**Nuclear Power in the USA**

*(Updated December 2011)*

Related pages: [US Nuclear Power Policy](http://www.world-nuclear.org/info/inf41_US_nuclear_power_policy.html)
[US Nuclear Fuel Cycle](http://www.world-nuclear.org/info/inf41_US_nuclear_fuel_cycle.html)

* 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 807 billion kWh in 2010, 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 2020, the first of those resulting from 16 license applications to build 24 new nuclear reactors made since mid-2007.
* However, lower gas prices since 2009 have put the economic viability of some of these projects in doubt.
* 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.

In 2009, the USA generated 3950 billion kWh net of electricity, 45% of it from coal-fired plant, 24% from gas and 7% from hydro. Annual electricity demand is projected to increase to 5,000 billion kWh in 2030, though in the short term it is depressed and is not expected to recover to the 2007 level until about 2015. Annual per capita electricity consumption is currently around 12,400 kWh. Total capacity is 1025 GWe, less than one tenth of which is nuclear.

The USA has 104 nuclear power reactors in 31 states, operated by 30 different power companies. In 2009 these plants achieved a capacity factor of 91.1%, generating 799 billion kWh and accounting for 20% of total electricity generated. In 2010, 807 billion kWh was generated by nuclear plant.

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](http://www.world-nuclear.org/info/inf41ai_US_operating_nuclear_reactors.html)). 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 2013 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 utilization through improved refueling, maintenance and safety systems at existing plants.

While there are plans for a number of new reactors (see section on [Preparing for new build](http://www.world-nuclear.org/info/inf41.html#New_build#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](http://www.world-nuclear.org/info/inf54.html).[a](http://www.world-nuclear.org/info/inf41.html#Notes#Notes) Westinghouse designed the first fully commercial pressurized 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](http://www.world-nuclear.org/info/inf41.html#Notes#Notes) 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 amortized 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.

**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 Illinois, 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 2011 Exelon agreed a merger with Constellation Energy, which will add 5 reactors at three plants and take the total capacity to 18.5 GWe. Subject to shareholder and regulatory approvals this should be closed in 2012.

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.

In January 2011 Duke Energy agreed to purchase Progress Energy, and after shareholders in both companies overwhelmingly approved, this $26 billion deal is likely to be finalized by the end of the year. The combined company will operate 12 power reactors, the largest regulated nuclear fleet in the USA.

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 license 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](http://www.world-nuclear.org/info/inf41aii_US_Power_Plant_Purchases.html)).

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](http://www.world-nuclear.org/info/inf41aii_US_Power_Plant_Purchases.html)). 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, Massachusetts, 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 Dominion 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 license 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.

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, totaling over 6000 MWe, and another 3200 MWe is prospective, under NRC review[c](http://www.world-nuclear.org/info/inf41.html#Notes#Notes). 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 license extensions (see below), which require extensive review of plant equipment condition[d](http://www.world-nuclear.org/info/inf41.html#Notes_from_d#Notes_from_d).

Florida Power & Light is adding 450 MWe in uprates to four reactors over 2011-13: 12% for St Lucie 1 & 2, and 15% for Turkey Point 3 & 4.

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 refueling 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.

**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 licenses 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 licenses 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 and upgrades of instrument and control systems\*, can be justified.

\* All US operating plants have analogue control systems. Duke Energy is converting its three Oconeee units to digital control systems over 2011-13.

At September 2011, the NRC had extended the licenses of 71 reactors, well over two thirds of the US total. The NRC is considering license renewal applications for further units (13 at October 2011), 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. The original 40-year period was more to do with amortization of capital than implying that reactors were designed for that lifespan.

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 recognized 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 recognized 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 from about 2012.

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 license (COL) process. All have some costs shared by the DOE.

US nuclear power reactors under construction, planned and proposed[e](http://www.world-nuclear.org/info/inf41.html#Notes_from_e#Notes_from_e)

| Site | Technology | MWe gross | Proponent/utility | COL lodgment date | Loan guarantee; start operation |
| --- | --- | --- | --- | --- | --- |
| **Watts Bar 2**[**f**](http://www.world-nuclear.org/info/inf41.html#Notes_from_e#Notes_from_e)**, TN** | Westinghouse PWR | 1218 (1177 net) | Tennessee Valley Authority | No COL[f](http://www.world-nuclear.org/info/inf41.html#Notes_from_e#Notes_from_e)  | Start end 2012 or early 2013, on line 2013 |
| **Subtotal 'under construction': 1 unit (1218 MWe gross, 1177 MWe net)**  |
| **Vogtle**[**\* g**](http://www.world-nuclear.org/info/inf41.html#Notes_from_e#Notes_from_e)**, GA** | AP1000 x 2 | 2400 | Southern Nuclear Operating Company | 24/7/08,COL due end 2011 | granted loan guarantee;2016, 17 |
| **V. C. Summer, SC** | AP1000 x 2 | 2400 | South Carolina Electric & Gas | 31/3/08,COL due Jan 2012 | short list loan guarantee; 2016, 19 |
| **Levy County, FL** | AP1000 x 2 | 2400 | Progress Energy | 30/7/08 | 2021-22 |
| **Bellefonte 1**[**g**](http://www.world-nuclear.org/info/inf41.html#Notes_from_e#Notes_from_e)**,** [**h**](http://www.world-nuclear.org/info/inf41.html#Notes_from_h#Notes_from_h)**, AL** | B&W PWR | 1263 | Tennessee Valley Authority | 30/10/07 for unit 3 (and unit 4)[h](http://www.world-nuclear.org/info/inf41.html#Notes_from_h#Notes_from_h) but COL review suspended | 2018-20  |
| **Subtotal 'planned': 7 units (8460 MWe gross)**  |
| **Comanche Peak, TX** | US-APWR x2 | 3400 | Luminant(merchant plant) | 19/9/08 | 2019, 2020 |
| **South Texas Project**[**\***](http://www.world-nuclear.org/info/inf41.html#Notes_from_e#Notes_from_e)**, TX** | ABWR x 2 | 2712 | Toshiba, NINA, STP Nuclear (merchant plant) | 20/9/07 | short list loan guarantee;2016, 17 |
| **Calvert Cliffs**[**\***](http://www.world-nuclear.org/info/inf41.html#Notes_from_e#Notes_from_e)**, MD** | US EPR | 1710 | UniStar Nuclear(merchant plant) | 7/07 and 13/3/08 | refused an offered loan guarantee, needs US equity; 2017 |
| **North Anna**[**\***](http://www.world-nuclear.org/info/inf41.html#Notes_from_e#Notes_from_e)**, VA** | US-APWR[i](http://www.world-nuclear.org/info/inf41.html#Notes_from_h#Notes_from_h)  | 1700 | Dominion | 20/11/07 | 2022  |
| **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](http://www.world-nuclear.org/info/inf41.html#Notes_from_h#Notes_from_h)  | 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 |  |
| **River Bend, LA** | ESBWR[i](http://www.world-nuclear.org/info/inf41.html#Notes_from_h#Notes_from_h)  | 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 | ESP expected late 2013 |  |
| **Salem/Hope Creek, NJ** | To be decidedin 2012 | Perhaps 1200 | PSEG | ESP only | On line 2021 |
| **Fresno, Ca** | US EPR | 1710 | Fresno Nuclear Energy Group |  |  |
| **Clinch River, TN** | mPower x 2 | 250 | TVA | Expected 2012 |  |
| **Subtotal 'proposed': 27 units (ca. 37,400 MWe gross), 14 COL applications to March 2010, including 3 suspended**  |
| **Victoria County**[**i**](http://www.world-nuclear.org/info/inf41.html#Notes_from_h#Notes_from_h)**, TX** | 2, unspecified | perhaps. 2400 | Exelon(merchant plant) | 03/9/08 but withdrawn,Now ESP only, 25/3/10 | 12/07 MHI |
| **Callaway**[**j**](http://www.world-nuclear.org/info/inf41.html#Notes_from_h#Notes_from_h)**, MO** | US EPR | 1710 | AmerenUE | 24/7/08. Now suspended, project cancelled | Areva had ordered forgings |

*NB: WNA reactor table lists only three projects above as 'Planned', on the basis of various announced developments. Watts Bar 2 is under construction.*

Of the above, for four AP1000 units, site work is well under way at Vogtle, Georgia, with about $1.6 billion invested in the project to October 2010, and work has also started at Summer, South Carolina, with $1.4 billion spent to February 2011, and original cost projections decreased. See also section below.

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](http://www.world-nuclear.org/info/inf08.html). 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 license (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](http://www.world-nuclear.org/info/inf41.html#Notes_from_k#Notes_from_k)
* The Westinghouse AP1000 is the first Generation III+ reactor to receive certification. 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 about August 2011.

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 2012, with full certification in mid-2013. 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 certification is expected late in 2013. Two US-APWR reactors have been proposed in the Luminant-Mitsubishi application for Comanche Peak, and one for Dominion's North Anna, but the COLs for these will not be complete before late 2013.

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 in 2012.
* A Westinghouse design certification application is expected by NRC at the end of 2012, apparently for its 200 MWe integral PWR.
* The Babcock & Wilcox 125 MWe modular mPower reactor is expected to be submitted for design certification late in 2013. TVA is considering an initial pair of these for its Clinch River site, and expects to decide on this in 2011 with a view to building up to six modules. (see section on [mPower](http://www.world-nuclear.org/info/inf33.html#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](http://www.world-nuclear.org/info/inf08.html), or for the [mPower](http://www.world-nuclear.org/info/inf33.html#mPower) and other small modular reactors, in the page on [Small Nuclear Power Reactors](http://www.world-nuclear.org/info/inf33.html).

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 license

In 2003, the Department of Energy (DOE) called for combined construction and operating license (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 license 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](http://www.world-nuclear.org/info/inf41aiii_COL_applications.html).

However, the only construction of new plants in the short term is in regulated markets, where costs can reliably be recovered.

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](http://www.world-nuclear.org/info/inf41aiii_COL_applications.html).

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](http://www.world-nuclear.org/info/inf41_US_nuclear_power_policy.html).

**Reactors under construction and planned, or which have been '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 was expected to start up in October 2012 and come on line in 2013 at a cost of about $2.5 billion, but this schedule has slipped a few months. 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 base-load 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. It is a regulated plant, with guaranteed cost recovery.

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 late in 2011, and a license is expected mid-2012. The units are expected on line in 2016 and 2017. It is a regulated plant, with guaranteed cost recovery.

Georgia Power as 45.7% owner reduced its earlier cost estimate for building its share of the new plant from $6.4 billion to $6.1 billion as a result of being able to recover financing costs from customers during construction. Over the life of the plant, the utility's customers will save about $1 billion through federal loan guarantees, production tax credits and the early recovery of financing costs in the rate base.

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. In September 2011 SCEG was starting to assemble the containment vessel for the first unit and was starting construction on the four cooling towers. 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 late in 2011 and the units are expected to enter commercial operation in 2016 and 2019. SCEG's loan guarantee application was accepted by DOE and the project was short-listed in May 2009. It is a regulated plant, with guaranteed cost recovery.

**Comanche Peak**

Luminant plans to use two US-APWR units for its merchant plant in Texas, and in May 2011 remained positive about the prospects for these by 2109-20. WNA lists the plant as "proposed" pending progress with design certification and COLs. Design certification and COL are scheduled late in 2013. In May 2011 the NRC concluded that there are no environmental considerations that would hinder the project. Luminant's loan guarantee application was accepted by DOE and it was understood that this was the first alternative to the four short-listed projects, two of which are now not proceeding for the time being.

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 early in 2013, but the COL – now scheduled in mid-2013 – will require a new US partner for the project. In May 2011 the NRC concluded that there are no environmental considerations that would preclude issuing the COL for construction and operation of the proposed US-EPR at the site. The NRC is now completing the safety evaluation. Unistar's loan guarantee application was accepted by DOE and the project was short-listed in May 2009.

In the light of equity developments WNA has moved the project from planned back to "proposed". Exelon, merging with Constellation (owner of units 1 & 2 there, and in which EdF has 49.9% equity) said in November 2011 that with the advent of shale gas, a new nuclear plant at Calvert Cliffs was "utterly uneconomic" by a factor about two.

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 m3/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 were expected to go on line over 2016-18, but this schedule has been delayed. A final decision to build will be made when the NRC issues a license for the project – the COL review is due to be complete about August 2012. WNA lists the plant as "proposed". It is a regulated plant, with guaranteed cost recovery.

**South Texas Project 3 & 4**

This is to be a merchant plant with two 1356 MWe Advanced Boiling Water Reactors[m](http://www.world-nuclear.org/info/inf41.html#Notes_from_m#Notes_from_m). NRG Energy already operates two reactors at the site, and works were under way preparing for the new units.. The project is owned 92.375% by Nuclear Innovation North America (NINA), and 7.625% by CPS Energy of San Antonio. Toshiba America Nuclear Energy holds 12% of NINA with NRG Energy 88%, but following NRG's withdrawal from STP 3&4, it may come to hold up to 90% of it, according to the NRC. The COL review by the NRC was due to be completed late in 2011, and the units were expected on line in 2016 and 2017, but the COL schedule is now "under review" by NRC pending resolution of foreign control questions. The new units would be operated by the South Texas Project Nuclear Operating Co. (STPNOC), a US company owned by NRG Energy, CPS Energy and Austin Energy. STPNOC already operates STP units 1 & 2.

NINA awarded the EPC contract to Shaw Group and Toshiba America Nuclear Energy in November 2010. One reactor pressure vessel was ordered from IHI in May 2010.

However, based largely on low natural gas prices in Texas compounded by the Fukushima accident, in April 2011 NRG decided to pull out of the project and write off its $331 million investment in it. Toshiba had spent $150 million and has agreed to persevere with the project. It is assumed that Tepco will not be in a position to maintain any involvement. In the light of developments WNA has moved the project from planned back to "proposed".

North Anna 3

In December 2010, Dominion announced that it had agreed with Mitsubishi Heavy Industries to continue pre-construction efforts for this US-APWR unit, but Dominion says it does not have a schedule for building it, so it remains 'proposed' in WNA reckoning. Design certification and COL are scheduled in late 2013. Dominion suggests start-up in 2022 if it proceeds. It is a regulated plant, with guaranteed cost recovery.

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 1213 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, such as instrument and control system, steam generators and main condenser tubing. In August 2011 TVA decided to complete unit 1 at a cost of about $4.9 billion rather than building a new AP1000 reactor as unit 3 (see Appendix 3: [COL Applications](http://www.world-nuclear.org/info/inf41aiii_COL_applications.html)).

In August 2010, TVA had committed to spending $248 million to September 2011 towards that[8](http://www.world-nuclear.org/info/inf41.html%22%20%5Cl%20%22References#References" \o "See Reference 8) and 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. Following TVA's decision to proceed, it includes construction and component replacement work on the plant's nuclear systems plus fuel design and fabrication. Areva will also supply a digital reactor instrumentation and control (I&C) system, a completely modernized control room and plant simulator for personnel training. TVA has asked the NRC to defer consideration of its COL for units 3 & 4. Heavy construction will start when Watts Bar 2 is complete. No decision has been made on completing unit 2. It is a regulated plant, with guaranteed cost recovery.

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 concentrated solar power plant. Possible locations are being investigated.

Other planned or proposed new US nuclear capacity is described more fully in [Appendix 3 on COL Applications](http://www.world-nuclear.org/info/inf41aiii_COL_applications.html).

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](http://www.world-nuclear.org/info/inf77.html) 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](http://www.world-nuclear.org/info/inf41_US_nuclear_power_policy.html).

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](http://www.world-nuclear.org/info/inf33.html#Hyperion) 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](http://www.world-nuclear.org/info/inf41ai_US_operating_nuclear_reactors.html)
Appendix 2: [Power Plant Purchases](http://www.world-nuclear.org/info/inf41aii_US_Power_Plant_Purchases.html)
Appendix 3: [COL Applications](http://www.world-nuclear.org/info/inf41aiii_COL_applications.html)

**Related information pages**

[US Nuclear Power Policy](http://www.world-nuclear.org/info/inf41_US_nuclear_power_policy.html)
[US Nuclear Fuel Cycle](http://www.world-nuclear.org/info/inf41_US_nuclear_fuel_cycle.html)

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 Shipping port demonstration PWR reactor in Pennsylvania, which started up in 1957 and operated until 1982.

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.

c. To the end of September 2010, the Nuclear Regulatory Commission (NRC) had approved 135 power uprates totaling 5810 MWe (not including capacity recapture up rates for provisional operating license 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](http://www.nrc.gov/reactors/operating/licensing/power-uprates.html))

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.

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.

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 license for the reactor.

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 license application from TVA’s Bellefonte nuclear site to Southern Nuclear’s Vogtle Electric Generating Plant."[1](http://www.world-nuclear.org/info/inf41.html#References#References)

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.In May 2010 the TVA staff identified completion of unit 1 as the best option for the site, and in August 2011 the TVA Board decided to complete unit 1.[2](http://www.world-nuclear.org/info/inf41.html#References#References)

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.

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.

k. The ABWR design that has NRC certification is the GE-Hitachi design, some aspects of which are proprietary to GE-Hitachi. While the license 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).

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.

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 license (COL) application was prepared by STP Nuclear Operating Company (STPNOC) together with GE-Hitachi Nuclear Energy and Bechtel and submitted in September 2007.[3](http://www.world-nuclear.org/info/inf41.html%22%20%5Cl%20%22References#References" \o "See Reference 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](http://www.world-nuclear.org/info/inf41.html%22%20%5Cl%20%22References#References" \o "See Reference 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](http://www.world-nuclear.org/info/inf41.html%22%20%5Cl%20%22References#References" \o "See Reference 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](http://www.world-nuclear.org/info/inf41.html%22%20%5Cl%20%22References#References" \o "See Reference 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](http://www.world-nuclear.org/info/inf41.html%22%20%5Cl%20%22References#References" \o "See Reference 7).