Chapter 7

WCI And Grid Reliability

The WCI plan calls for new power generation in the West to come almost exclusively from renewable resources such as solar and wind power in the decades ahead. It calls for no new hydropower generation, no new nuclear power, no new natural gas-fired generation and no coal-fired power beyond that already planned and committed through 2020. Even CO_2 capture and sequestration technologies for fossil-fueled generation are excluded.

The WCI plan would require Western states to meet large projected increases in electricity demand entirely with intermittent technologies such as wind and solar and increased energy efficiency and/or demand destruction. This approach goes well beyond even the most optimistic extrapolations of virtually every expert in electric power system analysis, who contend that a blend of baseload and intermittent power generation are essential for stable, reliable, relatively low-cost power grids.

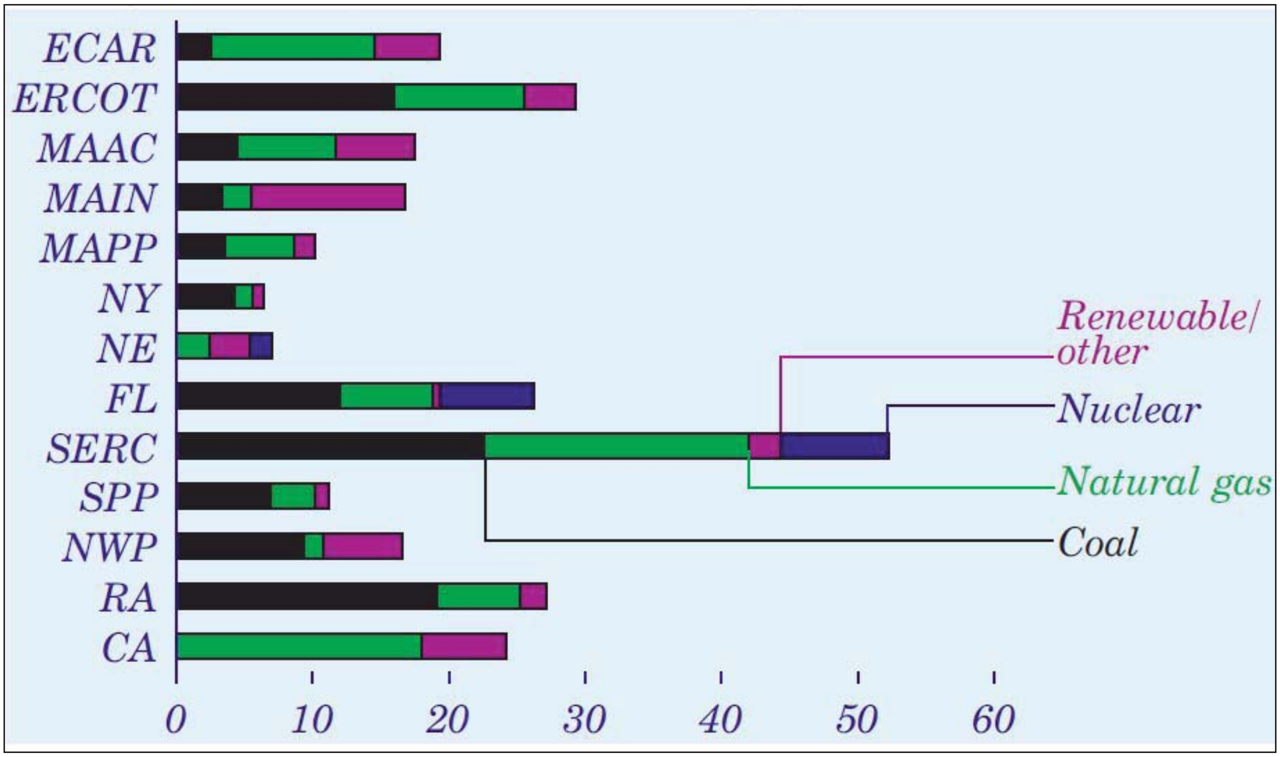
All Western states are currently pursuing aggressive expansions of their renewable energy power generation. However, if states limit all new generation to intermittent resources, there are legitimate concerns about the ability of the resultant system to "keep the lights on" as economies grow and older baseload power plants are retired.

7.A. Electricity Demand is Growing in the West

As shown in Figure 7-1, projections of future electricity demand in the U.S., from the Energy Information Administration's "Annual Energy Outlook, 2008"[94], estimates that total electricity sales increase nationwide will increase by 29 percent from 2006 to 2030, from 3,659 billion kilowatt hours in 2006 to 4,705 billion in 2030. This represents average rate of increase of only 1.1 percent per year.[95]

94 "Annual Energy Outlook 2008," U.S. Energy Information Administration, 2008.
95 EIA notes in its Annual Energy Outlook 2008 report that "the relatively slow growth follows the historical trend, with the growth rate slowing in each succeeding decade."

Figure 7-1 Annual electricity generation capacity additions, including combined heat and power, by region and fuel, 2007-2030 (GW)



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

EIA projects that in the three regions comprising the West – the Northwest Power Pool (NWP), the Rocky Mountain Power Area (RA) and California (CA) – electricity demand will require additions of approximately 66 gigawatts of new electrical generating capacity by 2030. EIA estimates that this new generating capacity will come from a mix of resources, including coal, nuclear, natural gas, and renewable power generation (including hydropower). The WCI believes that a reconfigured power grid is possible, based on an intermittent source expansion. Experienced power system experts would contend that is physically impossible to transition to a grid capable of delivering reliable, low cost power based on a large fraction of intermittent power generators (wind and solar) without major breakthroughs in technology, which cannot be forecast.

7.B. Electric Grids In The West Are Currently Stressed

> If states limit all new generation to intermittent resources, as the WCI assumes in its modeling, there are legitimate concerns about the ability of the resultant system to "keep the lights on" as economies grow and older baseload power plants are retired.

In its recently released "2008 Long-Term Reliability Assessment," the North American Electricity Reliability Corporation (NERC) repeated previous warnings about the future reliability of the West's electric grid.

NERC is projecting that net capacity the Western region, referred to geographically as the Western Electricity Coordinating Council (WECC), will fall below the recommended minimum capacity reserve margin in the Winter of 2009. This means that the West faces a heightened risk of service interruptions, such as brownouts and blackouts, as early as next year.

Perhaps the most pervasive issue raised in the comments NERC received was the current trend to replace and displace coal-fired generation with natural gas-fired generation. In their comments, the American Public Power Association has called this "dash to gas" the "most immediate risk to reliability."

The NERC report reinforced many of the findings of another recent analysis, "Lights Out In 2009?", issued by the NextGen Energy Council.[96] The heightened risk now faced by the West is the result of inadequate additions to region's energy infrastructure – new baseload power plants generation and high-voltage transmission lines – according to NextGen. That analysis concluded that the primary causes of the region's inability to strengthen its energy infrastructure were the following:

1. Regulatory uncertainty tied to federal and state climate change policies;

2. Challenges associated with integrating more intermittent power sources on the transmission grid;

3. Reluctance by state regulators to approve rate increases related to the imposition of new environmental or climate-related regulation;

[96] "Lights Out in 2009?", NextGen Energy Council, 2008 (http://www.nextgenenergy.org)

4. Lawsuits by environmental groups against power plants, transmission lines and natural gas production; and

5. The relatively shorter-term approach to resource planning and acquisition that industry has been forced to adopt because of all of the above factors.

7.C. Problems with Intermittent Generation

Here we focus on the issues associated with the massive buildup of wind, photovoltaics, and solar thermal power. Wind and photovoltaics are inherently intermittent, which means that electric power production from each can vary from zero to full name-plate output over time, so transmission capacity must be sized to at least the full name-plate power levels of the generators.

Solar thermal coupled with on-site natural gas-fired backup can be a different story and must be separately considered. If the region were to prohibit new natural gas generation to couple with solar thermal or wind or photovoltaics, then there is no hope for a viable electric power grid.

In all cases, new or expanded transmission lines are almost certain to be needed to accommodate the envisioned new generation, because the power levels are expected to be well above the capacities of existing transmission lines. In addition, the existing transmission system must be massively upgraded to so-called "smart grid" capability, a time consuming and costly undertaking. It should be noted that transmission line requirements depend on a myriad of factors, so a limited number of generalizations are all that can be made without detailed planning for the entire grid system. Within these constraints, consider the following.

7.C.1. Wind

Good to excellent wind conditions typically occur in locations far from load centers, so massive wind energy production will require massive construction of transmission lines to bring wind power to end-users. The capacity of wind energy transmission lines must equal a multiple of the maximum output of the wind generators – multiple because there must be redundancy in transmission capacity to guard against a single line being damaged or malfunctioning, thereby shutting down the whole power system.

With excellent wind resources, wind power generation capacity factors are of the order of 30-35 percemt, which is the average power that wind systems will deliver. However, transmission line capacity will cost roughly three times more than lines that carry these levels, because the lines must be capable of delivering maximum, name-plate power to end-users.

Transmission line investments over time and ultimate transmission sizing are important planning considerations. Transmission lines are always built with future expansion in mind. Thus, the lines built to move the first megawatt of wind power to market are likely to be sized for hundreds of times initial wind energy production in order to provide for future wind expansion. In other words, it is impractical to continuously upgrade transmission capacity to accommodate increasing wind generator power production.

The bottom line is that dedicated transmission lines are almost certain to be required for wind energy, and their initial cost will be very high in order to provide for the variable nature of wind power and future expansion. Typical power carrying capacity will be sized to maximum wind power generation levels but will typically carry roughly a third of maximum rating, so wind power dedicated lines will be considerably more expensive than normal.

Finally, there is the issue of the location of the backup power systems capable of compensating for wind variability. Such plants are typically sited near fuel delivery systems. Natural gas combustion systems are the logical backup choice because such systems can throttle from standby power levels to full power on the short notice typical of wind variability. However, natural gas pipelines are not often located close to good wind locations, so additional transmission for backup power must also be factored into planning.

7.C.2. Photovoltaics (PVs)

Photovoltaic systems are more easily sited than wind energy systems, so it is possible for PV generation to be located closer to ultimate customers. However, because PV power requires full backup when used in large scale, new transmission lines may be required to bring backup power to the end users to maintain the steady power that users require. Because of the multitude of variables, it is nearly impossible to make any blanket assessments of the transmission requirements for PV power.

These comments should not be taken as an endorsement for PV power over wind. PVs are very sensitive to cloudiness and produce no power when the sun does not shine at night, while wind systems often operate around the clock. Also, PV power is now more expensive than wind power. Thus, selection of how much wind and how much PV might be utilized in a region is a complex optimization problem involving a large number of variables.

7.C.3. Solar Thermal

Solar thermal systems are typically very large systems requiring large areas of land, preferably flat, in areas of low cloudiness. In the past, the few solar thermal power systems have been located remote from urban areas and a long distance from end users. The degree to which distant siting will be used in the future is a complex geographical, climate, and transmission problem for which few generalizations can be properly made. In the extreme, the same transmission considerations described for wind systems could also apply to solar thermal.

Solar thermal power plants have been built with integrated natural gas backup power on site so that the power from the combined system is essentially constant or easily controlled to meet the needs of the users. (Such systems are capable of providing peak and intermittent power, as well as base load power). High power solar thermal systems with on-site natural gas backup are almost certain to require both new electric power transmission lines and new natural gas transmission capacity. To repeat, without natural gas backup, an operable power system is impossible based on a large fraction of intermittent power generation.

7.D. Current Grid Constraints

While the United States is moving ahead with the research and development of new and cleaner sources of electrical energy, little has been done to ameliorate the aging and inadequate North American system for the transmission of electricity.

The current U.S. grid system has evolved over the last century in a piecemeal process in which local power generating facilities were placed in proximity to their markets and the fuel used to generate electricity was transported to the facility[97]. As markets expanded, and electricity was supplied to an ever increasing number of customers, the transmission grid grew as well, interconnecting cities and then regions. Today there is a network of 200,000 miles of transmission lines owned by some 500 different companies.[98] Further, although power lines cover the country, the grid is not completely integrated. Instead of one large grid, we have three separate regional grids called 'interconnects' – the Western Interconnect, the Eastern Interconnect and the Texas Interconnect – and the current structure does not have adequate capacity to carry significant amounts of power between the three regions.[99]

The first major obstacle, then, to bringing on significant quantities of electrical power from renewable sources such and solar and wind is the fact that currently there is a shortage of transmission capacity from those remote desserts and plains where solar and wind resources are plentiful to the markets where the power is needed.

A 2003 study by the U.S. Department of Energy called for the construction of a new 2,100 mile national high-voltage system to modernize the country's grid and provide the capacity needed for anticipated growth. The cost of the new grid is estimated at $60 billion.[100] While the cost of the proposed system is significant[101],

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[97] Excepting, of course, for hydro generated electricity.
[98] Matthew L. Wald, "The Energy Challenge: Wind Energy Bumps Into Power Grid's Limits", *New York Times*, August 27, 2008
[99] Kit Batten and Kari Manlove, "Identifying Hurdles to Renewable Electricity Transmission", Center for American Progress, December 18, 2008.
[100] U.S. Department of Energy, *"Grid 2030": A National Vision for Electricity's Second Hundred Years*, Washington, July 2003.
http://www.oe.energy.gov/DocumentsandMedia/Electric_Vision_Document.pdf
[101] The bill for the system raises the issue of who should pay and how the costs should be allocated. Should they be added to consumers' electrical bills?; should the Federal Government cover the costs; should those receiving electrical power from distant sources pay more than those living where the power is generated? These are all difficult political issues that must be resolved.

> At worst, limiting the West's options for electricity generation to intermittent renewable resources such as solar and wind could potentially put the entire Western electrical grid at risk.

perhaps the most serious obstacles to its implementation are the political, legal and procedural hurdles.

The political obstacles begin with the way in which the original grid was developed, for state and local jurisdictions currently hold most of the power when it comes to regulating power transmission lines. This institutional structure makes it much more likely that political and/or legal challenges will hinder any expansion of the grid across state lines.

The Energy Policy Act of 2005 requires the Secretary of Energy to designate National Interest Electricity Transmission Corridors (NIETCs) in areas in which electricity transmission constraints are a problem. The law also grants the Federal Energy Regulatory Commission eminent domain authority to speed the construction of needed lines. To date, only two NIETC corridors have been designated – in the Southwest and in the Mid-Atlantic – and both have been challenged by politicians, environmentalists and the usual "NIMBY" activists.[102]

In addition to political obstacles, new transmission facilities also face permitting and environmental obstacles. Owing to the balkanized nature of control over the construction of power lines, the permit process usually involves many jurisdictions with different and sometimes conflicting rules and regulations. While constructing new transmission lines will speed the introduction of cleaner, more environmentally benign electrical production, the act of constructing the power line infrastructure itself has significant environmental impacts that must be addressed.[103]

The grid-related issues discussed thus far can likely addressed with existing technology – the problem is of inadequate capacity and lines that are in the wrong places. However, since the WCI plan would required massive expansion of the electrical grid to accommodate a large number of new solar and wind facilities, an additional and more troublesome issue arises in that solar and wind power are intermittent, and the existing power grid is not equipped to handle large quantities of intermittent power. The grid does not have

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[102] Bitten and Manlove, op.cit.
[103] Keith Johnson, "Careful What you Wish For: California's Tougher Renewable-Energy Targets A Mixed Blessing for Greens", *New York Times*, November 18, 2008.

adequate capacity to store the energy generated on sunny or windy days for use when clouds appear or the wind dies.

One solution is to construct enough excess coal, oil, or gas-fired thermal capacity to offset power losses when the sun and/or wind fade. Another is to use excess renewable power to pump water into uphill reservoirs to turn generators when needed. Both of these solutions will require massive investments well in excess of the expenses of solar and wind facilities. Also, the number of sites available for the construction of reservoirs is limited, and the water needed in this type of system would offset one of the ecological benefits of wind and solar power – they require less water than fossil or nuclear plants. Germany, the world's largest user of wind energy, is familiar with these problems and has struggled to maintain a stable power supply as a result.[104]

A more promising approach to the problem of the intermittent nature of solar and wind power is to invest in "smart grid" technology that addresses both the supply and demand for energy. The current "dumb" grid is a one-way affair that sends a supply of energy down the line that, hopefully, is adequate to meet current demand. With intermittent wind and solar power sources, this means temporarily firing a gas-turbine generator to provide the power when the supply of wind/solar power is inadequate. Germany does this, but it is inefficient as well as being difficult to manage smoothly. In a "smart grid" system, both supply and demand are in play and shortfalls in wind/solar power could be met with a decrease in demand. Specifically:

". . . . in a smart grid, the controller could send a message down to a regional distribution system, seeking a reduction in demand. Instantly, a signal would go out to meters in the homes or offices of customers who had agreed, in exchange for rate reductions, to let the utility rig some of their appliances to cut power consumption during supply drop-offs. Within seconds, electric water heaters would shut off for a few minutes, and electronic thermostats would be automatically adjusted by two or three degrees. There would be no need to power up the natural-gas plant.

In one of the more advanced pilot projects testing such a system, the Minneapolis-based utility Xcel Energy and several vendors are investing $100 million to install a smart-grid infrastructure in

[104] David Talbot, "Lifeline for Renewable Power", *Technology Review,* MIT, January-February 2009.

Boulder, CO. These days, a 115-person Xcel crew is out full time, installing two-way electric meters at 50,000 houses. Homeowners are getting software that lets them view and manage their energy consumption on the Web, and some of their appliances are being fitted with switches that will let the utility shut them off remotely during periods of high demand.

Smart-grid technologies could reduce overall electricity consumption by six percent and peak demand by as much as 27 percent. The peak-demand reductions alone would save between $175 billion and $332 billion over 20 years, according to the Brattle Group, a consultancy in Cambridge, MA. Not only would lower demand free up transmission capacity, but the capital investment that would otherwise be needed for new conventional power plants could be redirected to renewables. That's because smart-grid technologies would make small installations of wind turbines and photovoltaic panels much more practical. "They will enable much larger amounts of renewables to be integrated on the grid and lower the effective overall system-wide cost of those renewables," says the Brattle Group's Peter Fox-Penner."[105]

Thus, without significant investments in new power line facilities – both quantitative to increase capacity and qualitative to offset the crippling defect of intermittent power from wind and solar power – the dream of displacing fossil fuel generated electricity with renewable solar and wind will remain just that, a dream.

[105] Talbot, op. cit.