The Role & Barriers For Electricity Energy Storage In Mitigating Greenhouse Gas Reduction Challenge

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Electrical energy storage (EES) technologies have applications throughout the electrical grid system. The ubiquitous electricity storage applications also hold promise in mitigating the greenhouse gas (GHG) reduction challenge at the generation, transmission, distribution and consumer levels. The following discussion provides rationale for valuation of such GHG reduction. It identifies some emerging and uncommon opportunities within the electrical grid system where, in addition to the well known benefits of electricity storage, benefits attributable to GHG reduction are possible, measurable, and can be monetized. This paper also discusses the barriers to the valuation of GHG reduction and possible steps to overcome the barriers.

Reasons for Measuring & Monetizing Carbon Reductions

Several factors drive the need for exploring, quantifying and emphasizing the added benefits of GHG reduction achieved through the use of EES technologies. One key factor is the desirability of adding another measurable, reliable and monetized value to improve the economic viability of electricity storage applications. An emerging technology such as EES needs a broad set of benefits to get past the early adopters. A second compelling factor is the regulatory or legislative pressures in some locations in the United States and elsewhere that have set limits on the GHG emissions. Many assets in the electrical grid system are direct or indirect contributors to GHG, and can use EES technologies to reduce GHG emissions to comply with the new limits on carbon emissions. Augmenting or substituting these assets with EES technologies often bestows system level or site level benefits such as reliability, capital equipment deferral or reducing peak electrical demand etc. Yet many such projects are not implemented because the additional costs of EES technologies inhibit financial viability. Use of the EES technologies in conjunction with some of these assets can improve their economic feasibility when the value of the GHG reduction and other emissions are convincingly factored in the economic calculations.

Several well accepted applications of EES, such as transmission and distribution (T&D) asset deferral or peak shifting, have been well researched for their economic value to the grid. The valuation is based on the cost of deferred assets, ancillary services and/or the differential electrical rates. When EES applications are used for the T&D applications, the EES equipment is owned by an electric utility. Utility's accounting practices allow capital cost recovery over a longer duration, and the capital expenditure is incurred under the annual budgeting process, provided the technology performance is assured. In spite of this accounting advantage, if a utility or an independent transmission services operator were to explore using EES for procuring ancillary services such as voltage support, VAR support or frequency control, it is difficult to economically justify the use of EES when the competing options are inexpensive fossil fuel burning assets. Several of the EES applications would have higher value if the quantifiable benefits of GHG reduction and other emissions are included.

The economic calculus and the methods of financing are quite different when the EES applications are on the industrial or commercial energy user's side of the meter. For this market, the increasing interest in GHG reduction has intensified the need for technologies that reduce or displace standard combustion technologies. Energy storage technologies, both by themselves and in combination with the conventional generation sources, can reduce the GHG emission. The current high cost of EES technologies, juxtaposed with the need for payback periods faster than the utilities, has made it necessary to include the value of GHG reduction achievable through EES application.

Regardless of desirability of accurate measurement and valuation of GHG reduction credits, the effort faces many barriers. Some of them are discussed below.

Barriers to Assessing EES Based Carbon Reduction Credits

Many technical and institutional barriers currently thwart the use of electricity storage for GHG reduction. One technical barrier is the lack of a transparent, standardized and defendable methodology for determining the quantity and benefits of GHG reduction. . At present even the non-GHG benefits of EES applications themselves are poorly understood and the methodology for their evaluation still evolving. Thus the tasks of measurement and valuation of GHG reductions can not proceed till the non-GHG reduction benefits analyses and processes are firmly established The nascent nature of some EES technologies, and the limited time they have spent performing in the field, raises the question about the duration over which the GHG reduction could be realized. On the other hand some advanced technologies such as sodium-sulfur, flow-batteries and flywheels have now had sufficient operating time in the field to dispel lingering doubts on technologies' durability. Yet in the non-utility sector ownership, the potential financiers are likely to use high discount rates in calculating the returns on investment (ROI) thus adversely affecting the economics. Adding the value of GHG reduction could improve the economics.

One of the institutional barriers is the evolving nature of carbon trading market. Although the barrier is not unique to the EES technologies, the infancy of the carbon trading market in many parts of the world has delayed the effective use of EES for GHG reduction. Within the United States the rules for setting allowances and trading in carbon markets are still in a formative stage. Consequently, the full economic benefits of an EES application for GHG reduction will have to wait till the carbon markets are fully developed and functioning properly. Nevertheless, the development and standardization of a methodology for determining the tons of CO2 avoided by using EES can and should still be undertaken in earnest for the reasons discussed below.

A major reason for expediting the development of quantification and valuation methodology for GHG reduction through EES applications is to claim the current and proposed rebates & tax incentives available for technologies that reduce GHG. EES applications have salutary impacts at the electrical grid level and also at the user's site where the EES application might be installed. Currently several states in the United States have set quantitative goals for GHG reductions. Since GHG reductions provide "public goods" by averting global warming, to encourage attainment of goals some government agencies are exploring possible financial incentives for the GHG reduction. Public hearings are often held to identify technologies that might be eligible for such incentives. Those familiar with the EES technologies and their benefits are often absent from such hearings. For example, California recently passed a legislation setting the goals for GHG reduction by the years 2010 and 2020, and various agencies are actively seeking suggestions for GHG reduction technologies for possible rebates & financial incentives. EES could be considered a viable option for GHG reduction if a defendable methodology for establishing reduction in carbon emissions is established.

Since the rebates are based on the contributions to the "public good", they are often set administratively or by some technical proxy and could be available in the near future. In such instances, those contemplating installing EES systems need not await development of a mature carbon market to realize cash value from tangible GHG reduction. Rebates of $250 and higher per kilowatt for electrical load displacement alone are common in California markets. Adding the value of GHG reduction will augment the cash available through such rebates. The GHG reduction rebates, however, should be strictly viewed as a short term opportunity and not as a substitute for a well structured and functioning market for valuation of carbon reduction. Nonetheless, this short window of opportunity is valuable as the rebates could help defray the high first-costs of the emerging EES technologies.

Another institutional barrier to a wider acceptance of EES technologies based GHG reduction is the lack of awareness and acceptance of EES technologies by those who generally finance energy projects – with or without carbon reduction. The same could be said of those who trade in carbon credits. Till both these groups become familiar with EES technologies and their benefits, and accept the methodology for calibrating GHG reduction, using GHG credits for improving the economic of EES applications will be difficult.

Early EES Markets to Benefits from GHG Reduction Credits

A compelling example where the GHG valuation, combined with other benefits of an EES application, could tip the balance in favor of EES installations is distributed generation at an industrial or a commercial site. Under pressures to reduce the load on the electrical grid by curtailing electricity use during the peak demand periods, these customers would prefer to have back-up generation. Currently installed generation assets are for emergency use only. However, several localities in California have restriction on emitting oxides of nitrogen (NOx), and have limited the number of hours a fossil-fuel based back-up generation could be operated. Some EES technologies could substitute for the fossil-fuel based distributed generation to comply with the load curtailment request without exceeding the permitted pollution limits. Since the emerging EES technologies have high costs due to the limited production runs, it hurts their sales in this market. When GHG reduction rebates or tax incentives based on a defendable methodology become available, they could bring down the first costs of installing the EES technologies.

During the 2001 electrical shortages and brownouts in California, about 1500 MW power was supplied by the back-up generators, and yet they provided only 18% of the requested load curtailments. A survey sponsored by the California Energy Commission showed that approximately 4100 back-up systems in California, counting only the system 300 kW and larger in size, can supply up to 3200 MW of power. California has contemplated using the back-up generation as a long-term solution for peak load reduction and load curtailment requests. 87% of the back-up generators use diesel. Collectively these systems emit 59,000 tons of CO_2 & 706 tons of NOx per day. EES can possibly provide the same service and be cost-effective against the mature diesel back-up generation technology if the GHG reduction credits are high enough. Quantification of system-level and site-level GHG reduction will be a major step in capturing this market.

The early markets need not be limited to California or even the United States. The need for the back-up generation is quite acute in places such as India, and the electricity users often rely heavily on diesel based generation. EES applications, combined with the monetized benefits of carbon reduction, may be cost effective. Moreover, well accepted methodology for determining the carbon reduction can facilitate packaging and selling the carbon reductions in a secondary, international market.

In places such as California, besides backup generation, EES assets also can provide an ability to participate in demand-response capabilities where the industrial and commercial electric customers are expected to reduce their electric use during certain times. Such programs have had an uphill battle in gaining acceptance because the options for alternative generation are limited due to restrictions on emissions. Using EES technologies to reduce or eliminate GHG and other emissions, and adding the GHG reduction credits to improve the economics, can increase the number of participants in the program.

Port of Long Beach – EES Use for Carbon Reduction Improves Economics.

An excellent example where the inclusion of emission reduction has markedly improved the economics is a recent application of a flywheel technology at a shipping port in the Los Angeles area. The port has 400 cranes for handling large containers. Several have diesel engines and operate round the clock. The Port Authority is under a severe pressure to reduce pollution and has a goal to reduce it by 50% by year 2012. An EES technology vendor demonstrated the use of a flywheel to capture wasted kinetic energy and reduced the diesel engine emissions. The deployment of flywheel reduced the particulate matters (PM10) by 66%, NOx by 26% and hydrocarbons by 23%. The system can reduce carbon dioxide emissions by almost 600 tons per year. An independent institution at the University of California -Riverside validated the reduction for the California Air Resources Board - an agency responsible for reducing GHG in California. The low fuel cost, however, has made it difficult to justify project based on the energy savings alone, but the requirement to reduce pollution may still prompt the Port Authority to install many more flywheels. In this instance as yet the carbon reduction is **not** a mandatory requirement, only the NOx and particulate matters have to be reduced. Even if the mandatory requirement to reduce other pollutants were not there, the carbon reduction alone, when valued at the current European carbon trading rates of $30 per ton, is sufficient to make the EES application economically attractive. Table (1) below shows the reduction achieved in various pollutants after the installation of the flywheel system on a single crane.

Table (1)

Emission Reduction in Greenhouse Gases & Other Pollutants Cumulative Yearly Reductions Due to Flywheel Installation at the Port of Long Beach (Data From the University of California –Riverside)									
Year >>	2007	2008	2009	2010	2011	2012	2013	2014	2015
Particulate Matter (lbs)	429	858	1,287	1,716	2,145	2,574	3,003	3,432	3,861
NOx (lbs)	8,176	16,352	24,528	32,074	40,880	49,056	57,232	65,408	73,584
THC (lbs)	533	1,066	1,599	2,132	2,665	3,198	3,731	4, 264	4,797
CO (lbs)	2,271	4,542	6,813	9,084	11,355	13,626	15,897	18,168	20,439
CO_2 (tons)	599	1,198	1,797	2,396	2,995	3,594	4,193	4,792	5,391

Table (2) shows the impact on the project economics with and without the use of carbon reduction credits. At the current cost of $150,000 for the flywheel, the installation does not breakeven till the 8th year of installation. Clearly, had pollution requirement not been mandatory, the system would not have been installed. Adding the value of carbon reduction improves the economics substantially. In September 2007, CO_2 was trading for $3.00 /ton in the US markets and $30.00 per ton in the European markets. When the system is credited with the cost of $3.00 per ton per year, the 600 per ton of carbon dioxide reduced can bring additional $1800 per year besides the fuel savings. Addition of carbon credit improves the economics but not by much. But if the same carbon reduction is traded at $30 per ton, the payback is reduced to 3.5 years, a pay-back period commonly acceptable to many businesses.

Table (2)

Economics of Installing a Flywheel for Energy Recovery with and Without Carbon Reduction Credits

Flywheel System Cost >>> $150,000									
Year >>	2007	2008	2009	2010	2011	2012	2013	2014	2015
Fuel Savings	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000
Net Cost without GHG Credits	$130,000	$110,000	$90,000	$70,000	$50,000	$30,000	$10,000	($10,000)	($30,000)
Net Cost with $3/ton /yr CO_2 credit	$128,200	$106,400	$84,600	$62,800	$41,000	$19,200	($2,600)	($24,400)	($46,200)
Net Cost with $30/ton/yr CO_2 credit	$112,000	$74,000	$36,000	($2,000)	($40,000)	($78,000)	($116,000)	($154,000)	($192,000)

Possible Action Items for the EES Industry

In the near future the EES industry should focus on developing methodology for assessing GHG reductions. Adopting a commonly acceptable Clean Development Mechanism (CDM) such as the Swiss Gold Standard that has well defined criteria for qualifying carbon reduction should be used. The Gold Standard is commonly used for qualifying renewable energy and energy efficiency projects, and is acceptable to the companies that trade in the carbon credits. In developing and validating a methodology, it is important to actively engage those who provide financing through public sector rebates or from capital markets. Equally important is an active presence at the forums where the eligibility criteria for rebates for carbon reduction technologies are being discussed and determined. This includes venues such as the US Congress as well as the states such as California. The early demonstrations of some EES technologies, in addition to instrumentation for technology performance, should also include instrumentation for assessing the GHG reductions. Given the potential for EES applications throughout the electrical grid system, such efforts would yield rich dividends for the EES industry and its supporters.

References

1. Air Quality Implications of Backup Generators in California
   Volume II: Emission Measurements from Controlled and Uncontrolled Backup Generators. Report # CEC-500-2005-049 July 2005.
   Published by the Public Interest Energy Research Program, California Energy Commission

2. Air Quality Impacts of Distributed Generation: PIER Final Project Report
   CEC-500-2005-069-F, October 2005
   Published by the Public Interest Energy Research Program, California Energy Commission

3. Flywheel Takes Off in Ports: Cerritos-based Company Sells Fuel-saving Device to Port Crane Operators. By Kristopher Hanson, Los Angeles Times, November 11, 2006