Track 3.B.2 Forward Energy Workshop

January 8, 2021

9 a.m. – 12:30 p.m.

California Public Utilities Commission

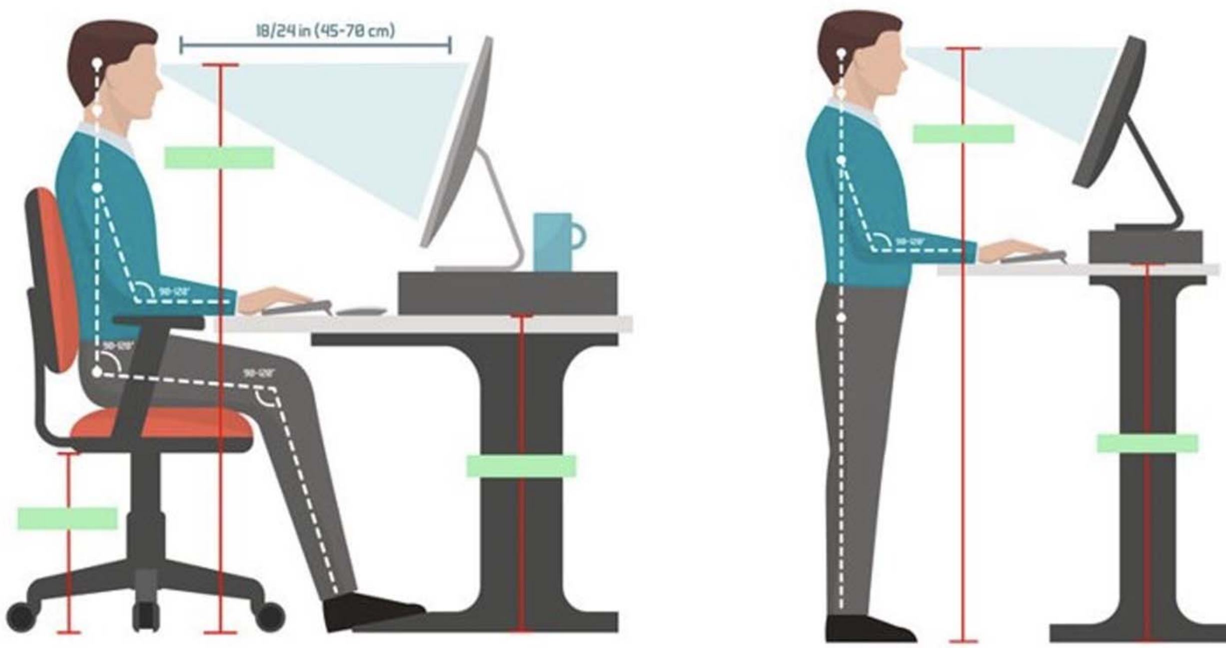
Logistics

- Online and will be recorded

- Today's presentation & recording will be uploaded onto RA history website
    - https://www.cpuc.ca.gov/General.aspx?id=6316

- Hosts (Energy Division Staff)
    - Jaime Rose Gannon
    - Linnan Cao

- Safety
    - Note surroundings and emergency exits
    - Ergonomic check



Logistics

- All attendees have been muted
- Presenters for each topic will be identified as panelists only when their topic is being addressed
- To ask questions, please use the "Q&A" function (send "To All Panelists") or raise your hand
- Questions will be read aloud by staff; attendees may be unmuted to respond to the answer. (Reminder: Mute back!)

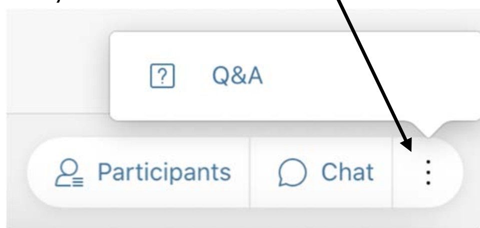
Mute/ Unmute

Participant List

Chat

Audio Options

"Q&A": on the bottom right of screen, click "3 dots"



Ground Rules

- Workshop is structured to stimulate an honest dialogue and engage different perspectives.
- Keep comments friendly and respectful.
- Please use Q&A feature only for questions, or technical issues.
- Do NOT start or respond to sidebar conversations in the Chat.

Agenda

Time	Topics	Presenters/Time Duration
9:00-9:10 a.m.	Introduction	CPUC, 10 min.
9:10-10:10	Presentation on forward energy contracting framework	Frank Wolak, 60 min.
10:10-10:30	Academic panelists initial response and discussion	James Bushnell, 10 min. Shaun McRae, 10 min.
10:30-10:45	Stretch/Coffee Break (15 minutes)	
10:45-11:55	Party panelists response and discussion (including academic panel)	Nick Pappas, CalCCA Peter Griffes, PG&E Matthew Barmack, Calpine Eric Little, SCE
11:55-12:25 p.m.	Q&A from attendees	All, 30 min.
12:25- 12:30	Next steps	CPUC, 5 min.

Track 3B.2 - December 11, 2020 revised Scoping Memo

- Divides Track 3B into two sub-tracks 3B.1 and 3B.2
- The scope of Track 3B.2 includes the following issues:

1. Examination of the broader RA capacity structure to address energy attributes and hourly capacity requirements, given the increasing penetration of use limited resources, greater reliance on preferred resources, rolling off of a significant amount of long-term tolling contracts held by utilities, and material increases in energy and capacity prices experienced in California over the past years.
   a) Specifically, address the direction the Commission intends to move in with respect to larger structural changes (e.g., capacity construct addressing energy attributes and reliance on resource use-limitations forward energy requirement construct). Set forth the necessary milestones and additional details that must be determined in order to implement the adopted direction for a compliance year no earlier than 2023.

Goals of Todays Workshop

- Provide parties and decision makers with a better understanding of a forward energy reliability construct with a focus on the revised Staff proposal titled “Long-Term Resource Adequacy in an Intermittent Renewable and Import Dependent Future in California”
- Receive feedback from academic and party panels
- Provide parties an opportunity to ask questions to help in understanding the proposal

Problem Statement/Drivers Recap

- ❖Reduced reserve margins (on a net qualifying capacity basis)
- ❖Decline in forward contracting (e.g., through multi-year tolling agreements) creating the opportunity for the exercise of system and local market power, particularly in the energy and resource adequacy (RA) markets;
- ❖The fact that "peak capacity" is a regulatory construct, which does not ensure electrons will flow (or the curtailment of demand will occur). Consequently, this construct can be speculative in nature and potentially unreliable;
- ❖Growing reliance on use limited resources (e.g., renewables, hydroelectric, pumped storage, batteries and other storage devices, demand response, etc.), makes it challenging to design a reliable hourly capacity construct;
- ❖Growth in retail choice and the relationship with the provider of last resort makes it difficult to plan for reliability. This load uncertainty prevents entities from entering long-term contracts with new or existing resources; and
- ❖Retirement of other assets throughout the West reduces imports that can be reliably counted on to serve California load during peak demand periods

Presentation

9:10 - 10:10 a.m.

Frank A. Wolak, Director, Program on Energy and Sustainable Development, Department of Economics, Stanford University

PESD STANFORD | PROGRAM ON ENERGY AND SUSTAINABLE DEVELOPMENT

Long-Term Resource Adequacy in an Intermittent Renewable and Import Dependent Future in California

Frank A. Wolak

Director, Program on Energy and Sustainable Development

Professor, Department of Economics

Stanford University

January 8, 2021

CPUC RA Workshop

California's Future Electricity Industry

California has ambitious renewable energy and climate goals

- Renewable energy share of 60 percent by 2030 most likely to met from intermittent solar and wind resources
- Reduce greenhouse gas (GHG) emissions to 40 percent below 1990 levels by 2030

California obtains between 25 and 30 percent of its annual electricity consumption from imports

- Imports to California occur because more energy is produced outside of state than is consumed outside of state in Western Interconnection (and the opposite is true for California)

California's long-term resource adequacy mechanism must recognize and account for these factors

- Least cost long-term resource adequacy mechanism for California depends on its resource mix

California's Future Electricity Industry

Large intermittent renewables share will require

- Investments in both grid-scale and distributed storage
- Active demand-side participation by customers with interval meters using dynamic retail electricity prices
- Automated distribution network monitoring and on-site load-shifting technologies

Long-term resource adequacy mechanism should support business models that lead to efficient levels of investment in these technologies

Policy Question: What long-term resource adequacy mechanism will facilitate a least-cost transition to a future electricity supply industry in California with these pricing policies and technologies?

California's Future Electricity Industry

Capacity-based mechanism--Increasingly expensive approach to long-term resource adequacy, particularly in import dependent regions with a large share of intermittent renewable resources

- Defining firm capacity of intermittent renewables is difficult, if not impossible, as California is learning
- Defining firm capacity of imports is typically not possible because how they are provided
- Limits economic benefits from dynamic pricing and storage and load flexibility investments

Conclusion: Standardized long-term energy contracts provide a lower cost approach to long-term resource adequacy for future electricity supply industry in California

- Supports storage investments and investments in flexibility technologies on supply and demand side of market

What is the Problem?

All Wholesale Markets with a Finite Offer Cap Require a Long-Term Resource Adequacy Mechanism (LT-RA)

(Energy-Only Market versus Capacity Market is a False Dichotomy)

Need for LT-RA Mechanism

In former vertically-integrated geographic monopoly regime, utility is responsible for ensuring that demand is met under all possible future system conditions

- Regulator penalizes monopoly for supply shortfalls

In wholesale market regime no single entity is responsible for ensuring system demand is met under all possible system conditions

- Independent System Operator (ISO) can only operate market with resources offered into market
- Generation unit owners can only supply energy from the generation units they control
- Retailers can only purchase the energy that generation unit owners supply to wholesale market

Conclusion—Unless regulator treats electricity like any other product (see next slide), wholesale market regime requires a long-term resource adequacy mechanism

Need for Resource Adequacy Mechanism

A long-term resource adequacy mechanism is necessary because of "reliability externality"

- Unwillingness of regulator to commit to using real-time price of energy to clear market under all possible future system conditions creates a "reliability externality"
  - Lack of interval meters often used to justify this unwillingness of regulator "to treat electricity like any other product"

All consumers know that random curtailment will occur if aggregate supply is less than aggregate demand

- This implies that no customer faces full expected cost of failing to procure adequate energy in forward market
- Cannot curtail individual customers that failed to procure adequate energy in forward market, only all customers in a specific region of grid

Because of existence of "reliability externality," in markets with a finite offer cap regulator must mandate a long-term resource adequacy mechanism

- *Ensure adequate supply to meet system demand under all future system conditions and allowed short-term prices*

Historical Long-Term Resource Adequacy Challenge

- Initial Conditions: Electricity supply industry with dispatchable (typically, thermal) generation resources, mechanical meters, and offer cap on short-term wholesale market
- Major concern: Sufficient installed capacity to meet system demand peak
- Mechanical meters: Only allow measurement of total electricity consumption between consecutive meter reads
  - Typically done on monthly or bi-monthly basis
  - Precludes use of dynamic prices to reduce system peaks
- Offer cap on short-term market: Can prevent units that run infrequently to recover their total cost

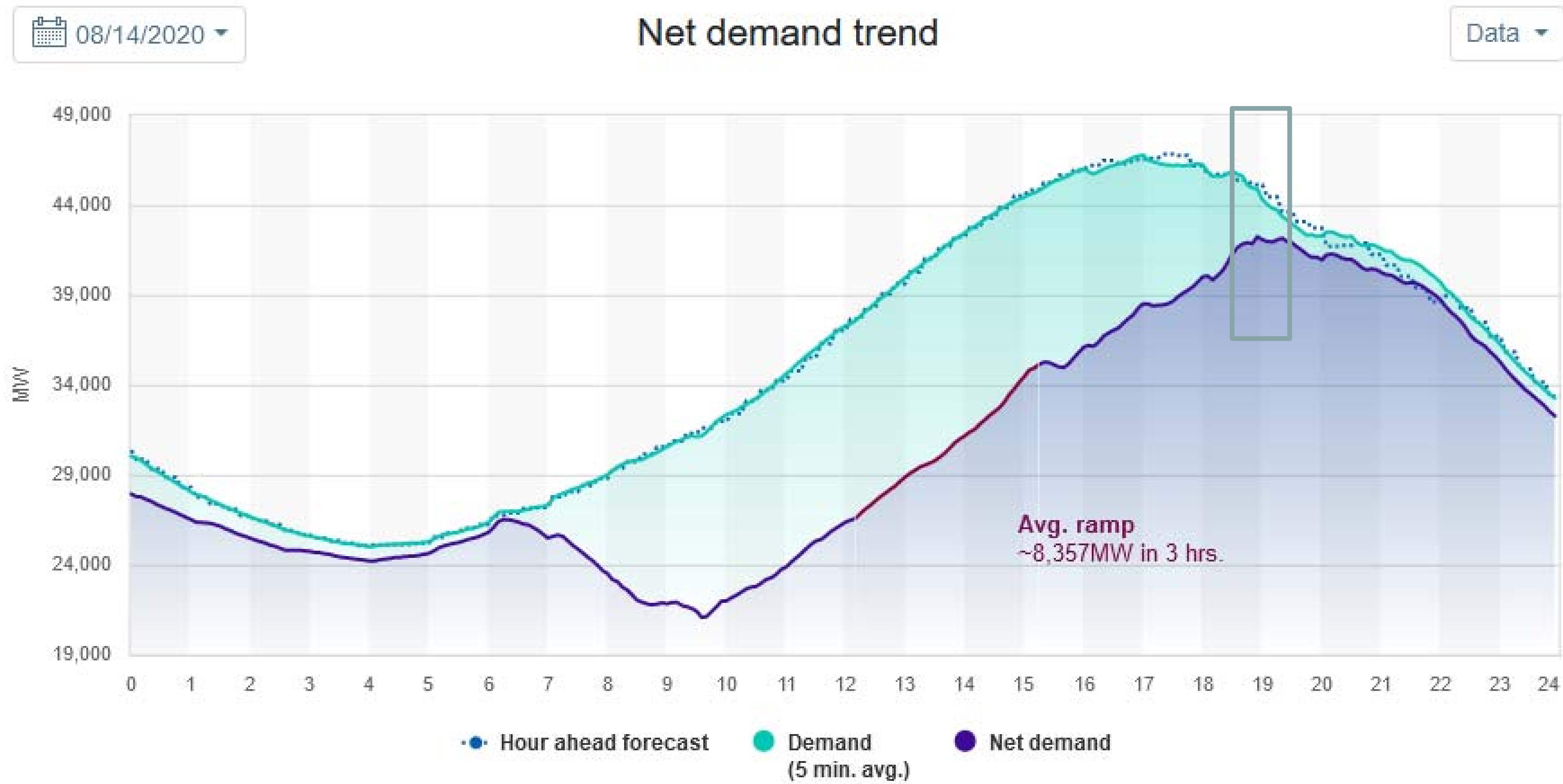
Capacity Payments: Historical Solution to Problem

- Assign all retailers firm capacity obligations equal to a multiple of their annual peak demand
  - Between 110 to 120 percent, depending on region
- All generation units assigned firm capacity quantity equal to amount of energy unit can produce under stressed system conditions
  - For thermal resource this is typically equal to nameplate capacity times the availability factor of the unit
  - For hydro units, typically based on historically worst hydrological conditions
    - For example from Colombia, see McRae and Wolak (2016) “Diagnosing the Causes of the Recent El Nino Event and Recommendations” available from web-site.
  - For solar and wind resources, it is extremely difficult to determine firm capacity of generation units
    - Firm capacity of a MW of wind or solar capacity declines with share of wind or solar energy in system demand because of high degree of correlation in output across locations
      - For case of California, “Wolak, Frank A. "Level versus Variability Trade-offs in Wind and Solar Generation Investments: The Case of California." *The Energy Journal* 37, (2016).

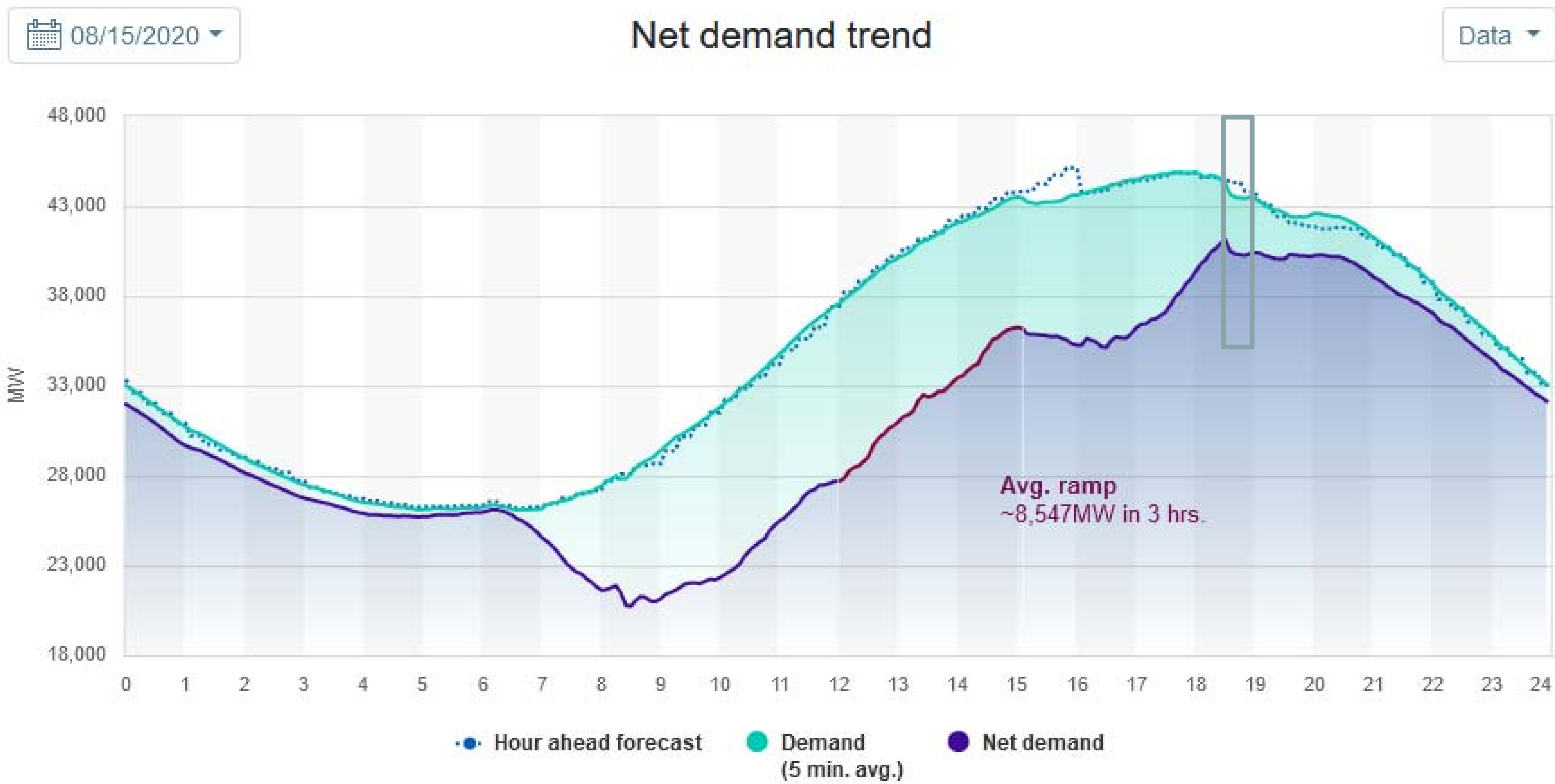
Firm Capacity of Intermittent Resources

- Firm capacity of solar or wind resource typically determined by effective load carrying capacity (ELCC)
  - If stressed system conditions occur when it is dark, firm capacity of solar generation unit should be zero
  - If stressed system conditions occur when wind is not blowing, firm capacity of wind generation unit should be zero
- Assignment of firm capacity to intermittent renewable resources likely to be overly optimistic
  - Values used for August 2020 were 27% of installed capacity for solar PV and solar thermal and 21% of installed capacity for wind
    - Rolling blackouts occurred in late evening on August 14 and 15
  - Recent study by three CA investor-owned utilities estimated effective load carrying capability (ELCC) of solar PV at ~5 percent of nameplate capacity
    - *2020 Joint IOU ELCC Study*, prepared by Astrape Consulting
- Conclusion: Firm capacity approach to long-term resource adequacy poorly suited to regions with high shares of intermittent renewable energy

The Rolling Blackouts of 8/14/20-8/15/20



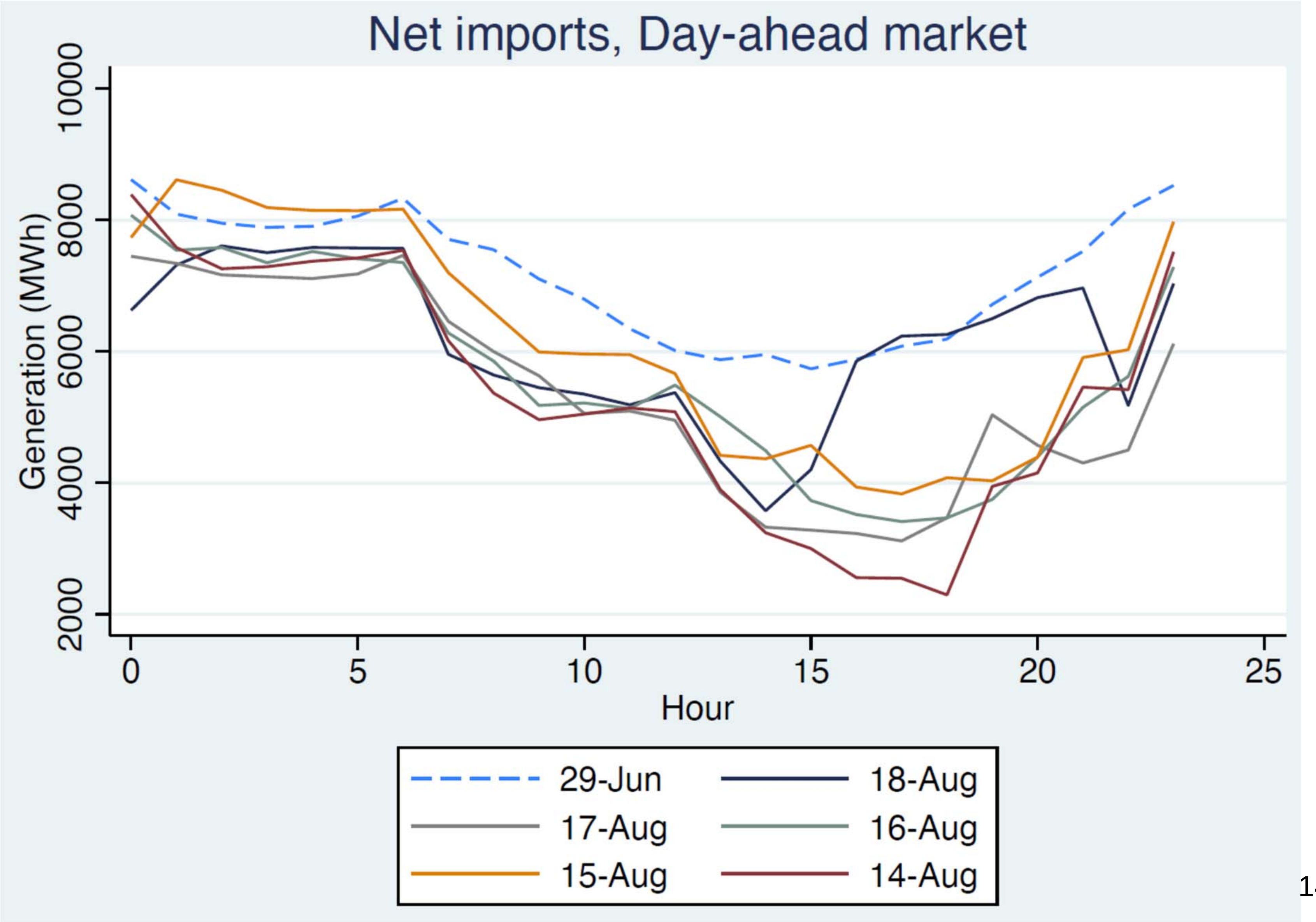
The Rolling Blackouts of 8/14/20-8/15/20



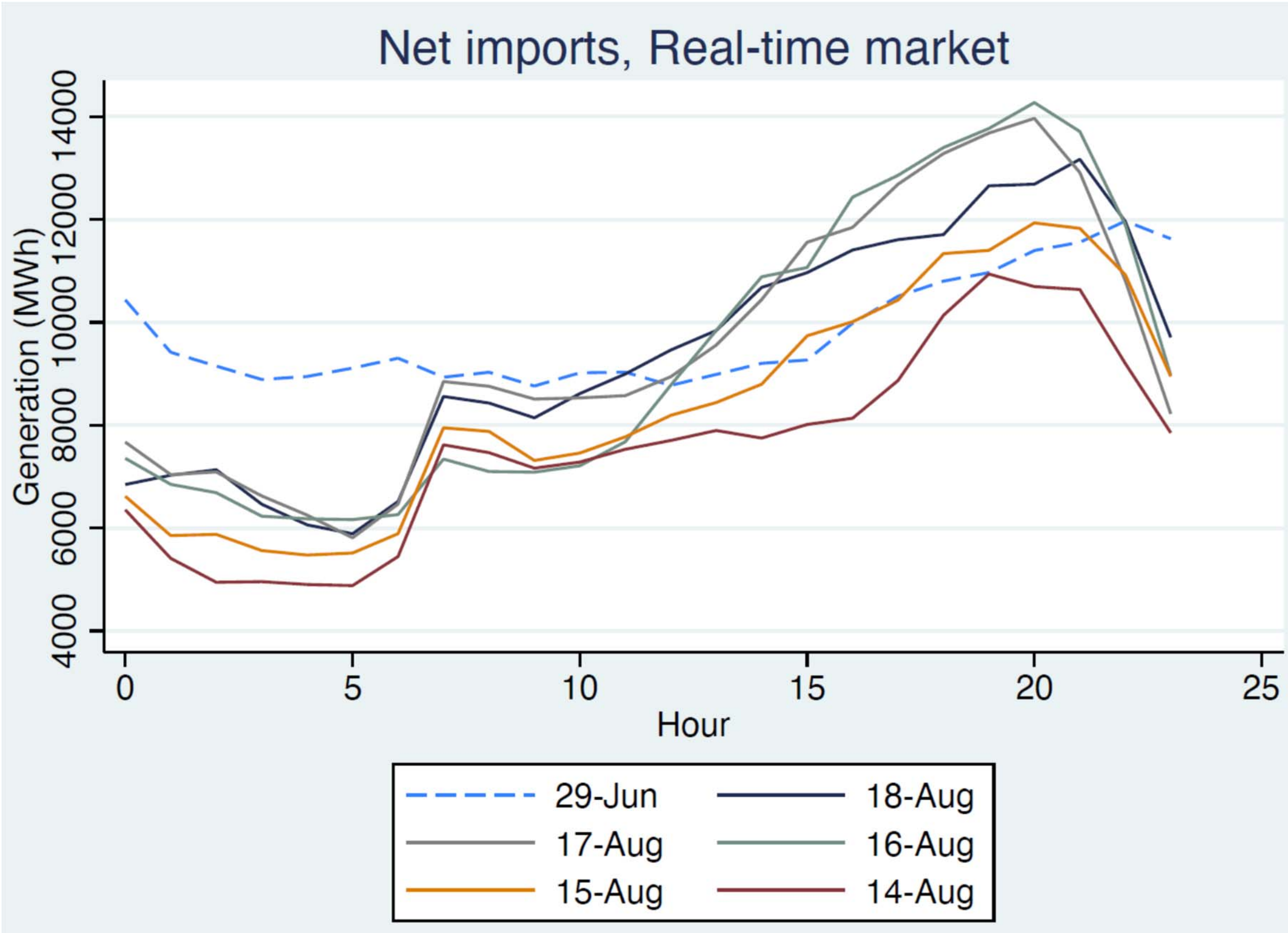
Firm Capacity of Imports?

- Generation source of an electricity iimport is primarily a financial construct
  - Regulators in neighboring states are very unlikely to allow generation units owned by their utilities to sell capacity from specific units to California
- Importers can sell fixed quantity of energy to “delivered” to a location in California at a fixed price
  - 500 MWh of energy “delivered” to specific node in California
    - Delivered = Financially settled against price at that node
  - Provide price certainty to a retailer or load serving entity for a fixed quantity of energy
- The harsh reality of electricity imports
  - In real time imports goes to party willing to pay the highest price
  - Under stressed conditions in WECC, even if out-of-state supplier offers capacity or energy into California market, buyer can purchase energy at or below price cap in California market and sell it outside of state at a higher price

Day-Ahead Net Imports-August 2020



Real-Time Net Imports-August 2020



Summary Comments on Capacity Mechanisms

Capacity payments are an increasingly expensive mechanism for attempting to achieve long-term resource adequacy in import-dependent regions with significant intermittent generation resources

- Does not address primary reliability challenge in import-dependent and intermittent-renewable-dominated wholesale markets
  - Energy shortfalls
- No guarantee that adequate capacity or least cost mix of capacity to meet hourly demands throughout year will be built or available
- Market-based pricing of capacity extremely challenging, particularly locationally
- Little empirical evidence that markets with capacity payments in the US have achieved higher levels of short-term or long-term reliability

Long-Term Resource Adequacy for Markets Dominated by Intermittent Renewables

Question is not an energy-only market versus capacity market

- Key Point: A long-term resource adequacy mechanism is necessary in any energy market with a finite offer cap because of the reliability externality
- Higher offer caps on short-term market only reduce magnitude of reliability externality, but do not eliminate it

Consumers want system demand for electricity to be met under all possible future system conditions

- For environmental reasons, consumers would likely prefer to have fewer MWs of generation capacity

Long-term resource adequacy mechanism should focus on meeting system demand, not demand for each individual retailer

- Electricity supplied to a load comes from grid, not from specific generation units
- Recall that in wholesale market regime, no market participant is responsible for meeting system demand all hours of the year

What is the Solution?

Long-term resource adequacy mechanism that

- Ensures that system demand is a met for all hours of the year under all possible future system conditions
- Meets California's renewable energy goals and greenhouse gas emissions goals
- Ensures long-term financial viability of the all resources necessary to meet these goals
- Minimizes annual cost of wholesale and ancillary services to consumers subject to meeting above goals
  - Allow maximum flexibility to suppliers and retailers to meet these goals

Important trade-off in design of long-term resource adequacy mechanism

- All revenues paid to generation unit owners come from electricity consumers
- Implication: For consumers to pay less, suppliers and retailers must find lower cost way to meet annual demand for energy and ancillary services

Standardized Forward Energy Contract Long-Term RA Mechanism

- Purchase actual hourly system demands throughout the year in advance at a fixed price
  - Sellers of these contracts have strong financial incentive to meet system demand during all hours of the year under all possible future system conditions
  - All suppliers know that all load in California is covered by a standardized fixed-price forward contract
- Mechanism is consistent with meeting California's renewable energy goals and greenhouse gas emissions goals
- Physical feasibility of meeting system demand dealt with by assigning a maximum sales value for standardized energy contract quantity to each generation resource
  - California ISO and CPUC assign annual firm energy value to all in-state resources
  - Backstop resource procurement by CPUC can occur to achieve its integrated resource plan (IRP)
- Fosters formation of liquid market for financial contracts between all market participants at delivery horizons that allow new generation resources to compete in this market

Energy-Contracting Resource Adequacy Process

Mandate *standardized fixed-price forward contract holdings* by retailers for pre-specified fractions of realized system demand at various horizons to delivery

- 100% of demand one year in advance
- 97% of demand two years in advance
- 95% of demand three years in advance
- 92% of demand four years in advance

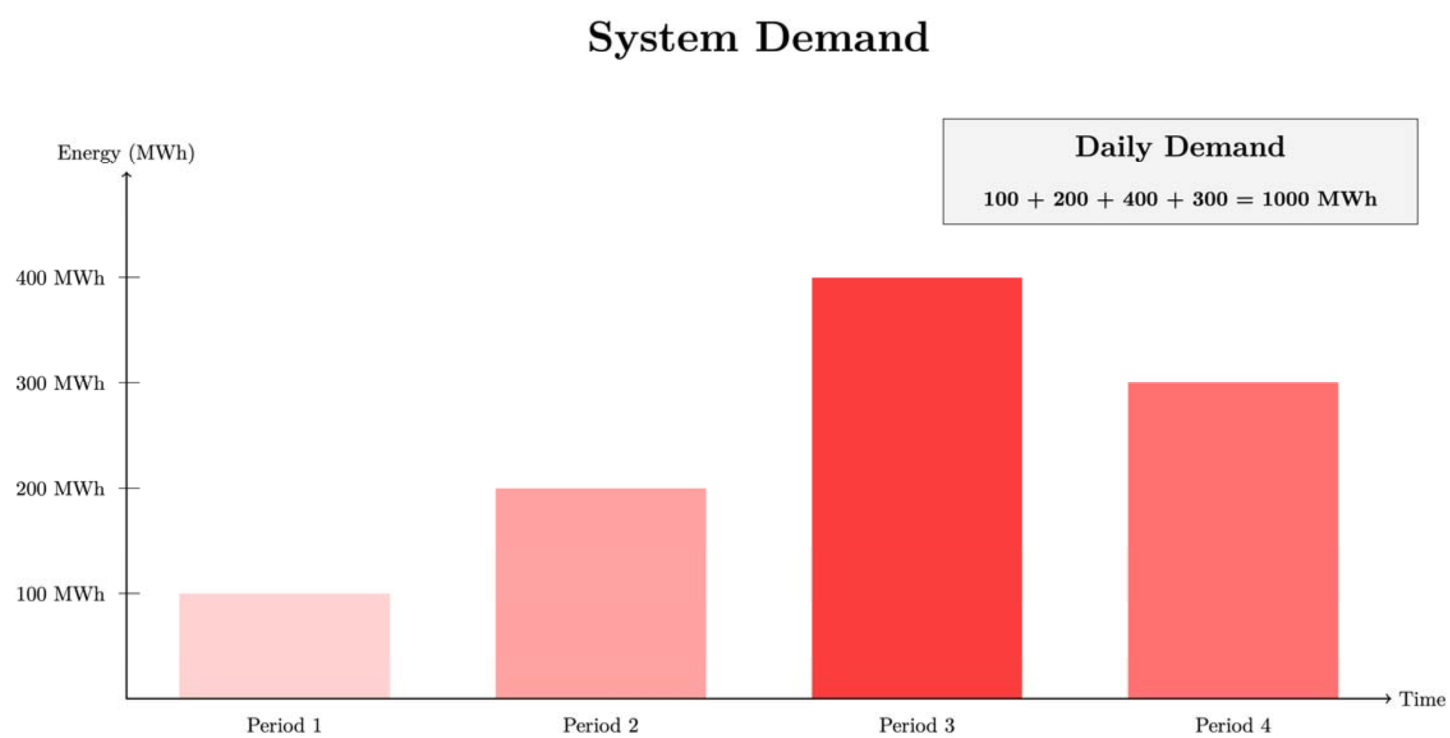
Above percentages are not set in stone, nor is years in advance contracts must be purchased

- Higher percentages provides greater confidence in resource adequacy
- Purchases more years in advance provides greater confidence in resource adequacy

Contracts are shaped to actual hourly system demand during “delivery” period

- Hourly standardized contract quantity, QC_h, varies with realized values of hourly system demand, QD_h
- Sellers of contracts have ability to manage this quantity risk through use of own generation units or through their own bilateral hedging arrangements
- Sellers can set price for standardized contract that incorporates cost of managing quantity risk associated with meeting actual system demand every hour of the year

Energy-Contracting Resource Adequacy Process



Realized Total System Demand ($\sum_{h=1}^{4} QD_h$) is equal 1,000 MWh
and Has the Above Hourly Values, QD_h, h=1,2,3, and 4

Energy-Contracting Resource Adequacy Process

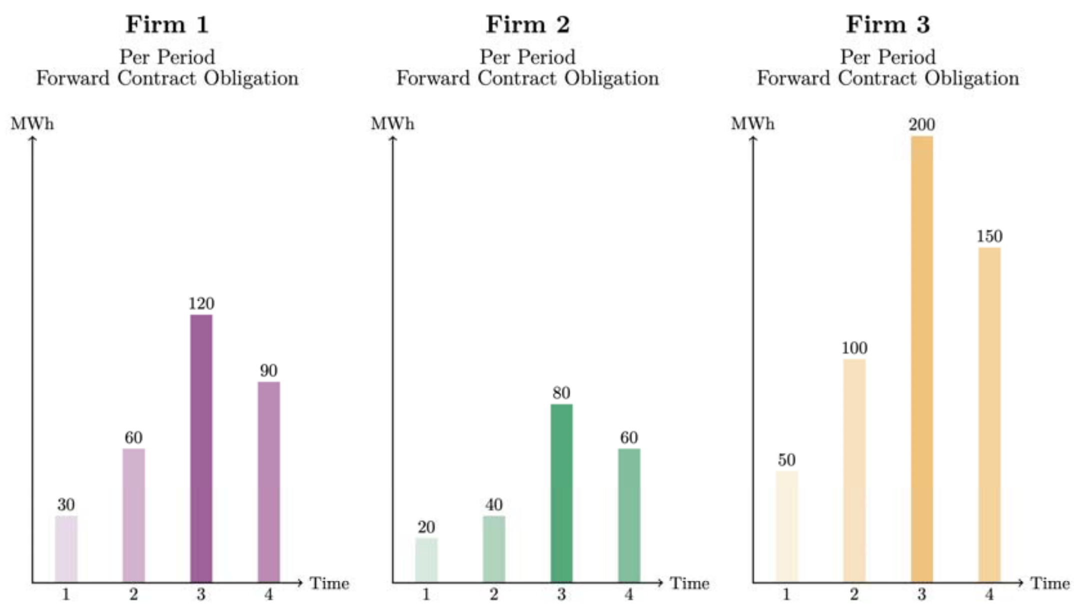
There are Three Firms:

Firm 1 sells 300 MWh

Firm 2 sells 200 MWh

Firm 3 sells 500 MWh

Total Amount Sold by Three Firms = 1000 MWh



Period-Level Values of QC_{hk} for Total Sales $Q_{total,k}$ of Each Firm k=1,2,3

$\sum_{k=1}^{3} QC_{Total,k} = 1000$ MWh = $\sum_{k=1}^{4} QD_h$

Energy-Contracting Resource Adequacy Process

Delivery of initial annual contracts should begin far enough in advance of delivery that new sources of supply can compete to provide this energy

- At least three years between close of auction and delivery of energy
- Time horizon necessary for new entry to compete with existing generation unit owners to supply standardized forward contract

Contracts for annual energy are procured through centralized auction each year (or more frequently)

- Ex post true-up auctions (discussed below) needed to ensure total annual energy held by all loads equals actual annual demand

Simple auction mechanism can be used to procure energy because single product is being purchased

- Can run simple declining price auction to purchase standardized contract energy shaped hourly pattern of demand
- Each round of auction suppliers offer quantity of annual standardized contract energy they are willing to supply at prevailing price
  - Participants can only reduce quantity they are willing to supply each round
  - Price determined by first auction round that supply is less than or equal to demand

Energy-Contracting Resource Adequacy Process

No capacity requirement

- Lets suppliers figure out least cost way to meet system demand for energy and ancillary services
  - Allocating quantity risk associated with meeting hourly variation in aggregate forward contract quantity among suppliers creates supply of operating reserves that can sell ancillary services
- Focuses on primary reliability problem in import-dependent market with significant amounts of intermittent renewables—adequate energy to serve demand
  - There has never been a shortage of generation capacity in California and other high renewables regions--New Zealand, Colombia, Brazil, and Chile--in wholesale market regime

Can increase offer cap on short-term market because all load is covered by standardized fixed-price forward energy contract

- Avoids sale of energy outside of California during stressed system conditions
- Creates level playing field for demand-side and supply-side solutions

Energy-Contracting Resource Adequacy Process

Periodic standardized auctions run by Market Operator overseen by CPUC

- Purchases of standardized contracts are made and allocated to all loads based on their monthly (quarterly or annual) share of system load
- Clearinghouse manages counterparty risk between retailers and sellers of contracts
  - Counterparty risk assigned to retailers based on current share of system demand served and suppliers based on their contract sales

If allocation interval is a monthly, then retailers have hourly value of forward contract quantity, QC_{ik}, equal to their monthly share of system demand

- Can assign forward contract quantity to retailers at lower or higher degree of temporal aggregation than monthly
- Monthly allocation allows forward contract obligation to follow retail load as retailers lose and gain load across months
  - Retailer knows it will allocated monthly value of standard forward contract energy based on its share of monthly demand served

Energy Contract Allocation Process

There are Four Retailers:

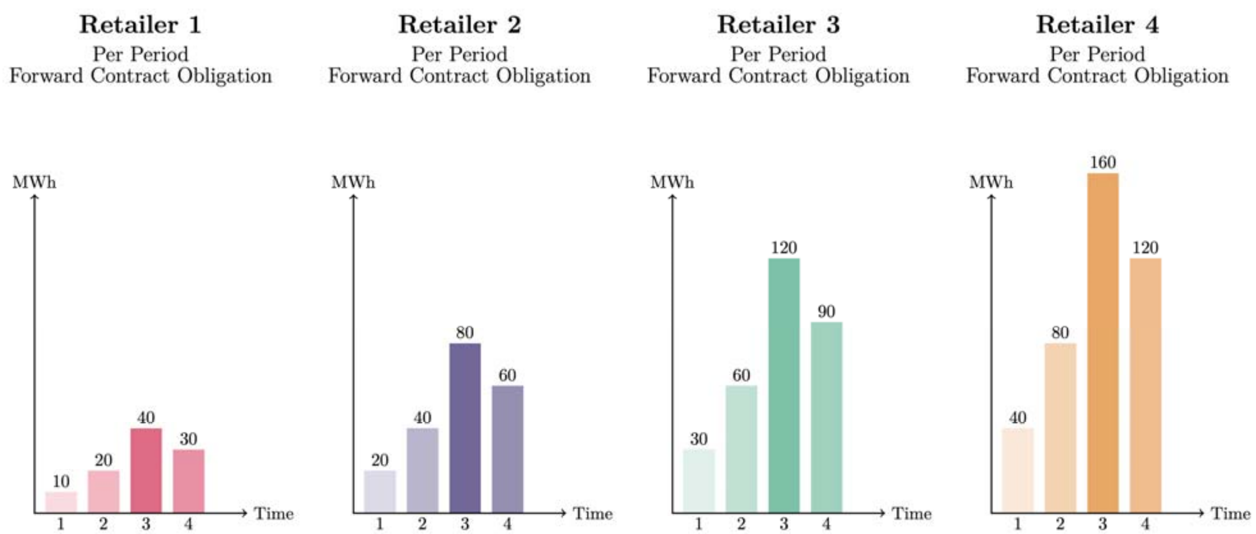
Retailer 1 sells 100 MWh

Retailer 2 sells 200 MWh

Retailer 3 sells 300 MWh

Retailer 4 sells 400 MWh

Total Amount Sold by Four Retailers = 1000 MWh



Sum of Hourly Forward Contract Obligations (QR_{hr}) Assigned to r=1,2,3,4 Retailers is equal to Hourly System Demand (QD_h) and Aggregate Forward Contract Obligations of Generation Unit Owners (QC_{hk})

$$\sum_{r=1}^{4} QR_{hr} = QD_h = \sum_{k=1}^{3} QC_{hk} \;\; for\; h = 1,2,3,4$$

Energy-Contracting Resource Adequacy Process

All suppliers and load-serving entities know that actual system demand is fully hedged for all hours of the year

- Hourly output of individual suppliers is not fully hedged
- Hourly demand of individual load serving entities is not fully hedged

All suppliers and load serving entities are free to sign bilateral hedging arrangements to manage this residual short-term quantity and price risk

Wholesale energy markets typically start from zero hedging of system energy demand

- This typically leads to inadequate amounts of energy contracting because of reliability externality
  - In virtually all markets, participants complain about lack of liquidity in forward market for energy at delivery horizons needed to finance new investments

Standardized long-term contracting approach to resource adequacy starts from position that 100% of actual system load is hedged at delivery horizons necessary to financial new investment

- Suppliers and load-serving entities can expose themselves to more or less short-term price risk through additional forward market arrangements

Ex Post True-Up Process for 100% Coverage

There will be a need for true-up auctions to buy or sell standardized contracts for energy after the actual hourly output levels for the year have been realized

- Sales or purchases of incremental standardized fixed-price forward contracts occur and these contracts are allocated to loads using same monthly (quarterly or annual) load fractions

No suppliers and load-serving entities are disadvantaged by over-procurement or under-procurement of standardized fixed-price forward contracts

- Allocation of purchases and sales known before they occur

Ex Post Purchase for 100% Coverage

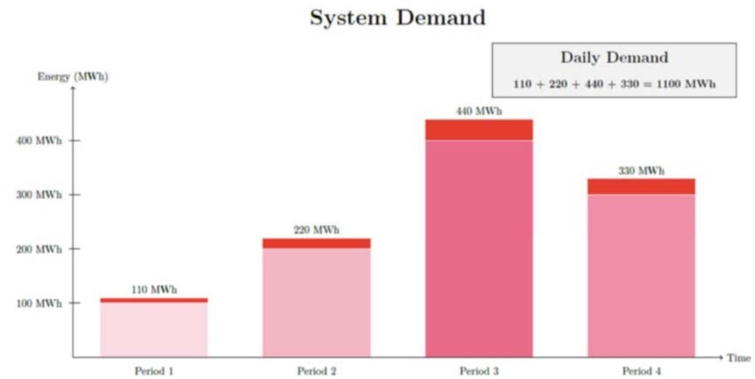


Figure 4: Hourly System Demands (10 Percent Higher)

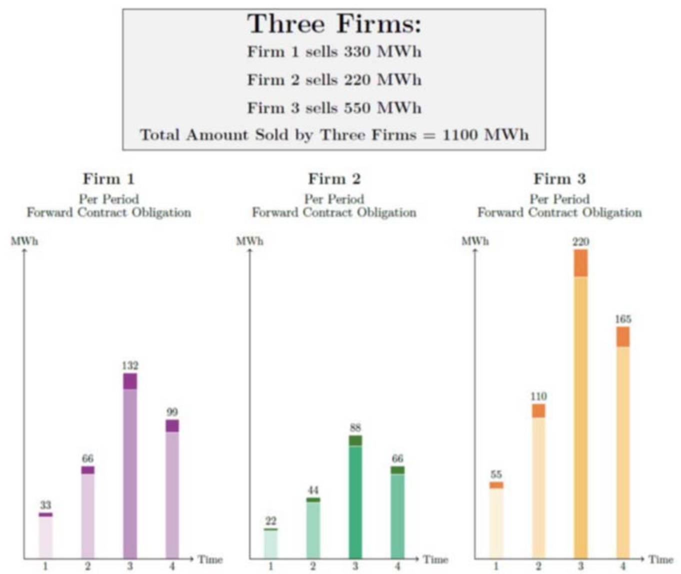


Figure 5: Hourly Forward Contract Quantities for Three Suppliers (10 Percent Higher)

Figure 6: Hourly Forward Contract Quantities for Four Retailers (10 Percent Higher)

Ex Post Sale for 100% Coverage

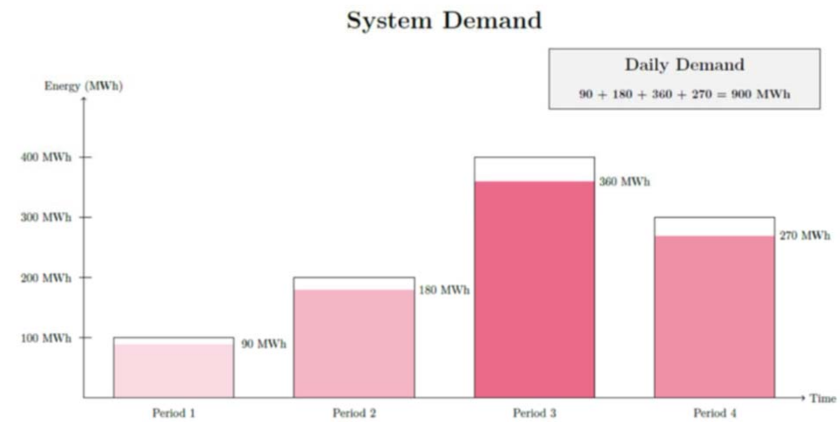


Figure 7: Hourly System Demands (10 Percent Lower)

Three Firms:
Firm 1 sells 270 MWh
Firm 2 sells 180 MWh
Firm 3 sells 450 MWh
Total Amount Sold by Three Firms = 900 MWh

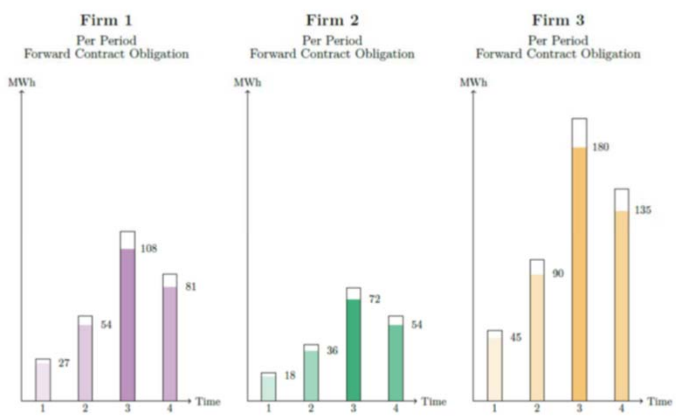


Figure 8: Hourly Forward Contract Quantities for Three Suppliers (10 Percent Lower)

Four Retailers:
Retailer 1 holds 90 MWh
Retailer 2 holds 180 MWh
Retailer 3 holds 270 MWh
Retailer 4 holds 360 MWh
Total Amount Held by Four Retailers = 900 MWh

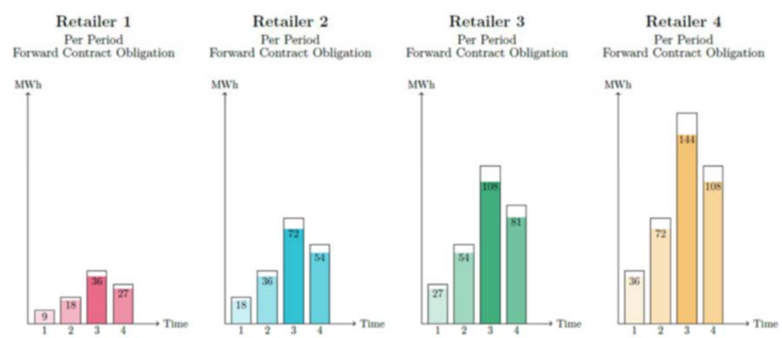


Figure 9: Hourly Forward Contract Quantities for Four Retailers (10 Percent Lower)

Financial Settlement of Contracts

Hourly variable profits for retailers

(P(retail) – P(spot))Q(retail)+(P(spot) - P(contract))Q(contract)

= (P(retail) - P(contract))Q(contract)

+ (P(retail) – P(spot))(Q(retail)-Q(contract))

Hourly variable profits for generation unit owners

P(spot)Q(spot) + (P(contract) – P(spot))Q(contract) – C(Q(spot))

= P(contract)Q(contract) + P(spot)(Q(spot) – Q(Contract)) – C(Q(spot)

Generation unit owner that produces no energy during hour earns

(P(contract) – P(spot))Q(contract)

Retailers that consumes Q(contract) during hour earns

= (P(retail) - P(contract))Q(contract)

Incentives for Generation Unit Operation

There is no requirement that seller of contract must actually produce electricity sold in standardized forward contract

- Suppliers to have strong incentive to make least cost for consumers "make versus buy" decision to meet their hourly standardized fixed-price forward contract obligation

Behavior of dispatchable (thermal) generation unit owners with standardized forward energy contract obligations

- Owners will typically buy energy from short-term market instead of produce energy when there is a substantial amount of wind and solar energy produced

Encourages active demand-side participation in wholesale market (no need for low offers caps on short-term market)

- Consumers in aggregate protected from high wholesale prices by financial contract coverage of final demand
- Retailers that are willing to manage some short-term price risk can sell bilateral contract to expose themselves to this risk

Incentives for Generation Unit Operation

To make efficient "make versus buy" decision to meet standardized forward contract obligation, thermal suppliers will submit offer to supply energy at marginal cost

- If Price > MC, supplying from unit is cheapest way to meet forward contract obligation
- If Price < MC, buying from short-term market is cheapest way to meet obligation

Allocation of standardized contracts across dispatchable (thermal) suppliers ensures that all are committed to the short-term market at marginal cost for at least the hourly value of QC

Allocation of standardized contracts across intermittent suppliers ensures that they have strong incentive to make arrangements to supply or purchase at least hourly value of QC

- If ISO and CPUC does not believe renewable resource can provide actual required energy to meet obligations under standardized forward contracts, they should reduce value of firm capacity and therefore quantity that supplier can sell of standardized energy contract
  - This increases demand for standardized energy contracts from all dispatchable resources

Physical Feasibility of Contracted Energy

Making ISO comfortable with transition to an standardized forward energy-contracts resource adequacy mechanism

- The firm capacity construct from capacity mechanism can be used to limit the quantity of standardized contract energy a unit owner can sell
- Do not want unit owners in the aggregate to sell more standardized energy than they are able to provide under all possible future system conditions

Dispatchable (typically thermal) resources will typically produce much less energy than they are capable of producing during extreme system conditions

Intermittent resources will typically produce much more energy than they are capable of producing during extreme system conditions

Mechanism encourages necessary cross-hedging between dispatchable resources and intermittent resources required to ensure demand is met under all possible future system conditions

- Intermittent units purchase quantity insurance from dispatchable resources for standardized energy contracts sold
- Intermittent unit owner can purchase cap contract with payment stream max(0,P(spot)-P(strike))Q(contract) for hours that renewable

Physical Feasibility of Contracted Energy

Ensuring cross-hedging between intermittent and dispatchable resources

- Allow existing resources only to sell up to their annual firm energy (AFE)
  - Firm capacity is amount of energy unit can produce under stressed system conditions (determined by California ISO and CPUC)
  - Engineers determine this value as they do for existing capacity construct under current Resource Adequacy (RA) process
- Annual Firm energy (AFE) in MWh = Firm Capacity (in MW) x 8760

Each participant in standardized contract auction can only sell a total amount of annual energy than is less than or equal to annual firm energy value (AFE)

- AFE of thermal resources significantly larger than amount of energy typically produced annually
- AFE of intermittent resources significant small than amount of energy typically produced annual

Ensures that total standardized contracts for energy sold can actually be delivered under all possible future system conditions

- Under typical conditions, most energy produced by intermittent resources and dispatchable (thermal) resources purchase this energy to meet standardized energy contract obligations
- Under scarcity conditions, most energy produced by dispatchable (thermal) resources and intermittent resources only provide their firm energy

New Entrants in Energy-Contracting RA Process

How do new entrants compete in these auctions?

- New entrant sells energy to be delivered three years in the future must show reasonable progress towards having amount of AFE sold in real-time
- If reasonable progress according to CAISO and CPUC is not shown, then contract is liquidated and purchase must be made in upcoming standardized energy auction to meet this shortfall
- Reasonable progress showing can be done every six months through filing by new entrant and site review by CPUC and CAISO staff
- Cost of forward energy purchased to replace energy not supplied by new entrant is allocated to all loads in proportion to load share as described earlier

Incorporating California's IRP Process

CPUC can run integrated resource planning (IRP) process with resources that sell AFE in auctions

- To the extent the CPUC believes additional resources are needed, it can order resource to be constructed
- AFE associated with this resource and cost of energy provided allocated to all retailers according to same monthly load share served
- Excess infeasible annual energy must be refunded to retailers at actual price paid
  - Burden shared among sellers of standardized energy contracts based on sales shares of annual energy contracts
- Create strong incentives for suppliers to meet system demand with resource mix that avoids violating CPUC's IRP process

Incorporating Renewable Energy Goals

Renewable energy goals can be met by retailers purchasing renewable energy certificates (RECs) equal to annual demand times required renewable energy share

- Retailer with 100 MWh demand purchases 40 RECs to meet 40 percent Renewables Portfolio Standard (RPS)

Different REC requirements can be met the same way

- Bucket 1, 2, and 3 REC requirements
- Purchase of Bucket 1 REC (energy+REC in same hour) simply implies a different hourly net load for retailer
  - Retailer's hourly net load is difference between actual hourly load and bundled RECs produced during that hour
  - Retailer can hedge difference between hourly net load and hourly standardized forward contract quantity in bilateral market

This logic is reinforces need to assign an AFE value to intermittent renewable resources consistent with amount of energy these resources can provide under stressed (not typical) system conditions

- Significantly less than values assigned for wind and solar resources in August of 2020

Meeting Local Energy Requirements

Two approaches to managing *local long-term resource adequacy*

- Allow suppliers to sort out least cost way to meet local reliability constraints
- Can run auctions for standardized contracts that clear against different pricing hubs
  - Different spatial aggregated prices for each retailer
  - Need to determine service territory-level demands that sum to total system demand

Suppliers with fixed-price forward contract obligations that clear against geographically aggregated prices have a strong incentive to limit difference between price at their location and geographically aggregated price

- Buying energy at injection point and selling at geographically aggregated price
- Suppliers jointly have strong incentive to sort out least cost way to meet local reliability constraints

CPUC and ISO can decide to make backstop resource procurement as described earlier to the extent local resource adequacy is not met

- Refunds of excess annual forward contract energy equal to energy that backstop resource provides

Meeting Local Energy Requirements

This logic reinforces need to purchase standardized energy contract far enough in advance of delivery to allow new entrants to compete to supply products

- Suppliers with local market power can be disciplined by actions of suppliers that have sold forward standardized forward contracts
- Backstop process should operate far enough in advance to make it is a credible source of energy in future
  - Reduces regulatory burden of managing local market power
- Important goal of standardized contract-based resource adequacy approach is to allow entities best able to manage supply risk, manage this risk
  - Avoid costly legal process at FERC and CPUC to obtain necessary generation capacity to meet demand under all possible future system conditions

Transition to Energy-Contracting RA Process

Transitioning to this approach to long-term resource adequacy requires significant advance notice

- First procurement of contracts should start delivery at least three years in advance

Retailers and generation owners need sufficient time to adapt to an energy-contracting resource adequacy process

Significantly more cross-hedging between resources to ensure system demand is met under all possible future system conditions

- Intermittent resources re-insurance with dispatchable resources
- Dispatchable resources earn premium for providing this insurance

Mechanism values a firm MWh more than a non-firm MWh

Bonus Topic:

Experimental Comparison
of Capacity-Based versus
Energy Contracting-Based
Long-Term Resource Adequacy Mechanisms

Application to Long-Term Resource Adequacy

Energy Market Game

Game Creators | Publications | Using the game | About

About the Game

Welcome to the website for the Energy Market Game—a tool developed at the Program and Energy and Sustainable Development (PESD) at Stanford University to help policymakers, regulators, market participants, and students improve their understanding of how energy and environmental markets work. On this site, you will find documentation about how the game works, interesting results from past runs of the game, information about customized educational workshops using the game, and, soon, simple games that you can be played in "solo mode" against computer-simulated agents.

Each player in the Energy Market Game takes on the role of an electricity generating company ("genco") or of a company selling electricity to retail customers ("retailer"). In each hour of each simulated electricity market day, gencos offer in the capacities of their various generating units at whatever prices they choose. Retailers may enter into fixed-price forward contracts for electricity with gencos or simply buy electricity on the spot market. They may also call "critical peak pricing rebates," in which they pay their simulated retail customers to reduce demand in a given period.

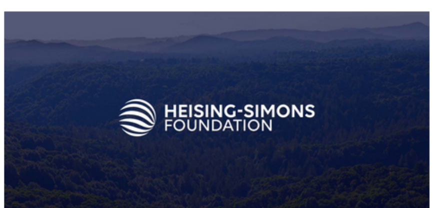
The Energy Market Game can incorporate environmental policies that are found in real markets, such as a cap and trade system for greenhouse gas emissions and a renewable portfolio standard (RPS) to incentivize the development of wind and solar facilities. When these additional elements are added to the basic features described above, the game becomes a sophisticated simulation of an electricity market subject to overlapping environmental regulations.

These kinds of complex markets have significant scope for strategic behavior and can be difficult to analyze theoretically. Our hope is that the game—and this website—will help policymakers, regulators, market participants, and students gain a higher level of comfort with these markets, as well as an improved sense of how markets may respond to different policies.

For further details about the Energy Market Game please read Features of the Energy Market Game.

PESD gratefully acknowledges funding support from the following organizations:

William and Flora Hewlett Foundation

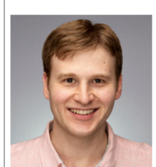


iew History Bookmarks Tools Help
www.energymarketgame.org/pages/about-us.html
sited Getting Started competitiontoolbox: A...

Energy Market Game

Game Creators | Publications | Using the game | About

Game Creators

Frank Wolak 	Frank is the Director of the Program on Energy and Sustainable Development (PESD) and the Holbrook Working Professor of Commodity Price Studies in the Department of Economics at Stanford University. His recent work studies methods for introducing competition into infrastructure industries - telecommunications, electricity, water delivery, and postal delivery services - and on assessing the impacts of competition policies on consumer and producer welfare. From January 1, 1998 to March 31, 2011, Frank was the Chair of the Market Surveillance Committee of the California Independent System Operator for the electricity supply industry in California. Frank was also a member of the Emissions Market Advisory Committee (EMAC), which advised the California Air Resources Board on the design and monitoring of the state's cap-and-trade market for Greenhouse Gas Emissions allowances.
Mark Thurber 	Mark is Associate Director of the Program on Energy and Sustainable Development (PESD) at Stanford University. He uses the energy market game as a central teaching tool in a course he teaches with Frank in the Stanford Graduate School of Business ("Energy Markets and Policy"). Mark studies markets for oil, natural gas, and coal in addition to electricity markets. He coedited and contributed to *Oil and Governance*, a 2012 book on state-controlled oil companies, and *The Global Coal Market*, a 2015 book on how policies toward coal in the most important coal producing, consuming, and exporting countries (specifically, China, India, Indonesia, Australia, South Africa, and the United States) affect economic and environmental outcomes.
Trevor Davis 	Trevor Davis is a Postdoctoral Scholar in the Department of Economics at Stanford University. He researches policy impacts on electricity markets and is the lead developer of the Energy Market Game. Prior to arriving at Stanford Trevor worked at the Federal Reserve Board of Governors in Washington, DC.

Application to Long-Term Resource Adequacy

Run capacity market versus energy contracting market experiment with Western US States regulators and members of staff of ANEEL, Brazilian Electricity Regulator (separately)

In each game players face identical demand and renewable energy realizations

- Only difference in games is long-term resource adequacy process

Capacity Market—Players compete to sell firm capacity equal to 110 percent of peak demand in a uniform price auction

Players given table of firm capacity, fixed cost, variable for each possible technology they can build

Players must construct at least the amount of firm capacity they won in capacity auction

Players required to meet 33% renewables portfolio standard

Players then compete to sell electricity in offer-based short term market

Energy Contracting Market—Players compete to sell long-term energy contracts tailored to daily load shape equal to 100 percent of expected demand in game

Players given same table of fixed cost and variable cost for each technology

Players were free to construct any mix of generation units to meet their forward contract obligations

Players required to meet 33% renewables portfolio standard

Players then compete to sell electricity in offer-based short-term market

Application to Long-Term Resource Adequacy

Run capacity market versus energy contracting market experiment with Western US States regulators and members of staff of ANEEL, Brazilian Electricity Regulator (separately)

In each game players face identical demand and renewable energy realizations

- Only difference in games is long-term resource adequacy process

Capacity Market—Players compete to sell firm capacity equal to 110 percent of peak demand in a uniform price auction

Players given table of firm capacity, fixed cost, variable for each possible technology they can build

Players must construct at least the amount of firm capacity they won in capacity auction

Players required to meet 33% renewables portfolio standard

Players then compete to sell electricity in offer-based short term market

Energy Contracting Market—Players compete to sell long-term energy contracts tailored to daily load shape equal to 100 percent of expected demand in game

Players given same table of fixed cost and variable cost for each technology

Players were free to construct any mix of generation units to meet their forward contract obligations

Players required to meet 33% renewables portfolio standard

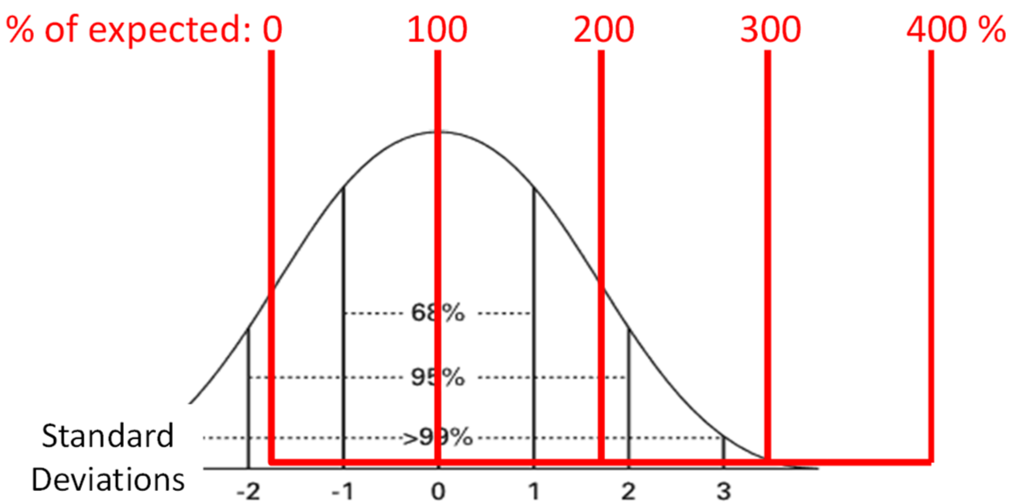
Players then compete to sell electricity in offer-based short-term market

Variable Energy Resources

- Intermittent renewable generation units produce throughout day in similar pattern to actual pattern of production in California

Type	Expected Generation (Normalized to Overall Average)				Variable Cost ($/MWh)
	4am	10am	4pm	10pm	
Wind	1.3	0.7	0.7	1.3	$0
Solar PV	0	2.0	2.0	0	$0

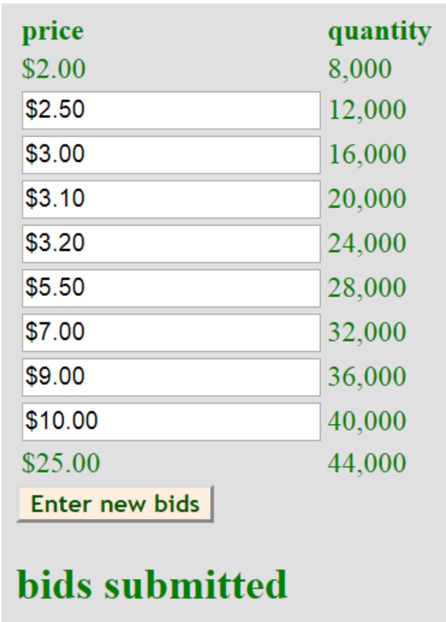
Variability

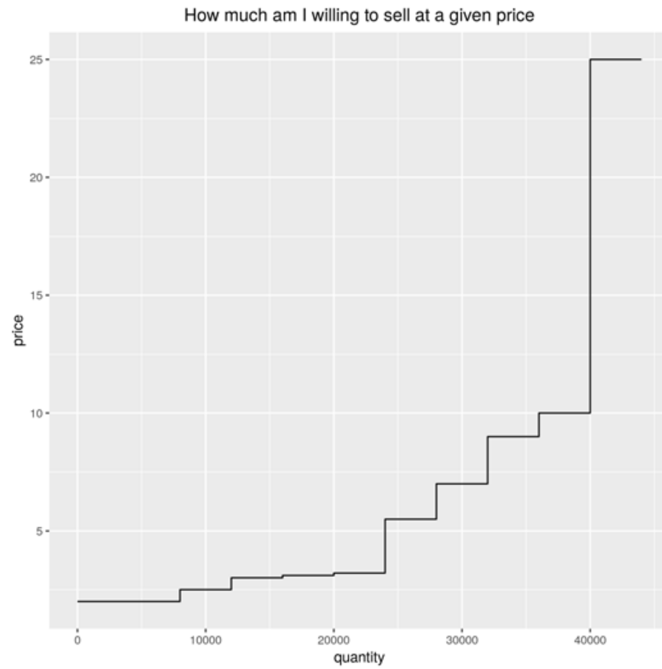


Renewable generation will fall between 40% and 160% of its “expected” value 68% of the time

Capacity Market game mechanics

1) Submit auction bids ($/MW-hr) for available capacity





- Minimum bid is $2/MW-hr (2/3 of fixed cost of Peak unit)
- Maximum bid is $25/MW-hr (full fixed cost of Base unit)
- Renewables counted at expected 4pm output
- Your existing capacity is bid in at minimum

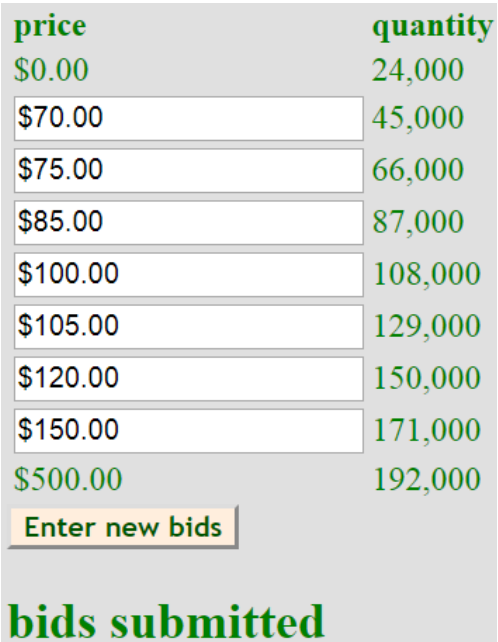
2) Buy/decommission units to meet capacity contracts you won (*required*)

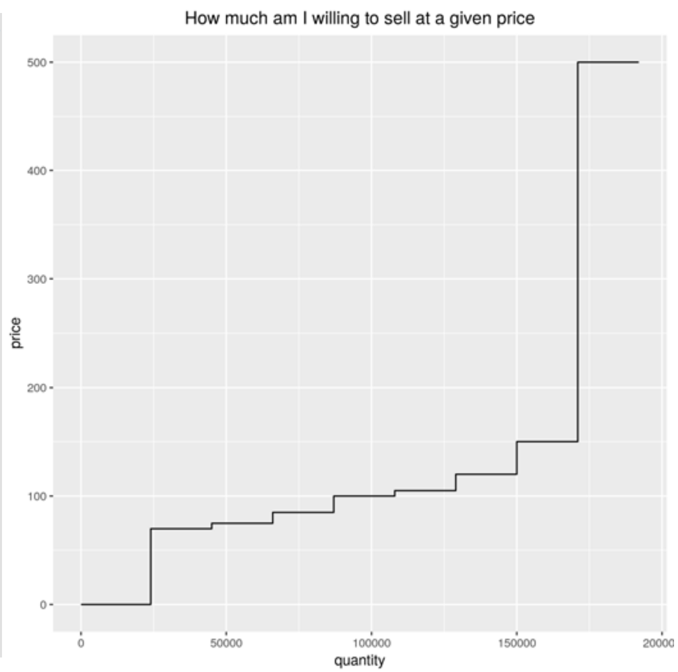
Plant Type	Capacity (MW)	Var Cost ($/MWh)	Fixed cost ($/hr)	Fixed cost ($/MW-hr)	LCOE ($/MWh) -- by portion of hours running				
					10%	25%	50%	75%	100%
Base	2000/1000	20	100,000/25,000	25	270	120	70	53	45
Intermediate	1000	45	10,000	10	145	85	65	58	55
Peak	1000	90	3,000	3	120	102	96	94	93

3) Bid in all thermal units to maximize returns

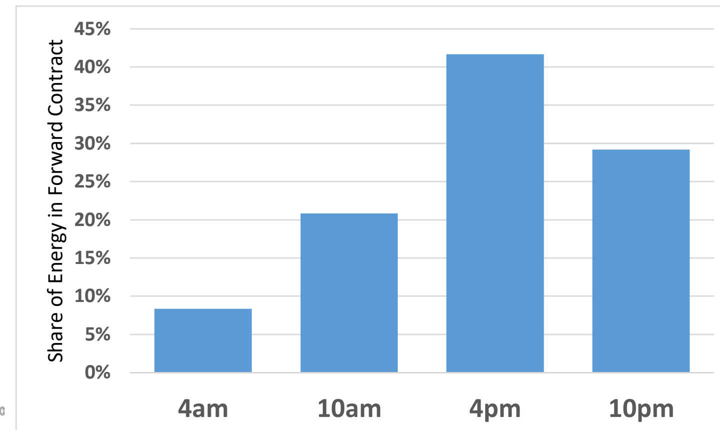
Forward Energy Contracting game mechanics

1) Submit auction bids ($/MWh) for available forward contracts (~100% of demand)





- Forward contracts have fixed load shape expected to meet demand



2) Buy/decommission units to physically hedge forward contracts you won

Plant Type	Capacity (MW)	Var Cost ($/MWh)	Fixed cost ($/hr)	Fixed cost ($/MW-hr)	LCOE ($/MWh) -- by portion of hours running 10%	25%	50%	75%	100%
Base	2000/1000	20	100,000/25,000	25	270	120	70	53	45
Intermediate	1000	45	10,000	10	145	85	65	58	55
Peak	1000	90	3,000	3	120	102	96	94	93

- Renewables are not firm! (Can hedge if desired with more extra thermal capacity)

3) Bid in all thermal units to maximize returns. (Remember incentives w/contracts!)

Summary of Experiment Results

- For both games and both set of players—Western US regulators and ANEEL staff--computed average revenues paid by load and average cost to serve demand for game
- Capacity payment mechanism
  - Capacity payments, energy contracting and short-term energy market revenues divided by total demand served ($/MWh)
  - Total cost of serving demand divided by total demand ($/MWh)
- Energy contracting market
  - Energy contracting and short-term energy market revenues divided by total demand served ($/MWh)
  - Total cost of serving demand divided by total demand ($/MWh)
- For both Western US regulators and ANEEL staff average wholesale revenues per MWh from capacity mechanism was close to double that for energy contracting approach
  - Average cost to serve demand slightly lower for energy contracting approach

Concluding Comments

- Hard to find empirical evidence anywhere in the world of a well-performing capacity market
  - Even capacity market based on peak energy rent refunds in Colombia appears to reduce rather that improve market efficiency
- Standardized forward financial contracting approach appears to come closest to achieving goals for long-term RA process
  - Buy necessary energy far enough in advance of delivery to allow maximum flexibility of suppliers to meet these obligations at least cost and limit market power in short-term market
  - Mechanism consistent with state's RPS, Climate and IRP goals
- Head-to-head comparison of capacity market approach to energy contracting approach for two diverse groups—Western US regulators and staff of ANEEL yields same conclusions
  - Energy contracting yields lower average cost per MWh to consumers for same set of system conditions
  - Lower average cost of production approach

Concluding Thought

There is nothing more difficult to take in hand, more perilous to conduct, or more uncertain in its success, than to take the lead in the introduction of a new order of things. Because the innovator has for enemies all those who have done well under the old conditions, and lukewarm defenders in those who may do well under the new."

– Niccolo Machiavelli (The Prince)

Thank you

Questions/Comments

Academic Panel

10:10 - 10:30 a.m.

James Bushnell, Professor, Co-Director, Davis Energy Economics Program, Department of Economics, University of California, Davis

Shaun McRae, Assistant Professor of Economics, Centro de Investigación Económica, ITAM

Stretch Break :)

Please be back at 10:45 a.m.

Image Source: iamthinks.blogspot.com

Party Panel

10:45 - 11:55 a.m.

Eric Little, Principal Manager, Regulatory Affairs, CAISO and GHG Market Design, Southern California Edison

Matthew Barmack, Vice President, Governmental and Regulatory Affairs, Calpine Corporation

Nick Pappas, Director of Strategic Initiatives and Outreach, California Community Choice Association

Peter H. Griffes, PhD, Chief, Comprehensive Procurement Framework, Pacific Gas & Electric, Co.

Q&A from Attendees

Until 12:25 p.m.

Next Steps

TRACK 3B.2 CALENDAR	
Event	**Date**
Revised Track 3B.2 proposals due	December 18, 2020
Comments on Revised Track 3B.2 proposals due	January 15, 2021
Workshop on Revised Track 3B.2 proposals	Early - mid February 2021
Second Revised Track 3B.2 proposals	February 26, 2021
Comments on Revised proposals and workshop	March 12, 2021
Reply comments on Revised proposals and workshop	March 23, 2021

California Public Utilities Commission

Thank you for attending today's Track 3.B.2 Workshop.
Feedback welcome.

Hosts contact:

Jaime Gannon – jaimerose.gannon@cpuc.ca.gov
Linnan Cao - linnan.cao@cpuc.ca.gov