ABSTRACT
The City of St. Petersburg, FL (City) produces an average of 41,000 wet tons per year (WTpY) of Class-B biosolids and 40,000 WTpY of yard waste. The City operates four Water Reclamation Facilities (WRFs): Albert Whitted WRF, NEWRF, NWWRF, and SWWRF. Plans are underway to decommission the Albert Whitted WRF and pump that service area’s wastewater to the SWWRF for treatment. The Biosolids- and Yard-Waste-to-Energy Feasibility Study (Study) was driven by the State of Florida’s “effective ban” on Class-B biosolids land application (Florida Administrative Code Chapter 62-640) and the City’s desire to produce renewable power from currently under-used resources.

During the feasibility study and post-study optimization, the team (City of St. Petersburg and Brown and Caldwell staff) investigated over 35 options and determined that an initial phase upgrade could save the City up to $40 million over the next 20 years. The planned upgrades will consolidate all solids processing at the SWWRF through a combination of sludge forcemains and the existing collection system. Add primary clarifiers to “catch” the conveyed solids and other settleable solids at the SWWRF and upgrade the digestion at that plant to Class-A, temperature-phased, anaerobic digestion (TPAD). Digester gas would be converted to vehicle fuel (renewable compressed natural gas, rCNG) for the City’s sanitation truck fleet. The project would also include new engines for production of power (fueled by either natural gas or treated digester gas) and the heat needed for Class-A digestion. Additional thickening and dewatering capacity would also be required.

KEYWORDS
Biosolids Planning; Renewable Power; Vehicle-Fuel Conversion; Class-A Digestion; Land Application; and Bioenergy.

INTRODUCTION
The City of St. Petersburg provides wastewater treatment and yard waste collection for over 315,000 residents. Four WRFs with service areas shown in Figure 1 currently provide the required wastewater treatment. The Albert Whitted WRF will, however, be decommissioned and its flow pumped to the SWWRF. The average flows, and waste activated sludge (WAS) and...
biosolids production for each WRF are summarized in Table 1.

The State of Florida recently promulgated Florida Administrative Code Chapter 62-640 that put new requirements on the land application of Class-B biosolids. The rule change takes effect in January of 2013. Under the new rules, individual biosolids application site permits are required with significant site new restrictions and development, maintenance, and conformance with nutrient management plans for nitrogen and phosphorus. Because the additional cost of continued Class-B land application would likely increase dramatically under the new rules, The City wanted to investigate alternative beneficial reuse options.

The feasibility study started in August of 2010 and included four workshops and four technical memoranda (TM) as deliverables. The project execution was fluid and new options were investigated and additional analyses performed as warranted answering new questions.

The following problem statement was identified in the first workshop and revisited in each subsequent workshop:

“The Solution must provide a cost-effective system to process sludge and yard waste using reliable, advanced technologies, considering partnerships and regional involvement, with community input while meeting regulatory and grant requirements. The community-acceptable solution will reduce energy expenses, greenhouse gas emissions, and the City’s carbon footprint; benefit rate payers; and produce renewable energy by incorporating green and sustainable technologies. The solution must also be operational by January 2013.”

This statement served as a consistent reminder of what the study’s objectives were and allowed each new option/question to be considered in this context.

### FEASIBILITY STUDY

The Feasibility Study took place in slightly under one year, spanning from August of 2010 to July of 2011. Figure 2 shows the various project activities and linkages between deliverable and group workshop.

The City staff was well represented at the meetings with a diverse group, including:

- City Public Works Administrator
- City Director of Engineering and Capital Improvements

<table>
<thead>
<tr>
<th>Source/WRF</th>
<th>WAS Solids (dry lb/D)</th>
<th>Biosolids (dry lb/D)</th>
<th>Flow (mgd)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albert Whitted WRF</td>
<td>7,500</td>
<td>5,000</td>
<td>6.2</td>
</tr>
<tr>
<td>Northeast WRF (NEWRF)</td>
<td>11,300</td>
<td>7,600</td>
<td>8.5</td>
</tr>
<tr>
<td>Northwest WRF (NWWRF)</td>
<td>18,500</td>
<td>13,500</td>
<td>9.7</td>
</tr>
<tr>
<td>Southwest WRF (SWWRF)</td>
<td>11,300</td>
<td>7,600</td>
<td>8.9</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>48,600</strong></td>
<td><strong>33,700</strong></td>
<td><strong>33.3</strong></td>
</tr>
</tbody>
</table>

Table 1: Annual Mass of WAS and Biosolids
Workshop 1 included development of the earlier-discussed problem statement and brainstorming of an initial set of 9 options. Between Workshops 1 and 2, the options list was expanded/refined to include three other options, bringing the total reviewed at the second workshop to 12 options.

Workshop 2 reviewed the mass and energy balances for 12 options and TM1 on process loading/basis of design. All mass and energy balances were developed based on current average production but that installed facilities must be able to accommodate the peak-month and peak-day solids production. The City considers their service area to be “built out” and as such, did not forecast significant increases in solids production over the considered 20-year life of the study.

One realization made during Workshop 2 was that it is extremely difficult to process and make determinations based on “wet tons hauled”, “average megawatts produced or consumed”, or “cubic feet of natural gas used”. While it was apparent that some options had “better” energy profiles or resulted in “considerably fewer” truck trips; it was very difficult to determine “how much better” or to “normalize the relative advantages” of considered options. It was determined that economics, presented in terms of 20-year present worth, would be developed for each subsequent option so that the relative benefits could be compared based on a uniform, easily understood metric: dollars.

Finally, all of the present-worth evaluations were run at average solids production conditions, as economic performance tracks most closely with these criteria as opposed to other design criteria. Seasonal variations were “checked” against the average performance to ensure that winter or summer demands would not result in unforeseen, negative or positive implications.

It was also determined at the second workshop that two questions needed to be answered to help inform future investigations. These questions were answered in TMs 2 and 3 on the following subjects:

**TM2.** TM2 investigated whether solar energy, either for drying or power/heat generation, could improve the overall. 5 new options used either solar greenhouses or concentrating solar arrays coupled with indirect thermal dryers to dry biosolids to partially address the evaporation load on downstream thermal processes. Options for direct production of either heat or power were also considered. It was determined that the solar components would not improve the overall project economics unless the solar aspects would enhance the percentage or amount of associated grant funding.

**TM3.** It appeared that consolidation of solids handling would have many significant benefits; TM3 investigated how to best consolidate solids from three plants at one site. 6 new options were considered and included hauling dewatered WAS; hauling dewatered, digested biosolids; WAS forcemains; and WAS forcemains to the service area of the centralized solids handling facilities. It was determined that decommissioning the solids operations at the NEWRF and NWWRF was indeed beneficial and that WAS forcemains to the SWWRF service area collection system would save significant operational cost.

In Workshop 3, the results of TMs 2 and 3 were reviewed. It was decided that the solids handling should be consolidated as recommended in TM3 and that solar options could be considered in the future would not be part of the base project. It was also decided, based on the existing anaerobic digestion infrastructure at the SWWRF that digestion would be included as it helped the overall energy profile and would address the needs created by Florida Administrative Code Chapter 62-640.
Another final short list of 10 new/refined options was created at Workshop 3. These options tested various conventional thermal dryers and the possibility of sale of heat to Eckerd College (located immediately adjacent to the SWWRF) in lieu of producing power in excess of that used at the SWWRF. Additional mass balances and present worth were developed for these options for final selection at the final Workshop 4. At Workshop 4, a two-phase approach was “adopted” as the recommended plan. The phases consisted of the following elements:

1. Consolidate all solids processing at the SWWRF upgrade the digestion at that plant to Class-A, temperature-phased, anaerobic digestion (TPAD) with 1.2MW of engine-derived power. The recommended elements include:
   - Consolidating wastewater solids handling by conveying waste activated sludge (WAS) produced at the NEWRF and NWWRF to the SWWRF using a combination of new forcemains and the existing collection system.
   - Adding primary clarification to the SWWRF to collect the conveyed WAS.
   - Upgrading the solids treatment facilities at the SWWRF to Class-A digestion and certification of the produced Class-AA biosolids as a fertilizer.
   - Expanding the SWWRF gravity-belt thickening (GBT), digestion, and dewatering capacity to accommodate the City's entire wastewater solids production.
   - Addition of a 1.2- to 1.5-MW digester-gas fueled engine with three-stage gas treatment and boilers for back-up heat.
   - Providing a Fat, Oil and Grease (FOG) tipping station at the SWWRF

2. Yard-waste-fueled thermal process (currently envisioned as gasification with syngas used to fuel internal combustion engines). The Phase-2 Project is on hold as it currently does not have an improved present worth over the Phase-1 Project and that the economics and technical feasibility should improve over time with respect to:
   - Current inability of gasifiers to co-process yard waste and biosolids. Existing vendors are cautious and have indicated that separate gasification units would have to be separately “tuned” to these different waste streams. In the developed thermal balances, yard-waste derived heat is needed to dry the biosolids so that the likely phase-2 gasification operation is for yard waste only, with Class-A land application of biosolids. This limitation does not constrain fluid bed combustion units.
   - Lack of operational US gasifiers that use syngas to fuel internal combustion engines. Such configurations should be able to produce between 50 and 100 percent more electricity than Rankin-cycle (steam turbine) systems. Proof of this concept elsewhere is needed (likely either in Germany or Japan) before implementation in St. Petersburg.
   - Feasibility to wheel excess power to other City facilities. Implementation of yard-waste-to-energy will produce considerably more power than can be used by any one of the City's existing WRFs. The economic evaluation assumes that the City can “wheel” excess power to other City-owned facilities. The feasibility of this option has not yet been verified with Progress Energy; it has been assumed that excess power can be wheeled to other city-owned facilities for a charge of 0.5¢/kWh.
   - Current value of produced power does not quite satisfy phase-2 economics. In the Feasibility Study, electrical power was assumed to be worth 10¢/kWh for power used on site (current prices) and 9.5¢/kWh for electricity used at another facility. No value has been assumed for renewable energy credits (RECs). REC value may increase significantly once the State of Florida's initial Renewable Portfolio Standard (RPS) compliance milestone is reached in 2014, increasing the value of the RECs accordingly. Higher power costs and/or high REC values could accelerate the phase-2 financial viability.
The agreed-upon solution was defined in TM4. The City Public Works Administrator presented the recommended approach to the City Council in late July, 2011. The presentation was very positively received and implementation efforts are underway.

The Feasibility Study methodology used is considered very defensible by City staff because:

1. The “universe” of potential options was considered. These options included Class-A and phased anaerobic digestion; gasification; fluid-bed incineration; conventional thermal drying; greenhouse and concentrating solar drying; screw-press, centrifuge, and belt filter press dewatering; generation of electricity using engines or steam turbines; solids consolidation by hauling dewatered WAS or digested solids, sludge forcemain, and sewer conveyance of WAS; and production of/possible sale of energy in the form of heat or electrical power.

2. City staff participated in the development of the options and had significant input in the identification, development, and refinement of the recommended phases.

RECENT UPDATES AND ONGOING DESIGN

In early 2013, after completion of the Feasibility Study, the project renewable fuel direction changed from renewable electricity production to conversion of digester gas for use as rCNG vehicle fuel in City-owned/City-operated sanitation fleet. The vehicle fueling value was more attractive from an economic standpoint and was even further enhanced by the relatively high value ($1.23/gallon diesel equivalent, GDE) of the environmental attribute for renewable vehicle fuels (Renewable Information Numbers or “RINs”) compared with RECs. The $1.23/GDE is derived by multiplying a $0.68/gallon ethanol equivalent (GEE) publically-traded price by a 1.8GDE/GEE energy factor per equivalent volumetric fuel value.

At this time the power costs were adjusted from an annual average basis of 9.5 to 10¢/kWh to match their actual rate structure which covers different rates for two times of day: St. Petersburg pays 16¢/kWh for the 9-hour-per-day peak period and 6¢/kWh for the 15-hour balance of each day. This distinction identified that the engines can be very cost effectively run for 9 hours per day on natural gas – allowing the digester gas to be used predominantly for vehicle fuel production.

The scope of the project was also increased to include:

- Complete replacement rather than rehabilitation of two of the SWWRF’s three digesters. This was due principally to the age and condition of the existing tanks.
- Primary clarifier diameter was increased to provide improved performance at peak flow conditions.
- Gas upgrading system and high-pressure gas compression for vehicle fuel use. The gas quality after treatment is comparable to natural gas in terms of heating value and impurities so that this same fuel is usable in the CHP engines as if it were natural gas.

The project is currently in preliminary design and a number of firms are designing the associated improvements. Specifically:

3. Brown and Caldwell is providing programmatic overview and designing the liquid stream integration, primary clarifiers, digesters and class-A digestion upgrades, digester-gas treatment/vehicle fuel conversion, and odor control.

4. Black & Veatch is responsible for the design of 12kV electrical loop improvements, engines, and boilers.

5. Corollo is designing the GBT thickening upgrades.

6. URS is designing the dewatering and biosolids loadout facilities.
RESULTS

Table 2 presents the 2-year, present-worth costs of the current operation, continued land application of Class-B biosolids and the Phase-1 improvements as currently envisioned. Three operational modes are presented in terms of engine operation on either natural gas or upgraded biogas.

The Phase-1 project:

- Produces 1,300 to 1,750 GDE of rCNG per day
- Produces just under 1 MW of power from a combination of natural gas and upgraded biogas.
- Reduces current annual costs of operation by ~$4.0 to $4.5 million per year.
- Has a 20-year present worth of $35 to $40 million less than maintaining the status quo.

NEXT STEPS

The City is currently evaluating the capacity of the SWWRF to handle the additional loading proposed under the Phase-1 solids upgrades and the Albert Whitted WRF decommissioning. Discussions are ongoing to better understand and/or refine the overall direction, specifically:

- Progress Energy is being consulted on
the feasibility and cost implications of wheeling power from the SWWRF to other City-owned electrical demands (like the two northern WRFs).

- Options that could reduce the total power generated to below that used at the SWWRF so that wheeling would not be needed:
  - Other options for digester gas use (cleaning and compression to compressed natural gas quality for vehicle fueling or tube-truck conveyance to other stationary, gas-fueled engines) are being investigated.
  - Less efficient power generation from the Phase-2 thermal upgrades so that less capital investment could reduce the overall life cycle costs.
  - Sale of excess generated power to Progress Energy or others.
  - Various combinations of the above and other options.

CONCLUSIONS

The process employed for the City of St. Petersburg’s Biosolids- and Yard-Waste-to-Energy Feasibility Study provided a defensible recommendation that met the City’s needs. The process was effective in large part due to the fluidity of the process and willingness to investigate and develop economics analysis for any and every identified option.

Consolidation of their solids operation and producing renewable vehicle fuel and power support of the City’s sustainability and cost reduction goals, and the need to address the State’s revised biosolids land application rules. The Phase-1 improvements are planned to be designed by mid-2014 and be operational by the end of 2017.