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MEMORANDUM | 29 APRIL 2021

TO Charles Paris & Martin Heinze, Bureau of Ocean Energy Management

FROM Jason Price and Derek Ehrnschwender, Industrial Economics, Inc.

SUBJECT MarketSim 2020 Updates – Expert Elasticity Review

INTRODUCTION

As a component of IEc's broader review of elasticity values used in MarketSim, IEc contacted academic experts to elicit their input on several key supply elasticity categories. These categories, identified by BOEM following IEc's preliminary review of elasticities, are (1) Oil, Offshore; (2) Oil, Other; (3) Oil, Rest of World; (4) Oil, Imports from Canada; and (5) Gas, Lower 48 Unconventional. IEc, in consultation with BOEM, identified three experts with a history of work and familiarity in the field of energy supply elasticities: Dr. Gavin Roberts of Weber State University, Dr. Charles Mason of the University of Wyoming, and Dr. Seth Blumsack of Pennsylvania State University.

IEc scheduled preliminary calls with each of the experts to describe the project and gauge their interest and subject-area knowledge. IEc then developed sets of questions specific to each of the supply elasticity categories to send to the experts to provide added context for the ensuing discussions. IEc held calls with each expert individually to understand their thoughts on the current elasticity estimates and potential replacement values. Each expert took the approach of viewing the existing values as a null hypothesis against which they would consider the evidence for alternate values. Dr. Roberts and Dr. Mason each pulled energy supply and price data relevant to each category and performed calculations to arrive at their own estimates to compare against the existing estimates. Dr. Blumsack relied on his knowledge of the current literature and industry trends to critique the existing estimates and suggest alternate values.

Exhibit 1 below summarizes the existing values for each of the five categories, as well as each expert's initial suggestions for revised estimates. The detailed notes from each conversation are appended to this document.

EXHIBIT 1: SUMMARY OF EXPERT INPUT

ELASTICITY CATEGORY	EXISTING VALUE		ROBERTS SUGGESTION		MASON SUGGESTION		BLUMSACK SUGGESTION	
	VALUE	NOTES	VALUE	NOTES	VALUE	NOTES	VALUE	NOTES
Oil, Offshore	0.51	Assumed value from Brown (1998)	0.16 to 0.20	Calculated 0.2 using Brent prices and Gulf Coast production, pointing toward the 0.16 value derived by BOEM.	0.24	Calculated using Baker-Hughes Gulf of Mexico production and Brent prices, post-2005.	0.16	Leans toward the BOEM-derived 0.16 estimate due to the complexity and longer timelines involved in extracting offshore oil.
Oil, Other	0.51	Assumed value from Brown (1998)	1.0	Natural gas liquids likely have a high elasticity; if they dominate this category Roberts suggests 1.0. [*IEc confirmed that natural gas liquids make up more than 80% of projected Oil, Other production in AEO 2021*]	0.11	Calculated using EIA production data for natural gas liquids and oil prices, post-2000.	0.9	Suggests an updated higher elasticity for the pre-shale period, perhaps a weighted average of the Newell & Prest value (1.2) and the Brown value: .8(1.2) + .2(.5) = 0.9.
Oil, Rest of World	0.40	From Brown et al. (2014)	0.15 to 0.3	Calculated using WTI prices. OPEC was between 0.25 and 0.3; non-OPEC (non-Canada) was 0.15.	0.3	Calculated using Baker-Hughes production data for a variety of time horizons. 0.3 comes from data 2005-present.	0.2 to 0.4	Suggests a range between the Brown source and a more recent estimate from Caldara (0.4).
Oil, Imports from Canada	1.00	Assumed value	0.4 to 0.6	Calculated 0.45, but thinks that may be a little low and suggests the range.	0.35	Calculated using EIA production data for Canadian imports, pre-2005. In Mason's opinion, the Canadian oil industry still hasn't recovered from the Great Recession.	0.2 to 0.4	Blumsack would expect this to be lower than 1.0, perhaps in line with Rest of World.
Gas, Lower 48 Unconventional	1.60	From Medlock (2012) and EMF (2013)	1.0 to 1.3	Would not necessarily reject 1.6, but believes the range is likely between 1.0 and 1.3, citing his recent paper with Ben Gilbert.	0.7	Newell & Prest as well as Mason & Roberts have ranges around 0.7. Mason notes the Medlock source was not peer reviewed.	1.2	Blumsack suggests that this value is closer to that of unconventional oil, because the technologies are similarly flexible.

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EXPERT INTERVIEW QUESTION SET, BOEM MARKETSIM UPDATES 2020/2021

To inform our discussion regarding select elasticity parameters in MarketSim, IEc has prepared the list of questions below. These questions relate to elasticities for four segments of oil supply, as well as the supply of unconventional natural gas. The existing elasticity values for these and other elasticity parameters are in Exhibit 1 at the end of this document.

Notes from discussion with Dr. Roberts shown in *blue* below.

QUESTIONS

Oil, Offshore

- Do you have any specific thoughts on a likely value for the own-price supply elasticity for offshore oil? For reference, MarketSim's current estimate for offshore oil supply elasticity is 0.51, from Brown (1998). Additionally, BOEM has derived an offshore oil supply elasticity of 0.16 from EIA's 2020 low, reference, and high price cases from the *Annual Energy Outlook*, though this value has not been included in MarketSim.
    - Do you have a view on whether the actual offshore oil supply elasticity value would be higher or lower than these values?
    - If so, how much higher or lower?
    - Do you have any thoughts on the difference between the EIA 2020 AEO derived value and the existing offshore oil estimate from Brown (1998)? Do you believe one of these values is a better representation of the actual supply elasticity for offshore oil?
- As a further reference point, our existing elasticity estimates for onshore conventional oil supply is 1.1 and onshore tight oil supply is 1.2, both from Newell & Prest (2019).[1]
    - Do you have a view on whether the offshore oil supply elasticity value would be higher or lower than these values for onshore oil supply?
    - If so, how much higher or lower?
- Dr. Roberts' methodology: In advance of the call, he specified a simple regression of log of Brent prices on log of production in the Gulf Coast (using publicly available data). He also ran a comparison using the lagged log of production.
    - This method resulted in an elasticity estimate of 0.2, which suggests that the 0.51 estimate in the model is likely too high. The estimate of 0.16 derived by BOEM from the EIA data seems more realistic.
    - Elasticity values were likely higher in the past because Gulf Coast oil used to be a higher proportion of the supply in the past.

[1] These values were identified through a literature review conducted by IEc in the fall of 2020. Although they have been approved for use in MarketSim by BOEM, the MarketSim documentation has not yet been updated to include these values.

Oil, Other

- Do you have any specific thoughts on a likely value for the own-price supply elasticity for oil in the "other" category? The "oil, other" category refers to "refinery processing gain, product stock withdrawal, natural gas plan liquids, and liquids from coal."
- For reference, our existing estimate for "oil, other" is 0.51, from Brown (1998). As a further reference point, our existing elasticity estimates for onshore conventional oil supply is 1.1 and onshore tight oil supply is 1.2, both from Newell & Prest (2019).
    - Do you have a view on whether the other oil supply elasticity value would be higher or lower than these values for onshore oil supply?
    - If so, how much higher or lower?
- Dr. Roberts suggests assuming an elasticity value of 1 for this category as opposed to elsewhere, as the components of "Oil, Other" likely have radically different elasticities.
    - Liquids from coal are probably so far up the supply curve that the elasticity is very high.
    - Refinery processing gains likely have a very low elasticity since refineries will also push this as much as they can. Production probably shows pretty stable growth over time.
    - It's probably worth ignoring product stock withdrawals if it's storage withdrawals. In effect, these would just be intertemporal transfers, with injections and withdrawals cancelling each other out over time.
    - Natural gas liquids probably have a high elasticity. Assuming this sub-category is much larger than the others, an elasticity of 1.0 for "Oil, Other" would be appropriate. [*IEc: Based on the AEO 2021, natural gas liquids account for the vast majority (more than 80%) of projected Oil, Other production*].

Oil, Rest of World

- Do you have any specific thoughts on a likely value for the own-price supply elasticity for oil in the rest of world category?
- For reference, our existing estimate for oil, rest of world, is 0.40, from Brown et. al (2014).
    - Do you have a view on whether the actual offshore oil supply elasticity value would be higher or lower than these values?
    - If so, how much higher or lower?
- As a further reference point, our existing elasticity estimates for onshore conventional oil supply is 1.1 and onshore tight oil supply is 1.2, both from Newell & Prest (2019).
    - Do you have a view on whether the oil, rest of world supply elasticity value would be higher or lower than these values for onshore oil supply?
    - If so, how much higher or lower?
- Dr. Roberts used the same approach as for Oil, Onshore. He switched to WTI as opposed to Brent prices, using prompt month prices. He also calculated two different values for OPEC (non-Canada) and non-OPEC (Non-Canada) nations.
    - OPEC (non Canada): between .25 and .3
    - Non-OPEC (non Canada): 0.15
    - Dr. Roberts' overall impression is that a bit below the existing value of 0.4 is probably best, but these results do not lead to rejecting the null hypothesis that the elasticity is 0.4.

Oil, Imports from Canada

- Do you have any specific thoughts on a likely value for the own-price supply elasticity for the oil pipeline imports from Canada category?
- For reference, our existing estimate for oil pipeline imports from Canada is 1.00, an assumed value.
  - Do you have a view on whether the actual offshore oil supply elasticity value would be higher or lower than these values?
  - If so, how much higher or lower?
- As a further reference point, our existing elasticity estimates for domestic onshore conventional oil supply is 1.1 and onshore tight oil supply is 1.2, both from Newell & Prest (2019).
  - Do you have a view on whether the oil, imports from Canada supply elasticity value would be higher or lower than these existing values for the North American oil supply?
  - If so, how much higher or lower?
- Dr. Roberts' estimate is 0.45 using the same process, but that may be a little low. He suggests a range between 0.4 and 0.6. The assumed value of 1 is definitely too high, as the competition from fracked oil in the U.S. is too stiff. Canada can't respond to prices at that level unless fracking becomes much more expensive in the U.S., an unlikely outcome.
  - Canadian imports are growing steadily over time despite price variation occurring in the background. This could just be following pipeline capacity, but he doesn't see jumps corresponding to that. Dr. Roberts surmises this probably reflects steady growth in Canadian oil sands over time.

Gas, Lower 48 Unconventional

- Do you have any specific thoughts on a likely value for the own-price supply elasticity for the unconventional gas category?
- For reference, our existing estimate for unconventional gas is 1.60, from Medlock (2012) and EMF (2013). As a further reference point, the current estimate for conventional natural gas is 0.29, also from Medlock (2012).
  - Do you have a view on whether the lower 48 natural gas unconventional supply elasticity value would be higher or lower than these existing values for conventional and unconventional gas production?
  - If so, how much higher or lower?
- Dr. Roberts took a different approach with natural gas due to his recent paper looking at unconventional plays. He would not necessarily reject 1.6, but he believes the elasticity value is likely between 1.0 and 1.3 overall.
  - It's worth knowing that in the Permian (lots of unconventional gas), liquids pricing drives everything. Because gas is co-produced with oil, gas production may increase dramatically as oil prices increase (even if gas prices or flat or even trending downward).

REFERENCES

Brown SPA. 1998. Global warming policy: some economic implications. Federal Reserve Bank of Dallas Economic Review. Fourth Quarter 1998.

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Newell, R. G., & Prest, B. C. (2019). The unconventional oil supply boom: Aggregate price response from microdata. *The Energy Journal*, *40*(3).

NEMS 2019 Reference Case (2019). Supplemental data provided by EIA.

EXHIBIT 1. MARKETSIM DEFAULT SUPPLY ELASTICITIES, CURRENT

FUEL	SOURCE	SUPPLY ELASTICITY
Oil	Lower 48 Onshore, Conventional[1]	1.1
	Lower 48 Onshore, Tight[1]	1.2
	Lower 48 Offshore[2]	0.51
	Alaska Onshore[4]	2.85
	Alaska Offshore[4]	2.20
	Other[2]	0.51
	Biodiesel[3]	0.24
	Rest of World[8]	0.40
	Canadian Pipeline Imports[7]	1.00
Natural Gas	Lower 48 Conventional[5]	0.29
	Lower 48 Unconventional[6]	1.60
	Lower 48 Offshore[5]	0.29
	Alaska Onshore[4]	1.35
	Alaska Offshore[4]	1.35
	Other[2]	0.51
	Pipeline Imports[4]	0.52
	LNG Tanker Imports[7]	1.00
Electricity	Oil[4]	0.46
	Natural Gas[7]	1.00
	Coal[4]	1.07
	Nuclear[7]	1.00
	Other Electric[7]	1.00
	Hydro[4]	0.13
	Wind Onshore[7]	1.00
	Wind Offshore[7]	1.00
	Solar[9]	1.24
	Imports[4]	0.06
Coal	Domestic[10]	4.39
	Imports[7]	1.00

Notes:

1. Newell & Prest (2019)
2. Brown (1998).
3. Luchansky and Monks (2009).
4. Derived from specialized NEMS runs provided to BOEM by EIA, July 2016.
5. Medlock (2012).
6. Medlock (2012) and EMF (2013).
7. Assumed value.
8. Brown et. al (2014).
9. Derived from *AEO 2014*.
10. Derived from *NEMS 2019*.

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EXPERT INTERVIEW QUESTION SET, BOEM MARKETSIM UPDATES 2020/2021

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Notes from discussion with Dr. Mason shown in *green* below.

QUESTIONS

Oil, Offshore

- Do you have any specific thoughts on a likely value for the own-price supply elasticity for offshore oil? For reference, MarketSim's current estimate for offshore oil supply elasticity is 0.51, from Brown (1998). Additionally, BOEM has derived an offshore oil supply elasticity of 0.16 from EIA's 2020 low, reference, and high price cases from the *Annual Energy Outlook*, though this value has not been included in MarketSim.
  - Do you have a view on whether the actual offshore oil supply elasticity value would be higher or lower than these values?
  - If so, how much higher or lower?
  - Do you have any thoughts on the difference between the EIA 2020 AEO derived value and the existing offshore oil estimate from Brown (1998)? Do you believe one of these values is a better representation of the actual supply elasticity for offshore oil?
- As a further reference point, our existing elasticity estimates for onshore conventional oil supply is 1.1 and onshore tight oil supply is 1.2, both from Newell & Prest (2019).[1]
  - Do you have a view on whether the offshore oil supply elasticity value would be higher or lower than these values for onshore oil supply?
  - If so, how much higher or lower?
- *Dr. Mason's view is that long run elasticities would effectively be the elasticity of drilling with respect to price. Obtaining a lease and drilling can take multiple months if not years. His focus is on the effect of prices upon drilling. The Baker-Hughes dataset informed his responses, in addition to looking at publicly available elasticity estimates in the literature. For price, he used the spot market price of Brent crude.*
- *Most price data are monthly, but Gulf Coast (offshore) is weekly. Dr. Mason aggregated this to the monthly level.*
  - *Using data for 1995-present, his estimate was just above 0.09. However, he said that may not reflect the elasticity today, as pre-2005 data reflects activity in shallow water, whereas most activity is now in deeper water.*
  - *Mason thinks post-2005 is the most appropriate time to focus on. Using data for this period, the supply elasticity is 0.24*

[1] These values were identified through a literature review conducted by IEc in the fall of 2020. Although they have been approved for use in MarketSim by BOEM, the MarketSim documentation has not yet been updated to include these values.

  - *Even expanding the sample to 2000-present, 0.25 or a bit lower would be Dr. Mason's guess.*

Oil, Other

- Do you have any specific thoughts on a likely value for the own-price supply elasticity for oil in the "other" category? The "oil, other" category refers to "refinery processing gain, product stock withdrawal, natural gas plan liquids, and liquids from coal."
- For reference, our existing estimate for "oil, other" is 0.51, from Brown (1998). As a further reference point, our existing elasticity estimates for onshore conventional oil supply is 1.1 and onshore tight oil supply is 1.2, both from Newell & Prest (2019).
  - Do you have a view on whether the other oil supply elasticity value would be higher or lower than these values for onshore oil supply?
  - If so, how much higher or lower?
- *Based on EIA production data for natural gas liquids and oil prices, Dr. Mason estimates an elasticity value of 0.1056 for the post-2000 period. He recommends the use of this value.*
- *As a point of comparison, Dr. Mason also suggested looking at estimates for vertical wells.*
  - *For oil onshore, looking at vertical wells up to 2008 as represented in the Baker-Hughes data, Dr. Roberts calculated an elasticity value of 0.374. Newell & Prest pointed to 0.5.*

Oil, Rest of World

- Do you have any specific thoughts on a likely value for the own-price supply elasticity for oil in the rest of world category?
- For reference, our existing estimate for oil, rest of world, is 0.40, from Brown et. al (2014).
  - Do you have a view on whether the actual offshore oil supply elasticity value would be higher or lower than these values?
  - If so, how much higher or lower?
- As a further reference point, our existing elasticity estimates for onshore conventional oil supply is 1.1 and onshore tight oil supply is 1.2, both from Newell & Prest (2019).
  - Do you have a view on whether the oil, rest of world supply elasticity value would be higher or lower than these values for onshore oil supply?
  - If so, how much higher or lower?
- *Using the same methodology as for offshore oil, Dr. Mason used the Baker-Hughes data on international drilling by month.*
  - *Dr. Mason used a variety of timeframes for this, as in the last two decades there has been a migration to deeper waters which have higher costs.*
  - *From 1995, 2000, 2005 to present, Dr. Mason's estimates were between 0.30-0.37. He would recommend 0.3, based on data for 2005-present.*

Oil, Imports from Canada

- Do you have any specific thoughts on a likely value for the own-price supply elasticity for the oil pipeline imports from Canada category?
- For reference, our existing estimate for oil pipeline imports from Canada is 1.00, an assumed value.

    - Do you have a view on whether the actual offshore oil supply elasticity value would be higher or lower than these values?
    - If so, how much higher or lower?
- As a further reference point, our existing elasticity estimates for domestic onshore conventional oil supply is 1.1 and onshore tight oil supply is 1.2, both from Newell & Prest (2019).
    - Do you have a view on whether the oil, imports from Canada supply elasticity value would be higher or lower than these existing values for the North American oil supply?
    - If so, how much higher or lower?
- *To derive elasticity estimates, Dr. Mason used a similar methodology as described above for offshore oil and ROW oil, pulling monthly observations on Canadian imports from EIA.*
    - *For the whole sample 1995-present, Dr. Mason calculates 0.37.*
    - *Under the 2000-2020 timeframe, the estimated elasticity comes in around 0.23*
    - *Data is available 1995-present, but for the Canadian elasticity Dr. Mason suggests BOEM may be better served with pre-2005. In his opinion, the Canadian oil industry still hasn't recovered from the oil shock associated with the Great Recession. Using pre-2005 data, he estimates a supply elasticity of 0.35. He recommends something around this value. The value of 1.0 currently used in the model is too high in his opinion.*

Gas, Lower 48 Unconventional

- Do you have any specific thoughts on a likely value for the own-price supply elasticity for the unconventional gas category?
- For reference, our existing estimate for unconventional gas is 1.60, from Medlock (2012) and EMF (2013). As a further reference point, the current estimate for conventional natural gas is 0.29, also from Medlock (2012).
    - Do you have a view on whether the lower 48 natural gas unconventional supply elasticity value would be higher or lower than these existing values for conventional and unconventional gas production?
    - If so, how much higher or lower?
- *Unconventional natural gas—Newell & Prest initially produced different estimates than Dr. Mason did in a recent paper with Gavin Roberts, though the two papers differed in their geographic scope (i.e., the Mason-Roberts paper focused on Wyoming). Also, the early version of the Newell & Prest paper used revenue instead of price to derive an elasticity value; the most recent version switched from revenue to price. When using price, Newell & Prest estimate a supply elasticity of 0.65 to 0.7. By comparison, Mason and Roberts estimate a range of 0.61 to 0.73.*
- *Dr. Mason notes that the Medlock paper was not peer reviewed.*
- *Overall, Dr. Mason recommends a value of approximately 0.7.*

REFERENCES

Brown SPA. 1998. Global warming policy: some economic implications. Federal Reserve Bank of Dallas Economic Review. Fourth Quarter 1998.

Brown SPA, Mason C, Krupnick A, Mares J. 2014. Crude behavior: how lifting the export ban reduces gas prices in the United States. Resources for the Future Issue Brief 14-03. http://www.rff.org/RFF/Documents/RFF-IB-14-03-REV.pdf

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	Lower 48 Unconventional[6]	1.60
	Lower 48 Offshore[5]	0.29
	Alaska Onshore[4]	1.35
	Alaska Offshore[4]	1.35
	Other[2]	0.51
	Pipeline Imports[4]	0.52
	LNG Tanker Imports[7]	1.00
Electricity	Oil[4]	0.46
	Natural Gas[7]	1.00
	Coal[4]	1.07
	Nuclear[7]	1.00
	Other Electric[7]	1.00
	Hydro[4]	0.13
	Wind Onshore[7]	1.00
	Wind Offshore[7]	1.00
	Solar[9]	1.24
	Imports[4]	0.06
Coal	Domestic[10]	4.39
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Notes from discussion with Dr. Blumsack shown in *red* below.

QUESTIONS

General Discussion:

- *Dr. Blumsack notes that there's been a series of papers written recently on supply elasticities, but they are likely short run and less relevant. From Caldara, Dallas Fed.*
- *Suggests that elasticities will vary between periods of low prices and high prices.*
- *Papers by Newell & Prest, Hilde Bjornland (NBS); these find lower unconventional oil elasticities (0.9). Bjornland makes the argument that you can drill but not complete wells in unconventional fields, which provides a measure of flexibility. Thus, the long run elasticity economically defined should be much higher for unconventional than for conventional. Producers are much more able to intertemporally allocate investments in supply.*
- *The Bjornland finding is different than papers by Baumeister & Hamilton, which have concluded that the elasticity for unconventional supply is still pretty low. Dr. Blumsack tends to agree with Newell & Prest/Bjornland, but notes that these papers contradict.*

Oil, Offshore

- Do you have any specific thoughts on a likely value for the own-price supply elasticity for offshore oil? For reference, MarketSim's current estimate for offshore oil supply elasticity is 0.51, from Brown (1998). Additionally, BOEM has derived an offshore oil supply elasticity of 0.16 from EIA's 2020 low, reference, and high price cases from the *Annual Energy Outlook*, though this value has not been included in MarketSim.
    - Do you have a view on whether the actual offshore oil supply elasticity value would be higher or lower than these values?
    - If so, how much higher or lower?
    - Do you have any thoughts on the difference between the EIA 2020 AEO derived value and the existing offshore oil estimate from Brown (1998)? Do you believe one of these values is a better representation of the actual supply elasticity for offshore oil?

- As a further reference point, our existing elasticity estimates for onshore conventional oil supply is 1.1 and onshore tight oil supply is 1.2, both from Newell & Prest (2019).[1]
    - Do you have a view on whether the offshore oil supply elasticity value would be higher or lower than these values for onshore oil supply?
    - If so, how much higher or lower?
- *Dr. Blumsack would lean toward the lower BOEM-derived estimate 0.16 due to the level of complexity in extracting offshore oil and the longer timelines involved.*

Oil, Other

- Do you have any specific thoughts on a likely value for the own-price supply elasticity for oil in the "other" category? The "oil, other" category refers to "refinery processing gain, product stock withdrawal, natural gas plan liquids, and liquids from coal."
- For reference, our existing estimate for "oil, other" is 0.51, from Brown (1998). As a further reference point, our existing elasticity estimates for onshore conventional oil supply is 1.1 and onshore tight oil supply is 1.2, both from Newell & Prest (2019).
    - Do you have a view on whether the other oil supply elasticity value would be higher or lower than these values for onshore oil supply?
    - If so, how much higher or lower?
- *Dr. Blumsack thought the existing value was relatively low. He wasn't able to trace back Brown's source.*
- *Dr. Blumsack might suggest a higher elasticity now that we're past the "pre-shale" period. Suggests maybe using a weighted an average of .8(1.2)+.2(.5) = 0.9 or so. This is the weighted average of the Newell & Prest value above and the Brown (1998) value above.*

Oil, Rest of World

- Do you have any specific thoughts on a likely value for the own-price supply elasticity for oil in the rest of world category?
- For reference, our existing estimate for oil, rest of world, is 0.40, from Brown et. al (2014).
    - Do you have a view on whether the actual offshore oil supply elasticity value would be higher or lower than these values?
    - If so, how much higher or lower?
- As a further reference point, our existing elasticity estimates for onshore conventional oil supply is 1.1 and onshore tight oil supply is 1.2, both from Newell & Prest (2019).
    - Do you have a view on whether the oil, rest of world supply elasticity value would be higher or lower than these values for onshore oil supply?
    - If so, how much higher or lower?
- *Dr. Blumsack says 0.4 is relatively low, as expected. A more recent estimate (0.2) from Caldara is also low. Caldara uses more recent data than the Brown paper which will rely on lower oil prices we see today. Dr. Blumsack suggests 0.2-0.4 as a reasonable range.*

[1] These values were identified through a literature review conducted by IEc in the fall of 2020. Although they have been approved for use in MarketSim by BOEM, the MarketSim documentation has not yet been updated to include these values.

Oil, Imports from Canada

- Do you have any specific thoughts on a likely value for the own-price supply elasticity for the oil pipeline imports from Canada category?
- For reference, our existing estimate for oil pipeline imports from Canada is 1.00, an assumed value.
  - Do you have a view on whether the actual offshore oil supply elasticity value would be higher or lower than these values?
  - If so, how much higher or lower?
- As a further reference point, our existing elasticity estimates for domestic onshore conventional oil supply is 1.1 and onshore tight oil supply is 1.2, both from Newell & Prest (2019).
  - Do you have a view on whether the oil, imports from Canada supply elasticity value would be higher or lower than these existing values for the North American oil supply?
  - If so, how much higher or lower?
- *Dr. Blumsack hasn't seen an estimate anywhere, but thinking theoretically: Why is long run rest of world so low? Producers pick long term commitments that might not be optimizable on a short timeline. It's different with tar sands. He would expect this elasticity to be a bit lower than 1. Maybe more in line with rest of world (0.2 to 0.4).*

Gas, Lower 48 Unconventional

- Do you have any specific thoughts on a likely value for the own-price supply elasticity for the unconventional gas category?
- For reference, our existing estimate for unconventional gas is 1.60, from Medlock (2012) and EMF (2013). As a further reference point, the current estimate for conventional natural gas is 0.29, also from Medlock (2012).
  - Do you have a view on whether the lower 48 natural gas unconventional supply elasticity value would be higher or lower than these existing values for conventional and unconventional gas production?
  - If so, how much higher or lower?
- *Dr. Blumsack says 1.6 is pretty high and wonders if that might be skewed by the ramp up of unconventional gas in the face of higher prices. He mentioned the Mason paper.*
- *Dr. Blumsack would posit that the elasticity value is closer to that of unconventional oil, because the technologies are similarly flexible. Perhaps 1.2. He recommends looking at Kellogg and Hausman 2015.*

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EXHIBIT 1. MARKETSIM DEFAULT SUPPLY ELASTICITIES, CURRENT

FUEL	SOURCE	SUPPLY ELASTICITY
Oil	Lower 48 Onshore, Conventional[1]	1.1
	Lower 48 Onshore, Tight[1]	1.2
	Lower 48 Offshore[2]	0.51
	Alaska Onshore[4]	2.85
	Alaska Offshore[4]	2.20
	Other[2]	0.51
	Biodiesel[3]	0.24
	Rest of World[8]	0.40
	Canadian Pipeline Imports[7]	1.00
Natural Gas	Lower 48 Conventional[5]	0.29
	Lower 48 Unconventional[6]	1.60
	Lower 48 Offshore[5]	0.29
	Alaska Onshore[4]	1.35
	Alaska Offshore[4]	1.35
	Other[2]	0.51
	Pipeline Imports[4]	0.52
	LNG Tanker Imports[7]	1.00
Electricity	Oil[4]	0.46
	Natural Gas[7]	1.00
	Coal[4]	1.07
	Nuclear[7]	1.00
	Other Electric[7]	1.00
	Hydro[4]	0.13
	Wind Onshore[7]	1.00
	Wind Offshore[7]	1.00
	Solar[9]	1.24
	Imports[4]	0.06
Coal	Domestic[10]	4.39
	Imports[7]	1.00

Notes:

1. Newell & Prest (2019)
2. Brown (1998).
3. Luchansky and Monks (2009).
4. Derived from specialized NEMS runs provided to BOEM by EIA, July 2016.
5. Medlock (2012).
6. Medlock (2012) and EMF (2013).
7. Assumed value.
8. Brown et. al (2014).
9. Derived from *AEO 2014*.
10. Derived from *NEMS 2019*.