The Energy-Water Nexus:
A Case Study of Tampa Bay Water

Emerging Energy Issues and Topics In-Service Training
University of Florida, PREC

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Presentation Objectives

- Share details of a Florida case study that exemplifies the energy-water nexus from a local water supply perspective
- Improve understanding of the complexity and various costs associated with operating a large, regional alternative water supply system
- Convey the values/benefits of water conservation and efficiency as means to reduce energy consumption and associated greenhouse gas emissions
- Discuss practical applications for Extension programming

*Unless otherwise noted, all images courtesy of Dave Bracciano, Tampa Bay Water*
Motivation

Program for Resource Efficient Communities (PREC) Mission:

• To promote the adoption of best design, construction and management practices that measurably reduce energy and water consumption and environmental degradation in residential communities.

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

Model Home in *Madera*: a low impact development community
(Image courtesy Glenn Acomb, PREC)
Motivation

- Global Change
- Energy, Water, and Land
- Natural Systems
- Human Systems
- Policy, Management, Design, Engineering
- LID, Smart Growth, Green Infrastructure, Sustainability

Systems Approaches – Interdisciplinary Solutions
Water-Energy Nexus: National Scope

- Water embedded in energy: ~2/5 of U.S. freshwater withdrawals used for electricity production (DOE, 2006)
- Energy embedded in water: ~1/8 of U.S. electricity production used for water supply (pumping, treating and heating water) (River Network, 2009)
- Climate change both affecting and affected by water and energy use and management decisions
Water-Energy Nexus: National Scope

100 Most Water-Vulnerable Coal-Fired Power Plants
“Water and Watts” in the Southeast (WRI/SEEA/Southface, 2009)

- ~2/3 of regional freshwater withdrawals (40 billion gallons daily) used for thermoelectric power plant cooling needs
- Energy for water and wastewater treatment ~1/3 of municipal energy costs
- Typical home spends about $250 per year on energy for hot water

Water-Energy Nexus: Florida

Figure 5. Projected Water Demand by Sector

- Public Water Supply
- Domestic and Small Public Supply
- Agricultural Irrigation
- Recreational Irrigation
- Commercial/Industrial/Institutional
- Power Generation

Water Demand (billion gallons per day) vs. Year

Water-Energy Nexus: Florida

Figure 5. Projected Water Demand by Sector

- Public Water Supply
- Domestic and Small Public Supply
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- Commercial/Industrial/Institutional
- Power Generation

Water Demand (bgd)

Year

Florida climate legislation

- Executive Orders (2007)
  – GHG Emissions Targets for 2017, 2025, and 2050
- House Bill 697 (2008)
  – Building code standards
  – Local government comprehensive planning and accountability measures addressing energy efficiency
Coquina Coast Desalination Project

Proposed 10-15 MGD Seawater Desalination Plant in Palm Coast

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Coquina Coast Desalination Project

FlaglerLive.com – August 17, 2011:

A Wake for Palm Coast Desalination: Consultants Talk “Hiatus” Rather Than Demise

“Palm Coast itself is not running out of water by any means.”

“Consultants found out from Florida Power and Light that there is capacity to generate the 7 to 40 megawatts needed to run the plant without need for – as one individual wondered – nuclear power. But it is less clear whether the existing grid can support a [desalination] plant located in Palm Coast.”

http://flaglerlive.com/26890/desalination-palm-coast-end
Research Goal

Energy-for-water analysis
Research Goal

Energy-for-water/embedded energy analysis: Estimate and compare the annual *carbon footprints* and *carbon intensities* associated with producing potable water...
Energy-for-water/embedded energy 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 Tampa Bay Water’s system.


Research Goal

**Conservative in scope:** We evaluate only the electricity use of Tampa Bay Water’s production facilities for water collection, treatment, and delivery to member governments (their wholesale customers). Excludes energy and carbon costs of distribution to end users, end use consumption, and wastewater treatment.
• Over 2.4 million customers served
• Member demand forecasts:
  – 2010: 236 MGD
  – 2025: 271 MGD
• Tampa Bay Water supplies > 150 MGD
  – Supplemented by the City of Tampa
Context

Tampa Bay Water Regional Facilities

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

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
  – 120 MGD treatment capacity
Context

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
  - 120 MGD treatment capacity

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

Tampa Bay Water Regional Facilities

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- **Regional reservoir**
  - 15.5 billion gallon storage capacity
Data & Analysis

Tampa Bay Water

- 37 collection, treatment, and delivery facilities
- Water Years (WY) 2006-2009 water pumped and produced, electricity used, electricity cost, electric provider

U.S. EPA’s eGRIDweb

- Year 2005 greenhouse gas emissions for 6 power plants
- [http://cfpub.epa.gov/egridweb/view.cfm](http://cfpub.epa.gov/egridweb/view.cfm)
## Power Plant GHG Emissions Factors

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

Tampa Bay Water Production Blend (2006-2009 averages, by supply type)

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

[Diagram showing the distribution of water production blend by type.]
Results (2006-2009)

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>
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<tbody>
<tr>
<td>2006</td>
<td>46</td>
<td>137</td>
<td>137</td>
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<tr>
<td>2007</td>
<td>5</td>
<td>43</td>
<td>130</td>
</tr>
<tr>
<td>2008</td>
<td>19</td>
<td>42</td>
<td>113</td>
</tr>
<tr>
<td>2009</td>
<td>17</td>
<td>33</td>
<td>128</td>
</tr>
</tbody>
</table>

Average production: 178 MGD
Results (2006-2009)

Annual Production

- 6 MGD = 3% Decrease

MGD

0 50 100 150 200 250 300 350 400 450

2006 2007 2008 2009

Results (2006-2009)
Results (2006-2009)

Annual Production

- 6 MGD = 3% Decrease
Results (2006-2009)

Annual Production vs. Electricity Use

GWh

MGD

2006 2007 2008 2009

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Results (2006-2009)

Annual Production vs. Electricity Use

+ 93 GWh = 109% Increase
Results (2006-2009)

Annual Production vs. Electricity Costs

<table>
<thead>
<tr>
<th>Year</th>
<th>MGD</th>
<th>$ Million</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>180</td>
<td>0</td>
</tr>
<tr>
<td>2007</td>
<td>230</td>
<td>1.5</td>
</tr>
<tr>
<td>2008</td>
<td>450</td>
<td>6</td>
</tr>
<tr>
<td>2009</td>
<td>450</td>
<td>10</td>
</tr>
</tbody>
</table>

Results (2006–2009)
Results (2006-2009)

Annual Production vs. Electricity Costs

+ $9.9 Million = 138% Increase

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Results (2006-2009)

Annual Production vs. Carbon Footprints

- **MGD**
- **Metric Tons CO₂e (Thousands)**

- **2006**: 150 (MGD) vs. 200 (CO₂e)
- **2007**: 160 (MGD) vs. 220 (CO₂e)
- **2008**: 200 (MGD) vs. 350 (CO₂e)
- **2009**: 180 (MGD) vs. 300 (CO₂e)
Results (2006-2009)

Annual Production vs. Carbon Footprints

+ 74,000 m.t. CO₂e = 95% Increase
Results (2006-2009)

Annual Production vs. Carbon Footprints

> 9,000 homes’ electricity for 1 yr.
**Results (2006-2009)**

**Carbon Footprints by Supply Type**

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

<table>
<thead>
<tr>
<th>Year</th>
<th>Desalinated (Thousands)</th>
<th>Surface Water (Thousands)</th>
<th>Groundwater (Thousands)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>16</td>
<td>31</td>
<td>29</td>
</tr>
<tr>
<td>2007</td>
<td>14</td>
<td>30</td>
<td>26</td>
</tr>
<tr>
<td>2008</td>
<td>14</td>
<td>26</td>
<td>29</td>
</tr>
<tr>
<td>2009</td>
<td>71</td>
<td>29</td>
<td>29</td>
</tr>
</tbody>
</table>

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Results (2006-2009)

Carbon Intensities by Supply Type

Metric Tons CO₂e/MG Produced

- Groundwater
- Surface Water
- Desalinated
- Blended Product

Graph showing the carbon intensities by supply type from 2006 to 2009.
Results (2006-2009)

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

Surface water is 1.6 times more carbon intense than groundwater supply

Surface Water: 11.7
Groundwater: 0.6, 1.0
Results (2006-2009)

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

Desalination is 18 times more carbon intense than groundwater supply

0.6
1.0
11.7
Average Unit Cost by Water Supply (Electricity Costs/MG Produced)

Surface water is 1.9 times more expensive than groundwater supply

- **Surface Water**: $135
- **Groundwater**: $70
- **Total**: $1343
Results (2006-2009)

Average Unit Cost by Water Supply (Electricity Costs/MG Produced)

Desalination is 19 times more expensive than groundwater supply

$70

$135

$1343
Results (2006-2009)

Average cost for desalinated water, including other fixed and variable costs ($/MG Produced)

$4020
Applications: Conservation

Tampa Bay Water Member Governments’ Water Conservation BMPs

- Non-potable irrigation source replacement or rebates
- Water-efficient landscapes and irrigation evaluations and rebates
- High-efficiency clothes washer retrofits
- Ultra low flush toilet retrofits
- High efficiency toilets
- Urinal rebates
- Non-residential water use evaluations/implementation
Applications: Water Conservation

Tampa Bay Water member governments’ avoided GHG emissions (m.t. CO$_2$e) via water conservation

• 2009: 1,346

• 2009 at the margin (i.e., assuming avoided supply from desal): 7,090

• Cumulative (since 1996): 20,267
Applications: Water Conservation

Opportunity Costs of Water Consumption / Benefits of Water Conservation

• 2009: 1,346 m.t. CO$_2$e
  = 163 homes’ electricity for one year

• 2009 at the margin: 7,090 m.t. CO$_2$e
  = 1,390 passenger vehicles’ fuel for one year

• Cumulative (since 1996): 20,267 m.t. CO$_2$e
  = 47,133 barrels of oil
Applications: Landscape Management

79 lbs CO$_2$e per 1000 ft$^2$ landscaped area

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

Groundwater Supply

(Image credits: UF/IFAS)
Applications: Landscape Management

**165 lbs CO$_2$e per 1000 ft$^2$ landscaped area**

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

**Blended Supply**

(Image credits: Pierce Jones (top) and UF/IFAS (bottom))

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Bottom Line – True Costs

- When we flip the switch, we also turn on the tap; when we turn on the tap, we also flip the switch.
- At the margin with existing systems, and to an even greater extent with those yet to be constructed, energy-intensive water supplies are costly **economically, ecologically, and socially**.
- Conservation and efficiency are often the most cost-effective “alternative supplies”.
- Demonstrated value/benefits of DSM programs, and land use planning for resource efficiency.
Bottom Line - Opportunities

SUPPLY

Consumers

Researchers & Educators

Utilities

Planners & Policy-makers

DEMAND
Water-Energy-Land Ethic
Water-Energy-Land Ethic

1. Transportation
Water-Energy-Land Ethic

1. Transportation
2. Housing
Water-Energy-Land Ethic

1. Transportation
2. Housing
3. Food
Water-Energy-Land Ethic

1. Transportation
2. Housing
3. Food
4. Conservation and sufficiency
Water-Energy-Land Ethic

1. Transportation
2. Housing
3. Food
4. Conservation and sufficiency
5. “WE”
   - Systems approaches and interdisciplinary collaboration
Moving Forward

- Alliance for Water Efficiency, American Council for an Energy-Efficient Economy (May 2011)
- Identifies eight thematic elements and specific strategies to address the energy-water nexus and collaboratively promote energy and water efficiency

http://www.aceee.org/white-paper/addressing-the-energy-water-nexus
Water-Energy Nexus Blueprint for Action

1. Increase the level of collaboration between the water and energy communities in planning and implementing programs.
2. Achieve a deeper understanding of the energy embedded in water and the water embedded in energy.
3. Learn from and replicate best practice integrated energy-water efficiency programs.
4. Integrate water into energy research efforts and vice versa.
5. Separate water utility revenues from unit sales, and consider regulatory structures that provide an incentive for investing in end-use water and energy efficiency.

6. Leverage existing and upcoming voluntary standards that address the energy-water nexus.

7. Implement codes and mandatory standards that address the energy-water nexus.

8. Pursue education and awareness opportunities for various audiences and stakeholders.
Emerging Issues / Tough Questions

- We are facing real and increasing constraints on water, energy, and land that directly affect human quality of life and ecosystem health.
- Extension can play an important role in finding solutions to address these constraints, but there is no silver bullet.
- What are the practical applications of this type of research for Extension programming?
- What should Extension’s “energy-water nexus” role be?
- What information and technical resources will help advance our sustainability programming?
Thank You

Questions?
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