IWESS, from Here to Where: CMU’s Intelligent Workplace Energy Supply System

Power, Cooling, Heating, and Ventilation from Solar Heat and Renewable Fuel

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IWESS/BAPP Guidelines

- deliver more useful energy than that used by the space, more than that supplied by external sources, except for solar and renewable sources
- recognize that IW architectural features minimize building power, cooling, heating, ventilation loads
- supply cooling, heating by chilled, heated water
- ventilate by ample fresh air at comfortable temperature, appropriate humidity
- provide energy at an efficiency twice conventional by a system integrated, modularized, controlled
IWESS Components

• steam driven absorption chiller
• solar thermal heat supply with hot water driven chiller, (storage)
• bioDiesel engine generator with heat recovery equipment for steam and hot water
• ($solid oxide fuel cell with heat recovery at high temperature$)
• fan coil cooling/heating units with advanced controls
• radiant cooling/heating units: mullions, radiant panels
• ventilation system with enthalpy recovery, heat pump, and solid desiccant dehumidification
• building grids: power, natural gas, steam, chilled water, heated water
IWESS Components Integrated with IW through Grids

Notes:
1. All grid lines are parallel supply/return connections.
2. Electrical, and instrumentation and control connections for the components are not shown.
3. Dashed lines and boxes indicate instrumentation: sensors, actuators, controls, and data processing equipment.
4. Proposed order of installation: mullions (existing), chiller/aux steam (existing), ventilation (existing); solar (October 2006), fan coil and vent diffusers (December 2006), engine generator (December 2006), fuel cell (2007).
# IWESS Status Table

<table>
<thead>
<tr>
<th>Component</th>
<th>Preliminary Design</th>
<th>Procurement</th>
<th>Detailed Design</th>
<th>Installation</th>
<th>Test, Evaluation</th>
<th>Integration, Operation*</th>
<th>Optimization, Diagnostics*</th>
<th>Cost</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam driven chiller</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$219 k</td>
<td>Awaits engine provided steam supply</td>
</tr>
<tr>
<td>Solar heat, hot water driven chiller</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$387 k</td>
<td>Commissioning now underway</td>
</tr>
<tr>
<td>BioDiesel engine generator with heat recovery</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$644 k</td>
<td>Installation starts December 2006</td>
</tr>
<tr>
<td>High temperature fuel cell with heat recovery</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$314 k</td>
<td>Funds $$$ required</td>
</tr>
<tr>
<td>Fan coils with advanced control system</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$74 k</td>
<td>Benefits are already obvious</td>
</tr>
<tr>
<td>Radiant cooling/heating units; mullions, panels</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Modeling for performance studies</td>
</tr>
<tr>
<td>Ventilation, conditioned air supply system</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$1,638 k</td>
<td></td>
</tr>
</tbody>
</table>

* Require advanced control
## IWESS Investment

<table>
<thead>
<tr>
<th>Component</th>
<th>Equipment</th>
<th>Auxiliary Equipment</th>
<th>Engineering</th>
<th>Instrumentation and Control</th>
<th>Installation</th>
<th>Total Installed Hardware Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam driven chiller</td>
<td>$12 k</td>
<td>$9 k</td>
<td>$38 k</td>
<td>$63 k</td>
<td>$97 k</td>
<td>$219 k</td>
</tr>
<tr>
<td>Solar receivers, hot water driven chiller</td>
<td>$45 k</td>
<td>$5.4 k</td>
<td>$53 k</td>
<td>$62.5 k</td>
<td>$221 k</td>
<td>$387 k</td>
</tr>
<tr>
<td>BioDiesel engine generator, heat recovery</td>
<td>$116 k</td>
<td>$31 k</td>
<td>$47 k</td>
<td>$71 k</td>
<td>$379 k</td>
<td>$644 k</td>
</tr>
<tr>
<td>High temperature fuel cell, heat recovery</td>
<td>($300 k)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fan coils, advanced control system</td>
<td>$27 k</td>
<td>--</td>
<td>$27 k</td>
<td>$200 k</td>
<td>$60 k</td>
<td>$314 k</td>
</tr>
<tr>
<td>Radiant cooling/heating units; mullions, panels</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ventilator, conditioned air</td>
<td>$55 k</td>
<td>$3 k</td>
<td>$0.5 k</td>
<td>$17 k</td>
<td>$75 k</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>$255 k</strong></td>
<td><strong>$48 k</strong></td>
<td><strong>$165 k</strong></td>
<td><strong>$397 k</strong></td>
<td><strong>$774 k</strong></td>
<td><strong>$1,639 k</strong></td>
</tr>
</tbody>
</table>
IWESS Investment

- components installed as research equipment: extensive instrumentation, data acquisition, test auxiliaries
- components installed in an existing building, not outfitted as a laboratory
- components installed to be integrated with the IW, with the building energy supply grids, and with each other
IWESS Systems Studies

• combine components and IW: determine performance, effectiveness, efficiency, over a day, season, year: Trnsys-Comis modeling platform
  – solar receivers, chiller, fan coils, IW: space cooling/ heating: operational strategies, storage, insulation: annual energy use. Extend to economics, environment, storage alternatives
  – operable windows: cooling, ventilation: strategies, energy use. Extend strategies, economics, environmental

• future studies
  – solar reflectors, blinds, IW: annual energy loads: operational strategies
  – radiant cooling/heating, ventilation, IW: annual energy use: benefits of dehumidification, comparison radiant, convective cooling/heating
  – fan coil (operational and control models) cooling/heating, ventilation, IW, single and multizone: considering temperatures, humidities, occupancy: operational and control strategies: annual energy use
  – engine generator with heat recovery equipment, chiller, fan coils, ventilator: strategies: annual effectiveness, energy use
IWESS to Where

• complete component installation, test, evaluation
• integrate operation with the IW, with other components
• develop operation, control, optimization, diagnostic strategies based on component and system modeling, including economic, environmental aspects
• identify, develop promising applications: residential, commercial, CMU’s BAPP
• develop system guidelines, design procedures, tools: component characterization; system synthesis; technical, economic performance evaluation through component, system modeling, CMU’s BAPP
• component adaptation, integration for performance improvement, cost reduction
• EDUCATION
IWESS Journey Requirements

• another generation of capable graduate students: six students/four years, $1.2 million
• faculty/staff guidance: four persons/four years, $1.2 million
• equipment: fuel cell, modified existing components, $0.8 million
Personal Thanks

- Students, particularly Dr. Hongxi Yin
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IWESS Additional Slides

• Operation, control: fan coil off-on transfer energy as required up to limit; control valve, fan setting supply temperature pressure provides energy
• Equipment modification: ventilator replace heat pump, burner with exchangers
• Equipment integration
• Investment, justification
IWESS Components Integrated with IW through Grid Pipes
IWESS BioDiesel Engine Generator with Heat Recovery Equipment
IWESS Component Status, IWESS Program Steps

- component selection, modeling
- preliminary system design: loads, flow diagram, material and energy balances, instrumentation diagram, equipment specifications/descriptions, operational description, layout
- procurement
- detailed design
- installation
- component test, data evaluation, performance analysis
- component integration into the IW, with other components, test, systems annual performance analysis
- advanced control: optimization, diagnostics
- system design guidelines, procedures, tools, economics, applications
- component redesign, optimization, integration
- education
IWESS Mission to Educate

- students: graduate, undergraduate
- profession: technical publications, website, WBDG’s
- public: promotional literature, website
- conferences, open house tours: architects, developers, building owners/operators, regulators