Wind Energy is Expensive, by Willem Post; 23 July, 2011

As the US moves to increased use of renewable energy to reduce CO2 emissions, it is important to recognize efficient technologies, such as gas-fired, advanced, 60%+ efficient, combined cycle gas turbines, CCGTs, that emit about one third the CO2 per kilowatt-hour of a coal plant.

The more cost effective renewables should have incentives towards deployment. The less cost effective renewables should have incentives towards further development.

An undesirable situation would arise if politically-inspired deployment would occur prior to a renewable being ready for deployment, as was, and still is, the case with ethanol-from-corn which costs not only billions of dollars in subsidies each year, but does not even reduce CO2 emissions; a most egregious policy disaster.

Levelized Costs of Energy; a partial list

The US Energy Information Administration projects levelized production costs (national averages, excluding subsidies) of NEW plants coming on line in 2016 as follows (2009$) :

Offshore wind $0.243/kWh; PV solar $0.211/kWh (significantly higher in marginal solar areas, such as New England); Onshore wind $0.096/kWh (significantly higher in marginal wind areas with greater capital and O&M costs, such as on ridge lines in New England; significantly lower in the Great Plains states); Conventional new coal (base-loaded) $0.095/kWh; Advanced 60%+ efficient CCGT (base-loaded) $0.0631/kWh.
http://www.energytransition.msu.edu/documents/ipu_eia_electricity_generation_estimates_2011.pdf

Comparison of Wind Energy with Advanced CCGT Energy

Without subsidies, the US average levelized cost of onshore wind energy is 0.96/0.0631 x 100% = 52% higher than advanced CCGT.

Without subsidies, the levelized cost of offshore wind energy is about 0.243/0.0631 x 100% = 385% higher than advanced CCGT, because of much greater capital and O&M costs. Capital costs exceed $4,200/kW, O&M is 3 to 4 times that of a Great Plains wind turbine facility and the offshore capacity factor is about 0.38 - 0.40, the same as the Great Plains.
http://theenergycollective.com/willem-post/47519/base-power-alternatives-replace-base-loaded-coal-plants

Wind facilities on New England ridge lines are expensive to build, $2,500 - $2,800 per kW, versus about $2,000/kW on the Great Plains, and their O&M costs are about twice that of a wind turbine facility on the Great Plains which has the additional benefit of much better winds than New England, yielding capacity factors of 0.38 - 0.40 versus 0.30 - 0.33 on ridge lines in New England.

Without subsidies, the levelized cost of wind energy on ridge lines in New England would be at least 0.15/0.0631 x 100% = 238% higher than advanced CCGT.

With subsidies, using 3 MW Vestas units with 373-ft diameter rotors on 280-ft masts, on 2,000 ft-high ridge lines, the levelized cost of wind energy is estimated at about (0.092/0.0631) x 100% = 46% higher than advanced CCGT, according to Green Mountain Power. If the production tax credit of $0.021/kWh expires, then it is about {(0.092+0.021)/0.0631} x 100% = 79% higher than advanced CCGT.
http://vtdigger.org/2011/07/10/lowell-mountain/

For reference: Maine wind turbine facilities have an average installed cost of about $2,500/kW and an average capacity factor of 0.32. The 99 MW Granite Reliable Power Windpark, Coos County, NH, has 33 Vestas units @ 3 MW each, installed cost about $2,778/kW.

The above costs should be compared with the average New England grid price of about $0.055/kWh.

It is important to note the above wind energy costs/kWh do not include various other costs. For example:

- wind energy is variable and intermittent and requires quick-ramping balancing plants to accommodate it to the grid.
- increased grid reorganization is required as wind energy penetration percent increases.

http://www.coalitionforenergysolutions.org/maine_wind_farms.pdf
http://www.energytransition.msu.edu/documents/ipu_eia_electricity_generation_estimates_2011.pdf
http://theenergycollective.com/willem-post/57905/wind-power-and-co2-emissions
http://theenergycollective.com/willem-post/59747/ge-flexefficiency-50-ccgt-facilities-and-wind-turbine-facilities
http://theenergycollective.com/willem-post/61309/lowell-mountain-wind-turbine-facility-vermont

Onshore Wind Energy is Expensive

Kibby Mountain Wind Turbine Facility: TransCanada Power which owns the 132 MW Kibby Mountain Wind Facility in Maine has

a 10-yr PPA with NStar, an electric utility, at a flat $0.105/kWh, plus the associated renewable energy certificates.
Power production is estimated at 132 MW x 8,760 hr/yr x CF 0.31 = 0.357 GWh/yr.
Capital cost is estimated at $320 million, or $2,424/kW.

The Kingdom "Community" Wind Project: The Green Mountain Power-proposed 63 MW Lowell Mountain wind turbine facility with (21) 3 MW Danish, Vestas V-112 wind turbines, 373-ft (112 m) rotor diameter, 280-ft (84 m) hub height, total height 466.5 ft, stretched along about 3.5 miles of ridge lines. The housings, 47 ft (14 m) long, on top of the 280-ft towers are the size of a greyhound bus.
With subsidies the levelized energy cost would be about $0.096/kWh, according to GMP
Power production is estimated at 63 MW x 1 GW/1,000 MW x 8,760 hr/yr x CF 0.32 = 176.6 GWh/yr
Capital cost is estimated at 63 MW x $2,500,000/MW = $157.5 million, excluding grid modifications.
Useful service life is estimated at 20 - 25 year.
http://vtdigger.org/2011/07/10/lowell-mountain/

Offshore Wind Energy is Very Expensive

Cape Wind: Cape Wind Associates, LLC, plans to build and operate a wind facility on the Outer Continental Shelf offshore of Massachusetts. The wind facility would have a rated capacity of 468 MW consisting of 130 Siemens AG turbines each 3.6 MW, maximum blade height 440 feet, to be arranged in a grid pattern in 25 square miles of Nantucket Sound in federal waters off Cape Cod, Martha's Vineyard, and Nantucket Island; the lease is for 46 square miles which includes a buffer zone.

The Massachusetts Department of Public Utilities approved a 15-yr power purchase agreement, PPA, between the utility National Grid and Cape Wind Associates, LLC. National Grid agreed to buy 50% of the wind facility's power starting at $0.187/kWh in 2013 (base year), escalating at 3.5%/yr which means the 2028 price to the utility will be $0.313/kWh. The project is currently trying to sell the other 50% of its power so financing can proceed; so far no takers.

A household using 618 kWh/month will see an average wind power surcharge of about $1.50 on its monthly electric bill over the 15 year life of the contract; if the other 50% of power is sold on the same basis, it may add another $1.50 to that monthly bill.
Power production is estimated at 468 MW x 8,760 hr/yr x CF 0.39 = 1.6 GWh/yr.
The capital cost is estimated at $2.0 billion, or $4,274/kW. Federal subsidies would be 30% as a grant.

Block Island Offshore Wind Project: The 28.4 MW Block Island Offshore Wind Project has a 20-yr PPA starting at $0.235/kWh in 2007 (base year), escalating at 3.5%/yr which means the 2027 price to the utility will be $0.468/kWh. A State of Rhode Island suit is pending to overturn the contract; the aim is to negotiate to obtain a lower price.
Power production is estimated at 28.4 MW x 8,760 hr/yr x CF 0.39 = 0.097 GWh/yr.
Capital cost is estimated at $121 million, or $4,274/kW. Federal subsidies would be 30% as a grant.

Delaware Offshore Wind Project: The 200 MW Delaware Offshore Wind Project has a 25-year PPA starting at $0.0999/kWh in 2007 (base year), escalating at 2.5%/yr which means the 2032 price to the utility will be $0.185/kWh.
Power production is estimated at 200 MW x 8,760 hr/yr x CF 0.39 = 0.68 GWh/yr.
Capital cost is estimated at $855 million, or $4,274/kW. Federal subsidies would be 30% as a grant.

Wind Energy O&M Costs

O&M costs are related to a limited number of cost components, including: insurance, regular maintenance, repair, spare parts, and administration.

The standard warranty of an onshore, utility-scale wind turbine is about 2 years. After that period owners are vulnerable to significant O&M costs for gearboxes, generators, drive trains and blades. For example: A gearbox changeout may cost $500,000 and up, plus about 30 days of down time. Gearboxes and blades sometimes fail within 2 -3 years. Extended warranties are available at significant fees.

The average O&M costs of onshore, utility-scale wind turbines is about 2.7 cents/kWh; the O&M costs are from actual cost data of existing wind turbine facilities throughout the world. See below websites.

The 2.7 cents/kWh is about 3 to 5 times the values used in spreadsheets of wind turbine vendors and project developers to attract investors, secure financing and obtain government approvals.

On ridge lines of New England O&M would be about 2 times the average. Offshore it would be about 3-4 times the average.

O&M increases with wind turbine age: a lifetime average of 20 - 25 percent of the levelized generating costs, starting at about 10 - 15 percent for unsubsidized newer units, gradually increasing to 20 - 35 percent for unsubsidized older units.

http://www.renewableenergyworld.com/rea/partner/first-conferences/news/article/2010/06/true-cost-of-wind-turbine-operations-maintenance
http://www.croh.info/index.php?option=com_content&view=article&id=1402:prwebcom-newswire-httpwwwdigitaljournalcom&catid=10:news

http://spectrum.ieee.org/energywise/green-tech/wind/trouble-brewing-for-wind
http://www.slideshare.net/WindEnergyReports/summary-the-wind-energy-operations-maintenance-report

Wind Energy and Subsidies; a partial list

Wind turbine owners receive federal and state subsidies equivalent to about 50% of the capital cost. The object of the subsidies is deployment of wind turbines. The laws that establish the subsidies do not have a performance standard regarding CO_2 emissions reduction/kWh based on measured fuel consumption/kWh and CO_2 emissions/kWh of the wind energy balancing plants. This enables wind proponents to claim CO_2 emissions reductions/kWh without any factual basis. With enough PR, they have fooled almost everyone, including legislators, who oblige by passing more subsidy laws. The following is a partial list of subsidies:

- Federal grant for 30% of the total project cost which also applies to Spanish, Danish, German and Chinese wind turbines thus creating jobs in those nations instead of the US. These nations would not dream to have such a measure benefitting US wind turbine companies.

- Federal accelerated depreciation allowing the entire project to be written off in five years which is particularly beneficial to wealthy, high-income people looking for additional tax shelters.

- Federal production credit of $0.022/kWh of wind energy produced.

- Owners of wind turbine facilities receive Renewable Energy Certificates which they can sell on the open market. The RECs are subsequently bought by polluting companies that find it less expensive to buy the RECs than clean up their pollution.

- State legislatures and state agencies are pressured to provide above-market feed-in-tariffs, FITs, and to approve generous power purchase agreements.

- State legislatures and state agencies are pressured to provide increasingly greater state incentives to politically well-connected renewables vendors, developers, financial entities and high-income future wind facility owners.

- State legislatures and state agencies are pressured to pave the regulatory ways to essentially circumvent state environmental and quality of life laws. Pro-forma hearings, usually required by law, are held to create a semblance of democratic process but effectively are rubber-stamp approvals of pre-ordained decisions.

Wind Energy Variability; a burden on electric grids

As wind speeds are highly variable and wind energy is proportional to the cube of the wind speed, a doubling of wind speed causes an 8-fold increase in highly-variable wind energy. As a result, wind energy consists of irregularly-spaced, sporadic spurts varying in amplitude and duration. About 10 to 15 percent of the year no wind energy is produced because of insufficient wind speeds or too high wind speeds.

Wind energy curtailment by feathering the blades or stopping the wind turbines is often used to limit wind energy surges, because grids have insufficient quick-ramping balancing plant capacity.

Wind energy by itself would be a disturbing influence on the grid. However, if the wind energy is correctly combined with the energy from balancing plants, it would be seen by the grid as a constant-output, base-loaded plant.

Balancing Energy

The balancing energy for a year is about (1.0 - 0.30)/0.30 = 2.33 times the wind energy for a year, if the wind facility capacity factor = 0.30. This assumes the wind turbine facility would operate near 100% of rated capacity a few times of the year.

However, the highest observed capacity percent for areas with many wind turbines, such as northwest Germany, is about 90 percent of rated capacity. This happens when a weather front moves through such an area, as often happened across the Iberian (Spain/Portugal) peninsula.

The adjusted balancing energy for a year becomes (0.90 - 0.30)/0.30 = 2 times the wind energy for a year. This means at 20% wind energy penetration in New England, as envisioned by the New England Wind Integration Study by GE-Wind, about 40% would be balancing energy, for a total of 60%. All remaining plants would supply only 40% of the energy to the grid.

It may be assumed about 90% of rated capacity is the maximum wind surge or wind ebbing. Almost all wind surges and ebbings are much less. Their amplitudes (horizontal axis) and frequencies (vertical axis) can be presented as a normal distribution with standard deviations. In New England large and very large wind surges and ebbings occur about 1 to 2 percent of the time, or about 85 to 175 hours per year.

Balancing Plants

Balancing plants accommodate wind energy to the grid and thereby help maintain voltage and frequency at target values, i.e., they ramp down corresponding to an incoming wind energy surge and ramp up corresponding to a wind energy ebbing.

Balancing operations require the balancing plants to operate at a percent of rated output which is inefficient, and simultaneously ramp up and down which is even more inefficient.

The balancing plants usually consist of gas-fired, open cycle gas turbines, OCGTs, and combined cycle gas turbines, CCGTs. Hydro plants are also used for balancing wind energy, but their use is limited to relatively few grid areas with significant hydro power plant capacity, such as the Bonneville Power Authority, Hydro-Quebec, and Denmark using the hydro plants of Norway and Sweden, and Spain and Portugal using their own hydro plants.

At wind energy penetrations of less than 1%, existing spare, quick-ramping, gas-fired gas turbine capacity will be adequate for providing the balancing energy on many grids. On the New England grid, currently with about 0.5% penetration, the presence of wind energy is not yet "noticeable", according to ISO-NE personnel. The main reason it is not yet noticeable is because of a lack of proper measuring and recording of power plant and wind turbine facility operating data.

At wind energy penetrations up to about 2%, more existing spare, quick-ramping gas turbine capacity will be needed for balancing operations.

At wind energy penetration greater than 2%, the existing spare gas turbine capacity will have been used up and additional quick-ramping gas turbine plants will need to be added to each grid. The installed cost of CCGT plants is about $1,250/kW.

Attempts to use existing, slow-ramping plants, such as coal plants, as balancing plants during periods of larger wind energy surges and ebbings have been less than successful, as experienced by Colorado and Texas. See Bentek report.

This lack of success is a serious issue and should not be dismissed by the American Wind Energy Association as “excessive focussing on outlier events”, i.e., larger wind energy surges and ebbings, because as wind energy penetration increases, such “outlier” events will become more frequent and severe, if gas-fired, quick-ramping CCGT facilities are not added to the grids to correctly balance wind energy. These facilities must be utility-owned to ensure control over their operation.

Many grids have wind energy penetrations greater than 2%, but most utilities on those grids have not yet added balancing plant capacity hoping other, less expensive “fixes” will show up, such as weather prediction, smart grid, demand/supply management, storage, etc. Such fixes are a decade or more in the future, whereas the lack of adequate, quick-ramping balancing capacity exists now.

Will wind turbine facility owners be charged a percentage of the cost of the additional CCGT facilities, or any of the other “fixes”, or will they all become additional hidden subsidies?

http://docs.wind-watch.org/BENTEK-How-Less-Became-More.pdf
http://www.hwecoop.com/advice/Rational%20Look%20Renewables%201%202.pdf

Increased Owning and O&M Costs Due to Balancing Wind Energy

If each up or down ramp lasts, say 5 minutes, there will be 12 x 24 = 288 ramps a day, or about 100,000 ramps per year. If 10 minutes per ramp, then about 50,000 ramps per year. In any case, major wear and tear of balancing plants which will result in increased owning and O&M costs due to shortened useful service life and increased O&M.

Those costs have not been adequately quantified by utilities and are not charged, or not fully charged, to wind turbine facility owners as wind energy accommodation fees; a hidden subsidy for wind energy. Political winds may prevent any charges.

Increased Fuel Consumption and CO2 Emissions Due to Balancing Wind Energy

Gas turbines are about 15% less efficient at 50% of rated output than at rated output; ramping up and down further reduces their efficiency. From turbine performance curves one can infer a heat rate degradation of about 20% due to balancing operations.

http://www.ge-mcs.com/download/bently-nevada-software/1q05_performancemonitoring.pdf
http://www.etsap.org/E-techDS/PDF/E02-gas_fired_power-GS-AD-gct.pdf

The about 20% heat rate degradation requires increased fuel consumption/kWh and produces increased CO2 emissions/kWh. These increases offset nearly all of the reduction of fuel consumption and CO2 emissions claimed by wind energy proponents.

Because of a lack of real-time measurements of fuel consumption and CO2 emissions of the balancing plants before and after wind energy, these quantities have not been adequately quantified. Political winds may prevent any quantifying.

The extra fuel costs are not charged, or not fully charged, to wind turbine facility owners as wind energy accommodation fees; a hidden subsidy for wind energy.

Energy Used by Wind Turbines (Parasitic Energy)

One of the big secrets of the wind industry is wind turbine parasitic energy. Little information can be found on the internet. Yet, all of the information would be revealed if a proper wiring diagram were published and some real-time measurements were made.

Parasitic energy is the energy used by the wind turbine itself. During spring, summer and fall it is a small percentage of the wind turbine rated output. During the winter it may be as much as 10 to 20 percent of the wind turbine rated output. Much of this energy is needed whether the wind turbine is operating or not. At low wind speeds, the turbine output may be less than the energy used by the turbine; the shortfall is drawn from the grid.

In winter, the wind speed has to be well above 4.5 m/s, or 10.7 miles/hour, to offset the parasitic energy. Speeds less than that means drawing from the grid, speeds greater than that means feeding into the grid.

This will significantly reduce the net wind energy produced during a winter. On cold winter days the nacelle (on big turbines the size of a greyhound bus) and other components require significant quantities of electric energy.

Below is a representative list of equipment and systems that require electric energy; the list varies for each turbine manufacturer.

- rotor yaw mechanism to turn the rotor into the wind
- blade pitch mechanism to adjust the blade angle to the wind
- lights, controllers, communication, sensors, metering, data collection, etc.
- heating the blades during winter; this may require 10 to 20 percent of the turbine rated output
- heating and dehumidifying the nacelle; this load will be less if the nacelle is well-insulated.
- oil heater, pump, cooler and filtering system of the gearbox
- hydraulic brake to lock the blades when the wind is too strong
- thyristors which graduate the connection and disconnection between turbine generator and grid
- magnetizing the stator; the induction generators used to actively power the magnetic coils. This helps keep the rotor speed constant, and as the wind starts blowing it helps start the rotor turning (see next item)
- using the generator as a motor to help the blades start to turn when the wind speed is low or, as many suspect, to create the illusion the facility is producing electricity when it is not, particularly during important site tours. It also spins the rotor shaft and blades to prevent warping when there is no wind.

Do wind turbine facility owners pay for the energy drawn from the grid, or is this just another hidden subsidy?

Lack of Real-Time Measurements

The lack of real-time measurements is beneficial to wind energy proponents enabling them to say: Oh, the extra fuel consumption and extra CO_2 emissions of the balancing plants are not that much, they may reduce the benefits of wind energy by at most a few percent, etc.

That statement has no factual basis supported by real-time measurements of operating parameters before and after wind energy.

Ignorance of the people, maintained with deceptive PR slogans ("so many households served, so much CO_2 reduced, grid parity in a few years, its renewable, energy independence, etc.") means continued bliss of subsidies and profitability for vendors, project developers and financiers and reelection of legislators, but increasing pain due to higher electric rates, lower living standards and adverse impacts on quality on life (noise, visual, psychological and health), property values and the environment for everyone else.

Projected Capital Cost of Wind Energy in the UK

The UK has an ambitious and controversial goal of 33 GW of onshore and offshore wind turbines by 2030. The goal would require the following:

- at least 11,000 wind turbines @ 3 MW each, each at least 465-ft tall, at a cost of about $99 billion @ $3,000/kW (average on/offshore cost)

- about 33 x 0.9 = 29.7 GW of quick-ramping CCGTs for balancing at a cost of about $37.1 billion @ 1,250/kW. Whereas the UK has a significant capacity of CCGT plants, most of it may not be available for balancing operations during larger wind energy surges and ebbings which can occur at any time during a day, including during higher electric demand periods.

- reorganization of the grid, including HVDC lines on several thousand towers that are 85 to 135 ft tall from Ireland, Northern Ireland, Scotland, Wales and offshore wind turbine facilities to England, at a cost of at least $30 billion

The total cost will be at least $175 billion, a sizable investment that will have a useful service life of about 20-25 years, about the same period it will take to build the wind turbine facilities.

People living within about 2 miles would be disturbed by an around-the-clock machinery noise and an irregular din of whoosh-type sounds, especially during nighttime. The noise will be similar to 18-wheelers, on top of 280-ft towers, spread out throughout the countryside, simultaneously and continuously running their engines at a distance, 24/7/365 for 20 or more years; a total madness. See "Increased Energy Efficiency" below.

Having No Wind Energy is More Economical for the UK

The 33 GW of gas-fired, 60% efficient CCGT balancing plants would be able to produce all of the wind energy PLUS all of the balancing energy, at a much lower installed cost ($37.1 billion) and at a much lower cost/kWh with only a few percent of additional fuel consumption/kWh and a only a few percent of additional CO2 emissions/kWh, if they were operated at about 60% efficiency, at rated output, in base-loaded mode.

This would be accomplished without adverse impacts on quality on life (noise, visual, psychological and health), property values and the environment.

New GE CCGT Plant

GE is marketing a new CCGT plant and has sold a few of them. The new "GE FlexEfficiency 50" plant has a capacity of 510 MW and a 61% efficiency at rated output. Its design is based on a unit that has performed utility-scale power generation for decades. The plant fits on about a 10-acre site.

It is quick-starting: from a cold start, it reaches its rated output in about one hour. Various options are available to reduce the start up times to as little as 30 minutes.

Its average efficiency is about 60% from rated output to 87% of rated output (444 MW) and about 58% from 87% to 40% of rated output (204 MW). It can be ramped at 50 MW/minute.

Without wind, the GE unit is designed to efficiently produce electric energy in base-loaded mode and daily-demand-following mode.

With wind, its high ramp rate enables it to also function as a cycling plant to accommodate the variable energy from wind turbine and solar facilities, albeit at reduced efficiency. Below 40% of rated output its efficiency decreases rapidly, as with all gas turbines. This means its economic ramping range is limited.

Using the new GE CCGT plant for wind energy balancing would be technically and economically an incredibly irresponsible thing to do. Consumers and taxpayers would be paying the owning and O&M cost of:

- the CCGT plant, which, by itself, could produce the wind energy + balancing energy at a lower cost per kWh than the wind turbine facility at a slightly greater fuel consumption and CO2 emissions.
- the wind turbine facility
- the reorganization of the grid.

http://www.ge-energy.com/content/multimedia/_files/downloads/FlexEfficiency%2050%20Plant%20eBrochure.pdf

Three Better Alternatives to Wind Energy

60% Efficient Combined Cycle Gas Turbines

The Green Mountain Power-proposed 63 MW Lowell Mountain wind turbine facility with (21) 3 MW Danish, Vestas V-112 wind turbines, 373-ft rotor diameter, 280-ft hub height, total height 466.5 ft, stretched along about 3.5 miles of ridge lines. The housings (nacelles) on top of the 280-ft towers are about the size of a greyhound bus or an 18-wheeler.

http://energy.worldconstructionindustrynetwork.com/news/green_mountain_power_selects_vestas_turbines_for_kingdom_community_wind_project_110607/
http://www.vestas.com/Files/Filer/EN/Brochures/Vestas_V_112_web_100309.pdf

The wind energy production would be about 63 MW x 1 GW/1,000 MW x 8,760 hr/yr x capacity factor 0.32 = 176.6 GWh/yr.

The capital cost of the wind turbine facility would be at least 63 MW x $2,500,000/MW = $157.5 million, excluding grid modifications.

The Lowell wind turbine facility facility would have a 20 - 25 year useful service life. However, gearboxes and blades often fail within 5-10 years.

For the same capital cost a new 60% efficient combined cycle gas turbine facility, operated at rated output, in base-loaded mode, would produce about ($157.5 million/$1,250,000/MW) x 1 GW/1000 MW x 8,760 hr/yr x CF 0.90 = 993.4 GWh/yr, or

993.4/176.6 = 5.63 times the electrical energy per invested dollar. The facility would have a 35 - 40 year useful service life.

The levelized energy cost for advanced 60% efficient CCGT would be about $0.0631/kWh, according to the US Energy Information Administration.
http://www.energytransition.msu.edu/documents/ipu_eia_electricity_generation_estimates_2011.pdf

Some of the advantages of a gas-fired CCGT facility are:

- No grid modifications would be required
- No inefficient operation of gas-fired wind energy balancing facilities would be required
- Impacts on quality of life (noise, visual, psychological and health), property values and the environment would be minimal
- The facility would take up only a few acres
- The electrical energy would be low-cost, steady 24/7/365, reliable and dispatchable
- Low CO_2 emissions/kWh; about 1/3 the CO_2 emissions/kWh of coal plants
- No particulate emissions
- Domestic energy supply, good for energy independence, national security

Increased Energy Efficiency

The real issue regarding CO_2 reduction is energy intensity, Btu/$ of GDP; it must be DECLINING to offset GDP and population growth. To accomplish this energy efficiency needs to be at the top of the list, followed by the most efficient renewables of which hydro power is the best and residential small wind is the worst, in fact, it is atrocious. EE is so good that it should be subsidized before any and all renewables, because it is much more effective per invested dollar.

Effective CO_2 emission reduction policy requires that all households eagerly participate. Current subsidies for electric vehicles, residential wind, PV solar and geothermal systems benefit mostly the top 5% of households that pay enough taxes to take advantage of the renewables tax credits, while all other households are required to pay for them by means of fees and taxes or higher electric rates; the net effect is much cynicism and little CO_2 reduction. Improved energy efficiency policy will provide much greater opportunities to many more households to significantly reduce their CO_2 emissions.

Energy efficiency will have a much bigger role in the near future, as energy system analysts come to realize that tens of trillions of dollars will be required to reduce CO_2 from all sources and that energy efficiency will reduce CO_2 at a lesser cost and more effectively. Every household, every business can participate.

For example: there is a massive energy source right at our fingertips — but, so far, this resource remains largely untapped. This energy resource is available in every state, every city and every town, does not require mining and drilling and costly power plants, makes no noise, is invisible, does not harm the environment and fauna and flora and creates more jobs than renewables per invested dollar.

The majority of our existing building stock is old and most are inefficient buildings that are destined to be in service at least 25 years or longer. Reducing the energy that is normally wasted in existing buildings offers more potential for cost-effective energy savings and CO_2 emission reductions than any renewables strategy.

Energy efficiency projects:

- will make the US more competitive, increase exports and reduce the trade balance.

- usually have simple payback periods of 6 months to 5 years.

- reduce the need for expensive and highly visible transmission and distribution systems.

- reduce two to five times the energy consumption and greenhouse gas emissions and create two to three times more jobs than renewables per dollar invested; no studies, research, demonstration and pilot plants will be required.

- have minimal or no pollution, are invisible and quiet, are peaceful; no opposition groups demonstrating against them, something people really like.

- are by far the cleanest energy development anyone can engage in; they often are quick, cheap and easy.

- have a capacity factor = 1.0 and are available 24/7/365.

- use materials, such as for taping, sealing, caulking, insulation, windows, doors, refrigerators, water heaters, furnaces, fans, air conditioners, etc., that are almost entirely made in the US. They represent about 30% of a project cost, the rest is mostly labor. About 70% of the materials cost of expensive renewables, such as PV solar, is imported (panels from China, inverters from Germany), the rest of the materials cost is miscellaneous electrical items and brackets.

- will quickly reduce CO_2 at the lowest cost per dollar invested AND make the economy more efficient in many areas which will raise living standards, or prevent them from falling further.

- if done before renewables, will reduce the future capacities and capital costs of renewables.

German Passivhaus standard applies to houses and apartment buildings, about 5-10 percent more expensive, windows (min R-7 or U-0.14), doors (min R -8), walls (R-40), ceilings (R-60), concrete basement (R-20 applied to the OUTSIDE for new construction), insulation and sealing on the inside and outside of the walls to keep cold AND warm air out of the walls, positive ventilation for good health 0.5 air changes per hour, optional HEPA filter, foul air-to-clean air heat exchanger, efficient appliances and lighting. Such house may have thermal and PV solar systems and battery storage systems added to make them energy surplus houses capable of charging EVs.

Motor Vehicles

Before embarking on heavily-subsidized, expensive electric vehicles that would be charged with electricity from CO_2-producing fossil-fueled plants, some low-cost and quick measures to reduce CO_2 are:

- high-efficiency diesel engines in passenger cars getting 50 to 60 mpg are widely used in Europe. This should be implemented in the US before PEVs; a fully mature technology, no-fingers-crossed situation and no subsidies.

- next hybrid/diesel-powered vehicles that get about 60+ mpg; again a fully mature technology, no-fingers-crossed situation and no subsidies.

- next plug-in-hybrid/diesel-powered vehicles that have a 40-mile electric range; again a fully mature technology, no-fingers-crossed situation and no subsidies. The benefits are less diesel fuel consumption, but for at least the next 10-20 years more coal-generated power consumption to charge the hybrids, until renewables and natural gas become a greater percentage of US power.

- improving worldwide mpg of future gasoline-powered vehicles. This is an on-going effort that should be accelerated with subsidies. Cars with high mpgs usually are small and low-cost. If tens of millions/yr are sold worldwide, it will have a major impact on reducing CO_2.