Institute *for* Policy Integrity
NEW YORK UNIVERSITY SCHOOL OF LAW

March 9, 2018

VIA ELECTRONIC SUBMISSION

Attn: Department of the Interior, Bureau of Ocean Energy Management, 1849 C Street, NW, Washington, D.C. 20240

Subject: Comments on the 2019-2024 Outer Continental Shelf (OCS) Oil and Gas Leasing Draft Proposed Program

The Institute for Policy Integrity at New York University School of Law[1] respectfully submits these comments to the Department of the Interior's (Interior) Bureau of Ocean Energy Management (BOEM) on its draft proposed five-year offshore leasing program for 2019-2024 (Draft Proposed Program or DPP). Policy Integrity is a non-partisan think tank dedicated to improving the quality of government decisionmaking through advocacy and scholarship in the fields of administrative law, economics, and public policy.

EXECUTIVE SUMMARY

The Outer Continental Shelf Lands Act (OCSLA) directs the Secretary of the Interior (Secretary) to develop and periodically revise a five-year schedule of proposed Outer Continental Shelf (OCS) oil and gas lease sales that specifies the size, timing, and location of leasing activity that will, in the Secretary's determination, best meet national energy needs.[2] When developing the program, the Secretary must consider all relevant factors[3] including "the potential for environmental damage, the potential for the discovery of oil and gas, and the potential for adverse impact on the coastal zone,"[4] and quantify all costs and benefits as fully and as accurately as possible.[5] Additionally, leasing activities must be

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[1] No part of this document purports to present New York University School of Law's views, if any.
[2] 43 U.S.C. § 1344(a).
[3] *California v. Watt* ("Watt I"), 688 F.2d 1290, 1317 (D.C. Cir. 1981) (holding courts can review Interior's leasing discretion for arbitrariness and failure to consider relevant factors); *Motor Veh. Mfrs. Ass'n v. State Farm Ins.*, 463 U.S. 29, 43 (1983) (agency decisions are arbitrary if they entirely fail to consider an important aspect of the problem).
[4] 43 U.S.C. § 1344(a)(3).
[5] Exec. Order No. 12,866 § 1(a), 58 Fed. Reg. 51,735, 51,735 (Oct. 4, 1993) (codified at 45 C.F.R. pt. 88); Exec. Order No. 13,563 § 1(a), 76 Fed. Reg. 3821, 3821 (Jan. 18, 2011) (affirming cost-benefit principles specified in Exec. Order 12,866); Exec. Order No. 13,777 § 2(a), 82 Fed. Reg. 12285, 12285 (Feb. 24, 2017) (listing Exec. Order 12,866 as an initiative and policy guiding regulatory review).

conducted “to assure receipt of fair market value for the lands leased and the rights conveyed by the Federal Government.”[6]

Part I of our comments explains that the Draft Proposed Program fails to meet Interior’s statutory mandates. Before it finalizes the program, BOEM must take additional steps to strengthen its analysis in order to meet OCSLA’s requirements, including its duty to balance economic, social, and environmental values in managing the Outer Continental Shelf. Specifically, BOEM must:

- **Keep the deepwater offshore royalty rate at 18.75 percent, as this rate, set under the George W. Bush administration, is necessary to ensure fair market value for the public’s resources.** Decreasing the royalty rate would deliver less total revenue to the public for its oil and gas resources, confer an unjustified windfall to private industry at the expense of the public, and violate Interior’s mandate to ensure fair market value for OCS resources.
- **Significantly reduce the number of OCS areas and tracts scheduled for lease sales.** BOEM should end “area wide leasing,” which has ushered in record-low bids and little to no competition for offshore leases, violating its mandates to earn fair market value and hold competitive auctions.
- **Quantify and monetize climate change effects, and include these calculations in its “net social value” (NSV) calculation.** BOEM’s NSV calculation is deficient because it does not include cost estimates for greenhouse gas (GHG) emissions (upstream or downstream).
- **Improve its option value analysis by quantifying environmental and social uncertainties, and exclude several areas from the Program on this basis.** BOEM should use existing techniques to quantify environmental and social cost uncertainties and incorporate them into its option value analysis. Further, as detailed in Part II below, BOEM’s hurdle price analysis—a key component of its option value analysis—suffers from myriad flaws which render the analysis deficient and unfairly biased towards including too many OCS regions in the Program.
- **Give adequate weight to possible catastrophic effects from oil spills and the outsized risk that heavily-populated coastal areas face from increased drilling.** BOEM vastly understates the risk of catastrophic oil spills and, therefore, the potential for adverse impacts on the coastal zone. In addition, BOEM must consider that densely populated areas without a recent history of drilling activity face an outsized risk from inclusion in the Program.
- **Apply in an evenhanded manner to all states the principles that led Secretary Zinke to exclude offshore areas bordering Florida from new offshore leasing.** At least nine coastal states, thus far, have submitted comments opposed to new or increased offshore leasing off their coasts, citing dependence on coastal tourism and concerns about environmental, social, and environmental

[6] 43 U.S.C. § 1344(a)(4).

effects associated with offshore oil and gas activity. The Secretary must apply the same principles that led him to exclude offshore areas bordering Florida to these other states, and explain why he made this decision outside of the OCSLA process.

- **Exclude from the program any areas that were withdrawn from oil and gas leasing for a time period without specific expiration by President Obama pursuant to OCSLA section 12(a).** The President does not have authority to remove these protections, and Interior does not have authority to offer these areas for lease.

In addition, Part II of our comments (beginning on page 15) addresses technical and economic issues, including modeling errors, inconsistencies, and arbitrary assumptions in BOEM's models and corresponding analyses. BOEM must correct several inaccurate assumptions, errors, and omissions that bias its models and analyses toward leasing and development of the OCS. Specifically, BOEM must:

- **Ensure consistency in the inputs of its models and various analyses, selecting the modeling input with the strongest underlying factual basis.** BOEM conducts its net economic and social valuation analyses assuming price-levels of $40, $100, and $160. These prices are inconsistent with its estimated $90 per barrel of oil (in 2019 USD) trend price and corresponding volatility of 32% in its fair market value analysis. BOEM should apply the statistics-based $90 price estimate using a range of $30 to $150 in all analyses.

- **Model and analyze the full impacts of increased environmental risks and externality costs that will result from expanding drilling in the OCS.** BOEM should integrate the critical risks of catastrophic oil spills and greenhouse gas emissions into both its net social value analysis (by revising Offshore Environmental Cost Model (OECM)) and its fair market value analysis (by revising Web3). State representatives are clearly concerned with risks of catastrophic oils spills, endangered species loss, and greenhouse gas emissions from the Draft Proposed Plan. Despite the availability of monetary estimates, BOEM excluded the cost of catastrophic oil spills and GHG emissions from its net social value and fair market value analyses. BOEM must include the cost of catastrophic oil spills and GHG emissions in all of its modeling and analyses.

- **Make all relevant data and models freely available for public download so that the public can review them.** BOEM does not sufficiently explain all of the calculations and assumptions underlying its analyses. Because the data and models are also unavailable, it is impossible for the public to determine BOEM's full set of modeling assumptions, and thus to replicate its work. BOEM should provide all data and models, or at minimum, full instructions and explanations.

- **Correct its hurdle price analysis in Web3 to address methodological errors that bias its resulting estimates towards development.** BOEM incorrectly calculates a hurdle price for each OCS region by: (1) failing to explicitly model the delay time until development, and (2) incorrectly calculating the expected field size. Instead of modeling the development delay, BOEM incorrectly uses *uncertain* forecasted prices of oil and gas, missing the whole point of hurdle prices and option value. Correcting these errors would likely result in fewer OCS regions passing the hurdle price threshold. Further, instead of using the arithmetic mean to measure expected value of field size, BOEM incorrectly uses maximum field size, despite a lack of information on the location of larger fields, leading to premature development of OCS regions. Additionally, BOEM fails to recognize that expected field size is a function of price and that it holds an American-style option (i.e., multiple concurrent options), not a Europe-style option. BOEM must correct its hurdle price analysis to avoid inefficiently opening OCS regions or including them in the Program before their optimal development time.

- **Provide reasoned explanations for changing its definition of maximum field size and its choice of price forecasts in its hurdle price analysis, as these changes also bias BOEM's analysis towards development.** While BOEM should not be using maximum field size at all (see bullet point above), if BOEM fails to address this deficiency, it must also address errors in how it defines maximum field size. BOEM updated its definition of maximum field size from the 90^{th} percentile to the 95^{th} percentile of the distribution of undiscovered economically recoverable oil and gas quantities without providing a reasoned explanation. Similarly, BOEM updated forecasted oil and gas prices from the 2016 AEO forecasts to the 2017 AEO forecasts, without providing a reasoned explanation for ignoring the 2018 AEO forecasts and other price forecasts used in the 2017-2022 Proposed Plan. At minimum, BOEM should use the currently available 2018 AEO forecasts, which would significantly narrow the number of OCS regions passing the hurdle price analysis to only five out of fifteen. BOEM's hurdle price analysis suffers from myriad flaws which render it unfairly biased towards including too many OCS regions in the Program.
- **Explicitly model the portion of option value corresponding to environmental and social costs.** Contrary to BOEM's assertions, the option value literature in the natural resource context is increasingly well developed. BOEM must account for all uncertainty relevant to BOEM's fair market value assessment. This includes the uncertainty of market, social, and environmental costs (including non-catastrophic and catastrophic oil spills and upstream greenhouse gas emissions). BOEM has the data to calibrate the corresponding stochastic processes.
- **Conduct sensitivity analyses, including Monte Carlo simulations, to improve transparency and test the robustness of its numerical results.** BOEM's minimal level of sensitivity analyses (of only resource price) is unacceptable given the significant uncertainties that underlie each of BOEM's analyses**.** BOEM should review the literature to calibrate central parameter values and their corresponding ranges (or underlying distributions). When unavailable, BOEM should employ expert elicitation. BOEM should then conduct sensitivity analyses, including Monte Carlo simulations, with regard to key

modeling parameters: market, social, and environmental costs, the assumed stochastic processes, elasticities, and underlying scenarios. Such analysis should be conducted using each of BOEM's models.

Our detailed comments follow below.

I. THE PROGRAM MUST BE IMPROVED TO ENSURE THE RECEIPT OF FAIR MARKET VALUE AND TO STRIKE AN APPROPRIATE BALANCE AMONG ECONOMIC, SOCIAL, AND ENVIRONMENTAL VALUES.

Section 18(a)(1) of OCSLA requires that Interior conduct its leasing program "in a manner which considers economic, social, and environmental values of the renewable and nonrenewable resources contained in the OCS and the potential impact of oil and gas exploration on other resource values of the OCS and the marine, coastal, and human environments."[7] In selecting the timing and location of leasing, the Secretary must strike a proper balance between "the potential for environmental damage, the potential for the discovery of oil and gas, and the potential for adverse impact on the coastal zone."[8] BOEM must improve its analysis for the 2019-2024 program in order to strike an appropriate balance among economic, social, and environmental values, and consider the full range of factors in making any future decisions.

OSCLA also requires that Interior use "competitive bidding"[9] to lease tracts, and that it receive "fair market value for the lands leased and the rights conveyed by the Federal Government."[10] By proposing to decrease the offshore royalty rate and continue to hold uncompetitive lease auctions, Interior fails to meet its statutory mandates.

A. Interior should keep the deepwater offshore royalty rate at 18.75 percent, as this rate, set under the George W. Bush administration, is necessary to ensure fair market value for the public's resources.

OCSLA requires that the royalty rate for offshore oil and gas leases be set at no lower than 12.5 percent,[11] but Interior is authorized to set a higher rate. Interior should retain the current deepwater offshore royalty rate of 18.75 percent, which is consistent with more than a decade of bipartisan efforts to deliver fair market value to the American public.

The deepwater offshore royalty rate was raised from 12.5 percent to 18.75 percent during the George W. Bush administration.[12] At the time, Interior estimated that the rate

[7] 43 U.S.C. § 1344(a)(1).
[8] *Id.* at § 1344(a)(3).
[9] 43 U.S.C. § 1337.
[10] 43 U.S.C. § 1344(a)(4).
[11] 43 U.S.C. § 1337(a)(1)(A).
[12] *See* CONG. RES. SERV., OUTER CONTINENTAL SHELF: DEBATE OVER OIL AND GAS LEASING AND REVENUE SHARING at CRS-2 (2008), http://www.au.af.mil/au/awc/awcgate/crs/rl33493.pdf; U.S.

increase would raise revenue by $8.8 billion over the next 30 years.[13] Interior increased the rate in response to technological improvements that made exploration and production more efficient, increased oil and gas prices, and strong interest in offshore leases. A former Secretary of the Interior stated that increasing the offshore rate was necessary to ensure that "the American taxpayer is getting a fair return for the oil and gas that the American people own."[14]

Despite the increased revenue associated with higher royalty rates, in the DPP, BOEM states that it is contemplating lowering the rate, including by switching from a fixed royalty rate to a price-based royalty.[15] This system would tie royalty rates to oil and gas prices, which would allow the government to lower royalty rates in times of low oil prices.[16] Decreasing the royalty rate would deliver less total revenue to the public for its oil and gas resources, would deliver an unjustified windfall to private industry at the expense of the public, and would violate the Secretary's mandate to ensure fair market value for OCS resources. The stark lack of analysis supporting a lower offshore royalty shows that Interior lacks a reasoned basis for such a change. Accordingly, Interior should not lower the royalty rate, nor switch to a price-based royalty system that could decrease the royalty rate below current levels.

Instead, Interior should consider raising the royalty rate. A higher royalty rate would likely lead to a higher return for the American public. As an illustrative example, a study recently reviewed by the U.S. Government Accountability Office (GAO) estimated that raising the federal royalty rate for onshore oil and gas to 16.67 percent, 18.75 percent, or 22.5 percent could increase net federal revenue by $125 to $939 million over 25 years.[17] The Congressional Budget Office estimated that if the royalty rate for onshore oil and gas parcels were raised from 12.5 percent to 18.75 percent, net federal revenue would increase by $200 million over the first 10 years, and potentially by much more over the following decade.[18]

Bureau of Ocean and Energy Mgmt., Proposed Final Outer Continental Shelf Oil & Gas Leasing Program 2012-2017 96 (2012), https://perma.cc/NTZ6-HRBQ.

[13] Government Accountability Office, OIL AND GAS ROYALTIES: THE FEDERAL SYSTEM FOR COLLECTING OIL AND GAS REVENUES NEEDS COMPREHENSIVE REASSESSMENT 17 (Sept. 2008), https://www.gao.gov/assets/280/279991.pdf.

[14] Hon. Ken Salazar, Secretary of the Interior, "Interior, Environment, and Related Agencies Appropriations for 2013," Testimony before the House Committee on Appropriations, Subcommittee on Interior, Environment, and Related Agencies (Feb. 16, 2012), pp. 46–47, http://www.gpo.gov/fdsys/pkg/CHRG-112hhrg74739/pdf/CHRG-112hhrg74739.pdf ("The underlying principle is we are mandated by statute, mandated by fairness to make sure the American taxpayer is getting a fair return for the assets the American people own.").

[15] Draft Proposed Program at 10-21.

[16] Draft Proposed Program at 10-21.

[17] U.S. GOVT. ACCOUNTABILITY OFFICE, GAO-17-540, OIL, GAS, AND COAL ROYALTIES (2017) at 22–23, https://www.gao.gov/assets/690/685335.pdf.

[18] *Id.* at 22 (citing Congressional Budget Office (CBO), Options for Increasing Federal Income from Crude Oil and Natural Gas on Federal Lands (Washington, D.C.: April 2016),

Increasing federal royalty rates would also bring Interior's rates more in line with those imposed by states and other countries. A recent survey found that most energy-rich states set royalty rates for production of their resources between 15 and 20 percent; Texas has a 25 percent rate for oil and gas production.[19] Further, a 2008 report found that the United States "receives one of the lowest overall 'takes' worldwide for oil, gas, and coal leases."[20] And as recently as July 2017, GAO reported that "state oil and gas rates tend to be higher than federal royalty rates," and that raising federal fossil fuel royalty rates would increase total revenue for the federal government and the states with which it shares that revenue.[21]

Moreover, fossil fuel royalty rates are inefficiently low because they do not account for environmental and social impacts. These low rates do not require oil and gas companies to internalize the pollution costs they impose on the environment and the public through their exploration and production activities, and as a result, they encourage inefficiently high levels of extraction and production, and place the expense of mitigating costly climate and other pollution on the public.

Interior can price climate-related externalities into royalty rates using the Social Cost of Carbon and the Social Cost of Methane.[22] Incorporating social costs into the royalty rate works particularly well given that both environmental externalities and the total value of the royalty rate vary as production levels vary.[23] By raising the royalty rate to include these externality costs, the Secretary can better fulfill his statutory mandate to balance environmental values and development, and ensure fair market value for the lands leased.[24]

In short, available data indicate that Interior should consider raising royalty rates, rather than lowering them. Interior has a duty to the public to ensure fair market value, and must take actions consistent with that mandate.

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https://www.cbo.gov/sites/default/files/114th-congress-2015-2016/reports/51421oil_and_gas_options-OneCol-3.pdf).

[19] Jayni Foley Hein, *Harmonizing Preservation and Production*, Institute for Policy Integrity at 20 (June 2015).

[20] *Id.* at 21.

[21] U.S. GOVT. ACCOUNTABILITY OFFICE, GAO-17-540, OIL, GAS, AND COAL ROYALTIES (2017) at 1, 16, https://www.gao.gov/assets/690/685335.pdf.

[22] Jayni Foley Hein, *Federal Lands and Fossil Fuels: Maximizing Social Welfare in Federal Energy Leasing*, 42 HARV. ENVTL. L. REV. __, [9], [22] (2018). ("The Social Cost of Carbon quantifies the economic damages associated with a small increase in carbon dioxide emissions, conventionally one metric ton, in a given year… EPA's Social Cost of Methane builds on this framework" to similarly quantify the social costs of methane.). *Id.* at [37].

[23] *Id.* at [22].

[24] *See id.; See generally* Jayni Foley Hein & Caroline Cecot, *Mineral Royalties: Historical Uses and Justifications*, 28 DUKE ENVTL. L. & POL'Y F. 1 (2017).

B. **BOEM should significantly reduce the number of OCS areas and tracts presently scheduled for lease sales, and end "area wide leasing," which has ushered in record-low bids and little to no competition for offshore leases, violating Interior's mandates to earn fair market value and hold competitive auctions.**

The Secretary is directed to allocate oil and gas leases through "competitive bidding."[25] However, the vast majority of recent lease sales have been anything but competitive. In BOEM's last offshore lease sales in August 2017, 90 percent of tracts received only one bid.[26] And over the past 20 years, 76.6 percent of the leases awarded in the Gulf of Mexico were awarded based on a single bid.[27] This uncompetitive bidding leaves a staggering sum of money that belongs to the public on the table. For example, in one of the rare instances in the August 2017 offshore lease sale where there were two bidders for a tract, one company bid $3.5 million and the second, winning company bid more than triple that amount—$12.1 million.[28]

The problem of uncompetitive offshore lease sales is not new. It has persisted ever since Interior adopted "area wide leasing" in 1983. Area wide leasing means that all available (unleased and not restricted) acreage in the planning area is offered in the sale auction.[29] Adjusted for inflation, the average price paid per offshore tract since 1983 has declined from $9,068 to $391 per acre in each Gulf of Mexico auction—a decline of 95.7 percent.[30] The Project on Government Oversight's analysis shows the American people have lost tens of billions of dollars in revenue over the last three decades because of area wide leasing and Interior's failure to reject inadequately low bids.[31] This is revenue that supports important state, local, and federal projects, including (but not limited to) environmental protection and recreation. The State of Louisiana requested on several occasions the use of leasing systems other than area wide leasing, such as agency tract selection.[32]

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[25] 43 U.S.C. § 1337.
[26] *See* Michael Livermore & Jayni Hein, *The Keys to Our Coastal Kingdom*, U.S. NEWS (Jan. 10, 2018, 2:30 PM), https://www.usnews.com/opinion/economic-intelligence/articles/2018-01-10/oil-wins-american-coast-and-people-lose-under-offshore-drilling-expansion.
[27] David S. Hilzenrath & Nicholas Pacifico, *Drilling Down: Big Oil's Bidding*, PROJECT ON GOV'T OVERSIGHT (Feb. 22, 2018), http://www.pogo.org/our-work/articles/2018/drilling-down-big-oils-bidding.html?wpisrc=nl_energy202&wpmm=1.
[28] Bureau of Ocean Energy Management, Oil and Gas Lease Sale 249, Preliminary Bid Recap, Gulfwide Lease Sale (August 16, 2017) at 16, https://www.boem.gov/Sale-249-Preliminary-Bid-Recap-by-Areaand-Block-for-All-Bids/.
[29] Draft Proposed Program, *supra* note 1 at 10-16.
[30] Project on Government Oversight, Drilling Down: Big Oil's Bidding (Feb. 22, 2018), http://www.pogo.org/our-work/articles/2018/drilling-down-big-oils-bidding.html.
[31] Project on Government Oversight, Press Release: Offshore Giveaway to Big Oil Cheats Taxpayers out of Billions (Feb. 22, 2018), http://www.pogo.org/about/press-room/releases/2018/press-releaseoffshore-giveaway-to-big-oil-cheats-taxpayers-out-of-bilions.html.
[32] Draft Proposed Program at 10-16.

BOEM itself has recognized that some bidders have received windfalls due to its methodological shortcomings, stating, "[I]n some cases BOEM issued leases where it estimated the block [lease tract] values to be negative, the blocks were issued for near minimum bid, and the lessees made discoveries of substantial size."[33]

Basic principles of supply and demand show that the extensiveness of the DPP's contemplated lease sales would lower overall bid prices and, as a result, the government's bid revenue. If the market is flooded with potential offshore tracts, then the price paid for those leases will decline relative to a more restricted market.

By purporting to offer an even *greater* number of OCS tracts for lease in the 2019-2024 program, while continuing to conduct sales in an uncompetitive manner, the Secretary is abdicating his duties to hold competitive auctions and earn fair market value for taxpayers.[34] BOEM must hold competitive lease sales and limit the number of tracts offered for lease at each auction, in order to earn fair market value.

C. BOEM should quantify and monetize climate change effects, and include these calculations in its net social value calculation.

BOEM uses its Offshore Environmental Cost Model (OECM) to calculate the environmental and social costs associated with OCS exploration and development, and uses these costs to calculate the Net Social Value (NSV) of OCS activities. The NSV "provides the secretary with a quantitative ranking of planned areas based on resources and the economic, environmental, and social costs required to extract those resources."[35] However, the NSV calculation is deficient because it does not include cost estimates for greenhouse gas (GHG) emissions, whether upstream or downstream.[36] Further, because the OECM does not consider certain catastrophic effects such as major oil spills in its NSV calculation,[37] its calculation of upstream costs is incomplete.

As discussed further in Part II, below, while the OECM model estimates upstream air emissions for the greenhouse gases carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (NO_x), it does not apply a monetary value to these pollutants.[38] BOEM should monetize these emissions, including by using the Interagency Working Group's (IWG's) Social Cost of Carbon and Social Cost of Methane, and incorporate these costs into its NSV calculation. To improve accuracy, BOEM should also monetize the emissions of downstream GHG emissions and include those costs in its NSV analysis.

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[33] Bureau of Ocean Energy Management, https://www.boem.gov/2017-2022-OCS-Oil-and-GasLeasing-PFP/.
[34] *See* 43 U.S.C. § 1344(a)(4).
[35] Draft Proposed Program at 5-16.
[36] Draft Proposed Program at B-8.
[37] Draft Proposed Program at B-8.
[38] Draft Proposed Program at B-8–9.

BOEM's discussion of upstream environmental and social costs is also inadequate because the OECM model does not include effects that are subject to high levels of uncertainty or are not easily monetized, such as those from catastrophic oil spills or effects on endangered or threatened species.[39] The devastating effects of a major oil spill occurring as a result of exploration and development is a concern shared by governors whose coasts would be open to exploration under the DPP.[40] BOEM must account for possible catastrophic effects in its analysis. See Part II, below, for technical details.

Finally, at the next stage, BOEM must conduct substitution analysis properly. In general, it would be arbitrary for BOEM to make methodological improvements that support BOEM's desired outcome only; updates to its methodology must be made holistically.

D. BOEM should strengthen its option value analysis and exclude several areas from the Program on this basis.

BOEM's current approach to option value falls short in its failure to quantify environmental and social cost uncertainty. BOEM should use existing techniques to quantify these uncertainties and incorporate them into its option value analysis. Further, BOEM's hurdle price analysis suffers from myriad flaws which render it unfairly biased towards including too many OCS regions in the Program. Moreover, even BOEM's current option value analysis supports excluding areas from the 2019-2024 Program.

Option value is the value of delaying a decision until a later time when more information is available. BOEM states that it considers option value in the DPP in analyzing the size, timing, and location of its lease sales. Relevant uncertainties that BOEM acknowledges include resource uncertainty, capital and operating costs and extractive technology uncertainty, environmental and social cost uncertainty, regulatory and legal environment uncertainty, and price uncertainty.[41]

BOEM analyzes price uncertainty quantitatively, through a "hurdle price" analysis, but considers other uncertainties that can affect OCS oil and gas development value in only a qualitative manner, "given difficulties in quantifying the informational value of delay and lack of well-established methods to quantify such considerations."[42] The D.C. Circuit has recognized the "tangible present economic benefit to delaying the decision to drill for fossil fuels to preserve the opportunity to see what new technologies develop and what new information comes to light."[43] BOEM notes that it is "evaluating existing literature on

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[39] Draft Proposed Program at B-8.
[40] Edmund G. Brown, Kate Brown & Jay Inslee, Request for Information and Comments on Preparation of 2019-2024 Outer Continental Shelf Oil and Gas Leasing Program (2017), available at http://www.opc.ca.gov/webmaster/_media_library/2017/08/Tri-state-OCS-letter-to-Zinke-FINAL-9-8-17.pdf.
[41] Draft Proposed Program at 10-3–12.
[42] Draft Proposed Program at 10-6.
[43] *Center for Sustainable Economy v. Jewell*, 779 F.3d 588, 611-12 (D.C. Cir. 2015).

quantifying the informational value of delay [for unquantified uncertainties] and could incorporate these methods" in future analyses.[44]

First, BOEM must utilize existing methodologies that have been used in the natural resources context to quantify relevant uncertainties and strengthen its option value analysis. BOEM is now capable of estimating portions of option value corresponding to both market and environmental costs. BOEM's option value analysis is deficient because it does not include quantitative considerations of environmental and social cost uncertainty, or the possibility of irreversible damage.[45] See Part II.F., below, for more detail.

Second, BOEM's hurdle price analysis suffers from myriad flaws which render it deficient and unfairly biased towards including too many OCS regions in the Program. See Parts II.D. and II.E., below, for more detail.

Third, even BOEM's existing (deficient) option value analysis supports excluding certain OCS regions from the Program at this stage. For example, the DPP shows that the Central California Planning Area had a hurdle price sufficiently high to delay leasing.[46] The Secretary maintains, however, that this finding does not obligate the Secretary to exclude the area.[47] The Secretary should exclude this area from further leasing due to the outcome of the hurdle price analysis in furtherance of his mandate to achieve fair market value, as well as his duty to strike the proper balance between "the potential for environmental damage, the potential for the discovery of oil and gas, and the potential for adverse impact on the coastal zone."[48]

Moreover, BOEM's option value analysis, especially with the improvements noted above, also supports excluding several other areas, including the Washington/Oregon, Northern California, Chukchi Sea, Gulf of Alaska, North Atlantic, Mid-Atlantic, and the South Atlantic Planning Areas,[49] all of which possess significant uncertainty as to commercial resource development potential and environmental and social risks.

Finally, BOEM includes many OCS regions in the DPP that it previously excluded from OCS leasing in its Final Program (for 2017-2022), due in part to option value. BOEM should exclude these areas from the Program or, at minimum, offer a rational explanation as to why it is including them going forward, breaking with its past conclusions.

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[44] Draft Proposed Program at 10-6.
[45] Draft Proposed Program at 10-11.
[46] Draft Proposed Program at 10-15.
[47] *Id.* ("To capture the option value of new information becoming available that could make an area more or less profitable to lease, the Secretary may choose to include or exclude areas regardless of the relationship between the hurdle prices and current prices."). The Secretary has not definitively said whether this area would be excluded, and noted that "additional and more robust analysis could be conducted at later stages." *Id.*
[48] 43 U.S.C. § 1344(a)(3).
[49] *See* Draft Proposed Program at 4-6 - 4-7.

E. BOEM must give adequate weight to possible catastrophic effects from oil spills, and the outsized risk that heavily-populated coastal areas would face from increased drilling.

OCSLA Section 18(a)(3) requires the Secretary to structure the leasing program in such a manner "as to obtain a proper balance between the potential for environmental damage, the potential for the discovery of oil and gas, and the potential for adverse impact on the coastal zone."[50] The DPP suggests that BOEM is vastly understating the risk of catastrophic oil spills, and therefore, the potential for adverse impacts on the coastal zone. In addition, in conducting its required OCSLA balancing, BOEM should acknowledge that the economic benefits alleged may be s to the economic costs in the long-run, and that the benefits cited in the DPP will be enjoyed nationally, while the potential costs will be borne disproportionately by the coastal areas closest to production.

The DPP understates the potential for increased oil production to have significant, deleterious effects on the environment. For example, regarding the risk of oil spills, the DPP focuses on the reforms and safety improvements made since the 2010 Deepwater Horizon spill, rather than the ever-present risk of another catastrophic spill occurring.[51] While the DPP includes the potential for oil spills in its analysis of social and environmental costs, it does so with the assumption that the reforms implemented post-Deepwater Horizon will improve safety significantly.[52] However, it is not clear that these regulations will prove sufficiently effective absent other improvements, many depending on voluntary industry compliance,[53] and BOEM concedes that the risk of another catastrophic spill cannot be reduced to zero as long as OCS oil and gas production continues.[54] More fundamentally, this assumption is problematic in light of recent efforts by the administration to weaken several such safety regulations.[55] And as detailed in Part II.B., below, catastrophic oil spills are far from unexpected and can and should be accounted for in BOEM's modeling and analysis. These risks must be given sufficient weight in attempting to strike a proper balance under Section 18(a)(3).

BOEM also concedes that the risk of adverse environmental effects may be higher in the areas off of more densely populated areas, as well as areas that have seen little offshore

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[50] 43 U.S.C. § 1344(a)(3).
[51] Draft Proposed Program at 2.
[52] *Id.*
[53] *See* Joseph E. Aldy, *Real-Time Economic Analysis and Policy Development During the BP Deepwater Horizon Oil Spill* 22 (Harv. Kennedy School Regulatory Policy Program, Working Paper RPP-2011-04, 2011) ("New government regulations may not be sufficient" to achieve optimal safety in offshore drilling).
[54] Draft Proposed Program at 2.
[55] *See, e.g,* Institute for Policy Integrity, Comment Letter on Proposed Revisions of Oil and Gas Production Safety Systems (Jan. 19, 2018), http://policyintegrity.org/documents/NYU_Policy_Integrity_Comments-Oil_Gas_and_Sulphur_Proposed_Rule-Final.pdf.

drilling recent years, such as the Atlantic and Pacific Coasts.[56] This weighs strongly in favor of excluding them from further consideration.

Finally, in conducting its required OCSLA balancing, BOEM should acknowledge that the economic benefits alleged may be smaller than the economic costs in the long-run, and that the benefits cited in the DPP will be enjoyed nationally, while the potential costs will be borne disproportionately by the coastal areas closest to production. Section 18(a)(2)(b) mandates consideration of "an equitable sharing of developmental benefits and economic risks among the various regions."[57] The DPP describes increased revenue, jobs, and wages as the main examples of developmental benefits attached to leasing.[58] However, these stated benefits do not account for the possibility that any production may be short-lived; any growth in jobs or revenue, for example, will not extend past a lapse in production, while certain environmental harms may last much longer. Furthermore, many of the benefits cited in the DPP will be enjoyed nationally (such as bonus bid, rental payments, and the majority of royalty revenue), while the potential costs will be borne disproportionately by the coastal areas closest to production.

F. Interior must apply in an evenhanded manner to the other states the principles that led Secretary Zinke to exclude Florida.

Under OSCLA Section 18(a)(2)(f), the Secretary must consider the "laws, goals, and policies of affected States which have been specifically identified by the governors of such States as relevant matters for the Secretary's consideration."[59] At least nine coastal states, thus far, have submitted comments by their governor (or an agency specifically designated to comment on behalf of the governor) opposed to increased offshore leasing and citing environmental, social, and environmental risks associated with increased exploration and production activities.[60] Other state governors noted several concerns that must be addressed before they will provide full support for increasing offshore leasing.[61]

For example, Massachusetts Governor Charles Baker submitted a comment explaining that "the Commonwealth does not support inclusion of areas of the North Atlantic adjacent to or affecting Massachusetts," and stated that neither exploration nor leasing has been justified in the North Atlantic for more than three decades and that model still holds true."[62] The governors of California, Oregon, and Washington authored a joint comment in which they noted, among other concerns, "that the states' people understand the looming catastrophe of climate change that requires the Nation to move away from fossil fuel consumption to a more prosperous, sustainable and clean energy economy."[63]

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[56] Draft Proposed Program at 7-33 ("Impacts could be more evident where there is a higher coastal population density.").
[57] 43 U.S.C § 1344(a)(2)(B).
[58] Draft Proposed Program at 8-3; *id.* at 8-9 – 8-10.
[59] 43 U.S.C § 1344(a)(2)(F); *Watt*, 668 F.2d at 1311 (holding that OSCLA mandates the Secretary must give adequate consideration to "the potential impediments to exploration and development posed by state laws and policies").
[60] Draft Proposed Program at 9-2–3.
[61] *Id.*; Draft Proposed Program at 9-9.
[62] Draft Proposed Program at A-21.
[63] *See* Draft Proposed Program at A-17.

North Carolina Governor Roy Cooper stated that "drilling threatens the state's coastal economy and environment" and requested that the current prohibition of leasing off North Carolina's coast be maintained.[64] Interior must give adequate consideration to these statements and not lease off the coasts of these states unless it can provide a compelling reason to do so.

On January 9, 2018, Secretary Zinke announced, via Twitter, that Florida would be "tak[en] off the table for oil and gas" offshore leasing.[65] He made this statement even though the DPP as released on January 4, 2018 (just four days earlier) lists several proposed lease sales off Florida's coast: in the Southern Atlantic, Straits of Florida, and Eastern Gulf of Mexico OCS regions.[66] Secretary Zinke cited the opposition expressed by Republican Governor Rick Scott and Florida's reliance on coastal tourism revenue as the basis for his decision.[67] If this standard (*governor objection* + *tourism dependence* = *exclusion*) is applied universally, it should also cover several other states whose governors have requested equal treatment, such as California,[68] New York,[69] and Virginia.[70]

Indeed, while Florida's revenue from ocean-related tourism is estimated at $7.7 billion per year[71], the Draft Proposed Program estimates that New Jersey's revenue from ocean-related tourism is $10.8 billion per year, and New York's reaches $33.9 billion.[72] The Secretary must explain the standard used to arrive at his decision to exempt Florida and then apply it across-the-board to all states *see*king to be removed from the five-year program. [73]

The Administrative Procedure Act prohibits an agency from taking action that is "arbitrary, capricious, an abuse of discretion, or otherwise not in accordance with law."[74] To satisfy this standard, the Secretary must provide an adequate rationale for his

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[64] Draft Proposed Program at A-22.
[65] Secretary Ryan Zinke (@SecretaryZinke), TWITTER (Jan. 9, 2018, 3:48 PM), https://perma.cc/8RU4-M38W (linking to longer statement and stating, "Read my full statement on taking #Florida off the table for offshore oil and gas. Local voice matters.")).
[66] Draft Proposed Program at 8, 9.
[67] Secretary Ryan Zinke (@SecretaryZinke), TWITTER (Jan. 9, 2018, 3:48 PM), https://perma.cc/8RU4-M38W.
[68] Darryl Fears, *Beaches Line the Coast Like Pearls. Other States Ask Why Florida's are More Special.*, WASH. POST (Jan. 10 2018), https://www.washingtonpost.com/news/energy-environment/wp/2018/01/10/beaches-line-the-coast-like-pearls-other-states-ask-why-floridas-are-more-special/?utm_term=.ae67eb6b80ea (quoting the California Attorney General as replying: "If that's your standard, we, too, should be removed from your list. Immediately.").
[69] Andrew Cuomo (@NYGovCuomo), TWITTER (Jan. 9, 2018, 5:01 PM), https://twitter.com/NYGovCuomo/status/950895402953428992.
[70] Ralph Northam (@RalphNortham), TWITTER (Jan. 9, 2018, 7:07 PM), https://twitter.com/RalphNortham/status/950927169517248512.
[71] Draft Proposed Program at 6-29.
[72] *Id.*
[73] *See Nat. Res. Def. Council v. Hodel*, 865 F.2d 288, 305 (D.C. Cir. 1988) (finding the Secretary has a duty "to identify his legal or factual basis and to explain why he acted as he did" in adjudicating nominations for exclusion).
[74] 5 U.S.C. § 706(2)(A).

premature exclusion of Florida and any subsequent refusal to apply the same standard to other states.[75]

G. Interior should not include any offshore areas in the Program that were withdrawn from oil and gas leasing for a time period without specific expiration by President Obama pursuant to OCSLA section 12(a).

Section 5 of Executive Order 13795, reversing action taken by President Obama in a December 20, 2016 Presidential Memorandum to withdraw certain unleased lands in the Chukchi Sea, Beaufort Sea, and Atlantic Ocean,[76] is unlawful. OSCLA grants the President the authority to "withdraw from disposition any of the unleased lands of the outer Continental Shelf," but it does not allow a subsequent President to reverse such an action, and there is no sufficient basis to find implied authority.[77] All areas of the OCS that have been withdrawn from oil and gas leasing pursuant to OCSLA section 12(a) must be removed from further consideration in this Program, as the President and Secretary do not have authority to offer them for lease.

PART II: ECONOMIC AND TECHNICAL COMMENTS

This part of our comments focuses on improving the economic modeling and corresponding analyses underlying BOEM's 2019-2024 Draft Proposed Program.[78] In preparing the Program, BOEM uses three models: Offshore Environmental Cost Model (OECM), When Exploration Begins, version 3 (Web3), and the Market Simulation model (MarketSim). Our comments at this stage focus primarily on modeling errors,

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[75] *Encino Motorcars, LLC v. Navarro*, 136 S. Ct. 2117, 2125 (2016) ("One of the basic procedural requirements of administrative rulemaking is that an agency must give adequate reasons for its decisions."); *See also Animal Legal Def. Fund, Inc. v. Perdue*, 872 F.3d 602, 619 (D.C. Cir. 2017) ("Agency action may be consistent with the agency's authorizing statute and yet arbitrary and capricious under the APA") (citing *Humane Soc'y of the United States v. Zinke*, 865 F.3d 585, 2017 WL 3254932, at *10 (D.C. Cir. 2017)).

[76] *See* Juliet Eilperin, *Trump signs executive order to expand drilling off America's coasts: 'We're opening it up.'*, WASH. POST (April 28, 2017), https://www.washingtonpost.com/news/energy-environment/wp/2017/04/28/trump-signs-executive-order-to-expand-offshore-drilling-and-analyze-marine-sanctuaries-oil-and-gas-potential/?utm_term=.597777307f09; *See also* Valerie Volcovici & Timothy Gardner, *Obama Bans New Oil, Gas Drilling Off Alaska, Part Of Atlantic Coast*, REUTERS (Dec. 20, 2016), https://www.reuters.com/article/usa-obama-drilling/obama-bans-new-oil-gas-drilling-off-alaska-part-of-atlantic-coast-idUSL1N1EF1MH.

[77] *See, e.g.* Kevin Leske, *"Un-shelfing" Lands Under the Outer Continental Shelf Lands Act (OCSLA): Can a Prior Executive Withdrawal Under Section 12(A) be Trumped by a Subsequent President?*, 26 N.Y.U ENVTL. L.J. 1 (2017); Jayni Hein, *Monumental Decisions: One-Way Levers Towards Preservation in the Antiquities Act and Outer Continental Shelf Lands Act*, 48 ENVTL. L. 1 (forthcoming 2018), available at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3028341.

[78] *See* U.S. DEPARTMENT OF THE INTERIOR, BUREAU OF OCEAN ENERGY MANAGEMENT, 2019-2024 OUTER CONTINENTAL SHELF OIL AND GAS LEASING DRAFT PROPOSED PROGRAM (January 2018) [hereinafter "DRAFT PROPOSED PROGRAM"].

inconsistencies, and arbitrary assumptions in OECM and Web3, and BOEM's corresponding analyses.[79]

As brief background, BOEM applies OECM to calculate the social and environmental externalities from drilling within an OCS region to use as an input into its Net Social Value (NSV) analysis.[80] The NSV analysis calculates the net social benefits of drilling in each OCS regions using three alternative oil price scenarios. BOEM uses WEB3 to calculate a hurdle price due to oil price uncertainty in its Fair Market Value (FMV) analysis.[81] With the aim of maximizing present value of social net benefits over time, the hurdle price of an OCS region is the barrel of oil equivalent (BOE) price at which BOEM should open the OCS region to exploration (of at least one field) when the BOE price goes above it. [82]

BOEM must correct several inaccurate assumptions, errors, and omissions that bias its models toward leasing and development of the OCS in the near-term, as opposed to not leasing.

A. BOEM must ensure consistency in the inputs of its models and various analyses, selecting the modeling input with the strongest underlying factual basis.

BOEM currently conducts its net economic value (NEV) and net social value (NSV) analyses using three price-level assumptions: $40, $100, and $160.[83] Yet, BOEM does not provide a reasoned explanation for this price range, or adequately explain the empirical basis for this range, which may be too high and therefore improperly bias the analysis towards lease sales.

BOEM states that it selected these values because "these price cases are consistent with the Bureau of Ocean Energy Management's (BOEM) *Assessment of Undiscovered Technically Recoverable Oil and Gas Resources of the Nation's Outer Continental Shelf, 2016*." (hereinafter, the 2016 National Assessment).[84] But these numbers are inconsistent with BOEM's own regression analysis of historical oil and gas prices.[85] Assuming a mean-reverting model, BOEM estimates a trend price of $90 per barrel (bbl) of oil (in 2019

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[79] BOEM is expected to use MarketSim at later stages of the five-year program planning process; we plan to submit comments on BOEM's MarketSim model and analysis at that time.
[80] *Id.* at B4-B10.
[81] *Id.* at 6; *id.* at 10-1-10-23; *id.* at B17-B20.
[82] *Id*. Alternatively, BOEM defines hurdle price as "The price below which delaying exploration for the largest potential undiscovered field in the sale area is more valuable than immediate exploration." As we discuss below, this definition is inaccurate in its reference to the "largest potential undiscovered field" instead of the expected (i.e., arithmetic mean) field size. BOEM's definition is also inconsistent with its own application of the hurdle price in that it compares the hurdle price to an expected price, and not the current BOE price.
[83] We will presume that these prices are in 2016 U.S. dollars given the date of the 2016 National Assessment, though we were unable to find this in either the Draft Proposed Program or 2016 National Assessment. U.S. DEPARTMENT OF THE INTERIOR, BUREAU OF OCEAN ENERGY MANAGEMENT, ASSESSMENT OF UNDISCOVERED TECHNICALLY RECOVERABLE OIL AND GAS RESOURCES OF THE NATION'S OUTER CONTINENTAL SHELF (2016) [hereinafter, the 2016 National Assessment].
[84] Draft Proposed Program at B-6; *Id.*
[85] Draft Proposed Program at B-19.

dollars) with a volatility of 32% (i.e., a standard deviation of $28). Assuming a normal distribution of price, the 95th percent confidence interval for price is $33 to $146. Thus, each price used in BOEM's analysis should be shifted down by $10. Without this shift, the current price range lacks a statistical basis and is inconsistent with BOEM's fair market value (FMV) analysis.

A $10 shift in the current analysis is significant. Looking at Figure 5-15 on page 5-23 and Table 5-3 on page 5-25 of the Draft Proposed Program, drilling in many OCS regions provides relatively small net social benefits even at the $100 price; this is without accounting for the non-monetized costs of catastrophic oil spills and GHG emissions (See Section II.B). A shift downwards by $10 may result in some regions having "negligible development value," and therefore, would support their removal from the 2019-2024 Program. As such, BOEM is unable to assert that drilling in a significant portion of the currently considered OCS regions has positive net social value at the long-run trend price of $90/bbl.

BOEM should adjust each of its prices downwards by $10 for its NEV and NSV analyses and explain or rectify the disparity between its two analyses.

B. BOEM must model and analyze the full impacts of increased environmental risks and externality costs that will result from expanding deepwater drilling in the OCS. Specifically, it must integrate the critical risks of catastrophic oil spills and greenhouse gas emissions into both its net social value analysis (by revising Offshore Environmental Cost Model (OECM) and its fair market value analysis (by revising Web3).

By contemplating an aggressive expansion of the number of OCS regions offered for leasing for oil and gas production—including near populous coastal communities, in extreme climates, and in uniquely sensitivity ecosystems—the public will be exposed to greater environmental and social risk. However, BOEM does not adequately quantify this risk in its analyses of net social value (NSV) or fair market value (FMV).

Following BOEM's publication of the DPP, many state governors and representatives, from both political parties, wrote to Secretary Zinke to request the removal of their corresponding OCS region from consideration in the Program. In addition to impacts on tourism and coastal economies, many of these letters cited three critical concerns: the risk of catastrophic oils spills, increased greenhouse gas (GHG) emissions, and the loss of species and their habitat.[86]

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[86] Letter from Andrew Cuomo, Governor, State of New York, to Ryan Zinke, U.S. Secretary of the Interior, Department of the Interior (January 15, 2018) available at https://www.governor.ny.gov/news/governor-cuomo-issues-letter-calling-us-secretary-interior-ryan-zinke-exempt-new-york-offshore; Letter from Henry McMaster, Governor, State of South Carolina, to Ryan Zinke, U.S. Secretary of the Interior, Department of the Interior (January 16, 2018), available at https://cdn.southcarolinaradionetwork.com/wp-content/uploads/2018/01/McMasterletter1.pdf; Letter from Larry Hogan, Governor, State of Maryland; Dannel P. Malloy, Governor, State of Connecticut; John C. Carney, Governor, State of Delaware; Roy Cooper, Governor, State of North Carolina; Charles D. Baker, Governor, State of Massachusetts, Gina M. Raimondo, Governor, State of Rhode island; Ralph S. Northam, Governor,

BOEM does not place a monetary value on catastrophic oil spills, greenhouse gas emissions, or the loss of endangered and threatened species in its NSV and FMV analyses.[87] Nor does the agency measure the impacts of onshore oil infrastructure or loss of bequest, existence, and altruistic values. Finally, BOEM models only a small portion of ecological impacts—to habitat and organisms—excluding catastrophic oil spills, the impacts of cleanup (e.g., air pollution from boats and the impacts of chemical dispersants), and the impacts of general operations (i.e., non-spill related ecological impacts). The small subset of ecological impacts captured by BOEM's Offshore Environmental Cost Model (OECM) from non-catastrophic oils spills are monetized using the cost of replacement methodology, thus excluding "the values above the restoration costs at which society could value the damaged resources" (Draft Proposed Plan 2019-2024, B-14).[88] Due to the omission of these social costs, OECM substantially underestimates the social costs of drilling, leading to misleading NSV and hurdle price analyses.

For some of these excluded impacts, monetized impacts are available from BOEM itself. In the case of catastrophic oil spills, BOEM's *Economic Analysis Methodology for the*

State of Virginia, to Ryan Zinke, U.S. Secretary of the Interior, Department of the Interior (January 17, 2018), available at https://governor.delaware.gov/wp-content/uploads/sites/24/2018/01/Offshore-Drilling-Governors-Joint-Letter-01172018.pdf); Letter from Cory A. Booker, U.S. Senator, State of New Jersey; Robert Menendez, U.S. Senator, State of New Jersey; Chris Christie, Governor, State of New Jersey; Chris Christie, Governor-Elect, State of New Jersey, to Ryan Zinke, U.S. Secretary of the Interior, Department of the Interior (January 15, 2018), available at file:///C:/Users/howardp/Documents/NYU/Comments/BOEM/2019-2024/Popular/Letters/1.14.17%20-%20NJ%20Zinke%20Letter%20_%20Coast%20_%20New%20Jersey.html; Office of Governor Edmund G. Brown, Statement from Edmund G. Brown, Jr., Governor, State of California; Kate Brown, Governor, State of Oregon; Jay Inslee, Governor, State of Washington, *Pacific Coast Governors Condemn Federal Decision to Expand Offshore Drilling* (January 4, 2018), https://www.gov.ca.gov/2018/01/04/news20123/. BOEM quantifies GHG emissions, but focuses exclusively on "upstream" GHG emissions and avoids valuation altogether. "Upstream" emissions are GHG "emissions associated with the initial exploration, production, and transport of OCS oil and gas resources." BOEM ignores "downstream" GHG emissions from consumption (by consumers and industry) of oil and gasoline, as BOEM is not required to monetize them per the U.S. Court of Appeals ruling for the District of Columbia Circuit in Center for Biological Diversity v. United States Department of the Interior. Though not required to value downstream GHG emissions, BOEM should measure and value them in that these emissions impose real costs on U.S. citizens. Furthermore, despite the case law on downstream GHG emissions for the Draft Proposed Plan, BOEM will also have to look at downstream greenhouse gas emissions for the corresponding environmental impact statement. *Id*. at 5-22.

[87] U.S. DEPARTMENT OF THE INTERIOR, BUREAU OF OCEAN ENERGY MANAGEMENT, ECONOMIC ANALYSIS METHODOLOGY FOR THE 2017–2022 OUTER CONTINENTAL SHELF OIL AND GAS LEASING PROGRAM (November 2016) [Hereinafter "Economic Analysis Methodology"] ("The OECM is not designed to represent impacts from global climate change, catastrophic events, or impacts on unique resources such as endangered species.").

[88] OECM also values the cost of non-GHG air pollutants focusing on non-ecological impacts to human health, agricultural productivity, and physical structures. BOEM also omits several non-market benefits: recreational fishing and diving, national energy security, and the U.S. trade deficit. *Id.* at 1-21; Draft Proposed Program at B-10 to B-14; footnote 3 on B-8.

*2017-2022 Outer Continental Shelf Oil and Gas Leasing Program (*hereinafter, Economic Analysis Methodology) provides regional risk (*See Tables 2-1 and 2-*2) and cost (*Tables 2-3 to 2-7*) estimates. Not only are these cost estimates or similarly derived estimates not applied in the current NSV and FMV analyses, they are not provided in the Draft Proposed Program at all. BOEM justifies these exclusions on the grounds of additional uncertainty relative to other costs.[89] In the case of upstream greenhouse gas (GHG) emissions (from exploration and development), BOEM provides estimates of GHG emissions in Table B-2 of the current Draft Proposed Program. However, it fails to monetize these values using the Interagency Working Group's Social Cost of Carbon (SCC): a monetary estimate of the cost to society of an additional unit of CO2 equivalent ($CO2_e$) emissions. This is despite BOEM citing its own report that values GHG emissions using the SCC methodology. Though not stated explicitly in the Draft Proposed Program, BOEM appears not to apply the SCC because the SCC measures global and future damages.[90]

BOEM's reasoning for excluding the catastrophic oil and GHG impacts from its NSV and FMV analyses is arbitrary and capricious. The argument that some cost estimates are "too" uncertain is not sound. All benefit and costs estimates are to some degree uncertain, yet BOEM does not exclude the revenue from OCS drilling despite the uncertainty of both oil price and quantity.[91] Instead, BOEM argues that "unexpected costs" of catastrophic oil spills are "less meaningful and more uncertain than the other measures considered in the NSV analysis." While never clearly defining "unexpected costs," the agency later refers to catastrophic events as "statistically unexpected to occur but would still be possible." In other words, catastrophic oils spills are excluded because they are low probability, high cost events.

Excluding events that "rarely" occur in a given year is arbitrary in that there is no clear probability cutoff for such events, particularly given that they are more likely to occur when considering longer time periods. BOEM's analysis on page 7-36 of the Draft Proposed

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[89] Draft Proposed Program at 5-19 ("Given the unpredictable nature of catastrophic oil spills including the many factors that determine severity, efforts to quantify unexpected costs are less meaningful and more uncertain than the other measures considered in the NSV analysis. In addition to the difficulty in calculating the cost of the potential impacts of a catastrophic spill, there are similar difficulties in calculating the risk. For these reasons, the risk and impact of catastrophic oil spills are not considered in the NSV analysis.").

[90] U.S. DEPARTMENT OF THE INTERIOR, BUREAU OF OCEAN ENERGY MANAGEMENT, OCS OIL AND NATURAL GAS: POTENTIAL LIFECYCLE GREENHOUSE GAS EMISSIONS AND SOCIAL COST OF CARBON (November 2016); *Id.* at 8-11 ("While the risks associated with air quality are largely regional, the risks from GHG emissions are national and international in scale. Climate change is a global phenomenon, and climate change impacts are a function of worldwide GHG emissions, including the contribution of emissions from the National OCS Program. In addition, because GHGs, like carbon dioxide, could influence climate over decades to millennia, the potential impacts of any source could extend well beyond the active lifetime of the source or production associated with the National OCS Program.").; Economic Analysis Methodology at 3-1 ("The main reason for not incorporating those costs is that benefits and costs in the net benefits analysis are assessed at the domestic and national level, not at a global scale.").

[91] Draft Proposed Program at B-17 ("Both the quantity of resources and price inputs are random variables determined by the WEB3 model.").

Program appears to consider any spill equal or greater than 150,000 bbl catastrophic; a maximum spill of this size occurs with a probability of 2.5% annually and with a probability of 12% during any five-year plan. If we consider a longer time period (i.e., a lifespan of the wells being considered for leasing), the probability of such an event is between 32% and 53% over 15 to 30 years, respectively. These 5-, 15-, and 30-year probabilities are even higher if BOEM's cut off for catastrophic events is for an even small spill (i.e., 16,000 or 50,000 bbl). [92] We know from experience (i.e., Deepwater Horizon) that these catastrophic events occur and with relatively significant probabilities over the five-year planning horizon of BOEM (i.e., greater than 10% of the time). From a rationale economic perspective, catastrophic oil spills are far from unexpected and should be accounted for in the BOEM analysis.

Similarly, the argument that the costs of catastrophic oil spill are too uncertain is similarly arbitrary. We know for certain that costs are not zero, as implicitly assumed by the current NSV and FMV analyses and as shown by BOEM's own estimates in their *2017-2022 Economic Analysis Methodology*. Instead, if BOEM is truly concerned about uncertainty, economics has developed additional methodologies for addressing uncertainty, e.g., sensitivity analysis, Monte Carlo simulation, and risk and ambiguity premiums.[93] In fact, the hurdle price analysis conducted by BOEM within the Draft Proposed Program using WEB3 is one such methodology. It captures option value: "the value of waiting to make an irreversible investment until critical new information arrives . . . . The hurdle price analysis considers the uncertainty of oil and gas prices and the expected hydrocarbon endowment."[94] Thus, BOEM's own argument for excluding the cost of catastrophic oil spills is instead a reason for including these costs in their hurdle price analysis (See Part II.D., below). If anything, uncertainty is a reason to further delay drilling as evidenced by option value and risk premiums.[95]

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[92] The exact "statistical" cut off between a large and catastrophic oil spill is unclear and could potentially be lower. BOEM states that "Extreme value results show that 90 percent of any "annual maximum" oil spills are expected to be less than approximately16,000 bbl; 95 percent of any "annual maximum" oil spills are expected to be less than approximately 50,000 bbl (BOEM 2016). Spill sizes corresponding to a range of larger sizes and statistically useful benchmarks were also considered". According to BOEM's own statistics, spills greater than 16,000 and 50,000 are expected to occur 40% and 23% of the time during a five-year plan. Over 15 to 30 years, the probabilities of these two types of events increase to 79% to 96% and 54% to 79%, respectively. Draft Proposed Program at 7-36.

[93] If BOEM still feels that it cannot sufficiently address these uncertainties through option value, sensitivity analysis, and risk and ambiguity premiums, it can also employ expert elicitation as it chose to do in its MarketSim model for unavailable elasticities. *See* U.S. DEPARTMENT OF THE INTERIOR, BUREAU OF OCEAN ENERGY MANAGEMENT, CONSUMER SURPLUS AND ENERGY SUBSTITUTES FOR OCS OIL AND GAS PRODUCTION: THE 2015 REVISED MARKET SIMULATION MODEL (MARKETSIM), OCS STUDY BOEM 2015-054 (December 2015) (hereinafter 2015 Revised MarketSim); Geoffrey Heal & Antony Millner, *Reflections: Uncertainty and Decision Making in Climate Change Economics*, 8 REV. OF ENVTL. ECON. AND POL'Y 120 (2014).

[94] Draft Proposed Program at 10-3.

[95] This point is made frequently by climate economists where uncertainty greatly outweighs the uncertainty considered by BOEM in its 5-year plan. Sonja Peterson, *Uncertainty and Economic*

With respect to valuing the GHGs using the SCC, BOEM's arguments are both invalid. No inconsistency arises in the inclusion of costs of greenhouse gases in either the NSV or FMV analyses due to the time scale and global nature of climate impacts. Like all other costs and benefits in these analyses, the SCC measures the cost of GHG emissions in present value terms.[96] This standard economic practice of adjusting all benefits and costs to their current worth allows economists to compare benefits and costs over time. Similarly, using a global SCC is consistent with measuring the full benefits of GHG emission reductions. Please see our separate SCC comments for more information.

C. BOEM should make all relevant data and models freely available for public download so that the public can review them. Alternatively, BOEM should provide complete instructions and explanations of its modeling decisions, such that members of the public can replicate its results.

BOEM should make all data and models that are, or will be, used in the analysis of the Program available to the public for download. It currently fails to do so, preventing the public from a meaningful opportunity to participate in the comment process.

The Draft Proposed Program states that "Appendix B: Economic Analysis Methodology provides a further explanation of the analytic approach used for the analyses presented in Part III, including an explanation of the calculations and assumptions in the net social value analysis described in Section 5.3 and the FMV analysis discussed in Chapter 10."[97] However, all calculations and assumptions are not explained in Appendix B. For example, the Draft Proposed Program (B-19) and the *2017-2022 Economic Analysis Methodology* (4-4) state that with regards to BOEM's FMV analysis that, "These parameters were estimated by BOEM by a regression analysis of historical oil and gas prices, where the regression model was the mean-reverting model." However, it is unclear whether BOEM

Analysis of Climate Change: A Survey of Approaches and Findings, 11 ENV'T MODELING & ASSESSMENT 1 (2006): ("Most modeling results show (as can be expected) that there is optimally more emission abatement if uncertainties in parameters or the possibility of catastrophic events are considered."); Alexander Golub, Daiju Narita & Matthias GW Schmidt, *Uncertainty in Integrated Assessment Models of Climate Change: Alternative Analytical Approaches*, 19 ENV'T MODELING & ASSESSMENT 99, 107 (2014): ("The most important general policy implication from the literature is that despite a wide variety of analytical approaches addressing different types of climate change uncertainty, none of those studies supports the argument that no action against climate change should be taken until uncertainty is resolved. On the contrary, uncertainty despite its resolution in the future is often found to favor a stricter policy.").

A similar argument for excluding these costs is that including catastrophic oil spills may lead to "a scenario where the social and environmental impacts are likely overestimates of the impacts that might occur." This argument is similarly arbitrary and capricious because excluding these values certainly leads to a scenario that underestimates the impacts that might occur. Furthermore, this argument is a misinterpretation of uncertainty, which implies that the cost estimates could be lower or higher than their current estimated values. Economic Analysis Methodology at 2-1.

[96] William Nordhaus, *Estimates of The Social Cost Of Carbon: Concepts and Results From The DICE-2013R Model and Alternative Approaches*, 1 J. Ass'n ENVTL. & RES. ECON. 273 (2014); Richard SJ Tol, *The Economic Effects of Climate Change,* 23 J. ECON. PERS. 29 (2009).

[97] Draft Proposed Program at xiii.

estimated this regression using daily, weekly, monthly or annual data and over what time period. Fackler (2007) argues that analysts should exclude pre-1974 data and avoid annual data.[98] Similarly, it is unclear in the hurdle price analysis whether economically recoverable oil and gas resources were used in the calculation of expected field size, rather than technically recoverable. Conrad and Kotani (2005) make clear that economically recoverable oil and gas is the appropriate measure.[99]

Due to the public unavailability of data and models, BOEM'S insufficient explanation of its modeling assumptions in the Draft Proposed Program makes it impossible for the public to determine how BOEM reached certain conclusions, including its NSV and FMV analyses. Given the application of three models in the Program (OECM, WEB3, and MarketSim) and the central importance of the NSV and FMV analyses, the inputs and model code for all three of these models should be available to the public to download.

D. BOEM must correct its hurdle price analysis in Web3 to address methodological errors that bias its resulting estimates towards oil and gas leasing in the near-term.

BOEM incorrectly calculates the hurdle price for each OCS region corresponding to the uncertainty underlying the price and quantity of oil. Specifically, BOEM misspecified price and expected quantity of oil in WEB3. BOEM must correct these errors.

BOEM misspecified its mean-reversion hurdle price model. In specifying its model, BOEM fails to account for the time until the OCS region is open for development, i.e., the minimum delay of two to seven years from 2017 (the year of the underlying analysis) to 2019-2024.[100] Instead of explicitly accounting for the delay, BOEM compares its estimated hurdle price to the 2017 AEO forecast of 2019 oil and natural gas prices. However, this misses the whole point of the hurdle price analysis. Development of the OCS region should be triggered when the observed price crosses the hurdle price threshold.[101] If a forecasted

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[98] Paul L. Fackler, *Comment on Conrad and Kotani*, 29 RESOUR. & ENERGY ECON. 159, 160-162 (2007).
[99] Jon M. Conrad & Koji Kotani, *When to Drill? Trigger Prices For The Arctic National Wildlife Refuge*, 27 RESOUR. & ENERGY ECON 273, 276 (2005).
[100] Hahn and Dyer (2008) discuss the need to explicitly model the delay in oil production. In the Conrad and Kotani (2005) analysis to which the Draft Proposed Program explicitly cited (10-9), this delay is equivalent to their λ (i.e., the construction phase). Specifically, BOEM should specify a value of λ between 2 and 7 depending on when the OCS region would be open for leasing; this value should potentially be adjusted upwards further to account for additional time for exploration and development plans to be submitted and approved and time it takes to explore and develop the first field in the OCS region before oil is actually removed from the ocean bed. Conrad & Kotani, *supra* note 27; Warren J. Hahn & James S. Dyer, *Discrete Time Modeling of Mean-Reverting Stochastic Processes for Real Option Valuation*, 184 Eur. J. OPL. RESOUR., 546, 534-548 (2008).
[101] AVINASH K. DIXIT & ROBERT S. PINDYCK, INVESTMENT UNDER UNCERTAINTY 6-7 (Princeton Univ. Press, 1994) ("Firms invest in projects that are expected to yield a return in excess of a required or "hurdle" rate. Observers of business practice find that such hurdle rates are typically three or four times the cost of capital. In other words, firms do not invest until price rises substantially above long-run average cost."); this does *NOT* say the firm invests when the price is expected to rise above costs by certain amount. Similarly, BOEM makes similar statements. Draft Proposed Program at B-19 ("If the market price at the time of leasing happens to be lower than the calculated hurdle price, then a delay of leasing is indicated."); Economic Analysis Methodology at 4-4 ("If the market price at

price is applied instead, a second option value corresponding to the value of learning about this forecasted price needs to be calculated; this is critical because these price forecasts are relatively inaccurate.[102] If forecasted prices tend to increase over time (as is generally the case for the last five AEO forecasts), the current methodology is likely to be biased towards development.

Comparing the adjusted (corrected) hurdle price to current prices would likely result in fewer OCS regions passing the hurdle price threshold. Accounting for the delay in opening the OCS region to development increases the hurdle price.[103] Similarly, current oil and natural gas prices are lower than the 2017 AEO predictions.[104] Therefore, an update is necessary because the current model is incorrectly specified and biases the FMV analysis towards development now.

BOEM also miscalculates "expected hydrocarbon endowment," also referred to as the "potential field size." According to BOEM, the potential field size equals "the probability that the lessee finds resources during exploration, and, if resources are found, the expected field sizes."[105] BOEM correctly assumes that the former probability equals 20% based on the average success rate of drilling, and then incorrectly specified "expected field size" as the maximum field size.[106] However, traditionally the expected value of a random variable equals the arithmetic mean;[107] this is also the standard interpretation in real options problems in the non-renewable resource economics literature when quantity is not modeled as deterministic (i.e., no uncertainty) or a separate stochastic process (for resource reserves) is not applied.[108] Of course, the use of an arithmetic mean is only

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the time of leasing happens to be lower than the calculated hurdle price, then a delay of leasing is indicated."). Again, they do not say "expected price."

[102] From the 2015 to 2018 AEO forecasts, the 2018 oil price forecasts vary from $59 to $105. Furthermore, these predictions appear to become more accurate over time. U.S. ENERGY INFORMATION ADMINISTRATION. ANNUAL ENERGY OUTLOOK 2017 (January 2017) (hereinafter "2017 AEO").

[103] *See* Table 5 in Conrad & Kotani, *supra* note 99, at 284.

[104] 2017 AEO, at *supra* note 102.

[105] Draft Proposed Program at 10-3; *id.* at B-18.

[106] Draft Proposed Program at B-18 ("WEB3 uses two separate resource assumptions in calculating the potential field size in a region: the probability that the les*see* finds resources during exploration, and, if resources are found, the expected field sizes. BOEM assumes a 20 percent success rate for exploratory drilling. BOEM uses an approximation of the largest field size in each planning area as the expected field size. The largest field size, all else being equal, tends to have the highest net value per equivalent barrel of resources and thus would be the most profitable in a sale and provide the lowest hurdle price. The reason for focusing on just the largest field is that the decision criterion using the hurdle price is intended to be conservative, to avoid the risk of withholding, on economic grounds, an area that might have at least one field that ought to be developed immediately. This decision is appropriate at the programmatic level where the decision is simply made whether or not to include an area in the OCS National OCS Program, not to make a final decision on hold the sale, its configuration, and its financial terms.").

[107] 7 CARL P. SIMON & LAWRENCE BLUME, MATHEMATICS FOR ECONOMISTS 895 (Norton, 1994).

[108] Conrad and Kotani (2005) - an article cited by BOEM in the Draft Proposed Program - states that in their model expected quantity equals "average annual production". In Mezey & Conrad (2010), only deterministic and stochastic reserve assumptions are made. *See* Conrad & Kotani, *supra* note

appropriate if developers have no information with regards to the geographic dispersion of field size within the OCS region.

BOEM's reasoning for using the maximum field size as a substitute for expected field size is flawed, except under a very narrow condition that does not hold. Its logic that an OCS region should be developed if one field "ought to be developed immediately" holds if, and only if, the OCS developer can identify the maximum field before drilling;[109] this seems unlikely given the assumption that the same developer only has a 20% probability of drilling success. In other words, the first identified field is unlikely to be equal to the maximum field size in the OCS region if drawn randomly from the OCS region's distribution of field size. A less extreme assumption would be that the developer has some information with respect to geographic dispersion of oil reserves. In this case, expected quantity of oil in the first developed field in an OCS region could exceed the mean – by some reasonable amount such as one standard deviation – though still not the maximum field size assumed in the BOEM analysis. However, according to BOEM's own statements in the Draft Proposed Program, the developers have no knowledge of field location and any leasing that occurs based on the maximum field size will incur social costs when small fields (which would be 95% fields according to BOEM's own analysis) are developed.[110]

BOEM should use the arithmetic mean of field size as its measurement of expected oil reserves in the first explored field. A resulting lower expected quantity of oil will increase the hurdle price.[111] Thus, if the current assumption is maintained, it will bias BOEM towards development. For purposes of clarity, BOEM should measure the mean quantity of oil in an OCS field using economically recoverable oil and gas resources, not technically recoverable oil and gas resources.

BOEM also assumes that resource quantity is not a function of price. However, according to BOEM's 2016 National Assessment, economically recoverable oil and gas reserves are explicitly a function of price.[112] As a consequence, the quantity of resource (and thus gross revenue) should follow a mean-reversion process like price. Regardless of whether BOEM incorrectly maintains a maximum or adopts mean field size, it should address this error.

Finally, contrary to BOEM's assumption in WEB3 of holding one option, BOEM holds multiple concurrent options (i.e., an American option and not a European option).

99, at 276; Esther W. Mezey & Jon M. Conrad, *Real Options in Resource Economics*, *2* ANNU. REV. RESOUR. ECON*.* 33 (2010).

[109] Again, BOEM argues that "The rationale for basing the hurdle price analysis on large fields relates to the likelihood that larger fields are more valuable to develop, even after including social costs, than smaller fields. It is possible, for certain price assumptions, that social benefits would be optimized by leasing large fields in the 2019–2024 Program while holding small fields for later leasing." Draft Proposed Program at 10-14.

[110] Draft Proposed Program at 10-14 ("Since the locations of undiscovered fields are unknown, however, a single timing decision must be made for areas in their entirety. If the area is included in the National OCS Program and leasing conducted due to the possibility of large fields, a social cost of prematurely leasing some small fields might be incurred.").

[111] Draft Proposed Program, at B-18.

[112] *See* Figure 4 in 2016 National Assessment, *supra* note 83, at 5.

Specifically, BOEM's optimization problem is not whether to develop an OCS region now or in X-years (where X is one- to ten-years) as it currently assumes in its hurdle price analysis.[113] Instead, BOEM has the choice to develop each OCS region now, in *any* following five-year period, or to never develop. Thus, BOEM should explicitly model concurrent option values.[114] If this is difficult using its current model structure, BOEM should consider a simplified lattice model to improve the ease of the calculation.[115] Alternatively, BOEM could explore running the model over a longer time range of 1 to 50 years.

E. BOEM must provide reasoned explanations for changing its definition of maximum field size and its choice of price forecasts in its hurdle price analysis.

As noted in the previous sub-section, BOEM should not set the expected quantity of oil in an OCS region equal to the maximum field size. Instead, it should explicitly set the expected quantity equal to the mean quantity of oil in the OCS region. However, if BOEM were to incorrectly continue in its application of maximum field size instead of mean field size, then it must also provide a reasoned explanation of why it changed its definition of maximum field size from the 90th percentile in the 2017-2022 Final Plan to the 95th percentile in the 2019 to 2024 Draft Proposed Program. The language in the Draft Proposed Program explaining this decision is nearly identical to the language in the previous Program using the 90th percentile.[116] Given that we are in the tail of the distribution, this change significantly increases the maximum quantity of oil in some OCS regions, and thus lowers the hurdle price for those corresponding OCS regions. For example, the largest field size in the Beaufort Sea and Chukchi Sea OCS regions more than triples from 113 million barrels of oil equivalent (MMBOE) to 357 MMBOE and 190 MMBOE to 706 MMBOE, respectively.[117] Increasing the field size in this manner will have the effect of lowering the hurdle price for the region, therefore biasing the results towards development. This significant change must be justified.

As noted in the previous section, BOEM should explicitly model the time until an OCS region is open for development in its FMV analysis. However, if BOEM fails to do so and incorrectly uses expected price in its analysis, then it must provide a reasoned

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[113] Draft Proposed Program at B-17.

[114] *See* Hahn & Dyer, *supra* note 100..

[115] *Id.* As shown in Hahn and Dyer, a binomial distribution can approximate a mean-reverting stochastic process.

[116] Draft Proposed Program at B-19 ("The 95th percentile field size provides a practical estimate of a large field size by eliminating the tails of the resource distribution. Although the 95th percentile corresponds to a 1 in [20] chance of discovering a field that exceeds the largest field size shown, this percentile constitutes a reasonable assumption based on known discoveries and/or analog information in each planning area. BOEM reviewed discovered field sizes and determined that the 95th percentile field provides an appropriate estimation of a large field size for the hurdle price analysis"); Economic Analysis Methodology, *supra* note 11 at 4-3 ("The 90th percentile field size provides a practical estimate of the largest field size by eliminating the tails of the resource distribution. Although the 90th percentile corresponds to a 1 in 10 chance of discovering a field that exceeds the largest field size shown, this percentile constitutes a reasonable assumption based on known discoveries and/or analog information in each program area").

[117] *See* Table 10-1 in Draft Proposed Program at 10-15; *see* Table 4-3 in Economic Analysis Methodology, *supra* note 87, at 4-7.

explanation for updating forecasted oil and gas prices from the 2016 AEO forecasts to the 2017 AEO forecasts instead of the more up-to-date 2018 AEO forecasts or other potential forecast sources. Specifically, BOEM should use the most up-to-date price forecasts. If BOEM used the 2018 AEO forecasts (currently available) instead, only five out of the 15 OCS regions currently considered by BOEM would pass the hurdle price analysis: Central GOM, Cook Inlet, Eastern GOM, Southern California, and Western GOM.[118]

Similarly, if BOEM incorrectly uses expected price, BOEM should use multiple price forecasts, applying the average to minimize forecast error, and conduct sensitivity analysis to the alternative forecasts.[119] In the 2017-2022 Proposed Program, BOEM used three forecasts: BOEM internal forecasts, EIA's Annual Energy Outlook, and the Office and Management and Budget.[120] BOEM must provide a reasoned explanation as to why it no longer uses these three forecasts in its FMV analysis.[121]

F. BOEM should model and analyze the portion of option value corresponding to environmental and social cost uncertainty.

BOEM's hurdle price analysis accounts solely for price uncertainty. As noted by BOEM, it fails to account for cost uncertainty: capital, operational, and environmental and social.[122] In particular, BOEM notes that future learning will occur with regards to the magnitude of environmental and social impacts and costs. BOEM further recognizes that its current hurdle price analysis omits the portion of option value associated with market and social cost uncertainty (referred to as environmental option value henceforth). Citing "few studies" estimating environmental option value in the OCS context, BOEM argues that it cannot currently estimate this omitted portion of option value due to the difficulty of making it empirically operational. Instead, BOEM argues that the hurdle price findings should be taken as a guide only for price-based option value.[123] And to capture the option value of new information becoming available that could make an area more or less profitable to lease, the Secretary may choose to include or exclude areas regardless of the relationship between the hurdle prices and current prices.

Contrary to BOEM's assertions, the option value literature in the natural resources context is increasingly well developed.[124] There are papers addressing option value in the

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[118] *See* U.S. ENERGY INFORMATION ADMINISTRATION. ANNUAL ENERGY OUTLOOK 2018 (February 2018) (hereinafter "2018 AEO").
[119] Mark C. Freeman & Ben Groom, *Positively Gamma Discounting: Combining the Opinions of Experts on the Social Discount Rate*, 125 ECON. J. 1015 (2015).
[120] *See* U.S. DEPARTMENT OF THE INTERIOR, BUREAU OF OCEAN ENERGY MANAGEMENT, 2017-2022 OUTER CONTINENTAL SHELF OIL AND GAS LEASING PROPOSED PROGRAM (March 2016) (hereinafter, "2017-2022 Proposed Plan"). *See* Table 10-2 in 2017-2022 Proposed Plan, *id.* at 10-15.
[121] U.S. DEPARTMENT OF THE INTERIOR, BUREAU OF OCEAN ENERGY MANAGEMENT, 2017-2022 OUTER CONTINENTAL SHELF OIL AND GAS LEASING FINAL PROGRAM (November 2016) (hereinafter, "2017-2022 Final Plan").
[122] *See* Draft Proposed Program at 10-8 to 10-11; *id.* at B17-B18.
[123] *See* Draft Proposed Program at 10-15.
[124] *See generally* Mezey & Conrad, *supra* note 108; Courtney M. Regan, et al., *Real Options Analysis for Land Use Management: Methods, Application, and Implications for Policy*, 161 J. ENVTL. MGMT. 144

context of oil and natural gas extraction,[125] catastrophic oils spills,[126] and greenhouse gas emissions.[127] Thus, BOEM is now capable to estimating the portions of option value corresponding to costs, both market and environmental. In addition to the introduction of simplified methods for calculating real option value (lattice models and Monte Carlo simulations),[128] BOEM can apply simplifying assumptions, well known approximation methods/models,[129] and/or breakeven analysis. Failing to address uncertainty more generally would be arbitrary in that BOEM already looks at one factor (price uncertainty) to the exclusion of equally important components of uncertainty facing society. BOEM's current approach leads to misleading policy conclusions.

A. Expanding the BOEM Model

To calculate the hurdle price, BOEM employs an optimal stopping model WEB3 that solely considers the option value corresponding to the uncertainty of oil price. According to BOEM's model, the present value of the first OCS field at the time of development is:

$$V_{BOEM}(P, K, C) = -F + \mathbf{E}[Q] \int_0^{\tau} (\mathbf{E}[P] - V - ESC) e^{-\delta t} dt$$

where $\mathbf{E}[Q]$ is the expected quantity of resources in the first field drilled in the OCS region, $\mathbf{E}[P]$ is the expected BOE price in the OCS region, F is the capital (i.e., fixed) cost of development, V is the operational (i.e., marginal) cost, and ESC is the environmental and social cost. As notation indicates, quantity and price are the only random variables. In the former case, BOEM sets $\mathbf{E}[Q] = 0.2 * Q_{max}$ where 0.2 is the 20% probability of drilling success and Q_{max} is the maximum expected field size in the OCS region (*See* discussion in Sections II.D & II.E). BOEM assumes the oil price follows a mean reversion process.[130] Finally, τ is the time it takes to extract the oil in the OCS region relative to when the extraction begins, which for purposes of simplicity appears to be instantaneously in the

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(2015); Jon Anda, Alexander Golub & Elena Strukova, *Economics Of Climate Change Under Uncertainty: Benefits Of Flexibility*, 37 ENERGY POL'Y 1345 (2009).

[125] *See generally*, Mezey & Conrad, *supra* note 108 at 44-47; Conrad & Kotani, *supra* note 99; Fackler, *supra* note 98; Jon M. Conrad, *Wilderness: Options to Preserve, Extract, or Develop*, 22 RES. AND ENERGY ECON. 205 (2000).

[126] *See generally*, George Dikos & Sgouris P. Sgouridis, *On The Optimal Timing of the Oil Pollution Act: Is There More Value In Waiting Than Acting*, 1 INT'L. J. OCEAN SYSTEMS MGMT. 100 (2008).

[127] *See generally*, Anda et al, *supra* note 124; Alexander Golub & Michael Brody, *Uncertainty, Climate Change, And Irreversible Environmental Effects: Application Of Real Options To Environmental Benefit-Cost Analysis*, 7 J. OF ENVT'L STUDIES & SCI. 519 (2017).

[128] *See* generally, Regan et al., *supra* note 124.

[129] Walter Schachermayer & Josef Teichmann, *How Close Are the Option Pricing Formulas of Bachelier and Black–Merton–Scholes?*, 18 MATHEMATICAL FIN. 155 (2008).

[130] This assumption is supported by several studies: 3 ROBERT S. PINDYCK & DANIEL L. RUBINFELD, ECONOMETRIC MODELS AND ECONOMIC FORECASTS (McGraw-Hill, 1991); Eduardo S. Schwartz, *The Stochastic Behavior of Commodity Prices: Implications for Valuation and Hedging,* 52 J. FIN. 923 (1997); Henrik Andersson, *Are Commodity Prices Mean Reverting?,* 17 APPLIED FIN. ECON. 769 (2007). However, there is evidence that supports alternative stochastic distributions: Mohammed A Aba Oud & Joanna Goard, *Stochastic Models For Oil Prices and the Pricing of Futures on Oil*, 22 APPLIED MATHEMATICAL FIN. 189 (2015).

BOEM model ($\tau = 1$). BOEM considers the decision to maximize the present value of the field by selecting to develop now or in period T (between 1 and 10 years).

This approach allows the analyst to specify a stochastic process that can be estimated using available data. BOEM estimates the mean-reverting stochastic process $P_{t+1} = P_t \left[\frac{T_{t+1}}{Pt}\right]^{\alpha} \varepsilon_{t+1}$.[131] Using a regression of historical oil and gas prices, BOEM estimates that the stochastic price tends towards a mean of $90 at a "rate of 12 percent of the difference per year" and a standard deviation of 32% (i.e., $28.8).[132] Unlike price and quantity, all cost variables are deterministic. The market cost inputs are from the Que$tor cost modeling system, MAG-Plan, and cost estimates used in tract evaluations. The environmental and social costs are from the OECM model. See Section II.E for a discussion of the data source for maximum field size.

In addition to the errors discussed earlier (Section II.D), the main shortcoming of BOEM's analysis is that it assumes that the market and externality costs of leasing are certain.

We propose a possible extension of the Conrad and Kotani (2005) model[133] to utilize in place of the BOEM's current hurdle price analysis.[134] If BOEM chooses to preserve the OCS region in period t, society receives a net return equivalent to the magnitude of amenities from the OCS region (A). Alternatively, if BOEM leases within the OCS region in period t, society receives net social welfare equal to

$$V_F(A, P, F, V, ESC) = \mathbf{E}[A] - \mathbf{E}[F] + 0.2 \int_{\lambda}^{\lambda+\tau} \bar{Q}(\mathbf{E}[P] - \mathbf{E}[V] - \mathbf{E}[ESC])e^{-\delta t} dt$$

where all notation is as before. Additionally, λ is the time it takes to start extraction relative to when the leasing decision is made (i.e., 2 to 7 years at a minimum in this case) and $\bar{Q}$ is the mean amount of resources extracted (i.e., the mean undiscovered economic recoverable oil and gas quantities) from an OCS field;[135] $\bar{Q}$ is directly a function of BOE price (See Section II.D). To simplify, amenities can be ignored since they are present with and without drilling, and the result is a problem similar to BOEM's

$$V_F(P, F, V, ESC) = -\mathbf{E}[F] + 0.2 \int_{\lambda}^{\lambda+\tau} \bar{Q}(\mathbf{E}[P] - \mathbf{E}[V] - \mathbf{E}[ESC])e^{-\delta t} dt$$

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[131] There are multiple mean reverting processes in the literature. The "the most well-known one factor model for oil prices…used by various authors" is $dP = \alpha P(\mu - \ln(P)) + \sigma P$ where $\mu = T_{t+1}$ and σ is the standard deviation of the price path. Oud & Goard, *supra* note 130, at 190-192.

[132] *See* Draft Proposed Program at B19.

[133] *See* Conrad & Kotani, *supra* note 99.

[134] An extension of BOEM's hurdle price analysis would require similar adjustments to their WEB2 model.

[135] *See* Figure 4 in 2016 National Assessment, *supra* note 83 at 5. *See* Figure 4 in U.S. DEPARTMENT OF THE INTERIOR, BUREAU OF OCEAN ENERGY MANAGEMENT, ASSESSMENT OF UNDISCOVERED TECHNICALLY RECOVERABLE OIL AND GAS RESOURCES OF THE NATION'S OUTER CONTINENTAL SHELF (2011).

with more stochastic parameters and where amenities lost from mining are folding into the external cost estimates (ESC). Instead of solving for a trigger price, BOEM can solve the model for a set of trigger prices given various states of the world in the F-P-V-ESC space.[136]

Given our earlier suggestions (*See* Section II.B), we suggest splitting the social and environmental externalities into the expected costs of oil spills (OC), GHG emissions (GC), and non-GHG air pollution emissions (AC), such that

$$\mathbf{E}[ESC] = \mathbf{E}[TOC] + \mathbf{E}[GC] + \mathbf{E}[AC] = \mathbf{E}[NOC] + \mathbf{E}[COC] + \mathbf{E}[GC] + \mathbf{E}[AC]$$

where BOEM can either model total oil spill costs (TOC) or its non-catastrophic (NOC) and catastrophic (COC) components. Each externality is a product of the quantity of emissions (i.e., oil leaked, GHG emissions, and non-GHG air emissions) and the unit value of the externality. Both the quantity and price of the externality are uncertain, such that separate stochastic processes can be specified.[137]

The main advantage of optimal stopping models (specified as partial differential equations) is that they provide a clear method to estimate the stochastic processes underlying uncertain price and cost variables. For other resources (e.g., copper), papers have modeled mining production costs as a mean-reversion process.[138] Assuming a mean-reversion process for oil and gas costs, BOEM can estimate the underlying parameters using time series data available from EIA[139] or other sources. With respect to environmental and social costs, amenities are often modeled as following geometric Brownian motion.[140] Thus, it is reasonable to assume that the price portion of social costs also follows a geometric Brownian motion, as has been done for the cost of oil spills[141] and the social cost of carbon.[142]

It should be noted that the drift parameter (if included) is likely positive as the relative value of non-market goods increases with scarcity.[143] With respect to the quantity of emissions, there are several options. Anda et al. (2009) assumed geometric Brownian motion for GHG emissions.[144] In the case of oil spills, a jump-diffusion process is more realistic where often Poisson jumps are used to capture the possibility of catastrophic oil spills. Directly modeling the possibility of catastrophic oils spills using a jump process is

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136 Under certain parameter values, no solution may exist, implying permanent preservation is optimal from a societal point of view.
137 Dikos & Sgouridis, *supra* note 126, at 112.
138 Mezey & Conrad, *supra* note 108, at 44-45.
139 U.S ENERGY INFORMATION AGENCY, T-17, *Exploration and Development Expenditures by Region (Million 2009 Dollars)* (April 2011), available at https://www.eia.gov/finance/data.php; Energy Information Agency, T-18, *Production (Lifting) Costs by Region (April 2011)*, available at https://www.eia.gov/finance/data.php. Data are available for the US. Offshore for both cost components.
140 Mezey & Conrad, *supra* note 99, at 47-48.
141 Dikos & Sgouridis, *supra* note 126, at 112.
142 Anda et al., *supra* note 124, at 1348.
143 Catherine M. Chambers, Paul E. Chambers, and John C. Whitehead, *Conservation Organizations and The Option Value to Preserve: An Application To Debt-For-Nature Swaps*, 9 ECOLOGICAL ECON. 137 (1994); Conrad, *supra* note 125, at 213.
144 Anda et al., *supra* note 124, at 1348

critical given that excluding them can significantly bias the policy analysis.[145,146] The diffusion process with which it is combined can be a mean reverting diffusion process[147] or a GBM diffusion process with drift if BOEM is interested in potentially capturing the reduced risk of oil spills over time.[148] BOEM has the necessary data on upstream GHG emissions[149], oil spills[150], and non-GHG emissions, as well as their costs, such that calibrating these stochastic processes is possible.[151] Including these omitted stochastic processes will increase the resulting hurdle price (and the corresponding option value).

If BOEM believes insufficient data is available to calibrate regional-stochastic processes (due to the lack of long-time series), it can augment this data using expert opinion as they have already done for the inputs to MarketSim for fuel-source (i.e., fuel, region, and mine/well type) specific parameter values.[152] A similar adjustment may be necessary for the stochastic process of various OCS regions.

B. Approximation

As seen in the previous sub-section, a more realistic model of BOEM's optimal develop decision is more complex than BOEM's current hurdle price approach, WEB3. Simplification is likely necessary, particularly given BOEM's specification of the problem using partial differential equations.[153] Following a standard practice in the real options problems in resource economics,[154] BOEM can estimate the stochastic process underlying net economic value (NEV), instead of price, using a mean-reversion process. This can be

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[145] Dikos & Sgouridis, *supra* note 126, at 114. Similarly, Mezey & Conrad, *supra* note 108, at 38. In both cases, the use of a Poisson jump process to model the risk of a catastrophic event – oil spill and wildfire, respectively – significantly impacts option value. In the case of deciding when to drill, the risk of catastrophic oils spills would increase the option value.
[146] Dikos & Sgouridis, *supra* note 108, at 100 ("We demonstrate that neglecting the occurrence of extreme events can be misleading.").
[147] *Id.* at 113.
[148] Economic Analysis Methodology, *supra* note 87, at 2-6 ("The historical statistical frequency exceedance value used in this analysis is likely significantly higher than the actual future frequency due to the proactive actions of the government and industry to reduce the chance of another blowout and catastrophic oil spill.").
[149] *See* Table B2 in the Draft Proposed Program at B-11.
[150] Economic Analysis Methodology, *supra* note 87, at 1-17 to 1-23 and 2-1 to 2-14. Chapter 1 highlights the availability of air and non-catastrophic oil emissions data, while Chapter 2 (specifically Tables 2-1 and 2-2) demonstrates the availability of catastrophic oil emissions and risk data.
[151] *See* INTERAGENCY WORKING GROUP ON SOCIAL COST OF CARBON, U.S. GOVERNMENT, TECHNICAL SUPPORT DOCUMENT: - TECHNICAL UPDATE OF THE SOCIAL COST OF CARBON FOR REGULATORY IMPACT ANALYSIS - UNDER EXECUTIVE ORDER 12866 (August 2016) ((hereinafter "2016 Interagency Working Group"); Economic Analysis Methodology, *supra* note 87, at 1-17 to 1-23 and 2-1 to 2-14. Chapter 1 highlights the availability of air and non-catastrophic oil cost data, while Chapter 2 (specifically Tables 2-3 to 2-7) demonstrates the availability of catastrophic oil cost data.
[152] *See* 2015 Revised MarketSim, *supra* note 93.
[153] *See* Regan et al., *supra* note at 124 ("When applied to complex real option problems with multiple sources of uncertainty, simplifying assumptions are often needed.")
[154] *See generally* Mezey & Conrad, *supra* note 108.

appropriate in the BOEM context since in the Draft Proposed Program, BOEM assumes resource quantity and costs move proportional to price. Specifically, BOEM currently estimates quantity using undiscovered economically recoverable oil and gas reserves which are explicitly a function of price;[155] and BOEM also assumes that production costs are roughly half of price.[156] For environmental and social costs, BOEM can simplify the above model by focusing on stochasticity of the key uncertain component of the externality by assuming that the other component; this would allow BOEM to model each externality using one stochastic process instead of two.

For example, BOEM could focus on the amount of emissions in the case of oil spills and the social cost of carbon in the case of GHG emissions. More generally, upon estimating stochastic processes for various random variables, BOEM could determine which variables have a (relatively) minimal contribution to option value due to low levels of observed variation.[157] In this case, BOEM can apply a deterministic value. Even then, the BOEM optimization problem has multiple stochastic processes. There are many examples of solutions for optimization problems with multiple stochastic processes in the literature.[158]

To make the problem easier to solve, BOEM can further simplify its optimization problem by reformulating its structure as a lattice model or applying Monte Carlo simulations. BOEM can approximate the above problem using a binomial-option price model (or lattice model) that collapses the model down to a decision tree. Binomial approximations of most well defined stochastic processes – including geometric Brownian motion and mean-reversion – are possible; these approximations collapse to the approximated process as the time step becomes increasingly small. Given the short-time periods considered by BOEM (1 to 10 years), problems of dimensionality are less likely to arise.[159] Alternatively, BOEM can apply a Monte Carlo simulation in multiple ways to solve for option value (or the hurdle price). These models can be solved using dynamic programming, though "simulation methods are commonly applied to real option problems by creating a distribution of expected possible future asset values."[160] Both methodologies are capable of solving for American options where the holder can exercise the option at any time (i.e., holds multiple concurrent options) before the expiration date passes (this is similar to the BOEM problem as discussed in Section II.D). [161] Computer programs are available to apply these methodologies, including the *Real Option Analysis Toolkit*.[162]

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[155] *See* Figure 4 in 2016 National Assessment, *supra* note 83, at 5.
[156] Draft Proposed Program at 10-8 ("Through internal modeling efforts and validation with external sources, BOEM has estimated that costs increase at roughly half the rate of increase in resource prices.").
[157] For example, if a geometric Brownian motion is assumed for a random variable, then a small level of volatility (standard deviation as % of mean) implies a low option value. *See* Anda et al., *supra* note 124, at 1351.
[158] *See generally* Mezey & Conrad, *supra* note 108; Conrad, *supra* note 125; Dikos & Sgouridis, *supra* note 126.
[159] *See generally* Regan et al., *supra* note 124 at 146-147*; see* Hahn & Dyer, *supra* note 100.
[160] Regan et al., *supra* note 124, at 147.
[161] *Id*.
[162] Anda et al., *supra* note 124, at 1351.

Several papers combine the above Monte Carlo approach with approximate formulations of option value to further simplify the calculation methods. Anda et al. (2009) demonstrates the ease of applying this latter methodology in the context of selecting a climate target. Both the climate sensitivity parameter and climate damages are uncertain; fat-tailed (log-normal) distributions are specified since time-series data are unavailable. Even without time-series data, Anda et al. (2009) calculate option value by running a Monte Carlo distribution to calculate the distribution of net social value (NSV). They then solve for option value using the Black-Scholes formulation, Bachelier model, and Gram-Charlier model.[163] Similarly, Golub and Brody (2017)[164] apply the Bachelier formula – option value approximately equals the product of 0.4 and the standard deviation of a geometric Brownian motion process – to find the option value corresponding to the SCC.[165] A similar approach to Golub and Brody (2017) could be applied to calculate the option value of oil spills, though BOEM should apply a Gram-Charlier model to account "for skewness and kurtosis of [the] asset returnee distribution" resulting from catastrophic oil spills (i.e., fat tails).[166] This methodology also raises the possibility of replacing random variables following GBM processes with their deterministic value plus their corresponding option value to further simplify BOEM's hurdle price problem. The availability of option-value approximations (such as those discussed above) and computer problems that solve for these approximations, such as *Real Option Analysis Toolkit*,[167] further emphasizes the ease at which BOEM can find option value (and thus hurdle price) in the above problems with appropriate simplification assumptions.

C. Breakeven Analysis

At a minimum, BOEM should conduct a break-even analysis. There is a simple way to conduct such an analysis using WEB3. BOEM must first assume that environmental externalities follow a mean-reversion process. Given the simplification discussed in the previous sub-section that NEV is a mean-reversion process, BOEM can now assume that net social value (NSV) follows a mean-reversion process.[168] Using a grid search, BOEM can then run WEB3 to solve for a plane (trend average NSV, reversion rate, and standard deviation) for which the trigger price equals current price. To restrict the grid search, we can limit the search space by setting the trend average NSV less than the trend price ($90); further restrictions may be possible. Comparing the differences in the reversion rate and standard deviation between the hurdle price and hurdle average NSV runs, BOEM can determine

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[163] *Id.*
[164] *See* Golub & Brody, *supra* note 127.
[165] As per correspondence with the authors, this calculation visually approximates the standard deviation from the 2013 Interagency Working Group's Technical Support Document. Using the full set of 2020 SCC estimates from the 2016 Interagency Working Group runs (previously available on the White House website), Policy Integrity more accurately estimate this number as $28. Due to the tail risk of the SCC (i.e., non-normal skewness and kurtosis), this likely still underestimates the SCC, and a more accurate approximation using the Graham-Charlier model is possible (Anda et al., 2009). *See* 2016 Interagency Working Group, *supra* note 151; Anda et al., *supra* note 124, at 1352.
[166] Anda et al., *supra* note 124, at 1352.
[167] *Id.* at 1351.
[168] Anda et al. (2009) analyzes the stochastic process underlying net social value. *Id.*

whether any of the set of values on the solution plane are consistent with the level of variation underlying current market and environmental cost estimates.

G. BOEM should conduct sensitivity analyses, including Monte Carlo simulations, to improve transparency and test the robustness of its numerical results.

BOEM states in its Draft Proposed Program that uncertainty is particularly important, but it incorrectly argues that uncertainty is a reason for excluding catastrophic oil spills from its analyses. BOEM even discusses uncertainty underlying the inputs into its analyses in "Section 10.1.1 Information and Uncertainty": quantity of reserves, cost of extraction, and environmental and social externalities. These concerns are inconsistent with its current lack of numerical treatment of uncertainty, except for resource price in OECM and WEB3. Specifically, each analysis using the *OECM* and *WEB3* models should include a sensitivity analysis to highlight the robustness of BOEM's models' conclusions.

For each model, BOEM should conduct a thorough review of the literature and provide more detail about parameters. Specifically, BOEM should provide a central (mean or median) estimate and a range of estimates drawn from the literature. Ideally, BOEM would specify a triangular or normal distribution for parameters using these values, and the variances of the underlying estimates. At a minimum, BOEM should conduct such an analysis over key parameter values.

For parameters where estimates are unavailable in the literature, the use of expert elicitation is an acceptable alternative. This is consistent with the use of expert opinion (i.e., Dr. Stephen Brown) in the calibration of MarketSim. However, this elicitation should not rely on one author only. Instead, BOEM should identify multiple experts to survey to develop a range of possible estimates, which can be further characterized by its central value and variance.[169] This would allow BOEM to conduct an informed sensitivity analysis over these parameter values.

There are two types of sensitivity analysis that BOEM should adopt. First, BOEM should explore the impact of key parameters on model results. Second, BOEM should run a Monte Carlo simulation. In its simplest version, BOEM should calibrate triangular or normal distributions for each key parameter based on the range of estimates in the literature and the central value and variance of these estimates, and then randomly draw from these distributions to run the model. Conducting these analyses would allow BOEM to determine the robustness of its current results.

A. Offshore Environmental Cost Model

Currently, BOEM models price uncertainty in its net economic value (NEV) and net social value (NSV) analyses. However, BOEM arbitrarily limits its sensitivity analysis to price, failing to provide equal treatment for the market, social, and environmental costs of

[169] For example, EPA surveyed twelve experts in an expert elicitation on the mortality impacts of a decrease in PM2.5 in the United States. It utilized its responses to specify a concentration-response function, and explore uncertainty. Henry A. Roman, Katherine D. Walker, Tyra L. Walsh, Lisa Conner, Harvey M. Richmond, Bryan J. Hubbell, & Patrick L. Kinney, *Expert Judgment Assessment of the Mortality Impact of Changes in Ambient Fine Particulate Matter in the US*, 42 ENV'T SCI & TECH 2268 (2008).

drilling. Specifically, the uncertainty analysis of market and social costs of drilling is limited to the portion of market cost that is captured by price uncertainty. In the case of market (i.e., capital and operating) costs, BOEM assumes that they "increase at roughly half the rate of increase in resource prices," ignoring other factors like "changes in international demand for oil and natural gas extraction resources."[170] Similarly, environmental and social costs are also directly linked to price, as they are function of the undiscovered economically recoverable resources (via OECM),[171] which in turn is a function of price. Thus, all market and social cost uncertainties captured in the NEV and NSV analyses capture price uncertainty only.

Given BOEM's own discussion of the potential importance of market and social cost uncertainty, the choice to model price uncertainty, alone, is arbitrary and should be addressed. BOEM should explicitly model uncertainty in the quantity of economically recoverable resources. With respect to market costs, BOEM should model uncertainty in capital and operation costs in addition to the uncertainty in their relationship to price. Finally, with respect to social costs, BOEM should model uncertainty in social costs by including a sensitivity module in OECM. As discussed earlier, OECM should also be expanded, or its output modified, to include the cost of catastrophic oils spills and greenhouse gas emissions. Thus, BOEM should address the uncertainty in the quantity of oil and GHG emissions and their social costs; this is particularly important for catastrophic oil spills, given BOEM's mention of the considerable uncertainty underlying them. In the case of the Social Cost of Carbon, the Interagency Working Group on the Social Cost of Carbon (2016)[172] already provides an SCC distribution corresponding to the employed 3% discount rate, although modeling the uncertainty underlying the quantity of GHG emissions is also necessary.

It is critical that BOEM conduct sensitivity analysis in its NEV and NSV analyses. According to BOEM, its current omission of uncertain of market costs could significantly impact its NEV and NSV calculations.[173] BOEM has also highlighted the significant uncertainty underlying catastrophic oils spills.

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[170] Draft Proposed Program at 10-8 ("A portion of the cost uncertainty is driven by changes in resource prices. Increased oil prices create additional competition for existing drilling rigs and investment dollars from other parts of the world, which raises the cost of exploration, development, and production. Through internal modeling efforts and validation with external sources, BOEM has estimated that costs increase at roughly half the rate of increase in resource prices. In addition to price, capital and operating costs are driven by changes in international demand for oil and natural gas extraction resources.").

[171] *See* Figure 5-14 in the Draft Proposed Program at 5-21.

[172] *See* Figure 1 in 2016 Interagency Working Group, *supra* note 151.

[173] Draft Proposed Program at 10-8 ("Uncertainties surrounding the magnitudes of capital and operating costs also influence the net benefits estimates for each planning area. Because the capital and operating costs are inherent in calculating the NEV (a major component of a planning area's net benefits calculation), changes in costs could alter the estimate of NEV in each of the planning areas").

B. When Exploration Begins, version 3

Consistent with the options value literature on natural resources—see Conrad and Kotani (2005)[174] —BOEM should also conduct sensitivity analysis in its calculation of each OCS region's hurdle price using its WEB3 model. BOEM should conduct a sensitivity analysis to determine how the hurdle price changes with its various deterministic parameters; this analysis should be consistent with the NEV and NSV analyses.

In the case of WEB3 (and its corresponding FMV analysis), sensitivity analysis over the assumed stochastic processes is also critical. The stochastic process can greatly impact the results of a hurdle price (and option value) analysis (Mezey and Conrad, 2010). There are a variety of one factor processes in addition to geometric Brownian motion and mean reversion models that BOEM can consider.[175] In fact, Oud and Goard (2015) test a variety of one-factor stochastic models using oil price data finding that their proposed "three-quarters models" outperform the more common GBM and mean-reversion models.[176] BOEM could also consider two-factor and three-factor stochastic models which better predict price, though these multi-factor models are not without their own shortcomings.[177] Given BOEM's modeling of both oil and natural gas prices, BOEM should consider analyzing dual correlated one-factor mean-reverting processes (Hahn and Dyer, 2008) to jointly model the stochasticity of oil and natural gas prices.[178] Even if BOEM maintains its mean-reversion model, there are alternative specifications that it should consider.[179]

Finally, as discussed in Part II.D., BOEM should switch to modeling concurrent options for each OCS region. However, if BOEM continues to model its optimization problem as holding one option for each OCS region (i.e., a European style option instead of an American style option) then it should conduct sensitivity analysis to the alternative development period beyond 10 years, as is currently assumed.[180] In the case of environmental externalities, like greenhouse gas pollution, learning may take some time to occur. We suggest considering delays of up to 50 years.

CONCLUSION

Interior must correct and strengthen its analysis in several important respects in order to meet OCSLA's requirements, including its duty to adequately balance economic, social, and environmental values in managing the Outer Continental Shelf and to earn fair market value for the public's resources.

Respectfully,

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174 *See* Table 5 in Conrad & Kotani, *supra* note 99.
175 *See generally*, Oud & Goard, *supra* note 130.
176 *Id.* at 197.
177 *Id.* at 190.
178 *See* Hahn & Dyer, *supra* note 100.
179 *See* Oud & Goard, *supra* note 130, at 190-93.
180 Draft Proposed Program at B-17.

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