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Extending Locational Marginal Cost Pricing to Retail Electricity Markets and Distributed Energy Resources

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It may be time for a paradigm shift in our approach to electricity pricing, Boston University professor Michael Caramanis suggested in his presentation to the energy policy seminar on Monday. Today's power markets are tailored to manage large generators transmitting power out to distribution hubs—a low-resolution, large-scale picture which has permitted pricing schemes to largely ignore nuances such as the value of reactive power (power that affects the flow and reliability of electricity, but which does not directly serve the customer). As more utility-scale renewables enter the market, along with more distributed energy resources--both distributed generation and enhanced forms of flexible consumption, such as EV battery charging, responsive HVAC systems, etc.--there may be significant value in looking more closely at the 35%-40% of electricity system costs that are attributed to the distribution sector, Caramanis suggested.

This potential value is the product of many different power sector changes that are currently taking place. At the wholesale level, the large-scale stability of the system is decreasing as the sheer physical inertia previously provided by huge natural gas or coal-powered turbine generators is diluted by increasing penetration of wind and solar resources—with the result that a stable system requires greater reserves than it once did. At the distribution level, the growth of Distributed Energy Resources provides a potential source of these needed reserves, at the same time as the increased complexity of traffic on the distribution networks creates its own demand for additional reactive power and voltage control at the distribution level.

Current pricing schemes are not set up to optimize the value provided by distribution level real power, reactive power, and reserves. But improved pricing is possible, Caramanis argued, outlining the potential for an interactive, iterative system for developing locational marginal cost prices for energy at the distribution level. Tackled at the level of the whole grid system, given the multitude of distribution nodes, such a problem would be "intractable." But, Caramanis argued, there is no reason the problem cannot be broken up and handled separately at each individual distribution node, bringing the complexity down to a manageable level.

In the world envisaged by Caramanis, individual Distributed Energy Resources (for example, a rooftop solar system, an HVAC system capable of tailoring usage to respond to prices, or a smart electric vehicle charger) would communicate iteratively at the distribution node level to reach an optimal marginal cost price for the provision of resources that could include not only "real" power, but also reactive power and reserves—leveraging capabilities in many cases already installed, but currently underutilized. For example, Caramanis explained, residential solar systems often include inverters capable of providing reactive power on demand twenty-four hours a day—a potential source of income for solar that does not depend on the sun shining.

This theory has been tested in a distribution feeder system in upstate New York. Caramanis presented the results of the test, which showed significant potential value in this kind of dynamic distribution-level pricing.

Caramanis spoke as part of the Kennedy School's Energy Policy Seminar Series, which is jointly sponsored by the Energy Technology Innovation Policy research group of the Belfer Center and by the Consortium for Energy Policy Research of the Mossavar-Rahmani Center on Business and Government.