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A future auction mechanism for distributed generation

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The electricity network of the future will likely be subject to increasing 'new' energy sources, more significant small-scale (renewables) suppliers and increased consumer participation. At the moment we can envisage that these will be some combination of customer owned PV panels, small-scale distributed electrical energy storage (EES) facilities and responsive demand – smart electricity consuming devices - capable of being turned up and down by artificial intelligence in near real time. Additional small-scale distributed supply and demand might come from electric vehicles (EV) and heat and cooling systems (heat pumps) with smart energy storage capability. The growth and exact grid location of PV, EES, smart demand, EVs and controllable heating and cooling and their degree of allowed controllability is highly uncertain, because it involves several variables including consumer acceptance, technological developments and their interaction with progress in large-scale energy technologies.

One of the most important challenges of the future is a more sophisticated bidding environment, where small-scale consumers/producers will be market players through smart technology. Currently, electricity consumers can only ask for instant supply of electricity at one price and consumers face very unsophisticated contracts with prices not varying by location, time of day or power quality. The true price can vary during the day, and is expected to vary more in the future, but consumers are not given the flexibility and opportunity to subscribe different levels of response time of electricity at a given price.

We present a VCG mechanism that makes the electricity network ready for our vision of the future. The VCG is based on social welfare, which is missing in the designs used today. Specifically, the VCG yields efficiency and can be applied to the electricity market, where potential surpluses (negative or positive) are reallocated to elsewhere in the system. It can contribute positively to a social optimum.

We are in an environment of small-scale suppliers, but there may be areas with less competition, because of congestion, where suppliers enjoy a potentially higher uniform-price, for example, the preferred design in today's electricity markets. In our design, each supplier will have individual prices. Also, unlimited (relative to today) computer power gives us the opportunity to work with package bidding, because it eliminates today's computational problems.

We suggest that future auctions should have a number of key features. They should use a VCG mechanism, they should allow package bidding for multiple products and they should make use of proxy agents to encourage mass participation of individually small players.

Our examples illustrate the mechanism in action. We imagine prices that vary in time, location and power quality with a trading period. Our illustration shows the price resolution with two products and two zones. It is built up around heterogeneous goods allowing for different electricity subscriptions (Gold and Silver), package bidding and a proxy agent. The proxy agent will ensure optimal bidding strategies from non-professional bidders. Real electricity markets will require a wider range of products to be defined, the careful specification of the units of quantity and the definition of the time periods and number of zones for which price resolution is possible. Hence we suggest the use of package bidding. However, the basic principles of good auction design, which we illustrate, still apply.

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