

Questions for Technology Cost Experts About Natural Gas-Fueled Electricity Generating Plants with Carbon Capture

Background and General Instructions

Thank you for agreeing to participate in this expert elicitation on natural gas-fueled electricity generating plants with carbon capture. The purpose of this expert elicitation is to estimate the costs of natural gas-fueled electricity generating plants with carbon capture with and without enactment of the most directly relevant portion of some legislation (the American Energy Innovation Act) currently pending before the US Congress. Your answers will help us in preparing a public report on the expected impacts of the legislation on reducing the costs of this technology by 2035. Expert names will be preserved to enable public thanks in our report/paper and competent peer review but will not be associated individually with responses in anything we publish.

In this packet, you should have received four documents:

1. these instructions;
2. a summary of the proposed Legislation;
3. a questionnaire in the form of an Excel workbook containing three tabs labeled Part 1, Part 2, and Part 3; and
4. the Legislation itself in case you wish to refer to it

Before beginning your answers in the Excel workbook regarding cost projections for this technology, please carefully read through 1) all of the instructions in this document, 2) the questions in the associated Excel workbook, and 3) the associated Legislation summary. We would like for all of these to be clear for you and all participants, so if you have a question or suggestion as you read or answer, please contact Dr. Daniel Shawhan of RFF at 202-328-5027 (8am-midnight ET including weekends) or shawhan@rff.org. We expect to collect information from five experts about this technology.

Instructions that apply to all of the questions

The questions are in the associated Excel workbook, on three tabs labeled "Part 1," "Part 2," and "Part 3." This section of instructions applies to all three parts. Below it are additional important instructions for Parts 2 and 3.

The questions below are about the costs and characteristics of new natural gas-fueled electricity generating plants with carbon capture ("NG-CCS") that will be or could be designed in 2035 and subsequently built. We are interested in your unbiased projections of these costs and characteristics with and without the enactment of the Legislation described in the attached summary. After you finish reading these instructions, please carefully study that summary. We have written it to be a faithful and comprehensive summary of the Legislation. However, we are also providing the full legislative language in case you wish to refer to it.

In order to help our readers understand the implications of your answers, we will be explicit in the report about all assumptions that we are asking you to make, and we will make all of the materials that we are providing to you available to the readers as well as online appendices.

When answering the questions, please make the following key assumptions :

- Please assume that if the Legislation is enacted, it will be enacted in 2021 and will then be fully implemented. Assume that it will be **funded for ten years (fiscal years 2022-2031)** as described in the attached summary of it.
- **Assume that if the Legislation is enacted, it will increase total US federal government funding for carbon capture and sequestration research, development, and demonstration (RD&D) by the amounts specified in the summary, relative to the scenario in which it is not enacted.** In other words, assume that it will neither crowd out nor crowd in other US federal government spending for natural gas-fueled electricity generating plants with carbon capture RD&D, except to the extent specified in the attached summary of it.
- Assume that after the ten years are over, US federal government funding for RD&D will no longer be affected by the Legislation, and will return to being the same as it would be if the Legislation had never been enacted.
- In developing your answers to our questions, please **include indirect effects**. For example, if you anticipate that enactment of the Legislation would have a positive probability of also influencing private RD&D and/or commercial deployment by 2035 and thereby of further changing the cost of plants designed in 2035, please include those indirect effects in your answers.
- In your answers about the cost of the plant, please include the costs of building, maintaining, and operating the CO₂ compression equipment at the plant site, but do not include the other costs of transporting or sequestering the CO₂. We will ask separate questions about those.
- In formulating your answers about the costs of the technology, please give values that do not reflect subsidies. For example, even if you think there might be a tax credit or other subsidy for building or operating this type of facility, please give cost estimates without reducing them by the expected amount of the subsidy.
- However, we are otherwise looking for all-inclusive cost estimates. For example, please include all the costs of developing the facility, including the cost of financing it while it is under development.

Importantly, when we use the word “develop” and derivatives such as “development,” we mean the whole process, from early steps such as site selection through commencement of operation. This includes construction.

When we write the “most cost-competitive” subtype of the technology, we mean the one that is being built the most in the US (in terms of capacity commercially brought online per year), or, if no subtype is profitable to commercially build, then the subtype that would require the least subsidy to be profitable, per dollar of levelized cost. By “subtype,” we simply mean a specific plant type. Question 4 in Part 1 gives two examples.

In this study, we would like to focus on the subtypes of Natural Gas-Fueled Electricity Generating Plants with Carbon Capture that have the potential to be the most cost-competitive choice even at a large scale of deployment. Please base your answers on subtypes that could be chosen by investors for at least 50 GW of new capacity in the event of eventual deployment of 100 GW of new capacity of Natural Gas-Fueled Electricity Generating Plants with Carbon Capture. Some subtypes might not meet this criterion because some needed resource such as favorable sites or a necessary material is too scarce. This scarcity issue might or might not apply to the technology type we are asking you about.

The differences between your answers in the two columns are crucial in the analysis, so please pay special attention to them. Instead of using round numbers in both columns, please set the difference between the values in the two columns so that it is your best, most precise guess of the expected value of the effect that enactment of the Legislation would have.

Instructions for answer explanations

In a separate document in the format of your choice (Word, Excel, LaTeX, or other), or on the answer spreadsheet (e.g. to the right of each question), please explain how you arrived at your answers to each of the questions. It is fine to be brief. It is also fine and appropriate that judgment plays a frequent role. As part of this explanation, if you used sources, calculations, or a model, please let us know what they were. Your explanations will allow us to check that our questions were clear enough to be understood correctly and will allow us to verify and explain any surprising answers. It will also allow us to better explain to readers of our report/paper how experts think the costs of the technologies will be determined and how policies such as the Legislation are likely to affect those costs.

Instructions for Part 2

Part 2 is just a checklist to help you check that you are remembering the assumptions we have asked you to make when answering the questions in Parts 1 and 3. If the answer to any of the questions in Part 2 is no, please return to the answers you've given and revise them with the corresponding assumption in mind.

Important additional instructions for Part 3

All of the Part 1 instructions above apply equally to the Excel worksheet called "Part 3—Levelized Cost." In addition, here are further instructions for Part 3.

What we most need are the 90th, 50th, and 10th percentiles of levelized cost of energy from a typical facility that is planned in 2035 (and built shortly thereafter) if the Legislation is not enacted, and the same if the Legislation is enacted. We would like for your three pairs of levelized cost values together to represent your best projections of how much the Legislation would shift the high, middle, and low portions of the probability distribution of levelized cost in 2035.

We also need the breakdown of levelized cost in each case so that we can compare it with other estimates that use different assumptions regarding weighted average cost of capital, capacity factor, and energy input costs; and so that we can represent your projections well in realistic simulation modeling.

In this context, the 90th percentile is the levelized cost that the true value of levelized cost in 2035 has a 1 in 10 chance of exceeding, representing the high or pessimistic projection. The 50th percentile is the levelized cost that the true 2035 value has an equal chance of being greater or less than. The 10th percentile is the levelized cost that the true 2035 value has a 1 in 10 chance of being less than, representing the low or optimistic projection. Please note that we are looking for these percentiles from the *perspective of today*. (One participant interpreted the question as asking for the costs of a high-cost facility, a medium-cost facility, and a low-cost facility in a single version of the future. That is **not** what we are requesting.)

There are six columns in Part 3. For example, your entries in the first column are your answers to the implicit question, "If the Legislation is not enacted, what is the 90th percentile of the levelized cost of energy, and what is the most representative combination of cost and performance characteristics that would result in that 90th percentile of levelized cost of energy?" **In the first beige row (row 4), please enter the levelized cost. In the other beige rows, please enter the most likely or representative combination of component values that would result in that levelized cost. Please adjust your answers**

until they are your best answers and the levelized cost calculated from your component answers (row 7) matches the levelized cost you entered (row 4) to within 1%.

Note that the 90th percentile of levelized cost is generally not the same as the levelized cost that results from the 90th percentiles of all of the components of levelized cost, and might differ greatly from it.

Please base your answers on the most cost-competitive subtype (or subtypes) of the technology, but take into account that there is uncertainty about which subtype that will be. Please give answers that are a weighted average across the subtypes that might be most cost-competitive, weighted by estimated probability of being the most cost-competitive. Do not limit yourself to the two subtypes you named in Part 1.

A few last details

If for any answer you use different units than the ones we ask for (or we are not specific enough about units), please let us know exactly what units you use. If you need to use a different year's dollars for one or more answers, let us know what year's dollars you are using for that answer or those answers.

For the plant cost values that apply to multiple years and may change as the plant gets older (for example, variable operating and maintenance cost, annual fixed cost), please report estimated life-cycle weighted average, with each year's value weighted 4% less (in real i.e. constant-year dollars) than the one before it. The reason for using 4% real is that we plan to use 4% real to harmonize and compare different estimates of levelized cost, including yours. However, we do not want this to affect your answers to our question about projected weighted average cost of capital.

For variable costs and determinants of them such as heat rate, please also weight them by expected production quantity in each year, which might for example tend to decline as the plant ages.

If you need for us to keep any of your explanations or sources confidential, just let us know which.

We adapt these instructions and the questions file for multiple generation and CO₂ capture technologies. For this reason, you might notice intentionally blank rows or wording that is not entirely customized to your technology.

Again, if you have a question or suggestion as you read or answer, please do not hesitate to contact Dan Shawhan of RFF at 202-328-5027 (8am-midnight ET including weekends) or shawhan@rff.org.

We thank you very much for your thoughtful answers!