FEBRUARY 22, 2017

SCL Western-EIM Benefits Analysis

OVERVIEW

City Light is considering joining the CAISO-run Energy Imbalance Market (EIM).

Consulting firm Energy & Environmental Economics (E3) did a "first cut" analysis in Spring 2016 that yielded a gross revenue range of $4 MM - $23 MM per year.

City Council requested "a detailed analysis of costs, benefits, and potential risks of participation in the CAISO EIM" (Ordinance 125176, passed October 31, 2016).

Accordingly, Risk Oversight Division has independently simulated over 200 scenarios utilizing 2 different modeling approaches to provide management and City Council with a range of possible revenue outcomes.

As with any modeling exercise involving a new market, there is significant uncertainty around outcomes and revenues. The purpose of Risk Oversight's modeling is simply to provide order of magnitude of the possible outcomes, not precise and specific forecasts. The results here should be used as references and guides.

The modeling approach is discussed at a high level in the following pages and technical details are available with Risk Oversight.

MODEL 1: ENHANCED E3 MODEL

The enhanced E3 model includes 2016 price and hydro data as well as market operations in addition to the 2015 data used by E3.

The E3 model is a Linear Optimization that maximizes revenue for a given price stream. It simulated the revenues City Light could have realized in 2015 had it been participating in EIM. Like any model, it has advantages and disadvantages.

On one hand, the well-known advantages are that it is fast and works with defined parameters, e.g., it uses known historical prices and hydro levels, reducing uncertainty around price and City Light volumes.

On the other hand, well-understood disadvantages are that it assumes perfect market price foresight, perfect liquidity/market depth for a given market size (e.g., market always ready to buy/sell up to 300 MW) and no need to bid into the market.

In addition to adding 2016 data to the analysis, Risk Oversight staff introduced two elements of market operations while holding other elements constant to enhance the E3 model framework:

- Simulate City Light submitting bids into the market, as would occur under EIM market participation. Bids were anchored to the Mid-C daily price. The amount bought/sold at any point would depend on the EIM price and City Light's bids. E.g., if City Light offered to sell 100 MW at $25 for a given hour and all the 5-minute and 15-minute prices in that hour were $20, City Light would sell 0 MW.

- In order to address the issue of market depth and resource availability in any given hour, the amount bought/sold in any given period was varied utilizing a random process, as would occur in the market, and the market depth was constrained with varying degrees of market depth assumptions. For example, even if market depth was, say, 300MW in any given hour, City Light may not have the resources to sell that much quantity to take advantage of the available depth and thereby fully benefit from such market imbalance. Similarly, if City Light offered to sell 300 MW into the market for a given hour, the market depth may be only 100 MW, once again constraining the potential benefits.

Elements which Risk Oversight did not change from the original E3 study were:

- Continued to assume that City Light has some market price foresight and City Light's fleet has extremely high ramping capacity.

- Continued to use historical prices at Chehalis (EIM) and Mid-C.

Risk Oversight staff ran the model for 114 scenarios, encompassing 4 different levels of market depth (100 MW, 150 MW, 200 MW and 300MW) and a wide range of hourly sales (25-300 MW). Such scenarios consisted of revenues for all 12 months for the years 2015 and 2016 and producing hourly transaction distributions.

The model design allowed for flexibility to incorporate a wide range of possibilities, from pure intraday arbitrage (0 MWh net sales on day) to trying to sell as much surplus as possible into EIM (subject to market depth and hourly sales limits).

RESULTS

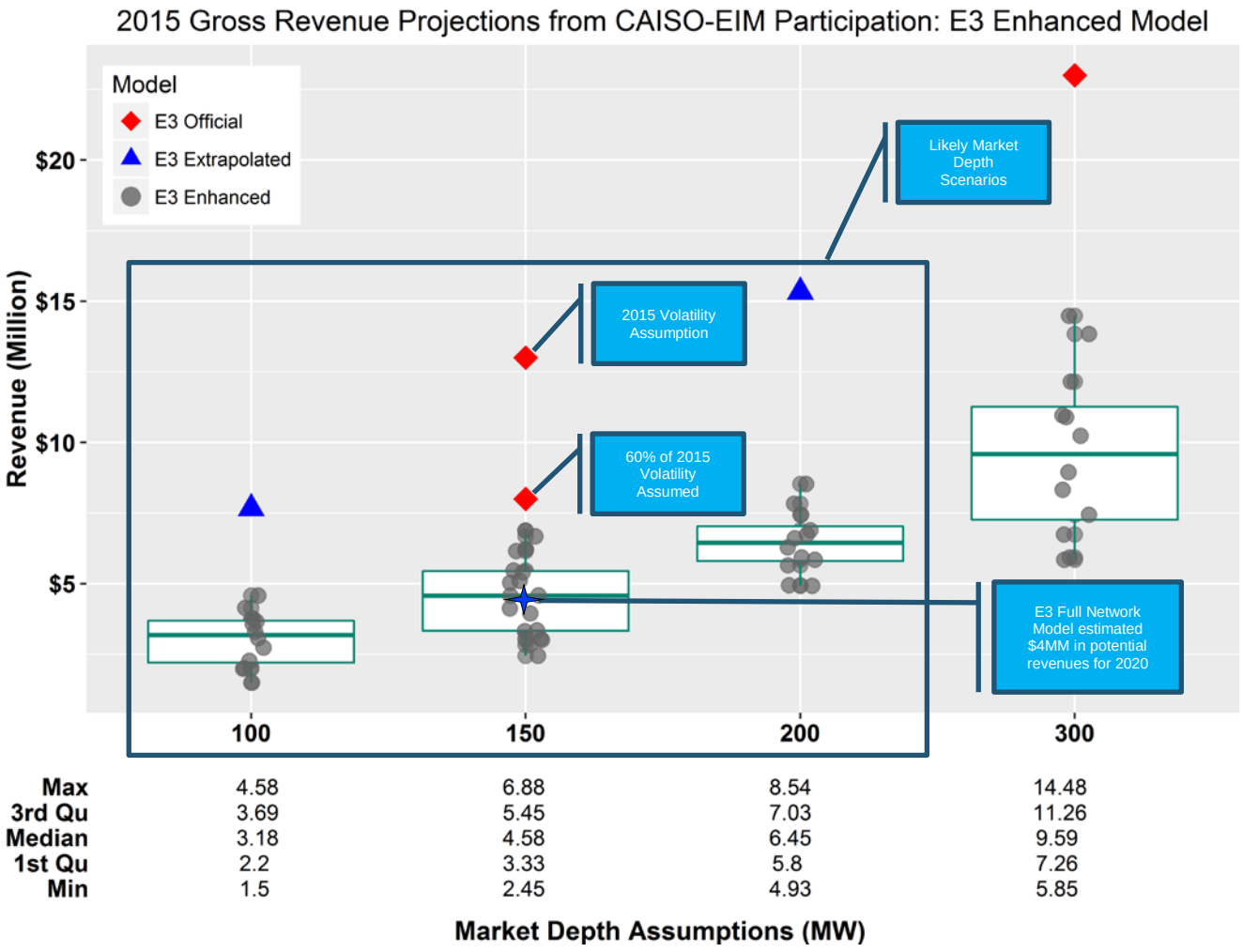
Risk Oversight verified its model output matched E3's estimates for 2015 before introducing the stated enhancements to market operations (bids and varying hourly sales).

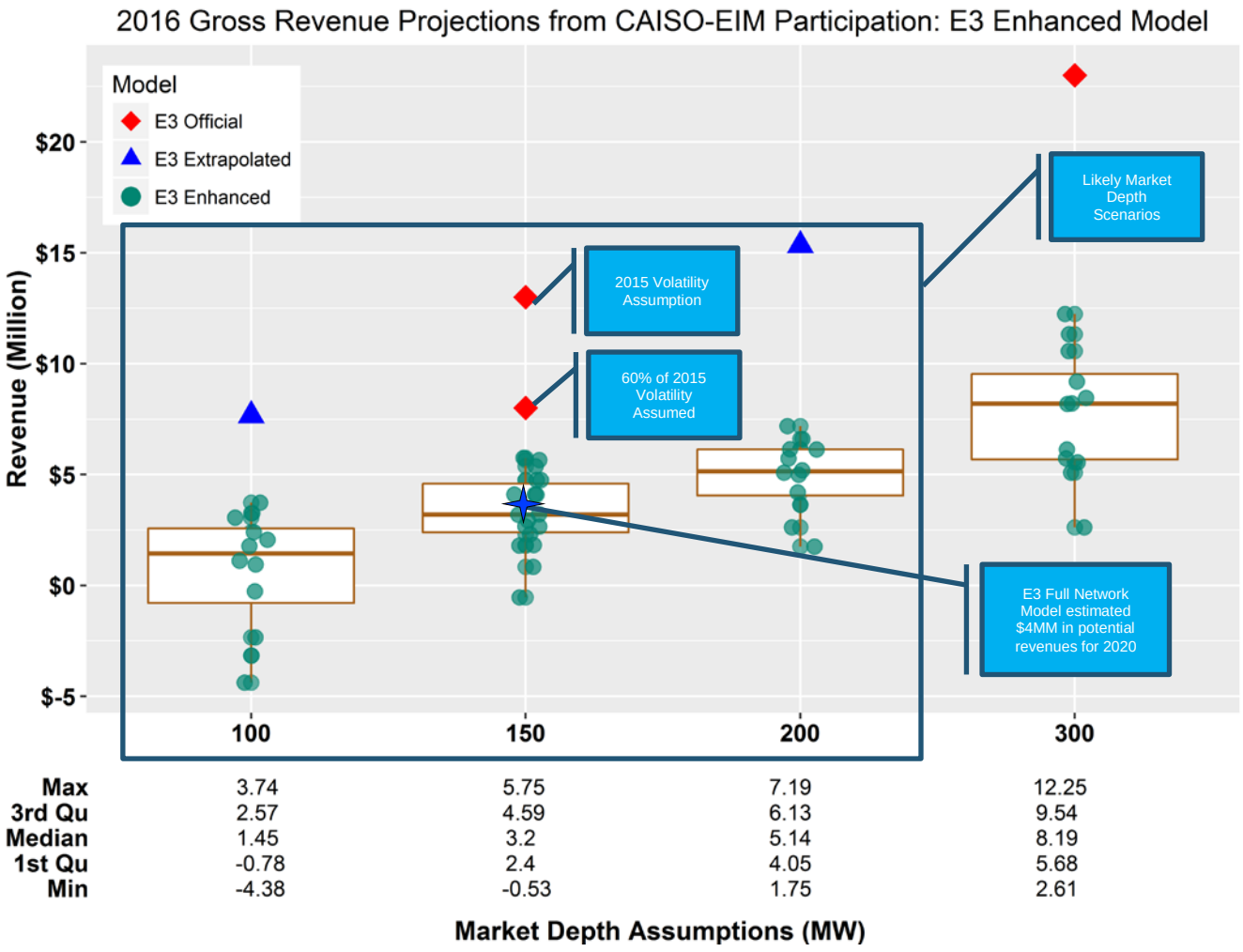
To the extent the entire wholesale surplus/deficit could not be transacted in EIM on a given day, the model assumed any remaining shortfall/excess was covered in the Real-time Mid-C market the next day (Hour Ending 1-8).

EIM requires all participants to enter each hour balanced. Deviations from that balanced situation are handled in EIM. Based on the last two years of data, the EIM market did not exhibit the capacity to absorb a large surplus/shortfall (that is, greater than 200MW) except on rare occasions. As with any market, this figure can change in the future based on the characteristics of the load and variable generation mix in the CAISO-EIM footprint.

Revenues were calculated as Incremental Revenues over Mid-C. The charts on the following two pages show EIM revenues for 2015 and 2016 scenarios. These revenues ranged from $1.5 MM to $14.5 MM and $(4.4) MM to $12.3 MM, respectively, for the two years. For comparison, E3 estimates ranged from $8 MM to $23 MM and their Full Network model for the year 2020 projected a potential benefit of $4 MM. These are also shown in the following charts as reference.

As can be noted, revenues generally scaled with quantity transacted (a function of market depth and resource availability). Some scenarios resulted in negative revenues owing to the cost of liquidating the excess/shortfall at Mid-C.


2015 Gross Revenue Projections from CAISO-EIM Participation: E3 Enhanced Model
Model
E3 Official
E3 Extrapolated
E3 Enhanced
Likely Market Depth Scenarios
2015 Volatility Assumption
60% of 2015 Volatility Assumed
E3 Full Network Model estimated $4MM in potential revenues for 2020
Revenue (Million)
$20
$15
$10
$5
100
150
200
300
Max 4.58 6.88 8.54 14.48
3rd Qu 3.69 5.45 7.03 11.26
Median 3.18 4.58 6.45 9.59
1st Qu 2.2 3.33 5.8 7.26
Min 1.5 2.45 4.93 5.85
Market Depth Assumptions (MW)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Revenue (Million)
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100
150
200
300
Max 3.74 5.75 7.19 12.25
3rd Qu 2.57 4.59 6.13 9.54
Median 1.45 3.2 5.14 8.19
1st Qu -0.78 2.4 4.05 5.68
Min -4.38 -0.53 1.75 2.61
Market Depth Assumptions (MW)

MODEL 2: HOURLY TRADING APPROACH

To provide an alternate view of potential revenues from EIM participation, Risk Oversight stepped outside the E3 modeling framework to create a simple hourly trading model. The primary goal was to eliminate the perfect price foresight issue.

This model looks at Mid-C prices for a given hour and bids into EIM for that hour based on surplus availability and Mid-C price. The model sequentially steps through hours, starting at midnight, instead of targeting the most attractive hours of the day.

For example, if Mid-C is trading at $25 for Hour Ending (HE) 10, the model offers to buy from EIM at $22 and sell to EIM at $28 in HE 10. (Illustrative bids. The model makes 3 bids to buy and 3 offers to sell.) Bids clear based on EIM prices in the 15-minute and 5-minute markets. If a bid clears, the daily surplus is adjusted accordingly and the model proceeds to the next hour.

Once again, with this approach revenues are measured for the entire year for both 2015 and 2016 scenarios.

The amount City Light transacts on any given day is primarily driven by daily surplus/deficit levels. It transacts sequentially until the surplus/deficit is covered. After that, it can buy/sell up to 500 MWh more to reflect City Light's ability to pond at Boundary or cover in Mid-C. This also reflects the need for some operational flexibility.

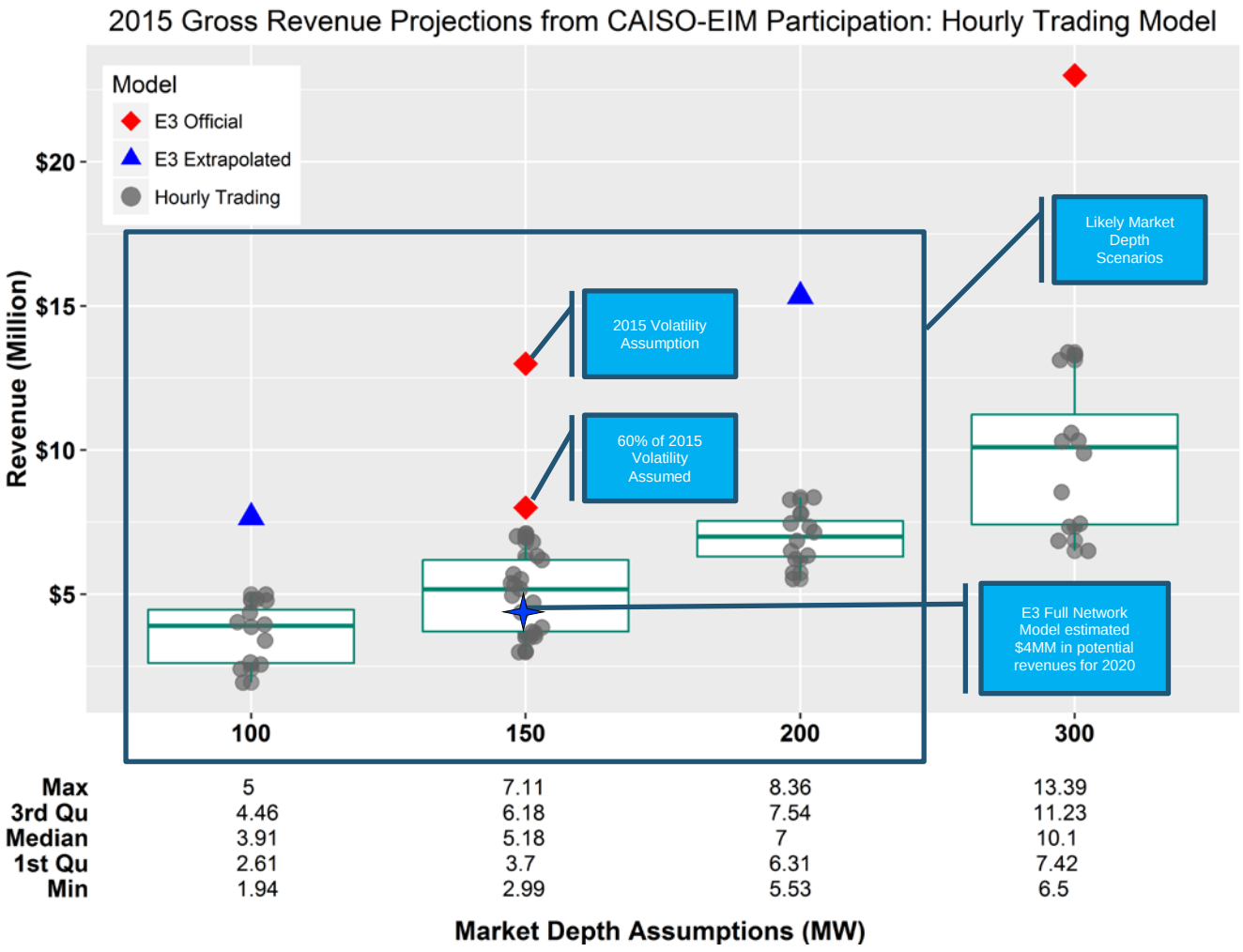
Other parameters were similar to the E3 Enhanced parameters: market depth limits, variability in hourly sales, no transmission modeling, very high fleet ramping ability, flexibility to do everything from pure intraday arbitrage to selling entire surplus into EIM, etc.

Again, a total of 114 scenarios were run for this model. As with the E3 enhanced model, a scenario consisted of a given year, market depth and hourly transaction distribution.

RESULTS

Once again, for the hourly trading model, revenues were calculated as Incremental Revenues over Mid-C. The charts in the following two pages show EIM revenues for 2015 and 2016 scenarios. Revenue ranged from $1.9 MM to $13.4 MM and $(1.3) MM to $11.0 MM, respectively, for the two years. For comparison, E3 estimates ranged from $8 MM to $23 MM and their Full Network model for the year 2020 projected a potential benefit of $4 MM. These are also shown in the following charts as reference.

Once again, revenues generally scaled with quantity transacted (a function of market depth and resource availability). Some scenarios resulted in negative revenues owing to the cost of liquidating an excess/shortfall at Mid-C.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E3 Official
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Hourly Trading
Revenue (Million)
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$5
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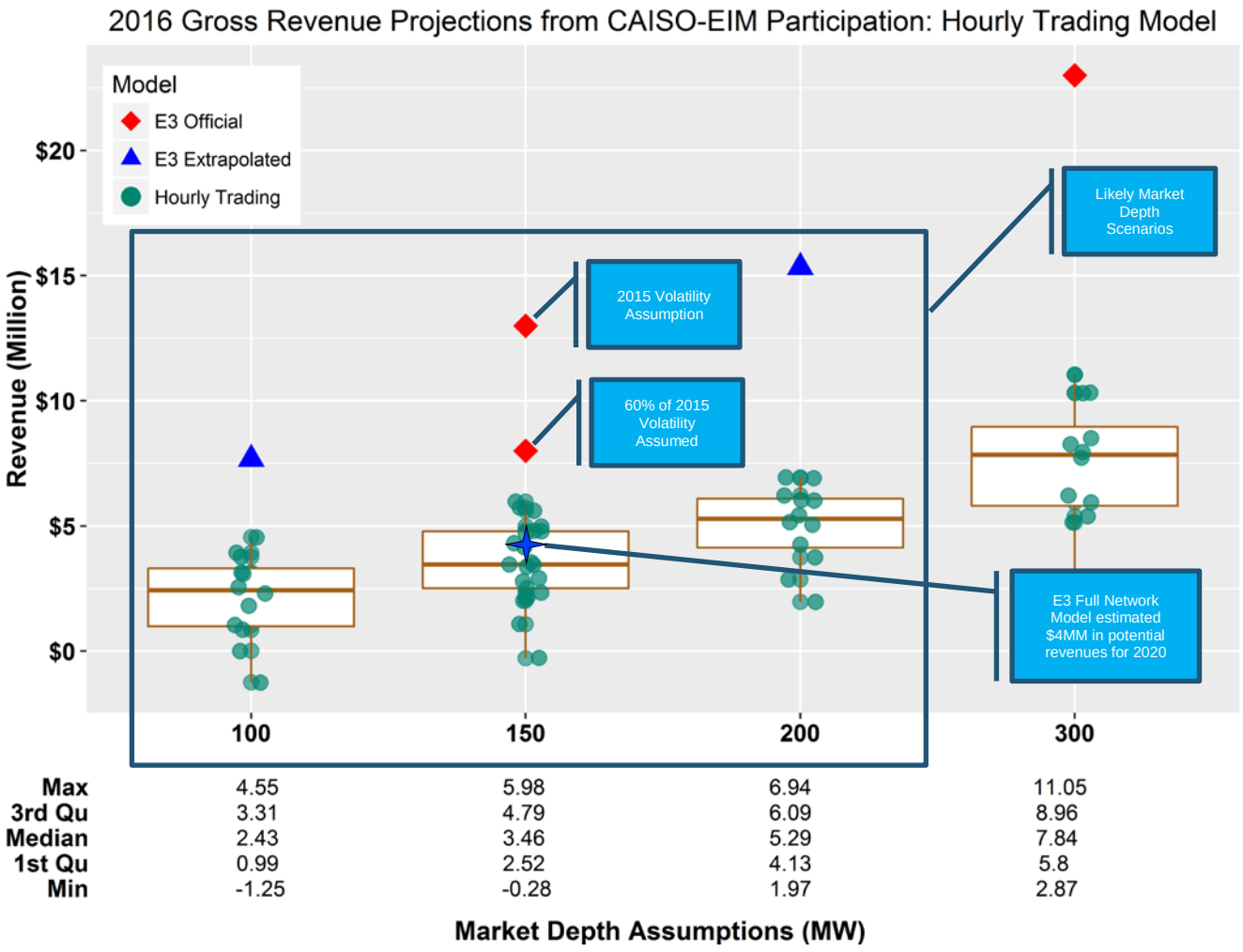
60% of 2015 Volatility Assumed
Likely Market Depth Scenarios
E3 Full Network Model estimated $4MM in potential revenues for 2020
100
150
200
300
Max 5 7.11 8.36 13.39
3rd Qu 4.46 6.18 7.54 11.23
Median 3.91 5.18 7 10.1
1st Qu 2.61 3.7 6.31 7.42
Min 1.94 2.99 5.53 6.5
Market Depth Assumptions (MW)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Revenue (Million)
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60% of 2015 Volatility Assumed
Likely Market Depth Scenarios
E3 Full Network Model estimated $4MM in potential revenues for 2020
100
150
200
300
Max 4.55 5.98 6.94 11.05
3rd Qu 3.31 4.79 6.09 8.96
Median 2.43 3.46 5.29 7.84
1st Qu 0.99 2.52 4.13 5.8
Min -1.25 -0.28 1.97 2.87
Market Depth Assumptions (MW)

SUMMARY/CONSIDERATIONS/RISKS

- Risk Oversight has generated over 200 scenarios across 2 different modeling approaches applying actual price data for the years 2015 and 2016.
- Incremental revenues from EIM participation range from $1.5 MM to $14.5 MM for 2015 and from $(4.4) MM to $12.3 MM in 2016, with a market depth assumption ranging from 100MW to 300MW for both years. Thus, median scenario figures for the 2016 year were ~25% lower, on average, when compared to the 2015 average of all median scenarios.
- Note that these are incremental gross revenues over 'business-as-usual' at Mid-C prices. Net revenues/benefits from EIM would be incremental gross revenues less annual - amortized up-front capital cost, O&M, transmission costs, incremental maintenance of generation assets, procurement of GHG offsets (if needed) etc.
- The City Light business case anticipates O&M costs of $3.2 MM/year and upfront capital expenditures are expected to be approximately $9MM. Estimates of other afore-mentioned costs were not available at the time of this write-up.
- The business case currently budgets $0 for transmission and estimates that transmission costs (based on market value) could be up to at least $1/MW; thus, the total transmission cost will vary based on the assumption of market depth and the transmission capacity reserved for EIM related market activity.
- As with any model, revenues are sensitive to assumptions and thus vary considerably based on quantity available to transact and market depth, thereby impacting the economic analysis of City Light participation in the EIM market.
- The greater the market depth (how much City Light can theoretically transact) and the amount City Light actually transacts, the higher the revenues.
- PSE observed that median transfers with EIM, the closest proxy we currently have for market depth, are about 80 MW; but PSE may have limited ramping abilities and thus their transfers may not have captured all available market depth.
- Additionally, EIM participation is not expected to 'cannibalize' our current bilateral transactions. However, our current transactions with CAISO managed via a 3rd party may be 'cannibalized'. These transactions netted approximately $3 MM in 2016 on an average of 40MW traded through the year.
- City Light will need clarification from either the CAISO market monitor or FERC to ensure that physical or economic withholding of resources is not construed as market manipulation.
- While benefits to current participants in the EIM market mostly accrue as savings from 'avoided costs'[1], for City Light the benefits will be attained mostly from incremental revenues resulting from taking advantage of arbitrage opportunities arising from market imbalances.

[1] From either fuel savings resulting from generation optimization, lower reserves requirement obligations or avoided curtailments

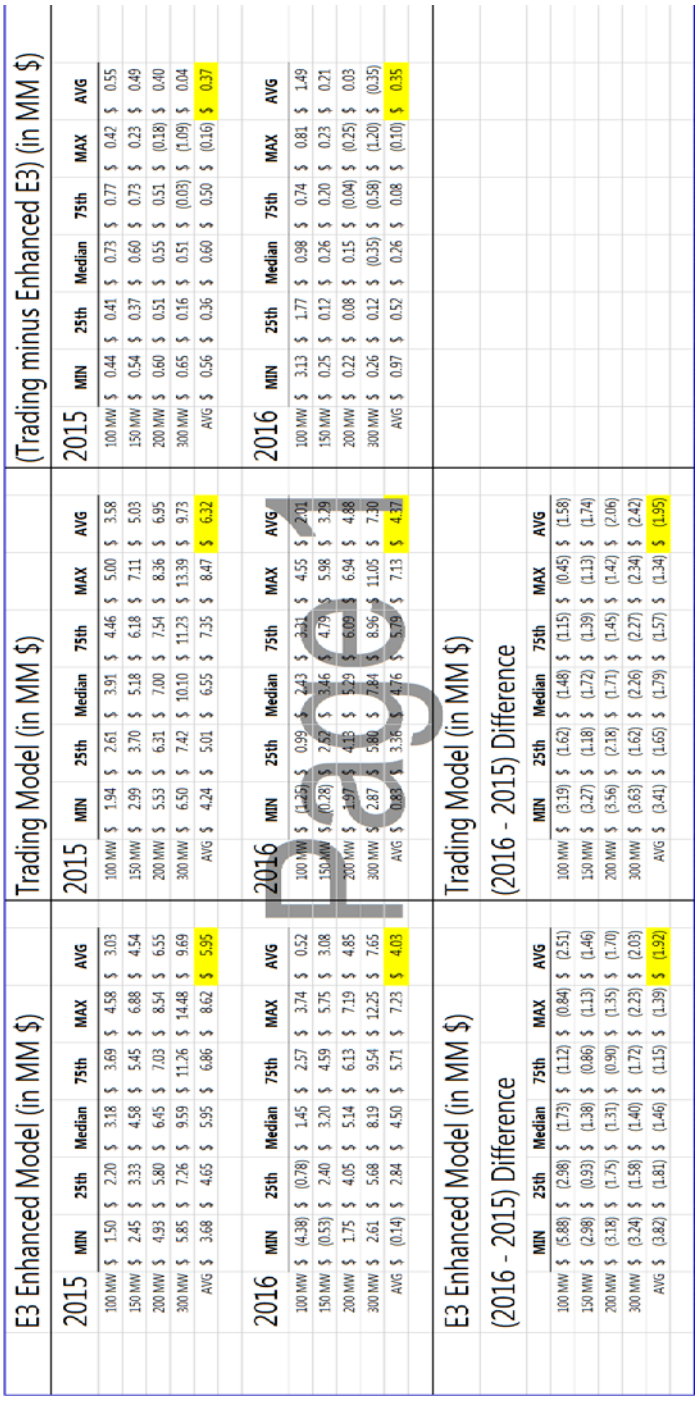
- Change in market dynamics, such as increase in the number of EIM participating entities, can impact the potential revenues. Such increased participation can result in either higher or lower revenues depending on the variable generation proportion of the total EIM footprint which in turn will impact the market imbalances available for City Light to arbitrage.

- There is significant risk with identifying the necessary technology solution (related to metering, bid-to-bill, settlements, OMS, forecasting etc.) and its timely implementation, this is critical to effective & successful participation in EIM. The EIM Steering committee recognizes this and is exploring all possible options available to mitigate this risk early on.

- Several California utilities are currently networking solar panels, battery storage, two-way communication devices and software to create "virtual power plants" that manage green power and feed it into the power grid as needed. It is expected that by 2020, one such battery solution alone will have a 360MW capacity to meet imbalances at a very short notice.[2] This has can have significant adverse impact on potential revenues for City Light as market arbitrage opportunities available will shrink.

[2] https://www.wsj.com/articles/how-california-utilities-are-managing-excess-solar-power-1488628803

APPENDIX I: MODEL RESULTS SUMMARY



E3 Enhanced Model (in MM $)

2015	MIN	25th	Median	75th	MAX	AVG
100 MW	$ 1.50	$ 2.20	$ 3.18	$ 3.69	$ 4.58	$ 3.03
150 MW	$ 2.45	$ 3.33	$ 4.58	$ 5.45	$ 6.88	$ 4.54
200 MW	$ 4.93	$ 5.80	$ 6.45	$ 7.03	$ 8.54	$ 6.55
300 MW	$ 5.85	$ 7.26	$ 9.59	$ 11.26	$ 14.48	$ 9.69
AVG	$ 3.68	$ 4.65	$ 5.95	$ 6.86	$ 8.62	$ 5.95

2016	MIN	25th	Median	75th	MAX	AVG
100 MW	$ (4.38)	$ (0.78)	$ 1.45	$ 2.57	$ 3.74	$ 0.52
150 MW	$ (0.53)	$ 2.40	$ 3.20	$ 4.59	$ 5.75	$ 3.08
200 MW	$ 1.75	$ 4.05	$ 5.14	$ 6.13	$ 7.19	$ 4.85
300 MW	$ 2.61	$ 5.68	$ 8.19	$ 9.54	$ 12.25	$ 7.65
AVG	$ (0.14)	$ 2.84	$ 4.50	$ 5.71	$ 7.23	$ 4.03

Trading Model (in MM $)

2015	MIN	25th	Median	75th	MAX	AVG
100 MW	$ 1.94	$ 2.61	$ 3.91	$ 4.46	$ 5.00	$ 3.58
150 MW	$ 2.99	$ 3.70	$ 5.18	$ 6.18	$ 7.11	$ 5.03
200 MW	$ 5.53	$ 6.31	$ 7.00	$ 7.54	$ 8.36	$ 6.95
300 MW	$ 6.50	$ 7.42	$ 10.10	$ 11.23	$ 13.39	$ 9.73
AVG	$ 4.24	$ 5.01	$ 6.55	$ 7.35	$ 8.47	$ 6.32

2016	MIN	25th	Median	75th	MAX	AVG
100 MW	$ (1.25)	$ 0.99	$ 2.43	$ 3.31	$ 4.55	$ 2.01
150 MW	$ (0.28)	$ 2.52	$ 3.46	$ 4.79	$ 5.98	$ 3.29
200 MW	$ 1.97	$ 4.13	$ 5.29	$ 6.09	$ 6.94	$ 4.88
300 MW	$ 2.87	$ 5.80	$ 7.84	$ 8.96	$ 11.05	$ 7.30
AVG	$ 0.83	$ 3.36	$ 4.76	$ 5.78	$ 7.13	$ 4.37

(Trading minus Enhanced E3) (in MM $)

2015	MIN	25th	Median	75th	MAX	AVG
100 MW	$ 0.44	$ 0.41	$ 0.73	$ 0.77	$ 0.42	$ 0.55
150 MW	$ 0.54	$ 0.37	$ 0.60	$ 0.73	$ 0.23	$ 0.49
200 MW	$ 0.60	$ 0.51	$ 0.55	$ 0.51	$ (0.18)	$ 0.40
300 MW	$ 0.65	$ 0.16	$ 0.51	$ (0.03)	$ (1.09)	$ 0.04
AVG	$ 0.56	$ 0.36	$ 0.60	$ 0.50	$ (0.16)	$ 0.37

2016	MIN	25th	Median	75th	MAX	AVG
100 MW	$ 3.13	$ 1.77	$ 0.98	$ 0.74	$ 0.81	$ 1.49
150 MW	$ 0.25	$ 0.12	$ 0.26	$ 0.20	$ 0.23	$ 0.21
200 MW	$ 0.22	$ 0.08	$ 0.15	$ (0.04)	$ (0.25)	$ 0.03
300 MW	$ 0.26	$ 0.12	$ (0.35)	$ (0.58)	$ (1.20)	$ (0.35)
AVG	$ 0.97	$ 0.52	$ 0.26	$ 0.08	$ (0.10)	$ 0.35

E3 Enhanced Model (in MM $)

(2016 - 2015) Difference

	MIN	25th	Median	75th	MAX	AVG
100 MW	$ (5.88)	$ (2.98)	$ (1.73)	$ (1.12)	$ (0.84)	$ (2.51)
150 MW	$ (2.98)	$ (0.93)	$ (1.38)	$ (0.86)	$ (1.13)	$ (1.46)
200 MW	$ (3.18)	$ (1.75)	$ (1.31)	$ (0.90)	$ (1.35)	$ (1.70)
300 MW	$ (3.24)	$ (1.58)	$ (1.40)	$ (1.72)	$ (2.23)	$ (2.03)
AVG	$ (3.82)	$ (1.81)	$ (1.46)	$ (1.15)	$ (1.39)	$ (1.92)

Trading Model (in MM $)

(2016 - 2015) Difference

	MIN	25th	Median	75th	MAX	AVG
100 MW	$ (3.19)	$ (1.62)	$ (1.48)	$ (1.15)	$ (0.45)	$ (1.58)
150 MW	$ (3.27)	$ (1.18)	$ (1.72)	$ (1.39)	$ (1.13)	$ (1.74)
200 MW	$ (3.56)	$ (2.18)	$ (1.71)	$ (1.45)	$ (1.42)	$ (2.06)
300 MW	$ (3.63)	$ (1.62)	$ (2.26)	$ (2.27)	$ (2.34)	$ (2.42)
AVG	$ (3.41)	$ (1.65)	$ (1.79)	$ (1.57)	$ (1.34)	$ (1.95)