Energy Management at Toronto Pearson Airport

GREATER TORONTO AIRPORTS AUTHORITY

By Ronak Patel, P.Eng. CEM
Presentation Agenda

- About Greater Toronto Airports Authority
- About Toronto Pearson International Airport
- Energy Management at Toronto Pearson
  - What we consume/ Where we consume
  - What we manage/ How we manage
  - Why we conserve/ How we conserve
  - What we could achieve
- Energy Efficiency Challenges for Airports
About Us
Greater Toronto Airport Authority

- Created under the federal government’s National Airport Policy
- Non-share capital corporation
- Responsible for operation, maintenance and development of Toronto Pearson International Airport since 1996
- 60-year ground lease with 20-year renewal option
Quick Stats: Toronto Pearson Int. Airport

- Canada’s largest airport with over 35% of total air traffic
- Fourth largest entry point into North America
- Seventh largest port of entry in the U.S.
- Second largest airport in North America in terms of international passenger traffic
- Over 70 airlines authorized to operate at Toronto Pearson, 180 destinations worldwide
- 67% of world economy accessible from TPIA
- 41 million passengers (Canada’s population 35.7 million)
Our Building Stock

- Terminals (5,828,679 SQ.FT)
- Parking Garages (5,516,278 SQ.FT)
- Hangers and Cargos (3,296,135 SQ.FT)
- Office Buildings (315,070 SQ.FT)
What we consume

- 287 Gigawatt Hours of Electricity a year
- 123 eGigawatt Hours of Natural Gas a year
- 40 MW of Demand
- Equal to 13,800 Homes

This makes us a large neighbor to our surrounding communities and a large user of power!
Where we consume!

Toronto Pearson Airport
334 eGWh
(2015)

Our Tenants
76 eGWh
(2015)
Total Energy Breakdown

* Including heating/cooling provided by CUP.
Terminal Electricity Breakdown

2015 Electricity Usage Breakdown

- Emergency, 21.99%
- HVAC, 17.07%
- Mixed, 8.90%
- Lights_Power, 9.36%
- Lights_Power_MC, 25.88%
- Baggage, 4.83%
- Elevator, 0.68%
- Other, 0.16%
- T1_Differences, 3.61%
- AIRFIELD, 0.11%
- Disposal, 0.10%

Energy Loads at Pearson Airport

1) Heating, Ventilation And Air Conditioning
2) Interior/Exterior Lighting
3) Airfield Lighting
4) Baggage Systems
5) Aircraft Support Systems
6) IT and Security
7) Domestic Hot Water
8) Navigation Systems
9) De-icing Pumps
10) Catering Kitchens
11) Automated People Movers
What we manage

5 Commodities to track

Electric  Gas  Water  Hot Water  Chilled Water

14M+ Square-feet area

90+ Utility accounts

800+ Sub-meters

250+ Buildings

250+ Chargeback accounts
Energy Management Information System

Save Energy and Cost

Electric, Gas, Water, Hot Water, Chilled Water
Electricity Use/Cost Profile/ Toronto Pearson

**Unit Cost Summary**
(FY begins in Jan of year shown)

<table>
<thead>
<tr>
<th>Year</th>
<th>$/KWH</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>0.10</td>
</tr>
<tr>
<td>2014</td>
<td>0.10</td>
</tr>
<tr>
<td>2015</td>
<td>0.10</td>
</tr>
<tr>
<td>2016YTD</td>
<td>0.12</td>
</tr>
</tbody>
</table>

**Total Use & Cost Summary**
(FY begins in Jan of year shown)

<table>
<thead>
<tr>
<th>Year</th>
<th>$ (K,000,000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>25</td>
</tr>
<tr>
<td>2014</td>
<td>30</td>
</tr>
<tr>
<td>2015</td>
<td>35</td>
</tr>
<tr>
<td>2016YTD</td>
<td>30</td>
</tr>
</tbody>
</table>

**Daily Average Cost**

- **Percentage Change from Previous Year to Current Year**
  - **Previous Year:** Nov 2014 - Oct 2015
  - **Current Year:** Nov 2015 - Oct 2016
  - **$56,517.94**
  - **$77,778.79**
  - **27.3%**

**Daily Average Usage**

- **Percentage Change from Previous Year to Current Year**
  - **Previous Year:** Nov 2014 - Oct 2015
  - **Current Year:** Nov 2015 - Oct 2016
  - **790,914.05 KWH**
  - **809,521.89 KWH**
  - **2.4%**
Monthly Profile

Monthly Cost

$ (x 1,000,000)

Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec

0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5

Monthly Use

KWH (x 1,000,000)

Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec

30 | 25 | 20 | 15 | 10 | 5 | 0

Monthly Unit Cost

$/KWH

Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec

0.00 | 0.02 | 0.04 | 0.06 | 0.08 | 0.10 | 0.12 | 0.14 | 0.16

Previous 12 Months

Current 12 Months
Weather Normalized Usage Profile

Total Use Summary
Normalized to 2015
(FY begins in Jan of year shown)

Current Year:
Nov 2015 - Oct 2016
808,168.70 KWH

Previous Year:
Nov 2014 - Oct 2015
785,349.10 KWH

2.9%

Monthly Use Trend
Normalized to 2015
(FY begins in Jan of year shown)
<table>
<thead>
<tr>
<th>Account Code</th>
<th>Billing Period</th>
<th>Begin Date</th>
<th>End Date</th>
<th>Total Cost</th>
<th>Usage</th>
<th>Usage Unit</th>
<th>Use/Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>GTAA-ELE-TOT</td>
<td>Oct 2016</td>
<td>10/01/2016</td>
<td>11/01/2016</td>
<td>$1,348,067.60</td>
<td>23,460,425 kWh</td>
<td>756,787.91</td>
<td></td>
</tr>
<tr>
<td>GTAA-ELE-TOT</td>
<td>Sep 2016</td>
<td>09/01/2016</td>
<td>10/01/2016</td>
<td>$1,427,273.20</td>
<td>23,973,303 kWh</td>
<td>799,110.09</td>
<td></td>
</tr>
<tr>
<td>GTAA-ELE-TOT</td>
<td>Aug 2016</td>
<td>08/01/2016</td>
<td>09/01/2016</td>
<td>$1,870,036.60</td>
<td>26,725,366 kWh</td>
<td>862,106.57</td>
<td></td>
</tr>
<tr>
<td>GTAA-ELE-TOT</td>
<td>Jul 2016</td>
<td>07/01/2016</td>
<td>08/01/2016</td>
<td>$1,828,656.90</td>
<td>26,461,337 kWh</td>
<td>853,591.50</td>
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<tr>
<td>GTAA-ELE-TOT</td>
<td>Jun 2016</td>
<td>06/01/2016</td>
<td>07/01/2016</td>
<td>$1,905,418.50</td>
<td>23,842,546 kWh</td>
<td>794,751.54</td>
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<tr>
<td>GTAA-ELE-TOT</td>
<td>May 2016</td>
<td>05/01/2016</td>
<td>06/01/2016</td>
<td>$1,792,757.40</td>
<td>24,220,912 kWh</td>
<td>781,319.75</td>
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<tr>
<td>GTAA-ELE-TOT</td>
<td>Apr 2016</td>
<td>04/01/2016</td>
<td>05/01/2016</td>
<td>$1,830,152.60</td>
<td>23,592,308 kWh</td>
<td>786,410.26</td>
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<tr>
<td>GTAA-ELE-TOT</td>
<td>Mar 2016</td>
<td>03/01/2016</td>
<td>04/01/2016</td>
<td>$1,714,270.40</td>
<td>25,089,386 kWh</td>
<td>809,335.04</td>
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<tr>
<td>GTAA-ELE-TOT</td>
<td>Feb 2016</td>
<td>02/01/2016</td>
<td>03/01/2016</td>
<td>$1,756,829.70</td>
<td>24,292,441 kWh</td>
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<tr>
<td>GTAA-ELE-TOT</td>
<td>Jan 2016</td>
<td>01/01/2016</td>
<td>02/01/2016</td>
<td>$1,850,485.90</td>
<td>26,074,169 kWh</td>
<td>841,102.22</td>
<td></td>
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<tr>
<td>GTAA-ELE-TOT</td>
<td>Dec 2015</td>
<td>12/01/2015</td>
<td>01/01/2016</td>
<td>$1,839,403.84</td>
<td>24,687,303 kWh</td>
<td>796,364.60</td>
<td></td>
</tr>
</tbody>
</table>
## Natural Gas Normalized Usage Data/ CUP

<table>
<thead>
<tr>
<th>Location: Buildings-&gt; Toronto Pearson Airport-&gt; GTAA-UTILITY-CUP-&gt; NG-20-EN [CUP]</th>
<th>Created By: gtaa</th>
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<tbody>
<tr>
<td>Commodity: Natural Gas</td>
<td></td>
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<tr>
<td>Time: 12/08/2016 8:46:10 AM</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Month</th>
<th>2016 (CUB)</th>
<th>2015 (CUB)</th>
<th>2014 (CUB)</th>
<th>2013 (CUB)</th>
<th>2012 (CUB)</th>
<th>2011 (CUB)</th>
<th>2010 (CUB)</th>
<th>2009 (CUB)</th>
<th>2008 (CUB)</th>
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</thead>
<tbody>
<tr>
<td>Jan</td>
<td>1,819,418.80</td>
<td>1,217,710.37</td>
<td>1,328,156.37</td>
<td>1,644,751.77</td>
<td>1,463,493.00</td>
<td>1,342,001.10</td>
<td>1,595,472.76</td>
<td>1,251,812.62</td>
<td>1,473,845.36</td>
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<tr>
<td>Feb</td>
<td>1,780,905.28</td>
<td>1,272,624.85</td>
<td>1,186,840.13</td>
<td>1,594,088.50</td>
<td>1,810,926.25</td>
<td>1,513,885.57</td>
<td>1,734,773.78</td>
<td>1,459,395.50</td>
<td>1,349,598.96</td>
</tr>
<tr>
<td>Mar</td>
<td>1,315,540.27</td>
<td>1,294,180.03</td>
<td>937,644.615</td>
<td>1,300,380.05</td>
<td>1,221,925.30</td>
<td>1,256,868.24</td>
<td>1,250,045.72</td>
<td>1,038,912.36</td>
<td>962,475.304</td>
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<tr>
<td>May</td>
<td>186,157.387</td>
<td>144.000</td>
<td>158,567.743</td>
<td>29,232.260</td>
<td>97,934.900</td>
<td>163,200.600</td>
<td>85,656.820</td>
<td>102,021.045</td>
<td>242,622.827</td>
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<tr>
<td>Jun</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
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<tr>
<td>Jul</td>
<td>0.000</td>
<td>0.000</td>
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<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Aug</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
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<tr>
<td>Sep</td>
<td>2,155,352</td>
<td>1,948.491</td>
<td>5,980.430</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>5,199.290</td>
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<tr>
<td>Oct</td>
<td>221,863.477</td>
<td>216,005.302</td>
<td>395,629.663</td>
<td>355,031.534</td>
<td>477,301.750</td>
<td>327,827.880</td>
<td>481,769.960</td>
<td>456,193.800</td>
<td>342,029.954</td>
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<tr>
<td>Nov</td>
<td>585,302.221</td>
<td>710,487.946</td>
<td>571,814.943</td>
<td>675,265.350</td>
<td>697,070.950</td>
<td>719,606.260</td>
<td>556,880.000</td>
<td>463,149.965</td>
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<tr>
<td>Dec</td>
<td>918,357.885</td>
<td>934,625.183</td>
<td>829,568.857</td>
<td>926,754.400</td>
<td>833,747.840</td>
<td>872,227.640</td>
<td>910,621.800</td>
<td>862,375.321</td>
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</tr>
</tbody>
</table>

### Previous 12 Months vs. Current 12 Months (CUB/CM)

<table>
<thead>
<tr>
<th>Month</th>
<th>Previous 12 Months (CUB/CM)</th>
<th>Current 12 Months (CUB/CM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>1,223,770.00</td>
<td>1,383,112.00</td>
</tr>
<tr>
<td>Feb</td>
<td>1,257,492.00</td>
<td>1,251,368.00</td>
</tr>
<tr>
<td>Mar</td>
<td>1,318,868.00</td>
<td>1,083,113.00</td>
</tr>
<tr>
<td>Apr</td>
<td>753,116.00</td>
<td>875,850.00</td>
</tr>
<tr>
<td>May</td>
<td>144.00</td>
<td>257,499.00</td>
</tr>
<tr>
<td>Jun</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Jul</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Aug</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Sep</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Oct</td>
<td>198,150.00</td>
<td>198,150.00</td>
</tr>
<tr>
<td>Nov</td>
<td>569,703.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Dec</td>
<td>920,806.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>
Natural Gas GHG Emission/ CUP

Calendar Year Emissions

Calendar Year Emissions - CO2 Equivalent

Factors Linked

<table>
<thead>
<tr>
<th>Start Date</th>
<th>End Date</th>
<th>Factor Type</th>
<th>Factor</th>
<th>CO2 Equivalent</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>01/01/1980</td>
<td>01/01/3000</td>
<td>Carbon Dioxide</td>
<td>0.176494</td>
<td>1.000000</td>
<td>GTAA_NG</td>
</tr>
<tr>
<td>01/01/1980</td>
<td>01/01/3000</td>
<td>Methane</td>
<td>0.000004</td>
<td>21.000000</td>
<td>GTAA_NG</td>
</tr>
<tr>
<td>01/01/1980</td>
<td>01/01/3000</td>
<td>Nitrous Oxide</td>
<td>0.000003</td>
<td>310.000000</td>
<td>GTAA_NG</td>
</tr>
</tbody>
</table>
Automatic E-mail Batch Report/ CUP Facility

Cost Avoidance Chart
Facility Management Reports

**Executive Summary by Commodity BL - 12**

Use Percentage
Floor Area: 12,328,237 SqFt

- Electric: 15.8%
- Natural Gas: 84.2%
- Water: 0.0%

Total: 100.0%

Cost Percentage

- Electric: 83.7%
- Natural Gas: 5.7%
- Water: 10.6%

Total: 100.0%

**Billing Period between Jan 2015 and Dec 2015**

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Common Unit</th>
<th>Cost/Unit</th>
<th>Energy Use</th>
<th>Energy Percentage</th>
<th>Cost</th>
<th>Cost Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric</td>
<td>12,356,426kWh</td>
<td>$0.0960 / kWh</td>
<td>12,356,426</td>
<td>$0.0960 / eKWH</td>
<td>16%</td>
<td>$1,186,370.23</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>6,247,066M3</td>
<td>$0.0172 / M3</td>
<td>65,719,134</td>
<td>$0.0016 / eKWH</td>
<td>04%</td>
<td>$107,534.54</td>
</tr>
<tr>
<td>Water</td>
<td>105,769M3</td>
<td>$1.4190 / M3</td>
<td>78,077,561</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Grand Totals: 78,077,561 $1,443,987.61
Energy Conservation Program Report/ AMF

Cumulative Energy Savings

- **Expected Energy Usage**: 5,798,636 KWH
- **Actual Energy Usage**: 5,221,279 KWH
- **Program Savings**: 577,357 KWH
- **Percent Savings**: 10.0%

**Expected Energy Usage**
Anticipated usage without energy management.

**Actual Energy Usage**
Actual energy usage for electricity, gas, etc. obtained directly from utility bills.

**Program Savings**
The difference between Expected and Actual Usage, calculated in accordance with the International Performance Measurement & Verification Protocol.

Cumulative Energy Savings

<table>
<thead>
<tr>
<th>Month</th>
<th>Energy Savings in KWH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan 14</td>
<td>0</td>
</tr>
<tr>
<td>Jan 15</td>
<td>10,000</td>
</tr>
<tr>
<td>Jan 16</td>
<td>50,000</td>
</tr>
<tr>
<td>July 16</td>
<td>200,000</td>
</tr>
</tbody>
</table>

**Cumulative Greenhouse Gas Reduction**

- **Energy Reduction Impact**: 577,357 KWH
- **Metric tons of CO2**: 6 equiv.
Electricity Cost Avoidance/ Terminal 1

Cost Avoidance Manager
Code: locate M2T1
Info: M2T1

<table>
<thead>
<tr>
<th>Period</th>
<th>Year</th>
<th>Without CAP Cost</th>
<th>Actual Cost</th>
<th>Cost Avoidance</th>
<th>With Htg</th>
<th>With Clp</th>
<th>CA%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oct 2016</td>
<td>$567,909</td>
<td>$537,367</td>
<td>($30,542)</td>
<td>x</td>
<td>x</td>
<td>1.0</td>
<td></td>
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<tr>
<td>Sep 2016</td>
<td>$547,052</td>
<td>$557,205</td>
<td>($10,153)</td>
<td>x</td>
<td>x</td>
<td>1.9</td>
<td></td>
</tr>
<tr>
<td>Aug 2016</td>
<td>$733,867</td>
<td>$708,804</td>
<td>$25,063</td>
<td>x</td>
<td>x</td>
<td>3.4</td>
<td></td>
</tr>
<tr>
<td>Jul 2016</td>
<td>$621,964</td>
<td>$613,092</td>
<td>$8,872</td>
<td>x</td>
<td>x</td>
<td>1.4</td>
<td></td>
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<tr>
<td>Jun 2016</td>
<td>$704,232</td>
<td>$701,777</td>
<td>$2,455</td>
<td>x</td>
<td>x</td>
<td>0.3</td>
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<tr>
<td>May 2016</td>
<td>$621,964</td>
<td>$647,677</td>
<td>($25,713)</td>
<td>x</td>
<td>x</td>
<td>4.2</td>
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<tr>
<td>Apr 2016</td>
<td>$572,423</td>
<td>$599,391</td>
<td>($26,968)</td>
<td>x</td>
<td>x</td>
<td>4.0</td>
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<tr>
<td>Mar 2016</td>
<td>$569,947</td>
<td>$505,093</td>
<td>$64,854</td>
<td>x</td>
<td>x</td>
<td>1.2</td>
<td></td>
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<tr>
<td>Feb 2016</td>
<td>$511,038</td>
<td>$639,162</td>
<td>($128,124)</td>
<td>x</td>
<td>x</td>
<td>4.6</td>
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<tr>
<td>Jan 2016</td>
<td>$716,029</td>
<td>$726,452</td>
<td>($10,423)</td>
<td>x</td>
<td>x</td>
<td>1.5</td>
<td></td>
</tr>
</tbody>
</table>

Cost Avoidance Graph

Motor Code: M2T1
Meter Name: M2T1
Baseline Rate: 0.203
Total W/O CAP Use: 8,545.34 kWh
W/O CAP Use: 8,545.34 kWh
W/O CAP Cost: $1,643,350

Use and Cost Breakdown by Day

Without CAP Usage Broken down by day

- Non-Weather
- Weather

Cost Avoidance
Staged: $24,763
Conservation Program
20-Year Strategic Framework
“Our Connection”

VISION
The best airport in the world: Making a difference, connecting the world.

STRATEGIC GOALS
Passenger & Customer Service
Safety
People
Financial Sustainability
Aviation Growth
Corporate Responsibility

RULES OF THE RUNWAY
Results First - Safety Always
Act Now - Be Transparent - Be Accountable
Win As A Team
Relationships Matter

PASSENGERS ARE OUR PASSION

VALUES
Respect • Integrity

BEHAVIOURS
Execute Flawlessly • Lead People • Improve and Innovate • Influence

For You. The World.
Social License to Operate/Grow

Local community’s acceptance or approval of a company’s project or ongoing presence in an area.

It is increasingly recognized by various stakeholders and communities as a prerequisite to development.

Not obtaining a social license can lead to conflict, delays or costs

‘You don’t get your social license by going to a government ministry and making an application or simply paying a fee... It requires far more than money to truly become part of the communities in which you operate.’
- Pierre Lassonde, President of Newmont Mining Corporation.
The development of social license:
• Intangible and informal
• Occurs outside of formal permitting or regulatory processes
• Requires sustained investment by proponents to acquire and maintain social capital within the context of trust-based relationships.
• Can be realized through a robust suite of actions centered on timely and effective communication, meaningful dialogue, and ethical and responsible behavior.
Energy Conservation / GHG Road map
Projected GHG Growth and Reduction Strategy

The diagram illustrates the projected GHG growth and reduction strategies over time, focusing on the reduction of CO2e emissions. Key strategies include:

- Airport growth and cogeneration facility
- Energy reduction and renewables
- Electric boilers and/or carbon credits

The chart compares actual emissions from 2014 with projected emissions under different strategies, aiming to reach a 2020 target. Each strategy is color-coded for easy identification.

- **2014**: Baseline emissions.
- **Growth**: Increased emissions due to expansion.
- **New Concourse**: Reductions from new infrastructure.
- **Hard Stands**: Additional investments for efficiency.
- **Energy Management Plan**: Strategies to manage energy use effectively.
- **Electric Boilers/Carbon Credits**: Use of electric boilers and carbon credits.
- **1 MW Solar Plant**: Incorporation of solar energy.

The goal is to significantly reduce emissions beyond the baseline to meet the 2020 target.
Road Map - 5 yr. Plan

Road Map Budget (5yrs)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Campus Wide - Enhancements to Energy Management Program</td>
<td>$642.9</td>
<td>$642.9</td>
<td>$642.9</td>
<td>$642.9</td>
<td>$642.9</td>
</tr>
<tr>
<td>T1 Energy Audit and Recommissioning (No Cost Measures)</td>
<td>$308.3</td>
<td>$308.3</td>
<td>$308.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T1 Low-Cost Measures</td>
<td></td>
<td>$462.5</td>
<td>$462.5</td>
<td></td>
<td></td>
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<tr>
<td>T3 Enhancements \ Ongoing Commissioning</td>
<td>$183.3</td>
<td>$183.3</td>
<td>$183.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T1 Pier G - Improved EE Design \ System Commissioning</td>
<td></td>
<td>$1,166.7</td>
<td>$1,166.7</td>
<td>$1,166.7</td>
<td></td>
</tr>
<tr>
<td>Total (in Thousands)</td>
<td>$1,134.5</td>
<td>$1,134.5</td>
<td>$2,763.7</td>
<td>$2,272.1</td>
<td>$1,809.6</td>
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<tr>
<td>Cummulative Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$9,114.4</td>
</tr>
</tbody>
</table>

- **Continue funding annual energy efficiency program ($2-3M/Yr)**
- **Incremental benefits regarding avoided energy cost of $15.8M**
- **GHG reduction of 7,123 tonne at an average price of $25 per ton (Carbon Tax) equals $178,075 per year in tax avoidance**
## Energy Efficiency Measures / Opportunities

<table>
<thead>
<tr>
<th>Opportunity</th>
<th>Annual Energy Cost Savings</th>
<th>NPV</th>
<th>Discounted Payback Period (years)</th>
<th>Annual Emission Reduction Potential (t CO₂e)</th>
<th>Total Emission Reductions (10 years)</th>
<th>Cost (-NPV) / t CO₂e</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terminal 1 - Recommissioning and Energy Study, correct deficiencies, no-cost measures (A1)</td>
<td>$693,889</td>
<td>$3,022,468</td>
<td>3.3</td>
<td>2,334</td>
<td>18,670</td>
<td>-$162</td>
</tr>
<tr>
<td>Terminal 1 - Low-Cost Measures (A2)</td>
<td>$531,749</td>
<td>$2,327,499</td>
<td>3.2</td>
<td>1,711</td>
<td>14,547</td>
<td>-$160</td>
</tr>
<tr>
<td>Terminal 1 - Capital Investments (A3)</td>
<td>$540,403</td>
<td>-$2,731,404</td>
<td>13.5</td>
<td>1,731</td>
<td>14,713</td>
<td>$186</td>
</tr>
<tr>
<td>Pier G - Improved Design / Best Practice Commissioning (B1)</td>
<td>$438,858</td>
<td>-$1,061,551</td>
<td>11.0</td>
<td>1,426</td>
<td>9,981</td>
<td>$106</td>
</tr>
<tr>
<td>Pier G - Additional Energy Upgrades / Best Practice Design (B2)</td>
<td>$296,883</td>
<td>-$2,172,500</td>
<td>16.5</td>
<td>1,106</td>
<td>7,745</td>
<td>$281</td>
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<tr>
<td>Tenants – Commissioning / Reconrissioning and/or Energy Audits (C1)</td>
<td>$0</td>
<td>-$4,212,364</td>
<td>n/a</td>
<td>2,998</td>
<td>20,985</td>
<td>$201</td>
</tr>
<tr>
<td>Tenants - Subsidize Low-Cost Upgrades (C2)</td>
<td>$0</td>
<td>-$6,318,546</td>
<td>n/a</td>
<td>2,774</td>
<td>19,415</td>
<td>$325</td>
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<tr>
<td>Terminal 3 - Enhanced Recommission including Comprehensive Energy Audit (D1)</td>
<td>$302,323</td>
<td>$1,185,917</td>
<td>3.8</td>
<td>1,137</td>
<td>9,097</td>
<td>-$130</td>
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<tr>
<td>Terminal 3 - Additional &quot;Low-Cost&quot; Upgrades (D2)</td>
<td>$181,314</td>
<td>-$750,642</td>
<td>12.5</td>
<td>713</td>
<td>6,057</td>
<td>$124</td>
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<tr>
<td>Terminal 3 - Capital Intensive Upgrades (D3)</td>
<td>$181,314</td>
<td>-$1,659,270</td>
<td>18.0</td>
<td>713</td>
<td>6,057</td>
<td>$274</td>
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<tr>
<td>General Campus - On-Going</td>
<td>$823,401</td>
<td>-$307,583</td>
<td>9.5</td>
<td>2,368</td>
<td>14,205</td>
<td>$22</td>
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</table>

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15 The MACC curve presents the maximum annual emission reduction potential achievable, by 2020.
16 Payback period for tenant reduction opportunities is not calculated as their associated energy cost savings do not provide a direct economic benefit to the GTAA. Refer to Section 3.2 for further discussion.
### Energy Efficiency Measures / Opportunities

<table>
<thead>
<tr>
<th>Opportunity</th>
<th>Annual Energy Cost Savings</th>
<th>NPV</th>
<th>Discounted Payback Period (years)</th>
<th>Annual Emission Reduction Potential (t CO₂e)¹⁹</th>
<th>Total Emission Reductions (10 years)</th>
<th>Cost (-NPV) / tCO₂e</th>
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</thead>
<tbody>
<tr>
<td>Terminal 3 - Capital Intensive Upgrades (D3)</td>
<td>$181,314</td>
<td>-$1,659,270</td>
<td>18.0</td>
<td>636</td>
<td>5,408</td>
<td>$307</td>
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<tr>
<td>General Campus - On-Going Commissioning and Energy Management (E1)</td>
<td>$823,401</td>
<td>-$307,583</td>
<td>9.5</td>
<td>1,772</td>
<td>10,634</td>
<td>$29</td>
</tr>
<tr>
<td>General Campus - Low-Cost Upgrades (E2)</td>
<td>$307,902</td>
<td>-$2,760,484</td>
<td>20.2</td>
<td>636</td>
<td>3,815</td>
<td>$724</td>
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<tr>
<td>General Campus - 1 MWp Solar PV System (F)</td>
<td>$80,000</td>
<td>-$4,128,174</td>
<td>62.5</td>
<td>108</td>
<td>1,079</td>
<td>$3,827</td>
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</tbody>
</table>
## Energy Master Plan 2016 Projects

<table>
<thead>
<tr>
<th>Project Name - O&amp;M Initiatives</th>
<th>Type</th>
<th>Status</th>
<th>Completion</th>
<th>eKW/Hr Savings/Year</th>
<th>GHG (Tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1 Parking garage 150w MH - LED bulb replacement Pilot</td>
<td>O&amp;M</td>
<td>In progress</td>
<td>31-Aug-16</td>
<td>75,000</td>
<td>3</td>
</tr>
<tr>
<td>4000 LED Lamps replacement</td>
<td>O&amp;M</td>
<td>Complete</td>
<td>30-Jun-16</td>
<td>420,480</td>
<td>17</td>
</tr>
<tr>
<td>CDF Wallpacks</td>
<td>O&amp;M</td>
<td>Complete</td>
<td>31-Mar-16</td>
<td>10,000</td>
<td>0</td>
</tr>
<tr>
<td>T1 Gate Sign LED replacement</td>
<td>O&amp;M</td>
<td>In progress</td>
<td>30-Sep-16</td>
<td>92,243</td>
<td>4</td>
</tr>
<tr>
<td>Control Tower RGB lights</td>
<td>O&amp;M</td>
<td>In progress</td>
<td>15-Sep-16</td>
<td>12,000</td>
<td>0</td>
</tr>
<tr>
<td>T1 Lighting management - Photocells and scheduling</td>
<td>O&amp;M</td>
<td>In progress</td>
<td>30-Sep-16</td>
<td>500,000</td>
<td>21</td>
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<tr>
<td>Sustainability Screen-Admin building</td>
<td>O&amp;M</td>
<td>In progress</td>
<td>30-Sep-16</td>
<td>NA</td>
<td>0</td>
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<tr>
<td>AMF LED tubes replacement</td>
<td>O&amp;M</td>
<td>In progress</td>
<td>31-Oct-16</td>
<td>600,000</td>
<td>25</td>
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<tr>
<td>T1 West elevator lobby lighting improvement</td>
<td>O&amp;M</td>
<td>In progress</td>
<td>31-Oct-16</td>
<td>NA</td>
<td>0</td>
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<tr>
<td></td>
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<td></td>
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<td></td>
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<td></td>
<td>1,709,723</td>
<td>70</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Project Name - Asset Renewal Initiative</th>
<th>Type</th>
<th>Status</th>
<th>Completion</th>
<th>eKW/Hr Savings/Year</th>
<th>GHG (Tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1 Curb canopy lights</td>
<td>Capital</td>
<td>Complete</td>
<td>30-Jun-16</td>
<td>800,000</td>
<td>33</td>
</tr>
<tr>
<td>409 High mast lights</td>
<td>Capital</td>
<td>In progress</td>
<td>31-Aug-16</td>
<td>300,000</td>
<td>12</td>
</tr>
<tr>
<td>T3 Apron lighting</td>
<td>Capital</td>
<td>In progress</td>
<td>30-Sep-16</td>
<td>256,000</td>
<td>11</td>
</tr>
<tr>
<td>T3, T-8/12 to LED tubes</td>
<td>Capital</td>
<td>In progress</td>
<td>30-Nov-16</td>
<td>91,000</td>
<td>4</td>
</tr>
<tr>
<td>T3 Baggage road</td>
<td>Capital</td>
<td>Complete</td>
<td>31-Jul-16</td>
<td>147</td>
<td>0</td>
</tr>
<tr>
<td>Infield Tunnel</td>
<td>Capital</td>
<td>In progress</td>
<td>31-Dec-16</td>
<td>900,000</td>
<td>37</td>
</tr>
<tr>
<td>T1 HVAC improvement</td>
<td>Capital</td>
<td>In progress</td>
<td>31-Dec-16</td>
<td>500,000</td>
<td>121</td>
</tr>
<tr>
<td>6A Parking lights LED replacement</td>
<td>Capital</td>
<td>In progress</td>
<td>31-Oct-16</td>
<td>425,000</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3,272,147</td>
<td>234</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td></td>
<td>4,981,870</td>
<td>305</td>
</tr>
</tbody>
</table>
GTAA Electricity Trend

Toronto Pearson Airport Electricity Usage Report, Year over Year

- Actual Consumption, kWh
- Weather Normalized Consumption, kWh
- Normalized Energy Intensity, kWh/Sq. ft
- Normalized PAX Intensity, kWh/PAX

Year

- 2006
- 2007
- 2008
- 2009
- 2010
- 2011
- 2012
- 2013
- 2014
- 2015

Electricity Consumption, kWh

Intensity, kWh/Sq. ft or kWh/PAX
GTAA Natural Gas Trend

Toronto Pearson Airport Natural Gas Usage Report, Year Over Year

- Actual Consumption, kWh
- Weather Normalized Consumption, kWh
- Normalized Energy Intensity, kWh / Sq ft
- Normalized PAX Intensity, kWh/Passenger
Energy Conservation \ GHG Program results

- Excess of 29,427,233 KWh savings from 2004
- Over $2,741,309 per year in avoided energy spend
- Electricity usage per PAX from 2014 to 2015 was down by more than 10%
Conservation Projects
Brief Look at our Baggage System...

104,000 Pieces of luggage DAILY

Toronto Pearson Baggage System

Did you know?

Electric baggage vehicles can be recharged in 30 minutes.

27,000,000 Bags processed in 2012

For You. The World.
## Energy Conservation in the Baggage System

<table>
<thead>
<tr>
<th>Measures</th>
<th>Savings (kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Efficient Belts</td>
<td>30,800</td>
</tr>
<tr>
<td>Improved Carousel Control</td>
<td>280,000</td>
</tr>
<tr>
<td>New Pusher Control</td>
<td>558,300</td>
</tr>
<tr>
<td>Install VFDs on Motors</td>
<td>248,800</td>
</tr>
<tr>
<td>Time Out Control</td>
<td>128,300</td>
</tr>
</tbody>
</table>
PROBLEM:

182 Pushers within the baggage system, are used to transfer outbound baggage, idle constantly when not actively pushing (78% of the time)

Pusher arm activated

Motor behind the pusher
SOLUTION:
To Save on the constant power draw; VFD controllers were added to turn off the motor when idling while also reducing the systems vibrations by 90%.

The project is expected to save **558,300 kWh** of electricity each year.
BACKGROUND:

1,591,724 SQ.FT garage with 2087 high pressure sodium and metal halide fixtures.

PROBLEM:

Majority of the fixtures were high pressure sodium with poor color rendition and low uniformity levels. Operational 24/7 with exception to few that are controlled through photo cells.
SOLUTION:
1900 x 50W LED Fixtures and the removal of 184 unnecessary HPS fixtures. Improving the color and quality of light and achieving the target of 50 maintained lux.
Terminal 3 Parking Garage

SAVINGS:

2,193,000 kWh/Year
Other Energy Efficient Lighting Projects

Terminal 1 Interior (Piers)

1017 LED Fixtures (30 kW Total) to replace Metal Halide spot lights with a savings of

630,000 kWh/Year
**HVAC in Terminal Buildings**

**PROBLEM:**
Constant Air Volume units worked to the 100% design occupancy.

**SOLUTION:**
CO2 sensors and VFD’s controllers were added to operate these units on demand when the airport experienced low traffic.

**SAVINGS:**
5,719,537 kWh/Year
Roadway Lighting

Converting all roadway lights to LEDs and Experimenting with off grid applications
Roadway Lighting

Converting all roadway lights to LEDs and Experimenting with off grid applications
Smaller Lighting Projects

- Terminal Underpass Lighting (50,000 kWh)
- High bay Lighting (200,000 kWh)
- Central Utilities Plant Lighting (110,000 kWh)
Solar powered stop signs

These stop signs were wired on the same circuits as the runway edge lights. Solar powered beacons were installed over stop signs made with reflective material, allowing them to turn off the runway edge circuit when not in use.
The runway guard lights (Wigwags) consist of two lamps of 100w (200 watt unit) replaced with the new LED unit is 50 watts
Red Obstruction Light Removal or Upgrade

Of these 605, 432 were deemed unnecessary and removed. The 173 remaining were converted to a 15w LED.
Wash Bay lighting replacement
Traffic Lights Converted to LED

The red traffic lamp was 100w the green and amber were 69w
They have been changed to 13w and 9w
Operation requires a continuous circulation of water and chemicals through the system and used a large 520hp pump where high volume flow of water is only required while the generators are running or during cool down cycle. Installed a bypass pipe and 75 hp pump for when the Co-Gen is not running. This resulted in a 371kw reduction for an average of 18.93 hours per day and an annual savings of $256,000.
Photocell
Re-circuiting for scheduling

Service Level

Cove lights
Re-circuiting for scheduling - Photocell

Perimeter lighting

Mechanical Rooms
Lighting Upgrade to regular T5 and to LED T5

- 400w MH replaced with 4 lamp T5 fixtures consuming 360w
- Equipped with occupancy sensors
- One in 4 fixtures is wired to have 2 of the 4 lamps on 24/7
- Payback of less than 2 years
1000w MH light fixtures replaced with 500w LED fixtures
64% energy reduction
Pole lighting LED replacement.
GREEN FLEET PROGRAM
The Future of Energy Conservation at YYZ

10 years of energy conservation projects identified

- Worth 40 GWh of avoided energy savings by 2025
- Representing 15% of our total electricity consumption

Projects currently in progress (2016):

- Terminal 1 HVAC Retro-Commissioning
- T3 Energy Enhancement
- Terminal 1 all Interior Lighting to LED
- Infield Tunnel lighting
- Apron Lighting
Challenges

• Airports as buildings,
  • Continuously changing processes and occupancy levels
  • Peaks and valleys
  • Pressurization issues
  • Fresh air issues
  • Sudden demand changes

• Lighting Management
  • Circuitry
  • Some activity always on
  • Hi-definition age

• Continuous changing perceptions and expectations
Challenges - Cont.

- Airports are heavily regulated
- Various occupants with conflicting interests
- Pre-conditioned Air and Ground Power systems are unique to airports and deals with many airlines
- Different generation of building stocks
Vision:

GTAA will endeavor to reduce its energy and environmental impact on nearby communities by implementing capital and operational initiatives in energy consumption, maintenance and life cycle economies.

The GTAA will use the methods of continuous improvement to constantly strive for community leadership in greenhouse gas and energy reductions in all new buildings, remodeling of existing GTAA buildings and the maintenance of GTAA and GTAA tenant buildings.
Thank you
Questions ?
Discussion?