

Latest and Greatest LED Products

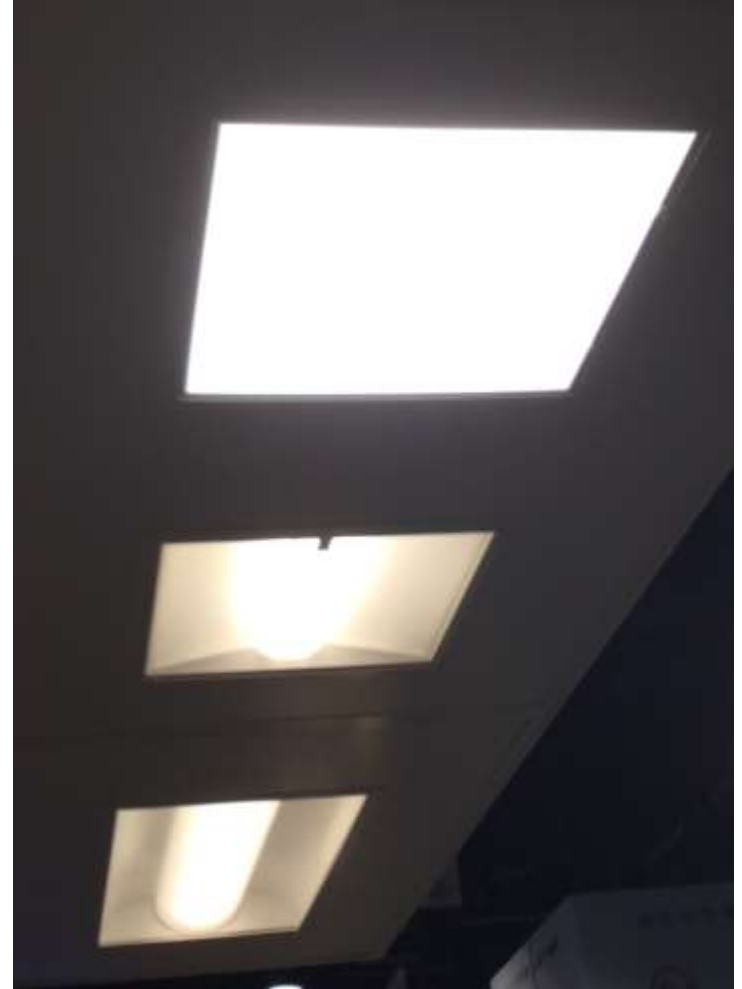


E Source

Troffers Are Ubiquitous

The most common fixture:

- Operate 10.5 hours/day
- Draw 25 to 113 watts
- Contribute to peak load
- 42 percent of lighting energy
- Converting all to LEDs saves equivalent of 27 million homes
- (Source: DOE:
http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/caliper_21_t8.pdf)



Source: E Source



Lots of LED troffer choices

- Tubes
 - use existing ballasts
- Tubular kits
 - tubes and drivers
 - bypass ballasts
 - Driver may be internal, external
 - May or may not use existing sockets
- Retrofit Kits
 - Use existing housing; may include lenses
- Luminaires



Source: Lithonia



LED Tubes, existing ballast

- Pros

- Lowest LED cost
- Easy to install, no rewiring

- Considerations

- Persistence
- Life and efficacy similar to HP T8
- Need to confirm ballast compatibility, light distribution
- Ballast life and losses
- Check condition of lenses or louvers
- Thermal management challenges



Source: Cree



Tubular Retrofit Kits

- Pros

- Moderately easy to install
- Less expensive than troffers and full kits

- Considerations

- Life and efficacy similar to HP T8
- Installation requires electrician
- Need to check light distribution
- Check condition of lenses or louvers
- Apply labels to inform maintenance



Source: Cree



DOE recommendations for LED tubes

- Recent [DOE tube study findings](#):
 - Choose carefully: good and bad products out there
 - Tube performance will vary with fixture type
 - Consider retrofit kits, high performance fluorescents
 - LED T8s may be cost effective: high electric rates, long hours, low installation costs
 - Do a mock-up/pilot



LED tubes getting better, but...

	High performance T8	Philips InstantFit LED	Cree T8 series	LG retrofit kit
CRI	80s (R9~10)	85 (R9~20)	90 (R9~50)	82
Life, hrs	24,000-75,000	40,000	50,000	50,000
Efficacy, lm/W	98	100 (95-116)	100	130
Cost, \$	5	24-39	30	130-175
Dimmable?	yes	no	Yes	Yes
Ballast compatibility	all	IS, some PS, no dimming (yet)	90% of IS, PS, dimmable	NA

Notes: different definitions of “life” for LEDs, fluorescents;
IS=instant start; PS=programmed start

Source: E Source



LED Troffer References

- DOE: [LED Linear Lamps and Troffer Lighting](#)
- SMUD: [Tubular LED Guide](#)
- CLTC: [LED Retrofit Options for Linear Fluorescent Luminaires](#)



Daylight-Redirecting Film



E Source

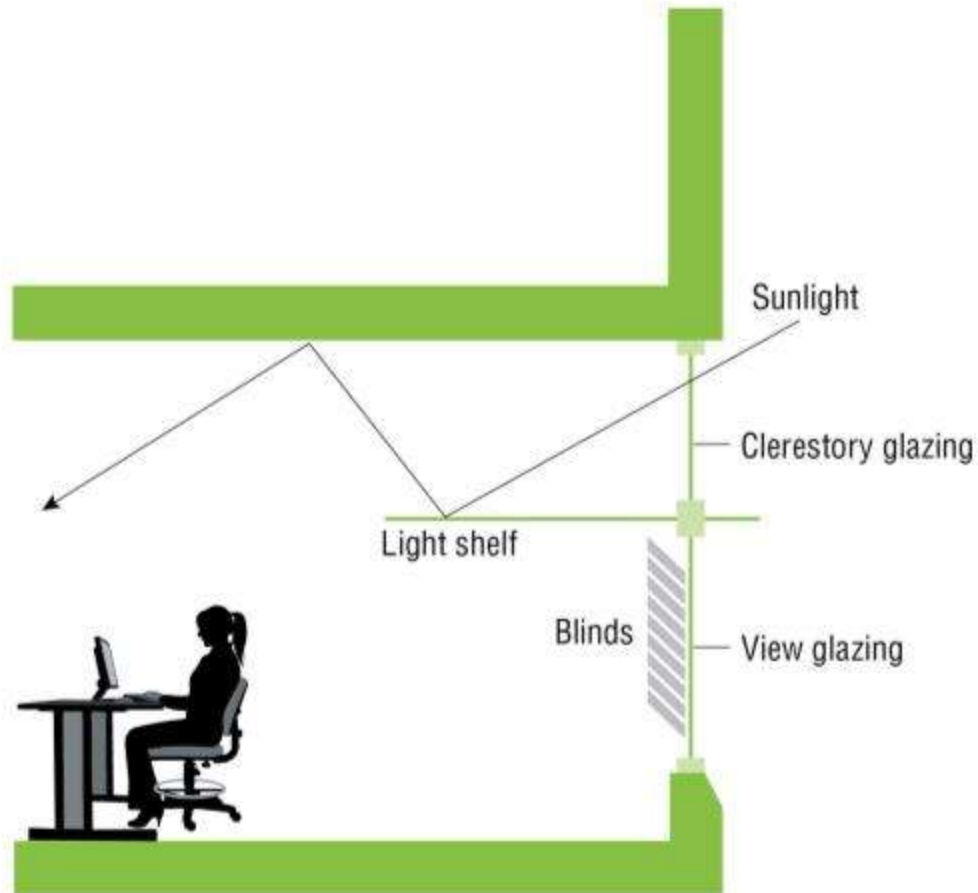
What's the Matter with Daylighting?



Courtesy: National Renewable Energy Laboratory



Old Solution: Light Shelves



© E Source



Why Are They So Seldom Seen?



Source: Ann Arbor District Library



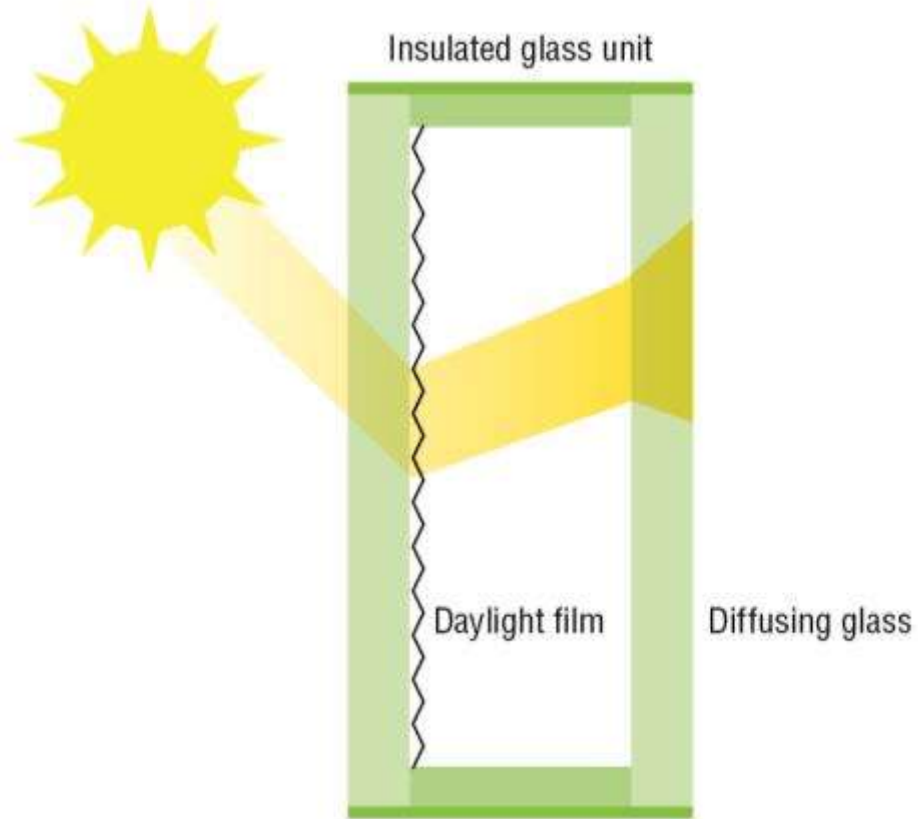
New Solution: 3M Daylight-Redirecting Film



Source: Sacramento Municipal Utility District



How It Works



© E Source; adapted from 3M



Cheaper and Deeper



Source: Sacramento Municipal Utility District



By the Numbers

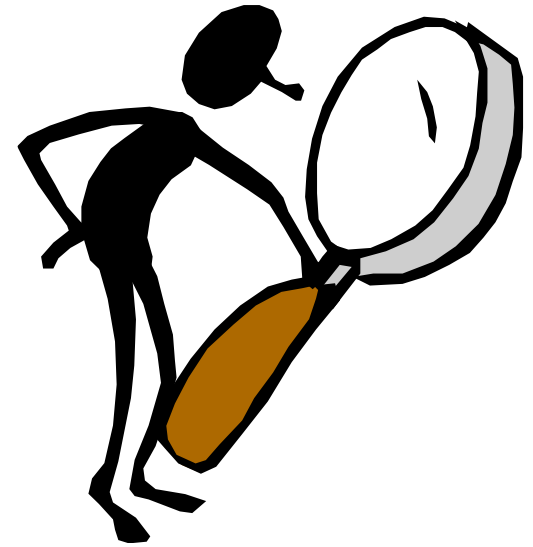
Metric	Minimum	Maximum
Cost (\$ per square foot)	30	35
Energy savings (%)	20	22
Simple payback period (years)	3	21

© E Source; data from Lawrence Berkeley National Laboratory and 3M



Conclusion

- Energy savings have been well documented
- Work better than light shelves, and are less expensive
- Can compete with lighting controls products, but no clear winner



Commercial Laundry



E Source

New Technologies on the Rise...

Liquid
carbon
dioxide
(CO₂)



Courtesy: Scott A. Miller

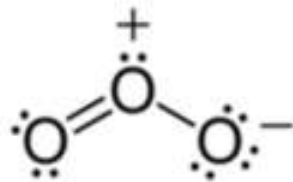


Courtesy: Xeros

Polymer beads

And an old technology is being revived

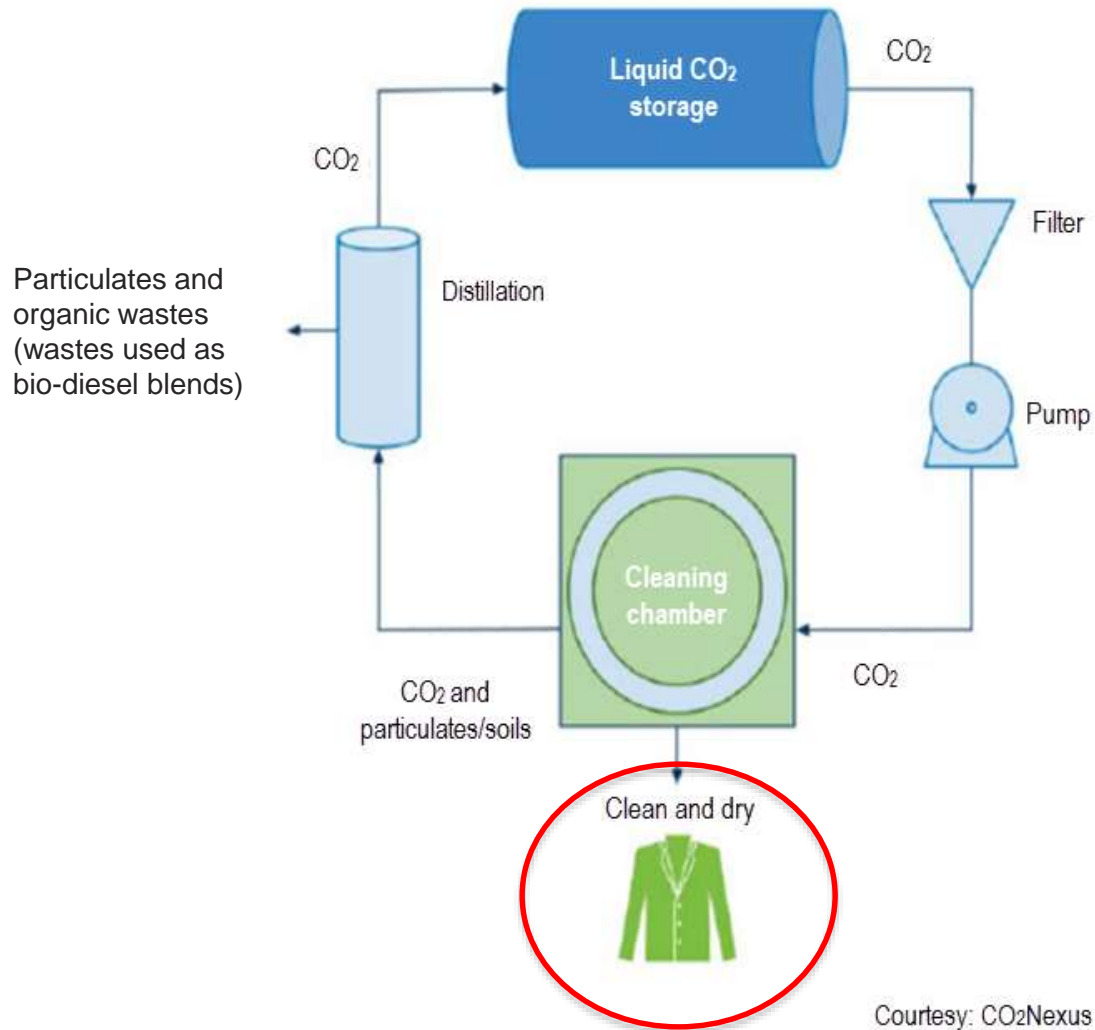
Ozone



Liquid CO₂



How the Process Works



Liquid CO₂ Savings

Annual
process consumption

	Water-based system	CO ₂ -based system	Percentage reduction
Water (gallons)	4 million	0	100%
Electric energy (megawatt-hours)	444	200	33%
Natural gas energy (megawatt-hours)	667	300	22%
Chemicals (pounds)	30,000 (disposed of in municipal water system)	9,000	70%
Garment life	50+ cycles	2 to 3 times longer life	NA

Note: Based on 1.2 million pounds of garments throughput per year.

© E Source; data from CO₂Nexus



Non-Energy Benefits

- CO₂ is recycled
- Clothes come out dry
- No secondary waste stream
- Short cycle times (approximately 20 minutes)
- High throughput
- Increased fabric/garment life
- No shrinkage or color bleeding
- Cleans a wide variety of fabrics
- Non-toxic, non-hazardous, non-flammable, and inexpensive



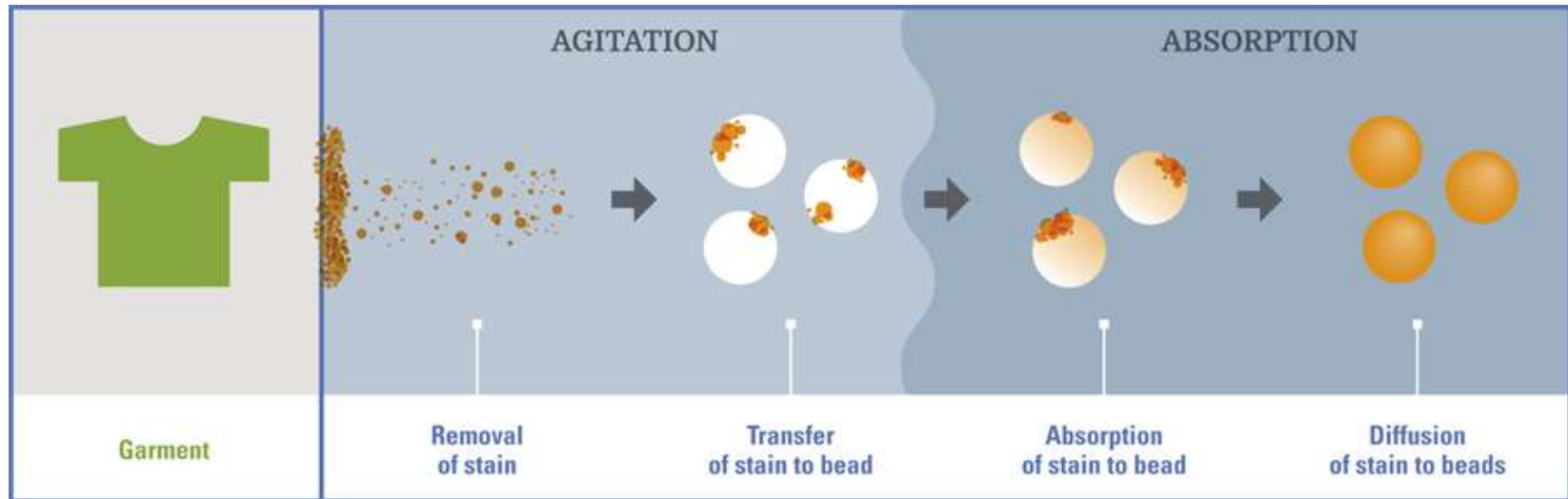
Source: MS Clipart



Polymer Beads



How Polymer Beads Clean and Work



© E Source

■ Polymer beads:

- Spheroidal
- The size of BBs
- 1:2 mass ratio of laundry to beads
- Expand with moisture
- Polarized with special additive

■ The Process:

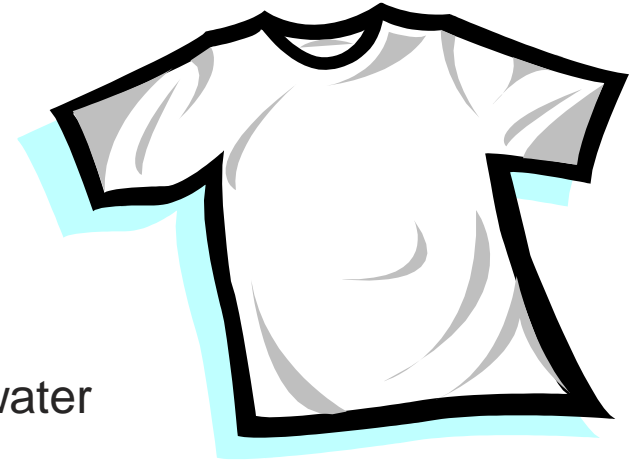
- Beads enter drum of specially made machine
- Polarizing additive added
- Agitate with fabrics
- Beads lift and absorb stains
- Beads exit drum for reuse
- No treatment of beads necessary



Why Polymer Bead Is Better



Courtesy: Liberty Utilities



Source: MS Clipart

- One-quarter of the water
- ~~Heat~~
- Half the detergent
- Less time
- Reduced drying*



Big Savings

Liberty Utilities laundry study

- Two machines: Milnor (baseline) vs. Xeros (polymer bead)
- Three types of fabrics: Bath towels, white linens, colored linens

Per load	Milnor (baseline)	Xeros (polymer bead)	Savings
Time (minutes)	54 to 78	50 to 51	4 to 26
Water (gallons)	134 to 156	35 to 37	80% <small>© E Source</small>
Therms	1.02 to 1.59	0	100%
Electricity	2 kWh	3 kWh	-4,600 kWh^a

Notes: kWh = kilowatt-hours.

a. total additional electricity use in a year (compared to baseline).



Non-Energy Benefits



- Gentler on fabrics
- No sorting colors
- Improved cleaning
- No bleach



Economics

Costs

\$56,000 installed



Source: MS Clipart

Simple payback period

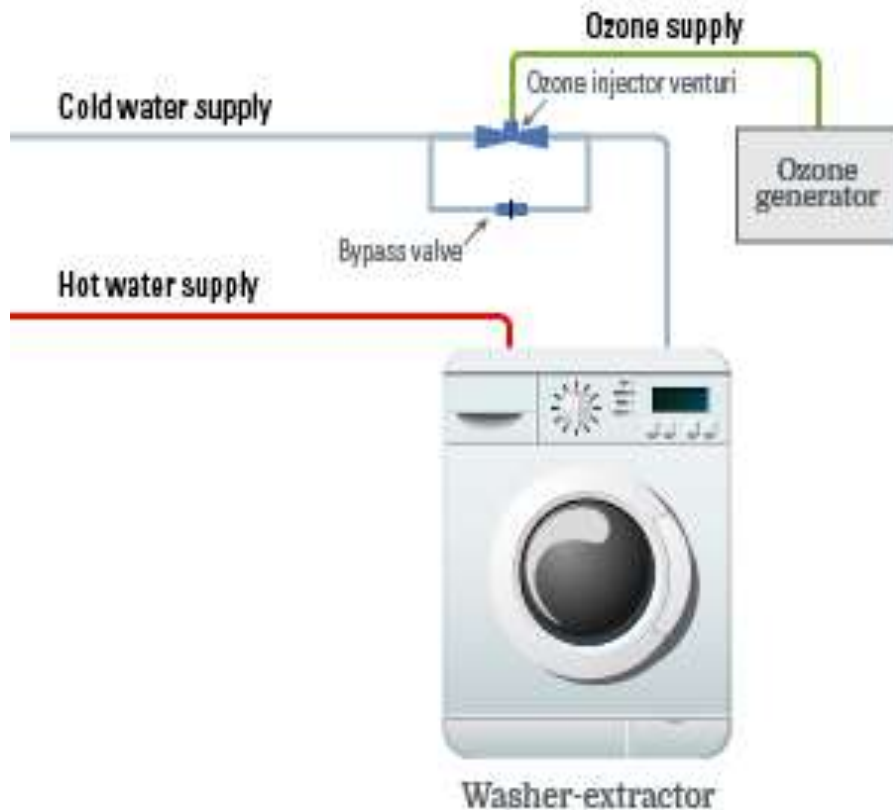
10 years



OZONE



How the Process Works



© E Source

- New or existing washer
- Ozone produced in generator
- Injected into cold water supply
- Ozone is reduced to oxygen (O_2) during wash process



Savings



Source: MS Clipart

Natural gas: 91% therm savings

Electricity: approximately 0.5 kWh
per load



Source: MS Clipart



Source: MS Clipart

Water: 35% standard;
70% for recycling systems



Economics

Costs

\$14,000 installed
(includes ozone generator
and plumbing)



Source: MS Clipart

Simple payback period

7.5 months
(all-in savings)



Non-Energy Benefits and Concerns

■ Benefits

- Increased garment life
- Improved effluent quality
- Reduced:
 - Water use
 - Chemical use
 - Cycle time
 - Drying time

■ Concerns

- Toxic gas code requirements
- British Columbia requires:
 - Special piping
 - Eye-wash station



Source: MS Clipart



Resources

Liquid CO₂

[Demonstration of a Carbon Dioxide–Based Industrial Laundry Machine](#) (PDF), California Energy Commission (2012)

Polymer Bead

[Xeros Laundry Technical Assessment Study](#) (PDF), Liberty Utilities (2014)

Ozone

[Demonstration of Advanced Technologies for Multi-Load Washers in Hospitality and Healthcare – Ozone Based Laundry Systems](#) (PDF), Pacific Northwest National Laboratory (2014)

[Project Test Report: Santa Barbara County Jail Ozone Laundry Detergent](#) (PDF), Southern California Gas Co. (2011)

[The Benefits of Ozone in Hospitality On-Premise Laundry Operations](#) (PDF), Pacific Gas and Electric Co. (2009)

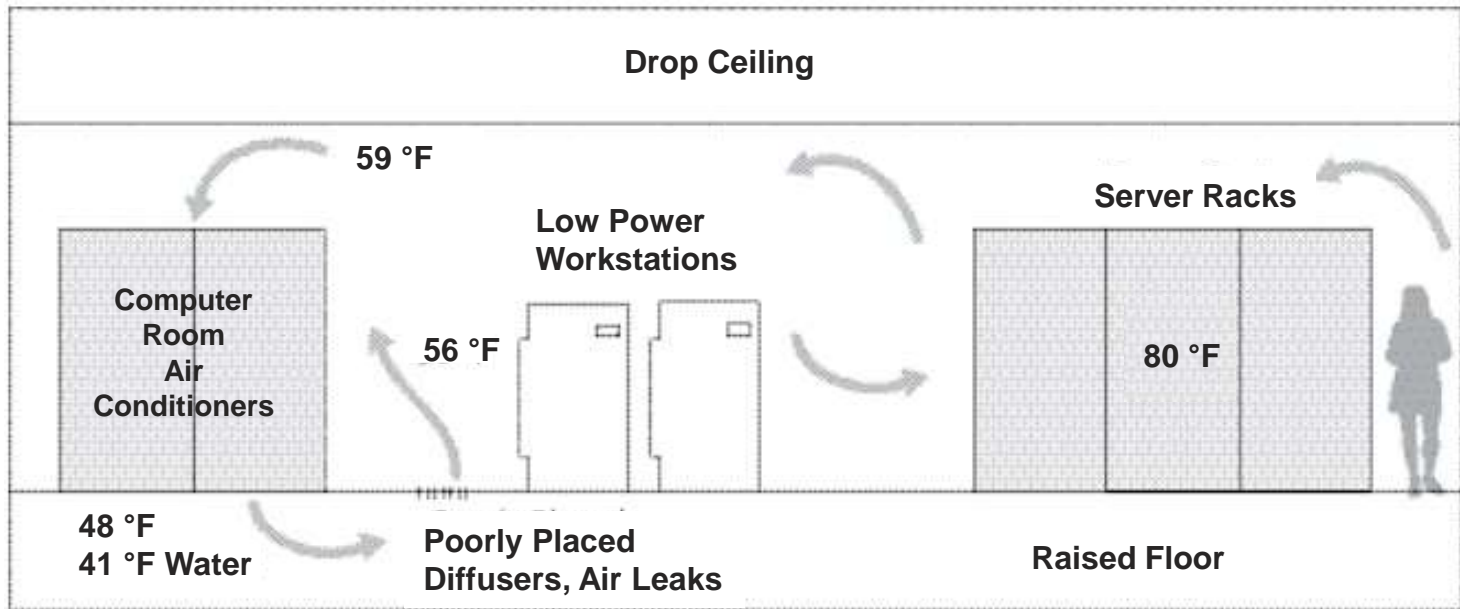


Liquid Submerged Servers



E Source

Data Center Cooling is Frequently Complicated and Inefficient



Why Not Submerge Servers in Liquid?

- Liquid is a much better heat transfer medium
- Pull heat directly off hot components
- Massive energy savings potential in data centers
 - Up to 90% claimed cooling energy savings
 - Up to 50% claimed overall data center energy savings



Courtesy: Green Revolution Cooling



Potential Non-Energy Benefits

Existing buildings

- Increase computing power density of servers
- Run existing servers faster



New construction

- Eliminates need for:
 - Air handling equipment
 - Chillers
 - CRACs/CRAHs
 - Raised Flooring
 - Hot/Cold aisles
- Faster, less expensive construction/ installation
- Use servers with simplified architecture (e.g. no fans)
- No needless conditioning of space around servers



Promising Test Results from PG&E

- Evaluated four CarnotJet tanks from Green Revolution Cooling
- Results: **82% energy and demand savings!**
- All demand savings are 100% coincident with peak demand



Courtesy: Green Revolution Cooling



Some Caveats to Consider

- Need the right type of servers
 - Need to remove fans and thermal paste
 - Requires solid state drives
 - Manufacturers don't yet offer "off the shelf" servers to submerge into mineral oil
- May need to ensure that warranties are honored
- Servers may require additional time to service



Courtesy: Redline



Conclusion

- Looks promising, but...
 - Only one study so far
 - Young company
 - Requires server and hard drive retrofits



For More Information

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