Nuclear Power in the USA

(Updated December 2010)

Related pages: US Nuclear Power Policy
US Nuclear Fuel Cycle

- **The USA is the world's largest producer of nuclear power, accounting for more than 30% of worldwide nuclear generation of electricity.**
- **The country's 104 nuclear reactors produced 799 billion kWh in 2009, over 20% of total electrical output.**
- **Following a 30-year period in which few new reactors were built, it is expected that 4-6 new units may come on line by 2018, the first of those resulting from 16 licence applications to build 24 new nuclear reactors made since mid-2007.**
- **Government policy changes since the late 1990s have helped pave the way for significant growth in nuclear capacity. Government and industry are working closely on expedited approval for construction and new plant designs.**

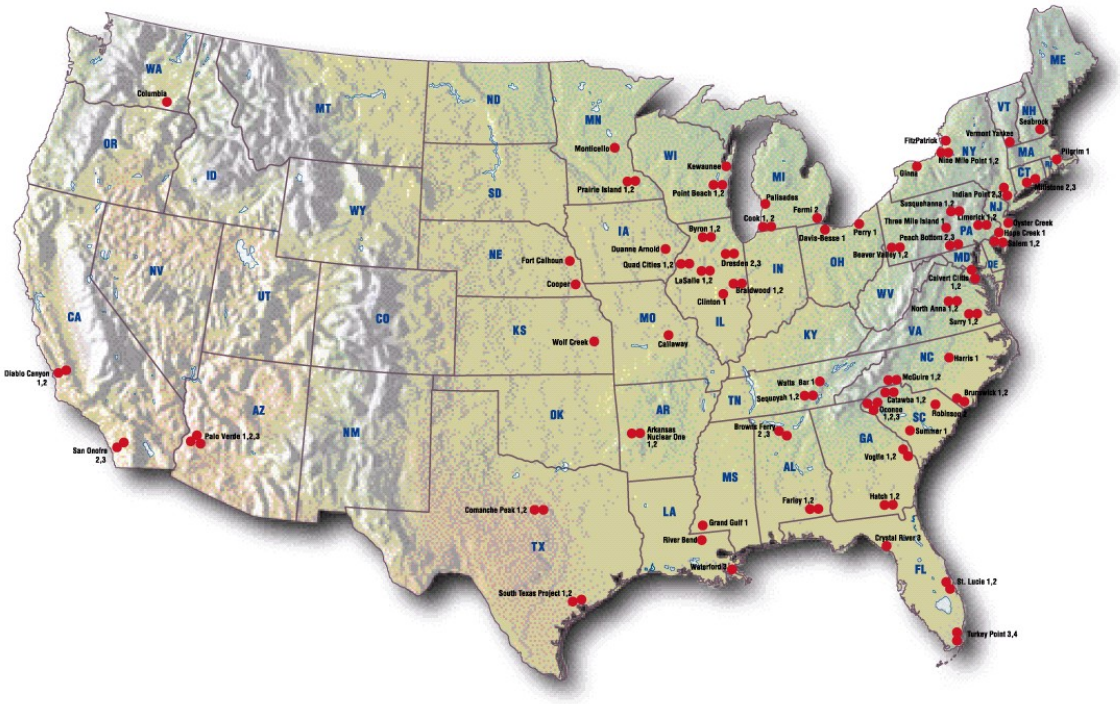
The USA has 104 nuclear power reactors in 31 states, operated by 30 different power companies. In 2008, the country generated 4,119 billion kWh net of electricity, 49% of it from coal-fired plant, 22% from gas and 6% from hydro. Nuclear achieved a capacity factor of 91.1%, generating 805 billion kWh and accounting for almost 20% of total electricity generated in 2008. Total capacity is 1088 GWe, less than one-tenth of which is nuclear.

Annual electricity demand is projected to increase to 5000 billion kWh in 2030. Annual per capita electricity consumption is currently around 12,400 kWh.

There are 69 pressurized water reactors (PWRs) with combined capacity of about 67 GWe and 35 boiling water reactors (BWRs) with combined capacity of about 34 GWe – for a total capacity of 101,263 MWe (see Nuclear Power in the USA Appendix 1: US Operating Nuclear Reactors). Almost all the US nuclear generating capacity comes from reactors built between 1967 and 1990. There have been no new construction starts since 1977, largely because for a number of years gas generation was considered more economically attractive and because construction schedules were frequently extended by opposition, compounded by heightened safety fears following the Three Mile Island accident in 1979. A further PWR – Watts Bar 2 – is expected to start up by 2012 following Tennessee Valley Authority's (TVA's) decision in 2007 to complete the construction of the unit.

Despite a near halt in new construction of more than 30 years, US reliance on nuclear power has continued to grow. In 1980, nuclear plants produced 251 billion kWh, accounting for 11% of the country's electricity generation. In 2008, that output had risen to 809 billion kWh and nearly 20% of electricity, providing more than 30% of the electricity generated from nuclear power worldwide. Much of the increase came from the 47 reactors, all approved for construction before 1977, that came on line in the late 1970s and 1980s, more than doubling US nuclear generation capacity. The US nuclear industry has also achieved remarkable gains in power plant utilisation through improved refuelling, maintenance and safety systems at existing plants.

While there are plans for a number of new reactors (see section on Preparing for new build below), the prospect of low natural gas prices continuing for several years has dampened these plans and probably no more than four new units will come on line by 2020.



Background to nuclear power

The USA was a pioneer of nuclear power development.[a] Westinghouse designed the first fully commercial pressurised water reactor (PWR) of 250 MWe capacity, Yankee Rowe, which started up in 1960 and operated to 1992. Meanwhile the boiling water reactor (BWR) was developed by the Argonne National Laboratory, and the first commercial plant, Dresden 1 (250 MWe) designed by General Electric, was started up in 1960. A prototype BWR, Vallecitos, ran from 1957 to 1963.

By the end of the 1960s, orders were being placed for PWR and BWR reactor units of more than 1000 MWe capacity, and a major construction program got under way. These remain practically the only types built commercially in the USA.[b] Nuclear developments in USA suffered a major setback after the 1979 Three Mile Island accident, though that actually validated the very conservative design principles of Western reactors, and no-one was injured or exposed to harmful radiation. Many orders and projects were cancelled or suspended, and the nuclear construction industry went into the doldrums for two decades. Nevertheless, by 1990 over 100 commercial power reactors had been commissioned.

Most of these were built by regulated utilities, often state-based, which meant that they put the capital cost (whatever it turned out to be after, for example, delays) into their rate base and amortised it against power sales. Their consumers bore the risk and paid the capital cost. (With electricity deregulation in some states, the shareholders bear any risk of capital overruns and power is sold into competitive markets.)

Operationally, from the 1970s the US nuclear industry dramatically improved its safety and operational performance, and by the turn of the century it was among world leaders, with average net capacity factor over 90% and all safety indicators exceeding targets.

This performance was achieved as the US industry continued deregulation, begun with passage of

the Energy Policy Act in 1992. Changes accelerated after 1998, including mergers and acquisitions affecting the ownership and management of nuclear power plants. Further industry consolidation is likely.

Improved performance

At the end of 1991 (prior to passage of the Energy Policy Act), there was 97,135 MWe of operable nuclear generating capacity in the USA. In March 2009, it was 101,119 MWe. The small increase conceals some significant changes:

- A decrease of 5,709 MWe, due to the premature shutdown of eight reactors, due to their having high operating costs.
- A net increase of 6,223 MWe, due to changes in power ratings.
- An increase of 3,470 MWe due to the start-up of two new reactors (Comanche Peak 2, Watts Bar 1) and the restart of one unit (Browns Ferry 1).

So far, some 135 uprates have been implemented, totalling 5810 MWe[c]. The Shaw Group has undertaken about half of the uprates so far, and early in 2010 it said that companies are planning more uprate projects and aiming for bigger increases than in the past. It perceived a $25 billion market. A further 67 uprate projects are in sight, many being $250 to $500 million each. The largest US nuclear operator, Exelon, has plans to uprate much of its reactor fleet to provide the equivalent of one new power plant by 2017 – some 1,300-1,500 MWe, at a cost of about $3.5 billion. The company has already added 1,100 MWe in uprates over the decade to 2009. In addition to increasing power, many of the uprates involve component upgrades. These improve the reliability of the units and support operating licence extensions, which require extensive review of plant equipment condition[d].

A significant achievement of the US nuclear power industry over the last 20 years has been the increase in operating efficiency with improved maintenance. This has resulted in greatly increased capacity factor (output proportion of their nominal full-power capacity), which has gone from 56.3% in 1980 and 66% in 1990 to 91.1% in 2008. A major component of this is the length of refuelling outage, which in 1990 averaged 107 days but dropped to 40 days by 2000. The record is now 15 days. In addition, average thermal efficiency rose from 32.49% in 1980 to 33.40% in 1990 and 33.85% in 1999.

All this is reflected in increased output even since 1990, from 577 billion kilowatt hours to 809 billion kWh, a 40% improvement despite little increase in installed capacity, and equivalent to 29 new 1,000 MWe reactors.

Ownership consolidation

The US nuclear power industry has undergone significant consolidation in recent years, driven largely by economies of scale, deregulation of electricity prices and the increasing attractiveness of nuclear power relative to fossil generation. As of the end of 1991, a total of 101 individual utilities had some (including minority) ownership interest in operable nuclear power plants. At the end of 1999, that number had dropped to 87, and the largest 12 of them owned 54% of the capacity. With deregulation of some states' electricity markets came a wave of mergers and acquisitions in 2000-1 and today the top 10 utilities account for more than 70% of total nuclear capacity. The consolidation has come about through mergers of utility companies as well as purchases of reactors by companies wishing to grow their nuclear capacity.

In respect to the number of operators of nuclear plants, this has dropped from 45 in 1995 to 25 today, showing a substantial consolidation of expertise.

Mergers

Most of the of nuclear generation capacity involved in consolidation announcements has been associated with mergers, some of which failed due to regulatory opposition.

The $32 billion merger of Unicom and PECO in 2000 to form Exelon created the largest nuclear power producer in the USA, and the third largest in the world. In December 2003, Exelon purchased British Energy's 50% interest in AmerGen, which was originally a 50:50 partnership between PECO and British Energy. AmerGen owned the Clinton, Oyster Creek and Three Mile Island 1 nuclear reactors. Exelon has 10 operating nuclear plants with 17 reactors that generated 20% of US nuclear production in 2007. A proposed merger in 2004 between Exelon, with headquarters in Ilinois, and PSEG in New Jersey was rejected by the State of New Jersey. In 2008, Exelon made a $6.2 billion takeover bid for NRG Energy, which operates the two South Texas reactors, but this was rebuffed in mid-2009.

In 2000, Carolina Power & Light merged with Florida Progress Corporation to become Progress Energy, which now owns five reactors in North Carolina, South Carolina and Florida. Thirty-five percent of the electricity in those three states comes from nuclear power. In 2001, FirstEnergy Corporation, based in Ohio and itself the product of a merger three years earlier, merged with GPU Inc., based in New Jersey. The successor company, FirstEnergy, operates four reactors that provide 28% of the electricity for customers in Ohio, Pennsylvania and New Jersey.

In October 2007, TXU Corp. and Texas Energy Future Holdings Limited Partnership merged to form Energy Future Holdings Corp. The owner and operator of the two unit Comanche Peak nuclear plant is Energy Future Holdings' power generation subsidiary, Luminant.

Another means of consolidation has been via management contracts. The Nuclear Management Company, a joint venture formed in 1999 by four Midwest utilities, was approved by the Nuclear Regulatory Commission as a nuclear operating company. It took over operation, fuel procurement and maintenance of eight nuclear units (4,500 MWe) at six sites, which continue to be owned by the utilities, each with 20% of NMC. These remain responsible for used fuel and decommissioning. As with mergers, the main drivers for NMC were cost reductions and streamlined operations. However, with sales of plants achieving consolidation in that way, only two plants (three reactors) – Monticello and Prairie Island – remained with NMC and these had the same owner. Accordingly the operating licence was transferred back to the owner and NMC was incorporated into Xcel Energy, the parent company, in 2008.

Purchase of reactors

Acquisitions have been skewed toward plants in regions with high electricity rates due to the potential for higher profit margins if the plants' production costs can be reduced. Of the 5,900 MWe involved to mid-2000, half was associated with plants having 1998 production costs above 2.0 cents per kWh. Sellers tended to consider the higher-cost plants as potential liabilities and were willing to get rid of them for a fraction of their book value, whereas the larger utility buyers considered the plants to be potential assets, depending only on their ability to lower the production costs (see Nuclear Power in the USA Appendix 2: Power Plant Purchases).

In the last ten years, there have been 19 reactor purchases, usually in states where electricity pricing has been deregulated (see Nuclear Power in the USA Appendix 2: Power Plant Purchases). The plants acquired were often those with high production costs, offering the potential for increased margins if costs could be reduced. In many cases, large power companies have acquired plants from local utility companies and at the same time entered contracts to sell electricity back to the former owners. Entergy Corporation, for example, bought two reactors from New York Power Authority in 2000 and agreed to make the first 500 MWe of combined output available at 2.9 cents/kWh and the remainder at 3.2 or 3.6 cents/kWh.

Along with Exelon, Entergy is a prominent example of the consolidation that has occurred over the last decade. Originally based in Arkansas, Louisiana, Mississippi and eastern Texas, Entergy has doubled its nuclear generation capacity since 1999 with the acquisition of reactors in New York, Massachussets, Vermont and Michigan, as well as a contract to operate a nuclear plant in Nebraska. Other companies that have increased their nuclear capacity through plant purchases are FPL Group based in Florida (four units), Constellation Energy based in Maryland (three units) and Domininion Resources based in Virginia (two units).

Representing significant international rather than simply US consolidation, Constellation Energy in January 2009 accepted the Electricité de France (EDF) $4.5 billion bid for half of its nuclear power business – more than 60% of its production. The deal gives EDF a major foothold in the USA, with the share of 3,994 MWe at Calvert Cliffs in Maryland, and Nine Mile Point and Ginna in New York. All the five reactors have been granted 20-year licence extensions, and the deal values them at about $2,250/kWe net, but including fuel. (The NY plants were bought by Constellation for $533/kWe without fuel earlier in the decade.) EDF already owned 9.5% of Constellation itself, and had committed $975 million to the UniStar Nuclear Energy joint venture which it set up with Constellation to build, own and operate a fleet of US-EPR units in North America with the "objective of leading the nuclear renaissance in the USA". In October 2010, Constellation pulled out of Unistar and sold its share to EDF for $140 million.

Lifetime extensions and regulation

The Nuclear Regulatory Commission (NRC) is the government agency established in 1974 to be responsible for regulation of the nuclear industry, notably reactors, fuel cycle facilities, materials and wastes (as well as other civil uses of nuclear materials).

In an historic move, the NRC in March 2000 renewed the operating licences of the two-unit Calvert Cliffs nuclear power plant for an additional 20 years. The applications to NRC and procedures for such renewals, with public meetings and thorough safety review, are exhaustive. The original 40-year licences for the 1970s plants were due to expire before 2020, and the 20-year extension to these dates means that major refurbishing, such as replacement of steam generators, can be justified.

As of November 2010, the NRC had extended the licences of 60 reactors, over half of the US total. The NRC is considering licence renewal applications for further units, with more applications expected by 2013. In all, about 90 reactors are likely to have 60-year lifetimes, with owners undertaking major capital works to upgrade them at around 30-40 years.

Also the NRC has a new oversight and assessment process for nuclear plants. Having defined what is needed to ensure safety, it now has a better-structured process to achieve it, replacing complex and onerous procedures which had little bearing on safety. The new approach yields publicly-

accessible information on the performance of plants in 19 key areas (14 indicators on plant safety, two on radiation safety and three on security). Performance against each indicator is reported quarterly on the NRC web site according to whether it is normal, attracting regulatory oversight, provoking regulatory action, or unacceptable (in which case the plant would probably be shut down).

On the industry side, the Institute of Nuclear Power Operations (INPO) was formed after the Three Mile Island accident in 1979. A number of US industry leaders recognised that the industry must do a better job of policing itself to ensure that such an event should never happen again. INPO was formed to establish standards of performance against which individual plants could be regularly measured. An inspection of each member plant is typically performed every 18 to 24 months.

Preparing for new build

Today the importance of nuclear power in USA is geopolitical as much as economic, reducing dependency on imported oil and gas. The operational cost of nuclear power – 1.87 ¢/kWh in 2008 – is 68% of electricity cost from coal and a quarter of that from gas.

From 1992 to 2005, some 270,000 MWe of new gas-fired plant was built, and only 14,000 MWe of new nuclear and coal-fired capacity came on line. But coal and nuclear supply almost 70% of US electricity and provide price stability. When investment in these two technologies almost disappeared, unsustainable demands were placed on gas supplies and prices quadrupled, forcing large industrial users of it offshore and pushing gas-fired electricity costs towards 10 ¢/kWh.

The reason for investment being predominantly in gas-fired plant was that it offered the lowest investment risk. Several uncertainties inhibited investment in capital-intensive new coal and nuclear technologies. About half of US generating capacity is over 30 years old, and major investment is also required in transmission infrastructure. This creates an energy investment crisis which was recognised in Washington, along with an increasing bipartisan consensus on the strategic importance and clean air benefits of nuclear power in the energy mix.

The Energy Policy Act 2005 then provided a much-needed stimulus for investment in electricity infrastructure including nuclear power. New reactor construction is expected to get under way early in the next decade.

There are three regulatory initiatives which enhance the prospects of building new plants in the next few years. First is the design certification process, second is provision for early site permits (ESPs) and third is the combined construction and operating licence (COL) process. All have some costs shared by the DOE.

US nuclear power reactors under construction, planned and proposed[e]

Site	Technology	MWe gross	Proponent/utility	COL lodgement date	Loan guarantee; start operation
Watts Bar 2[f], TN	Westinghouse PWR	1218 (1177 net)	Tennessee Valley Authority	No COL[f]	On line 2013
Subtotal 'under construction': 1 unit (1218 MWe gross, 1177 MWe net)					
South Texas Project*, TX	ABWR x 2	2712	NRG Energy, Toshiba, Tepco, CPS Energy/STP Nuclear (merchant plant)	20/9/07	short list loan guarantee; 2016, 17

Vogtle*[g], GA	AP1000 x 2	2400	Southern Nuclear Operating Company	24/7/08	granted loan guarantee; 2016, 17
Virgil C. Summer, SC	AP1000 x 2	2400	South Carolina Electric & Gas	31/3/08	short list loan guarantee; 2016, 19
Calvert Cliffs*, MD	US EPR	1710	UniStar Nuclear (merchant plant)	7/07 and 13/3/08	short list loan guarantee; 2017
Levy County, FL	AP1000 x 2	2400	Progress Energy	30/7/08 but delayed	2021-22
Subtotal 'planned': 9 units (11,622 MWe gross)					
Bellefonte 1 or 3[g, h], AL	B&W PWR or AP1000	1263 or 1200	Tennessee Valley Authority	30/10/07 for unit 3 (and unit 4)[h] but COL review suspended	
North Anna*, VA	US-APWR[i]	1700	Dominion	20/11/07	2018
William States Lee III, SC	AP1000 x 2	2400	Duke Energy	13/12/07	2021, 2023
Shearon Harris, NC	AP1000 x 2	2400	Progress Energy	19/2/08	2020
Grand Gulf, MS	ESBWR[i]	1600	Entergy	27/2/08 but COL application review suspended for some years	
Fermi, MI	ESBWR	1600	Detroit Edison	18/9/08 but no decision to proceed	
Comanche Peak, TX	US-APWR x2	3400	Luminant (merchant plant)	19/9/08	2019, 2020
River Bend, LA	ESBWR[i]	1600	Entergy	25/9/08 but COL application review suspended	
Nine Mile Point, NY	US EPR	1710	UniStar Nuclear (merchant plant)	30/9/08 but COL application review partially suspended	
Bell Bend (near Susquehanna), PA	US EPR	1710	PPL merchant plant	10/10/08	2018-20
Turkey Point, FL	AP1000 x 2	2400	Florida Power & Light	30/6/09	2022, 2023
Hammett, ID	AP1000, US-APWR or APR-1400	1200, 1700 or 1455	Alternate Energy Holdings Inc. (merchant plant)	Expected 2011-12	
Amarillo, TX	US EPR x 2	3420	Amarillo Power (merchant plant)	Expected 2010	
Blue Castle, UT	? x 2	2400-3420	Transition Power Development		
Piketon (DOE site leased to USEC), OH	US EPR	1710	Duke Energy		
Salem/Hope Creek, NJ	To be decided in 2012	Perhaps 1200	PSEG	ESP only	On line 2021
Subtotal 'proposed': 22 units (ca. 32,000 MWe gross), 11 COL applications to March 2010, including 3 suspended					
Victoria County[j], TX	2, unspecified	perhaps. 2400	Exelon (merchant plant)	03/9/08 but withdrawn, Now ESP only, 25/3/10	12/07 MHI
Callaway[j], MO	US EPR	1710	AmerenUE	24/7/08. Now suspended, project cancelled	Areva had ordered forgings

NB: WNA reactor table lists South Texas Project (2 units), Vogtle (2 units), Summer (2 units), Calvert Cliffs and Levy County (2 units) – total 9 units and 11,662 MWe – as 'Planned', on the basis of various announced commitments. Site work is well under way at Vogtle, and has also started at Summer.

Design certification

As part of the effort to increase US generating capacity, government and industry have worked closely on design certification for advanced Generation III reactors. Design certification by the

Nuclear Regulatory Commission (NRC) means that, after a thorough examination of compliance with safety requirements, a generic type of reactor (say, a Westinghouse AP1000) can be built anywhere in the USA, only having to go through site-specific licensing procedures and obtaining a combined construction and operating licence (see below) before construction can begin. Design certification needs to be renewed after 15 years.

Designs now having design certification and being actively marketed are:

- The GE Hitachi advanced boiling water reactor (ABWR) of 1300-1500 MWe. Several ABWRs are now in operation in Japan, with more under construction there and in Taiwan. Some of these have had Toshiba involved in the construction, and it is now Toshiba that is promoting the design most strongly in the USA.[k]
- The Westinghouse AP1000 is the first Generation III+ reactor to receive certification.[l] It is a scaled-up version of the Westinghouse AP600 which was certified earlier. It has a modular design to reduce construction time to 36 months. The first of many of them is being built in China. Westinghouse has submitted revisions to its design, and the NRC has requested another change, so the revised design will not be cleared until early 2010.

Reactor designs undergoing design certification are:

- GE Hitachi's Economic Simplified BWR (ESBWR) of 1550 MWe, developed from the ABWR. The ESBWR has passive safety features and is included in the proposals of several companies planning to build new reactors. GE Hitachi submitted the application in August 2005, with design certification then expected in 2010, but in 2009 it submitted a revised application which extended the schedule to September 2011.
- The US Evolutionary Power Reactor (US EPR), an adaptation of Areva's EPR to make the European design consistent with US electricity frequencies. The main development of the type will be through UniStar Nuclear Energy, but other US proposals also involve it. The application was submitted in December 2007 and approval is expected in February 2012. The 1600 MWe Generation III EPR is being built in Finland, France, and Guangdong in China.
- The Mitsubishi US-APWR, a 1700 MWe design developed from the design for a reactor about to be built at Tsuruga in Japan. The application was submitted in December 2007 and approval is expected early in 2012. Two US-APWR reactors have been proposed in the Luminant-Mitsubishi application for Comanche Peak, and one for Dominion's North Anna.

In addition:

- The Korean APR-1400 reactor, which has been sold to the United Arab Emirates, is the subject of discussion with the NRC, and a design certification application is likely about 2012.
- The Babcock & Wilcox 125 MWe modular mPower reactor is expected to be submitted for design certification late in 2012. TVA is considering an initial pair of these for its Clinch River site, and expects to decide on this in 2011 (see section on mPower in the information page on *Small Nuclear Power Reactors*).

A fuller account of new reactor designs, including those certified but not marketed in the USA, is in the information page on Advanced Nuclear Power Reactors, or for the mPower and other small modular reactors, in the page on Small Nuclear Power Reactors.

Early site permit

The 2001 early site permit (ESP) program attracted four applicants: Exelon, Entergy, Dominion and Southern, for Clinton, Grand Gulf, North Anna and Vogtle sites respectively – all with operating nuclear plants already but room for more. In March 2007, Exelon was awarded the first ESP for its Clinton plant in Illinois, after 41 months processing by the NRC and public review. The NRC then awarded ESPs to Entergy for its Grand Gulf site, Dominion for North Anna, and Southern for Vogtle.

No plant type is normally specified with an ESP application, but the site is declared suitable on safety, environmental and related grounds for a new nuclear power plant.

In March 2010, Exelon applied for an ESP for its Victoria County, TX, site and withdrew the COL application for that project. PSEG Nuclear lodged an application for an ESP for a reactor at its Salem/Hope Creek site on the Delaware River in New Jersey in May 2010, and expects it to take three years to process.

Combined construction and operating licence

In 2003, the Department of Energy (DOE) called for combined construction and operating licence (COL) proposals under its Nuclear Power 2010 program on the basis that it would fund up to half the cost of any accepted. The COL program has two objectives: to encourage utilities to take the initiative in licence application, and to encourage reactor vendors to undertake detailed engineering and arrive at reliable cost estimates. For the first, DOE matching funds of up to about $50 million are available, and for the second, up to some $200 million per vendor, to be recouped from royalties.

Several industry consortia have been created for the purpose of preparing COL applications for new reactors. By mid-2009, COL applications for 26 new units at 17 sites had been submitted to the Nuclear Regulatory Commission. A summary of submitted and expected applications is given in the Table above (New US nuclear power reactors), and further information is given in Nuclear Power in the USA Appendix 3: COL Applications.

Advance orders for heavy forgings

Several companies have ordered heavy forgings and other long lead time equipment for building new plants, in advance of specific plans or approvals. Some have even proceeded to full engineering, procurement and construction (EPC) agreements while the relevant COL applications are being processed, thus indicating a strong probability of actually building the plants concerned. These are indicated in the above Table and further details are given in Nuclear Power in the USA Appendix 3: COL Applications.

Reactors under construction and firmly planned

Watts Bar 2

While the focus is on new technology, TVA undertook a detailed feasibility study which led to its decision in 2007 to complete unit 2 of its Watts Bar nuclear power plant in Tennessee. The 1177 MWe reactor is expected to come on line in 2013 at a cost of about $2.5 billion. Construction was suspended in 1985 when 80% complete and resumed in October 2007 under a still-valid permit, and is progressing on time and budget. Its twin, unit 1, started operation in 1996. Completing Watts Bar 2 utilizes an existing asset, thus saving time and cost relative to alternatives for new baseload capacity. It was expected to provide power at 4.4 ¢/kWh, 20-25% less than coal-fired or new nuclear alternatives and 43% less than natural gas.

South Texas Project 3 & 4

This is to be a merchant plant with two 1356 MWe Advanced Boiling Water Reactors[m]. NRG Energy already operates two reactors at the site, and works are under way preparing for the new

units. With Toshiba, NRG is part of Nuclear Innovation North America (NINA), which awarded the EPC contract to Shaw Group and Toshiba America Nuclear Energy in November 2010[m]. The COL review by the NRC is expected to be completed in the first half of 2012, and the units are expected on line in 2016 and 2017. One reactor pressure vessel was ordered from IHI in May 2010.

Vogtle 3 & 4

Site works are largely complete in preparation for two 1200 MWe Westinghouse AP1000 reactors. Some of the reactor steelwork is on site. In April 2008, Georgia Power signed an EPC contract with Westinghouse and The Shaw Group consortium. Southern Nuclear has been awarded government loan guarantees, the COL review by NRC is due to be complete early in 2011, and a licence is expected mid 2012. The units are expected on line in 2016 and 2017.

Summer 2 & 3

Site works are well advanced for two 1200 MWe Westinghouse AP1000 reactors. In May 2008, South Carolina Electricity & Gas and Santee Cooper signed an EPC contract with Westinghouse and the Shaw Group consortium. The total cost of $9.8 billion includes forecast inflation and owners' costs for site preparation, contingencies and project financing. The COL review by the NRC is due to be completed early in 2011 and the units are expected to enter commercial operation in 2016 and 2019.

Calvert Cliffs 3

Unistar, now owned by EDF, plans to build a 1710 MWe Areva US-EPR alongside Constellation's units 1 & 2, as a merchant plant. The NRC design certification for US-EPR is due in late 2011, but the COL – originally expected in 2012 – will require a new US partner for the project.

Calvert Cliffs 3 will have a closed-loop cooling system using a single hybrid mechanical draft cooling tower, giving it a much larger footprint than units 1 & 2 together. It will also have a reverse osmosis desalination plant for potable water, producing 4700 m^3/day.

Levy County

Site works have started for two 1200 MWe Westinghouse AP1000 reactors on a Greenfield site in Florida. In September 2008, Progress Energy Florida signed an EPC contract with Westinghouse and The Shaw Group consortium. The contract is for $7.65 billion ($3462/kWe), of an overall project cost of about $14 billion. The reactors would go on line over 2016-18. A final decision to build will be made when the NRC issues a licence for the project – the COL review is due to be complete in mid-2011.

Other new capacity

TVA upgraded and restarted Browns Ferry 1 in May 2007. The unit had originally commenced commercial operation in 1974 but all three Browns Ferry reactors were shut down in 1985 to address management and operational concerns. Units 2 and 3 were returned to service in 1991 and 1995, respectively. The five-year refurbishment program of unit 1 also increased its power to 1,155 MWe, similar to the newer units 2 & 3.

TVA also has a pair of uncompleted 1,213 MWe PWR reactors: Bellefonte 1 & 2. Construction on these units was abandoned in 1988 after $2.5 billion had been spent and unit 1 largely (88%)

completed and unit 2 about 58% completed. In February 2009, the NRC reinstated the construction permits for these (and later the status of the reactors classified as 'deferred'). Today unit 1 is considered about 55% complete due to the transfer or sale of many components and the need to upgrade or replace others. TVA is considering the option of completing unit 1 or building a new AP1000 reactor as unit 3 (see Appendix 3: COL Applications). In August 2010, TVA committed to spending $248 million to September 2011 towards completing unit 1, though a final board decision on the question is deferred until early 2011.[8] An engineering contract was awarded to Areva SA in October 2010 for work on unit 1, including engineering, licensing and procurement of long-lead materials in support of a possible start-up date in the 2018-19 timeframe. Also TVA asked the NRC to defer consideration of its COL for units 3 & 4. Cost estimates for unit 1 range from $4.3 to $4.7 billion.

In April 2010, Areva signed an agreement with Fresno Nuclear Energy Group for a clean-energy park near Fresno in California, including a 1600 MWe EPR and solar plant. Possible locations are being investigated.

Financial incentives

The Energy Policy Act of 2005 provided financial incentives for the construction of advanced nuclear plants. The incentives include a 2.1 cents/kWh tax credit for the first 6,000 MWe of capacity in the first eight years of operation, and federal loan guarantees for the project cost. After putting this program in place in 2008, the DOE received 19 applications for 14 plants involving 21 reactors. The total amount of guarantees requested is $122 billion, but only $18.5 billion has been authorized for the program. In light of the interest shown, industry has asked that the limit on total guarantees be raised to $100 billion.

For further discussion see information page on US Nuclear Power Policy.

Future nuclear reactor designs

After 20 years of steady decline, government R&D funding for nuclear energy is being revived with the objective of rebuilding US leadership in nuclear technology.

In an effort that brings together government research laboratories, industry and academe, the Federal government has significantly stepped up R&D spending for future plants that improve or go well beyond current designs. There has been particular attention to the Next Generation Nuclear Plant (NGNP) project to develop a Generation IV high-temperature gas-cooled reactor, which would be part of a system that would produce both electricity and hydrogen on a large scale. The DOE has stated that its goal is to have a pilot plant ready at its Idaho National Laboratory (INL) by 2021. The total development cost has been estimated at $2 billion. General Atomics, Areva and Westinghouse/PBMR have been awarded pre-conceptual design contracts. See also information page on US Nuclear Power Policy.

Savannah River Nuclear Solutions (SRNS), which manages the Savannah River Site (SRS) in South Carolina on behalf of the DOE, has proposed a demonstration complex with prototype or demonstration models of up to 15 small reactors. Hyperion has signed an agreement to build the first (see section on Hyperion Power Module in the information page on *Small Nuclear Power Reactors*), and SRNS has approached several other small-reactor developers, including General Atomics (re GT-MHR or EM2), GE Hitachi (re PRISM) and Terrapower. It is understood that the DOE has the authority to build and operate such small reactors if they are not supplying electricity to

the grid.

Further Information

Appendices

Appendix 1: US Operating Nuclear Reactors
Appendix 2: Power Plant Purchases
Appendix 3: COL Applications

Related information pages

US Nuclear Power Policy
US Nuclear Fuel Cycle

Notes

a. The first nuclear reactor in the world to produce electricity (albeit a trivial amount) was the small Experimental Breeder Reactor (EBR-1) in Idaho, which started up in December 1951. In 1953, President Eisenhower proposed his *Atoms for Peace* program, which reoriented significant research effort towards electricity generation and set the course for civil nuclear energy development in the USA. The Mark 1 naval reactor of 1953 led to the US Atomic Energy Commission building the 60 MWe Shippingport demonstration PWR reactor in Pennsylvania, which started up in 1957 and operated until 1982. [Back]

b. Fort St. Vrain in Colorado was a 330 MWe high-temperature gas-cooled reactor (HTGR) operating 1976-89. The technology was developed from an earlier 40 MWe HTGR at Peach Bottom, Pennsylvania, which operated from 1967 to 1974. [Back]

c. To the end of September 2010, the Nuclear Regulatory Commission (NRC) has approved 135 power uprates totalling 5810 MWe (not including capacity recapture uprates for provisional operating licence plants). A further 10 applications for power uprates totaling 1125 MWe were under review. In addition, the NRC said that it expected to receive 40 power uprate applications by 2014. If approved and implemented, these uprates would add 2400 MWe. Information on power uprates is available on the NRC website (www.nrc.gov/reactors/operating/licensing/power-uprates.html) [Back]

d. Contra to uprates, occasionally plants install equipment such as new cooling towers which increases internal power consumption, and therefore reduces net power slightly (without changing gross power). There is also sometimes a 2-3% difference between summer and winter power, due to cooler ambient temperatures in winter increasing thermal efficiency. [Back]

e. An asterisk (*) denotes reference COL for reactor type. EPC = Engineering, procurement and construction agreement. Merchant plants are without regulated cost recovery. 'Planned' status shows a higher level of commitment – such as an order for large forgings or an EPC contract – than 'Proposed' status. [Back]

f. Construction of Watts Bar 2 was suspended in 1985 and resumed in 2007. In July 2008, the

Nuclear Regulatory Commission issued an order extending the Watts Bar Unit 2 construction permit completion date to 31 March 2013. TVA still requires an operating licence for the reactor. [Back]

g. The site chosen by the NuStart Energy Development consortium for the reference COL application for the AP1000 was originally TVA's Bellefonte. However, NuStart later decided to transfer the AP1000 reference COL application to Vogtle on the grounds that the Vogtle application had "specific near-term construction plans." In May 2009, NuStart announced that it was "consulting with the Nuclear Regulatory Commission and Department of Energy to develop a process for transferring the reference combined construction and operating licence application from TVA's Bellefonte nuclear site to Southern Nuclear's Vogtle Electric Generating Plant."[1] [Back]

h. A COL application for two proposed AP1000 units as units 3 and 4 at TVA's Bellefonte site was submitted to the Nuclear Regulatory Commission in October 2007. This COL application was originally the reference COL application for the AP1000 design but the reference application is being transferred to Vogtle (see Note g above). The site also has two unfinished 1,213 MWe PWRs (unit 1 being about 88% complete and unit 2 about 58% complete) and TVA has been considering all options for the site, including the completion of units 1&2. As of August 2009, the options were narrowed to completing unit 1 or building a single new AP1000 as unit 3.[2] Hence, only one proposed unit for Bellefonte – either unit 1 or 3 – is counted in the Table. [Back]

i. Dominion's North Anna COL application referenced the ESBWR, but in March 2009 it issued a new request for proposals from reactor vendors and in May 2010 it selected the Mitsubishi US-APWR. The COL reviews of Entergy's applications for Grand Gulf and River Bend, along with the review of Exelon's application for the Victoria County site were suspended by the NRC, following the decisions by Entergy and Exelon to review their initial reactor design choice of the ÉSBWR. Exelon had initially proposed two ESBWR units for its Victoria County site but, early in 2009, switched to the ABWR design, to be built by GE-Hitachi. Shortly afterwards, citing adverse economic conditions, Exelon withdrew its COL application and instead said it would submit an early site permit application in late 2009/early 2010. [Back]

j. AmerenUE announced in April 2009 that it was suspending its efforts to build a new unit and in June 2009 the company requested the Nuclear Regulatory Commission to suspend all review activities relating to the Callaway 2 COL application. [Back]

k. The ABWR design that has NRC certification is the GE-Hitachi design, some aspects of which are proprietary to GE-Hitachi. While the licence application for the first new ABWRs to be announced for the USA – at the South Texas Project (STP) – references the certified GE-Hitachi design, Toshiba was selected as the main contractor to build the units. In November 2010, Toshiba submitted an application to renew the design, which includes revisions to bring the certified design in line with the STP units (see Note m below). [Back]

l. The NRC had approved full design certification for the Westinghouse AP1000 in 2005 and issued a final rule certifying the design in January 2006. However, in May 2007, Westinghouse submitted an application to amend the AP1000 final design certification rule. The NRC expects a final safety evaluation report for the amendment to be issued late in 2010. [Back]

m. Since the decision to go ahead with South Texas Project (STP) units 3& 4 was first announced, there have been a number of developments. The combined construction and operating licence (COL) application was prepared by STP Nuclear Operating Company (STPNOC) together with

GE-Hitachi Nuclear Energy and Bechtel and submitted in September 2007.[3] Just before submittal of the COL application, NRG Energy and STPNOC signed a project services agreement with Toshiba to support the design, engineering, construction and procurement of the units. Fluor was then enrolled to support Toshiba[4]. In November 2010, Nuclear Innovation North America LLC (NINA, the nuclear development company jointly owned by NRG Energy and Toshiba) announced that it had awarded the engineering, procurement and construction (EPC) contract to a "restructured EPC consortium" of Toshiba's US subsidiary Toshiba America Nuclear Energy Corporation (TANE) and The Shaw Group[5].

In the meantime, the reactor technology has moved from being based on the GE design certified by the US Nuclear Regulatory Commission in 1997. The design had to be renewed by 2012 and a renewal application by Toshiba was submitted in November 2010.[6] The renewal application includes revisions in accordance with the STP design. Hence, the STP reactors are now considered to be Toshiba ABWRs, whereas the original intention was to use the 1997 certified design "with only a limited number of changes to enhance safety and construction schedules," with these changes incorporated into the COL application[7]. [Back]

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1. NuStart Members Step Toward COL Completion, NuStart Update (1 May 2009) [Back]

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3. NRG Energy Submits Application for New 2,700 Megawatt Nuclear Plant in South Texas, NRG Energy news release (24 September 2007) [Back]

4. Contractors in flux for South Texas Project, World Nuclear News (20 August 2007) [Back]

5. NINA Announces Newly Developed EPC Consortium to Advance South Texas Project, Nuclear Innovation North America news release (29 November 2010) [Back]

6. Toshiba works on ABWR certification, World Nuclear News (4 November 2010) [Back]

7. NRG Forms Company to Develop Advanced Boiling Water Reactor Nuclear Power Projects in North America, NRG Energy news release (25 March 2008) [Back]

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US Operating Nuclear Reactors

Nuclear Power in the USA Appendix 1

(Updated 12 July 2010)

Related page: Nuclear Power in the USA

Reactor	State	Type	Net capacity (MWe)
Arkansas Nuclear One 1	Arkansas	PWR	842
Arkansas Nuclear One 2	Arkansas	PWR	997
Beaver Valley 1	Pennsylvania	PWR	911
Beaver Valley 2	Pennsylvania	PWR	904
Braidwood 1	Illinois	PWR	1,194
Braidwood 2	Illinois	PWR	1,166
Browns Ferry 1	Alabama	BWR	1,040
Browns Ferry 2	Alabama	BWR	1,100
Browns Ferry 3	Alabama	BWR	1,102
Brunswick 1	North Carolina	BWR	938
Brunswick 2	North Carolina	BWR	920
Byron 1	Illinois	PWR	1,164
Byron 2	Illinois	PWR	1,136
Callaway	Missouri	PWR	1,190
Calvert Cliffs 1	Maryland	PWR	873
Calvert Cliffs 2	Maryland	PWR	862
Catawba 1	South Carolina	PWR	1,129
Catawba 2	South Carolina	PWR	1,129
Clinton	Illinois	BWR	1,043
Columbia 2	Washington	BWR	1,131
Comanche Peak 1	Texas	PWR	1,209
Comanche Peak 2	Texas	PWR	1,158
Cooper	Nebraska	BWR	770
Crystal River 3	Florida	PWR	860
Davis Besse	Ohio	PWR	901
Diablo Canyon 1	California	PWR	1,122
Diablo Canyon 2	California	PWR	1,118
Donald C. Cook 1	Michigan	PWR	1,029
Donald C. Cook 2	Michigan	PWR	1,077
Dresden 2	Illinois	BWR	867
Dresden 3	Illinois	BWR	867
Duane Arnold	Iowa	BWR	580
Edwin I. Hatch 1	Georgia	BWR	876
Edwin I. Hatch 2	Georgia	BWR	883
Fermi 2	Michigan	BWR	1,122
Fort Calhoun	Nebraska	PWR	482
Ginna	New York	PWR	581
Grand Gulf 1	Mississippi	BWR	1,259
H.B. Robinson 2	South Carolina	PWR	710
Hope Creek 1	New Jersey	BWR	1,210
Indian Point 2	New York	PWR	1,025

Indian Point 3	New York	PWR	1,040
James A. Fitzpatrick	New York	BWR	854
Joseph M. Farley 1	Alabama	PWR	851
Joseph M. Farley 2	Alabama	PWR	860
Kewaunee	Wisconsin	PWR	556
La Salle 1	Illinois	BWR	1,118
La Salle 2	Illinois	BWR	1,120
Limerick 1	Pennsylvania	BWR	1,130
Limerick 2	Pennsylvania	BWR	1,134
McGuire 1	North Carolina	PWR	1,100
McGuire 2	North Carolina	PWR	1,100
Millstone 2	Connecticut	PWR	877
Millstone 3	Connecticut	PWR	1,227
Monticello	Minnesota	BWR	572
Nine Mile Point 1	New York	BWR	621
Nine Mile Point 2	New York	BWR	1,143
North Anna 1	Virginia	PWR	903
North Anna 2	Virginia	PWR	903
Oconee 1	South Carolina	PWR	846
Oconee 2	South Carolina	PWR	846
Oconee 3	South Carolina	PWR	846
Oyster Creek 1	New Jersey	BWR	615
Palisades	Michigan	PWR	778
Palo Verde 1	Arizona	PWR	1,311
Palo Verde 2	Arizona	PWR	1,314
Palo Verde 3	Arizona	PWR	1,317
Peach Bottom 2	Pennsylvania	BWR	1,112
Peach Bottom 3	Pennsylvania	BWR	1,112
Perry 1	Ohio	BWR	1,245
Pilgrim 1	Massachusetts	BWR	685
Point Beach 1	Wisconsin	PWR	510
Point Beach 2	Wisconsin	PWR	516
Prairie Island 1	Minnesota	PWR	551
Prairie Island 2	Minnesota	PWR	545
Quad Cities 1	Illinois	BWR	867
Quad Cities 2	Illinois	BWR	867
River Bend 1	Louisiana	BWR	978
Salem 1	New Jersey	PWR	1,175
Salem 2	New Jersey	PWR	1,175
San Onofre 2	California	PWR	1,070
San Onofre 3	California	PWR	1,080
Seabrook 1	New Hampshire	PWR	1,245
Sequoyah 1	Tennessee	PWR	1,152
Sequoyah 2	Tennessee	PWR	1,130
Shearon Harris 1	North Carolina	PWR	900
South Texas Project 1	Texas	PWR	1,280
South Texas Project 2	Texas	PWR	1,280
St. Lucie 1	Florida	PWR	839
St. Lucie 2	Florida	PWR	839
Surry 1	Virginia	PWR	799
Surry 2	Virginia	PWR	799
Susquehanna 1	Pennsylvania	BWR	1,280
Susquehanna 2	Pennsylvania	BWR	1,230

Three Mile Island 1	Pennsylvania	PWR	786
Turkey Point 3	Florida	PWR	693
Turkey Point 4	Florida	PWR	693
V.C. Summer	South Carolina	PWR	966
Vermont Yankee 1	Vermont	BWR	620
Vogtle 1	Georgia	PWR	1,150
Vogtle 2	Georgia	PWR	1,152
Waterford 3	Louisiana	PWR	1,176
Watts Bar 1	Tennessee	PWR	1,100
Wolf Creek 1	Kansas	PWR	1,160
Total (104 units)			**101,216**

Source: US EIA data via Nuclear Energy Institute 5/2010, updated from company sources

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Related information pages

Nuclear Power in the USA

Power Plant Purchases

Nuclear Power in the USA Appendix 2

(Updated July 2009)

Related page: Nuclear Power in the USA

In mid-1999, the 670 MWe Pilgrim plant was sold to Entergy by Boston Edison for $14 million plus $67 million for fuel.

AmerGen, the joint venture of British Energy and PECO Energy (now Exelon), completed its purchase of the 930 MWe Clinton nuclear plant and the 790 MWe Three Mile Island plant at the end of 1999. However, its plan to acquire control of the two-unit Nine Mile Point nuclear power station (614 & 1140 MWe) was derailed by a minor shareholder exercising its veto. Constellation later bid successfully for the units.

In 1999, AmerGen won the *Boldest Successful Investment Decision* award from the *Financial Times*. AmerGen was cited as "a huge success ... with expected strong financial returns" and "a bold investment which has created new confidence in the US nuclear industry."

In March 2000, Entergy Corporation reached agreement to buy the New York Power Authority's (NYPA) Indian Point 3 (965 MWe) and Fitzpatrick (778 MWe) nuclear power plants for $967 million, topping a bid by Dominion Resources. The complexity of the transaction is indicated by the terms that included $636 million for the two mid-1970s units, nearly $171 million for the fuel, $92 million to reduce NYPA's decommissioning obligation, and other amounts related to power purchase. There are also provisions for further payments if licences for the 25 year old plants are extended. NYPA retains the $630 million decommissioning funds and pay them when required, while Entergy accepts the $250 million risk of any adverse tax ruling on these. Up to 500 MWe of the combined output is available to NYPA at 2.9 cents/kWh, the remainder at 3.2 or 3.6 cents/kWh. The sale closed in November 2000.

In November 2000, Entergy became the successful bidder for Con Edison's (ConEd) 939 MWe Indian Point 2 unit (including the shut down unit 1 and 76 MWe of gas turbine capacity). The price was $502 million plus about $100 million for fuel. The companies also entered into a power purchase agreement for Entergy to sell the output of Indian Point 2 to Con Edison at an average of 3.9 cents/kWh through the end of 2004, as well as a capacity purchase transaction agreement for Entergy to sell the installed capacity of Indian Point 2 to Con Edison through April 2005, with options for capacity purchases for another six years.

In June 2000, AmerGen received approval to purchase the elderly 650 MWe Oyster Creek plant for $10 million, and the 522 MWe Vermont Yankee plant for $61 million. However, the latter deal was vetoed by state regulators and the plant was auctioned.

In August 2000, Dominion Resources agreed to pay $1.3 billion in cash for the Millstone nuclear plant, about $600 for each kilowatt of generating capacity. The Northeast Utilities plant comprises the 1150 MWe unit 3 and the 858 MWe unit 2, which were 14 and 25 years old at the time of the deal. Unit 1, which is being decommissioned, was also included. The price included $105 million

for fuel, but only 93.5% of unit 3, since minority shareholders wished to remain.

In December 2000, Constellation Energy, owner of Calvert Cliffs nuclear power plant, agreed to buy Nine Mile Point for $815 million from Niagara Mohawk Power Corporation and other utilities. The deal included unit 1 (609 MWe, started in 1969) and 82% of unit 2 (1,148 MWe, started 1988) for $737 million, plus $78 million for fuel. This is about 3.5 times the price AmerGen agreed to pay for the plant in 1999. Constellation agreed to sell 90% of its output to the vendors for 10 years at about 3.5 cents/kWh. Some $450 million in decommissioning funds were to be transferred to Constellation.

In 2001, PECO (now Exelon) and PSEG concluded the purchase of minor shares in five large reactors from Connectiv Energy.

In August 2001, Entergy Corporation became the successful bidder for the 29-year-old Vermont Yankee power station. Entergy paid $180 million for the 522 MWe plant, $35 million of this for fuel. I took over both the decommissioning liability and the existing fund for this. Power is sold to local utilities (former owners) for 3.9 to 4.5 cents/kWh to 2012. Entergy paid almost three times the price which had been agreed in 2000 with AmerGen.

In April 2002, FPL Energy became the successful bidder for 88.2% of the 12-year-old Seabrook plant. The utility agreed to pay six utility vendors $836.6 million for the share in the 1161 MWe PWR reactor, being $749.1 million for the plant (including decommissioning trust fund), $61.9 million for fuel and the balance for components of an uncompleted second unit. FPL Energy is the US leader in wind energy generation and a sister company to Florida Power & Light, which operates four PWR units.

In September 2003, British Energy (BE) agreed to sell its most profitable asset - the half share of US utility AmerGen - to FPL Energy for $276.5 million. The proposed deal was the result of its plan to realise the value of its AmerGen equity independently of Exelon, its joint venture partner. Exelon then exercised its right of first refusal and bought the share. The sale was required by the UK government's restructuring provisions for BE. In 2008, Amergen was absorbed into Exelon.

In November 2003, Dominion agreed to pay $220 million cash for Kewaunee, a 540 MWe Wisconsin reactor, the figure including $36.5 million for fuel. The sale was finalised in July 2005. Some $392 million in decommissioning funds were transferred.

Also in November 2003, Constellation Energy agreed to buy the R E Ginna nuclear power plant from New York utility Rochester Gas and Electric Corporation (RG&E) for $401 million plus $21.6 million for fuel. The 495 MWe PWR started up in 1969 and is among the best-performing in the US. The sale was contingent upon the licence extension taking its life to 2029. (The Nuclear Regulatory Commission approved the licence renewal in May 2004.) A planned uprate enabled by a steam generator replacement in 1996 increased capacity to 610 MWe. A sales contract commits 90% of ten years output to RG&E at 4.4 cents/kWh average.

In March 2004, Cameco Corporation agreed to buy American Electric Power's 25.2% stake in the South Texas Project plant - two 1,250 MWe PWRs which started up 1988-89 - for $279 million plus fuel, but two of the owners - Texas Genco Holdings and City Public Service Board of San Antonio - then exercised right of first refusal, leaving Cameco with a $7 million consolation fee. (Texas Genco was acquired by NRG Energy in 2005.)

In July 2005, FPL Energy agreed to pay $380 million for 70% of the Duane Arnold BWR (600 MWe

capacity, following an uprate approved in November 2001) from an Alliant Energy subsidiary, which continued to buy the power. The plant is run by Nuclear Management Company and a licence extension application was submitted in September 2008.

In July 2006, Entergy agreed to buy the 798 MWe Palisades nuclear power plant from CMS subsidiary Consumers Energy for $242 million ($301/kWe) plus $83 million for the fuel and $55 million for other assets. It started up in 1971 and a 20-year licence extension to 2031 was granted early in 2007. Entergy is selling all the power back to Consumers Energy for 15 years. Responsibility for eventual decommissioning of the plant was transferred to Entergy, though the vendor retained $200 million of the $566 million decommissioning funds, with the later return of $116 million more pending a favorable federal tax ruling.

In December 2006, FPL Energy agreed to buy the Point Beach nuclear plant. The two units total 1012 MWe and had just had licences extended to 2030 and 2033. The vendor is Wisconsin's We Energies, which continues to buy the power. The final price was $719 million for the plant, plus $205 million for fuel and inventory. FPL assumed responsibility for decommissioning and $390 million in trust funds were transferred to FPL for this. The deal was approved in September 2007.

Also in December 2006, Duke Energy and North Carolina Electric Membership Corporation (NCEMC) announced agreements to purchase Saluda River Electric Cooperative's 19% ownership interest in unit 1 of the Catawba nuclear plant in South Carolina. Duke paid $158 million for about 72% (approximately 154 MWe) of Saluda River's stake, and NCEMC paid $42 million for the remaining 28% (approximately 60 MWe) share. Following the deal, NCEMC and Duke Energy own approximately 62% and 38% of Catawba 1, respectively.

The private equity buyout of TXU Corporation, with its two 1,150 MWe Comanche Peak reactors, announced in February 2007 was completed in October of that year. TXU has become Energy Future Holdings Corp which comprises three operations: TXU Energy for retail, Luminant for power generation and Oncor for transmission and distribution. Luminant has taken over plans to build two new 1700 MWe Mitsubishi US-APWR reactors at Comanche Peak in Texas and possibly others as well. Plans for eight coal-fired plants were scrapped earlier in the year. Environment groups have supported the buyout with its changed policies, and a new director who is chairman of one such group "will lead the effort to make climate stewardship central to corporate policies."

In December 2008, Constellation Energy accepted a bid by Electricité de France (EDF) for half of its nuclear business, which consists of two reactors at Calvert Cliffs in Maryland, two at Nine Mile Point in New York and the Ginna reactor in New York. All the five reactors have been granted 20-year licence extensions, and the deal values them at about $2250/kWe net. The New York plants were bought by Constellation for $533/kW earlier in the decade.

US nuclear power plant purchases since mid-1998

Buyer	Reactors	Net MWe sold	Plant price $ million	Sale completed (expected)	P
Entergy	Pilgrim	670	14	July 1999	
AmerGen	Three Mile Island	786	23	Dec 1999	
AmerGen	Clinton	924	20	Dec 1999	
AmerGen	Oyster Creek	619	10	Aug 2000	

PECO (Exelon) et al	Peach Bottom, Hope Creek, Salem	714	20	Jan & Oct 2001
Entergy	Fitzpatrick & Indian Point 3	1743	636	Nov 2000
Entergy	Indian Point 2	939	502	Sept 2001
Dominion	Millstone	1947	1193	March 2001
Constellation	Nine Mile Point	1536	675	Nov 2001
Entergy	Vermont Yankee	510	145	July 2002
FPL Energy	Seabrook	1024	749	Nov 2002
Exelon	Clinton, TMI, Oyster Creek	1210	276	Oct 2003
Constellation	R E Ginna	495	408	June 2004
Genco & CPS	South Texas	630	279	May 2005
Dominion	Kewaunee	540	192	July 2005
FPL Energy	Duane Arnold	419	300	Jan 2006
Entergy	Palisades	798	242	April 2007
FPL Energy	Point Beach	1012	719	Sept 2007
Duke, NCEMC	Catawba	229	200	
EDF	Calvert Cliffs, Nine Mile Point, Ginna	1997	4500	(2009)

** Price excludes fuel*
*** Value based on years between announcement and end of operating licence*

Further Information

General sources

U.S. Nuclear Plant Sales table on the Nuclear Energy Institute website (www.nei.org)

Related information pages

Nuclear Power in the USA

COL Applications

Nuclear Power in the USA Appendix 3

(Updated 29 October 2010)

Related page: Nuclear Power in the USA

The US Department of Energy (DOE) has made provision for companies to apply for combined construction and operating licences (COLs) for new nuclear power plants, with costs being shared by DOE (see page on US Nuclear Policy). COL applications for 26 new nuclear reactors at 17 sites had been submitted to the US Nuclear Regulatory Commission (NRC) by mid-2009. The NRC expects applications for a further seven reactors by 2010.

COL applications are lodged with a particular design and site nominated, though the design certification need not be complete. The NRC is expected to take at least three years to review each COL application, although the NRC estimates 42 months for processing the first few applications.

Most of the COLs are for plants in regulated electricity markets, where state government and regulators allow utilities to adjust rates so that they can recoup financing costs of new plants over a longer period before the plants become operational. This lowers the overall cost of each new plant and, ultimately, the price of electricity to the consumer. Elsewhere, merchant plants are without regulated cost recovery and must bear all financing costs as part of the capital commitment, to be recovered after the plant becomes operational.

NuStart Energy Development

NuStart Energy Development was formed in 2004 to use the NRC's licensing process for obtaining a combined construction and operating licence for an advanced nuclear power plant, and to complete the design engineering for two reactor technologies. The consortium comprises ten major utilities brought together by Entergy and representing more than half of the US nuclear plants.[a] It also involves vendors Westinghouse and General Electric, and will pursue the Westinghouse AP1000 and GE's ESBWR technology options. NuStart is headed by Marilyn Kray, an Exelon senior executive. In May 2005, it signed an agreement with the DOE to split the estimated $520 million cost of completing detailed engineering work on one of the two designs.

In September 2005, NuStart identified Entergy's Grand Gulf site for an ESBWR reactor and Tennessee Valley Authority's (TVA's) Bellefonte site for two AP1000 reactors. Entergy submitted the application for Grand Gulf in February 2008 and, in September 2008, submitted a further application, also referencing the ESBWR design, for its River Bend site. However, early in 2009, Entergy announced it was reviewing its choice of reactor technology and asked the NRC to suspend its review of its COL applications until it had re-evaluated alternative technologies. The project is now suspended for several years. The COL application for the AP1000 units at Bellefonte was submitted by TVA in October 2007, but alternative options are also being considered (see TVA-led consortium below).

Dominion-led consortium

The second consortium is led by Dominion and originally included Atomic Energy of Canada Ltd (AECL), Hitachi and Bechtel. It started to pursue AECL's ACR-700 option, developed from the successful CANDU-6 heavy-water design but with light water cooling. Hitachi and Bechtel were key contributors to the successful completion of recent CANDU plants in China. However, in January 2005, AECL and Hitachi were replaced by General Electric and the ESBWR became the favoured technology. The reason given for this was NRC indication that certification of the ACR design would be very slow, whereas that of the US technology - developed from designs already approved - would be much quicker.

In April 2005, Dominion signed an agreement with the DOE to split the estimated $500 million cost of its COL work on the ESBWR. Then in 2007, GE and Hitachi formed the GE Hitachi partnership, bringing that Japanese expertise back into play. In October 2007, NuStart announced that it was working with Dominion on developing the ESBWR reference application for the North Anna station and, in November 2007, a COL application for an ESBWR at North Anna was filed. About then, the NRC awarded an early site permit for North Anna (with no reactor type specified).

In 2009, Dominion Virginia Power said that it had been unable to negotiate a contract with GE Hitachi, so launched a competitive bidding process, as a result of which the Mitsubishi APWR was selected in May 2010. This will require an amendment to the COL application, and some delay in its processing.

TVA-led consortium

In addition to being a member of NuStart, TVA formed its own consortium consisting of TVA plus Bechtel, Global Nuclear Fuel-Americas and USEC, as well as vendors Toshiba and GE. The consortium carried out a $4 million feasibility study, half funded by the DoE, into constructing two GE ABWRs on the Bellefonte site and found that it could be done in 40 months at a cost of $1611/kWe (at 1,371 MWe) and $1535/kWe (at 1,465 MWe).[1] However, TVA rejected the proposal, apparently because it believed they would be the only ABWR units in the USA. The 1,350 MWe ABWR already has design certification in the USA and was the first Generation III reactor design to enter service (at the Kashiwazaki-Kariwa plant in Japan).

While TVA is still proceeding with the COL application with NuStart for two AP1000 reactors at Bellefonte, the company is considering other options for the site. The site has two unfinished 1,213 MWe PWR units, unit 1 being about 88% complete, and unit 2 about 58% complete. In April 2006, TVA requested that the NRC terminates the construction permits of the two unfinished units, a request that was granted in September of that year. But in August 2008, citing changing power-generating economics, TVA stated that completing the Bellefonte reactors might be viable and requested that the NRC reinstate the permits. In February 2009, the NRC authorized the reinstatement of the construction permits but denied TVA's request to reinstate the classification of the reactors as 'deferred'. Instead, the reactors were classified as 'terminated', meaning that TVA would first need to re-establish certain physical conditions and records quality of the units before the NRC would change the status back to 'deferred'.

In August 2009, TVA announced it was preparing a Supplemental Environmental Impact Statement, which would evaluate three scaled-back options for the Bellefonte site: completing one of the partially completed units; constructing a single AP1000 unit; and taking no action to operate a nuclear unit at the site.[2]

UniStar Nuclear

UniStar Nuclear started in September 2005 as a joint venture between Areva (France) and Constellation Energy to develop a business framework for building at least four of Areva's US-EPR nuclear units in North America. Later, in July 2007, Constellation Energy and EDF formed a joint venture holding company, UniStar Nuclear Energy, focused on the potential deployment of a fleet of new nuclear power plants in North America. EDF paid $350 million cash upfront and pledged up to $625 million in total to UniStar Nuclear Energy, while Constellation Energy contributed the subsidiary companies and interests from its pre-existing UniStar Nuclear line of business. UniStar submitted the first part of a COL application for a US-EPR at the Calvert Cliffs site in July 2007 and the second part in March 2008.

After the DOE put unrealistic terms on a loan guarantee offer for Calvert Cliffs to Unistar[3], Constellation agreed to sell its half share in Unistar to EDF for $140 million[4]. Some $817 million had been invested by both companies in Calvert Cliffs 3 to that point. Unistar will own the site for Calvert Cliffs 3 as well as a potential fourth reactor there, and other sites at the Nine Mile Point and RE Ginna nuclear power plants. While EDF through Unistar may pursue the construction of Calvert Cliffs 3, it would still need to find a US-based partner before the NRC could grant a COL. Under the US Atomic Energy Act, the NRC may not issue any commercial licences to an entity 'owned, controlled or dominated' by a foreign company or government. (As a result of the agreement between EDF and Constellation, the EDF share of Constellation Energy dropped to 6%, and it continued to own 49.99% of Constellation Energy Nuclear Group.)

Calvert Cliffs 3 will have a closed-loop cooling system using a single hybrid mechanical draft cooling tower, giving it a much larger footprint than units 1 & 2 together. It will also have a reverse osmosis desalination plant for potable water, producing 4700 m^3/day.

NRG Energy and Nuclear Innovation North America

In mid-2006, NRG Energy announced plans to build 8 GWe of baseload capacity across the US over the next decade, notably including two 1358 MWe ABWR nuclear units from Toshiba at its South Texas Project (STP) site, coming on line 2014-15. [NRG Energy (44%) and CPS Energy (40%) are the main shareholders in STP.] The new build project originally had NRG and CPS as 50:50 joint venturers, but after reappraisal by CPS it reduced its share to 7.625%, the balance being a new NRG partnership: NINA (see below).

The new STP expansion would be a merchant plant. In 2006 the project cost was estimated at $5.2 billion but, by June 2009, the price was quoted as $10 billion, or $13 billion with financing charges.[b] Japan's Tepco, the most experienced operator of ABWRs, agreed to assist NRG Energy and STP Nuclear Operating Co with these. NRG Energy aims to reduce dependence on natural gas and reduce the carbon intensity of its baseload fleet by 20-25%. This is the most conservative equipment choice among potential new nuclear build in USA, reflecting the fact that such ABWR units are well proven, four of them having been operating in Japan for up to ten years, and they are fully certified in the USA. Most of the rest of the baseload capacity is to be coal-fired. The company was the first to apply for a COL, in September 2007.

In March 2008, NRG formed a partnership with Toshiba to market the ABWR in North America. Toshiba received a 12% stake in Nuclear Innovation North America LLC (NINA), in return for a $300 million investment over six years. Half of this investment is to support the proposed new ABWRs at South Texas Project (STP 3 and 4) through NINA Investments Holdings. The other half is for new ABWR projects in North America with other potential partners.

In August 2009, NRG Energy signed provisional agreements for long-term sale contracts (20 to 40 years) for more than half of the power from the new South Texas units, which will greatly assist financing them. In May 2010, NINA agreed with Tepco (which has been a technical consultant to the project since 2006) to take a 10% share in STP 3&4 for $155 million, subject a loan guarantee from the US government. The sum includes an option enabling Tepco to take a further 10% for $125 million within 12 months. With the initial Tepco equity, STP 3&4 shares would be: Tepco 9.2375%, NRG Energy 73.1610%, Toshiba 9.9765% and CPS Energy 7.6250%.

Comanche Peak Nuclear Company

Another partnership was formed between Luminant (a subsidiary of Energy Future Holdings, formerly TXU) and Mitsubishi Heavy Industries (MHI) in February 2009. Luminant holds an 88% ownership share in Comanche Peak Nuclear Power Company and MHI a 12% share. The joint venture was set up to fund project development costs during the period preceding the issuance of the COL for two US-Advanced Pressurized Water Reactor (US-APWR) units at Comanche Peak (units 3 and 4). Luminant submitted the COL application in September 2008.

Further COL applications

Several other COL applications have been received by the NRC. Duke Energy lodged a COL for two Westinghouse AP1000 units at William States Lee III, a new site near Charlotte in Cherokee County, South Carolina; South Carolina Electricity & Gas for two AP1000 units also in South Carolina (at its Virgil C. Summer nuclear site); Southern Nuclear Operating Company for two AP1000 units at its Vogtle site in Georgia; and Progress Energy for four AP1000 units – two at its Shearon Harris site in North Carolina and two at its new site in Levy County, Florida. Also in Florida, Florida Power & Light applied in June 2009 for a COL for two AP1000 reactors at the Turkey Point site.

For the ESBWR, in addition to Dominion's North Anna application and the two suspended Entergy applications for Grand Gulf and River Bend, the NRC has received two other applications: Detroit Edison lodged an application for an ESBWR at its Fermi plant in Michigan and Exelon for two ESBWR units at a new site in Victoria County, Texas. However, in February 2009, the NRC review of this application was suspended and Exelon then said it had chosen the ABWR design, to be built by GE Hitachi[6]. Then, citing adverse economic conditions, Exelon withdrew its COL application and instead submitted an early site permit application in March 2010.[7]

For the US-EPR, in addition to UniStar's Calvert Cliffs application, the NRC has received COL applications for three more US-EPRs: at AmerenUE's Callaway site in Missouri (application submitted July 2008 but suspended June 2009); at Constellation's Nine Mile Point site in New York (submitted September 2008 and then partly suspended); and at PPL's Bell Bend site, a new site adjacent to PPL's Susquehanna nuclear plant in Pennsylvania (submitted October 2008).

In June 2009, Duke Energy, Areva, UniStar Nuclear Energy, USEC, and the Southern Ohio Diversification Initiative (SODI) announced the formation of the Southern Ohio Clean Energy Park Alliance, which would investigate the feasibility of building a 1600 MWe US EPR at the DOE's Portsmouth site in Piketon, Ohio[8]. The reactor would form part of a "clean energy park demonstration project" which replaces a lot of Duke's coal-fired plant in the state. It would be a regulated generator, not a merchant plant, enabling it to be funded from rates before it is finished, thus diminishing the overall cost. For licensing support the new plant would come under the UniStar

arrangement. USEC would handle site issues and would be involved in any early site permit application.

Outside the mainstream utilities, Alternate Energy Holdings Inc (AEHI) proposed a US-EPR nuclear unit near the town of Hammett in Elmore County, in southwest Idaho. Unistar Nuclear initially agreed to assist AEHI with the approval and construction process for the reactor, but this agreement lapsed. In its grand plan, the project would be a key part of the proposed $4.5 billion Idaho Energy Complex, which would provide electricity for local farm co-op irrigation, but with the majority of output being sold in the national energy market and the waste heat being used to co-generate ethanol. In June 2007, AEHI announced that Cobblestone Financial Group provided a letter of intent to fund 100% of the Idaho Energy Complex, which at that time was estimated at $3.5 billion. The target date for submitting a COL application was moved to 2011. Meanwhile, AEHI said it had gained the support of local Native American tribesmen for the plant. A second company, MidAmerican Nuclear Energy Co, was also looking at nuclear possibilities in Idaho but decided not to proceed.

UniStar is also working with Amarillo Power towards submitting an application for two US-EPRs at an undisclosed site in near Amarillo, Texas. Formed by Amarillo commercial and residential developer George Chapman in December 2005, Amarillo Power (originally named Pleasant Valley Power) had planned to submit an early site permit application for two ESBWRs by the end of 2007. In March 2007, Amarillo Power decided to switch the proposed reactor design to the US-EPR and, in May 2008, UniStar told the NRC that a COL application for the Amarillo site had been delayed until late 2009.

In October 2007, Transition Power Development (TPD) was established by EnergyPath Corporation to develop a nuclear plant in Utah. TPD wrote to the NRC in January 2008, saying it intends to submit an early site permit application and/or a COL application for the two-unit Blue Castle Generation Project by April 2010. In March 2008, Kane County Water Conservancy District applied to permit the use of 36.5 gigalitres water per year for the project. The water rights had previously been approved for the abandoned Kaiparowits coal-fired power project. In April 2008, EnergyPath Corporation signed an agreement with Emery County for an option to buy land a few miles west of the town of Green River, where the Mancos Hills (or Green River) industrial park is planned.

Advance orders for heavy forgings

Several companies have ordered heavy forgings and other long lead time equipment for building new plants, in advance of specific plans or approvals. Some have even proceeded to full engineering, procurement and construction (EPC) agreements while the relevant COL applications are being processed.

In 2006, Areva (for the UniStar Nuclear joint venture) ordered heavy forgings from suppliers in Japan and France in anticipation of US orders for new US-EPR reactors – evidently for Constellation at Calvert Cliffs and AmerenUE at Callaway (although plans to the latter have since been suspended). Areva also arranged with Babcock & Wilcox in Virginia to supply major EPR components such as steam generators and pressure vessels. In May 2007, AmerenUE contracted with Areva for heavy forgings from Japan, to be delivered in 2010-11.

In 2006, GE Energy arranged production slots for forgings from Japan Steel Works for ESBWR and ABWR units. In April 2007, Dominion contracted with it – now GE Hitachi Nuclear Energy – for

major ESBWR components such as large forgings and other nuclear and turbine island parts for North Anna, and in July Entergy signed up for ESBWR components for either Grand Gulf or River Bend. Then in December, Exelon Nuclear ordered ultra-large forgings, reactor pressure vessels and steam generators to keep its options open for two ESBWR units in Texas. These moves will put them in front of any supply bottlenecks when orders are confirmed.

In April 2008, the AP1000 consortium of Westinghouse and the Shaw Group signed an EPC contract with Georgia Power for two AP1000 nuclear units at the existing Vogtle site in Georgia. It already has two 1,215 MWe reactors on the site. The units are expected to enter commercial operation in 2016 and 2017, and were awarded the first federal loan guarantee in February 2010.

Six weeks later Westinghouse and Shaw signed a second EPC contract with South Carolina Electricity & Gas and Santee Cooper to build two AP1000 reactors at their VC Summer site in South Carolina, which already has one 966 MWe unit. The total cost of $9.8 billion includes forecas inflation and owners' costs for site preparation, contingencies and project financing, all of which would approximately double the bare plant costs. The units are expected to enter commercial operation in 2016 and 2019.

At the end of December 2008 Westinghouse and Shaw signed a third EPC contract with Progress Energy Florida to build two AP1000 units on a greenfield site in Levy county, Florida. The contract is for $7.65 billion ($3462/kWe), of an overall project cost of about $14 billion, including land, inflation, site preparation, licensing, financing costs and fuel. A further $3 billion will be required for transmission infrastructure. The reactors would go on line over 2016-18. A final decision to build wil be made when the NRC issues a COL for the project, in about 2012.

In 2007, Toshiba signed a project services agreement with NRG Energy and South Texas Project Nuclear Operating Co. (STPNOC, which operates South Texas Project 1 and 2) for two 1,358 MWe ABWR units at the South Texas site. NRG ordered heavy components for the plant including a reactor pressure vessel. In February 2009, an EPC contract was signed with STPNOC, which was acting as the agent for CPS Energy and Nuclear Innovation North America (NINA, the 88:12 partnership between NRG Energy and Toshiba). CPS and NINA were 50:50 partners in the plannec new units, but following a dispute the respective shares are now 7.625% and 92.375%.

Toshiba said that at mid-May 2008 it had orders for six Westinghouse AP1000 reactors and for twc ABWR units in the USA. The former appear to be: Georgia Power/Southern Nuclear – two Vogtle units; South Carolina Electricity & Gas – two Summer units; and Progress Energy – two Levy County units. The ABWR units would be for NRG's South Texas plant.

Further Information

Related information pages

Nuclear Power in the USA

Notes

a. The NuStart consortium was formed in March 2004 by five utilities and two vendors: Constellatior

Generation Group, a subsidiary of Constellation Energy; EDF International North America, a subsidiary of EDF; Entergy Nuclear; Exelon Generation; Southern Company; Westinghouse Electric Co; and GE Energy. Tennessee Valley Authority (TVA), Florida Power & Light Company, Duke Energy and Progress Energy joined soon after, followed by South Carolina Electric & Gas, a subsidiary of SCANA Corporation, about two years later. Late in 2007 Constellation Energy left it to pursue its Unistar plans with EDF, and DTE subsidiary Detroit Edison replaced it. [Back]

b. Cost estimates for the two proposed ABWRs at South Texas Project have increased. A January 2007 fact sheet published by NRG, titled South Texas Project Unit 3&4 Expansion - Powering Texas with NRG, says the units would "cost more than $6 billion." And in June 2009, following three years of detailed study of various energy options, CPS Energy (a 50:50 partner with NRG in South Texas Project 3 and 4) said the total estimated cost of the two units was $10 billion, or $13 billion with financing. CPS Energy recommended pursuing the project, but added that it was exploring ownership options that would trim the company's share to $5.2 billion with financing.[5] [Back]

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1. New Nuclear Power Plant Licensing Demonstration Project: ABWR Cost/Schedule/COL Project at TVA's Bellefonte Site, Tennessee Valley Authority (August 2005) [Back]

2. TVA to Update Environmental Impacts Evaluation for Nuclear Unit at Bellefonte Site, TVA news release (7 August 2009) [Back]

3. Constellation Energy Releases Statement Regarding U.S. Department of Energy Loan Guarantee, Constellation Energy press release (9 October 2010) [Back]

4. EDF and Constellation Energy Announce Comprehensive Agreement, Constellation Energy press release (26 October 2010) [Back]

5. CPS Energy sees need for new STP units, World Nuclear News (30 June 2009) [Back

6. Exelon opts for resurgent ABWR, World Nuclear News (26 March 2009) [Back]

7. Victoria nuclear build put back, World Nuclear News (1 July 2009) [Back]

8. Leading Energy Companies Form Alliance to Develop First U.S. Clean Energy Park Project in Ohio, Areva press release (18 June 2009) [Back]