ENERGY EFFICIENCY AND WIND AND PV SOLAR POWER, by Willem Post, March 29, 2010

http://www.coalitionforenergysolutions.org/

INTRODUCTION

US total installed electricity generating capacity is about 1,000,000 MW, of which wind is 35,000 MW (produced about 1.7% of all power in 2009), and nuclear is about 100,000 MW (produced about 20.2% of all power in 2009). For about 25 years utilities have been adding gas-fired combined cycle gas turbine, CCGT, plants and retiring coal and oil fired plants. For the past 5 years they have also built many (heavily subsidized) wind plants. Current power production is from coal 44.4%, gas 23.7%, nuclear 20.2%, hydro 6.8%, oil 1% (even less from IMPORTED oil) and Other 3.6%, of which Wind about 1.7%, Biomass about 1%, Geothermal about 0.8%, PV solar about 0.1%. Transportation uses about 28% of US energy consumption and 75% of that is IMPORTED oil. http://www.eia.doe.gov/cneaf/electricity/epm/epm_sum.html

The energy intensities, BTU/$GDP, of the US, Germany, UK, Switzerland, Denmark and Japan are 9111, 7396, 6145, 4901, 4845 and 4519, respectively. The US has some catching up to do regarding energy efficiency, just as Detroit with foreign cars. It took a near-death experience for Detroit to wake up from its 50-year slumber. The way Congress is acting and debt is growing, the US near-death experience may come sooner than later. Greece, the UK and the US have budget deficits exceeding 12% of GDP. Will China bail out the US? http://www.icleikorea.or.kr/board/bbs/download.php?bo_table=foreign_news&wr_id=102&no=1

Doing energy efficiency FIRST and then renewables is the most economical way to go; especially important when funds are scarce. Vermont's rush into renewables before doing energy efficiency is unwise. Vermont is shooting itself in the foot. It will take at least $250 million of scarce funds to build 50 MW of expensive renewables that produce expensive power, that will make Vermont less efficient at exactly the time it needs to become more efficient. About 35% of the $250 million would be supplied by Vermont sources, the rest, mostly equipment, by non-Vermont sources. There would be spike of job creation during the 1-3 year construction stage (good for vendors) which would flatten to a permanent net gain of 13 full-time jobs (jobs are lost in other sectors) during the operation and maintenance stage, according to a December 2009 VT-DPS white paper. Germany and Spain, big on renewables, had similar misallocations of capital, the fallout of unwise government policies.
http://publicservice.vermont.gov/planning/DPS%20White%20Paper%20Feed%20in%20Tariff.pdf
http://www.rwi-essen.de/pls/portal30/docs/FOLDER/PUBLIKATIONEN/GUTACHTEN/P_RENEWABLE+ENERGY+REPORT+RWI+FORMAT.PDF

Some people claim we must do renewables to diversify our power sources. The ISO-NE grid already has a large diversity of power plants and fuels that provide reliable power. Vermont does not need to invest scarce funds in a multitude of renewables to achieve its own diversity and become less efficient in the process.

There are major side benefits from becoming more efficient. People have to put on their thinking caps. It leads to better trained people, technological advances and better designs that are more productive and competitive which helps exports, reduces the trade deficit, increases household incomes and tax collections. Excellence has its rewards. Vermont spends far too little on energy efficiency. More than $20 million of the $30 million annual budget of Efficiency Vermont is expenses for payroll, office, travel, etc., of its 170 person staff. None of that $20 million saves energy. It would be more effective to use the $30 million/yr, augment it to $100 million/yr, and use all of it as DIRECT incentives to the bottom 90% of households to make their houses and their vehicles more energy efficient; the lower the household income, the greater the incentives.

Vermont has one of the LOWEST per capita emissions of CO2 in the the US, largely because of CO2-free power from Hydro-Quebec and Vermont Yankee that provide about 65% of Vermont's power. Commercial and residential buildings and transportation produce about 71% of Vermont's CO2 emissions. Given Vermont's CO2 condition, one would think improving the efficiency of buildings and vehicles would be at the top of the legislative agenda, instead of dabbling in renewables. Legislators may think improving efficiency is somewhat mundane. They, aided by renewables proponents, vendors and tax shelter specialists, rather promote the feel good, magic aura of expensive renewables that produce expensive power.

ECONOMIC IMPACTS OF ENERGY DECISIONS

Vermont and most of its people are in dire financial straits. Vermont, a poor state with a weak economy and big deficits for years to come, does not HAVE to waste taxpayer money to subsidize expensive renewables that produce expensive power. Let richer states be the "forward-looking pioneers". Vermont needs measures to increase worker productivity and to make Vermont more efficient in ALL areas, including energy. Subsidies usually SHIFT jobs from one sector to another; there is little NET job gain. Job gains usually come from improving worker productivity and becoming more efficient and BROADLY DISTRIBUTING the benefits of those efficiencies.

Legislators came up with renewable power schemes that: keep many state employees and highly-paid outside consultants busy with studies, administration, etc.; are capital intensive, when capital is scarce; require large subsidies and investments per job created; produce expensive power, when large quantities of much less costly, CO2-free power from Hydro-Quebec and Vermont Yankee are readily available to Vermont requiring NO capital investment; waste taxpayer money, when Vermont's aggregate household income and tax revenues are dropping and will be stagnant for some years.

The Vermont Public Service Board and the legislature led by Shumlin enact laws that require the Vermont Department of Public Service, VT-DPS, to spend great efforts to study and prepare testimonies regarding the financial viability of renewable power projects; the veto-proof majority ensures laws will be changed to adjust subsidies and feed-in-tariffs to provide renewables projects with desirable rates of return.

It is unwise policy to provide subsidies for expensive renewables that produce expensive power that make Vermont LESS efficient and LESS competitive. Efficiency Vermont claims it can produce savings at $0.03/kWh through efficiency measures. It would be wiser to augment those efforts, instead of producing renewable power at $0.20-$0.40/kWh, as shown by the VT-DPS spreadsheets. Are legislators so rose-colored green they can't see the forest for the trees? Were 70% of the legislators just voting as told by their leaders, or were they possessed by a herd mentality. Did they not understand the tax shelter implications and gross inequities of Act 45?

Some legislators, to defuse criticism of Act 45, repeat talking points from surveys predating the GREAT RECESSION when pointing out that Vermonters love to pay more for renewable power. I think Vermonters did not realize legislators would turn renewables into multimillion dollar tax shelters for a few lottery winners at the expense of everyone else. The inequities of ACT 45 and ratepayers' economic predicaments have given Vermonters pause to do some rethinking, and legislators need to listen to them; it is an election year.

The Clean Energy Development Fund, CEDF, normally gets about $4-$7 million/yr from Entergy which owns Vermont Yankee. Because of the Great Recession, federal stimulus funds were received by Vermont, but instead of more incentives for energy efficiency, legislators, seeing an opportunity to fund Act 45, quickly assigned about $21,000,000 to the CEDF. As a result, the CEDF 2010 Fiscal Year budget will be about $28 million. It plans to dole out most of it as grants and low interest loans for expensive renewables that produce expensive power. Legislators should reverse this unwise spending. However, the spending is doled out throughout Vermont and legislators are eager to point it out to voters. There is even a CEDF map showing how projects are distributed. A conundrum. http://publicservice.vermont.gov/energy/ee_files/cedf/Annual%20Plan%20FY%202010.pdf

Pres. Andrew Jackson, Democrat, Populist: When government subsidizes, the well-connected benefit the most. Effective CO2 policy requires all households be involved with reducing CO2, not just the top 5% of households which benefit the most from the existing, rather elitist incentives, such as for a Prius, a PV solar system, a $40,500 wind turbine for $550,000 LEED Platinum house, and grants, low interest loans and tax shelters for the already well-off, etc. If the $28 million were used for energy efficiency incentives for the bottom 90% of households, it would quickly lead, not to inequities and tax shelters, but to a surge of renewal of tens of thousands of houses all over the state providing hundreds of jobs. This renewal would quickly lead to lower fuel bills, lower CO2 emissions, less need for fossil power plants and renewables, AND would quickly put money in the pockets of people which they would quickly spend to stimulate the economy which would quickly raise revenues to help balance Vermont's budget. Just imagine what $250 million would do.

Sen. Sanders obtained $500,000 of federal funds (taxpayer money) for PV solar systems at 10 Vermont schools. This is good PR for Sanders and vendors of PV solar, but it creates the false impression in communities and among parents, teachers and children, that PV solar is the government-sanctioned way to go, when, in fact, it is the most expensive way to go, as shown by the VT-DPS spreadsheets.
Sen. Sanders proposed PV solar systems on 10 million roofs. If the systems average were 5 kW, it would cost $275 billion at $5,500/kW to produce 68.62 TWh/yr of expensive VARIABLE, INTERMITTENT, mostly summer power for 30 years. The same $275 billion invested in nuclear plants would produce 315.62 TWh/yr, 4.6 times as much, of relatively low-cost, STEADY, 24/7/365 power for 60 years. A few more such proposals and the US WILL be bankrupt.
http://sanders.senate.gov/newsroom/news/?id=429c59fa-56c7-47a9-808d-67de390a9822
http://sanders.senate.gov/newsroom/news/?id=7b209b1c-a3bb-4811-92ca-7ed0137de06e

The Center for Labor Market Studies reports the bottom 50% of households with $39,000-$50,000/yr, $29,680-$39,000/yr, $20,725-$29,680/yr, $12,160-$20,725/yr and $12,160/yr or less have 9.0%, 12.2%, 15.3%, 19.1% and 30.8% unemployment, respectively.
The Center for Labor Market Studies reports the top 50% of households with $150,000 or more/yr, $100,000-$149,999/yr, 75,000-99,999/yr, $60,000-74,999/yr and $50,000-59,999/yr have 3.2%, 4%, 5%, 6.4% and 7.8% unemployment, respectively.
Sen. Sanders should be working to reduce unemployment among low-income families, increase their household incomes, make their houses and vehicles more efficient and increase their worker productivity. See attachment. http://timecuriouscapitalist.files.wordpress.com/2010/02/unemploy2.jpg

ENERGY EFFICIENCY

There are less costly, more efficient ways forward, detailed below, that will quickly reduce CO2 AND make Vermont more efficient in many areas which will raise living standards, or prevent them from falling further. By doing efficiency measures FIRST, the capacities and capital costs of renewables will be much less later; putting the horse before the cart is so much better, as any Vermont FARMER knows.

Efficiency improvements we can do NOW. They would reduce CO_2 emissions NOW. They would create many more jobs than renewables, especially for the depressed building and automotive sectors. No studies, research, demonstration and pilot plants will be required. Significant reductions of CO_2 emissions from renewables and alternatives will be years or even decades away. Regarding global warming, time is of the essence.

A more cost effective use of scarce federal and Vermont funds would be to cancel/reduce/place-on-hold the existing, mostly elitist incentives for expensive renewables, and instead provide major incentives to:
- reduce the heating, cooling and electricity costs of buildings; higher R-values, less air infiltration, efficient light bulbs and HVAC systems, ENFORCED statewide building energy codes.
- build more compact communities to reduce the time and energy to travel from residences to workplace buildings.
- construct gas-fired combined cycle gas-turbine, CCGT, power plants with electrical efficiencies up to 60% and emissions of about 0.50 lb of CO_2/kWh. Some of the CCGT plants could serve for district heating with a thermal/electrical efficiency up to 85%, as is done in Germany, Sweden, Denmark, Finland, the Netherlands, etc. Note: coal-fired power plants are about 30% efficient, emit about 2.0 lb CO_2/kWh, plus many pollutants that weaken/sicken/kill fauna (includes us) and flora.

Vermont should provide energy efficiency incentives directly to the bottom 90% of households; the lower the household income, the greater the incentive.
The energy efficiency incentives would speedily lead to:
- an increase in the efficiency of house envelopes, appliances, lighting, heating and cooling systems
- the replacement of old, polluting, inefficient wood and coal stoves and oil furnaces with new, clean-burning, high efficiency ones
- the exchange of old gas guzzlers (20 mpg or less) with new high mileage (30 mpg or more) vehicles; the higher the mileage, the greater the incentive. http://www.fueleconomy.gov/feg/FEG2010.pdf

Households might replace appliances and redo kitchens and/or laundry rooms at the same time.
A new energy-efficient refrigerator, cost $1,000-$300 incentive, would reduce energy cost by about 360 kWh/yr x $0.129 = $46.44/yr, a tax-free payback of $46.44/$7 = 6.63%, compared to a 15-20 year-old model.
Current programs winterize about 1,000 houses per year at a cost of about $10 million. In Vermont, there are about 100,000 households with incomes less than $50,000/yr and likely living in energy-hog houses and driving gas-guzzler vehicles. A tenfold increase of weatherizing houses, 10,000 houses/yr, would make their houses more habitable in winter, reduce their energy consumption and CO_2 emissions and provide thousands of jobs for at least the next ten years.

Example of a Near Zero Energy Housing Development

The RDI designed Wisdom Way Solar Village is a development of 20 super insulated, 2-story, 1,400 sq ft houses with roof-mounted PV and solar hot water systems, located near the center of Greenfield, MA, priced at $210,000 - $240,000; HERS = 7 - 17
A state subsidy allowed 16 of the houses to be sold to low and medium income households at about $110,000; an example of Massachusetts helping low income households.
A typical 2-story, three-bedroom house in the development has a heating load of 12,600 Btu/hr when the outside temperature is 2F. It has the following features:
- Southern orientation, open floor plan, 1,392 sq ft of heated space above an unheated full basement
- Roof-mounted 3.4 kW PV system generates about 4,000 kWh/yr and provides for most of the electricity use
- Roof-mounted 87 sq ft solar hot water system with 105-gal storage tank provides for most of the hot water use
- Building envelope ACH = 2 or less @ 50 Pascals
- Recycled blown-in dry cellulose encircling the building envelope: 12 inches in the offset double 2x4 walls, R-42; 14 inches in the ceilings, R-52; 11 inches in the basement ceiling, R-38
- High efficiency windows north, east, and west; U = 0.18, Solar Heat Gain Coefficient (SHGC) = 0.26, Visible Light Transmission (VLT) = 0.42
- High efficiency windows south; U = 0.26, SHGC = 0.36, VLT = 0.53
- Continuous 50 CFM exhaust ventilation
- ENERGY STAR refrigerator, dishwasher, and clothes washer (plus natural gas cook stove and clothes dryer)
- Compact fluorescent light bulbs throughout
- On-demand natural gas hot water heater as back up to solar hot water system
- Sealed combustion Monitor room heater in the central living area on the first floor (no fossil fuel-based central heating system is necessary)
- No air conditioning
- Air distribution system to move air and heat from the first floor to the second floor bedrooms. The ducts for this system, as well as the vent fans, are sealed with mastic; duct tape deteriorates with time.

Example of Heat Loss Reduction by Superinsulating and Sealing an Existing House

A house, 80 years old, 2-family, 2-story, 3,000 sq ft total, located in Arlington, Massachusetts, was selected to demonstrate the energy reduction that can be achieved by superinsulating, etc. The house was in need of new roofing and siding. Fuel oil consumption for space heating and hot water was about 2,500 gal/yr. The project cost was about $100,000, of which $50,000 was donated by the state and participating vendors and contractors which benefitted from the publicity. After improvements the fuel oil consumption for heating and hot water is about 800 gal/yr, for a saving of 68%. Whereas the payback will be several decades, the house will be more comfortable, and just as the Toyota Prius market value went up when gas was $4/gal, so will the market value of superinsulated houses go up in the future which will greatly shorten the payback period.

- The existing roof was R-25. To obtain an R-60 roof, existing roof shingles were removed, 2 layers of styrofoam, 7" total, were added. All seams were taped. Roof reshingled and retrimmed.
- The existing walls were R-13. To obtain R-33 walls, existing clapboards were removed, 2 layers of styrofoam, 4" total, were added. All seams were taped. Walls reclapboarded and retrimmed.
- Existing windows were replaced with double-pane energy efficient windows
- Existing exterior doors were replaced with foamcore doors
- Heat recovery ventilation system was installed to ensure fresh air
- Carbon monoxide monitors were installed

A future project could be insulating the interior basement walls.

Examples of Annual Energy use for Heating, Cooling and Electricity of Inefficient Buildings:

NY State Office Building Campus/SUNY-Albany Campus; average 186,000 Btu/sq ft/yr. Source: a study I did in the 80s.
Vermont State Government buildings; average 107,000 Btu/sq ft/yr. http://www.publicassets.org/PAI-IB0806.pdf
Not much can be done with such buildings other than taking them down to the steel structure and start over.

Examples of Annual Energy use for Heating, Cooling and Electricity of Efficient buildings:

Building energy demand management using smart metering, smart buildings (including increased insulation and sealing, efficient windows and doors, entries with airlocks, variable speed motors, automatic shades, Hitachi high efficiency absorption chillers with heat recovery, plate heat exchangers, task lighting, passive solar, etc.) were used in the Xerox Headquarters Building, Stamford, CT, designed in 1975 by Syska & Hennessey, a leading US engineering firm. As a result, its energy intensity is 28,400 Btu/sq ft/yr for heating, cooling and electricity, which compares with 50,000 Btu/sq ft/yr, or greater, for nearby standard headquarters buildings.

France and Germany are building high-rise office buildings; automatic shades, with passive and PV solar, average less than 10,000 Btu/sq ft/yr. State-of-the-art.
China is building zero-energy high-rise office buildings; double glass walls to reduce heat gain, automatic shades, with passive and PV solar, integrated wind turbines, 60% less energy for HVAC than standard high-rise buildings, designed by Skidmore, Owens, Merrill, a leading US architect-engineering firm.

WIND POWER

In 2009, the US added about 10,000 MW of wind power. US wind power capacity was about 35,000 MW at end 2009. Wind power is not available when wind speeds are too low, too high, and during windless periods, requiring year-round purchases from the grid. Wind power is variable and intermittent.

Generation costs of wind power without incentives is about $0.08/kWh at sites with a capacity factor of 40%, and about $0.12/kWh at sites with a capacity factor of 25%. The costs of transmitting the power from regional New England wind farms to the ISO-NE grid, distributing it to users, and the costs of utility overhead and profit add about $0.06/kWh, for a total consumer cost of $0.14/kWh-$0.20/kWh. Efficiency Vermont claims it can produce savings at $0.03/kWh through efficiency measures. http://www.issues.org/25.1/apt.html

Wind Power Variability and Intermittency

Integrating wind power into grids will be a major challenge. The recent Eastern Wind Integration and Transmission Study, EWITS, states so, and also states it is possible to bring wind power from the windy Northern Plain states to the East Coast at a cost of about $90 billion, 2009$, in transmission facilities by 2030. Integrating wind power already is a challenge in Germany, 6.5% wind CONSUMPTION, because it lacks sufficient hydro to "smooth" the wind power. Denmark, wind production 20% of which 9% is CONSUMED in Denmark and the rest exported, uses hydro plants in Norway and Sweden to smooth its wind power. Spain, its grid not connected to nearby grids, 11.1% wind CONSUMPTION, uses its own hydro plants, some with pumped storage, and CCGT plants to smooth its wind power.
http://www.awea.org/publications/reports/4Q09.pdf

On February 26, 2008, the Texas power system narrowly avoided a breakdown by rapidly shedding loads and increasing the output of its spinning reserve and standby power plants. At

3 p.m., wind power was supplying a bit more than 5% of its 40,000 MW demand. But over the course of the next 3.5 hours, an unforecast/unexpected wind lull caused wind power to fall from 2,000 MW to 350 MW, just as evening demand was peaking. Grid operators declared an emergency and blacked out 1,100 MW of load in a successful attempt to avoid a system collapse. According to the Electric Reliability Council of Texas, ERCOT, this was not the first or even the worst such incident in ERCOT's area. Of 82 alerts in 2007, 27 were strongly correlated to the drop in wind. The Texas electric grid, capacity 105,000 MW, consumption 404.8 TWh in 2008 is not connected to nearby grids. For comparison 2008 consumption in US 4,119.4 TWh, New England 130 TWh, Vermont 6.0 TWh. To minimize future emergencies, Texas is planning to connect to nearby grids to utilize their standby power plants.
http://www.issues.org/25.1/apt.html

Wind Power and Net CO2 Reductions

In general, spinning reserve power plants and standby power plants usually operate at part load which is less fuel efficient than at full load and produces more CO2/kWh delivered. This is especially the case for the combined cycle gas turbine, CCGT, plants that are commonly used as standby power plants, because they can be quickly started and their outputs can be quickly varied with demand (a maximum of about 4%/min) without damaging equipment. An analogy most people understand: Cars are most fuel efficient/least polluting at steady highway speeds, but least fuel efficient/most polluting in stop-and-go traffic. Airplane jet (gas turbine) engines are most fuel efficient/least polluting at cruising speeds, but least fuel efficient/most polluting during takeoffs and landings.

Because the penetration of PV solar power is minor, insufficient data exists to perform valid studies regarding the net CO2 reductions from PV solar power. Because penetration of wind power is significant in some US states and nations, data is available and studies have been performed regarding the net CO2 reductions from wind power. For example, if wind penetration is 15%, proponents would claim a reduction in CO2 emissions equivalent to the CO2 quantity produced by the displaced fossil fuel power, but studies using New York and California data show the net CO2 reduction is only 5%, a third of what wind power proponents claim. Studies performed in Germany, a big wind nation, yielded similar results, i.e., big investments and subsidies in wind and solar projects created expensive jobs, produced little, but expensive power and less CO2 reduction than anticipated.
http://arxiv1.library.cornell.edu/pdf/1002.2243>>.
http://www.rwi-essen.de/pls/portal30/docs/FOLDER/PUBLIKATIONEN/GUTACHTEN/P_RENEWABLE+ENERGY+REPORT+RWI+FORMAT.PDF

Residential Wind Power

Example of residential wind system for a $550,000 LEED Platinum house, Charlotte, Vermont: Capacity 10 kW, grid-connected, 80-ft mast, all-in cost $40,500, or $4,050/kW, grant from Vermont's taxpayers $12,500. It produces about 6,286 kWh/yr, 6,094 kWh is used, 192 kWh is sold to the utility as part of "net-metering". Capacity factor, CF = (6,094 + 192) kWh/yr/(10 kW x 8,760 hr/yr) = 0.0712. The owner pays the utility $9/mo. for standby power. The useful service life is about 10-15 years. The levelized cost of buying electricity from the utility for 25 years is about $0.230/kWh, from wind with no incentives about $0.459/kWh, from wind with current incentives about $0.319/kWh. Residential wind power systems are very uneconomical investments. See spreadsheet.

Community Wind Power

Example of a community wind system: Northern Power Systems, Barre, VT, Northwind 100 kW wind turbine, mast 125 ft, 70 ft dia rotor, all-in cost $664,000, or $6,664/kW. Community wind turbines typically are located in areas where wind speeds are low relative to high ridge lines. As a result the CFs are 0.20 or less which adversely impacts the project economics. According to a VT-DPS 20-yr cash flow spreadsheet using a CF = 0.20, the power needs to be sold at about $0.35/kWh for 20 years to provide a utility company internal rate of return = 12.13%; this exceeds the Act 45 feed-in-tariff of $0.125/kWh. Community wind power systems are very uneconomical investments, except where power costs are very high, as in Hawaii and Alaska. See spreadsheet.

Utility Wind Power

Example of a utility wind farm: Iberdrola, a Spanish wind turbine company, designed, built, owns and operates a wind farm on Bean Mountain, Lempster, NH. The farm is at an elevation of 2,326 ft (709 m), consists of 12 Gamesa G87 turbines, 2,000 kW each, masts 256 ft, blades 136 ft, all-in cost $48 million, or $2,000/kW. It has been in operation about 1.5 years. According to the NH wind map, Lempster is located in a uniquely windy area, Class 6 and 7, southeast of Claremont/Goshen. Potential output = 44,000 kW x 8,760 hrs/yr x CF 0.333 = 128,351,000 kWh/yr. The vast majority of Class 5, 6, and 7 ridge line areas are in the White Mountains in northern NH. The rest of NH is mostly Class 1, 2, 3 and 4, i.e., not commercially viable without huge subsidies.

- The Searsburg, VT, wind farm, owned by Green Mountain Power, older technology, online since 1997, average CF = 22.9.
- Iberdrola is planning to build a wind farm with (15) 2,000 kW units at Searsburg which is in the Green Mountain National Forest.
- Maine has 5 operating wind farms, total capacity 174 MW; 2 under construction, total capacity 91.5 MW; 4 in permitting stage, total capacity 471.5 MW. See spreadsheet.
- The US added about 10,000 MW of wind turbines in 2009. With current incentives, including tax sheltering, utility wind power is competitive with NEW power plants.

PV SOLAR POWER

In 2008, the US added 292 MW of grid-tied PV solar power. US PV solar grid-tied capacity was 791 MW at end 2008. PV solar power is available mostly in summer (8 am to 5 pm), less in spring and fall, and even less in winter (9 am to 4 pm), not at night and on cloudy days, requiring year-round purchases from the grid. Daily variations in cloud cover, such as in New England, cause daily variations in PV solar output. PV solar power is much less variable and intermittent than wind power.
http://ceramics.org/ceramictechtoday/energy-environment/us-installed-solar-capacity-up-16/

Generation costs of PV solar power in New England without incentives is at least $0.31/kWh. The costs of transmitting the power to the ISO-NE grid, distributing it to users, and the costs of utility overhead and profit add about $0.06/kWh, for a total consumer cost of at least $0.37/kWh. Efficiency Vermont claims it can produce savings at $0.03/kWh through efficiency measures. http://www.issues.org/25.1/apt.html

PV Solar Power and Electric Demands of Large Buildings

Daily PV solar output peaks usually occur earlier, around noon, than daily building demand peaks. Big buildings with large flat roofs equipped with PV solar systems and demand management systems can adjust their hr-by-hr daily profiles of heating, cooling and electricity usages to maximize daily PV solar power utilization, thereby reducing utility demand charges, electricity purchases, the variability of PV solar power on the grid and increasing CO2 reductions. A large number of such buildings will flatten the daily demand profile of a utility, reduce the outputs of spinning reserve power plants and standby power plants and their CO2 emissions.
http://www.cleanpower.com/research/customerPV/SLC_CPE_Validation.pdf

Residential Solar PV Power

Example of a residential PV system in Burlington, Vermont: Capacity 4 kW DC/3.3 kW AC, roof-mounted, fixed-tilt, grid-connected, all-in cost $24,000, or $6,000/kW. It produces about 5,043 kWh/yr (as calculated by the NREL pvwatts program), which is about 65% of total use, and has a value of $650.55/yr at $0.129/kWh. The warrantee period of PV panels is 25 years, the useful service life of a PV solar system is about 30 years. The levelized cost of buying electricity from the utility for 25 years is about $0.230/kWh, from PV solar with no incentives about $0.404/kWh, from PV solar with current incentives about $0.258/kWh. Residential PV solar systems are very uneconomical investments. See spreadsheet.
http://www.pvwatts.org/

Utility Solar Power

Example of hybrid plant in Florida: Florida Power and Light, FPL, Martin County, Florida, 75 MW sun tracking, parabolic trough plant on 500 acres, all-in cost $476 million, or $6,350/kW; it uses 748 F synthetic oil to produce steam. The plant produces about 75,000 kW x 5.66 peak sun hrs/d x 365 d/yr = 155 million kWh/yr, which avoids using 1.3 billion cu ft of gas/yr and avoids emissions of about 183 million lb CO2/yr. (Compare this with the production and all-in cost of the above Lempster wind farm.) The fuel cost saving from solar power is 1.3 billion cf ft/yr x 1,000 Btu/cu ft x $4.00/million Btu = $5.2 million/yr and the retail value of the solar power is 155 million x $0.13/kWh = 20.15 million/yr, a total of $25.35 million, less 155 million kWh/yr x $0.06/kWh = $9.3 million for utility costs of operation and maintenance, overhead, profit, etc., at about $0.06/kWh, for a net of $20.15 million-$9.3 million = $10.85 million/yr. Return on investment is $10.85/$4.76 = 2.3%/yr; a few more such investments and FPL will be bankrupt. During midday peak demand periods the output of the solar plant is highest. The plant is next to a 3,705 MW gas/oil fired CCGT plant. http://en.wikipedia.org/wiki/Florida_Power_&_Light

NUCLEAR POWER

Nuclear power is relatively low-cost, CO2-free, steady, 24/7/365 power. Nuclear power is not renewable, but the world, i.e., India and Australia, has enough thorium to operate hundreds of 1,000 MW thorium/uranium fueled reactors for at least one thousand years.

Germany and Sweden have decided to continue using their existing nuclear plants, because their rational people have concluded they cannot achieve CO2 targets with renewables. The UK will make a similar decision. The US decided to continue existing nuclear plants AND build new plants; other nations will follow.