Single Schedule Market Pricing Issues

Presented by

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Phase 1, Session 3

Module F: Load Pricing

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Recap of Session 2 (June 2nd)

Module A: Energy Pricing

- Locational Marginal Cost Pricing (LMP)
- HOEP/MCP
- LMP Components: reference bus price, congestion component, loss component
- Supplier Pricing
- Intertie Pricing

Module B: Reserve Pricing

Module C: Pricing Constraint Violations

Module D: Multi-interval Optimization and Pricing

- Multi-interval Optimization
- Ex Ante Pricing

Module E: Pricing Operating Restrictions and Operator Actions

PHASE 1 TOPICS Session 3 (Today)

Module F: Load Pricing

- Locational Marginal Cost Pricing (LMP) Review
- Principal Load Energy Pricing Issues
- Incentive Issue
- Financial Transmission Rights (FTRs)

Module G: Market Power Mitigation

Module H: Make-Whole Payments and Uplift

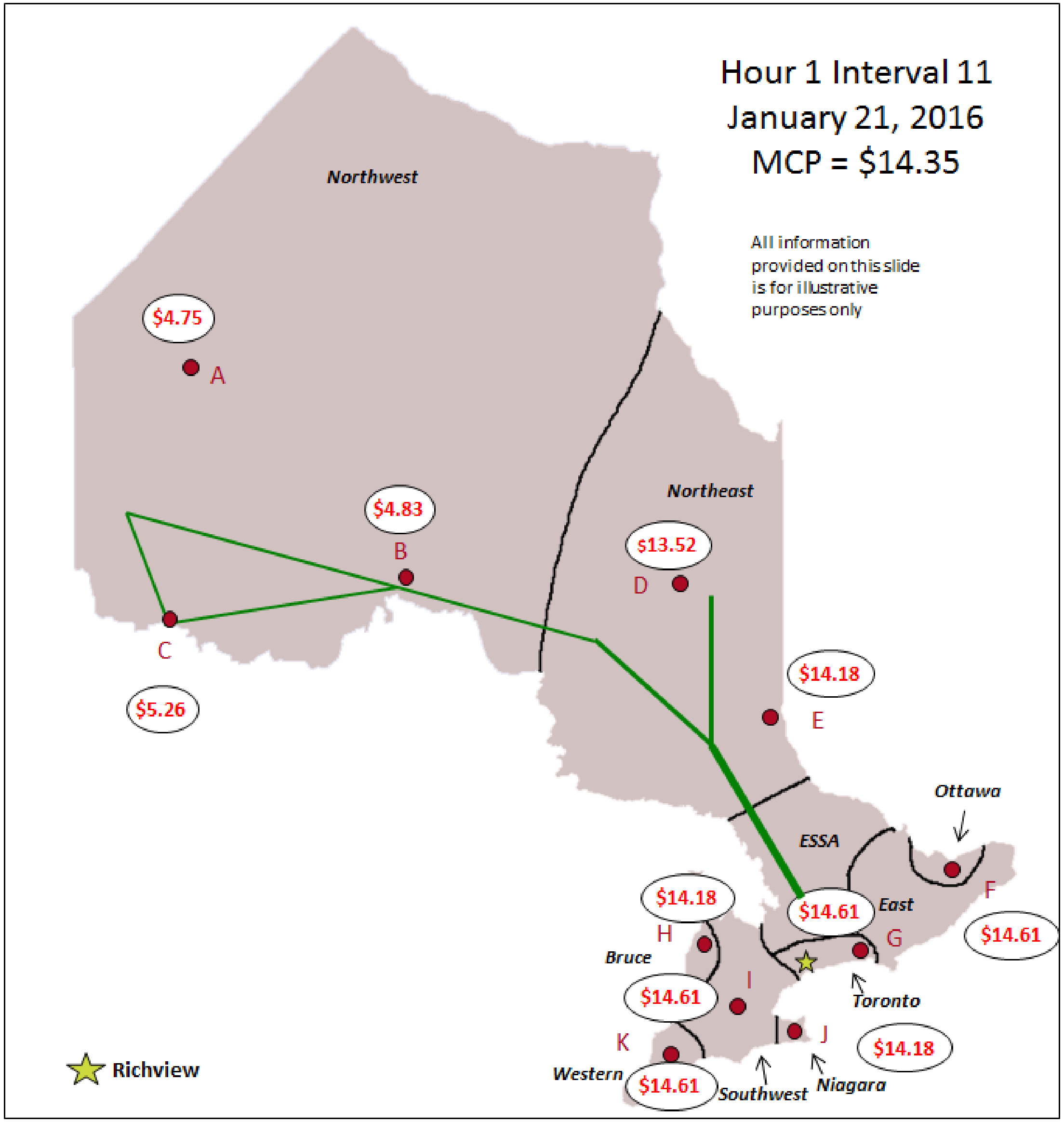
MODULE F: LOAD PRICING

Locational Marginal Pricing (LMP) for energy is a fundamental element of a Single Schedule Market (SSM).

- LMP prices are currently determined from the result of the IESO's constrained schedule.
- LMP prices may differ between locations due to:
  - Transmission congestion.
  - Transmission losses.

LMP = Price at Reference Bus + Congestion Component + Loss Component

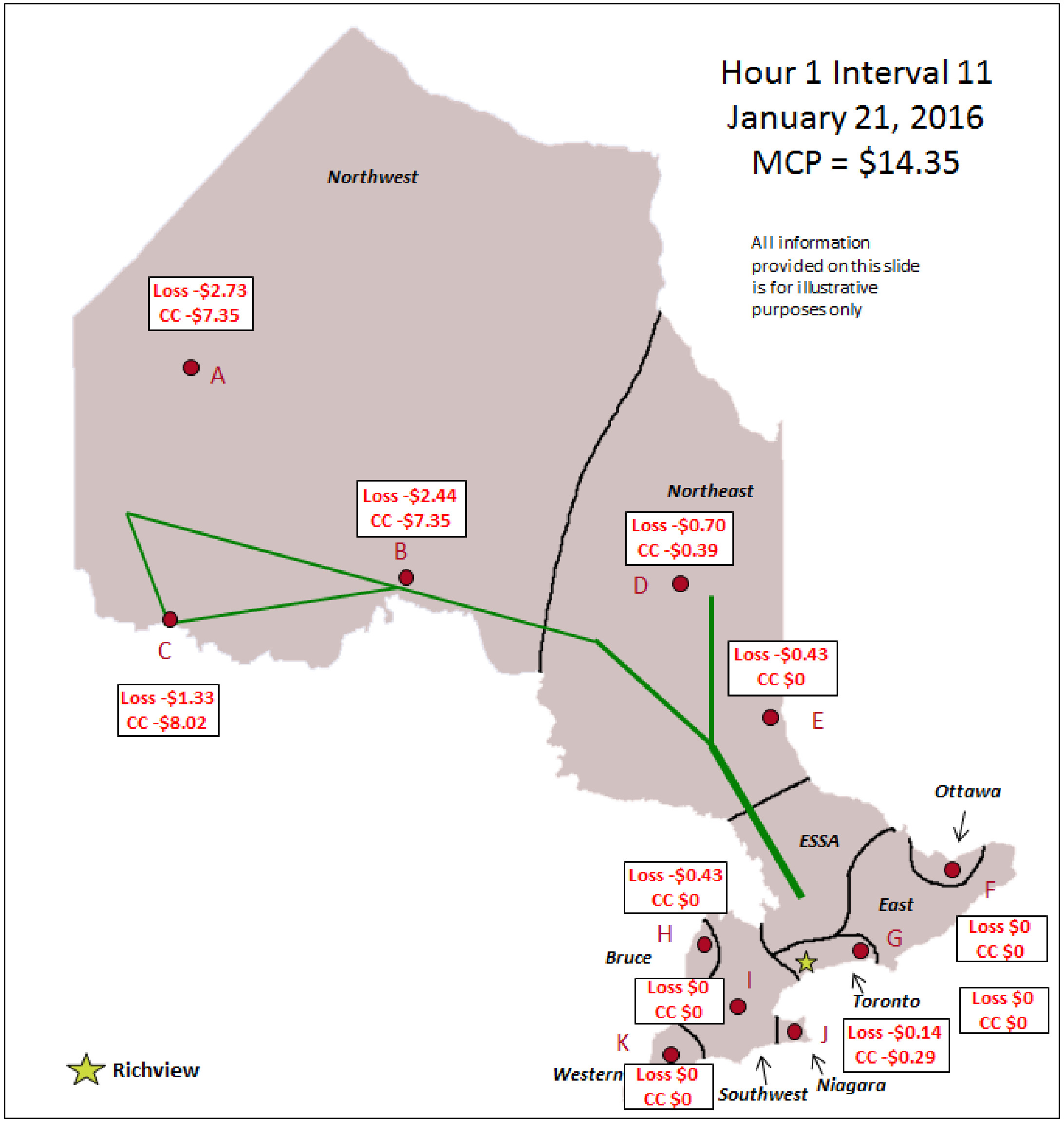
The LMP price is the offer-based cost of re-dispatching the system at least cost to supply an increment of load at a specific location on the transmission grid.



LMP PRICING

LMP pricing takes account of locational differences in the cost of meeting incremental load resulting from:

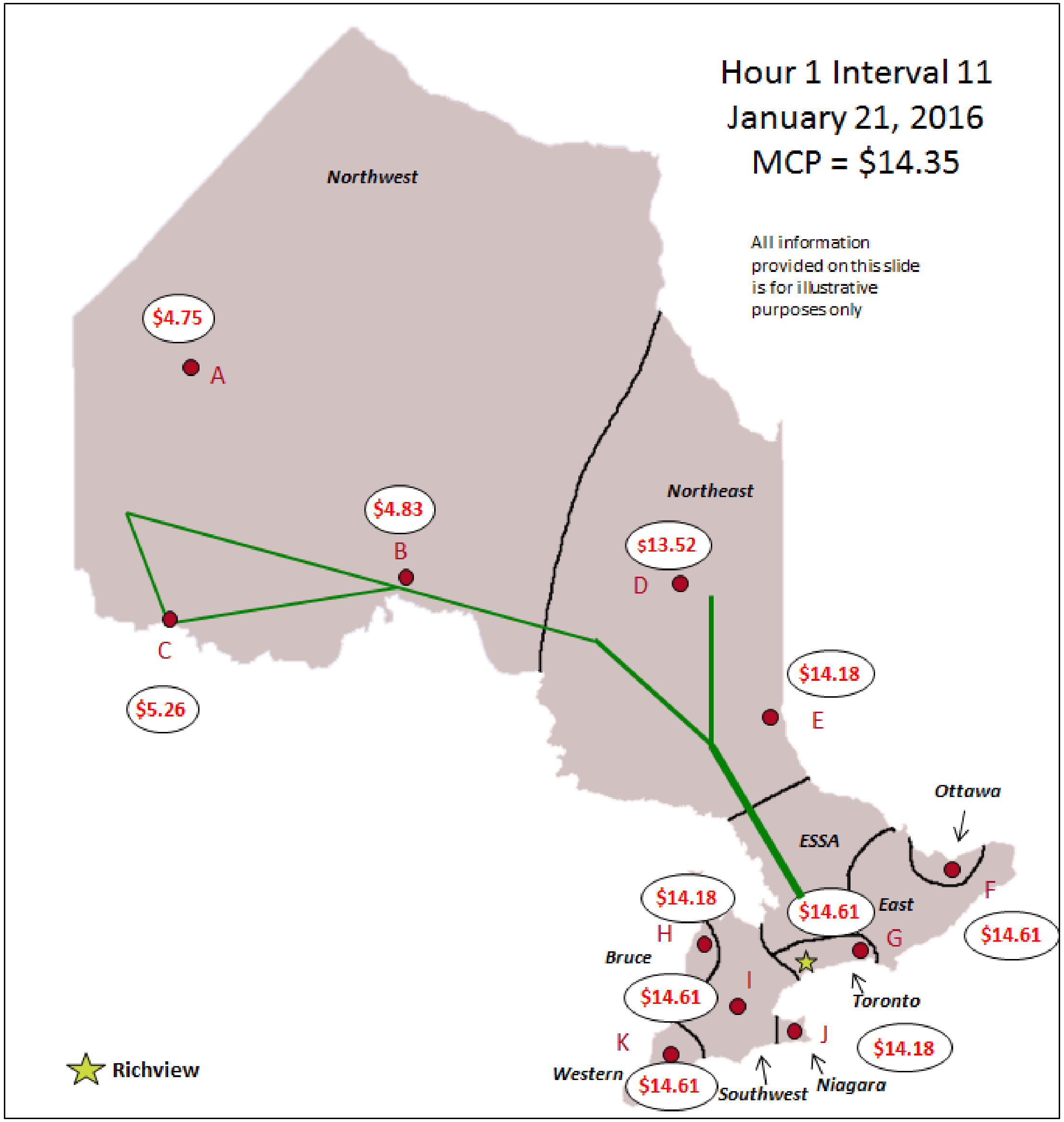
- Re-dispatching generation to avoid exceeding transmission limits;
- The cost of incremental transmission losses.



LMP PRICING

Refresh

LMP pricing supports transmission system reliability by providing generators and other dispatchable resources with financial incentives to respond to real-time dispatch instructions.



FTI

The IESO's current constrained schedule takes account of transmission constraints and the cost of marginal losses. It calculates shadow prices that are "raw" LMPs.

- The constrained schedule corresponds to the physical operation of the IESO grid, so the raw LMPs do as well.
- The raw LMPs will be processed by a pricing run of the constrained schedule to obtain settlement-ready LMPs.
- In an SSM, Suppliers are typically paid the LMP at their location under an SSM.

Three issues will drive the methodology developed for pricing load under SSM:

1. Whether the price charged to loads will include the marginal or average cost of losses and congestion;
2. Whether loads will pay a nodal, zonal or uniform price;
3. Whether the prices will differ for dispatchable versus non-dispatchable loads.

To support discussion of the pros and cons of alternatives during Phase 2, the following slides will describe each of the above issues.

ISSUE #1 Marginal or Average Cost of Losses and Cong.?

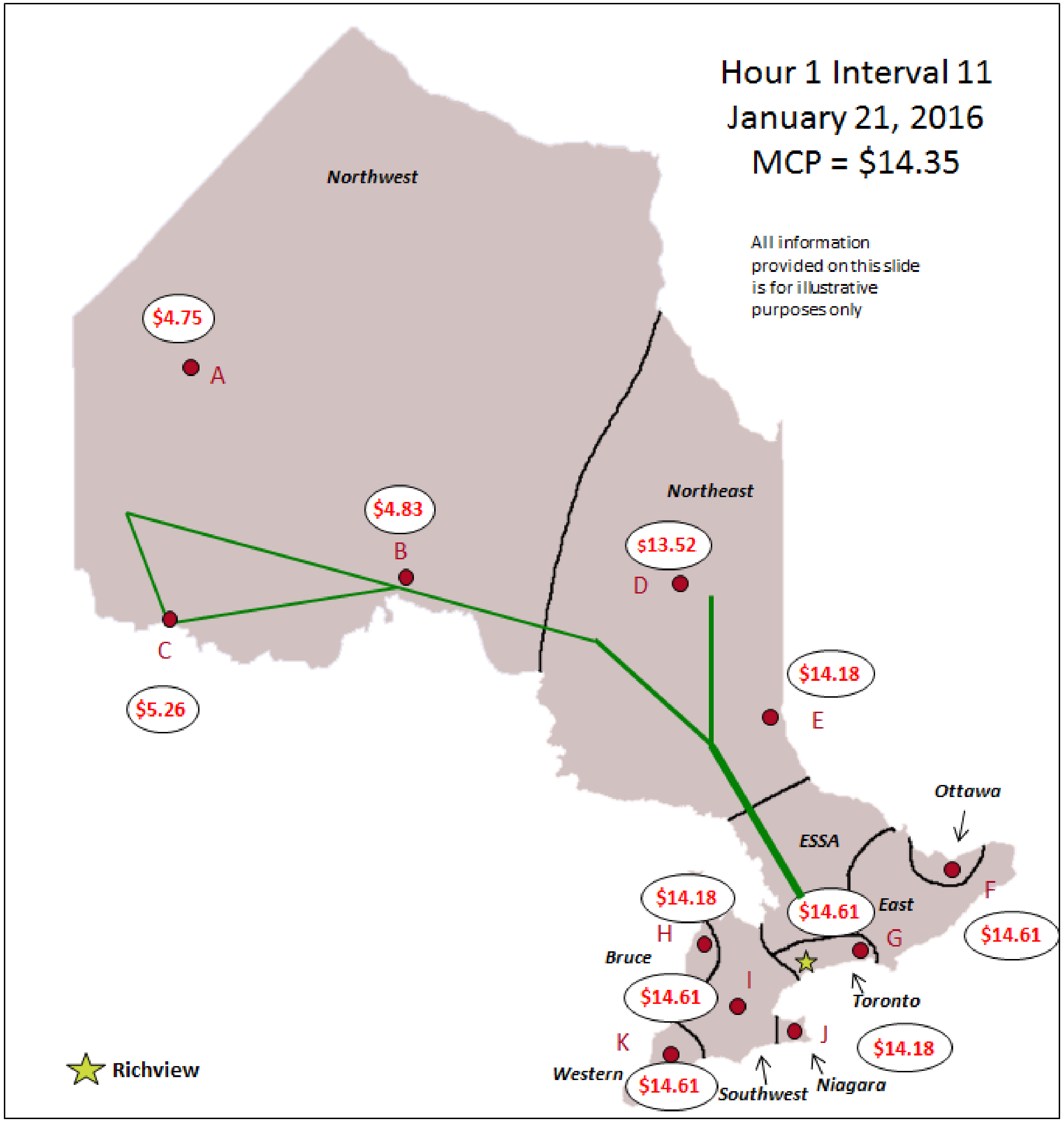
One of the central issues will be whether the SSM energy prices for loads will charge the marginal or average cost of losses and congestion for serving loads.

Two possibilities for developing SSM load prices:

1. Use LMPs at Supplier Nodes;
2. Use LMPs at Load Nodes.
   - The IESO's constrained schedule currently only calculates prices for generator and dispatchable load locations.
   - This approach could be implemented using the prices calculated for nearby generator locations to approximate the price at load locations.
   - Could also choose to increase the set of load nodes where prices are calculated.

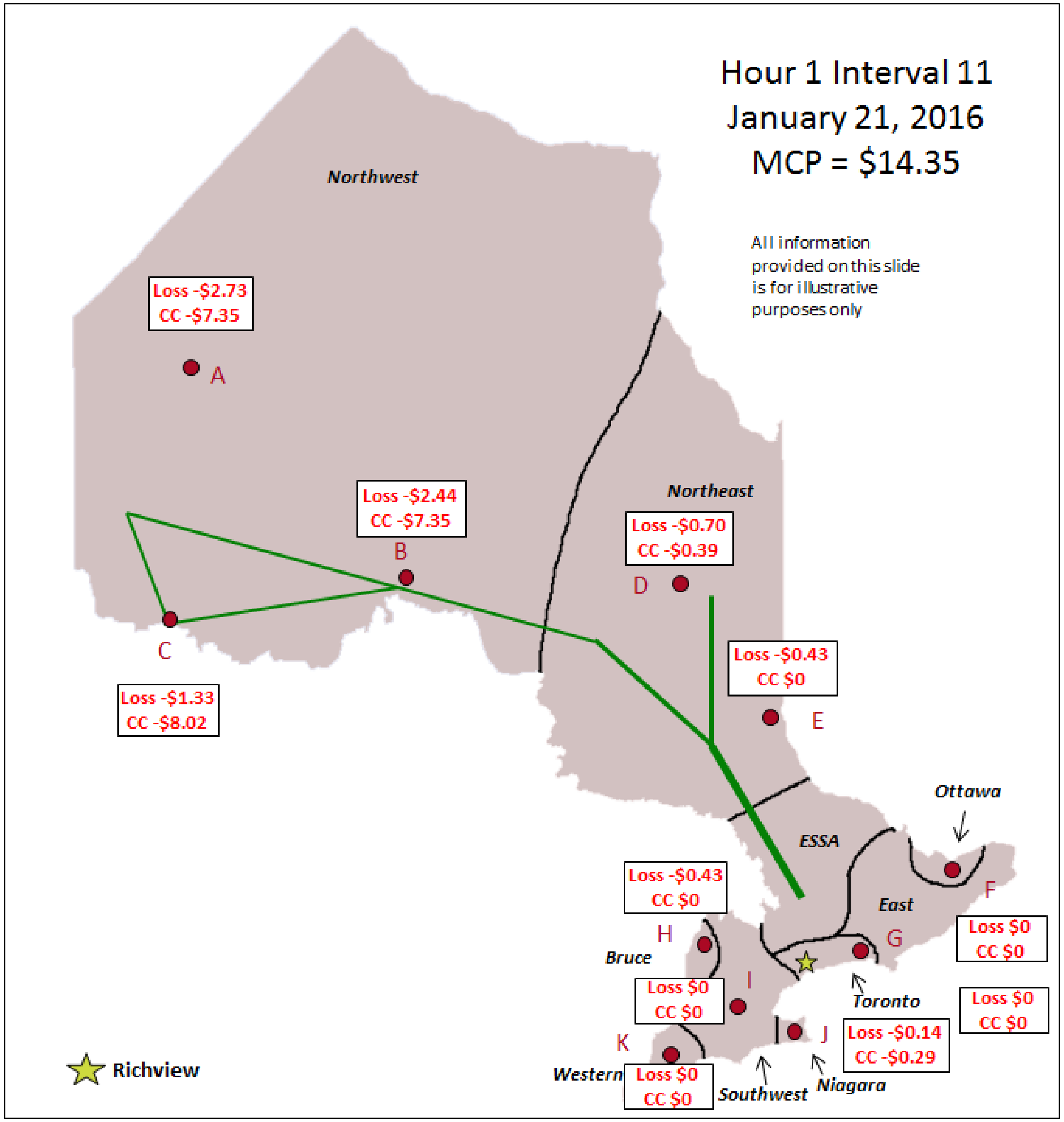
ISSUE #1 Based on Supplier LMPs

An SSM settlement price for loads calculated from the LMPs at the locations of supplier injections **<u>would charge the average cost</u>** of congestion and losses for the transmission of power to the locations of loads.



ISSUE #1 — Based on Load LMPs

An SSM settlement price for loads calculated from the LMPs at the locations of load withdrawals **<u>would charge the marginal cost</u>** of congestion and losses for the transmission of power to the locations of loads.



If SSM prices for load were calculated from the LMPs at load locations, the congestion charges to loads would result in a settlement residual in each interval in which there was congestion.

- This residual would occur because when there is congestion the congestion components of LMPs at load locations exceed those at supplier locations, on the whole.
- In a SSM, the congestion cost settlement residual is referred to as “congestion rents”.
- The congestion rent settlement residual can be used to fund payments to congestion hedges such as Financial Transmission Rights (FTRs).
- Under SSM, congestion rents must be allocated to loads through FTRs or an alternative mechanism.

The illustration shows the congestion rent residual for a hypothetical design in which each load pays the nodal LMP at its location. Similar congestion rents would result from other load pricing designs based on the LMPs at load locations.

ILLUSTRATIVE CALCULATION OF CONGESTION RENTS FOR SINGLE INTERVAL

Load	Withdrawal (MW)	LMP ($/MWh)	Congestion Component of LMP ($/MWh)	Congestion Charge Calculated Nodally
Load V	125	$30	$7.75	$969
Load W	38	$25	$2.90	$110
Load X	40	$22	$0.80	$32
Load Y	25	$20	($1.85)	($46)
Load Z	10	$18	($2.30)	($23)
Total	238	-	-	$1,042

Generator	Injection (MW)	LMP ($/MWh)	Congestion Component of LMP ($/MWh)	Congestion Charge Calculated Nodally
Generator A	75	$30	$7.75	$581
Generator B	50	$25	$2.90	$145
Generator C	40	$22	$0.80	$32
Generator D	30	$20	($1.85)	($56)
Generator E	55	$18	($2.30)	($127)
Total	250	-	-	$576

Congestion Residual (Rents) = $1,042 - $576 = $466

The overall congestion rent residual is positive by design, but may be negative (especially in real-time) for reasons that are outside of this discussion.

If SSM prices for load were calculated from the LMPs at load locations, the collection of the marginal cost of losses from loads would result in a settlement residual in each interval.

- The collection of a loss surplus occurs in every interval because the marginal losses incurred in serving an increment of load exceeds the average losses incurred in serving all load.
  - The prices paid by load would reflect the marginal cost of losses at the location of the load.
  - This would exceed the revenue paid to suppliers to supply the physical losses.
- Under SSM, the loss surplus must be allocated to loads. This will be discussed in the module on Make-Whole Payments and Uplift.

Alternatives for the level of aggregation of LMPs for the SSM load pricing design are:

- **Nodal** – price is based on the LMP for a specific load location;*
  - To maximize efficiency, ideally all loads would pay the LMP at their locations.
  - However, this would be a large change to the current policy in which Ontario has one uniform price for all internal load.
- **Zonal** – aggregated price is based on a zonal average of load LMP prices (i.e. Province is divided into two or more zones); *
- **Uniform** – aggregated price is based on a Province-wide average of LMP prices.

There are several methods for deriving an aggregated price based on LMPs.

*To be workable these alternatives would use LMPs at load locations even if the LMPs were estimated, for practical reasons, from LMPs at nearby supplier locations;

By aggregating the load settlement price to either a zonal or uniform price, there may be locations where the LMP at a load's location is higher or lower than the aggregated price.

- In areas with a high LMP, the LMP may exceed the value that a load would be willing to pay for consumption.
  - If charged an aggregated price, the load would consume if the aggregated price was low enough.
  - This represents an inefficiency as the actual cost to supply energy to the location of the load is greater than what the consumer may be willing to pay.
- In areas with low LMP, there may be load that would consume at the low price but not at the higher aggregated price.
  - This also represents an inefficiency in that an opportunity for efficient consumption is lost.

Zonal vs. Uniform Efficiency

Load settlement prices based on a zonal or uniform aggregation of LMPs would be less efficient than nodal load pricing.

- Aggregating the load price by zone would be less efficient than nodal pricing, but more efficient than uniform pricing for loads.
- Uniform pricing would be aligned with the current pricing system for Ontario loads, but would be the least efficient alternative.

ISSUE #2 Efficiency of Zonal vs. Uniform

In addition to addressing short-run operating incentive issues for dispatchable loads more efficiently than uniform pricing, zonal prices (calculated as a weighted-average of LMPs for loads in a zone) would signal locations where it would be relatively expensive vs. inexpensive to supply energy to new large loads.

- With zonal load pricing, this long-run price signal would be communicated to all participants.
- However, the zones might not incent efficient long-term consumption decisions if congestion patterns were to change.

ISSUE #2 Zonal Efficiency Driven by Zone Definition

For zonal pricing, it is most efficient to define load pricing zones so that there would be a relatively small difference between the zonal price for each zone and the LMP at load nodes within the zone.

- The number of zones could be defined by typical congestion patterns and would, ideally, be small.
- The relative efficiency of zonal vs. uniform pricing or nodal vs. zonal pricing for loads depends on how the zones are defined.
- U.S. markets typically use several zones as a compromise between nodal pricing and a single uniform price.

Aggregation Alternatives

Possible (non-LMP) pricing designs to provide an aggregated price for loads under SSM include:

1. Uniform load price equal to the average of supplier LMPs;
2. Uniform load price equal to injection-weighted average of supplier LMPs;
3. Uniform load price equal to withdrawal-weighted average LMP for loads;
4. Zonal load price equal to withdrawal-weighted average load LMPs within defined zones.

One possibility would be to charge all loads in Ontario a uniform price per MWh calculated as the straight (*unweighted*) average LMP for supply injections (including losses), per MWh of load withdrawals, in each interval or hour, i:

$$\frac{\frac{\left[\sum_{all\ suppliers\ s}(LMP_{s,i})\right]}{number\ of\ suppliers,\ s} \times [total\ injections_i]}{MWh\ load_i}$$

Using a uniform settlement price for load equal to the *unweighted* average per-megawatt LMP paid for supply would over-recover or under-recover the total amount paid to all suppliers.

ISSUE #2 Weighted Avg. Supplier LMP

Alternatively, the SSM uniform load price could be calculated as the *weighted* average LMP for supply injections (including losses), per MWh of load withdrawals, in each interval or hour, i:

$$\frac{\left[\sum_{all\ suppliers\ s}\left(LMP_{s,i}\right)*\left(MWh\ injection_{s,i}\right)\right]}{MWh\ load_i}$$

This is equal to the total LMP payments made to suppliers divided by total load withdrawals.

ISSUE #2 Weighted Avg. Supplier LMP

An SSM uniform settlement price for load equal to the weighted average per-megawatt LMP paid for supply would recover the LMP paid to all suppliers who injected power (load plus losses). It would charge loads for the average (not marginal) cost of congestion and losses.

Generator	Output (MW)	LMP ($/MWh)	Payment to Generator
Generator A	50	$25	$1,250
Generator B	75	$30	$2,250
Generator C	40	$22	$880
Generator D	30	$20	$600
Generator E	55	$18	$990
Total	250	-	$5,970

MWh of Load (excludes losses)	238
Aggregated Price to Load	$25.08
Total Collections from Load	$5,970

Charge and Payment are the same

A third alternative that could apply to either a uniform or zonal price would be to charge the per MWh load-weighted average LMP for load withdrawals in each interval or hour.

The load-weighted LMP price for an interval or hour, i, is:

$$LMP_i^{load} = \frac{\left[\sum_{all\ loads\ l}\left(LMP_{l,i}\right) * (MWh\ withdrawal_{l,i})\right]}{MWh\ load_i}$$

ISSUE #2 Weighted Average Load LMP

If the SSM pricing calculation for load were based on a load-weighted average of the prices at individual load locations, the same total amount would be collected from load as if each load were individually charged its LMP. It would charge loads for the marginal cost of congestion and losses.

Load	Withdrawal (MW)	LMP ($/MWh)	Charge to Load
Load V	38	$25	$950
Load W	125	$30	$3,750
Load X	40	$22	$880
Load Y	25	$20	$500
Load Z	10	$18	$180
Total	238	-	$6,260

MWH of Load (excludes losses)	238
Weighted Avg. LMP	$26.30
Total Charges to Load at Weighted Avg. LMP	$6,260

Total charge stays the same

ISSUE #2 — Related to Issue #1

Decisions concerning the level of aggregation (Issue #2) and the use of supplier versus load LMPs as the basis for load prices (i.e., whether loads are charged for marginal or average losses and congestion, Issue #1) are interrelated.

- For-the zonal (or nodal) pricing alternatives a reasonable definition of a "supplier LMP-based" design converges to an approach that would use supplier LMPs to proxy for prices at load buses.
- Calculation of zonal prices for loads from supplier LMPs and injection-based weights for suppliers in a zone would create settlement-complications and would be less efficient than basing the calculation on load LMPs and withdrawal-based weights.
- For nodal load pricing, there is no workable approach based on supplier LMPs, unless they are serving as proxies for load node prices.

ISSUE #2 Dispatchable Load Bidding

The efficiency issue caused by aggregating LMPs to calculate the load price is most relevant for dispatchable loads that actively participate in the market.

- Dispatchable loads submit bids into the marketplace and are dispatched according to their bid value.
- The larger the discrepancy between the price used to evaluate the load's bid (its LMP) and the aggregated price used for its settlement, the larger the efficiency and incentive problem between bidding and settlement.

With zonal pricing, the marginal incentives of dispatchable loads could be approximately aligned with efficient dispatch.

- Dispatchable load would have a price-based incentive to bid its willingness to pay into the dispatch because it would be dispatched to consume only when willing to pay its LMP (≅ zonal price).
- Dispatchable load in high-price locations would be dispatched down before load in low-price locations without the need for side payments.

While the use of zonal vs. uniform pricing reduces the incentive problem for dispatchable loads, it is still an approximation.

- Using a nodal price would provide the clearest incentive for the efficient dispatch of loads.
- A consideration is the IESO goal of increasing competition from all qualified supply resources in a technology-neutral manner. This includes increased participation from dispatchable loads.

SSM will need to consider methods for load pricing which manage the tradeoffs between incentives and immediate impact to market participants.

ISSUE #3 Dispatchable/ Non-Dispatchable Prices

A third issue to consider in the design of SSM prices for loads is whether the prices will differ for dispatchable versus non-dispatchable loads. The following combinations are possible:

- Same price for dispatchable and non-dispatchable loads.
  - Nodal*;
  - Zonal*;
  - Uniform.
- Different prices for dispatchable and non-dispatchable loads.
  - Nodal*/Zonal*;
  - Nodal*/Uniform;
  - Zonal*/Uniform.

*Requires LMPs (and weights) at load locations.

ISSUE #3 Dispatchable/ Non-Dispatchable Prices

Charging a different price to dispatchable loads than to other loads in Ontario could help to bridge the trade-offs of nodal vs. zonal vs. uniform load pricing.

- Dispatchable loads could be charged a nodal or zonal price in order to provide an improved incentive for efficient consumption decisions.
- Loads that are not dispatchable could be charged a zonal or uniform price that is more consistent with current pricing.

ISSUE #3 Incentive Issue with Different Prices

If dispatchable loads were charged a higher (or lower) price on average than non-dispatchable loads at the same location, it may impact their willingness to participate as dispatchable loads in the Ontario market.

- At locations where the average LMP was higher than the average non-dispatchable price there would be a material incentive for dispatchable loads to become non-dispatchable.
- At locations where the average LMP was lower than the average uniform non-dispatchable price there would be a material incentive for non-dispatchable loads to find a way to be settled as dispatchable loads.

An SSM design using different prices for dispatchable vs. non-dispatchable load would need some way to address this incentive issue.

ISSUE #3 Incentive Issue with Different Prices

A payment could be designed for dispatchable load in high-priced locations to address the incentives that arise from their paying a less aggregated price, while non-dispatchable load in the same location pays a lower average aggregated price.

- The payment could be temporary (or not).
- It could compensate dispatchable loads in high-priced locations for the approximate increase in their costs from paying the LMP at their location rather than the more aggregated price.
- The intent would be to prevent dispatchable load from opting to become a non-dispatchable load in order to pay the more favorable aggregated price.

The payment could be designed so as to:

- Maintain an incentive for dispatchable loads to respond to LMP.
  - It could be a purely financial product to true-up the payments by dispatchable load to be roughly the same as for non-dispatchable load, but the payment would not vary directly based on load consumption decisions.
  - In this way it would differ from a CMSC.
- Maintain an incentive for the dispatchable loads to remaining dispatchable.
  - The payments would reduce the net price paid by each dispatchable load over a period of time to approximately the average aggregated price (uniform or zonal) at its location.

ISSUE #3 Payment Funding

Funding for the payments could be provided by:

- Congestion rents (depending on the outcome of Issue #1);
- Marginal loss surplus (depending on the outcome of Issue #1); or
- Separate uplift charge

Congestion rents and the marginal loss surplus would be collected from a load pricing design based on the LMPs at load locations.

Financial Transmission Rights (FTRs) could be the basis for a payment design funded by congestion rents.

- FTRs are a financial hedge against congestion charges that have been used in other ISOs to accomplish objectives similar to those described here for the payment to dispatchable loads.
- In Phase 2, consideration will be given to:
  - What FTRs could accomplish for Ontario;
  - The costs and complexity of implementing FTRs, given other alternatives.
- FTR implementation need not include an FTR market.

FTR EXAMPLE Congestion Hedge to Aggregated Price

The following example illustrates the mechanics of FTRs.

If a load were allocated FTRs from the uniform/zonal pricing point to its location, it would receive an FTR payment to off-set the difference in congestion charge between the LMP it pays at its location and the uniform/zonal aggregated price. (The load also receives the FTR payment if it does not consume.)

Illustration of 70 MW FTR Settlement from Uniform Price Point to Sink A

Hour	FTR Settlements				Load in Hour (MW)	LMP Energy Settlements Minus FTR Receipts		
	Source LMP -- Uniform Price ($/MWh)	Sink A LMP ($/MWh)	Congestion Rent Payment for 1 MW FTR	Congestion Rent Payment for 70 MWs of FTR		LMP Charge to Load	Net Payment by Load	Net Cost per MWh
6:00	$13.12	$14.18	$1.06	$74.20	45	$638.10	$563.90	$12.53
7:00	$15.77	$16.68	$0.91	$63.70	50	$834.00	$770.30	$15.41
8:00	$18.29	$19.04	$0.75	$52.50	68	$1,294.72	$1,242.22	$18.27
9:00	$17.95	$19.75	$1.80	$126.00	80	$1,580.00	$1,454.00	$18.18
10:00	$18.04	$19.85	$1.81	$126.70	71	$1,409.35	$1,282.65	$18.07
					314	$5,756.17	$5,313.07	$16.92

Note: For simplicity this example excludes the marginal loss component of the LMP, so Sink LMP minus Source LMP equals Congestion Cost.

FTR EXAMPLE Congestion Hedge to Aggregated Price

If loads were allocated FTRs from the uniform/zonal aggregated pricing point to their location, their average net price could be close, but not necessarily identical, to the uniform/zonal aggregated price.

Illustration of 70 MW FTR Settlement from Uniform Price Point to Sink A

Hour	FTR Settlements				Load in Hour (MW)	LMP Energy Settlements Minus FTR Receipts			Charge to Load based on Uniform Price
	Source LMP -- Uniform Price ($/MWh)	Sink A LMP ($/MWh)	Congestion Rent Payment for 1 MW FTR	Congestion Rent Payment for 70 MWs of FTR		LMP Charge to Load	Net Payment by Load	Net Cost per MWh	
6:00	$13.12	$14.18	$1.06	$74.20	45	$638.10	$563.90	$12.53	$590.40
7:00	$15.77	$16.68	$0.91	$63.70	50	$834.00	$770.30	$15.41	$788.50
8:00	$18.29	$19.04	$0.75	$52.50	68	$1,294.72	$1,242.22	$18.27	$1,243.72
9:00	$17.95	$19.75	$1.80	$126.00	80	$1,580.00	$1,454.00	$18.18	$1,436.00
10:00	$18.04	$19.85	$1.81	$126.70	71	$1,409.35	$1,282.65	$18.07	$1,280.84
					314	$5,756.17	$5,313.07	16.92	$5,339.46

Note: For simplicity this example excludes the marginal loss component of the LMP, so Sink LMP minus Source LMP equals Congestion Cost.

Issues to be addressed in the design of SSM pricing rules for loads include:

1. Whether to charge loads the marginal or average cost of losses and congestion.
2. The level of aggregation of the load prices and the tradeoffs between nodal, zonal, and uniform pricing.
3. Whether prices will differ for dispatchable versus non-dispatchable loads.
   - Incentive issues arising from using the same aggregated settlement methodology (uniform or zonal) for different classes of loads.
   - Whether to implement a system of payments, such as FTRs, to address incentive issues.