



Climate Policy Economics Insights

What Every Company Should Do to Prepare for a Mandatory US Greenhouse Gas Cap-and-Trade Program

By Dr. David Harrison, Jr. and James Johndrow

The United States is poised to develop mandatory programs to limit emissions of carbon dioxide and other greenhouse gases (GHGs). Although renewable energy and energy efficiency programs will be part of the package, a federal cap-and-trade program for GHG emissions seems destined to become the centerpiece of the US effort, just as it has been at the center of policies in Europe and proposed policies in Australia and elsewhere.

Federal climate change policy will have widespread impacts on companies in the US. The constraints on carbon and other GHG emissions created by a mandatory cap-and-trade program will affect the demand and supply of virtually all products in the US, particularly electricity and other energy products, and also products from energy-intensive industries such as iron and steel, chemicals, aluminum, cement, and many others. Every company needs to prepare for mandatory climate policy—to minimize costs, assess new opportunities, and take climate policies into account in key decisions—and economic analysis can help to point the way to the right decisions.

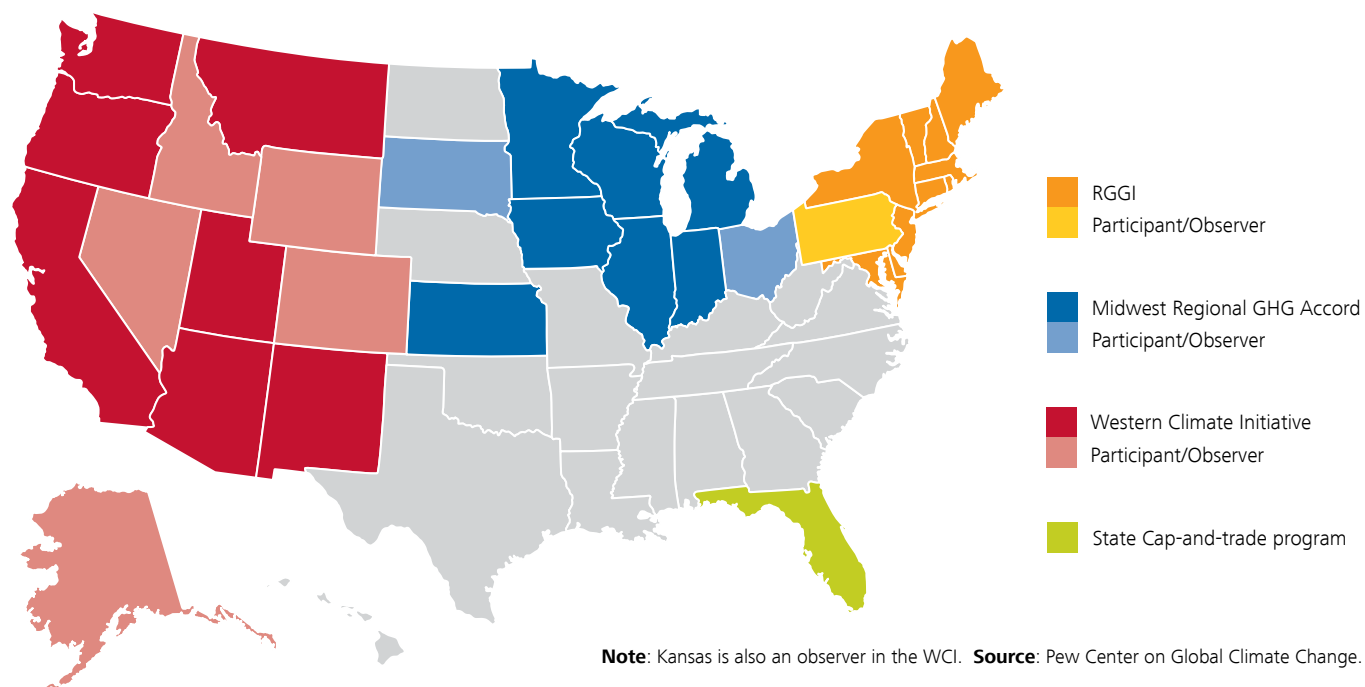
Companies should be trying to answer five fundamental questions as they prepare for mandatory climate change policies.

1. What future climate change policies might be put in place?
2. What would be the financial impacts for us?
3. Given the possibility of a future policy, what should we do now?
4. What internal procedures should we put in place?
5. What should be our external activities?

This article focuses on the first three questions. We show how economic modeling—and the NERA Carbon Financial Impacts Model in particular—can help to clarify what is at stake. The model, which we have used to evaluate the effects of renewable portfolio standards, cap-and-trade programs, and other policies, can be an important tool to help integrate the effects of climate policy in key decisions.¹

Federal Greenhouse Gas Emissions Cap-and-Trade Program on the Horizon

Over the last several years, numerous federal cap-and-trade proposals have been introduced in the US House of Representatives and Senate. Moreover, as Figure 1 illustrates, state officials have been busy designing regional programs in the Northeast, Midwest, and West. The Northeast program (the Regional Greenhouse Gas Initiative, or RGGI) began in January 2009. The Obama administration's expected cap-and-trade proposal will undoubtedly draw on prior proposals and experience, including the experience with the European Union's Emissions Trading Scheme (which has been running since 2005)² as well as the substantial discussion related to regional and federal US proposals.

Figure 1: **Map of US states and regional cap-and-trade programs/proposals**

Basic features and importance

The use of emissions trading reflects a fundamental shift in environmental regulation from a centralized “command-and-control” approach to a market-based one. Prior experience suggests that market-based approaches can cost much less than more traditional regulatory ones. For example, studies of the acid rain trading program for sulfur-dioxide emissions indicate that the program achieved cost savings on the order of 50 percent relative to a command-and-control approach.³ Moreover, the cap-and-trade approach can provide greater certainty that environmental targets will be met, because command-and-control regulations are often accompanied by “extensions” and “exceptions.”

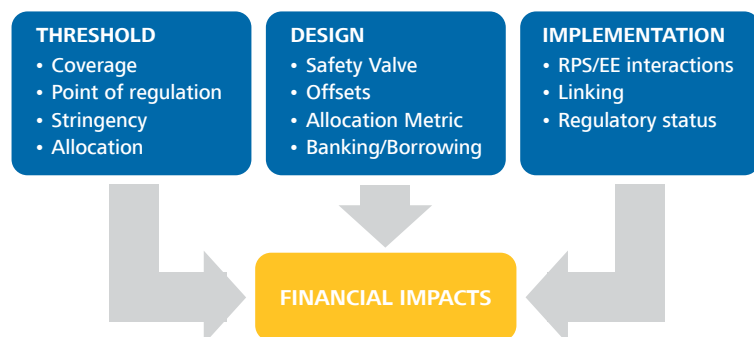
Thus, although a GHG emissions cap-and-trade program would have major impacts, the approach will be much more flexible and cost-effective than bans on certain technologies, requirements to install other technologies, or other command-and-control policies that would achieve the same overall GHG reductions. Indeed, the cap-and-trade approach shifts a company’s focus away from environmental compliance toward the economic management of GHG emissions costs. Emissions become a new “factor of production” that has a cost, but whose efficient use can yield benefits for the bottom line.

Key Elements That Affect Financial Impacts

The financial impacts of a GHG cap-and-trade program can be analyzed by focusing on a number of important elements. These can be usefully (but somewhat arbitrarily) grouped into *threshold*, *design*, and *implementation issues*.

Threshold elements form the basic structure of the cap-and-trade program.

- *Coverage (sectors, sources).* Coverage refers to which sectors and facilities ultimately are covered by the program, with the trend in legislative proposals toward comprehensive coverage of all large emissions sources, and possibly small ones as well.
- *Point of regulation.* Effects can vary depending on whether the point of regulation (i.e., responsibility for surrendering emissions allowances) is “upstream” at the level of fuel producers (e.g., oil refineries, coal mines) or “downstream” at the level of emitters (e.g., power plants and industrial sources), with some recent proposals involving a “hybrid” of oil and gas upstream and coal downstream.
- *Stringency.* Impacts are greater with more stringent emissions target trajectories.
- *Allowance auction versus free allocation.* Since the value of allowances in a federal program could be on the order of \$100 billion-\$400 billion per year, whether

Figure 2: **Key cap-and-trade elements affecting financial impacts**

allowances are auctioned or allocated for free will have major financial consequences (although there is of course a continuum from 100-percent free allocation to 100-percent auctioning).

Design elements include many of the specifics of the program that also can have a large influence on financial impacts.

- *Safety valve.* A safety valve is a ceiling on allowance prices that would constrain potential costs and limit allowance price volatility.
- *Offsets.* The rules governing the use of offsets (i.e., credits for emissions reductions from energy efficiency and other projects) can have a substantial effect on allowance prices for a given level of stringency.
- *Allocation metric.* The method used to allocate free allowances (e.g., historical emissions or some input or output benchmark) will affect financial impacts.
- *Banking/borrowing.* Allowing companies to bank (i.e., “save” extra allowances for future use) and borrow (i.e., “borrow” allowances from the future when they have insufficient allowances) affects both the level of allowance prices and their trajectory.

Implementation elements affect the results of the program once it is implemented.

- *Interaction with other policies.* Interactions between the cap-and-trade program and other government regulations can be significant. This is particularly true of renewable portfolio standards and other renewables policies and energy efficiency policies.⁴
- *Linking.* If the cap-and-trade program is “linked” with other programs (i.e., trading of allowances with other cap-and-trade programs is allowed), then allowance prices could be significantly affected.

- *Regulatory status of electricity generation.* The regulatory status of electricity generation in a jurisdiction can have significant impacts on costs and on who bears the costs of the program.

Modeling the Financial Impacts of a Cap-and-Trade Program

Evaluating the likely effects of a cap-and-trade program ultimately requires empirical analysis. NERA has developed a comprehensive empirical framework to evaluate the financial impacts of climate legislation.

NERA Carbon Financial Impacts Model

Figure 3 (*following page*) summarizes the structure of the NERA Carbon Financial Impacts Model, which NERA has used for more than five years to evaluate the impacts of climate change policies for numerous companies and sectors, including electricity, oil and gas, refining, pulp and paper, cement, aviation, and others.

The NERA model uses information from three major sources—the company (or sector), the details of climate policy scenarios, and results of national modeling of climate policy, including carbon-dioxide allowance prices, energy prices, and other product prices and quantities—to estimate the effects of the program on a company’s financial situation. As discussed below, a fourth set of inputs supplements the modeling to provide assistance with investment decisions and ongoing analyses.

Developing Financial Impact Estimates

Figure 4 (*following page*) provides an illustration of allowance prices under three potential cap-and-trade programs.⁵ Because of substantial uncertainties regarding the various design issues discussed above as well as potential compliance costs, future allowance prices are highly uncertain. The three trajectories in Figure 4 illustrate this uncertainty and underscore the importance of sensitivity analyses and quantitative risk analysis in understanding what is at stake due to future climate change policies.

As Figure 5 illustrates, allowance prices and other modeling results are used to determine the likely financial impacts due to the GHG cap-and-trade program. The figure shows the financial impact of four distinct factors that are included in most analyses.⁶

Figure 3: Overview of the NERA Carbon Financial Impacts model

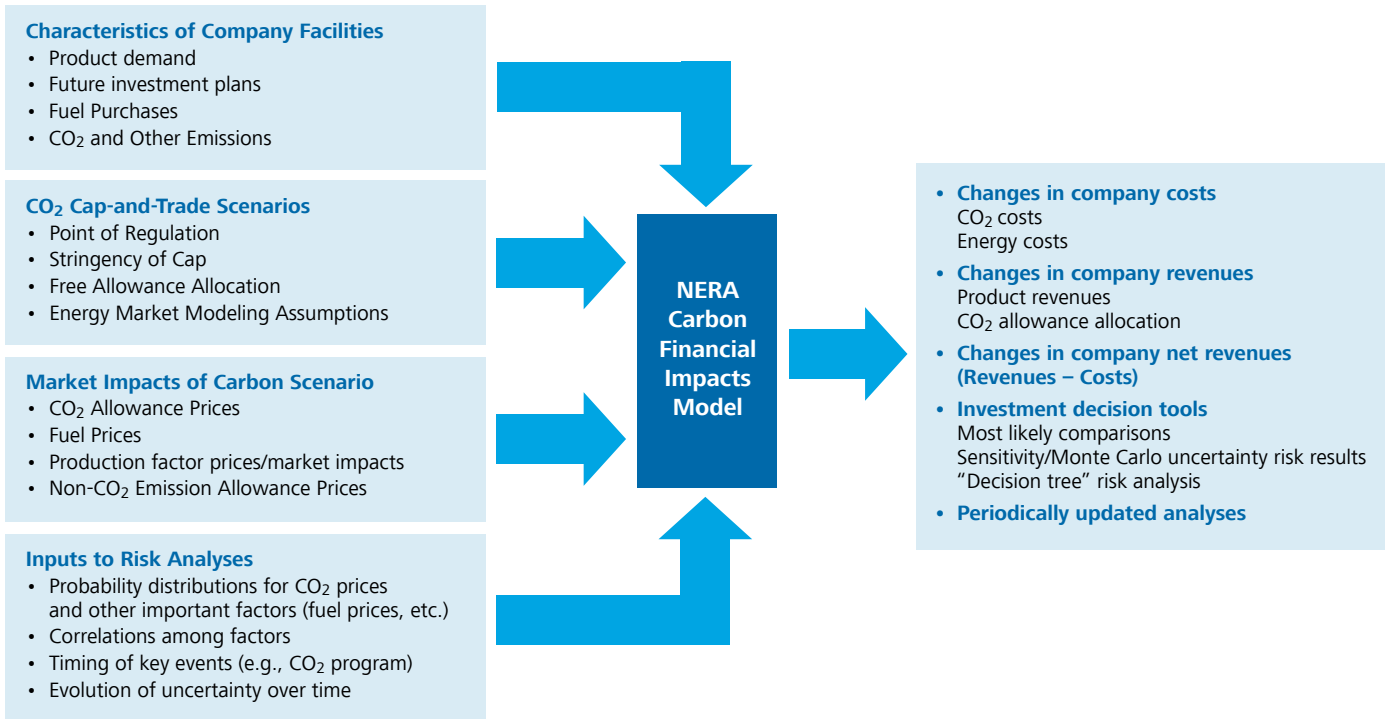
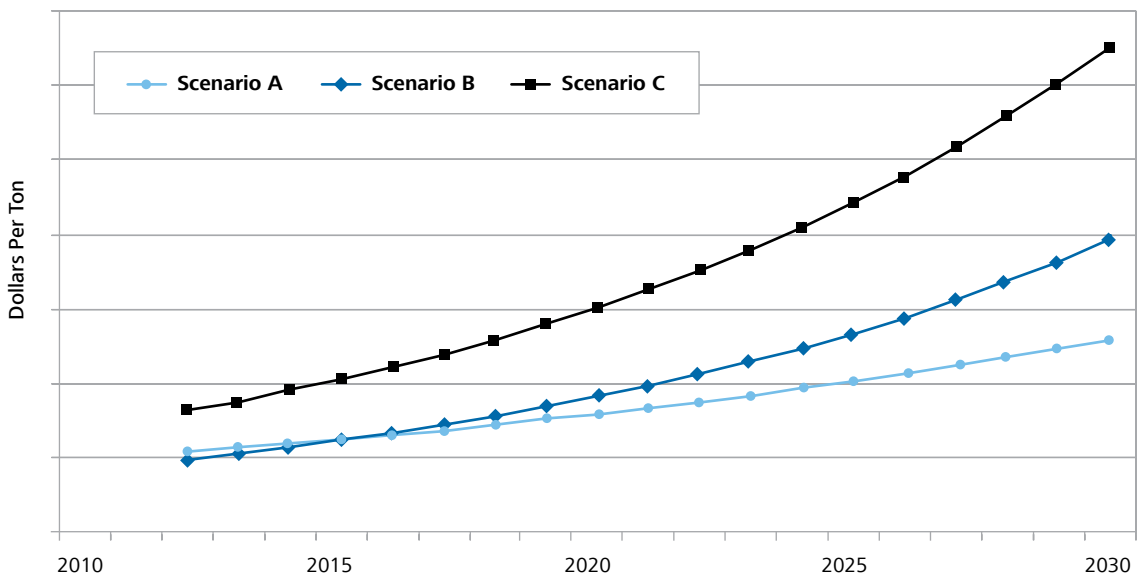


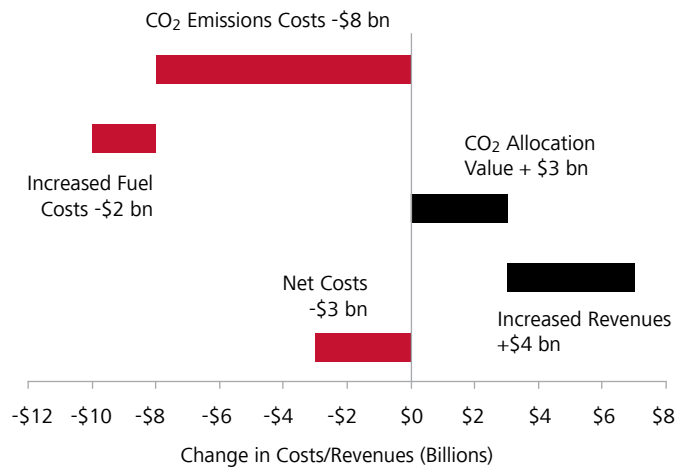
Figure 4: Illustrative CO₂ allowance prices in three scenarios



- Costs of the allowances required to cover the companies' direct CO₂ emissions;
- Energy cost increases due to changes in prices of fuel, power, and other inputs due to the cap-and-trade program;
- Implicit revenues due to the free allocation the company receives; and
- Changes in product revenues due to the "pass through" of increased costs.

various parameters lead to increases or decreases the net impacts of the program. The company can use these types of results to clarify how different policy alternatives might affect it.

Figure 5: **Hypothetical financial impacts of US GHG cap-and-trade program for an illustrative company using the NERA Carbon Financial Impacts Model**

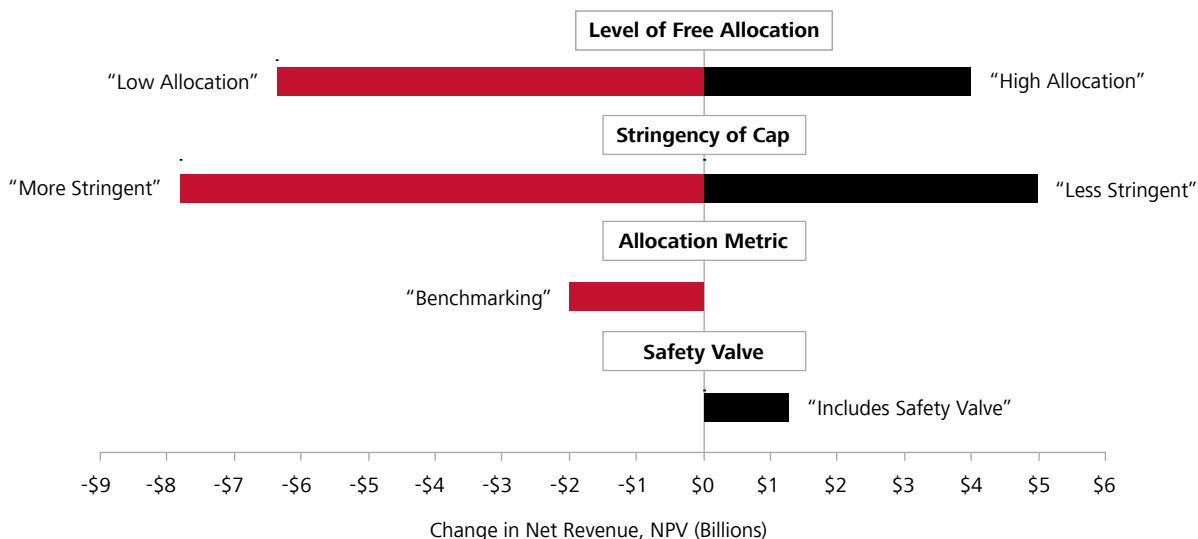


Note: All numbers are illustrative and do not reflect modeling for any individual company. For simplicity, the figure excludes the effects of costs to reduce emissions and the resulting changes in emissions costs.

The results are reported in terms of the present value of costs over the time period covered by the modeling (e.g. from 2012 to 2030). In this illustrative example, the company would have costs of \$8 billion to cover its CO₂ emissions, increased energy (fuel and purchased electricity) costs of \$2 billion, a free allocation worth \$3 billion, and increases in product revenues of \$4 billion for a decline in net income of \$3 billion. (This example does not include the costs of reducing emissions costs; these effects are included in the model.) The model also provides annual results so one can see how these cost and revenue components change over time.

The financial impacts will of course depend upon the company's specific circumstances as well as the details of the climate change policy. Figure 6 illustrates how changes in

Figure 6: **Changes in net financial impacts for an illustrative company due to changes in the features of US GHG cap-and-trade program**



Note: These are illustrative results in a pattern consistent with findings from various studies.

Implications of Future Climate Change Policy for Key Investment Decisions

Climate policy may have major impacts on a company's investment decisions, particularly if alternatives are being considered that have very different carbon emissions rates—for example, the choice between coal and natural gas for industrial boilers, or the choice between fossil fuels and nuclear or renewables for electricity generation. These decisions will need to take into account the potential direct costs of CO₂ emissions as well as the impacts on other costs (e.g. of energy) and revenues.

Although standard investment analysis based upon the present values of different alternatives can be useful to clarify the implications of alternative investment choices, deeper insights are often available from the use of two sets of decision-making tools:

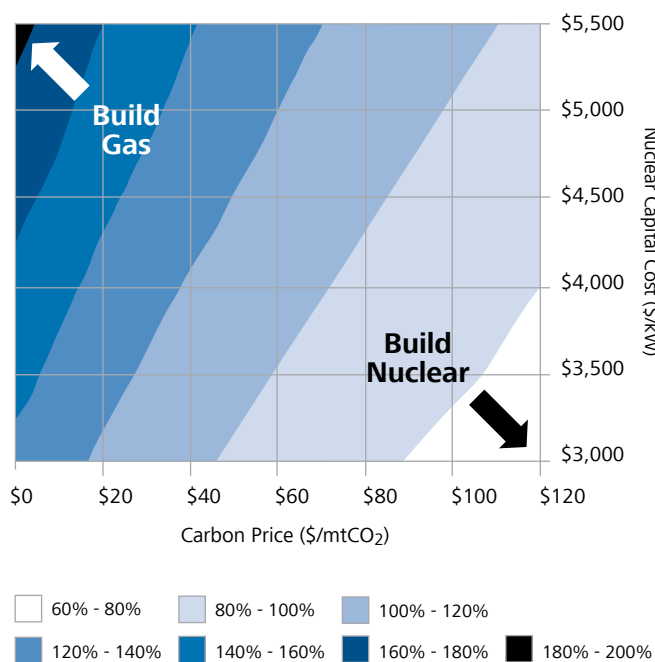
1. Uncertainty analyses, which provide information on the range of potential results; and
2. Decision analysis, which can be used to evaluate the timing of key decisions.

Uncertainty Analyses

Traditionally, those making major investment decisions have used sensitivity analysis to assess the implications of changes in key parameters for the relative desirability of different choices. In the future, uncertainties related to climate change policy should be added to the key considerations. The NERA Carbon Financial Impacts Model has a module to assist in this process by providing two types of analyses.

- *Sensitivity analyses.* These include calculations of the integrated effects of different climate policies—including effects on CO₂ costs, fuel prices, and electricity prices—on the values of different investment alternatives.
- *Monte Carlo analyses.* The NERA model includes a Monte Carlo analysis component, which allows us to evaluate thousands of sensitivity cases and distill the results in a useful summary. The Monte Carlo analysis includes the effects of interactions between variables (i.e., joint probability distributions). These interactions can be important in considering the best means of hedging against uncertain prices (e.g., CO₂ allowance and natural gas prices).

Figure 7: Illustration of information on relative costs of gas and nuclear generation due to CO₂ prices and nuclear capital costs



Note: Values represent the percentage of nuclear costs to natural gas costs. Numbers are illustrative and do not represent specific cost comparisons.

Figure 7 shows how the relative cost of nuclear and gas units change as a result of variations in two parameters—the CO₂ allowance price and the nuclear capital costs. Low CO₂ prices and high nuclear capital costs favor natural gas, whereas high CO₂ prices and low nuclear capital costs favor nuclear. The colors reflect the net present value of profits from building either type of generation, with the percentages in the legend indicating the ratio of profits from nuclear to profits from natural gas. By specifying the likelihood of the various outcomes (i.e., probability distributions for nuclear capital costs and CO₂ prices, as well as other variables such as future gas prices), a Monte Carlo analysis can be performed to assess the likelihood that conditions will favor nuclear over gas (or vice versa).

Decision analysis

Investment decisions often involve some flexibility with respect to timing. It is often possible to delay a decision on which type of capacity to build to meet anticipated future increases in demand. This delay can provide the opportunity to wait until additional information is available on key factors,

including likely CO₂ prices. A key question is whether it is worthwhile to spend money (e.g., on a nuclear permit application, or on additional power purchases) to keep an option open (e.g., the option to construct a nuclear rather than a natural gas plant if CO₂ prices are high), thereby delaying a final decision on which investment to make.⁷

Decision analysis provides a means of assessing choices regarding timing and the value of keeping options open. “Real options” make it possible to calculate the amount of money that an electricity company should be willing to spend now to keep open the option of constructing the “right” unit (e.g., natural gas if CO₂ prices are low, nuclear if CO₂ prices are high) in the future. The NERA Carbon Financial Impacts Model includes a module to develop these assessments.

Figure 8 provides a highly simplified example of the type of analysis that can be performed to evaluate the wisdom of spending money now to keep the option open to construct a nuclear unit in the future.⁸

In this simple example, the present value of expected profits (i.e., revenues minus costs) over the planning horizon is calculated to be \$1 billion if natural gas capacity is built and \$0.9 billion if a nuclear unit is built, based upon the likelihood of three potential CO₂ price regimes (no, low, and high). Thus, if the decision had to be made today, the company in this simple example would choose natural gas as the most profitable alternative. There is, however, an additional

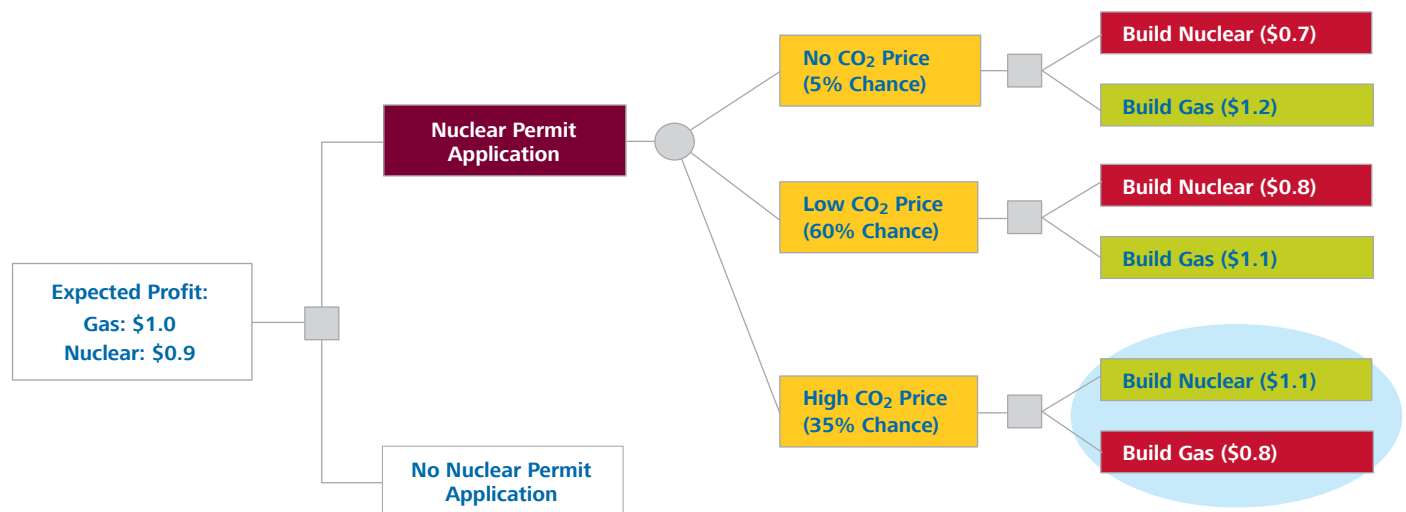
option of delaying the choice until there is more information concerning which of the CO₂ price regimes will occur. Note that if the high CO₂ price regime prevailed, it would be better to build the nuclear unit (see the circled node in the decision tree in Figure 8).

This simple example illustrates the calculations to determine whether it would be worthwhile to spend money now (e.g., for a permit application or preparatory analyses) in order to keep the option of constructing a nuclear unit open. One can calculate the lowest cost option (i.e., nuclear or gas) in each of the carbon cases and estimate the likelihood of each case in order to determine the value of the option to build a nuclear unit. Since developing the nuclear option involves some expenditures (e.g., permit application, initial engineering work), the question facing the company in this simple example is whether the value of the option to build the nuclear unit is greater than the cost of developing (or maintaining) the option.

The information in the figure illustrates how the option value can be calculated in this simple example. The carbon cases, choices, and costs are the following (all illustrative values are present values over the relevant planning horizon):

- High CO₂ price: 35% chance, choose nuclear at an expected profit of \$1.1 billion
- Low CO₂ price: 60% chance, choose natural gas at an expected profit of \$1.1 billion

Figure 8: **Illustrative decision tree for nuclear permit application**



Note: Dollar figures are illustrative and taken to indicate billions.

- No CO₂ price: 5% chance, choose natural gas at an expected profit of \$1.2 billion
- Expected profits conditional on knowing CO₂ price regime = $(35\% * \$1.1) + (60\% * \$1.1) + (5\% * \$1.2) = \1.105 billion

Thus, waiting to make the decision until information is available about carbon prices results in expected profits that are \$105 million higher than making the decision to build natural gas units today. Put another way, in this simple example, the company would be willing to pay a maximum of \$105 million to keep the nuclear build option open and thus have the option to construct a nuclear unit or natural gas units, depending upon the level of carbon prices.

Conclusions

Mandatory climate policies in the US are getting closer and promise to lead to major impacts on companies in virtually every sector, particularly the energy-intensive sectors. Every company can and should prepare for these developments. In particular:

- *Every company should understand the implications of a carbon price for its business.* At a minimum, companies need to understand what a carbon-constrained world could mean for them. In many cases, indirect effects like changes to the prices of inputs and impacts on revenue may be just as important as the costs of direct emissions.
- *Every company should evaluate the financial impacts of alternative future mandatory carbon policies.* These policies should include potential cap-and-trade programs as well as various renewable and energy efficiency programs that are likely to be put in place. These analyses can clarify “what is at stake” under different potential policies.
- *Climate policy effects should be included in planning for investment and other major decisions.* Climate policy affects the costs and revenues of major investments, both directly through emissions costs and indirectly through changes in fuel prices and product prices. Economic modeling can help clarify these impacts and point the way to superior decisions.
- *Assessing climate policy impacts is an ongoing task.* Companies will need to address the effects of climate policy in numerous ongoing decisions, including pricing decisions. Economic modeling is thus an ongoing task to make sure the right information is available for these decisions.

The modeling tools that NERA has developed and applied in the NERA Carbon Financial Impacts Model can assist companies in developing these key analyses.

End Notes

- 1 The NERA Carbon Financial Impacts Model has been developed by a team at NERA that includes (in addition to the authors, in alphabetical order) Per Klevnas, Mark LeBel, Meghan McGuinness, David Nagler, Albert Nichols, and Daniel Radov. Various NERA colleagues have provided helpful comments on this article including Adam Borison, Jonathan Falk, Adam Findeisen, Meghan McGuinness, David Nagler, Albert Nichols, Hethie Parmesano, and Daniel Radov. Although grateful for these contributions, the authors alone are responsible for the content of the article and any errors or omissions it might contain.
- 2 For an overview of the European Union Emissions Trading Scheme, see, e.g., Harrison, David, Per Klevnas, Albert Nichols and Daniel Radov, "Using Emissions Trading to Combat Climate Change: Programs and Key Issues." *Environmental Law Reporter*, June 2008. http://www.nera.com/Publication.asp?p_ID=3506
- 3 See Ellerman, A. Denny, Paul Joskow and David Harrison, *Emission Trading in the U.S.: Experience, Lessons, and Considerations for Greenhouse Gases*. Washington, D.C.: Pew Center on Global Climate Change May 2003. http://www.nera.com/Publication.asp?p_ID=146
- 4 See Harrison, David, Steve Sorrell, Daniel Radov, Per Klevnas, Andrew Foss, *Interactions of Greenhouse Gas Emission Allowance Trading with Green and White Certificate Schemes*, prepared for the European Union Commission Directorate-General Environment, November 2005. http://www.nera.com/PracticeArea.asp?pa_ID=35&more=ClientExp&c_id=482
- 5 We use the National Energy Modeling System (NEMS) model developed by the US Department of Energy, Energy Information Administration to develop the national price and quantity forecasts.
- 6 The model results also include the effects of emission reductions, which lead to changes in operating/investment costs ("compliance costs") and reductions in allowance costs. For simplicity, these effects are not included in Figure 5. Note that in the case of regulated utilities, revenue effects depend upon regulatory decisions rather than just market effects.
- 7 For a general discussion of decisions regarding nuclear units, see Falk, Jonathan, "Why Planning a Nuclear Plant Is a Good Idea Even if Building One Turns Out to Be a Bad Idea," in *The Line in the Sand: The Shifting Boundary between Markets and Regulation in Network Industries*. Sarah Potts Voll and Michael J. King, White Plains, New York: NERA Economic Consulting, 2007. http://www.nera.com/Publication.asp?p_ID=3254
- 8 This basic example includes several simplifying assumptions. For one, CO₂ price uncertainty is assumed to be completely resolved at some specific point (e.g., when cap-and-trade legislation is passed). In practice, uncertainties regarding future CO₂ prices would be reduced but not fully resolved. In addition, this simple example does not include the disadvantages of delaying the build decision. The simple example also does not include other uncertainties (e.g., capital costs) and how they might be resolved over time. These and other complexities can be included in modeling of specific decisions.



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