Energy Exchange Opportunities Leveraging Building Wastewater

•Presentation by: Rick Lawlor P. Eng. LEED® AP Eastern Regional Sales Manager
Sanitary Water Energy Exchange – Why?

SWEE

✓ Environmentally & Economically beneficial
  Heat Source  Reduced fossil fuel demand / GHG emissions
  Heat Sink  Water evaporation eliminated / Significant Electrical Energy Savings

✓ Delivers LEED® goals & supports HPBC - High Performance Building Culture

✓ Increased Asset Value of Buildings

✓ Economically viable;
  ✓ Simple pay-back periods from immediate to ??
  ✓ New and Evolving Life-cycle Financing Solutions ; PPA / HPA
Some of the places worth exploring;

- Aquatic Centers / Natatoriums
- Hospitals & Long-term Care
- University/College Campuses
- Prisons

- Commercial & Retail Buildings
- Condominiums & Apartments
- Sport & Fitness Facilities
- Industrial Processes

- Geothermal Systems
- District Energy Systems
Sanitary Water Energy Exchange Technology

Off-Line Energy Exchange
2012

Seven35 – Condos
North Vancouver, BC

In-Line Energy Exchange
2016
Typical Potable Water Flow

- Condos & Apartments
- Commercial & Retail Buildings
- GEOTHERMAL
- District Energy
- Sport & Fitness Facilities
- Aquatic Centers / Natatoriums
- Hospitals & Long-term Care
- University/College Campuses
- Prisons
- Industrial
- Breweries
Daily DHW demand profile

REFERENCE: ASHRAE HANDBOOK HVAC Applications 2011 – SERVICE WATER HEATING – CHAPTER 50
2012 Deployment of Off-Line Energy Exchange
Canada’s first multi-family project built to LEED Platinum and Built Green Gold Standards

Sanitary water heat recovery used for domestic hot water heating
SWEE Potable Water Flow

Off-Line Energy Exchange

Sanitary Storage

Potable Water Supply

Hot Water Usage

Filter Unit

Heat Exchange

1) Hot Water Tank

Heat Pump (Optional)

Pump

Solids Out
2012 Deployment of Off-Line Energy Exchange System
2012 Deployment of Off-Line Energy Exchange System

Off-Line Energy Exchange System

Site Sanitary Storage
Seven35 – Condos
North Vancouver, BC

Independent Owner Validation

✓ 75% Energy Reduction vs Ngas
✓ Offline Sanitary Energy Exchange System
✓ Primary DHW Heating system – Ngas Top-up
✓ System NET Blended HCOP 3.63
2012 Deployment of In-Line Energy Exchange System

- Independent Owner Validation – End of Year 1
2012 Deployment of In-Line Energy Exchange System

- CDN $ 275,000 Green Technology Investment
  - SWEE System, Heat Pumps, Concrete Tank, Hot Water & Sewage Pumps, Water & Sewage Piping, Four PH Storage Tanks, Electrical, Civil, Labour

- Simple Payback – ? ? ?

- Immediate

- Density allowances permitted additional Condo suites to be sold by using SWEE at Parking Level - Not possible with Roof Wind Turbine or Solar Panel options
2012 Deployment of In-Line Energy Exchange System

Off-Line Energy Exchange System

Site Sanitary Storage
2016 Deployment of In-Line Energy Exchange System

In-Line Energy Exchange System

Site Sanitary Storage
2016 Deployment of In-Line Energy Exchange System

Seven35 – Condos
North Vancouver, BC
2016 Deployment of In-Line Energy Exchange System
In-Line Energy Exchange
In-Line Energy Exchange

Performance Data:

Chart depicts the Piranha coefficient of performance and domestic hot water leaving temperature based on source water temperature of 74 F.
In-Line Energy Exchange

Operational sequence:

1) Sewage flows by gravity to a collection tank
2) Sewage is pumped on a timed schedule into the PIRANHA
3) There is an overflow on the PIRANHA that returns to the wastewater collection tank
4) There is an actuated valve that is used to empty the PIRANHA 1 time per day before the morning hot water demand
5) Heat is transferred from the sewage into the refrigerant through the walls of the PIRANHA tank.
6) There is a mixer on the larger units (T7.5, T10, T15) within the PIRANHA tank to increase heat transfer rate
7) The refrigerant flows through a standard water to water heat pump module which includes a condenser
8) Heat is transferred from the refrigerant to the potable water flowing on the other side of the condenser
9) Potable water is flowing from the pre-heat tanks to the condenser and returned to the preheat tanks as warmed water
In-Line Energy Exchange

Approximate Rule of Thumb for Sizing the PIRANHA System*
(Contact IWS directly for additional selection and design assistance)

<table>
<thead>
<tr>
<th>Number of Residential Units (Assuming 2 people per unit.)</th>
<th>PIRANHA Model</th>
<th>Ancillary Wastewater Storage Tank Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>~10-30</td>
<td>T3</td>
<td>500-750 gallons (1890-2800 litres)</td>
</tr>
<tr>
<td>30-60</td>
<td>T5</td>
<td>750 gallons (2840 litres)</td>
</tr>
<tr>
<td>60-100</td>
<td>T7.5</td>
<td>1000-1500 gallons (3785 – 5680 litres)</td>
</tr>
<tr>
<td>100-150</td>
<td>T10</td>
<td>1500 gallons (5680 litres)</td>
</tr>
<tr>
<td>150-200</td>
<td>T15</td>
<td>1500-2000 gallons (5690-7570 litres)</td>
</tr>
</tbody>
</table>

*Installation of multiple units is possible for larger buildings and for redundancy.
Seven35 – Condos North Vancouver, BC

2016 Deployment of In-Line Energy Exchange System

In-Line Energy Exchange System

Site Sanitary Storage
2016 Deployment of In-Line Energy Exchange System

✓ CDN $ 55,000 Green Technology Upgrade Investment
  ✓ Re-use existing wet-well tank ( $ Equivalent New Fibreglass $ 10,000 close-couple install)
  ✓ Re-use PH Tanks

Below Ground Tank:

1. 1500 gallon inground fiberglass sewage chamber
2. Submersible solid handling pump
3. Motorized butterfly valve N.C.
4. Pre-heat 500 gallon DHW storage tank
5. 500 gallon DHW storage tank
6. Boiler
Above Ground Tank:

1. Inground fiberglass sewage chamber
2. Submersible duplex pump set. Duty-standby operated
3. Submersible pump
4. Three-way diverting valve
Example;
Pre-design Feasibility Study
Orlando Florida Hotel Complex
1100 Room Hotel & Convention Center (Design Stage)  
Orlando, Florida

- Proposed 1100 Room Project
- Kitchens
- Pool
- On-site Laundry
3 Estimation of the domestic hot water demand
The hot water load is the main design data required to size a Piranha system. This data is not available but has been estimated using a reference value of 32 gal/room and an average 80% room occupancy rate. The average daily hot water consumption has been estimated to be 28,160 gallons.

The assumptions made to perform the analysis are shown in table 1.

<table>
<thead>
<tr>
<th>Table 1. Estimated DHW demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter</td>
</tr>
<tr>
<td>Specific water demand</td>
</tr>
<tr>
<td>Specific hot water demand (at 140°F)</td>
</tr>
<tr>
<td>Cold water temperature</td>
</tr>
<tr>
<td>Average room occupancy</td>
</tr>
<tr>
<td>Daily hot water demand (at 140°F)</td>
</tr>
<tr>
<td>Annual hot water demand (at 140°F)</td>
</tr>
<tr>
<td>Daily net energy demand</td>
</tr>
<tr>
<td>Annual net energy demand</td>
</tr>
</tbody>
</table>
4 Energy and cost savings analysis

Two technical system configurations have been compared:

1. Base case: DHW heating system with gas fired boilers
2. Energy efficiency solution: PIRANHA system coupled with gas fired boilers (see fig.2)

The utility costs used to perform the analysis are shown in table 2.

Table 2. Local energy rates used in the calculations

<table>
<thead>
<tr>
<th>Utility</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>US $/kWh</td>
<td>$0.0905</td>
</tr>
<tr>
<td>Natural gas</td>
<td>US $/Thousand Cubic Feet</td>
<td>$10.48</td>
</tr>
</tbody>
</table>
4.1 Base case
An annual cost and energy representation of the base case system is shown in table 3.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net Energy demand</td>
<td>Btu/year</td>
<td>7,740,517,797</td>
</tr>
<tr>
<td>System efficiency</td>
<td>%</td>
<td>90%</td>
</tr>
<tr>
<td>Natural Gas demand</td>
<td>Therm/year</td>
<td>86,026</td>
</tr>
<tr>
<td>Natural Gas cost</td>
<td>US $</td>
<td>$90,290</td>
</tr>
</tbody>
</table>
1100 Room Hotel & Convention Center (Design Stage)
Orlando, Florida

Table 4. Preliminary PIRANHA unit design

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIRANHA model 160</td>
<td>No.</td>
<td>2</td>
</tr>
<tr>
<td>Nominal heating capacity</td>
<td>kW/unit</td>
<td>47</td>
</tr>
</tbody>
</table>

Table 5. PIRANHA system

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-heat load</td>
<td>%</td>
<td>40%</td>
</tr>
<tr>
<td>Net Energy demand</td>
<td>Btu/year</td>
<td>3,096,207,119</td>
</tr>
<tr>
<td>System efficiency</td>
<td>%</td>
<td>500%</td>
</tr>
<tr>
<td>Power Consumption</td>
<td>kWh/year</td>
<td>181,489</td>
</tr>
<tr>
<td>Electricity cost</td>
<td>US $</td>
<td>$16,425</td>
</tr>
</tbody>
</table>

Table 6. Top-up boiler

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat load</td>
<td>%</td>
<td>60%</td>
</tr>
<tr>
<td>Net Energy demand</td>
<td>Btu/year</td>
<td>4,644,310,678</td>
</tr>
<tr>
<td>System efficiency</td>
<td>%</td>
<td>90%</td>
</tr>
<tr>
<td>Natural Gas demand</td>
<td>Therm/year</td>
<td>51,616</td>
</tr>
<tr>
<td>Natural Gas cost</td>
<td>US $</td>
<td>$54,174</td>
</tr>
</tbody>
</table>
### Table 7. Summary of annual energy consumption and savings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Gas boilers</th>
<th>PIRANHA + Gas boilers</th>
<th>Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel demand</td>
<td>T/yr</td>
<td>86,026</td>
<td>51,616</td>
<td>34,411</td>
</tr>
<tr>
<td>Electricity demand</td>
<td>kWh/yr</td>
<td>0</td>
<td>181,489</td>
<td>-181,489</td>
</tr>
</tbody>
</table>

### Table 8. Summary of annual costs and savings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Gas boilers</th>
<th>PIRANHA + Gas boilers</th>
<th>Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel cost</td>
<td>US $</td>
<td>$90,290</td>
<td>$54,174</td>
<td>$36,116</td>
</tr>
<tr>
<td>Electricity cost</td>
<td>US $</td>
<td>$0</td>
<td>$16,425</td>
<td>-$16,425</td>
</tr>
<tr>
<td>Total primary energy cost</td>
<td>US $</td>
<td>$90,290</td>
<td>$70,599</td>
<td>$19,691</td>
</tr>
</tbody>
</table>
1100 Room Hotel & Convention Center (Design Stage)
Orlando, Florida

![Bar chart showing annual energy costs and savings.]

**Fig. 3 Annual energy costs and savings**
### Table 9. Cost estimates

<table>
<thead>
<tr>
<th>Description</th>
<th>Equipment and Installation Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>• 2 No. PIRANHA Model 160</td>
<td></td>
</tr>
<tr>
<td>• 1 No. Above ground sewage holding tank (2,000-gal volume)</td>
<td></td>
</tr>
<tr>
<td>• 2 No. Solids handling pumps</td>
<td>US $125,000</td>
</tr>
<tr>
<td>• Piping to/from Piranha and wastewater tank</td>
<td></td>
</tr>
<tr>
<td>• Piping to/from Piranha and mechanical room</td>
<td></td>
</tr>
</tbody>
</table>
1100 Room Hotel & Convention Center (Design Stage)  
Orlando, Florida

The PIRANHA system provides a total estimated annual savings of $19,691 for the first year, generating a client ROI of 20%. The annual energy cost savings is expected to increase annually with inflation and rising energy costs. The energy cost escalation rates shown in table 10 have been used for this economic assessment.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Gas cost escalation rate</td>
<td>4%</td>
</tr>
<tr>
<td>Electricity cost escalation rate</td>
<td>4%</td>
</tr>
</tbody>
</table>
1100 Room Hotel & Convention Center (Design Stage)
Orlando, Florida

Fig. 3 Cumulative savings
Sewage Heat Recovery Hybrid Geothermal
WASTEWATER & GEOTHERMAL
800 units + retail

Geothermal – Cooling Dominant

GEO Field = Building footprint

AC rejection load > Geo field

Field limited to 233 Boreholes @ 600 Feet Depth

Excess AC Rejection to;
(1) Conventional Tower / Fluid Cooler
(2) Site sanitary water
Impact on GEOTHERMAL Systems

SWEE

10-year thermal response of the ground - Soil temp (F)

- Only geothermal - original number of boreholes
- Hybrid system - original number of boreholes
- Hybrid system - reduced number of boreholes

233 BHs
Impact on GEOTHERMAL Systems

10-year thermal response of the ground - Soil temp (°F)

- Only geothermal - original number of boreholes
- Hybrid system - original number of boreholes
- Hybrid system - reduced number of boreholes

233 BHs + Sanitary
S W E E Impact on GEOTHERMAL Systems

10-year thermal response of the ground - Soil temp (F)

- Only geothermal - original number of boreholes
- Hybrid system - original number of boreholes
- Hybrid system - reduced number of boreholes

110 BHs + Sanitary
**SWEE Financial Impact on GEOTHERMAL Systems**

<table>
<thead>
<tr>
<th></th>
<th>Only geothermal original # of boreholes</th>
<th>Hybrid system reduced # of boreholes</th>
<th>Savings $</th>
<th>Savings %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground loop cost</td>
<td>$2,796,000</td>
<td>$1,326,000</td>
<td>$1,470,000</td>
<td>53%</td>
</tr>
<tr>
<td>Total Capital Cost</td>
<td>$2,796,000</td>
<td>$1,596,000</td>
<td>$1,100,000</td>
<td>39.3%</td>
</tr>
<tr>
<td>10-year energy cost</td>
<td>$1,315,395</td>
<td>$1,270,313</td>
<td>$45,082</td>
<td>3.4%</td>
</tr>
<tr>
<td>Net 10-year savings</td>
<td>$4,111,395</td>
<td>$2,966,313</td>
<td>$1,145,082</td>
<td>27.9%</td>
</tr>
</tbody>
</table>

$ 20 / Foot GEO Drilling Install Costs
District Energy

**Low-carbon, Sustainable Energy** - Multiple buildings connected to more sustainable sources

**Affordable Energy** – More stable and cost competitive prices

**Fuel Flexibility** – It’s possible to switch to different fuel systems, and take advantage of future innovation

**Decreased Building Costs** – Less HVAC equipment for each building and more usable space
Sanitary Water Energy Exchange
Sanitary Water Energy Exchange

Now what is the Simple Payback for a Marble Floor? (*)

(*) Reinhold Wieland
Specialist in Energy Performance Contracting & Real Time Energy Management
LinkedIn November 8 2016
https://www.linkedin.com/pulse/now-what-simple-payback-marble-floor-reinhold-wieland
Sanitary Water Energy Exchange

Or a Fire Sprinkler System?
An Emergency Lighting System?
A Security System?
Air Conditioning Maintenance?
A New Roof?
An Insurance Package?
Rewire of Electrical System?
An Energy Efficiency Project?

Which one needs to have a Simple Payback calculated every time?

(*) Reinhold Wieland
Specialist in Energy Performance Contracting & Real Time Energy Management
LinkedIn November 8 2016
https://www.linkedin.com/pulse/now-what-simple-payback-marble-floor-reinhold-wieland
Simple Payback is only one way to compare investments

Consider SIR (Savings to Investment Ratio), or ROI, or IRR or Net Present Value or Lifecycle Savings.

(*) Reinhold Wieland
Specialist In Energy Performance Contracting & Real Time Energy Management
LinkedIn November 8 2016
https://www.linkedin.com/pulse/now-what-simple-payback-marble-floor-reinhold-wieland
THANK YOU

CONTACT

Email: rickl@iwhes.com
O: +1 604 475 7710
C: +1 905 741 2139
F: +1 604 294 0042

www.sewageheatrecovery.com
Canada HQ: 1443 Spitfire Place Port Coquitlam V3C 6L4
UK HQ: 15 Wheeler Gate Nottingham NG1 2NA