Sub-hourly settlement
Stakeholder session 3

Sept. 23, 2020

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AESO Stakeholder Engagement Framework

Agenda

Items	Time	Presenter
Welcome and introductions	9:00 – 9:15	Nicole LeBlanc
Stakeholder feedback review and market participant meeting summary	9:15 – 9:30	Murray Hnatyshyn
Costs with Q&A	9:30 – 10:15	Thanh Nguyen
Break	10:15 – 10:30	☺
Benefits with Q&A	10:30 – 11:30	Brendan Jewitt
Payment for load on the margin with Q&A	11:30 – 11:45	Thanh Nguyen
Next Steps & Conclusion	11:45 - noon	Murray Hnatyshyn

Review - Objectives
Sub-hourly settlement stakeholder process

- Determine if there is value in moving towards a shorter interval and if yes, what interval?
- Through the stakeholder engagement the AESO is looking to better understand
  - The expected enhancement in price fidelity and flexibility
  - The expected financial impact on loads and generators
  - Implementation costs for AESO and market participants
  - Timing required to transition to a sub-hourly settlement interval

Review of Session 2 and Stakeholder Feedback

Session 2 review
Summary of time interval considerations

	Hourly	15 minutes	5 minutes	Transition 15 – 5minutes
Fidelity: aligns production/ consumption with price				
Flexibility: promotes flexible response from generators				
Flexibility: promotes flexible response from loads				
Complexity of implementation for generators				
Complexity of implementation for price responsive load				
Complexity of implementation for commercial and residential loads				
Change implications for AESO				
Change implications for LSA/ MDM				
Costs		TBD	TBD	TBD

- Outcome: AESO to pursue investigation of the 15 minute settlement option

Session 2 review
Summary of participation applicability

(assumes 15minute settlement interval)	Mandatory all gen	Mandatory all loads	Mandatory all interval metered gen and load	Voluntary for all
Fidelity: aligns production/ consumption with price	⊕	△	⊕	⊘
Flexibility: promotes flexible response from generators	⊕		⊕	△
Flexibility: promotes flexible response from loads		⊕	⊕	△
Complexity of implementation for generators	⊕		⊕	⊕
Complexity of implementation for price responsive load		⊕	⊕	⊕
Complexity of implementation for commercial and residential loads – true up requirements		⊘	△	△
Change implications for AESO	⊕	△	⊘	⊘
Change implications for LSA/ MDM		△	△	⊘
Costs	TBD	TBD	TBD	TBD

- Outcome: AESO to better understand cost estimates for
  - a) mandatory for all load and generation and
  - b) interval metered loads and generation

Session 2 stakeholder comments

- Interval duration – 15 minutes
  - Majority of stakeholders preferred 15 min intervals
  - A couple preferred hourly
  - 1 expressed a preference for 5 min intervals
- Participation – implement for all participants
  - Most preferred that all participants would be on sub-hourly settlement
  - A few preferred that only interval meters would be on sub-hourly settlement

Session 2 stakeholder comments, cont.

- Mechanics
  - Hourly offers
    - Most respondents believed that hourly offers should continue
    - Some wanted to match settlement intervals with offers and that T-2 restrictions should change
  - Ad-hoc dispatch
    - Most respondents believed that ad-hoc dispatches should continue and that 15 and 5 minute dispatches weren't warranted
    - Restricting timing of dispatch would increase regulating reserves
- Continuation of consultation – mixed outlook
  - Most preferred to delay consultation due to economic conditions or that further analysis was needed before decision could be made
  - A small number of participants, mainly loads, wanted to continue due to expected economic benefits

Market participant meeting summary

- Since Session 2 AESO met with a number of stakeholders on a one on one basis to discuss SHS and potential impacts
- Load Settlement Agents
  - FortisAlberta, ENMAX, EPCOR, ATCO, Cognera for the City of Lethbridge
  - Preference was for all loads to be settled with shorter interval - less complications
  - IT system changes would be required
  - Alignment of AUC metering standards would be beneficial
- Retailers
  - ENMAX, ATCO, EPCOR, Direct Energy
  - Would require a few years of lead time in order to minimize impacts to current contracts
  - Requires smart meter to allow all customers to fully take advantage of shorter settlement
- Loads
  - ADC, IPCAA, ANC, West Fraser, AltaSteel
  - Loads would become more price responsive under a SHS regime
  - If SHS does not proceed would like payment for loads on the margin

Cost estimate summary

Cost Summary
Load Settlement Agent

- Cost estimates ranged from $500K to $5M with $500K of ongoing costs
  - Wide range of estimates reflect difference in participants' systems and options that could be implemented

- Metering: low costs for most
  - 1 participant anticipated significant changes with their meter replacement
  - Majority of participants believed that their existing meters were sufficient and that they would be able to profile on 15 minute basis
- IT system: medium costs
  - Most participants believed that their systems had the ability to accommodate sub-hourly settlement intervals, but that rigorous testing would be needed to ensure it performed as expected
- Data Storage: medium costs
  - There would be an increase in data storage as there would be 4 times the amount of data

Cost Summary
Retailers

- Cost estimates ranged from $1M to $9M with $5M of ongoing costs
  - Wide range of estimates reflect difference in participant's systems and options that could be implemented
- Metering: minimal cost
  - Retailers do not own meters
- IT system: high cost
  - Changes to billing and settlement systems would be required
  - Changes to profiling, forecast and pricing models to account for sub-hourly intervals
- Data Storage: low cost
  - Storage needs will increase but magnitude unknown until implementation details are known
- Other:
  - Cost could be reduced if timing of implementation aligned with future contract expiry. i.e. contracts of 3 year would require lead time of same length so costs of change in law for contracts can be avoided

Cost Summary
Loads

- Estimated minimal costs: under $50K to move to 15 minute settlement intervals

- Metering: minimal costs
- IT systems: minimal costs
  - Changes to the settlement systems would be required but expected to be minimal
- Data Storage: minimal costs
  - No specific costs provided for data storage

Cost Summary
Generation

- Cost estimates ranged from minimal to $4M

- Metering: minimal costs
  - All existing generators are on 15 minute interval meters and thus no changes required
- IT systems: medium costs
  - Settlement systems and other internal systems would require changes which is the bulk of the cost estimates
- Data storage: low costs
  - Participants indicated that there may be some increase as potentially there would be 4 times the amount of data but were unable to provide estimates

Cost Summary
Others

- Meter Data Managers
  - Cost estimates would be minimal especially if implementation of sub-hourly settlement interval aligned with meter replacements

- Not all companies able to provide estimates
  - Some companies required 6 – 12 months to develop estimates – no costs provided for these entities

Cost Summary
AESO

- Cost estimates ranged from $1.5M to $3M
  - Range depends on complexity of option chosen

- Metering: not applicable
  - AESO does not own meters
- IT system: medium cost
  - With changes required to approximately 5 market tools
- Data Storage: low cost
  - Storage needs will increase but magnitude unknown until implementation details are better defined

Cost Summary
Overall cost by systems

	One Time Costs Low Range ($)	One Time Costs High Range ($)	Incremental Ongoing Costs ($)
Metering	1.1M	4.1M	None provided
IT systems	24.0M	34.9M	0.1M
Data storage	2.9M	2.9M	2.7M
Others	3.1M	3.1M	3.3M
Total	**31.1M**	**45.0M**	**6.2M**

- Total costs ranges from $31M to $45M
  - Costs are dependent on implementation options that have not been fully defined at this stage
- IT system was the largest cost category
- Costs associated with other category included contract renegotiations, customer education and other internal system support

Cost Summary
Overall cost by participants

	One Time Costs Low Range ($)	One Time Costs High Range ($)	Incremental Ongoing Costs ($)
Generators & Loads	4.4M	5.1M	None provided
LSA	4.9M	8.3M	0.9M
Retailers	20.3M	29.3M	5.3M
AESO	1.5M	2.3M	None
Total	**31.1M**	**45.0M**	**6.2M**

- Retailers had the highest implementation costs
- AESO costs aligned with individual LSA costs

Questions

- Any questions on the stakeholder cost summary?
- Any questions on the AESO cost summary?

Break

Benefit estimate summary

Benefit summary

- This section analyzes both the static (real-time) and dynamic (long-run) benefits of sub-hourly settlement
- As is typical in analyzing these types of problems, static benefits are easier to estimate using historical data, while dynamic benefits are expectations of the future and as such rely on theory and principle

Static benefits

Economic analysis
Objective

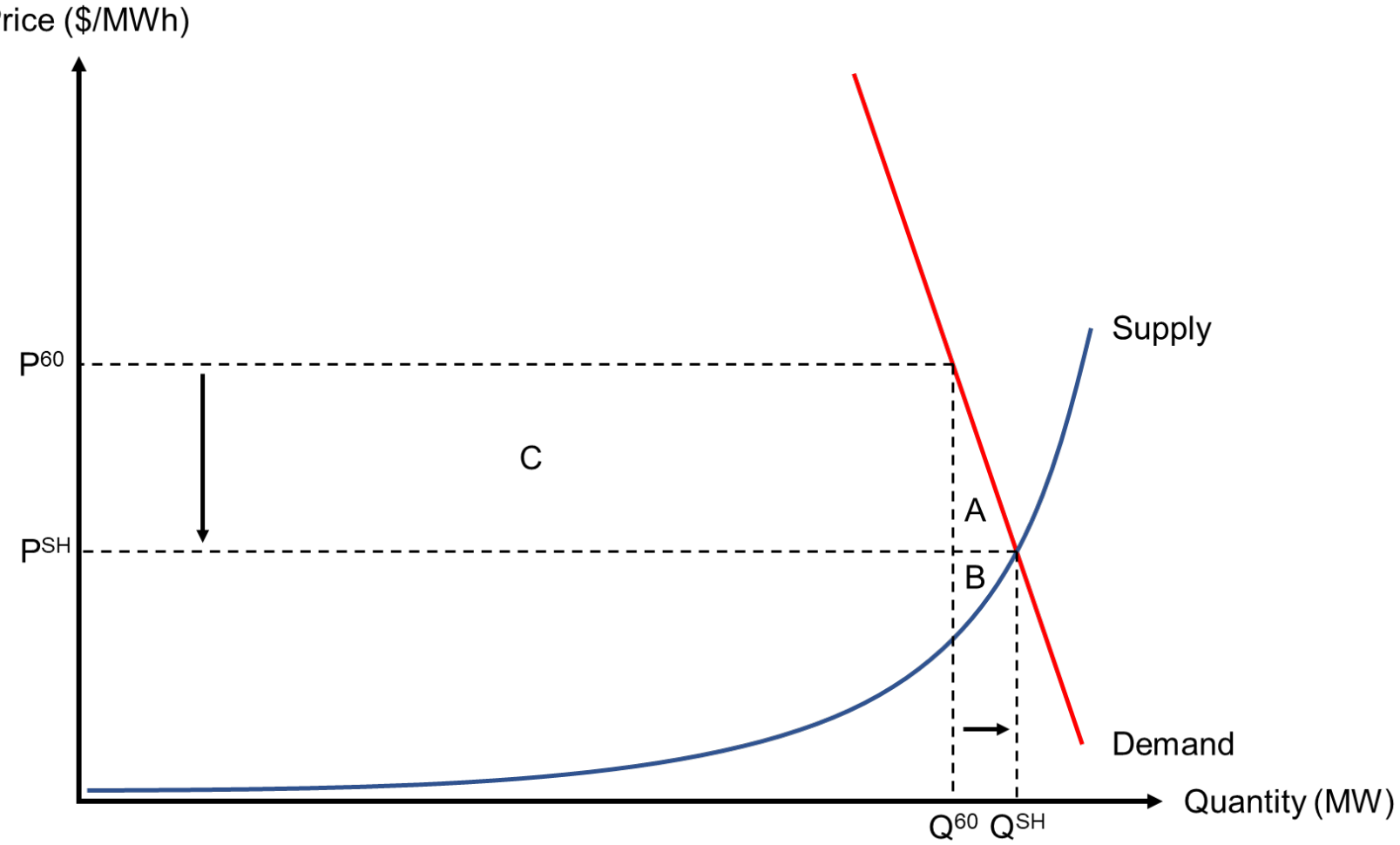
- Previous analysis estimated the financial impact to generators and loads of sub-hourly settlement
  - This analysis did not allow for system marginal prices to change as a result of behavioural shifts from sub-hourly settlement
  - Measurement was limited to ‘how the pie is divided’
- While impacts to individual stakeholders must be considered, we want to understand the benefits from moving to sub-hourly settlement for market as a whole

- AESO’s additional analysis measures changes in static efficiency by allowing loads to respond to sub-hourly prices
  - This analysis measures the change in the ‘size of the pie’

Economic analysis
Methodology

- The static efficiency measured by this model is called allocative efficiency
  - How close the market clearing price and quantity are to the true underlying supply and demand equilibrium
- The hypothesis for this analysis is that sub-hourly settlement will allow market prices to better reflect supply and demand fundamentals at any given time, thereby enhancing static efficiency

Economic analysis Methodology



Area A: Increase in allocative efficiency for loads

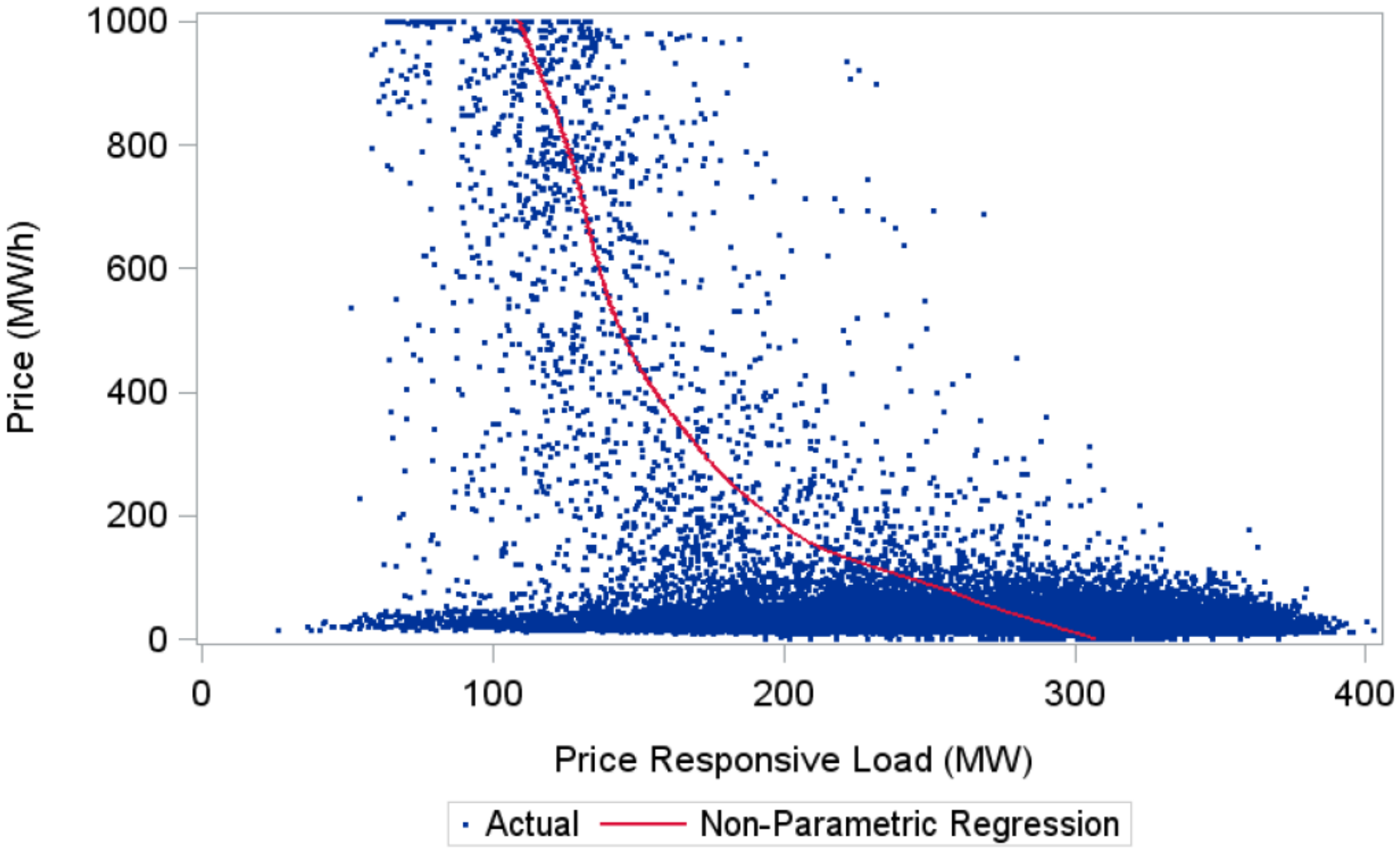
Area B: Increase in allocative efficiency for generators

Area C: Transfer from generators to loads

Economic analysis
Demand curve

- To model the response from loads, a demand curve is used
  - This same demand curve has been used to measure static efficiency in the market power mitigation report
- The demand curve reflects the willingness to pay of price-responsive loads
- Assuming that price-responsive loads consume electricity when it is profitable for them to do so, this also means that the value of their production is imbedded in this curve

Economic analysis
Demand curve



Economic analysis
Demand curve

- Assumptions and limitations:
  - The actual behaviour of loads is more sophisticated than a simple price-quantity relationship can capture
    - Price-responsive loads perform a complex optimization that includes forward-looking expectations and operational constraints
  - Loads are assumed to react the same way to sub-hourly prices as they do to hourly prices
  - The curve effectively represents an average response from 2013-2018
    - Changes in demand between these years is not reflected
    - Behaviour in past years may not be reflective of future behaviour
  - This curve does not capture exogenous factors such as LSSi arming, coincident peak avoidance, etc.
    - This will be partially addressed

Economic analysis
Supply curve

- To model the impact on generators, it is necessary to estimate the supply curve
- A merit order – the way generators offer into the AESO - is not a supply curve
  - Supply curves represent the marginal cost of production
  - The merit order determines the equilibrium, while the supply curve determines how efficient that equilibrium is
- The supply curve –based on marginal cost is – was estimated in a manner consistent with recent AESO market power mitigation analysis
  - Includes components such as fuel, carbon, and O&M costs

Economic analysis
Other considerations

- Exogenous demand factors (LSSi, coincident peak, etc.)
  - These factors typically result in demand outliers, which could cause the model to predict too large of a change in demand than what would be reasonable to expect
  - The model takes into account the deviation from the average
    - The logic for this process varies depending on the scenario
      - *e.g. If demand is already lower than usual, further decreases due to high prices will be smaller than if demand was at an average level*

Economic analysis
Model

- The model runs 15-minute and 5-minute scenarios for the years 2014, 2015, 2018, and 2019
  - 2016 and 2017 were omitted due to flat prices that would likely see little change with sub-hourly settlement and are not expected to reflect future market conditions
- With the supply and demand curves, the model calculates a new price and quantity equilibrium for each sub-hourly interval
- This sub-hourly equilibrium is then compared to the hourly equilibrium to measure the change in efficiency

Economic analysis Results

5 minute results

Year	Load Gain (Area A)	Generator Gain (Area B)	Total Gain
2014	-$81,246	-$181,476	-$262,722
2015	-$3,848	-$75,358	-$79,206
2018	-$11,409	-$41,555	-$52,963
2019	$2,082,829	$1,287,692	$3,370,521
Total	**$1,986,326**	**$989,303**	**$2,975,630**

15 minute results

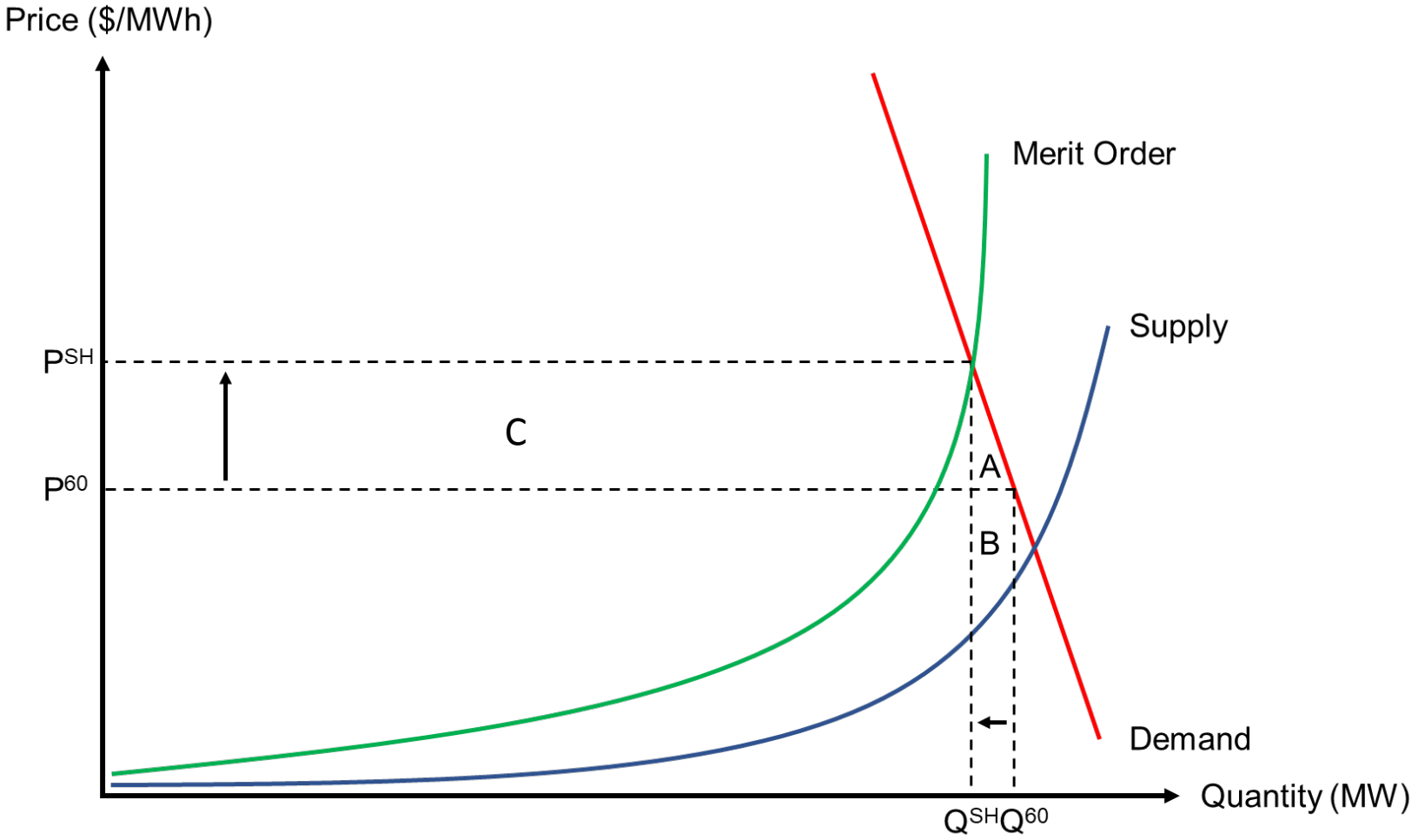
Year	Load Gain (Area A)	Generator Gain (Area B)	Total Gain
2014	-$98,848	-$187,433	-$286,281
2015	$2,883	-$66,380	-$63,497
2018	-$21,517	-$48,255	-$69,772
2019	$2,062,836	$1,284,792	$3,347,629
Total	**$1,945,354**	**$982,724**	**$2,928,079**

Marginal benefit of moving to 5 minutes is extremely small

Economic analysis
Results

- Sub-hourly settlement results in a very small loss in efficiency in 2014, 2015, and 2018 and a relatively larger gain in 2019
- While the total impact in most years is small, there are hours with both gains and losses that approximately net out
- Reductions in static efficiency from sub-hourly settlement are the result of more direct exposure to market power
  - Because the merit order is not always a true reflection of the underlying supply curve, sub-hourly settlement may move the market equilibrium away from the supply/demand equilibrium

Economic analysis
Results



Area A: Decrease in allocative efficiency for loads

Area B: Decrease in allocative efficiency for generators

Area C: Transfer from generators to loads

Economic analysis
Sample results

While market power is the cause of inefficiencies resulting from sub-hourly settlement, this does not mean that more/less market power results in more/less inefficiencies

Sample Period	Hourly Pool Price	15 min Pool Price	Dispatch Change	Load Efficiency Change (Area A)	Gen Efficiency Change (Area B)
3/20/2019 16:00	$762.54	$801.46	-3 MW	-$15.84	-$551.94
3/20/2019 16:15	$762.54	$801.46	-3 MW	-$15.84	-$551.94
3/20/2019 16:30	$762.54	$749.00	0 MW	$0	$0
3/20/2019 16:45	$762.54	$125.39	+85 MW	$3453.21	$2094.14

Sample Period	Hourly Pool Price	15 min Pool Price	Dispatch Change	Load Efficiency Change (Area A)	Gen Efficiency Change (Area B)
12/13/2019 21:00	$273.43	$248.74	0 MW	$0	$0
12/13/2019 21:15	$273.43	$817.17	-50 MW	-$2560.87	-$3011.61
12/13/2019 21:30	$273.43	$174.84	+3 MW	$2.62	$106.34
12/13/2019 21:45	$273.43	$110.00	+11 MW	$154.75	$239.50

Economic analysis
Static efficiency conclusions

- In providing its market power mitigation advice to the Minister of Energy, the AESO described that the tradeoff of static efficiency for dynamic efficiency gains is a necessary feature of the energy-only market framework
  - Sub-hourly settlement appears to have a negligible impact on static efficiency
  - Therefore, the determination of the merits of sub-hourly settlement will lie primarily in its ability to deliver gains in dynamic efficiency

Dynamic benefits

Dynamic benefits

- While reductions in load due to market power technically reduce static efficiency, these high prices are how the Alberta market signals scarcity
- Sub-hourly settlement may enhance price fidelity by strengthening price signals during scarcity events
  - Loads will be encouraged to respond to both scarcity of supply and scarcity of ramping capability
- This may create greater opportunities for investment in flexible and fast-ramping generation and / or load response
  - For generators this incentive is already partially provided through payments to suppliers on the margin (PSM)
  - SHS may provide that incentive for loads

Dynamic benefits

- Investments in more flexible generation and load may increase competition and reduce the ability for large participants to exercise market power
- In the table below, from the AESO's market power mitigation advice, we found the following inefficiencies due to market power
- To the extent that market power is disciplined, sub-hourly settlement may result in some reduction of these inefficiencies but the values is difficult to estimate with any certainty

Year	Productive Inefficiencies ($million)	Allocative Inefficiencies ($million)	Total Inefficiencies ($million)
2013	$16	$21	$38
2014	$23	$7	$30
2015	$10	$5	$16
2016	$5	$0	$5
2017	$11	$1	$11
2018	$37	$9	$46

Questions

- Any questions on the benefit analysis?
- Any other analysis that needs to be performed?

Summary of Cost & Benefits

Benefits summary

Year	Generator transfer (Area C) $M	Load transfer (Area C) $M	Generator efficiency change (Area B) $M	Loads efficiency change (Area A) $M	**Generator total impact $M**	**Load total impact $M**	**Total impact $M**
2014			-0.19	-0.1	**-0.19**	**-0.1**	**-0.3**
2015	0.6	-0.6	-0.07	0	**0.53**	**-0.6**	**-0.1**
2016	0.17	-0.17			**0.17**	**-0.17**	**0**
2017	0.28	-0.28			**0.28**	**-0.28**	**0**
2018	1.06	-1.06	-0.05	-0.02	**1.01**	**-1.08**	**-0.1**
2019	1.52	-1.52	1.28	2.06	**2.8**	**0.54**	**3.34**
Total	**3.63**	**-3.63**	**0.97**	**1.94**	**4.6**	**-1.69**	**2.91**

- Transfers show money moving from one party to another (how pie is divided)
- Efficiency change shows gains in allocative efficiency (size of pie)

Average yearly static benefits = $2.91 million / 6 years
~ $0.5 million annually

Consolidated estimate combined costs and benefits

	Total Benefit $M	Total Cost Low $M	**Net Impact $M**
One time cost or benefit	0	-31.1	**-31.1**
Ongoing cost or benefit	0.5	-6.2	**- 5.7**
Total	**0.5**	**-37.3**	**-36.8**

- While the AESO believes SHS incents flexibility and promotes price fidelity, it seems unlikely the costs associated with implementation would ever be outweighed by identifiable static benefits
- The AESO expects that SHS will promote improved competition as assets that can ramp quickly / change demand quickly will be able to counter price extremes
  - However, the costs associated with the change to SHS will largely be bourne by the load customers that can't currently participate in the market.
- There will be longer term dynamic efficiency benefits but the timing and magnitude of these benefits is highly uncertain

Conclusion

Do not proceed with the SHS initiative at this time

- The AESO believe sub-hourly settlement is a superior market design to the current hourly settlement interval as it allows for better price fidelity, incents flexibility, and reduces uplift payments. However,
- Costs currently far outweigh benefits
  - Now is not the time to assign additional costs to industry
  - Benefits are not aligned with costs
    - Little ability for LSA customer base – commercial and retail consumers – to currently benefit from initiative. Benefits are enjoyed by a few large industrial loads
- This initiative could be aligned with other future initiatives that require IT system changes to allow for cost efficiencies
- Planning ahead
  - While adoption now is not recommended, this market design may pursued in the future
  - Market participants should incorporate the ability to settle sub-hourly when making future upgrades to their systems

A sub-hourly settlement alternative
Payment for Load on the Margin

Payment for load on the margin (PLM)

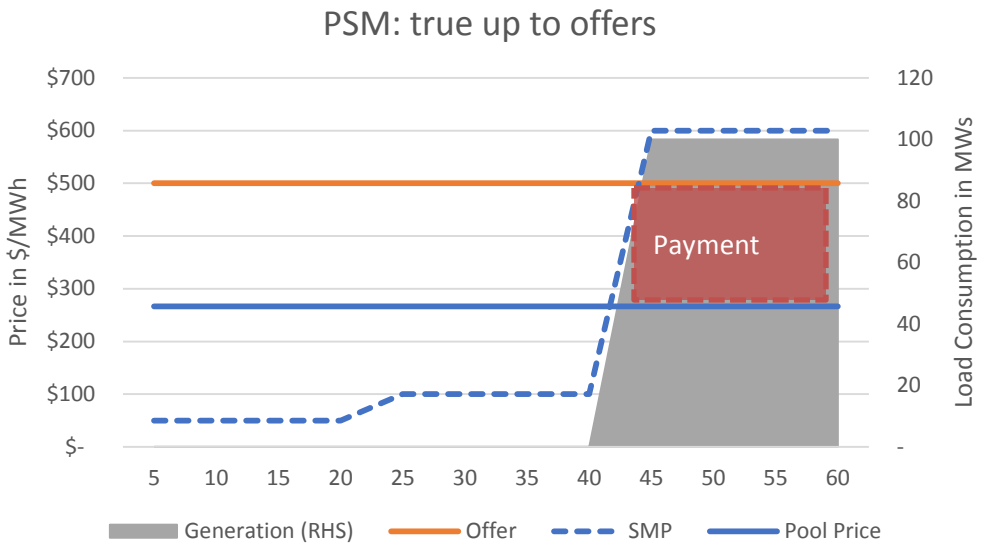
- We've heard from some participants that payment for load on the margin should be considered
  - Pros
    - Allows for dynamic benefits of sub-hourly settlement to be realized with much lower implementation cost
      - *Would incent load to bid into the market*
      - *Load pays energy prices more reflective of price during consumption*
      - *Fair as it is somewhat equivalent to payment for suppliers on the margin*
    - Increase system controller certainty as a demand curve could be created and used for dispatch
  - Cons
    - Increases uplift as an additional out of market payment is applied
    - Increases complexity
    - Some loads indicated that PLM would not incent them to bid in, as the compliance burden would outweigh the benefits

PLM two options considered

- AESO considered two alternatives for PLM implementation
  - Option 1 – lost opportunity approach - proposed by a load customer
  - Option 2 – true-up to bid approach
- Both approaches require loads to
  - Submit bids into the AESO
    - Allows for accurate bid volume determination
  - Follow dispatch instructions issued by the AESO
    - The true-up payment can only be made if loads are responding to dispatch requirements
- But first – a Payment to Suppliers on the Margin refresher

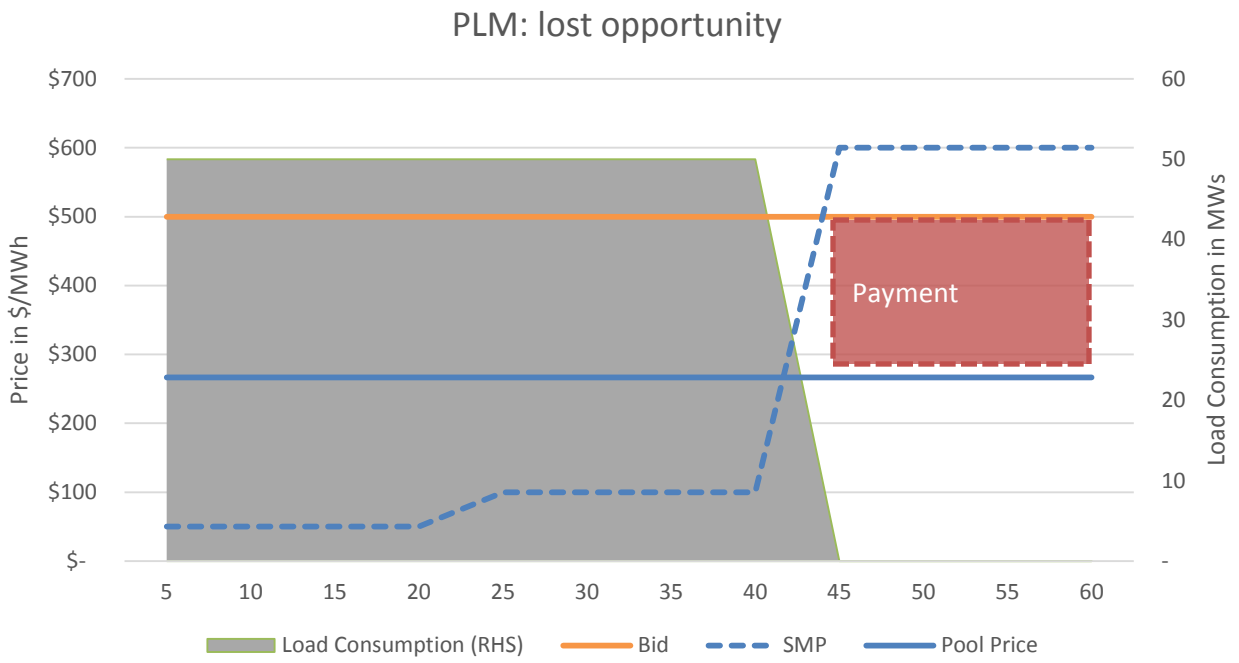
Payment to Suppliers on the Margin Refresher

- PSM is meant to keep the generator whole to their offers and to incent generators to follow dispatch
  - Generators receive an uplift payment when the hourly pool price is below their offer price and they've been dispatched by the ISO
  - Payment equals the difference between pool price and offer price multiplied by volume of energy produced in marginal offer block



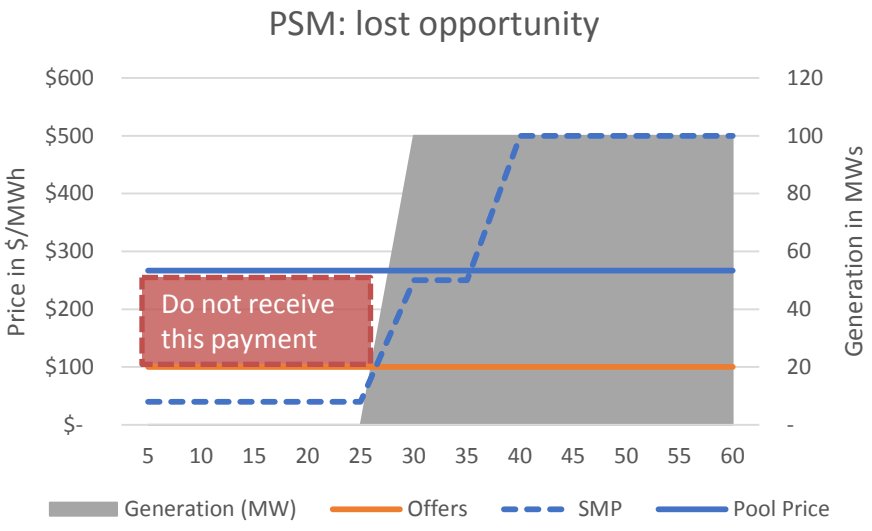
PLM Option 1
Payment for lost opportunity

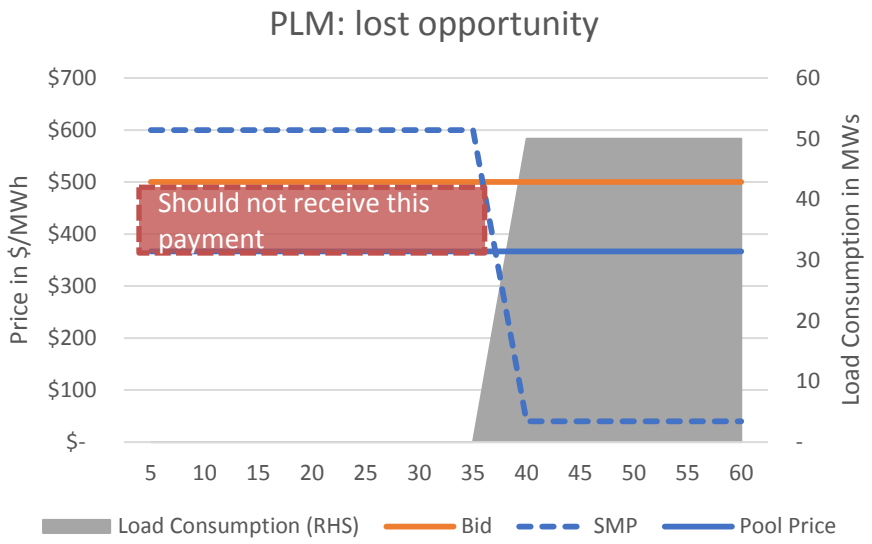
- Load bids, if the settled pool price is below the bid during periods the load had curtailed consumption, the AESO would pay an uplift equal to the difference between the bid price and the hourly pool price
- Payment represents lost opportunity of missed consumption



PLM Option 1 Remarks

- This differs from the Payment for Supplier on the Margin (PSM)
- PSM compensation is not for lost opportunity but to keep the generator whole to their offers when they generate
  - Generators do not receive an uplift payment when SMP is low, they have not been dispatched, and pool price settles above offer price

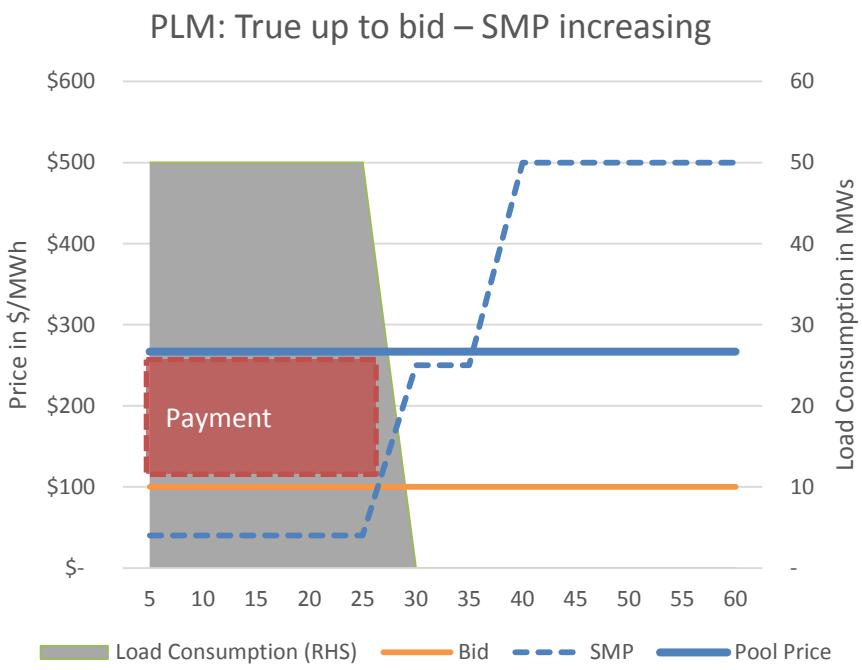


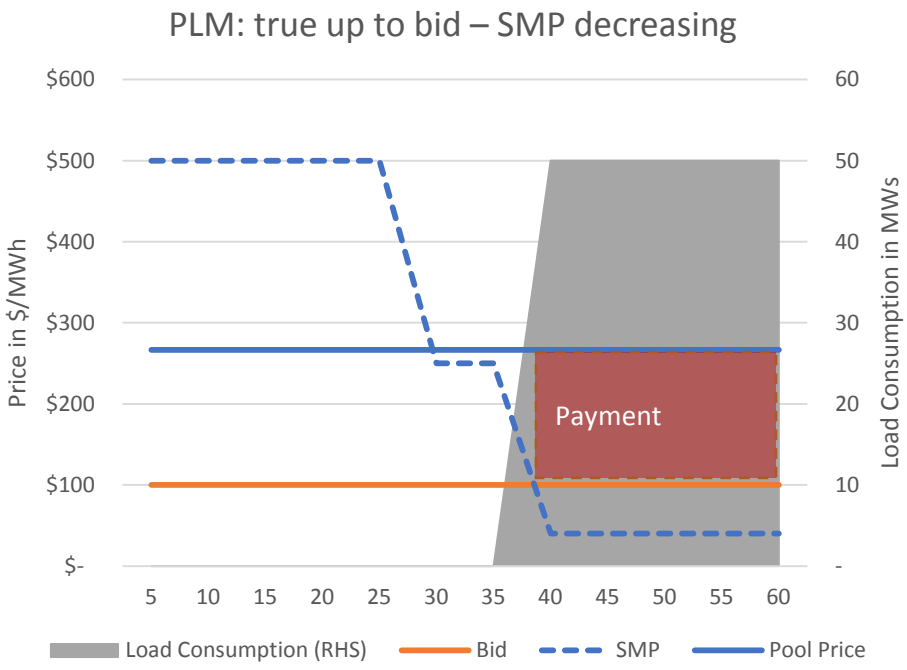


The AESO will not contemplate changes where it will compensate for lost opportunity for either load or supply

PLM Option 2
True-up to bid

- True-up to bid approach is analogous to PSM
- Payment equals the difference between pool price and bid price multiplied by volume of energy consumed in the dispatched bid block
  - This ensures load does not pay any more than the bid price for energy consumed
  - This also promotes consumption when prices are low, curtailment when prices are high





Review of potential past PLM payouts

- PLM Option 2 would have resulted in approximately $50k - $950k in annual uplifts
  - Assumes price responsive load bids in, based on the price and volume contained in load bid curve presented earlier in this session
- PLM payout is very small compared to energy payments
  - Neither approach would have accounted for more than 0.05% of energy payments

Year	Energy Payments ($)	PLM Option 1 Lost Opportunity ($)	PLM Option 2 True-up to Bid ($)
2015	$1,753,333,420	$149,139	$566,008
2016	$1,059,156,351	$15,249	$47,393
2017	$1,422,568,073	$57,251	$157,674
2018	$3,294,946,721	$207,899	$545,122
2019	$3,498,828,088	$338,744	$931,418

PLM conclusion

Further exploration of option 2: true-up to bid may be warranted

- PLM could be beneficial to the market
  - Promotes fairness
    - Participating loads will not pay more than bid price for energy
    - Participating load dispatch requirements and payments are analogous to generator treatment
  - Promotes efficiency
    - Provides the right settlement signal to incent load participation and flexible consumption
    - The least cost option available to enable flexible load consumption
    - While long term integration is still being developed – this approach could be applied to energy storage assets
  - Promotes competition
    - Demand curve from load bids would provide a better price signal for both market and AESO system controller

PLM considerations

- Determine the size of potential participation
  - AESO will seek further stakeholder input to determine the number of market participants that would participate in a PLM product
- Rule related issues
  - Determine new rule and rule change needs
    - Similar to 103.4: Payment to suppliers on the margin
  - Determine how to measure compliance for loads
    - Must bid/must comply a likely requirement
  - Who makes the payments to participating loads
- Costs
  - IT costs for AESO expected to be small as we can utilize some of the process in place for PSM
  - Explore further costs to the market

Do you think there is value in exploring payment to load on the margin given the benefits and issues identified?

Conclusion and Next Steps

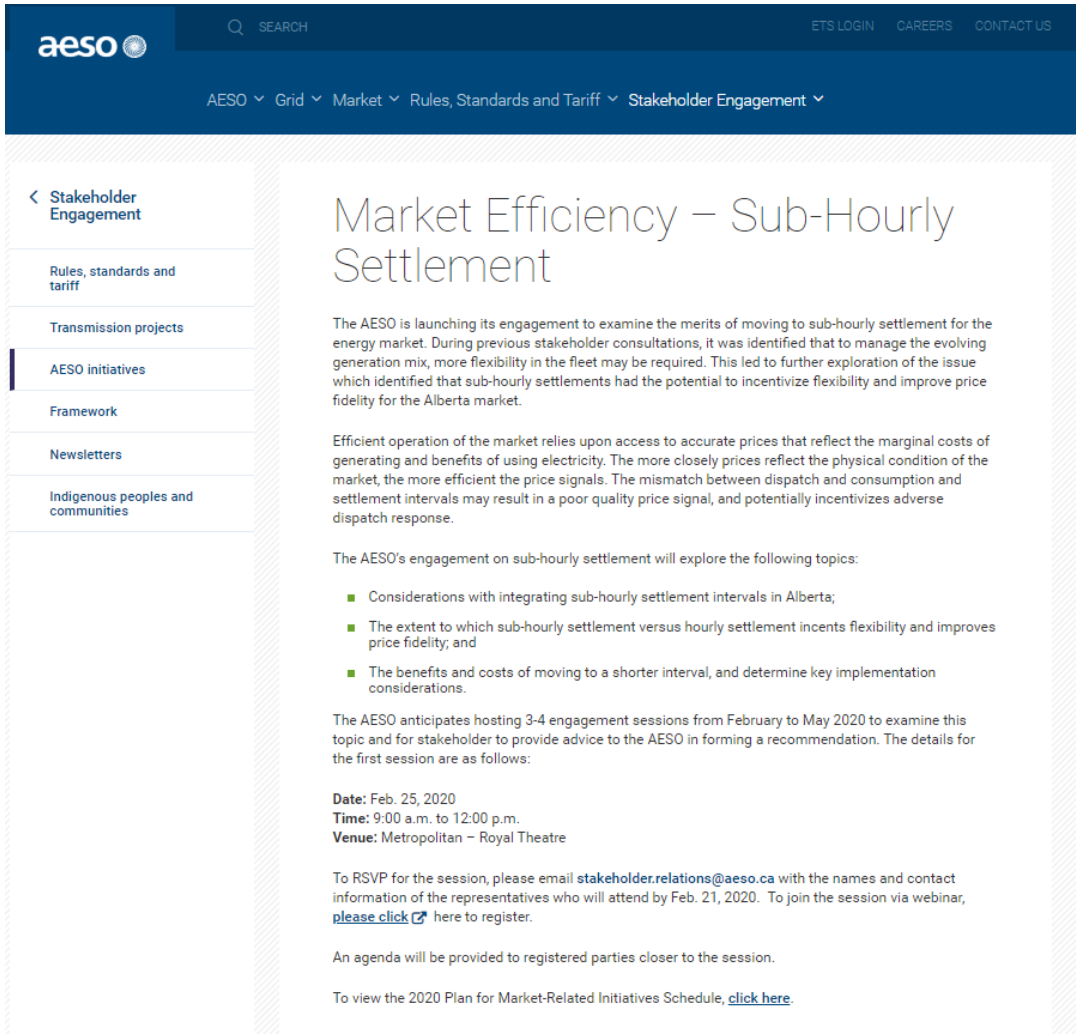
Conclusion and next steps

Next steps

- Solicit feedback from stakeholders to see if Payment for Load on the Margin warrants further exploration

Sub-hourly settlement engagement materials

Information on SHS



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Thank you