Escalating Estimates of the Cost of Nuclear Power Plants

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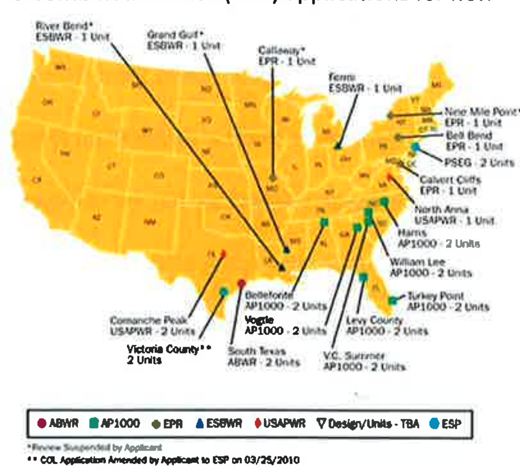
ANALYSIS GROUP
ECONOMIC, FINANCIAL and STRATEGY CONSULTANTS

Summary: Escalating Estimates of the Cost of Nuclear Power Plants

- The cost of building the first wave of nuclear power plants was substantially greater than originally anticipated. The situation is similar today.
- The U.S. Nuclear Regulatory Commission (NRC) has received 18 Combined License (COL) applications for new nuclear power plants in the last three years.
- Based on an initial review of regulatory filings, utility press releases, and press reports, 12 of the 18 projects are still active, and two or more comparable cost estimates are readily available for 8 of these.
- For 7 of these 8 projects, cost estimates have increased over time.
  - Updated estimates are often double or triple initial estimates.
- Cost estimates have decreased over time for only 1 of the 8 projects.
  - In this case, the cost estimate was revised downward between 2009 and 2010 to reflect anticipated declines in the growth of construction costs.

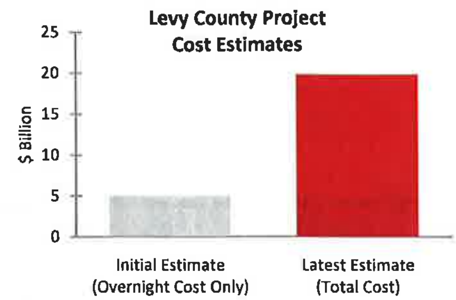


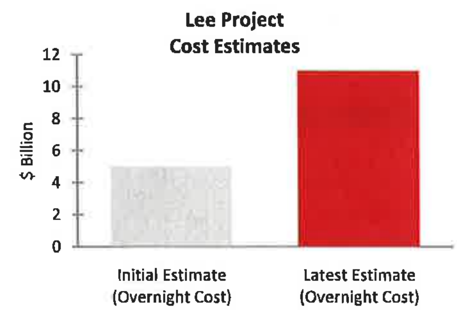
http://www.nrc.gov/reactors/new-reactors/col/new-reactor-map.html

Note: Analysis Group (www.analysisgroup.com) was commissioned by Noranda Aluminum to review and summarize readily available information on estimated costs for new nuclear reactors. This analysis focuses primarily on the 18 plants that submitted Combined License (COL) applications to the Nuclear Regulatory Commission in 2007, 2008, and 2009. The findings presented here reflect an initial review of regulatory filings, utility press releases, press reports, and academic literature on these plants and selected nuclear power projects in Europe. Additional research may yield additional data on the 18 projects. Detailed information is provided in the following pages, and a list of sources can be found on pp. 18-21. For more information, contact Jonathan Borck (jborck@analysisgroup.com).

Summary: Escalating Estimates of the Cost of Nuclear Power Plants

- Example 1: **Levy County Project**, Florida (Progress Energy)
  - Estimate of "overnight" cost (2006): **$4-6 billion**
  - Estimate of "overnight" cost (2008): **$9.3-10.5 billion**
  - Estimate of total cost (2010): **$17.2-22.5 billion**
- Example 2: **Lee Project**, South Carolina (Duke Energy)
  - Estimate of "overnight" cost (2005): **$4-6 billion**
  - Estimate of "overnight" cost (2008): **$11 billion**
- Evidence on current projects is consistent with general results from independent studies.
  - For example, a widely cited MIT study estimates that "overnight" costs nearly doubled between 2002 and 2007.
- Experts predict that costs could follow a similar trajectory in the future.





Note: Comparing different cost estimates can be challenging because the individual estimates often include different elements of cost. For example, "overnight cost" is an estimate of the cost at which a plant could be constructed assuming that the entire construction process, from planning through completion, could be accomplished in one day. "Total cost" includes all the costs of completing a project, including overnight cost, financing cost, projections of future labor and materials costs, etc. See http://www.eia.doe.gov/oiaf/beck_plantcosts.

Summary: Recent Cost Overruns in Europe

- Escalating costs of nuclear power are not unique to the United States.
- Construction costs using French company AREVA's "Evolutionary Power Reactor" (EPR) technology in Europe are currently much higher than initially estimated.
  - Olkiluoto Nuclear Power Plant (Finland): **90 percent cost overrun** to date
  - Flamanville Nuclear Power Plant (France): **50 percent cost overrun** to date
- The European projects are not yet completed and are years behind schedule. Cost overruns may increase.
- Several proposed nuclear plants in the United States (including Ameren's original proposal for the Callaway expansion) intend to use EPR technology.

> **"The credibility of both the EPR and the ability of the French nuclear industry to successfully build new reactors have been seriously undermined by difficulties at Finland's Olkiluoto site and Flamanville."**
>
> – Francois Roussely, former president of EDF

Summary: Ratepayers on the Hook

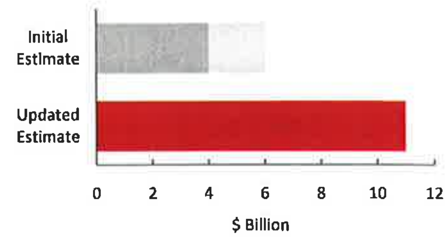
- In certain states, utilities are permitted to recover costs through higher rates during the development and construction stages of a plant, long before the plant comes into service.
  - This is known as "Construction Work in Progress" (CWIP) financing.
- Where CWIP financing is permitted, rates have increased and will likely become even more burdensome over time, before a single kilowatt of electricity is generated.
- Example 1: **Levy County Project**, Florida (Progress Energy)
  - In 2011, Progress Energy will collect $4.99 per month in CWIP on an average (1000-kWh) residential bill (approximately 4 percent) to fund the development of the Levy County nuclear power plant.
- Example 2: **Plant Vogtle Expansion**, Georgia (Georgia Power)
  - In 2011, Georgia Power will collect approximately $10 per month on an average electricity bill to fund the addition of two nuclear generating units at Vogtle.
- If a utility cancels a project – as has frequently occurred in the past – ratepayers may not be able to recover their expenditures.

> **"If the plant is not built or suffers cost overruns, the ratepayers will bear the burden."**
>
> – Mark Cooper, Institute for Energy and the Environment, Vermont Law School

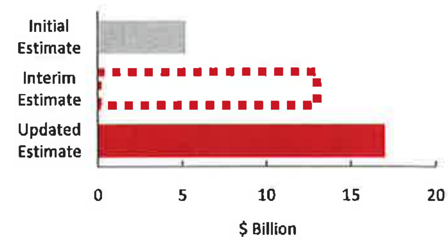
Supporting Materials

Estimates of Construction Costs Have Increased Over Time

- **Project 1: William States Lee III Nuclear Power Plant, Duke Energy, South Carolina**
  - Two units with combined capacity of 2,234 MW
  - Initial estimate from Duke Energy (2005): $4-6 billion
  - Updated estimate from Duke Energy (2008): $11 billion



- **Project 2: South Texas Project, STP Nuclear Operating Company, Texas**
  - Two units with combined capacity of 2,700 MW
  - Initial estimate (2006): $5.2 billion
  - Interim estimate (2009): $13 billion
  - Updated estimate (2009): $17 billion



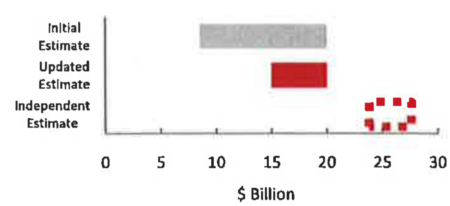
Notes and Sources

Project 1: Costs exclude financing costs and inflation. http://www.world-nuclear-news.org/NN-Duke_raises_cost_estimate_for_Lee_plant-0711084.html; http://www.reuters.com/article/idUSN1324347520071213.

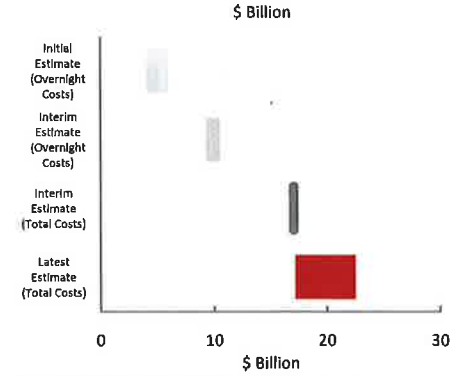
Project 2: Interim estimate includes financing costs. Initial and updated estimates may include the financing costs as well. http://www.gulfcoastpower.org/default/8-06meeting-winn-austin.pdf; "CPS staff recommending nuclear option," San Antonio Business Journal, June 29, 2009; http://www.mysanantonio.com/default/article/Nuclear-cost-estimate-rises-by-as-much-as-4-844529.php.

Estimates of Construction Costs Have Increased Over Time

- **Project 3: Comanche Peak, Luminant, Texas**
  - Two units with combined capacity of 3,400 MW
  - Initial estimate from CEO (2008): $8.5-20 billion
  - Updated estimate from CEO (2010): $15-20 billion
  - Independent estimate (2010): $23.8-27.6 billion



- **Project 4: Levy County, Progress Energy, Florida**
  - Two units with combined capacity of 2,200 MW
  - Initial estimate, overnight costs only (2006): $4-6 billion
  - Interim estimate, overnight costs only (2008): $9.3-10.5 billion
  - Interim estimate, total costs (2008): $17 billion
  - Latest estimate, total costs (2010): $17.2-22.5 billion



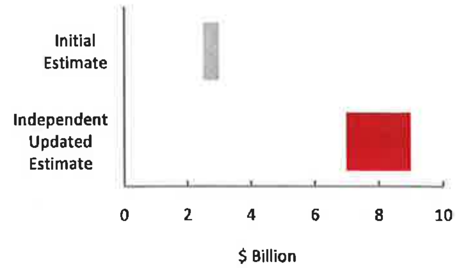
Notes and Sources

Project 3: No cost breakdown information is available for these estimates. http://www.reuters.com/article/idUSN1952971720080919; http://www.star-telegram.com/2010/08/28/2430046/nuclear-plant-has-towering-ambitions.html.

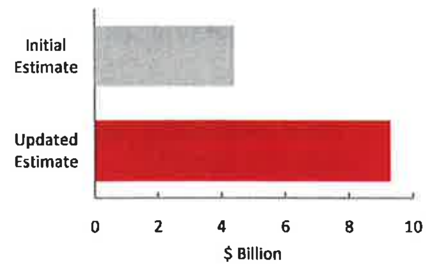
Project 4: http://www.sptimes.com/2007/12/12/State/Nuclear_power_costs_s.shtml; Progress Energy, In Re: Petition for Determination of Need for Levy Units 1 and 2 Nuclear Power Plants, Testimony of Daniel Roderick, 2008, Docket 080148-EI; http://www.neimagazine.com/story.asp?storyCode=2049878; http://www.eenews.net/Greenwire/print/2010/02/12/8; http://www.neimagazine.com/story.asp?sectioncode=147&storyCode=2050690; http://progress-energy.com/aboutus/news/article.asp?id=23962.

Estimates of Construction Costs Have Increased Over Time

- **Project 5: Calvert Cliffs, UniStar Nuclear Energy/Constellation Energy, Maryland**
  - One unit with a capacity of 1,600 MW
  - Initial estimate from Constellation (2005): $2.5-3 billion
  - Independent updated estimate (2008): $7-9 billion



- **Project 6: Shearon Harris, Progress Energy, North Carolina**
  - Two units with a capacity of 2,200 MW
  - Initial estimate from Progress (2008): $4.4 billion
  - Updated estimate from Progress (2008): $9.3 billion



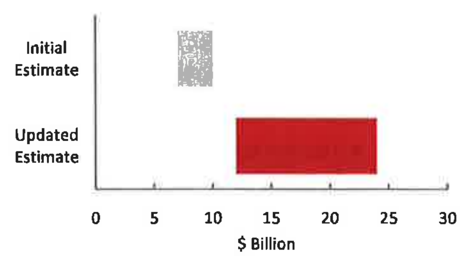
Notes and Sources

Project 5: No cost breakdown information is available for the initial estimate. The second estimate excludes finance costs. UniStar Nuclear Energy is a 50/50 joint venture between Constellation and the EDF Group. http://articles.baltimoresun.com/2005-08-21/news/0508210114_1_calvert-cliffs-calvert-county-liquid-natural-gas; Testimony of David Schlissel on behalf of the Maryland Public Interest Research Group Foundation, Case No. 9127 before the Maryland Public Service Commission, July 16, 2008; http://www.unistarnuclear.com/projects/Calvert3_062008.pdf.

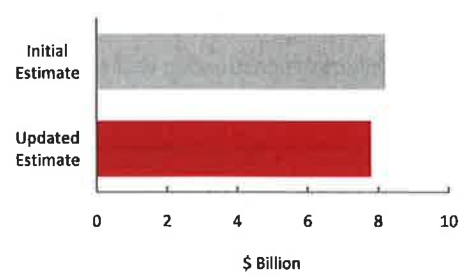
Project 6: No cost breakdown information is available for the estimates. http://www.mcclatchydc.com/2008/10/17/54331/2-nuclear-reactors-proposed-for.html.

Estimates of Construction Costs Have Increased Over Time

- **Project 7: Turkey Point, Florida Power and Light, Florida**
  - Two units with a capacity of 2,234 MW
  - Initial estimate from FPL (2007): $7-10 billion
  - Updated estimate from FPL (2009): $12-24 billion



- **Project 8: Virgil C. Summer, SCE&G, South Carolina**
  - Two units with a capacity of 2,234 MW
  - Company's share is 55% of the total cost
  - Initial estimate from SCE&G (2009): $8.2 billion
  - Updated estimate from SCE&G (2010): $7.8 billion



Notes and Sources

Project 7: No cost breakdown is provided for either estimate. Initial estimates are calculated from $/kW numbers provided by FPL in their filing to the Florida PUC. Sources: In re: Florida Power & Light Company's Petition to Determine Need/or Turkey Point Nuclear Units 6 and 7 Electrical Power Plant, Docket 070650, October 16, 2007, p. 26; http://nuclearstreet.com/nuclear_power_industry_news/b/nuclear_power_news/archive/2009/07/17/florida-power-amp-light-seeks-to-build-two-new-reactors-783.aspx.

Project 8: SCE&G is a 55 percent owner. All costs have been scaled up to estimate the total project cost. All costs are overnight costs. Sources: V. C. Summer Nuclear Station Units 2 & 3, Quarterly Reports to the South Carolina Office of Regulatory Staff, South Carolina Electric & Gas Company, Quarters Ending March 31, 2009, and September 30, 2010; http://www.sceg.com/en/news-room/archives/2008/sceg-santee-cooper-to-build-nuclear-units.htm.

Experience with EPR Technology: Cost Overruns, Construction Delays, and Safety Concerns

AREVA

Ameren

- Estimates of construction costs using French company AREVA's "Evolutionary Power Reactor" (EPR) technology in Europe have increased dramatically over time
- Several US nuclear COL applications (including Ameren's original application for Callaway) specify the use of EPR technology
- The U.S. Nuclear Regulatory Commission (NRC) is currently reviewing the safety of EPR technology
  - In July 2010, the NRC informed AREVA that it has concerns about several design issues, including the complexity of the computer systems
- Based on the European experiences and NRC's concerns, current cost estimates and construction schedules for plants using AREVA's EPR technology may not be not reliable

Sources

http://www.nytimes.com/cwire/2010/07/30/30climatewire-a-late-scramble-to-fund-nuclear-renaissance-83656.html;
http://www.bizjournals.com/stlouis/news/2010/11/19/nixon-backs-ameren-nuclear-plant-bill.html.

Experience with EPR Technology: Olkiluoto

- Olkiluoto Nuclear Power Plant
  - On Olkiluoto Island off the southwestern coast of Finland
  - Approved for construction in 2002 and originally scheduled to be completed in 2009
  - First using AREVA's EPR technology
  - Expected 1,600 MW output
- Olkiluoto's construction cost overruns have almost reached the initial estimate of total construction costs
  - Construction cost estimate in 2005 = **€3 billion**
  - Estimated overruns through 2010 = **€2.7 billion**
- Plant construction is years behind schedule
- AREVA is involved in a dispute with the Finnish company for whom the plant is being built over the allocation of the excess costs

Olkiluoto "has become an example of all that can go wrong in economic terms with new reactors."

– University of Greenwich Professor of Energy Studies Stephen Thomas

Sources

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http://www.psr.org/safe-energy/the-myth-of-the-european.html.

Experience with EPR Technology: Flamanville

- Flamanville Nuclear Power Plant
  - Located in northwest France
  - Construction began in 2006 and originally scheduled to be completed in 4.5 years
  - Like the Olkiluoto Plant, uses AREVA's EPR technology
  - Expected 1,650 MW output
- Flamanville's estimated construction costs have increased 50 percent between 2005 and 2010
  - Construction cost estimate in 2005 = **€3.3 billion**
  - Construction cost estimate in 2008 = **€4 billion**
  - Construction cost estimate in 2010 = **€5 billion**
- Reports indicate that plant construction is approximately two years behind schedule

"The credibility of both the EPR and the ability of the French nuclear industry to successfully build new reactors have been seriously undermined by difficulties at Finland's Olkiluoto site and Flamanville."

– Francois Roussely, former president of EDF

Sources

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Independent Studies Document Cost Progression

- Higher-than-expected costs are consistent with independent studies of the costs of nuclear power
- MIT study on the costs of nuclear power found that overnight costs increased dramatically between 2002 and 2007
  - "The Future of Nuclear Power" estimated overnight costs of $2,000 per kW (2002 dollars)
  - "Update on the Cost of Nuclear Power" estimated overnight costs of $4,000 per KW (2007 dollars), or $3,471 per kW (2002 dollars) – an increase of 73 percent in real terms
    - By contrast, the MIT study estimates an increase in overnight costs of 54 percent for coal and 48 percent for natural gas
  - MIT study cites increases in the prices of key commodities necessary for constructing power plants as the driver of the increase in cost estimates between 2002 and 2007. These prices have increased at a rate much greater than the general rate of inflation.
  - MIT study reports that commodity prices have fallen since mid-2008 but notes that "it is impossible to predict" whether commodity prices will stay lower or merely represent "a temporary respite" from ever-escalating costs
- After examining cost data for 99 U.S. reactors in operation, a 2007 study in *Environmental Science and Technology* concluded that "past technology development patterns indicate the importance of including high-cost surprises in the planning process."

"No one has ever built a contemporary reactor to contemporary standards, so no one has the experience to state with confidence what it will cost," said Stephen Maloney, a utilities management consultant. "We see cost escalations as companies come up the learning curve."

Sources

Du and Parsons (2009), "Update on the Cost of Nuclear Power," May 2009; Hultman, Koomey, and Kammen, "What History Can Teach Us about the Future Costs of U.S. Nuclear Power," *Environmental Science and Technology*, April 1, 2007; http://www.nytimes.com/2010/07/27/business/global/27iht-renuke.html?ref=global.

As a Result of Escalating Costs, Many Projects Have Been Postponed or Cancelled

- As a result of these factors, many plants have been postponed or even cancelled altogether due to the increasingly unattractive economics of nuclear technologies
- Several nuclear projects have suspended their NRC combined license (COL) application review or have cancelled their proposed projects:
  - Grand Gulf (Entergy) – 2009 – Considering alternate reactor design technologies after failing to come to terms with reactor supplier; also cites limited demand after Hurricane Katrina and excess supply in region
  - River Bend (Entergy) – 2009 – Considering alternate reactor design technologies after failing to come to terms with reactor supplier; also cites limited demand after Hurricane Katrina and excess supply in region
  - Nine Mile Point (UniStar) – 2008 – Uncertainties in federal loan guarantee funding
  - Victoria County (Exelon) – 2009 – Economic uncertainties and limited availability of federal loan guarantees; Exelon resubmitted a more modest "Early Site Permit" application in 2010
  - Callaway (Ameren) – 2009 – "Financial and regulatory uncertainty" related to financing/CWIP; may be revived
  - Bellefonte (TVA) – 2009 – Falling electricity prices and financial burden of unrelated environmental cleanup costs

Sources
http://www.eenews.net/Greenwire/print/2009/04/24/9; http://www.bizjournals.com/stlouis/news/2010/11/19/nixon-backs-ameren-nuclear-plant-bill.html; http://www.eenews.net/Greenwire/print/2009/01/13/12; http://www.nola.com/business/index.ssf/2010/03/entergy_asks_psc_to_affirm_sup.html; http://www.reuters.com/article/idUSN0329520120091103; http://www.syracuse.com/news/index.ssf/2009/12/application_reivew_for_buildin.html; http://www.eia.doe.gov/cneaf/nuclear/page/nuc_reactors/reactorcom.html; http://www.nrc.gov/reactors/new-reactors/col.html; http://www.nrc.gov/reactors/new-reactors/esp.html; http://www.unistarnuclear.com/projects/nmp3.html; http://www.world-nuclear-news.org/NN-COL_review_for_Callaway_suspended-2906094.html; http://www.eenews.net/Greenwire/print/2009/08/10/8; http://edocket.access.gpo.gov/2009/E9-19045.htm; http://www.tva.gov/news/keytopics/bellefonte.htm; http://www.knoxnews.com/news/2010/aug/21/248m-okd-for-tva-site-in-ala/.

As a Result of Escalating Costs, Many Projects Have Been Postponed or Cancelled

- Other projects face significant economic uncertainty:
  - Calvert Cliffs (Constellation) – Rejected federal loan guarantee because of unfavorable financial terms; project status in doubt
  - Turkey Point (Florida Power and Light) – Stopped work on expansion because of a decision by the Florida Public Service Commission to reject a proposed rate increase to finance construction

"New projects have encountered delays attributable to such factors as rising costs, adverse regulatory decisions, difficulties in negotiations for new reactors, and last-minute reactor design changes. Another factor that might cause delays is the current low prices of some competing fuels. The flood of COL applications that began in July 2007 with the Unistar/Constellation application to build and operate an EPR at the Calvert Cliffs Nuclear Plant has abated."

– U.S. Energy Information Administration, July 2010

Given the industry's poor track record in estimating plant costs and the substantial uncertainties associated with building new nuclear power plants (as I have discussed above), it is reasonable to expect that the actual costs of new plants will be much higher than the industry now claims...

– Testimony of David A. Schlissel to the Public Service Commission of Maryland, July 16, 2008

Sources
http://www.eenews.net/Greenwire/2010/10/11/archive/3; http://www.world-nuclear-news.org/NN_Turkey_Point_nuclear_suspension_1410102.html; http://www.eia.doe.gov/cneaf/nuclear/page/nuc_reactors/reactorcom.html; Testimony of David Schlissel on behalf of the Maryland Public Interest Research Group Foundation, Case No. 9127 before the Maryland Public Service Commission, July 16, 2008.

CWIP Included in Retail Rates Poses Additional Risk to Ratepayers

- Where Construction-Work-in-Progress (CWIP) is included in retail rates, upfront recovery of plant development costs have contributed to increasing rates and likely will become increasingly burdensome over time, before a single kilowatt is generated

- **Example 1: Georgia Power collects CWIP for Vogtle 3 and 4 construction costs in Georgia**
  - Georgia Power first requested CWIP recovery in 2009 and received authorization to raise rates in January 2011
  - CWIP "will add an additional 10 dollars per month to the average [electricity] bill"
  - Moreover, for the first time since 1995, Moody's downgraded Georgia Power's credit rating, citing concerns about its nuclear expansion at Vogtle

Sources

http://www.ajc.com/business/downgrade-for-southern-co-591588.html; http://www.gainesville.com/apps/pbcs.dll/article?AID=/20101026/articles/101029590; http://www.gpb.org/news/2010/11/22/more-hearings-for-plant-vogtle-expansion; http://www.politicalaffairs.net/georgia-power-psc-sticks-it-to-ratepayers.

CWIP Included in Retail Rates Poses Additional Risk to Ratepayers

- **Example 2: Progress Energy collects CWIP for Levy County construction costs in Florida**
  - In 2010, Progress Energy collected $6.78 per month in CWIP on an average (1000-kWh) residential bill (approximately 5.3 percent) for its Levy County project
  - For 2011, Progress Energy reduced its CWIP request to $4.99 per 1000 kWh due to its decision to focus its efforts on licensing, not on construction
  - Should Progress Energy abandon the Levy County project, none of ratepayers' CWIP payments to date would be recoverable

- **Example 3: South Carolina Electric and Gas collects CWIP for the Virgil C. Summers nuclear project**
  - Rates are scheduled to increase approximately 2 percent per year
  - If rates increase 2 percent per year over ten years – the typical time to license and construct a nuclear facility – rates will end up 22 percent higher due to CWIP recovery

Sources

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"Bellefonte Nuclear Site," *Tennessee Valley Authority,* June 2010, <http://www.tva.gov/news/keytopics/bellefonte.htm>.

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