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Companies Reconnect Edison's Dream of Direct Current Transmission

By PETER BEHR and CLIMATEWIRE

A billion-dollar transmission line is being planned to deliver hydroelectric power from Canada to New England. A rival project would bring wind power from Maine via submarine cable to Boston. Both would carry power that doesn't produce greenhouse gases.

Both would move power via direct current, which was Thomas Edison's obsession. "We're set up for direct current in America," he predicted in 1884. "People like it, and it's all I'll fool with." But the nation's electric system was built on a rival technology -- alternating current. Edison's vision became a forgotten stepchild of the effort to electrify the United States.

But now direct current (DC) is making a bit of a comeback, thanks to the expansion of wind and solar power. "I think there are a bunch of places where DC makes sense," said Edward Krapels, CEO of Anbaric Holdings LLC, parent of the company that strung a direct current line between New Jersey and Jones Beach, Long Island.

Steve Holliday, CEOs of National Grid, said that DC will become the choice for delivering power from large offshore wind farms. "Anything beyond 6 or 7 miles will be DC," he said.

Anbaric's new project is the DC line that would connect wind power in Maine to downtown Boston, with DC lines that would also go under water. It is also planning another line from New Jersey to midtown Manhattan.

Its formidable competitor in New England is the proposed Hydro-Québec line that would run 175 miles from Quebec into central New Hampshire, delivering 1,200 megawatts of power. The singular properties of direct current transmission make it ideal for this project, said Jim Robb, senior vice president for planning and development at Northeast Utilities in Berlin, Conn.

A 'long extension cord' to cool New England

Hydro-Québec, the Montreal-based utility, has power to spare in summers, when New England needs it to meet peak demand driven by air conditioning. The DC line would start in its system and deliver power to New England over a closed cable that would bypass the alternating current (AC) grid en route. It assures Hydro-Québec that its power will go through whether or not the AC grid is congested, and it knows the transmission costs will be fixed in advance by contract, Robb explained.

"For Hydro-Québec, it's like having a long extension cord," Robb said. Northeast Utilities and NSTAR, the Boston-based power company that is its partner in the project, would build and pay for the line. Hydro-Québec would pay the companies for its use, based on the construction costs and a return. The Canadian company will sell the power competitively to utilities via long-term contracts, Robb said. "The market risk is borne by Hydro-Québec," he added. The project would provide a certain outlet for its power as it proceeds with a major expansion of hydropower facilities in its region.

The Federal Energy Regulatory Commission has approved the project's pricing approach. State regulators have not approved either the Quebec line or the proposed Maine-to-Boston underwater line.

"There are three advantages to direct current," Krapels said. "The line losses [of electric power in transit] are very small, particularly in a point-to-point situation. It's controllable and that adds a lot of benefits if you're injecting power into a particular market." DC lines can be built with somewhat shorter towers, and they do not raise the concerns about risks from electromagnetic radiation that occur with AC transmission lines, he added.

DC's drawback is cost. When a DC line connects into the AC grid, conversion stations must be built to switch the power to DC and then back again at the other end. The stations cost $50 million or more, Krapels said.

If the line is long enough, then the advantages of DC transmission become significant, said Rich Logan, technology director for power systems at the Electric Power Research Institute in Palo Alto, Calif. "There is a break-even point, and people argue about where that is. It's in the ballpark of 100 miles."

Tesla short-circuits Edison's plan

Distance, however, is what doomed Edison's foray into direct current transmission.

Direct current, the kind that batteries deliver, is a stream of energy that flows in only one direction. Alternating current is far more complex and harder to control, Logan notes. As an electromagnetic armature of an AC generator spins, its poles rotate within a wire-wrapped collar, alternately pushing and pulling on electrons in wires that lead from the generator toward the grid. There are many more variables that must be precisely controlled to deliver AC power reliability than is the case with DC.

The self-taught Edison was a superb experimenter, but didn't have a technical understanding of AC current at the time, said Robert Schainker, senior technology executive at EPRI.

Nikola Tesla did. The brilliant, eccentric Serbian engineer who worked for Edison at one point conceived that the push-pull forces of AC could be used to deliver power over a grid and to drive machinery efficiently at the other end. According to Tesla, the eureka moment came to him as he watched a sunset, Schainker said.

The key was to connect several wires to the generator so that at every rotation, pushing energy would be constantly transmitted, akin to a bicycle with two pedals. (AC high-voltage transmission employs three lines, suggesting a bicycle with three pedals for a three-legged cyclist.)

The properties of AC current allow the voltage to be stepped up dramatically higher by transformers, and the higher the voltage, the less electric power is lost in transmission. Edison's DC systems, launched in 1882, lacked the means to do that and so were limited by the size of the copper wire that carried the current. That forced him into a strategy of many small generators serving sections of cities. "Edison had to build a plant for every five blocks," said Schainker.

DC's comeback aided by solid state electronics

When Edison reneged on what Tesla thought was a financial commitment to him, Tesla took his AC insights to George Westinghouse, a successful manufacturer of air brakes. Westinghouse grasped the potential of Tesla's system for delivering electricity from large plants over longer distances.

Edison sought to stigmatize AC as a lethal technology, going so far as to promote electrocution for capital murder cases -- using alternating current. Edison wanted to have that form of execution called being "Westinghoused," Schainker said, but failed.

And so did direct current as a power source for homes and businesses. By the early 1900s, AC dominated the scene, opening the way to ever larger generators, longer transmission lines and the monopolization of much of the industry.

Transistors and other solid state electronics put DC back in the picture, Logan said. Today, banks of electronic switches are used to step up direct current for transmission, then bring it down at the end of the line.

With that issue solved, DC's advantages versus AC become important in certain applications. Pepco Holdings Inc. in Washington, D.C., chose direct current for a major part of a proposed line that would run from northern Virginia under the Chesapeake Bay and into the Delmarva Peninsula. The properties of alternating current running within underground conduits create electromagnetic problems that aren't present when DC is used, said Vince Maione, manager of Pepco's MAPP powerline project.

The lower part of the Delmarva peninsula is a kind of cul-de-sac for electricity flow. Adding a new AC line into the area might not alleviate power shortages in the rural southern area, Maione said, because of the difficulty in controlling where the more willful AC current flows. Once the line was connected to the existing grid, the greater demand for power to the north could shift flows in that direction, leaving the southern part still short of power.

Using DC permits Pepco to channel power precisely to the point in the AC grid where it is most needed. "We can direct and control the amount of current without concern to whether it might flow north," he said.

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