Accounting for the Carbon Costs of Alternative Water Supplies in the Tampa Bay Region

Water Energy Sustainability Symposium
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Presentation Overview

• Goal and Motivation
• Context
• Data and Analysis
• Results
• Applications
• Bottom Line
• Moving Forward

Desalination RO Membranes

*Unless otherwise noted, all images courtesy of Dave Bracciano, Tampa Bay Water*
Energy-for-water analysis: Estimate and compare the annual carbon footprints and carbon intensities associated with producing potable water from traditional (groundwater) and alternative (surface water and desalinated seawater) sources in the Tampa Bay Region.
Goal

**Conservative in scope:** Evaluates only electricity use for water pumping, treatment, and delivery to Tampa Bay Water’s member governments (excludes distribution to end users and energy-for-water from consumptive use).
Motivation

Program for Resource Efficient Communities’ (PREC) Mission:

• To promote the adoption of best design, construction, and management practices that \textit{measurably} reduce energy and water consumption and environmental degradation in new residential community developments.

• [http://buildgreen.ufl.edu](http://buildgreen.ufl.edu)

Model Home in \textit{Madera}: a low impact development community
(Image courtesy Glenn Acomb, PREC)
Motivation

Tampa Bay Water Mission:

• To serve the public by supplying and protecting the region’s drinking water.

• Regional water supply authority established in 1998 by Florida Statutes and Interlocal Agreement among six member governments.

• [www.tampabaywater.org](http://www.tampabaywater.org)
Motivation

- Global Change
- Energy, Water, and Land
- Natural Systems
- Human Systems
- Policy, Management, Design
- LID, Smart Growth, Green Infrastructure, Community-Based Social Marketing

Holistic and Interdisciplinary Solutions
Context

Florida climate legislation

• Governor Christ Executive Orders
  – “Immediate Actions to Reduce Greenhouse Gas Emissions in Florida”
  – We’re #2...
• House Bill 697
  – Building code standards
  – Local government planning and accountability

“Greenhouse Gas Reduction and Energy Conservation: Development Impacts Under Florida’s HB 697”
(Image courtesy Pierce Jones, PREC)
Context

- Regional water supply authority serving over 2.4 million customers
- Supplies > 150 MGD
  - Supplemented by City of Tampa
- Member demand forecasts:
  - 2010: 236 MGD
  - 2025: 271 MGD
Context

Production Blend by Supply Type (fiscal year to date)
155 MGD

- 106.7 MGD, 69%
- 35.5 MGD, 23%
- 12.4 MGD, 8%
Tampa Bay Water Regional Facilities

- **Groundwater**
  - Consolidated water use permit
  - 90 MGD 12-month running average

- **Surface water**
  - Hillsborough River, Alafia River
  - Regional surface water treatment plant
  - Up to 72 MGD treatment capacity

- **Desalination treatment plant**
  - Seawater intake via TECO Big Bend facility
  - Largest in North America
  - Up to 25 MGD treatment capacity

- **Regional reservoir**
  - 15.5 billion gallon storage capacity
Water Facilities Data

37 Tampa Bay Water collection, treatment, and delivery facilities

- Water Years (WY) 2006-2009
- Key WY facilities metrics:
  - Water pumped (MG)
  - Water produced (MG)
  - Electricity used (kWh)
  - Electricity cost ($)
Water Facilities Data

Facilities Data Coding

- Carbon cost metrics estimated for each water type, with groundwater supply used as the baseline for comparison.

Groundwater pumps  Surface water intake  Desal membranes
GHG Emissions Data

U.S. EPA’s eGRID (Emissions & Generation Resource Integrated Database)

http://cfpub.epa.gov/egridweb/view.cfm
GHG Emissions Data

U.S. EPA’s eGRID

• Data years 2004-2005
• Political subdivision, grid region, power plant, and company aggregation levels
• Key power plant metrics:
  – Carbon dioxide (CO₂) emissions (short tons)
  – Nitrous oxide (N₂O) emissions (lbs)
  – Methane (CH₄) emissions (lbs)
  – Net generation (MWh)
  – Generation fuel mix
Linking GHG Emissions to Facilities’ Data

• 3 electricity service providers with generation from 6 power plants:
  – TECO
    • Big Bend Power Station
    • H.L. Culbreath Bayside
  – Progress Energy
    • P.L. Bartow
    • Anclote
  – WREC
    • Seminole
    • Hardee Power Station
Analysis

GHG Emissions Factors

• For each power plant, \( \text{CO}_2 \text{e (lbs/kWh)} \)

\[
= \frac{(\text{CO}_2 \text{ lbs} + 21\times \text{CH}_4 \text{ lbs} + 310\times \text{N}_20 \text{ lbs})}{\text{kWh generated}}
\]

where emissions multipliers correspond to each GHG’s global warming potential (GWP)

• For each electricity service provider, weighted average of power plants’ emission factors based on net generation

\[
= \left( \text{CO}_2 \text{e}_{PP1} \times \frac{\text{kWh}_{PP1}}{\text{kWh}_{ESP}} \right) + \left( \text{CO}_2 \text{e}_{PP2} \times \frac{\text{kWh}_{PP2}}{\text{kWh}_{ESP}} \right)
\]
## Power Plant GHG Emissions Factors

<table>
<thead>
<tr>
<th>TECO</th>
<th>Generation Fuel Mix</th>
<th>CO$_2$e lbs/kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Big Bend</td>
<td>97% Coal / 3% Oil</td>
<td>2.40</td>
</tr>
<tr>
<td>H.L. Culbreath</td>
<td>100% Natural Gas</td>
<td>0.90</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Weighted Emissions Factor 1.69</strong></td>
</tr>
<tr>
<td>Progress Energy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P.L. Bartow</td>
<td>97% Oil / 3% Natural Gas</td>
<td>2.00</td>
</tr>
<tr>
<td>Anclote</td>
<td>99% Oil / 1% Natural Gas</td>
<td>2.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Weighted Emissions Factor 2.01</strong></td>
</tr>
<tr>
<td>WREC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seminole</td>
<td>74% Coal / 26% Oil</td>
<td>2.07</td>
</tr>
<tr>
<td>Hardee</td>
<td>98% Natural Gas / 2% Oil</td>
<td>1.03</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Weighted Emissions Factor 2.04</strong></td>
</tr>
</tbody>
</table>
Analysis

Individual Facilities’ Annual Carbon Footprints
• Electricity service provider emissions factors linked to corresponding facilities
• Facility footprint = \( \text{CO}_2e_{\text{ESP}} \) (lbs/kWh) * \( \text{kWh}_{\text{FAC}} \)

Water Supply Type Carbon Footprints and Intensities
• \textit{Carbon footprints} = sum of facility footprints for common water types (e.g., all facilities coded for surface water).
• \textit{Carbon intensities} = carbon footprints/MG produced from each water supply type.
Results

Production Blend by Supply Type (2006-2009 Average)
178 MGD

- Groundwater: 127 MGD (70%)
- Surface Water: 41 MGD (23%)
- Desalinated: 14 MGD (7%)
Results

Annual Production by Supply Type (Average 178 MGD)

- Desalinated
- Surface Water
- Groundwater

<table>
<thead>
<tr>
<th>Year</th>
<th>Desalinated</th>
<th>Surface Water</th>
<th>Groundwater</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>46</td>
<td>137</td>
<td>128</td>
</tr>
<tr>
<td>2007</td>
<td>5</td>
<td>130</td>
<td>130</td>
</tr>
<tr>
<td>2008</td>
<td>19</td>
<td>113</td>
<td>113</td>
</tr>
<tr>
<td>2009</td>
<td>17</td>
<td>33</td>
<td>33</td>
</tr>
</tbody>
</table>
Results (2006-2009)

Annual Production

- 2 Billion Gallons = 3% Decrease

<table>
<thead>
<tr>
<th>Year</th>
<th>Production (Billion Gallons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>67</td>
</tr>
<tr>
<td>2007</td>
<td>65</td>
</tr>
<tr>
<td>2008</td>
<td>64</td>
</tr>
<tr>
<td>2009</td>
<td>65</td>
</tr>
</tbody>
</table>
Results (2006-2009)

Annual Production vs. Electricity Use

+ 93 GWh = 177% Increase

(2006‐2009)
Results (2006-2009)

Annual Production vs. Electricity Costs

+ $9.9 Million = 138% Increase
Results (2006-2009)

Annual Production vs. Carbon Footprints

+ 75,400 s.t. = 146% Increase
Results (2006-2009)

Carbon Footprints by Supply Type

Desal = <10% of Supply and >50% of Carbon Footprint

Short Tons CO₂e (Thousands)

<table>
<thead>
<tr>
<th>Year</th>
<th>Desalinated</th>
<th>Surface Water</th>
<th>Groundwater</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>34</td>
<td>17</td>
<td>32</td>
</tr>
<tr>
<td>2007</td>
<td>33</td>
<td>16</td>
<td>17</td>
</tr>
<tr>
<td>2008</td>
<td>29</td>
<td>15</td>
<td>17</td>
</tr>
<tr>
<td>2009</td>
<td>32</td>
<td>17</td>
<td>17</td>
</tr>
</tbody>
</table>
Results (2006-2009)

Carbon Intensities by Supply Type (Short Tons CO$_2$e/MG Produced)
Results (2006-2009)

Average Carbon Intensities by Water Supply
(Short Tons CO₂e/MG Produced)

Desalination is 18 times more intense than groundwater supply

0.7
1.1
12.9
Results (2006-2009)

Average Carbon Intensities by Water Supply (Short Tons CO$_2$e/MG Produced)

Surface water is 1.6 times more intense than groundwater supply

<table>
<thead>
<tr>
<th>Water Supply</th>
<th>Carbon Intensity (Short Tons CO$_2$e/MG Produced)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface water</td>
<td>12.9</td>
</tr>
<tr>
<td>Groundwater supply</td>
<td>0.7</td>
</tr>
</tbody>
</table>

0.7 1.1 12.9
## Tampa Bay Water Supply and Carbon Costs (‘06-’09 Averages)

<table>
<thead>
<tr>
<th>Water Type</th>
<th>Production (MGD)</th>
<th>Portion of Production</th>
<th>Carbon Footprint (short tons CO₂e /yr)</th>
<th>Portion of Carbon Footprint</th>
<th>Carbon Intensity (short tons CO₂e /MG)</th>
<th>Intensity Relative to Groundwater</th>
<th>Average Electricity Cost ($/MG)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground-water</td>
<td>127</td>
<td>71%</td>
<td>32,147</td>
<td>34%</td>
<td>0.69</td>
<td>1:1</td>
<td>$70</td>
</tr>
<tr>
<td>Surface Water</td>
<td>41</td>
<td>23%</td>
<td>16,468</td>
<td>17%</td>
<td>1.12</td>
<td>2:1</td>
<td>$135</td>
</tr>
<tr>
<td>Desalinated</td>
<td>14</td>
<td>8%</td>
<td>46,585</td>
<td>49%</td>
<td>12.87</td>
<td>18:1</td>
<td>$1343</td>
</tr>
<tr>
<td>Blended Product</td>
<td>178</td>
<td>--</td>
<td>95,200</td>
<td>--</td>
<td>1.88</td>
<td>3:1</td>
<td>$194</td>
</tr>
</tbody>
</table>
Applications: Conservation

Tampa Bay Water Member
Government Water Savings

- 2009: 1.7 MGD
- Cumulative: 25.6 MGD

Avoided GHG Emissions
(short tons CO₂e)

- 2009: 1,484
- 2009 at the margin: 7,815
- Cumulative: 22,341
Applications: Conservation

Avoided GHG Emissions (short tons CO$_2$e)

• 2009: 1,484
  – 257 passenger vehicles’ GHG emissions

• 2009 at the margin: 7,815
  – 860 homes’ electricity for one year

• Cumulative: 22,341
  – 47,134 barrels of oil
Applications: Landscape Management

Carbon Costs (lbs CO$_2$e per 1000ft$^2$ landscaped area)

- Mowing: 15, 19%
- Fertilizer: 29, 37%
- Pesticides: 1, 1%
- Irrigation: 34, 43%

Groundwater Supply
Applications: Landscape Management

Carbon Costs (lbs CO$_2$e per 1000ft$^2$ landscaped area)

- **Irrigation**: 120, 73%
- **Fertilizers**: 29, 17%
- **Mowing**: 15, 9%
- **Pesticides**: 1, 1%

**Blended Supply**
Applications: Land Use Planning

**Restoration**

- 5,187-acre master-planned community development
- Major revisions to master plan (2006 vs. 2009)
  - Low Impact Development
  - New Urbanism principles
  - Resource-efficient landscaping
- Applied carbon accounting results to estimate impact

(Images courtesy Canin Associates)
Applications: Land Use Planning

Landscaping Restoration

**Annual Inputs**

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<th>Input</th>
<th>2006 Plan</th>
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<td>Pesticides (lbs a.i.)</td>
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**Associated Annual GHG Emissions**

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<th>Emission (mt CO₂e)</th>
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<td>Fertilizer</td>
<td>543</td>
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<td>Mowing</td>
<td>281</td>
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<td>Irrigation – Groundwater</td>
<td>637</td>
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**Metric tons CO₂e/yr:** 1,479
## Landscaping Restoration

### Annual Inputs

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### Associated Annual GHG Emissions

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**Metric tons CO₂e/yr:** 1,479 - 668 = 55% less

$68 million less in landscape improvements
Bottom Line – True Costs

Triple Bottom Line

• At the margin with existing systems, and to an even greater extent with those yet to be constructed, alternative water supplies are costly:
  
  Financially, Environmentally, and Socially
Bottom Line - Opportunities

Consumers

Water Utilities

Electric Utilities

Planners and Policy-makers

DEMAND

SUPPLY

Water + Energy | Pittsburgh | 09.29.10
Tampa Bay Water continues to work with its six member governments and private and public partners to:

• Provide outreach and education on conservation and efficiency tools

• Evaluate alternative supply scenarios to optimize supply, minimize environmental impact, and satisfy demand

  – 2011 budget calls for operating the desalination plant at 3 MGD
Analysis

• Expand to include costs associated with member governments’ distribution to end users, and to end user consumption

• Apply to member governments’ reclaimed water supply systems

• Expand with current emissions and water use data directly from electric provider/power plant personnel to assess water-for-energy-for-water costs
Five Little Piggies

1. Transportation
2. Housing
3. Food
4. Conservation and sufficiency
5. “WE”
   - Systems approaches, collaboration, and cooperation
Thank You!

Questions?

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Dave Bracciano, dbracciano@tampabaywater.org