London Economics International LLC

PowerNex Associates Inc.

Density Study Results

Stakeholder Consultation

Prepared for Hydro One Networks, Inc.

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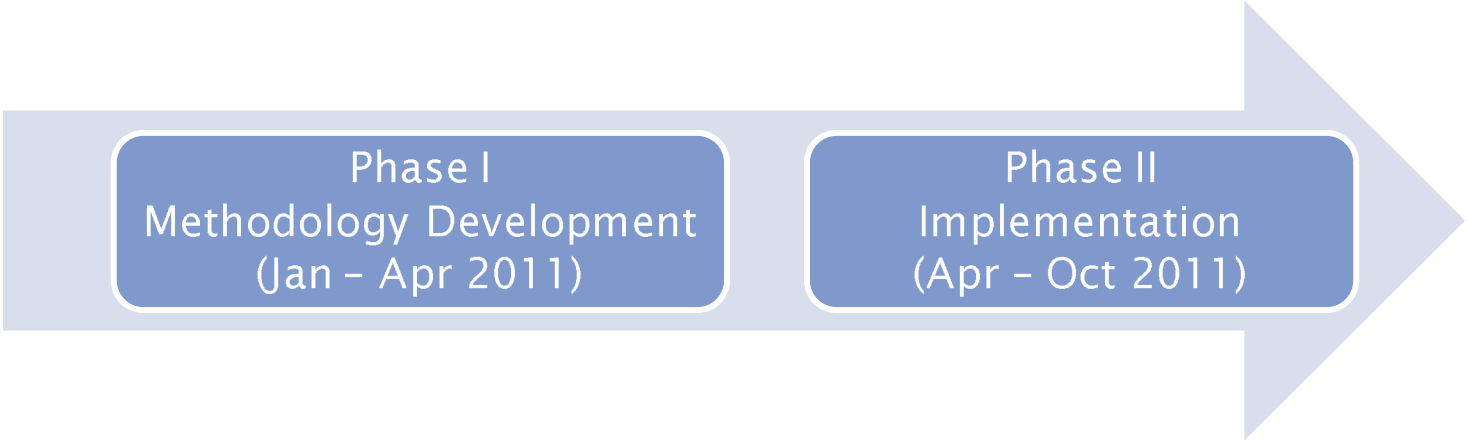
Plan of Presentation

1	Review of Study Objectives
2	Implementation of Methodology
3	Summary of Results and Findings
4	Questions and Answers

The study had three objectives

- **The study was initiated in response to a request from the Ontario Energy Board ("OEB")**
- **The objectives closely follow the OEB's direction**
  - Evaluate the relationship between customer density and distribution service costs
  - Assess whether the existing density-based rate classes and density weighting factors appropriately reflect this relationship
  - Consider, qualitatively, the appropriateness and feasibility of establishing alternate customer class definitions
- **Used a phased approach**
  - Comprehensive stakeholder engagement session held on March 22, 2011



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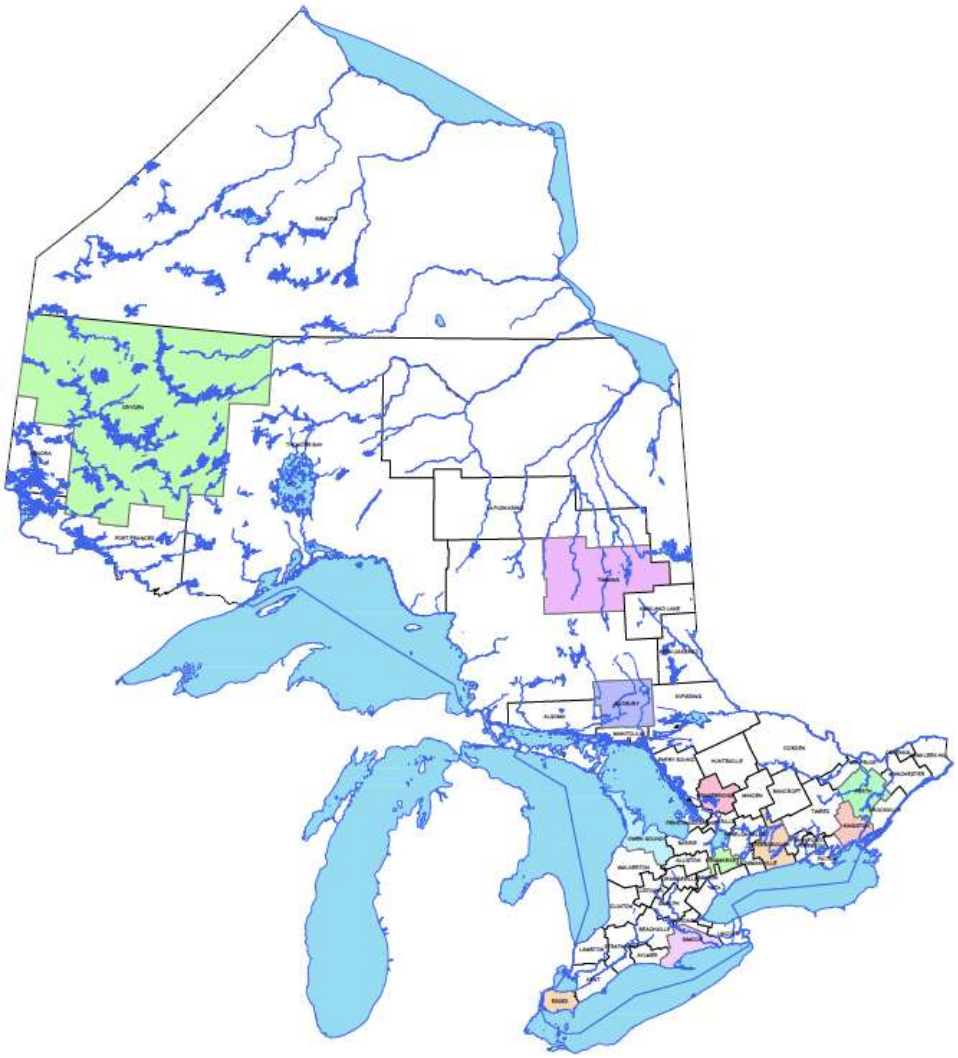
Methodology consisted of two separate but complementary analyses

- **Econometric**
  - Operating area level data
  - 48 HONI operating areas were analyzed
  - Data reflects natural observations
  - Statistical analysis used to interpret and understand relationships between drivers
- **Direct Cost Assignment**
  - Sample area level data
  - Sample areas selected from 11 operating areas
  - A total of 62 sample areas
  - Unique "assignment factors" developed to distribute operating area and provincial-level costs to sample areas
- **Both analyses used five or more years of historical data (2006-10)**
- **Both analyses considered operating, maintenance and administrative ("OM&A") cost and proxies for capital costs**

Operating Areas in HONI's Distribution Service Territory



Functional form of the econometric model was chosen based on theory and prior experience

- **The chosen functional form was "quadratic" and has the following general formula**

$$\ln C = a_0 + \sum_i a_i \ln Y_i + \sum_j a_j \ln W_j + \sum_k a_k \ln Z_k + a_t T + \frac{1}{2}\left[\sum_i b_i \ln Y_i \ln Y_i + \sum_j b_j \ln W_j \ln W_j\right] + \varepsilon$$

  - "Yi" denotes a variable that quantifies output
  - "Wi" denotes an input price
  - "Z" denotes additional business conditions
  - "T" is a trend variable
  - "ε" denotes the error term
  - "a" and "b" represent the estimated coefficients

- **Note, that because each of the independent and dependent variables is represented as a natural logarithm ("ln") the coefficients are "elasticity" estimates**

- **LEI and PNXA analyzed two specific cost functions, one where C denotes OM&A costs only and the other where C denotes OM&A and a proxy for capital costs**

Determining the cost function was an iterative process, where a number of different specifications were tested

- **Concerns such as the sign of the estimated coefficients, the statistical significance of the coefficients, and the overall "fit" of the regression were weighted in determining which independent variables to include**

- **The five independent variables included in the final model were:**
  - customer density ("CD")
  - number of customers ("N") and its square term ("N^2" or "NN")
  - energy density ("ED"), and
  - a time, or trend, variable ("T")

- **This choice of variables is consistent with other econometric analyses where customer density was considered as an independent variable**

- **Utilized a modified generalized least squares algorithm to estimate the regression coefficients**

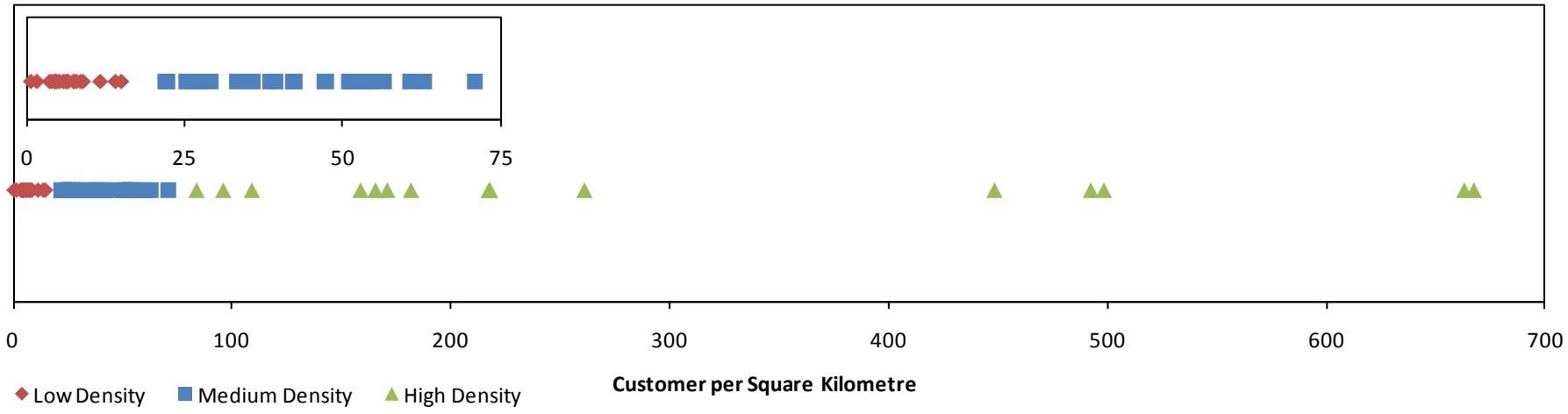
A representative cross section of sample areas was selected

- **A total of 11 operating areas were utilized for the direct cost assignment analysis**
  - Bracebridge, Dryden, Essex, Kingston, Newmarket, Owen Sound, Perth, Peterborough, Simcoe, Sudbury, and Timmins
  - The operating areas include: three in the north, three in the southwest, three from the central part of the province, and two in the east
  - Operating areas were selected to represent diversity in terms of geology, the prevalence of storms, and overall size
- **A total of 62 sample areas were selected; between four and seven from each of the 11 operating areas**
  - Sample areas divided into three groups based on customer density, not based on existing rate classes
  - Four general guidelines for selecting sample areas:
    - similar size, approximately 20 km^2
    - low-density between 100 and 200 customers
    - medium-density between 700 and 1,200 customers
    - high-density around any large "urban" concentration of customers (typically more than 2,000 customers)
- **Study included 24 low-density ("LD"), 22 medium-density ("MD"), and 16 high-density ("HD") sample areas**

The sample areas cover a wide spectrum of customer densities

- Low-density sample areas range from 0.7 to 14.9 customers per km²
- Medium-density sample areas range from 22.0 to 70.9 customers per km²
- High-density sample areas range from 83.9 to 667.9 customers per km²

Spectrum of Sample Area Customer Densities



- The sample areas are representative of the varying conditions and customer types across HONI's service territory

Costs were directly assigned to the individual sample areas

- **Lines & Stations Operations, Maintenance and Administrative Costs**
  - Costs were assigned based on seven unique assignment factors
  - Factors consider number of customers, distance from service centre, length of underground conductor, frequency of outages, etc.
- **Vegetation Management**
  - Historic cost data for tree clearing and brush control covering a 10-year period were provided for feeders in the sample areas
  - Annual cost data put on a common 2010 dollar basis
  - Vegetation management costs were totalled and divided by 10 to provide a levelized annual cost for each feeder
  - The vegetation control costs for each sample area were calculated based on the length of feeder within the sample area, relative to the total feeder length
- **Asset Intensity (a proxy for capital costs)**
  - The replacement value of existing distribution assets attributable to the individual sample areas based on the number of assets and their individual replacement cost
  - Total replacement cost divided by the total number of customers in the sample area to obtain the per-customer replacement cost (the "asset intensity")
- **Administrative and general and certain customer care costs were not assigned to the sample areas, at this stage of the analysis**

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Econometric analysis indicates negative relationship between cost and customer density

- **Four distinct models were analyzed**

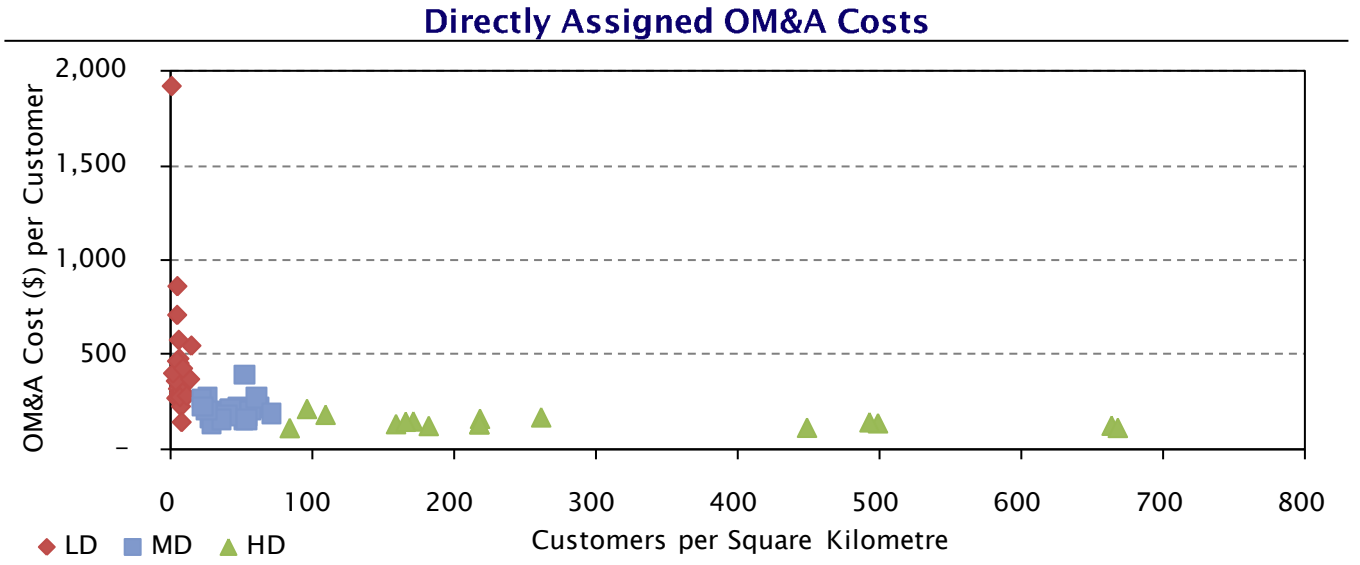
Estimated Customer Density Coefficients

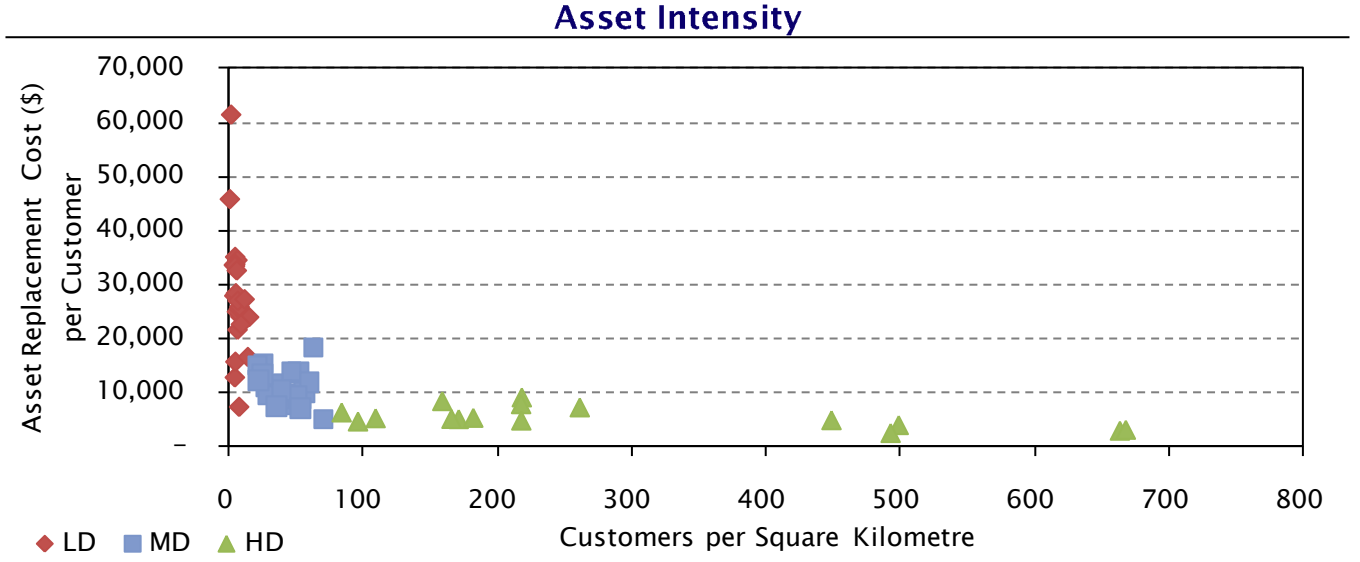
Costs Modeled in Econometric Model	Density Measure	Estimated Coefficient	95 Percent Confidence Interval	
			Low	High
OM&A	$CD_{ciircuit-km}$	-0.299	-0.368	-0.23
OM&A	CD_{km^2}	-0.100	-0.124	-0.076
OM&A and Capital Proxy	$CD_{ciircuit-km}$	-0.121	-0.349	-0.225
OM&A and Capital Proxy	CD_{km^2}	-0.287	-0.151	-0.092

- **Estimated coefficients for customer density in all four models are statistically significant at the 95 percent confidence interval**
- **More specifically, all four models show a negative relationship between costs and customer density**
- **Based on the results of the fourth model, which considers OM&A and the Capital Proxy, a fivefold increase in customer density would lead to a 150 percent increase in cost**
  - For example, an increase from 5 customers per km^2 to 25 customers per km^2, or from 25 to 125 customers per km^2

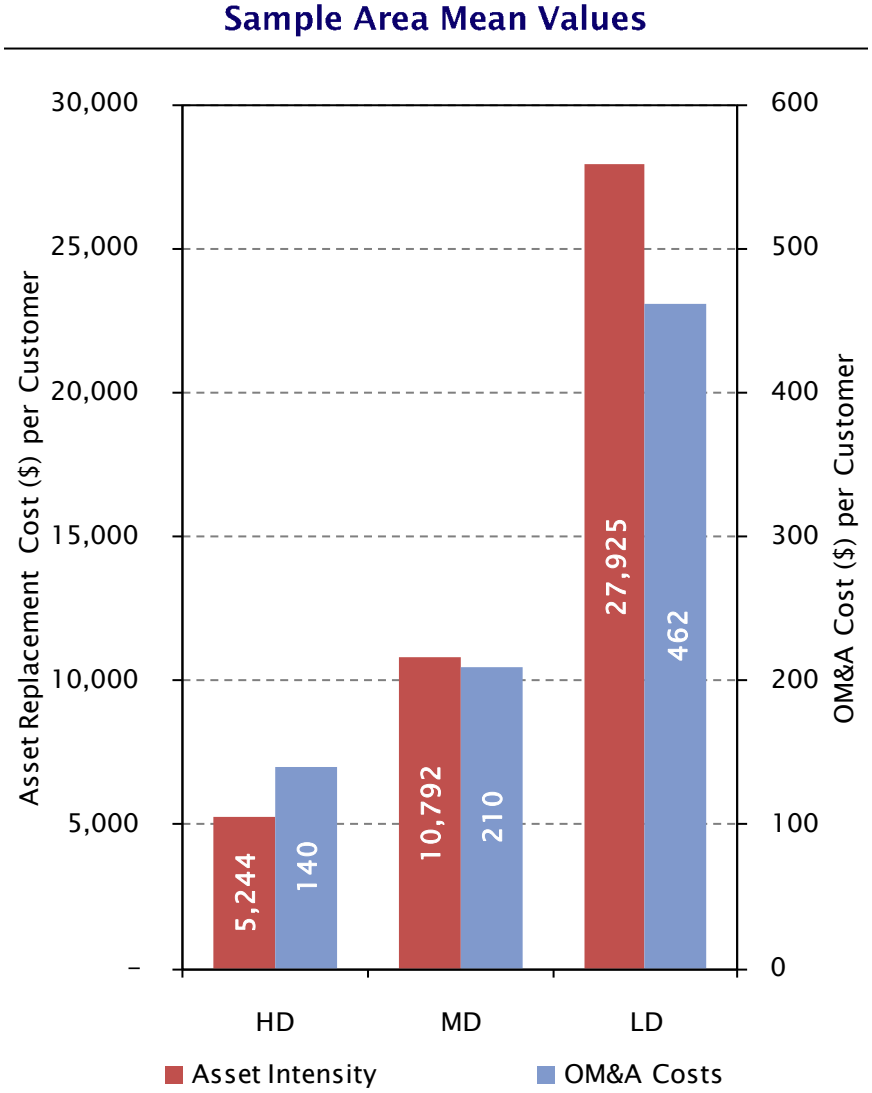
Individual sample area results reveal a sharp decline in cost per customer as density increases

- Some overlap across groups in terms of cost per customer for individual sample areas
- Variability of per-customer assigned costs decreases as density increases
- Results are consistent for OM&A and Asset Intensity





Sample means are distinct and confirm negative relationship



- Used a t-test to establish whether the mean values were statistically different
- Established that with 99 percent confidence, the mean asset intensity and OM&A cost for the low-, medium-, and high-density sample areas were distinct
- Direct cost analysis confirms negative correlation between customer density and distribution costs

Conclusion: The two independent analyses confirm that the average cost to serve HONI customers increases as the customer density decreases

Four elements of HONI's existing rate class structure to consider: type of rate classes, number of rate classes, demarcation points, and the cost allocation factors

▶ Type of Rate Classes

- Analyses demonstrate that HONI's cost to serve customers of different "densities" is different
- Reasonable for HONI to use rate classes differentiated based on customer density

▶ Number of Classes

- Currently, three year-round residential and two general service density-differentiated classes
- Analyses showed that there is a statistically significant difference between the mean assigned costs for the high-, medium-, and low-density sample areas
- Supports three density differentiated rate classes
- Fewer general service customers (approximately 1/10th) supports fewer classes
- Variability of assigned costs increased as density decreased; cost to serve low-density customers varies more so than medium- and high-density customers

▶ Demarcation Points

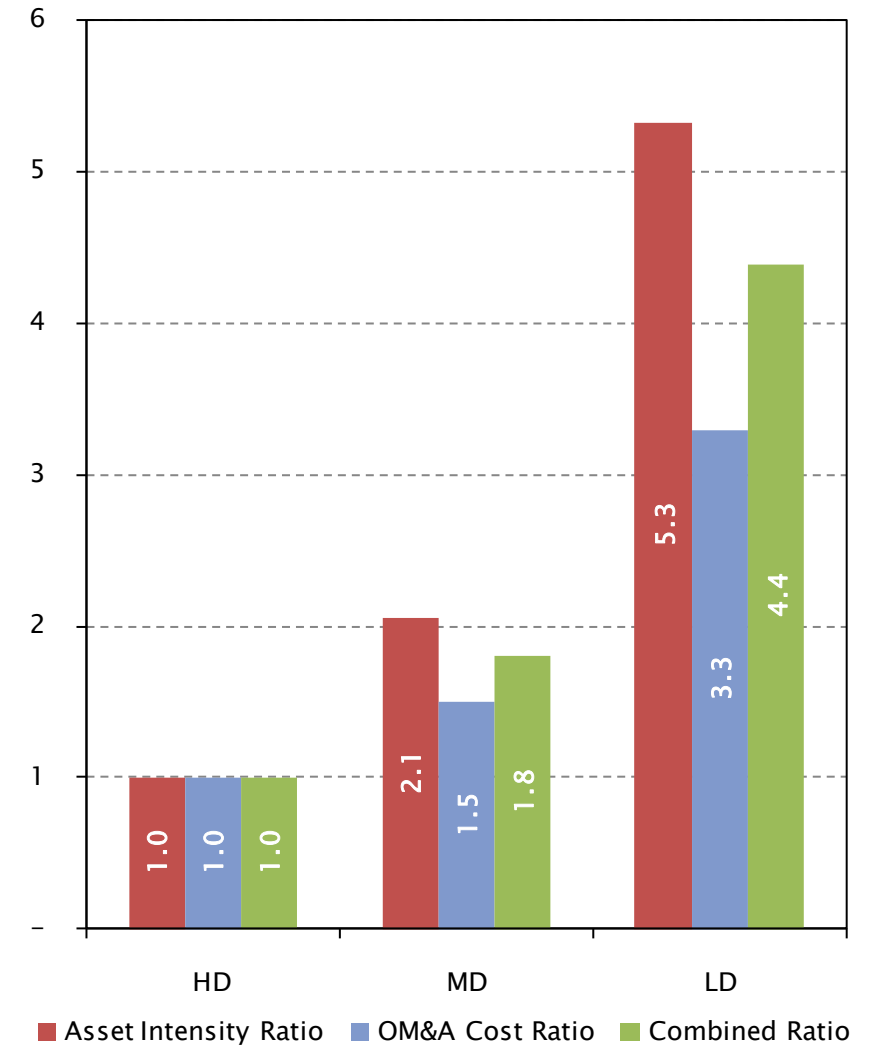
- Study did not provide clear evidence to support changing the existing demarcation points
- Minor adjustments could be made, however, costs and benefits associated with a transition
- Report considered alternative rate designs, i.e. municipal boundaries and regional rates

▶ Cost Allocation Factors

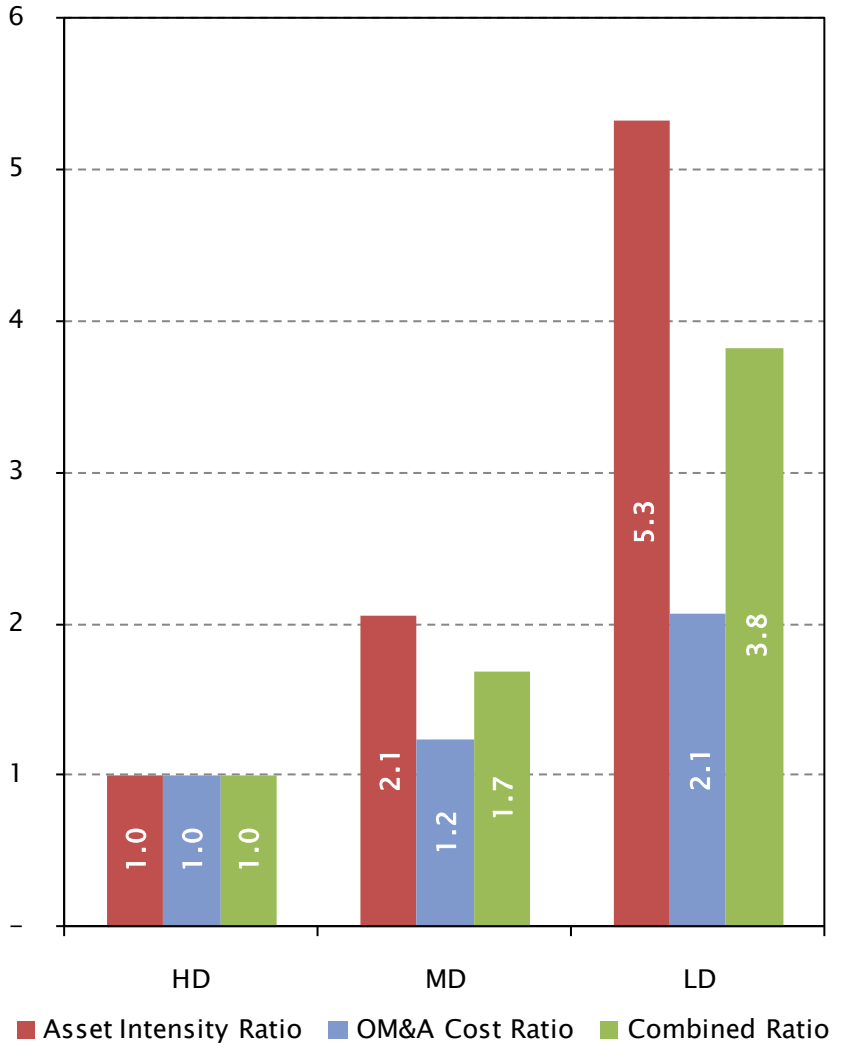
- Non-density allocation factors
- Density weighting factors

Reasonableness of existing allocation factors can be assessed based on outcome of cost allocation model, relative to results of direct cost assignment analysis

"Unadjusted" Ratio of Average Sample Area Costs

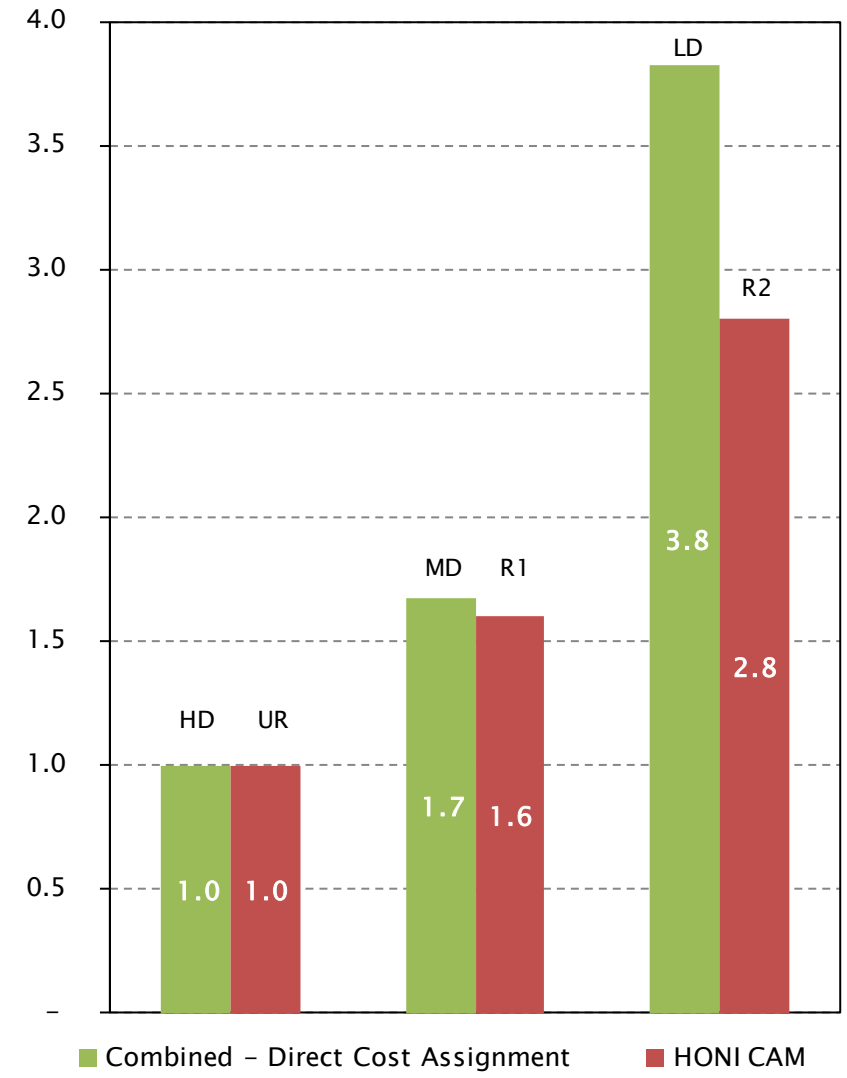


"Adjusted" Ratio of Average Sample Area Costs



Directionally the results are consistent; existing allocation may not capture the actual difference between the mean cost to serve year-round residential customers

Comparison of Output from HONI CAM to Adjusted Ratios of Average Sample Area Costs



- Mean density of the high-density sample areas likely understates the mean density of the UR class
- Mean density of the low-density sample areas likely overstates the mean density of the R2 class
- Average customer density of the Seasonal rate class falls between that of the R1 and R2 classes
- Average customer density of the urban general service classes (UGe and UGd) is similar to that of the UR class
- Average customer density of the non-urban general service classes (GSe and GSd) falls between that of the R1 and R2 classes

Study objectives were accomplished

Objective 1: *Evaluate the relationship between customer density and distribution service costs*

- **Two independent analyses demonstrated that there is a statistically significant negative relationship between customer density and HONI's distribution service costs**

Objective 2: *Assess whether the existing density-based rate classes and density weighting factors appropriately reflect this relationship*

- **Study demonstrated that cost to serve customers of different "densities" is different, supporting the use of density-differentiated rate classes**
- **Existing allocation and weighting factors may not capture the magnitude of the difference in costs to service customers of varying density**

Objective 3: *Consider, qualitatively, the appropriateness and feasibility of establishing alternate customer class definitions*

- **Report addresses alternate customer class definitions, including structures based on municipal boundaries or regional rates**
- **Move to such a design is a long-term decision that should be considered in the context of a broader provincial dialogue**

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