores, "an equitable transition away from fossil fuel production must recognize countries' differentiated responsibilities and capabilities" and that "governments with greater transition capacity [such as Norway] should aim for more ambitious reductions and help finance the transition processes in countries with limited capacities."[32]

Summary of findings

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[v] There is no mention in the Rystad report of the source of additional zero-carbon electricity that power the offshore facilities. If dedicated new zero emission generation were built as the direct result of the project (and would not have otherwise been built), then this would be a good assumption. Otherwise, the outcome could be fewer electricity exports to the rest of Europe, where some gas or coal resources could be on the margin, though effects would be muted by the EU ETS.

[vi] If gas plants are still being built, as they still are in the WEO APS, they will be fueled by available gas supplies, not just non-Norwegian ones. Therefore, by lowering gas prices and increasing its availability, this project will also contribute, indirectly, to the build-out – and lock-in – of new gas fired power plants, gas-fueled heating systems, and other gas using infrastructure.

The Government's assertion that as a result of the Yggdrasil development "global greenhouse gas emissions would be reduced by around 52 million tonnes CO_2 equivalents" is based on an analysis that appears to be systematically biased and seriously flawed. More likely, the Yggdrasil development, over its lifetime, will *increase* global GHG emissions, on the order of about 80 MtCO2e when the analysis is adjusted to be more consistent with the IEA's APS and with other peer-reviewed literature. This is well over a year's worth of Norway's current GHG emissions, which totaled 49 $MtCO_2e$ in 2020 from all sources[33]. Furthermore, development of oil and gas in Yggdrasil appears likely to be inconsistent with agreed global climate goals, as suggested by IEA's Net Zero roadmap, and risks locking-in new GHG emitting infrastructure that could undermine a just and equitable transition to clean energy.

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