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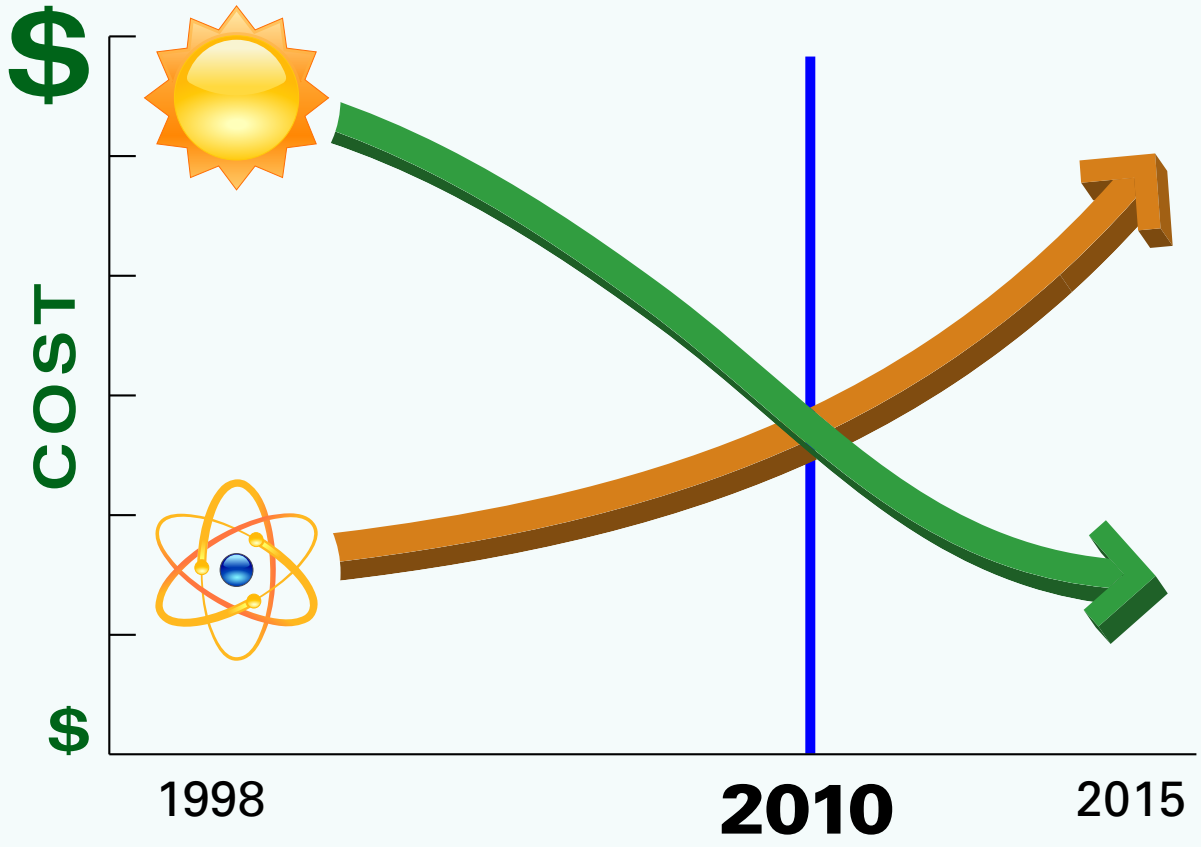
Solar and Nuclear Costs — The Historic Crossover

Solar Energy is Now the Better Buy



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July 2010

Prepared for NC WARN

NC WARN

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NC WARN: Waste Awareness & Reduction Network is a member-based nonprofit tackling the accelerating crisis posed by climate change — along with the various risks of nuclear power — by watch-dogging utility practices and working for a swift North Carolina transition to energy efficiency and clean power generation. In partnership with other citizen groups, NC WARN uses sound scientific research to inform and involve the public in key decisions regarding their well-being.

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SUMMARY

Solar photovoltaic system costs have fallen steadily for decades. They are projected to fall even farther over the next 10 years. Meanwhile, projected costs for construction of new nuclear plants have risen steadily over the last decade, and they continue to rise.

In the past year, the lines have crossed in North Carolina. Electricity from new solar installations is now cheaper than electricity from proposed new nuclear plants.

This new development has profound implications for North Carolina's energy and economic future. Each and every stakeholder in North Carolina's energy sector — citizens, elected officials, solar power installers and manufacturers, and electric utilities — should recognize this watershed moment.

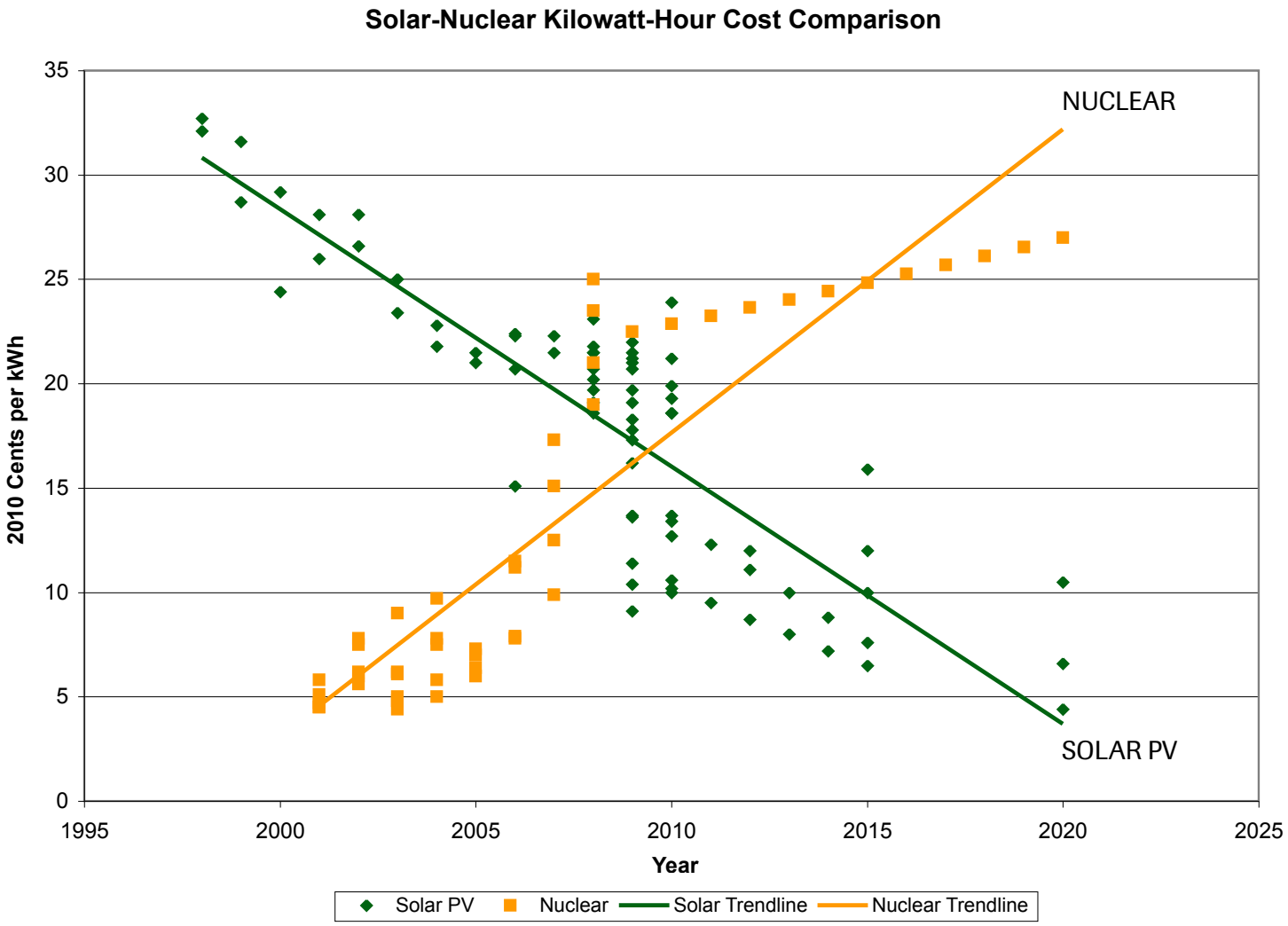

Figure 1: The Historic Crossover — Solar photovoltaic costs are falling as new nuclear costs are rising.[1]

The Solar PV least-squares trendline is fit to data points representing the actual cost of producing a kilowatt-hour in the year shown through 2010 and for cost projections from 2010 to 2020. The nuclear trendline is fit to cost projections made in the year shown on the x-axis of eventual kilowatt-hour cost if projects reach completion. See complete methodology in Appendix A.

State law requires that the development of the electricity system follow a "least-cost" path and that available resources be added as necessary. Less expensive resources are to be added first, followed by more expensive ones, provided that system reliability is maintained. Energy efficiency, wind power, solar hot water (displacing electric water heating) and cogeneration (combined heat and power), were already cheaper sources than new nuclear plants. This report illustrates that solar photovoltaics (PV) have joined the ranks of lower-cost alternatives to new nuclear plants. When combined, these clean sources can provide the power that is needed, when it is needed.

Here in North Carolina, solar electricity, once the most expensive of the "renewables," has become cheaper than electricity from new nuclear plants.

The state's largest utilities are holding on tenaciously to plans dominated by massive investments in new, risky and ever-more-costly nuclear plants, while they limit or reject offers of more solar electricity. Those utilities seem oblivious to the real trends in energy economics and technology that are occurring in competitive markets.

Everyone should understand that both new solar and new nuclear power will cost more than present electricity generation costs. That is, electricity costs will rise in any case for most customers, especially those who do not institute substantial energy efficiency upgrades. Power bills will rise much less with solar generation than with an increased reliance on new nuclear generation.

Commercial-scale solar developers are already offering utilities electricity at 14 cents or less per kWh. Duke Energy and Progress Energy are limiting or rejecting these offers and pushing ahead with plans for nuclear plants which, if ever completed, would generate electricity at much higher costs — 14–18 cents per kilowatt-hour according to present estimates. The delivered price to customers would be somewhat higher for both sources.

It is true that solar electricity enjoys tax benefits which, at the moment, help lower costs to customers. However, since the late 1990s the trend of cost decline in solar technology has been so great that solar electricity is fully expected to be cost-competitive *without subsidies* within the decade. Nuclear plants likewise benefit from various subsidies — and have so benefitted throughout their history.

Now the nuclear industry is pressing for more subsidies. This is inappropriate. Commercial nuclear power has been with us for more than forty years. If it is not a mature industry by now, consumers of electricity should ask whether it ever will be competitive without public subsidies. There are no projections that nuclear electricity costs will decline.

Very few other states are still seriously considering new nuclear plants. Some have cancelled projects, citing continually rising costs with little sign of progress toward commencing construction. Many states with competitive electricity markets are developing their clean energy systems as rapidly as possible. North Carolina should be leading, not lagging, in the clean energy transition.

We call on Governor Perdue, the General Assembly, the Energy Policy Council and the N. C. Utilities Commission to investigate these matters and see for themselves that a very important turning point has been reached.

An average North Carolina homeowner can now have a solar electricity system installed for a net cost ranging from $8,200 to $20,000 or more, depending on how much electricity the homeowner wants to generate.
Photo courtesy NOVEM (Netherlands Agency for Energy and the Environment).

THE BACKDROP FOR CHANGE

Electricity supply systems all over the world are facing the most rapid changes in their operating environments and technologies since the formative years of the industry. A tide of change is sweeping over the industry, one that challenges industry managers to stay abreast of these developments or risk presiding over costly anachronisms. The era of "build plants, sell power" is over; the rapid changes underway require a more agile, many-faceted approach to meeting energy demand in a responsible manner.

For thirty years, increasing the efficiency of electricity use has been known to be a faster and cheaper alternative to building new power plants. Energy efficiency advances are working their way into the marketplace and into consumer habits so that electricity demand is hardly growing at all. The accelerated adoption of energy-saving methods in the building industry, in the manufacture of appliances and lighting, and in retrofitting existing buildings means that annual electricity demand in homes, businesses and public buildings soon will begin a slow decline.[2] The partial electrification of transportation will open new markets for electricity, but when used in vehicles, electricity is much more efficient than fossil fuels. The overall additional demand will be modest,[3] and can be accommodated at off-peak times, or even better, powered by solar installations.

The emergence of wind power as a relatively cheap source of electricity has further complicated life for the traditional generating industry. Those who think it too intermittent to be useful have had to revise their opinions as successively larger amounts of wind power have been absorbed into many utility systems. Careful modeling has shown that penetrations of 20%, climbing to 30%, of overall electricity usage can be accommodated — mainly by rearranging the management of existing generation equipment rather than by building extensive backup facilities.[4]

Combined heat and power (cogeneration) has long been a means of generating electricity by burning a fuel for a primary use, then using the leftover heat for other purposes. Industries using process heat have found this beneficial for years. Commercial buildings with heating and cooling loads now also find it economical. Unfortunately, this highly efficient technology is under-utilized in North Carolina. By comparison, coal and nuclear plants are extremely inefficient; they waste large amounts of heat — two-thirds of the energy content of the fuels — and consume enormous quantities of water in the process.

Wind energy can complement solar to offset the intermittency of each technology. Several states are developing off-shore wind along the eastern seaboard.

THE SUN IS CHANGING THE GAME

By 2009, energy efficiency methods, combined heat and power, wind generation and solar water heating had all challenged the traditional business model of "build plants; sell power" favored by the big North Carolina utilities. All are cheaper and can be put into service much faster than building new fossil and nuclear power plants.

Now, in 2010, comes the final blow to the old way of doing business for utilities. In many places around the world, and here in North Carolina, solar electricity, once the most expensive of the "renewables," has become cheaper than electricity from new nuclear plants.

Figure 2 tracks the downward trend in solar PV electricity costs from 1998 to 2008. According to researchers at the Lawrence Berkeley National Laboratory, solar photovoltaic system costs declined from $12 per installed watt in 1998 to $8 in 2008 on average — a one-third decline in ten years. In 2009 and 2010, costs declined more rapidly as module prices fell sharply, bringing the 12-year system cost decline to 50%. At mid-2010, based on figures provided by North Carolina installers, large systems can produce electricity at 12–14 cents or less per kilowatt-hour, while the middle range

for residential systems comes in at 13–19 cents per kilowatt-hour, hence the average cost shown in Figure 1 of 16 cents.[5] The possibility of selling renewable credits tilts the advantage farther in the direction of solar electricity.

Experienced industry observers see photovoltaic system costs continuing to decline in the coming decade as the industry — from cell makers to installers — expands at a record pace and moves rapidly along the typical industrial "learning curve." Figure 1 illustrates these projections from 2010 through 2020. Present mid-range costs are 14–19 cents per kilowatt-hour for rooftop solar electric systems, and approximately 14 cents for commercial-scale systems. Sector-wide costs in 2020 are projected to be 7.5 cents per kilowatt-hour.[6]

Similarly, solar water heating has an "avoided cost" advantage over heating water with electricity from a new nuclear plant. Water heating accounts for 15–25% of a typical homeowner's power bill.

In 2009 more than 7,000 megawatts (MW) of solar generating capacity was installed in the world, of which half was in Germany. In the U.S., 429 MW was installed, with California and New Jersey as the leading states. North Carolina installed 8 MW.

Cumulative worldwide installations at the end of 2009 passed the 22,000 MW mark. Germany, Spain and Japan led in total installed capacity with 9000 MW in Germany alone. The U. S figure stood at 1653 MW of which 1102 MW was in California and 128 MW in New Jersey. North Carolina's share was 13 MW.[7]

Dramatic changes face the utilities as efficiency-conservation, combined heat and power, and most solar power are located in homes or businesses, not at centralized power plants.

The PV market is poised to explode worldwide as a "least-cost" way to generate electricity. By comparison, no U.S. nuclear power plants have been put into service in many years. Most proposed reactors are in the range of 1100 to 1200 MW.

The dramatic change facing the utility industry is highlighted by the observation that efficiency gains, combined heat and power, and most of the solar supply is located at homes,

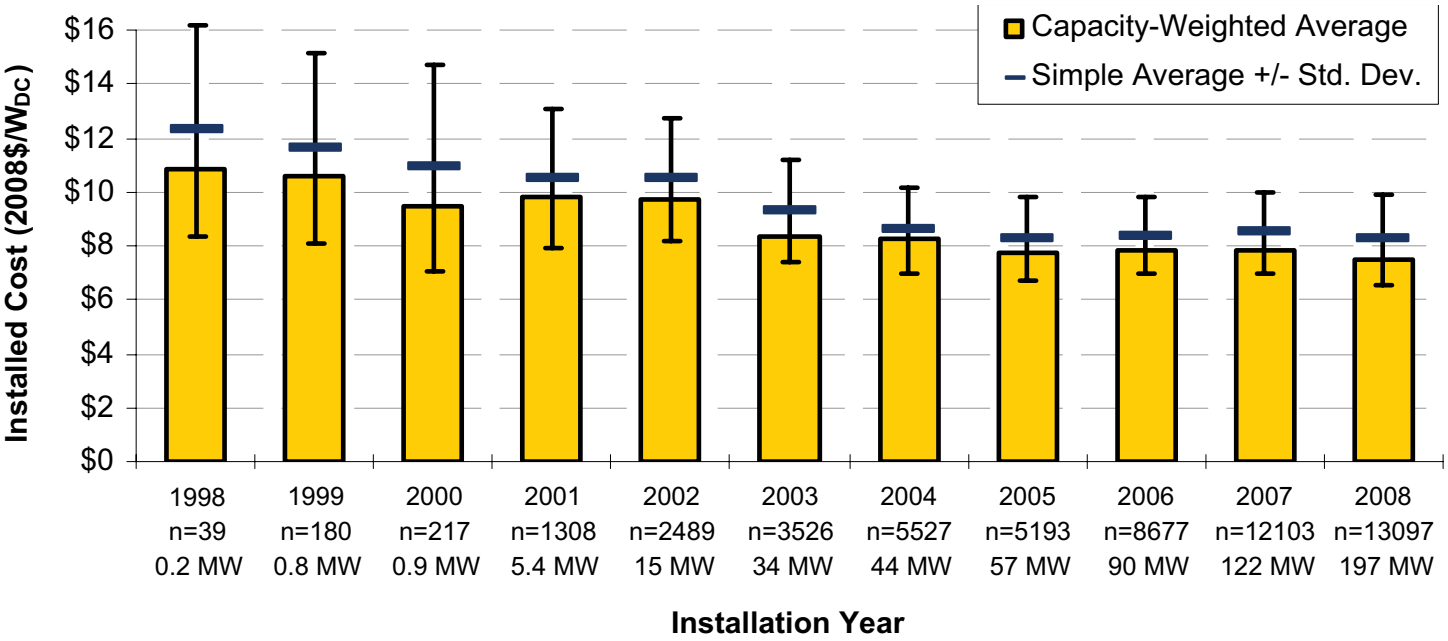

Figure 2: Falling installed cost for solar PV, 1998–2008 (Wiser, 2009).

These installed costs per watt of capacity, reported by the Lawrence Berkeley National Laboratory, are used to compute kWh costs from 1998–2008 in Figure 1.

businesses and public buildings, and is not sourced from centralized power plants. The power industry and the energy economy as a whole are being driven toward this "distributed" power model.

WHO PAYS FOR NEW NUCLEAR?

A number of tradition-oriented utility executives have persisted in pursuing nuclear plant licenses. Some have even begun to raise rates in the process, as Duke Energy did in 2009 in order to cover "pre-development" costs of its proposed Lee nuclear plant in South Carolina.

Utility CEOs are well aware of the enormous risks and financial commitments of this business strategy. That is why those who are still considering new nuclear plants are seeking to shift costs to taxpayers through federal loans and loan guarantees, and to electricity consumers through state legislation allowing immediate recovery of planning and financing charges through electric rates.[9] In normal circumstances, they would accumulate these costs and recover them in rates once plants are completed and actually producing electricity.

The economic irony is that rising rates inhibit the projected demand on which the supposed need for the plants is based. This is only the beginning. Electricity from new nuclear plants, if constructed, will continue to raise rates since electricity from nuclear plants is now more costly than alternative sources — wind, solar and combined heat and power generation. Nuclear power is much more costly than continued efficiency gains in electricity use.

North Carolina needs a "nuclear cost cap," not the one now in place for solar power.

The 2007 North Carolina legislation which established renewable and efficiency standards contains a provision to protect consumers from a too-rapid rise in rates that might result from developing "expensive" renewable sources like solar electricity — a "solar cost cap".[10] It appears that what is needed instead is a "nuclear cost cap". We are being asked to pay up front for nuclear electricity that we may never get.

The North Carolina Utilities Commission should instead require the utilities to use ratepayers' money for new solar electricity from which consumers can benefit immediately.

Since the much-heralded "nuclear renaissance" began during the past decade, cost estimates for new nuclear plants have risen dramatically. Projects first announced with costs in the

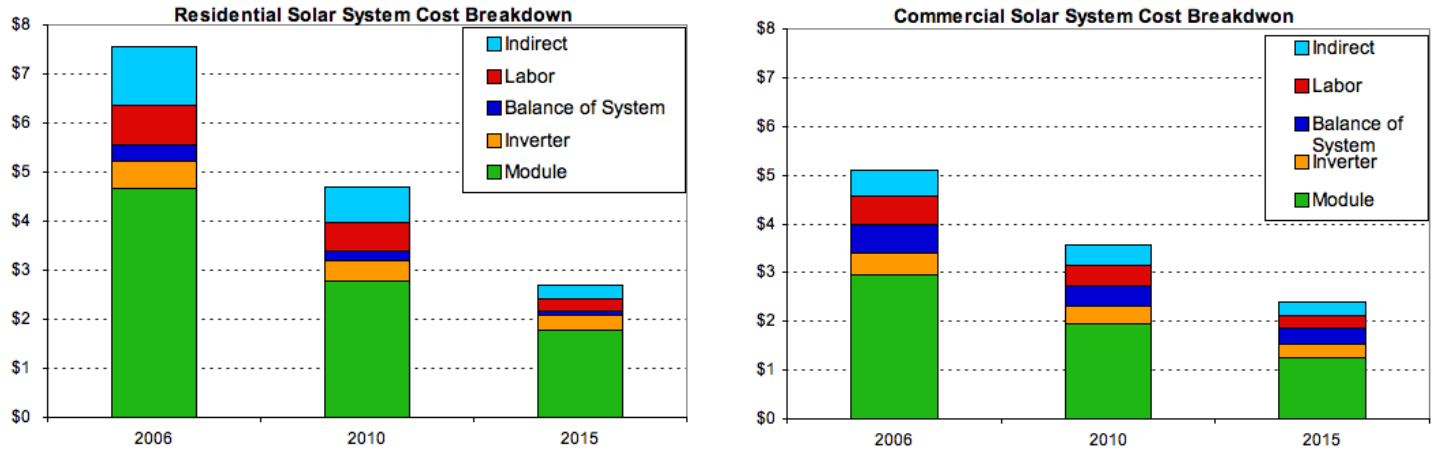

Figure 3: Residential and Commercial cost breakdown for solar PV in 2005 $ per watt installed, 2006–2015, U.S. Department of Energy.[8]

Total installed costs continue to decline for U.S. residential and commercial solar photovoltaic electricity. Crystalline silicon module costs, which are the most significant portion of system cost, are expected to bottom-out around one dollar.

$2 billion range per reactor have seen several revisions as detailed planning proceeds and numerous design and engineering problems have emerged. The latest price estimates are in the $10 billion range per reactor. Moreover, it will be at least six years before any plant could begin operating, and most projects are 10 to 12 years from possible completion. The Westinghouse AP 1000 reactor design, used in most current license applications, was being revised for the seventeenth time by September 2009. (See Appendix B, Nuclear plant cost estimates and upward revisions per reactor.)

Since capital costs represent some 80% of nuclear electricity's generation costs, projected kilowatt-hour prices have skyrocketed accordingly. Studies which showed expected electricity costs of 7 cents per kilowatt-hour have been updated to show nuclear electricity costs exceeding 18 cents per kilowatt-hour. Transmission and distribution costs would raise the delivered costs to residential customers to 22 cents per kilowatt-hour. This is twice the price North Carolina residential customers now pay to the big utilities.

In this analysis we follow the work of Mark Cooper, Senior Fellow for Economic Analysis at the Vermont Law School's Institute for Energy and the Environment (Cooper, 2009). After examining numerous utility estimates and those of other analysts, he concludes that new nuclear plants will produce electricity at costs of 12–20 cents per kilowatt-hour (with a mid-range figure of 16 cents) at the plant site, before any transmission charges. Plant cost escalations announced by utilities since Cooper's paper was published suggest that his lower figure is optimistic. Accordingly, we use here a range of 14–18 cents, with a midpoint of 16 cents. The 18 cents upper figure makes our findings somewhat more conservative. As shown in Figure 1, by the time plants could be built prices are likely to be much higher.

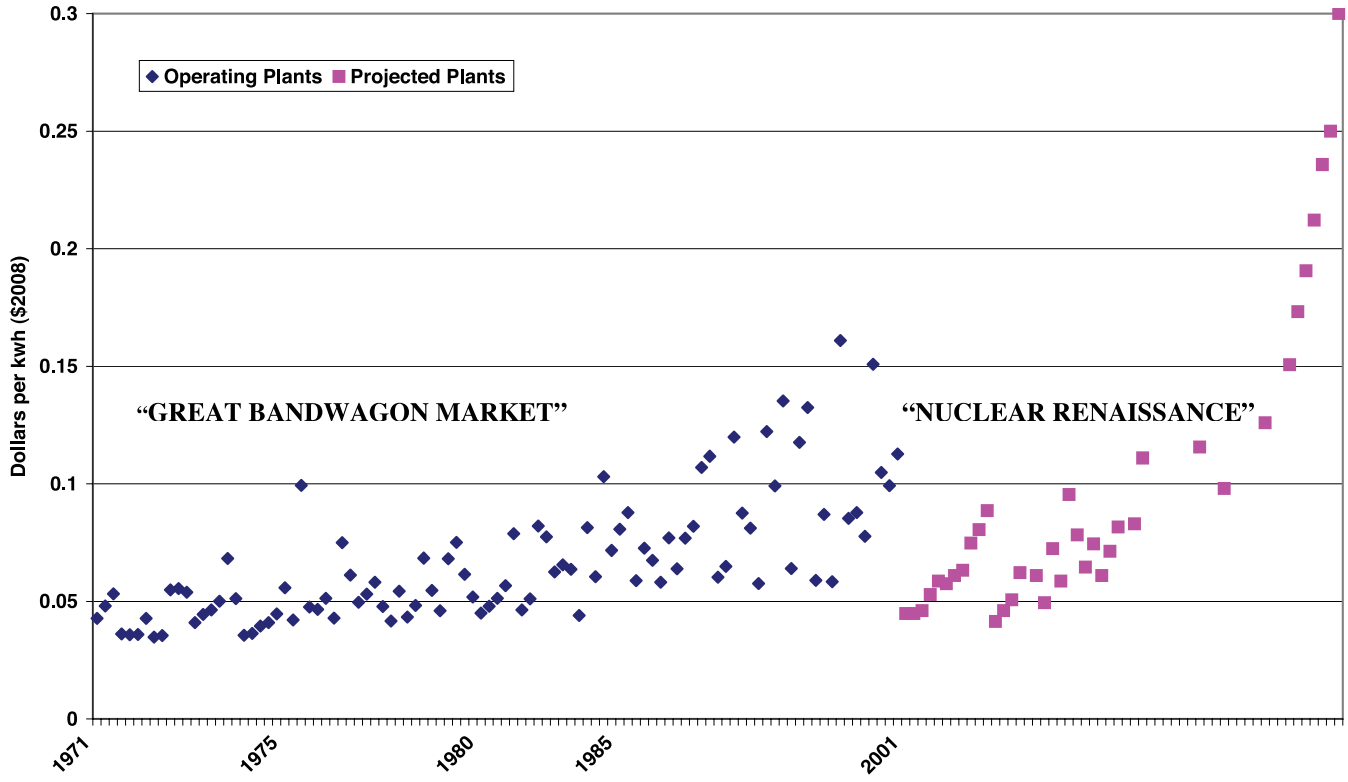

Figure 4: Nuclear power generation cost — operating reactors compared to proposed reactors (Cooper, 2009).

Clearly, new nuclear plants would generate power at a higher cost than solar electricity. These costs have just reached this crossover point in North Carolina in 2010, while nuclear costs continue to rise and solar costs continue to fall.

We further project that nuclear power from new plants would deliver residential electricity at 22 cents per kilowatt-hour and commercial electricity at 18–19 cents per kilowatt-hour, after adding transmission and distribution costs. Homeowners and businesses could readily choose on-site solar electricity as a cheaper alternative to new nuclear power.

WITNESSING THE CROSSOVER

Solar electricity has numerous advantages other than cost. Rooftop solar can be installed in a few days. Small incremental gains in total generating capacity start producing electricity immediately. One does not have to wait ten years for huge blocks of new capacity to come online. Solar panels leave no radioactive wastes. They do not consume billions of gallons of cooling water each year. There are no national security issues with solar installations. An accident would be a small local affair, not a catastrophe.

Utilities like to argue that solar PV and wind are not a substitute for baseload power from coal and nuclear plants because "the sun doesn't shine all the time and the wind doesn't blow all the time." That argument, and indeed the distinction between intermittent sources and baseload sources, is rapidly becoming obsolete. Fortunately, solar energy is strongest during periods of daily and seasonal peak demand, especially when supplemented by ice storage in air conditioning systems.

When solar generated electricity is added to a power grid with wind, hydroelectric, biomass and natural gas generation, along with existing storage capacity and "smart grid" technology, intermittency becomes a very manageable issue. Numerous studies in various parts of the U.S. and elsewhere — including most recently North Carolina — have demonstrated this point.[13]

Homeowners and businesses could readily choose on-site solar electricity as a cheaper alternative to new nuclear power.

Indeed, even the head of the Federal Energy Regulatory Commission now dismisses the need for new coal and nuclear power plants due to advances in wind, solar and smart grid technology that mitigate problems of distance and intermittency long associated with wind and solar power.[14]

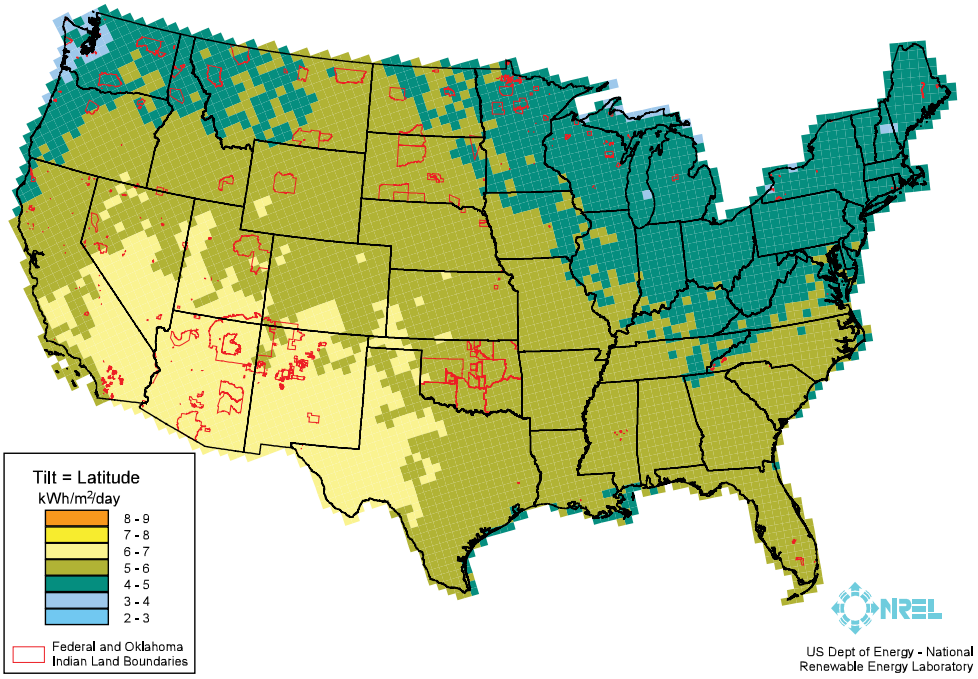

Figure 5: Solar photovoltaic resource potential.[11]

In the Southeast, nuclear utilities sometimes claim that our climate is not conducive to solar.[12] However, this region is second only to the Southwest in solar potential. Note also that New Jersey is a U.S. leader in implementing solar power, even though it has a less favorable solar resource.

The utilities' long range forecasts indicate that neither Duke Energy nor Progress Energy propose to open nuclear plants until after 2020.[15] This window of time can readily allow proven energy-saving programs, customer cogeneration and renewable energies to further develop toward providing most of the state's electricity needs.

JOBS AND MANUFACTURING – IN *NORTH* CAROLINA

Employment in North Carolina has more to gain from investment in solar electric and solar water installations than from the same amount of investment in nuclear plant construction and operation — by a factor of three.[16] The solar power industry is poised to bring in new production facilities and create good jobs distributed across the state. All that is required is for the N.C. Utilities Commission to enforce its own "least cost" requirements.

Environment North Carolina, citing data from the U.S. and abroad, estimates that raising the state's solar power production to 14% of total electricity by 2030 would create 28,000 permanent high-quality jobs.[17] Encouraging the manufacturing of solar components in-state — by extending manufacturing tax credits, for example — would raise the number of jobs created in this scenario to over 40,000. All told, the solar industry could provide billions of dollars of positive economic impact for North Carolina.

Nationwide, 6,000 high-quality jobs were created in the solar sector in 2007, according to the Solar Energy Industries Association. More than 100 currently planned commercial-scale solar energy projects represent potential for roughly 56,000 megawatts of electric power, over 100,000 construction jobs and 20,000 permanent jobs.[18]

The federal 30% tax credit for installing solar power — effective through 2016 — is expected to create 440,000 permanent jobs in the U.S. and spur $325 billion of private investment in the solar industry (Navigant, 2008).

By comparison, two new reactors proposed for the Shearon Harris plant by Progress Energy would concentrate jobs around Wake County, and Duke Energy's proposed Lee Station reactors would generate jobs in Cherokee County, South Carolina although North Carolina customers would absorb 70% of the cost and risk.[19]

IS THE PUBLIC AHEAD OF THE UTILITIES?

The North Carolina public seems to understand the many advantages of renewable energy and efficiency investments. A recent poll by Elon University showed that 80% of the public favored the development of solar and wind power.[20]

Regrettably, neither Duke Energy nor Progress Energy seem interested in any additional solar purchases beyond the miniscule (two-tenths of one percent) and easily-reached solar requirement of North Carolina's Renewable Energy and Energy Efficiency Portfolio Standards enacted in Senate Bill 3 in 2007. That "set-aside" for solar had been intended as a minimum level that would help the industry develop, but the utilities have apparently interpreted it as a maximum level beyond which they need not go. Solar installers complain that Duke Energy has turned down a host of competitively priced proposals, and that Progress Energy generally considers only small-scale projects to meet its 0.2% solar requirement.[21] The utilities apparently prefer to pursue more expensive power from new nuclear plants.

A recent poll showed that 80% of the public favored the development of solar and wind power.

We must be clear that new solar and nuclear electricity costs are both above most present North Carolina electricity rates. Rates from the state's two largest utilities, Duke Energy and Progress Energy, are 10.5 cents per kilowatt-hour for residential customers and 6–7 cents for commercial customers, while customers of municipal systems and cooperatives already

pay rates as high as 18 cents. Most rates will go up; that is unavoidable, but they will rise much less in an efficiency-solar-wind electricity future than they will in a nuclear-electricity future.

FINANCING SOLAR EQUIPMENT

Even though long-term energy savings begin immediately with rooftop solar energy, an upfront investment is required. Would-be solar buyers need financing; they need access to loans at reasonable rates of interest and monthly payments that are manageable. To date, some of the best financing programs are the plans under which local governments borrow at tax-exempt rates, lend those funds to homeowners for solar equipment installations, then collect the periodic payments with the tax bill. Should the homeowner sell the property before the loan is paid off, the solar system obligation remains with the property. This arrangement, the PACE (Property Assessed Clean Energy) loan, originated in Berkeley, California in 2008 and has spread rapidly across the country since then. In August 2009 the North Carolina General Assembly gave authority for local governments to use this plan but none has yet been announced.[22]

The emerging solar industry in North Carolina must credit the constructive role played in recent years by NC GreenPower, an independent nonprofit organization approved by the NC Utilities Commission that supports solar PV and other renewable energies by providing a market for small-scale residential generation. Owners of small (less than 10 kW) solar PV systems can sell their electricity to the grid at a guaranteed subsidized rate of 19 cents per kilowatt-hour. This guarantee has not only created demand for PV systems from a first wave of consumers, it has also helped small-system owners secure financing by reducing the variability and duration of system payback.

An arrangement in some states allows all solar users to feed excess power to the grid, then buy it back at night at the same retail rate. In this way, the grid becomes an important storage mechanism, and many homes

Various programs are growing around the nation that allow rooftop solar customers essentially to pay for their systems through monthly energy savings.
Photo courtesy Evergreen Power, Ltd.

and businesses can therefore self-supply a high percentage of their total electricity needs. Although on-site storage is not included in prices shown in this report, some homeowners choose to add batteries so that solar electricity can be used when the sun is not shining.

WHAT ABOUT SUBSIDIES?

As pointed out in the summary above, solar and nuclear costs given here reflect the costs that would actually be paid by consumers. They are net of a variety of financial incentives for each technology. This is as close as one can get to an "apples to apples" comparison (see note 6). In the solar case, the incentives are federal and state tax credits. Nuclear power incentives or subsidies are rarely collated and published, so they are difficult to express as costs per kilowatt-hour. Among the nuclear subsidies:

- The nuclear industry insists on taxpayer insurance against catastrophic accidents. The Price-Anderson act caps the liability for an accident at a level that now totals approximately $11 billion, which would be distributed among all reactor owners. Federal studies estimate that the damage from non-worst case accidents could exceed $500 billion.[23]

- Ten billion dollars has been expended over two decades to license the Yucca Mountain repository for used commercial fuel rods, but in 2010 the Obama administration is attempting to cancel the project. That wasted sum was accumulated through utility bills, so it was included in the kilowatt-hour cost of nuclear power. To date there are no credible plans or cost estimates for managing this highly radioactive waste for thousands of years, but much or all of the outlay will be borne by the federal taxpayer.
- The Department of Energy's 2011 budget request includes $1.8 billion for nuclear power — 44% of all energy R&D. This amount is lower than in previous years, but high for a decades-old industry that operates so efficiently, according to its supporters.[24]

The nuclear industry, well aware of the economic and financial disasters of the 1980s, already has successfully transferred some costs and risks to consumers. It will not proceed without federal loans, or at least loan guarantees, for the enormous borrowing that would be necessary. This is because the financing institutions, "Wall Street" in the popular press, will not lend for nuclear projects without taxpayer backing. This risk transfer is necessary due to scores of project cancellations and loan defaults experienced during the first generation of reactors.[25]

Credit rating agencies are weighing in on the uncertainty that nuclear development projects will convert mountains of debt into viable investments. A 2009 Moody's report warns of "future rate shocks" for electricity consumers resulting from "bet-the-farm" nuclear endeavors.[26] The Institute for Southern Studies reported that as of July 2009 two of the 17 proposed nuclear projects have had their construction bonds rated as "junk" status and 13 others are rated as just one step above junk.

Most utilities have cancelled or delayed projects due to soaring cost estimates, myriad design problems, growing uncertainty about licensing and construction — and increasing competition by clean technologies that are now cheaper. For example, Entergy CEO Wayne Leonard, in explaining why he suspended license applications to build four new reactors in Mississippi and Louisiana, said there are too many risks the utility cannot control, especially uncertainty in construction costs.[27]

The utilities are turning down or limiting solar proposals priced at rates lower than power from new nuclear plants.

Still, many utilities hope to build new nuclear plants — mostly with public money:

- In 2005, the Bush administration's energy bill included $18 billion in new subsidies, including loan guarantees, to incentivize utilities to seek licenses for new nuclear plants.
- This year the Obama administration went several steps farther, upping the loan guarantee total to $54 billion, and quietly agreeing to even lend taxpayer funds for Plant Vogtle. The Georgia plant might become the first project to receive a license — possibly late in 2011 — to construct and operate a new plant.
- Some in Congress want to do even more. A new analysis conducted for Friends of the Earth shows that tax breaks totaling $9.7 billion to $57.3 billion (depending on the type and number of reactors) would come on top of proposed subsidies totaling $35.5 billion in the Kerry-Lieberman bill. If this bill succeeds, nuclear plant owners might essentially bear no risk.[28]
- In 2007, North Carolina joined other southeastern states in passing legislation that allows power companies to pre-charge customers for some of the costs of licensing and building nuclear plants. Duke Energy has signaled that it will soon seek even more transfer of financial risks to North Carolina customers, apparently through additional Construction Work in Progress measures that create an automatic pass-through of costs to consumers without Duke Energy or

Progress Energy having the costs reviewed in a rate case before the utilities commission.

North Carolina's current approach does not fare well in comparison with that of other states. Twenty states have renewable portfolio standards of 20% or more, compared to our 12.5%. The following examples are from the Database of State Incentives for Renewables & Efficiency.[29]

- Hawaii's goal of 40% renewable power is supplemented by an efficiency goal of 30% by 2030.
- California, which will meet its 20% goal in 2010 or 2011, has an executive order, now about to be reinforced by legislation, to raise this to 33% by 2030. This commitment to renewable energy, added to existing hydroelectric output, will bring the state's renewable electricity to nearly half of total generation.
- Colorado was ahead of schedule to meet its 20% goal, which was then raised to 30% by 2020.
- New Jersey's Energy Master Plan earlier called for 3200 MW of wind capacity and 1500 MW of solar capacity — all by 2020. In 2010, the solar requirement was increased to approximately 4000 MW.
- Alaska has adopted a renewable electricity goal of 50%.
- New York seeks a 15% efficiency gain and a 30% share for renewable electricity by 2015.
- Maine's renewable electricity goal is 40% by 2017.

One reason North Carolina and most southeastern states are lagging is that their utilities are granted monopoly service areas, which exclude competition and create captive customer bases. In such "regulated" states, utilities are succeeding with legislative efforts to transfer the financial risks of nuclear plant construction to ratepayers, as noted above.

CONCLUSION

Many U.S. utilities are finding solar and wind energy to be profitable and preferable to risking investments in new nuclear facilities. In fact, Duke Energy considers itself a leader in clean technologies, and indeed is developing significant solar and wind energy projects — but those projects are in other states where Duke must compete for market share.

For many years the U.S. nuclear power industry has been allowed to argue that "there is no alternative" to building new nuclear plants. This is just not true. It is time for the news media and the public to see the compelling evidence that clean, efficient energy is the path forward and to make sure their elected representatives hear this message repeatedly.

North Carolina faces an opportunity to join the critical global transition to clean, affordable energy. Building new nuclear plants would commit North Carolina's resources in a way that impedes the shift to clean energy for decades.

We must make decisions now that allow us to look back at the spring of 2010, when solar energy became cheaper than new nuclear plants, as the time when North Carolina changed its future.

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[2] California began a serious effort to increase energy efficiency in the 1970s and never stopped. As a result, its per capita electricity consumption has barely changed in the years since. The average annual efficiency gain is around 1.5%. Other states, starting later, have achieved similar results. Nationwide, building codes are making commercial and residential buildings more energy-efficient. Federal, state and local government buildings are receiving special attention. Stimulus funds have recently been applied to weatherization projects. North Carolina's building code decreased the electricity consumption of new residences by 19% and further tightening measures are nearing adoption.

[3] The Chevrolet Volt, by no means the most energy-efficient vehicle, is expected to go five miles on 1 kilowatt-hour — the equivalent of 180 miles per gallon.

[4] Iowa now generates 17-20% of its electricity from wind turbines. Some of this capacity is sold out-of-state and the rest is integrated into the state energy mix.

Zavadil, Robert. "National Transmission Issues for Wind: A Perspective." EnerNex Corporation. *Nebraska WindPower 2009*, 9-10 November, 2009. <http://www.neo.ne.gov/Powerpoints/Monday%20Track%20A/Transmission%20issues/Zavadil/National_Wind_Transmission_Issues_-_A_Perspective_-_RZ.ppt>.

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[5] Wiser, Ryan, et al. "Tracking the Sun II: The Installed Cost of Photovoltaics in the U.S. from 1998-2008." Lawrence Berkeley National Laboratory, Environmental Energy Technology Division. October 2009.

[6] Solar PV cost per watt or per kilowatt figures are translated into kilowatt-hour costs with respect to the following parameters: 18% capacity factor, 25-year period of cost amortization, and 6% borrowing rate. Both the 30% Federal and 35% North Carolina tax credits have been applied where appropriate. See Appendix A for a thorough explanation of methodology.

[7] Solar Energy Industry Association. "U. S. Solar Industry Year in Review." 2009.

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[8] United States Department of Energy, Solar Energy Technologies Program. "Solar Energy Industry Forecast: Perspectives on U.S. Solar Market Trajectory." 27 May 2008.

[9] The rate increase that Duke Energy sought in its 2009 filing was approved in part and took effect on 1 January, 2010. The costs sought to be recovered contained $160,000,000 related to the two proposed reactors at the William Lee site in South Carolina.

[10] N.C. Session Law 2007-397, Senate Bill 3.

[11] United States Department of Energy, National Renewable Energy Laboratory. "Solar Photovoltaic (PV) Resource Potential." 29 April 2003. 9 June 2010 <http://www.eia.doe.gov/cneaf/solar.renewables/ilands/fig11.html>.

[12] Newkirk, Margaret. "Solar industry challenges Georgia Power." *The Atlanta Journal-Constitution*. 13 June 2010. 21 June 2010 <http://www.ajc.com/business/solar-industry-challenges-georgia-548016.html>.

[13] Eastern Wind Integration and Transmission Study," prepared for the National Renewable Energy Laboratory, Enernex Corporation. January, 2010.

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Blackburn, John. "Matching Utility Loads with Solar and Wind Power in North Carolina: Dealing with Intermittent Electricity Sources." Institute for Energy and Environmental Research. March 2010.

Similar studies are underway at Stanford University and in Europe.

[14] O'Grady, Eileen. "U.S. utilities, regulator disagree on generation." *Reuters*. 6 May 2009. 23 June 2010 <http://uk.reuters.com/article/environmentNews/idUKTRE5447HI20090505>.
The nation's top power industry regulator on Tuesday suggested that U.S. utilities don't need to build big nuclear or coal-fired power plants to fill the nation's future power supply needs. Instead, Jon Wellinghoff, chairman of the Federal Energy Regulatory Commission, said future electricity demand growth can be met with a low-emission supply from wind, solar and other renewable sources, combined with more efficient use of all sources of electricity. "We have the potential in the country, we just have to go out and get it," Wellinghoff said at a briefing with reporters at the American Wind Energy Association's conference in Chicago, monitored by telephone.

[15] "Progress Energy Carolinas Integrated Resource Plan." Progress Energy Carolinas, Inc. 1 September 2009.

"Duke Energy Carolinas Integrated Resource Plan (Annual Report)." Duke Energy Carolinas, Inc. 1 September 2009.

[16] Garrett-Peltier, Heidi. "$1 Million = More jobs for green industries." Political Economy Research Institute, University of Massachusetts Amherst.

[17] Madsen, Travis and Elizabeth Ouzts. "Working With the Sun: How Solar Power Can Protect North Carolina's Environment and Create New Jobs." Environment North Carolina, Research & Policy Center. May 2010. 11 June 2010 <http://www.environmentnorthcarolina.org/uploads/ca/80/ca809d139d551c92990e082edc6e4b15/Working-with-the-Sun.pdf>.

[18] Navigant Consulting, Inc. "Economic Impacts of Extending Federal Solar Tax Credits." 15 September 2008. 22 June 2010 <http://seia.org/galleries/pdf/Navigant%20Consulting%20Report%209.15.08.pdf>.

[19] Duke Energy serves approximately 2.4 million customers across 24,000 square miles of North Carolina and South Carolina. Of this total, roughly 70% of Duke Energy's ratepaying customers reside in North Carolina.

[20] Elon University Poll. 1 March 2010. 21 June 2010. <http://www.elon.edu/docs/e-web/elonpoll/elonpoll_data_tables_3_1_10.pdf>.

[21] Downey, John and Susan Stabley. "Duke Energy's solar effort clouding growth?" *Charlotte Business Journal* 28 May 2010, 1+.

[22] "North Carolina PACE Financing." *PACE Financing — PACE Program Information*. 2010. 17 June 2010 <www.pacefinancing.org/state-financing/north_carolina>.

[23] Brookhaven National Laboratory. "Severe Accidents in Spent Fuel Pools in Support of Generic Safety Issue 82." NUREG/CR-4982. 1997.

[24] The U.S. Department of Energy's Fiscal Year 2011 Budget Request. Analysis by Robert Alvarez, Senior Scholar, Institute for Policy Studies. February 2010.

[25] United States Nuclear Regulatory Commission. "2009-2010 Information Digest." NUREG-1350, Vol. 21. August 2009.

[26] The Institute for Southern Studies. "Nuclear plans hurting power companies' credit ratings." July 2009. 15 June 2010 <http://www.southernstudies.org/2009/07/nuclear-plans-hurting-power-companies-credit-ratings.html>.

[27] "Entergy says nuclear remains costly." *Reuters*. 25 May 2010. 15 June 2010 <http://uk.reuters.com/article/idUSTRE64N5S420100524>.

[28] Koplow, Doug. "Massive tax subsidies to nuclear in Kerry-Lieberman legislation." *Friends of the Earth*. 17 June 2010. 22 June 2010. <http://www.foe.org/more-kerry-lieberman-nuclear-subsidies/>.

[29] DSIRE: Database of State Incentives for Renewables & Efficiency. 22 June 2010 <http://www.dsireusa.org/>.

APPENDIX A: METHODOLOGY

The conclusions of this report depend upon a cost per kilowatt-hour comparison between electricity generated by nuclear reactors and solar photovoltaic systems — both net of subsidies. The authors of this report have implemented a methodology to derive kilowatt-hour (kWh) costs from project installation costs in a transparent manner.

Historical installation costs (per watt) were collected from solar industry sources and public research organizations — most notably the Lawrence Berkeley National Laboratory. Present installed costs for solar generating capacity were calculated by collecting installed cost data from North Carolina installers. Future cost projections were sampled from published industry analyses and third-party studies (see citations for Figure 1). The authors made further projections from 2010 to 2015 by applying a regular rate of decline to the Department of Energy Solar America Initiative base projections for 2010. Dollar amounts are reported in 2010$.[1]

For kWh prices of nuclear generated electricity from 2001–2008, the authors rely on the Cooper (2009) study of nuclear price trends. Nuclear kWh price projections from 2009–2020 are made by applying a 1.67% annual price level increase to the average of Cooper's 2008 projections.[2] Refer to Appendix B for the purpose of comparing this conservative estimate of nuclear price escalation to recently observed trends.

The authors derived solar cost per kWh using the following calculation:

$$\text{Capital Cost (\$ per kWh)} = \frac{\text{Project Cost (\$)} \times \text{Amortization Factor}}{\text{Generating Capacity (kW)} \times \text{Capacity Factor (\%)} \times \text{8760 hours}}$$

Capacity factor indicates the percentage of hours in a year that a solar installation generates electricity output. A reasonable industry standard for North Carolina is 18%, given the state's solar insolation profile. This figure will vary slightly as a function of site and module specifics — including shading, roof pitch, and whether or not the photovoltaic unit includes a "sun tracking" device. Before kWh calculations were made, the authors adjusted actual generating capacity by a derating factor (15%) to reflect the line-loss that occurs when a central inverter converts direct current (DC) to alternating current (AC) for use. 15% is a consensus derating factor, although interviewed installers cited rapid improvement in inverter efficiency and/or the use of micro-inverters on the back of each PV panel — both of which are limiting line-loss to less than 10% and as little as 3%.

Amortization factor reflects the annual payment due on each borrowed dollar of investment. The amortization factor, for given parameters *borrowing rate (i)* and *amortization period in years (n)*, is calculated:

$$\text{Amortization Factor} = \frac{i}{1 - (1 + i)^{-n}}$$

Capital costs for solar generation were calculated with a 6% borrowing rate and a 25-year amortization period. Standard solar modules are warrantied for 25 years.

A 30% Federal tax credit and a 35% North Carolina tax credit were applied to the capital cost to reach a net cost per kWh.

Example: 3 kW residential solar installation, $6/watt installed cost, 6% borrowing rate, 25-year amortization period, 18% capacity factor, 15% derating factor.

$$\text{Cents / kWh} = \frac{\$18{,}000 \times 0.078227}{(3\text{ kW} \times 0.85) \times 18\% \times 8760\text{ hours}} = 35.0¢$$

Taking 30% and 35% Federal and state tax credits yields a net system cost of $8,190 and a net production cost of 15.9¢/kWh.

[1] The U.S. Department of Commerce Bureau of Economic Analysis reports that the index for gross private domestic investment has increased from 89.947 in 2000 to 106.623 in 2009 (base year 2005 = 100). Projections made in 2005$ were adjusted to 2010$ using the 6.623% increase in the price of gross private domestic investment.

[2] The same BEA report indicates an annual 1.67% price increase from the year 2000 index to the year 2009 index.

APPENDIX B: NUCLEAR PLANT COST ESTIMATES AND UPWARD REVISIONS PER REACTOR

Utility and Project	Reactors Planned	Year of Estimate	Reactor Capacity (MW)	Cost per Reactor (Billion $)
Florida Power & Light Turkey Point (FL)	2	2007	1550	9.00
		2010	1550	12.51
Progress Energy Shearon Harris 2 & 3 (NC)	2	2008	1100	2.20
		2008	1100	4.60
Progress Energy Levy (FL)	2	2009	1105	8.50
		2010	1105	11.25
CPS South Texas Project	2	2007	1358	7.10
		2009	1358	9.10
S. Carolina Elec. & Gas V.C. Summer (SC)	2	2008	1117	4.90
		2009	1117	5.70
		2010	1117	6.25
Duke Energy William Lee (SC)	2	2005	1117	2.00–3.00
		2009	1117	5.60
PPL Bell Bend (PA)	1	2008/09	1600	4.00
		2010	1600	13.00–15.00
TVA Bellefonte (AL)	2	2007	1100	7.10
		2008	1100	8.75
Atomic Energy of Canada, Ltd. Darlington*	2	2007	1200	3.48
		2009	1200	12.96
Constellation Energy Calvert Cliffs (MD)	1	2005	1600	2.00
		2007	1600	5.00
		2008	1600	9.60

*Project cancelled due to cost escalation.

NOTE: Utilities have been reluctant to disclose nuclear plant estimates, and have done so on different bases. Some include financing costs and escalation during construction; some are not at all current. We have used these estimates as supporting evidence to the Cooper report.