Environmentally Preferable Power: Emerging Tool for Policy Makers

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ABSTRACT

The construction and operation of an electrical power facility can have significant environmental effects. These impacts can vary greatly depending on how and where a specific technology is applied, the energy source used and the receiving environment. Efforts by states and others to establish and promote "green" energy sources have resulted in a panoply of conflicting and confusing information. The resulting policies appear to be driven much more by politics than by scientifically verifiable information.

Environmentally Preferable Power (EPP) seeks to establish a scientific basis for evaluating the "environmental footprint"of an electrical facility through life cycle assessment. It begins by utilizing a set of indices of key environmental resources. Changes in these key indices caused by a proposed or existing generator are used to determine the facility's environmental footprint. Since EPP uses a common metric, such as the production of a gigawatt hour of electricity, comparisons can be made among competing electrical facilities. Moreover, every facility can be evaluated against a baseline of electrical generators within a region or against a baseline of the policy maker's choosing.

The EPP method is scientifically based, peer reviewed and uses a common metric. Using information developed by an EPP study, a policy maker can evaluate an electrical facility based on its environmental performance; either in comparison with competing facilities or against a standard preferred by the policy maker.

Given the natural attraction of a science-based approach to the issue of "green power", EPP is starting to come into use by policy makers and others to make informed decisions. In addition, the American Society for Testing and Materials (ASTM) has formed a new task for to develop a standard for addressing.

Interest in Developing Programs of "Renewable" and "Green" Electrical Energy

Programs that promote electrical energy resources which are "renewable" and "green" have gained popularity in the United States. The growing interest in these programs has come from both "supply-side" and "demand-side" economic agents. A number of consumers are interested in buying electrical energy which has negligible environmental impact. On the supply-side, a growing number of regulatory agencies and electrical power producers have an interest in meeting society's growing energy needs with more environmentally benign technologies.

The interests of these parties have manifested themselves through either state-level renewable portfolio standards (RPS), through special programs by electrical utilities who allow voluntary participation in the purchase of "green" electricity and through privately organized efforts that allow consumers of electricity to purchase "green" electricity certificates that represent the environmental attributes of production methods that are said to be environmentally benign.

What is "Green Power"? Conflicting and Confusing Definitions

Efforts by states regulatory agencies, electrical utilities and non-governmental organizations to establish and promote "green" energy sources have resulted in a panoply of conflicting and confusing information. The resulting policies appear to be driven much more by politics than by scientifically verifiable information.

An illustration of these contradictory policies if offered by a review of how state RPS and others treat electricity generated from hydroelectric facilities:

1. In California, qualifying hydropower is limited to facilities with a maximum nameplate capacity of 30MW. Incremental improvements such as generator rewinds that can

increase capacity without additional water use are not even considered in California's RPS. This leads to the ironic and absurd result that an increase in the nameplate capacity of hydroelectric generator due to such improvements can actually jeopardize a facility's RPS qualification if it lifts the capacity over 30MW.

2. Nevada, on the other hand, will require 15% renewables by 2013 of which 5% must be from solar facilities. Hydropower is not considered.
3. Texas calls for over 2,000 MW of renewable capacity by 2009. Any size and type of hydropower may be included.
4. Arizona required a mere 0.2 percent of retail sales to come from renewables and of those, half must be from solar. The remainder must come from "environmentally friendly" sources.
5. Minnesota's proposed RPS allows hydroelectric facilities that are less than 60 MW of nameplate capacity.
6. Unpassed national energy bill: only incremental improvements in hydro.
7. The Low Impact Hydro Institute will certify a hydroelectric facility, regardless of size, as a "low impact" electrical facility if the operation of the powerplant conforms to the preferred operation of regulatory agencies such as the U.S. Fish and Wildlife Service and state fish and game agencies.
8. The TerraChoice group will certify hydroelectric power facilities if they are "small" and "run of the river", but will only certify new (not existing) facilities.

While we've chosen the treatment of hydroelectric power by state RPS and private "green power" standards to illustrate the confusing and contradictory array of policies and regulations, similar discrepancies exist across states and NGOs with regard to solar, wind, geothermal, and biomass.

The situation I describe here has prompted researchers to conclude:

> *"The RPS, on a state by state level, appears convoluted, inconsistent, and arbitrary."*

Moreover, these authors state:

> *"An RPS that, for example, discourages and potentially disqualifies a hydro facility from upratings that would provide more electricity with no change in passed-through water seems counterproductive or, at minimum, ill-informed[4]."*

A critical review of contradictory state RPS and NGO policies prompts the question of the basis for the determining what's "in" and what's "out". A cynical mind might conclude that these standards are merely the outcome of a complicated political game. If so, these exercises are distracting effort and attention from the desires of a growing number of households and businesses – the cleaner production of electricity.

Environmental Impacts of Electrical Generation Facilities

The construction and operation of an electrical power facility can have significant environmental effects. These impacts can vary greatly depending on how and where a specific technology is applied, the energy source used and the receiving environment. While this conclusion is axiomatic, the surprising result for many is that, once scientifically-based environmental impact analysis is conducted, this statement applies equally well to so-called "green" technologies.

The Environmental Impact of "Large" Hydropower Generators: As noted above, one of the underlying assumptions of state regulators and NGOs that produce qualifying standards for "green power" is that a "large" hydroelectric generating facility has significant detrimental environmental effects. Contradicting this assumption is a recent comparison of hydropower generators of different sizes and the associated disruption in habitat[5.] Figure 1 is a graphical summary of this work; comparing five hydropower facilities of significantly different sizes to the amount of habitat disrupted.

An examination of this figure reveals a startling conclusion: size doesn't matter. There appears to be no relationship between habitat disruption and generating capacity of the hydroelectric powerplants examined in this comparative analysis. While this is not comprehensive analysis of all hydropower plants and is thus, anecdotal evidence, it calls into question the public and private standards in use today that limit the size of "green" hydropower facilities.

Another clear indication of the environmental consequences of adding hydropower generating capability is the example of Glen Canyon Dam: a Federally-owned powerplant in Arizona. Through rewinds and efficiency improvements, this generator has added 350 MW of capacity since is construction in 1963. This capacity was added without any additional environmental

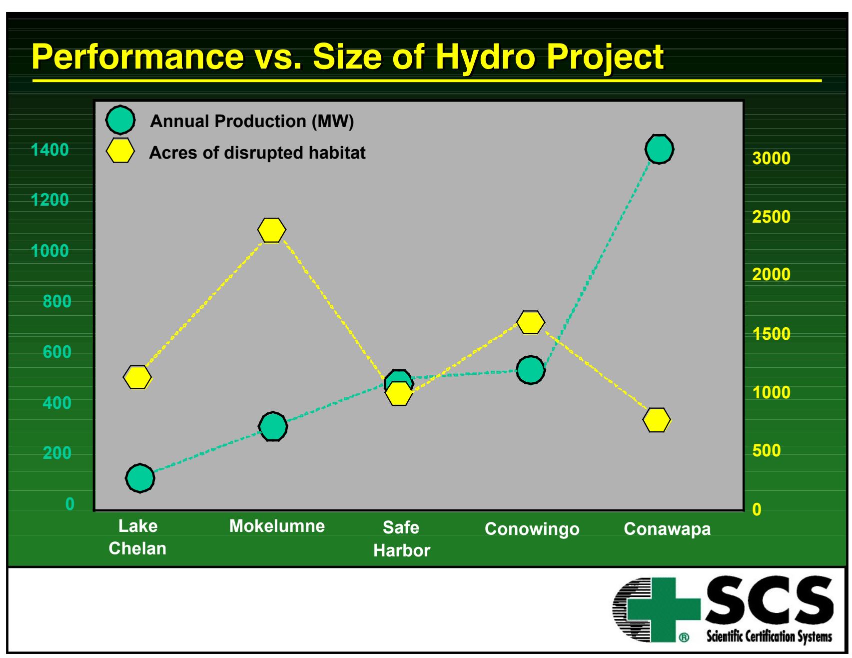

Figure 1. Comparison of Five Hydropower Generators and Habitat Disrupted.

impact. In fact, almost all of the Federally-owned dams in the Western United States have significantly improved generating capability since they were constructed.

A final example of the "size doesn't matter" conclusion for hydropower facilities is that of Skagit Dam in Washington State. It is a 650 MW facility, the 3rd highest dam in North America and has been recently certified by the Low Impact Hydro Institute (LIHI) as being a low-impact hydro facility.

Environmental Impact of Hydropower Generators Compared to Other Generation Technologies:

Above, I have compared the environmental impacts of hydroelectric power generators of various sizes. Environmental impacts can also be compared among generation technologies[6]. Figure 2 illustrates ecosystem disruption of a variety of generation technologies.

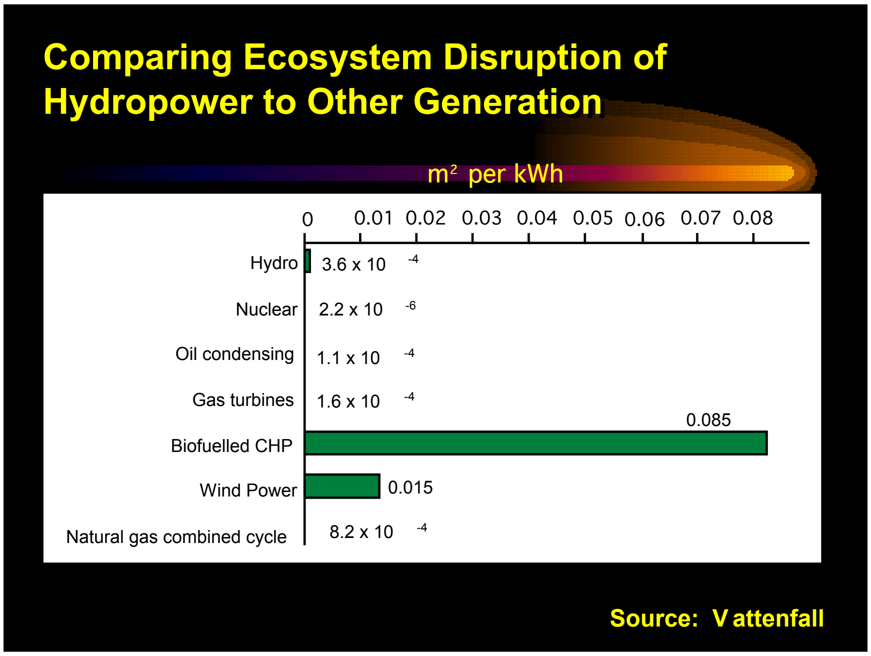

Figure 2. Land Use per kWh by Electrical Generation Technology[7].

Note that this Figure 2 is a comparison of different generating technologies on a kWh basis. This is a significant improvement over traditional comparison techniques. In some venues, hydroelectric power is vilified because this technology often includes a water storage facility and water storage reservoirs disrupt habitat. However, rarely is there a comparison made regarding the amount of environmental impact per kWh of electrical production. This is necessary because, large electrical generating facilities are large because they produce a lot of electricity. These large facilities may replace many smaller generating facilities which, taken together, may have greater environmental impact.

Figure 2 illustrates this point. According to the Vattenfall research summarized here, electrical production technologies that are often included in "green" energy programs, such as Biofuelled CHP, require land inputs that are several orders of magnitude larger than hydroelectricity, when using a "unit of production" comparison.

Electrical Production Technologies Included in "Green" Programs Can Have Significant Environmental Impacts

The idea that so-called "green" technologies may carry their own environmental "baggage" and may give rise to significant environmental impacts in their own right first occurred to me as I was giving a tour of the electrical power facilities at Blue Mesa Dam on the Gunnison River in Colorado. A tour participant remarked that the reservoir backed up by the dam caused environmental damage because it destroyed an erstwhile valley by filling it with water. The tour participant suggested that an environmental improvement would occur if the electricity was produced by wind power instead. I contemplated this idea. I then calculated that a hypothetical "Blue Mesa Wind Farm" – a wind farm with the same generating capability as the existing powerplant - would require the land equivalent occupied by Blue Mesa Reservoir, and 38% more land. Moreover, since the water stored in Blue Mesa Reservoir allows the powerplant to be dispatched to meet changes in electrical demand, provide regulation service, spinning and nonspinning reserve, and black start capability some further investment would be required in a wind farm to make it equally valuable as an electrical generating facility. There, of course, would also be a need for supplementary, or firming, generation held in reserve to support the wind technology when the wind was not blowing.

In all fairness, wind technology can potentially have significant environmental consequences. A proposal to provide one half of the electrical needs of the United States was put forth by Professor Heronemus of MIT in 1984. His proposal to provide economical wind power would involve 300,000 towers, each 850 feet high, distributed over the Great Plains from Texas to Canada.[8] Clearly, wind production of a sufficient scale to meet a significant portion of U.S. electrical energy requirement could have notable environmental impacts.

Geothermal power is included in all "Green" power programs. Yet, the textbook description is that: "Geothermal energy is clearly not a renewable resource in the same sense that solar energy is renewable[9]" with lifetimes of 20 to 50 years. This information has been recently confirmed by an examination of geothermal facilities in the Western United States which describes the lifetime of these facilities as being between 15 and 20 years[10].

Of course, the purpose of this paper is not to vilify or dismiss any electrical technology. Wind-powered electricity contributes significantly to the electrical resource portfolio of several European countries and potentially can make a significant and environmentally benign contribution in the U.S. The purpose of this analysis is to convey to the reader a critical examination of existing state and private programs to promote either "green" or renewable electrical production leads to contradictions and absurdities. The current hodge-podge of policies lead some analysts to conclude:

The potential outcome of these competing efforts is to effectively create a marketing platform for certain generation technologies regardless of their proven environmental impacts rather than generation with proven, substantive measures of environmental compatibility. A gulf seems to exist between technologies that may seem intuitively appealing and proven, site-specific performance results[11].

Environmental Performance-Based Approach

It seems obvious from the above that an approach to setting standards for "green" power that would eliminate a number of the problems described herein would be a "performance-based" standard. A performance-based standard would require that an electrical generating facility be able to demonstrate, using objective, reproducible, scientific methods that the environmental impact of producing electricity at this facility would be an improvement over some agreed upon baseline before it could wear a "green" label.

Such a standard would require that the environmental impacts be assessed at every stage of production, distribution and consumption in order to avoid claims of being environmentally benign from electrical producers who could demonstrate a "clean footprint" in production, but not in the construction stage (e.g. a "cradle to grave" approach).

A single life-cycle standard for environmental performance would alleviate many of the previously mentioned problems. A standard that evaluates all technologies on equal terms would avoid political preference for "in vogue" technologies, would communicate a common currency of environmental impact to consumers, and would set a common environmental goal for producers of electricity. Promoters of free market choice would presumably support a life-cycle standard as providing consumers with clear, comparable information unencumbered by regulation and political manipulation by special interest groups or representatives of particular technologies.

A performance-based approach would require environmental claims of "green power" to be demonstrated against objective performance metrics. For this approach to be useful, it would have to have a scientific basis, with methods and results that could be reproducible. A desirable characteristics of a science based approach would be the standardized environmental indicators that could be used as the metrics for performance. It would also be necessary for the assessment method to use a life-cycle approach. Finally, it would have to be technologically "blind".

Examples of Performance Based Standards in Development

A performance-based approach to evaluating the environmental impact of electrical power generation has been completed by Vattenfall in Sweden[12]. Vattenfall is the fifth largest electricity generator in Europe and provides half of the electric needs in Sweden. Vattenfall examined a variety of generation technologies including hydropower, nuclear, wind, combined heat and power, gas turbines, oil condensing, natural gas combined cycle, coal, and solar. All of these technologies were examined using Life Cycle Assessment (LCA)[13.] Vattenfall's flagship effort is an analysis of a series of hydropower projects. An LCA analysis was completed on three of their hydropower facilities on the Lule River. Following this analysis, Vattenfall released an Environmental Product Declaration (EPD) that communicates to the industry and Vattenfall's customers, the environmental impact of these facilities[14].

The Canada Electric Association (CEA) Report – CEA commission a performance-based study of electrical generators in Canadian provinces. The report was published in 2005 and uses a performance-based, life cycle approach to evaluate the environmental "footprint" of several electrical generating technologies in Canadian provinces[15.]

Western Area Power Administration has commissioned a similar study as a demonstration project: is a performance based environmental assessment of electric power facilities practical? Is it useful for planning purposes or for identifying environmentally preferable power facilities? In this study, the environmental performance of several existing electrical generators will be compared to the regional baseline. This evaluation is large in geographic scope (WECC) and is hoped to be a complementary study to the Canadian study cited above.

SachPower, of Saskatchewan province, Canada, is currently developing a performance based method to act as a planning tool as it makes planning decisions to meet growing demand. It intends to examine different possible electrical facilities and use life-cycle, performance based evaluations as part of the decision making for electrical supply options.

Scientific Certification Systems (SCS) is a private consulting firm based in California. It has been in the process of developing environmental indices and methods for analyzing the environmental footprint of a power facility on a production unit basis, against a regional baseline. An example and visual illustration of some of the analysis is has prepared in shown in Figure 3. In this figure, 15 environmental indices have been developed intended to cover the range of possible impact. The horizontal bars represent the scale of adverse impact on that particular resource. The environmental footprint of an average production unit generated in the region is shown by the black line in the middle of the graph.

Developing American Standards for Testing and Materials (ASTM) Standard

ASTM is developing a standard for evaluating the environmental "footprint" of electrical generation facilities and associated structures based on scientifically reproducible environmental performance. The scope of this work product, as stated by ASTM is:

> *"This practice covers a procedure for identifying, quantifying, and reporting the environmental performance of electric power generation facilities and infrastructure across their life cycle."*

Further, ASTM states that:

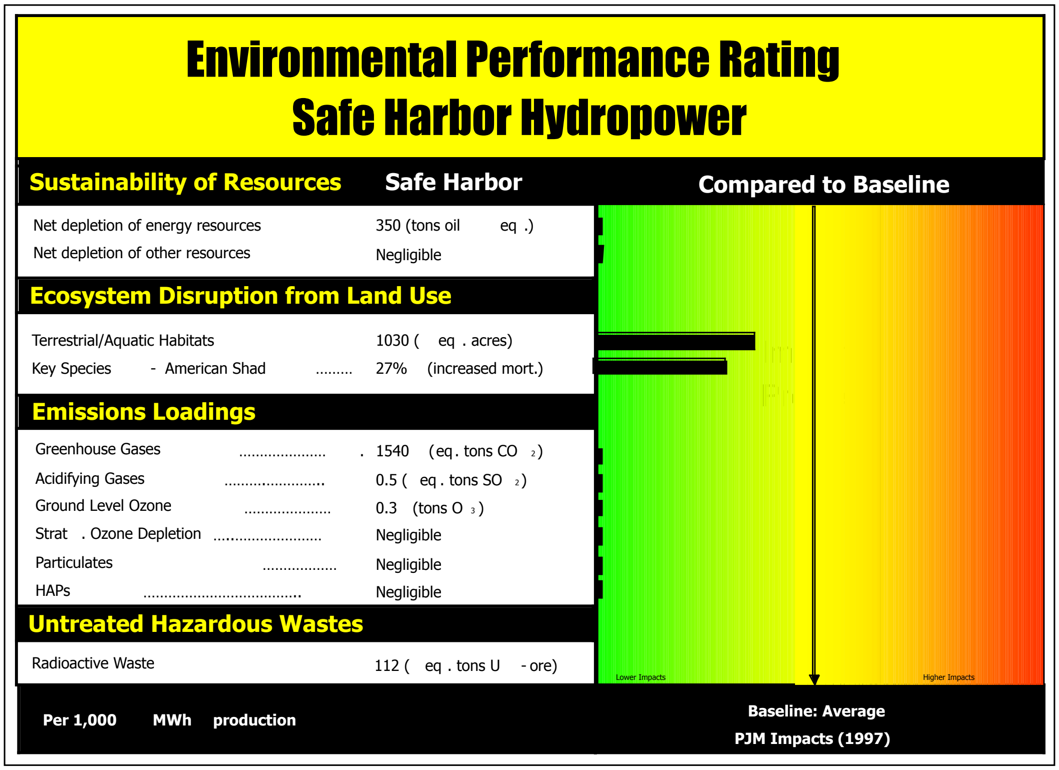

Figure 3. An Example of a Performance Based Approach to Establishing "Green" Standards.

> *"This practice is not intended to define a preference for one technology relative to another. The construction and operation of electric power generation facilities and infrastructure can have significant environmental impacts. These impacts can vary greatly not only between energy sources, but also among power production infrastructure and facilities using the same type of energy source, differences in the technology in place, as well as differences in the surrounding environments. To make informed decisions, it is necessary to have objective and verifiable environmental performance data and information in a consistent format."*[16]

This standard is still in development. It is currently being balloted.

Footnotes

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[3]Disclaimer: the opinions and recommendations expressed in this document are solely those of the authors and do not necessarily represent the views of Western Area Power Administration or the U.S. Bureau of Reclamation.

[4]Rader, Nancy and Scott Hempling. 2001. *The Renewables Portfolio Standard: A Practical Guide*. National Association of Regulatory Utility Commissioners: Washington, D.C.

[5]Rhodes, Stan; *Assessing Environmental Performance in the Electricity Sector*, Scientific Certification Systems, unpublished, May, 2004.

[6]*Vattenfall's Life Cycle Studies of Electricity*, Vattenfall AB and Explicare AB, October, 1999.

[7]As indicated on Figure 2, the data source is Vattenfall (see footnote 7), but this figure was adapted from the Vattenfall data by Scientific Certification Systems.

[8]Kraushaar, J.J. & Ristinen, *R., Energy and Problems of a Technical Society*, John Wiley & Sons, Inc., (1984), page 207.

[9]Ibid, page 221.

[10]Rhodes, S., *Assessing Environmental Performance in the Electricity Sector*, Scientific Certification Systems, unpublished, (May, 2004).

[11]Rader, Nancy and Scott Hempling. 2001. *The Renewables Portfolio Standard: A Practical Guide*. National Association of Regulatory Utility Commissioners: Washington, D.C.

[12]"*Vattenfall's Life Cycle Studies of Electricity"*, Vattenfall AB and Explicare AB, October, 1999. (Found at: www.sylvatica.com/lcaeng.pdf)

[13]A Life-cycle assessment is described as a systematic measure of the resource consumption and environmental impacts of a particular product or service system through all stages of its life cycle. This is sometimes called "cradle to grave" study since it includes the impacts of resource extraction, production, transportation, distribution, consumptions and waste disposal.

[14]Vattenfall conformed it report to the requirements of ISO TR 14025 Type III environmental declarations.

[15]"An Environmental Assessment of Selected Canadian Electric Power Generation Systems Using a Site-Dependent Life-Cycle Impact Assessment Approach", Canada Electric Association, February, 2005.

[16]Description and information on this developing work product can be found at: www.astm.org. It is under the E06 committee: performance of buildings, under the 0.71 sustainability sub-committee. It is work product: WK 4879. The full citation is: www.astm.org/cgi-bin/SoftCart.exe/DATABASE.CART/WORKITEMS/WK4879.htm?L+mystore+pfzi1370+1152066978