AIC

EMISSION REDUCTION MEASURE FORM

TITLE: Advanced Flow Battery

TYPE OF MEASURE: Monetary Incentive

RESPONSIBLE AGENCIES: California Energy Commission and/or California Air Resources Board

SECTOR: Electricity Generation

2020 BASELINE EMISSIONS ASSUMED: 492 mm mt CO_2 (2004 estimate)

PERCENT REDUCTION IN 2020: 1.13% (6.24 mm mt/yr CO_2)

COST EFFECTIVENESS IN 2020: (–)$124/metric ton CO_2

DESCRIPTION

Approach: Energy-Efficient Power On-Demand Through Advanced Flow Batteries

The concept is to reduce greenhouse gases by aligning energy collection with energy consumption through the use of high-capacity electrical storage batteries. These batteries, based on advanced flow battery technology, can house electricity generated by both conventional and renewable energy sources and then deliver that electricity directly to the power grid during peak usage periods. In other words, these batteries will offer energy-efficient power on demand. Compared to conventional batteries, advanced flow batteries are also more cost effective and technically more efficient.

Peaking power plants, for instance, are typically simple cycle combustion turbines, as it is both costly and ineffective to cycle base-load thermal and nuclear power plants to meet peak demands. Also, renewable energy sources cannot be relied on 24/7, since the sun doesn't shine at night, tides turn, and winds fluctuate. However, advanced batteries can capture energy from these renewable sources for later use and substantially reduce the need for peaking turbines.

Emission reduction would occur because of the higher efficiency of base-load generators (assumed to be combined cycle combustion turbines) compared to peakers. Aside from the decrease in greenhouse gas emissions, advanced batteries could provide a much-needed economic incentive for non-thermal generators from renewable sources. Because the energy collected by the batteries can be sold back into the system at or near peak periods, they can become much more profitable enterprises. An enhanced rate of return should provide additional incentive to build and operate these plants and, thus, further reduce fuel use and CO_2 emissions.

How A Battery Technology Works

A flow battery stores its electrolyte outside the electrolyzer in tanks of fluid. During the charging process, the electrolyte is pumped through the electrolyzer, where it is charged and then pumped on into the tanks where it is stored. During the discharge process (releasing the energy), the electrolyte is pumped back through the electrolyzer where it can be re-charged. The name "flow battery" derives from the flow of electrolyte through the electrolyzer(s). Because a flow battery relies on reusable electrolytes, the system has an exceptionally long life span.

This advanced flow battery can economically store multi-MWs of power with environmentally friendly materials and fault-tolerant chemistry. The rate of charge or discharge (MW) sets the size of the electrolyzer, while the energy stored (MWH) determines the amount of electrolyte, providing a high degree of flexibility in setting the design to meet grid needs.

EMISSION REDUCTION CALCULATIONS AND ASSUMPTIONS

ASSUMPTIONS:

2004 Power consumption: 293,000 gwh
2020 Power consumption: 330,000 gwh
2004 CO_2 emissions: 492 mm mt/yr
2020 Peak power demand ~ 10% = 33,000 gwh
Peaking turbine heat rate: 10,000 btu/kwh
Base load heat rate: 6,500 btu/kwh
Natural gas heat content: 1025 btu/cf

CALCULATIONS:

Heat rate savings: 10,000 – 6,500 = 3,500 btu/kwh
Fuel savings: 3,500 btu/kwh x 33,000 gwh = 115 mm mm btu/yr
@1025 btu/cf = 112.5 mmcf/yr
@359 cf/lb mol = 312.5 mm lb mol/yr CH_4 /CO_2
= 6.875 mm st/yr CO_2
=6.24 mm mt/yr CO_2
2020 CO_2 emissions: 492 x 330,000/293,000 = 554 mm mt/yr
2020 savings: 6.24/554 x 100 = 1.13%

COST EFFECTIVENESS CALCULATIONS AND ASSUMPTIONS

ASSUMPTIONS: Capital cost peaking facility equal to capital cost of advanced flow battery.

CALCULATIONS: If capital cost for the two systems are equal, operating cost savings for the battery are fuel cost savings.

115 mm mmbtu/yr @ $7.00/mmbtu = $805 mm
805/6.2 = $124/mm mt CO_2 savings

An additional unquantified cost savings by the implementation of advanced battery storage technology is deferral of new transmission line construction. Because battery storage facilities can be built at major load centers, the power for peak, and even some intermediate load, can be transmitted off hours when line capacity is readily available.

IMPLEMENTATION BARRIERS AND WAYS TO OVERCOME THEM

The primary barrier to widespread and timely introduction of advanced flow battery technologies is perception of risk. It is true that this technology is still in the development stage, but it is proceeding rapidly, with a 1MW demonstration facility projected to be operational in Scotland in the near term. To gain full acceptance by California electricity generators, both public and private, an additional demonstration facility should be constructed, tied in to the California grid and operated by utility operators. This would demonstrate not only the technical performance of the technology, but also its operability, maintainability, and cost performance under California utility operating conditions.

Under typical circumstances, the tendency would be to wait for the Scottish-based unit to operate for six months to a year and then consider a local unit, wait for that to by fully operational, and then perhaps consider a full-scale plant. Under this scenario, the 2020 time frame for substantive greenhouse gas emissions would be unlikely met.

The State of California can shortcut the process by co-funding a demonstration plant. An important criterion is that a California electric utility generator be, at least, a major part of the project. In addition, the State should include flow batteries as part of all future planning and provide assistance in minimizing the permitting time for such facilities.

The State's financial involvement should be limited to jump starting the process in order to accelerate deployment of the technology. Once the perception of risk has been eliminated, the technology should be rapidly deployed without the need for subsidies or tax concessions because it is economically attractive.

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