Analysis on Fast Start Pricing for ISO's real-time market

Zhu Liang, Ph.D.
Kun Zhao, Ph.D.
Guillermo Bautista Alderete, Ph.D.
Market Performance and Advanced Analytics

Market Surveillance Committee Meeting
General Session
December 18, 2023

ISO's analysis effort is to explore potential implications and benefits to price formation of fast start pricing (FSP) and help guide subsequent FSP discussions

First Stage. December 2023	Second Stage. March 2024
• Statistics on generation fleet • Foundational analysis of FSP • Provide analysis and opportunity for discussion of the first stage of analysis	• Includes feedback for the final stage of analysis • Expand it to all WEIM areas • Define final scope of analysis • Provide an opportunity for discussion of final analysis

Scope of this preliminary round of analysis on FSP

- Analyzes the characteristics of the WEIM generation fleet relative to the definitions of FSP
- Analyzes the historical bid-cost recovery in the overall WEIM market based on attributes applicable to FSP
- Analyzes impacts of FSP for ISO area only in real-time market
  Analysis includes the effect of WEIM market in ISO area
  by accounting for the economical displacement of transfers
- Includes the effect of flexible ramping product by capturing the economical displacement of capacity to set prices
- Assesses 4 sensitivity scenarios to calculate FSP
  - Constant adder
  - Minimum averaged-cost adder (suggested by Michael Cadwalader)
  - 30-minute and 60-minute FSP for each type of adder
- Expands the application of FSP to transitions of multi-stage generator units
- Considers the impacts of minimum-online constraints (MOC)

There are several design considerations to implement fast start pricing

Day-ahead vs. real time markets

Commitment time definition

Eligible resources

Type and extent of cost amortization

Type of participation

The generation fleet in the ISO's market is diverse and some types of resources may naturally fit the definition of fast start units

By technology type

- Proxy demand resources
- Storage
- Solar/Wind
- Hydro
- Gas-fired
- MSG
- Imports

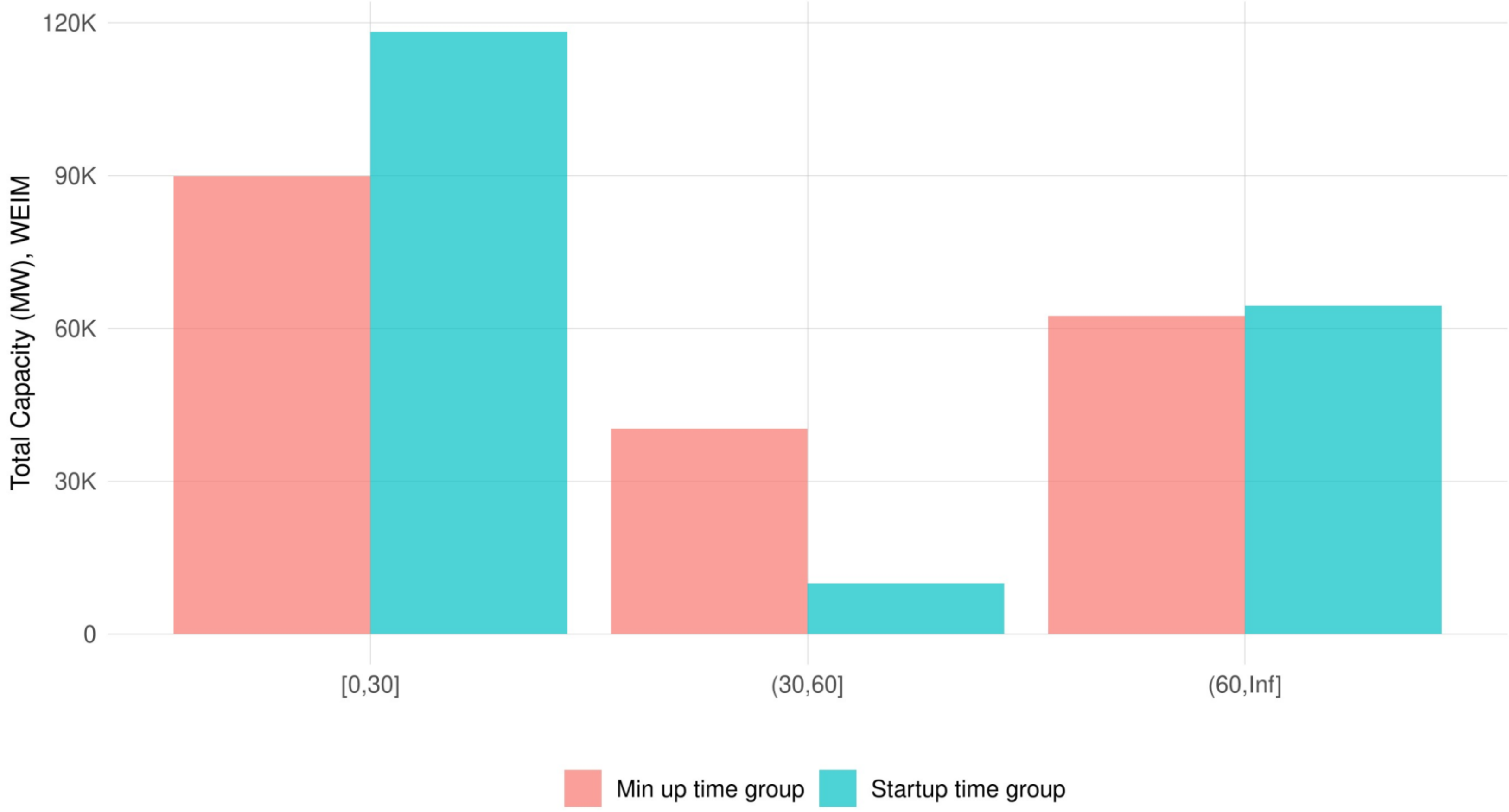
By type of participation

- Economical participation
- No self-schedules
- ISO market uses minimum online constraints to secure commitments
- Resources with $0 commitment costs

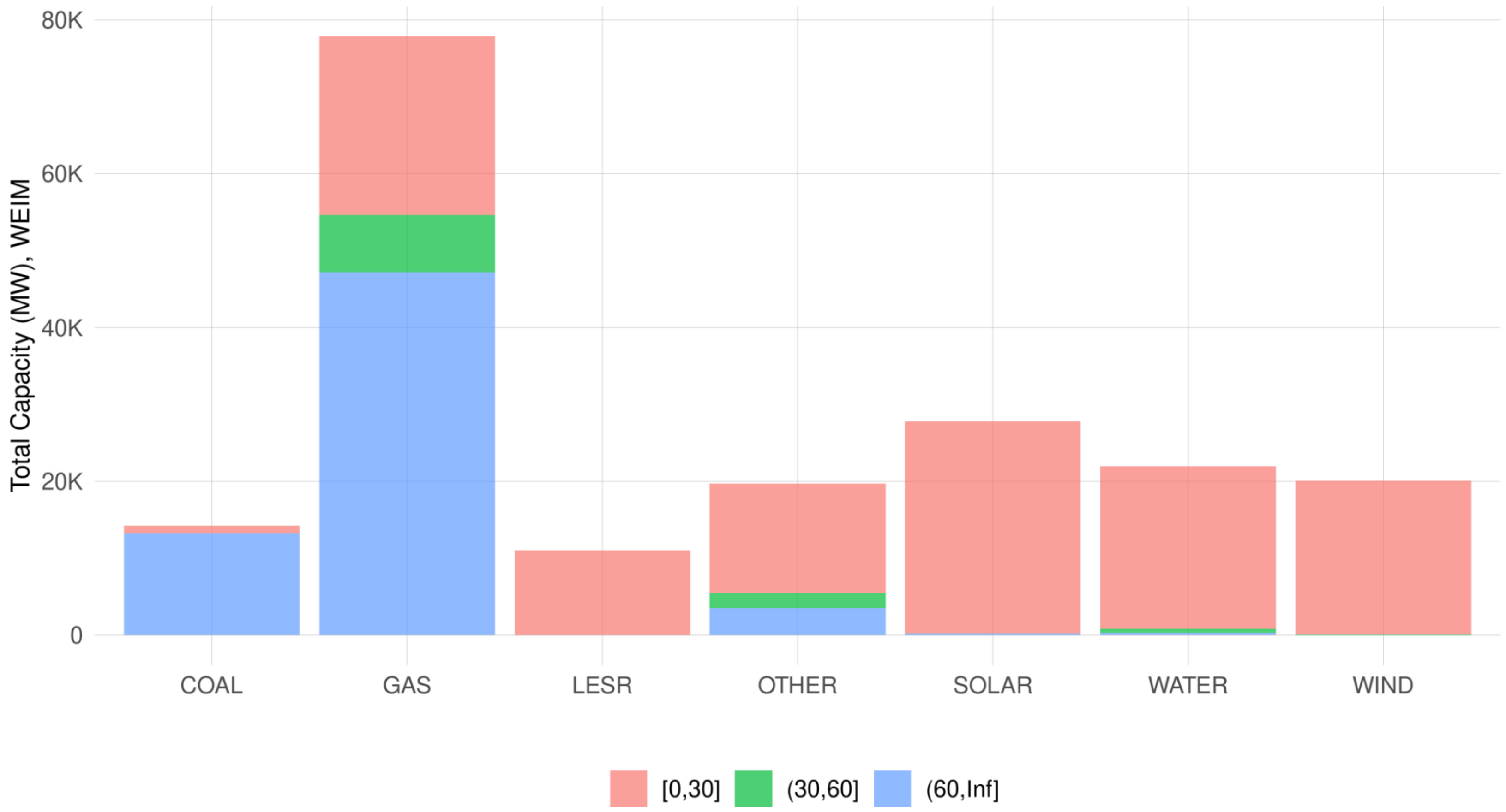
Commitment time definition

- Resources are subject to temporal constraints, including:
  – Start-up time
  – Minimum-up time
  – Transition time for multi-stage generators (MSG)
- What time definition should apply to ISO's markets?
  – 30-minute, 60-minute or something else
  – Should the time threshold apply concurrently to MUT and STUT, and MUT and transition time
- In this analysis we consider two scenarios: 30-minute and 60-minute concurrent thresholds

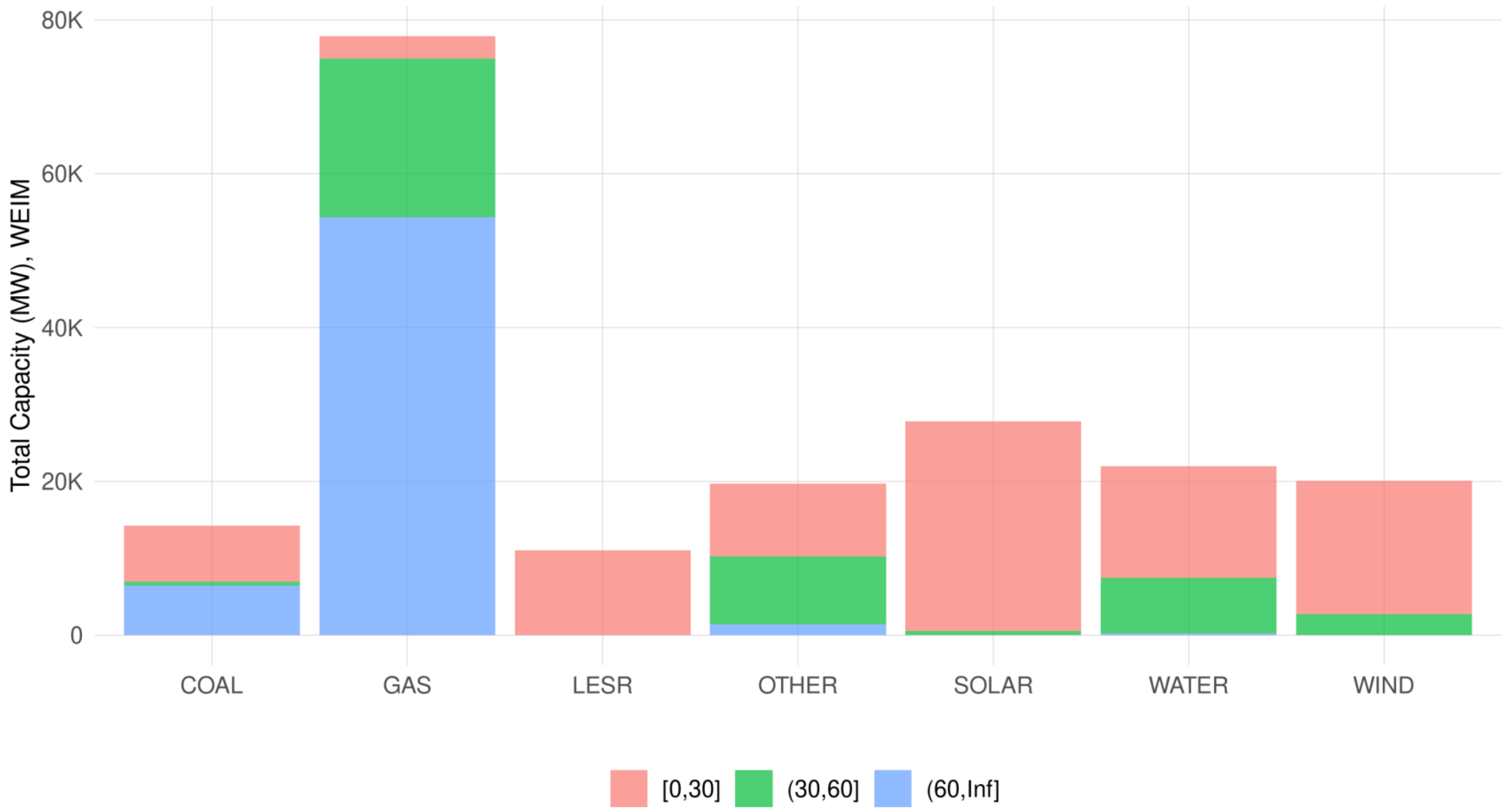
There is a significant share of the generation fleet in the WEIM footprint with fast times that could meet different FSP definitions



Units with fast-start times are spread across different technologies in the WEIM generation fleet

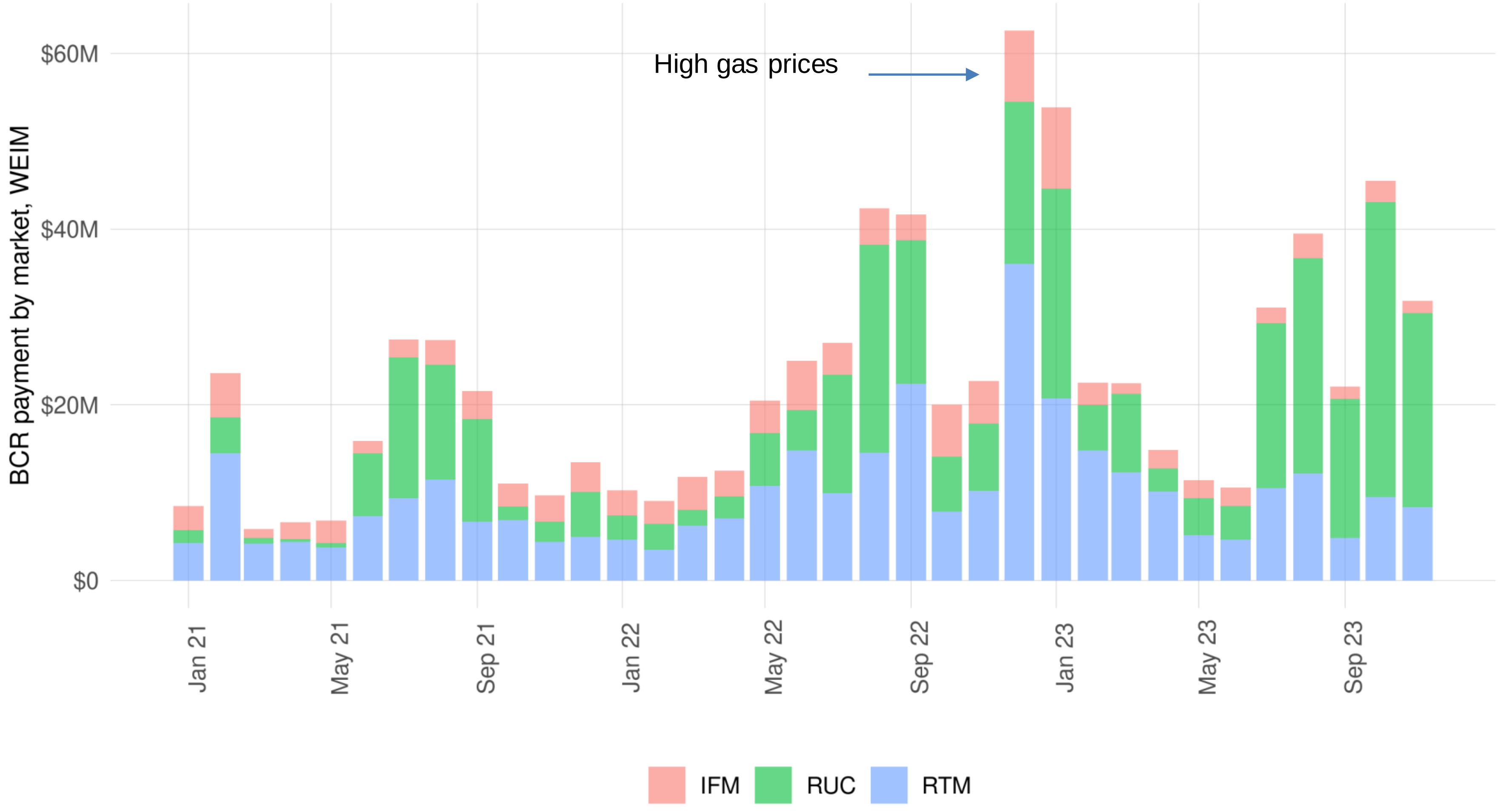


Units with fast minimum-up times are spread across different technologies in the WEIM generation fleet



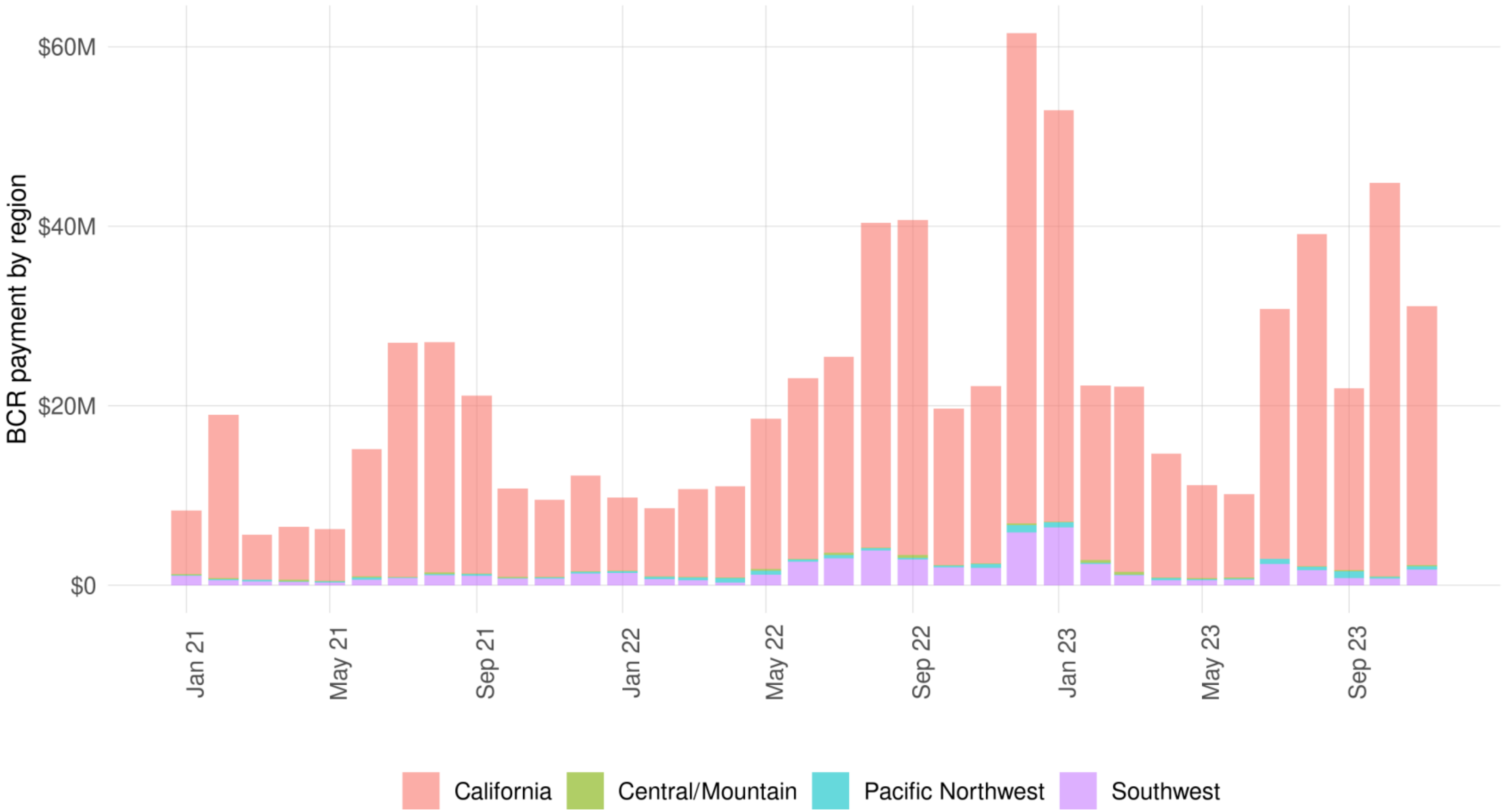
Although some resource type like solar could meet the FSP definition, there may be no material impact with them since they may generally have $0 commitment costs

Bid-cost recovery is a mechanism to make whole units dispatched uneconomically in the WEIM markets

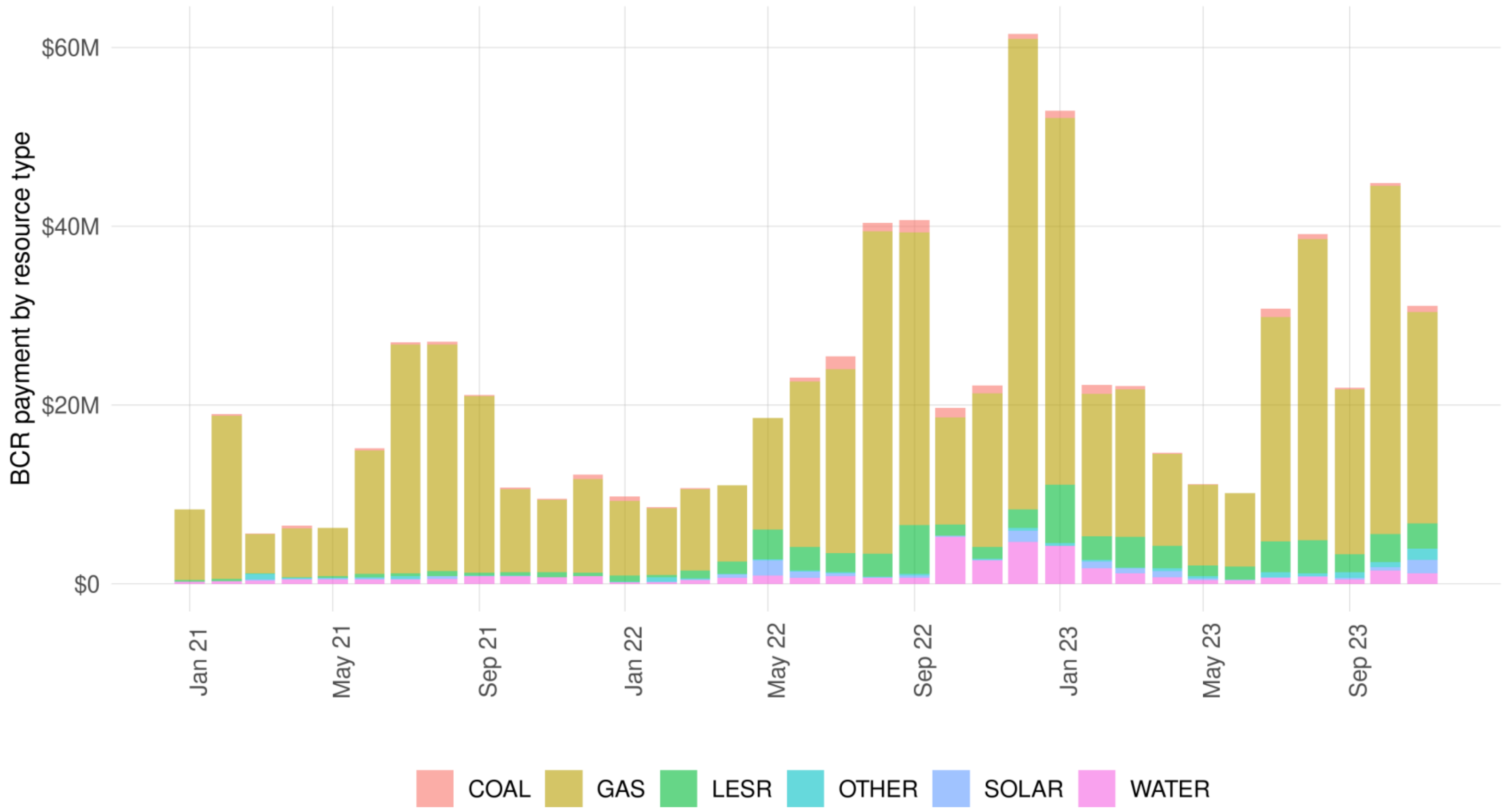


Bid cot recovery averages about $21 million per month in this reported period.

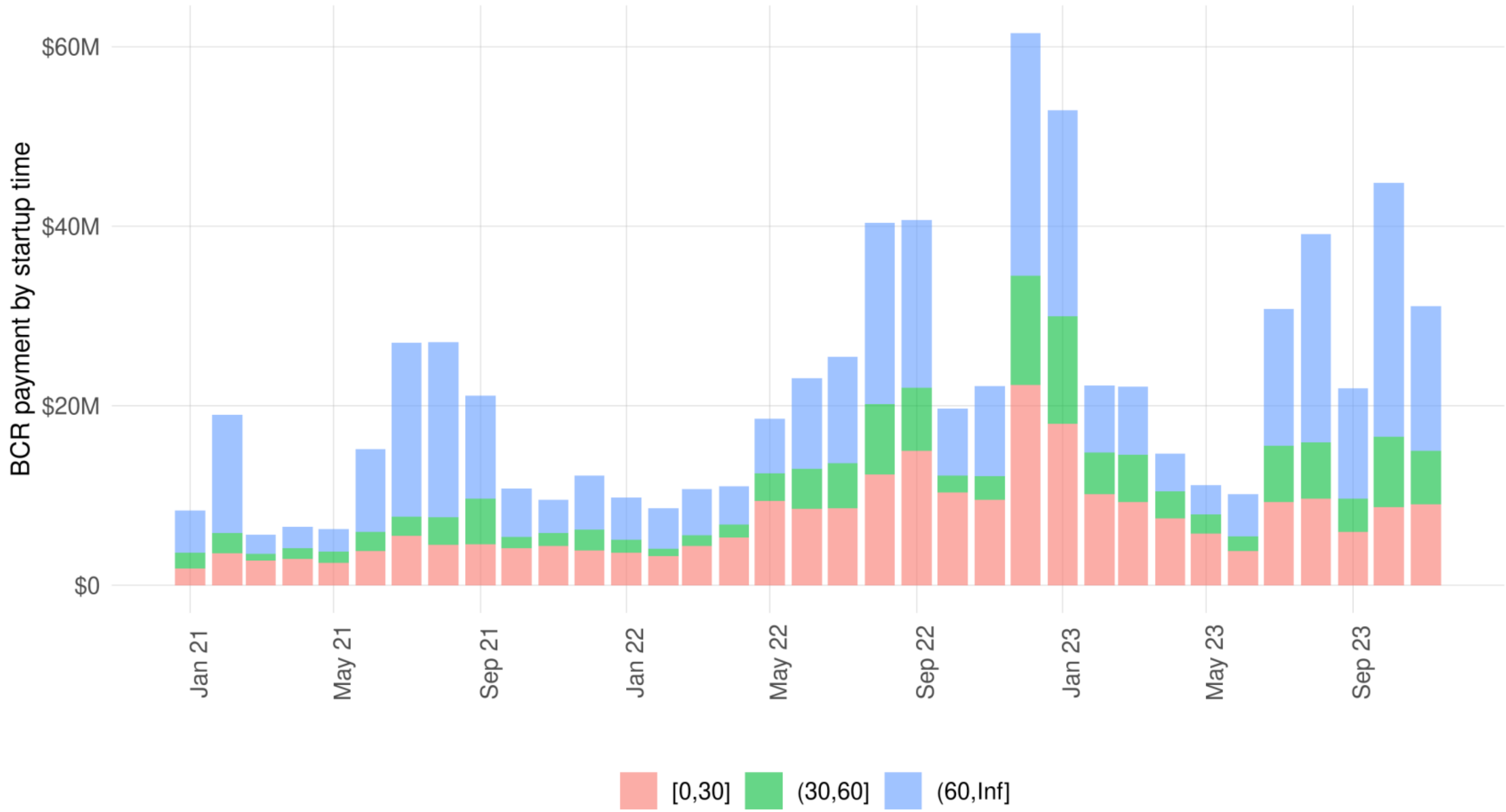
The main share of bid cost recovery is accrued in the ISO area and largely driven by RUC component of the day-ahead market



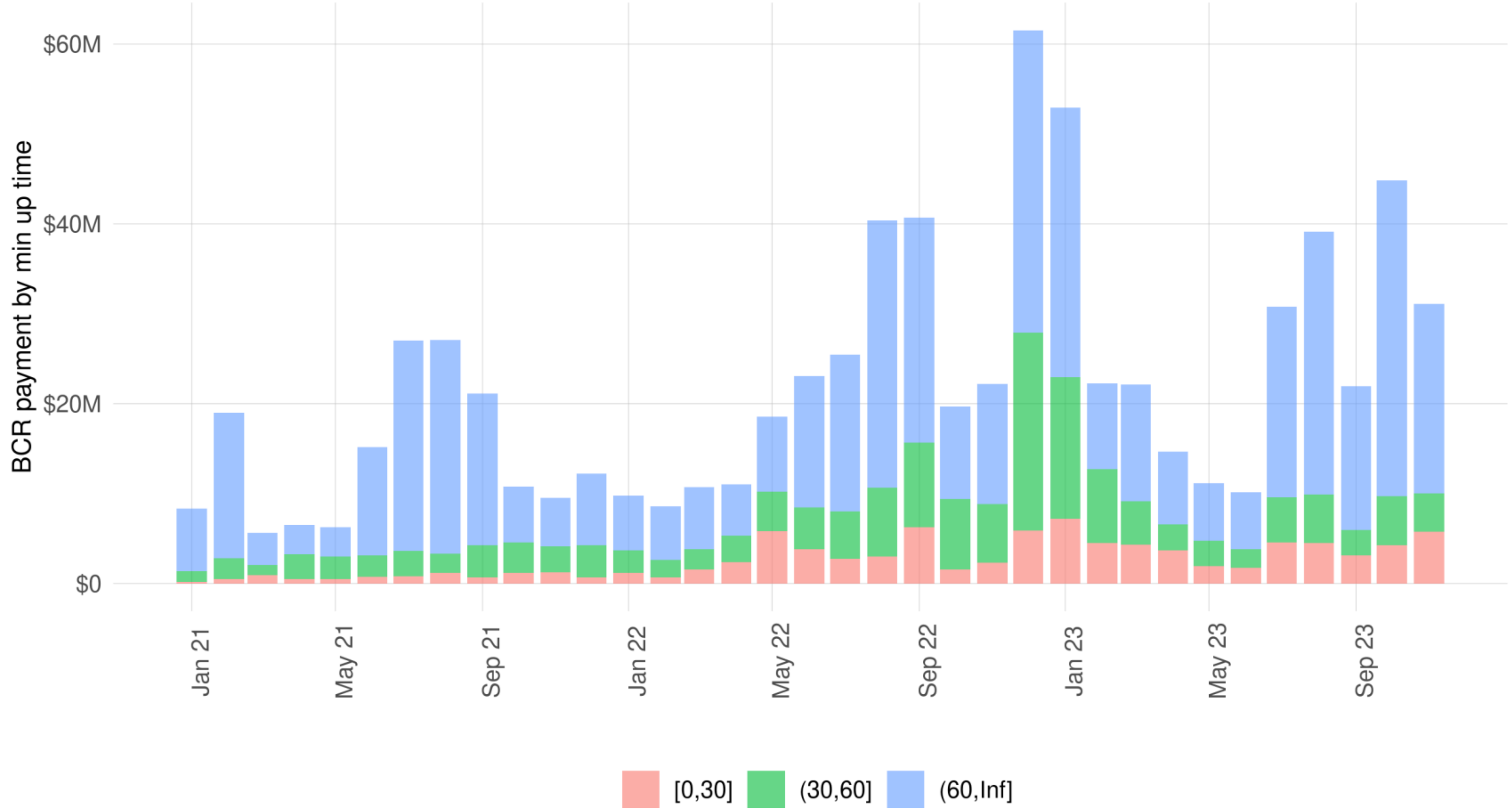
Gas-fired units are largely the main recipient of bid cost recovery



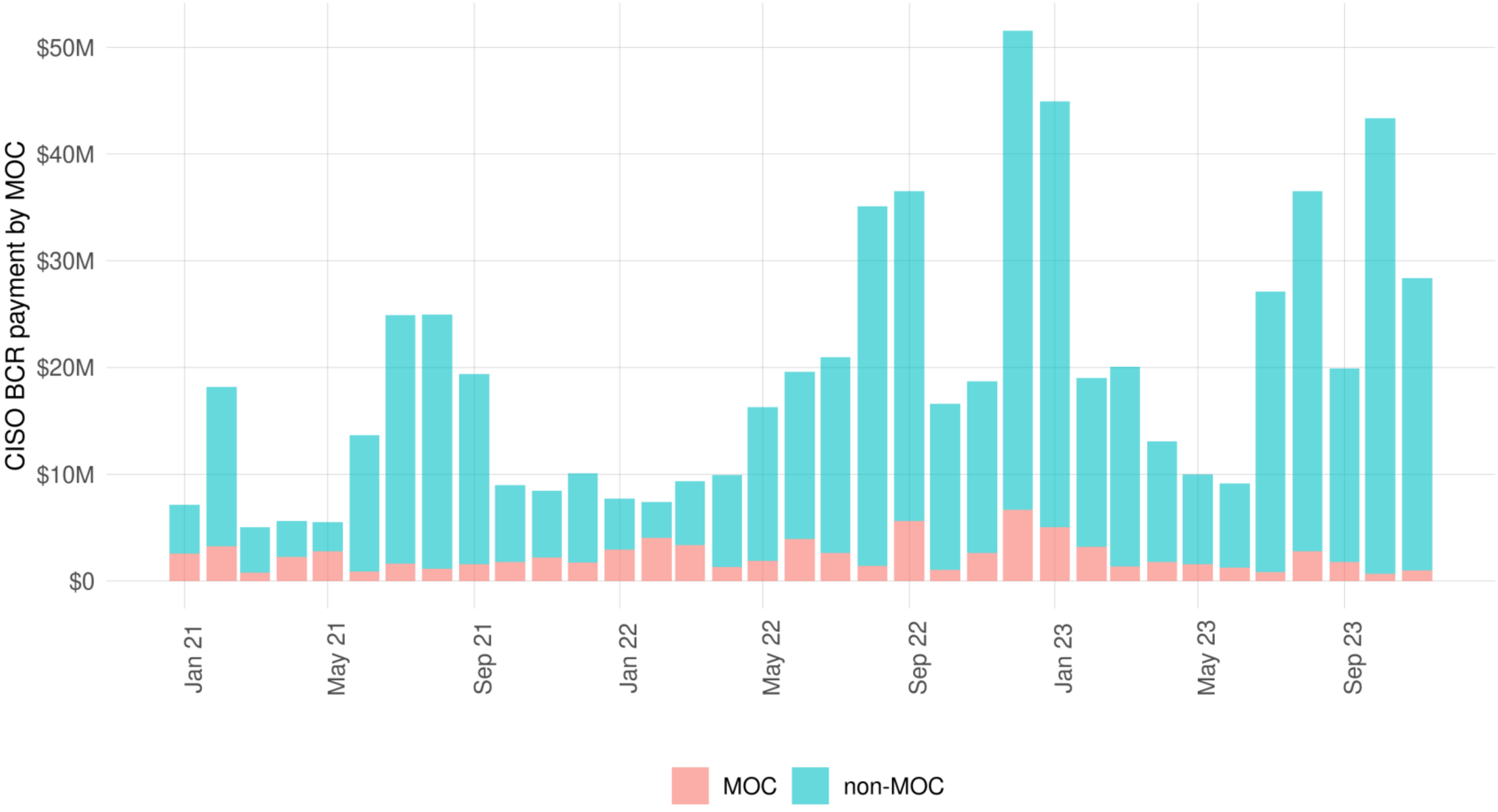
When organized by startup times, the bid cost recovery is more balanced across the different time ranges



The largest share of bid cost recovery is paid to units with minimum up times longer than an hour



Units associated with minimum-online constraints represent a relatively small share of the whole bid cost recovery



This metric only covers ISO area since minimum online commitments are currently applicable to ISO

Fast Start pricing

- It incorporates in some fashion commitment costs into the variable-range bids
- Cleared, and higher, prices will reflect these commitment costs
- Higher-cleared prices will reduce bid cost recovery to some extent for units dispatched uneconomically
- Standard approach relies on the market clearing engine consisting of two market passes:
  - scheduling run determines optimal commitment and dispatches used scheduling parameter to guide priorities
  - Pricing run estimates clean market prices reflecting economical signals
- Fast start pricing applies only in pricing run. It does not change the optimal commitment and dispatches

What are the basics to consider fast start pricing in the ISO market?

- How to amortize the commitment cost into the variable cost? This analysis explores two options,
  - constant and
  - average amortization

- How long the amortization should apply for? Only through the MUT?

- Should MLC continue to be amortized beyond MUT for as long as the unit is online?

- This analysis amortizes commitment costs only through the MUT

Illustration: Simplest amortization approach is a constant adder through the variable range

MLC=$5,000/hr
STUC=$2000 per start
MUT= 1 hr
Pmax=450 MW

A constant adder is estimated to reflect both MLC and STUC

$$\delta^e = \frac{\$2000 + \$5000}{450\ MW} = \$15.55/MWh$$

This adder applies to each segment of the market bid

First segment is extended to 0 MW to model unit with flexible start

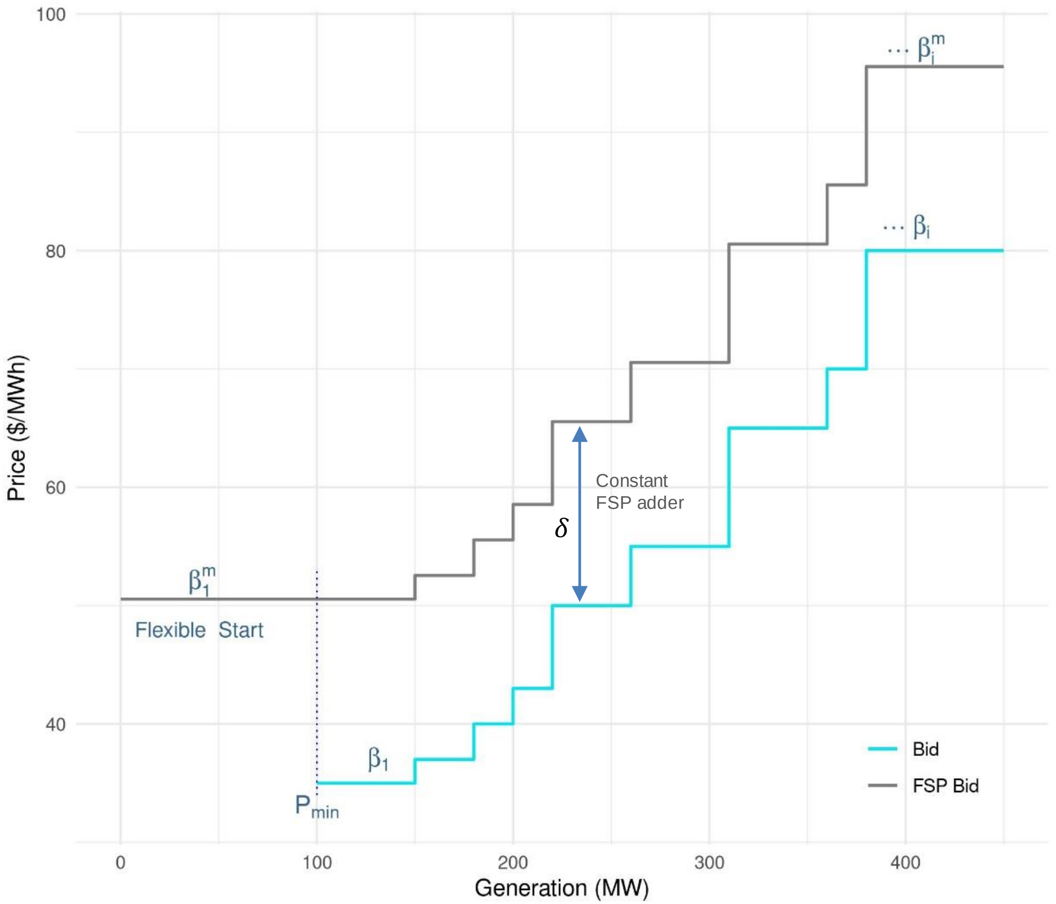


Illustration: Minimum averaged-cost is a different scheme to amortize commitment costs

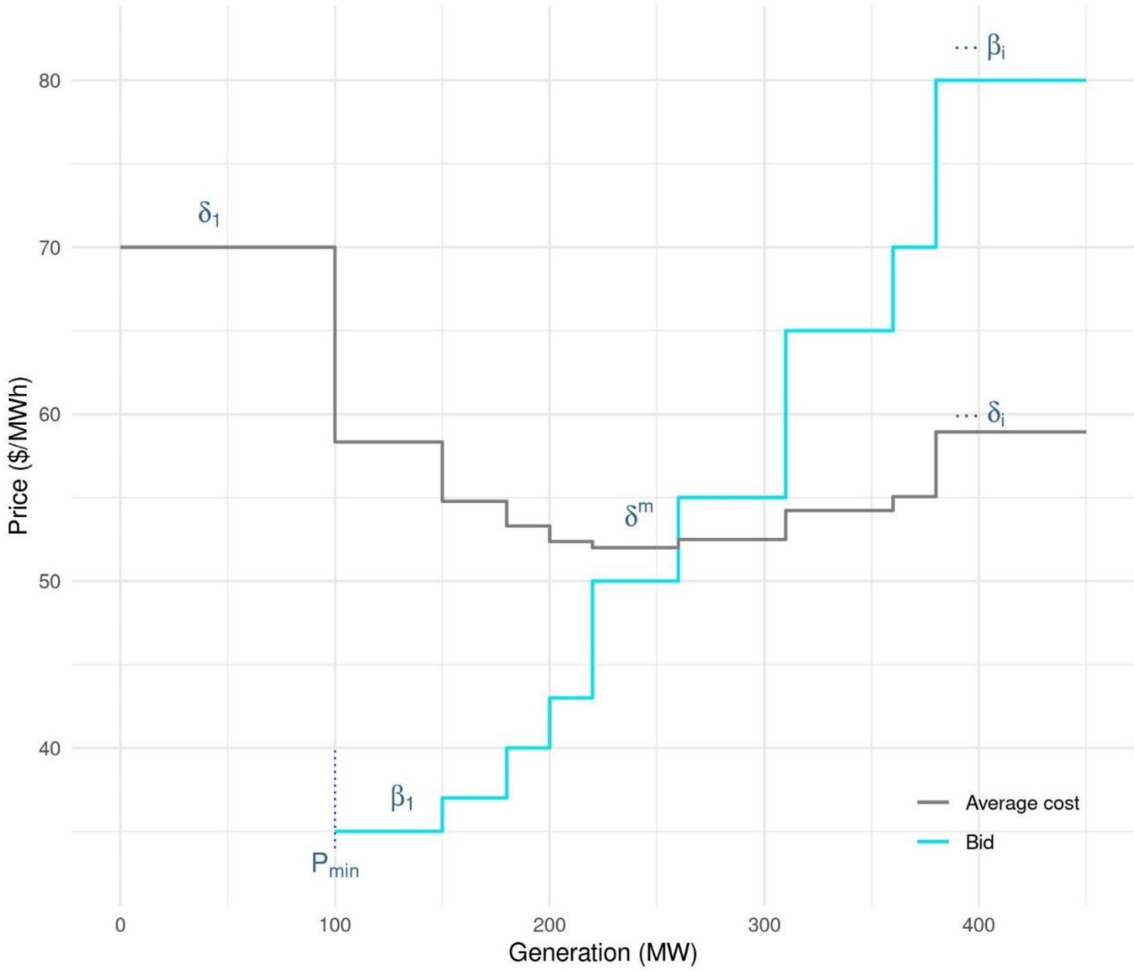
MLC=$5,000/hr
STUC=$2000 per start
MUT= 1 hr
Pmax=450 MW

Between 0 and 100 MW, MLC and STUC define the average cost at Pmin

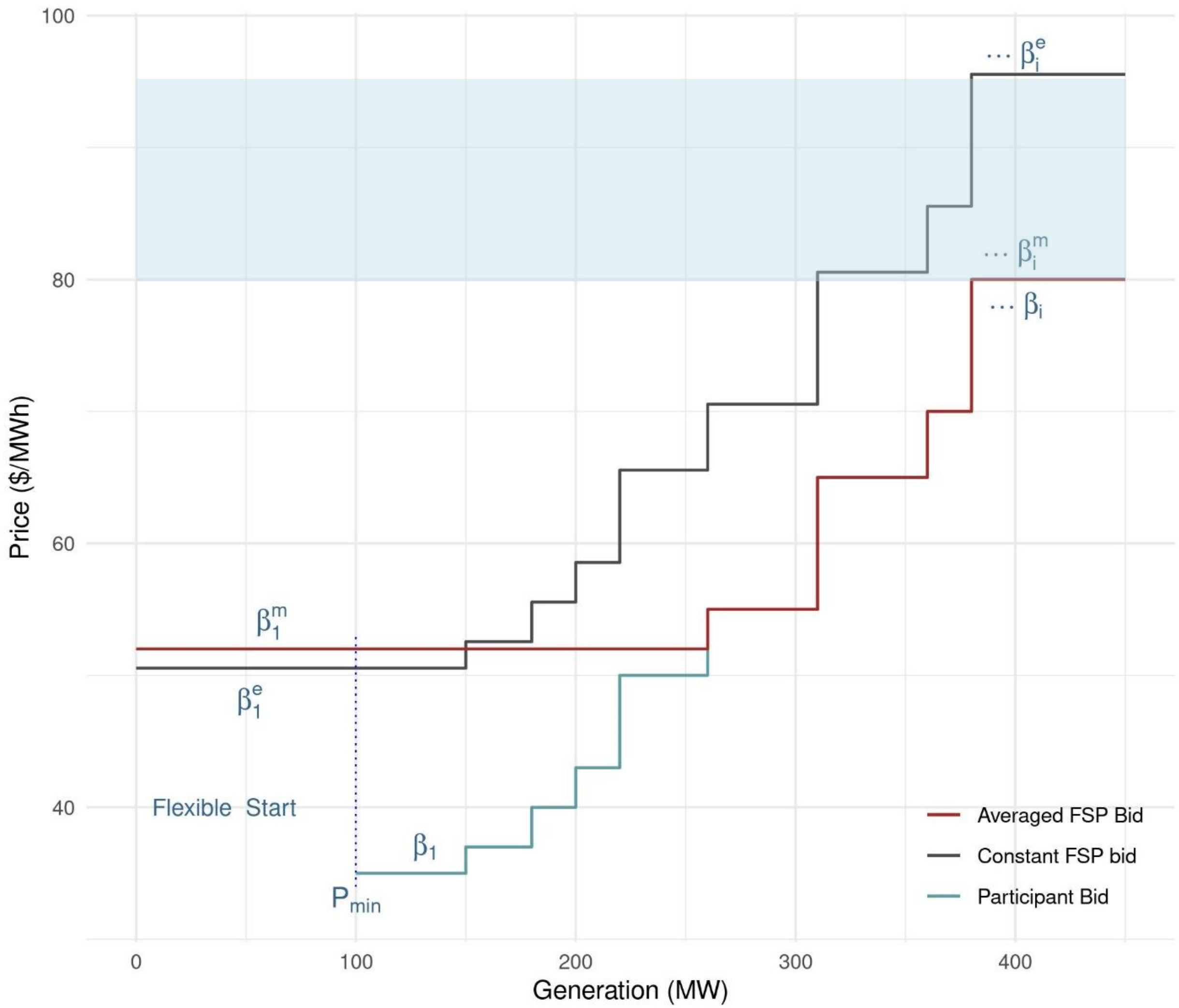
$$\delta_0 = \frac{\$2000+\$5000}{100\ MW} = \$70/MWh$$

Subsequent segments incorporate the cumulative variable cost

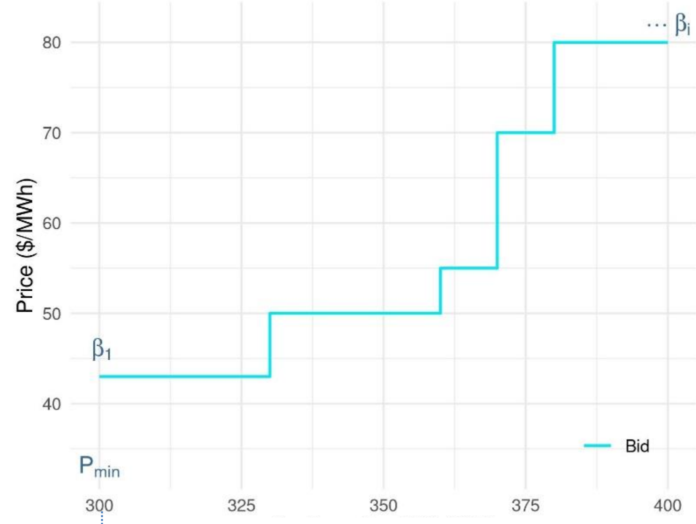
The resulting curve (in grey) will attain a minimum average cost

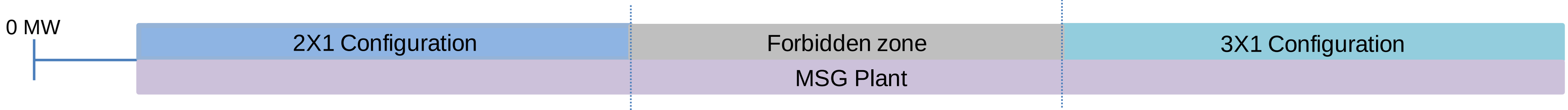


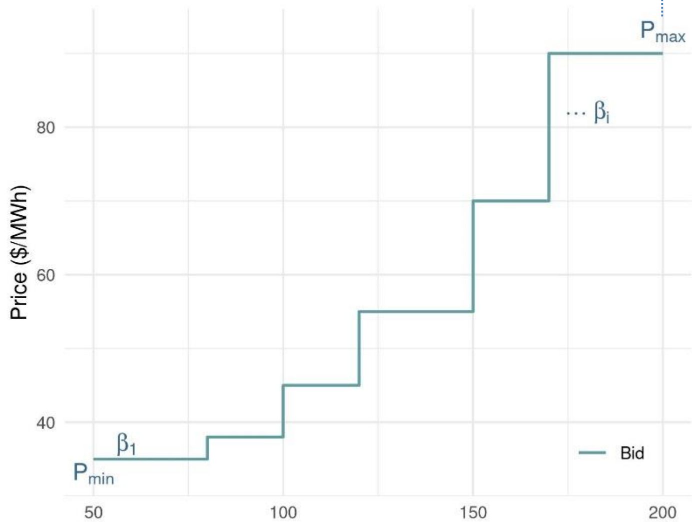
Constant amortization may tend to have higher-priced segments towards the end of the range than averaged-cost amortization



ISO's market has sophisticated multi-stage unit model for combined cycle plants, which involves transitions between configurations





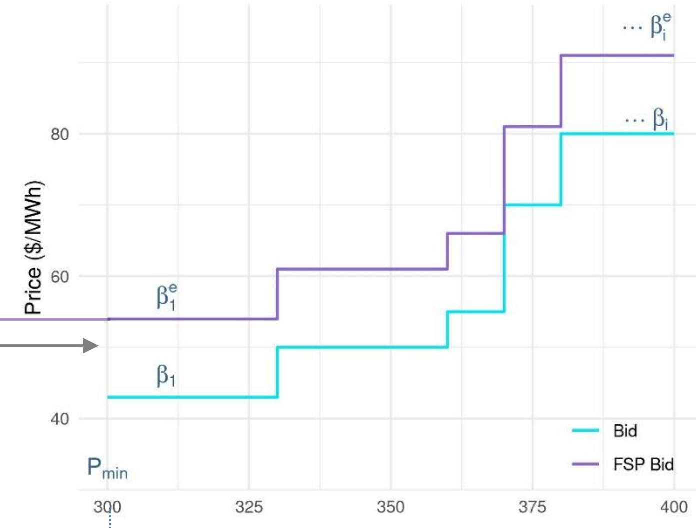


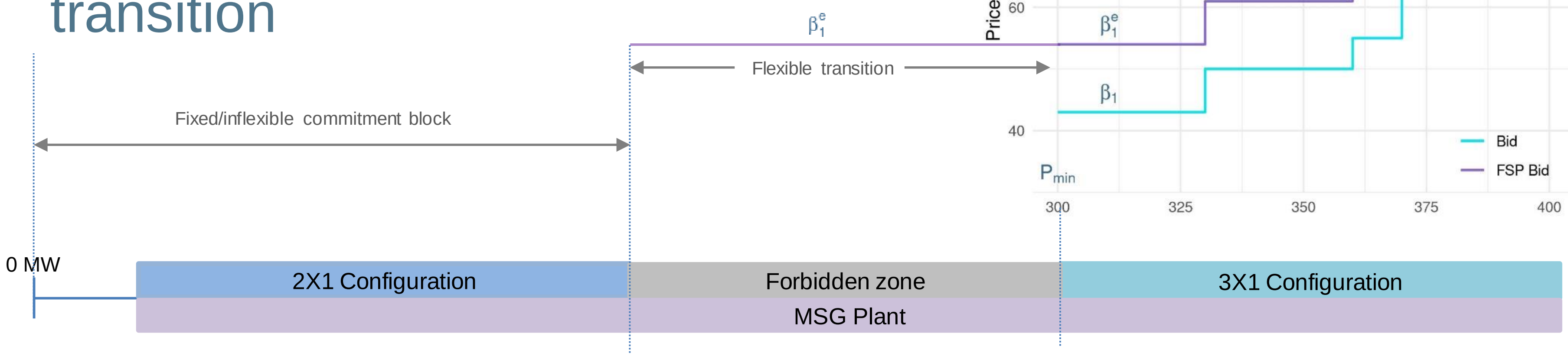
A transition involves the FROM and TO configurations

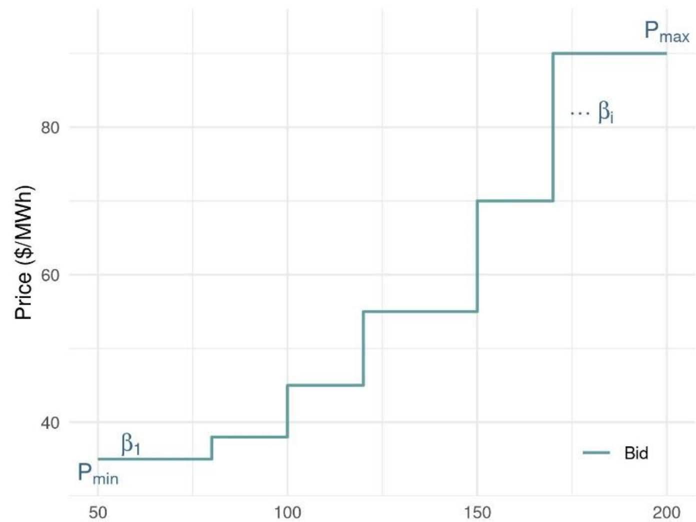
A transition involves discrete costs:
- transition costs
- change of MLC

Each configuration has its own MLC and MUT

Similar to startups, FSP can be applied to transitions by modelling it as a flexible transition







The natural extension of FSP is to bridge configurations between the forbidden zone to have a continuous bid range

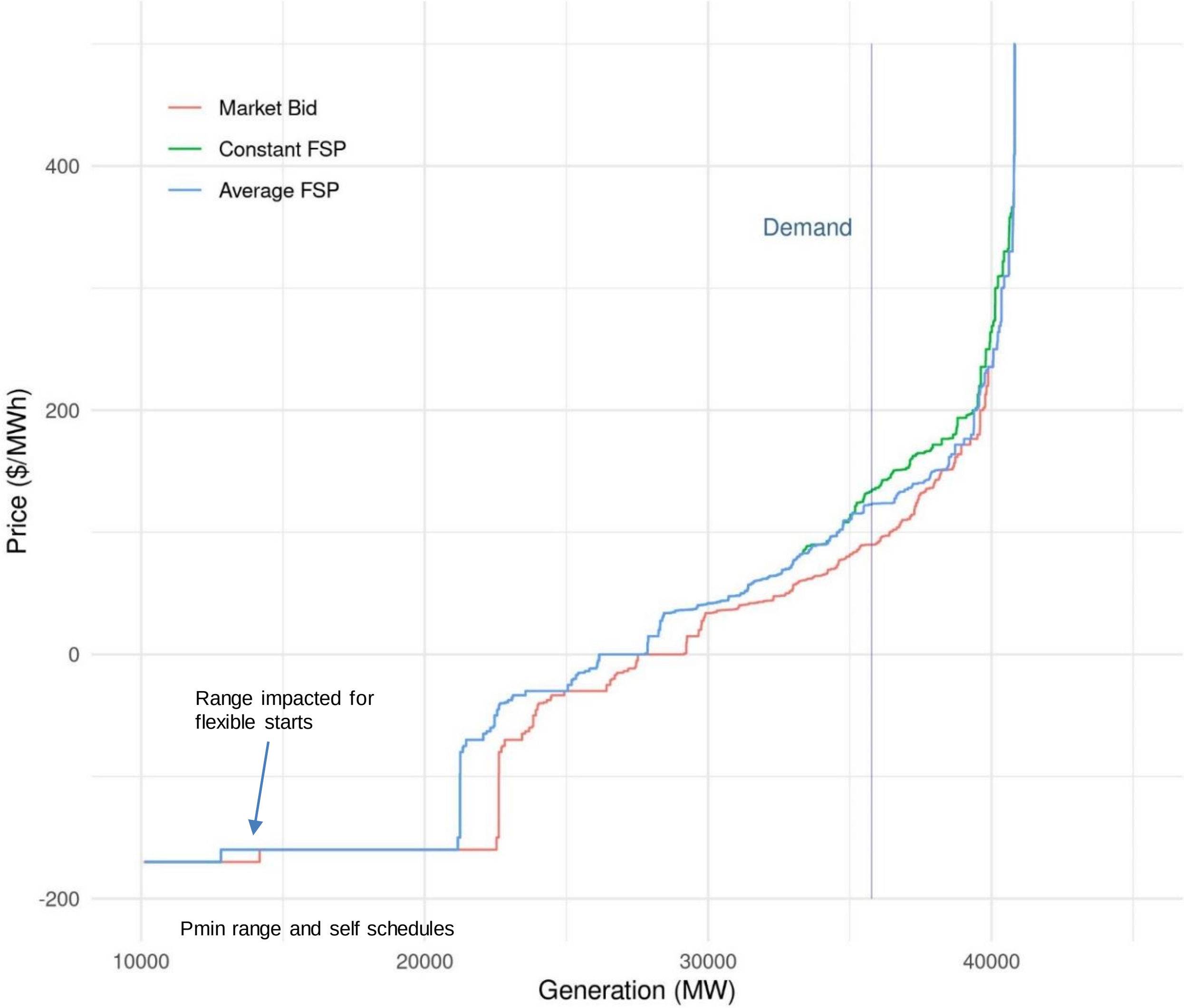
This requires to extend the first segment of the TO config down to the Pmax of the FROM config

The range from 0 MW to Pmax of the FROM config is modelled as fixed as it is not dispatchable

There are more nuances when applying FSP to MSG units

- ISO's model allows for overlapping configurations; in these scenarios, the analysis considers that there is no range for flexible transition
- Transition costs and MLC of the TO configuration are amortized in the variable-cost bid of the TO configuration
- The definition of fast transition unit can be based on both the transition time and MUT
- Upward transitions are the natural extensions of fast startups;
  - Downward transitions are not an obvious natural extension of FSP
  - Potentially, only MLC can be amortized in the TO configuration
  - This analysis did not apply any processing to downward transitions

With bids adjusted for higher prices, the FSP logic shifts the supply stack. Illustration of October 19, 2023. HE18



The intersect of the vertical demand curve with each of the supply bids define the market clearing price for each scenario

Supply and demand considerations

The FSP analysis uses the following power balance

$$G + I + X^I = D + E + PS + \zeta + X^E + \phi$$

where:

G Internal supply

I , E Imports and exports transactions

X^I, X^E Transfers in and out of CAISO area

PS Demand from pumps

ζ Transmission losses

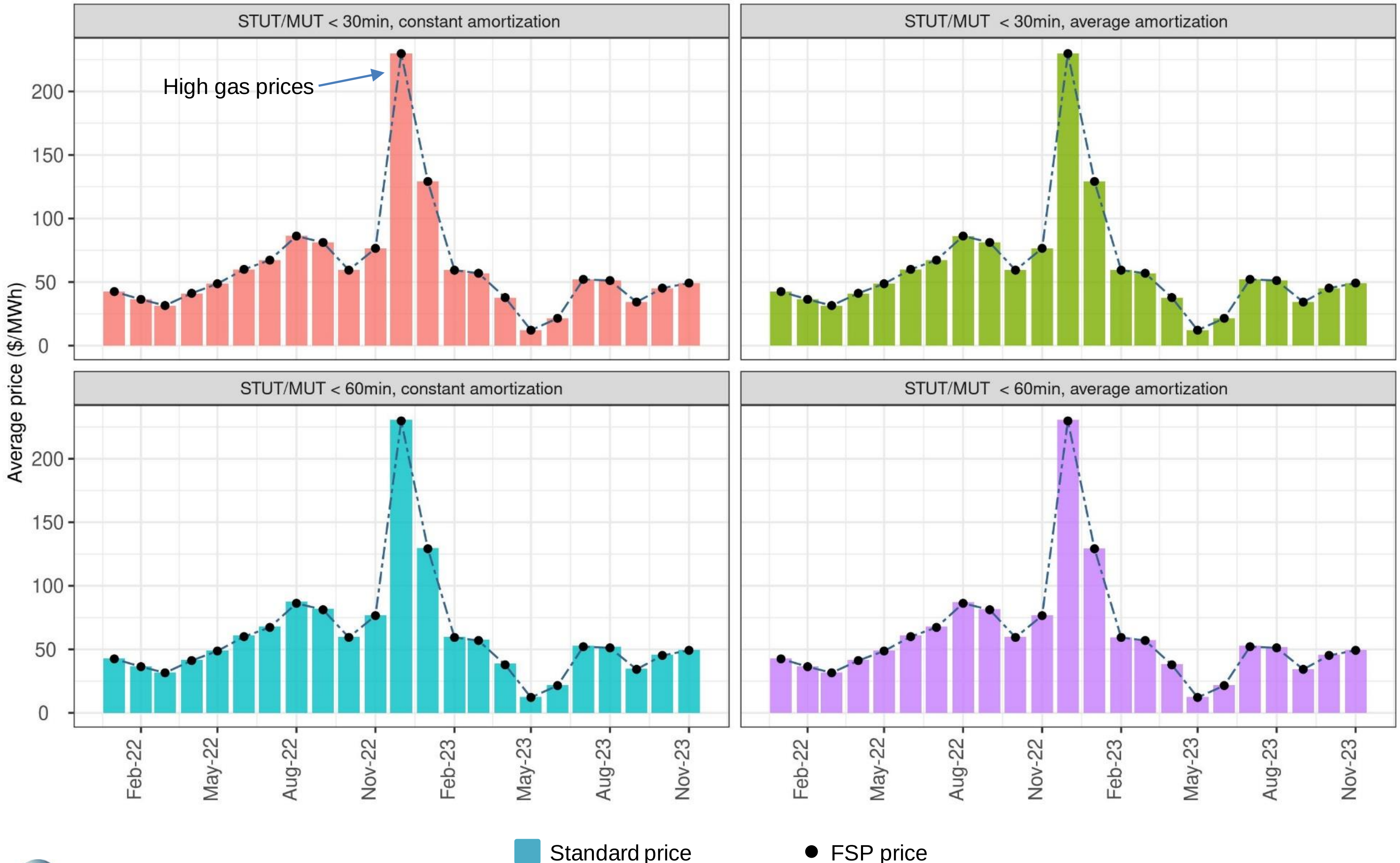
ϕ Load conformance

- In this way, the effect of WEIM is incorporated into each area by using the optimal transfers
- In FMM, hourly intertie transactions are not cleared nor priced; they were cleared in HASP

Consideration of minimum online constraints

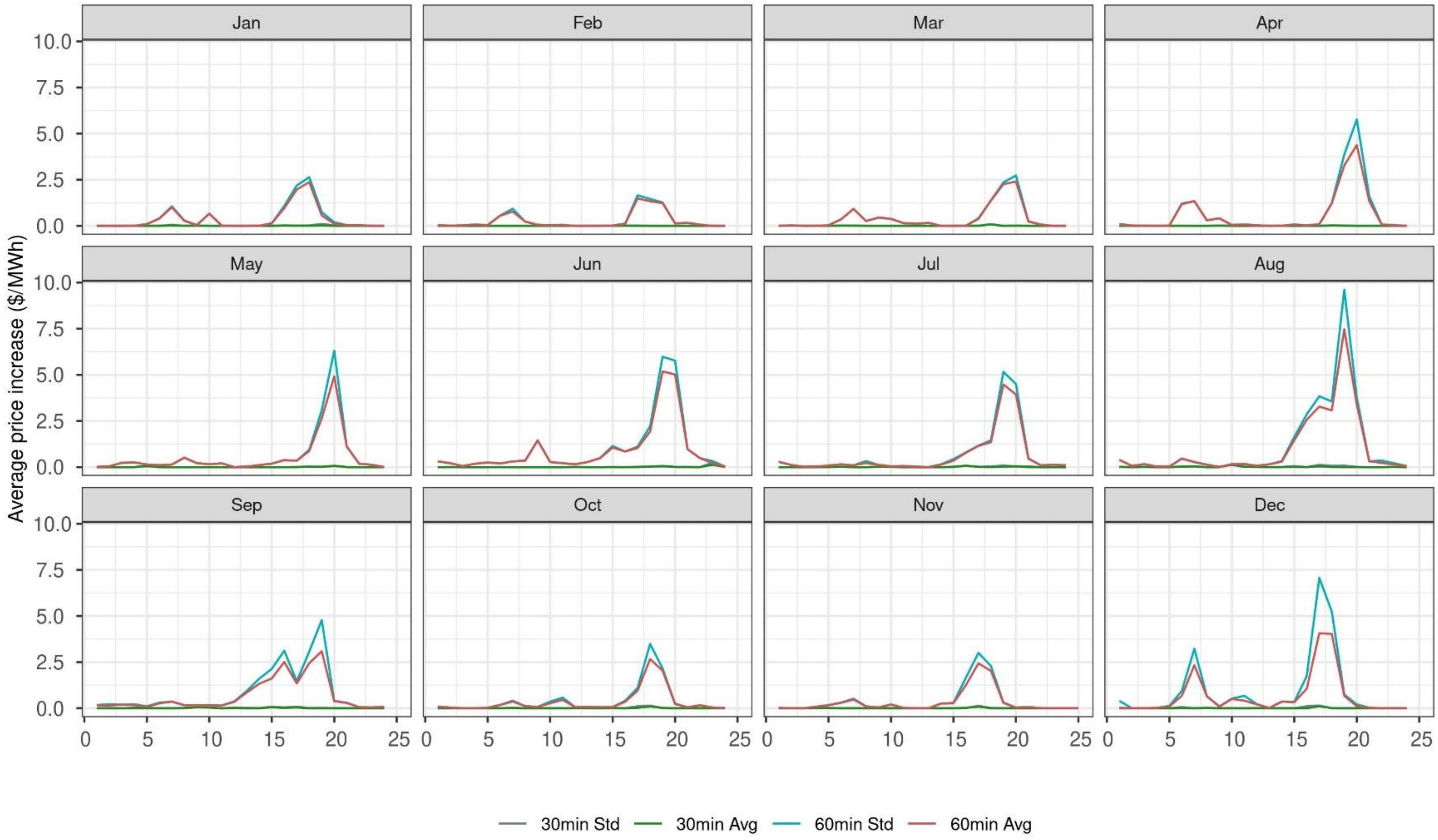
- Based on operating procedures, there may be requirements of minimum online capacity for a defined area
- In order to reduce manual exceptional dispatches, ISO uses minimum online constraints
- These constraints are defined in terms of minimum online capacity based on the Pmax of resources
- MOCs are currently enforced as needed in the day-ahead market; they are not enforced in real-time
- Even if fast start resources were used in the DAM constraint, they will be re-optimized in real-time
- Whether a unit is part of an MOC is not relevant in the real-time market and can therefore be considered for FSP

Prices formed with fast start pricing exhibit on average minor increases relative to non-FSP prices

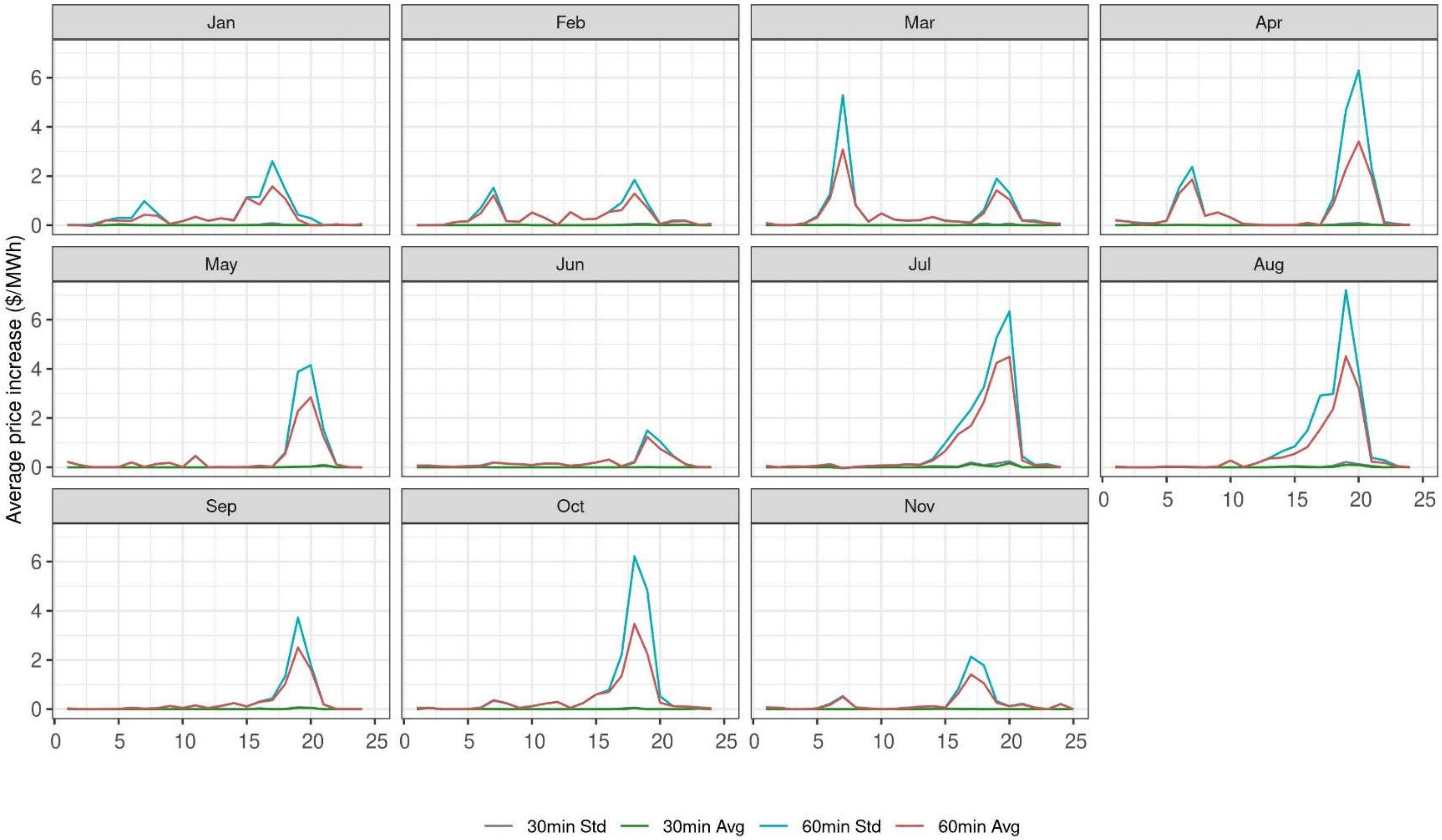


On average, price increases with FSP are under 1$/MWh when applicable to resources with up to 60 minutes

FSP prices tend to increase during peak hours when resources are started or transitioned up. Year 2022



FSP prices tend to increase during peak hours when resources are started or transitioned up (year 2023)



Incremental costs when using FSP varies widely based on system conditions, and averages between \$13.5 and \$10.5 million per month

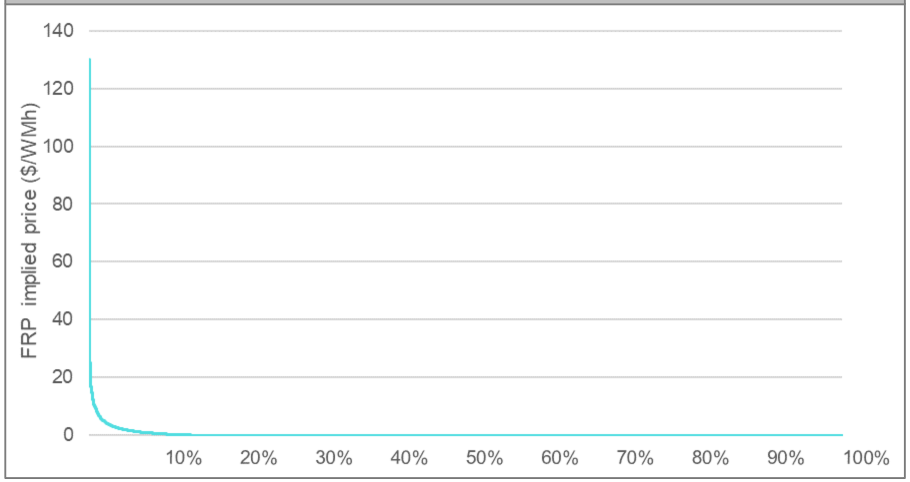
This metric is based on absolute costs (total demand times clearing price).
Actual settlements is based on two-step calculation using differences between DA and RTM

Consideration of flexible ramp capacity yields non-zero prices in less than 10 percent of intervals

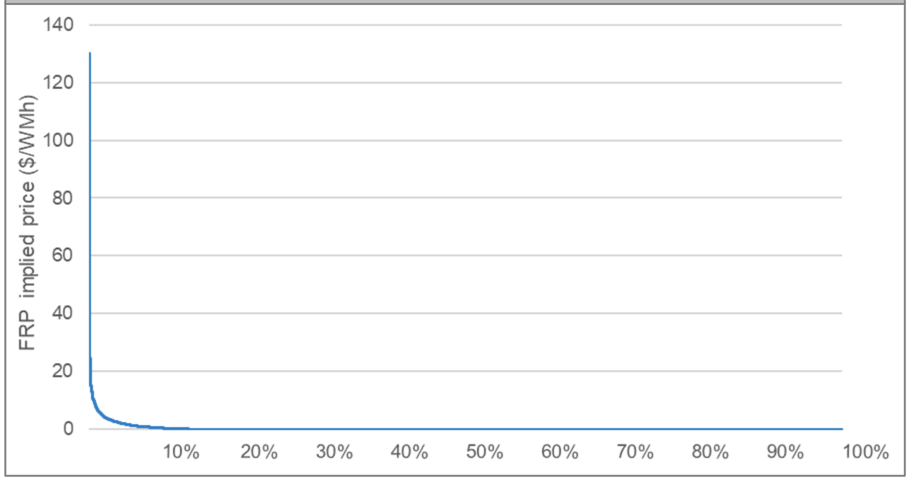
FRP product enhancements went into effect on February 1, 2023. This data covers Feb-Nov 2023

The flow frequency of non-zero prices in the FSP analysis aligns with actual production trends

STUC/MUT<60 min. Constant Amortization



STUC/MUT<60 min. Average Amortization



Next steps

- First stage of analysis focused on building the foundational components
- Next stage is to assess all WEIM areas
- Analyze on further cost implications
- Assess and incorporate participant's feedback

Appendix

Scenario 1: Constant amortization derives a single adder that applies to each segment of the variable-cost bid

Given:

MUT: Minimum up time (minutes)

$STUC$: Startup cost in ($ per start)

MLC: Minimum load cost ($/MWh)

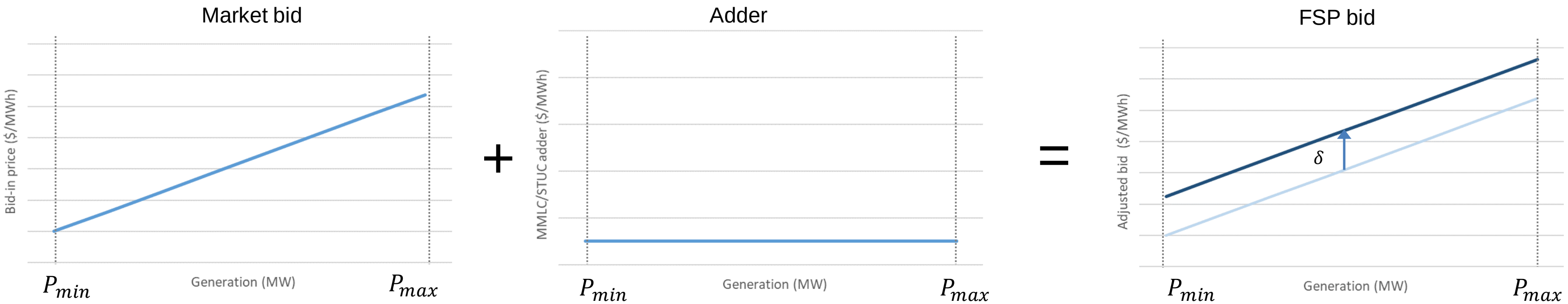
Δt: Market interval; FMM=15 min

All elements are parameters and therefore the adder δ is constant

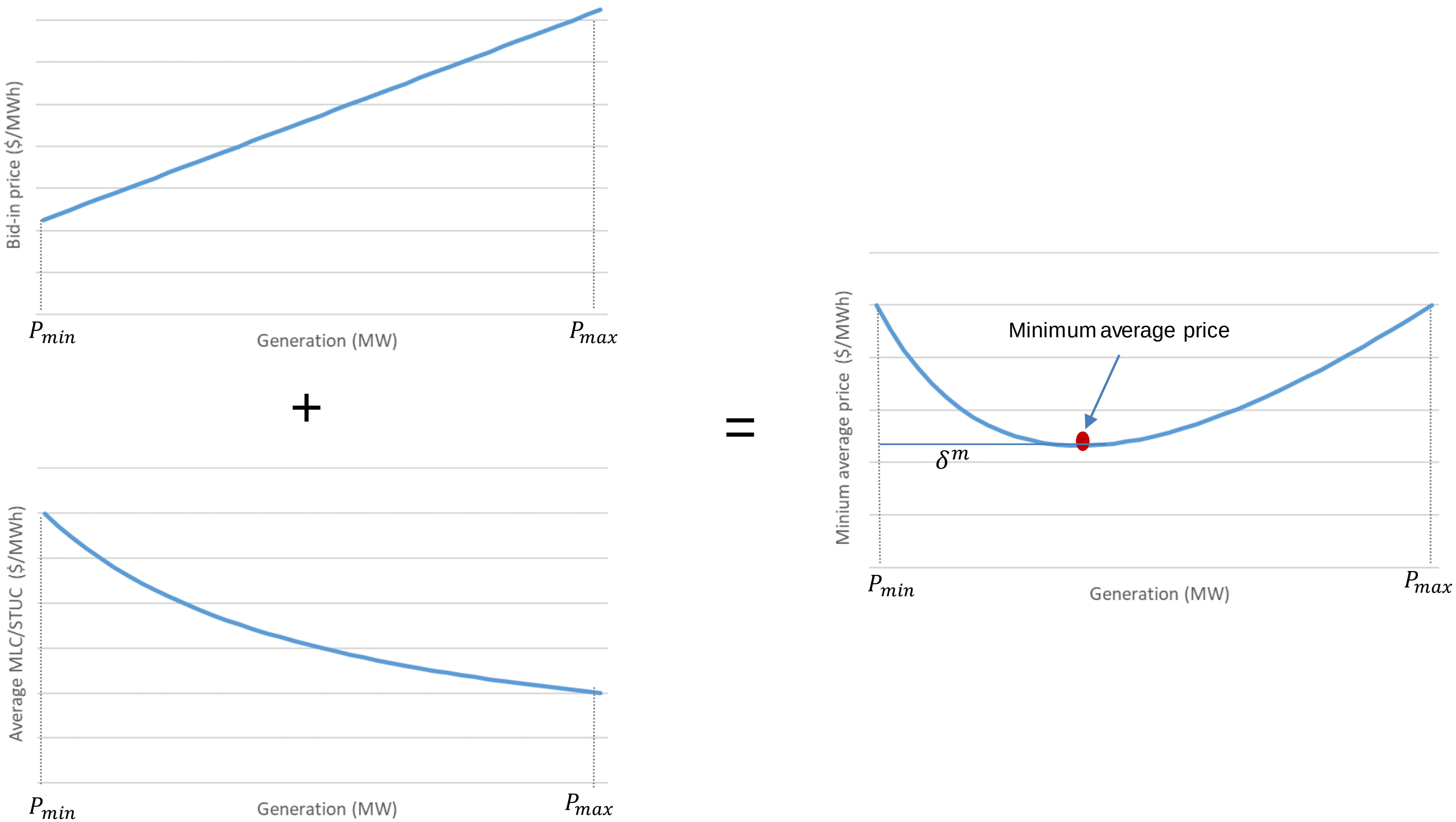
MUT is rounded up to # of intervals

If MUT=0 then STUC is amortized in 1 interval

The FSP adder is
$$\delta = \frac{MLC}{P_{max}} + \frac{STUC}{\frac{\Delta t}{60} max\left\{1, \left\lceil \frac{MUT}{\Delta t} \right\rceil\right\} P_{max}}$$



The minimum average price defines the breaking point for the adjusted bid



Scenario II: Average amortization relies on the least average-cost across the variable range

Average cost at segment i

$$\psi_i = STUC + \left\{MLC + \sum_{k=1}^{i}(p_k - p_{k-1})\beta_k\right\}\frac{\Delta t}{60} max\left\{1, \left\lceil\frac{MUT}{\Delta t}\right\rceil\right\}$$

where

β_i is the bid-in price for segment i

p_i is the i-*th* generation break point of the step-wise bid

This yields the minimum average price as

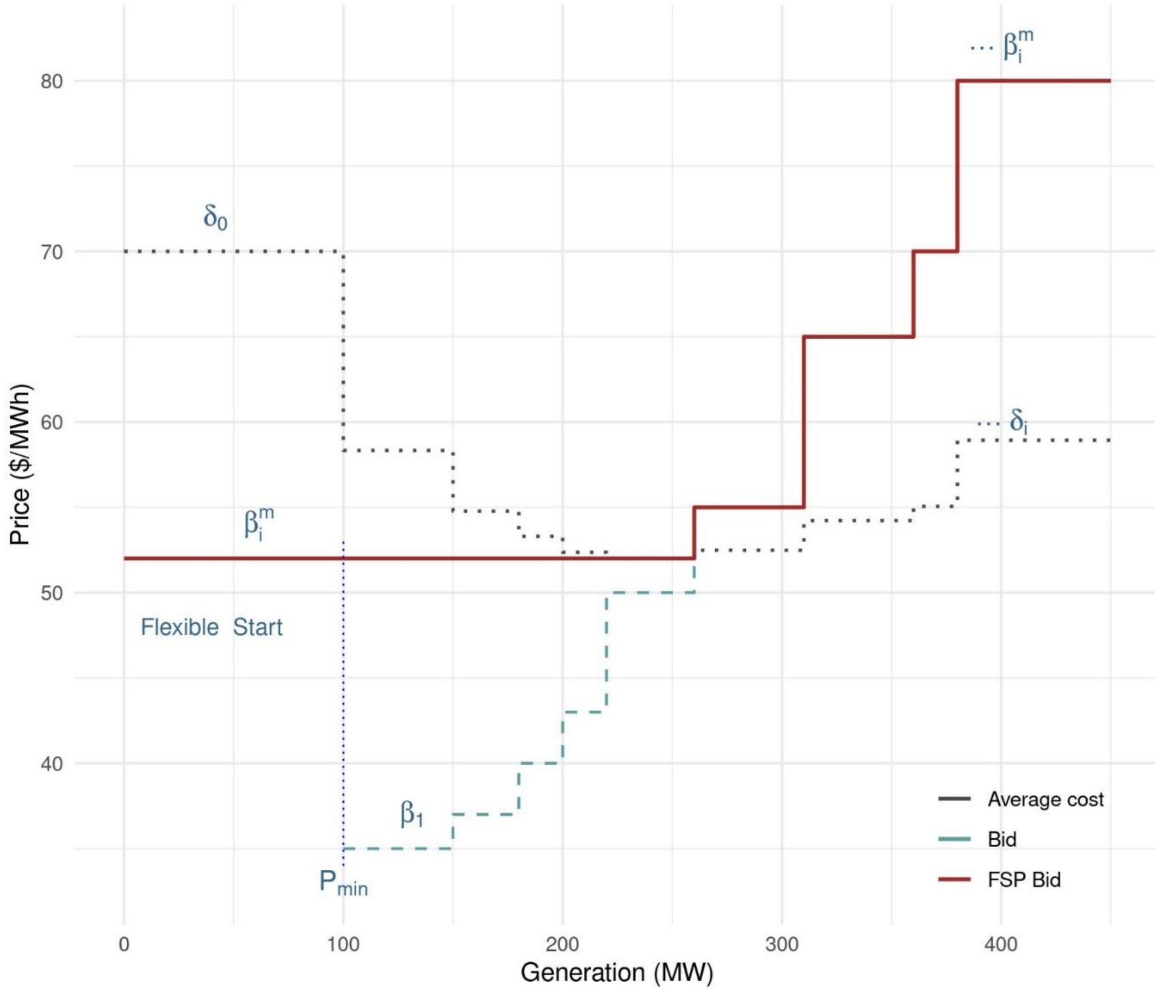
$$\delta^m = \min_{p_i^*} \frac{\psi_i}{\frac{\Delta t}{60} max\left\{1, \left\lceil\frac{MUT}{\Delta t}\right\rceil\right\} p_i}$$

This cost is estimated at each generation segment rather than only at Pmax

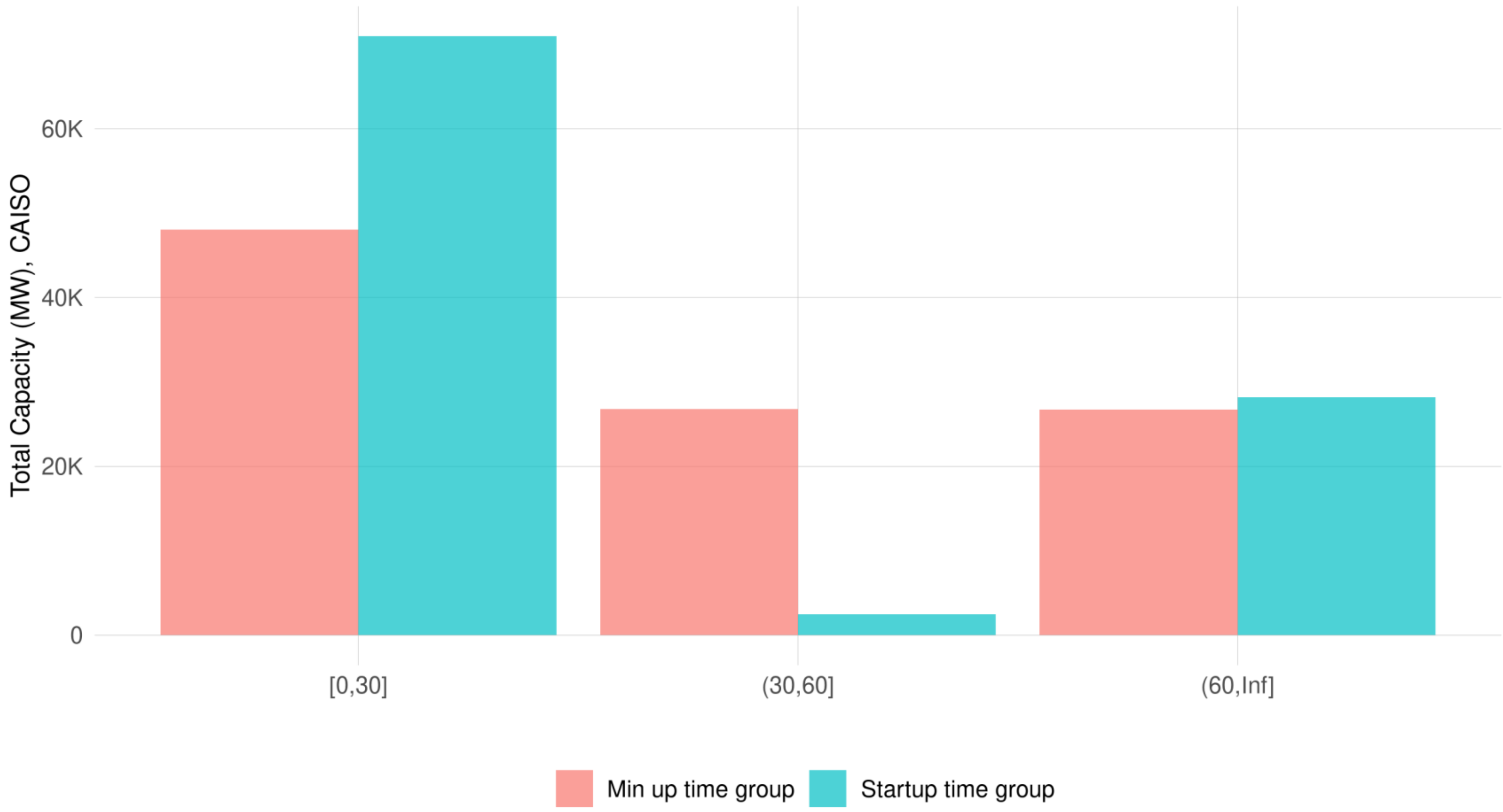
The minimum average cost defines the first segment of the adjusted bid curve

The minimum average cost extends to the left up to 0 MW and covers the flexible startup range up to Pmin

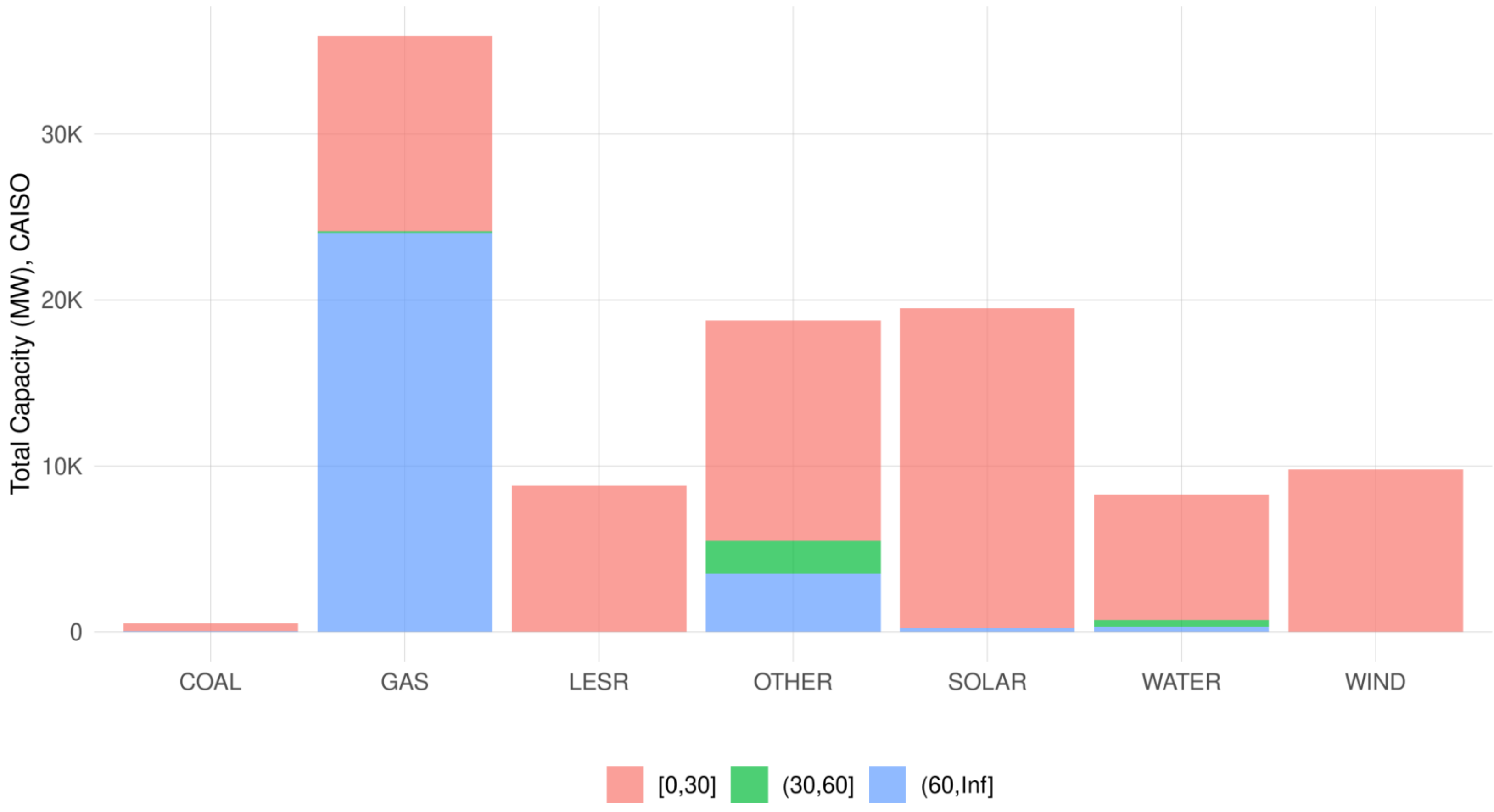
Segments to the right of the minimum-cost segment use the original bid curve



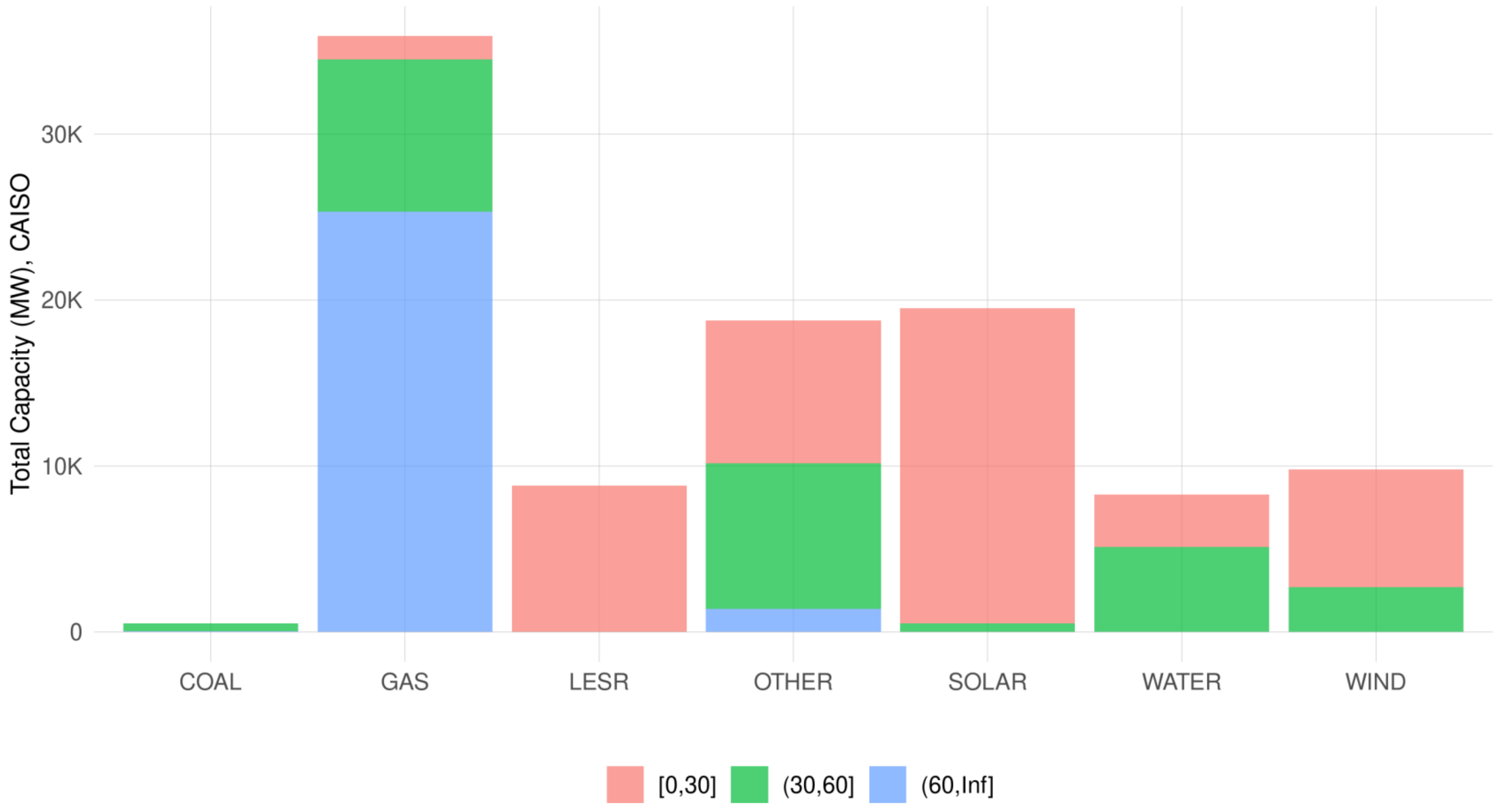
Installed capacity by min up time, startup time for ISO area (no imports)



Installed capacity by startup time in ISO area and organized by resource type



Installed capacity by min up time in ISO area and organized by resource type



Installed capacity by both startup time and min up time ISO Aggregated resource types