Looking Back to the Future: 10+ Years of New and Emerging Energy Technologies

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May 5, 2011

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1998 – 2011: The Technology Journey

- Energy in perspective
- End-use technologies
  - Lighting
  - HVAC and Appliances
  - Water
- Near future technologies

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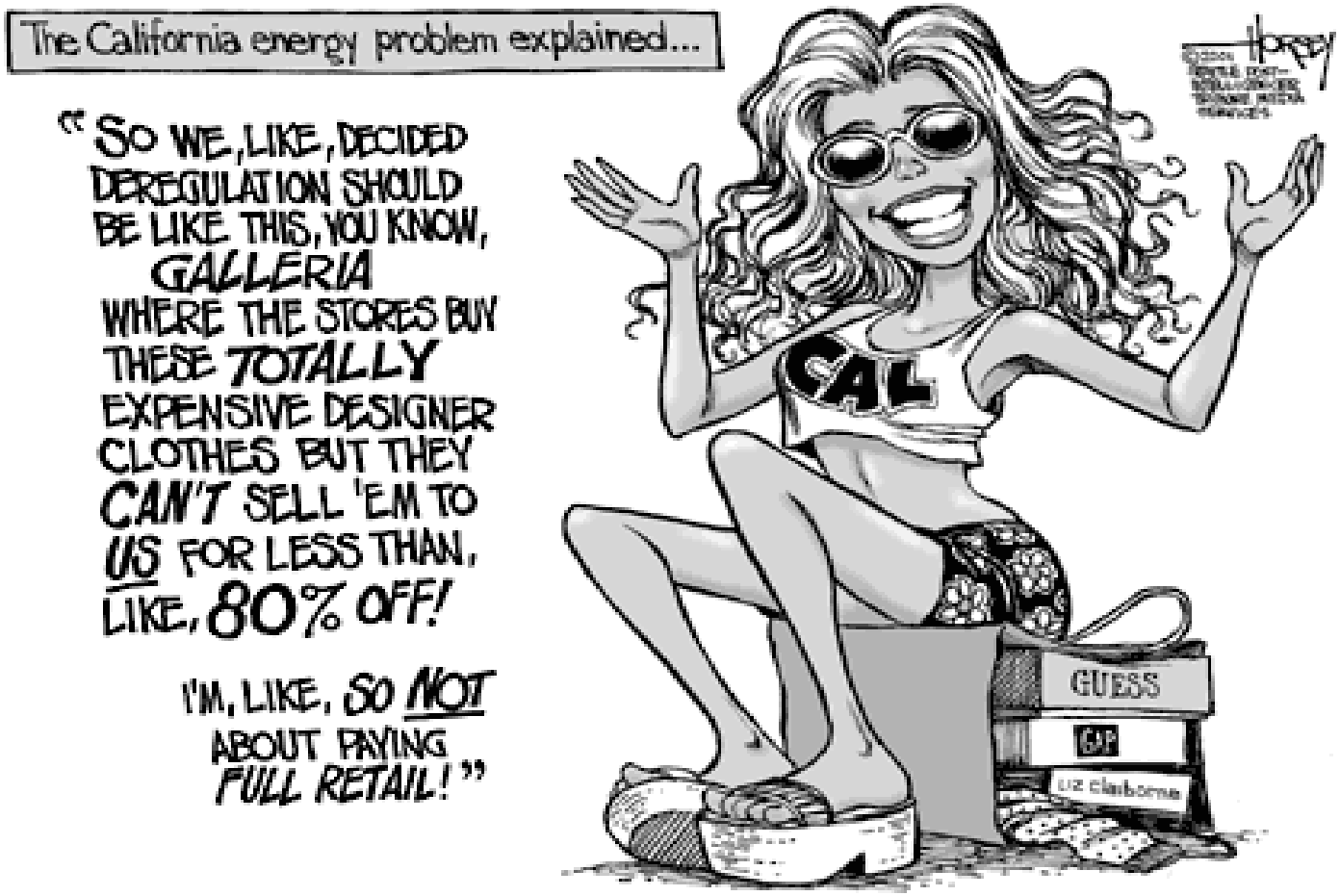
2008: International Energy Agency (IEA) on Energy Efficiency

"Using energy-efficient equipment is the most cost-effective short-term path to greater energy security and lower greenhouse gas emissions to combat climate change. It reduces pressure on energy resources".

April 1, 2008. IEA Implementing Agreement for a Co-operating Programme on Efficient Electrical End-Use Equipment. www.iea-4e.org

2011: NOTHING HAS CHANGED……..

1998: The *Real* Explanation for the Utility Crisis?



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2004: Management Style

- "Ninety percent of your problems results from ineffective communication; the other sixty percent is due to not getting closure."

Tinley's Second Law of Project Management

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2011: Management Style – Updated

- "Ninety percent of your problems results from ineffective communication **using email**; the other sixty percent is due to not getting closure."

Tinley's Second Law of Project Management: Updated

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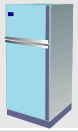
Household Energy Costs in Perspective

Typical Household 	2003 $	% of Income	2011 $	% of Income
Income	43,000	100	75,600	100
25 ft^3 Refrigerator 	1,000	2.3	1,100	1.5
New Auto 	26,500	62	29,500	39
Gasoline (2000 gal) 	3,500	8.1	7,800	10
Natural Gas (830 therms) 	625	1.5	996	1.3
Electricity (20,000 kWh) 	1,000	2.3	2,200	2.9
16 oz mocha (1/day) 	1,300	3.0	1,550	2.0
All Energy	*5,125*	*12*	*10,996*	*14.5*

Lighting

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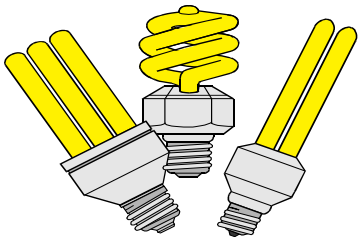
1998: DOE Sub-CFL Volume Purchase

- On behalf of DOE, PNNL issued and awarded competitive procurement for CFLs
- Basic Ordering Agreement with 3 suppliers established 4/98 for Phase I
- 15-26 Watt screw-base 5.0-5.75 inch CFLs available at **$6-10/lamp** delivered in quantities as few as 6-pack; 1-year warranty
- Shorter products expected in Phase II

www.pnl.gov/cfl



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2011: CFLs

- "Billions" sold; the backbone of many utility efficiency programs for over 10 years.
- All major manufacturers offer CFLs, most are ENERGY STAR.
- Multiple wattages, shapes, sockets, colors and dimmability.
- Street price is now **$6-$10/multi-pack.**
- Still millions of sockets with incandescent light bulbs.
- Federal standards will create new products, some of which are CFL hybrids.

GE hybrid light bulb (75W replacement)
20W/1,100 lumens/8,000 hrs/1 mg mercury
$5.99-$9.99 ea

2005/2011: Efficiency and Cost of White-Light Sources

Source efficacy	**2005**	**2011**	
Incandescent (75W)	13 lm/W	13 lm/W	
Fluorescent (T8)	92 lm/W	96 lm/W (98 lm/W for super T8)	
Fluorescent (T5)	N/A	111 lm/W	
HID (Metal Halide)	93 lm/W	98 lm/W	
SSL (White LED)	**50 lm/W***	**120 lm/W**	+140%!

Retail lamp price	**2005**	**2011**	
Incandescent (75W)	$0.60/klm	$0.60/klm	
Fluorescent (T8)	$0.70 /klm	$0.60/klm	
Fluorescent (T5)	N/A	$2.40/klm	
HID (Metal Halide)	$1.27 /klm	$1.40/klm	
SSL (White LED)	**$150/klm***	**$42/klm****	-60%!

*Cree X-Lamp 7090 **2x4 fixture

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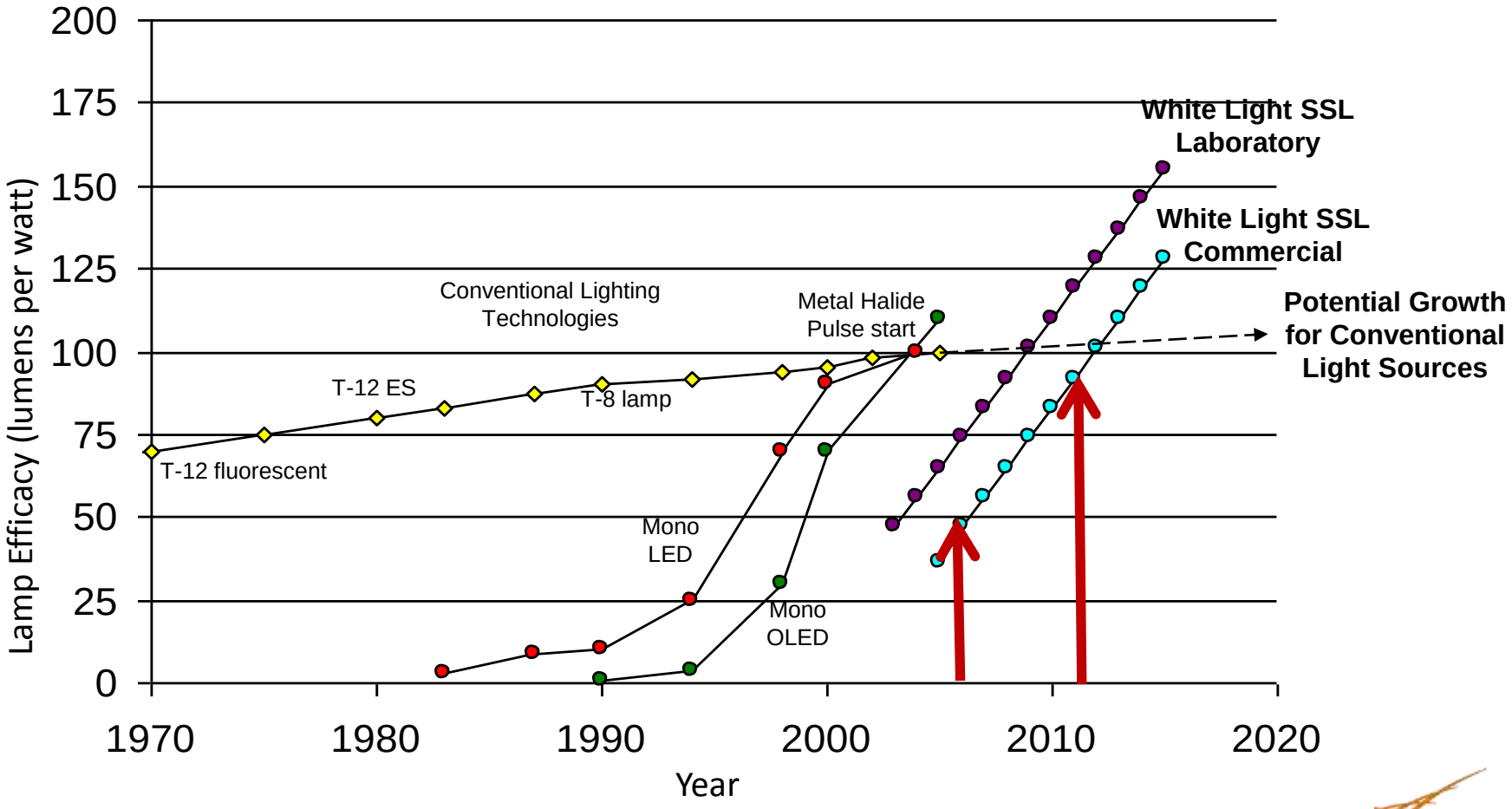
2006: Solid State Lighting R&D Forecast

Accelerated R&D for White Light SSL



SSL Laboratory and Commercial Curves, revised May 2006 DOE/EERE Roadmap

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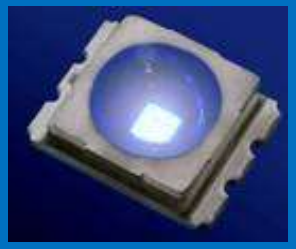
2005: Newest SSL Chips

All major manufacturers now have at least a 1W LED product



©Cree – XLamp

©Lumileds – Luxeon

©Nichia – Jupiter

©OSRAM Opto – Dragon

	Flux per device (lm)	Efficacy (lm/W)
Cree	35 – 50	25 – 30
Lumileds	18 – 120	20 – 30
Nichia	15 – 25	20 – 24
OSRAM Opto	25 – 40	20 – 24

*white light at 350 mA

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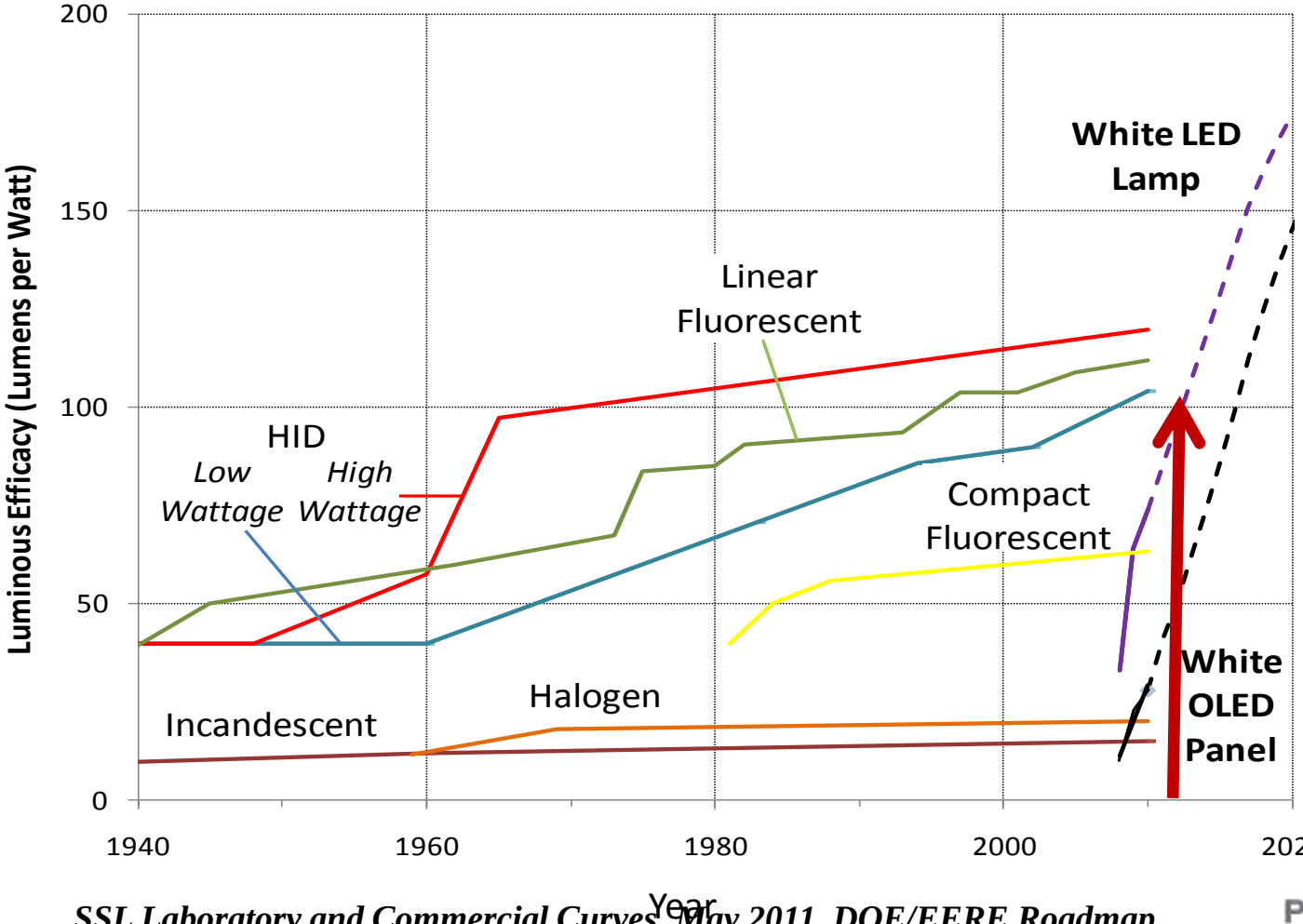
2011: Solid State Lighting R&D Forecast

Accelerated R&D for White Light SSL



SSL Laboratory and Commercial Curves, May 2011 DOE/EERE Roadmap

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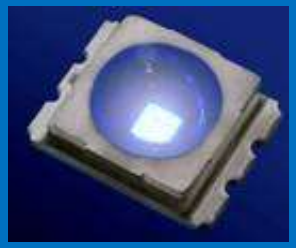
2011: Newest SSL Chips



©Cree – XLamp

©Lumileds – Luxeon

©Nichia – Jupiter

©OSRAM Opto – Dragon

	Flux per device (lm)*	Efficacy (lm/W)*
Cree XLamp	280-370	>100
Philips Lumileds	175+	100
Nichia	Up to140	Up to 135
OSRAM Opto	Up to 140	Up to 142

*white light at 350 mA

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2005: Hybrid Solar Lighting System Collector & Luminaire

- Collector on top of building focuses the *visible* portion of light into optic fibers
- Collector converts IR radiation from light into electricity via thermo-photovoltaic cell
- Hybrid lu… both con… (T8/T5) +…
- Lamps dim… provides mo… required light…
- With little or no… electric lamps r… desired illuminat…

Overcome by better and less expensive FL and LED fixtures! See Next Slide……

Oak Ridge National Laboratory

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2010: 2’x2’ LED Luminaries

Goal

- Fixtures designed to replace 2’x2’ or 2’x4’ T8 fixtures
- Designed to meet or exceed efficacy of fluorescent fixtures.
- Life-cycle cost-effective

Cree Lighting, Inc.

2011: 2’x2’ and 2’x4’ LED Luminaries

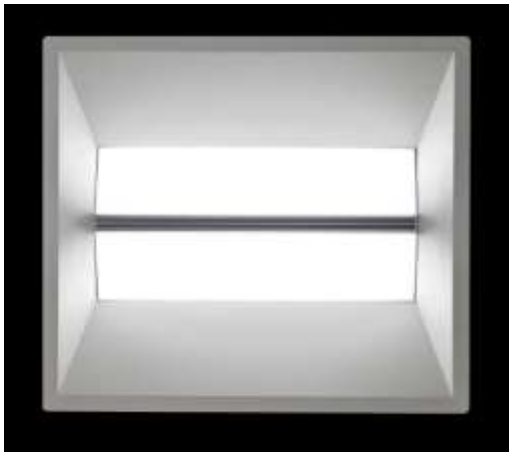
Goal

- Fixtures designed to replace 2’x2’ or 2’x4’ T8 fixtures
- Designed to meet or exceed efficacy of fluorescent fixtures.
- Life-cycle cost-effective.

Status

- May 2011 Cree will announce 2’x4’ and 2’x2’ LED troffer
  - 4,000 lumens
  - 90, 100, and 110 lumens/watt
  - 3500K and 4000K
  - 90 CRI
  - Optional 2-step dimming

Cree Lighting, Inc.



$200 MSRP/$169 distributor price

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2005: Electroluminescent Exit Sign - Revisited

- 0.25-0.50 Watts/face panel*
- 30-year lifetime with ~30% degradation over life
- Meets or exceeds NFPA*, NEC** and OSHA requirements
- Annual operating cost 18¢/year @6¢/kWh; no maintenance cost.
- Single face: retrofit kit ~$40; new sign ~$45 – quantity price

*LED exit signs consume 5 Watts/face

www.lightpanel.com

***National Fire Protection Agency**
****National Electrical Code**

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2011: Electroluminescent Exit Sign

- 0.25 - 0.50 Watts/face panel*
- 30-year lifetime with ~30% degradation over life
- Meets or exceeds NFPA*, NEC** and OSHA requirements
- Annual operating cost ~~18~~ 40¢/year @~~6~~ ¢/kWh 13¢/kWh; no maintenance cost.
- Single face: retrofit kit ~~~$40~~; new sign ~~~$45 –~~ $65 quantity price.
- Available from several vendors

*LED exit signs consume 5 Watts/face

http://fire.exitsigns.com/exit/p/LEC.html

***National Fire Protection Agency**
****National Electrical Code**

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2005: Residential CFL Downlights DOE Solicitation

www.pnl.gov/cfldownlights

Challenge

- 350 million recessed cans in residences; few (0.4%) are CFL.
- Insulated ceiling airtight (ICAT) requirements creates elevated temperature environment; CFL a new requirement of Title 24 in CA.
- Screw-based CFL downlights options are suboptimal.

Competitive Solicitation/Testing

- 10,000hr short- and long-term testing
  - Initial light output: 900 lumens
  - No failure of lamp or ballast (or fixture)
  - Fixture efficiency 50% or greater
- 3 models passed initial testing; more are in process

PNNL photo.

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2011: Residential ~~CFL~~ Downlights ~~DOE Solicitation~~ Update

Status

- Insulated ceiling airtight (ICAT) CFL downlights are ubiquitous and available for <$30/can
- However, inexpensive non-ICAT incandescent downlights still dominate the building industry (except in CA).
- **3rd generation of LED downlights are on the market and may be a better choice for many applications.**
  - **500-1000 lumens/90 CRI**
  - **10-12 Watts (42-80 lumens per Watt)**
  - **New or retrofit**
  - **$60-$100/fixture**
  - **Dimmable (to 10%)**

PNNL photo.

Cree Lighting, Inc.

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HVAC and Appliances

Source: Joe Kinney, New Yorker Hotel

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2008: GE “Hybrid Electric" Water Heater [aka Heat Pump Water Heater]

- Water heater first uses a heat pump to bring the water up to the temperature of the ambient air. Then the electric water heater takes over, bringing the water up to 140°F.
- GE claims 50% more efficient than standard electric water heaters. A same size water heater uses ~4800 kWh/yr; the new GE water heater will use ~2300 kWh/yr.
- Because the new device uses a heat exchanger, it will make your furnace work harder during the winter. But in the summer, and in warm climates, it will actually help cool your house!

http://www.geconsumerproducts.com/pressroom/press_releases/appliances/energy_efficient_products/doetanklesshybrid.htm

2011: “Hybrid Electric" Water Heater [aka Heat Pump Water Heater]

- Now *widely* available from 4 major manufacturers: GE, Rheem, A. O. Smith and American Water Heater.
- Available at big box retailers for ‘carry-out’ and on-line for delivery.
  - **Price range: $1,400 - $2,200**
- Several demonstrations also being undertaken nationwide.

2006: High Efficiency Rooftop Commercial Unitary Air Conditioner

- In cooperation with DLA, DOE organized technology procurement to pull new high efficiency models into the market.
- Competitive solicitation resulted in five winning models from two companies

Lennox

Model	Btu/hr	EER	IPLV	Price
LCA090H	90,000	11.3	12.0	$2,990
LCA102H	101,000	11.0	12.0	$3,390
LCA120H	120,000	11.0	11.8	$3,990

Global Energy Group

Model	Btu/hr	EER	IPLV	Price
PH007C	88,000	13.5	13.9	$4,325
PH010C2	115,000	13.4	14.0	$5,525

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2011: High Efficiency Rooftop Commercial Unitary Air Conditioner "Challenge"

- GEG is no longer in business; Lennox now offers UAC >65,000 Btu/hr up to 12.8 EER/15.5 IPLV exceeding the 2006 specs.
- CEE has established criteria near the specifications of the 2006 procurement.

CEE Tier	**Btu/hr**	**EER**	**IPLV**	
1	>65,000 and <135,000	11.5	11.9	
2	>65,000 and <135,000	12.0	12.4	

- Many other manufacturers offer products similar to today's high performance Lennox UAC.
- DOE has recently issued a rooftop challenge for 120,000 to 240,000 Btu/h capacity units with minimum IEER 18.0
- http://www1.eere.energy.gov/buildings/alliances/rooftop_specification.html

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2005: Low Temperature ('Cool Climate") Heat Pump

- **Patent held by EnerKon Corp (www.enerkoncorp.com)**
  - Master distributor for the heat pump
  - Heating cost comparison calculator
- **U.S unit not yet in full pr… …t units available**
  - "Limited prod… …l 2005
  - Estim… …mental cost over high performance

2011: Put a Fork in it!

2006: Dyson Airblade Hand-dryer

http://www.dysonairblade.com/

- Many people dislike air dryers because they are slow, noisy and power-sucking.
- Paper towels are an ongoing source of waste.
- The Dyson *Airblade* is up to 80% more efficient than conventional air dryers, using a fast (400 mph), thin (0.3mm) sheet of air to dry hands in about 12 seconds.
- Air is NOT heated but instead "wipes" water away.

2011: High Performance Hand-dryers

Dyson AirBlade

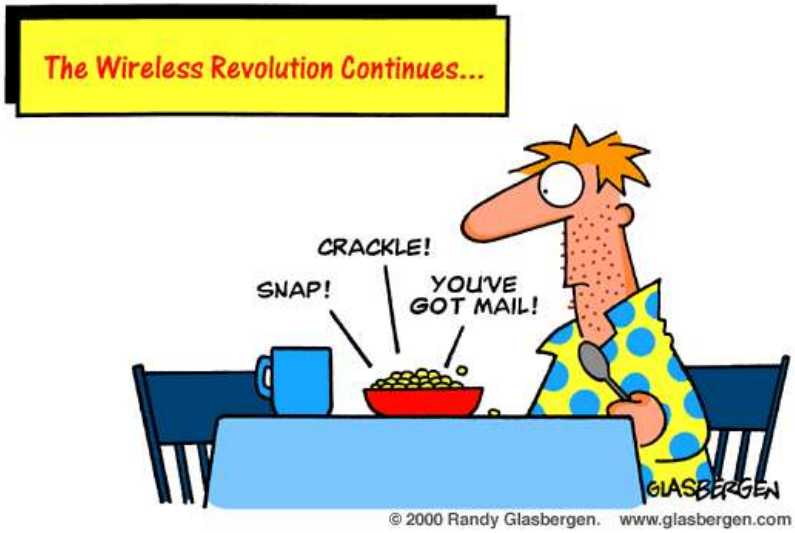
- Though Dyson was first to the market and found in many public restrooms, others have followed and are catching up.
  - Street price: $600-$1,000

Mitsubishi Jet Towel™

Toto

Putt's Law of Research

"Research is dominated by two types of people: those who understand what they do not manage, and those who manage what they do not understand."



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Water Technologies

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2006 Commercial Front-Load Washer

- Whirlpool/Maytag is replacing the venerable MAH21 commercial machine with the ‘MAH22’.
- Whirlpool/Maytag indicates this new machine will meet *CEE Tier 3*, but no formal submittal to CEE has taken place.
- Awaiting confirmation……

2011 Commercial Front-Load Washer

- Whirlpool/Maytag, Speed Queen and LG all have commercial family-sized washers that meet CEE Tier 3 Specifications
  - MEF 2.20
  - WF 4.5
- Today's CEE Tier 3 is ~20% greater MEF and **40% better WF** than ENERGY STAR.

Maytag, Inc.

LG, Inc.

2006: Waterless Urinals

Waterless, Inc.

Uridan

Falcon Waterfree

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2011: Waterless Urinals WOW!

American Standard.

Uridan

FlowWise

Neo-Metro

Falcon Waterfree

???????

ZeroFlush.

Waterless, Inc.

Sloan

Sierra

Caroma

Kohler.

Zurn

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2011: High Efficiency Urinals are Competing with Waterless

- High Efficiency Urinals (HEF)
  - Most use 0.5 gallons/flush; some use 0.5 liters/flush (1/8 gal)
- High reliability and low maintenance automatic flush valves.
- *Never* smell even when not cleaned regularly.
- Overall lower costs and less 'hassle' for many commercial businesses.

Kohler

American Standard

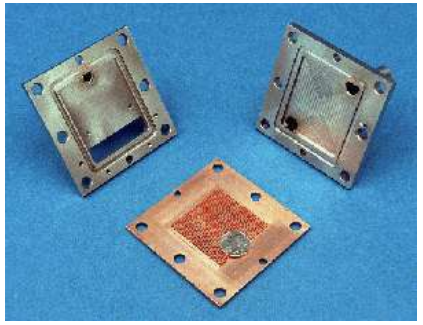
Toto

Sloan

Zurn

2002: Tomorrows Technologies

- **Advanced (Smart) Windows**: Improved R-value through "optical switching": passive glazing potochromic/thermochromic) and active glazing (electrochromic)
- **Smart Appliances**: Internet-enabled appliances that "respond" to utility price signals, self-diagnose condition, and operate via remote (internet-based) signals



So what advances have been made……

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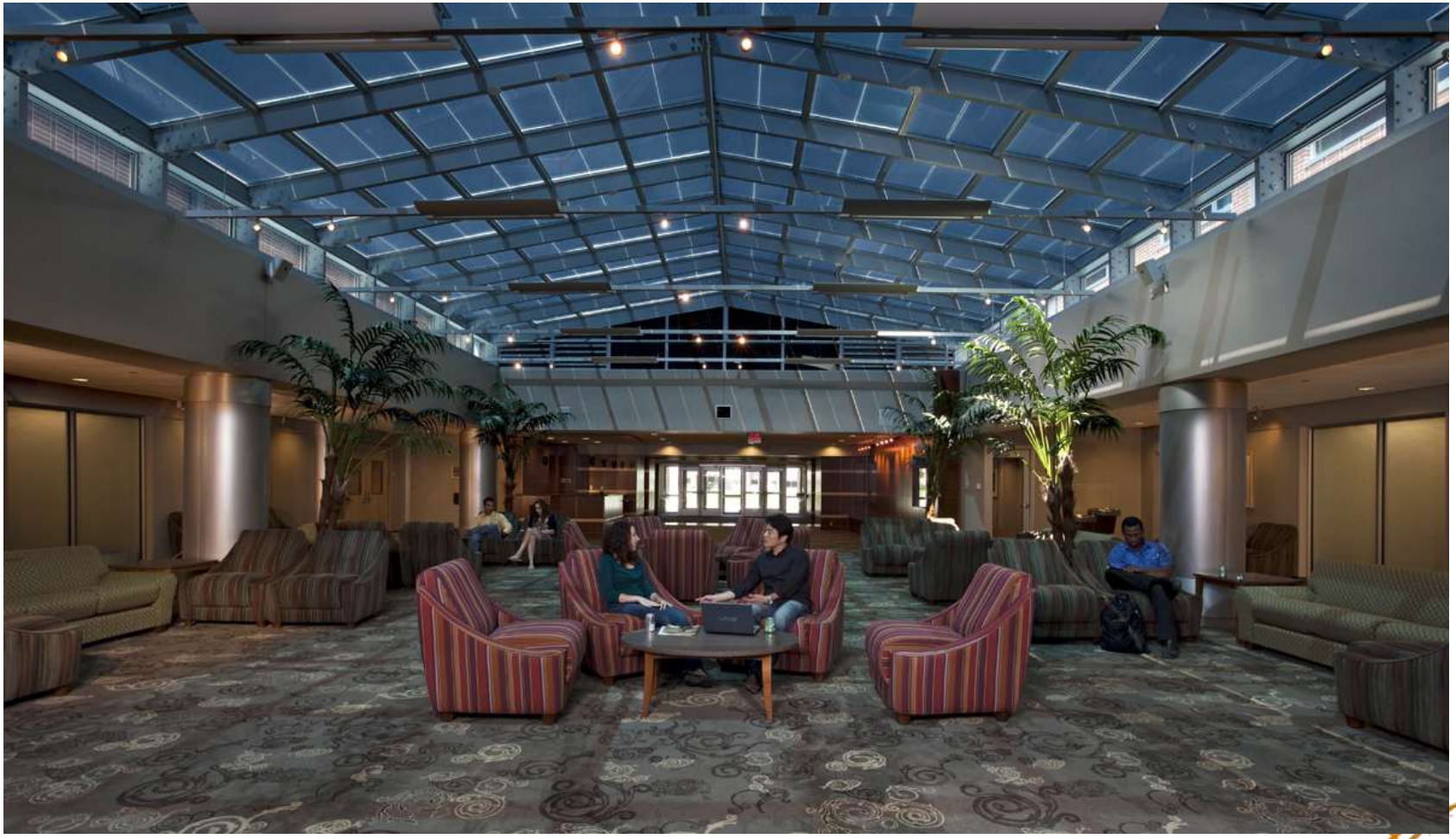
2011: Advanced (Smart) Windows are Here!
Dynamic Windows – 'Cost Neutral' within 5-7 Years

DeHority Hall, Ball State University, Muncie, IN



Courtesy of Sage – DO NOT USE WITHOUT SAGE PERMISSION

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2011: Smart Appliances are Here!

- Major appliance manufacturers are now offering smart (grid-friendly) appliances.
- A suite of smart appliances from GE are being evaluated by PNNL in the laboratory.
- Whirlpool announced they will offer smart grid compatible appliances by 2015.
- LG just announced an entire suite of domestic appliances for ‘smart houses’.

LG Electronics, Inc.

G.E. Appliances

G.E. Appliances

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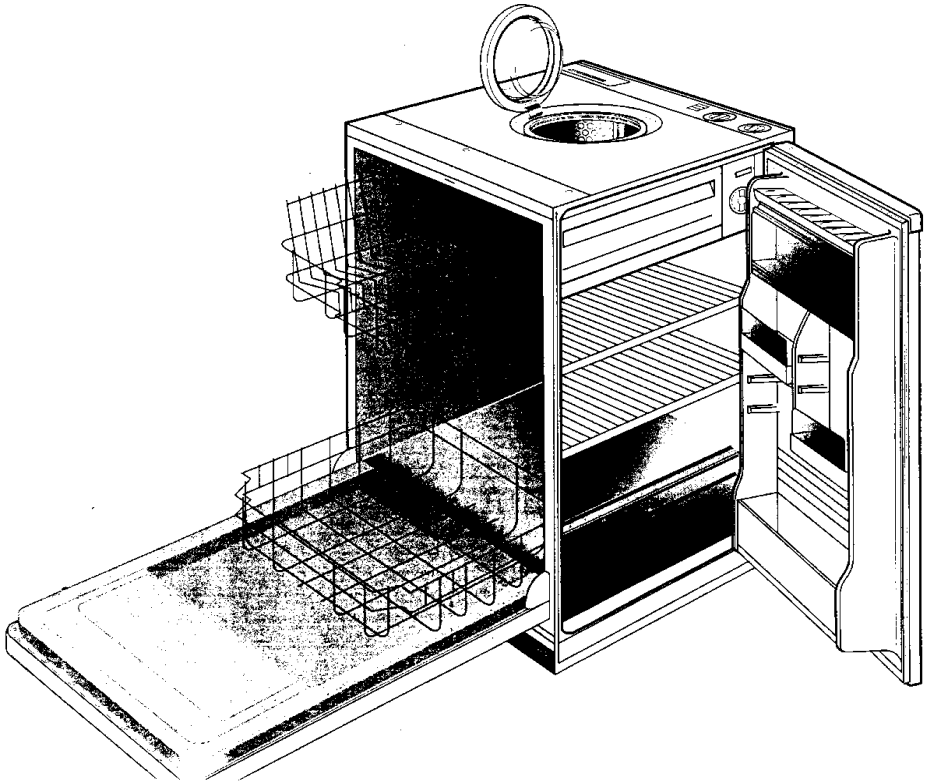
1999: Wash N' Fridge



2011: Not here; still waiting for its introduction…..

2005: Clocky!

- A shag rug-covered clock for people who have trouble waking up!
- When “clocky” goes off, the sleeper must locate *IT* to turn *IT* off since clocky moves to a safe hiding spot
- Smart chip allows clocky to find a new hiding place every day!

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2011: New and Improved Clocky! The Running Away Alarm Clock in Colors

- New sleek ‘designer’ colors
- Will still run away and hide!

Nanda Home, Inc.