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USING FAIR RETURN PRICES TO ASSESS THE VALUE AND COST OF FINANCIAL GUARANTEES FOR NEW NUCLEAR POWER PLANTS

Bernell K. Stone*

ABSTRACT

Financial guarantees change risk and therefore change the cost of financing and the return required by investors. Financial guarantees by the government are a form of subsidy. They are now pervasive in the energy sector and are proposed for new nuclear generating plants. Both the value to recipients and the cost to provide are difficult to assess for long-lived nonmarketable assets with great uncertainty about construction cost, operating cost, and prospective revenue. Therefore, in turn, it is difficult to assess potential costs for providing the guarantees. It is also difficult to compare financial guarantees with other types of subsidies (e.g. production credits). This Article adapts the idea of fair return rate regulation and the associated determination of a fair return price to the evaluation of a proposed project for generating nuclear power. Knowing the price required for a given level of return provides an easy-to-understand framework for assessing the value and cost of financial guarantees. The analysis can then be based on the difference in required return with and without guarantees to find the associated difference in required fair return price.

From the viewpoint of policy analysis and strategic planning, the merits of using differences in fair return prices include the fact that they are (1) easy to understand, (2) scale independent, and (3) consistent with both standard capital investment analysis and the fair return pricing that

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takes place in setting rates at the level of the overall utility. More importantly, reducing the value/cost of financial guarantees to a difference in price per kilowatt-hour makes financial guarantees easy to compare with production credits and other alternative subsidies that directly impact price and/or that can be easily translated into a price per kilowatt-hour.

I. INTRODUCTION

This Article has two primary purposes. First, it provides a non-technical overview and illustrative examples of the methodology for converting input assumptions about the required return on invested capital as well as assumptions about required capital outlays, operating costs, and operating efficiency into an associated fair return price. Second, this Article uses best case operating costs and industry estimates of the capital outlays to address the four key questions on value, cost, default probability, and market viability when applied to federal government debt guarantees for new nuclear power plants.

A debt guarantee refers to a commitment by one party to assume responsibility for performance on a debt contract or commitment when the primary party cannot perform. This Article addresses a particular type of debt guarantee, namely a federal government guarantee for a substantial portion of the debt of a risky capital investment project (e.g., the 80% debt guarantee for new nuclear power plants in the Energy Policy Act of 2005). A federal government debt guarantee is a subsidy. In order to understand and evaluate federal government debt guarantees as incentives for undertaking desirable capital investment projects, policymakers and the public need to understand four critical factors:

1) Value: The value of the guarantee to the recipient company or organization must be determined.

2) Cost: The likely cost to the government (or, ultimately, to taxpayers) of this subsidy compared to alternative subsidies and incentives must be determined.

3) Default Probability and Default Cost: Default probability refers to the chance that the company/organization receiving the federal debt guarantee will default so that the federal government will have to perform on the guarantee. Default cost is the amount that the government would have to pay to

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honor the guarantee.

(4) Economic Viability: Economic viability refers to the ability to generate earnings at least sufficient to service the guaranteed debt and ideally to service all project debt and earn as well at least a fair return on invested equity. When a substantial fraction of project debt is guaranteed, having economic viability is the key requirement for not having default occur and thus for assessing both default probability and cost.

Because a debt guarantee is a financial subsidy, its value, cost, and default risk are usually expressed in financial impact terms, such as change in debt cost, change in debt capacity, change in required project return, and change in project net present value. While these financial impact characterizations are understandable to economists and finance professionals, neither policymakers nor the general public find them easy to understand or easy to compare with alternative subsidies. Many other subsidies are either quoted in price terms or can be easily translated into price impacts. For instance, production subsidies are quoted as additional payments per unit of subsidized production. Tax credits and other output-based tax benefits per unit of output (such as depletion allowances) can also be easily translated into a direct price impact. Even pollution charges can be translated into a change in price required to recover the charge.

Translating debt guarantees and other financial subsidies into prices has several benefits. First, prices are easier for policymakers and the public to understand in terms of value of the incentive to the receiving company/organization. Second, prices and price impacts are the common numeraire for the evaluation of most other policies. Therefore, converting debt guarantees into price impact provides for easier comparison with alternative policies. Finally, for alternative methods of

2. See U.E. Reinhardt, Break-Even Analysis for Lockheed’s Tristar: An Application of Financial Theory, 27 J. Fin. 821-38 (1972) [hereinafter Reinhardt] (serving as an example of a debt guarantee evaluated thoroughly in terms of debt cost, overall financing cost, and net present value (in preference to the simpler payback measure)). The federal debt guarantee for the Lockheed TriStar and the Reinhardt framework are both summarized more thoroughly infra Section III.

3. In addition to the price subsidies, taxes, and direct charges mentioned here, see Table 23 for a list of ten subsidies to incentivize shale oil development. This list of ten incentives with summary evaluation including subsidy effect, includes, in addition to loan guarantees, both subsidized interest and accelerated depreciation as additional financial subsidies. U. S. experience with shale oil guarantees is treated further in Section III of this Article. See generally, OFFICE OF TECH. ASSESSMENT, EVALUATION OF POTENTIAL FINANCIAL INCENTIVES FOR OIL SHALE DEVELOPMENT: AN ASSESSMENT OF SHALE OIL TECHNOLOGIES (1980).

4. Financial subsidies are not alone in being difficult to convert into a price or a price change. There are other policies, especially pollution regulations capping the level of emissions that involve uncertain prices and/or that entail capital outlays that are also difficult to reduce to price
generating electricity, answering the questions of market viability, likelihood of default, and the ultimate expected cost, can all be reduced to the price per kilowatt-hour with the debt subsidy compared to competitive prices from other generation alternatives.

This Article addresses the conversion of federal debt guarantees into an associated price impact. It focuses on federal debt guarantees for long-lived capital investment projects that guarantee a high percentage of the financing (e.g., the provision for 80% federal debt guarantees for the financing of new nuclear power plants in the Energy Policy Act of 2005). The key idea is to adapt traditional net present value methods for capital budgeting to solve for a fair return price (or, a competitive return price) given assumptions about costs and operating efficiency. The difference between the fair return price with a federal debt guarantee and the fair return price without the guarantee is a price-based measure of the value of the guarantee.

In this Article, fair return price is defined as the price of electricity that provides a rate of return on invested capital just equal to an assumed fair return on investment given assumptions about certain factors, including construction costs (capital outlays), operating costs, operating efficiency, and plant life. Fair return price in this Article is a market-based fair return that should reflect current interest rates and risk to both debt and equity providers. This market-based fair return price is not necessarily the same as the prices that would be set by a utility commission to provide a regulatory fair return on invested capital for regulated electric utilities. However, as established in Section IV, they...
should generally be very close.

Moreover, in today’s deregulated electric power generation market, the companies/organizations that are the owner-developers of a nuclear power project are generally not a regulated electric utility. Refinement of this definition as a return able to service debt and provide a fair market return on invested equity is developed further in Sections IV and V (including its relation to the regulatory fair return on invested capital) and illustrated in Sections VI, VII, and VIII.

Section II of this Article provides background information on global climate change and the current critical role of federal government debt guarantees in low carbon nuclear electricity strategy for the United States. Section III provides a background discussion on federal financial guarantees for capital investment projects. Section IV reviews frameworks for assessing the value of financial guarantees and focuses on the adaptation of traditional capital investment project valuation methods to solve for the fair return price associated with assumptions about costs and a given discount rate. Section V presents an illustrative example of this proposed methodology using differences in required returns with a financial guarantee and without a financial guarantee to obtain differences in the associated fair return prices. Section VI discusses the disagreements/uncertainty surrounding both construction costs and operating costs. Continuing the example introduced in Section V, it then illustrates cost-based sensitivity analysis by summarizing fair return prices for a range of possible construction costs. Section VII continues treating uncertainty in costs and rates. It establishes the required price per kilowatt-hour with a financial guarantee (i.e., with low-cost, subsidized financing) as a critical and easy-to-understand measure of economic viability. The proposed viability assessment is a straightforward comparison of the fair return price with either current prices or with electricity prices from other competing generation alternatives. Section VIII uses the fair return price for the best possible case of nuclear operating costs and industry hopes for plant construction

notes that “judicial concepts of a fair return are few and far between.” He notes: (1) a fair rate of return should be higher than one that entails confiscation, (2) no single rate of return is always fair, and (3) public utilities are not guaranteed a fair rate of return. Id.

8. See JOEL KLEIN, CAL. ENERGY COMM’N, COMPARATIVE COSTS OF CALIFORNIA CENTRAL STATION ELECTRICITY GENERATION TECHNOLOGIES, CEC-200-2009-017-SD (Aug. 2009) (recognizing explicitly that there are at least three different ownership structures, namely: (1) merchant non-utility independent power generators, (2) investor owned electric utilities, and (3) public electric utilities. Each have different risks, debt capacities, and required returns on power generation projects); also, the different debt capacities, debt cost rates, and overall required returns are reflected by solving for a different required price in all the summary tables for each of twenty-one alternative generation technologies evaluated. See id.
costs first to determine economic viability and then to assess the likelihood of default. Section IX first lists methodology contributions and then summarizes final conclusions.

II. GLOBAL CLIMATE CHANGE AND THE NEED FOR LOW CARBON ELECTRICITY GENERATION

Concerns with climate change have led to a global focus on reducing carbon in the atmosphere. Of particular concern is reducing the emission of carbon from fossil fuels for the generation of electricity. However, the reduction of carbon emissions is believed to have a number of economic costs, including possible changes in national competitiveness. First, there is capture or other control of carbon from current fossil fuel electricity generation, especially coal-based electric generation. Second, it is generally believed that, with the possible exception of wind-generated electricity, low carbon electricity generation is simply much more expensive than fossil fuel (especially coal-based) electricity generation.9

The Kyoto Protocol was an attempt to coordinate carbon reductions by obtaining national commitments for lower carbon emission targets.10 Notably, the United States refused to ratify,11 primarily because of the perceived high conformity costs and asymmetric distribution of the cost burden.12

Since Kyoto, states seem to have varying climate change strategies, including those aimed at electricity generation. For example, state strategies differ even within the European Union. Germany and Spain both represent strong state commitment to renewables by offering tax credits and production subsidies as incentives.13 In contrast, France

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9. See id. at 14–24 (providing a thorough cost projection, comparing levelized costs, and noting that only wind and hydro have a lower cost per kilowatt-hour than coal and natural gas generation alternatives).


12. See Cass R. Sunstein, Of Montreal and Kyoto: A Tale of Two Protocols, 31 HARV. ENVTL. L. REV. 1, 27 (2007) ("By far the largest loser, in terms of the actual anticipated costs of mandatory cuts, was the United States.").

already uses highly subsidized nuclear to generate approximately 80% of its electricity. While the United States has not undertaken new nuclear power plants since the 1970s, the current U.S. strategy for baseload low-carbon electricity is to preserve the almost 20% of U.S. electricity generation currently produced from nuclear. The Energy Information Agency (EIA) has made baseload capacity projections, including projections of additional nuclear power plant capacity. The Department of Energy (DOE) has estimated fifty more nuclear plants by 2030 and more than one hundred by 2050.

The provision of financial guarantees for debt financing of the proposed new nuclear plants is central to the current U.S. strategy. The Energy Policy Act of 2005 provides for federal guarantees of debt financing for up to 80% of a nuclear generation project. DOE approval is required for a particular nuclear project to obtain the federal guarantee of its debt. The industry views the debt guarantees as critical for proceeding with new nuclear power plants.

Knowing the value and likely cost of financial guarantees is essential to intelligent nuclear energy policy—for not only the United States but also for the many other states now considering and/or engaging in similar strategies. In addition to policy and planning, knowing the value, cost,
and risk of financial guarantees for nuclear is important knowledge for state utility commissions, utility executives and planners, equipment-infrastructure suppliers, investors, and even credit rating agencies. Finally, U.S. ability to produce low-carbon electricity economically is vital to the new round of U.N.-sponsored global climate treaty negotiations that occurred in December 2009 in Sweden. While knowledge of and confidence in the ability to produce low-carbon electricity are pertinent to the way the United States negotiates, they are even more critical to obtaining Congressional approval for any treaties developed.

Ultimately, there is a clear need to assess properly both the value and cost of financial guarantees for new nuclear. In addition to a technically correct economic assessment, there is a need to structure both the value and cost assessments in terms understandable to policymakers and other key players.

III. BACKGROUND: FEDERAL FINANCIAL GUARANTEES FOR CAPITAL INVESTMENT PROJECTS

As already noted, the aim of this Article is to develop a framework for assessing both the value and the cost of federal debt guarantees for long-lived risky capital investment projects such as the 80% debt guarantees in the Energy Policy Act of 2005. As background, this Article reviews two prior instances of federal guarantees for capital investment projects. Section A considers Lockheed TriStar as an example of the value of federal debt guarantees. Section B considers the Exxon-Tosco Colony Oil Shale Project as an example of using federal financial guarantees to incentivize development of synthetic fuels. Section C then analyzes and compares these two examples.

A. Example One: Federal Debt Guarantees for the Lockheed TriStar

The Lockheed TriStar is a classic example of the value of federal debt guarantees that has received formal academic analysis. Economist Uwe E. Reinhardt’s treatment of the Lockheed TriStar is especially

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21. See generally Reinhardt, supra note 2.
pertinent to the subsidy assessment framework proposed here for two reasons. First, Reinhardt convincingly establishes that subsidy merit and especially economic viability should use net present value capital budgeting methods rather than the simple dollar breakeven criterion used by Lockheed. The net present value capital budgeting methods advocated by Reinhardt are the underlying valuation framework used here to convert financing rates into fair return electricity prices. Second, Reinhardt uses the weighted average cost of capital as the project discount rate (fair required return for economic viability) and explicitly recognizes uncertainty in the discount rate for both the role of the relative use of debt and equity and for uncertainty about the economically correct costs for debt and especially equity. As a consequence, Reinhardt uses discount rate sensitivity analysis (a range of possible discount rates) to treat this uncertainty in the required return as done in this Article in Sections VII and VIII.

In 1971, both the Senate and House held hearings to assess a request by Lockheed, a major defense contractor, for the federal government to guarantee a $250 million bank credit line loan for $250 million. The stated purpose of the bank loan was to allow Lockheed first to complete its in-process development of the Lockheed TriStar (at that time, a new generation of wide-body, high-passenger-capacity, fuel-efficient jet plane for which Lockheed had already invested approximately a billion for development and other TriStar start-up expenses) and then to finance plant construction and start-up plane production. Without a guarantee, Lockheed spokesmen testified that they could not obtain the required financing. With a guarantee, the bank loan would cost 5% to 6%. Before Lockheed’s financing crisis, the

22. See id. at 834–35 (focusing especially on Section III-B, “The Economic Value of the Tri Star Program in 1971”).

23. Capital budgeting refers to the economic evaluation of capital investment projects. See Bierman, supra note 6; see also supra text accompanying note 6.

24. In arguing that the TriStar project was economically viable, Lockheed spokesmen used simple breakeven analysis as their measure of economic of viability. As explained well by Reinhardt, simple breakeven analysis only measures the ability of project cash income to cover the initial capital outlays. The deficiency of breakeven is that there is no provision for debt interest payments let alone a fair return on invested equity.


27. In testimony before the House Committee on Banking and Currency, Lockheed spokespersons argued that the project itself was economically sound but that Lockheed had run out of debt capacity because of cost overruns on unrelated defense contracts. See Hearings on Emergency, supra note 25.
before-tax cost of debt to Lockheed was 10% to 12% annual interest cost in the late 1960s.\textsuperscript{28} Taking the difference between the 10 to 12% cost of debt financing without a guarantee and the 5 to 6% cost with a federal guarantee, the federal debt guarantee would reduce the annual interest cost for Lockheed by at least 5% to 6%. The phrase “at least” refers to the fact that Lockheed’s cost of debt would be greater in 1971 than in the late 1960s because Lockheed was much less risky before the cost overruns and the associated financing crisis that prompted the request for the federal guarantee. The concern here is not the precise numerical magnitude of the interest cost reduction from the fundamental guarantee, but rather the fact that the reduction in interest expense was a significant amount.

The pertinent key facts are that Lockheed was granted the guarantee, produced the planes, and repaid the debt. Thus, the Lockheed TriStar can be viewed as an example where a company received value without significant out-of-pocket federal costs. The public received jobs, preserved a major aerospace defense contractor/manufacturer, and ensured a viable competitor for a new generation of efficient commercial jet aircraft.

\textit{B. Example Two: Financial Guarantees for the Exxon-Tosco Colony Shale Oil Project}

The United States has previous experience with a range of subsidies including federal financial guarantees to incentivize development of synthetic fuels, especially shale oil development. In 1980, DOE committed $2.616 billion to three synthetic fuels projects. The largest of these three projects was the Exxon-Tosco Colony Oil Shale Project. It received a financial guarantee of $1.15 billion. In a recent review of past DOE synthetic fuels programs, Anthony Andrews notes that in 1980 Exxon bought Tosco’s interest in the project, and announced plans to invest more than $5 billion for a planned 47,000 barrel per day plant in Garfield County, Colorado based on the Tosco retort design.\textsuperscript{29} However, Andrews reports that “after spending more than $1 billion, Exxon announced on May 2, 1982 that it was closing the project and laying off 2,200 workers” even after building a company town able to house more

\textsuperscript{28} See Hearings on Emergency, supra note 25; Hearings on Legislation to Authorize Emergency Loan Guarantees to Major Business Enterprise Before the H. Comm. on Banking and Currency, 92d Cong., First Session, (1971); see also Reinhardt, supra note 2, at 821–38.

than 2,000 workers. While the Tosco retort design was a technically feasible method for producing synthetic crude oil, the project was abandoned because of the cost per barrel for the synthetic shale oil relative to the current and anticipated future market prices for crude oil. In an Article on the project termination, *Time Magazine (Time)* noted that “Exxon’s long-term forecasts still anticipate an increase in oil prices, but not as rapid as previously expected.” R. P. Larkins, the manager of the synthetic-fuels department at Exxon, stated “nothing over the long-term would offset our costs.” John Lichtblau, President of Petroleum Industry Research Foundation stated “[t]he fact is that from a market point of view, most synfuel projects are not economically viable.” Even with receiving a financial guarantee from the federal government, Exxon could not pursue this project of developing synthetic fuels because it was not in the company’s best economic interest.

**C. Lockheed and Colony Shale Oil Analysis**

Lockheed and Colony Shale Oil provide historical contrasts in the use of federal financial guarantees. Lockheed is an example where a financial guarantee provided a valuable financial subsidy with very little out-of-pocket cost to the federal government. The reason for successful production without performance on the guarantee by the federal government was the financial viability of the TriStar project. Lockheed could produce and sell aircraft at a profit sufficient to at least service the guaranteed debt.

The Colony Oil Shale Project illustrates that financial guarantees can be a high risk strategy for incentivizing development that is not otherwise market competitive. If the financial guarantee subsidy (whether shale oil in the 1980s or new nuclear today) is not sufficient to ensure financial viability, then guaranteeing a high percentage of project financing lowers the cost of abandonment; this in turn means a high performance cost by the fundamental government and no realization of the desired production with its intended societal benefits. Andrews’s recent Congressional Research Service Report summarizes the unrealized but desired societal benefits of synthetic fuels:

> The United States Synthetic Fuels Corporation Act of 1980 (P.L. 96-
294) established the U.S. Synthetic Fuels Corporation “to improve the nation’s balance of payments, reduce the threat of economic disruption from oil supply interruptions, and increase the nation’s security by reducing its dependence on foreign oil.” The Corporation was authorized to provide financial assistance to qualified projects that produce synthetic fuel from coal, oil shale, tar sands, and heavy oils. Financial assistance could be awarded as loans, loan guarantees, price guarantees, purchase agreements, joint ventures, or combination of those types of assistance. An energy security reserve fund was also established in the U.S. Treasury and appropriated 19 billion to stimulate alternative fuel production.\textsuperscript{34}

While federal financial guarantees can provide support to companies for implementing various projects, these guarantees may still not be enough for some companies despite the social benefits the projects could provide.

\textbf{IV. Valuation Frameworks for Determining a Fair Return Price}

A debt guarantee may be viewed in terms of options. There are two pertinent options. The recipient of the guarantee has the option to abandon the project if changes in costs, revenues, or other economic circumstances indicate that the project is no longer economically attractive.\textsuperscript{35} The debt providers have the option of a federal debt guarantee, which is itself an option to shift the obligation for financial performance to the federal government in the event of default.\textsuperscript{36}

If a project is not financially attractive, the company holding the guarantee can exercise its option to abandon it. With a debt guarantee, exercising the abandonment option may have a much lower cost than without a debt guarantee. This point is illustrated by the decision of Exxon to stop work on the Colony Shale Oil Project. At the time that Exxon stopped work, Exxon had invested approximately $1 billion of its planned investment of approximately $5 billion.\textsuperscript{37}

\textsuperscript{34} ANDREWS, supra note 29, at 27 (quoting Title 1, Part B of the Energy Security Act of 1980).

\textsuperscript{35} In capital budgeting, abandonment refers to the option to terminate a project once started if there are adverse changes in expected costs, revenue, or other economic circumstances. For more details on abandonment, see, e.g., BREALEY ET AL., supra note 6, at 255–56.


\textsuperscript{37} The option to abandon a project and the associated cost are part of the valuation of any capital investment project. For background on the abandonment option, readers are referred to any introductory corporate finance text. See, e.g., BREALEY ET AL., supra note 6, at 255–56.
Given the options associated with the debt guarantee, one might try to use option pricing methods to assess both the value of the abandonment option and the value of the federal protection from debt default. Option pricing is not the pertinent valuation approach. This is true for several reasons. One is simply the complexity of nuclear projects, including the disagreement on construction costs and operating costs and the absence of readily usable probability distributions for these cost inputs. Another pertains to understandability by policymakers, which is difficult to achieve given the mathematical complexity associated with option pricing. The most important reason pertains to the two primary objectives of this Article, namely: (1) to express the value of the financial guarantee subsidy as an electricity price so that both policymakers and the public can understand and compare the value of federal debt guarantees with alternative price impacting subsidies and charges; and (2) to use the fair return price per kilowatt-hour with the federal financial guarantee to assess economic viability and therefore provide a framework for assessing the likelihood of default and the associated cost of performing on the guarantee. For both of these objectives, the logical valuation framework is the use of traditional net present value capital investment methods to determine a fair return price. Because traditional project analysis methods obtain our policy objectives, it is clearly logical to use the net present value methods rather than option pricing methods.

As noted in the Introduction, the primary purpose of this Article is to develop and illustrate an easy-to-understand framework that uses traditional capital investment analysis to obtain fair return prices for nuclear projects with and without guarantees. Recall that a fair return price is the price per kilowatt-hour that a nuclear plant would have to charge to provide a fair return on invested capital. The fair return project prices provide an easy-to-understand method for assessing project value and viability for given assumptions about costs. For a project that is economically viable, any good measure of the value of federal debt guarantee is reduced to assessing the difference in the fair return electricity prices for financing with a federal debt guarantee and without

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38. Federal financial guarantees on a capital investment project like a new nuclear power plant, both the value of the guarantee and its expected cost, are derived from several factors, which include the current value of the project, the likely distribution of project values over time, and especially the probability of default (option exercise) and the value distribution under default.

39. As regulated monopolies, investor-owned electric utilities are presumed to earn a fair return on invested capital. Given invested capital and operating costs and an assumed quantity of electricity sold, the mechanism for providing a fair return on invested capital is to set the price per unit (price per kilowatt-hour) to provide the presumed fair return.
any financial guarantees. Assessing financial viability with a federal debt guarantee is a question of whether the fair return price is a market competitive price.

In rate setting, the process of finding a fair return is applied to the overall utility capital base and overall cash flows. This Article adapts the fair return price setting to an individual generation project to see what price this project would have to command to provide a fair return on invested capital.

In a classic textbook capital budgeting problem, one obtains a summary net present value (NPV) by discounting all project cash flows at a discount rate, which reflects the opportunity cost of capital.\(^{40}\) If the NPV is zero, the discount rate provides a fair return in the sense that the project has an internal rate of return that is equal to the opportunity cost of capital. If the project NPV is positive, the project provides a more-than-fair return and the assumed price of electricity in projecting revenue could be reduced. Conversely, if the project NPV is negative, the project provides a less-than-fair rate of return. For the project to have an internal rate of return (IRR) equal to the discount rate, the price of electricity assumed in projecting cash flow would have to be increased.

The above problem presents the key assumptions of this analysis. The factors are a scenario for operating costs, an assumed value for construction costs, and an assumed rate of capacity utilization. The result is a fair return price for the assumed discount rate used to compute the project NPV; or in other words, a price per kilowatt-hour that make the project IRR equal to the discount rate (the assumed required return on invested capital).

Rather than assuming a given price and using a discount rate to solve for the net present value, one solves for the fair return price that makes the net present value of the cash flows equal to zero. This fair return price is the price per kilowatt-hour that makes the assumed discount rate (the assumed required return on invested capital) equal to the IRR.

A financial measure of the value of the subsidy implicit in a federal debt guarantee is simply the change in the financing cost. An alternative price-based quantitative measure of the subsidy value associated with the change in financing cost is the change in the fair return price. Fair return price depends on not only the discount rate (required return) but also on the assumed construction costs, operating costs, and capacity utilization. For example, assume that the cost of land, licensing, and other

\(^{40}\) Capital budgeting refers to the evaluation of capital investment projects. See BREALEY ET AL., supra note 6, at 238–91.
preconstruction costs is $500 per kilowatt of peak capacity. Assume further that the construction cost is $5000 per kilowatt-hour of peak capacity that is spent evenly at $1000 per year for five years. Thus, one can focus on the difference in fair return prices with a total capital cost of $5500, a value close to the best case current dollar cost estimate for the license application of Florida Power & Light nuclear plant.\(^{41}\)

As a first pass, assume that the project will sell its electricity at 13¢ per kilowatt-hour and that the plant operates at 70% capacity in year 6 (its first year of operation) and increases to 90% by year 10. Assume that the operating cash expenses are just 49.5% of revenue (compared to 74.5% as the industry average rate of cash expenses in 2007). Because one makes the heroic assumption that cash operating expenses are well below the current industry average cost rate, one calls this operating cost scenario the \textit{best possible operating cost scenario}.

Exhibit 3 summarizes the cash flows with the bottom line being the net cash flow in each year. The dotted line from year 11 to year 50 indicates that the cash flows are the same in year 10 to year 50. For simplicity of exposition, this example uses the same value for operating costs in all years. Using current dollar costs in each year means that the solution procedure for the fair return price is also finding a corresponding current dollar fair return price.\(^{42}\) It reflects the fact that electricity prices tend to change in parallel with changes in the costs of generating electricity. It may understate slightly, however, the fair return price. Thus, one should interpret the fair return price in this Article as the current dollar price.

Discounting these cash flows at discount rates of 6% and 8% gives net present values of +$660 and -$700 respectively. The positive net present value for 6% means the project has an IRR greater than 6% when the assumed price per kilowatt-hour is 13¢. If one solves for the price per kilowatt-hour that gives a net present value of zero and therefore an

\(^{41}\) For the best case scenario in their licensing application, Florida Power & Light assumes five years for construction time and approximately $5600 in construction costs before land and licensing and before any inflation in materials or labor. See generally, Florida Power & Light, Nuclear Power Plant Approval/Construction Costs, http://www.fpl.com/environment/nuclear/approval.shtml (last visited Jan. 28, 2010). Here, construction costs exclude interest or other financing charges.

\(^{42}\) The implicit assumption in using the current dollar projection is that prices for electricity and the overall level of operating cash expenses inflate at roughly the same rate. If nuclear operating prices were to inflate at a faster rate than overall electricity prices, then this simplification (made here primarily for expositional simplicity) would understate the fair return price at a given discount rate and would then overstate economic viability relative to a faster inflation future. In this sense, this current dollar projection may be slightly biased in favor of indicating that nuclear is more viable than in a future of more rapidly escalating costs.
internal rate of return of 6%, one finds that fair return price at a required return of 6% is just 11¢ per kilowatt-hour.

For the case of an 8% discount rate, the negative net present value indicates that the assumed 13¢ per kilowatt-hour is not high enough to give the project an IRR of 8%. Given the assumed costs, the project can earn an 8% return only if the price is increased. Solving for the higher price that makes the net present value zero at an 8% discount rate gives a fair return price of 15¢ per kilowatt-hour.

This example illustrates two points. First, given assumed costs, a higher return requires a higher price. Second, the fair return price is very sensitive to the discount rate: increasing the required return from 6% to 8% increased the fair return price from 11¢ to 15¢ per kilowatt-hour, a change of 4¢.

The sensitivity of the relationship between the fair required price and the discount rate is even more dramatic if one uses discount rates of 16% and 18%, which are illustrative of the rates that would be required without guarantees. For 16% and 18% discount rates, the associated fair return prices that make the net present value of all the cash flows zero are 37¢ and 43¢, respectively. Given that these prices arise in the best possible scenario for operating costs and for relatively optimistic construction costs, it is clear why proponents of new nuclear want financial guarantees as the industry preferred form of subsidy: rates of 37¢ and 43¢ are clearly uneconomic given that current prices average about 10¢ per kilowatt-hour.

One can use differences in fair return prices for discount rates without a guarantee and with a guarantee to estimate a value for the guarantee. If the required return were 16% without a guarantee and just 6% with a guarantee, then the associated price difference is 26¢ per kilowatt-hour (37¢ - 11¢ = 26¢). This change in fair return price means that the production subsidy equivalent of the implicit subsidy associated with a change in required return from 16% to 6% is 26¢. If the market rate were 18% and the guarantee rate were 8%, then the difference would be production subsidy equivalent of 31¢ (46¢ - 15¢).

Whether the difference is 26¢ or 31¢, or anything close to these amounts, it is evident that the subsidy implicit in this type of financial guarantee is immense compared to a wind production credit of 0.5¢ per kilowatt-hour. Likewise, it is large compared to estimates of the increase in coal-generated electricity of about 2¢ to at most 3¢ from a tax of $45 per ton of coal burned or carbon sequestration costs of about $50 per ton.

43. All electricity prices discussed here are rounded to the nearest cent.
of coal.  

V. ESTIMATES OF SUBSIDIES FOR A RANGE OF CONSTRUCTION COSTS

The above example used an assumed construction cost of $5000 per kilowatt of peak capacity and $500 for land and other start-up costs, providing for a total capital outlay of $5500 per kilowatt of peak capacity. Given that the construction cost is a subject of disagreement, providing the fair return price for a range of construction costs and discount rates is useful to policymakers. Exhibit 4 summarizes the fair return price for construction costs from $3000 to $9000, which results in a cost range of $3500 to $9500 with land and start-up of $500 added to the construction costs.

The difference between the fair return prices for discount rates of 18% and 8% is the production subsidy equivalent of a financial guarantee that changes the required return on a nuclear power plant from 18% to 8%. Exhibit 4 shows that both the fair return prices and their differences increase rapidly with an increase in the construction outlay.

Because of uncertainty about project costs, and therefore economic viability, risk to the providers of both debt and equity financing is high. Therefore, financing costs are high without a guarantee (about 16% to 22%), and much lower with a guarantee (about 6% to 10%). Even the required returns are a subject of disagreement. As with construction cost uncertainty, policymakers, legislators, and investors can understand how differences in required returns changes the fair return price associated with difference costs.

VI. FAIR RETURN PRICES FOR A RANGE OF COSTS AND DISCOUNT RATES

Given that the United States has not undertaken any nuclear power generation projects since the early 1970s, there is no contemporary experience for building new nuclear power projects in the United States at current construction and material costs and current safety standards.

Economist Mark Cooper wrote a review of estimates of nuclear power costs by more than thirty entities between 2001 and 2009 with estimates of construction costs (or, overnight costs) ranging from less

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44. See BRIAN J. MCPHERSON, UNIVERSITY OF UTAH, GEOLOGIC CARBON SEQUESTRATION AS AN APPROACH TO EMISSIONS REDUCTION & BENEFIT TO UTAH (2008).
45. See STANDARD AND POOR’S, supra note 20.
than $2000 to more than $10,000 per kilowatt-hour.\textsuperscript{46} This disagreement in overnight cost ranges complicate an assessment of how much nuclear electricity will cost and therefore uncertainty about its economic viability, which this Article assesses by the associated fair return price. Uncertainty in economic viability in turn translates into uncertainty about the value of federal financial guarantees and especially about the potential cost of federal financial guarantees. The time trend and source of cost estimates are both pertinent to understanding the disagreement about construction costs.

Cooper notes a “sharp increase in projected costs over a short period of time.”\textsuperscript{47} In Figure III-1, Institutional Origins and Levels of Recent Cost Projections,\textsuperscript{48} Cooper plots estimates of overnight costs (in 2008 dollars per kilowatt-hour) versus year of estimate. All fourteen estimates plotted in Figure III-1 developed between 2001 and 2005 are less than $3,500 per kilowatt-hour while 23 of the 24 estimates for 2007 to 2009 are greater than $3500. For 2009, the six estimates (rounded to the nearest $100) range from $5,400/kwhr to $10,400/kwhr. He attributes the sharp time trend to two factors. One factor is inflation in cement, steel, and other construction materials at a higher rate than the increase in overall prices. The second factor is the viewpoint and type of entity making the projection. Early studies were made by proponents while later studies have been by critics and third parties such as credit rating agencies.\textsuperscript{49}

In any case, there is very little consensus. This lack of agreement indicates uncertainty and should signal high risk to policymakers and legislators, especially in light of overruns for projects undertaken in the 1960s and 1970s. In that era all projects had actual construction costs that were at least double the estimated projection and the average overrun was four times the projection made in the initial authorization to build.

Importantly, Cooper considered the assessment of operating costs.\textsuperscript{50} Of the thirty-six studies he surveyed that disclosed operating cost detail, all but one used a very narrow subset of the operating expenses; for example, fuel and direct operating expenses or possibly just fuel, direct

\begin{footnotes}
\item[46] See MARK COOPER, THE ECONOMICS OF NUCLEAR REACTORS: RENAISSANCE OR RELAPSE?, VT. LAW SCHOOL, INST. FOR ENERGY AND THE ENV’T 11, 24, 30 (June 2009), especially Figure I-1 and Figure III-6.
\item[47] Id. at 22.
\item[48] See COOPER, supra note 46, at 24.
\item[49] See STANDARD AND POOR’S, supra note 20.
\item[50] Cooper, supra note 46, at 27–28.
\end{footnotes}
operating expenses, and direct maintenance costs.\textsuperscript{51} Thus, while possibly giving an indication of the cost to generate before transmission,\textsuperscript{52} distribution, and all other operating expenses (like those summarized in Exhibit 2 for EIA standard industry income statements), these studies do not allow a realistic assessment of the retail price that utilities would have to charge their customers in order to provide a fair return on project capital. \textit{It is the retail price that determines the economic viability of new nuclear or any other competing technology.}

Because the fair return price depends on the construction costs, operating costs and capacity utilization, it seems impossible to assess the financing subsidy without having the assessment disputed on the basis of assumed costs and capacity utilization. One way to settle this cost uncertainty is to resolve the problem of finding fair return prices for a range of costs and even a range of discount rates. Exhibit 5 defines three operating cost scenarios. The best possible case is the one used in the previous examples, which means about 20\% below current industry average operating expenses. This best possible scenario is the one that is most pertinent to assessing viability and therefore the likelihood of default.

If the fair return price with a financial guarantee for \textit{best possible operating expenses} and reasonable construction costs is not a competitive market price (at least no more than 3\textcent to 5\textcent above competing alternatives), then default is a virtual certainty.

Exhibit 6 summarizes the price-rate dependency for construction costs ranging from $2000 per kilowatt of peak capacity to $9000 per kilowatt of peak capacity\textsuperscript{53} in steps of $1000 for a range of discount rates with the operating cost scenario, \textit{best possible operating expenses}. Exhibit 6 illustrates two additional methodology ideas for structuring policy decisions in a more usable and understandable form. The first idea is simply to develop a summary fair return price response surface for a range of construction costs and discount rates for pertinent scenarios for operating expenses. The second idea pertains to assessing viability and the probability of default. The best possible operating expense scenario sets a threshold for assessing viability. If the fair return price for this scenario cannot compete with other generation alternatives, then nuclear

\textsuperscript{51} See id.

\textsuperscript{52} This cost, usually called a \textit{Busbar cost}, is useful for direct comparison of two similar generation alternatives but is not useful for policy analysis including especially issues of financial viability. Financial viability and the value of guarantees both depend on retail prices.

\textsuperscript{53} With land and start-up costs of $500, the total capital outlay ranges from $2500 to $9500 per kilowatt-hour of peak capacity.
cannot compete in any operating cost scenario even with financial guarantees. Default is a virtual certainty.

Even though a range of discount rates and costs is covered, the data in Exhibit 6 are still dependent on the structural assumptions made in the Stone-Adolphson spreadsheet model.54 The point is not to argue the correctness of that model (from the Stone-Adolphson working paper), but rather to showcase methodology that can improve comparative policy analysis and decision-making.

VII. SUMMARY, SYNTHESIS, AND CONCLUSIONS

Climate change and energy are complex and interrelated concepts. The world is focused on multinational coordination and parallel formulation of national climate-energy policy. The United States serves as an example of a state that plans on extensive increases in the number of new nuclear power plants. To make new nuclear power economically viable in its private enterprise system of energy delivery, the current and presumed form for necessary subsidies is government financial guarantees for a high fraction of plant costs.

Financial guarantees for long-lived assets are hard to evaluate using conventional option pricing (or insurance costing), especially when both construction costs and operating costs are difficult to predict. When financial guarantee values and costs are characterized by percentage changes in financing costs, they are difficult for most policymakers, legislators, and the general public to understand. Moreover, conventional use of changes in financing costs makes it difficult to compare the value and cost of subsidies as financial guarantees with other price-impacting subsidy alternatives, such as production credits and price guarantees, as well as cost-impacting laws such as taxes, carbon caps, and carbon charges.

New nuclear, debate on climate treaties, formulation of natural energy policy, and public understanding are further confused by disagreement on construction costs, operating costs, and even the required financing rates with and without financial subsidies. A need exists for reliable and clear frameworks for evaluating new nuclear and comparing it with other low-carbon energy alternatives. There is especially a need to assess the value, potential cost, and societal risk associated with the proposed use of government financial guarantees.

This Article makes three methodology contributions for greater understandability:

1) **Fair Return Prices**: Converting differences in required returns into differences in fair return prices provides a subsidy assessment that allows comparison with production subsidies and other price impacting subsidies, laws, and regulations. Moreover, price per kilowatt-hour is relatively easy to understand and evaluate in terms of current electricity prices.

2) **Best Case Benchmark**: Using the fair return price with a financial guarantee for best case costs to evaluate financial viability and therefore establishing the likelihood of default, thus the expected cost of performing on the guarantee.

3) **Sensitivity Analysis Framework**: Organize cost uncertainty/disagreement by using sensitivity analysis on construction costs and even discount rates to obtain a fair return price plot for pertinent ranges of costs and required returns. This allows policy makers to see the implications of the uncertain costs on fair return prices and therefore assess financial viability and risks.

From the data and the analysis summarized in this Article, the primary conclusions about proposed new nuclear with government financial guarantees are:

1) **Potentially High Subsidy Value**: The production subsidy implied by differences in the fair return prices for high discount rates and low discount rates is large. It is much more than 10¢ per kilowatt hour and much more than the production subsidy required to make wind, thermal solar, photovoltaic solar, or geothermal into economically viable low-carbon alternatives able to compete with coal and natural gas.

2) **High Prices for Best Case**: For a scenario of low operating costs (20% below industry average costs) with relatively low construction costs and discount rates, the fair return price is much higher than current electricity rates and more than comparably subsidized wind and solar. Therefore, nuclear even with financial guarantees is uneconomic and entails a high probability of default.

3) **High Probability of Costly Default**: Given that the best case fair return price is well above current electricity prices (and probable prices even with high carbon charges), and
considering historical construction cost overruns in the industry and the high operating costs for current nuclear power generation, there is a high likelihood of default. This will create the need for the government to perform on the guarantees as was the case with the failure of financial guarantees for shale oil in the 1980s.

In a competitive economic system, subsidies, taxes, and controls all change costs and thereby distort the allocation of resources relative to the efficiency of a competitive system. In seeking to encourage non-carbon electricity generation, it is desirable to preserve competitive mechanisms as much as possible, especially when dealing with hard to predict competitiveness and especially future innovation required to produce the most efficient long-run electricity production at a given level of carbon emissions. For these reasons, it is desirable to subsidize all alternative generation methods equally so that competition and informed private decisions produce the most efficient electricity generation systems. Given the negative evidence on nuclear viability cited in this Article and the potentially high cost of government financial guarantees, policymakers should clearly address the questions formulated below.

(1) **Subsidy Distortion**: Given the implied magnitude of the financial guarantee subsidy for nuclear (more than 10¢ per kilowatt hour), why use a much greater subsidy for nuclear than for other noncarbon renewable energy alternatives? To ensure efficient allocation of scarce resources, should competing alternatives not be subsidized equally?

(2) **Competitive Equality**: Given that the administration of the federal financial guarantees means selecting a few producers that will be the guarantee beneficiaries and thus precluding all other potential producers, why use a form of subsidy that requires government selection of a small number of preferred producers?

(3) **Encouraged Abandonment Risk**: Given that financial guarantees, especially guarantees for a high percentage of the capital outlays, actually encourage abandonment, why are we using a subsidy that encourages abandonment and high costs with no output benefit rather than a straightforward production subsidy of so many cents per kilowatt hour?

(4) **Best Form of Subsidy**: Given that financial guarantees work well when there is a virtual certainty of economic viability and are very costly when there is not economic viability, an
obvious question is: why are we using financial guarantees for nuclear production rather than performance-based output subsidies? In particular, why not have the same time decreasing output subsidy for all non-carbon new electricity generation?
Exhibit 1\(^{55}\)


(Mills per Kilowatthour)

<table>
<thead>
<tr>
<th>Plant Type</th>
<th>2007</th>
<th>2002</th>
<th>1997</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Operation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nuclear</td>
<td>9.2</td>
<td>8.54</td>
<td>11.02</td>
</tr>
<tr>
<td>Fossil Steam</td>
<td>3.49</td>
<td>2.54</td>
<td>2.22</td>
</tr>
<tr>
<td>Hydroelectric[1]</td>
<td>7.71</td>
<td>5.07</td>
<td>3.29</td>
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<tr>
<td>Gas Turbine and Small Scale[2]</td>
<td>2.89</td>
<td>2.72</td>
<td>4.43</td>
</tr>
<tr>
<td><strong>Maintenance</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nuclear</td>
<td>5.79</td>
<td>5.04</td>
<td>6.9</td>
</tr>
<tr>
<td>Fossil Steam</td>
<td>3.39</td>
<td>2.68</td>
<td>2.43</td>
</tr>
<tr>
<td>Hydroelectric[3]</td>
<td>5.17</td>
<td>3.58</td>
<td>2.49</td>
</tr>
<tr>
<td>Gas Turbine and Small Scale[2]</td>
<td>2.53</td>
<td>2.38</td>
<td>3.43</td>
</tr>
<tr>
<td><strong>Fuel</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Nuclear</td>
<td>5.01</td>
<td>4.6</td>
<td>5.42</td>
</tr>
<tr>
<td>Fossil Steam</td>
<td>24.02</td>
<td>16.11</td>
<td>16.8</td>
</tr>
<tr>
<td>Hydroelectric[3]</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Gas Turbine and Small Scale[2]</td>
<td>56.69</td>
<td>31.82</td>
<td>24.94</td>
</tr>
<tr>
<td><strong>Total</strong></td>
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</tr>
<tr>
<td>Nuclear</td>
<td>20</td>
<td>18.18</td>
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</tr>
</tbody>
</table>

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### Exhibit 2


(Million Dollars)

<table>
<thead>
<tr>
<th>Description</th>
<th>2007</th>
<th>2002</th>
<th>1997</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Utility Operating Revenues</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electric Utility</td>
<td>282,875</td>
<td>219,389</td>
<td>215,083</td>
</tr>
<tr>
<td>Other Utility</td>
<td>251,959</td>
<td>200,135</td>
<td>195,898</td>
</tr>
<tr>
<td><strong>Utility Operating Expenses</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electric Utility</td>
<td>252,216</td>
<td>188,745</td>
<td>182,796</td>
</tr>
<tr>
<td>Operation</td>
<td>223,297</td>
<td>171,291</td>
<td>165,443</td>
</tr>
<tr>
<td>Production</td>
<td>161,939</td>
<td>116,374</td>
<td>104,337</td>
</tr>
<tr>
<td>Cost of Fuel</td>
<td>128,914</td>
<td>90,649</td>
<td>80,153</td>
</tr>
<tr>
<td>Purchased Power</td>
<td>42,178</td>
<td>24,132</td>
<td>31,861</td>
</tr>
<tr>
<td>Other</td>
<td>78,124</td>
<td>58,828</td>
<td>37,991</td>
</tr>
<tr>
<td>Transmission</td>
<td>8,632</td>
<td>7,688</td>
<td>10,301</td>
</tr>
<tr>
<td>Distribution</td>
<td>6,095</td>
<td>3,494</td>
<td>1,915</td>
</tr>
<tr>
<td>Customer Accounts</td>
<td>3,870</td>
<td>3,113</td>
<td>2,700</td>
</tr>
<tr>
<td>Customer Service</td>
<td>2,959</td>
<td>1,821</td>
<td>1,917</td>
</tr>
<tr>
<td>Sales</td>
<td>249</td>
<td>261</td>
<td>501</td>
</tr>
<tr>
<td>Administrative and General</td>
<td>14,933</td>
<td>12,872</td>
<td>13,384</td>
</tr>
<tr>
<td>Maintenance</td>
<td>13,675</td>
<td>10,843</td>
<td>12,368</td>
</tr>
<tr>
<td>Depreciation</td>
<td>18,662</td>
<td>17,319</td>
<td>23,072</td>
</tr>
<tr>
<td>Taxes and Other</td>
<td>27,839</td>
<td>26,755</td>
<td>25,667</td>
</tr>
<tr>
<td>Other Utility</td>
<td>28,347</td>
<td>17,454</td>
<td>17,353</td>
</tr>
<tr>
<td><strong>Net Utility Operating Income</strong></td>
<td><strong>30,659</strong></td>
<td><strong>30,644</strong></td>
<td><strong>32,286</strong></td>
</tr>
</tbody>
</table>

---

Exhibit 3
Table Illustrating Project Cash Flows per Kilowatt-hour of Nuclear Capacity:
The Case of $5000 Construction Costs, Best Possible Case for Operating Expenses

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
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<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>..</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land</td>
<td>-.500</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constr. Costs</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Revenue</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Purchased Power</td>
<td></td>
<td>-.34</td>
<td>-.29</td>
<td>-.23</td>
<td>-.17</td>
<td>-.11</td>
<td>-.11</td>
<td>..</td>
<td>-.11</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Operating Expense</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net</td>
<td></td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

Exhibit 3 Notes:
In this projection, the assumed $5000 construction cost is spread equally in the assumed 5 years to build, $1000 in year 0 to year 4.
Capacity utilization is assumed to grow from 70% in year 6 in increments of 5% per year to the target level of 90% in year 10 and to remain at 90% until the end of year 50.
This example does not assume a decommissioning cost, a reserve for processing nuclear waste, incremental working capital for increased production, or even that the debt is repaid at the end of the project. Adding in these uses of cash would increase the fair return price above the values computed here.
Exhibit 4
An Illustrative Increase in the Production Subsidy Value of a Financial Guarantee for a range of Construction Costs for the Best Possible Operating Expense Scenario

<table>
<thead>
<tr>
<th>Construction costs</th>
<th>3500</th>
<th>4500</th>
<th>5500</th>
<th>6500</th>
<th>7500</th>
<th>8500</th>
<th>9500</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fair Return Price: 18%</td>
<td>28</td>
<td>36</td>
<td>43</td>
<td>57</td>
<td>58</td>
<td>66</td>
<td>74</td>
</tr>
<tr>
<td>Fair Return Price: 8%</td>
<td>10</td>
<td>13</td>
<td>15</td>
<td>18</td>
<td>21</td>
<td>24</td>
<td>26</td>
</tr>
<tr>
<td>Guarantee Value</td>
<td>18</td>
<td>23</td>
<td>28</td>
<td>29</td>
<td>37</td>
<td>42</td>
<td>48</td>
</tr>
</tbody>
</table>

Exhibit 4 Notes:
The column labeled 5500 is the combination of land and construction costs that was used previously in Exhibit 3. In this exhibit, we are summarizing how the fair return price changes with a change in construction costs in increments of $1000s. Same purchased power and operating expense.

Exhibit 5
Summary-Overview of Three Scenarios for Operating Expenses

<table>
<thead>
<tr>
<th>Scenario</th>
<th>% Revenue</th>
<th>Explanation of Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Best Possible</td>
<td>All-in costs are 58% of revenue</td>
<td>Purchased power costs are set at 10% (percent of sales) compared to an industry average of 27.6% (percent of sales). Maintenance is much lower than reported in EIA data such as the summary in Exhibit 2 to the other tables at 9.7% (percent of sales).</td>
</tr>
<tr>
<td>Industry Average</td>
<td>All-in costs are 70-78% of revenue</td>
<td>Purchased power is 27.6% (percent of sales) Maintenance is 13.1% (percent of sales)</td>
</tr>
<tr>
<td>Realistic Nuclear</td>
<td>All-in costs are between 78-88% Revenues</td>
<td>Purchased power is 27.6% (percent of sales) Maintenance is 14% (percent of sales)</td>
</tr>
</tbody>
</table>

Exhibit 5 Notes:
Bernell Stone, Troy Carpenter, and Ricardo Torres estimate empirically the current cost of nuclear generated electricity relative to the average price. With high statistical significance, nuclear is found to be at least 4 cents above average, which is more than 20% above the average price of 9 ½ cents in
Exhibit 6

Price-Cost-Rate Response Subsurface for Baseload Nuclear for the Case of Reference Scenario Operating Costs

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