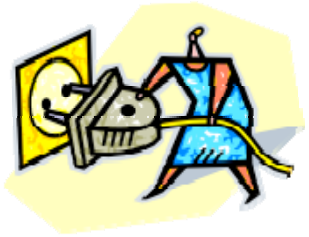


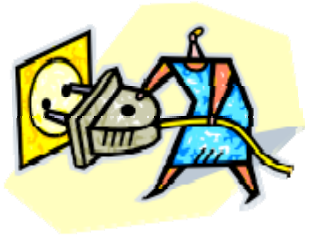
DOE Best Practices Workshop
Power Management
San Francisco, Sept. 28-29, 2010

Alternative Energy Solutions

Breakout Report

Dave Cowley, PNNL, Lead

Marc Berman, PNNL, Co-lead



Breakout participants

Marc Berman

Dave Cowley

Helmut Breinlinger

Ladina Gilly

Patricia Kovatch

Pete Kulesza

Dave Martinez

Tommy Minyard

Dave Prucnal

Mark Seager

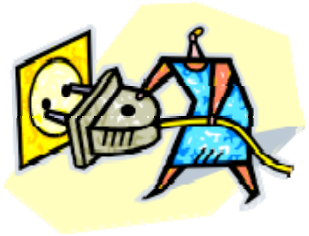
Ash Vadgama

<u>Special thanks to:</u>

Patricia Kovatch

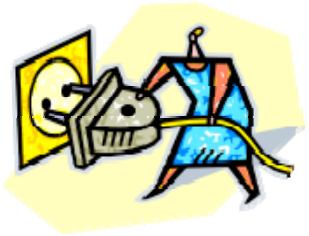
Natalie Bates

Sam Graves



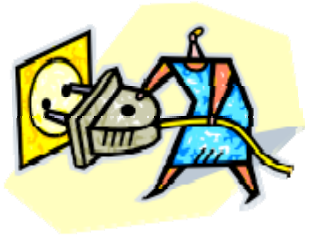
Outline of Breakout Discussion

1. *Short talks on more sustainable and energy efficient HPC centers:*
   - *Sam Graves, Associate Principal, GLUMAC*
   - *Ladina Gilly, CSCS*
   - *Marc Berman, PNNL*
   - *Others*
2. *Energy Re-Use Factor: A new metric for energy re-use*
3. *Brainstorming/Discussion: What creative, untapped ways are there to:*
   - *Power and cool systems with minimal environmental impact and energy use/waste?*
   - *Take advantage of local natural resources (while observing the first question)?*
4. *Cross-cutting questions*



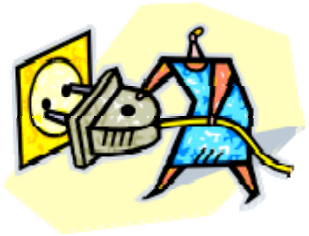
Alternative Energy Solutions: Novel/interesting approaches

- Two approaches considered:
- Reuse of energy/heat
  - Ultimate Goal is to reuse heat and not waste any
- Renewable sources of power
  - Wind, solar, fuel cells, other approaches exist, but often aren't steady enough sources of power
  - Some new energy storage technology would be needed to ride out production "troughs"
  - Other possible sources:
    - Solar troughs that use mirrors to reflect and concentrate solar power to make steam from water (solar millennium)
    - Create own gas power?



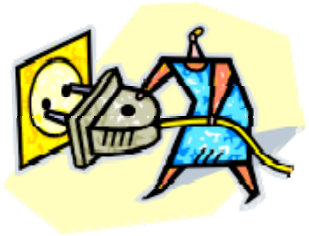
Experiences

- Use data center heat in another location that needs heat
  - Lots of waste heat from HPC, so modified a heat recovery system to use the heat during winter for the building
  - New LEEDS Gold building installed a common heat pump system for the bio lab and the computer building (40% lower energy use!)
- Cold isn't necessary—cool is good enough: big gap in perception of how cold a room needs to actually be



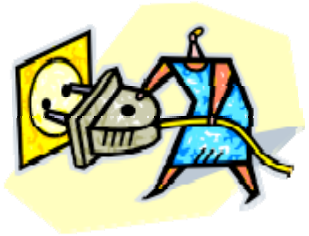
Novel/interesting approaches, cont'd

- Generate electricity from the steam/waste heat from the data center and feed it back into the grid or reuse it?
  - Steam required for efficient generation
  - Maybe new technologies on the horizon can help?
- Recover methane from landfills and generate power (e.g. Univ of CA and Livermore, CA)
- Going to try natural gas fuel cells; take steam from it
- Are there any center level energy storage mechanisms? Sodium sulfur batteries for the grid but in the future…?
- Use kinetic energy of expelled water to produce energy
- Investigate heat storage in the ground, solar, wind, geothermal
  - CSCS: More efficient to store "cold" in the ground instead of "heat"
- Put warm water into manmade lakes, grow algae and use for biofuel
- Contribute power back into local utility (some vendors wanted to test out their products so the only cost was installation)



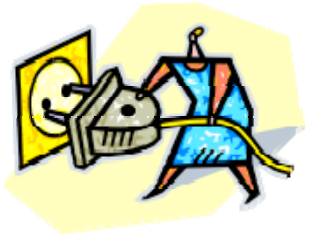
Best Practices

- Use most current technology:
  - Reduce/replace UPS's: More centers realizing that 20 minute batteries aren't helpful
  - More energy efficient chillers, tower fans, CRAC units with plug fans (instead of centrifugal fans)
  - Use cold side control based on load (design facility to have range of input temperatures)



Best Practices

- Liquid cooling high density/high absolute temperatures
- Raising the temperature of the floor of the computer room from 55 -> 70 degrees; cultural change
- Use 480V power
- Often there are modest investments that can be made (e.g. controllable dampers (40% more) that can make big differences in energy efficiency and economizations over time (payback in a year)
- Geothermal cooling effective but 15-20 year payback and more upfront capital required
- Using more direct and indirect evaporative cooling – e.g. IDEC – depends on the local environment



Gaps looking forward to new systems

- Waste heat temperatures aren't high enough for efficient reuse
- Lots of renewable sources don't have constant enough output to be reliable (storage is insufficient to keep the output constant)
- Culture/mindset (resistant to change)
- Cost (more expensive to be efficient than inefficient)
- Funding not incentivized for energy efficiency
- New facilities think they need both water and air cooling because they don't know how the vendors will go

Evolve or start over for future systems?

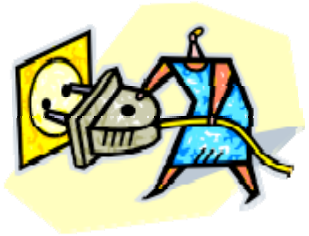
- Mobility
  - Centers are locating their facilities to optimize their operating costs (where possible)
  - Centers are locating containers to optimize for use
- New high temperature liquid cooled racks?

Issues shared with large commercial centers

- All concerned about carbon tax
- Use most efficient in technologies (compressors, etc.)
- Electricity/energy prices
- Using a lot of potable water for cooling (very expensive)
- Lots of technologies available, but the culture holds organizations back – people are resistant to change

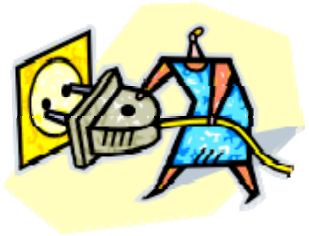
Hardware/facility/system interfaces to influence

- Influence the vendors to have higher inlet/outlet temperatures
  - Engineer chips for a specific, higher temperature range
  - Higher temperature chips will have more leakage too
  - What is the overall power profile—higher temperature chip might save more on the chillers or liquid cooling
- How can we incentivize batteries at the MW level?
- Centers are starting to push back on utilities to reduce their carbon footprint



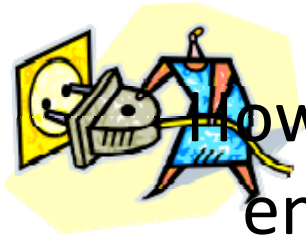
Status of (de facto) standards

- Energy Reuse Factor (ERF) is a new proposed metric from Green Grid
  - Allows credit for reuse of waste energy outside the data center perimeter
  - Complements PUE
- No standardization in containers/cabinet cooling or electrical interfaces: maybe there should be? Now everything is customized!



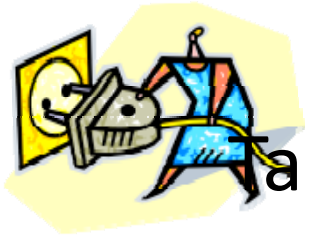
Key findings

- HPC must not only be efficient, but sustainable and beneficial to the community
- Conflict between policy and funding incentives:
  - All federal agencies have to reduce their greenhouse gasses by 28% (how will it be measured and done—especially with funding reductions and need for more computing power?)
  - incentivize renewable sources as a competitive advantage
- Want hotter inlet/outlet temperatures for energy reuse and reduced cooling for inlets
- Vendors will respond to the right incentives (e.g. pay lifetime (i.e. 5 years) power and cooling costs in current solicitation at LRZ)



How do we Power and cool systems with minimal environmental impact and energy use/waste?

- Environmental effects are important to investigate
- CSCS Worked with local gas/electricity companies to run water pipes with with gas/electricity together so everyone benefits.
- Provide range of inlet temperatures to fit the efficiency curves
- Use waste heat for heating other buildings/infrastructures in the community and make sure the return water doesn't heat up the lake (e.g. CSCS)
- PNNL/CSCS lake/aquifer water cooling



Take advantage of local natural resources?

- Use what you've got, where you are!
  - Water/air resources for cooling
  - Solar heat if it's available
- But:
  - Environmental issues are very sensitive, especially in the local communities
  - Investigate long term environmental impacts
  - Free (air/water) cooling is not sustainable or "free"