Hedging Strategies: Electricity Investment Decisions under Policy Uncertainty

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Executive summary

Global climate change remains a major challenge for national governments to collectively address. Because of uncertainty in science, economic factors, and future technology, we do not yet know what reductions in carbon dioxide and other greenhouse gas emissions will be needed by later in this century. This uncertainty poses a dilemma to today's regulators and energy industry. Before we know what the long-term goals will be, how much of new investment in energy facilities over the next decade should be non-carbon emitting technologies? Investments will certainly be made in the next several years, and those facilities will still be productive in a few decades when sharper cuts in emissions may or may not be required.

The decision of what share of new investment should be non-carbon must balance two risks that imply opposing responses. There is a risk of over-investing in non-carbon generation and later not needing it, which would impose unnecessary costs. This implies that we should hedge against this risk by investing less in wind, solar, new nuclear, or carbon-capture power plants. There is also a risk that we invest too little in non-carbon generation, and later find out that steep reductions are required. The lack of preparation and flexibility could impose very high costs in the future, which implies that we should hedge against this risk by investing more in these non-carbon technologies.

This paper presents a quantitative analysis of how to balance these two concerns in finding an optimal investment strategy before we know the future emissions restrictions. We develop a computational model that represents, in simplified fashion, the different sectors of the economy, including the electric power sector. Building on this, we represent the decision for 2010-2020 about the fraction of new electricity investment that is non-carbon and also the emissions limit to impose, which determines the relative share of coal and natural gas generation. This decision is made under uncertainty in the emissions limit that must be met by 2030. Then, after the emissions limit is learned in 2020, the model chooses the share of non-carbon generation investment for 2020-2030 and how to operate existing generation capacity to meet the carbon target.

We find that for a broad range of assumptions about the uncertainty in future emissions limits, 5-30% of the new generation in the near-term should be from non-carbon sources. In general, the cost of under-investing in non-carbon technologies is larger than the cost of over-investing. The reason is that if too much non-carbon generation is built but not needed to meet emissions limits, it can and will still be utilized fully. In contrast, carbon-intensive generation that is built now may become stranded capital in the future if the emissions limits are very strict, preventing the plants from being used. This imposes much higher costs. An additional benefit to early investment in non-carbon technologies is that it can develop the capacity and the infrastructure needed to be

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able to scale up non-carbon generation quickly if a much higher share is needed in subsequent decades.

We compare the investment strategy from our model ("Optimal") with three alternative strategies that are often used in the face of uncertainty. One strategy is "Myopic", which ignores uncertainty and does not make any investment in non-carbon in the first decade. A second strategy, "Deterministic", is to take the best guess of the uncertainty, in this case a mid-range emissions limit by 2030, and find the best strategy for that case. The final alternative strategy is to take a precautionary approach, "Aggressive", and make substantial near-term investments in non-carbon generation and emissions reductions. We compare the performance of the four strategies by drawing random samples from the distribution of possible emissions limits, and seeing what the cost is of using the strategy from 2011-2020 and meeting each emissions limit in the least costly way in 2021-2030. We find that most of the possible outcomes under the "Optimal" strategy are low-cost. The "Myopic" and "Deterministic" strategies can have lower cost outcomes, but can also experience much worse outcomes (larger losses). The "Aggressive" strategy, has the least variability of all the strategies, but almost always has somewhat higher costs than "Optimal".

Very aggressive, precautionary strategies are able to avoid the very worst outcomes, but are also unable to take advantage of unexpected opportunities. Ignoring uncertainty or using average values to determine a strategy tend to run much higher risks of very costly outcomes. The best strategy is inevitably a balance, in this case investing in a range of different energy technologies to preserve the flexibility to make sharper cuts in emissions or back off, depending on what we learn in the future.

Keywords Uncertainty, Electricity, Emissions, Policy, General Equilibrium, Approximate Dynamic Programming

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