Economic, Employment and Environmental Benefits of Renewed U.S. Investment in Nuclear Energy

National and State Analysis

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Oxford Economics
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Contents

Executive Summary

- A substantial program of new investment in nuclear energy infrastructure will generate up to **350,000 new jobs and almost $45bn in value-added**.

- In this study, we assess the economic benefits of a reinvestment program for the nuclear energy industry. This program would involve two overlapping phases of work:

    - **The investment phase** – the construction and manufacture of a new fleet of nuclear reactors, nuclear recycling plants and enrichment plants.

    - **The operation phase** - when the reactors and the recycling plants start generating electricity.

- The economic benefits of the investment program have three components (as shown in the charts below):

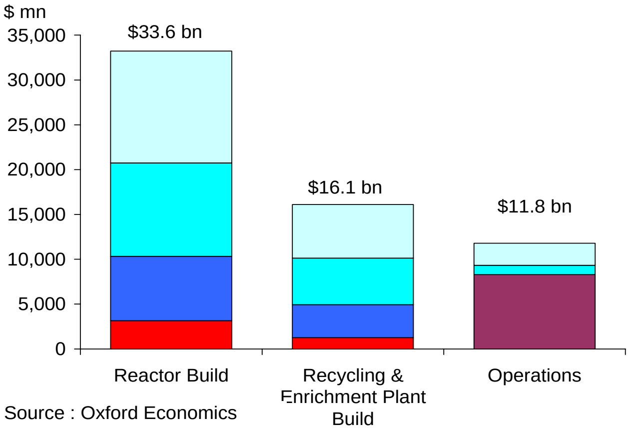
    - **Direct employment and value added** – how many people are employed in the construction, manufacturing and operation of the new nuclear energy industry as a result of the reinvestment program, and how much value added do they create?

    - **Indirect employment and value added** – how many jobs and how much value added are supported down the supply chain to the nuclear energy industry, in each of the three phases of the project?

    - **Induced employment and value added** – how much do the direct and indirect employees of the nuclear energy industry spend in the US economy, and how many jobs and how much value added is supported by that spending?

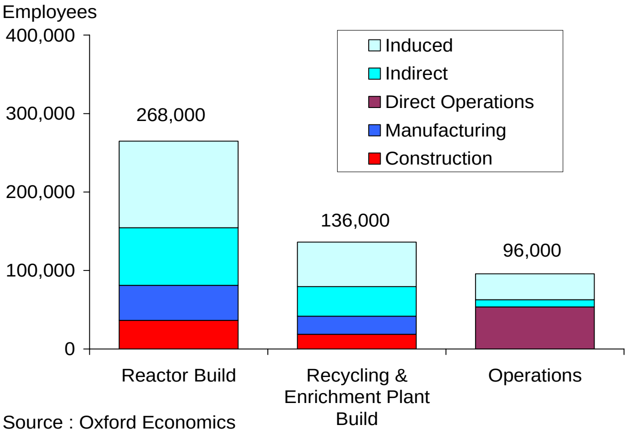
- Associated wage and tax benefits have also been calculated for all stages, while expected

Value-Added Benefits of Investment Program



Source : Oxford Economics

Employment Benefits of Investment Program



Source : Oxford Economics

carbon emissions savings have also been estimated.

- The extent to which each these benefits are experienced in each state has been estimated in the first instance according to planned construction and then according an assumed replacement of existing capacity.

- Without this substantial program of new investment, the capacity of the US nuclear energy industry will dwindle to zero by 2050. The specific jobs and associated value-added and tax benefits that industry would support will also be lost.

- Of course, demand for electricity would be unlikely to change, so generation capacity would have to be expanded in other ways, for instance with coal power. Further conventional generation capacity would also involve some direct, indirect and induced economic benefits.

- Crucially, however, a large proportion of the jobs that would be supported by the nuclear investment program are manufacturing jobs in the production of the capital goods necessary to support the nuclear energy industry. These are high-tech, high-value-added jobs that reflect high spending on R&D and fixed investment: jobs that the US economy can ill afford to lose. Alternative ways of meeting US electricity generation needs would be unlikely to create so many high-value-added manufacturing jobs.

- An investment program to maintain the US nuclear energy industry's current generation capacity into the long term would secure these vital manufacturing jobs, and would position the US economy to regain the lead in nuclear reactor technology globally, and claim the lead in recycling technology, both of which potentially represent major sources of export earnings into the long term.

- Many of these impacts will to be generated in states according to the expected concentration of the necessary skills. Benefits of the investment program are not confined to states which are expected to increase nuclear capacity.

- Maintaining the current generation capacity of the US nuclear energy industry would also imply a reduction in US reliance on fossil fuel imports for generation of up $49bn per year, while higher fossil fuel prices would make these savings even greater.

- Finally, nuclear energy produces electricity without the attendant carbon emissions that come from burning fossil fuels. Maintaining the current nuclear generation capacity would mean reducing future US emissions by 450 million tonnes of CO2 per year compared to a zero-nuclear-generation baseline.

1. Introduction

This study updates previous estimates of the macroeconomic benefits of a program of investment in nuclear energy in the US over the next 20-25 years to replace the current ageing generation capacity, with the following key additions:

- More recent assumptions regarding costs and the assumed timetable of construction are taken into account.
- Analysis is extended to determine the economic impacts at the state level.

The proposed investment scheme involves the design, manufacture, construction and operation of 52 new nuclear reactors plus one new recycling facility and four new enrichment facilities. Each of these plants will create a significant number of jobs and value-added directly in construction and operation as well as in the wider economy. These benefits are quantified in this study as well as the associated wage and tax impacts.

Renewed investment in nuclear generation capacity will also have other benefits which are not measured in the traditional economic impact assessment approach above. Restoring nuclear generation capacity will reduce dependence on fossil fuels. We estimate the associated reduction in carbon emissions as well as the expected trade benefit.

The rest of this paper is organized as follows:

- Section 2 summarizes the key macroeconomic results of our research.
- Section 3 summarizes the key macroeconomic benefits by state.
- Section 4 details the other expected benefits of a nuclear investment program.
- Section 5 sets out our methodology and explains key assumptions used in determining the wider macroeconomic benefits of restoring nuclear capacity during the investment phase.
- Section 6 describes the methodology and assumptions applied in determining the wider economic benefits of operating the new nuclear reactors.
- Section 7 describes the methodology and assumptions used in estimating the economic impacts at the state level.
- Section 8 offers some conclusions.

2. US Macroeconomic Benefits

The macroeconomic benefits of the proposed nuclear energy investment program come in two phases: the **investment phase** (while the new capacity is being created); and the **operations phase** (when the new capacity is up and running). Below, we go through each of these in turn.

The benefits of the nuclear investment program, and the associated high value-added manufacturing jobs, are considered relative to a plausible alternative. In the absence of the new nuclear investment, it is likely that further coal-fired power stations would be constructed.

2.1. Investment Phase

2.1.1. Reactors

- 82,000 direct jobs, $10.4 billion direct value added
- 74,000 indirect jobs, $10.6 billion indirect value added
- 112,000 induced jobs, $12.6 billion induced value added

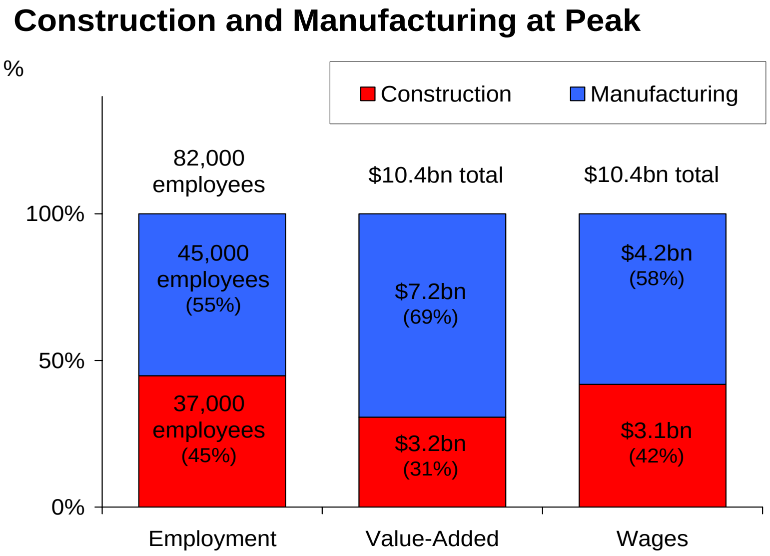
The direct jobs estimate includes a large number of highly skilled and well paid manufacturing jobs in sectors which supply the specific components required in the construction of nuclear power plants. This represents the most significant benefit to the wider economy, particularly when compared with the alternative of construction of fossil fuel plants. By retaining or repatriating these skilled functions, the US will be at the leading edge of nuclear expertise within the global economy. This creates a potential source of future export earnings as the US provides expertise to select countries expanding their nuclear energy capacity.

We estimate that the investment program will generate roughly 45,000 manufacturing jobs over the next 15-20 years. The new manufacturing jobs will come on top of an expected 37,000 jobs in the construction sector.

The balance of direct employment effects is weighted towards manufacturing rather than construction. Productivity and average wages for these manufacturing jobs are significantly higher than for the construction jobs, reflecting the highly-skilled nature of the specific jobs. As a result, the manufacturing sector benefits are even more pronounced when it comes to considering value added and total wages. The investment program will generate $10.4 billion of direct value added at its peak, of which $7.2 billion will be in the manufacturing sector.

These high value added, skilled manufacturing jobs are also an important feature of the investment program since they are unlikely to be generated by the alternative of further fossil fuel capacity.

Chart 2-1: Direct construction and manufacturing benefits

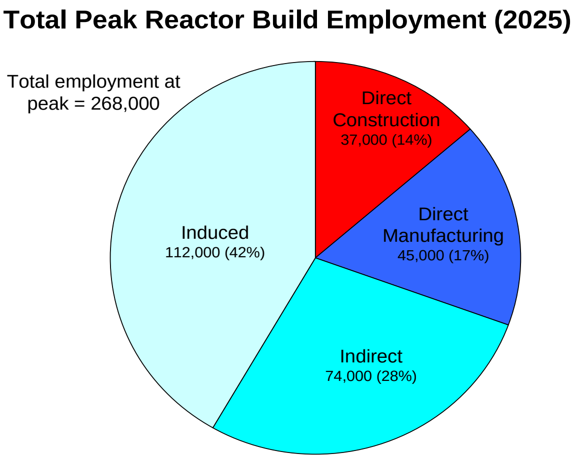


Source : DoE, Bechtel, Oxford Economics

In a sense, the manufacturing benefits could be viewed as an indirect effect as a supplier of materials to the construction process. However, we have identified the manufacturing benefits separately as part of the direct effect, reflecting its size and importance.

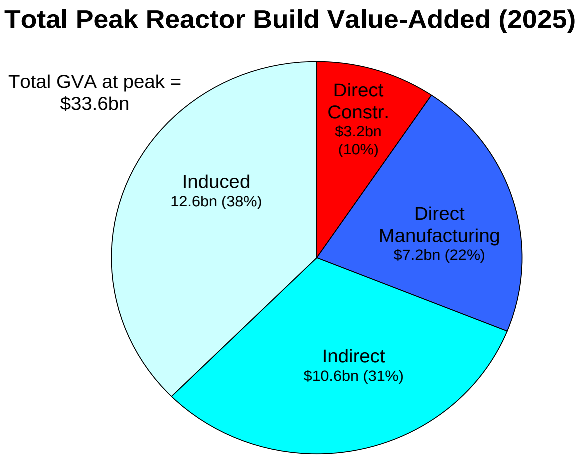
Further indirect economic effects would be generated through the supply chain by activity in both construction and manufacturing, and indeed in other sectors. The indirect effects supported by manufacturing activity are larger than those supported by construction activity, since the inputs to high-tech manufacturing tend to be more complex and therefore more expensive than for construction; even for construction of nuclear power plants which tend to require a higher level of worker training than for construction of a conventional power plant.

Chart 2-2: Total reactor build employment



Source : Oxford Economics

Chart 2-3: Total reactor build value-added



Source : Oxford Economics

Overall, we estimate that the indirect economic benefits are broadly equivalent to the direct benefits. Around 74,000 jobs and $10.6 billion of value added will be indirectly supported through the supply chain in 2025.

Finally, there are further significant benefits for the economy arising from the induced effects of spending of those directly or indirectly employed as a result of the nuclear energy investment program. Once again, these induced effects are particularly pronounced for the manufacturing phase, thanks to the relatively high wages (and therefore high spending of employees) in that sector.

Total economic benefits including induced effects, measured as both jobs and value-added, are estimated to be over three times larger than the direct effects alone.

The direct, indirect and induced effects in 2025 are set out in the table below.

Table 2-1: Peak reactor build economic benefits (2025)

	Economic benefits			
	Value added $ bn	Employment '000s	Wages $ bn	Taxes $ bn
Manufacturing Direct Impact	7.2	45	4.2	1.8
Construction Direct Impact	3.2	37	3.1	1.0
Indirect Effects	10.6	74	6.6	2.6
Induced Effects	12.6	112	7.1	2.9
Total	33.6	268	21.0	8.3

2.1.2. Recycling and Enrichment Plants

- 42,000 direct jobs, $4.9 billion direct value added
- 38,000 indirect jobs, $5.2 billion indirect value added
- 57,000 induced jobs, $6.0 billion induced value added

For the purposes of this study, we assume that the nuclear energy investment program includes the construction of one new fuel reprocessing plant in the US. As with the reactor build, this construction would also generate demand for skilled labor in the US.

We also quantify the impact of four new uranium enrichment plants which are currently being planned. These will remove the current reliance on imported enriched uranium and may allow net exports. In addition to current US capacity these new enrichment plants will generate more enriched uranium than required by planned generation.

We estimate that around 42,000 manufacturing and construction jobs will be directly generated in the investment phase of these plants, skewed slightly towards the manufacturing sector as with reactor build.

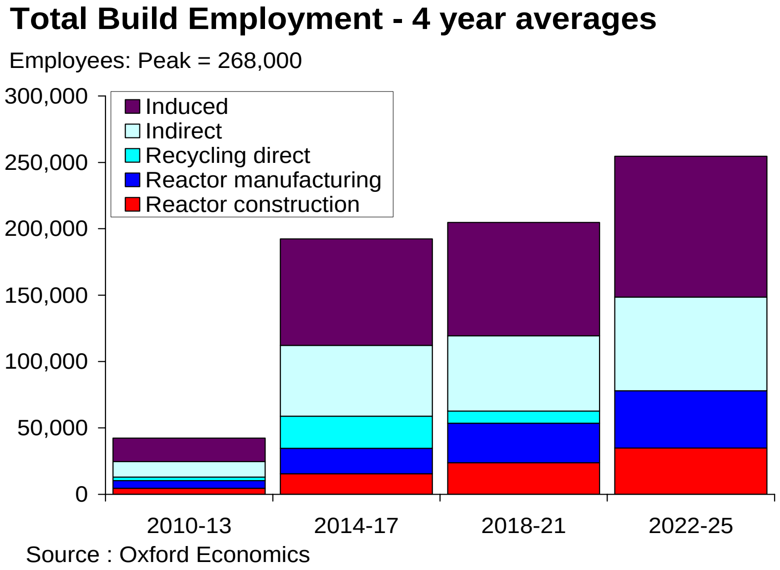
Including indirect and induced effects, the number of jobs generated by investment in these facilities may be as high as 136,000. On the value added side, as above, the manufacturing share of total direct value added is larger, thanks to higher manufacturing wages. And the indirect and induced effects are attributable mainly to the manufacturing rather than the construction impacts.

Table 2-2: Peak recycling & enrichment plant economic benefits (2017)

	Economic benefits			
	Value added $ bn	Employment ‘000s	Wages $ bn	Taxes $ bn
Manufacturing Phase	3.7	19	2.2	0.9
Construction Phase	1.3	23	1.2	0.4
Indirect Effects	5.2	38	3.2	1.3
Induced Effects	6.0	57	3.4	1.4
Total	16.1	136	10.0	4.0

Total employment demand for both reactors and the recycling plant will accumulate over time (see chart 2-4) allowing the necessary skills to be developed within the US labor force, rather than importing skilled labor. This includes all benefits of the building of reactors, recycling facilities and enrichment plants.

Chart 2-4: Total investment phase labor demand



Source : Oxford Economics

Value-added is expected to follow a similar profile for the investment phase, building up to peak impact of $33.6bn in the period 2022-25.

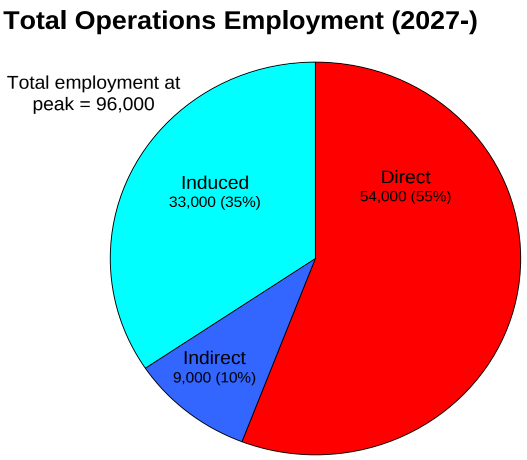
Total wages and taxes are also estimated to rise to peak at $21.0bn and $8.3bn respectively over the same time period.

2.2. Operations Phase

- 54,000 direct jobs, $8.3 billion direct value added
- 9,000 indirect jobs, $1.0 billion indirect value added
- 33,000 induced jobs, $2.5 billion induced value added

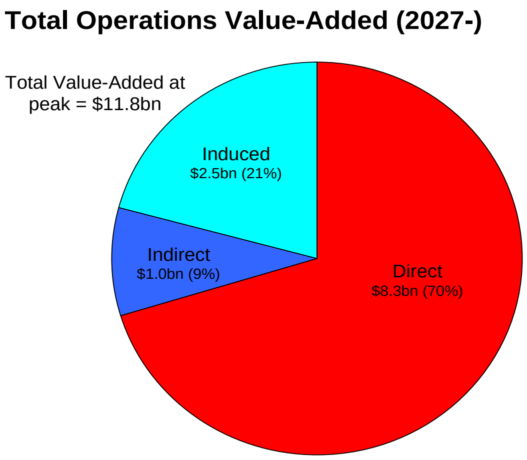
Ongoing operations of the new nuclear plants (reactors, recycling and enrichment plants together) are estimated to directly support around 54,000 skilled jobs from 2027 onwards, providing a secure long-term benefit from the investment program.

Chart 2-5: Total operations employment



Source : Oxford Economics

Chart 2-6: Total operations value-added



Source : Oxford Economics

The wider economic benefits of this phase, as well as the value-added effects, are strongly dependent on what we assume about the average productivity of each job in the operations phase, and about the extent to which operations of nuclear reactors require inputs of other fossil fuels. The key assumptions are laid out below:

- As an upper bound, applying current productivity rates for the power sector as a whole implies that operations would support total employment (direct, indirect and induced labor) of 221,000.
- However, the power sector as a whole in the US is heavily dependent on the burning of fossil fuels, and indirect effects for this involve large purchases of these fuels which support further activity. Stripping out the impact of purchases of fossil fuels reduces the estimate of total (direct, indirect and induced) employment to 198,000.
- Moreover, nuclear generation is much more labor intensive than fossil fuel generation, implying

that average labor productivity in the nuclear generation sector is lower than for the power sector as a whole. Taking account of this lower productivity reduces the employment multipliers still further, so the final estimate of total (direct, indirect and induced) operations employment is 96,000.

- The corrected productivity assumptions also imply that direct value-added which would be generated by the 54,000 direct employees in the operations phase would be $8.3bn.

The wider economic effects estimated here are significantly lower than in some other studies as a result of these adjustments. These effects are smaller than peak economic benefits for the investment phase, but they are still significant.

Table 2-3: Operations economic benefits (2027-)

	Economic benefits			
	Value added $ bn	Employment '000s	Wages $ bn	Taxes $ bn
Reactor Operations	7.5	47	6.7	2.7
Recycling & Enrichment Plant Operations	0.8	7	0.7	0.3
Indirect Effects	1.0	9	0.6	0.3
Induced Effects	2.5	33	1.4	0.7
Total	11.8	96	9.4	3.9

2.3. Counterfactual analysis: coal instead of nuclear

The nuclear investment program is expected to deliver significant benefits which would not be otherwise achieved under alternative investment. In the event that the investment in nuclear energy did not take place, US demand for electricity would not diminish, so electricity would have to be provided from some other source. The most likely alternative source of electricity is coal-fired power stations.

It is beyond the remit of this paper to assess in detail the economic impact of delivering the additional electricity from coal-fired power stations in the US. However, without detailed analysis, the following general points can be made:

- It is unclear to what extent the existing coal-fired electricity generation industry in the US could increase its generation of electricity without the need for further investment. But it is likely that some if not all of the additional generation would come from new capacity, driven by new investment.

- The construction and operations economic impacts of this new investment would probably be of a similar magnitude to the impacts of the nuclear energy investment program set out above.

- But the manufacturing impacts would be significantly smaller, since coal-fired electricity generation requires substantially fewer manufacturing inputs than does nuclear generation.

- The nuclear energy investment program has the potential for generating substantial 'spillover' or 'catalytic' benefits that would be less likely to accrue from further investment in coal-fired generation. These spillover effects have not been quantified in this study, but are likely to be substantial, and are worthy of further research. They include:

    - Benefits for manufacturing technology, advancing the technological frontier, to the benefit of other manufacturing firms based in the US. The proposed nuclear generation build out will involve bringing to market the fruits of R&D that have as yet not been exploited. The insights and advances made in the development phase of R&D projects can be large, and are often transferable, at least in part, into other industrial sectors. Those countries that undertake a lot of R&D tend to be the same countries that have high levels of average productivity, as the lessons from that R&D diffuse around the economy as a whole.

    - Benefits for the composition of employment, creating and retaining a cluster of high-tech manufacturing jobs in the US. While new skilled positions would have to be created to meet the requirements of the nuclear build, it is estimated by other studies[1] that any new equipment required for fossil fuel generation plant could be met by existing excess capacity in the manufacturing sector. The skill requirements associated with the nuclear build would increase steadily over time, allowing a gradual accumulation of these skills within the US workforce, rather than a requirement for importing skilled labor. The creation of these new skilled jobs would provide a significant boost to the stock of human capital in the US, and therefore to the average levels of productivity that the US workforce could achieve.

    - Benefits for exports, bringing the US nuclear industry to the forefront among its peers in the global economy, and creating a potential source of export earnings well into the future as US expertise is distributed around the world.

- The nuclear energy investment program also has different implications for US carbon emissions relative to increasing coal generation capacity. These effects, along with the potential impacts on US dependency on oil imports, are assessed in section 4.

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[1] US Job Creation Due to Nuclear Power Resurgence in the United States –Bechtel Power Corporation & Idaho National Engineering Laboratory. Prepared for the Department of Energy

3. State Level Economic Benefits

Results of the economic benefits by state are reported in the Annex tables, and this section features highlights of the results.

Impacts at the state level have been considered in two phases: first it is assumed that construction will begin on 33 reactors by 2021 in 15 states according to current plans. Next it is assumed that construction begins on 20 further reactors by 2025, in a further 6 states, according to the expected decline in capacity without the new investment.

3.1. Investment Phase

3.1.1. Reactors

- Up to 11,000 jobs per state will be generated by direct construction activity across 15 states for the reactors currently at the planning stage.
- Up to 10,000 direct jobs will be created in a further 6 states according to assumed construction.
- Up to 5,000 manufacturing jobs per state will be generated across all states.
- Over 1,000 jobs per state generated in 36 states taking all wider impacts into account.

States which are assumed to see an increase in nuclear capacity are expected to see an increase in construction sector employment under the investment program which would otherwise not occur. The estimated direct construction impacts at the state level are therefore dependent on the assumed locations of the new reactors. Direct impacts are more certain for the first phase for states which are currently planning new capacity, than for the second phase.

Table 3-1: Peak investment phase impacts by state – phase 1 (currently planned reactors)

(top 5 states ranked by total employment impact)

	Assumed reactors constructed	Construction Employment	Manufacturing Employment	Indirect Employment	Induced Employment
Texas	6	11,400	2,700	5,500	8,200
Florida	4	8,500	400	3,800	5,800
South Carolina	5	10,600	500	800	1,000
Maryland	3	6,100	100	1,500	2,700
California	0	0	1,000	3,100	5,600

The direct manufacturing benefits are expected to be experienced in states with a high expected concentration of the necessary skills, independent of the assumed reactor locations. Indeed, some states such as California are expected to experience significant benefits of the investment program despite a lack of any investment there.

The same is true to some extent for indirect and induced jobs which are generated by goods imported from other states. This explains how Florida is expected to see a greater overall employment benefit than South Carolina even though fewer reactors are expected to be constructed within the state.

These effects become even more noticeable when considering the value-added impact, with greater productivity in manufacturing sectors than in construction.

3.1.2. Recycling and Enrichment Plants

- 19,000 jobs and $1.3 bn value-added directly generated in construction across five assumed locations.
- 117,000 jobs and $14.8 bn value-added generated in the wider economy across all states

3.2. Operations Phase

- 30,000 direct jobs generated in 15 states according to current planned reactor build.
- 17,000 further direct jobs in a further 6 states according to additional assumed reactor construction.
- 7,000 jobs created across other states including indirect and induced effects

Direct employment impacts will be concentrated in the states which will house the assumed new reactors as with the direct construction impacts. This is also true for the recycling and enrichment facilities.

Wider impacts from the supply chain and employee spending will produce further benefits within these states. But this will also generate benefits across the entire US as goods are purchased relying on activity in other states.

Charts 3-1 and 3-2 illustrate the importance of wider effects to some states, especially when considering value-added since manufacturing benefits involves highly-skilled and well paid employment. Operations phase benefits are strongly linked to assumed construction and placement of a state on the y-axis is dependent on build assumptions. These assumptions are also important to some extent in determining the investment phase impacts on the x-axis. However, the expected concentration of required manufacturing skills is also important.

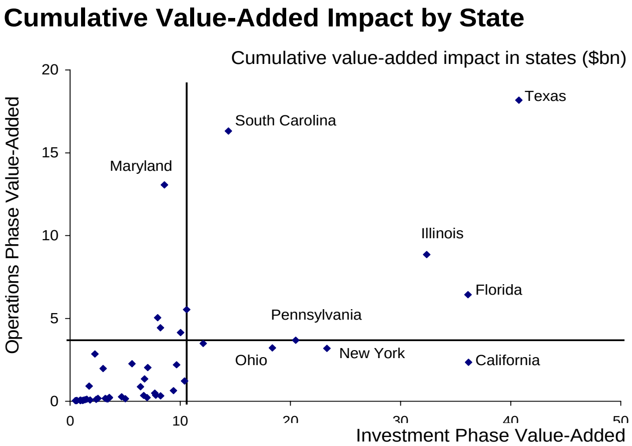
States such as Texas, Illinois, and Florida sit in the upper right segment of the charts and are expected to see significant benefits from both operations and direct construction of new nuclear facilities.

Manufacturing within these states will also receive benefit significantly from the investment program in all states.

Maryland and other states located in the upper left are not expected to receive significant benefits from the investment phase due to low concentration of the required skilled industries. These states are expected to receive significant ongoing benefits of operations employment according to current assumptions.

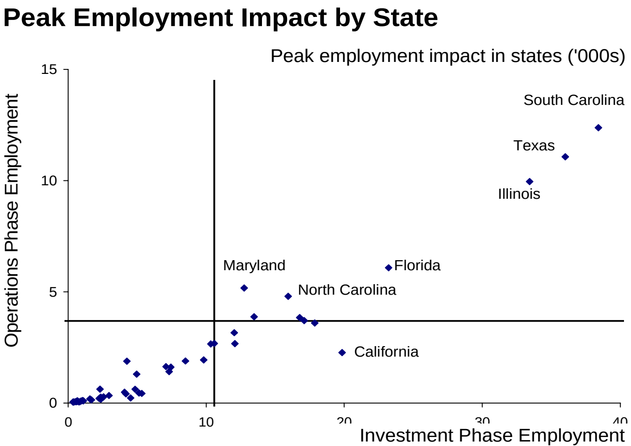
By contrast, states in the lower right and notably California are expected to receive disproportionately large benefits from the investment program due to the expected concentration of skills. Significant benefits will be accrued regardless of where in the US reactors are located. New York, Pennsylvania and Ohio also look well positioned to take advantage of the benefits arising from the assumed investment program.

Chart 3-1: Value-added by state



Source : Oxford Economics

Chart 3-2: Employment by state



Source : Oxford Economics

4. Fossil Fuel Replacement Benefits

Investment in new nuclear generation capacity will help to maintain the current generation mix and help to avoid a swing towards even greater use of fossil fuels in generation. At present the burning of fossil fuels accounts for around 70% of electricity generation. That proportion is likely to rise if nuclear capacity declines.

Increased non-nuclear generation would place further strain on limited fossil fuel resources and is likely to mean higher imports of increasingly costly fossil fuels. And, if policymakers are seriously committed to reducing US carbon emissions, then renewed investment in nuclear capacity would contribute to that goal.

4.1. Fossil Fuel Savings

- Fossil fuel use up to 4.5 quadrillion Btu lower than baseline forecast in 2030
- Import saving of between $8.5bn and $49bn

4.1.1. Direct substitution

The Energy Information Administration (EIA) produce forecasts of fuel demands out to 2030, including fuel use for generation, which we use as basis for the future non-nuclear fuel mix.

Table 4-1: Non-nuclear electricity generation by fuel type

	% share of non-nuclear generation capacity according to EIA	
	2006 – EIA data	2030 – EIA projection
Nuclear	-	-
Coal	60.7%	69.6%
Gas	25.3%	15.1%
Petroleum	2.0%	1.4%
Renewables	11.8%	13.9%
Other / imports	0.2%	0.0%

We take electricity demand and the non-nuclear fuel demand for generation from the EIA (table 4-1). Non-nuclear generation is met by the same share of fuels as in the EIA forecast. This implies that the majority of the extra demand for electricity by 2030 is met by burning fossil fuels and especially coal, although there is also some assumed increase in renewables generation.

Relative to this baseline, restoring an additional 72,800 MWe nuclear capacity by 2030 would involve a saving of 5 quadrillion Btu fossil fuel for generation. Added to the remaining capacity in the baseline, total nuclear generation capacity in the scenario is expected to rise to around 122,000 MWe by 2030.

At current capacity utilization rates, this would generate over 970bn KWh electricity; 570bn KWh more than in the baseline projection. With the same non-nuclear fuel mix, this implies that generation involving fossil fuels would be 510bn KWh lower than under the baseline projection (the remaining 60bn KWh comes largely from a reduction in the renewables share). Applying expected generator efficiency rates (consistent with EIA projections) implies that there will be a saving of 4.4 quadrillion Btu coal, 0.5 for gas and 0.1 for oil.

Table 4-2: Fuel demand for generation

	2030 – OE/ANCC baseline projection		2030 – OE/ANCC nuclear re-investment scenario	
	Generation demand (KWh bn)	Fuel demand (Btu qn)	Generation demand (KWh bn)	Fuel demand (Btu qn)
Nuclear	404	4.2	972	10.1
Coal	3761	35.2	3286	30.7
Gas	814	5.3	733	4.8
Petroleum	77	0.7	69	0.6
Renewables	753	7.6	750	7.6
Other / imports	1	0.0	1	0.0
Total	5810		5810	

4.1.2. Imports & Security of Supply

Rising fossil fuel use in the baseline forecast, with no new nuclear capacity, will place a strain on domestic supplies, and require increased imports. Even in the EIA forecast which assumes constant nuclear capacity, fossil fuel imports are expected to rise by around 1% each year.

By undertaking the nuclear investment program, US fossil fuel import requirements would be decreased representing a significant benefit to the economy.

Typically, fuels which are sourced in the US are consumed within the US, with very low exports. Imports make up the shortfall and therefore are likely to become more important as energy demand grows. Currently, imports are especially important for oil and gas use, while the US is a net exporter of coal. According to EIA projections, oil and gas imports are set to rise by 2030 in line with demand. However, coal imports are also expected to rise while exports are anticipated to fall and the US may become a net coal importer.

Natural gas imports in 2030 are likely to be around $4bn lower with the nuclear investment than under the baseline scenario. It is reasonable to assume that the 0.5 quadrillion Btu of natural gas saved by nuclear investment wholly represents a reduction in imports. Natural gas imports are expected to be 4.6qn Btu in 2030 according to the EIA projections. Assumed EIA natural gas prices are also used to derive the monetary value of the saving.

Coal imports could also be almost $4bn lower under the nuclear investment program than otherwise. EIA projections imply that annual coal imports will represent roughly 2qn Btu by 2030. The 4.4qn Btu coal saved under the investment program more than offsets this value.

Similarly, oil imports would be around 0.1 quadrillion Btu lower than in the baseline by 2030, equivalent to roughly 2.9 million tonnes or around 21.5 million barrels each year. At EIA assumed prices, this is a saving of just $0.8bn.

Direct fossil fuel savings arising from restoring nuclear capacity may deliver import savings in the range $8.5-9bn. However, this may represent a minimum estimate of the import savings. Larger impacts may be evident if there is greater substitution away from increasingly costly and uncertain oil use.

Oil (crude and refined petroleum products) accounts for the largest share of fuel imports and is expected to dominate future growth in fuel imports. US oil imports are to a large extent sourced from the Middle East and other politically volatile economies such as Venezuela and Nigeria, and increased US dependence on this region could raise political issues, including the risk of supply volumes or prices being subject to greater uncertainty. Imports of oil and oil products in the baseline forecast are expected to be around 30 quadrillion Btu by 2030 (based on EIA assumptions). Any falls in oil demand below this level are likely to generate a corresponding fall in oil imports while all domestically sourced fuel is used to the maximum possible level.

Investment in nuclear energy may coincide with other complimentary actions which may help to reduce US dependence on oil imports. Within the timeframe being considered a significant number of Plug-In Hybrid Electric Vehicles (PHEVs) are likely to come to market. These would reduce dependence on oil for transportation purposes with greater demand for electricity. Specifically, PHEVs are likely to be plugged in overnight, increasing baseload electricity demand, but not necessarily increasing the required overall generation capacity. Since nuclear generation is a baseload technology, the net result of greater hybrid vehicle use would be a reduction in fossil fuel imports in excess of minimum value of $8.5bn.

To determine a maximum impact, we consider a situation where, reduced generation demand for coal and gas, allows these products to be used elsewhere in the economy as substitutes for oil. Although heating systems and industrial processes cannot easily replace fossil fuels within the same equipment, over the timescale under consideration it is possible that decisions will be made by firms, households and the government, to invest in coal or gas burning hardware rather than oil. Expected oil demand for such functions is currently expected to exceed the total 5qn Btu fossil fuel savings in the generation sector. As such oil import savings could be this large as an upper estimate.

Oil imports could therefore be $49bn lower under the nuclear investment program, applying EIA projected oil prices of $59 per barrel in 2030. This represents a significant economic benefit as well as an improvement in energy security.

4.2. Carbon Emissions Benefits

- Carbon savings of 450 MtCO2 compared to baseline forecast by 2030

Based on the fuel savings outlined above, the nuclear investment program will deliver carbon emission reductions of 450 MtCO2. This is roughly equivalent to 11% reduction in generation emissions and over 5% reduction in whole economy emissions relative to the baseline projection.

Table 4-3: Fossil fuel demand and carbon emissions for power generation sector

	2030 power generation fuel demand (Btu qn)		2030 power generation carbon emissions (MtCO2)	
	Baseline	Nuclear Investment	Baseline	Nuclear Investment
Nuclear	4.2	10.1	-	-
Coal	35.2	30.7	3,310	2,890
Gas	5.3	4.8	280	250
Petroleum / oil	0.7	0.6	50	50
Total			3,640	3,190

Above calculations are also based upon EIA projections of fossil fuel use and carbon emissions. Specifically we have used the carbon intensity ratios implied for each fuel type for electricity and non-electricity use.

4.3. Carbon Savings by State

Carbon savings have also been estimated by state according to the assumed amount of nuclear investment and the generation fuel mix which it is likely to replace.

- The greatest carbon savings are expected to come in Illinois since it is assumed that more reactors will be constructed there than in any other state by 2030.
- Carbon impacts in South Carolina and Texas are the same despite the assumption of more reactor build in Texas. This is because non-nuclear generation, which is assumed to be offset by the new nuclear capacity, is more carbon–intense in South Carolina. Coal comprises a larger proportion of the current and expected non-nuclear generation fuel mix.
- Emissions savings are particularly low in Idaho because of the low reliance on fossil fuels for generation. It is assumed that the bulk of new generation is met by fossil fuels. The current fuel mix is heavily reliant on hydro-generation but it is assumed that no new hydro plants are constructed for environmental reasons. But proposed nuclear construction in this state (as well as some other states such as Washington) would account for more than the new fossil fuel capacity and some existing hydro capacity would be offset.

Table 4-4: Estimated carbon saving by state by 2030

	Total assumed new reactors	**Estimated Carbon Saving (MtCO2)**	Coal share of non-nuclear generation	Gas share of non-nuclear generation
Illinois	**7**	**66**	**96%**	**3%**
South Carolina	**5**	**45**	**81%**	**8%**
Texas	**6**	**45**	**58%**	**34%**
Florida	**4**	**31**	**56%**	**27%**
North Carolina	**3**	**28**	**90%**	**2%**
Maryland	**3**	**28**	**88%**	**3%**
Arizona	**3**	**26**	**80%**	**16%**
Tennessee	**2**	**19**	**91%**	**1%**
Ohio	**2**	**19**	**97%**	**2%**
Pennsylvania	**2**	**18**	**88%**	**7%**
Georgia	**2**	**18**	**83%**	**7%**
Alabama	**2**	**18**	**76%**	**11%**
New York	**2**	**16**	**53%**	**22%**
Louisiana	**2**	**14**	**50%**	**39%**
Missouri	**1**	**9**	**96%**	**3%**
Iowa	**1**	**9**	**82%**	**4%**
Virginia	**1**	**9**	**75%**	**7%**
Washington	**1**	**9**	**34%**	**5%**
Michigan	**1**	**9**	**82%**	**12%**
Mississippi	**1**	**8**	**62%**	**30%**
Idaho	**1**	**7**	**28%**	**5%**
	52	**450**		

5. Methodology and Assumptions - Investment Phase

5.1. Updated assumptions from previous analysis

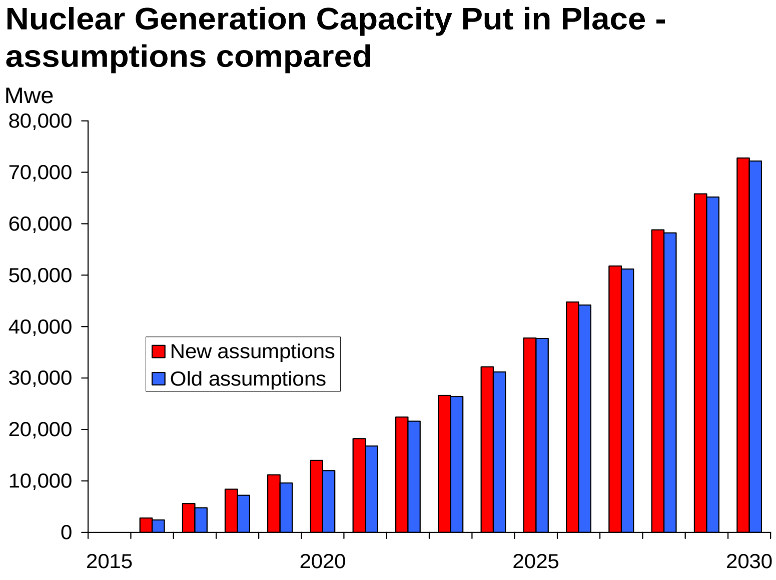
This study updates previous estimates of the benefit of nuclear investment which was undertaken in 2007. Since the previous study, changes in some key assumptions have been made, primarily to reflect changes in the likely costs and construction timetable. These are detailed below.

- Capital costs per unit of installed capacity are significantly higher than in the previous study at $3,500/KWe rather than $2,000/KWe. This is partly due to rising and higher than previously expected future raw materials costs.

- Capital costs are also higher due to rising labor costs for the required skills due to increased competition in this area.

- Assumed light-water reactors are assumed to have capacity of 1,400 MWe rather than 1,200 MWe in previous assumptions. This better reflects the capacity of current planned reactors. Previous assumptions also envisioned construction of a number of Generation IV and Fast Spectrum reactors. While some of these reactors may be commercially available and in operation by 2030, it appear to be too optimistic to include a significant number of these in an investment program and only light-water reactors are assumed.

Chart 5-1: Assumed timetable of new investment



- In order to maintain roughly the same new nuclear capacity, fewer reactors are assumed to be constructed for the larger reactor size. 52 reactors are assumed to be built with a total new capacity of 72,800 MWe.

- One new recycling plant with a capacity of 2,500 tons of used fuel per year is assumed to be built giving less capacity than in the previous assumptions, better reflecting possible construction.

- Four new enrichment plants are assumed to be built in line with current plans.

- Estimates also take into account updated information on the structure of industries and the supply chain from more recent input-output tables. This also includes higher productivity and wage information for key industries.

Employment impacts are estimated according to similar assumptions as before, detailed below, while value-added impacts are estimated by using the same methodology.

Reactor capital costs

Overnight capital costs for reactors are now assumed to be $3,500/KWe compared to previous estimates of $2,000/KWe which were consistent with reported cost estimates at the time. In checking this assumption new nuclear construction activity has been researched in similar overseas markets. This also been compared with domestic costs for new construction for other types of generation.

New reactor construction (of similar designs to those considered in this study) is underway in France, Finland, Japan and Bulgaria, at an average capital cost of around $2,500, more in line with previous assumptions. However, these costs were agreed in advance and do not necessarily reflect costs that would be faced by projects not yet underway. Indeed, the project in Finland is facing cost overruns and it is estimated that final costs will be closer to $3,000 / KWe.

Of course, construction costs in other markets do not fully reflect costs in the US, but suggest that the previous costs estimate of $2,000 / KWe is too low.

Within the US, the Watts Bar -2 Reactor in Tennessee was mothballed in 1985 when it was two-thirds complete. This has been approved for completion by Bechtel by 2012 at a cost of $2,100 / KWe. It is likely that construction of a new plant would incur greater costs than this, also suggesting that previous capital cost assumptions were too low. (Note: this plant is not included in this analysis since it is considered to be part of current capacity for the purpose of this study.)

As a further example of current Bechtel projects, an advanced coal reactor in Illinois is planned at a capital cost of $1,800 KWe. Recent comparative studies of different generation types by the Energy Information Administration (EIA), estimate that costs for such advanced coal plants lie in the range $1,200 - $1,400 / KWe, compared with a cost of roughly $2,000 / KWe for nuclear. Applying the same cost increase to nuclear implies that capital cost for a nuclear plant would be closer to $3,000 / KWe.

However, with construction costs still on a rising trend the estimate of $3,500 lies within a reasonable range. This cost is also consistent with other nuclear construction costs being reported elsewhere as possibilities, although not linked with any actual projects.

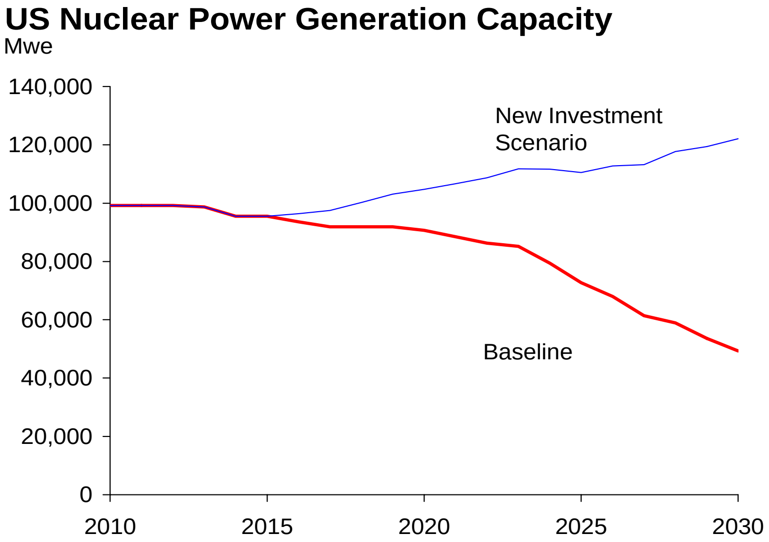
5.2. New Investment Schedule

5.2.1. Reactors

After consultation with the American Council on Global Nuclear Competitiveness, we have made the starting assumption that without the proposed new program of investment in Nuclear Energy, the generation capacity from nuclear will decrease as the current plants are decommissioned. Of the 104 nuclear reactors currently active in the US, 48 have received license extensions while a further 18 have filed for an extension. It is assumed that these plants run for 60 years from the date which operations began. The remaining plants are assumed to operate for the originally planned 40 years.

This is admittedly a very conservative set of assumptions and many of the plants that have not yet announced plans to apply for license extensions will likely do so in the future. In fact 80 year operating lives may be achievable for many currently operating plants. This would have some clear impacts on the expected mix of fuels used for generation and associated emissions; however the relative economic impacts of the new investment would not be affected. Plant closures would still be expected to begin in 2013, and while closures may be slower in coming, nuclear generation capacity would still eventually fall to zero without the assumed investment program.

Chart 5-2: Timetable of new investment



Source : American Council on Global Nuclear Competitiveness

The new investment program considers a scenario where 52 new light-water reactors are to be constructed to come on-line by 2030, restoring 72,800 Megawatts electric (MWe) of capacity, at a cumulative capital investment cost of $255bn (in constant 2008 prices). Assumptions regarding the timescale of this investment program, reactor capacity and associated costs were also developed in conjunction with the American Council on Global Nuclear Competitiveness.

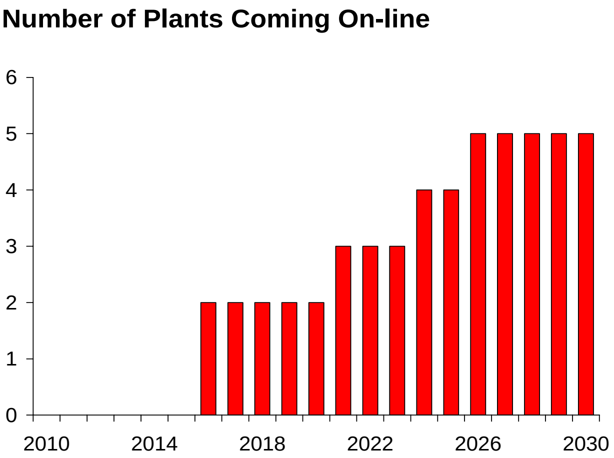
The assumed investment cost of $3,500/KWe is consistent with rising construction costs on similar current projects (see above) but is also consistent with assumptions being applied in other recent studies[2].

Table 5-1: Reactors under investment program

Facility	Number of plants	Cost - $/KWe	Cost - total	Capacity per reactor	Total capacity
Light-water Reactor	52	3,500	$255 bn	1,400 MWe	72,800 MWe

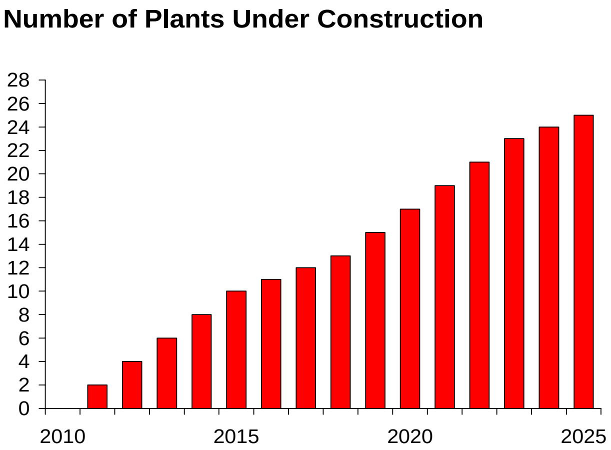
The first of the new plants is assumed to come on-line in 2016, and with plant construction over a five-year period, activity would begin in 2011. Two reactors are assumed to begin active operations each year from 2016 to 2020, gradually rising to five reactors each year after 2025.

Chart 5-3: Schedule of reactors becoming active



Source : American Council on Global Nuclear Competitiveness

Chart 5-4: Schedule of work in progress



Source : American Council on Global Nuclear Competitiveness, DoE

5.2.2. Recycling and Enrichment plants

Under the proposed new investment plan it is assumed that one large recycling facility is built in South Carolina with a capacity of 2,500 tons of used fuel per year, compared with an assumption of none being built without the investment program. As with the reactors, we have assumed a five year construction period, beginning in 2015, with full capacity on-line in 2020. Details of the plant investment are assumed

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[2] The New Economics of Nuclear Power – World Nuclear Association

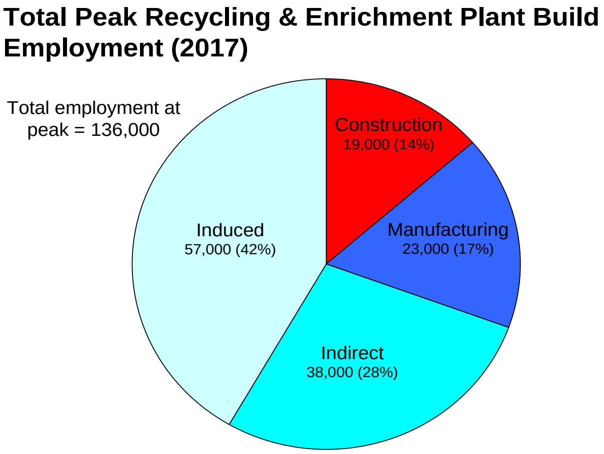
to be consistent with assumptions in a report prepared by the Boston Consulting Group for AREVA[3]. This study considers the construction of one facility of similar size within the same timeframe. The report's investment cost of $16.2bn is increased in line with recent reactor cost increases and a total capital cost of $11.3bn is assumed.

Regarding the construction process of this plant it has been assumed that employment in construction and manufacturing per dollar of investment is the same as for reactors, following the same five year phased profile.

This part of the investment program is expected to deliver, at peak, over 35,000 direct jobs in both construction and manufacturing, involving roughly 20,000 in highly skilled manufacturing jobs. These manufacturing jobs are estimated to generate value-added of $3.1 bn, a significant contribution to the total estimated direct value-added impact of $4.2.

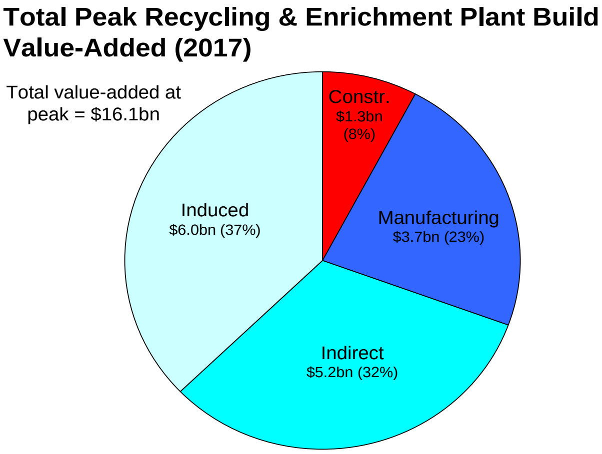
The same indirect and induced multipliers as were calculated for the reactor investment program can be applied to estimate wider economic effects.

Chart 5-5: Recycling plant employment



Source : Oxford Economics

Chart 5-6: Recycling plant value-added



Source : Oxford Economics

In addition to the recycling plant, it is also assumed that four enrichment facilities are also constructed within the timeframe. These facilities are all currently at different stages of planning and the location of the facilities in Idaho and North Carolina have only recently been announced. These are expected to be fully completed by 2020 in line with the reported schedule of construction, and coinciding with the construction of the assumed recycling plant. Work is already underway at the facilities planned for Ohio and New Mexico and these plants are expected to be put into operation in the next five years.

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[3] Economic Assessment of Used Nuclear Fuel Management in the United States – The Boston Consulting Group. Prepared for AREVA.

As with the recycling plant, it is assumed that employment in construction and manufacturing per dollar of investment is the same as for reactors, following the same five year phased profile.

Construction of these facilities is expected to generate a further 6,000 direct jobs in construction and manufacturing and an additional $2.1bn in value-added, skewed towards the manufacturing inputs consistent with assumptions for other investment.

Further employment will be generated by ongoing operations at these facilities, with the number of jobs being reported by each plant's operations varying in line with expected capacity. We assume that for each plant operations 125 jobs are created for each million separative work units (SWUs).

Table 5-2: Enrichment facilities under investment program

Location	Cost - total	Cost - $/SWU	Capacity (SWU mn)	Reported operations employment	Employment / SWU mn
Ohio	$3.5 bn	$921	3.8	500	132
New Mexico	$1.5 bn	$500	3.0	350	117
Idaho	$2.0 bn	$667	3.0	375	125
North Carolina	$3.0 bn	$667	4.5	-	-
Total	**$10.0 bn**	**$700**	**14.3**	**-**	**125**

5.3. Direct Construction Employment

Labor demand is phased over the five-year construction period, reaching a peak in the third year. The assumed level of employment demand is based upon estimates published by the Department of Energy[4]. Specifically, these reports detail the direct craft labor requirements as well as other direct on-site labor demand for comparable Generation III+ reactors. The number of jobs created in constructing different plants is not deemed to vary according to plant size according to the reports. Specifically, employment is the same for construction of 1,200MWe plants as it is for 1,500MWe plants. It is appropriate for us to apply the same assumptions for the 1,400MWe plants being considered in this study.

Labor demand for each of the five years of the construction period can also be gained from these reports, and the extent to which employment ramps up during the construction process. Average employment over the five year construction period for a reactor is lower than the peak employment. Since we are assuming that construction will begin on a number of new reactors each year the phased profile implies that total labor demand for all plants is less than just the sum of peak labor demand for each plant. By only beginning the construction of relatively few new plants each year, there is less of a strain on domestic labor demand for highly skilled jobs. This allows for training to take place, and the reports

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[4] DOE NP2010 Nuclear Power Plant Construction Infrastructure Assessment – Department of Energy
US Job Creation Due to Nuclear Power Resurgence in the United States –Bechtel Power Corporation & Idaho National Engineering Laboratory. Prepared for the Department of Energy

confirm that it is likely that such labor requirements can be met by the domestic pool of labor.

The two reports imply a similar phased profile over a five-year construction period, although the peak level of labor required for the construction of light-water reactors is reported as 2,300 or 2,400. We take the average value of 2,350 as our assumption here.

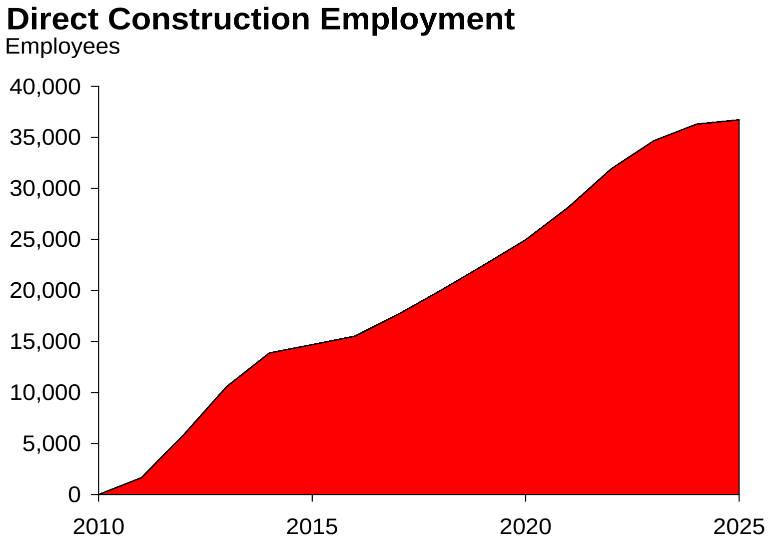
Table 5-3: Phased demand for construction employment

Year 1	Year 2	Year 3	Year 4	Year 5	Average
823	2,115	2,350	1,645	411	1,469

Applying published labor productivity rates for the construction sector over the five-year period for a light-water reactor implies that this employment will cost around $700mn in gross output. This is significantly below the assumed $4.9bn investment cost of each reactor, implying that either construction labor demand is too low or that there are further elements of direct reactor construction than direct construction effects. It is believed that construction labor costs for nuclear projects are higher than for conventional power plant construction accounting for some of the difference, while the NRC licensing process is also believed to make a significant contribution to project costs.

The cost of specific required manufactured components for the new reactors must also be considered, which are believed to account for a large proportion of the investment costs. Manufacturing costs, and associated employment, is calculated in the next section consistent with other studies and delivering output costs similar to the assumed investment costs.

Chart 5-7: Direct construction employment effects



Source : DoE, Bechtel, ACGNC, Oxford Economics

Direct employment in construction is estimated to rise steadily from 2010 to 2025, to reach almost 37,000 workers under the new investment program. This has been estimated by combining the employment profile for each reactor (consistent with the Bechtel and DoE reports) with the assumptions on the schedule of plant construction (developed with the American Council on Global Nuclear Competitiveness).

By applying the same employment assumptions to the investment program for the recycling and enrichment plants, as described previously, shows that a further 19,000 direct construction jobs will be generated before 2020.

5.4. Direct Manufacturing Employment

Arguably the most significant economic benefit of the new investment program will be from increased demand for specific manufactured goods and the highly skilled employment required for their production, consistent with assumptions used for other studies. Repatriating these positions to the US would contribute to an improvement in US manufacturing competitiveness, especially compared with requirements for other types of generation such as coal power reactors.

Labor demand in manufacturing sectors supplying the necessary components is essentially an indirect impact of the investment program (being used as inputs into construction), but it is treated separately here since effects are likely to be so significant. Effects are even larger relative to other direct effects when productivity is taken into account and treating these jobs as conventional indirect impacts is likely to underestimate the true effects.

According to Input-Output tables the manufacturing sector will indirectly benefit from construction sector activity, but effects are significantly smaller than would be realistically expected (and smaller than have been observed in past construction programs) for nuclear reactor construction, due to the large amount of complex components required. In order to avoid any double-counting in estimation of indirect construction benefits (see below for more detail) we have removed the activity in the detailed manufacturing sectors suggested by Input-Output tables.

Estimates of direct manufacturing demand have been gained from the report by Bechtel on behalf of the Department of Energy[5] as for the direct construction effects. This report implies that manufacturing demand follows a similar phased profile to construction employment over roughly a five year period. Manufacturing labor demand has a slight lead time on construction employment: work on manufactured products is required before they can be applied for construction. This is important in avoiding double-counting and also helps in accurately determining the high productivity rates for the goods. This is also useful in accurately determining the state level impacts.

The Bechtel report also implies that, at peak, and as an average over the entire build period,

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[5] US Job Creation Due to Nuclear Power Resurgence in the United States –Bechtel Power Corporation & Idaho National Engineering Laboratory. Prepared for the Department of Energy

manufacturing employment is greater than employment in construction. Whilst construction employment per reactor is the same regardless of capacity, manufacturing employment differs with size.

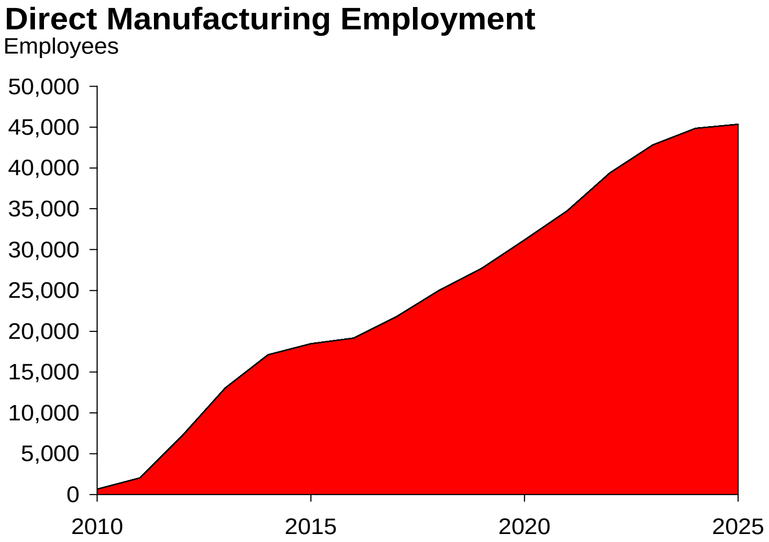
Specifically the Bechtel report estimates the employment demand for a series of 1,200MWe and 1,500MWe reactors. It is estimated that the number of manufacturing jobs created at peak and on average over the build period moves in proportion with the reactor capacity and we are able to estimate job creation for the assumed 1,400MWe plant in this study. As such we make the following assumptions about phased demand for employment in manufacturing.

Table 5-4: Phased demand for manufacturing employment

Reactor size	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
1,200MWe	293	587	2,262	2,514	1,760	440
1,500MWe	363	726	2,799	3,110	2,177	544
1,400MWe	**339**	**677**	**2,613**	**2,903**	**2,032**	**508**

Combining these assumptions with the assumed timetable for new plant investment implies that employment in manufacturing will rise steadily from 2010 to over 45,000 workers by 2025. On this simple basis, direct manufacturing effects of the new investment program are more important than the direct construction impacts. This becomes even clearer when relative productivity and wages are taken into consideration.

Chart 5-8: Direct manufacturing employment effects



Source : DoE, Bechtel, ACGNC, Oxford Economics

A further 23,000 direct manufacturing jobs are also estimated to be generated by the recycling and enrichment plants by 2020, by applying consistent assumptions.

5.5. Direct Value-Added Benefits

The levels of manufacturing employment detailed above are in high value-added processes, requiring highly skilled and highly paid workers. The economic effects of higher employment in manufacturing processes than in direct construction are magnified when value-added is considered.

Direct value-added is calculated as employment multiplied by labor productivity estimates for each sector. Productivity rates are shown in table 5-5, with our final estimates of value-added per worker displayed in the final column. This has to be calculated in this way since the requirements for nuclear construction do not accurately match data for any regularly published sectors.

Capital costs for generation construction, especially nuclear reactors, have risen significantly in recent years reflecting higher raw material costs as well as greater competition for the required skilled labor. These effects are not fully measured in the recent input-output table data sued as the basis for this study and amendments are required.

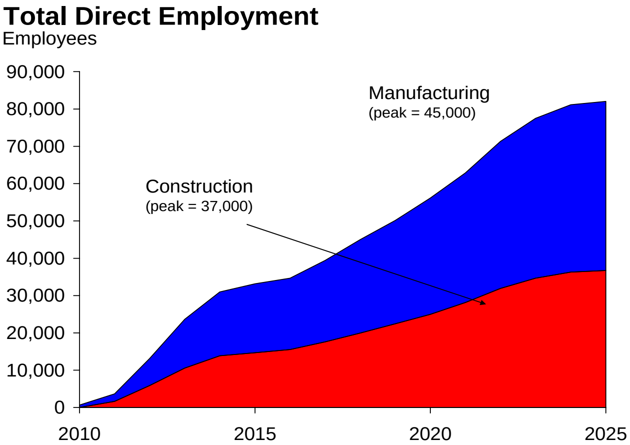
In table 5-5 raw productivity figures have been taken from Input-Output tables for both gross output per worker and value-added per worker and are shown in columns B and E. Construction sector data is taken from the sector “manufacturing and industrial buildings construction”. Manufacturing productivity is calculated as the weighted average of productivity for the detailed processes, with weights based upon assumptions taken from the Bechtel report.

Column A shows the total number of employee years required for the building of a light-water reactor. Multiplying average employment by gross output per worker gives total gross output (column C) for the entire build period: an estimated total of around $3.3bn in gross output, compared with an assumed investment cost of $4.9bn. This implies that the recent input-output table data does not measure productivity in nuclear generation construction due to the mis-match between sectors and the recent rises in cost estimates. Scaling ensures that assumptions are fully consistent.

Table 5-5: Employment productivity assumptions per reactor

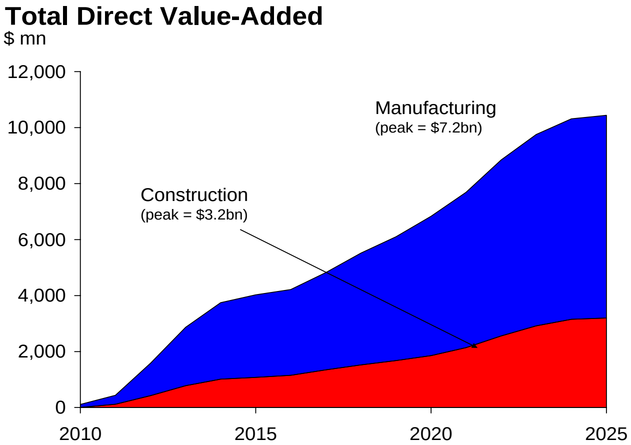
	Employment	Gross output			Value-added		
Source:	Employee years	I-O table: average per worker	Estimated total	Scaled: average per worker	I-O table: average per worker	GVA – gross output ratio	Scaled: average per worker
Calculation	*A*	*B*	*C=A*B*	*D=B * $4.9bn / $3.3bn*	*E*	*F=E/B*	*G=F*D*
Construction	7,344	$94,760	$696 mn	$139,443	$53,267	0.56	$78,385
Manufacturing	9,071	$290,362	$2,634 mn	$427,279	$108,514	0.37	$159,683
Total	16,415	$202,853	$3,330 mn	$298,507	$82,242	0.41	$116,699

Chart 5-9: Direct employment benefits



Source : DoE, Bechtel, ACGNC, Oxford Economics

Chart 5-10: Direct value-added benefits



Source : DoE, Bechtel, ACGNC, Oxford Economics

Overall, we estimate that for each worker in direct construction and manufacturing, value-added of $117,000 is generated. For the 82,000 direct jobs which are estimated to be generated by the program by 2025, value-added of around $10.4bn would be created.

Manufacturing productivity is significantly higher than for construction, with final value-added per worker estimated at around $160,000 and $78,000 respectively (column G of table 5-5), reflecting the greater skills involved. Manufacturing value-added at peak is estimated to be almost twice as large as that from the construction sector: $7.2bn relative to $3.2bn.

However, it should be noted that not all of this value-added difference represents wage differentials. There is a significant difference between value-added per employee and average wages. We estimate that average manufacturing wages are roughly $94,000 compared with construction wages of $75,000. The relative economic impact is still higher for manufacturing than construction on this basis, but it is less extreme than when looking at value-added.

5.6. Indirect Benefits

Even though we are defining some supply-chain effects directly as the manufacturing stage of production, further indirect effects will be generated by the investment process. Input-Output tables have been used to define other products used as inputs to both construction and manufacturing, and the associated employment and value-added. Multipliers for employment have been calculated for each sector representing employment (or value-added) generated elsewhere in the economy by one direct job (or one dollar of value added) in construction or manufacturing.

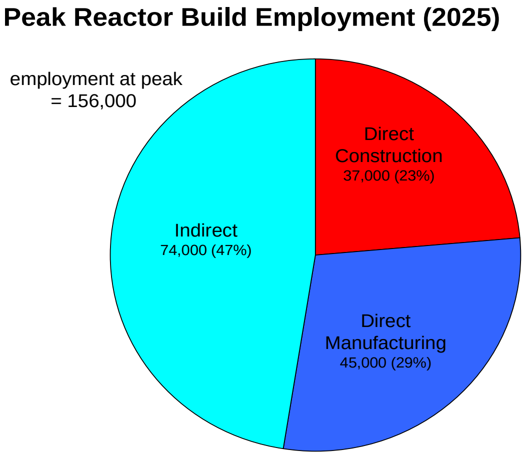
For the construction sector, we need to ensure that there is no double counting of manufacturing effects. We have adjusted the indirect effects to remove any indirect effects shown in the Input-Output tables for the manufacturing sectors already identified.

Table 5-6: Indirect multipliers

	Weight	Productivity		Indirect multiplier	
		Gross Output	**Value-added**	**Employment**	**Value-added**
Construction	-	$139,443	$78,385	0.37	0.58
Construction – adjusted	**-**	**$139,443**	**$78,385**	**0.33**	**0.53**
Manufacturing	**1.00**	**$427,279**	**$159,683**	**1.37**	**1.23**

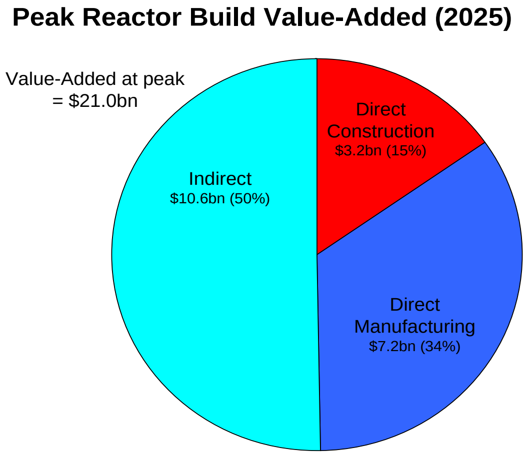
Table 5-6 also confirms that by applying just the indirect effects on manufacturing implied by Input-Output tables would underestimate the likely impacts. While it is believed that manufacturing employment would be slightly larger than construction employment (and value-added is almost twice as large) as a direct consequence of new nuclear construction, Input-Output tables suggest that the effects in the wider economy would be equivalent to just one-quarter of the size of construction activity. Within that manufacturing employment would be equivalent to just 4% of construction employment. Such low multipliers are sensible when considering the construction impacts on raw materials, basic goods and services, but underestimate requirements for specific manufactured components and the associated economic activity, validating our approach in section 4.3.

Chart 5-11: Direct and indirect employment



Source : Oxford Economics

Chart 5-12: Direct and indirect value-added



Source : Oxford Economics

For the manufacturing sector, indirect effects have been estimated using a weighted average of detailed sectors, consistent with the Bechtel report and with the value-added calculation described above.

Indirect effects are significantly larger for manufacturing due to the higher gross output relative to value-added ratio as greater purchases of raw materials and intermediate goods are required to produce the more complicated products. This is especially noticeable within the detailed manufacturing sub-sectors, with higher gross output per worker and multipliers for products with more detailed production processes, such as generators and turbines.

It should also be noted that employment and value-added multipliers differ according to the relative productivity of the supply-chain. Generators and turbines has the highest indirect employment effect, yet has a much lower value-added indirect multiplier, more in line with the manufacturing average. Output per worker is particularly high for activity in this sector, and goods purchased are generated with greater labor intensity. Job-for-job, indirect effects are large even if value-added effects are closer to the average. This effect is reversed for other sectors, and notably for indirect construction effects, due to the relatively low productivity in this sector.

Indirect effects are more significant for value-added than for employment, primarily due to the greater weight of manufacturing in direct effects. Indirect multipliers for manufacturing are roughly the same for employment and value-added, but are much larger than for construction due to the extra purchases required. Value-added is much larger for manufacturing than construction, while employment is more balanced across the two phases so the higher manufacturing multipliers have more of an overall effect.

5.7. Induced Benefits

Further large benefits for the economy can be derived by examining the wider economic benefits from the high earnings and spending of the employees already calculated, both directly and indirectly. These impacts are estimated to be large due to the high value-added nature of many of the inputs and associated high wage direct and indirect jobs. These effects just measure impacts within the US, with purchases of imported goods netted out.

Construction multipliers have been adjusted again to avoid any double counting of manufacturing effects. In this case, we have netted out any induced effects from the indirect output and employment in the specific manufacturing sectors according to Input-Output tables. As with the indirect effects it is notable that the wider value-added impacts are larger than estimated employment impacts due to the relatively low productivity in construction. This is also true for the total economic effects, defined as direct plus indirect plus induced effects, as employment is estimated to be around 2.2 times larger than the direct effects, while the value-added multiplier is estimated to be around 2.6.

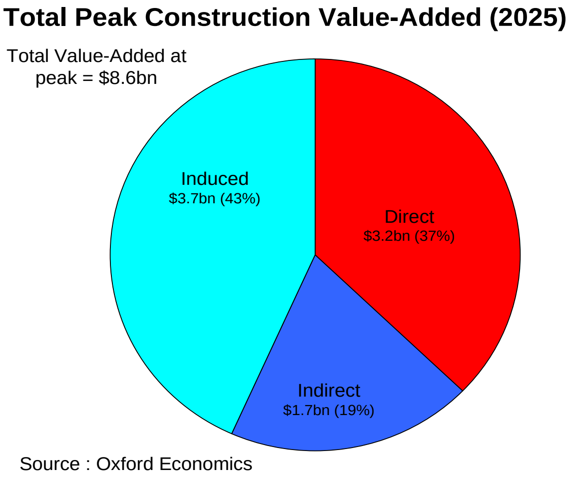
Overall, the differences between the induced employment and value-added impacts for construction offset those for manufacturing and induced multipliers for employment and value-added are similar. For each employee directly involved in the construction and manufacturing for the new nuclear plants, we estimate that around 1.4 additional jobs will be generated from induced spending. And for each employee directly and indirectly employed, spending generates an additional 0.8 jobs.

Table 5-7: Induced multipliers

	Induced multiplier			**Total multiplier**	
	Employment	**Value-added**		**Employment**	**Value-added**
Construction (adjusted)	0.84	1.17		2.17	2.70
Manufacturing	1.79	1.23		4.15	3.45
Total direct activity	1.36	1.20		3.27	3.11

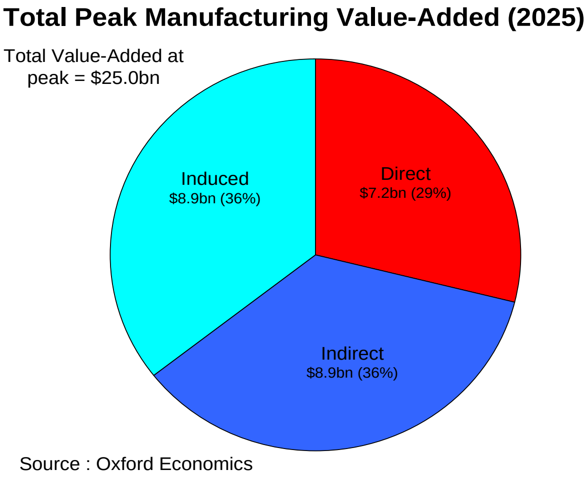
Including both indirect and induced effects, the total economic effects of investment in new nuclear capacity are estimated to be over 3 times larger than the direct effects.

Chart 5-13: Total construction value-added



Source : Oxford Economics

Chart 5-14: Total manufacturing value-added



Source : Oxford Economics

6. Methodology and Assumptions - Operations Phase

6.1. Direct Employment Benefits

6.1.1. Recycling & Enrichment Plants

Ongoing operation of the proposed reactors is expected to generate a total of roughly 47,000 new skilled jobs by 2027. With all plants under the proposed program assumed to be operational by 2030, this is consistent with an assumption that required staff are recruited three years prior to capacity coming on-line.

It is assumed that each reactor requires the creation of 900 new skilled jobs, consistent with the study by Bechtel[6] which describes three scenarios for employment in nuclear reactor operations. In addition to this, an equation has been estimated to determine ongoing employment in a reactor relative to capacity. The estimated relationship implies that there is a linear relationship between and increases in capacity and employment, in addition to a minimum number of staff. Larger plants require fewer employees per MWe than smaller employees. However the ratio is relatively stable for the range of plant sizes under consideration.

Table 6-1: Operations direct employment

	Number of reactors	Reactor capacity	Total employment	Employment per reactor	Employment per 100MWe
Bechtel Scenario 1	56	1,200 MWe	44,000	780	65
Bechtel Scenario 2	45	1,500 MWe	44,000	980	65
Bechtel Scenario 3	58	1,150 MWe	45,600	790	69
OE/ANCC scenario	**52**	**1,400 MWe**	**47,000**	**900**	**65**

6.1.2. Recycling & Enrichment Plants

The economic impacts of the regular operations for the recycling plant are based upon assumptions taken from the same Boston Consulting Group report[7] as the investment phase assumptions. It is reported that a 2,500 ton capacity facility similar to the assumed construction would support around 5,000 skilled jobs.

For the Enrichment plants it has been assumed that employment is proportional to capacity, according to reports of potential job impacts. These are detailed in table 5-1 in the previous section. Specifically it is estimated that 125 jobs are created for each million separative work units (SWUs). Total capacity of 14.3

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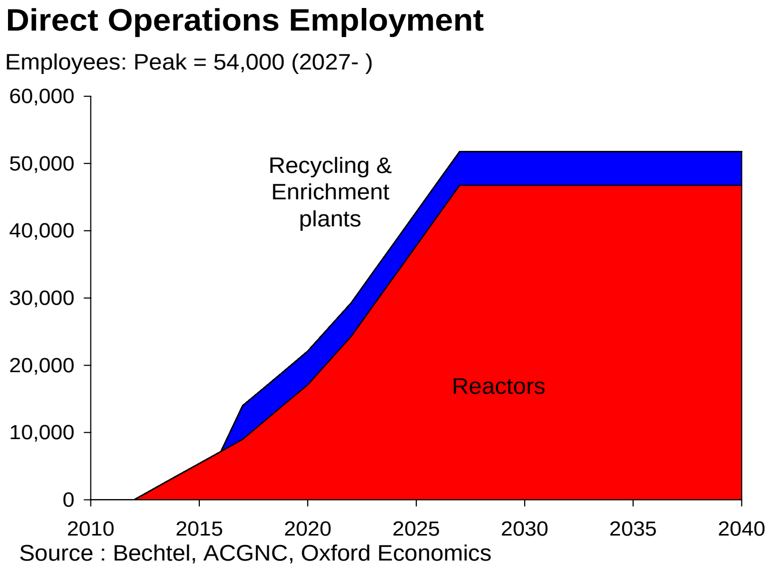
[6] US Job Creation Due to Nuclear Power Resurgence in the United States –Bechtel Power Corporation & Idaho National Engineering Laboratory. Prepared for the Department of Energy

[7] Economic Assessment of Used Nuclear Fuel Management in the United States – The Boston Consulting Group. Prepared for AREVA.

SWUs is anticipated, generating almost 1,800 new jobs ion the four locations.

As with the reactors, it is assumed that workers are in place in the new facilities three years before plants become fully operational to enable full training to occur.

Chart 6-1: Direct operations employment



Source : Bechtel, ACGNC, Oxford Economics

6.2. Direct Value-Added Benefits

Direct value-added is calculated as with value-added for the investment phase by applying an appropriate productivity rate to the above estimated direct employment impacts. However, specific productivity or value-added data for nuclear power generation, or recycling are not reported.

The productivity rate which is applied here is a key assumption in determining the economic impacts of the operations phase of the new nuclear plants.

6.2.1. Reactors

Value-added per employee in the entire power generation and supply sector is reported to be $529,834 in Input-Output table data which we believe represents a maximum possible productivity rate for nuclear generation. Applying this rate implies that operations of the new reactors would generate almost $25bn. We would expect to see lower value-added impacts than this. Indeed, this is greater than the value-added generated from all direct, indirect and induced impacts generated by the investment phase at its peak.

It is likely that the actual value-added figure for specific nuclear reactor operations is considerably lower than this figure, although we do not dispute the reported productivity data for the power sector as a whole. The reported productivity figure covers all types of generation, the majority of which in the US is from fossil fuel powered stations, which employ less labor than nuclear reactors for a comparable electricity output. Therefore, we would expect to see lower labor productivity for the more labor intensive nuclear operations than for generation as a whole.

A more reliable productivity figure can be determined by adjusting the reported power sector value according to employment in nuclear generation relative to all generation per kilowatt-hour of electricity generated. The Bechtel report on US job creation due to new investment in Nuclear Power for the DOE referenced previously compares nuclear generation with coal for the same electricity output. The nuclear reactors in this scenario require around five times as many employees as the coal generators for the same electricity output. However, wages and value-added are likely to differ since the two types of generation involve very different fuel inputs as intermediate purchase. The World Nuclear Association reports labor costs as a share of generation costs. On this basis, wage costs are four times larger for nuclear than for coal: a more reasonable productivity adjustment.

Table 6-2: Nuclear generation labor productivity calculation

	All generation	Non-nuclear	Nuclear
Share of generation	100%	80%	20%
Relative productivity (fossil fuels = 100)	85	100	25
Labor productivity	$529,834	$624,000	$155,000

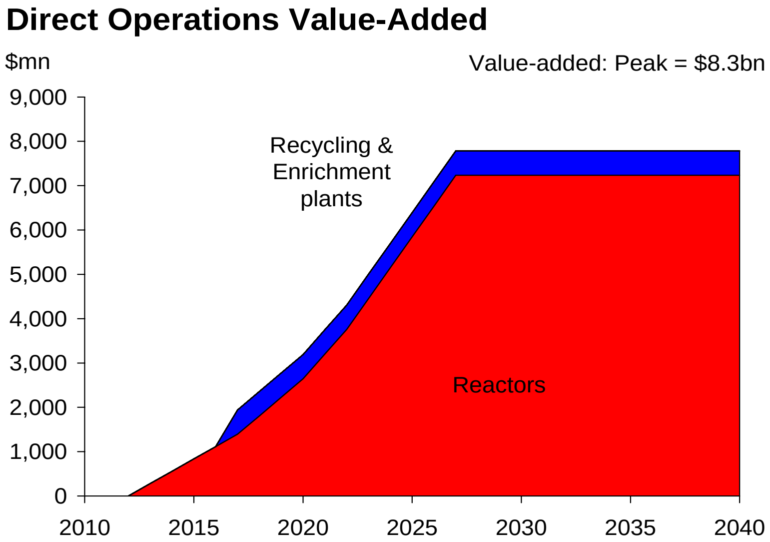
Table 6-2 details the calculation of productivity rates for fossil fuel and non-fossil fuel generation, with the assumption that all non-nuclear generation has the same productivity rate.

Nuclear generation activity is estimated to generate value-added of around $155,000 per employee or around $7.5bn in total by 2027.

We have explored other sources in order to confirm this lower productivity figure. While these do not give exact agreement, they indicate that significant differences are likely between productivity in generation using fossil fuels and nuclear fuels:

Comparing generation productivity across countries shows some large differences, partly related to the mix of fuels used for generation. The OECD STAN database gives comparable data for developed nations at a sectoral level. We have used this source to calculate labor productivity for the utilities sector (covering all electricity generation and supply, plus gas and water supply) relative to total manufacturing productivity for a range of large developed economies. The ratio for the US is the highest, while the UK and Japan, with a similar high share of generation from fossil fuels have similar high relative productivity rates. Relative labor productivity is particularly low in France which has high nuclear generation capacity.

Chart 6-2: Direct operations value-added



Source : Bechtel, ACGNC, Oxford Economics

Operating expenses for nuclear plants relative to fossil fuel plants show that fuel costs are much lower for nuclear reactors, although labor costs are much higher. The US Nuclear Regulatory Commission compare operating expenses for nuclear and fossil fuel plants in its Information Digest and shows that operating expenses are comparable for the two types of generation. Fuel costs represent around two-thirds of the total for fossil fuels, but only around a quarter for nuclear generators, with the rest due to operations and maintenance. Under the simple assumptions that these other operating costs are wholly labor related and that average pay is the same for each reactor, this would imply that nuclear reactors employ over twice as many workers per unit of electricity generated; and that labor productivity for nuclear reactors is lower than for fossil fuels by a similar magnitude. However, by ignoring other ongoing costs these figures are not wholly reliable, but are indicative of large differences.

6.2.2. Recycling & Enrichment Plants

Similar estimates of value-added productivity have been applied to the ongoing operations of the recycling and enrichment plants. This is in line with the methodology applied to the investment phase. We also assume that the following indirect and induced multipliers are consistent across reactors and the recycling facilities.

The difference here is that we know the likely locations for these facilities and apply state specific value-added (subject to similar adjustment). For the recycling plant in South Carolina, each job in ongoing operations is estimated to generate $110,000 in value-added.

The use of this productivity rate is validated by the BCG report which implies that total operating costs are around $180,000 per employee and we would expect gross output to be roughly equal to this. Applying consistent gross output to value-added ratios for the power generation sector from Input-Output tables proves that this is indeed the case.

For the enrichment plants, a weighted average measure of value-added generated per job is $120,000 across the four locations. This varies from a high of $155,000 per job in Idaho to a low of $113,000 in North Carolina.

6.3. Indirect Benefits

6.3.1. Power Sector Multipliers

As a first stage we take indirect multipliers for activity in the power generation and supply sector, but these must be adjusted. Firstly, the multipliers must be adjusted to remove the large purchases of fossil fuels and the wider economic effects of this. Secondly, the employment multipliers must be adjusted to take account of the specific productivity assumptions in the previous section.

Table 6-3: Nuclear generation indirect operations effects

	Indirect operations multiplier	
	Employment	Value-added
Power generation and supply	0.73	0.16
Fossil fuel adjustment	0.59	0.13
Productivity adjustment	0.17	0.13

Input-Output tables indicate that 100 employees in power generation and supply generate over 70 further jobs in the wider economy due to purchases of inputs to generation. However, these jobs are indicated to be much less productive than employment in power generation. Value-added generated relative to that in overall power generation is much lower, with a multiplier of less than 0.2.

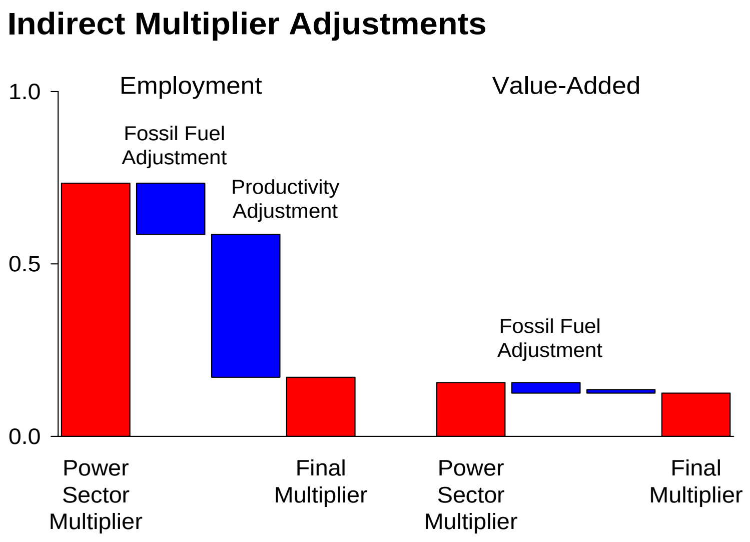
6.3.2. Adjustment for Fossil Fuels

Indirect purchases of fossil fuels, and the economic effects of this, are not valid effects when considering the economic impacts of nuclear generators. The power generation and supply sector included in Input-Output tables describes all generators, including a sizeable majority of fossil fuel generators. Employment and output relating to the supply of these products to the power generation sector have been excluded from the calculation of multipliers.

This adjustment reduces the wider economic effects of operations, compared with applying a multiplier based upon the entire power generation sector. Applying the multiplier after this adjustment would imply that each new job in nuclear generation would create one further job in the wider economy due to the supply chain. However, this is still based upon productivity rates for the entire generation sector, and further adjustment is required.

Adjusted value-added multipliers are likely to give a more accurate reflection of wider economic effects than employment multipliers at this stage. Having adjusted for fossil fuel use, the multipliers give a fair estimate of the value-added generated by non-labor inputs required for day-to-day activity. This is also consistent with our estimates of lower productivity, and a low value of non-labor inputs.

Chart 6-3: Multiplier adjustments



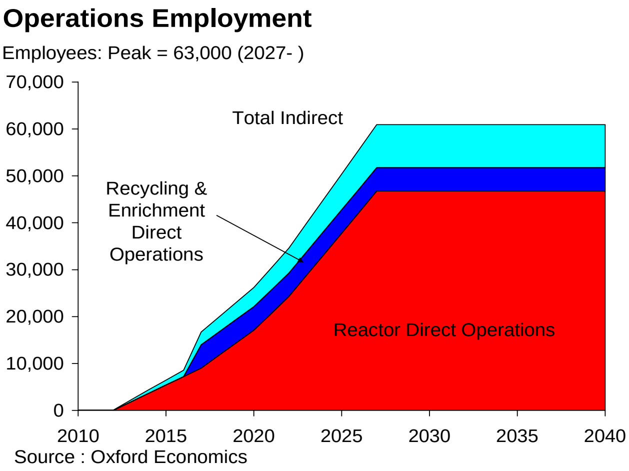
Source : Oxford Economics

6.3.3. Adjustment for Productivity

Employment multipliers need further downward adjustment to reflect the lower productivity in nuclear generation than in fossil fuel generation. Employment multipliers based on Input-Output table data, even after fossil fuel adjustments, imply that a large number of jobs are created elsewhere as a result of high value-added activity by relatively few jobs in generation as a whole.

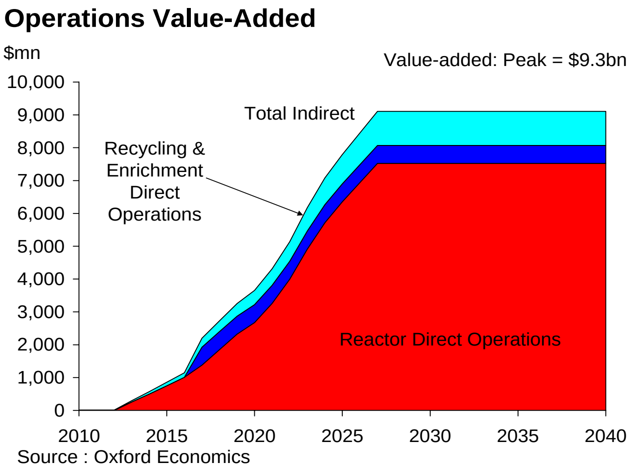
Specifically the multipliers show that almost 60 jobs will be generated through the supply chain for 100 people directly employed in power generation. More specifically, these extra jobs are generated by the input requirements for the output generated by 100 jobs at the productivity rate for generation as a whole. We have estimated that nuclear generation has lower productivity and that the same level of output will require greater employment, around 340 jobs rather than 100. So the indirect employment effect is 60 jobs generated by 340 jobs: a multiplier of less than 0.2.

Chart 6-4: Operations employment



Source : Oxford Economics

Chart 6-5: Operations value-added



Source : Oxford Economics

6.4. Induced Benefits

Induced impacts are also based upon effects shown in Input-Output tables for power generation and supply, but have been adjusted for the same effects as the indirect multipliers. For the raw induced effects from generation as a whole the difference between employment and value-added multipliers are particularly noticeable due to the very highly paid positions consistent with the high value-added figures. Even after adjusting for the induced effects from indirect spending by fossil fuel purchases, the induced employment multiplier of 2.1 is much larger than the value-added multiplier of 0.3.

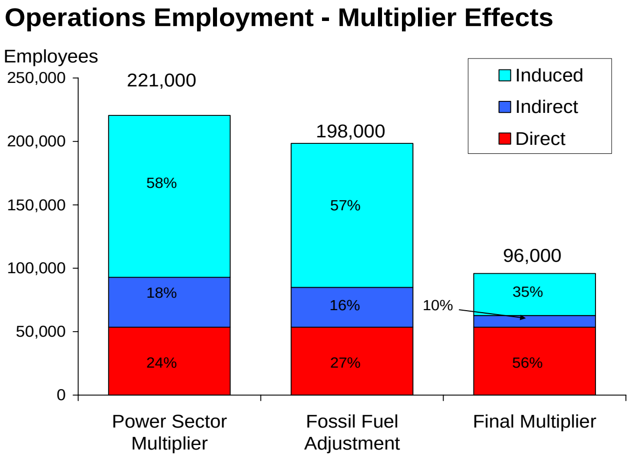
After taking productivity assumptions into account, the wider effects remain significant but are much reduced. These adjustments also imply that the wider impacts of the operations phase are smaller than the wider effects of the investment phase.

Table 6-4: Nuclear generation induced and total operations benefits

	Induced multiplier			Total multiplier	
	Employment	Value-added		Employment	Value-added
Power generation & supply	2.39	0.34		4.12	1.49
Adjusted for fossil fuel purchases	2.12	0.30		3.71	1.42
Adjusted for productivity	0.62	0.30		1.79	1.42

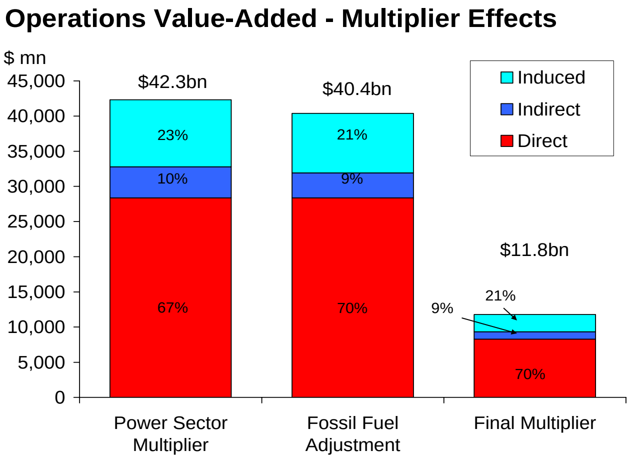
The wider benefits which we estimate are smaller than in some other studies due to the specific productivity assumptions applied here. We use similar source data to other studies and the unadjusted multipliers are comparable. For example, the Bechtel study reports a multiplier of around 5 (direct, indirect and induced jobs relative to just direct jobs), which it states as being consistent with other utilities sectors. However, this does not reference value-added effects and appears to overlook the impact of productivity. Multipliers of similar size are mentioned in the literature for recycling plant operations, validating our use of the same multipliers.

Chart 6-6: Operations employment



Source : Oxford Economics

Chart 6-7: Operations value-added



Source : Oxford Economics

While these results are for the US as a whole, economic impacts at a state or local level may be significantly higher due to the fiscal benefits. We have not made any specific assumption about how any additional tax revenue from this activity is used or distributed.

7. Methodology and Assumptions – State Level Calculation

State level impacts are calculated to be consistent with total US macroeconomic impacts. In the first instance this depends upon where reactors are assumed to be constructed. Direct construction jobs are likely to be within that state, along with a significant proportion of the wider impacts. However, a large proportion of the wider purchases, including the specific manufactured products for nuclear reactor construction are likely to be sourced from other states with a comparative advantage in production of those goods.

7.1. Assumed Locations

Analysis at the state level has been performed in two stages.

1. Initially, impacts have been estimated for the 15 states where 33 reactors are currently being planned. Construction is expected to begin at these locations in 2011 broadly in line with current progress in the planning process for plants. Reactors are assumed to become active in the period 2015-26 according to the assumed five-year construction timescale.

2. In the second phase, construction of a further 19 reactors is assumed to begin in 2022, with all reactors beginning operations in 2030. The 19 remaining reactors are assumed to be constructed in states according to the timetable of license expiry.

The assumed timetable for reactor construction described in section 5 envisages current active reactors being decommissioned according to current license expiration dates. It is assumed that the further 19 reactors are in states which are due to lose nuclear capacity. The 33 reactors being planned imply an increase in nuclear generation capacity in some states, accounting for any assumed increase in capacity for the US as a whole. The additional 19 reactors therefore involve replacing existing capacity rather than making any specific assumptions regarding increased demand by state.

- The licenses for 44 reactors are currently due to expire by 2030.
- 10 of these will be replaced by the reactors currently in the planning process.
- There is clear political opposition to any new nuclear construction in some states, which rules out the replacement of 11 of the 34 remaining reactors.
- 19 of the 23 reactors are assumed to be replaced – according to the current timetable for license expiration and the ability to renew.

For example, 2 reactors are currently being planned for the state of Georgia. There are also two reactors with licenses due to expire in this state. It is assumed that just the two currently planned reactors are constructed in the first phase.

By contrast, 4 new reactors are planned to be constructed in Florida. It is assumed that these are all built in the first phase. These are more than sufficient to offset the one reactor with a license due to expire before 2030, and a significant increase in nuclear generation capacity is expected.

As a further example, for Illinois there is 1 reactor currently being planned, while 8 reactors are currently due to close by 2030. Only 1 of these reactors has already had its license extended. It is assumed the planned reactor is constructed plus a replacement for the reactor which cannot be extended. It is then assumed that 6 of the other 7 reactors due to close are replaced, to give a total of 7 new reactors constructed by 2030.

Table 7-1: Assumed new reactors by state (number of reactors)

	Currently planned reactors	**Assumed additional reactors**	**Total assumed new reactors**
Alabama	2		2
Arizona		3	3
Florida	4		4
Georgia	2		2
Iowa		1	1
Idaho	1		1
Illinois	1	6	7
Louisiana	1	1	2
Maryland	3		3
Michigan	1		1
Missouri	1		1
Mississippi	1		1
North Carolina	3		3
New York		2	2
Ohio		2	2
Pennsylvania	1	1	2
South Carolina	5		5
Tennessee		2	2
Texas	6		6
Virginia	1		1
Washington		1	1
	33	**19**	**52**

If multiple reactors are assumed to be constructed within a state it is assumed that only 1 is built in the first year of construction, with work starting on up to 2 reactors per year in later years. In many cases, current plans indicate that multiple reactors are to be built on the same site. This is consistent with past construction trends, with construction and operations beginning in consecutive years for multiple reactors on one site. This allows local labor demand to increase gradually allowing sufficient time for recruitment and training, consistent with the assumed timetable for the US as a whole.

For example, five reactors are assumed to be constructed in South Carolina. Specifically, it is assumed that construction begins on the first reactor in 2015, with work beginning on two reactors per year in 2016 and 2017.

In addition to the above reactor construction, South Carolina is assumed to benefit from the construction of a recycling plant. Enrichment facilities are also assumed to be constructed in Ohio, New Mexico, Idaho and North Carolina as described in section 5.

7.2. Employment

The number of new jobs generated in the US as a whole has already been estimated. This section describes how these are allocated to states according to the location of plants and supply industries.

7.2.1. Direct Construction and Operations

The direct construction employment benefit is felt in the state where the reactor is being built, and is likely to largely involve local labor. Some skilled functions may be taken by workers from other states, and such labor may move around the US according to timetable of construction by state. Due to the long build time for a plant, any such workers are expected to be primarily based within the state of reactor construction and the direct economic benefits can be fully attributed to that state. And all jobs are assumed to be met by US workers according to previous assumptions while other studies suggest that the assumed timetable of construction would allow for full recruitment and training of staff from within the US.

Direct employment in the operations phase is estimated to be 100% located within the state where the reactor is based as all jobs would involve workers being physically present on-site.

Clear economic benefits are accrued in states which undertaken new nuclear investment.

7.2.2. Direct Manufacturing

It is assumed that all of the skilled, high value-added manufacturing demands are filled by US supply, consistent with detailed studies of potential labor market capacity, as previously mentioned. Current capacity is unlikely to be sufficient to meet demand, but existing firms are assumed to be able to recruit and train sufficient numbers of skilled workers.

Skill requirements associated with the assumed nuclear investment program would increase steadily over time, allowing gradual accumulation of these skills within the US workforce, rather than requiring imports. By gradually building current industrial capacity it follows that new jobs created would follow the current concentration of such employment as skill clusters are augmented.

Direct manufacturing employment is assumed to be located instates according to the current distribution of employment in the specific manufacturing sectors. These benefits do not necessarily impact on states which will house the new facilities. For example, no new nuclear construction is assumed to occur in California yet significant economic benefits are estimated in that state, dominated by direct manufacturing effects due to the current concentration of required industries. However, Texas and Florida are also expected to experience large gains from direct manufacturing effects in addition to the direct construction and operations effects from significant new investment.

7.2.3. Indirect & Induced

Wider economic effects are not limited to the state where the direct impacts are seen. Direct manufacturing within one state may source inputs from a number of other states and all states are expected to benefit from the new investment program to some extent.

Input-Output data has been compiled for all states individually to determine the extent to which indirect and induced effects remain within that state. The sum of these indirect and induced effects for all states is lower than the estimated effects for the US as a whole. This does not mean that the US total calculation overestimates the impact. Instead it implies that the shortfall is an economic benefit which occurs in states other than those where the direct impact occurs.

For example, we know that 100 new construction jobs would indirectly generate 33 new jobs and a further 84 induced jobs in the wider economy. Input-output table data for Arizona implies that 100 new construction jobs in that state would generate only 16 new indirect and 42 induced jobs within Arizona. The remaining 59 indirect and induced jobs must be generated in other states which supply industry and workers in Arizona.

The concentration of employment in key supply industries is used to allocate these additional job impacts across states.

7.3. Value-Added

Value-added per employee is also derived from input-output tables for each state for construction and manufacturing sectors as well as for supply chain and induced sectors. For operations impacts, productivity for the entire power generation and supply sector are taken for each state and adjusted to estimate specific nuclear power productivity as in the previous section.

These productivity values are applied to the estimated employment impacts for each state for each stage of impact to give a first approximation of value-added by state. These productivity multipliers are scaled to ensure that the total value-added impact across all states sums to the previously estimated US total value-added estimates.

7.4. Carbon Emissions

EIA data on the generation fuel mix is available for all states for the years to 2006. Nuclear generation in both the baseline and in the investment scenario is determined according to the assumptions on decommissioning and new investment as previously described.

The share of all non-nuclear generation types is expected to grow in line with EIA forecasts for the US as a whole in order to meet expected energy demand in each state. For example, the proportion of coal-powered generation for each state is expected to grow in line with the increase in coal as a share of non-nuclear generation according to EIA forecasts for the US. So a state with a greater than average share of generation from gas in the current fuel mix will still have a greater than average share of generation of gas in the forecasts.

For an increase in nuclear generation capacity relative to the baseline the type of generation being offset in each state can be determined. By applying relevant carbon factors to fuel demand by type the total emissions savings by state have been estimated.

8. Concluding Remarks

This study highlights the potential benefits that would accrue to the US economy as a result of an investment program to maintain the generation capacity of the US nuclear energy industry. These benefits break down as follows:

- Direct, indirect and induced employment and value added benefits of the investment phase: up to 270,000 jobs and almost $34 billion of GDP at peak.
- Direct, indirect and induced employment and value added benefits of the operations phase: over 95,000 jobs and roughly $12 billion of GDP at peak
- Savings of up to 400 million tones of CO2 emissions
- Savings of up to $49 billion of fossil fuel imports
- Creation of around 45,000 high-tech, high value added manufacturing jobs that would otherwise be lost

These effects would be distributed across states partly according to the likely location of the new plants, but also due to the concentration of key manufacturing industry. Some of the largest benefits are expected to be found in states such as Texas and Illinois which are expected to invest heavily in new nuclear capacity. However, states such as California will also see significant benefit due to the supply of key manufactured products.

There are other benefits, too, that we do not consider in this study, but which are likely to be important. These are potential areas for further research:

- The R&D and fixed investment that would be associated with the manufacturing jobs above would be very likely to generate substantial spillover benefits, boosting the productivity that could be achieved by other sectors of the US economy.
- The growth in nuclear industry expertise and the associated manufacturing capacity that would flow from the investment program would position the USA to reclaim the lead in the global nuclear energy industry, potentially an important source of comparative advantage and export earnings in the long term.
- The savings in terms of oil and gas consumption could free up that oil and gas for more productive uses in the chemicals and plastics industries.

ANNEX – Results Tables

Table A-1: Peak Employment – Total assumed impact

	Investment Phase	Operations Phase	Combined		Investment Phase	Operations Phase	Combined
Alabama	10,600	2,700	13,300	**Montana**	500	100	600
Alaska	400	0	400	**Nebraska**	1,700	100	1,800
Arizona	13,500	3,900	17,300	**Nevada**	1,600	200	1,800
Arkansas	2,400	200	2,600	**New Hampshire**	1,100	100	1,200
California	19,800	2,300	22,100	**New Jersey**	4,900	600	5,500
Colorado	3,000	300	3,300	**New Mexico**	2,300	600	2,900
Connecticut	2,300	300	2,600	**New York**	17,100	3,700	20,800
Delaware	600	100	700	**North Carolina**	15,900	4,800	20,700
Florida	23,200	6,100	29,300	**North Dakota**	800	100	800
Georgia	12,000	3,200	15,200	**Ohio**	16,800	3,800	20,600
Hawaii	600	100	700	**Oklahoma**	4,500	200	4,800
Idaho	4,200	1,900	6,100	**Oregon**	2,400	300	2,600
Illinois	33,400	10,000	43,400	**Pennsylvania**	17,900	3,600	21,500
Indiana	5,100	500	5,600	**Rhode Island**	600	100	700
Iowa	7,300	1,400	8,700	**South Carolina**	38,400	12,400	50,800
Kansas	2,300	200	2,500	**South Dakota**	800	100	900
Kentucky	2,600	300	2,800	**Tennessee**	12,100	2,700	14,800
Louisiana	10,300	2,700	13,000	**Texas**	36,000	11,100	47,100
Maine	900	100	1,000	**Utah**	2,400	200	2,500
Maryland	12,800	5,200	17,900	**Vermont**	400	0	500
Massachusetts	4,100	500	4,600	**Virginia**	8,500	1,900	10,400
Michigan	9,800	1,900	11,800	**Washington**	7,100	1,600	8,700
Minnesota	4,200	400	4,600	**West Virginia**	1,000	100	1,200
Mississippi	5,000	1,300	6,300	**Wisconsin**	5,300	400	5,800
Missouri	7,400	1,600	9,100	**Wyoming**	400	0	400

Table A-2: Peak Employment – Phase 1: current planned construction

	Investment Phase	Operations Phase	Combined		Investment Phase	Operations Phase	Combined
Alabama	10,500	2,600	13,100	**Montana**	500	0	600
Alaska	400	0	400	**Nebraska**	1,700	100	1,800
Arizona	3,900	200	4,100	**Nevada**	1,600	100	1,700
Arkansas	2,400	100	2,500	**New Hampshire**	1,100	100	1,200
California	19,600	1,500	21,100	**New Jersey**	4,800	400	5,200
Colorado	2,900	200	3,200	**New Mexico**	2,300	600	2,900
Connecticut	2,300	200	2,500	**New York**	10,500	800	11,300
Delaware	600	0	600	**North Carolina**	15,900	4,600	20,400
Florida	23,100	5,700	28,800	**North Dakota**	800	0	800
Georgia	12,000	2,900	14,900	**Ohio**	12,100	1,200	13,300
Hawaii	600	100	700	**Oklahoma**	4,500	100	4,600
Idaho	4,200	1,800	6,100	**Oregon**	2,400	200	2,500
Illinois	14,900	1,900	16,800	**Pennsylvania**	13,100	1,900	15,100
Indiana	5,100	300	5,400	**Rhode Island**	600	0	700
Iowa	3,700	100	3,900	**South Carolina**	38,400	12,300	50,700
Kansas	2,200	100	2,400	**South Dakota**	800	0	900
Kentucky	2,500	200	2,700	**Tennessee**	5,300	300	5,600
Louisiana	6,200	1,400	7,600	**Texas**	33,900	8,900	42,900
Maine	900	100	1,000	**Utah**	2,300	100	2,400
Maryland	12,700	5,000	17,800	**Vermont**	400	0	500
Massachusetts	4,000	300	4,400	**Virginia**	8,400	1,700	10,100
Michigan	9,700	1,700	11,400	**Washington**	3,500	300	3,800
Minnesota	4,100	300	4,400	**West Virginia**	1,000	100	1,100
Mississippi	4,900	1,200	6,200	**Wisconsin**	5,300	300	5,600
Missouri	7,400	1,500	8,900	**Wyoming**	400	0	400

Table A-3: Peak Investment Phase Employment – Total assumed impact

	Construction	Manufacturing	Indirect	Induced		Construction	Manufacturing	Indirect	Induced
Alabama	4,500	1,300	1,800	3,000	**Montana**	0	100	200	300
Alaska	0	0	100	200	**Nebraska**	0	400	500	700
Arizona	6,100	800	2,200	4,300	**Nevada**	0	300	500	800
Arkansas	0	700	700	1,000	**New Hampshire**	0	300	300	500
California	0	3,100	6,900	9,800	**New Jersey**	0	600	1,700	2,500
Colorado	0	500	1,000	1,500	**New Mexico**	800	200	500	800
Connecticut	0	400	800	1,100	**New York**	4,700	1,500	4,200	6,700
Delaware	0	100	200	300	**North Carolina**	6,100	1,800	3,000	5,000
Florida	8,500	1,500	5,000	8,300	**North Dakota**	0	200	200	300
Georgia	4,500	900	2,600	4,000	**Ohio**	4,500	2,600	3,700	6,000
Hawaii	0	0	200	400	**Oklahoma**	0	1,500	1,300	1,800
Idaho	2,400	100	600	1,100	**Oregon**	0	400	800	1,100
Illinois	12,600	3,100	6,100	11,600	**Pennsylvania**	4,500	2,500	4,100	6,800
Indiana	0	1,200	1,600	2,300	**Rhode Island**	0	100	200	300
Iowa	2,400	1,200	1,400	2,400	**South Carolina**	24,100	800	4,300	9,300
Kansas	0	500	700	1,000	**South Dakota**	0	200	300	300
Kentucky	0	500	900	1,200	**Tennessee**	4,500	1,400	2,300	4,000
Louisiana	4,500	900	1,700	3,200	**Texas**	11,400	4,800	7,500	12,300
Maine	0	200	300	400	**Utah**	0	600	700	1,000
Maryland	6,100	400	2,000	4,200	**Vermont**	0	100	100	200
Massachusetts	0	600	1,400	2,100	**Virginia**	2,400	1,100	1,900	3,100
Michigan	2,400	1,300	2,400	3,800	**Washington**	2,400	500	1,600	2,600
Minnesota	0	800	1,400	2,000	**West Virginia**	0	200	300	500
Mississippi	2,400	400	800	1,400	**Wisconsin**	0	1,300	1,700	2,400
Missouri	2,400	900	1,500	2,700	**Wyoming**	0	100	100	200

Table A-4: Peak Investment Phase Employment – Phase 1: current planned construction

	Constr-uction	Manufact-uring	Indirect	Induced		Constr-uction	Manufact-uring	Indirect	Induced
Alabama	4,500	1,300	1,800	3,000	**Montana**	0	100	200	300
Alaska	0	0	100	200	**Nebraska**	0	400	500	700
Arizona	0	800	1,300	1,800	**Nevada**	0	300	500	800
Arkansas	0	700	700	1,000	**New Hampshire**	0	300	300	500
California	0	3,100	6,800	9,700	**New Jersey**	0	600	1,700	2,500
Colorado	0	500	1,000	1,500	**New Mexico**	800	200	500	800
Connecticut	0	400	800	1,100	**New York**	0	1,500	3,600	5,300
Delaware	0	100	200	300	**North Carolina**	6,100	1,800	3,000	4,900
Florida	8,500	1,400	4,900	8,300	**North Dakota**	0	200	200	300
Georgia	4,500	900	2,500	4,000	**Ohio**	2,000	2,600	3,100	4,500
Hawaii	0	0	200	300	**Oklahoma**	0	1,500	1,300	1,700
Idaho	2,400	100	600	1,100	**Oregon**	0	400	800	1,100
Illinois	2,400	3,100	3,900	5,600	**Pennsylvania**	2,400	2,500	3,300	4,900
Indiana	0	1,200	1,600	2,300	**Rhode Island**	0	100	200	300
Iowa	0	1,200	1,100	1,500	**South Carolina**	24,100	800	4,200	9,200
Kansas	0	500	700	1,000	**South Dakota**	0	200	300	300
Kentucky	0	500	900	1,200	**Tennessee**	0	1,400	1,600	2,300
Louisiana	2,400	900	1,100	1,800	**Texas**	11,400	4,700	6,800	10,900
Maine	0	200	300	400	**Utah**	0	600	700	1,000
Maryland	6,100	400	2,000	4,200	**Vermont**	0	100	100	200
Massachusetts	0	600	1,400	2,100	**Virginia**	2,400	1,100	1,900	3,100
Michigan	2,400	1,300	2,400	3,700	**Washington**	0	500	1,200	1,700
Minnesota	0	800	1,400	2,000	**West Virginia**	0	200	300	500
Mississippi	2,400	400	800	1,400	**Wisconsin**	0	1,300	1,700	2,400
Missouri	2,400	900	1,500	2,700	**Wyoming**	0	100	100	200

Table A-5: Peak Value-Added ($mn) – Total assumed impact

	Investment Phase	Operations Phase	Combined		Investment Phase	Operations Phase	Combined
Alabama	1,000	300	1,300	**Montana**	0	0	100
Alaska	0	0	0	**Nebraska**	200	0	200
Arizona	1,400	400	1,800	**Nevada**	200	0	200
Arkansas	300	0	300	**New Hampshire**	100	0	100
California	2,800	200	3,000	**New Jersey**	700	100	800
Colorado	400	0	400	**New Mexico**	200	100	300
Connecticut	400	0	400	**New York**	2,200	500	2,800
Delaware	100	0	100	**North Carolina**	1,000	500	1,500
Florida	3,600	600	4,200	**North Dakota**	100	0	100
Georgia	1,200	400	1,600	**Ohio**	1,700	400	2,100
Hawaii	100	0	100	**Oklahoma**	500	0	600
Idaho	300	200	600	**Oregon**	300	0	300
Illinois	4,100	1,300	5,400	**Pennsylvania**	2,100	500	2,600
Indiana	600	0	600	**Rhode Island**	100	0	100
Iowa	700	100	800	**South Carolina**	3,100	1,200	4,300
Kansas	200	0	300	**South Dakota**	100	0	100
Kentucky	300	0	300	**Tennessee**	1,100	200	1,400
Louisiana	900	300	1,200	**Texas**	4,300	2,100	6,400
Maine	100	0	100	**Utah**	300	0	300
Maryland	1,400	1,000	2,400	**Vermont**	0	0	0
Massachusetts	600	0	600	**Virginia**	1,000	300	1,200
Michigan	1,100	200	1,400	**Washington**	800	200	1,000
Minnesota	500	0	500	**West Virginia**	100	0	100
Mississippi	400	100	500	**Wisconsin**	600	0	700
Missouri	600	100	800	**Wyoming**	0	0	0

Table A-6: Peak Value-Added ($mn) – Phase 1: current planned construction

	Investment Phase	Operations Phase	Combined		Investment Phase	Operations Phase	Combined
Alabama	1,000	300	1,300	**Montana**	0	0	100
Alaska	0	0	0	**Nebraska**	200	0	200
Arizona	500	0	500	**Nevada**	200	0	200
Arkansas	300	0	300	**New Hampshire**	100	0	100
California	2,700	200	2,900	**New Jersey**	700	0	800
Colorado	400	0	400	**New Mexico**	200	100	300
Connecticut	400	0	400	**New York**	1,600	100	1,700
Delaware	100	0	100	**North Carolina**	1,000	500	1,500
Florida	3,600	600	4,200	**North Dakota**	100	0	100
Georgia	1,200	400	1,600	**Ohio**	1,400	100	1,500
Hawaii	100	0	100	**Oklahoma**	500	0	500
Idaho	300	200	600	**Oregon**	300	0	300
Illinois	2,000	200	2,300	**Pennsylvania**	1,600	200	1,800
Indiana	600	0	600	**Rhode Island**	100	0	100
Iowa	400	0	400	**South Carolina**	3,100	1,200	4,300
Kansas	200	0	300	**South Dakota**	100	0	100
Kentucky	300	0	300	**Tennessee**	600	0	700
Louisiana	600	100	700	**Texas**	4,000	1,700	5,700
Maine	100	0	100	**Utah**	300	0	300
Maryland	1,400	1,000	2,400	**Vermont**	0	0	0
Massachusetts	600	0	600	**Virginia**	1,000	200	1,200
Michigan	1,100	200	1,300	**Washington**	400	0	500
Minnesota	500	0	500	**West Virginia**	100	0	100
Mississippi	400	100	500	**Wisconsin**	600	0	600
Missouri	600	100	800	**Wyoming**	0	0	0

Table A-7: Peak Investment Phase Value-Added ($mn) – Total assumed impact

	Construction	Manufacturing	Indirect	Induced		Construction	Manufacturing	Indirect	Induced
Alabama	300	200	200	300	**Montana**	0	0	0	0
Alaska	0	0	0	0	**Nebraska**	0	100	100	100
Arizona	500	100	300	400	**Nevada**	0	0	100	100
Arkansas	0	100	100	100	**New Hampshire**	0	0	0	0
California	0	600	1,100	1,100	**New Jersey**	0	100	300	300
Colorado	0	100	200	100	**New Mexico**	100	0	100	100
Connecticut	0	100	100	100	**New York**	400	300	800	700
Delaware	0	0	0	0	**North Carolina**	400	200	100	400
Florida	700	200	600	2,100	**North Dakota**	0	0	0	0
Georgia	300	100	400	400	**Ohio**	300	500	500	500
Hawaii	0	0	0	0	**Oklahoma**	0	200	200	200
Idaho	100	0	100	100	**Oregon**	0	100	100	100
Illinois	1,200	500	900	1,300	**Pennsylvania**	400	400	600	700
Indiana	0	200	200	200	**Rhode Island**	0	0	0	0
Iowa	200	200	200	200	**South Carolina**	1,600	100	400	900
Kansas	0	100	100	100	**South Dakota**	0	0	0	0
Kentucky	0	100	100	100	**Tennessee**	300	200	300	300
Louisiana	300	100	200	300	**Texas**	900	900	1,100	1,300
Maine	0	0	0	0	**Utah**	0	100	100	100
Maryland	600	100	300	500	**Vermont**	0	0	0	0
Massachusetts	0	100	200	200	**Virginia**	200	200	300	300
Michigan	200	200	300	400	**Washington**	200	100	200	300
Minnesota	0	100	200	200	**West Virginia**	0	0	0	0
Mississippi	100	100	100	100	**Wisconsin**	0	200	200	200
Missouri	200	100	200	200	**Wyoming**	0	0	0	0

Table A-8: Peak Investment Phase Value-Added ($mn) – Phase 1: current planned construction

	Constr-uction	Manufact-uring	Indirect	Induced		Constr-uction	Manufact-uring	Indirect	Induced
Alabama	300	200	200	300	**Montana**	0	0	0	0
Alaska	0	0	0	0	**Nebraska**	0	100	100	100
Arizona	0	100	200	200	**Nevada**	0	0	100	100
Arkansas	0	100	100	100	**New Hampshire**	0	0	0	0
California	0	600	1,100	1,100	**New Jersey**	0	100	300	300
Colorado	0	100	200	100	**New Mexico**	100	0	100	100
Connecticut	0	100	100	100	**New York**	0	300	700	600
Delaware	0	0	0	0	**North Carolina**	400	200	100	400
Florida	700	200	600	2,100	**North Dakota**	0	0	0	0
Georgia	300	100	300	400	**Ohio**	100	500	400	400
Hawaii	0	0	0	0	**Oklahoma**	0	200	200	100
Idaho	100	0	100	100	**Oregon**	0	100	100	100
Illinois	200	500	600	600	**Pennsylvania**	200	400	500	500
Indiana	0	200	200	200	**Rhode Island**	0	0	0	0
Iowa	0	200	100	100	**South Carolina**	1,600	100	400	900
Kansas	0	100	100	100	**South Dakota**	0	0	0	0
Kentucky	0	100	100	100	**Tennessee**	0	200	200	200
Louisiana	200	100	100	100	**Texas**	900	900	1,000	1,200
Maine	0	0	0	0	**Utah**	0	100	100	100
Maryland	600	100	300	500	**Vermont**	0	0	0	0
Massachusetts	0	100	200	200	**Virginia**	200	200	300	300
Michigan	200	200	300	400	**Washington**	0	100	200	200
Minnesota	0	100	200	200	**West Virginia**	0	0	0	0
Mississippi	100	100	100	100	**Wisconsin**	0	200	200	200
Missouri	200	100	200	200	**Wyoming**	0	0	0	0

Table A-9: Cumulative Value-Added ($mn) – Total assumed impact

	Investment Phase	Operations Phase	Combined		Investment Phase	Operations Phase	Combined
Alabama	8,200	4,400	12,600	**Montana**	600	0	700
Alaska	600	100	600	**Nebraska**	2,400	100	2,500
Arizona	9,700	2,200	11,900	**Nevada**	2,500	200	2,700
Arkansas	3,300	100	3,500	**New Hampshire**	1,800	100	1,900
California	36,200	2,400	38,500	**New Jersey**	9,400	600	10,000
Colorado	5,000	200	5,200	**New Mexico**	1,700	900	2,600
Connecticut	4,700	300	4,900	**New York**	23,300	3,200	26,500
Delaware	1,000	100	1,000	**North Carolina**	7,900	5,000	13,000
Florida	36,100	6,400	42,600	**North Dakota**	900	0	1,000
Georgia	10,600	5,500	16,100	**Ohio**	18,400	3,200	21,600
Hawaii	900	100	1,000	**Oklahoma**	7,000	200	7,200
Idaho	2,200	2,900	5,100	**Oregon**	3,500	200	3,800
Illinois	32,400	8,900	41,200	**Pennsylvania**	20,500	3,700	24,200
Indiana	7,800	400	8,100	**Rhode Island**	1,000	100	1,000
Iowa	6,400	900	7,300	**South Carolina**	14,400	16,300	30,700
Kansas	3,200	200	3,400	**South Dakota**	1,100	0	1,200
Kentucky	3,600	200	3,800	**Tennessee**	10,400	1,200	11,600
Louisiana	7,000	2,000	9,100	**Texas**	40,700	18,200	58,900
Maine	1,200	100	1,300	**Utah**	3,400	100	3,600
Maryland	8,600	13,100	21,600	**Vermont**	600	0	600
Massachusetts	7,700	500	8,200	**Virginia**	10,000	4,100	14,200
Michigan	12,100	3,500	15,600	**Washington**	6,800	1,400	8,100
Minnesota	6,700	300	7,000	**West Virginia**	1,400	100	1,400
Mississippi	3,000	2,000	5,000	**Wisconsin**	8,200	300	8,500
Missouri	5,600	2,300	7,900	**Wyoming**	500	0	500

Table A-10: Cumulative Value-Added ($mn) – Phase 1: current planned construction

	Investment Phase	Operations Phase	Combined		Investment Phase	Operations Phase	Combined
Alabama	4,900	2,400	7,300	**Montana**	300	0	300
Alaska	300	0	300	**Nebraska**	1,200	0	1,200
Arizona	3,200	100	3,300	**Nevada**	1,300	100	1,300
Arkansas	1,700	100	1,700	**New Hampshire**	900	0	900
California	18,100	900	19,000	**New Jersey**	4,700	200	4,900
Colorado	2,500	100	2,600	**New Mexico**	1,000	500	1,500
Connecticut	2,300	100	2,400	**New York**	10,500	600	11,100
Delaware	500	0	500	**North Carolina**	4,700	1,700	6,500
Florida	18,900	2,000	20,900	**North Dakota**	500	0	500
Georgia	6,300	3,000	9,200	**Ohio**	8,500	1,200	9,700
Hawaii	500	0	500	**Oklahoma**	3,500	100	3,600
Idaho	1,700	1,200	2,800	**Oregon**	1,800	100	1,900
Illinois	11,700	500	12,200	**Pennsylvania**	9,200	500	9,700
Indiana	3,900	100	4,000	**Rhode Island**	500	0	500
Iowa	2,800	100	2,800	**South Carolina**	12,000	7,800	19,800
Kansas	1,600	100	1,700	**South Dakota**	600	0	600
Kentucky	1,800	100	1,900	**Tennessee**	4,300	100	4,400
Louisiana	2,700	200	2,900	**Texas**	19,000	3,500	22,500
Maine	600	0	600	**Utah**	1,700	100	1,800
Maryland	6,100	6,000	12,100	**Vermont**	300	0	300
Massachusetts	3,900	200	4,000	**Virginia**	5,500	2,400	7,900
Michigan	6,600	1,900	8,500	**Washington**	2,800	100	3,000
Minnesota	3,300	100	3,500	**West Virginia**	700	0	700
Mississippi	1,900	1,200	3,000	**Wisconsin**	4,100	100	4,200
Missouri	3,300	1,300	4,600	**Wyoming**	200	0	300

Table A-11: Peak Wages ($mn) – Total assumed impact

	Investment Phase	Operations Phase	Combined		Investment Phase	Operations Phase	Combined
Alabama	700	200	900	**Montana**	0	0	0
Alaska	0	0	0	**Nebraska**	100	0	100
Arizona	1,000	300	1,300	**Nevada**	100	0	100
Arkansas	200	0	200	**New Hampshire**	100	0	100
California	1,700	100	1,800	**New Jersey**	400	0	500
Colorado	200	0	200	**New Mexico**	100	0	200
Connecticut	200	0	200	**New York**	1,500	400	1,900
Delaware	0	0	0	**North Carolina**	800	400	1,100
Florida	2,300	500	2,800	**North Dakota**	0	0	0
Georgia	800	300	1,100	**Ohio**	1,100	300	1,500
Hawaii	0	0	0	**Oklahoma**	300	0	300
Idaho	200	200	500	**Oregon**	200	0	200
Illinois	2,900	1,100	3,900	**Pennsylvania**	1,400	400	1,700
Indiana	400	0	400	**Rhode Island**	0	0	0
Iowa	500	100	600	**South Carolina**	2,400	1,000	3,400
Kansas	100	0	200	**South Dakota**	100	0	100
Kentucky	200	0	200	**Tennessee**	800	200	1,000
Louisiana	700	200	900	**Texas**	2,900	1,700	4,600
Maine	100	0	100	**Utah**	200	0	200
Maryland	1,000	800	1,900	**Vermont**	0	0	0
Massachusetts	400	0	400	**Virginia**	600	200	800
Michigan	700	200	900	**Washington**	600	200	700
Minnesota	300	0	300	**West Virginia**	100	0	100
Mississippi	300	100	400	**Wisconsin**	400	0	400
Missouri	400	100	600	**Wyoming**	0	0	0

Table A-12: Peak Wages ($mn) – Phase 1: current planned construction

	Investment Phase	Operations Phase	Combined		Investment Phase	Operations Phase	Combined
Alabama	700	200	900	**Montana**	0	0	0
Alaska	0	0	0	**Nebraska**	100	0	100
Arizona	400	0	400	**Nevada**	100	0	100
Arkansas	100	0	200	**New Hampshire**	100	0	100
California	1,600	100	1,700	**New Jersey**	400	0	400
Colorado	200	0	200	**New Mexico**	100	0	200
Connecticut	200	0	200	**New York**	1,100	100	1,100
Delaware	0	0	0	**North Carolina**	800	400	1,100
Florida	2,300	500	2,800	**North Dakota**	0	0	0
Georgia	800	300	1,100	**Ohio**	900	100	1,000
Hawaii	0	0	0	**Oklahoma**	300	0	300
Idaho	200	200	400	**Oregon**	200	0	200
Illinois	1,400	200	1,600	**Pennsylvania**	1,100	200	1,300
Indiana	300	0	400	**Rhode Island**	0	0	0
Iowa	300	0	300	**South Carolina**	2,400	1,000	3,400
Kansas	100	0	100	**South Dakota**	100	0	100
Kentucky	200	0	200	**Tennessee**	400	0	500
Louisiana	400	100	500	**Texas**	2,700	1,400	4,100
Maine	100	0	100	**Utah**	200	0	200
Maryland	1,000	800	1,900	**Vermont**	0	0	0
Massachusetts	300	0	400	**Virginia**	600	200	800
Michigan	700	200	900	**Washington**	300	0	300
Minnesota	300	0	300	**West Virginia**	100	0	100
Mississippi	300	100	400	**Wisconsin**	400	0	400
Missouri	400	100	600	**Wyoming**	0	0	0

Table A-13: Peak Tax impact ($mn) – Total assumed impact

(federal and state tax generated)

	Investment Phase	Operations Phase	Combined		Investment Phase	Operations Phase	Combined
Alabama	300	100	400	**Montana**	0	0	0
Alaska	0	0	0	**Nebraska**	0	0	0
Arizona	400	100	500	**Nevada**	0	0	100
Arkansas	100	0	100	**New Hampshire**	0	0	0
California	700	100	800	**New Jersey**	200	0	200
Colorado	100	0	100	**New Mexico**	100	0	100
Connecticut	100	0	100	**New York**	600	200	700
Delaware	0	0	0	**North Carolina**	300	200	400
Florida	900	200	1,100	**North Dakota**	0	0	0
Georgia	300	100	400	**Ohio**	400	100	600
Hawaii	0	0	0	**Oklahoma**	100	0	100
Idaho	100	100	200	**Oregon**	100	0	100
Illinois	1,000	500	1,500	**Pennsylvania**	500	200	700
Indiana	100	0	200	**Rhode Island**	0	0	0
Iowa	200	0	200	**South Carolina**	800	400	1,200
Kansas	100	0	100	**South Dakota**	0	0	0
Kentucky	100	0	100	**Tennessee**	300	100	400
Louisiana	200	100	300	**Texas**	1,100	700	1,800
Maine	0	0	0	**Utah**	100	0	100
Maryland	400	300	700	**Vermont**	0	0	0
Massachusetts	100	0	200	**Virginia**	200	100	300
Michigan	300	100	400	**Washington**	200	100	300
Minnesota	100	0	100	**West Virginia**	0	0	0
Mississippi	100	0	100	**Wisconsin**	200	0	200
Missouri	200	0	200	**Wyoming**	0	0	0

Table A-14: Peak Tax Impact ($mn) – Phase 1: current planned construction

(federal and state tax generated)

	Investment Phase	Operations Phase	Combined		Investment Phase	Operations Phase	Combined
Alabama	300	100	400	**Montana**	0	0	0
Alaska	0	0	0	**Nebraska**	0	0	0
Arizona	100	0	100	**Nevada**	0	0	100
Arkansas	100	0	100	**New Hampshire**	0	0	0
California	700	0	700	**New Jersey**	200	0	200
Colorado	100	0	100	**New Mexico**	100	0	100
Connecticut	100	0	100	**New York**	400	0	400
Delaware	0	0	0	**North Carolina**	300	200	400
Florida	900	200	1,100	**North Dakota**	0	0	0
Georgia	300	100	400	**Ohio**	300	0	400
Hawaii	0	0	0	**Oklahoma**	100	0	100
Idaho	100	100	200	**Oregon**	100	0	100
Illinois	500	100	600	**Pennsylvania**	400	100	500
Indiana	100	0	200	**Rhode Island**	0	0	0
Iowa	100	0	100	**South Carolina**	800	400	1,200
Kansas	100	0	100	**South Dakota**	0	0	0
Kentucky	100	0	100	**Tennessee**	200	0	200
Louisiana	200	0	200	**Texas**	1,000	600	1,600
Maine	0	0	0	**Utah**	100	0	100
Maryland	400	300	700	**Vermont**	0	0	0
Massachusetts	100	0	200	**Virginia**	200	100	300
Michigan	300	100	400	**Washington**	100	0	100
Minnesota	100	0	100	**West Virginia**	0	0	0
Mississippi	100	0	100	**Wisconsin**	200	0	200
Missouri	200	0	200	**Wyoming**	0	0	0