The Future: IWESS, BAPPESS, and Beyond:

Energy for Building Operation/2 + !;
$ for ESS Installed/1.2 + !.

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

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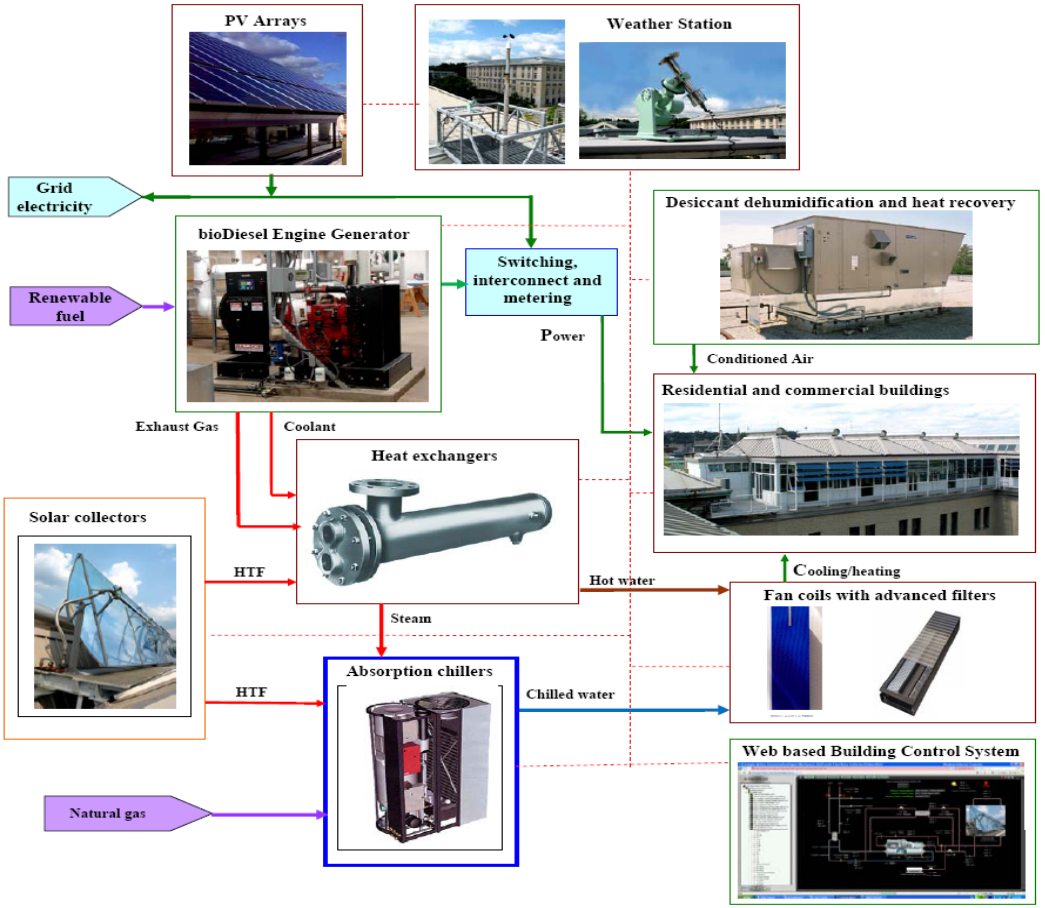
ESS: the Future, a Vision

- provides for occupants a building space
  - safe, secure (fire, emergency, intruders)
  - healthy (air: low particulates, contaminants)
  - comfortable (space temperature and humidity, illumination, noise level)

ESS: the Future, a Vision

- supplies
  - power
  - cooling/heating
  - ventilation
  - communication



ESS: the Future, a Vision




- includes
  - hvac equipment
  - lighting
  - operable building features
    - windows
    - reflectors
    - blinds
  - advanced instrumentation: sensors, control, automation, operation, diagnostics, optimalization, wireless, IP phone

ESS: the Future, a Vision

- benefits
  - increased security (fire, security, emergencies), health (abundant, clean conditioned air), comfort (proper temperature, humidity; appropriate lighting; quiet)
  - reduced operating cost (primary energy requirement half; routine maintenance scheduled, emergency maintenance facilitated), reduced environmental impact
  - reduced capital cost (model based equipment, systems, and operations design; plug & play equipment; modular systems)
- approach
  - integrated equipment, systems, operation
  - wireless, web based communications: occupants, sensors, controls, equipment, building operators, equipment suppliers
  - advanced control, automation, operation, diagnostic, optimalizing, performance reporting system

The Intelligent Workplace, the IW

IWESS System Components

ESS

- solar thermal heat supply with hot water driven chiller, (storage, drain back): photovoltaic power supply
- bioDiesel engine generator with heat recovery equipment for steam and hot water; steam driven absorption chiller
- cooling/heating units, fan coil and radiant, with advanced controls, IP phones
- ventilation system with enthalpy recovery, heat pump, and solid desiccant dehumidification

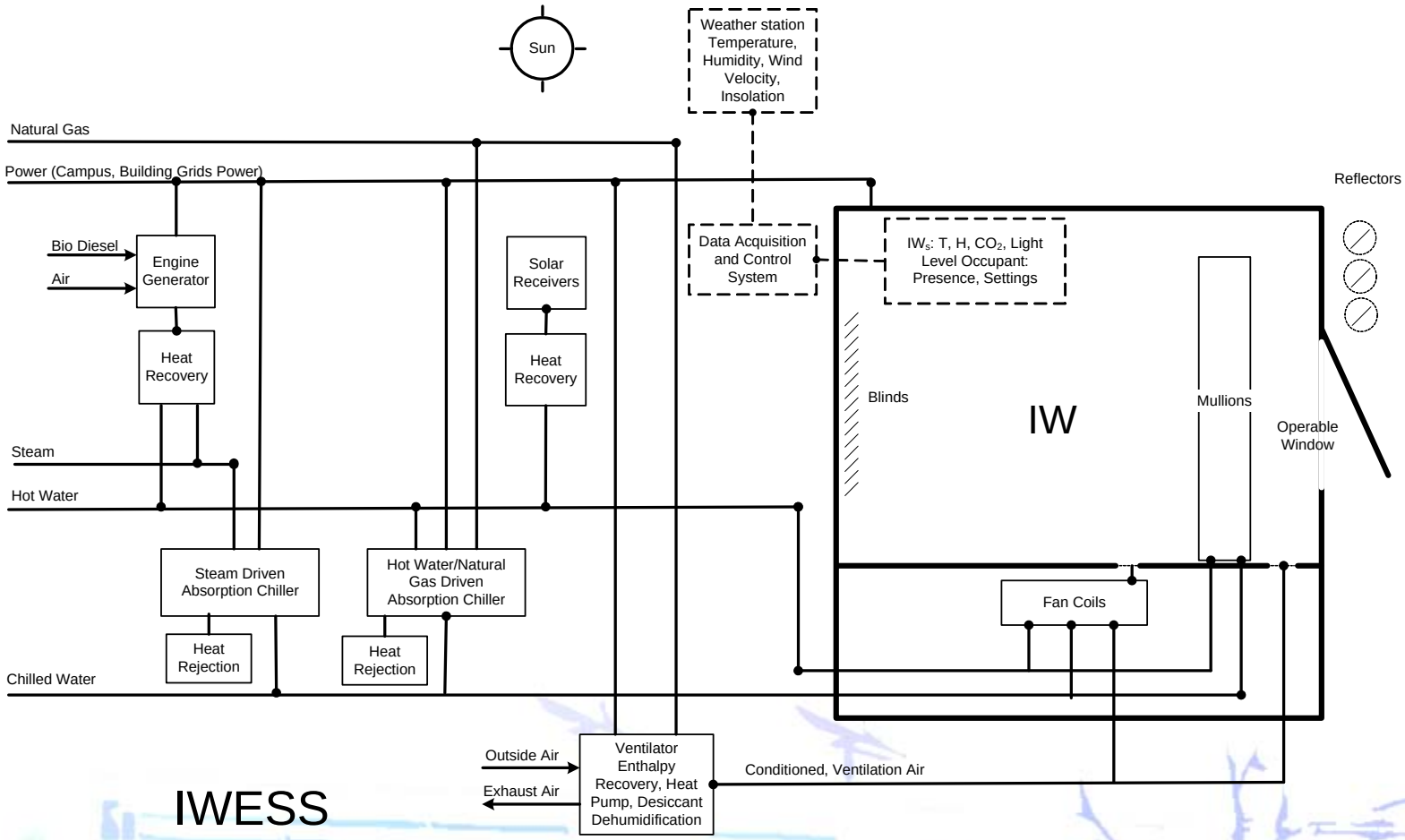
IW

- building space
- ambients, weather conditions
- schedules
- operable façade elements: windows, (mullions), reflectors, blinds
- building grids: power, steam, chilled water, heated water, natural gas

OPERATING SYSTEM

- automation, operation, control (Johnson, Luxmate, Automated Logic, LabView, Siemens)
- optimization
- diagnostics

IWESS Components Integrated with IW through Building Grids, Operating System



IWESS

IWESS Status Table

Component	Selected	Preliminary Design	Procurement	Detailed Design	Installation	Test, Evaluation	Operation, Integration*	Optimization, Diagnostics*	Cost
Steam driven chiller									$219 k
Solar thermal building cooling/heating									$387 k
BioDiesel engine generator with heat recovery									$644 k
High temperature fuel cell with heat recovery									
Fan coils with advanced control system									$314 k
Radiant cooling/heating units; mullions, panels									
Ventilation, conditioned air supply system									$74 k
Operable windows									$24 k
									$1,662 k

* Require advanced control

IWESS Results to Date

- all ESS component systems modeled, designed, procured, installed
- IW and ESS operations modeled, performance evaluated
- most ESS systems extensively tested – 1 to 2 years; ready for integrated, automated operation; exceptions bioDiesel, fan coils, operable windows, blinds
- component, IW, and overall operating system modeling used for test data analysis, design and performance improvement of component, system, and operations evaluation

IWESS Future, Next Year

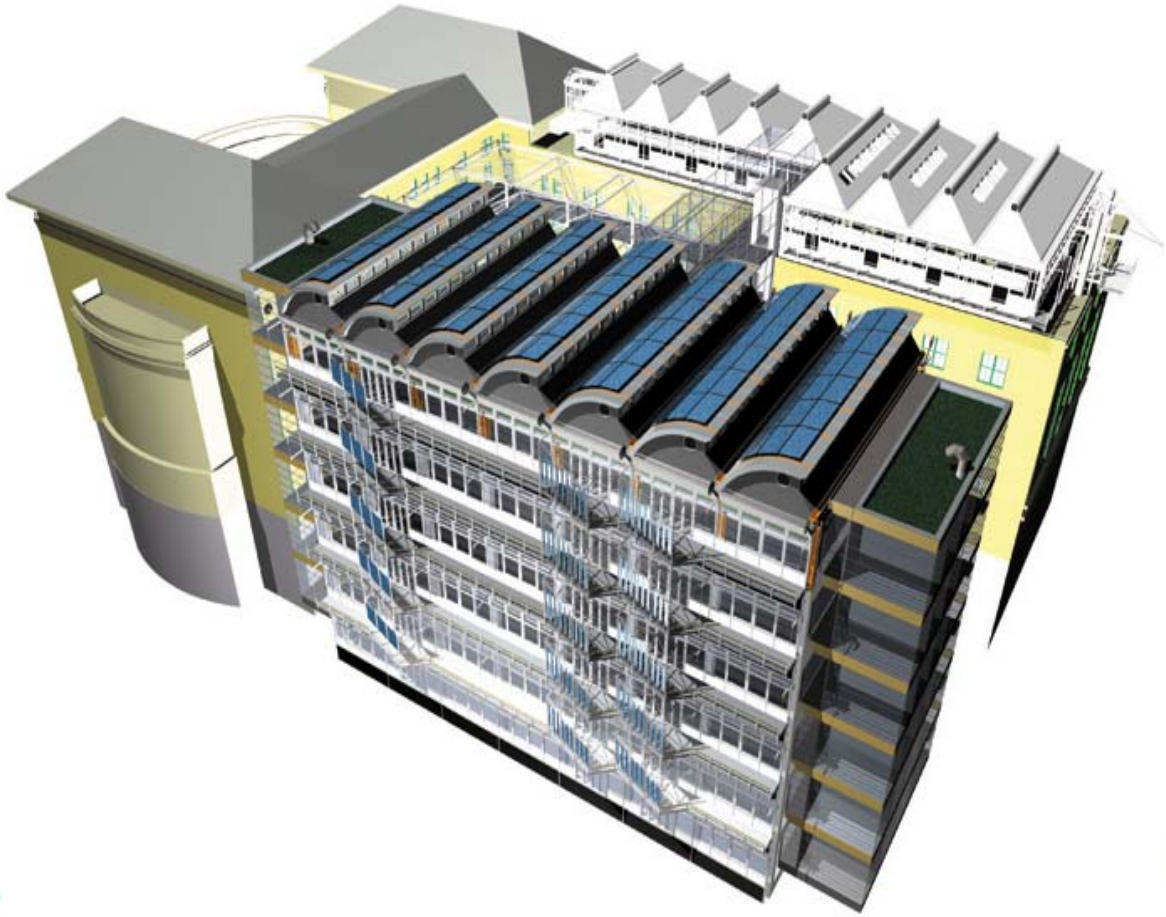
Integrated operation, automation, optimization, diagnostics

- solar
  - components +: tracking control, drain back, storage
  - automation: start up, cooling/heating load follow, shut down
  - performance evaluation
- bioDiesel
  - complete testing: fuels; electrical and heat recovery efficiencies; emissions
  - Integration, automation, performance evaluation, maintenance
- cooling/heating units
  - control system development
  - IP phone integration with lighting and ventilation
  - advanced fan coil: es precipitator, activated C filter
- ventilation unit
  - components +: replacement fan; chilled/heated water exchangers replace heat pump, gas burner
  - automated operation, modulation
- operable windows
  - install
  - automate
  - performance evaluation
- CFD cooling/heating, ventilation unit evaluation in a work space

IWESS Future, Following Years

- operation, control system advancement: equipment diagnostics, system operations optimization
- complete fan coil installation with an advanced wireless control system
- geothermal energy source/storage installation, test, evaluation
- SO fuel cell design, procurement, installation
- up graded, advanced components installed, evaluated

The Building as Power Plant, the BAPP



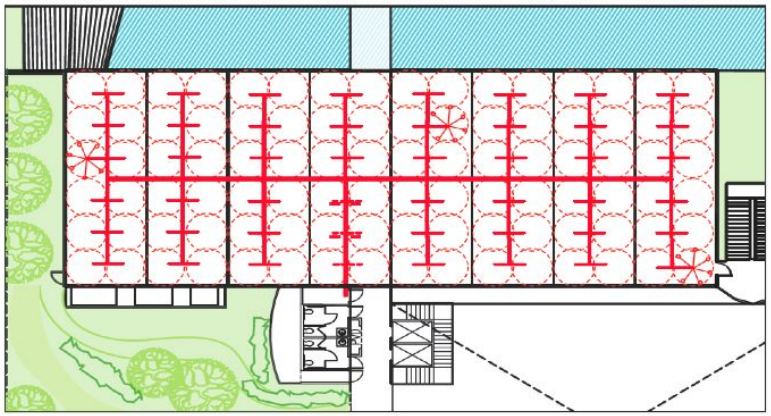
BAPPESS Future: General Principles

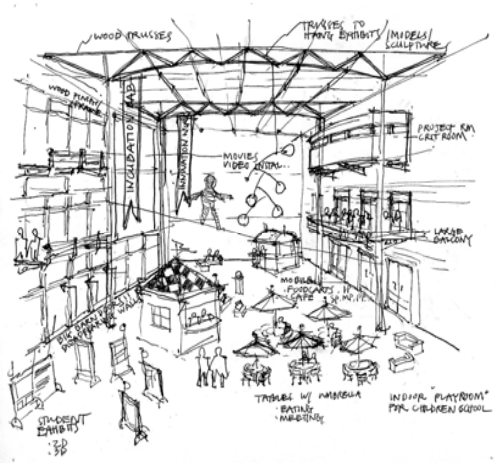
- basic energy sources: solar, renewable fuel (natural gas?)
- distributed power generation
- combined cooling/heating/power
- chilled/heated water based space cooling/heating
- ventilation with enthalpy recovery, temperature and humidity conditioning, solid desiccant
- integrated, advanced operation, control, performance evaluation, wireless, phone interfaced, turn off, set back/forward, ambient/imbient responsive
- alternate ESS's technical and economic merits evaluated by component, BAPP, and system modeling for annual performance calculations

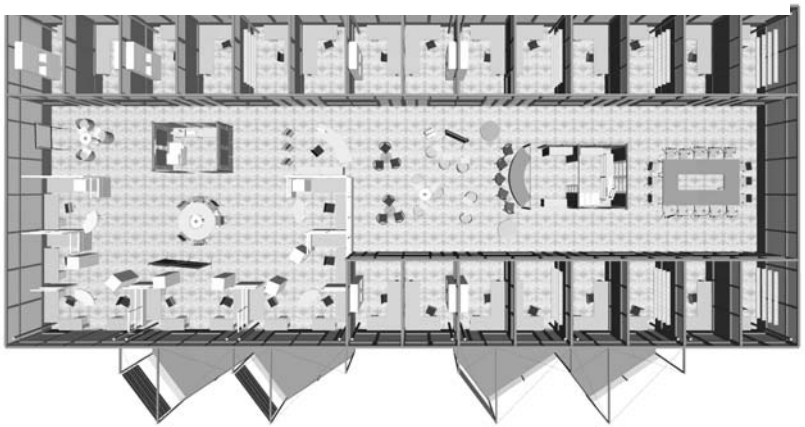
BAPPESS Future Results

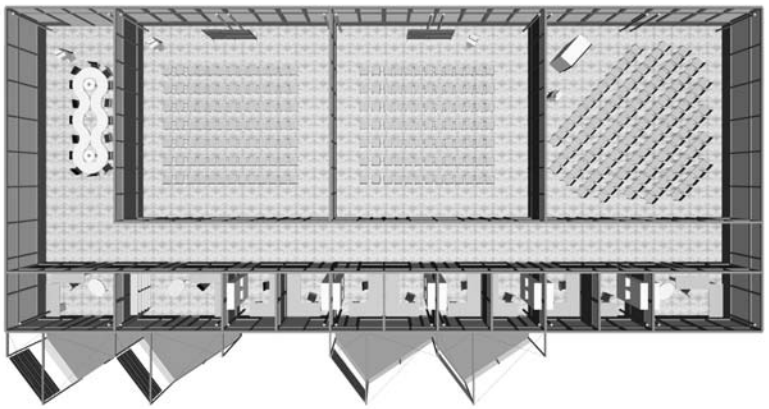
- healthy, productive, comfortable building environment
- primary energy consumption less than half that of conventional ESS
  - conventional: vav cooling/heating, lacking humidity control, utility power, natural gas fired heat and hot water
- advanced control for both comfort, efficiency, and cost reduction
- economic design
- enthalpy recovery reduces building cooling/ heating loads
- dehumidification increases cooling unit capacities, decreases cooling energy requirements
- cooling/heating unit location/operation effects capacity, efficiency
- model based design, advanced control reduces margins
- wireless improves flexibility, reduces cost
- chilled/heated water ventilation operation
- radiant façade panel reduces cost installation, operation
- façade based ventilation air supply
- grids provide back up, flexible operation

BAPPESS: Opportunities, Challenges



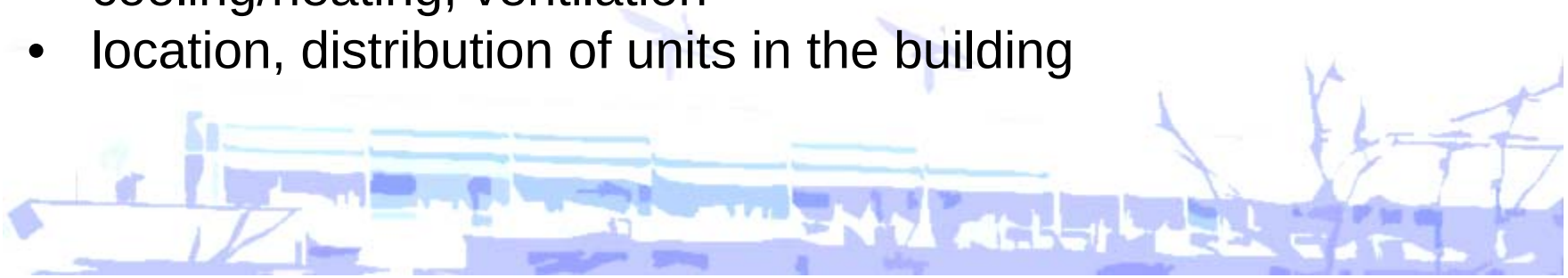






BAPPESS Design Alternatives

- solar output: thermal, photovoltaic
- solar thermal application: cooling/heating, domestic hot water
- renewable fuel: bioDiesel; ethanol; gas from land fill, waste digestion
- power generation: ic engine, gas turbine, boiler/steam turbine
- cooling/heating: thermal absorption chiller (1 or 2 stage)/exchanger; electric heat pump (ground or air source)
- cooling/heating units: fan coil, radiant panel (façade ceiling)
- ventilation: temperature conditioned by heat pump; chilled/heated water, humidity added in winter
- single or multiple, local, distributed units for power generation, cooling/heating, ventilation
- location, distribution of units in the building



BAPPESS Design Approach

- draw up several basic ESS design approaches with alternatives
- canvas equipment suppliers for info on performance, cost (but get it as a contribution)
- evaluate overall ESS performance for designs with an integrated ESS/BAPP/operating system annual performance model
- select approach based on performance, cost, educational value
- detailed design, procurement, installation, test, evaluation . . .

Beyond IWESS, BAPPESS

- dissemination
  - website <http://www.cmu.edu/iwess/>
  - technical publications
  - Whole Building Design Guides
  - web based, multi university course, NSF sponsored
  - continued student/faculty research, development
- commercialization
  - working with commercial equipment, service suppliers
  - developing advanced equipment, service concepts
  - providing computer based models, tools for ESS component and system evaluation/design
  - working cooperatively with the Tepper School on commercialization
- deployment
  - bulletins, brochures
  - workshops for architects, builders, developers
  - consulting in the design of advanced buildings
  - codes, standards
- diversification: district energy supply -- distributed power, CHP systems for residential and commercial complexes

$$$ Funding ???

- U. S. DOE, PA DEP, U. S. DOD, Siemens, ABSIC have provided funds. THANKS!
- Broad, Semco, LTG, Traco, Somfy, Cisco have provided equipment, thanks!
- funding is a constant concern and frequent diversion
- funds are needed for overall systems RD&D in building energy effectiveness, efficiency, economy
- energy policy: demand side reduction, supply side expansion is ultimately fatal

IW-, BAPP- ESS Vision: $ Requirements

- another generation of capable graduate students: six students: $260 k/yr
- faculty/staff guidance/support: four persons: $290 k/yr
- collaborating universities, $240 k/yr
- equipment: windows, fan coils, fuel cell, modified existing ESS components, advanced controls, $600 k

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