

Reducing Plug and Process Loads in NREL's Research Support Facility



Chad Lobato

**NREL Commercial
Buildings Research
Group**

BGBG Conference

Boulder, CO

April 26, 2010

Reducing Plug and Process Loads in NREL's Research Support Facility

Plug and Process Loads

Plug and process loads are the miscellaneous loads that are not direct HVAC and lighting loads

- Office Equipment
- Break Room Equipment
- Data Center Equipment
- Elevators

Plug loads are heavily owner / operator / occupant driven

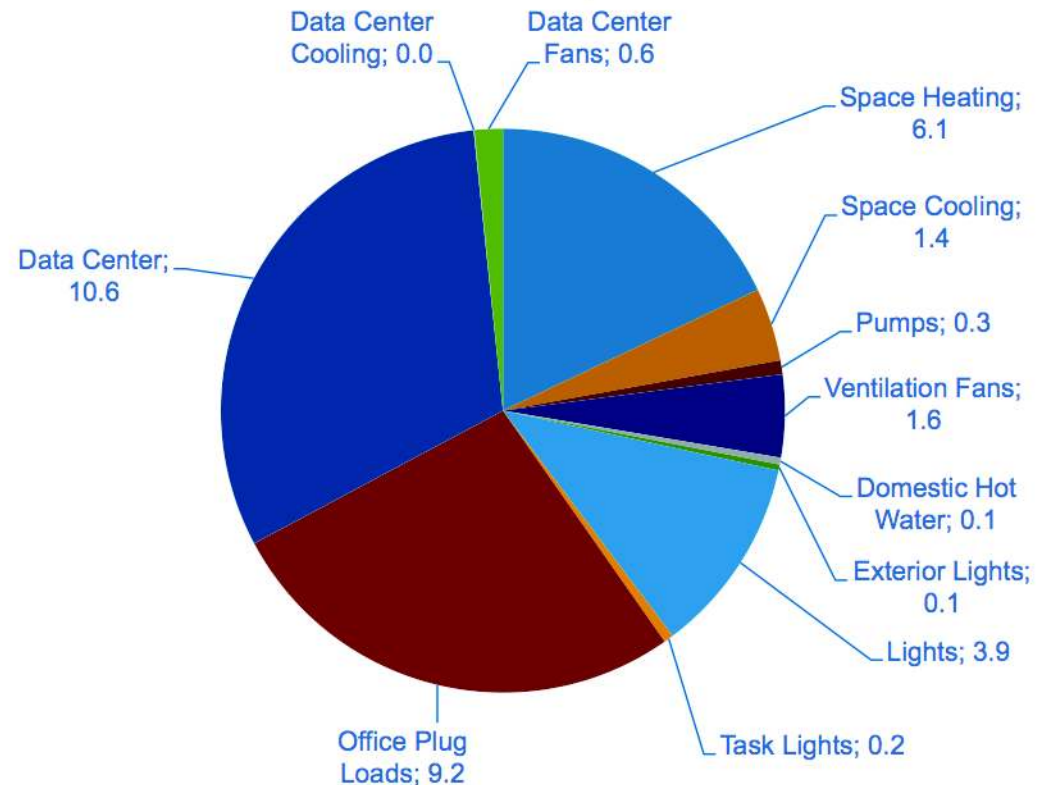
Importance of Plug and Process Loads

In a minimally code compliant building plug loads may account for 25% or less of the total EUI

In an energy efficient, zero energy building, plug loads become a significant contribution to the total EUI

- 50% or more of the total EUI
 - Baseline plug loads were 90% of the original EUI goal

RSF Energy Use Breakdown (kBtu/ft²)



Building Occupancy

Only occupied about $\frac{1}{3}$ of the time

- Nights Unoccupied
- Weekends Unoccupied
- Holidays Unoccupied

Cut the energy that is wasted in unoccupied hours

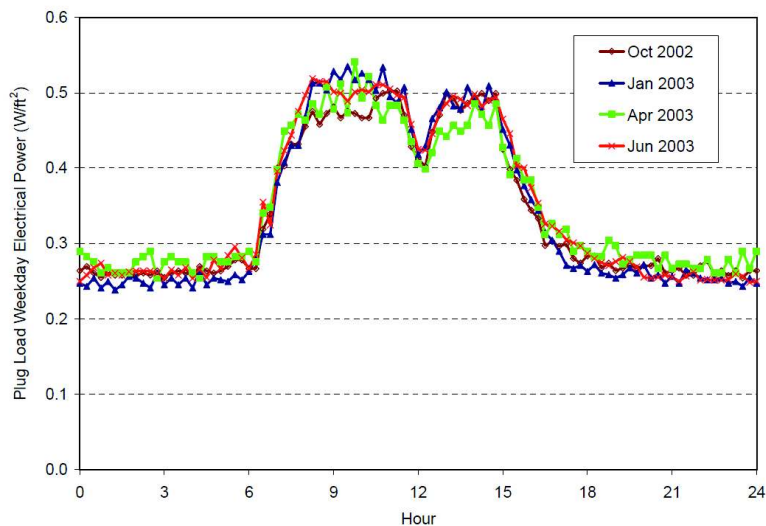


Figure 3-48 Cambria daily plug load profiles for weekdays

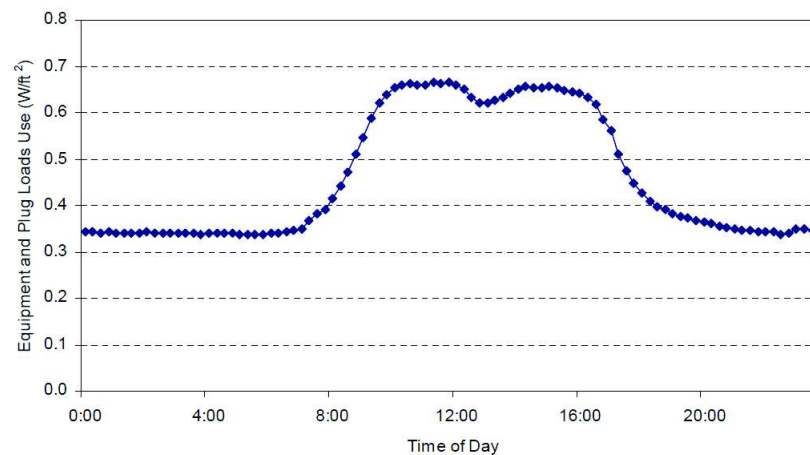


Figure 3-47 CBF average equipment and plug load use intensity

Day vs. Night Plug and Process Loads

		Annual Plug Load Energy Use Intensity (kBtu/ft ²)														
		Unoccupied Hours Power Density (W/ft ²)														
		0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00	1.10	1.20	1.30	1.40	1.50
Occupied Hours Power Density (W/ft ²)	0.10	3.0	5.2	7.4	9.7	11.9	14.1	16.3	18.6	20.8	23.0	25.2	27.4	29.7	31.9	34.1
	0.20	3.8	6.0	8.2	10.4	12.7	14.9	17.1	19.3	21.5	23.8	26.0	28.2	30.4	32.7	34.9
	0.30	4.5	6.8	9.0	11.2	13.4	15.6	17.9	20.1	22.3	24.5	26.8	29.0	31.2	33.4	35.6
	0.40	5.3	7.5	9.7	12.0	14.2	16.4	18.6	20.9	23.1	25.3	27.5	29.7	32.0	34.2	36.4
	0.50	6.1	8.3	10.5	12.7	15.0	17.2	19.4	21.6	23.8	26.1	28.3	30.5	32.7	35.0	37.2
	0.60	6.8	9.1	11.3	13.5	15.7	17.9	20.2	22.4	24.6	26.8	29.1	31.3	33.5	35.7	38.0
	0.70	7.6	9.8	12.0	14.3	16.5	18.7	20.9	23.2	25.4	27.6	29.8	32.1	34.3	36.5	38.7
	0.80	8.4	10.6	12.8	15.0	17.2	19.4	21.6	23.9	26.2	28.4	30.6	32.8	35.0	37.3	39.5
	0.90	9.1	11.4	13.6	15.8	18.0	20.3	22.5	24.7	26.9	29.1	31.4	33.6	35.8	38.0	40.3
	1.00	9.9	12.1	14.4	16.6	18.8	21.0	23.2	25.5	27.7	29.9	32.1	34.4	36.6	38.8	41.0
	1.10	10.7	12.9	15.1	17.3	19.6	21.8	24.0	26.2	28.5	30.7	32.9	35.1	37.3	39.6	41.8
	1.20	11.4	13.7	15.9	18.1	20.3	22.6	24.8	27.0	29.2	31.4	33.7	35.9	38.1	40.3	42.6
	1.30	12.2	14.4	16.7	18.9	21.1	23.3	25.5	27.8	30.0	32.2	34.4	36.7	38.9	41.1	43.3
	1.40	13.0	15.2	17.4	19.6	21.9	24.1	26.3	28.5	30.8	33.0	35.2	37.4	39.7	41.9	44.1
	1.50	13.7	16.0	18.2	20.4	22.6	24.9	27.1	29.3	31.5	33.8	36.0	38.2	40.4	42.6	44.9

Every Watt Counts!

Whole building energy use = 283 Watts continuous per occupant

- Equivalent to 4-5 incandescent light bulbs per occupant operating continuously
- \$8500 of PV per occupant to offset energy use

For every 1 watt continuous we save,
we avoid \$33 of PV needed to offset this 1 watt

Every Watt Counts!

Minimize parasitic loads

- Set idle equipment into a standby state
- Turn off or unplug items that are not used frequently

Question if Current Policy is Best Policy

Must question current building operations and policy

- Are there potential savings in building operations/schedules/policies?
 - Is energy being wasted?

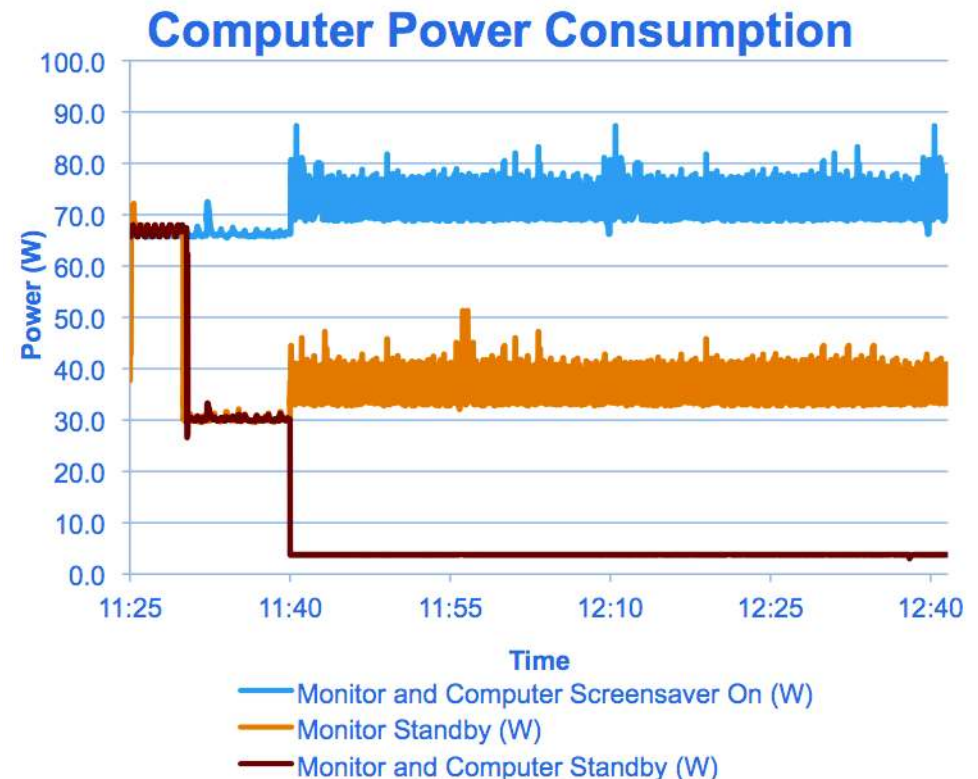
Metrics must be created to emphasize the impact of current policy vs. proposed policy

- \$33 of PV saved per Watt saved

NREL Computer Policy

Example of questioning policy

- NREL currently uses a screensaver to lock unused computers
 - The screensaver consumes on average 5W more than an idle computer
- Instead of a screensaver, if the monitors went into standby there would be a savings of 36W per person
- Additional savings can be had if the computer also went into standby
 - 4W vs. 72W



Results of Computer Policy Change

All computers in the RSF on and monitors off or in standby during unoccupied hours

- 5.0 kBtu/ft²
- \$1,234,000 of PV needed

All computers and monitors off or in standby during unoccupied hours

- 2.0 kBtu/ft²
- \$492,000 of PV needed

Savings of 3.0 kBtu/ft² and \$742,000 of PV

Plug and Process Load Opportunities:

Design Team Opportunities

How can space efficiency reduce office equipment?

- Maximize use of common spaces
 - Copy Rooms
 - Break Rooms

Design to use stairs

- Regenerative traction elevators
 - Slower is ok

Minimize distribution transformers (and account for them in models)

Exhaust transfer air for cooling of network/switch rooms

Opportunities to turn off parasitic office equipment

- Occupancy sensors?
- Integrate into light switch or CPU activity?

Integrated datacenter cooling

- Air side economizer with above and below cold isle distribution
- Evaporative cooling
- Waste heat recovery
- Fully contained hot isle exhaust

Plug and Process Load Opportunities:

Owner Opportunities

Document current space efficiency and plug load profiles

- Establish plug load baseline

Multifunction Devices

- 75% less printers
- Increase use of common copy rooms

Workstation

- VOIP 4 W phones

Efficiency datacenter operations

- Blade servers with virtualization
- ASHRAE temperature Guidelines
- Fully contained hot or cold aisle

All the other “STUFF”

- Energy Star as a starting point
 - Then identify “best in class” equipment
 - 120 Watt 55” LCD TV
- Minimize individual stuff
 - Space Heaters
 - Fans
 - Cell phone Chargers

Starting to estimate savings

RSF Plug Load Reduction Strategies

Energy audit of current office buildings

- Create baseline plug load energy use

Research energy efficient equipment to replace aging, inefficient, existing equipment

- Laptops instead of Desktops
- LCD instead of CRT
- Energy Star appliances
- Regenerative traction elevators instead of hydraulic elevators
- LED task lights instead of fluorescent task lights
- All-in-one printers

Develop an accurate operation schedule

- Turn off equipment when not in use or needed

Increased space efficiency

- Increased number of occupants per break room
 - Results in a decrease in the number of appliances
- Increased number of occupants per copy room
 - Results in a decrease in the number of all-in-one printers

RSF Plug Load Reduction Strategies

Elevators

- Use energy efficient traction regenerative elevators
- Change elevator lighting to energy efficient fluorescent lighting
- Turn off elevator lighting when the elevator is unoccupied

Break Rooms

- Increase the number of people that use each break room from approximately 20 to 30
- Eliminate the cooler on the drinking fountain

Task Lights

- Move from 35W fluorescent task lights to 15W LED task lights

Phones

- Go from 1000 standard phones to 1000 VOIP phone that consumes 4W each

Copiers, Printers, Fax Machines

- Decrease the number of people that use individual copiers, printers and fax machines
- Increase the number of people that use common, or group, copiers, printers and fax machines from 15 to 20
- Increase the use of all-in-one machines

Computers

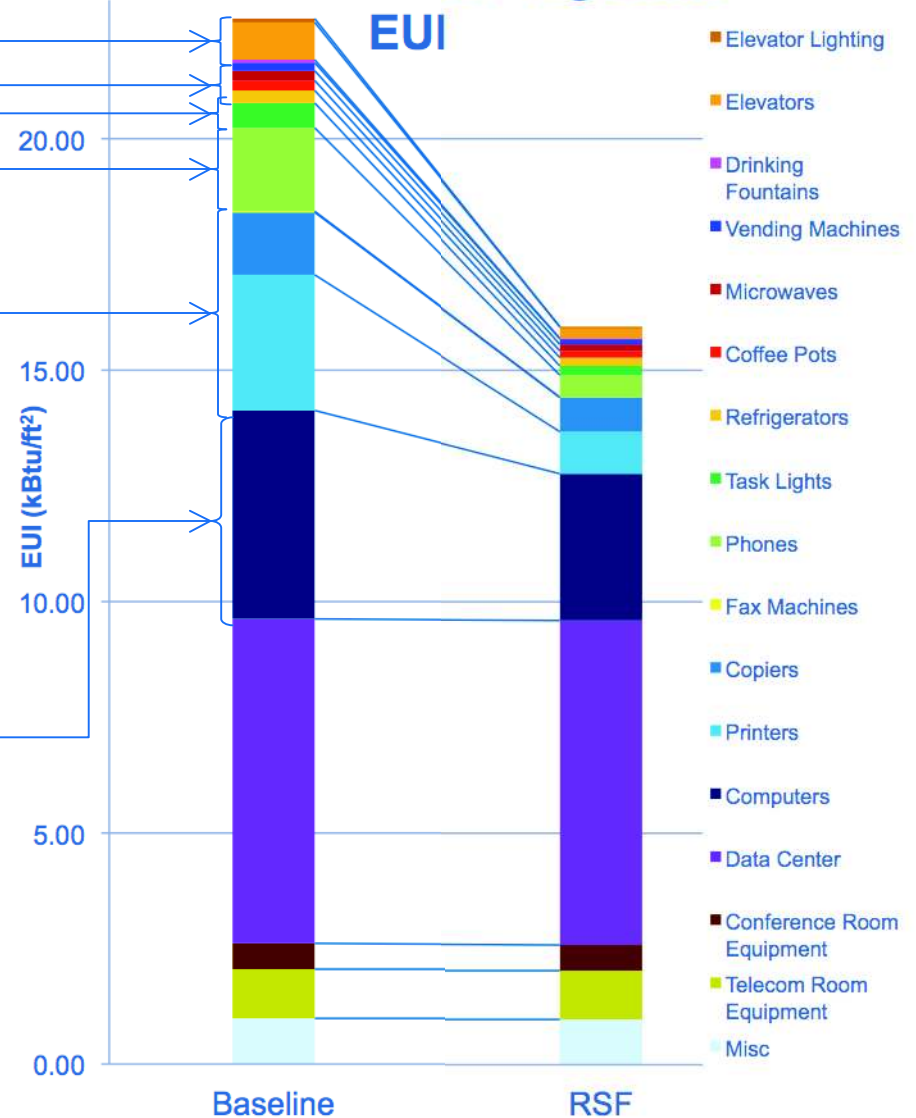
- Go from approximately 260 laptops, 33% of staff, to 720, 90% of staff

The result of the strategies is a 30% reduction in plug loads

Note:

- Additional savings from advance server technologies are not accounted for
- Additional savings from unoccupied hour controls are not accounted for
- Additional savings from higher efficiency kitchen appliances and office equipment are not accounted for

RSF vs. Baseline Plug Load



RSF Data Center

Moving towards high-density blade servers

- Highly efficient power supplies
- Variable speed fans
- Wake-on-LAN

Server virtualization

Dynamic Workload management

- Server resources go from “always on” to “always available”
- Resources are powered up or down as resources are needed

Hot aisle containment

Target PUE of 1.1 vs. current PUE of 2.5

Expected reduction of 65% in total data center power consumption

Continued RSF Plug Load Work

Enable occupants to **Easily** turn off all plug loads in at their workstation when unoccupied, and provide feedback to occupants if they forget

- Note a fully automatic motion sensor to turn on and off plugs would not necessarily empower occupants to “do good” and take responsibility for turning off lights and plugs when not in their cube

Easily accessible plug load switch should be mounted as a light switch would be

- At entry/exit to cube/office or on desktop
- Commercially available power strips with wireless battery-less switches are currently available

Need to evaluate parasitic load of plug load control system

- Don't want to use 3 Watts to save a parasitic load!!!

Feedback and Monitoring at Workstation Level

Feedback to occupant if plugs left on when workstation unoccupied is critical

Energy and/or current monitoring at the cube/office level needed

Combine workstation energy use with “workstation status” data to determine if unoccupied and all equipment has been turned off

Enables social engineering comparing your profile to your neighbor's

Thanks!

Chad Lobato

NREL

Chad.Lobato@nrel.gov

Questions?