Energy+Environmental Economics

Seattle City Light: GHG Impacts of EIM Participation

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Outline

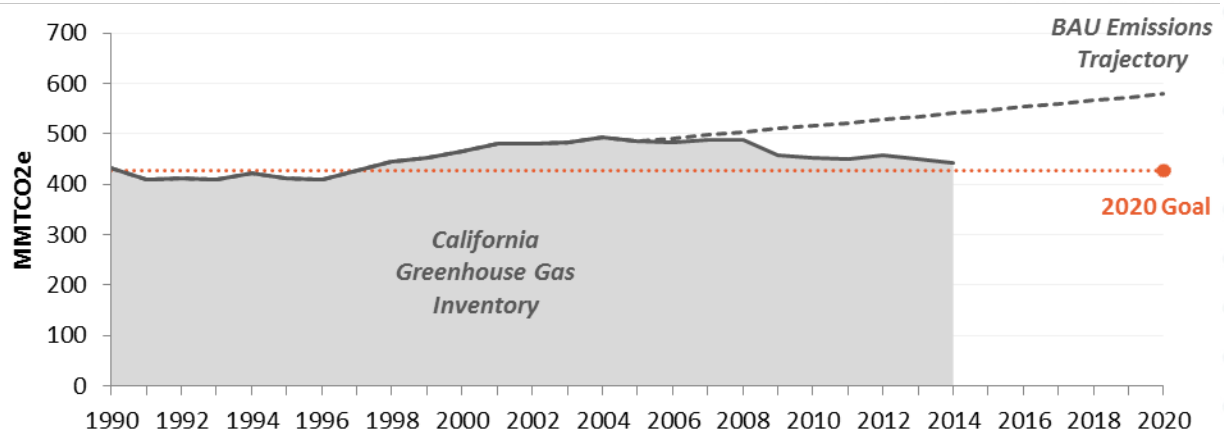
- **This presentation is a supplement to E3's 2016 study of EIM benefits for Seattle City Light that addresses three topics:**

1. **California regulatory overview:** how the EIM design has been created to capture the nuances of California's existing cap & trade regulations and avoid creating market distortions
2. **GHG benefits of City Light's participation:** estimate of the total reduction in system-wide GHG emissions that can be attributed to City Light's EIM participation
3. **Reduced spill with City Light's participation:** estimate of the total reduction in system-wide spill of hydro/wind generation that can be attributed to City Light's EIM participation

SUMMARY OF GHG ISSUES IN EIM

AB32 and California Cap & Trade

- **California's Assembly Bill 32 requires California to reduce greenhouse gas emissions to 1990 levels by 2020**
- **As part of its 2008 Scoping Plan, CARB implemented an economy-wide cap-and-trade program**
  - Quantity of allowances reduced over time to align with 2020 emissions target



Cap & Trade and the Electricity Sector

- **In the electricity sector, the "first jurisdictional deliver" is responsible for securing allowances through the cap & trade program**
  - For in-state resources: plant owners/contractors
  - For imports: entities responsible for importing power to California
- **Greenhouse gas ascribed to imports depends on whether power is "specified" or "unspecified"**
  - **"Specified"** power is associated with a specific out-of-state generator through e-tag and is attributed emissions based on the generator's physical emission rates
    - e.g. coal contracts, some Northwest hydro, dynamically transferred renewables
  - **"Unspecified"** power is generic wholesale power and is attributed emissions based on a rate deemed by the Air Resources Board (0.43 tons/MWh, roughly equivalent to mid-merit gas)
- **In regulations for electric sector, cap & trade explicitly prohibits "shuffling"—pairing buyers and sellers such that California receives low carbon power while no actual emissions reduction occurs**

Capturing GHG Compliance Costs in EIM

- **CAISO's framework for handling GHGs in EIM should adhere to two principles:**
  1. Provide a market signal to California generators and generators importing to California that captures the cost of carbon
  2. Avoid distorting the market signals to out-of-state generators when being dispatched for non-California uses
- **Generators in California submit a bid for energy that includes the cost of carbon allowances**
- **Generators outside California submit separate bids for energy and the cost of a GHG allowance**

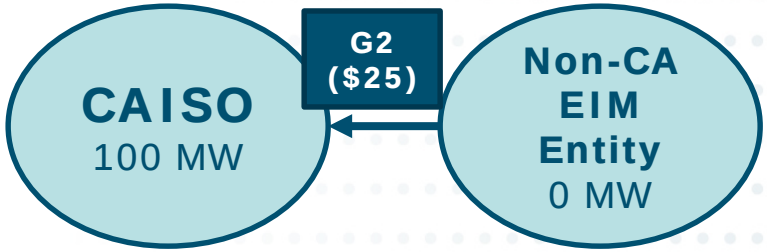
Generator 1	Generator 2	Generator 3
Gas, CAISO	Gas, Non-CA	Coal, Non-CA
Cost: $30	Energy Cost: $20	Energy Cost: $18
	GHG Cost: $5	GHG Cost: $10

- **CAISO uses this information to optimize resource dispatch both within and outside of California**
- **EIM optimized dispatch now identifies which out-of-state resources are dispatched <u>on behalf of California loads</u>**

Example Scenarios

- **The following examples are based on an EIM footprint with two entities:**
  - CAISO (subject to cap & trade)
  - Non-CA EIM entity (not subject to C&T)
- **Generators are dispatched as needed, subject to availability**
- **The model selects for lowest cost in all cases**
- **Three plants are available:**
  - Generator 1: a gas plant inside CAISO
  - Generator 2: a gas plant in the EIM footprint
  - Generator 3: a coal plant in the EIM footprint

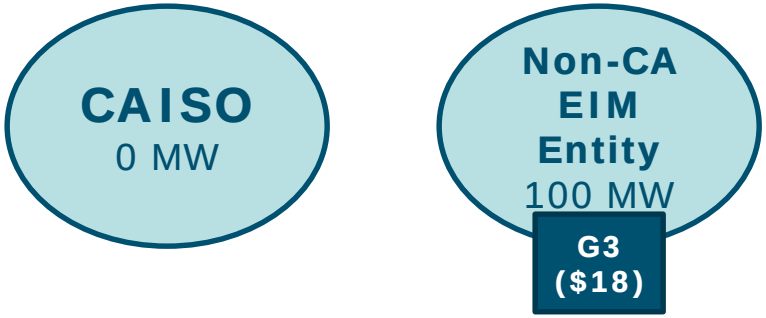
- **Example 1**
  - CAISO load = 100 MW
  - Non-CA EIM load = 0 MW
- **Generator 2 offers least cost energy & GHG**



Generator	Energy Price	GHG Price	Total Price	Dispatch
G1: CAISO gas			$30	0
G2: Non-CA gas	$20	$5	$25	100
G3: Non-CA coal	$18	$10	$28	0

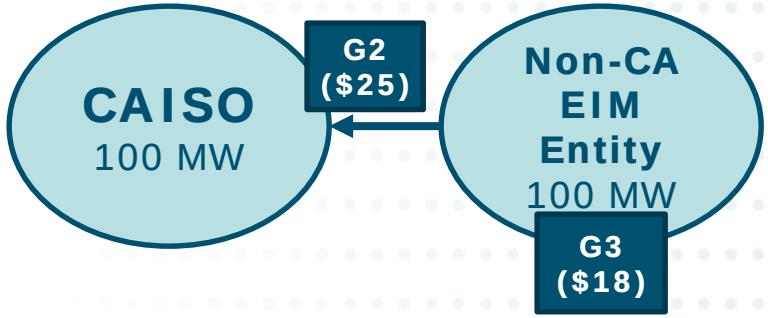
Example Scenarios

- **Example 2:**
  - CAISO load = 0 MW
  - Non-CA EIM load = 100 MW
- **Between G2 (gas, $20) and G3 (coal, $18), EIM chooses G3**



Generator	Energy Price	GHG Price	Total Price	Dispatch
G1: CAISO gas			$30	0
G2: Non-CA gas	$20	$5	$25	0
G3: Non-CA coal	$18	$10	$28	100

- **Example 3:**
  - CAISO load = 100 MW
  - Non-CA EIM load = 100 MW
- **Between G2 and G3, EIM still chooses G3**
- **Between G1, G2, and G3, CAISO chooses G2**



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G1: CAISO gas			$30	0
G2: Non-CA gas	$20	$5	$25	100
G3: Non-CA coal	$18	$10	$28	100

Challenges with Current Framework

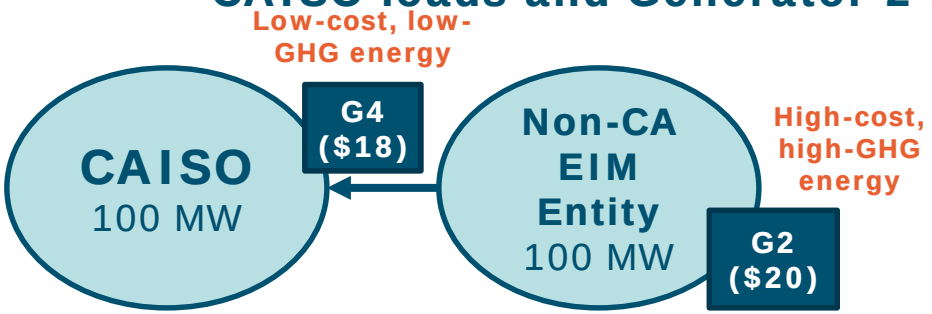
- Some ARB stakeholders have expressed concern that the current framework can lead to low-cost, low-GHG resources being preferentially dispatched to CAISO, while higher GHG resources may be dispatched to local loads not under same regulations

Generator 1
Gas, CAISO
Cost: $30

Generator 2
Gas, Non-CA
Energy Cost: $20
GHG Cost: $5

Generator 4
Hydro, Non-CA
Energy Cost: $18
GHG Cost: $0

- With a load of 100 MW in each region, optimization selects Generators 2 & 4 for dispatch
- Cost minimization results in Generator 4 being allocated to CAISO loads and Generator 2 being allocated to other EIM loads



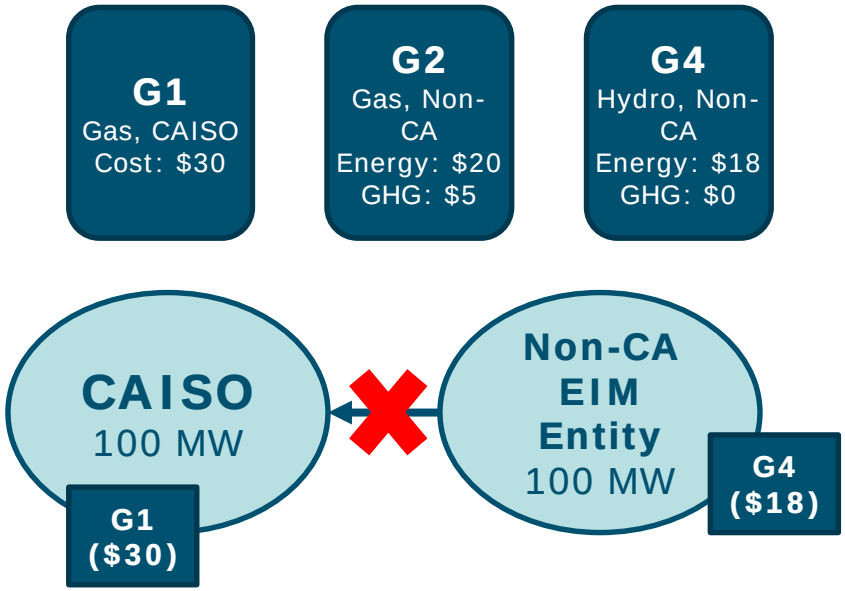
Generator	Energy Price	GHG Price	Total Price	Dis-patch
G1: CAISO gas			$30	0
G2: Non-CA gas	$20	$5	$25	100
G4: Non-CA hydro	$18	$0	$18	100

Revised EIM Dispatch Logic

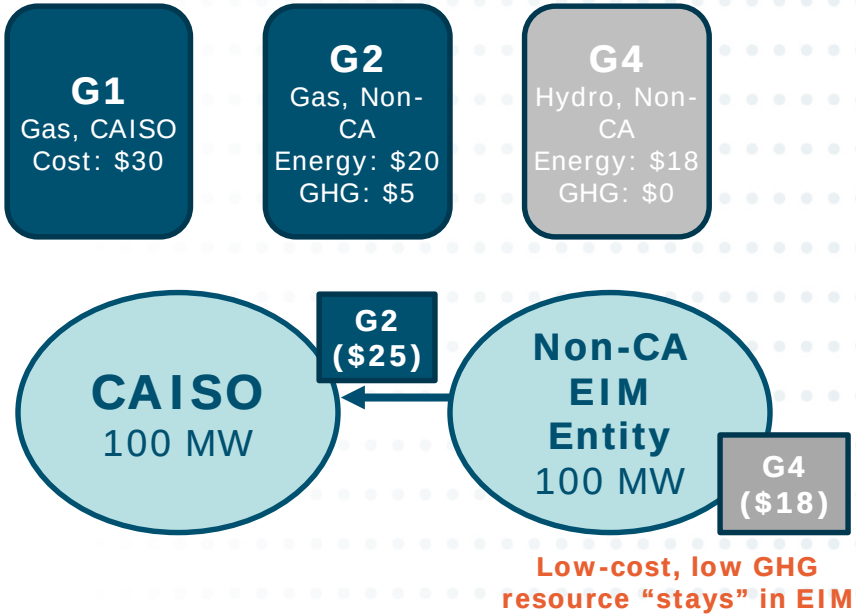
- **To address stakeholder concerns that the EIM optimization may not adequately capture GHG impacts of out-of-state resources dispatched on behalf of California loads, CAISO is currently working to revise its EIM dispatch logic**
- **After considering multiple possible options, CAISO has developed a strawman proposal to solve this issue using a 2-pass optimization**
- **First pass: determine optimized dispatch, <u>assuming no transfers</u> from non-CA EIM entities to CAISO (and without GHG cost considered)**
  - This pass determines the economically optimal dispatch schedule for the non-CA EIM footprint
- **Second pass: re-run dispatch optimization, <u>allowing transfers</u> from non-CA to CAISO but apply GHG cost to incremental upward dispatch**
  - This two pass approach allows CAISO to better distinguish which incremental dispatch is specifically for export to CA, and to apply GHG charges specifically when determining that incremental dispatch

Example with 2-Pass Optimization

- **First Pass:**
  - CAISO load = 100 MW
  - Non-CA EIM load = 100 MW
- **EIM chooses G4, the cheapest option**
- **This selection is locked in for the second pass**



- **Second Pass:**
- **G4 is unavailable since EIM already selected it**
- **Between G1 and G2, CAISO chooses G2 ($25).**



Low-cost, low GHG resource "stays" in EIM

QUANTIFYING GHG IMPLICATIONS OF EIM FOR SCL

E3's 2016 Study for SCL

- **EIM creates the option to buy or sell within the hour, with less notice, and at a lower volume and cost, and can use optimization to find beneficial match of buyers & sellers**
- **City Light is unique in comparison to existing EIM entities:**
  - Load primarily served by owned & contracted flexible hydro resources
  - Surplus hydro generation sold to market to reduce retail rates
- **E3 created a dispatch model to estimate City Light's net market revenues with and without EIM participation**
  - Captures City Light's market behavior under different wholesale price streams
  - Uses 5- and 15-minute price data from historical years
  - Assumes market could accommodate all desired City Light transactions at the historical market price
  - It was found that EIM participation could yield $8-23 million per year

In this follow-up study, E3 will determine a high-level estimate of the GHG impacts from City Light's participation in the EIM

Scenarios Analyzed

- **This analysis evaluated the GHG impacts of City Light's EIM participation under four scenarios (all included in original EIM benefits study):**

1. **2015 Base Case:** assumes City Light's hydro can redispatch **+/- 300 MW** in EIM; uses **2015 actual prices**
2. **Dampened Volatility:** assumes City Light's hydro can redispatch +/- 300 MW in EIM; uses price stream with **volatility reduced by 40%**
3. **Limited Participation:** assumes City Light's hydro can redispatch **+/- 150 MW** in EIM; uses 2015 actual prices
4. **Dampened Volatility & Limited Participation:** combines (2) and (3)

Impact of Hydro Generation on GHG Emissions in EIM

- **CAISO's Energy Imbalance Market dispatches resources on 15- and 5-minute basis to meet imbalances across its footprint**
- **Many of the generators currently dispatched by the EIM to meet imbalances are thermal generators (e.g. coal or natural gas)**
- **Adding hydro resources to the EIM can allows more efficient, lower GHG operations in multiple ways:**
  - Enables increased delivery of carbon-free resources that would otherwise be curtailed
  - Reduces the need to rely on thermal generators for ramping and cycling to meet subhourly variability
  - Reduces the need to dispatch highly inefficient gas generation during constrained periods

Methodology for Evaluating Emissions Impact

- **The impact of City Light's EIM participation is quantified based on: (1) City Light's incremental EIM dispatch; and (2) assumed marginal emissions rates in the EIM**

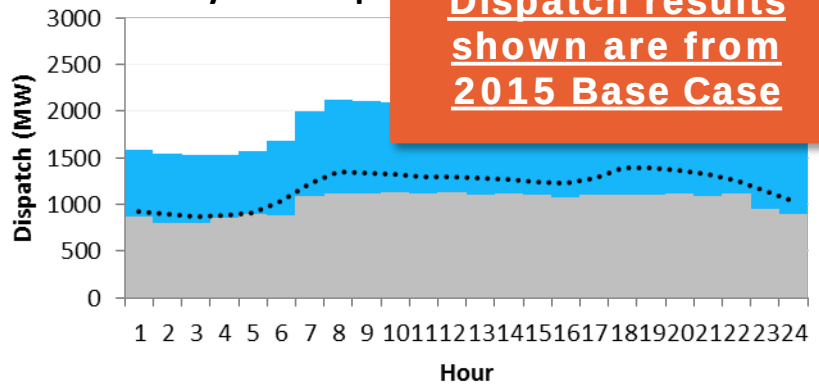
1. **How would City Light's hydro resources be dispatched in the EIM?**
   - Based on E3's 2015 study evaluating the benefits of EIM participation
2. **What is the marginal emissions rate of generation that is either displaced or dispatched?**
   - Approximated using a "market heat rate" approach to identify what types of plants are likely on the margin

- **Savings calculated are <u>societal</u> GHG benefits, and reflect GHG reductions across the EIM footprint.**

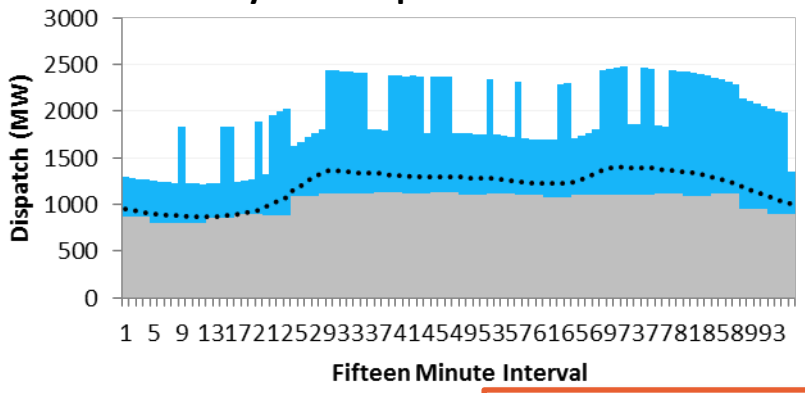
City Light Dispatch Patterns in CAISO EIM

Dispatch results shown are from 2015 Base Case

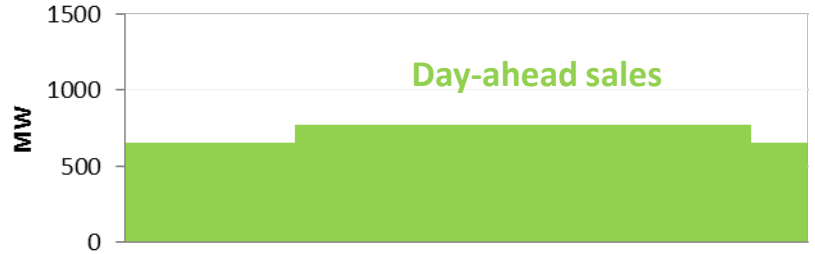
Hour-Ahead System Dispa



Fifteen-Minute System Dispatch



Day-Ahead Sales (Purchases)

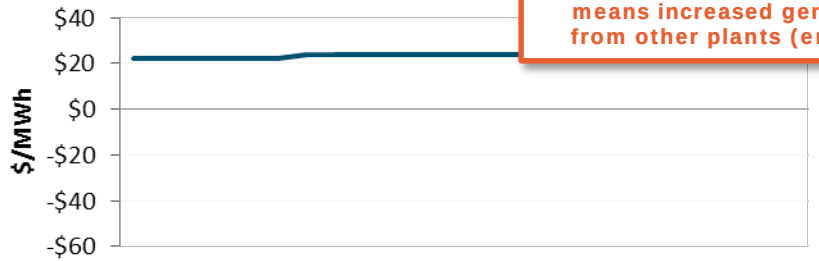


Fifteen-Minute EIM Net Sales

Selling hydro into the market displaces generation from plants with higher emissions, thereby cutting down on GHGs.

Purchasing from the market means increased generation from other plants (emitters)

Day-Ahead Mid-C Price



CAISO Fifteen Minute EIM Price

Estimating Marginal Emissions Rates

- **To approximate marginal emissions rates, E3 uses "market heat rates": the implied heat rate of the marginal generator in each interval, assuming a natural gas-fired plant is on the margin**

$$\text{Market Heat Rate [MMBtu/MWh]} = \frac{\textbf{LMP } [\$/\text{MWh}] - \textbf{Assumed VOM } [\$/\text{MWh}]}{\textbf{Daily Gas Price } [\$/\text{MMBtu}]}$$

- **When the resulting market heat rate is close to the physical heat rate of a natural gas generator, this typically indicates that gas is on the margin:**

$$\text{Market Heat Rate [MMBtu/MWh]} = \frac{\$\mathbf{23}/\text{MWh} - \$\mathbf{2}/\text{MWh}}{\$\mathbf{3}/\text{MMBtu}} = \underbrace{\mathbf{7.0}\ \text{MMBtu/MWh}}_{\text{Typical CCGT}}$$

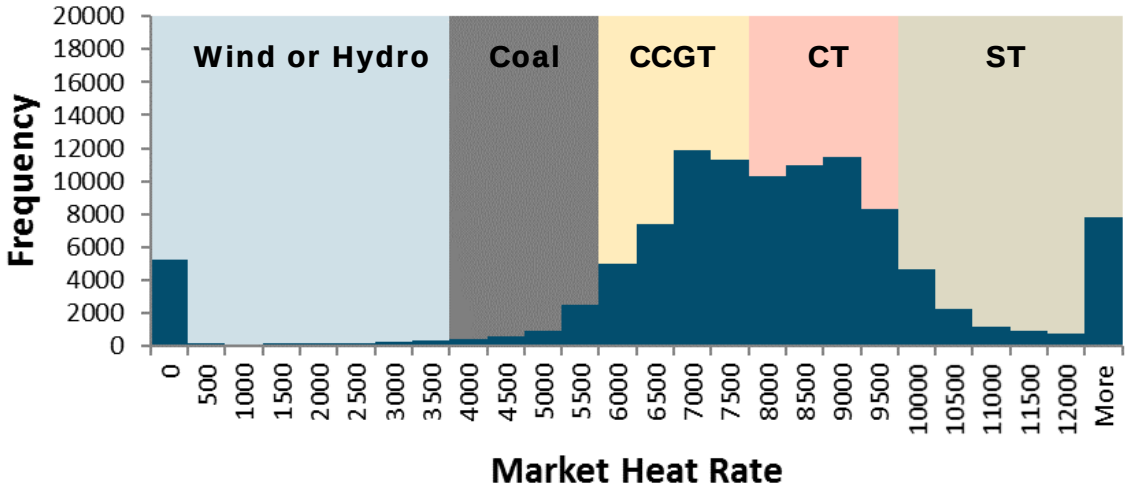
- **When the market heat rate is below typical gas plant heat rates, this could signify multiple phenomena:**
  - Zero/negative market heat rates typically indicate hydro spill/renewable curtailment
  - Low market heat rates could signify multiple things: gas plants bidding below cost, coal generation on the margin, hydro bidding phenomena

Market Heat Rate Distribution and Emission Savings

- Distribution of observed market heat rates in the 5-min market is discretized for emissions accounting purposes based on assumed rules of thumb
- Simulated dispatch based on 2016 EIM analysis

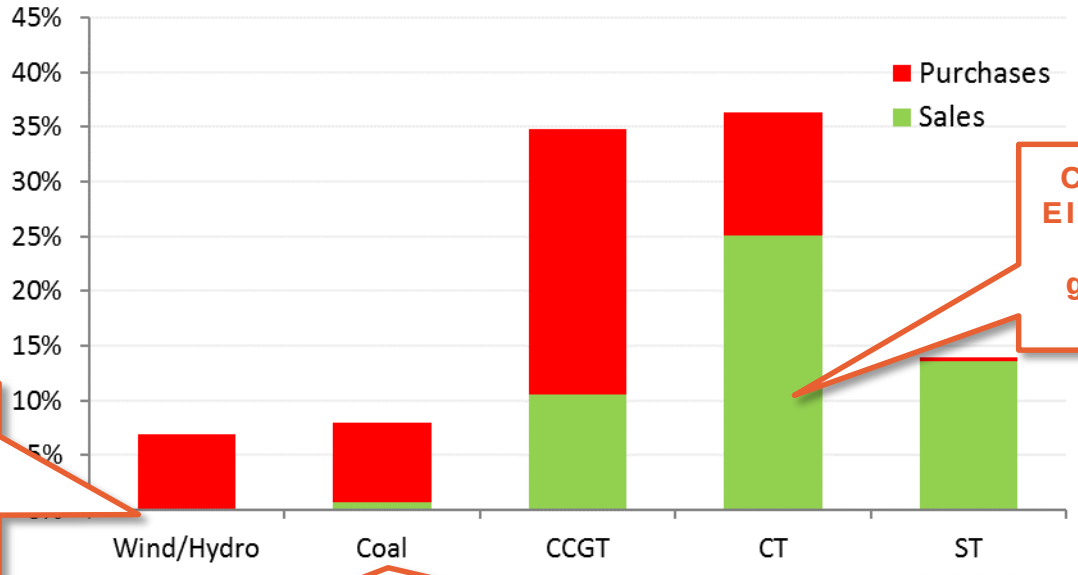
Assumed marginal emissions rates by market heat rate

Market Heat Rate (Btu/kWh)	Marginal Plant Type	Marginal emissions rate (metric tons/MWh)
< 4,000	Wind or Hydro	0
4,000 – 6,000	Coal	0.95
6,000 – 8,000	CCGT	0.37
8,000 – 10,000	CT	0.49
> 10,000	ST	0.56



Purchases / Sales by Generation Type

- City Light primarily <u>purchases</u> energy when wind, hydro, coal, and efficient gas units are on the margin
- City Light primarily sells energy to displace gas units (of all ranges of efficiency)



When wind & hydro are on the margin, City Light purchases from the market—reducing the need to curtail and / or spill carbon free generation

City Light's sales into EIM frequently displace inefficient gas generation, reducing emissions

During the periods when coal is on the margin, City Light purchases from the market, offsetting some of its emissions savings

Range of Savings Across Scenarios

- **Analysis indicates a wide range of potential emissions savings: 32,000 – 65,000 tons CO2 per year**
- **Main drivers of savings are (1) ability to deliver incremental quantities of wind / hydro to the system; and (2) displacement of inefficient gas generators**
- **Magnitude of potential savings is reduced, but not eliminated, by City Light's purchases when coal is on the margin**

Sensitivity	Total EIM Revenue ($MM)	Emissions Savings (000 tons CO2)
2015 Base Case	**$23**	65
Dampened Volatility	**$15**	65
Limited Participation	**$13**	32
Dampened Volatility, Limited Participation	**$8**	32

Range of Avoided Curtailment Across Scenarios

- **One of the major drivers of GHG savings is the reduction in renewable curtailment & hydro spill across the EIM footprint enabled by City Light's participation**
- **Analysis indicates reduced curtailment in the range of 50,000 – 117,000 MWh per year**

Sensitivity	Total EIM Revenue ($MM)	Avoided Curtailment (MWh)	Frequency (% of intervals)
2015 Base Case	**$23**	117,000	5.0%
Dampened Volatility	**$15**	101,000	4.2%
Limited Participation	**$13**	61,000	5.0%
Dampened Volatility, Limited Participation	**$8**	50,000	4.2%

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Thank You!

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