ARPA-E Advanced Buildings Workshop

Breakout Group:

Active and Passive Thermal Components #1 (Chair: Ravi Prasher, Intel)

What are the active and passive thermal components in a building?

- Active
  - Climate control
    - Space conditioning systems (heating, cooling, particulate, humidity, air quality control)
    - Thermal distributions system
  - Heat sources
    - Clothes dryers (old technology)
    - cooking ranges
    - Water heaters
    - Refrigerators
    - Lighting
    - Computing
    - Home entertainment, etc . . .
  - Envelope
    - Electrochromic windows, attic fans, ventilation
    - Solar storage systems
- Passive
  - Envelope
    - Natural ventilation
    - Building materials, walls, insulation, windows
- Thermal Storage
  - Water
  - Phase change materials
  - Structure
  - Contents

Active:

- Climate Control:
- Space conditioning systems (heating, cooling, particulate, humidity, air quality control)
- Thermal distribution system of a building

Heat Sources:

- Appliances: What about clothes drying technology? That is an ancient dinosaur. It's not talked about much
- Cooking ranges
- Water heaters
- Refrigerators
- Freezers
- Lighting
- Computing
- Home Entertainment, etc

Envelope

- Electrochromic windows, attic fans, ventilation
- Solar storage

Passive

- Natural Envelope
- Building materials, walls, insulation
- Solar- Is solar an actual component? Or is it just an energy source? Or both

Both

- Thermal storage
- Water (heated and chilled, ice)
- The structure and the contexts can be thermal storage
- Contents of the building

What are the transformational concepts to create new thermal devices?

- Integration of passive and active components
  - Interactions of subsystems and components
- Occupant specific climate control
- Low cost significant improvement at the component level
  - power windows for homes and offices enabled by low-cost sensor/actuator/control technology
  - Heat pumps and alternatives for clothes dryers
  - Alternative cooling/HVAC technology (e.g. refrigerator)
- Controllable access thermal mass
  - Quickly accessible
  - Accessible on demand (charge/discharge) and directional
  - PCMs and conductors in structural materials
- Switchable thermal and optical properties
- Solar/Thermal Polymer-based
  - Cost-driven; materials improvements required
  - Polymer science; stable, no UV degradation, freeze resistant, pressure
- What are the novel approaches at the system level (centralized and distributed for heating, cooling, and thermal storage?
  - Balance of plantDump AC heat into swimming pool

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- Integration of passive and active components
- Interaction of subsystems and components
- Integrating various thermal sinks and sources of a building
- Occupant dependent climate control
- Low cost significant improvements at the component level
- What about power windows? We need an actuater, sensor that are keep and work 99.9% of the time at low cost
- Electric dryer- why not just use a heat pump to dry to your clothes
- Alternative cooling/HVAC technologies (e.g. refrigerator)
- Controled access to thermal mass- access quickly and dispatch quickly
- Quickly accessible heat
  - Need to store and switch it quickly
- Highly effective conductivity
- Accessible on demand
  - Change your rate of charge and discharge
- Switchable thermal conductance
- What is the order of the cost magnitude- valuable if you can drop the AC unit or if you change the time of use pricing. What is a good target to shoot for?
- Solar/Thermal

    - Cost-driven; material improvements required
    - Solar hot water
    - Need an institution to tell them this is important
    - Need research on higher temperature solar water heaters
    - US largest developer of polymers for swimming pool so as not to destroy themselves at stable temperatures, no UV degredation, freeze resistant, pressure
    - Polymer based solar water heater with a 30 year life span
    - Can make a polymer 300 times more conductive
- Dump heat from you A/C to your swimming pool- community centers. Make A/C more
    - Efficient and no cost to heat your pool. Geothermal but not as deep. Cheaper. Can even combine with geothermal
- Identifying thermal sources and sinks
- Dump heat into the hot water
- Distributed A/C. – solid state coolants; low cost robust ice storage at night cooling during the day. Just need to cool a section
- Elimination of thermal distribution BUT hard time competing on cost
- Alternative working fluids- you can retrofit not just new construction
- Safe, non-flammable- for thermal distributional
- Personal climate system- localized zonal A/C
- Low cost low physical volume heat exchange to reduce your delta T
- For the money ground source heat pumps are a better idea than ground ducts
- Macro scale heat pipe- exchange and transport component
- Switchable building exteriors- switchable thermal and optical conductivity
- Lower cost, small scale Solar Thermal plants
- How do they communicate- anything that communicates its status; smart systems control and integration
- Tight envelope; air tightening in tight places
- Cost of storage

What are the novel approaches at the system level (centralized and distributed for heating, cooling, and thermal storage?

- Balance of plant
  - Dump AC heat into swimming pool
- Elimination of thermal distribution
  - Localized evaporators
- Alternative working and thermal transport fluids
  - safe; non-flammable
  - Non-GH
  - Leverage existing capital
- Low-cost, low physical volume heat exchangers and heat pumps
- Macro-scale heat pipes
- Ground source heat pumps
  - Cost, reliability, ground conductivity
- Low-cost, small-scale solar/thermal plants
- Smart systems, control and integration
- Air sealing in small, difficult-to-reach areas

How do we leverage ventilation to decrease HVAC requirements and increase overall system level efficiency?

- Smart power windows, low cost
  - Low pressure drop, high quality filtering
- Stack-effect ventilation
- Variable property membrane (porosity, air and water transport)

- Automatic windows
- Smart windows
- Filter technology
- Low pressure drop high quality filtering
- Using buoyancy in commercial buildings (if you have an atrium etc)
- Devices that promote stack effect further
- Pressurize the building just enough to prevent leakage but allow for ventilation
- Using ventilation to stop infiltration
- Variable porous membrane to deal with moisture as well as heat

What are the passive thermal components in a building? How do we tailor their properties to get the broadest operating range?

- Evacuated radiant barriers insulation
- Highly insulating, optically transparent glazing
  - Thermally optimized frame
- Natural-based insulation materials
- Highly insulated ducting
- Multilayer, gas filled insulation, low-e coating
- Sealing and spacer technology for insulation
- Self-sealing coatings; gap filling

- Passive thermal components
- Coatings
- Radiant barriers for use in walls
- Highly insulating, optically transparent glazing
- Thermally optimized frame
- Naturally based insulation materials
- Highly insulating ducts- fire issues
- Tubes for heating cooling around the building with high r values would be a win
- Multilayer gas filled insulation low-e coating
- Sealant technology and spacer technology
- Maintaing vacuum in non metallic containers is hard
- It all comes down to a cost issue
- Wall insulation- is it just fiber glass? For a 2x4 wall it is not enough; what about aerogels
- Way to seal to automatically seal the building. Air comes it in where you want it to; self sealing insulation to seal the building

Required Performance/Cost for Significant Economic Adoption in Highest Mission Impact Applications

- Distributed vs Centralized systems (1:10 energy usage):
  - Performance Metrics
    - Building level, room level, etc., time of day,
    - kW/m^2 vs. kWhr/m^2yr
    - Peak kW/m2 vs average usage per year
    - Asset rating (nominal conditions) vs. Operational rating
    - Efficiency of system delivery
    - Maintenance cost
    - Carbon footprints