# Business Case for Small Modular Reactors

## Report on Findings to the U.S. Department of Energy Office of Nuclear Energy


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# I. EXECUTIVE SUMMARY

## A. Introduction

In 2012, the U.S. Department of Energy ("DOE") began a program to help with the front-end design, development, certification, and licensing requirements for selected domestic Small Modular Reactor ("SMR") designs. SMRs are nuclear power plants that are smaller (300 MWe or less) than current generation base load nuclear power plants (1,000 MWe or higher). These smaller, compact designs are comprised of modular components that can be factory-fabricated and transported by truck or rail to a site to be assembled. Many industry participants believe that SMRs present a number of benefits including their simplicity of design and enhanced safety features, modularity, lower required capital investment, siting flexibility, higher efficiency, and nonproliferation safeguards and security.

After initiating a program to assist with the development, certification and licensing of SMR designs, DOE would now like to identify steps that might be taken to improve the commercialization potential for SMRs. DOE's overall approach will involve considering changes in policies, programs, and incentives that would promote the deployment of SMRs both domestically and internationally. DOE engaged Scully Capital to review the market for SMRs and develop a Business Case to identify incentives, policies, and programs that can be effectively implemented and have significant impact on the commercialization and deployment of SMRs.

## B. Overview of Approach

Scully Capital executed the scope in its proposal with the objective of providing DOE-NE with an assessment of current market conditions for SMRs, as well as an analysis of the impact and cost of various incentives on the economics of SMR projects. Scully Capital's approach consisted of the following activities:

- Conduct research to understand the current state of the SMR technology and the industry participants who are most interested in supporting the technology
- Interview industry stakeholders to identify the market, barriers to implementation, and incentives that are perceived to be beneficial for SMRs;
- Collect base economic data and develop a model to quantify the financial impacts of a variety of governmental incentives;
- Formulate policy, program, and incentive options;
- Quantify the cost of the various incentives to the taxpayer; and
- Recommend routes to implement the options.

## C. Findings and Conclusions

The following findings are based on research and interviews with market participants:

1. For a number of reasons, many believe that a market potential exists for SMRs. Industry participants indicated that they believed that SMRs belonged in their portfolio of generation assets because SMRs may accomplish the following: a) serve as a valuable part of a balanced generation portfolio; b) be of the appropriate size to fill gaps left by retiring fossil fueled power plants; and c) provide a safe, carbon-free source of base load power.

2. Nonetheless, there are barriers to implementing the SMR technology today, namely economic conditions in the electricity market (low demand growth, both current and forecast, and low electricity prices as well as price signals from the market) that currently do not support such an investment, and the uncertainty around the cost and timing of the licensing process.

3. Similar to the renewable energy industry, financial incentives, including credit and tax incentives, may play a significant role in overcoming barriers to the early adoption of the SMR technology. A meaningful reduction in the price of power from a SMR project can be achieved through the modification of existing tax incentives so that these incentives apply to SMRs.

4. Either power purchase agreements, perhaps with a federal purchasing agency, or regulatory action at the state Public Utility Commission (“PUC”) level may also play a role in overcoming existing demand and price barriers.

5. A PPA between the federal government and a utility can be designed to meet budget scoring targets while providing the utility and its public service commission a project with a risk profile sufficient to support its decision to make an investment in the project. Such a PPA can be valuable even though the purchase obligations may be less than the full capacity of the Project and for a term less than the project’s investment analysis horizon.

6. Consideration should also be given to designing a cost and risk sharing program that can ease the economic risk related to the uncertainty surrounding the NRC licensing process. As this uncertainty relates specifically to the timing of the NRC licensing process, the program should be designed around risk-sharing should the licensing process run longer than a specified period.

7. Both a domestic and international marketplace exists for SMRs. U.S. companies may be positioned to compete in the international marketplace once domestic regulatory goals have been achieved.

# II. INTRODUCTION

The United States is currently assessing and developing options for clean, affordable, domestic energy sources to achieve its energy security and greenhouse gas (GHG) emissions reduction objectives. Nuclear power has been a key component of the country's portfolio of technologies to meet these objectives. In 2010, the U.S. Department of Energy's Office of Nuclear Energy (DOE-NE) developed the Nuclear Energy Research and Development Roadmap to guide its research, development, and demonstration activities to ensure nuclear energy remains a viable energy source for the country. As part of this strategy, in 2012, DOE began a program to help with the front-end design, development, certification, and licensing requirements for selected domestic Small Modular Reactor (SMR) designs.

SMRs are nuclear power reactors that are smaller (300 MWe or less) than current generation base load plants (1,000 MWe or higher). SMRs offer a number of benefits, including the following:

- **Modularity:** Major components of SMRs may be fabricated in a factory environment resulting in improved quality and reduced cost.

- **Lower Capital Investment:** With a lower overall plant cost than that of a larger nuclear plant, SMRs may not require the owner to make as significant a capital investment. Furthermore, modular components and factory fabrication can reduce the costs and duration of construction.

- **Siting Flexibility:** SMRs may be sited where infrastructure does not support a large facility or a large plant is not needed. Sites that might benefit from an SMR include remote areas, smaller electrical markets, smaller grids, areas with water or acreage limitations, or specific industrial applications. Maybe most importantly, SMRs may be a good match to replace capacity lost from retiring coal plants, using existing infrastructure such as transmission equipment, cooling water intakes, and other balance of plant capabilities.

- **Higher Efficiency:** When coupled with other energy sources, particularly renewables, SMRs may enhance grid stability and security while operating at a higher efficiency level. Some advanced SMR designs can produce a process heat of a higher temperature that may be required for other industrial applications or desalination processes.

- **Nonproliferation/Safeguards and Security:** SMRs also provide safety and potential nonproliferation benefits to the international community by minimizing the transportation and handling of nuclear material. Since most SMRs will be built below grade for safety and security enhancements, the potential for sabotage and natural hazard scenarios may be reduced. Since SMRs may be fabricated and fueled in a factory and then transported to sites for power generation, the need for refueling and the safety and security risks associated with refueling may be minimized.

DOE would now like to identify steps that might be taken to improve the commercialization potential for SMRs. DOE's overall approach could involve considering changes in policies, programs, and incentives that would promote the deployment of SMRs both domestically and internationally.

## A. Purpose of the Study

This study was commissioned by DOE to assess the market for SMRs and develop a Business Case to identify incentives, policies, and programs that can be effectively implemented and have significant impact on the commercialization of SMRs.

This study seeks to accomplish the following:

- Assess current state of SMR technology and industry participants;
- Identify and assess the market for SMR technology, barriers to implementation and incentives for SMRs;
- Collect base economic data and develop a model to quantify the financial impacts of various government incentives;
- Quantify the cost of the various incentives to the taxpayer; and
- Recommend routes to implement the options.

## B. Objectives and Approach of the Market Study

Scully Capital's objective was to provide an analysis of the impact and cost of various incentives on the economics and financeability of SMR projects. Based on research, discussions with industry and DOE-NE personnel, and experience in the power generation sector, Scully Capital sought to develop a financial model that would accurately portray the economics of an SMR project, as discussed in the next section. Scully Capital also conducted research to understand the current state of the SMR technology and which industry participants are most interested in supporting the technology. This included an analysis of DOE-NE documents as well as recent literature and published reports. Scully Capital also reviewed the available information on basic economics of the technology to understand the barriers to eventual deployment.

Scully Capital contacted industry participants and conducted interviews to understand the market for the technology and identify the barriers for implementation of SMRs. Industry participants included utility groups, technology companies, and potential international parties. Scully Capital also interviewed senior executives in the construction and engineering firms and financial companies that are involved in providing financing, loans, and insurance to companies in the power generation business. These interviews were used to gather additional information on economic parameters for the technology and the industry participants' views on barriers to commercialization. Scully Capital compared the information learned from the interviews with published research on the market potential for SMRs.

## C. Objectives and Approach of the Financial Analyses

Scully Capital's objective was to provide an analysis of the impact and cost of various incentives on the economics and financeability of SMR projects. Based on research, discussions with industry and DOE-NE personnel, and its experience in the power generation sector, Scully Capital sought to develop a financial model that would accurately portray the economics of an SMR project. Ultimately the financial model is used to determine the power price needed to achieve a specified after-tax levered internal rate of return on the equity invested subject to various constraints, such as the amount of debt in the SMR project's capital structure and a minimum and average debt service coverage ratio. When compared to current market power prices, the necessary power price provides an indication of the potential financeability and market position of SMR projects.

### 1. Reference Plant

The first step in performing financial analysis was to develop a model of the economics and financing of a reference plant using assumptions developed from experience and discussions with DOE-NE, industry players, and power generators. Scully Capital developed assumptions surrounding the technical profile, capital costs, operating parameters, and financing options. The parameters of the reference plant that Scully Capital has developed and used in its analysis are presented below in Exhibit 1.

**Exhibit 1: Base Case Plant Assumptions**

| Technical Parameters | |
|---|---|
| Net Capacity | 798 MW |
| Capacity Factor | 90.0% |
| Construction Schedule | • 30 months to construct the first reactor<br>• 24 months to construct each additional reactor<br>• 6 month lag between start of construction for each reactor<br>• 6 month startup period for each reactor with the unit operating at 80.0% capacity factor |
| **Capital Costs** | |
| EPC Costs | • $740 million for the first reactor<br>• $658 million for each additional reactor<br>• $4,030 million total for six reactors |
| **Operating Parameters** | |
| Fuel Costs | $7.5 / MWh (2013 $), escalating at 2.0% per year |
| O&M Costs | $20.0 / MWh (2013 $), escalating at 2.5% per year |
| Reactor Capex | $1.25 million (2013 $) per year per reactor escalating at 2.5% per year |

Some of the assumptions for the reference plant would be modified in additional analyses to understand the impact of various variables on the potential financeability and market position of SMR projects.

### 2. Analysis of Financial Incentives

Given that current economic conditions in the electricity market create challenges to the implementation of SMRs, Scully Capital sought to understand how various financial incentives, including tax and credit incentives, might improve the marketability of SMR projects. For the analysis of each financial incentive, Scully Capital modified its assumptions used in the reference plant analysis to obtain the power price needed to achieve a specified after-tax levered internal rate of return on the equity.

### 3. Sensitivity Analyses

Scully Capital also sought to understand how sensitive base case power prices are to changes in key variables. Similar to the analysis of financial incentives, Scully Capital modified assumptions used in the reference plant analysis to obtain the power price needed to achieve a specified after-tax levered internal rate of return on the equity. The assumptions that Scully Capital tested included those related to Engineering, Procurement, and Construction (EPC) costs; capacity factors; and the duration of construction.

# III. RESULTS OF MARKET STUDY

Scully Capital conducted interviews with industry participants and surveyed the literature on the market for the implementation of SMR technology. In the interviews, industry participants indicated that they believed that SMRs belonged in their portfolio of generation assets because SMRs may accomplish the following: 1) provide a safe, carbon-free source of base load power; 2) be of the appropriate size to fill gaps left by retiring power plants; and 3) serve as a valuable part of a balanced portfolio that includes diverse fuel types. The interviews and literature review revealed the following additional information regarding the potential demand for the SMR technology.

## A. Diverse Participants in Industry

The industry has diverse players including regulated utilities, utility cooperatives, and independent power producers. A number of regulated utilities, as well as utility cooperatives, are strongly entertaining the use of SMRs as a critical part of their balanced generation portfolio. Scully Capital spoke with a number of utilities that believe that there is a role for SMR technologies in the overall generation portfolio.

Industry participants that Scully Capital spoke with have held discussions with their respective public service commissions in three states. The executives characterized the public service commissions as being positive and supportive in general, and this view extended to their discussions regarding the opportunity to include SMR technology in their generation fleet. The public service commissions were generally encouraging regarding the utilities' efforts. There were, however, some reservations that the commissions expressed. First, as mentioned previously, the commission expressed a condition that there would be a cap on the amount of the cost of the SMR project that the utility would be able to recoup through the ratemaking process. Scully Capital notes that this standard is beyond that typical approach used by utility commissions, which is a prudency of cost incurred standard. Second, the resulting power price for the project would have to fit within the confines of the integrated resource plan (IRP) results for the utility. None of those viewed these constraints as a long-term threat to SMR technology and felt that, although it would be difficult to meet those conditions today, they would be able to satisfactorily address those points in the not-too-distant future.

## B. Value in Hedging Fuel Risk and Fuel Diversity

Industry players generally find value in hedging their fuel risk. While natural gas may currently be inexpensive compared to other fuel sources, a mixed portfolio that includes nuclear generation generally reduces the overall risks associated with volatility in the price of a particular fuel type. The generators indicated that they need to carefully explain the value of fuel diversity to the Public Utility Commissioners. Public Utility Commissioners generally have to ensure that any new generation that is installed makes the best economic case for ratepayers in the near-term and over the time horizon of the IRP.

## C. SMR Role in New Utility Model Paradigm

If one believes that the large central station utility model will change in the future, SMRs can play a role in the new utility model paradigm, reflecting a greater level of distributed generation in the portfolio. Emphasizing this point, Moody's noted that "the commercial deployment of small modular nuclear reactors could be a credit positive" for utilities.[1]

## D. Role in Climate Change

Since the electricity generated through SMR technology is carbon free, this technology can play an important role in addressing the climate change issue. An appropriate incentive mechanism needs to be designed to capture the value of SMR technology in this role. To garner the support of the electric power generating industry, such an incentive would have to be designed to spur the installation of SMR technologies while at the same time avoid penalizing the operations of existing fossil-fueled facilities.

Recent EPA regulations have placed increased pressure on traditional carbon-based forms of electrical generation. SMR technology provides a path to a low carbon economy with generation that can be delivered in a reasonable price range competitive with renewable forms of power generation. Also, SMR technology can reliably deliver carbon-free base load power.

## E. Coal Retirements

The US Energy Information Agency's Annual Energy Outlook 2014 projects that 60GW of coal-fired capacity will be retired by 2020. Black & Veatch estimated a similar number, 58.7GW. Many in the industry expect that these retirements will be replaced mostly with base load natural gas-fired capacity. However, there are scenarios in which the increase in gas-fired capacity drives the cost of natural gas to a point at which SMR technologies become an economic alternative or that the long-term planning process reveals the need for SMRs in a balanced generation portfolio. Furthermore, remediated coal facilities provide a potential site for the location of SMRs due to similarities in the size footprint between SMRs and coal facilities as well as the proximity to necessary infrastructure, such as transmission lines and water supply.

## F. NRC Licensing Process

The challenges related to licensing risk were often cited as one of the major impediments. One major challenge to the SMR technology is the cost and time, as perceived by potential users, which is needed to complete NRC licensing. This risk primarily applies to first-adopters of SMR technology, since utilities that seek licenses after SMR designs have successfully moved through the process face timing risk, as the issues that would necessitate a lengthy review

[1] Moody's Investors Service. "Regulatory Framework Holds Key to Risk and Rewards Associated with Distributed Generation. 23 April 2014.

would have been settled in some manner and precedent established. Licensing risk is characterized along two dimensions:

1. **Technology Standards:** Industry professionals are concerned that standards for the technology may evolve to simply replicate those in place for larger units with respect to operations staffing, safety and security staffing, and evacuation zone parameters. For example, there is concern that the NRC may require that the evacuation zone size needs to be the same for SMRs as it is for larger nuclear facilities and not reflective of the smaller size of SMRs.

2. **Process Uncertainty:** The uncertainty of the process, particularly with respect to the schedule and timing, cost, and path to outcome is a major concern. Of primary concern is the timing of the process.

Those interviewed fully expect that securing a combined license could run for an extended period of time and thus create some difficulties for both vendors and utilities. From a vendor's perspective, the prospect of waiting years for a sale to occur and to recover the investment needed to support the design and certification effort while an applicant goes through the licensing process has two economic effects: a) competition would decrease as only those vendors with the financial capacity and wherewithal to wait through the licensing process would be able to survive; and b) the price for the SMR units would increase as the point at which vendors can begin to see a return on their investment is pushed far into the future.

From the view of a utility, the concern over timing centers mainly on the utility's planning horizon. As with any business, the utility is attempting to match its assets with its assessment of long-term demand projections. Thus, the utility's fear is that a prolonged process in receiving a license may prevent it from being able to construct capacity in the timeframe envisioned sufficient to meet its demand. To illustrate, if the licensing process were to take two years longer than originally forecast in the utility's planning, it then has to find a way to bridge the capacity requirements over that period. Since capacity additions take several years of design and permitting, the utility has limited options to rectify the situation if it were to find itself in this position. As such, a utility may wait to consider SMR technology until there is greater clarity around the time expected for approval.

The SMR vendor's investment balance is exposed to the time it takes an applicant using its technology to progress through the licensing process for a specific project because the vendor is most likely waiting to receive payment for equipment until that licensing process has reached completion. As an example, one utility executive commented that almost 25% of the investment that they have in a plant currently undergoing the licensing process is related to the carrying cost alone.[2]

To illustrate the increase in an SMR vendor's investment balance as a power-producing applicant using that vendor's technology progresses through the licensing process, Scully Capital analyzed the growth in the investment balance based on the time for the licensing process to reach completion as well as the sensitivity of that balance to changes in the SMR

[2] The carrying cost component of the utility's investment represents the return on the needed invested funds such that the utility earns its cost of capital.

vendor's cost of capital. At a 10% cost of capital, $1 invested will grow to $1.77 if the licensing process were to take six years and thus the vendor will have to recoup $1.77 through sales of SMR units. If the process takes 10 years, that amount would grow to $2.59. Given that the magnitude of investment may reach several hundreds of millions of dollars, the growth in the investment over time is extremely large. Exhibit 2 shows how a $1 investment would grow based on the cost of capital and licensing period.

**Exhibit 2: Growth in $1 Invested**

| Licensing Period (Years) | Cost of Capital | | |
|---|---|---|---|
| | 8% | 10% | 12% |
| 6 | $ 1.59 | $ 1.77 | $ 1.97 |
| 10 | $ 2.16 | $ 2.59 | $ 3.11 |

## G. Barriers Related to Economic Conditions in the Electricity Market

Market participants articulated two concerns about the economic condition in the electricity market. These relate to the current and future demand and market prices, as discussed below.

### 1. Demand

Scully Capital found that the industry views the current level of domestic economic growth insufficient to drive the need to build additional electric generating capacity. While electricity demand is driven by economic growth, the current macroeconomic environment is such that there is little growth in demand. Industry participants suggested that any demand that does exist is likely to be filled with either: a) gas-fired capacity because of the current low cost of natural gas; or b) renewable energy capacity which is driven by state renewable portfolio standards. In regions that do have demand growth, some view the pricing incentives to build new generation as insufficient. While some have postulated that SMRs could be a replacement for retiring coal-based units, many in the industry caution that any option to replace retiring capacity will likely be measured against the option that is in the best economic interests of the ratepayers, and in today's environment, the lowest cost option is gas-fired capacity.

### 2. Price

The market believes that the current and forecast prices for electricity are too low to support an SMR project as currently priced. Low natural gas prices have driven the cost of electricity to a point below that needed to make an SMR project feasible. Subsidies for renewable energy distort or even suppress electricity prices. Situations have existed for some time in which the prevalence of wind in the Midwest has driven electricity prices negative in the evening hours. Since it is difficult for a base load plant to reduce output for several hours during high wind generation, the power price for clearing is reduced below zero regardless of whether the production is from base load capacity or wind capacity.

## H. Ongoing DOE Support

Market participants have indicated that DOE support will be needed from the development of the SMR technology through the construction and operating period for the facilities. Power producers remain concerned that the suppliers of SMR technology may not be available for product support in the long-term. To alleviate this concern at the utility level, DOE support could help to ensure that the companies supplying reactors remain in business for the purposes of providing ongoing maintenance and operations support to power producers using SMRs.

## I. International Issues

The international market may be an attractive option for domestic suppliers and projects, but domestic producers would face competition from technologies produced in other countries. The licensing regime in some countries may be more attractive with less time-consuming processes. Furthermore, the power procurement process, if driven by a single governmental agency, may allow a project to secure an economically attractive Power Purchase Agreement in less time than it would otherwise be able to do domestically.

Several government programs exist that may be accessed to provide financing support for the commercialization of the SMR technology. Programs that may provide financing support include: Export-Import Bank, Overseas Private Investment Corporation, USAID, and other multi-lateral and bi-lateral agencies. The charters of these programs may need to be revised by Congress to include backing for a nuclear-related project.

# IV. TOOLS TO OVERCOME MARKET BARRIERS

Incentive programs, including credit and tax programs, may be used to overcome the economic barriers that currently exist for SMRs. These tools include:

- Power Purchase Agreement/State PUC Action;
- Federal PPA;
- Tax Incentives;
- Credit Incentives; and
- Programs to Reduce Licensing Risk.

## A. Power Purchase Agreement / State PUC Action

A Power Purchase Agreement ("PPA") or regulatory action by a state PUC leading to cost recovery of an SMR project may be used to overcome price and demand barriers.

A PPA is a legal contract between a seller who owns the electricity-generating project and a buyer. The buyer, or power purchaser, is typically a utility (or other such load-serving entity) that will use the purchases to meet the needs of its customers. The term of a PPA can be structured in a way suitable for both parties, and while the PPA is in place, the power purchaser is obligated, subject to the terms of the PPA, to purchase the project's output.

PPAs can ensure that the Project receives a rate for its power sales such that after operations and maintenance expenses, sufficient cash flow is available to satisfy the needs of its capital providers, including acceptable debt service coverage and an adequate equity rate of return. The PPA works in two ways: 1) by assuring lenders that a substantial portion of the power produced will be dispatched / purchased; and 2) by subsidizing the cost of power to the extent that the PPA is priced at above-market rates. A PPA is not an incentive but rather a critical element of making the project financeable.

A PPA can be designed with a variety of features that structure the economics to provide adequate returns to providers of capital and reflect the various other incentives available to the project. These tailored features may include:

1. **Power Pricing:** There are several options available depending on the risk that the parties to the PPA are willing to bear. To illustrate, a fixed price means that fuel expense is borne by the project.

2. **Portion of Project's Output:** The greater the output contracted under the PPA, the greater leverage the project owner has in crafting an agreement that meets its needs as well as decreasing the risk to the lenders.

3. **Fixed Date:** A PPA agreement often contains a date by which power must be delivered. If the project fails to meet that date, then in order to keep the project valid, liquidated damages up to a cap would be required.

PPAs would aid in risk mitigation by providing a level of certainty regarding future power sales and the price associated with those sales. However, while providing a degree of price and market certainty, typically a PPA does not serve to mitigate any risks related to construction and operations of a project.

The PPA is critical to the development of a power project as the terms of the PPA define the revenue stream for the project and, thus, it is a central element to the viability of the project. The revenue stream of the project is determined by price and quantity components. Prices for electricity can be structured in any way agreed upon by the buyer and seller, and may be fixed, escalate over time, or be modified in any other way agreed upon by both parties. The PPA will also specify the size of the project and the parameters around expected output.

Two critical risks are mitigated through a PPA. First, any risk related to the marketability of the project's output is mitigated as the buyer is obligated to purchase the power generated from the project. Second, the PPA provides definition around the price that the project will receive for the sale of its output.

As the owner of the project, the seller is responsible for operations and maintenance. The O&M provisions of a PPA can vary significantly. Some PPAs have strict performance standards that the project is required to meet. These standards may include maintaining an average capacity factor or generating a minimum amount of electricity over a defined horizon. Failure to meet these standards could result in liquidated damages being assessed against the project, or even termination. At the other end of the spectrum, there are PPAs that do not have any such performance standards.

In another avenue, the PUC would allow a utility to build a plant in return for rate action that permits the utility to recoup its investment in the SMR Project. A regulatory decision from a state PUC also serves to mitigate market and price risk related to power sales. Scully Capital found that at least in one instance, a utility with a supportive PUC presented the option of building an SMR project to the PUC. A condition of the PUC's approval required that the utility bear the risk of any cost overruns. Unfortunately, the utility believed that, at the current stage of the design, the uncertainty of the cost estimates was so large that it would be highly imprudent to take that risk. This represents an opportunity for the federal government to develop a program to cover cost overruns or escalation above a certain level.

## B. Federal PPA

A federal PPA may be used to overcome demand or price risk for SMR projects. Under a federal PPA option, DOE would act as an aggregator of demand that exists across the federal government and serve as the counterparty to a PPA with an SMR project.

OMB Circular A-11 provides the mechanism for assessing the budgetary impact of a multi-year contract that obligates the federal government to purchase goods and services for a multi-year period. This amount is scored at the time the obligation is entered into and represents the budgetary authority that the federal agency needs to assign to the project before it is able to execute the PPA.

Scully Capital scored the outlays under a federal PPA in accordance with OMB Circular A-11 and the resulting budgetary authority is equal to the sum of the outlays for the entire term of the PPA. Sometimes there is contract authority that allows annual scoring of the outlays. However, as the approach consists of summing all outlays over the term of the PPA in conformance with OMB budget scoring rules, it is conservative in that no assumptions have been made that would lead to a more aggressive scoring approach (i.e., annual scoring). Exhibit 3 shows the budgetary impact of a federal PPA under different ownership structures[3] and is based on the Base Case Reference Plant assumptions and analysis presented in Section V.

**Exhibit 3: Budgetary Impact of Federal PPA[4]**

| ($ Millions) | IPP | Utility | Public Power |
|---|---|---|---|
| Budgetary Impact | $ 15,573 | $ 13,061 | $ 10,926 |

Scully Capital notes that the budget impact is scored over the full term of the potential PPA (30 years). A PPA with a shorter tenor (e.g., 10 or 20 years) is feasible. However, a PPA with a shorter term would not lead to a lower budgetary impact as the shorter term PPA would require higher PPA prices in order to fully amortize the financing over that term.

To use federal PPAs as a tool to enhance the marketability of SMRs, Scully Capital suggests that DOE undertake the following steps:

1. Explore areas with a high concentration of energy demand by federal agencies and evaluate the ability to serve that load with energy supplied under a PPA with an SMR project located on or near federal property; and

2. Develop a strategy to create needed budgetary authority, which will involve budget developers at DOE, Congress, and the Administration.

Scully Capital notes however, that the preliminary analysis on the approach to determining the budgetary impact results in a required budgetary authority well in excess of the costs to construct an SMR project. To illustrate the magnitude of this excess, the total of payments made over the term of the PPA by the federal government to the project under a utility ownership model are approximately $13 billion. These payments, which are revenue to the project, are used by the project to pay for operations and maintenance cost, debt service, and to provide a return of capital invested by the project’s owners, as well as an after-tax return on that investment. However, the total cost to build the project in the utility ownership model is only $4.6 billion. One utility executive commented that in their discussions regarding the development of an SMR project to serve a federal load center, the budgetary impact for the federal agencies was sufficiently large that no further discussions were held. As such, a third step is recommended.

[3] Sum total of all payment to be made under the PPA based on the base case model.
[4] Based on a PPA with a term of 30 years.

3. Explore alternative contract authority that would permit the budgetary impact of a federal PPA to be scored on an annual basis or on some other basis less onerous than OMB Circular A-11. Such alternate approaches could involve scoring the expected PPA outlays on an annual, as-incurred basis or possibly developing an approach that reflects the incremental outlay arising from entering a PPA.[5]

Alternative PPA Structures and Budget Scoring Implications

Scully Capital's analysis thus far has been predicated on a federal PPA for the entire capacity of an SMR project. However, a federal PPA for less than the full capacity of the project and for a term of less than the 30 years envisioned in the Base Case is a valuable option and probably more realistic of the types of arrangements between the government and a utility contemplating an SMR project.

Scully Capital analyzed a scenario in which the federal government would enter into a 10 to 20 year PPA with a utility that will own an SMR project. Under that contract, the government would be obligated to purchase a fixed amount of generation for each year of the scheduled term of the PPA. The purchase obligation could range from 100MW to potentially 300MW of the 798MW base case capacity.

There are several elements to this arrangement that makes it attractive to the federal government. First, the amount of capacity that the government contracts for under the federal PPA could be sized to meet its needs and thus the capacity under the federal PPA may represent an amount less than the full capacity of the project. Second, the term of the contract is equally adjustable and can be based on the time horizon the government envisions. Just as important is that these two elements, in conjunction with the price under the PPA, can be adapted to achieve an acceptable budget scoring impact.

From the utility's perspective, such an arrangement would be beneficial in a number of ways. First, a portion of the output is contracted for the long-term at a fixed price with a creditworthy party. The federal PPA thus mitigates a portion of the volume and price risk to which the utilities and power projects are exposed. The intent would be to mitigate these risks to a point at which the utility is willing to underwrite the entire investment in the SMR project on its own balance sheet. Furthermore, and equally important, is that the utility can point to the reduced risk profile in order to garner approval for the project from the public service commission.

Thus, the design of the federal PPA will involve manipulating the variables related to the PPA such as PPA price, term and capacity, in order to meet the budget scoring targets while providing the utility, and by extension its public service commission, a project with a risk profile sufficient to support its decision to make an investment in the project.

Exhibit 3a provides an overview of the budget scoring impact for a range of possible PPA terms and purchase obligations. The base case capacity of the SMR project is 798MW and a utility is

[5] The current budget scoring methodology does not account for cost of current power purchases by the government. The entire PPA price is scored in the budget rather than accounting for the incremental purchase under a PPA with an SMR. To illustrate, if the government's current cost of power is 8 cents and the cost of a PPA is 12 cents, the scoring assumes a budget impact of 12 cents, rather than the incremental 4 cents over what the government has already incurred.

assumed to own the project. The purchase obligations range from 100MW to 300MW (12.5% to 37.6% of total project capacity). The analysis looked at the budgetary impact for terms of 10 and 20 years. Note that the base case analysis assumed a 30-year life for the project.

**Exhibit 3a: Budgetary Impact of Federal PPA**

| | Term, years | |
|---|---|---|
| Contracted Capacity, MW (1) | 10 | 20 |
| 100 | 518 | 1,058 |
| 200 | 1,036 | 2,117 |
| 300 | 1,554 | 3,176 |

(1) Based on a Project with a 798MW capacity

## C. Tax Incentives

A variety of tax incentives exist that can be modified to apply to SMRs and can meaningfully reduce the price of power. These incentives include the Investment Tax Credit ("ITC") / Cash Grant, Production Tax Credit ("PTC"), Accelerated Depreciation, and use of Tax-Exempt Debt. The nature of these tax credits and their potential impact on the marketability of SMRs will be discussed in more detail in Section VI.

While the existing tax code has a framework for the tax incentive options, some changes to accommodate SMR technology will be required. Scully Capital suggests the following steps to implement the necessary changes:

1. Develop concrete tax incentive proposals based on research of tax/legislative history of each tax incentive option;

2. Create consensus for change within the following constituencies:
   - Industry (equipment and technology suppliers);
   - Utilities and power producers; and
   - State government.

   The DOE working in concert with supportive industry trade associations can serve as a catalyst to develop a trade group specifically focused on SMRs. Once established that trade group can then engage lobbyists and other professional groups needed to drive discussion of SMR tax incentives.

3. Encourage industry participants to build legislative support for tax incentives that are targeted towards SMR technology.

## D. Credit Incentives

Credit incentives, which include the Loan Guarantee, may be used to mitigate price risk. With a Loan Guarantee, a federal agency guarantees the payment of interest and principal on a loan to a project. Additional information on the nature of a Loan Guarantee and its potential impact on the marketability of SMRs will be discussed in more detail in Section VI.

## E. Programs to Reduce Licensing Risk

To address the concern over the uncertainty of the licensing process, DOE should consider programs related to the process. Industry participants would like to see DOE continue its existing programs to share costs throughout the design and certification process, and thus reduce the overall investment needed by the private sector. One such program is the DOE Office of Nuclear Energy's Small Modular Reactor Licensing Technical Support program, which advances the certification and licensing of domestic SMR designs that are relatively mature and can be deployed in the next decade. This program provides funding for both vendors (for certification) and utilities (for licensing activities).

In addition, to reduce the investment that the SMR vendor would have to recoup arising from the carrying costs accruing in an extended licensing timeframe, some industry participants suggested that DOE could cap the costs if the NRC licensing process takes longer than a specified time. Financial support from the DOE in this manner would serve to reduce the investment that the SMR vendor would have to recoup through higher prices for SMR equipment. Capping this risk that applicants to the NRC face would be attractive to industry participants.

# V. Reference Plant Overview

Scully Capital developed a model of the economics and financing of a reference plant using assumptions developed from experience and discussions with DOE-NE and power generators. The following discusses the assumptions used for the reference plant as well as the resulting base case power prices.

## A. Assumptions

Scully Capital has developed a number of assumptions surrounding the technical profile, capital costs, operating parameters, and financing options of a hypothetical six-unit SMR project. A project that consists of six 133MW units was selected as the Base Case, since the capacity of each SMR unit is in the range between the capacities of competing SMR technologies while the number of units was chosen to give a sense of the economies that can be achieved through the installation of multiple units in a single installation. The assumptions follow in Exhibit 4.

**Exhibit 4: Base Case Plant Assumptions**

| Technical Parameters | |
|---|---|
| Net Capacity | 798 MW |
| Capacity Factor | 90.0% |
| Construction Schedule | • 30 months to construct the first reactor<br>• 24 months to construct each additional reactor<br>• 6 month lag between start of construction for each reactor<br>• 6 month startup period for each reactor with the unit operating at 80.0% capacity factor |
| **Capital Costs** | |
| EPC Costs | • $740 million for the first reactor<br>• $658 million for each additional reactor<br>• $4,030 million total for six reactors |
| **Operating Parameters** | |
| Fuel Costs | $7.5 / MWh (2013 $), escalating at 2.0% per year |
| O&M Costs | $20.0 / MWh (2013 $), escalating at 2.5% per year |
| Reactor Capex | $1.25 million (2013 $) per year per reactor escalating at 2.5% per year |

Scully Capital also evaluated the economics for a 4-unit, 532 MW plant (Medium Case) and 2-unit, 266 MW plant (Small Case). These cases were chosen to judge the economics arising from economies of scale from the installation of multiple units.

Scully Capital analyzed the first-year power price for the Base Case, 6-unit SMR project for three prospective ownership options: an Independent Power Purchaser (“IPP”); a Utility-owned project; and finally, a public power option. Under each ownership option, the financing assumptions and plant costs were tailored to reflect the specific ownership option and are shown in Exhibit 5.

**Exhibit 5: Assumptions for Each Ownership Option in the Base Case**

| | IPP | Utility | Public Power |
|---|---|---|---|
| Debt / Equity Ratio | 65% / 30% | 55% / 45% | 90% / 10% |
| Interest Rate | 6.0% | 5.0% | 4.5% |
| Target IRR* | 16.0% | 10.5% | 10.0% |
| Tax Rate | 39.2% | 39.2% | 0.0% |
| Plant Cost ($ Millions) | | | |
| EPC | $ 4,030 | $ 4,030 | $ 4,030 |
| Owner's Costs | 400 | 400 | 400 |
| Capitalized Interest | 212 | 147 | 219 |
| Debt Service Reserves | 120 | - | - |
| **Total** | **$ 4,762** | **$ 4,577** | **$ 4,649** |

* Equity return, post-tax, levered

## B. Results

Scully Capital calculated the resulting first year power prices that were necessary to achieve the target returns in the Base Case based on the aforementioned assumptions and constraints. Note that the 80% of the power price is fixed at the first year power price and the balance is assumed to escalate at the same rate as inflation. Exhibit 6 shows those resulting prices for the IPP, Utility-owned and Public Power producer options in the Base Case as well as in the Low and Medium Cases.

**Exhibit 6: Resulting Power Prices [6]**

| (¢ / kWh) | IPP | Utility | Public Power |
|---|---|---|---|
| Low Case - 2 units | 12.8 | 10.6 | 8.8 |
| Medium Case - 4 units | 12.6 | 10.3 | 8.4 |
| Base Case - 6 units | 11.9 | 9.9 | 8.4 |

The IPP option is the most expensive in terms of first year power price driven by high required equity returns, even though this ownership option has a significant amount of debt (65%) in the capital structure. While the capital structure in the Utility-owned scenario has more equity than the IPP structure, the lower cost of equity (10.5%) serves to lower the first year power price. The

[6] Scully Capital also examined a 2-unit utility case with a total net output of 360 MW. Scully Capital assumed that capital and operating costs would be approximately 30% higher than in the 2-unit utility case, where total net output is 266 MW. The resulting power price was 11.2 cents / kWh, or 0.6 cents / kWh higher than in the 2-unit, 266 MW case noted above.

Public Power option with 90% leverage results in the lowest first year power price of the three ownership options. Due to lower economies of scale, the 2-unit and 4-unit cases require higher power prices to meet required coverage ratios and equity returns.

# VI. Analysis of Financial Incentives

Scully Capital developed and analyzed the various financial incentives, including credit and tax incentives, which can be designed to help SMRs overcome market barriers related to the price of electricity. When properly structured, these incentives can serve to reduce the power price that an SMR project needs in order to achieve target returns. In addition, Scully Capital analyzed the use of a Loan Guarantee as a credit incentive.

For tax incentives, the analysis focused on incorporating the most-commonly used incentives available under the tax code, which include the ITC / Cash Grant, PTC, Accelerated Depreciation, and Tax-Exempt Debt. These tax subsidies reduce capital investment (ITC/Cash Grant), provide an ongoing subsidy as a reduction of either taxable income (depreciation) or taxes due (PTC), or reduce the cost of capital (tax-exempt debt). The following sections provide additional detail on each of the incentives and their estimated financial impact.

## A. Credit Incentive: Loan Guarantee

### 1. Description

With a Loan Guarantee, a federal agency guarantees the interest and principal on a loan to a project. Loans made under DOE Loan Programs consist of a borrowing from the Federal Financing Bank ("FFB") backed by a guarantee from DOE. The use of a loan guarantee results in a lower power price through a combination of the following:

- A lower interest rate than would otherwise be available to the SMR project through the capital markets;
- A longer tenor (loan term) than is typical of a privately-financed transaction; and
- A higher level of debt in the capital structure.

The Federal Credit Reform Act requires a credit subsidy to be paid at financial close for the guarantee. The determination of the credit subsidy is the result of an in-depth credit review process. Scully Capital notes that OMB scoring protocol would likely prevent the use of a Loan Guarantee in combination with a PPA from a federal agency.

Scully Capital analyzed the impact on the first year power price assuming the project incorporated a debt financing with a loan guarantee. The assumption is that the project would be structured such that it would be rated as a high noninvestment grade credit (BB+). Consistent with DOE Loan Programs Office (LPO) experience, such a credit would carry a credit subsidy cost of 11.5%. The assumptions of the loan guarantee financing are found in Exhibit 7.

**Exhibit 7: Loan Guarantee Financing Assumptions**

| Loan Guarantee Fee | |
|---|---|
| Debt / Equity Ratio | 70 / 30 |
| Interest Rate | 4.0% |
| Tenor | 30 Years |
| Credit Subsidy Costs | 11.5% |

### 2. Results

To the extent that the design of the specific program permits it, the credit subsidy cost can be paid from budgetary authority. Alternatively, if budgetary authority is lacking, the owners of the SMR project would be required to pay the credit subsidy. Exhibit 8 shows the power price needed to achieve a specified after-tax levered internal rate of return on the equity invested in the Base Case.

**Exhibit 8: Resulting Power Price with a Loan Guarantee**

| | Loan Guarantee Fee | |
|---|---|---|
| | From Budget Authority | From Equity |
| Power Price (¢ / kWh) | 9.8 | 11.6 |
| Credit Subsidy | 11.5% | 11.5% |

Note that if the owners of the SMR project were to pay the entire cost of the credit subsidy from equity funds, the cost to the project is almost 2¢/kWh. This amount reflects the additional power price needed to provide the owners with a return on the additional amount invested to pay the subsidy costs.

## B. Tax Incentives

A number of federal programs have been used to support renewable energy. These programs are a large reason why renewable energy has experienced success in recent years. For the first eleven months of 2013, renewable energy sources (i.e., biomass, geothermal, hydropower, solar, wind) have accounted for almost 35 percent of all new electrical generating capacity. Scully Capital sought to understand how these programs might impact the success or marketability of SMRs.

The tax code is the primary way in which the federal government incentivizes the development and construction of renewable energy projects. Under the tax code, owners of projects using qualified renewable energy technologies are able to reduce their tax liabilities through various subsidies such as tax credits and accelerated depreciation. One estimate is that the federal government pays as much as 65% of the capital cost of a renewable energy system through tax incentives.

Scully Capital sought to understand the impact that these tax incentives might have if they applied to SMR technologies. As a starting point in its analysis, Scully Capital assumed that SMR technology would benefit from the same subsidies that are generally available for renewable energy technologies.

### 1. Description - Accelerated Depreciation

Under the federal Modified Accelerated Cost-Recovery System ("MACRS"), businesses are permitted to recover their investments in certain property through depreciation deductions. The MACRS establishes a set of class lives for various types of property, ranging from three to 50 years, over which the property may be depreciated. Most renewable energy technologies are classified as five-year property under the MACRS, although some technologies are classified as seven-year property. The five-year schedule for most types of solar, geothermal, and wind property has been in place since 1986.

While the tax code currently permits a recovery period for nuclear power plant of 15 years, Scully Capital evaluated the impact of reducing the recovery period to 5 years from the in-service date. Under 5-year depreciation, 94.2% of the qualifying SMR project cost is depreciated in the first 5 years of operation while only 37.7% of the asset's value is depreciated in the first five years under a 15 year depreciation schedule.

### 2. Description - Investment Tax Credits

The Investment Tax Credit ("ITC") serves to reduce federal income taxes for tax-paying owners based on the capital investment in renewable energy projects. The ITC generally allows taxpayers to take a single tax credit against the project's tax basis equal to 10% or 30% of capital investment, depending on the renewable energy technology, in the year the project is placed in service.

The ITC is reduced for projects that receive other federal tax credits, grants, tax-exempt financing, or subsidized energy financing. Also, the depreciable tax basis of property for which the energy tax credit is claimed is reduced by 50% of the ITC. In addition, the ITC is subject to recapture of the accelerated depreciation if the energy property is disposed of or otherwise ceases to be energy property in the hands of the original owner within 5 years of being placed in service.

### 3. Description - Production Tax Credit

The federal renewable electricity production tax credit ("PTC") is a per-kilowatt-hour tax credit for electricity generated from a qualified renewable energy technology and sold during the tax year. The production tax credit amount is equal to 1.5¢/kWh in 1993 dollars (indexed for inflation) for some renewable energy technologies, and 50% of that amount for other technologies. For the 2013 calendar year, the value of the PTC ranged from 1.1¢/kWh to 2.3¢/kWh. The rules governing the PTC vary by resource and facility type. The PTC is generally available for a period of 10 years after the date the facility is placed in service. As with the ITC, the PTC is reduced for projects that receive other federal tax credits, grants, tax-exempt financing, or subsidized energy financing.

The PTC expired at the end of 2013 and projects that were not under construction prior to January 1, 2014 will be ineligible for this credit. Both chambers of Congress are, however, considering an extension of the PTC. Since 1999, the PTC has been extended eight times. On three occasions, the PTC was allowed to lapse before being retroactively extended.

### 4. Description - Tax-Exempt Debt

Through a tax-exempt issuer, corporations can issue tax-exempt bonds. Investors in these bonds do not have to pay federal income tax on the interest income from these bonds. As such, they demand a lower rate of return on tax-exempt bonds which translate into a lower interest rate. Corporations issuing tax-exempt debt are required to use a straight-line method for depreciation of the assets funded through the tax-exempt debt, rather than accelerated depreciation.

### 5. Results

The tax incentives serve to reduce the power price needed to achieve a specified after-tax levered internal rate of return on the equity invested. Tax incentives do not apply to the public power producer, which is a non-tax paying entity. Exhibit 9 shows the results of the various tax incentives on the power price in the Base Case.

**Exhibit 9: Resulting Power Prices with Tax Incentives**

| (¢ / kWh) | IPP | Utility |
|---|---|---|
| **Base Case** | 11.9 | 9.9 |
| **Sensitivity Case (Change from Base Case)** | | |
| ITC | (2.4) | (2.5) |
| PTC | (2.4) | (2.0) |
| 5-Year MACRS | (1.7) | (1.0) |
| Tax-Exempt Debt | 0.9 | 0.6 |

As shown above, the ITC and PTC provide the same level of benefit in the IPP Scenario while the ITC is 20% more valuable than the PTC in the utility scenario. Also, the 5-yr MACRS appears to provide more value in the IPP scenario than in the Utility scenario; however, as a percent of the Base Case power price, the difference is only 4%. The use of tax-exempt debt is actually more costly as the loss in value arising from the change in depreciation benefits (straight-line depreciation rather than MACRS) is not offset by the value arising from the project incurring a lower interest rate.

The amount of taxes paid or losses generated varies with the application of the tax incentives. Scully Capital did not examine the impact of tax incentives on the public power case, as it is unaffected by taxes. Exhibit 10 shows the impact on taxes for the Base Case and the various scenarios over both a 10-year window as well as over the project's lifespan.

**Exhibit 10: Taxes**

| | IPP | | Utility | |
|---|---|---|---|---|
| ($ Millions) | 10-year | Project Life | 10-year | Project Life |
| **Base Case** | $ (167) | $ 1,877 | $ (347) | $ 1,017 |
| **Sensitivity Case** | | | | |
| ITC | (1,786) | (629) | (1,966) | (1,531) |
| PTC | (1,528) | (828) | (1,725) | (1,745) |
| 5-Year MACRs | (1,017) | 895 | (1,071) | 439 |
| Tax-Exempt Debt | $ 753 | $ 2,870 | $ 455 | $ 1,708 |

A variety of credit and tax incentives exist that can be modified to apply to SMRs to address economic barriers. Given the significant impact that these incentives have on reducing economic barriers, DOE should consider formulating a plan to implement incentive programs. Including SMR technology in the tax code as a technology that qualifies for the various tax incentives is one such avenue.

# VII. SENSITIVITY ANALYSES

## A. Description of Sensitivities

Scully Capital analyzed a number of scenarios in the Base Case to gauge the sensitivity of project economics and the resulting power price to changes in key base case variables. These sensitivities include:

1. **EPC Costs:** A sensitivity was run at +/- 10% from the Base Case as well as a case that reduces the cost of Units 4-6 by 10% from the cost of the first 3 units. This last sensitivity attempts to capture the impact of a learning curve that many industry participants expect will result from the assembly-line approach of producing SMR components.

2. **Capacity Factor**: A sensitivity reducing the base case capacity factor from 90% to 80% was analyzed.

3. **Construction Schedule:** A sensitivity that analyzed the impact of an extended construction schedule was run.

## B. Results

Exhibit 11 indicates the change to the Base Case power price resulting from a change in the underlying assumptions.

**Exhibit 11: Resulting Power Prices for the Sensitivity Cases**

| (¢ / kWh) | IPP | Utility | Public Power |
|---|---|---|---|
| **Base Case** | 11.9 | 9.9 | 8.4 |
| **Sensitivity Case (Change from Base Case)** | | | |
| EPC Cost | | | |
| Increase by 10% | 0.8 | 0.5 | 0.6 |
| Decrease by 10% | (0.8) | (0.6) | (0.4) |
| Decrease for Units 4-6 by 10% | (0.3) | (0.3) | - |
| Capacity Factor at 80% | 1.0 | 0.8 | 0.5 |
| 6 Additional Months of Construction | 0.4 | 0.6 | 0.2 |

As shown above, changes in the EPC cost, capacity factor, or duration of construction have the potential to move the required power price to a level that may become less competitive. Most notably, across all three ownership options, the first year power price is most sensitive to changes in the capacity factor. Also, given the relatively small decrease in power price resulting from a 10% decrease in EPC costs for the last 3 units, additional evaluation is warranted to fully understand the extent to which learning curve effects exist.

# VIII. SUMMARY

The market demand for the SMR technology is dependent on a couple of factors: 1) given the magnitude of the investment needed to support the NRC licensing process, there needs to be a greater level of certainty surrounding the timing of that process; and 2) financial incentives are needed to improve the cost-competitiveness of the early plants. Industry participants and potential customers generally agree that the SMR technology has significant value as a part of a balanced portfolio of generation assets and provides a reliable base load option while reducing carbon emissions. Supported with the above noted financial incentives, the power price for an SMR facility would be in a range that would make the technology competitive with other technologies.

To develop SMR technology as a means of achieving the clean energy mandates that the federal government has set, consideration should be given to establishing a series of incentives for the technology similar in size and scope to those subsidies that renewable energy technologies currently enjoy and have been instrumental in the growth of renewable energy over the past decade. The suite of incentives would be similar to those outlined in this report.