Department of Energy

Analysis of Economic Impact

Supplemental Notice of Proposed Rulemaking, 10 CFR 810

January 13, 2013

Executive Summary

The Department of Energy (DOE) published a Notice of Proposed Rulemaking (NOPR) for part 810 of the Code of Federal Regulations (CFR) on September 7, 2011. This regulation governs the process of export control review and approval for nuclear technology exports from the United States. After careful consideration of all public comments received in response to the NOPR, DOE today is issuing a Supplemental Notice of Proposed Rulemaking (SNOPR). This report summarizes the analysis conducted by DOE of the economic impacts of the changes proposed in the SNOPR, relative to a baseline under the existing regulation.

The primary mechanism of possible economic impact in the SNOPR is the reclassification of export destination status it proposes, and any resulting effects on the viability of U.S. technology exports in the world markets. Under part 810, countries and territories are classified as generally authorized (GA) or specifically authorized (SA) for receipt of nuclear technology exports. Destinations that are SA require a more rigorous set of review procedures for proposed exports. Of 124 countries currently classified as GA under part 810, the SNOPR proposes a reclassification of 80 into the SA category in addition to the 76 countries that are currently classified in the SA category. The primary reason for this proposed change is to require more rigorous review of exports to countries and territories that do not now have significant civil nuclear programs or benefit from large nuclear trade volumes, but collectively represent a significant possible risk of technology transfer and eventual proliferation. At the same time, the SNOPR proposes that three of the 76 countries that are currently designated as SA for nuclear technology exports (Ukraine, United Arab Emirates (UAE), and Kazakhstan) be reclassified as GA.

The delay and possible denial of DOE approval of export transactions associated with a specific authorization is the primary postulated cause of economic impact, with the possible reduction of U.S. nuclear technology export trade being the postulated effect. Hence, the impacts of moving a given country from the GA to SA category will presumably have a negative effect on exports, and the impact of moving a country from the SA to GA category will, for the same reasons, positively affect exports.

While there is no statistical basis from which to confidently estimate the effect of moving a given country from GA to SA, it is clear that any such effect would be reversed by reclassification from SA to GA. Thus, the question of the *direction* (positive or negative) of net economic impact of the SNOPR becomes one of comparing the potentially affected technology trade volumes in the two sets of countries (GA to SA and SA to GA). The *magnitude* of impact depends on both the size of the affected trade volumes and the degree to which GA status results in more competitive U.S. export trade relative to SA status. This trade is currently in the range of $2 to $3 billion per year, based on DOE's proprietary trade database of individual export transactions submitted and approved over the last several years.

Using a method that involved assigning all transactions in *DOE's proprietary trade database of individual export transactions* to one of three underlying measures of nuclear power development, a set of base rates for technology trade volume was calculated. These three measures were the existing nuclear power generating capacity, the nuclear generating capacity under construction in any year, and the nuclear generating capacity planned for construction in each country.

While the limited data set did not allow for a robust statistical analysis, the association of specific transactions with the three categories of trade was clear in most cases, and base rates were calculated from the aggregate trade (both approved and pending approval) in each of these three categories during a 3 ½ year period. The base rates were then applied to four sets of nuclear capacity forecasts for the period 2013-2030, resulting in estimates of the nuclear technology trade in each of the reclassification categories (GA to SA and SA to GA). The annual trade volume estimates are presented in Table 1.

Table 1 - Estimated Annual Export Trade Volumes, by Category and Forecast

Forecast	SA to GA	GA to SA
NAC	$ 95,474,753	$ 20,184,751
UxC	$ 86,305,531	$ 54,931,258
WNA L	$ 154,776,849	$ 86,853,491
WNA H	$ 284,198,804	$ 836,326,584

The first application of the base rates was to the nuclear capacity forecasts by the consulting firm Nuclear Assurance Corporation (NAC International). These forecasts called for only $20 million of technology trade going to the destinations in the GA to SA reclassification, while $95 million was forecast for the three countries in the SA to GA reclassification category, resulting in a positive net impact.

Using the same logic, the base rates were then applied to a nuclear capacity forecast prepared by UxC (a nuclear consultancy and data source for uranium price information) yielding forecast trade volumes of $54 million per year for the GA to SA reclassification category, and $86 million per year for the SA to GA reclassification category.

The final two sets of capacity forecasts came from the World Nuclear Association (WNA) and included low and high forecasts. The low nuclear capacity forecasts resulted in an average of about $86 million per year over the 18-year window as potential export volume destined for countries in the proposed GA to SA category, while $154 million per year was forecast for trade with the SA to GA destination-set. In addition to this extent of impact calculation, DOE also calculated annualized costs and benefits of the 20% scenario at 3% and 7% discount rates. The analysis conducted at the 3% discount rate predicted an average annual trade volume of approximately $23 million for the GA to SA countries, and an average annual trade volume of $42 million for the SA to GA country set. At the 7% discount rate, the analysis predicted an average annual trade volume of approximately $22 million for the GA to SA countries, and an average annual trade volume of $42 million for the SA to GA country set.

The WNA high forecast calls for addition of about 950 GWe in nuclear generating capacity worldwide by 2030. Since we can predict with high confidence only about 100 GWe of new capacity by 2020, the WNA high forecast requires that an average of 85 GWe capacity come on line each year between 2010 and 2030. This worldwide nuclear deployment rate is about twenty times that observed in the last twenty years, and represents a very rapid expansion in the global capability to produce power reactors.

For this and other reasons[1], this forecast is thought to represent an unlikely sensitivity case in this analysis.

The *distribution* of the WNA high forecast among countries implies that trade volumes of the GA to SA reclassification category exceed those for the SA to GA reclassification category under the proposed regulation. Over $836 million per year in export trade is forecast using our base rates applied to this forecast for proposed GA to SA countries, while $284 million per year is forecast for the three SA to GA countries. This is a direct consequence of the number of countries deploying nuclear power for the first time in this forecast, and is thought to be an unlikely outcome. If this forecast were realized without further adjustment of the 810 regulation beyond that proposed in the SNOPR, there would be a potential for negative economic impact, the magnitude of which would depend on the extent to which GA status results in increased nuclear construction. Thus, three independent sets of destination-level nuclear growth forecasts, when combined with the "base-rate" model of nuclear technology export trade, support a conclusion that this trade is likely to be greater in countries for which trade is liberalized under the proposed regulation than for countries in which the SNOPR calls for greater scrutiny of export transactions. This is primarily due to the fact that all three countries proposed for SA to GA reclassification have significant civil nuclear programs or active emerging nuclear reactor construction, despite the fact that the number of destinations proposed for GA to SA status change far exceeds the number of proposed SA to GA status changes.

The analysis discussed above is a *relative* one that compares only the potential trade volumes for two sets of reclassification categories as defined in the SNOPR. The question of the absolute magnitude of impact requires an assumption regarding the degree of reduction that might result from reclassification, subject to a constraint of symmetry of impact between the two sets of effects.

Analysis

In September 2011, DOE published a Notice of Proposed Rulemaking (NOPR) for part 810 of the Code of Federal Regulations (CFR), which governs the process of export control review and approval for nuclear technology exports from the United States. After careful consideration of all public comments received in response to the NOPR, DOE today is issuing a SNOPR.

The analysis in this paper uses data only on *technology* transactions in *DOE's proprietary trade database of individual export transactions* to derive an economic model of future technology transfer export potential, and data on the probable nuclear futures for the countries proposed for reclassification to generate estimates of trade volumes. This report summarizes the analysis conducted by DOE.

Economic Model

The United States has been a leader in civil nuclear technology development and applications for over 60 years. Despite the pause in U.S. nuclear reactor construction, U.S. firms and institutions are still regarded as world leaders in technology for existing and new nuclear power plants, nuclear fuel, and

[1] See appendix C

fuel cycle facilities. The DOE operates several laboratories with world-class capability in nuclear technology, and the U.S. nuclear regulator, the Nuclear Regulatory Commission (NRC), is the accepted standard in nuclear safety and licensing evaluation for new power plants and designs.

On this basis, the export of U.S. nuclear technology remains a significant and viable business for U.S. firms, independent of the construction of new plants in the United States. The prospective growth of civil nuclear power worldwide promises to make this a growing business in the next few decades. Conceptually, the demand-side drivers of U.S. technology exports include [1] existing foreign nuclear infrastructure investments and the extent of their utilization, [2] the extent and nature of reactor and other fuel cycle construction activity at any given time, and [3] the extent and nature of planning and engineering activities for future facility construction.

Assuming that there will continue to be robust demand for U.S. products, the economic model will concentrate on the ability to supply desired goods. The primary mechanism of possible economic impact in the SNOPR is the reclassification of country status. Under part 810, countries and territories are classified as generally authorized (GA) or specifically authorized (SA) for receipt of nuclear technology exports. Destinations that are SA require a more rigorous set of review procedures for proposed exports. The delay and possible denial of DOE approval of export transactions associated with a specific authorization is the primary postulated mechanism of economic impact, with the possible reduction of U.S. nuclear technology export trade the postulated impact. This trade is currently in the range of $2 to $3 billion per year, based on records of all individual transactions submitted to and approved by DOE for several years.

Of 124 countries currently classified as GA under part 810, the SNOPR proposes the reclassification of 80 into the SA category. (The current regulation classifies 76 as SA.) The primary motivation for this change is to require more rigorous review of exports to countries that do not now have significant civil nuclear programs or benefit from large nuclear trade volumes, but collectively represent a significant possible risk of technology transfer and eventual proliferation. At the same time, the SNOPR proposes that three countries that are currently classified as SA for nuclear technology exports (Ukraine, United Arab Emirates, and Kazakhstan) be reclassified as GA under the revised regulation. Appendix A lists the individual countries and territories in each proposed reclassification.

Record of Transactions

To forecast the possible impact of adoption of the regulations proposed in the SNOPR, DOE utilized its proprietary database of pending and authorized technology export transactions that it has maintained since March 2009. This set of data represents both approved SA transactions and those currently in the pending SA queue. This approach was taken to establish the full extent of trade potential and economic impact. There are 97 transactions to 12 countries. Of the transactions, 72 have dollar values reported[2], totaling $13.6 billion. This is the primary dataset used in this paper. Details of this data are commercially sensitive, and have not been included in this report.

[2] There is no requirement to submit dollar volume information, and some companies choose not to include it with their applications.

Deemed Exports

Of the 97 transactions in the dataset, 18 are "deemed exports" – cases in which U.S. firms employ foreign nationals in positions with access to sensitive technology. These transactions are regulated as exports since they result in transfers of technology to a foreign national entity (person), just as the sale of the technology to a foreign entity. For purposes of commercial accounting and economic analysis, however, they are *not* export transactions, and in fact represent expenditures by U.S. firms rather than sales. On this basis they were not included in this analysis.

Characterization of Dominant Transactions

Of the non-deemed export transactions in the dataset, nine very large transactions (with an estimated value of least $1 billion each) account for over 90% of the total dollar volume of all civil nuclear technology exports. In general, these transactions are associated with power reactor projects either in the planning or construction stages. Once foreign reactors are complete, technology transfer transactions tend to be much smaller in dollar volume. While some of these transactions are pending (still to be approved by DOE), we chose to include them for the purposes of calculating base rates on the grounds that excluding them could bias the rates downward. The nature of these transactions indicates they are largely associated with planned reactors or reactors under construction.

Statistical Modeling

We initially conducted a multiple regression analysis to model country-level export-trade-volume-per-year as a function of country-level existing-nuclear megawatts electric (MWe), MWe-under-construction, and MWe-planned. For this initial exploratory analysis, we used tabular and graphical summaries to characterize and evaluate the data. The data contained 97 export-trade records of which 50 could support a targeted statistical model. Of the 47 remaining records, 29 records had no trade volume or a volume of zero was recorded. Another 18 were "deemed exports," in which U.S. firms hired foreign personnel. These 47 records provided no information for this statistical modeling and were excluded.

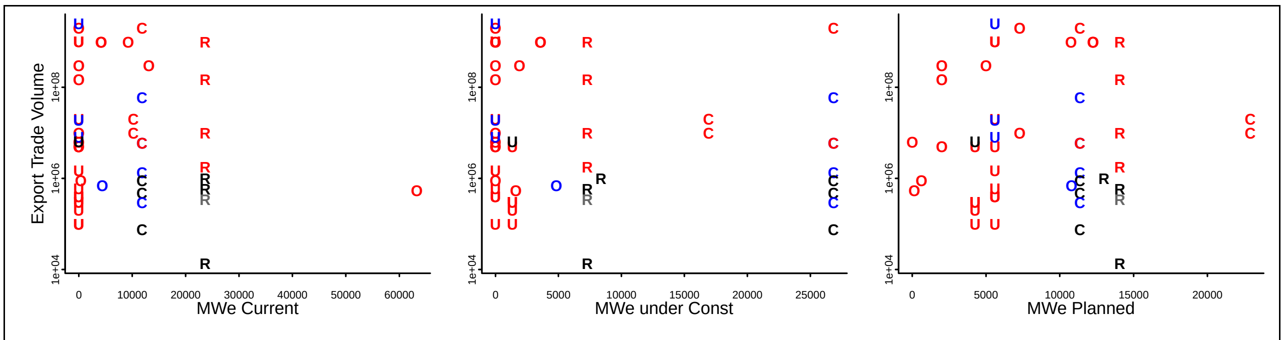
Three countries accounted for 74 percent, or 37, of the 50 transactions: United Arab Emirates (UAE) (18), China (11) and Russia (8), with the remaining 13 transactions distributed across nine countries. The distributions of export-trade-volumes (summarized in Table 2) were highly skewed with mean trade volumes greater than their 3rd quantiles. Export-trade-volume distributions were very similar for the UAE, China and Russia, while the distribution for the remaining countries tended higher than these three.

Table 2 - Distribution of Export Trade Volumes by Country

Country	N	Min	1st Quart.	Median	Mean	3rd Quart.	Max
UAE	18	1.0e5	3.3e5	3.3e6	2.5e8	1.6e7	2.5e9

China	11	7.5e4	6.9e5	6.0e6	1.9e8	1.5e7	2.0e9
Russia	8	1.3e4	5.3e5	1.4e6	1.5e8	4.5e7	1.0e9
Others	13	5.5e5	5.0e6	1.5e8	4.4e8	1.0e9	2.0e9
All	50	1.3e4	5.6e5	5.5e6	2.7e8	1.3e8	2.5e9

Variation in export-trade-volume displayed a constant trend over MWe and appeared directly related to country (Figure 1) with regression $R^2 = 0.03$ and estimated ETV-to-MWe rates no different than 0. Trade volume showed some separation by trade volume type, with trade volume related to planned GWe trending higher. This separation was not statistically significant (ANOVA $R^2 = 0.04$) given the wide and overlapping dispersions. When several regression models failed to fit this data with any degree of significance, we opted for an alternative approach.



UAE = U, China = C, Russia = R, Others = O. Trade volume type: GWe Current = black, GWe Under Construction = blue, GWe Planned = red.

Figure 1 - Distribution of Export Trade Volumes by MWe Type

Due to the failure of the statistical approach to yield results that could be used to estimate trade volume, and the dominance of trade relating to facilities either under construction or planned for construction, we developed a second, simpler approach (explained below) to predicting nuclear trade volumes.

<u>Predictive Model</u>

As an alternative to a regression approach, we developed a simpler, “base rate” approach to approximating trade flows. The results of this method yielded three coefficients (all in $/MWe), one for each category of nuclear demand: operating MWe, MWe under construction, and planned MWe. The first two categories were derived from the WNA’s Reactor Database, which is linked to the International Atomic Energy Agency’s Power Reactor Information System. The coefficients were then applied to four projections of nuclear growth across the applicable country set, yielding an estimate of trade volume potentially affected.[3]

To calculate the base rates, we assigned each transaction to one of the three MWe categories (or deemed exports, which were then excluded from the analysis).[4] We then approximated the Planned MWe values for each of the listed countries from WNA's 2030 Low Projection. We then derived the base rates by summing the total amount of trade per MWe per year and averaging across all years, for each category of MWe. The base rate calculation is presented in Tables 3A – 3C, and summarized in table 4.

Table 3A – Trade Value per Megawatt – Operating reactors

Year	Current Operating Capacity (MWe)	Operating Trade Volume	$ Trade/MWe
2009	224,125		$0.00
2010	225,944	$20,013,500	$88.58
2011	227,545	$2,045,000	$8.99
2012	226,838	$1,000,000	$4.41
AVERAGE $ Trade/operating reactor MWe			**$25.49**

Table 3B – Trade Value per Megawatt – Reactors under Construction

Year	MWe Under Construction	Under Construction Trade Volume	$ Trade/MWe
2009	19,371		$0.00
2010	32,427		$0.00
2011	41,208	$2,595,346,000.00	$62,981.61
2012	43,635	$6,500,000.00	$148.96
AVERAGE $ Trade/MWe Reactors under Construction			**$15,782.64**

[3] This consists of all countries moving from SA to GA, and vice-versa. The list of these countries is provided in Appendix B.
[4] All transactions with no pricing information were excluded.

Table 3C – Trade Value per Megawatt – Planned Reactors

Year	Planned MWe	Planned Trade Volume	$ Trade/MWe
2009	118,388	$2,001,500,000.00	$16,906.27
2010	103,513	$3,340,150,000.00	$32,267.93
2011	93,131	$4,197,246,000.00	$45,068.19
2012	91,411	$455,900,000.00	$4,987.36
AVERAGE $ Trade/ MWe Reactors planned Planned			**$24,807.44**

One feature of these estimates is that they are all highly variable on a year-to-year basis. None of the components of trade yields stable annual base rates. This is due to the heterogeneous nature of the underlying data – individual transactions are large, and chances of the success of reactor consortia involving U.S. firms are unpredictable on an individual transaction basis. Table 4 summarizes the *average* base rates for the three categories of trade.

Table 4 - Base Rates of Trade per MWe, (2010 dollars)

WNA 2030 LOW	$/Current MWe	$25.49
	$/Under Construction MWe	$15,782.64
	$/Planned MWe	$24,807.44

Conceptually, these base rates offer a method which can be used to forecast U.S. nuclear technology exports, given that forecasts of the underlying variables are available.

<u>Stability of Base Rates</u>

While the base rates in table 4 are clearly not stable on a year-to-year basis, there is an insufficient length of record to estimate any secular trend in the rates. Since they are rates per MWe of nuclear capacity, a mature technology, we see no structural reason for a trend in these rates. It would also be possible for the rates to increase or decrease as a function of increased or decreased competitiveness of U.S. firms vis-à-vis foreign competitors, or in response to increased or decreased dependence of foreign reactor builders on technology imports. Once again, we see no structural reason to assume any of these trends, and have assumed the base rates to be stable for this analysis. Since they were derived from data in current dollar terms from 2009 to 2012, they may be considered to be denominated in 2010 constant dollars.

Nuclear Capacity Forecasts

Many organizations generate and publish forecasts of nuclear construction and net nuclear generation capacity for a wide variety of purposes, including forecasts of nuclear waste volumes, energy prices, effects of carbon emissions from fossil fuel, and the need for and economic payoff to nuclear R&D. The range of assumptions used in these forecasts is similarly diverse. Some include only existing nuclear plants with no new orders for nuclear capacity, or assume that enough nuclear capacity is built to meet a pre-established objective for reducing carbon emissions. These assumptions produce a wide range of forecast outcomes in terms of new nuclear build and the associated growth rate of nuclear capacity. DOE considered the type of forecast appropriate for use here and defined two criteria including: [1] a forecast series allowing explicit disaggregation to the country sets of interest, and [2] a forecast series having a reasonable chance of realization.

Within this broad range of variability, there is a set of mid-range forecasts which are typically used for commercial nuclear planning. The lower group of forecasts pictured in Figure 2 are of this type. They include forecasts from the IAEA, UxC, the DOE's Energy Information Administration's (EIA) *International Energy Outlook,* the WNA, and a forecast generated by Energy Resources International, a well-known energy consultancy.

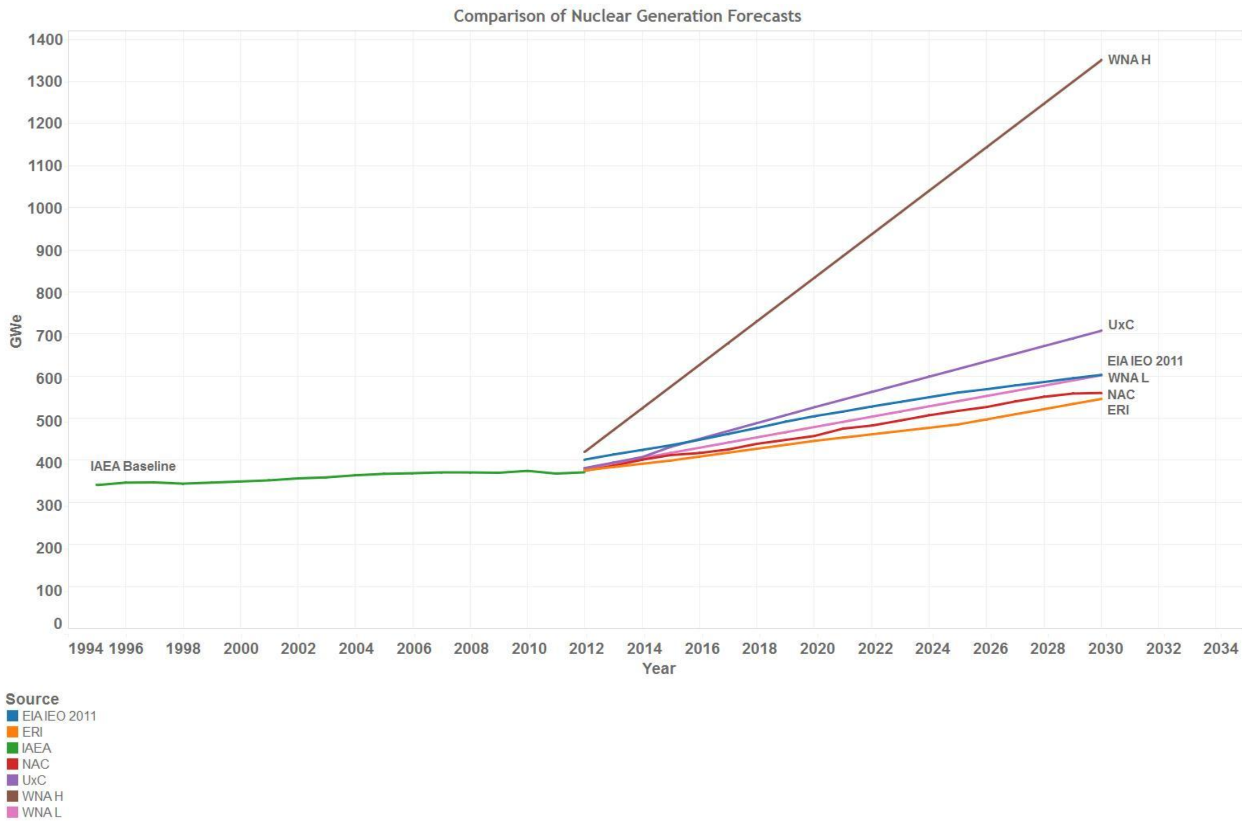


Figure 2 - Comparison of World Nuclear Generation Capacity Reference Forecasts

(Sources: IAEA Power Reactor Information System, WNA Nuclear Century Outlook, EIA International Energy Outlook 2010, UxC Fabrication Sector Market Outlook, NAC FuelTrac, Energy Resources International ERI-2012-120, a Detailed Review of the Need for Future Enrichment Capability -Response to ASLB Topic 5A, Prepared for GE-Hitachi Global Laser Enrichment LLC GLE Commercial Facility)

Of these forecasts, two (WNA low and UxC) were available at a country-specific level, which allowed aggregation to the reclassification categories of interest. DOE also had access to a forecast by NAC International, purchased on a proprietary basis for use in U.S. Government nuclear fuel cycle policy analysis, which provided country-level detail that supported forecast of trade volume for the two reclassification categories. This forecast, on a global basis, was near the lower bound of the forecasts in Figure 2.

The final set of nuclear capacity forecasts analyzed in detail in this impact analysis was the WNA high forecast. This forecast series is characterized by WNA[5] as the [upper] “boundary” for likely nuclear development. It calls for addition of about 950 GWe in nuclear generating capacity worldwide by 2030. Since we can predict with high confidence that perhaps only about 100 GWe of new capacity will come on line by 2020, the WNA high forecast requires that an average of 85 GWe capacity come on line each year between 2010 and 2030. This worldwide nuclear deployment rate is about twenty times that observed in the last twenty years, and represents a very rapid expansion in the global capability to

[5] World Nuclear Association, “Nuclear Century Outlook,” http://www.world-nuclear.org/WNA/Publications/WNA-Reports/WNA-Nuclear-Century-Outlook/

produce power reactors. For this and other reasons[6], this forecast is thought to represent an unlikely sensitivity case in this analysis.

The *distribution* of the WNA high forecast among countries is such that forecast U.S. technology export trade volumes of the GA to SA country set are higher than those for the SA to GA country set under the proposed regulation. This is a direct consequence of the number of countries deploying nuclear power for the first time in this forecast, and is thought to be an unlikely outcome. If this forecast were realized without further adjustment of the 810 regulation beyond that proposed in the SNOPR, there would be a potential for negative economic impact, the magnitude of which would depend on the extent to which GA status results increased.

Forecasts of Trade Volume

Using the base rates from Table 4, the definition of reclassification categories in Appendix A, and the four forecasts of nuclear capacity growth discussed above, DOE calculated expected trade volumes by year as shown in Table 5 below. The details of these calculations are presented in four sets of tables in Appendix B.

In each of these cases, the annual U.S. technology export trade volume forecast for the SA to GA reclassification category (Ukraine, Kazakhstan, and UAE) is greater than that forecast for the 76 countries proposed for reclassification from GA to SA. In the case of the NAC International forecast, the difference between trade volumes expected to be beneficially impacted and those expected to be negatively impacted is $75 million per year; for the UxC forecast, it is $32 million per year; for the WNA low forecast, it is about $68 million per year.[7]

For the WNA high forecast, and only for this forecast (of those we examined), the difference between trade volumes was in favor of the reclassification category proposed to be reclassified from GA to SA. Due to the very high number of plants forecast to be built in countries that now have no nuclear power[8] (most of which are in this set of countries), the difference in potential trade volumes was $552 million per year.

It is important to appreciate that the differences in trade volumes in the two sets of affected markets do not constitute "impact", except to the extent that the SA approval process constitutes a competitive disadvantage relative to the GA process. While we have no statistical basis to estimate this effect, it is addressed parametrically in the following section.

To summarize the analysis of prospective trade volumes potentially affected by the SNOPR;

> [1] The direction of trade impacts is sensitive to the forecast series used as a basis for trade volumes. Those forecasts representing a continuation of, or moderate increases

[6] See Appendix C

[7] These values represent the 100% trade effect calculation - rather than the asymmetric calculation described in the next section.

[8] The WNA low forecast predicts only 6 GWe of nuclear power to be developed in the proposed GA to SA country set by 2030, all in Jordan, Nigeria, or Philippines. The WNA high forecast predicts 61 GWe to be developed in the same three countries plus Bangladesh, Malaysia, New Zealand, Serbia, Croatia, and Venezuela.

in, existing rates of nuclear power development, show that the volume of positively affected trade always exceeds the volume of negatively affected trade.

[2] Within the context of these forecasts, for any degree of impact, net impacts on trade volume will always be positive.

[3] For the WNA high forecast, which represents a significant departure from currently observed nuclear build trends, the negatively affected trade volumes are larger by a wide margin than the positively affected trade volumes.

Table 5 - Aggregate and Annual Trade Volumes (2010 USD), by Nuclear Capacity Forecast: 2013-2030

	GA to SA		SA to GA	
Forecast	**Aggregate**	**Average Annual**	**Aggregate**	**Average Annual**
NAC	$363,325,524	$20,184,751	$1,718,545,555	$95,474,753
UxC	$988,762,643	$54,931,257	$1,553,499,558	$86,305,531
WNA Low	$1,563,362,834	$86,853,490	$2,785,983,282	$154,776,849
WNA High	$15,053,878,508	$836,326,584	$5,115,578,480	$284,198,804

Static Nature of Annual Trade Volume Model

The estimates in Table 4 reflect *planned nuclear capacity as now incorporated in four forecasts.* In the sense that "planned capacity" (for both the base rate calculation and the forecast) is defined as capacity planned for construction by 2030 at the latest, these forecasts assume "no new planning" during the forecast period[9]. As detailed in Appendix B, this results in a secular decrease in real trade volumes for both country sets (SA to GA and GA to SA) in all forecast cases. This is clearly an artifact of the model used, but there is no reason it should introduce any bias relative to the estimates for the two reclassification categories.

Extent of Impact

The impact of moving a given country from the GA to SA category will presumably have a negative effect on exports, since specific authorization involves additional cost to applicants and time for DOE to process and some small fraction of SA applications may ultimately not be approved. The impact of moving a country from the SA to GA category will, for the same reasons, positively affect exports.[10]

[9] The long times associated with nuclear licensing, siting and site-specific design, and construction serve to guarantee the that changes in the nuclear build rate (and thus opportunities to export US technology) are known with enough lead time to adjust 810 regulations to match emerging markets.

[10] While there is no simple basis for estimating the extent of such impacts, it is clear that the mechanisms involved for the two sets of regulatory changes should be mirror images, and the resulting effects should be quantitatively symmetric.

Using the method described above, we calculated the net effect on U.S. nuclear exports, the results of which are presented in Table 6 below, for all sets of capacity forecasts.[11]

It is important to note that the estimates of trade in Table 5 were derived from the previously described *DOE's proprietary trade database of individual export transactions* records of SA transactions. Thus, for GA to SA countries, those transactions represent forecasts which reflect the proposed regulatory change. For SA to GA countries, they reflect forecasts for the existing regulatory status. We allowed for this asymmetry in forecast frame-of-reference, but assumed that any effects on trade would be quantitatively symmetric (i.e., that a decrease of x% in trade in moving from GA to SA would imply and increase of (1/1-x) in moving from SA to GA).

While it would have been desirable to estimate the extent of impacts in moving from SA to GA and vice versa by estimating base rates separately for each set of transactions, and then comparing the two sets, the GA transactions data maintained by DOE does not include dollar volumes of GA transactions. Thus this analytical strategy was not possible. It can be argued on qualitative grounds that since there is a robust U.S. export business to countries now in the SA category, the penalty associated with SA status is not preemptively punitive.

On this basis, we used four trade effect assumptions (10%, 20%, 30% and 40%), and the average yearly trade derived in each nuclear capacity projection, to calculate the net effect on trade under each scenario for each forecast. The results of this calculation are presented in Table 6.

Table 6 - Annual Net Effect on Trade, by Forecast and Assumed Effect %

	10%	20%	30%	40%
NAC	$8,365,556	$18,822,500	$32,267,144	$50,193,334
UxC	$3,486,030	$7,843,568	$13,446,117	$20,916,182
WNA Low	$7,546,333	$16,979,250	$29,107,286	$45,278,000
WNA High	-$44,755,556	-$100,700,000	-$172,628,571	-$268,533,333

Conclusions

While the available data points are insufficient for a model which statistically estimates the trade effects of underlying civil nuclear market variables, the qualitative association of specific transactions with underlying variables is usually very clear from the country and product context. Exploiting this set of relationships allows derivation of three base rates for technology trade associated with existing nuclear capacity, capacity under construction, and planned capacity.

The first set of nuclear capacity forecasts, prepared by the consulting firm NAC International, supported the general conclusion that the SNOPR would have a net positive impact. These forecasts called for only $20 million of U.S. technology export trade going to the countries in the GA to SA reclassification

[11] Detailed results are shown in Appendix C

category, while $95 million was forecast for the three countries in the SA to GA reclassification category, again resulting in a larger trade volume subject to a positive impact than to a negative impact from reclassification.

The UxC forecasts of nuclear capacity growth, times our base rates for trade volumes per MWe, yielded an average annual trade volume of $54 million for GA to SA countries, while predicting an average trade volume of $86 million for SA to GA countries.

A set of nuclear capacity forecasts by the WNA (low projection) resulted in an average of about $86 million per year over the 18-year window as potential export volume destined for countries in the proposed GA to SA reclassification category, while $154 million per year was estimated trade with the three SA countries proposed for reclassification to the GA category. Based on the 20 percent assumed effect on trade for this one industry-generated analysis, it is possible that at the 3% discount rate this proposed rule could, hypothetically, have an average annual cost of approximately $23 million for the GA to SA countries, and an average annual benefit of $42 million for the SA to GA country set. At the 7% discount rate for the 20 percent assumed effect on trade, the analysis suggested a potential cost of approximately $22 million for the GA to SA countries, and an average benefit of $42 million for the SA to GA country set. DOE also provided a hypothetical high estimate based on the 40 percent assumed effect on trade. For the high estimate, the average annual cost of the proposed rule could be $63 million at a 3% discount rate and $61 million at a 7% discount rate while the benefits could be $115 at a 3% discount rate and $114 at a 7% discount rate. In DOE's low estimate based on the 10 percent assumed effect on trade, the agency estimated that the average annual cost of the proposed rule could be $11 million at a 3% discount rate and $10 million at a 7% discount rate while the benefits could be $19 at both the 3% and 7% discount rates.

Thus, even though the number of countries proposed for GA to SA status change far exceeds the number of SA to GA status changes, the net impact of reclassification on trade volumes is positive under this set of assumptions. This is because all three countries proposed for SA to GA reclassification have significant civil nuclear programs and/or active emerging nuclear reactor construction plans. Thus, for all three of the mid-range forecasts used, trade expected for the SA to GA reclassification categories is substantially larger than that for the countries proposed for reclassification from GA to SA.

The analysis above is a *relative* one in that it compares only the potential trade volumes for two sets of U.S. export recipients as defined in the SNOPR. The question of the absolute magnitude of impact requires an assumption regarding the degree of reduction or increase that might result from reclassification, subject to a constraint of symmetry of impact between the two sets of effects.

To summarize, under any of three nuclear construction forecasts that represent continuation or moderate increase in global nuclear build rates, and modest introduction of nuclear power in countries where there is now none, the nature of the two country sets proposed for classification status change dictates that the net impact of the proposed changes will be positive. Thus under these forecasts, probable nuclear reactor construction activity (and thus U.S. technology exports) in Ukraine, UAE, and

Kazakhstan will likely exceed that in all of the 76 countries proposed for GA to SA status change combined.

In the one sensitivity case where trade volumes were forecast for aggressive growth (in terms of global GWe deployment and number of new countries adopting nuclear), U.S. export trade volumes to the set of countries treated with higher scrutiny under the proposed regulation was higher than that in countries treated more leniently. This is regarded as a very unlikely outcome, since it requires unpredicted rates of growth in nuclear industrial capacity in a very short time. Appendix C details this set of considerations.

It is also true that should any of the countries proposed for reclassification from GA to SA develop a significant civil nuclear program, it is likely that they would seek a nuclear cooperation agreement ("123 agreement") with the United States, resulting in a future reclassification to the GA category under part 810.

APPENDIX A – COUNTRY STATUS UNDER SNOPR

This table shows the list of countries whose status would change under the SNOPR. Status under the current regulation is listed under "Old Status" and the status proposed in the SNOPR is shown under the "New Status" column. The table only lists countries which would be affected by the SNOPR.

	Name	Old Status	New Status
1.	Antigua and Barbuda	GA	SA
2.	Aruba	GA	SA
3.	Bahamas	GA	SA
4.	Bangladesh	GA	SA
5.	Barbados	GA	SA
6.	Belize	GA	SA
7.	Bhutan	GA	SA
8.	Bolivia	GA	SA
9.	Bosnia and Herzegovina	GA	SA
10.	Brunei	GA	SA
11.	Congo (Republic of)	GA	SA
12.	Costa Rica	GA	SA
13.	Cote d'Ivoire	GA	SA
14.	Croatia	GA	SA
15.	Curaçao	GA	SA
16.	Dominica	GA	SA
17.	Dominican Republic	GA	SA
18.	Ecuador	GA	SA
19.	El Salvador	GA	SA
20.	Ethiopia	GA	SA

	Name	Old Status	New Status
21.	Fiji	GA	SA
22.	Gambia, The	GA	SA
23.	Ghana	GA	SA
24.	Grenada	GA	SA
25.	Guatemala	GA	SA
26.	Guyana	GA	SA
27.	Honduras	GA	SA
28.	Hong Kong	GA	SA
29.	Iceland	GA	SA
30.	Jamaica	GA	SA
31.	Jordan	GA	SA
32.	Kiribati	GA	SA
33.	Kosovo	GA	SA
34.	Lebanon	GA	SA
35.	Lesotho	GA	SA
36.	Liechtenstein	GA	SA
37.	Macau	GA	SA
38.	Madagascar	GA	SA
39.	Malawi	GA	SA
40.	Malaysia	GA	SA
41.	Maldives	GA	SA
42.	Mauritius	GA	SA
43.	Monaco	GA	SA
44.	Montenegro	GA	SA

	Name	Old Status	New Status
45.	Namibia	GA	SA
46.	Nauru	GA	SA
47.	Nepal	GA	SA
48.	New Zealand	GA	SA
49.	Nicaragua	GA	SA
50.	Nigeria	GA	SA
51.	Palau	GA	SA
52.	Panama	GA	SA
53.	Papua New Guinea	GA	SA
54.	Paraguay	GA	SA
55.	Peru	GA	SA
56.	Philippines	GA	SA
57.	Saint Kitts and Nevis	GA	SA
58.	Saint Lucia	GA	SA
59.	Saint Vincent and the Grenadines	GA	SA
60.	Samoa	GA	SA
61.	San Marino	GA	SA
62.	Senegal	GA	SA
63.	Serbia	GA	SA
64.	Singapore	GA	SA
65.	Solomon Islands	GA	SA
66.	South Sudan	GA	SA
67.	Sri Lanka	GA	SA
68.	Suriname	GA	SA

	Name	Old Status	New Status
69.	Swaziland	GA	SA
70.	Timor–Leste	GA	SA
71.	Tonga	GA	SA
72.	Trinidad and Tobago	GA	SA
73.	Tunisia	GA	SA
74.	Tuvalu	GA	SA
75.	Uruguay	GA	SA
76.	Vatican City	GA	SA
77.	Venezuela	GA	SA
78.	Western Sahara	GA	SA
79.	Zambia	GA	SA
80.	Zimbabwe	GA	SA
81.	Kazakhstan	SA	GA
82.	Ukraine	SA	GA
83.	United Arab Emirates*	SA	GA

APPENDIX B – DETAILED PROJECTION RESULTS

The tables below summarize the projected effects for the nuclear projections considered in this report. The tables are organized as follows: Year, Type of MWe (Current = currently installed, Coming Online, UC = Under Construction and Planned), and estimated trade per year. This estimated trade is calculated by using the base rates found in the bottom left corner for each table. The estimates are divided between the GA to SA countries and the SA to GA countries, with projections summarized for annual impacts and net impacts across the selected time period.

NAC PROJECTION						
	Operating	Coming Online	UC	Planned	Estimated Trade per year	GA=>SA
2012	0	0	0	1100		
2013	0	0	0	1100	$27,098,368	
2014	0	0	0	1100	$27,098,368	
2015	0	0	0	1100	$27,098,368	
2016	0	0	0	1100	$27,098,368	
2017	0	0	0	1100	$27,098,368	
2018	0	0	0	1100	$27,098,368	
2019	0	0	0	1100	$27,098,368	
2020	0	0	1100	0	$17,360,906	
2021	0	0	1100	0	$17,360,906	
2022	0	0	1100	0	$17,360,906	
2023	0	0	1100	0	$17,360,906	
2024	0	0	1100	0	$17,360,906	
2025	0	0	1100	0	$17,360,906	
2026	0	0	1100	0	$17,360,906	
2027	0	0	1100	0	$17,360,906	
2028	0	0	1100	0	$17,360,906	
2029	0	0	1100	0	$17,360,906	
2030	1100	1100	0	0	$27,882	
	TOTAL		**TOTAL**	**TOTAL**	**$20,184,751**	**AVERAGE**
	$27,882		$173,609,063	$189,688,579	**$363,325,524**	**TOTAL**
	Operating	Coming Online	UC	Planned	Estimated Trade per year	SA=>GA
2012	13107	0	0	4905		
2013	13107	0	3245	4905	$172,380,992	
2014	13107	0	3245	4905	$172,380,992	
2015	14057	0	3245	4905	$172,405,072	
2016	15007	950	3650	3550	$145,440,859	
2017	15007	950	2700	3550	$130,447,349	
2018	15007	0	4150	2100	$117,611,604	
2019	15007	0	4150	2100	$117,611,604	
2020	15007	0	6250	0	$99,021,903	
2021	16352	1345	6250	0	$99,055,996	
2022	16352	0	4905	0	$77,828,342	
2023	16352	0	4905	0	$77,828,342	
2024	16352	0	4905	0	$77,828,342	
2025	17707	1355	4905	0	$77,862,688	
2026	17707	0	3550	0	$56,477,208	
2027	19157	1450	3550	0	$56,513,962	
2028	19157	0	2100	0	$33,629,131	
2029	21257	2100	2100	0	$33,682,360	
2030	21257	0	0	0	$538,812	
	TOTAL		**TOTAL**	**TOTAL**	**$95,474,753**	**AVERAGE**
	$7,527,094		$1,070,142,049	$640,876,413	**$1,718,545,556**	**TOTAL**
BASE RATES	$/Current MW			$25.35	**$1,355,220,031.49**	**NET TRADE EFFECT**
	$/Contructed MW			$15,782.64		
	$/Planned MW			$24,634.88		

UxC PROJECTION						
	Operating	Coming Online	UC	Planned	Estimated Trade per year	
2012	0	0	0	4071		GA=>SA
2013	0	0	1621	2450	$85,939,120	
2014	0	0	1621	2450	$85,939,120	
2015	0	0	1621	2450	$85,939,120	
2016	0	0	1621	2450	$85,939,120	
2017	0	0	1621	2450	$85,939,120	
2018	0	0	1621	2450	$85,939,120	
2019	0	0	1621	2450	$85,939,120	
2020	1621	1621	2450	0	$38,708,562	
2021	1621	0	2450	0	$38,708,562	
2022	1621	0	2450	0	$38,708,562	
2023	1621	0	2450	0	$38,708,562	
2024	1621	0	2450	0	$38,708,562	
2025	1621	0	2450	0	$38,708,562	
2026	1621	0	2450	0	$38,708,562	
2027	1621	0	2450	0	$38,708,562	
2028	1621	0	2450	0	$38,708,562	
2029	1621	0	2450	0	$38,708,562	
2030	4071	2450	0	0	$103,190	
	TOTAL		**TOTAL**	**TOTAL**	**$54,931,258**	**AVERAGE**
	$514,073		$565,760,372	$422,488,198	**$988,762,643**	**TOTAL**
	Operating	Coming Online	UC	Planned	Estimated Trade per year	
2012	13195			10300		SA=>GA
2013	13195	0	7560	2740	$187,150,807	
2014	13195	0	7560	2740	$187,150,807	
2015	13195	0	7560	2740	$187,150,807	
2016	14145	950	6610	2740	$172,181,377	
2017	15095	950	6880	1520	$146,412,217	
2018	15095	0	6880	1520	$146,412,217	
2019	15095	0	6880	1520	$146,412,217	
2020	20755	5660	2740	0	$43,770,527	
2021	20755	0	2740	0	$43,770,527	
2022	20755	0	2740	0	$43,770,527	
2023	20755	0	2740	0	$43,770,527	
2024	20755	0	2740	0	$43,770,527	
2025	20755	0	2740	0	$43,770,527	
2026	20755	0	2740	0	$43,770,527	
2027	21975	1220	1520	0	$24,546,627	
2028	21975	0	1520	0	$24,546,627	
2029	21975	0	1520	0	$24,546,627	
2030	23495	1520	0	0	$595,540	
	TOTAL		**TOTAL**	**TOTAL**	**$86,305,531**	**AVERAGE**
	$8,458,970		$1,162,707,245	$382,333,343	**$1,553,499,558**	**TOTAL**
BASE RATES	$/Current MW			$25.35	**$564,736,915.01**	**NET TRADE EFFECT**
	$/Contructed MW			$15,782.64		
	$/Planned MW			$24,634.88		

WNA L PROJECTION						
	Operating	Coming Online	UC	Planned	Estimated Trade per year	
2012	0	0	0	6000		
2013	0	0	1000	5000	$138,957,044	
2014	0	0	1000	5000	$138,957,044	
2015	0	0	1000	3000	$89,687,283	
2016	0	0	3000	3000	$121,252,567	
2017	0	0	3000	3000	$121,252,567	
2018	0	0	3000	3000	$121,252,567	
2019	0	0	3000	3000	$121,252,567	
2020	0	0	6000	0	$94,695,853	GA=>SA
2021	0	0	6000	0	$94,695,853	
2022	0	0	6000	0	$94,695,853	
2023	1000	1000	5000	0	$78,938,558	
2024	1000	0	5000	0	$78,938,558	
2025	1000	0	5000	0	$78,938,558	
2026	3000	2000	3000	0	$47,423,969	
2027	3000	0	3000	0	$47,423,969	
2028	3000	0	3000	0	$47,423,969	
2029	3000	0	3000	0	$47,423,969	
2030	6000	3000	0	0	$152,085	
	TOTAL		**TOTAL**	**TOTAL**	**$86,853,491**	**AVERAGE**
	$532,297.62		$946,958,527.53	$615,872,009.09	**$1,563,362,834.24**	**TOTAL**
	Operating	Coming Online	UC	Planned	Estimated Trade per year	
2012	13107	0	3245	9255		
2013	13107	0	3245	9255	$279,542,721	
2014	13107	0	4245	8255	$270,690,483	
2015	13107	0	5245	7255	$261,838,245	
2016	14057	950	5650	5900	$234,874,032	
2017	15007	950	5700	4900	$211,052,364	
2018	15007	0	7150	3450	$198,216,618	
2019	15007	0	8150	2450	$189,364,380	
2020	15007	0	10600	0	$167,676,397	SA=>GA
2021	15007	0	10600	0	$167,676,397	
2022	16352	1345	9255	0	$146,482,835	
2023	16352	0	9255	0	$146,482,835	
2024	17352	1000	8255	0	$130,725,541	
2025	18352	1000	7255	0	$114,968,246	
2026	19707	1355	5900	0	$93,617,112	
2027	20707	1000	4900	0	$77,859,817	
2028	22157	1450	3450	0	$55,011,740	
2029	23157	1000	2450	0	$39,254,445	
2030	25607	2450	0	0	$649,074	
	TOTAL		**TOTAL**	**TOTAL**	**$154,776,849**	**AVERAGE**
	$7,810,986.02		$1,756,686,981.78	$1,021,485,314.27	**$2,785,983,282.07**	**TOTAL**
BASE RATES	$/Current MW			$25.35	**$1,222,620,447.83**	**NET TRADE EFFECT**
	$/Contructed MW			$15,782.64		
	$/Planned MW			$24,634.88		

WNA H PROJECTION						
	Operating	Coming Online	UC	Planned	Estimated Trade per year	GA=>SA
2012	0	0	0	61000		
2013	0	0	8000	53000	$1,431,909,796	
2014	0	0	17000	44000	$1,352,239,652	
2015	0	0	20000	41000	$1,325,682,937	
2016	0	0	33000	28000	$1,210,603,840	
2017	0	0	36000	25000	$1,184,047,126	
2018	0	0	45000	16000	$1,104,376,981	
2019	0	0	48000	13000	$1,077,820,267	
2020	0	0	61000	0	$962,741,170	
2021	0	0	61000	0	$962,741,170	
2022	0	0	61000	0	$962,741,170	
2023	8000	8000	53000	0	$836,682,813	
2024	17000	9000	44000	0	$694,867,161	
2025	20000	3000	41000	0	$647,595,277	
2026	33000	13000	28000	0	$442,750,447	
2027	36000	3000	25000	0	$395,478,563	
2028	45000	9000	16000	0	$253,662,912	
2029	48000	3000	13000	0	$206,391,028	
2030	61000	13000	0	0	$1,546,198	
	TOTAL		**TOTAL**	**TOTAL**	$836,326,584	**AVERAGE**
	$6,793,131.57		$9,627,411,696.54	$5,419,673,679.98	$15,053,878,508.10	**TOTAL**
	Operating	Coming Online	UC	Planned	Estimated Trade per year	SA=>GA
2012	13107	0	3245	19355		
2013	13107	0	3245	16110	$448,414,826	
2014	13107	0	6245	13110	$421,858,111	
2015	13107	0	8245	11110	$404,153,635	
2016	14057	950	11650	7705	$374,035,844	
2017	15007	950	12700	6655	$364,765,074	
2018	15007	0	16150	3205	$334,224,852	
2019	15007	0	18150	1205	$316,520,375	
2020	15007	0	22600	0	$357,068,102	
2021	15007	0	22600	0	$357,068,102	
2022	16352	1345	21255	0	$335,874,541	
2023	16352	0	21255	0	$335,874,541	
2024	19352	3000	18255	0	$288,602,657	
2025	21352	2000	16255	0	$257,088,068	
2026	25707	4355	11900	0	$188,465,050	
2027	27707	2000	9900	0	$156,950,460	
2028	31157	3450	6450	0	$102,587,794	
2029	33157	2000	4450	0	$71,073,205	
2030	37607	4450	0	0	$953,244	
	TOTAL		**TOTAL**	**TOTAL**	$284,198,804	**AVERAGE**
	$9,053,013.81		$3,650,604,036.83	$1,455,921,429.49	$5,115,578,480.13	**TOTAL**
BASE RATES	$/Current MW			$25.35	**-$9,938,300,027.97**	**NET TRADE EFFECT**
	$/Contructed MW			$15,782.64		
	$/Planned MW			$24,634.88		

APPENDIX C - PROBABILITY OF REALIZING THE WNA HIGH NUCLEAR CAPACITY FORECAST

This appendix documents the current prospects of achieving nuclear capacity growth on the order of the WNA high forecast. WNA currently defines their high forecast as the "maximum nuclear commitment in most nations." In other words, if the best of all possible futures are achieved then the high forecast will reflect the growth of nuclear power. However, WNA states that both the high and low forecasts represent boundaries on the nuclear outlook, and that growth will likely occur somewhere in-between. In order to calibrate the analysis included in the body of this report, an evaluation of the likelihood of achieving the high forecast's enabling conditions was necessary.

Figure C-1 below plots historical net nuclear capacity changes. The greatest rate of net capacity addition occurred in 1984 and 1985, prior to the Chernobyl accident. Each of these years saw a net capacity addition of between 30 and 35 GWe worldwide. The peak rate of capacity addition was sustained for only two or three years.

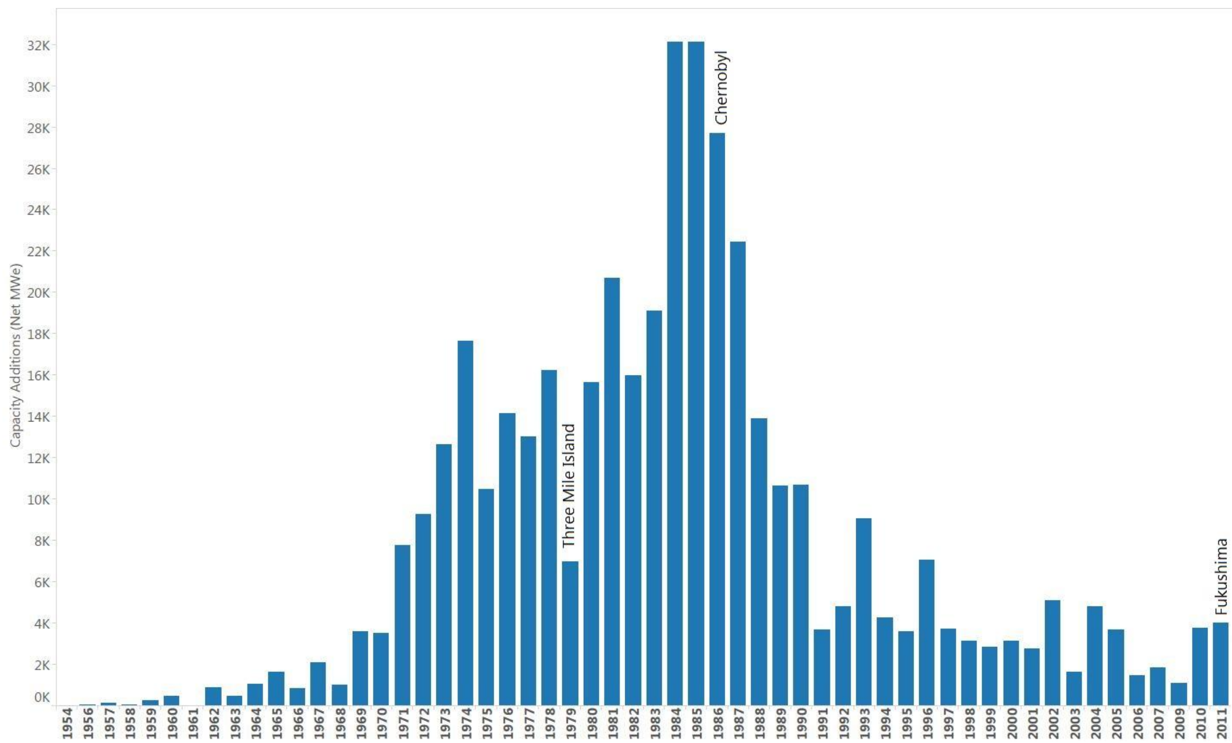


Figure C-1 – Net Nuclear Capacity Additions over Time

(Source: WNA Reactor Database)

Following the Chernobyl accident, net capacity additions declined rapidly, and over the last twenty years, net capacity additions have been on the order of 3- 5 GWe per year worldwide.

The WNA high forecast calls for a worldwide total of 1350 GWe to be operational by 2030, more than 950 GWe greater than the capacity currently on line. Given that nuclear capacity additions during the first part of this forecast window are known with high certainty to be on the order of 100 GWe, this leaves roughly 850 GWE to be deployed in the decade between 2020 and 2030.

Thus the WNA high forecast requires net nuclear generation capacity additions of 85 GWe per year, a rate about 20 times the average observed in the last twenty years, sustained over an entire decade. Given that the rate of plant retirements from the existing stock of plants will be greater in the 2020 to 2030 decade than historically, the rate of new plant construction required will be an even greater multiple of recently observed values, primarily in countries with no experience in nuclear construction.

To demonstrate this, both the WNA high and low forecasts were plotted against the middle 50% of worldwide build rates from 1990-2010, as shown in Figure C- 2.

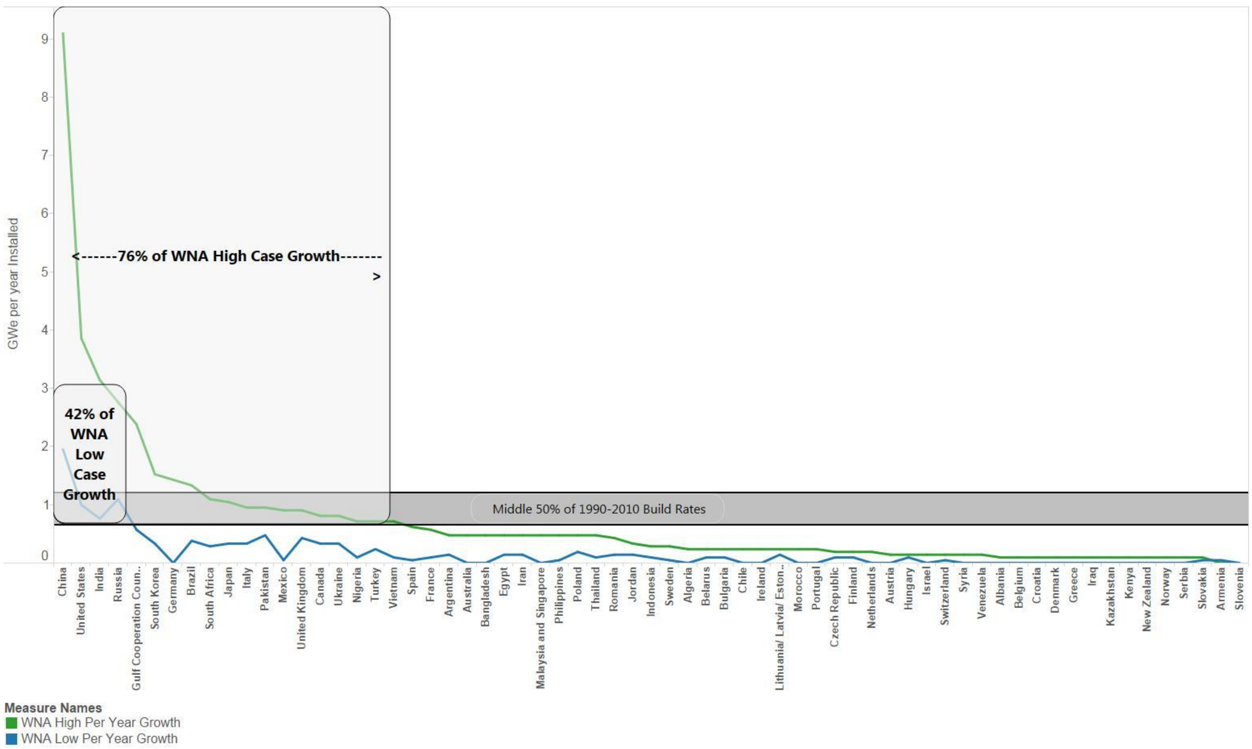


Figure C-2 - Comparison of Past and Projected Nuclear Growth Rates

Figure C-2 demonstrates that more than 76% of projected capacity under the WNA high forecast and 42% of the low forecast will need to be built as fast, if not faster, than the world has ever built reactors previously. Of note is the group of countries comprising these cohorts: in the high forecast, most countries have little to no experience in nuclear construction, while in the low forecast all included countries have significant experience in nuclear construction.

This industrial need raises the question of the nuclear industrial capacity that will be required to achieve these growth rates. Nuclear industrial capacity is defined here as the amount of generation capacity that can be created per unit time. Historically, it required about fifteen years (1970 to 1985) to increase the world's nuclear industrial capacity from its current level (about 5 GWe of net capacity addition per year) to the 30-35 GWe range. This represents a growth rate of almost 14% per year in nuclear industrial capacity. In contrast, the WNA high forecast requires a nuclear industrial capacity growth rate of 49.9 % per year over the next seven years, assuming that the assumptions above hold. Further complicating this is that the 14% per year growth rate was achieved in an era of robust world GDP growth, and that the prospective growth of 49% (per year over seven years) required for the WNA high scenario must occur in a stressed global economic climate. The Conference Board, a private business research association, recently noted that

> The long-term global slowdown we project to 2025 will be driven largely by structural transformations in the emerging economies. As China, India, Brazil, and others mature from rapid, investment-intensive 'catch-up' growth to a more balanced model, the structural 'speed limits' of their economies are likely to decline, bringing down global growth despite the recovery we expect in advanced economies after 2013.

There remains the possibility of an economic or political sea-change that could alter the status quo for nuclear. Both the rate of nuclear capacity growth and the resulting level of nuclear generation capacity implied by the WNA high forecast will require a huge investment in industrial capacity as well as large-scale institution and infrastructure-building. At present the underlying economic and political conditions do not appear amenable to these types of national decisions. Thus, at present the outlook for nuclear growth appears to indicate growth more closely aligned with the WNA low forecast.