Paying the Price: Costs of Transmitting, storing and Producing Electricity

This brings up another point hinted at earlier. Most of this power has to be generated fairly far from where it is consumed. There are various technical reasons wind farms need to be build far from cities - even when city wind speeds are suitable for turbines. If hydropower, geothermal, and solar thermal electricity are to mix with wind power to provide a reliable supply, we will need a few very long lines – some possibly up to 3,000 kilometers (1,864+ miles).

The longest DC lines in the world are around 1,700 or 1,800 kilometers. But most companies who have looked at the issue think that lines of up 5,000 kilometers are quite feasible if needed, let alone 3,000[283].

A 3,000 kilometer 3,000 Megawatt DC line will typically have an average 13% loss[283]. Most of the transmission lines would be less, so the overall average would be more like 11%. Wind, which is the vast majority of the proposed electricity grid, would mostly travel less than 1000 kilometers – with a fair percent of it traveling only via the local grid. (Not always of course; if we have such an extensive grid, and wind is blowing one place and not another, we will probably want to take advantage on occasion.) And a great deal of wind is much closer than 600 miles to where it is consumed. A 1,000 kilometer HVDC line typically suffers a 9% thermal and conversion loss. So we can average the power traveling up to 3,000 kilometers with the half derived from wind power traveling less than 1,000 kilometers – resulting at most in 10.36% loss. If you add in an additional 10% from normal AC transmission, conversion and distribution losses, the total is slightly less than 20%[i] - at most.

Minor grid improvements such as voltage regulators can reduce this. (For that matter there are small scale voltage regulators for homes and small business which can do the same thing[284].) Even before improvements, there are a lot of reasons losses don't have to be this high. But we will assume the 20% to be on the safe side.

Aside from power losses, what are the costs of the lines themselves, and of operations and management? The same source gives total levelized line costs and O&M of ~1 cent per kWh for a 15-17 cent per kWh total.

Let’s take another approach, to double check the costs of such an increased transmission network.

The electric utility industry, projecting a huge increase in demand, currently wants around 100 billion dollars in grid improvements[285].

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[i](Yes, having been asked this, the arithmetic is correct. Percentages multiply; they don’t add. Losing slightly more than 10%, followed by losing another 10% of **what remains** is a total loss of slightly less than 20%.

If, instead, we reduce electricity demand by slightly less than 80%, there is no justification for many of these requests. Large numbers of HVDC lines to transmit small amounts of power long distances would cost a great deal less than 110 billion dollars[286]. So if we really take a whole systems approach the transmissions costs of a renewable scenario are a great deal less expensive than the transmission costs of continuing on the same path.

Finally we still will need some backup. Depending on how much reliable geothermal and dam-based hydro-power is in the mix we will need between 1% and 5% of our electricity to come from fossil fuels - probably natural gas (which there is plenty of at this level of use.) Even 5% of our electricity via natural gas represents an acceptable emission level; and methane from existing dumps, sewage and other waste could displace some of this. Existing peaking natural gas generators could supply a large part of this; additional new one might add another cent per kWh to total costs.

Lastly we need to add on existing costs for utilities of normal transmission, distribution (other than power losses), general administration, meter reading and – well – everything else. These seem to average around 3 cents per kWh[287].

total before additional transmission costs		~.0825
20% line loss		~$0.040
Additional transmission levelized capital and O&M		~$0.010
Additional peaking natural gas generators + fuel		~0.0125
All other existing costs		~$0.030
Final cost per kWh for wind/solar/hydro/geothermal/ with no technical breakthroughs		**~$.165**

This compares to the existing average levelized cost of electricity – which according to the EIA statistics site in the pervious note was 8.14 cents per kWh in 2005. So we can provide renewable electricity for around twice the current market cost of fossil fuel electricity - with no technical breakthroughs. With efficiency measures in place that means total electric bills, including amortization of efficiency measure capital costs will be lower for the same service than at present.

End Notes

[283]Alessandro Clerici and Andrea Longhi, *Competitive Electricity Transmission as an Alternative to Pipeline Gas Transport for Electricity Delivery. 17th World Energy Council Congress, Houston, Texas, USA, 13-18 September 1998*. Sep 1998. *World Energy Council*, 23/Aug/2004 <http://www.worldenergy.org/wec-geis/publications/default/tech_papers/17th_congress/2_2_08.asp>.

Also: American Wind Energy Association, *FAQ: Cost of Wind Energy*. 2000, American Wind Energy Association, 22/Aug/2004 <http://www.awea.org/faq/cost.html>.

Also:Shimon Awerbuch, "Determining the Real Cost: Why Renewable Power is More Cost-Competitive Than Previously Believed,". *Renewable Energy World*, no. March-April 2003 Mar 2003, James & James, 27/Sep/2005 <http://www.earthscan.co.uk/news/article/mps/UAN/71/v/3/sp/332149698573342662256>.

[284]Energy Ideas Clearinghouse, *Product Technology & Review | Home Voltage Regulator (HVR)™, Enterprise Voltage Regulator (EVR)™*. 2004. *Washington State University Extension Energy Program (Manages Energy Ideas Clearinghuse for Northwest Energy Efficiency Alliance in Portland Oregon)*, 26/Mar/2005 <http://www.nwalliance.org/resources/documents/PTR/EI_PTR200407Microplanet.pdf>.

[285]"The scale of deploying the technology, and doing the detailed systems engineering to make it work as a seamless network, will require significant levels of investment, estimated at $100 billion over a decade."

T.J. Glauthier, Testimony of T.J. Glauthier President & CEO, Electricity Innovation Institute Affiliate of EPRI (Electric Power Research Institute) House Committee on Energy and Commerce Hearing on "Blackout 2003: How Did It Happen and Why?" Sep 2003, Electric Power Research Institute (EPRI), 27/Sep/2005 <http://www.epri.com/corporate/discover_epri/news/testimony_TJ-090403.pdf>.p5.

If they really mean what they say in the study, they are talking about a number closer to $200 billion per decade plus:

"..investment deficit is now on the order of $20 billion per year and must be accounted for over and above the investment levels of the 1990s if service demands are to be confidently met."

Electric Power Research Institute (EPRI), *Electricity Sector Framework for the Future | Volume I | Achieving the 21st Century Transformation*. 6/Aug 2003, Electric Power Research Institute (EPRI), 27/Sep/2005 <http://www.epri.com/corporate/esff/ESFF_volume1.pdf>.p16.

So this is $100 billion every five years, plus however many years of "deficit" they propose to make up for.

[286]Eric Hirst and Brendan Kirby, *Transmission Planning and the Need for New Capacity. National Transmisson Grid Study - Issue Studies*, Issue 4. May 2002, U.S. Department of Energy, 27/Sep/2005 <http://www.eh.doe.gov/ntgs/issuepapers/ISSUE_4.PDF>.pD-19.
Table 3. Typical costs, thermal capacities, and corridor widths of transmission lines
(Note: The table was reformatted by me to fit this document, some of the units converted, and a computed column added to the end.)

Voltage (kV)	**Capital cost $/mile**	**Capacity (MW)**	**Cost (Million $/GW-Mile)**	**Width (feet)**	**Cost for 3000 KM (1865 mile) Line**
230	480,000	350	1.37	100	895,200,000
345	900,000	900	1	125	1,678,500,000
500	1,200,000	2000	0.6	175	2,238,000,000
765	1,800,000	4000	0.45	200	3,357,000,000

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Generation, Distribution and various administrative, sales and miscellaneous expenses ran around 36.5% of total expenses in 2005.
Energy Information Administration, *Revenue and Expense Statistics for Major U.S. Investor-Owned Electric Utilities* (Electric Power Annual with data for 2005) - Published October 2006.
<http://www.eia.doe.gov/cneaf/electricity/epa/epat8p1.html>

Electricity costs per kWh in 2005 averaged 8.14 cents per kWh.
Table 7.4. Average Retail Price of Electricity to Ultimate Customers by End-Use Sector, 1994 through 2005 - (Electric Power Annual with data for 2005) - Published October 2006
<http://www.eia.doe.gov/cneaf/electricity/epa/epat7p4.html>

Hence 2.9697 or ~3.0 cents per kWh