

*Chapter 8*

# Separating Renewable Facts From Wishful Thinking

Nearly all of the members of the Western Business Roundtable are involved in some aspect of renewable energy, either as power generators using or purchasing renewable power, as natural resource developers that provide the necessary raw materials to construct or deploy renewable power systems, as manufacturers that make components for renewable energy systems or as users of electricity generated by renewable systems. The Roundtable has long supported policies that help renewables continue to tap into America's inexhaustible supply of renewable energy.

But the Roundtable also believes that public policymakers need to understand both sides of the renewable energy coin. Serious discussion of deploying the massive amount of renewable systems envisioned by the WCI plan requires a realistic assessment of what is possible and what is not. In other words, policymakers need to separate the "ground truth facts" about renewable energy deployment from "wishful thinking." There is, unfortunately, an abundance of the latter in many policy discussions today.

With this in mind, the Roundtable provides the following information to further inform policymakers, the news media and the general public on the promise – and realities – of major expansion of renewable energy systems in the West.

## **8.A. Realities of an All-Renewable Build-Out Plan**

The WCI's economic model includes an assumption that all of the West's increased energy requirements through 2020 will be met with ethanol, wind, other renewables (excluding hydro), and energy efficiency/demand response – virtually no new baseload power plants, beyond those presently planned, that are fueled by either

natural gas, nuclear, renewable hydropower or coal with any amount of carbon capture and sequestration technologies.

If this assumption is translated into policy, it would limit the West's options for electricity generation to intermittent renewable resources such as solar and wind and could potentially put the entire Western electrical grid at risk.

For example, a dramatic build-out of wind and solar power facilities will require significant amounts of fossil-fuel power generators – primarily natural-gas fired units – to integrate the renewable facilities into the grid and even out the intermittent nature of their power generation. Utilities in the West and elsewhere that are now adding new wind generation have found that for every one megawatt of new wind, one megawatt of fossil fuel generation needs to be build or dedicated to making that wind generation work.

However, the WCI assumes, and therefore recommends, that Western states allow no new natural gas-fired power plants. Clearly, without construction of new natural gas-fired facilities, the renewables-only strategy recommended by the WCI for meeting demand growth in the West makes little sense.

Moreover, renewable energy produced about seven percent of total U.S. energy in 2007, and 90 percent of that contribution was primarily hydroelectricity and industrial by-product biomass. The U.S. Energy Information Agency (EIA) forecasts that by 2030, renewable energy will produce about 11 percent of U.S. energy requirements. However, most of this renewable energy contribution will consist of the traditional renewable energy sources of hydro (22 percent) and industrial by-product biomass (60 percent).

Even in 2030, wind, photovoltaics, solar thermal, and all other renewable energy technologies will contribute only about two percent of total U.S. energy requirements, according to EIA.

In sum, renewables will likely remain a niche application for some years to come. The West – and the U.S. -- cannot rely on renewables solely or even primarily for its energy future.

More generally, Table 8-2 illustrates the different levels of difficulty of achieving the WCI goals in the various jurisdictions. Coal accounts for most of the electricity generated in four of the U.S. jurisdictions:

- Utah, nearly 90 percent.
- New Mexico, more than 80 percent.
- Montana, more than 60 percent.
- Arizona, nearly 40 percent.

The energy profiles of the eight geographic areas within the WCI economic modeling are very different. It is hard to see how these eight entities (seven states plus British Columbia) could coordinate the massive switch to wind power that is envisioned in the report. Montana, New Mexico and Utah all rely heavily on coal for electrical generation. In Utah 89.3 percent of its electrical power came from this source. California, with one-third of the electrical generation in the WCI group, generates virtually none of its electrical power from coal (one percent in 2006), while it imports about 20 percent of its electricity from out-of-state coal-fired plants. California generates nearly half of its electricity from natural gas.

**Table 8-1** Electricity Generation by Source in the U.S. Jurisdictions and British Columbia

<u>EIA Data</u> (MWH/yr)	<u>2006</u>	<u>SHARE</u>
Gas/Oil	172,169,064	26.8%
Coal	135,237,179	21.0%
Nuclear	65,299,129	10.2%
Hydro	236,078,365	36.7%
Landfill Gas/EFW	2,249,133	0.3%
Wind + Other	31,824,681	5.0%
TOTAL	642,857,551	100.0%

<u>WCI Data</u> (GWh/yr)	<u>2006</u>	<u>SHARE</u>	<u>2020</u>	<u>SHARE</u>
Gas/Oil	143,907	24.0%	164,782	23.4%
Coal	99,280	16.6%	101,454	14.4%
Nuclear	65,072	10.9%	65,072	9.2%
Hydro	256,243	42.8%	268,661	38.2%
Landfill Gas/EFW	2,036	0.3%	2,088	0.3%
Wind	8,733	1.5%	65,273	9.3%
Other	23,554	3.9%	36,219	5.1%
	598,825	100.0%	703,549	100.0%

Source: U.S. Energy Information Administration and the Western Climate Initiative, 2008.

**Table 8-2** 2006 Electricity Generation by Source in Each of the U.S. Jurisdictions and British Columbia

ENERGY SOURCE	Arizona	California	Montana	New Mexico	Oregon	Utah	Washington	British Columbia	WCI Total	U.S. Total
Coal	38.7%	1.0%	60.5%	80.1%	4.4%	89.3%	5.9%	0.0%	21.0%	49.0%
Petroleum	0.1%	1.1%	1.5%	0.1%	0.0%	0.2%	0.0%	0.0%	0.5%	1.6%
Natural Gas	31.5%	48.8%	0.3%	15.8%	21.0%	8.2%	6.9%	4.5%	26.3%	20.0%
Other Gases	0.0%	0.9%	0.0%	0.0%	0.0%	0.0%	0.3%	0.0%	0.3%	0.4%
Nuclear	23.0%	14.7%	0.0%	0.0%	0.0%	0.0%	8.6%	0.0%	10.2%	19.4%
Hydroelectric Conventional	6.5%	22.2%	35.9%	0.5%	71.0%	1.8%	75.8%	94.3%	36.7%	7.1%
All Other Renewables	0.1%	11.0%	1.9%	3.4%	3.5%	0.5%	2.3%	1.2%	4.8%	2.4%
Pumped Storage	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.2%
Other	0.0%	0.2%	0.0%	0.0%	0.1%	0.0%	0.1%	0.0%	0.1%	0.3%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
						%			%	%

Source: U.S. Energy Information Administration, 2008.

## 8.B. WCI's Implausible Transition Scenario

While the WCI 2020 scenarios do not envision a substantial decrease in electrical output from non-renewable sources, the huge increase in wind power generation envisioned in the study (an annual growth rate of nearly 14 percent, 2006 – 2020) raises the issue of electric power transmission. Currently, some potential wind power sites are not being developed because of the need for power transmission infrastructure. Yet the study apparently does not address this challenge to switching to wind power.

More basically, it is simply not realistic to assume that the West can, in 10 years, install the amount of wind and solar generating capacity projected by WCI. Energy transitions encompass the time that elapses between an introduction of a new primary energy source and its rise to claiming a substantial share of the overall market, or even to becoming a major contributor or an absolute leader in supply. There is one thing all energy transitions have in common: They are prolonged affairs that take decades to accomplish, and the greater

the scale of prevailing uses and conversions the longer the substitutions will take.<sup>106</sup>

For example, after the 1880s, the Western world rapidly increased its reliance on fossil fuels and hydroelectricity, but in large parts of Africa and Asia the grand energy transition from traditional biomass fuels to fossil fuels has yet to be completed. Looking only at modern primary energies on a global scale, coal receded from about 95 percent of the total energy supply in 1900 to about 60 percent by 1950 and less than 24 percent by 2000. However, coal's importance continued to rise in absolute terms, and in 2001 it even began to regain some of its relative importance. As a result, coal is now relatively more important in 2008 (nearly 29 percent of primary energy) than it was at the time of the first energy "crisis" in 1973 (about 27 percent). And in absolute terms it now supplies twice as much energy as it did in 1973:

The world has been returning to coal rather than leaving it behind.

Although oil became the largest contributor to the world's commercial energy supply in 1965 and its share reached 48 percent by 1973, its relative importance then began to decline and in 2008 it will claim less than 37 percent of the total. Moreover, worldwide coal extraction during the 20th century contained more energy than any other fuel, edging out oil by about five percent. The common perception that the 19th century was dominated by coal and the 20th century by oil is wrong: In global terms, the 19th century was still a part of the millennia-long wooden era and 20th century was the coal century.<sup>107</sup>

The pace of the global transition from coal to oil can be judged from the following spans: It took oil about 50 years since the beginning of its commercial production during the 1860s to capture 10 percent of the global primary energy market, and then almost 30 years to go from 10 percent to about 25 percent of the total. Analogical spans

Replacing the nation's fossil energy power plants with wind farms would require building more than 16,000 MW of wind farms every month for each of the next 10 years -- or rebuilding the entire existing system once every 39 days for the next ten years.

---

<sup>106</sup> See Vaclav Smil, "Moore's Curse and the Great Energy Delusion," *The American: A Magazine of Ideas*, November 19, 2008.

<sup>107</sup> While many African and Asian countries use no coal, the fuel remains indispensable: It generates 40 percent of the world's electricity, nearly 80 percent of all energy in South Africa (that continent's most industrialized nation), 70 percent of China's, and about 50 percent of India's.

for natural gas are almost identical: Approximately 50 years and 40 years. Nuclear fission reached 10 percent of global electricity generation 27 years after the commissioning of the first nuclear power plant in 1956, and its share is now roughly the same as that of hydropower.

These spans must be recognized when appraising potential rates of market penetration by wind. The absolute quantities needed to capture a significant share of the West's market are huge because the scale of the required energy transition is of an unprecedented magnitude.

In 2007 the U.S. had about 870 GW of electricity-generating capacity in fossil-fueled and nuclear stations. On average, these thermal power stations are at work about 50 percent of the time and hence they generated about 3.8 PWh<sup>108</sup> of electricity in 2007. In contrast, wind turbines work on average only about 23 percent of the time (and often much less), which means that even with all the requisite new high-voltage interconnections, more than two units of wind-generating capacity would be needed to substitute for a unit in coal, gas, oil, and nuclear plants. And even if such an enormous capacity expansion was technically feasible, the financial cost would be enormous.<sup>109</sup>

Further, because those new plants would have to be in areas that are not currently linked with high-voltage (HV) transmission lines to major consumption centers, the WCI would require a rewiring of the West. Limited transmission capacity exists to move electricity from what is to be the new power centers, and transmission constraints are already delaying new U.S. wind projects even as wind generates less than one percent of all electricity. The U.S. has about 165,000 miles of HV lines, and at least 40,000 additional miles of new high-capacity lines would be needed to rewire the nation, at a cost of close to \$100 billion. The WCI initiative would analogously require a very large effort and investment. And the costs are bound to escalate, because the regulatory approval process required before

---

<sup>108</sup> 3.8 x 10<sup>15</sup> watt-hours.

<sup>109</sup> Advocates of such transitions frequently cite Moore's Law, which describes a long-standing trend in computer processing power, observed by Intel cofounder Gordon Moore, whereby a computer's power doubles every year and a half. This has led the advocates to claim that since "the price paid for the same performance came down by 50 percent every 18 months, year after year," something similar can happen with energy systems. However, the doubling of microprocessor performance every 18 months is an atypically rapid case of technical innovation: It does not represent the norm of technical advances as far as new energy sources are concerned, and it completely ignores the massive infrastructural needs of new modes of electricity generation.

beginning a new line construction can take many years. It is simply not realistic to assume that the West can install in 10 years the wind and solar generating capacity required. Energy transitions take place across time spans measured in decades, not years.

These are matters of fundamental importance given the energy challenges facing the West and the U.S. New promises of rapid shifts in energy sources and anticipations of early massive gains from the deployment of wind systems -- such as the WCI proposal that the West should generate nearly 15 percent of its electricity supply from wind power by 2020 -- create expectations that will not be met and only distract policymakers from pursuing real solutions.

The historical verdict is clear: Because of the requisite technical and infrastructural imperatives and because of numerous (and often entirely unforeseen) socio-economic adjustments, energy transitions in large economies are inherently protracted affairs. Thus, the WCI electricity transition scenario is, at best, unrealistic.

### **8.C. Real-World Numbers Behind An All-Renewable Future**

While the WCI does not call for replacement of the West's current fossil energy power plants with renewable energy facilities, it does call for no new fossil energy power plants to be built in the West (beyond those currently under construction) and instead proposes that only renewable facilities be constructed. Moreover, many of the environmental organizations that are heavily involved in the WCI process publicly support the recommendation of the Alliance for Climate Protection to "switch 100% of America's electricity to clean energy sources within 10 years."<sup>110</sup>

If the U.S. agreed to the policies pushed by these environmental groups and sought to repower our existing fossil energy fleet with renewable energy, such as wind and solar, how much renewable energy generation would have to be built? These are the current numbers for energy production in the United States, represented in megawatt-hours (MWh):

---

<sup>110</sup> <http://www.wecansolveit.org/>

**Table 8-3** Energy Production In the U.S. By Fuel Source

Energy Resource	Megawatt-Hours
Coal	2,020,572,000
Nuclear	806,487,000
Natural Gas	893,211,000
Hydro	241,319,000
Oil	65,708,000
Renewables	102,988,000
Other	29,230,000
<b>Total</b>	<b>4,159,515,000</b>

Of this, fossil energy's contribution totals 2,979,491,000 MWh. Wind energy's total power generation is 32,143,244 MWh<sup>111</sup>. Thus, replacing the nation's fossil energy power plants with wind farms would require increasing the size of our existing wind system by a factor of 93 over the next ten years. This would require building more than 16,000 MW of wind farms every month for each of the next 10 years. Or, put another way, it is the equivalent to the entire existing system being rebuilt once every 39 days, for the next ten years.

And, of course, these wind generators are generally available at their rated value during the annual peak period is only between 5 - 20 percent.

Can solar energy replace fossil energy power plants? As noted recently by Kimball Rasmussen<sup>112</sup>:

*The single largest, newest, state-of-the-art solar facility in North America (and third largest solar energy output in the world) was recently installed at Nellis Air Force Base. The impressive system at Nellis AFB rests on 140 acres near sunny Las Vegas, Nevada. Installation was complete in December 2007.*

*The capital investment is listed by Nellis AFB at \$100 million. The expected output is between 25,000,000 kWh and 30,000,000 kWh per year.*

<sup>111</sup> [http://www.eia.doe.gov/cneaf/alternate/page/renew\\_energy\\_consump/table3.html](http://www.eia.doe.gov/cneaf/alternate/page/renew_energy_consump/table3.html)

<sup>112</sup> Id at 46.

*How many of these systems could be built in the U.S.? This is the first and largest such facility in North America. Could we site and build 100 of these? 1,000?*

*It turns out that, in order to meet our ten-year goal, we would need to build 1,039 of these facilities per month for the next ten years. This incomprehensible build-out would rack up a capital investment (assuming no inflation or upward cost pressure, in spite of the horrendous demand) of \$12.5 trillion dollars. The U.S. national debt now exceeds \$10 trillion, and gobbles up 37% of U.S. GDP. By comparison, this phenomenal solar investment is equal to 125% of our national debt. And this assumes that we could somehow learn to live on energy that is only available when the Sun is shining, or that we have some sort of amazing breakthrough in battery technology (which of course would add to the cost), and that we could build high-voltage transmission from the desert Southwest to most of the rest of the country (a siting issue). Assuming a modest 7% return on investment (a typical Investor Owned Utility would demand a much larger return) the capital investment of each such solar facility would amortize at a staggering \$268 per MWh, between triple and quadruple the existing household electric rate's across the U.S.*

## **8.D. A Realistic Look At The Potential for Renewables**

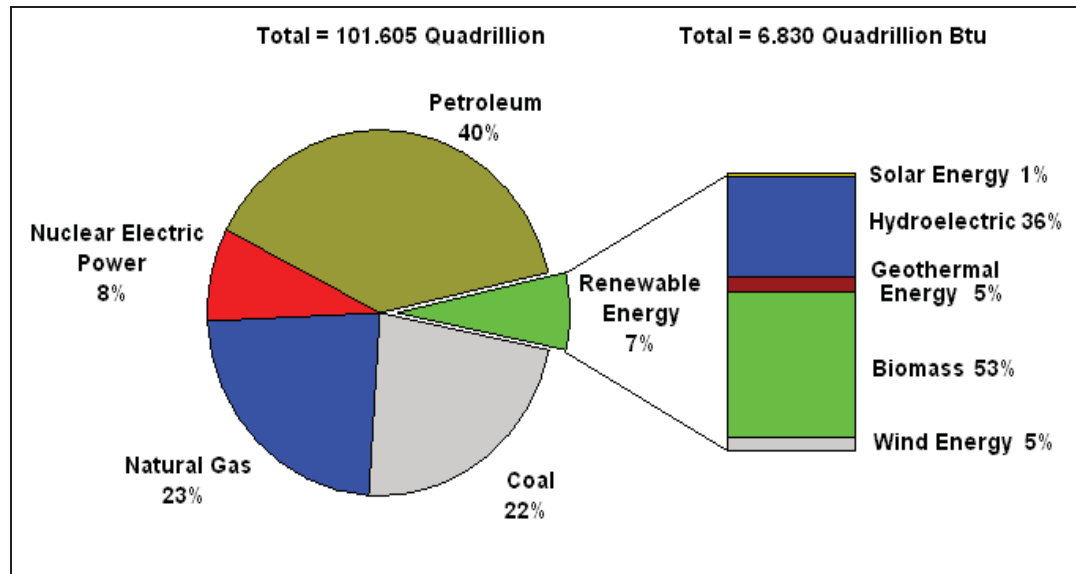
Except for hydropower and industrial by-product biomass, the contribution of renewable energy to U.S. energy requirements is small, and is forecast by EIA to remain small through 2030. As shown in Figure 8-1, renewable energy produced about seven percent of total U.S. energy in 2007, and 90 percent of that contribution was primarily hydroelectricity and industrial by-product biomass. EIA forecasts that by 2030, renewable energy will produce about 11 percent of U.S. energy requirements.<sup>113</sup> However, most of this renewable energy contribution will consist of the traditional renewable energy sources of hydro (22 percent) and industrial by-product biomass (60 percent). Even in 2030, wind, photovoltaics, solar thermal, and all other renewable energy technologies will contribute less than 20 percent of the total renewable energy contribution and will furnish only about two percent of total U.S. energy requirements. Nevertheless, WCI forecasts that most of the West's incremental energy requirements through 2030 can be met with renewables – primarily wind and ethanol.

---

<sup>113</sup> U.S. Energy Information Administration, *Annual Energy Outlook 2008*, June 2008.

There are numerous and serious limitations with the renewable energy technologies that the WCI report is counting on to provide most of the West’s incremental power needs through 2020. The WCI report does not seem to recognize these limitations.

**Figure 8-1** Renewable Energy in the U.S., 2007



Source: U.S. Energy Information Administration, 2008.

### 8.D.1. Wind

Wind power is the preferred, practical and most cost-effective renewable option currently available and is deployed now in 27 states. At the current rate of growth, wind will supply around two percent of U.S. electric energy by 2020, but many would like to speed that penetration rate so that 10, 13 and even 20 percent is available by 2030.

Unfortunately, many of the benefits of wind energy have been overstated for years and have led to subsidies, primarily in the forms of the production tax credit and advanced depreciation, completely out of range with the actual power that has been delivered. This had led to very expensive energy since it is not just the final price of the electricity produced, but the total cost to the taxpayer.

In the recent U.S. Department of Energy's report, the wind technology is shown to have received over \$724 million in subsidies and support, 100 times larger than the unit of output subsidy and support for the natural gas energy source and 50 times greater than that for coal.<sup>114</sup>

The technology does not fit well with our current pattern of use of electricity because of its intermittency, volatility, and unreliability. Wind turbines only produce electricity when the wind speeds are in a specific range conducive to preserving the capital equipment. They do not start until there is around seven mph of wind speed and they have to cut off as winds reach the 50 mph-range. Spare electricity generating capacity is required to be immediately available to come on-line to substitute for the loss of the wind contribution. In most cost studies of wind turbine installations, this factor is not considered. The wind resource itself does not provide peaking capabilities either, as minable wind speeds do not match the electricity demand profile typically found in the U.S. of high use during hot, summer days.<sup>115</sup>

This has severe implications to the electric grid system managers and those responsible for planning and monitoring a reliable electric service. Because there is such a mismatch of available wind-generated electricity and electricity demand, the value of the wind-generated electric capacity is extremely low and forces the system to also invest in reliable back-up capacity usually supplied by expensive gas turbine power.

Wind turbine capacity factors describe the percent of maximum rated capacity that is actually delivered from the equipment. Typical fossil fuel plants and nuclear plants have capacity factors over 90 percent. Rarely do capacity factors for wind farms reach 35 percent except in certainly locations like Texas, and can normally be as low as 20 percent. Unfortunately, there is no guarantee that early siting, design, and planning studies for wind installations will result in adequate estimates of what the capacity factor will be for a turbine or wind farm. This creates a financial vacuum, because eventual costs may be one-third higher if

---

<sup>114</sup> U.S. Energy Information Administration, *Federal Financial Interventions and Subsidies in Energy Markets 2007*, 2008.

<sup>115</sup> "The Wind Blows Less When Wind Power is Needed Most," Star Telegram, 08/05/08.

the capacity factor is 20 percent versus a planned capacity factor of 30 percent. There is now a history of expectations that exceed reality within the industry.

In Europe where wind turbine power provides a greater percent of electricity to the grid than in the U.S., the average European capacity factor was less than 21 percent, significantly lower than the 24 percent reported by the industry. In the U.S, an industry association claim of 35 percent can be contrasted to the actual measured capacity factor of 22.3 percent in California.<sup>1</sup> The capacity factor shows that in order to have the nameplate capacity actually delivering electricity, three to five times as much wind capacity capital must be purchased.

It is clear that there is a maximum amount of this intermittent, non-dispatchable, volatile and unreliable power that can be brought into the system.<sup>1</sup> Current estimates are that as much as 10 percent can be accommodated, but already there are numerous instances of emergency situations in some areas even with a lower contribution.<sup>1</sup> Because the U.S. has a relatively low excess generating capacity of around 12 percent, we can expect that emergency power situations will become a more common occurrence compared to other countries like Spain where a 90 percent excess capacity can handle the volatility induced by wind power sources.

Wind turbine power also has a long list of environmental issues, similar to other fossil and nuclear fuel sources, that must none the less be taken into account including:

- the external environmental costs related to producing the equipment.
- the environmental onsite construction damage, natural wildlife and marine habitat and migratory impacts.
- damage to vistas.
- and the impacts to the value of surrounding properties.

A recent analysis by three researchers at Carnegie-Mellon University made these observations and/or conclusions:<sup>116</sup>

---

<sup>116</sup> J. Apt, L. Lave and S. Pattanariyankool, "A National Renewable Portfolio Standard? Not

- Wind power helps to offset the use of fossil fuel, but not as much as proponents claim. For instance, wind farms that supply 15 percent of electricity to the grid do not offset 15 percent of fossil fuel generation, because other fossil-fueled generators necessary to back up the variable output of wind often run at idle even when the wind is blowing. The fuel economy of those units also suffers because they have to be ramped up and down to compensate for wind variability.
- Wind's variability often is a more difficult challenge to meet than many advocates claim. For example on February 26, 2008, the Texas grid narrowly avoided a outage when wind generators were hit with an unforecast lull which caused wind farm output to fall from 2,000 MW to 350 MW – just as electricity demand was peaking that day. A grid emergency had to be declared and about 1,100 MW of load was blacked out in order to avoid a more catastrophic collapse of the grid. The Electric Reliability Council of Texas (ERCOT) declared: “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’.”
- On the Big Island of Hawaii, wind provides more than one-third of electricity demand during the night. But during one week in June 2007, the wind resource became so variable that backup generators were not able to compensate quickly enough and the power frequency on the grid dipped from a normal 60 hertz Hz to 58 Hz. Such frequency dips can cause extensive and permanent damage to electronic equipment of the customers on the grid.
- Spain has been successful in integrating large amounts of wind on its system: 9.5% of its electric energy is supplied by wind generators. Grid operators are able to react to wind's variability there because of large hydroelectric facilities (which provide up to 18% of all generation capacity in

---

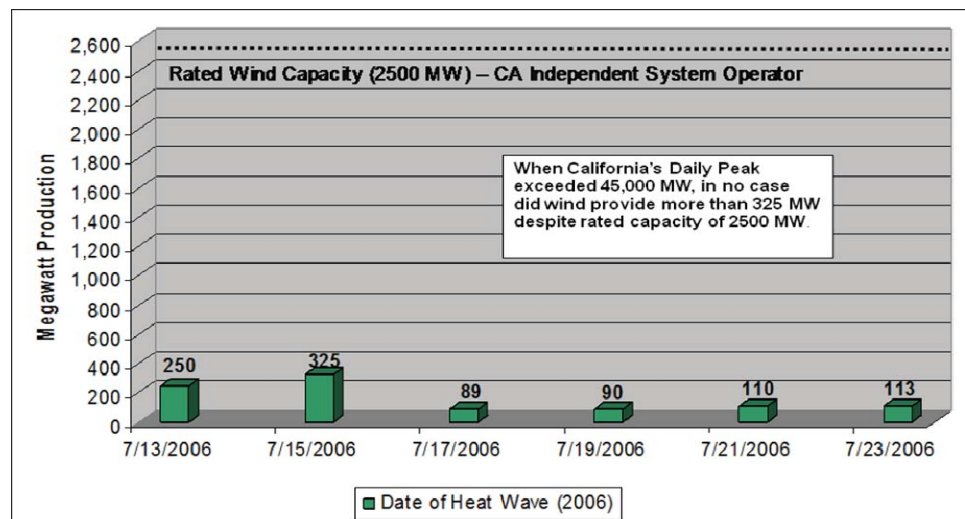
Practical," Issues in Science & Technology, (Fall 2008), <http://www.issues.org/25.1/apt.html>

Spain) and because it maintains a large amount of excess generating capacity (85 GW of generation to service a maximum load of 45 GW). The U.S. does not have management tools like this. In fact, in Texas, which produces the most wind energy in the nation, 6 GW of wind capacity can be back up with only 0.5 GW of hydroelectric capacity, and the state has only 13 percent excess capacity to manage wind's variability, in contrast to Spain's 90 percent excess capacity.

Also noted in the Carnegie-Mellon study was the fact that a group of researchers at Princeton University found that, at large scales, slowing down the wind by using its energy to turn turbines has other, unforeseen environmental consequences.

*"... (W)ind farms may change the mixing of air near the surface, drying the soil near the site. At planetary scales, David Keith (then at Carnegie Mellon) and coworkers found that if wind supplied 10% of expected global electricity demand in 2100, the resulting change in the atmosphere's energy might cause some regions of the world to experience temperature changes of approximately 1°C."<sup>117</sup>*

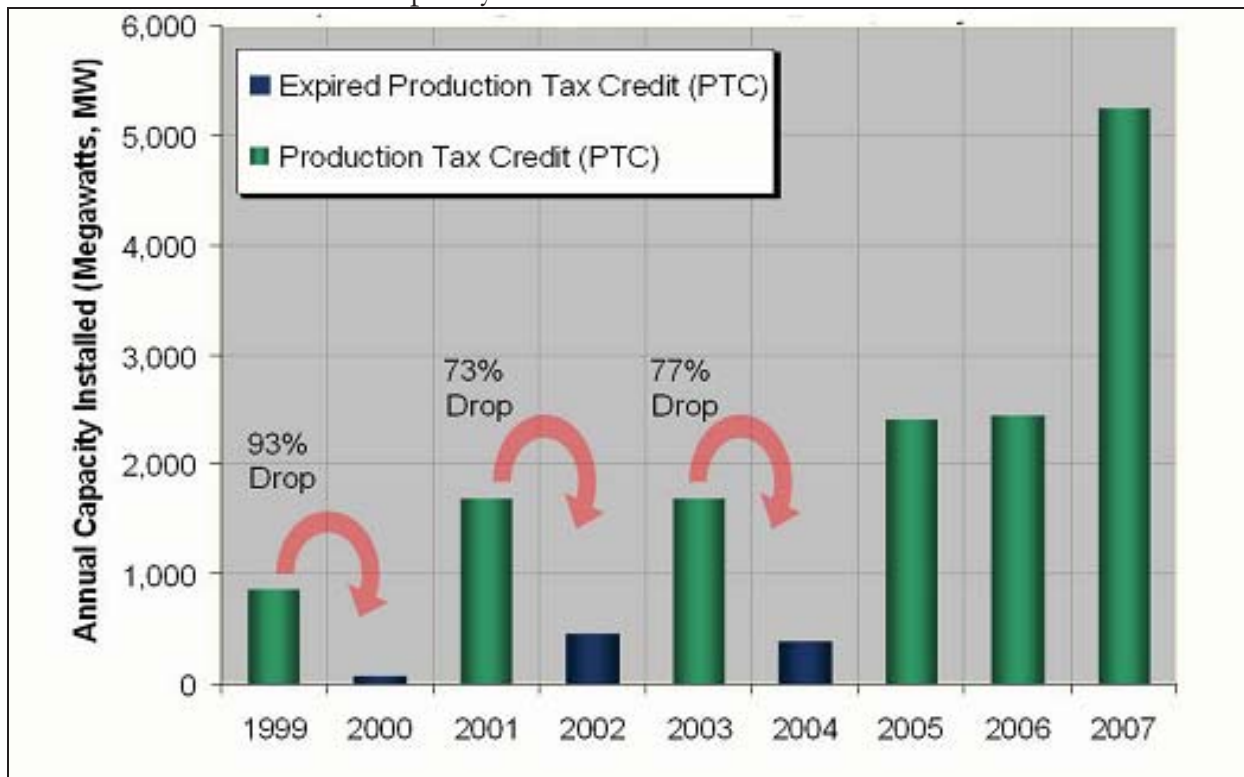
**Figure 8-2** Wind's Performance During 2006 California Heat Wave



Source: U.S. Department of Energy, 2006.

<sup>117</sup> Ibid.

**Figure 8-3** Historic Impact of PTC Expiration on Annual Installation of Wind Capacity



Source: American Wind Energy Association.

### 8.D.2. Hydroelectricity

- Hydroelectricity is the oldest and most viable renewable technology, and produced 36 percent of U.S. renewable energy in 2007.
- However, all of the best U.S. hydropower sites are already developed.
- Since the most advantages sites have been developed, hydro capacity can grow little.
- Many environmentalists now oppose hydro due to its impact on the environment, fish populations, silting, etc.<sup>118</sup>

<sup>118</sup> See, for example, Sarah Phelan, "Hydropower Doesn't Count as Clean Energy," *Earth Island Journal*, October 5, 2007.

- EIA forecasts that hydro's contribution to U.S. energy supply will remain constant at about 2.5 percent through 2030.
- The WCI report projects that no major new hydro plants will be developed in the West through 2020.

### 8.D.3. Biomass

- Biomass produces electricity by burning organic feedstock, and virtually all biomass electricity is produced in the pulp and paper industries which use residues as feedstocks.
- No dedicated U.S. biomass energy plantations currently exist.
- Biomass electricity production produces huge amounts of sulfur dioxide, nitrogen oxide, carbon monoxide, and particulate matter.<sup>119</sup>
- Per unit of energy output, biomass generates, by far, the greatest numbers of worker deaths and injuries.<sup>120</sup>
- Land requirements for 1,000 MW of biomass are immense: 2,600 sq. miles, 700 times larger than that of coal or nuclear.<sup>121</sup>
- Biomass produced about 50 percent of U.S. renewable energy in 2007.
- EIA forecasts that the biomass contribution to U.S. energy supply will increase from 3.7 percent in 2007 to about five percent in 2030.

---

<sup>119</sup> Roger H. Bezdek and Robert M. Wendling, "Establishing Benchmarks for Environmental Comparisons," *Modern Power Systems*, December 2006, pp. 11-14.

<sup>120</sup> Ibid.

<sup>121</sup> Ibid.

#### 8.D.4. Geothermal

- Geothermal capacity is site specific and limited.
- It may not even be “renewable”. Depletion occurs as more steam is withdrawn than is naturally recharged.<sup>122</sup>
- Geothermal contributes minimally to U.S. energy requirements: 0.3 percent in 2007; and EIA forecasts 0.7 percent in 2030.

#### 8.D.5. Ethanol

- The potential of corn-based ethanol and biodiesel is limited, and they are not energy efficient.
- Cellulosic ethanol (CE) is the holy grail of biomass liquids: If it cannot be made to be commercially viable, then biomass can never play a significant role in liquid fuels.
- Cellulosic ethanol is an alternative fuel made from a wide variety of non-food plant materials (or feedstocks), including agricultural wastes, industrial plant waste, and energy crops (like switchgrass).
- CE is essential because other forms of ethanol have limited potential.
- Cellulosic ethanol requires a more complex, difficult, and expensive conversion process than traditional corn-based ethanol.
- EROEI is energy return on energy invested; e.g., what is the “net energy” benefit of an energy option: Oil has EROEI of 8-15, coal

---

<sup>122</sup> “Geothermal Plants Find Natural Steam Source Running Out,” *U.S. Water News*, May 2001.

liquefaction 3-5, oil sands 2-4, oil shale 2-4, etc.

- If EROEI is less than one, more energy is consumed than is produced and net energy output is negative.
- Studies published in scientific journals indicate that the results for CE are mixed, but indicate that the EROEI of CE is about one.<sup>123</sup>
- Thus, it is still very much an open question as to whether or not cellulosic ethanol has a net positive energy benefit.
- Ethanol feedstock production is very fossil fuel intensive.
- The contribution to U.S. energy supply of all biomass liquids (ethanol used in E85, ethanol used in gasoline blending, biodiesel, and biomass liquids) is forecast by EIA to increase from 0.5 percent in 2007 to about 2.5 percent in 2030.

#### **8.D.6. Photovoltaics**

- Photovoltaic (PV) cells convert sunlight directly to electricity.
- Sunlight is available only in the daytime; it is weak in the morning,
- and late afternoon and is dramatically reduced by cloudiness.
- Therefore, PV is unreliable and requires large amounts of storage or conventional, grid-connected backup -- such as coal.

---

<sup>123</sup> See, for example, David Pimentel, "Ethanol Fuels: Energy Balance, Economics, and Environmental Impacts are Negative," *Natural Resources Research*, Vol. 12, No. 2, June 2003, pp. 127-134.

- PV (even with government subsidies) is orders of magnitude more expensive than most alternatives.
- PV makes no measurable contribution to U.S. energy requirements: 0.00 percent in 2007; and EIA forecasts 0.00 percent in 2030.

#### **8.D.7. Solar Thermal**

- A solar thermal power plant uses mirrors to concentrate sunlight on an absorber, and the energy is used to drive turbines.
- In the U.S., these plants can only be built in parts of the southwest and are subject to sunlight availability and intermittency.
- Solar thermal power stations are in the research phase, and it is not clear if they will ever be commercially viable.
- U.S. currently gets no energy from solar thermal plants, and may never get any – EIA forecasts a 0.00 percent contribution in 2030.

In sum, according to EIA, renewables will remain a niche application:

- The only major renewable options are hydro, biomass, and geothermal, and these are site and capacity limited.
- Combined they provided seven percent of U.S. energy in 2007, and EIA forecasts that they will provide 11 percent in 2030.
- The most publicized renewable options – wind, photovoltaics, and solar thermal – are and will remain niche applications: Combined they provided 0.2 percent of U.S. energy in 2007, and EIA forecasts that they will provide less than two percent in 2030.

- Even with subsidies and mandates, wind, PV, and solar remain prohibitively expensive and unreliable.<sup>124</sup>

## 8.E. Summary

Thus, the West – and the U.S. -- cannot rely on renewables for its energy future:

- Except for hydro (for which few new U.S. sites exist), renewable options are limited by severe technological and economic constraints.
- Renewable energy is dependent on substantial government subsidies and mandates, and is still not competitive.
- All renewables combined provided about seven percent of U.S. energy in 2007 and EIA forecasts they will provide about 11 percent in 2030.
- More than 90 percent of this contribution comes from hydro, biomass, and geothermal facilities – most of which that have been in-place for decades.
- Wind, PV, and solar are not capable of providing dependable, inexpensive electric power, and EIA forecasts they will provide less than two percent of U.S. energy in 2030.
- The 0.35 percent contribution of Wind, PV, and solar in 2007 and less than two percent forecast for 2030 can be contrasted with coal, which provided 24 percent of U.S. energy in 2007 and EIA forecasts will provide 24 percent in 2030.

---

<sup>124</sup> Roger H. Bezdek and Robert M. Wendling, “A Half Century of Federal Energy Incentives: Value, Distribution, and Policy Implications,” *International Journal of Global Energy Issues*, Vol. 27, No. 1 (January 2007), pp. 42-60.