8/15/22

Dear Commission,

I would to offer the following comments in support of Proceeding R2207005, "Order Instituting Rulemaking to Advance Demand Flexibility Through Electric Rates."

Executive Summary

I am a Ph.D. student in Electrical Engineering at UC Berkeley. My research, focused on distribution network optimization and electricity pricing, has led me to the conclusion that real-time electricity pricing is the correct way to engage customer flexibility and provide customers with cheaper, more equitable electricity service. I am therefore pleased to see Proceeding R2207005 from the California Public Utility Commission (CPUC), and I would like to offer my full support for the proposed "CalFUSE roadmap" in the CPUC Energy Division's Demand Flexibility Whitepaper.

The CalFUSE roadmap is a forward-looking approach and will create growth in California's electricity sector. Growth in this sector will be necessary to meet California's greenhouse gas emission goals. Currently, the growth of the electricity sector is being impeded by the static rates that Utility Distribution Companies (UDCs) and other Load Serving Entities (LSEs) charge their customers (see the "Replacing Demand Charges" comment below). The CalFUSE roadmap outlines sequential steps that UDCs and LSEs can take to offer their customers real-time electricity rates that will benefit the entire electricity sector.

The CalFUSE roadmap's call for real-time electricity rates to spur electrification in California is prescient. Real-time electricity rates, however, only address electricity consumption/production inefficiencies for consumers/producers who are *already* connected to the electric grid. Offering flexible interconnection agreements for certain subsectors — e.g., DC fast-charging stations and medium-to-large renewable energy plants — will benefit electricity consumers, electricity producers, and UDCs/LSEs by enabling *new* grid connections. The "Flexible Interconnections for Certain Subsectors" comment below provides more detail as to why real-time electricity rates should be accompanied by flexible interconnections for certain subsectors.

The time is now for real-time electricity rates and flexible interconnections. Emerging technologies have matured to the point where real-time electricity rates and flexible interconnections are both necessary and practical. The technologies that make real-time electricity rates and flexible interconnections necessary include electric vehicles and electric home heating/cooling, which are posed to double electricity consumption in California. The also include intermittent renewable electric generation, such as through solar and wind power. The technologies that make real-time electricity rates and flexible interconnections practical include home energy-management products and Internet and cloud computation infrastructure, which will make the determination and dissemination of the real-time prices and power limits practical at scale.

Regarding the technical aspects of implementing real-time electricity rates and flexible interconnections, I would like to make the point that there is active research in this field. Research resources are available today that may be tapped to sort out the technical challenges that will arise with the implementation of real-time electricity rates and flexible interconnections.

The rest of this comment discusses

1. the case for flexible interconnections for certain subsectors,
2. the case for replacing demand charges with scarcity pricing for capacity cost recovery,
3. the technical details of implementing delivery scarcity pricing.

I am submitting these comments because my Ph.D. research has focused on the best way to implement distribution-scarcity pricing and flexible interconnections. And while I would like to address certain of the technical details involved in this comment, I would also like to reiterate that the broader goals of implementing real-time pricing and flexible interconnections are what is truly important and timely. The implementation specifics, which I focus on in comment 3, can be determined at a later date in the implementation process.

Comment 1: Flexible Interconnections for Certain Subsectors

Real-time electricity rates only address electricity consumption/production inefficiencies for consumers/producers that are *already* connected to the electric grid. In addition to real-time electricity rates, offering flexible interconnection agreements to certain subsectors (e.g., those for DC fast-charging stations and medium-to-large renewable energy generation) will benefit electricity consumers, electricity producers, and UDCs/LSEs by enabling *new* grid connections.

In the coming years, it will be necessary to build a significant amount of new infrastructure to support the electrification of the transportation sector. For example, California will need to build many DC fast-charging stations, which pull orders of magnitude more electricity from the grid than standard Level 1 and Level 2 charging stations. The current Interconnection Capacity Analysis (ICA) process for siting new charging stations, however, actually impedes electrification because it rejects new charging station sites that need not be rejected.

The reason is that the current ICA process only allows new connections to the grid if it can be demonstrated that there is no possibility it will overload the grid infrastructure. Thus, the current ICA process is based on the premise that any load on the network should be allowed to extract as much power as it can at any moment in time. Operating a grid according to this max-power-at-any-time premise leads to overbuilt grid infrastructure because the aggregate max load (generation) on the system occurs at very few moments in the year, and even these could be avoided with active demand-management strategies.

While it may be appropriate for many types of electricity customers, such as residential or standard commercial customers, the max-power-at-any-time premise is inappropriate for electricity subsectors that either 1) use (or produce) a lot of electricity, or 2) are flexible in terms of when they can consume (or produce) that electricity. DC fast-charging stations are an example of an electricity subsector that matches both criteria (1) and (2) — as are medium-to-large intermittent renewable generation plants.

Flexible interconnection is an alternative to max-power-at-any-time interconnection. Flexible interconnection allows a utility to reduce the amount of power that a consumer can take from (or a producer can send to) the grid, and so avoid grid-constraint violations. The flexible interconnection can be based on either real-time grid measurements or fixed time-of-use criteria.

Flexible interconnection has grassroots support in the research community and has been implemented in industry. Smarter Grid Solutions, for example, released a flexible interconnection product in 2010 that enabled the U.K. grid to connect more wind power without requiring expensive infrastructure upgrades.

In addition to introducing new electricity rates, the CalFUSE roadmap should include a requirement that UDCs support flexible interconnections for both the DC fast-charging station and the medium-to-large renewable energy plant subsectors. Incorporating flexible interconnections for these sectors will increase electrification, reduce carbon emissions, use grid infrastructure more efficiently, and provide cheaper electricity service to customers.

Comment 2: Replacing Demand Charges

Demand charges have distorted the electricity market, prevented electrification, and encouraged customers to pursue inefficient consumption patterns. Thus, demand charges result in unnecessary costs for electricity consumers and unnecessary greenhouse gas emissions. Replacing demand charges with scarcity pricing for capacity cost recovery, as proposed in CalFUSE, will provide significant value to customers by allowing them to save money by aligning their consumption patterns to grid infrastructure constraints.

Demand charges are per-kW (power-based, rather than energy-based) rates that are intended to be a proxy for the infrastructure investment incurred by a grid-connected load or generator.

Unfortunately, demand charges are a poor proxy for infrastructure investment and severely impede the construction of new electric resources such as electric vehicle charging stations.

Regarding cost causation, demand charges are correlated with the capacity/maximum power flow of “local” grid infrastructure. However, individual peak energy use is *not* well-correlated with the peak energy use for nonlocal grid infrastructure. That is, the further you get from the customer, the less likely it will be that the customer’s peak power consumption will coincide with the peak power flowing through a given grid component. Most of the grid infrastructure falls into this “nonlocal” category.

Consider the example of an electric vehicle DC fast-charging station whose peak energy use occurs at noon. While the power flowing through the charging station’s service drop will peak at noon, if the charging station is in an area with a lot of solar power generation, the charging station’s power use might actually *reduce* the amount of power flowing through the main power lines or substation transformer at that time. Thus, the *time* of customer power consumption is critical and should be considered when determining the best way to recover capacity costs.

The CalFUSE roadmap proposes replacing demand charges with scarcity pricing for capacity cost recovery. This switch will create significant value for the entire electricity sector, including electricity customers, generators, UDCs, and LSEs. By allowing (a subset of) electricity customers to respond to real-time prices, the (subset of) customers may align their consumption with both the real-time generation cost and the grid infrastructure. This will help avoid unnecessary infrastructure replacement, and it will result in cheaper electricity prices for everyone. Cheaper prices will, in turn, lead to the growth of the electricity sector in California.

Comment 3: Implementing Delivery Scarcity Pricing

It will be important to implement scarcity pricing for capacity cost recovery in the correct manner. The CalFUSE roadmap splits the scarcity price framework up into delivery scarcity price, capacity scarcity price, and ramp scarcity price. The delivery scarcity price is focused on recovering the fixed costs that were used to build the distribution network infrastructure (the power lines, transformers, and other pieces of grid equipment). The following comments are focused on the specifics of implementing delivery scarcity pricing for distribution network capacity cost recovery.

Comment 3a: On Delivery Scarcity Pricing — the Pricing Mechanism

The mechanism that determines the delivery scarcity price must be transparent and fair. The best way to create transparency and fairness is with an algorithm. The algorithm's rules and settings can be publicly published and adjusted to meet the needs of society for equity, optimality, and other important concerns. Note, it is the algorithm's *rules and settings* that are adjusted by policy-makers, not the prices themselves.

Pages 58-60 of the CalFUSE whitepaper outline a method for determining scarcity prices using a quadratic function with hand-picked parameters. While simple, this quadratic-function-with-hand-picked-parameter method has several downsides. One is that the process for choosing the parameters could be corrupted and might become a topic of dispute among stakeholders. A second is that the hand-picked parameters cannot be adjusted in real time to match grid conditions as they evolve.

Lagrangian-based optimization is an alternative method for determining the delivery scarcity price. Lagrangian-based optimization is used ubiquitously in optimization. For example, the Locational Marginal Prices (LMPs) for the California Independent System Operator (CAISO) transmission network are calculated using Lagrangian-based optimization. A Lagrangian-based optimization algorithm would be a better way to determine the delivery scarcity prices than a quadratic-function-with-hand-picked-parameter method because Lagrangian-based optimization automatically adjusts the prices, rather than requiring an exogenous entity to hand-pick parameters.

Comment 3b: On Delivery Scarcity Pricing — Capacity Utilization vs. Constraint-Based Pricing

The delivery scarcity pricing method proposed on pages 58-60 of the CalFUSE whitepaper implements a rate-adder based on capacity utilization. A rate-adder based on capacity utilization would work well when individual customer electricity consumption can be mapped directly to the capacity utilization for an existing piece of grid infrastructure. For example, individual customer energy use can be easily mapped to substation transformer capacity utilization on a radial network that is served by that single substation transformer. Such a scenario corresponds to the example given in the CalFUSE whitepaper.

However, a rate-adder based on capacity utilization would not be easy to implement when there is not a clear mapping from individual customer energy use to capacity utilization. For example, if a feeder is served by multiple substation transformers in different locations, it would be more difficult to map individual customer energy use to substation transformer capacity utilization for each transformer.

Another example is related to voltage constraint violations. The voltage on the grid must be kept between minimum and maximum values, according to grid codes. While voltage violations cannot be mapped to capacity utilization of specific, existing infrastructure, voltage violations also demonstrate delivery resource scarcity. If delivery scarcity pricing is implemented based on (proximity to) *constraint violations*, rather than the capacity utilization of existing infrastructure, then the delivery scarcity pricing will apply to all types of delivery resource scarcity.

Lagrangian-based optimization, as proposed in Comment 1a, supports constraint-based pricing. Implementing delivery scarcity pricing with Lagrangian-based optimization will produce a system that automatically adjusts prices based on (proximity to) constraint violations, applies to all types of delivery resource scarcity, and does not require hand-picked parameters.

Conclusion

While I have pointed out improvements that could be made to the CalFUSE roadmap, I fully support the CalFUSE roadmap and Proceeding R2207005. I would welcome the opportunity to participate in a working group.

Regards,

Keith Moffat

Ph.D. Candidate
Electrical Engineering and Computer Science Department
UC Berkeley
email: keithm@berkeley.edu
web: keithmoffat.com