Renewable Energy for Electricity – The Reality
By Norman Rogers[1]

Renewable energy is mostly wind and solar electricity. An alliance of commercial and ideological interests promote wind and solar with wild and false claims. Wind and solar are much more expensive than traditional sources of electricity. Wind and solar are useless for preventing climate change as prominent supporters of climate change alarmism tell us. Wind and solar are heavily suppported with direct subsidies, and with regulations that mandate the purchase of wind and solar energy. Renewable energy is promoted with a clever public relations campaign. You don't have to dig very far to discover the reality of renewable energy. The important media organizations for some reason remain passive in the face of this major scam. This paper presents the facts surrounding renewable energy.

There is no clear definition of renewable energy. Many states of the U.S. have their own legal definitions of renewable energy written into law. A common feature of the definitions is that renewable energy must not emit CO2 except when it is expected that the CO2 will be reclaimed. States have varying rules regarding hydropower. Most states ban hydropower if it involves dams, usually with some exceptions for small installations. This is because environmental organizations don't like dams. Nuclear power is arbitrarily banned even though it emits no CO2 and is scalable. Burning wood, or anything that grows is allowed because it is assumed that the next crop will recover the CO2 emitted.

Various niche forms of renewable energy are geothermal heat, garbage dump methane, energy from waste, etc. The niche sources of renewable energy are ignored here because they generally are not scalable. Geothermal energy is often touted as renewable, but there are questions.[2] Geothermal energy is arbitrarily considered to be renewable energy by many laws. Geothermal energy is considered a niche source because special geology is necessary. Geothermal energy may create pollution due to undesirable elements in the water or steam. In Nevada costs for geothermal energy run double the cost of natural gas.

[1] Norman Rogers is the author of the book: **Dumb Energy: A Critique of Wind and Solar Energy**, available on Amazon.

[2] The Geysers large geothermal field in California has lost energy apparently due to exhaustion of underground water for steam. Adding water increased output. The sustainability of geothermal energy depends on details of the underground source of heat. The presence of magma as a heat source is positive. Much of geothermal energy is rooted in radioactive decay of elements inside the Earth.

Similar considerations apply to garbage dump methane, often proclaimed as renewable. It runs out once the decay of garbage finishes emitting methane.

The main sources of allowed renewable energy are wind and solar. Approximately 5 times as much wind is installed in the U.S. as solar. Solar is best in the sunny southwest. Wind is best in the middle longitudes of the U.S. Unlike the niche forms of renewable energy, wind and solar are scalable. There are plenty of locations where more wind and solar could be installed. Approximately 6% of U.S. electricity comes from wind and 1% from solar.

Wind and solar share a common crippling problem. They are intermittent sources of electricity. Wind only works when the wind is blowing and solar only works during the day when no clouds block the sunshine. As a consequence, wind or solar must be backed up by reliable generating plants that can be energized when the intermittent power slows or dies.

Some installations have been built with added batteries to store power and take over when the intermittent energy fails. Due to the high expense of batteries, they can only provide substitute power for a few hours. Storing electricity generated from wind or solar for 4-hours would add approximately $100 per megawatt hour to the $80 cost of generating the electricity with wind or solar, resulting in electricity costing $180 per megawatt hour.[3] The marginal cost of generating power with natural gas is about $20 per megawatt hour. The backup plants are still needed, even if batteries are installed, because only 4-hours of electricity is stored and only if it is sunny that day. A battery backed plant

[3] A battery system to provide 100 megawatts for 4-hours would cost about $38 million. The battery part of the system would wear out every 5 years and cost $21 million to replace. [2018 U.S. Utility-Scale Photovoltaics-Plus-Energy Storage System Costs Benchmark]. Figure ES-1. National Renewable Energy Laboratory. The system could store 400 megawatt hours each day. Amortizing the non-battery part of the system over 25 years and the battery over 5 years at 8% interest results in a cost of $145,000 per megawatt hour. Each year 365*4 megawatt hours of electricity are stored. The cost per megawatt hour is 145000/(4*365) = $99 per megawatt hour plus the $80 generation cost, or a total of about $180 per megawatt hour. A natural gas plant operating 4 hours per day could provide power for about $90 per megawatt hour, or half as much. Further the gas plant is not limited in duration of power delivery and is not affected by lack of sunshine. Typically older, less efficient and fully depreciated gas plants that already exist may be used for peak evening power. In that case the cost of the electricity may be less than $30 per megawatt hour.

with these features, designed to move daytime solar power to the early evening, is proposed in Nevada, the Gemini project.

Because the backup plants are fully adequate to supply the grid without wind or solar, the wind or solar are redundant sources of power rather than core grid power. The economic contribution of wind or solar is to save fuel in the backup plants when the wind or solar is generating electricity and the backup plants have been throttled back. The proper economic comparison is to compare the cost of operating the wind or solar with the cost of the fuel consumption that is displaced in the backup plants. It is a common accounting fallacy to compare the cost of electricity per megawatt hour between the wind or solar and the backup plants. Another way of saying this is that wind or solar displace some fuel consumption, but not the capital cost of the backup plants. A corollary is that wind and solar never replace traditional plants, they only supplement them. The advocates of wind or solar often claim, fallaciously, that wind or solar is replacing coal or natural gas plants. In some cases a statistical argument is made that wind or solar can replace a marginal amount of traditional generation on the assumption that there is a significant probability that wind or solar will be working when power reserves run low, so the size of the traditional power reserve can be reduced if wind or solar is present. This is treacherous ground of marginal utility.

Roughly, wind or solar generate electricity for about $80 per megawatt hour. Although they are very different technologies, the cost of generation is close to the same. The fuel needed by a natural gas generating plant to generate a megawatt hour of electricity costs about $20. So, society loses about $60 for every megawatt hour generated by wind or solar compared to using the existing natural gas plants. This reality is obscured by a number of different subsidies for wind and solar. After the various subsidies are applied, the apparent cost of wind or solar is reduced from about $80 per megawatt hour to about $25 per megawatt hour. The all-in cost of generating electricity with natural gas, including fuel and capital cost, is about $45 per megawatt hour. Commonly the advocates of wind and solar will loudly claim that it costs only $25 per megawatt hour compared to $45 for traditional power. So, it is allegedly a great bargain. But they are comparing the wrong things and ignoring the massive subsidies. They should be comparing the cost of wind and solar without subsidies against the cost of fuel in the backup plants.

There are additional negative effects from introducing wind or solar into an electric grid. Substituting wind or solar for fossil fuel energy decreases the capacity factor or duty cycle of the fossil fuel plants. That results in increased capital cost per megawatt hour, increasing the cost of electricity from the fossil fuel plants. New power lines often must be constructed to the remote locations where wind or solar is located. In Texas a huge powerline network was necessary to bring wind power from West Texas, where the wind is, to East Texas, where the power is needed. The power lines may be very expensive per megawatt hour moved, due to the low duty cycle of wind or solar. Cycling gas turbines to balance the erratic output of wind or solar stresses them and new controls and modifications to existing plants may be necessary.

Economically, wind and solar are a huge waste of money. A possible justification for this waste of money is that they don't add to the CO_2 in the atmosphere and thus will contribute to preventing global warming. There are serious problems with this justification. Some prominent promoters of a global warming catastrophe, such as the scientist James Hansen, are also advocates for nuclear energy. Hansen calls intermittent renewable energy a grotesque solution for global warming. Using wind or solar it costs approximately $140 for each metric ton of CO_2 emissions avoided. That cost comes from the subsidy that finances the negative value of wind or solar. Avoiding a metric ton of CO_2 emissions is called a carbon offset. Carbon offsets are produced by various methods, such as planting trees, and are sold in a marketplace for less than $10 per metric ton. Nuclear power is not competitive in the U.S. due to the high capital cost aggravated by political and legal campaigns against it by the environmental organizations. The fuel is extremely cheap, much less than the cost of natural gas. The cost of reducing carbon dioxide emissions by substituting nuclear power is far less than for wind or solar. Further nuclear is reliable and does not require backup plants.

There is a limit as to how much wind or solar can be added to the electric grid. If too much is added, there will be times when the wind or solar must be curtailed because they are generating more power than is needed. Curtailment raises the cost per megawatt hour, because fewer megawatt hours are produced for the same capital cost. Peak power output of wind or solar is 3-5 times the average power output. If one keeps adding wind or solar a state is reached where the curtailment becomes very large, yet the backup plants still provide a substantial portion of the power. There are also considerations of grid stability. The backup plants must be kept idling so as to be able to quickly compensate for sudden swings in the output of the wind or solar. A severe example is the transition from solar to thermal power in the late afternoon. Traditional thermal plants have limits on how fast they can ramp up power due to thermal gradients in the equipment. The more wind and solar is added, the worse the economics and problems become.

Nameplate Capacity versus Capacity Factor

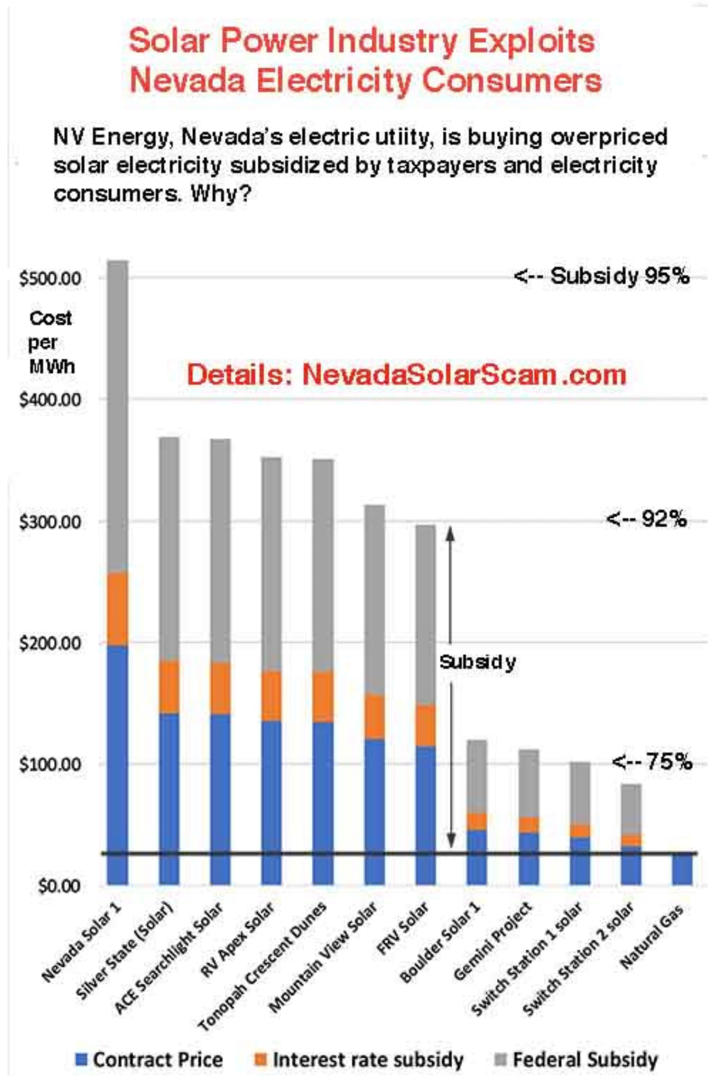
Wind or solar plants have a nameplate generating capacity – this is the maximum power they can generate. In the case of wind this is the power generated when wind is blowing at an ideal velocity. In the case of solar this is the amount of power when the sun is shining directly on the panels and the sky is clear. The capacity factor is the relation between the nameplate capacity and the average power actually generated. For example, if a wind or solar plant has a nameplate of 100 megawatts and a capacity factor of 35% the amount of power actually generated will be 35% of what would be generated if the plant could operate constantly at the nameplate capacity. For good plants wind capacity factor runs around 35%. For solar the capacity factor is in the 20% to 25% range in sunny areas like the U.S. southwest. Germany has extensive solar but poor sunshine. The capacity factor depends on the technical details of the plant and on the typical weather on the site. For either wind or solar, output can be close to zero for days at a time when the wind is calm or the sky is cloudy.

Calculating the Cost of Power from Wind or Solar

Most of the cost is the initial capital cost of the plant amortized over the life of the plant. There are operating costs for ongoing maintenance. Maintenance is much higher for wind that for solar. The initial cost is generally quoted as dollars per kilowatt of nameplate capacity. A good number for wind is $1800 per kilowatt. For solar, $1200 per kilowatt. For example, a wind plant with a nameplate of 100 megawatts (100,000 kilowatts) will cost $1800*100,000 = $180,000,000 to build. If the capacity factor is 35% it will generate an average of 35 megawatts per hour or 35*8760 = 306,600 megawatt hours per year. (8760 is the number of hours in a year.) If the life of the plant is 25 years, then the $180 million cost must be paid off over 25 years. The cost per year is simply the annual payment on a fully amortized 25-year mortgage (Excel PMT function). At this point he interest rate on the hypothetical mortgage enters the picture. Usually the interest rate is taken to be about 8%. In this case the annual payment would be close to $17 million per year. The cost of electricity per megawatt hour based on the capital cost will be 17,000,000/306,600 = $55 per megawatt hour. Adding maintenance cost, developer profit, and other costs will increase the cost per megawatt hour to close to $80. Naturally, these costs will vary depending on the details of the site and local costs.

Subsidies and What is the Correct Interest Rate?

A wind or solar plant will not usually be financed by a 25-year, no down payment mortgage. But the hypothetical interest rate assumed is the same as the rate of return on the investment needed by an investor. The rate of return needed to draw out the capital to construct a wind or solar plant depends on how speculative the investment is. As we have already discussed, wind or solar are not economically viable investments from the standpoint of society. Every megawatt hour generated causes the national economy to lose about $60. Government and electricity consumer subsidies are what make wind or solar economic from the viewpoint of an investor. There is no free market rate of return for wind or solar plants in the absence of government subsidies because no one would build such a plant without the subsidies.



There are three principal subsidies. Direct subsidies in the form of tax credits for the capital cost or for the production of electricity, tax subsidies related to special taxation rules that benefit wind and solar, and long-term power purchase agreements made necessary by state quotas for renewable energy. Utilities are in the position of being forced to buy high cost electricity to meet their quotas.

In principle, if one can sell wind or solar electricity to a utility for less than $20 per megawatt hour, the marginal cost of generating electricity with natural gas, it would be a good deal for the utility. That would imply a 75% government subsidy to bring the cost of wind or solar from $80 down to $20. Things are not that simple due to the erratic nature of wind or solar generation. Unlike a natural gas generating plant, the utility cannot schedule a certain amount of power at a particular time. The utility has to accept all the power generated by the wind or solar plant or else some of the potential output will be lost forever and the cost of generating the electricity will increase because fewer megawatt hours of electricity will be purchased for the same capital cost. Unless the price were considerably less than $20 per megawatt hour the utility would probably not want to deal with the erratic power.

In states where utilities are regulated by a rate of return on their investment, utilities love to build new plants that add to their rate base and thus to their allowed profit. Thus, if the state public utilities commission approves building wind or solar plants, the utility might go along, even though the plant makes no economic sense. It makes sense to the utility because it is then allowed to extract more profit from its customers. The public utilities commission may approve wasteful projects because citizen lobbies, ignorant of the real facts, demand more “green” power.

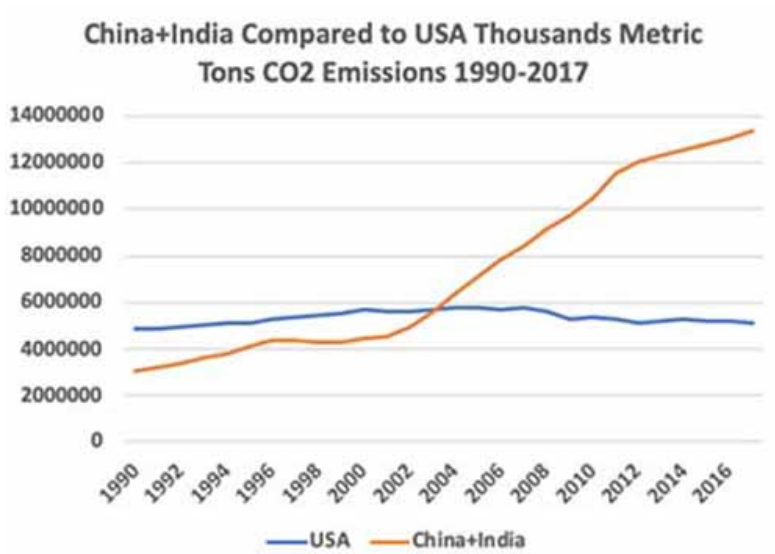
Some thirty states have adopted an official policy of demanding more renewable power by passing renewable portfolio laws. These laws require wasteful investment by requiring that increasing percentages of the state’s power come from renewable resources. In practice this is mostly wind or solar. Now the utility is required by law to constantly increase its use of wind or solar. In some cases, the utility may build the plants and operate them. In other cases, they buy electricity on long-term, usually 25-year, power purchase contracts from independent investors that build the plants.

If the utility builds and owns the wind or solar plants, it is usually allowed a rate of return of around 9% on its investment and is entitled to pass on operating costs to the rate payers (electricity customers). In this case all the costs are passed on to the rate payers including the 9% rate of return on (depreciating) capital investment. If the utility contracts with independent power producers to get it wind or solar, the usual terms are a 25-year power purchase agreement at a certain cost per megawatt hour. The utility is expected to take all the power produced. If a curtailment is ordered the utility may have to pay for power that could have been delivered but wasn’t due to the curtailment. Because the independent producer has in hand a 25-year power purchase agreement, generally before any construction begins, the independent producer can operate with a much lower rate of return than, for example, an independent power producer that sells power from a natural gas generating plant without guarantees of price or volume.

The renewable energy quota laws are a subsidy for wind and solar because they result in guarantees of volume and prices to the wind or solar producer from a credit worthy utility. Like a loan guarantee from the government or a bank, it is a gift to the independent developer of wind or solar. That guarantee has considerable value. The value is paid for by the electricity customers and the government that ultimately are responsible for keeping the lights on.

The Global Warming Justification Fallacy

The graph below shows the relative carbon dioxide emissions of the U.S. versus China and India. Not only do China and India emit almost three times as much CO2 as the U.S., but their emissions are increasing rapidly. In contrast U.S. emissions are declining. U.S. emissions are declining due to increased use of low-carbon natural gas resulting from increased natural gas supplies from fracking. Reducing emissions for electricity generation in the U.S. will not change world CO2 emissions much because only about 25% of U.S. emissions are from the electricity generation sector. Most emissions come from transportation, industry and space heating.



If the advocates of wind and solar are really concerned with global warming they would be busy propagandizing the Chinese and Indians to reduce their emissions by substituting natural gas or nuclear for coal generation. Coal is the most carbon intensive fuel. Instead the green promoters concentrate on forcing wind and solar on Americans.

Do Wind or Solar Ever Make Sense?

There are places in the world where electricity is generated by burning oil. Residual fuel oil costs about 5 times as much as natural gas or coal per unit of energy. Thus, the fuel to generate a megawatt hour that might cost $20 worth of natural gas may cost $100 for fuel oil. This can make wind or solar competitive at $80 per megawatt hour. But these oil burning plants are often obsolete, built when oil was cheap. Rather than adding wind or solar, these installations could be replaced with coal plants, coal being competitive with natural gas for the cost of fuel. Places such as small off grid communities may have no alternative to diesel generators, an expensive way to generate electricity.

Really small installations, such as an off-grid house in a sunny location, may be able to get along by using solar backed by batteries. These houses typically are designed to use little electricity, the solar electricity only needed for lighting, electronics and refrigeration. Heating and cooking may be done using wood or propane. Solar electricity from this type of installation may cost $500 per megawatt hour (50 cents per kilowatt hour) but the overall cost is bearable since very little electricity is used. Such an installation can be further backed up by a generator fueled by propane or diesel if loss of electricity during extended cloudy periods can't be tolerated.

Renewable Energy is Promoted by Propaganda Based on False Data

There is no technical definition of renewable energy that is universally accepted. There is some consensus on the idea that renewable energy is energy that is not subject to fuel exhaustion. But sources like geothermal energy or garbage dump methane, that are subject to exhaustion, are accepted. Wind and solar energy ultimately come from the sun's energy and the sun will last for billions of years. But the plants that turn the wind and solar energy into electricity wear out and must be replaced periodically – a form of exhaustion. Nuclear energy uses fuel, but for any practical purpose the fuel will not run out.

The Sierra Club, a big advocate of renewable energy and an enemy of coal energy avoids concrete analysis and uses a blizzard of debatable statements to make it seem that wind and solar are great sources of energy and coal energy is extremely dangerous. These are falsehoods, easily disputed. A favorite trick of the Sierra club is to publish pictures of smokestacks emitting white steam photographed with the sun behind the stack, so that the steam looks like black smoke. The giveaway in the photo, from a club website, is that the "smoke" is transparent near the top of the stack because the water vapor in the clear exhaust gas has not yet mixed with the cool air to form a white cloud of water droplets commonly called steam. Investigators have revealed financial connections between donors to the Sierra Club and the renewable energy industry.

The points made in this paper are not new or original. There is plenty of literature explaining in detail the problems with renewable energy. Somehow this obvious information does not get through to the press or our lawmakers. The fault most probably lies with the scientific and engineering community that advises the press and the government. They don’t have to courage to tell the truth and face the attacks from the renewable energy industry that would follow.