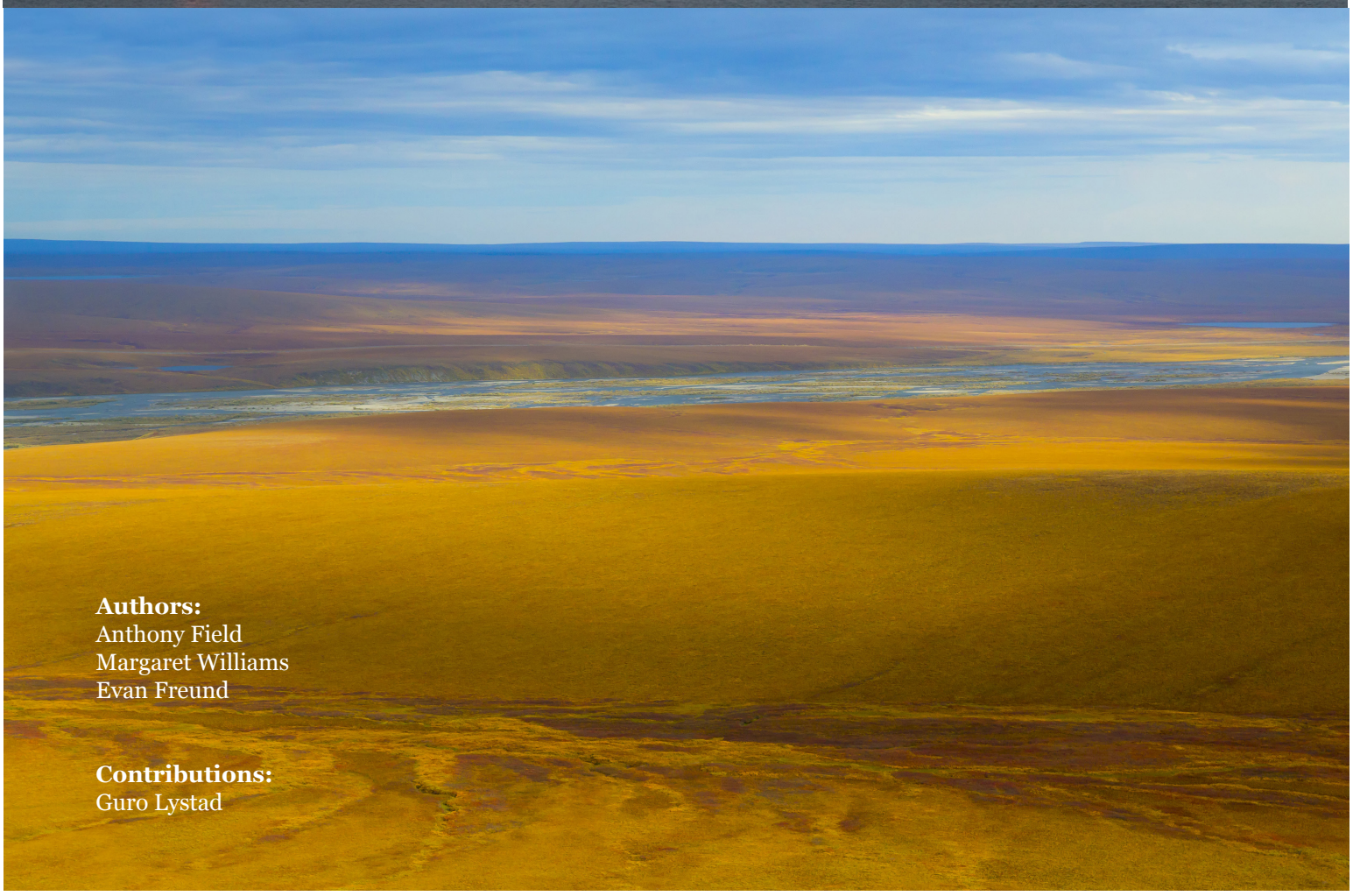
The Economics of Oil Development in the Arctic National Wildlife Refuge



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Executive Summary

Countries throughout the world are escalating their efforts to curb carbon emissions, seeking to reduce impacts from climate-related events such as extreme and unpredictable weather episodes occurring around the globe. Science continues to demonstrate humanity's growing contributions to climate change and for the need to take global action, as described in the 2021 report of the Intergovernmental Panel on Climate Change (IPCC)'s Working Group 1. The co-chairs of this IPCC Working Group called the report a reality check, stating that "[c]limate change is already affecting every region on Earth, in multiple ways. The changes we experience will increase with additional warming."[1]

To combat the worst impacts of climate change, governments, companies, and consumers alike are forcing a shift to low-carbon energy economies. The global energy system is changing rapidly with the accelerating penetration of reduced-cost, low-carbon renewable energy, energy efficient technologies, and energy saving initiatives. This shift to non-fossil fuel energy sources and energy efficiencies will have ripple effects on the price of oil worldwide over time. Leading economists and analysts now predict a decline in the price of oil over time as gains are made in energy efficiency and the transition to non-fossil fuel energy sources accelerates.

In this paper World Wildlife Fund-United States (WWF-US) examines the possibility of future oil developments within the Arctic National Wildlife Refuge (Arctic Refuge) given this changing energy landscape. WWF-US used the most recent data and modeling from Rystad Energy, an energy research and analytics company which is widely respected within the industry, to analyze future oil development in the Arctic Refuge in context of an economy that is shifting to a reduced carbon-based energy dependence.

WWF-US's analysis utilizes three oil price scenarios constituting a range of future oil prices as suggested by leading economists and analysts: constant $50 and $40 per barrel scenarios used by Rystad Energy and a decreasing price scenario described by the International Energy Agency (IEA) in its road map for the global energy sector. The IEA scenario predicts an oil price trajectory that would occur on the path to net zero by 2050. (Specifically, the prices fall to $35 per barrel in 2030 and $24 per barrel in 2050).

Based on a review of Rystad Energy's assessment and looking at the projected oil prices in the three oil price scenarios for 2040 ($50, $40, and $28), WWF concludes that the Arctic Refuge leases are unlikely to be economic to produce oil, and that the United States will not therefore achieve significant revenue from an Arctic Refuge oil and gas leasing program.

Using the most recent data and modeling from Rystad Energy, combined with the predicted range of future oil prices, WWF-US then assessed the economic "breakeven"[2] price of development that could occur on the nine Alaskan Refuge leases awarded in January 2021 to Knik Arm Services, Regenerate Alaska (a wholly owned subsidiary of 88 Energy Ltd), and the Alaska Industrial Development & Export Authority (AIDEA). As there has been little exploration for possible oil reserves in the Arctic Refuge to-date, an elevated degree of uncertainty exists in the industry data available to conduct modeling. However, the results of WWF-US's assessment provide the best estimate of the breakeven price to develop the nine Alaskan Refuge leases, as it is based on the best available data and the industry-trusted modeling used by Rystad Energy.

WWF-US's review of information and modeling from Rystad Energy shows that the breakeven price for oil development from the nine awarded leases in the Arctic Refuge ranges from $62.5 per barrel to $83.60 per barrel. Based on historical lease-to-development timelines, production from these leases is assumed to start around 2040. Based on a review of Rystad Energy's assessment and looking at the projected oil prices in the three oil price scenarios for 2040 ($50, $40, and $28), WWF concludes that the Arctic Refuge leases are unlikely to be economic to produce oil, and that the United States will not therefore achieve significant revenue from an Arctic Refuge oil and gas leasing program.

In addition to other factors explained in WWF-US's analysis, the low likelihood for profitability on the price per barrel of oil figures could help explain why no major oil companies chose to bid in the 2021 Arctic Refuge lease sale. In fact, the 2021 lease sale generated less than 1% of the federal revenue upon which Congress predicated the Arctic Refuge oil and gas leasing program. Furthermore, data from Rystad Energy's modeling shows a yield of only 1.64 million barrels of oil for the nine awarded leases in the Arctic Refuge, which is equivalent to a two-hour supply of oil for the United States

WWF-US's own analysis also contains new data from Rystad Energy's modeling as to the estimates of technically and economically recoverable oil located in the Coastal Plain of the Arctic Refuge. The current U.S. Geological Survey (USGS) estimate of technically recoverable oil suggests there are approximately 7.7 billion barrels of oil located in the Coastal Plain of the Arctic Refuge. However, as WWF-US's analysis discusses, USGS's number represents only technically recoverable oil, that is, the amount of oil that can be extracted using currently available technology and industry practices, regardless of the cost. When looking at the projected amounts of economically recoverable oil – the quantity that can be extracted at a profit – the best available data and modeling shows a different picture of the potential oil located in the Coastal Plain of the Arctic Refuge.

WWF-US's analysis of the resource potential for the awarded leases within the Arctic Refuge showed that there may in fact be only 668 million barrels of oil that could be considered economically recoverable in the Coastal Plain of the Arctic Refuge, if the current oil market scenario were to improve. This volume is equivalent to a thirty-seven-day supply of oil for the United States at current levels of consumption.

In this paper, WWF-US also examines the practical and economic uncertainties related to potential oil development in the Arctic Refuge brought about by the impacts of warming temperatures. These include challenges related to structures that are vulnerable to permafrost thaw and remote infrastructure that transports oil to market. The Trans-Alaska Pipeline is already being impacted by events such as permafrost thawing, which is threatening the integrity of the built environment at all scales around the circumpolar region. Indeed, scientists have issued stark warnings that thawing permafrost could result in a more rapid deterioration of Alaska's infrastructure than previously predicted, increasing the economic and environmental risks associated with oil and gas development.

In this paper WWF-US also examines corporate and legal risks associated with developing oil from Arctic Refuge leases, which have factored into the private sector's rejection of opportunities to invest in Arctic oil extraction. Banks, insurance companies, and shareholders are increasingly unwilling to finance, insure, or support oil and gas projects in the Arctic Refuge. Legal cases from indigenous and environmental groups could also slow or halt future developments.

In short, considering the modeled uneconomic breakeven price for oil leases in the Arctic Refuge, further exacerbated by other practical and economic uncertainties described in this research paper, WWF-US's review demonstrates that oil and gas development from the recently awarded Arctic Refuge leases is unlikely to be economically profitable to produce.

An Overview of the Quest for Oil in the Arctic Refuge

Alaskan oil

Discovery[3] of large oil fields in Alaska began in 1957 with the first commercial find in south-central Alaska on the Kenai Peninsula. Following statehood in 1959 and the creation of state natural resources agencies, oil production around south-central Alaska yielded moderate production gains in the state. Then in 1967, North America's largest oil field was discovered at Prudhoe Bay, on the North Slope of Alaska. The Trans-Alaska Pipeline was built between 1975 and 1977 to transport North Slope oil to market, resulting in a dramatic increase in production in 1977.[4]

Oil production in Alaska peaked in the late 1980s, driven by the development of the Prudhoe Bay oil field. Since then, production has been steadily declining (see Figure 1). This trend in recent decades has been spurred by a lack of new economically exploitable discoveries and increasing public and industry opposition to drilling in sensitive Arctic environments. In the last several years, major oil companies such as BP and Shell, long active and interested in Alaska oil, have moved or are moving their operations out of the state.

Alaskan oil production has also significantly declined as a proportion of U.S. oil production (see Figure 2).[5] Since 1981 Alaska's share of U.S. oil production has fallen from 19% in 1981 to 4% in 2020.[6]

However, the oil industry carries on in Alaska today with continued exploration, proposing more development, and bidding for, and winning, new leases. Most recently, in January 2021 the outgoing U.S. Administration held a lease sale that included parcels in the Arctic Refuge.

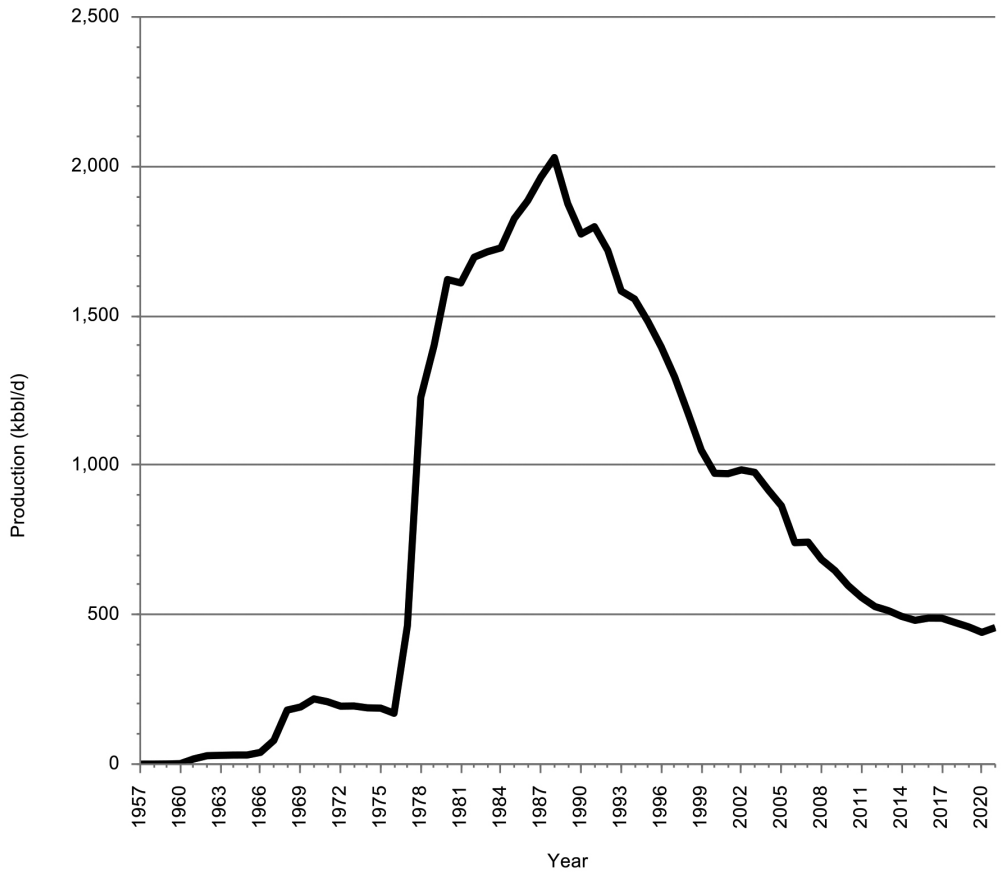

Figure 1. Alaskan crude oil production. Reference: Rystad Energy UCube (August 2021)

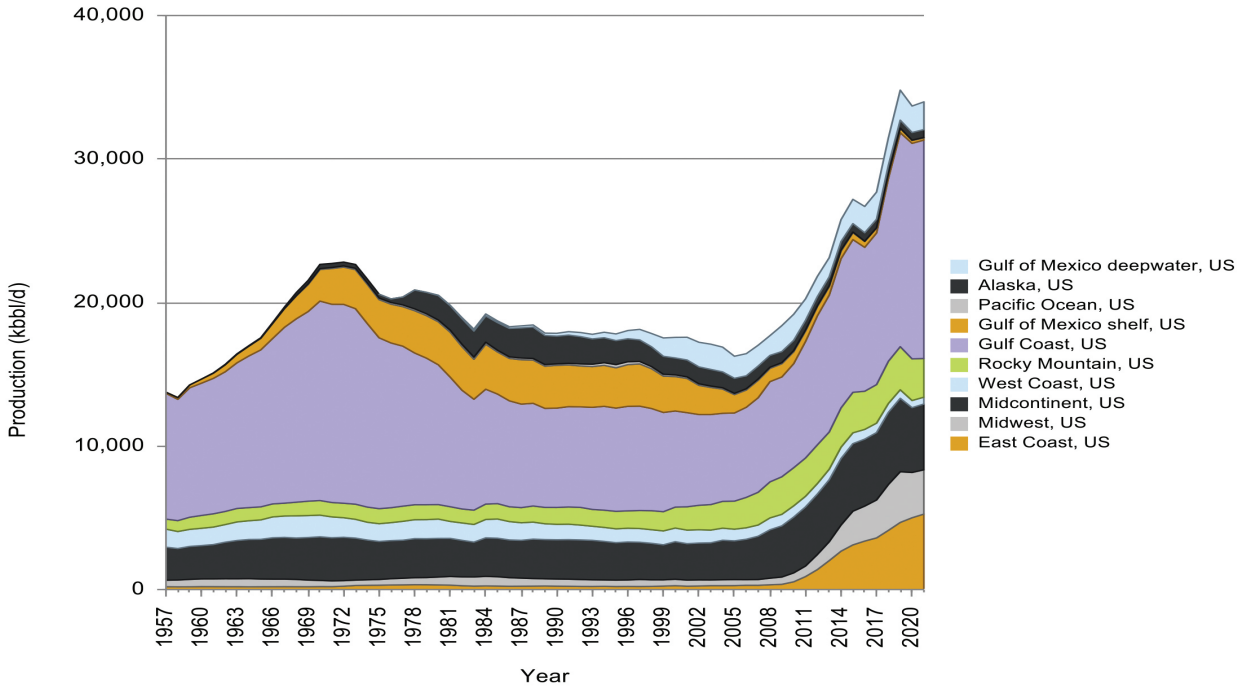

Figure 2. U.S. crude oil production. The contribution of Alaskan oil to the U.S. total is declining. Alaska oil production is the dark strip at the top of the graph. Reference: Rystad Energy UCube (August 2021)

The Arctic National Wildlife Refuge

The Arctic Refuge was designated in 1960 because of its "unique wildlife, wilderness, and recreational values." Originally called the Arctic National Wildlife Range, this was the first ecosystem-scale conservation area established in the United States. Through the Alaska National Interest Lands Conservation Act (ANILCA), in 1980 Congress expanded the Range and renamed it the Arctic National Wildlife Refuge. Through ANILCA Congress also precluded oil and gas development on the Coastal Plain of the Arctic Refuge absent specific congressional authorization.

Within the Arctic Refuge, one area in particular -- the Coastal Plain -- is a critically important area for wildlife, from polar bears denning along its coast in winter to the Porcupine Caribou Herd using the Coastal Plain as their birthing grounds and nursery in the spring. The Coastal Plain is also a place of importance for the Iñupiat and Gwich'in people; it has sustained these Indigenous peoples for thousands of years culturally and nutritionally. For the Gwich'in, the Coastal Plain is Iizhik Gwats'an Gwandaii Goodlit, the "Sacred Place Where Life Begins."

Potential oil in the Arctic Refuge

Little oil and gas exploration has occurred in the Arctic Refuge, and there are no proven oil and gas plays[7] at this point. The limited exploration wells and seismic testing undertaken in the Arctic Refuge in the 1980s were neither extensive nor comprehensive. Only a single oil and gas exploratory well has been drilled within the boundaries of the Coastal Plain, though the results from that effort have been held strictly confidential.

From 1998 to present, based on scant field data, United States Geological Survey (USGS) has carried out scientific assessments of technically and economically recoverable oil resources from the North Slope of Alaska, with the agency's data and conclusions varying from assessment to assessment.[8,9,10,11] These assessments included 1002 Area of the Arctic Refuge, either solely or aggregated into a wider geographic area. The U.S. government's economic assessments of the oil and gas resources located in the 1002 Area – the very assessments used to justify the 2021 Arctic Refuge lease sale – have been largely based on the USGS's outdated 1998 assessment of potential undiscovered oil resources in that region, an assessment that itself was based on limited seismic, old well, and sample data to extrapolate and predict the potential for oil in the Arctic Refuge.

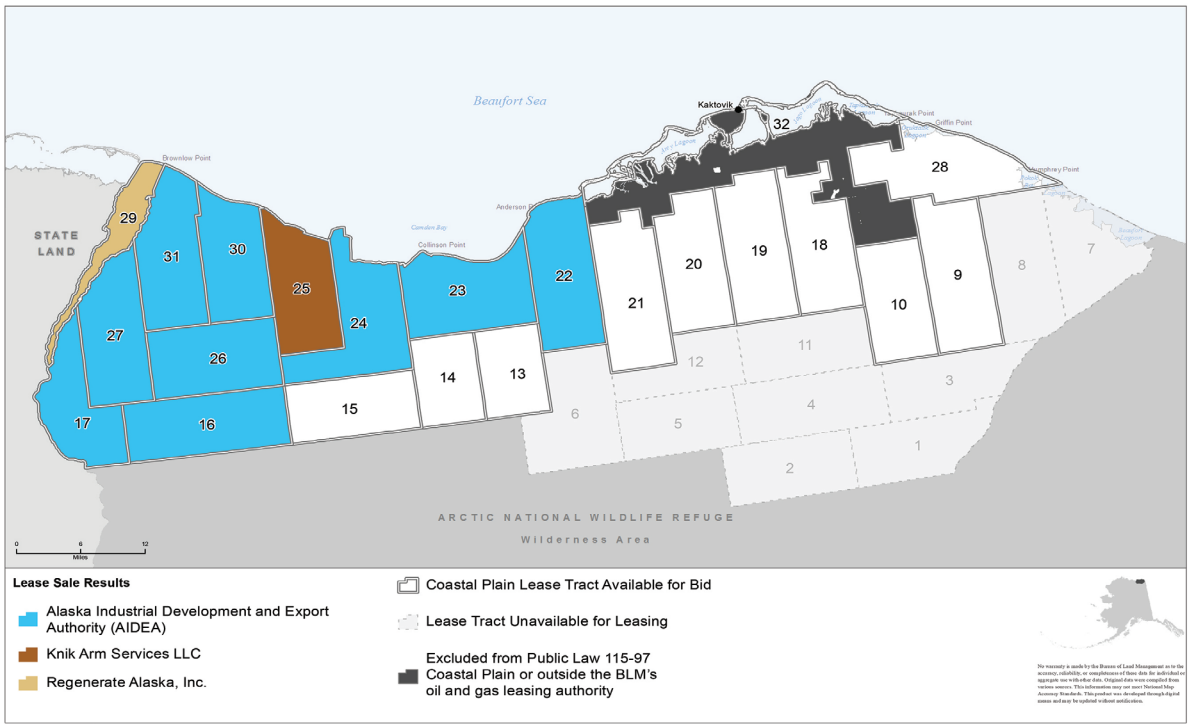

Figure 3. Coastal Plain lease sale results map 2021. Bureau of Land Management. 6 January 2021. Note: The final number of leases awarded was 9 (tracts 22 and 23 were not ultimately awarded).

In light of the energy transition away from oil and gas and lower oil prices predicted in the future, WWF-US set out to review the economics of potential oil discovery and exploitation in the Arctic Refuge. To conduct our review, WWF-US obtained the latest available economic and resource data from Rystad Energy, an independent energy consulting service and business intelligence data firm. In doing so, WWF-US's analysis notes a number of discrepancies with and criticisms of the outdated USGS economic assessments used by the U.S. Government to justify opening the Arctic Refuge to oil and gas leasing.

Status of oil leases in the Arctic Refuge

In December 2017, U.S. Congress passed a tax bill containing a provision authorizing two oil and gas lease sales to be held in the Arctic Refuge before 2024[12] on the premise that doing so would generate approximately one billion dollars for the U.S. Treasury.[13] In January 2021 the outgoing U.S. Administration held the first such lease sale. In total 22 leases were offered in the sale. Of those 22 leases offered, only 9 leases were sold (see Figure 3). Major oil companies, including those with deep Alaska experience, did not bid.

The first lease sale generated less than 1% of the revenue anticipated by Congressional leaders who advocated for a mandate to drill in the Arctic Refuge -- a mere $14.4 million. As a whole, industry showed little interest in investing here: 13 leases were left unsold. Of the nine leases sold, two were purchased by local companies – Knik Arm Services and Regenerate Alaska (a wholly owned subsidiary of the Australian company 88 Energy Ltd) – and the other seven to the Alaska Industrial Development & Export Authority (AIDEA), a state-formed public corporation and political subdivision of the State of Alaska.[14] Neither Knik Arm Services nor AIDEA has the experience or capacity to directly develop the leases; rather they bid on the speculation that actual oil companies may someday be interested in exploring their leases.[15] Of the $14.4 million raised through the sale only $2.4 million was raised from the two small companies, while the remaining $12 million was paid for by the State of Alaska itself.[16]

The Arctic Refuge oil and gas program authorized by the 2017 Tax Bill has been challenged in court by Indigenous organizations, tribes, non-governmental organizations, and 15 individual states of the Union. On his first day in office, President Biden issued an order pausing the program pending review of the previous administration's analyses that are legal prerequisites to holding a lease sale.[17] Months later the U.S. Secretary of the Interior (who is responsible for managing the Arctic Refuge) ordered the Interior Department to fully reevaluate the leasing program through a Supplemental Environmental Impact Statement.[18] While these lawsuits remain open today, the new U.S. administration has announced a suspension of any activities under the leases pending additional review of potential environmental impacts.[19]

Climate Change and the Future of Oil

Climate change

Climate change has already caused global temperatures to rise roughly 1.1°C above pre-industrial levels.[20] There is widespread agreement among scientists that unless the current trend of Greenhouse Gas emissions is reversed, temperatures could rise 1.5°C by 2040, 2°C by 2065, and 4°C by 2100, severely impacting nature and people.[21,22,23]

Climate change is impacting humans, from making extreme weather events such as the 2020 Siberian and 2021 northwestern American heatwaves more likely[24,25] to increasing rainfall resulting in deadly floods that also challenge existing infrastructure.[26,27] Globally, an average of 21.5 million people are displaced by weather related events every year.[28] Climate change also threatens wildlife and exacerbates existing pressures on nature. Many species cannot cope with the current rate of climate change. The United Nations (UN) estimates that one million species are threatened with extinction globally.[29]

This warming is not uniform across the globe. The Arctic is one of the most rapidly changing regions on Earth; it has been warming more than twice as fast as the global average for the past 50 years.[30] Arctic warming has led to thawing permafrost, the loss of land and sea ice resulting in increased coastal erosion, sea level rise, and an increase in frequency of some extreme weather events.

Countries around the world are responding to the urgent threat of climate change. In 2015 the UN's Paris Agreement was adopted by 196 countries.[31]By signing the Paris Agreement, these countries have agreed to limit warming to well below 2°C, and to pursue a 1.5°C goal, recognizing limiting carbon emissions to in order to limit warming to 1.5°C would significantly reduce the irreversible impacts of climate change.

The Paris Agreement momentum has been maintained with more than 125 countries representing almost 65% of global GDP making commitments to reduce their emissions to net zero by 2050.[32] However, countries will need to take more action to tackle climate change, as current government climate commitments are on target to take the world on a path towards 2.1-3.9°C global warming.[33]

The UN body for assessing the science related to climate change – the Intergovernmental Panel on Climate Change (IPCC)[34,35] – reinforces the importance of rapid and deep cuts to greenhouse gas emissions to stay within a 1.5°C scenario, calling for reducing emissions by at least 50% by 2030 and achieving net zero by 2050.[36] The IPCC's Sixth Assessment Report released this summer underlines the urgency for this change:[37]

> "Climate change ... brings more intense rainfall and associated flooding, as well as more intense drought in many regions. Further warming will amplify permafrost thawing, and the loss of seasonal snow cover, melting of glaciers and ice sheets, and loss of summer Arctic sea ice. Coastal areas will see continued sea level rise throughout the 21st century, contributing to more frequent and severe coastal flooding."[38]

In short, human activity is driving climate change at a pace and scale unprecedented in human history, making extreme weather events more intense and, for some, more frequent. The climate risk will only increase with continued addition of carbon dioxide to the atmosphere.

The Future of Oil and International Energy Agency's Net-Zero Scenario

Considering global trends in renewable energy and growing policy responses to climate change, financial think tank Carbon Tracker recently concluded that fossil fuel electricity generation has already peaked worldwide.[39] Indeed, the concept of "peak oil" -- that the oil market is driven by the supply of oil, an increasingly scarce resource -- has been replaced with a new economic understanding that market forces – and not availability of the resource – determine the future of oil. Reduced demand for oil associated with the growth of cleaner energy, more efficient technologies, and cheaper technologies has resulted in a global abundance of oil. Other analysts increasingly believe that the next critical trend for oil markets this decade will be an energy transition away from traditional oil. This trend away from oil-based energy will break the link between oil demand and gross domestic product (GDP) and accelerate the global decline of oil demand and production.

As an indicator of these trends, in May of this year the respected International Energy Agency (IEA) modeled a pathway to Net Zero emissions for the global energy sector by 2050, called the Net-Zero Emissions by 2050

(NZE) Scenario.[40] The NZE Scenario provides clarity on targets that must be met as part of the global Net Zero ambition and includes a total of 400 milestones that must be achieved. Five of these milestones clearly set out the trajectory:

- From 2021 there should be no new oil and gas fields approved for development;
- By 2035 no new internal combustion engine cars should be sold and global use of fossil fuels should be 50% of 2020 levels;
- In 2040 oil demand should be 50% of 2020 levels;
- In 2050 renewables should reach almost 90% of total electricity generation; and
- In 2050 almost 70% of electricity generation should come from solar photovoltaic and wind.

In launching the NZE Scenario the IEA recognized the increasing number of countries committed to reaching Net Zero by 2050. The IEA also noted that meeting the ambitious NZE Scenario "would bring major benefits for human prosperity and well-being" as well as provide an opportunity to limit global warming to 1.5oC.[41] Through the NZE Scenario, IEA emphasizes that "the contraction of oil and natural gas production will have far-reaching implications for all the countries and companies that produce these fuels. No new oil and natural gas fields are needed in the net zero pathway, and supplies become increasingly concentrated in a small number of low-cost producers."[42] Indeed, Carbon Tracker's modeling shows that Arctic oil projects are among the least resilient under the NZE Scenario. According to Carbon Tracker, even to meet the IEA's Sustainable Development Scenario (a slower decarbonisation pathway than the NZE Scenario), capital expenditures[43] in the Arctic would have to decline by 72% compared with the previous decade. Without such a reduction, oil projects in the Arctic risk a future of becoming stranded assets.[44]

These new economic analyses raise important questions for frontier oil fields and their future viability. Financiers of oil and gas production are already recognizing the associated risk to any returns. Rather than seek new investments, they are increasingly contemplating how to deal with what inevitably become stranded assets from existing oil and gas projects that have been approved but are not yet developed. The likelihood of this situation was underscored recently by Dr Fatih Birol, the executive director of the IEA, in an interview. Commenting on UK plans to open a new oil field, Birol said: "If we want to reach net zero target in 2050…we have to reduce the consumption of oil, gas and coal substantially. We do not need any more to explore, discover, new oil reserves. The ones we have today are more than enough to meet the demand."[45]

These new economic analyses raise important questions for frontier oil fields and their future viability. Financiers of oil and gas production are already recognizing the associated risk to any returns. Rather than seek new investments, they are increasingly contemplating how to deal with what inevitably become stranded assets from existing oil and gas projects that have been approved but are not yet developed.

In a speech made 100 days before the 2021 Conference of the Parties 26 of the UN Framework Convention on Climate Change (COP26) John Kerry, the US climate envoy, said there is "no need" for any new fossil fuel investments if the world is to meet its climate goals, and urged all major economies to set out tougher action plans for tackling emissions to "protect and preserve the fragile world we share."[46] Mr. Kerry's statement marks a shift in the position of key global policy-makers to recognize the importance of a world without oil and gas, hence raising critical questions and exposing uncertainty for existing and potential oil and gas investors.

Simply put, to avoid the worst consequences of climate change, and as driven by popular pressure, countries and companies around the world must address carbon emissions via robust policy interventions. And this is happening, with countries and businesses expressing unconditional net zero commitments and undertaking concrete actions to drive the global energy transition forward.

While not a global panacea, this dynamic is apparent in, for example, a number of countries (e.g., Denmark, France, Ireland, and New Zealand) initiating measures to phase out oil and gas exploitation. In advance of the 2021 COP26, countries continue to step up their commitments to tackle climate change through Nationally Determined Contributions (NDCs). In the Arctic, for example, the new Greenlandic government has halted all oil exploration, announcing that "[t]he future does not lie in oil. The future belongs to renewable energy, and in

that respect we have much more to gain." This is significant. Although Greenland has not discovered any oil reserves to date, it had been its' government's long-held ambition to explore for and exploit oil reserves to enable the country's independence.[47]

The continuing scientific consensus further drives our understanding of the urgent threat from climate change and need for a speedy energy transition. Climate change now ranks among the top concerns of people around the world, with a majority of global citizens surveyed saying they are very or somewhat worried about climate change (in the United States this number is 66%).[48] In the European Union, the world's largest trading block, a 2021 survey showed that 90% of Europeans surveyed agree that greenhouse gas emissions should be reduced to make the EU climate-neutral by 2050.[49] Consumer and governmental pressures are forcing oil companies to restructure their portfolios to reduce their exposure to potential stranded assets. Companies with a market capitalization of more than $20 trillion are committing to net zero targets by the mid-century, and investors are pushing them to deliver on those plans due to concerns about the potential catastrophic impact on investment returns.[50] As energy industry experts put it: "[t]he debate is no longer whether energy transition will happen but how quickly it will happen."[51]

Like these governments and businesses, WWF supports strong action to address climate change.[52] WWF's main recommendation is that in order to stay within a carbon budget that limits global warming to 1.5 oC, we have to cease exploration for new oil and gas and align existing production and infrastructure with the 1.5 oC threshold.

We now turn to the question of what these global dynamics mean for the economics of oil development on the Coastal Plain of the Arctic Refuge.

Companies with a market capitalization of more than $20 trillion are committing to net zero targets by the mid-century, and investors are pushing them to deliver on those plans due to concerns about the potential catastrophic impact on investment returns. As energy industry experts put it: "[t]he debate is no longer whether energy transition will happen but how quickly it will happen."

Modeling Future Oil Development

Rystad Energy

In this paper, WWF's breakeven oil price analyses and discussion of other economic considerations for oil development in the Arctic Refuge relied on data provided by Rystad Energy. Rystad Energy is one of the world's leading, independent energy consulting service and business intelligence data firms offering global databases, strategy advisory and research products for energy companies and suppliers, investors, investment banks, organizations, and governments.[53]

Rystad Energy maintains a rolling program of data collection and verification to keep their data current and accurate. This data is inputted into the company's UCube database at an individual asset level – the lowest unit of analysis. Rystad Energy's UCube database provides global past, present, and future economic and production data for oil, gas, and condensate projects and fields. The company's algorithm includes exploration, capital, and operational expenditure, taxes, abandonment costs, as well as subsidies for exploration and development. UCube's data has been gathered from government and company reports. Rystad Energy provides sophisticated tools that allow detailed interrogation of the data to model future scenarios based on different price scenarios. This data is used by industry to model their projects' economic viability and is used in this report to model oil project development in the Arctic Refuge based on differing price scenarios.

Future oil price scenarios used in this paper

Rystad Energy runs various future scenarios based on an analysis of, among other things, current energy usage trends, penetration of new energy technologies, oil price scenarios, and national energy policies. Rystad Energy allows users of its services to input their own future price scenarios – such as the IEA's NZE Scenario described above.

For the analysis in this paper, we used Rystad Energy's base case[54] for oil price (currently set at $50 a barrel until 2070) and its low case for oil price ($40 a barrel). The base case is the future oil price scenario that Rystad Energy believes will occur based on current government and company policies. Rystad Energy does not include energy policies addressing climate change that may be under deliberation, but have not been codified.

The IEA's NZE Scenario, also used in our analysis, models a pathway to achieving net-zero carbon emissions in alignment with the Paris Agreement. To model a pathway to net-zero the IEA focuses on carbon emissions from the global energy sector and industrial processes dependent on the energy sector. The IEA's NZE Scenario also includes minimizing methane emissions from the energy sector and reductions in CO2 emissions from land use. The IEA models a pathway to net zero in 2050 by working backwards from the desired aim to achieve the Paris Agreement Goal, showing what is needed if the world is to tackle climate change and avoid the potentially catastrophic consequences for nature, climate, and people. In this way, the NZE Scenario does assume new, more climate friendly, country and business policies.

Central principles in the NZE Scenario focus on the uptake of all the available technologies and emissions reduction options; that all countries cooperate towards achieving net zero emissions worldwide; and there is an orderly transition across the energy sector. The IEA scenarios are specifically designed to keep a balance between demand and supply, and both they and Rystad Energy recognize that predictions of energy prices are subject to uncertainty.

In the NZE Scenario, there are large reductions in the use of fossil fuels over time. As a share of total energy supply, fossil fuels fall from 80% in 2020 to just over 20% in 2050. Emissions reduction comes from sustainable new assets and infrastructure (50%), decarbonizing existing assets (35%), and behavior change and avoided demand (15%). Renewables and electrification make the largest contribution to decarbonization. The NZE Scenario then utilizes this trend of large reductions in the use of fossil fuels and transitions to cheaper renewable sources to conclude that, as demand for fossil fuels decreases, future global oil prices will likewise decrease over time.[55] The IEA's road map for the global energy sector sets out a price pathway to net zero by 2050, with oil prices dropping to $35 in 2030 and $24 a barrel in 2050.

Results

Possible oil assets in the Arctic Refuge

The USGS 1998 petroleum assessment estimates the 1002 Area[56] of the Coastal Plain of the Arctic Refuge holds between 4.3 and 11.8 billion technically recoverable barrels of oil, with a mean value of 7.7 billion barrels.[57] Data on exploratory drilling and seismic testing in the Coastal Plain gathered in the 1980s was included in the assessment, though it is largely held proprietary to, among others, the State of Alaska, as well as some major oil companies that chose not to bid on any leases in the 2021 Arctic Refuge lease sale.

To give us the best estimates for this analysis, we therefore assessed the data and internal modeling held by Rystad Energy related to the Coastal Plain. Rystad Energy's modeling for the 1002 Area suggests a figure of 4.55 billion barrels[58] of technically recoverable oil. However, this figure does not take into account whether that oil can be extracted profitably by a company. Disregarding the modeled uneconomic breakeven price (see *Modeled breakeven prices* section below) Rystad categorizes all undiscovered resources (listed as 'undiscovered awarded', 'undiscovered', 'open acreage' assets) as commercial as well as estimating the volume of resource available based on the data they have gathered. Factoring in the economics of any potential oil discoveries and taking into account other risk factors, the Rystad Energy estimate falls to 668 million barrels[59] of economically recoverable oil in the 1002 Area, if the current oil market scenario were to improve.

Data from Rystad Energy's modeling shows a yield of only 1.64 million barrels of oil for the nine awarded leases in the Arctic Refuge, which is equivalent to a two-hour supply of oil for the United States.

To put this volume of oil in perspective, in 2020 the United States consumed a total of about 6.63 billion barrels of petroleum.[60] At this level of consumption, 668 million barrels of oil is equivalent to a 37 day supply of oil for the United States.[61] Notably, the nine leases awarded in January do not cover the whole of Section 1002 Coastal Plain area. Data from Rystad Energy's modeling shows a yield of only 1.64 million barrels of oil for the nine awarded leases in the Arctic Refuge, which is equivalent to a two-hour supply of oil for the United States.[62]

Asset development time

Nine oil leases in the Arctic Refuge were awarded in January 2021. There is a significant time period between the issuing of leases and the point when assets start producing oil. During this phase, a company undertakes exploration, planning, gaining permissions, a Final Investment Decision,[63] and development, as well as the construction of associated infrastructure.

Lease	Operator	Production start-up Year	Resources (Million bbl)	Breakeven Oil Price (USD/ bbl)
AA 95889, US	AIDEA	2038	0.21	77.60
AA 95890, US	AIDEA	2040	0.18	78.50
AA 95893, US	AIDEA	2040	0.18	80.40
AA 95895, US	Knik Arm Services LLC	2037	0.24	70.80
AA 95897, US	AIDEA	2038	0.19	77.70
AA 95898, US	AIDEA	2040	0.19	80.60
AA 95899, US	88 Energy	2040	0.12	62.50
AA 95900, US	AIDEA	2040	0.16	82.00
AA 95901, US	AIDEA	2043	0.17	83.60

Figure 4. Model-based values for the nine awarded oil leases within the Arctic Refuge their estimated resources (oil and condensate) and their breakeven prices. Reference: Rystad Energy UCube Economic Model (September 2021)

As is usual in instances where data is limited, Rystad Energy analyzed oil leases adjacent to those in the Refuge, and other data on potential oil resources in the Arctic Refuge to build up their best estimate of the asset development time period for the Arctic Refuge leases. Rystad Energy's model suggests the Arctic Refuge oil leases awarded in 2021 could start production in years ranging from 2038 to 2043 (see figure 4).

Companies face the risk that production start dates may slip, given the numerous barriers such as the lack of previous exploration and current data, as well as the financial and legal uncertainties involved in developing potential discoveries in the frontier region. The average time line from the awarding of a lease to the start of production in Alaska is 26 years. If such a schedule were to be the case for development in the Arctic Refuge, actual production from the leases awarded in 2021 would begin in the mid to late 2040s– just at the time when the world needs to be close to net zero carbon emissions.

Modeled breakeven prices

As first noted above, a key determinant for whether an oil company will green light an asset for development is based on that asset's predicted economic breakeven price. The breakeven price indicates the oil price at which the asset is commercial, as seen from the current year (costs and prices). In other words it is the oil price required for a positive Net Present Value[64] for a project at the Final Investment Decision date.[65]

Rystad Energy's modeling suggests the earliest estimate that the Arctic Refuge oil leases could be in production is around 2040 (see Figure 4). In the NZE Scenario the price of oil around 2040 is approximately $28 a barrel, with the other scenario prices being $40 and $50. By comparison, Rystad Energy's modeling shows that the breakeven prices for these leases are between $62.5 and $83.60 – with an average of $77.10 (see Figure 5).

Both of these modeled breakeven oil prices are in line with USGS's previous hypothetical estimate that suggested breakeven oil prices for the Arctic Refuge could be as high as $55 in 2005 dollars,[66] which equals $77 in today's dollars allowing for inflation. The $28 per barrel predicted NZE Scenario price of oil for 2040 is thus 2.75 times lower than the $77 per barrel average breakeven price modeled for the Arctic Refuge leases. It is also noteworthy that the 2021 breakeven oil price for U.S. assets elsewhere is much lower – for example, the Gulf of Mexico deep water is $30.81 and the Gulf Coast is $31.56.

Given the results of modeling the breakeven prices for the nine Arctic Refuge leases, it is evident that in all oil price scenarios oil companies will not make money from such leases. Indeed, even if the current oil prices ($75 a barrel) were to stretch decades into the future only two of the leases could potentially be profitable. However, perhaps more realistically, and as set out above, this is an unlikely scenario. Rystad Energy's modeling indicates that as the world moves to meet NZE Scenario none of these Arctic Refuge oil leases will be economic to develop.

The results from modeling demonstrate that oil production from the Arctic Refuge is highly unlikely be economically viable. The failures of the first Arctic Refuge lease sale further suggest that that Congress' assumption of the total economic benefits to the United States of two Arctic Refuge lease sales appear almost certainly to be orders of magnitude off the mark.

Increased uncertainty and risk

An analysis of the economics of developing oil and gas leases in the Coastal Plain of the Arctic Refuge must also consider the practical and economic uncertainties related to potential oil development in this "frontier" region. These include the risks posed by warming temperatures as well as other corporate and legal risks and uncertainties. These "soft" economic factors and practical logistics will impact company decisions to bid on future lease sales as well as on any Final Investment Decision (FID) to move forward with developing oil and gas leases in the Arctic Refuge.

The Rystad Energy data and modeling are also consistent with other factors uniquely at play with respect to oil developed in the frontier of the Arctic. For example, operating in the harsh, challenging, and remote conditions results in relatively higher operating costs compared to similar projects in temperate climates. Alaska has a difficult and high-cost working environment, with only a brief window of opportunity each year for key activities when the frozen ground allows access.

Moreover, scientific research and recent incidents provide an image of increasing costs and increasing operating risks to oil development in Alaska related to, for example, thawing permafrost. Thawing permafrost poses immediate threats to existing oil and gas infrastructure.[67] The changing conditions impact supporting infrastructure and result in higher operations and maintenance costs. While there is some uncertainty on the gravity of impacts, scientists agree that the oil

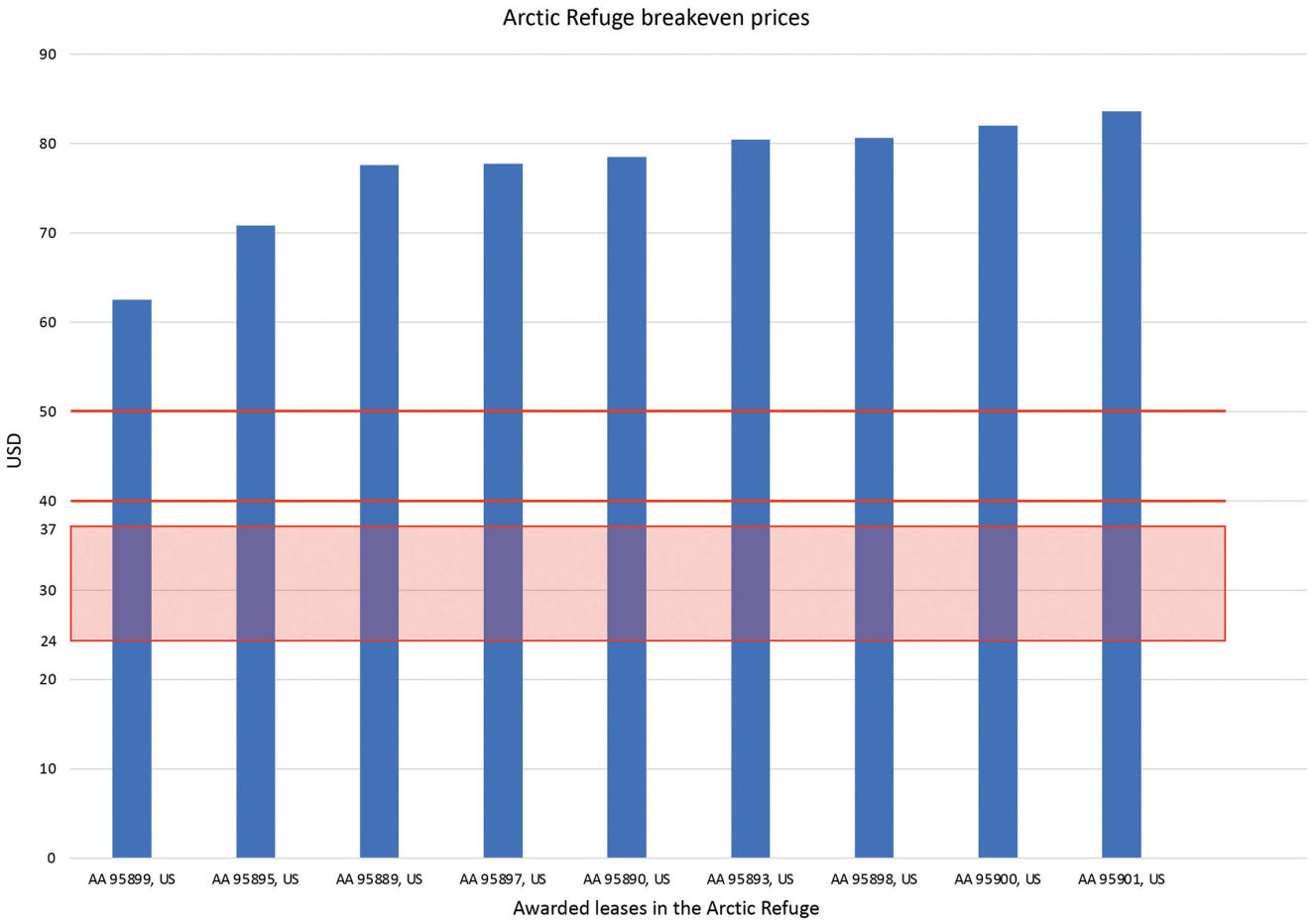

Figure 5: Modeled breakeven prices for the nine leases awarded within the Arctic Refuge. With a breakeven price of around $70 a barrel of oil none of the future oil price scenarios studied (red lines show $50, $40 future oil price scenarios and the red rectangle the varying prices under the IEA NZE scenario) make the leases economical to exploit. Reference: Rystad Energy UCube (September 2021)

and gas industry will be faced with increasing costs in order to adapt to the effects of climate change.[68] In 2019, for example, the Sagavanirktok River flooded a stretch along which the Trans-Alaska Pipeline is located, costing $10 million to repair the damage. In 2018, the State of Alaska spent $2 million to move a section of the Dalton Highway away from an encroaching mass of frozen debris moving down a mountain. The action secured the section of the road until 2038.[69]

Scientists have highlighted that over 500 kilometers of the Trans-Alaska Pipeline is in the region they have identified where near-surface permafrost thaw may occur by 2050.[70] In 2020 the Alyeska Pipeline Service Company pursued a stabilization project on a 250-meter section of slope where permafrost thaw had buckled some of the supporting pipeline braces.[71] More recent research suggests Alaska's roads, pipelines, and bridges will deteriorate faster than previously predicted.[72]

Perhaps a window into Alaska's future was given by Aleksandr Kozlov, the Russian Minister for Natural Resources, when in 2021 he highlighted the increasing difficulties in the construction of roads and railways in the Russian Arctic because of thawing permafrost.[73] In the Russian Arctic, 40% of buildings show signs of buckling and up to 29% of oil and gas production facilities can no longer be operated.[74]

Companies operating in Alaska are responding by adapting their oil projects in the face of the threat from thawing permafrost. For example, ConocoPhillips has proposed to use cooling devices to freeze the areas around the roads and well pads of their Willow project.[75] However these temporary measures will not stop the wider deterioration of the permafrost and its worsening impacts on infrastructure. These costs and uncertainties are unique to Arctic conditions and also support the conclusion that development of oil from the Arctic Refuge faces uniquely challenging economic barriers.

High infrastructure costs associated with development in frontier areas are another critical consideration in the Arctic. Oil fields have been discovered in Alaska that haven't been developed for decades because of the exorbitant expense of building oil pipelines to transport it to market. For example, the Umiat oil field was discovered in 1945,[76] but the current closest oil pipeline is 108 kilometers away. The lack of infrastructure has contributed to preventing its development for the past 76 years.

The Trans-Alaska Pipeline cost $8 billion to construct in 1974, or $44 billion in today's prices. At 789 miles long that is $55.76 million per mile in today's prices.[77] The closest oil pipeline to the mid-point of the Arctic Refuge leases that were awarded in early 2021 is 60 kilometers. To estimate the cost to build such a pipeline, we used the different costs per mile for the oil and gas pipelines across Alaska, acknowledging that oil and gas pipelines will have varying requirements and therefore costs. The loosely calculated estimate to build a 60km (37.5 mile) pipeline to deliver Arctic Refuge oil to current pipeline infrastructure would be between $1.8 and $2.1 billion. No pipeline has been built closer to the Arctic Refuge because only small oil fields have been found adjacent to the Arctic Refuge.

Furthermore, the larger oil companies that could fund exploration and development of expensive new frontier oil assets out of their own capital reserves stayed away from the Arctic Refuge lease sale held in 2021, including those holding the 1980s proprietary drilling data for the Coastal Plain area. All three lessees will need to raise significant capital or partner with other companies to pursue oil and gas exploration and development on the awarded leases.[78]

That no major oil companies bid during the 2021 Arctic Refuge lease sale is indicative of another trend impacting the likelihood of developing leases in the Arctic Refuge: corporate and reputational risk. A barrier to raising capital for Arctic oil and gas projects is the number of banks that have made commitments to exclude financing oil and gas projects in the Arctic Refuge or the wider Arctic region. Out of the 39 banks monitored by BankTrack, 37 have a full or partial exclusion policy for Arctic oil and gas.[79] Over recent decades, the challenges and risks to people, wildlife, and the climate from developing oil in the Arctic Refuge have come into greater focus. This awareness has led to a trend wherein five of the largest banks in the United States and dozens of banks and financial institutions worldwide publicly committed not to finance oil and gas projects in the Arctic Refuge.[80] Insurance companies have also publicly stated that they will not insure development projects in the Arctic Refuge.[81]

As Billy Nauman of the Financial Times summarizes it, "The zeitgeist is certainly changing in finance. Banks are finally waking up to the risk that fossil fuel companies will be forced to leave significant portions of their assets in the ground… At the end of the day, a banker's job is to assess risk — and investing in Arctic oil exploration is just not a smart bet."[82]

Finally, investor pressure and litigation are increasingly holding large oil companies to account on climate change.[83,84,85] Oil companies that ignore the increasing risks from climate change are not only going against global recognition that we need to transition to a low carbon economy but are also increasing the risks that their projects will become stranded assets in the future. Investors are concerned about this dynamic and are putting pressure on the larger companies to align themselves to a net zero pathway.

Larger oil companies are feeling investor and legal pressure to make the transition to a low carbon economy. But recent research questions whether smaller, privately-owned oil companies that do not have an objective to transition to a low carbon economy are aligned to countries' net zero commitments due to their different priorities.[86]

The 2021 Arctic Refuge lease sale was highly controversial. The leases are located in an area containing great ecological and cultural values. With brand values to uphold in the public eye, major oil companies also have reputational reasons to refrain from purchasing leases in the Arctic Refuge. This is reflected by the growing list of banks, financial institutions, and insurance companies unwilling to finance and insure oil and gas projects in the Arctic Refuge, or the Arctic in general. The avoidance of the major companies of the Refuge raises worrying signals for smaller oil companies seeking financial sponsorship to explore these leases as well as insurance cover for their future operations.

Summary

In conclusion, the best available data for the future price of oil, combined with our analysis of the modeling from industry-trusted Rystad Energy, demonstrates that oil production from the Arctic Refuge is unlikely to be economic. This finding is further backed up by the paltry results of the first Arctic Refuge lease sale, as well as other on-the-Arctic-ground and in-the-boardroom factors related to pursuing Arctic Refuge oil. This conclusion also means that the roughly $1 billion economic return to the United States on which Congress based its authorization for an Arctic Refuge oil and gas leasing program is magnitudes off the true mark and thus wholly unrealistic.

Endnotes

1 IPCC, 2021. Climate change widespread, rapid, and intensifying – IPCC

2 A breakeven price is the price at which the cost to manufacture a product is equal to its sale price. For a commodity such as oil, the breakeven price refers to the per-unit cost of production

3 "Discovery" of oil fields generally means the discovery of new fields with proved economic reserves or of new reservoirs of proved reserves in old fields. *See*, U.S. Energy Information Administration, Petroleum & Other Liquids Definitions last accessed 30 September 2021

4 Alaska Humanities Forum. *Oil Discovery and Development in Alaska*. Last accessed 9 September 2021

5 PricewaterhouseCoopers, 2021. *Impacts of the Oil and Natural Gas Industry on the US Economy in 2019*, prepared for American Petroleum Institute

6 U.S. Energy Information Administration. Crude oil production last accessed 19 September 2021

7 A "play" is a group of oil fields in the same region that are controlled by the same set of geological circumstances.

8 USGS, 2001. Arctic National Wildlife Refuge, 1002 Area, Petroleum Assessment, 1998, Including Economic Analysis

9 USGS. E.D. Attanasi and John H. Schuenemeyer, 2002. Frontier areas and resource assessment: case of the 1002 area of the Alaska North Slope

10 USGS. E.D. Attanasi, 2005. Economics of 1998 U.S. Geological Survey's 1002 Area Regional Assessment: An Economic Update.

11 USGS Emil D. Attanasi and Philip A. Freeman, 2009. Economics of Undiscovered Oil and Gas in the North Slope of Alaska: Economic Update and Synthesis.

12 Pub. L. No. 115-97, 131 Sta. 2054 at § 20001 (Dec. 22, 2017).

13 Congressional Budget Office, Cost Estimate, A Legislative Proposal Related to the Arctic National Wildlife Refuge (Nov. 8, 2017).

14 Bureau of Land Management, 2021 Coastal Plain Lease Report (Jan. 19, 2021).

15 KTOO, 2021. Drilling boosters, opponents consider next steps after first Arctic refuge lease sale

16 Bureau of Land Management, 2021 Coastal Plain Lease Sale Bid Recap (Jan. 6, 2021).

17 Executive Order 13990, Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis, Section 4(a) (Jan. 20, 2021).

18 Department of Interior, Secretarial Order No. 3401 (June 1, 2021).

19 Department of Interior, Secretarial Order No. 3401 (June 1, 2021).

20 IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J. B. R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu and B. Zhou (eds.)]. Cambridge University Press. In Press

21 IPCC, 2014: Summary for Policymakers. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. S

22 Current NDCs remain seriously inadequate to achieve the climate goals of the Paris Agreement and would lead to a temperature increase of at least 3°C by the end of the century. UNEP, 2020. Emission Gap Report 2020.

23 Climate Nexus website. Comparing climate impacts at 1.5°C, 2°C, 3°C and 4°C, last accessed 9 September 2021

24 World Weather Attribution initiative, 2020. Siberian heatwave of 2020 almost impossible without climate change

25 World Weather Attribution initiative, 2021. Western North American extreme heat virtually impossible without human-caused climate change

26 Reuters, 2021. From China to Germany, floods expose climate vulnerability

27 World Weather Attribution initiative, 2021. Heavy rainfall which led to severe flooding in Western Europe made more likely by climate change

28 Internal Displacement Monitoring Centre, 2016. Global Report on Internal Displacement

29 The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, 2019. Global Assessment Report on Biodiversity and Ecosystem Services

30 AMAP (2017) Snow, Water, Ice and Permafrost

31 United Nations, 2015. The Paris Agreement.

32 FT, 2021. Business can be a force for change on climate

33 According to Climate Action Tracker (https://climateactiontracker.org/) we are on an average path to 2.9°C warming with current policies (2021)). 2021 NDC Synthesis Report by UNFCCC, shows only marginal gap reduction

34 IPCC. 2018. Climate Change and Land, summary for policymakers

35 IPCC, 2019. Special Report on the Ocean and Cryosphere in a Changing Climate [SROCC].

36 IPCC Special Report Global warming of 1.5°C, Summary for policymakers "The report finds that limiting global warming to 1.5°C would require "rapid and far-reaching" transitions in land, energy, industry, buildings, transport, and cities. Global net human-caused emissions of carbon dioxide (CO2) would need to fall by about 45 percent from 2010 levels by 2030, reaching 'net zero' around 2050. This means that any remaining emissions would need to be balanced by removing CO2 from the air."

37 IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J. B. R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu and B. Zhou (eds.)]. Cambridge University Press. In Press.

38 IPCC, 2021: Climate change widespread, rapid, and intensifying – IPCC

39 Carbon Tracker, 2021. Switch to clean energy will cuts costs, create local jobs and save millions of lives

40 The IEA, 2021. Net Zero by 2050: A Roadmap for the Global Energy Sector. IEA analyses are widely used by governments and businesses to inform their strategies.

41 Ibid 40.

42 Ibid 40.

43 Capital expenditure means the funds used by a company to acquire, upgrade, and maintain physical assets such as property, plants, buildings, technology, or equipment. *Carbon Tracker*'s report utilizes capital expenditures for projects that are both: (1) fully approved by government and industry, with a final investment decision to move forward, and (2) projects that may be approved by government and industry with the final go-ahead in the next decade.

44 Carbon Tracker, 2021. Adapt to Survive: Why oil companies must plan for net zero and avoid stranded assets

45 Channel 4 news, 2021. Interview on 22 July reported on Twitter.

46 Independent, 2021. 'No need' for new fossil fuels anywhere in world, says John Kerry

47 AP, 2021. Greenland suspends oil exploration because of climate change

48 Leiserowitz, A., Carman, J., Buttermore, N., Wang, X., Rosenthal, S., Marlon, J., & Mulcahy, K. (2021). International Public Opinion on Climate Change. New Haven, CT: Yale Program on Climate Change Communication and Facebook Data for Good.

49 European Commission website, 2021. Citizen support for climate action. Last accessed 9 September 2021

50 FT, 2021. Big investors demand annual vote on companies' net zero plans

51 Gaffney Clime, 2021. State of Alaska: Assessment of Recent Trends in Upstream Oil & Gas and the State of Alaska's Competitive Position

52 WWF, 2021. The transition away from oil and gas: a WWF network policy position

53 Rystad Energy website: https://www.rystadenergy.com/

54 A "base case" analysis generally refers to the results obtained from running an economic model with the most likely or preferred set of assumptions and input values. Sensitivity analyses and use of "low case" analysis may then be used to explore how the results may deviate from those of the base case analysis when input values and/or modeling assumptions are altered.

55 The IEA used 2019 prices in its NZE Scenario, whereas Rystad uses 2021 prices meaning that the IEA scenario is not perfectly aligned with Rystad's modeling. That said, the impact on the future prices in the scenarios, and therefore our analyses was not deemed to be significant.

56 The 1002 Area generally covers the Coastal Plain of the Arctic Refuge, and the label comes from Section 1002 of ANILCA.

57 USGS website, 2001. Arctic National Wildlife Refuge1002 Area, Petroleum Assessment, 1998, Including Economic Analysis, Last accessed 9 Sept 2021

58 Rystad Energy's UCube figure of 4.552 billion barrels of oil includes only the conventional resource potential estimates (oil and condensate), and not unconventional resources. "Unconventional" refers to crude oil that is obtained through methods other than traditional vertical well extraction.

59 Likewise, Rystad Energy's UCube figure of 668 million barrels includes only the conventional resource potential estimates (oil and condensate), and not unconventional resources.

60 U.S. Energy Information Administration website. *How much oil is consumed in the United States?* Last accessed on 9 September 2021

61 668 million barrels in the Arctic Refuge / 6.63 billion barrels per year = 0.1007 * 365 days = 37 days. Assuming the Arctic Refuge supply was the sole source of oil and consumed all at once.

62 1.64 million barrels economically recoverable in the 9 leases / 6.63 billion barrels U.S. consumption per year * 365 days * 24 hours = 2.17 hours. Assuming the Arctic Refuge supply was the sole source of oil and consumed all at once.

63 The Final Investment Decision date is the date in the life cycle of a project when a company decides to move forward with it, or not.

64 "Net Present Value" refers to the difference between the present value of cash inflows and the present value of cash outflows over a period of time. Net Present Value is used in capital budgeting and investment planning to analyze the profitability of a projected investment or project. Net Present Value is the result of calculations used to find today's value of a future stream of payments. If the Net Present Value of a project or investment is positive, it means that the discounted present value of all future cash flows related to that project or investment will be positive, and therefore attractive to develop.

65 The "Final Investment Decision" means the date in the life cycle of a project when a company decides to move forward with it, or not.

66 Attanasi, E. D. 2005. Undiscovered Oil Resources in the Federal Portion of the 1002 Area of the Arctic National Wildlife Refuge: An Economic Update. USGS Open-File Report 2005-1217

67 E&E News, 2021. Permafrost thaw threatens Alaska's largest oil pipeline

68 Alaska Public Media, 2020, On warming North Slope, one flood response last year cost pipeline operator $10 million

69 Anchorage Daily News, 2018. State reroutes Dalton Highway to dodge migrating 'blob'

70 Hjort, J., Karjalainen, O., Aalto, J. *et al.* Degrading permafrost puts Arctic infrastructure at risk by mid-century. *Nat Commun* 9, 5147 (2018).

71 NBC News, 2021. Trouble in Alaska? Massive oil pipeline is threatened by thawing permafrost

72 University of Alaska, 2021. Roads, bridges, pipelines and other types of infrastructure in Alaska and elsewhere in the Arctic will deteriorate faster than expected

73 The Barents Observer, 2021. The looming Arctic collapse: more than 40% of north Russian buildings are starting to crumble

74 The Barents Observer, 2021. The looming Arctic collapse: more than 40% of north Russian buildings are starting to crumble

75 Bloomberg Law, 2020. Alaska Project Would Use 'Chillers' to Freeze Thawing Tundra (1)

76 88 Energy website, last accessed 9 September 2021

77 Alaska Centres. The Trans-Alaska pipeline, last accessed 9 September 2021

78 KTOO, 2021. Drilling boosters, opponents consider next steps after first Arctic refuge lease sale

79 BankTrack website. Banks and Arctic oil & gas. Last accessed 9 September 2021

80 Banktrack. Policy scores Excel spreadsheet in Exclusion table Arctic oil and gas

81 Gwich'in Steering Committee, 2020. *GSC Scorecard Rates Insurance Companies on Arctic Refuge Policies*

82 Financial Times, 2021. Empty gestures in the Arctic

83 Bloomberg, 2021. Shell Loses Climate Case That May Set Precedent for Big Oil

84 Reuters, 2021. Exxon loses board seats to activist hedge fund in landmark climate vote

85 Reuters, 2021. Chevron investors back proposal for more emissions cuts

86 DeSmog, 2021. 'Gathering Storm': How 'Rogue' Companies are Buying up North Sea Oil and Gas

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