31st Annual State Construction Conference

March 22nd, 2012

Senate Bill 668 – A Case Study

Senate Bill 668 – A Case Study

What is Senate Bill 668?

- Purpose is to promote energy and water savings in state owned and state supported buildings.
- New buildings are required to be 30% more efficient.
- Renovated buildings are required to be 20% more efficient.

Senate Bill 668 – A Case Study

The official title of Senate Bill 668 is Performance Standards for Sustainable Energy Efficient Public Buildings.

The legislation can be found under NCGS 143-135.35 through 143-135.40.

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Senate Bill 668 was codified in Senate Bill 1946 during the 2007 legislative session.

The legislation went into effect for projects with design contracts signed on or after August 8, 2008 or 08/08/08.

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2010 to 2011

Appalachian STATE UNIVERSITY

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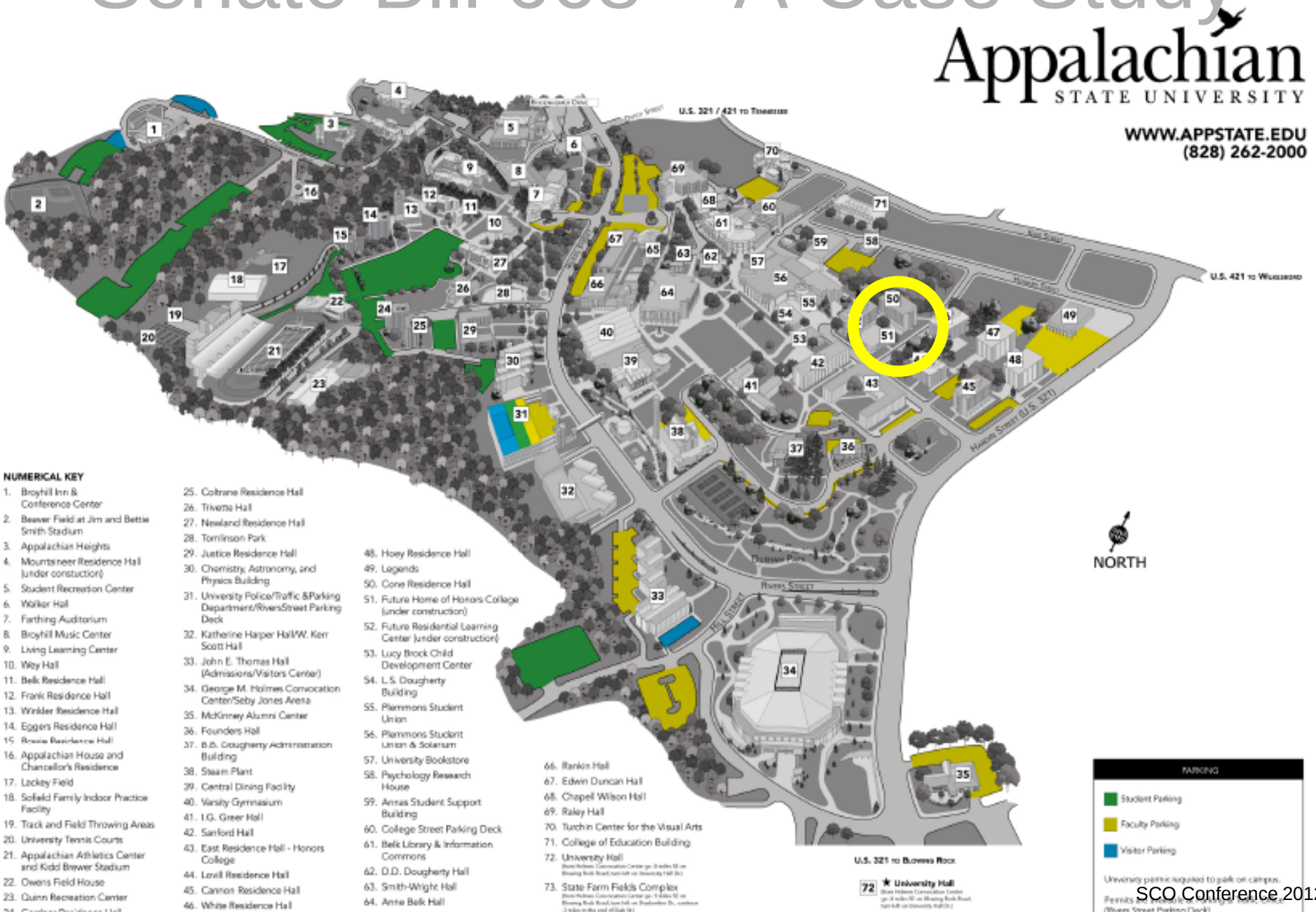

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Renovation projects require

- 20% less energy usage than a building complying with ASHRAE 90.1-2004
- 20% less indoor water usage than a building complying with the 2006 NC Plumbing Code

How do we get there?

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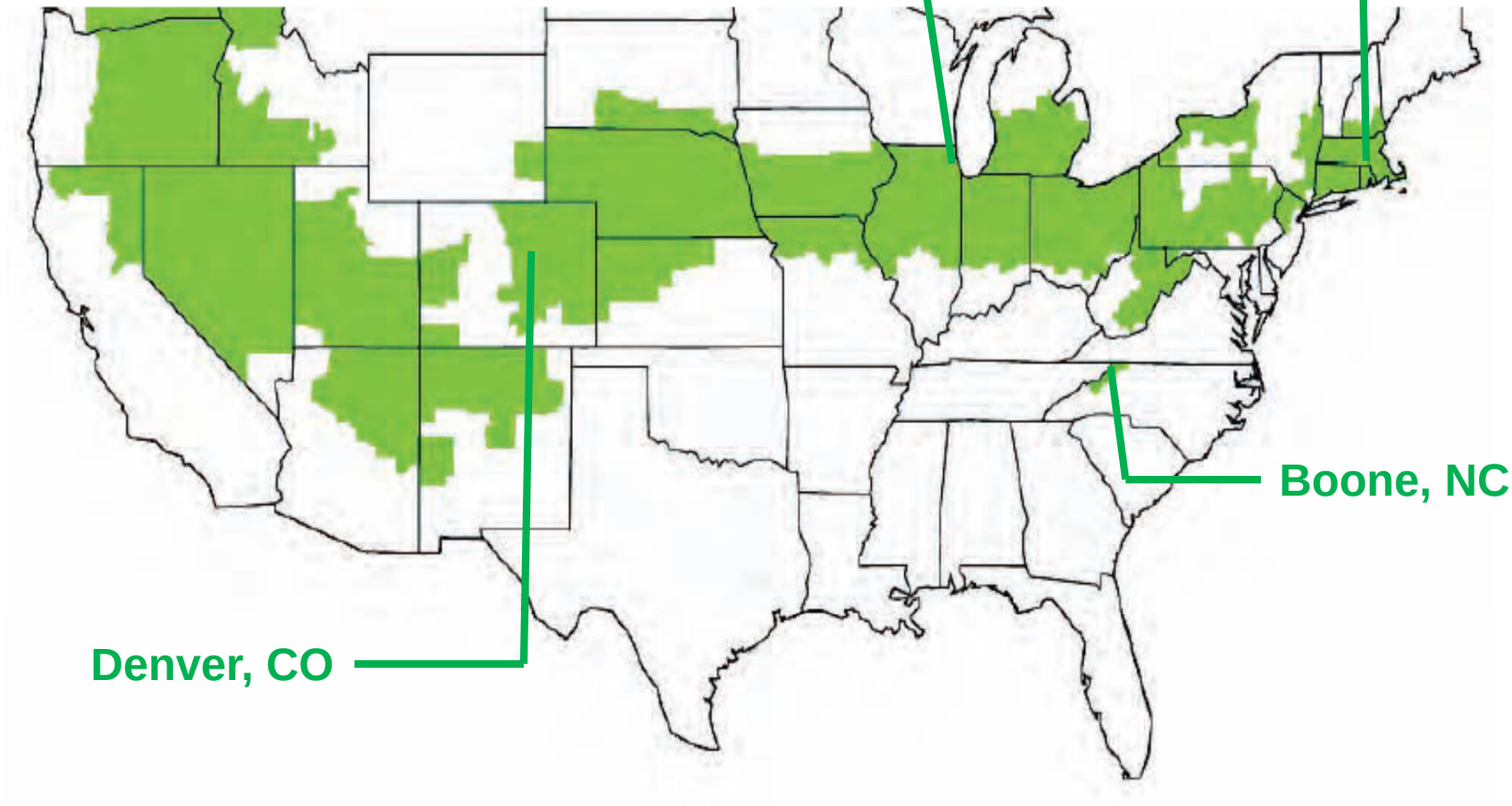

Zone 5

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Appalachian photo by University Photographer Troy Tuttle

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Cone Residence Hall – Original Construction

- Accepted December 18, 1968
- Total Building Cost: $941,000
- 8 Occupied Floors + Basement
- 58,803 Gross Square Feet
- 300 Students (All female)

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Cone Residence Hall - Renovation

- Beneficial Occupancy August 18, 2010
- Total Project Cost: $12,085,300
- 8 Floors + Basement
- 58,332 Gross Square Feet
- 287 Beds (Co-ed)
- Designed for LEED Silver – Tracking LEED Gold

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Envelope Improvements

- Replaced single glazed metal frame windows with low E insulated windows
- Added R-19 insulation to exterior walls
- Added sun screens to lounge windows on south facade

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	Existing Windows	Code Windows	New Windows
Glazing	Single	Compliance varies	Double with 1/2" air space
U factor	1.13	0.67	0.52
Visible Light Transmittance	85%	61%	48%
Solar Heat Gain Coefficient	0.72	0.39	0.24
Shading Coef	0.94	0.45	0.28
Frame	aluminum	Varies	aluminum with thermal break
Source	Carrier System Design Manual	ASHRAE 90.1-2004	Contract Specifications

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Envelope Improvement

- Added R-19 insulation to the exterior walls

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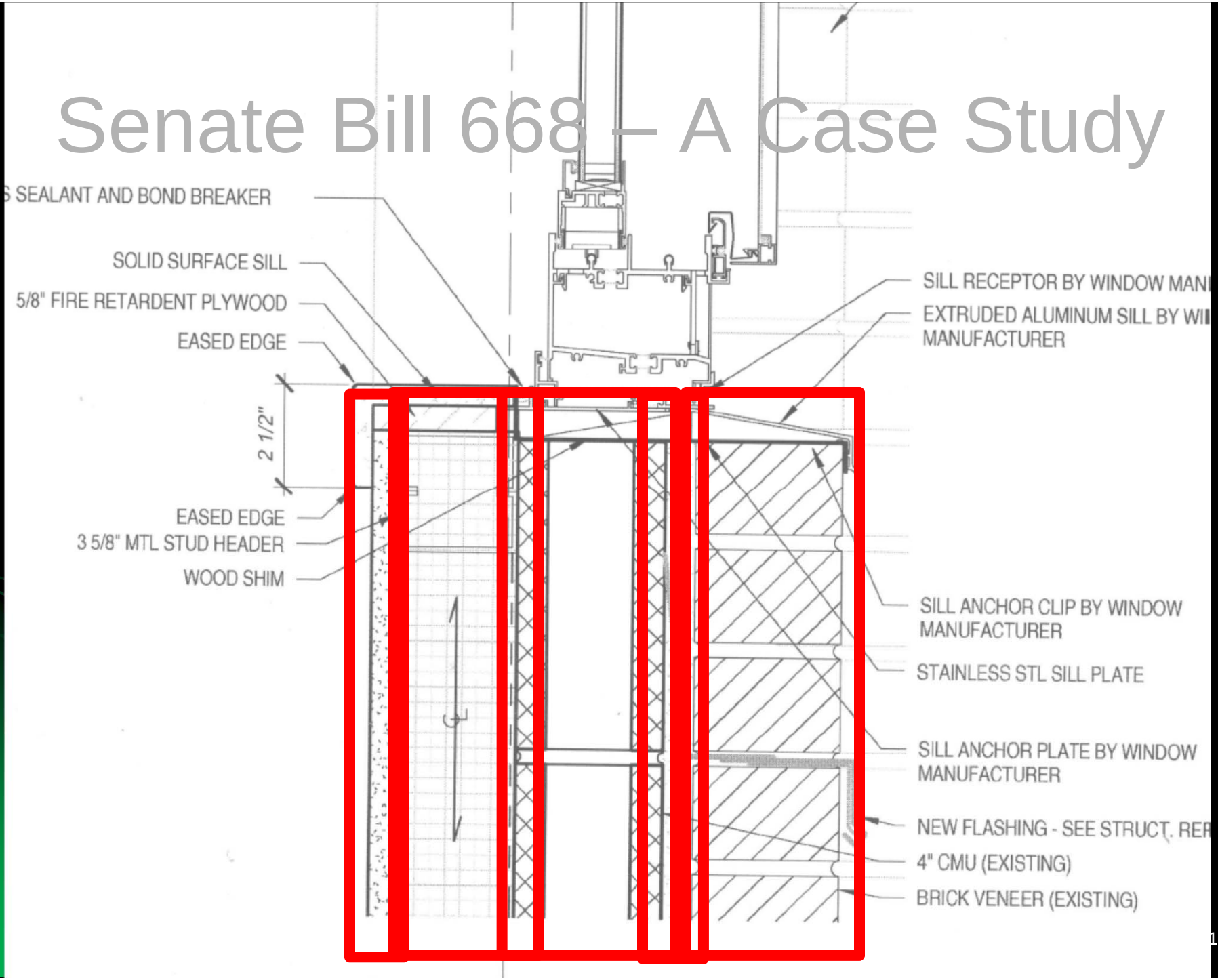

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Sun control devices or sunscreens

- Reduce solar heat gain
- Reduce glare in the lounges
- Improve building appearance

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HVAC Improvements

- Energy reclamation from exhaust air for ventilation
- Heating and cooling by 4 pipe fan coil units
- Low flow shower heads result in less hot water use and lower energy consumption


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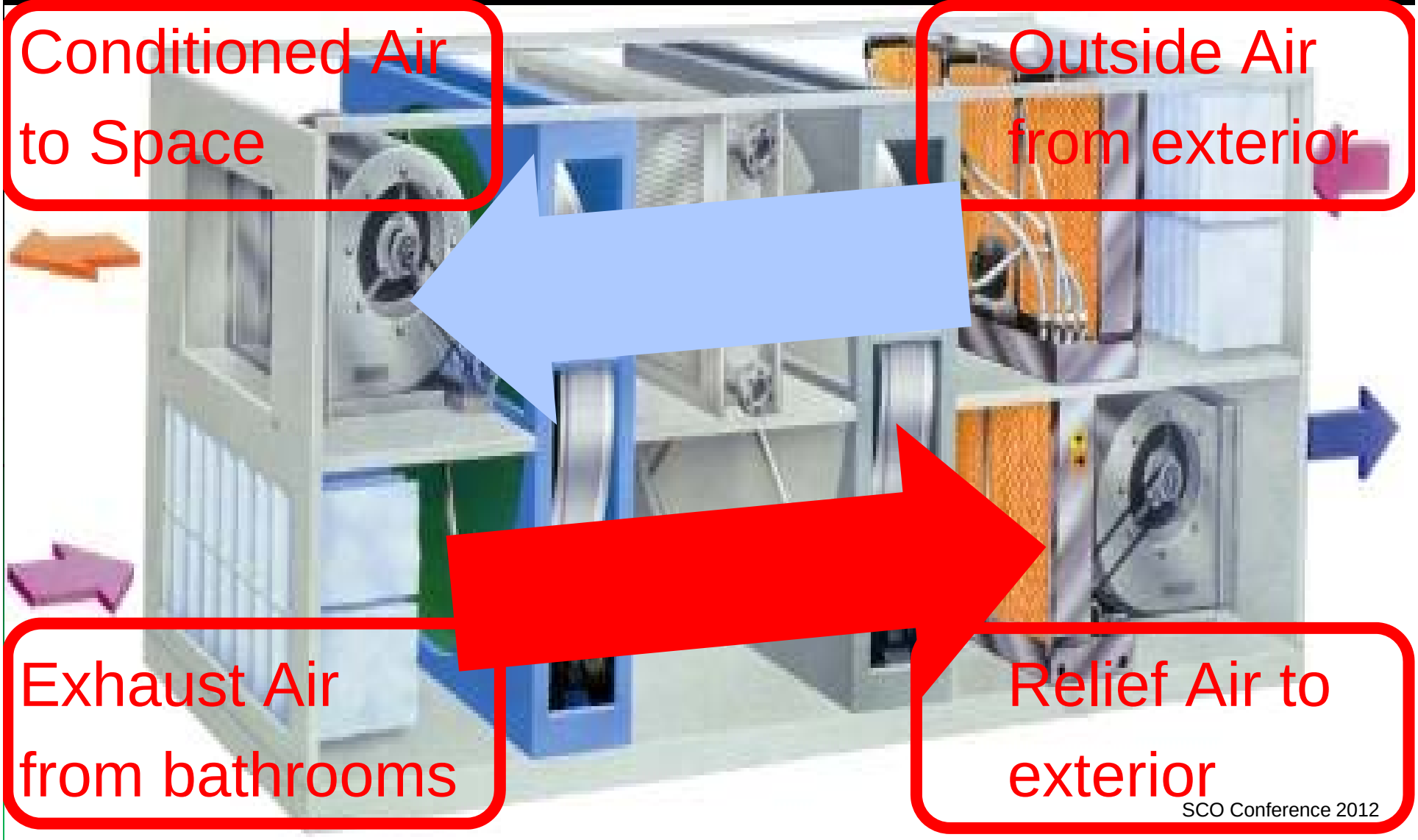

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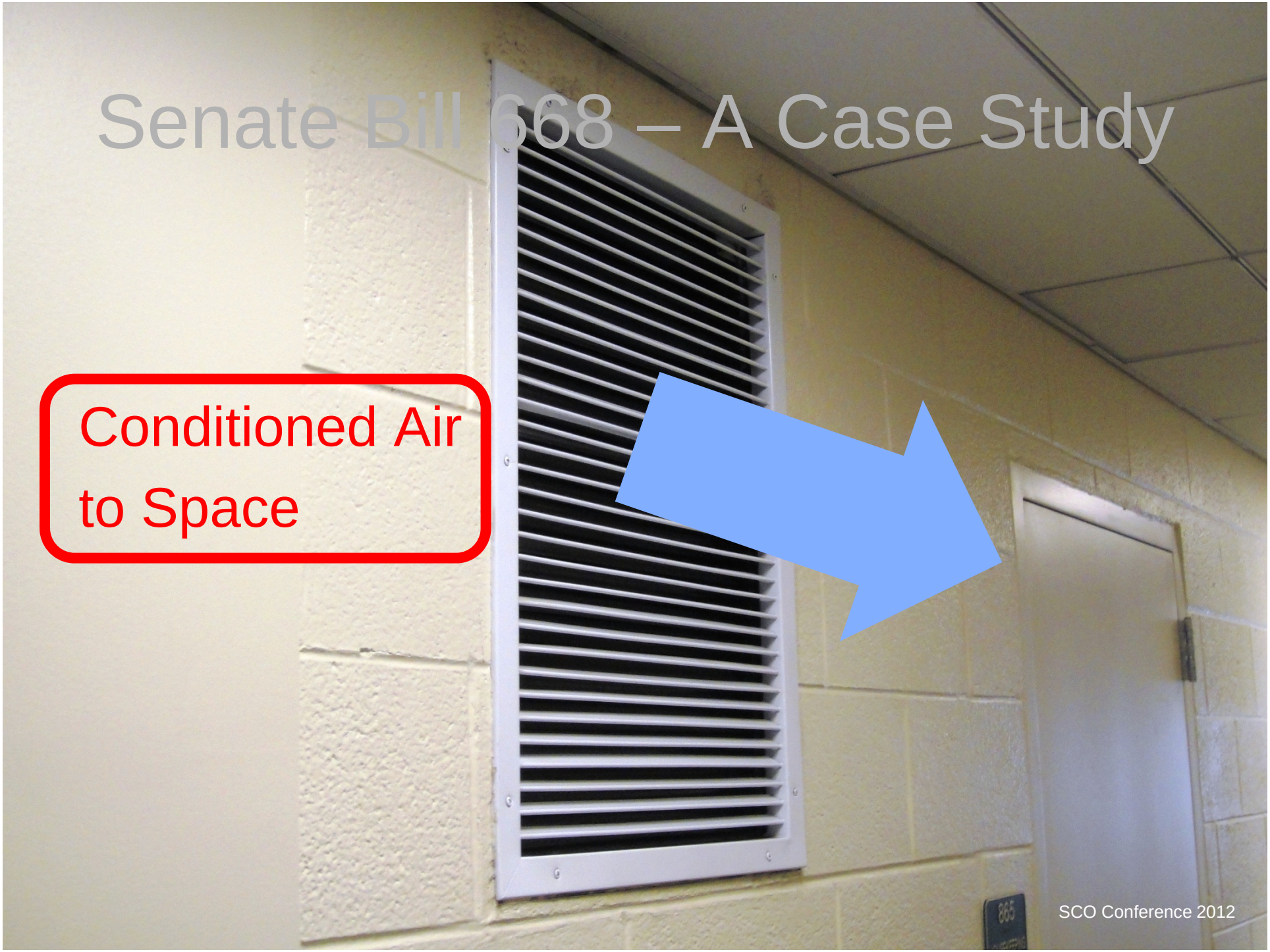

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1.5 gal/min (vs 2.5 gal/min)

results in

47% improvement in steam consumption

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Lighting Improvements

- Existing – Incandescent and T12 fluorescent
- New – T8 28 watts with advanced electronic ballasts
  - Occupancy sensors
  - Dual level switching

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Fluorescent T8 at 28 watts

(vs incandescent at 150 watts)

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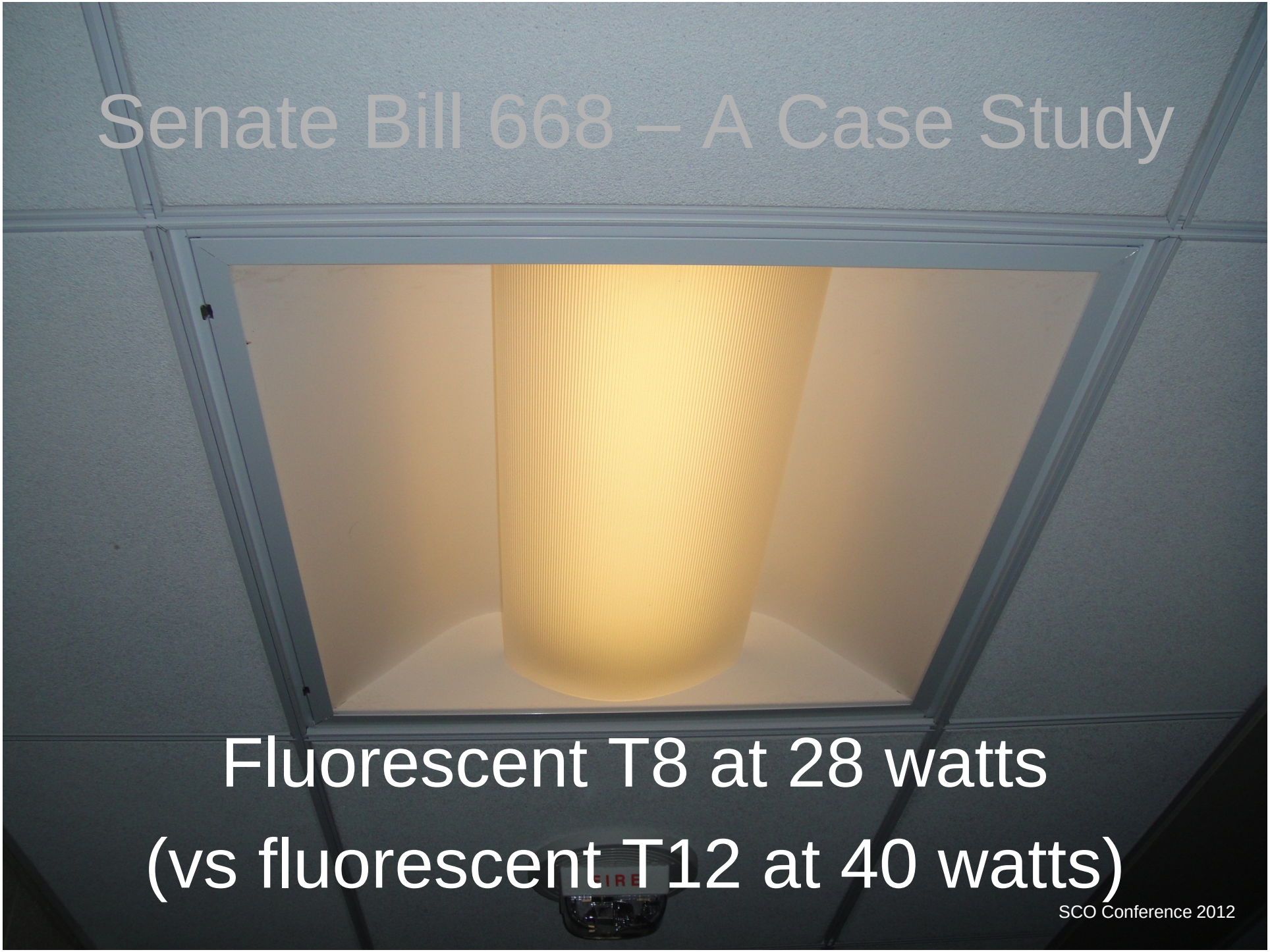

Fluorescent T8 at 28 watts

(vs fluorescent T12 at 40 watts)

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Occupancy sensors in common areas

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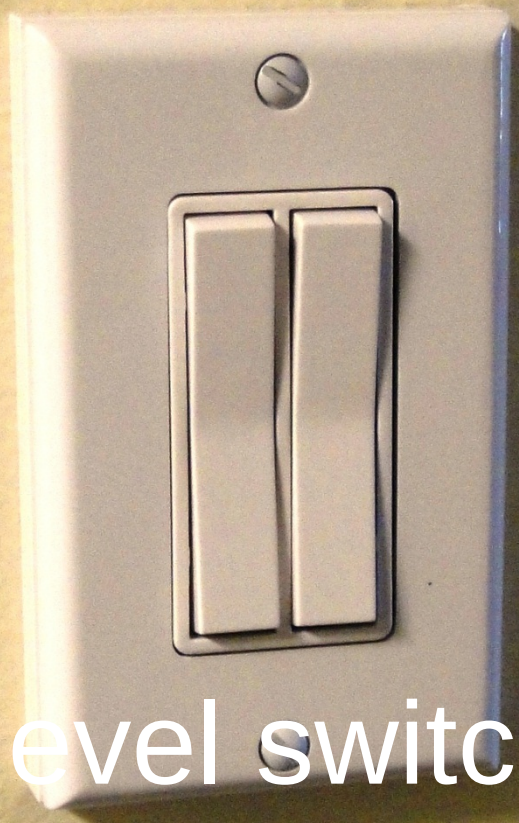

Dual level switching in other areas

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Plumbing Improvements

- Dual flush water closets
- Low flow shower heads
- Low flow lavatories

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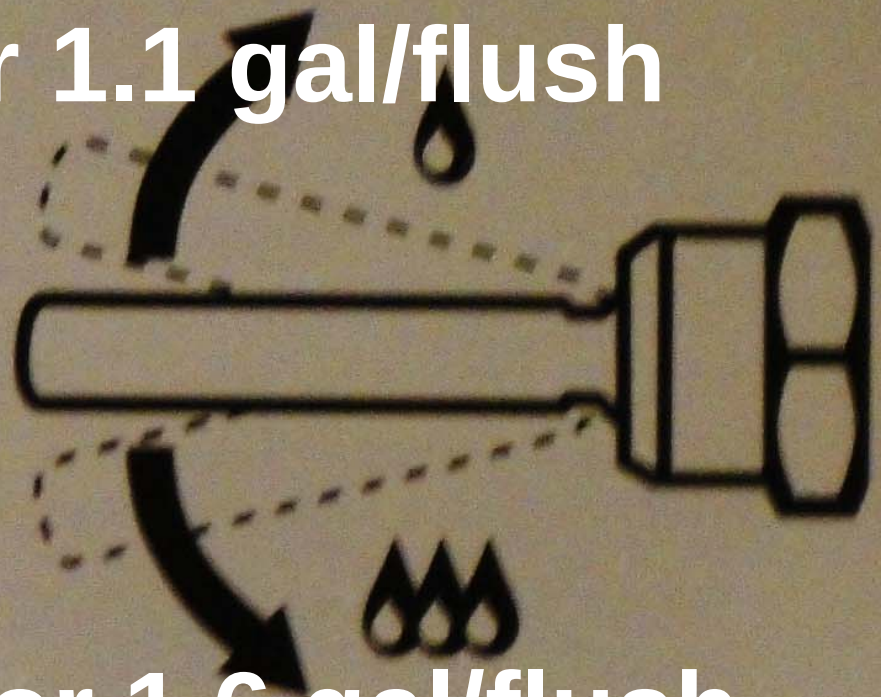
Water-Saving

UP for #1 (liquid waste)

Up for 1.1 gal/flush



Down for 1.6 gal/flush

DOWN for #2 (solid waste)

By installing this water saving handle with dual-function flush, this facility has demonstrated its commitment to protect and preserve the environment. For the system to work, we need your help. Please take a look at the diagram above and push the handle in the direction which best suits your needs. With your assistance, we can do our part to conserve this precious resource.

SLOAN

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Low Flow Shower Heads

1.5 gal/min

(vs 2.5 gal/min)

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Low flow lavatories

0.5 gal/min

(vs 2.2 gal/min)

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What did the improvements gain us in energy and water savings?

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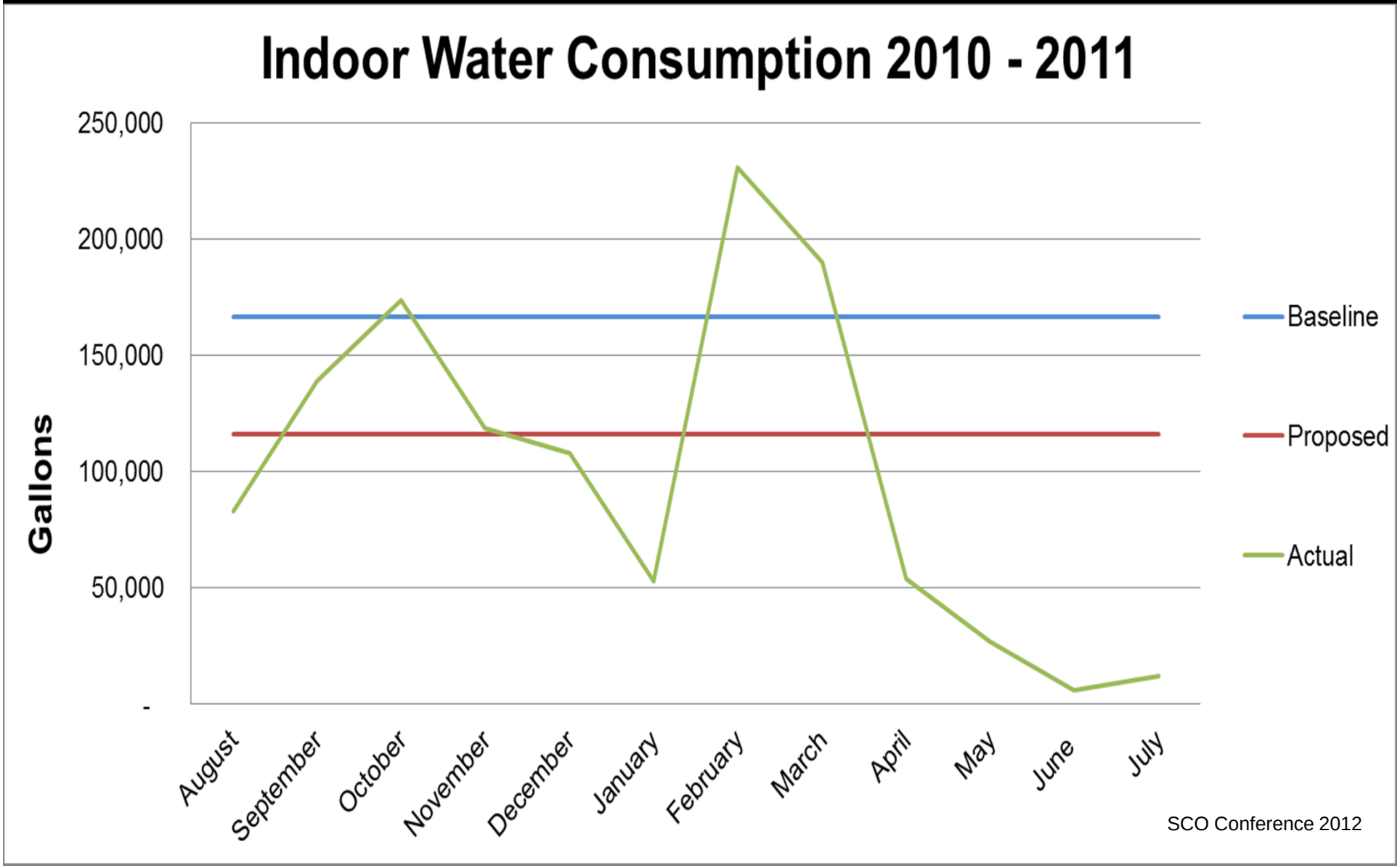

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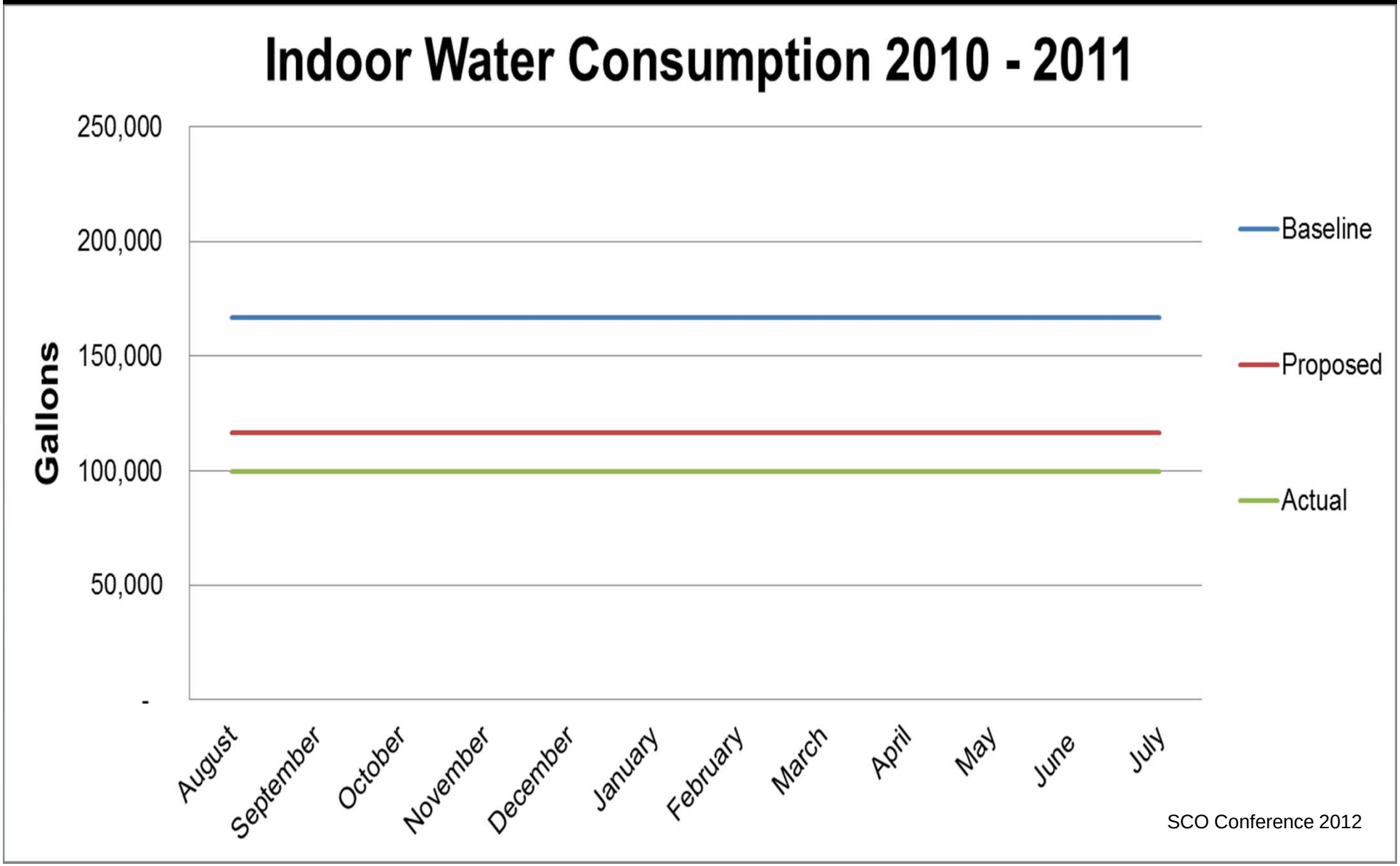

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Residence Hall Indoor Water Consumption			
21 Buildings Analyzed			
	Baseline (Gallons/Resident/Year)	Proposed (Gallons/Resident/Year)	Actual (Gallons/Resident/Year)
Low	2,280	1,793	4,302
High	13,355	10,651	4,302
Mean	10,177	5,790	4,302
Average	9,320	6,426	4,302
Cone	**7,196**	**5,026**	**4,302**

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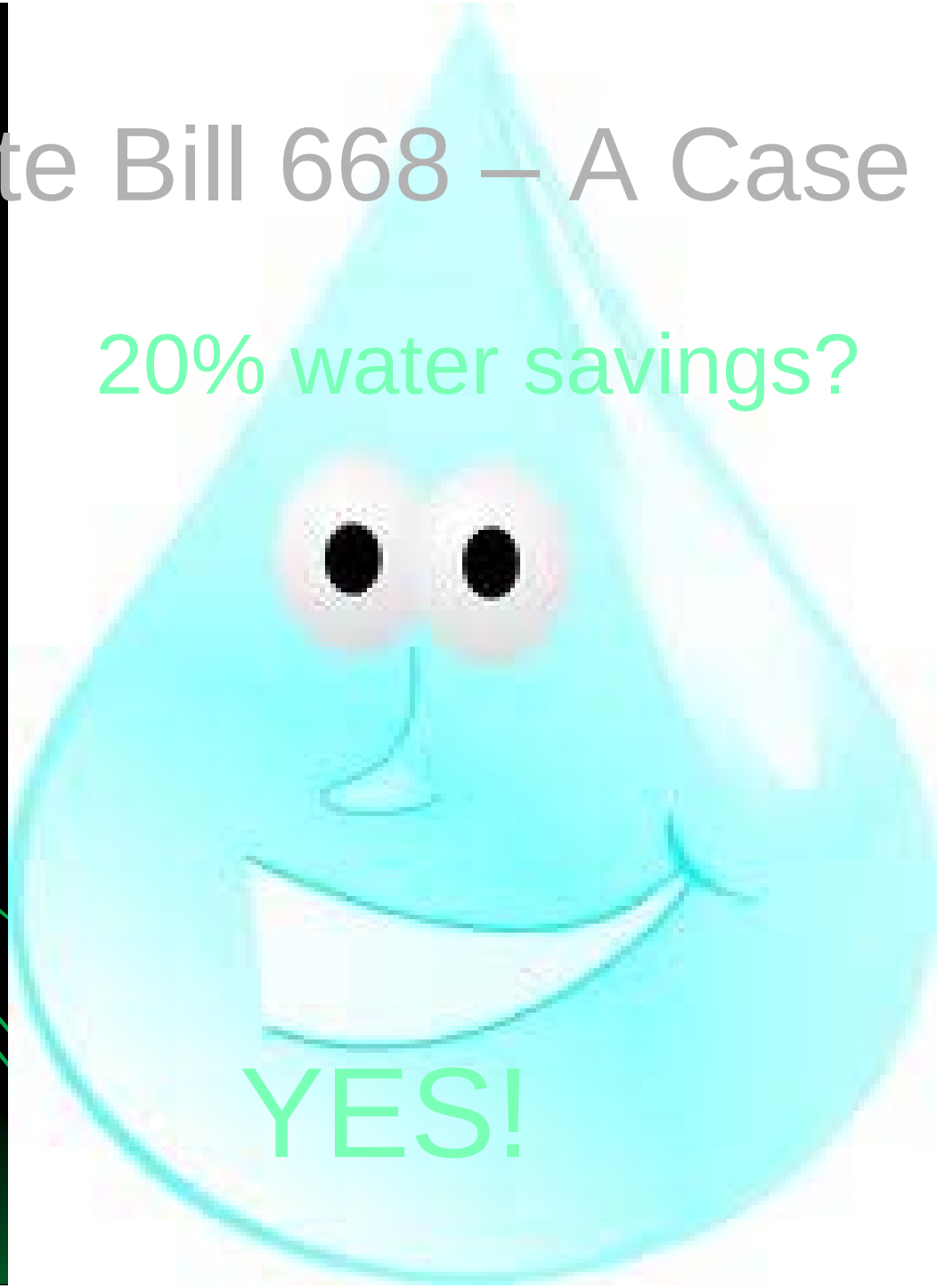
20% water savings?



YES!

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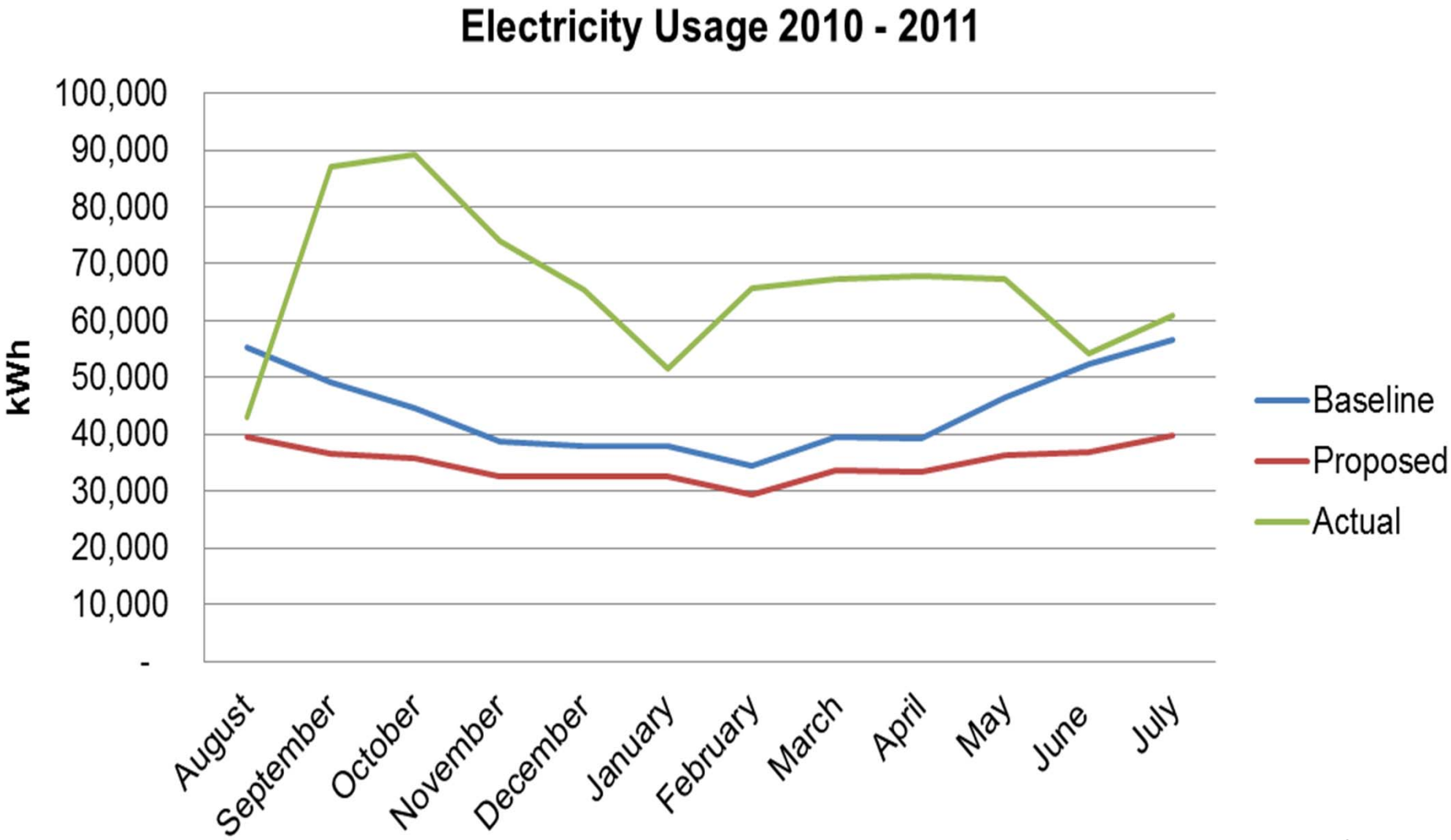

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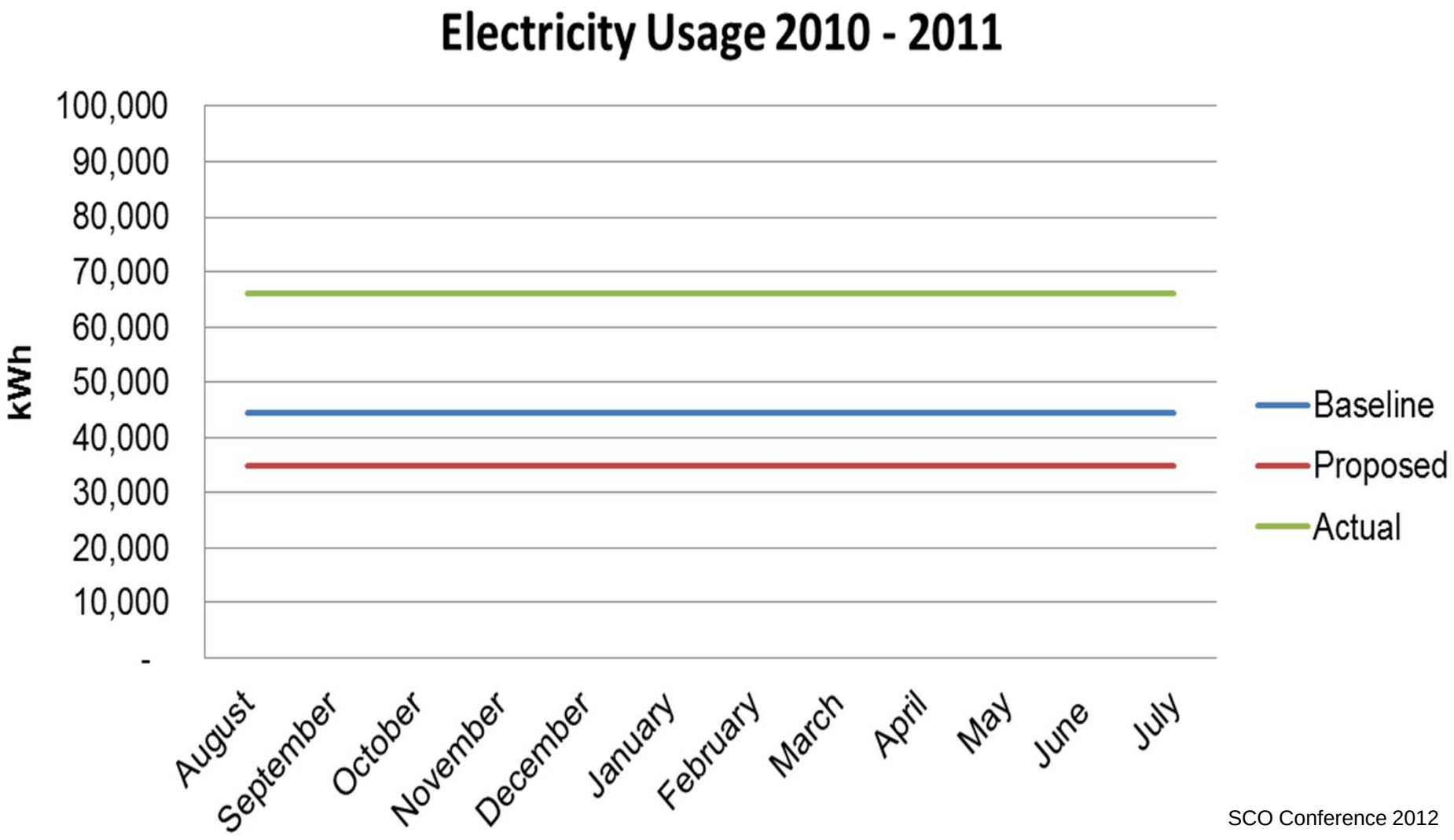

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20% Electricity Savings?

NO!

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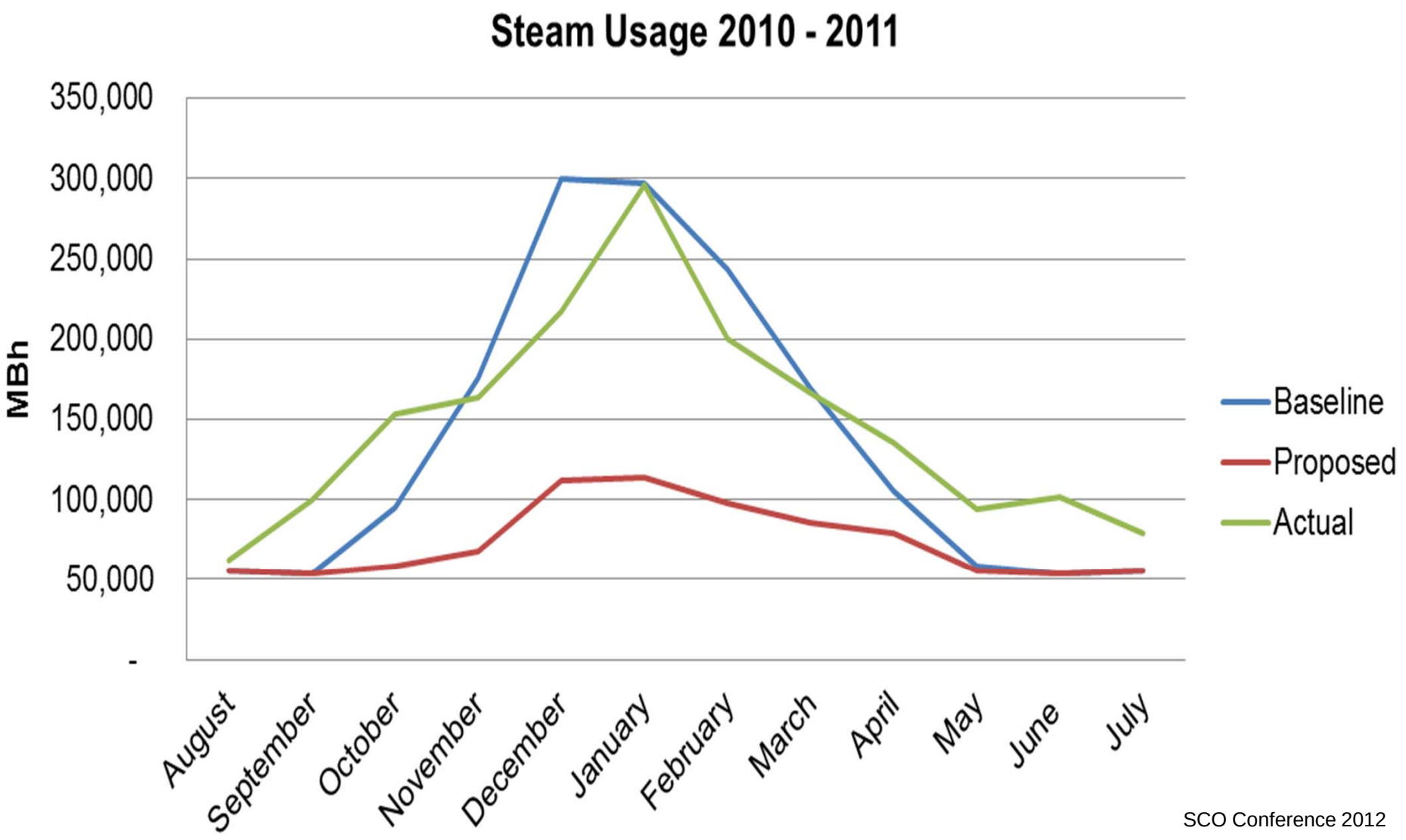

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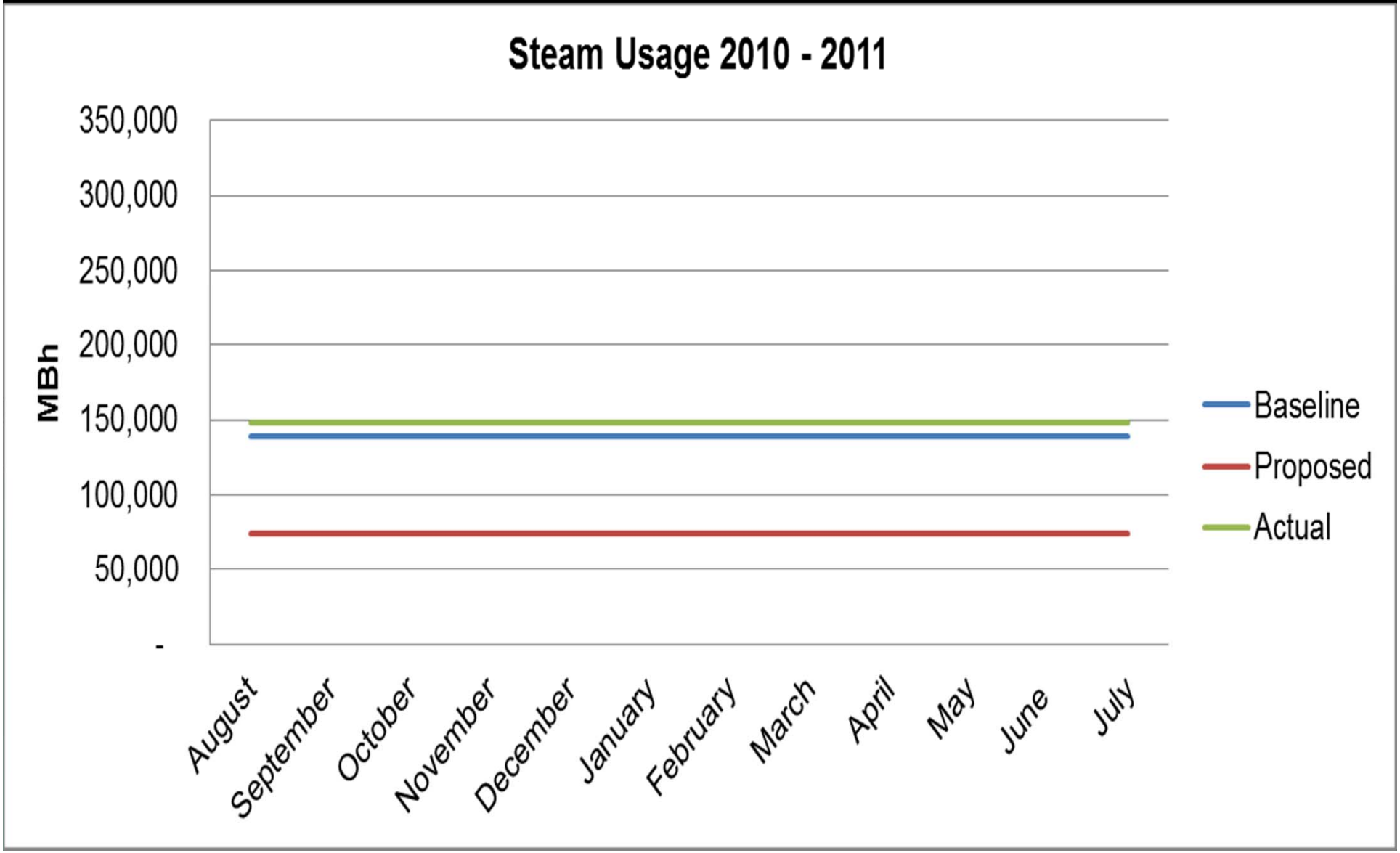

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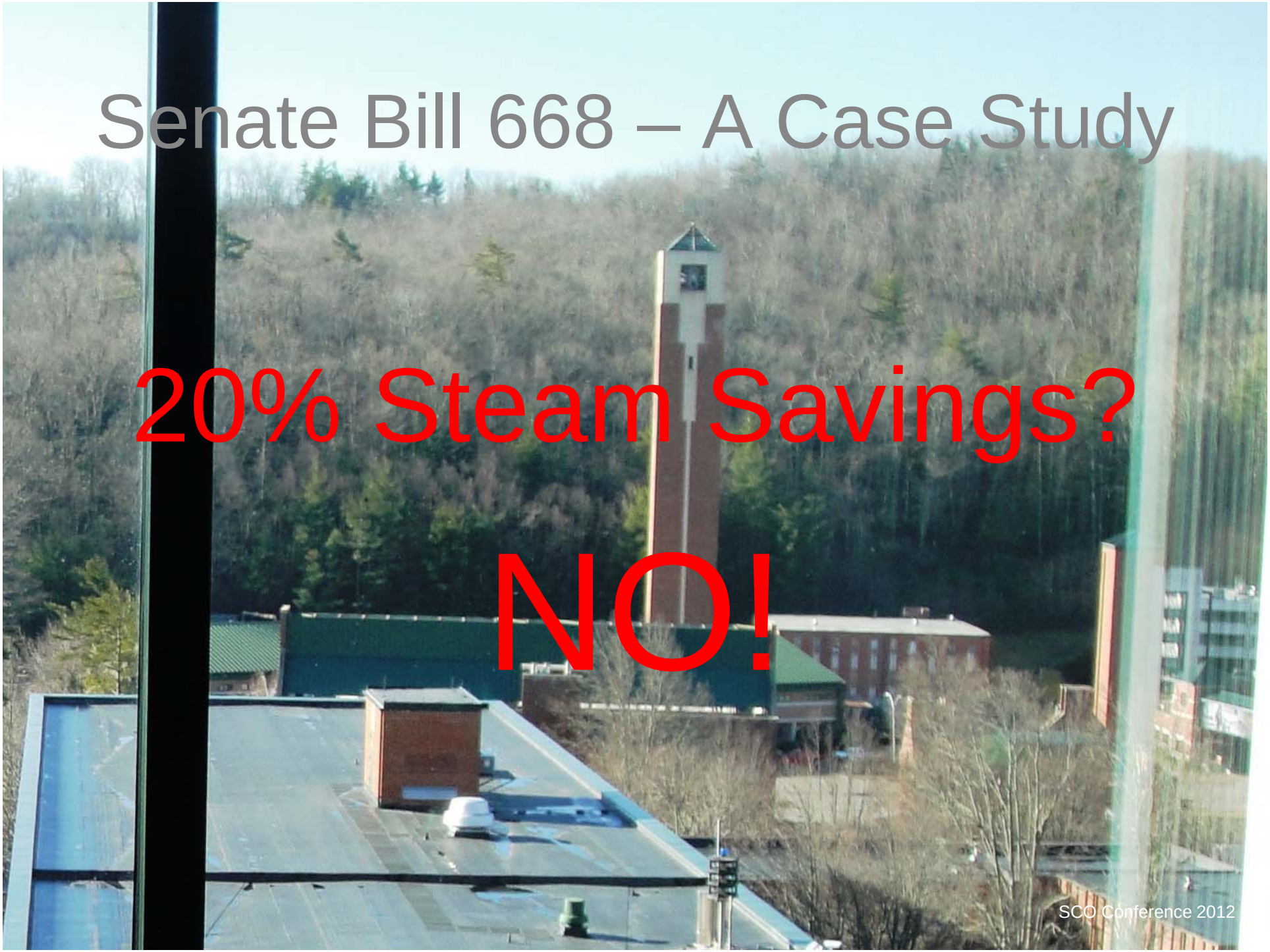

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Residence Hall Energy Use

21 Buildings Analyzed

EUI (Energy Use Intensity)

	Baseline (kBtu/SQ FT/yr)	Proposed (kBtu/SQ FT/yr)	Actual (kBtu/SQ FT/Yr)
Low	49	28	76
High	112	79	76
Mean	65	44	76
Average	71	46	76
Cone	**59**	**34**	**76**

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DOE Commercial Building Benchmarks – New Construction
Energy Use Intensities (EUIs) [kBtu/ft^2/yr]
October 2009

City	Miami	Houston	Phoenix	Atlanta	Los Angeles	Las Vegas	San Francisco	Baltimore	Albuquerque	Seattle	Chicago	Denver	Minneapolis	Helena	Duluth	Fairbanks	Benchmark Weighted Avg
Climate Zone	1A	2A	2b	3A	3B	3B	3C	4A	4B	4C	5A	5B	6A	6B	7	8	
Large Office	38	40	38	38	32	34	35	40	34	37	43	36	46	40	47	39	39
Medium Office	39	42	40	41	33	37	38	45	38	42	48	41	54	48	57	77	43
Small Office	44	44	43	41	33	39	35	46	41	42	51	45	57	51	61	83	45
Warehouse	30	19	19	18	14	18	15	21	20	18	24	23	29	27	33	52	21
Stand-alone Retail	62	63	60	61	44	56	50	72	61	65	81	69	93	83	104	145	69
Strip Mall	56	58	57	62	44	57	53	74	64	69	85	72	99	89	111	156	70
Primary School	57	57	55	55	46	52	51	61	54	54	65	58	75	66	79	113	60
Secondary School	56	57	55	57	42	54	50	68	58	61	76	64	89	77	97	141	66
Supermarket	158	167	159	170	153	158	166	184	168	181	195	179	208	197	223	266	179
Quick Service Restaurant	535	549	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	657	604	713	663	765	949	596
Full Service Restaurant	404	423	[illegible]	440	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	527	481	570	532	617	763	471
Hospital	145	147	138	142	137	135	142	148	127	[illegible]	148	130	153	137	155	185	145
Outpatient Facility	280	279	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	271	271	280	275	279	324	273
Small Hotel	71	71	69	71	62	68	64	75	70	69	80	74	87	80	92	112	73
Large Hotel	99	108	100	116	105	105	113	127	119	124	138	131	150	144	163	196	122
Mid-Rise Apartment	39	39	38	38	31	36	33	42	37	38	47	41	54	48	59	76	n/a

80 kBtu/ft2/yr

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U.S. Energy Information Administration

CONSUMPTION & EFFICIENCY

OVERVIEW DATA ANALYSIS & PROJECTIONS GLOSSARY ›

Home > Households, Buildings & Industry > Energy Efficiency > Commercial Buildings Energy Intensities > Table 5b

U.S. Commercial Buildings Energy Intensity

100 kBtu/ft2/yr

Released Date: December 2004
Page Last Modified: Jan 2007

Table 5b. U.S. Commercial Buildings Energy Intensity Using Site Energy [1] **by Census Region and Principal Building Activity, 1992-2003**
(Thousand Btu per Square Foot)

Principal Building Activity and Census Region	Survey Years			
	1992 [2]	**1995**	**1999**	**2003**
U.S. Total	80	91	85	91
Education	75	79	75	83
Food Sales	182	214	202	200
Food Service	206	245	241	258
Health Care	228	240	176	
Lodging	160	127	99	100
Mercantile and Service	71	76	83	
Office	96	97	90	93
Public Assembly	68	114	82	94
Public Order and Safety	110	97	87	116
Religious Worship	29	37	32	43
Warehouse and Storage	41	38	44	45
Other [3]	150	172	144	164
Vacant	28	21	16	21

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	1992	1995	1999	2003
Total Midwest	91	105	90	99
Education	82	87	79	86
Food Sales	194	Q	Q	219
Food Service	216	173	203	219
Health Care	290	309	167	206
Lodging	152	150	103	109
Mercantile and Service	77	101	81	97
Office	105	112	96	109
Public Assembly	86	113	79	102
Public Order and Safety	Q	99	Q	Q
Religious Worship	35	52	34	53
Warehouse and Storage	60	51	73	75
Other [3]	Q	Q	Q	Q
Vacant	38	Q	Q	Q

109 kBtu/ft2/yr

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Lessons Learned

What we know:

- Seven lounges housed three students each at the beginning of the semester

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Lessons Learned

What we know:

- Central chiller plant construction is on-going

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Lessons Learned

What we know:

- Building commissioning was ongoing
- Energy recovery unit
  - Not included in building model
  - Operating sequence changes during commissioning

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Senate Bill 668 – A Case Study

Lessons Learned

Energy Model:

- Baseline and proposed models low
- Operable window use impact
- Accuracy of Energy Model inputs

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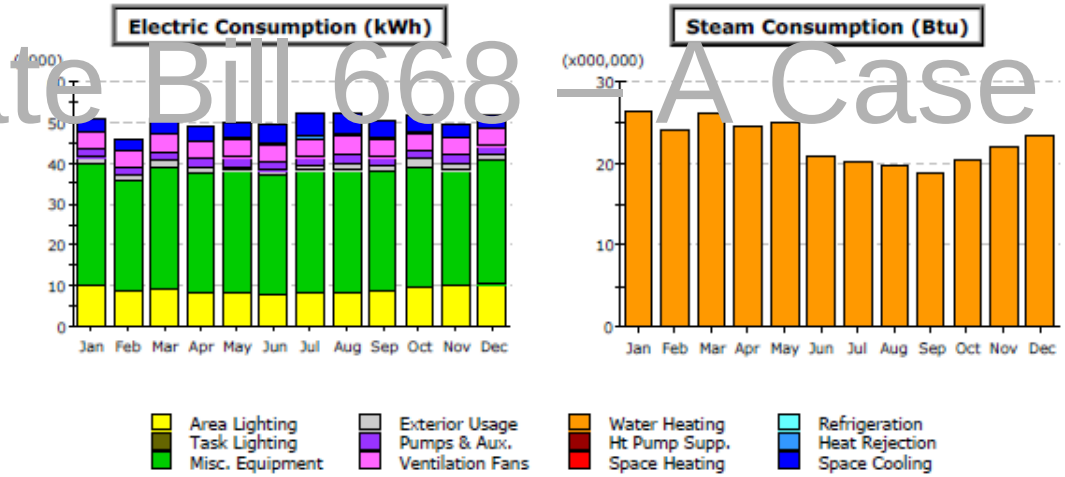
Senate Bill 668 – A Case Study



Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	3.11	2.90	3.66	3.69	4.13	4.65	5.68	5.40	4.40	3.96	3.56	3.16	48.30
Heat Reject.	0.00	0.00	0.03	0.11	0.33	0.46	0.52	0.52	0.44	0.21	0.04	0.00	2.66
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	4.36	3.94	4.36	4.22	4.36	4.22	4.36	4.36	4.22	4.36	4.22	4.36	51.30
Pumps & Aux.	1.92	1.76	2.08	2.05	2.17	2.13	2.20	2.20	2.11	2.15	2.02	1.94	24.72
Ext. Usage	1.65	1.31	1.45	1.40	1.07	1.04	1.07	1.59	1.53	1.59	1.60	1.65	16.96
Misc. Equip.	29.77	27.04	30.11	29.25	29.77	29.25	30.09	29.94	29.08	29.92	28.75	30.10	353.07
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	10.06	8.80	9.08	8.43	8.33	7.88	8.19	8.43	8.67	9.35	9.70	10.36	107.28
Total	50.87	45.76	50.75	49.14	50.15	49.62	52.12	52.43	50.46	51.54	49.88	51.57	604.29

Steam Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	26.41	24.17	26.17	24.43	25.05	20.84	20.33	19.75	18.71	20.56	22.19	23.45	272.08
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	26.41	24.17	26.17	24.43	25.05	20.84	20.33	19.75	18.71	20.56	22.19	23.45	272.08

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Lessons Learned

Energy Model:

- Accuracy of weather data

Asheville NC ≠ Boone NC

Climate Zone 4 ≠ Climate Zone 5

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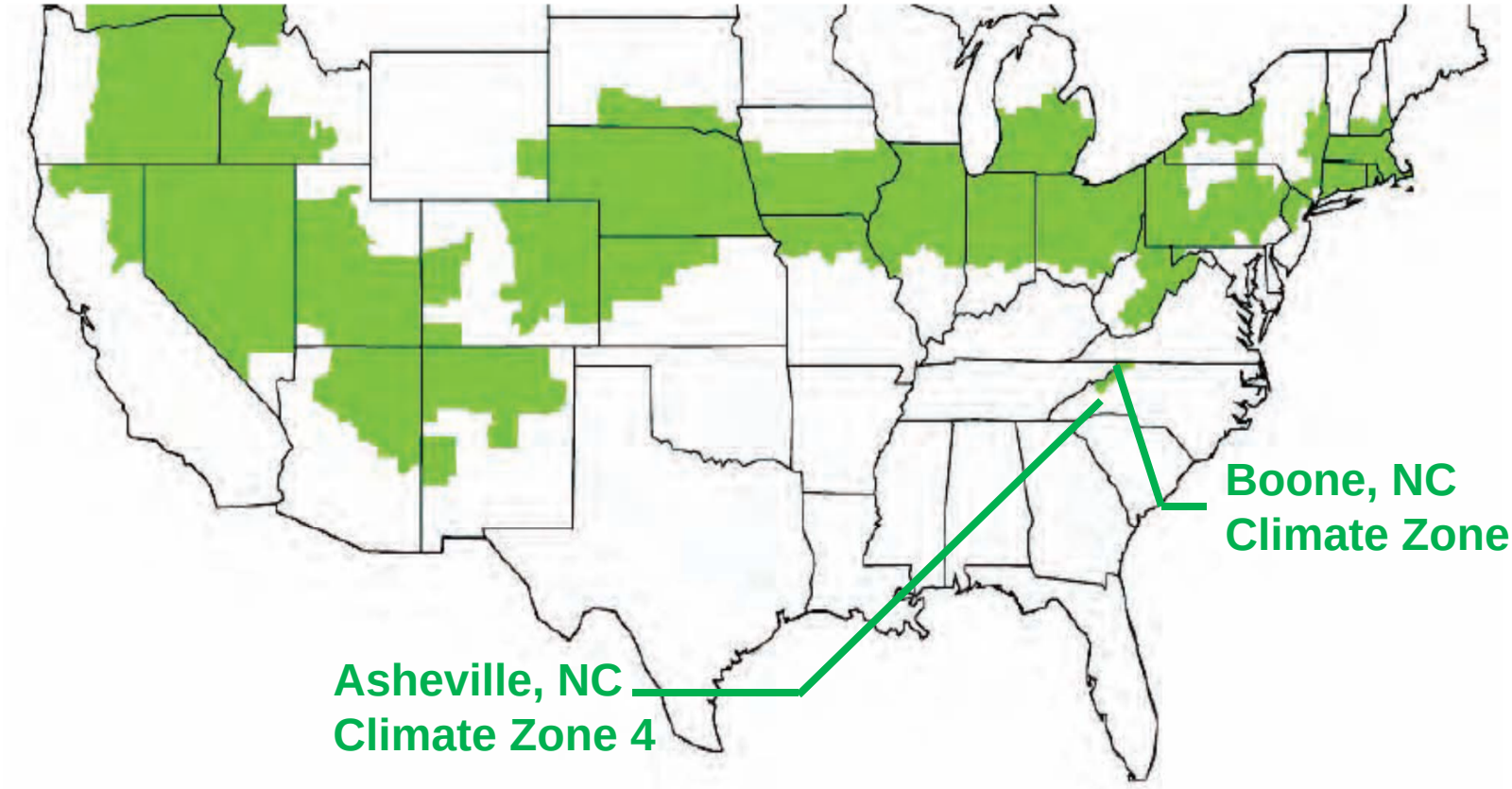

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Lessons Learned

What we don't know:

- Accuracy of plug and process load
  - Laundry Room
    - Washers
    - Dryers


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MAC GRAY
5
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Lessons Learned

What we don’t know:

- Disabling of lighting motion sensors

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Senate Bill 668 – A Case Study

Lessons Learned

Energy Model

- Students using building as scheduled and modeled
- Modeling and operation of lighting dual level switching
- Modeling and operation of occupancy sensors

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Lessons Learned

Energy Model

- Operation of building as modeled
  - Low delta T on chilled and hot water resulting in higher pumping energy
  - Accuracy of hot gas bypass in outside air unit modeling
  - Sequence of operation changes
  - Temperature set point changes

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Lessons Learned

Energy Model

- Value engineering changes
- Change orders during construction

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Lessons Learned

Energy Model

- Equipment changes or substitutions from the equipment specified to the equipment submitted to the equipment installed to how the equipment is operated

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Lessons Learned

Energy Model

- Remove plug and process loads from the model results
- Meter plug and process loads separately

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Plug and Process Loads

A standard two person dorm room could have the following:

2	Computers	2	Xbox, Wii, Playstation
2	Printers	?	Portable Electronics
2	Routers	2	Clock Radios
1	TV	1	Coffee Maker
1	Cable Box	1	Toaster Oven
1	Stereo	1	Circulating Fan
1	DVD Player	1	Strobe Light
1	Refrigerator	1	Black Light
1	Microwave	2	Task Lights


STROBE LIGHT
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GAME CONTROLLER
CIRCULATING FAN
Tide
SCO Conference 2012

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Lessons Learned

- The project is ongoing
- Commissioning is now complete
- Knowledge gained will be reinvested in future projects
- LEED Silver or Gold does not guarantee energy savings

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Question:

Are we saving energy?

Answer:

Yes!

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Are there energy savings compared to the energy model?

No.

Are there energy savings compared to similar buildings?

Yes!

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DOE Commercial Building Benchmarks – New Construction
Energy Use Intensities (EUIs) [kBtu/ft^2/yr]
October 2009

City	Miami	Houston	Phoenix	Atlanta	Los Angeles	Las Vegas	San Francisco	Baltimore	Albuquerque	Seattle	Chicago	Denver	Minneapolis	Helena	Duluth	Fairbanks	Benchmark Weighted Avg
Climate Zone	1A	2A	2b	3A	3B	3B	3C	4A	4B	4C	5A	5B	6A	6B	7	8	
Large Office	38	40	38	38	32	34	35	40	34	37	43	36	46	40	47	39	39
Medium Office	39	42	40	41	33	37	38	45	38	42	48	41	54	48	57	77	43
Small Office	44	44	43	41	33	39	35	46	41	42	51	45	57	51	61	83	45
Warehouse	30	19	19	18	14	18	15	21	20	18	24	23	29	27	33	52	21
Stand-alone Retail	62	63	60	61	44	56	50	72	61	65	81	69	93	83	104	145	69
Strip Mall	56	58	57	62	44	57	53	74	64	69	85	72	99	89	111	156	70
Primary School	57	57	55	55	46	52	51	61	54	54	65	58	75	66	79	113	60
Secondary School	56	57	55	57	42	54	50	68	58	61	76	64	89	77	97	141	66
Supermarket	158	167	159	170	153	158	166	184	168	181	195	179	208	197	223	266	179
Quick Service Restaurant	535	549	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	657	604	713	663	765	949	596
Full Service Restaurant	404	423	[illegible]	440	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	527	481	570	532	617	763	471
Hospital	145	147	138	142	137	135	142	148	127	[illegible]	148	130	153	137	155	185	145
Outpatient Facility	280	279	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	271	271	280	275	279	324	273
Small Hotel	71	71	69	71	62	68	64	75	70	69	80	74	87	80	92	112	73
Large Hotel	99	108	100	116	105	105	113	127	119	124	138	131	150	144	163	196	122
Mid-Rise Apartment	39	39	38	38	31	36	33	42	37	38	47	41	54	48	59	76	n/a

80 kBtu/ft2/yr

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U.S. Energy Information Administration

CONSUMPTION & EFFICIENCY

OVERVIEW DATA ANALYSIS & PROJECTIONS GLOSSARY ›

Home > Households, Buildings & Industry > Energy Efficiency > Commercial Buildings Energy Intensities > Table 5b

U.S. Commercial Buildings Energy Intensity

100 kBtu/ft2/yr

Released Date: December 2004
Page Last Modified: Jan 2007

Table 5b. U.S. Commercial Buildings Energy Intensity Using Site Energy [1] **by Census Region and Principal Building Activity, 1992-2003**
(Thousand Btu per Square Foot)

Principal Building Activity and Census Region	Survey Years			
	1992 [2]	**1995**	**1999**	**2003**
U.S. Total	80	91	85	91
Education	75	79	75	83
Food Sales	182	214	202	200
Food Service	206	245	241	258
Health Care	228	240	176	
Lodging	160	127	99	100
Mercantile and Service	71	76	83	
Office	96	97	90	93
Public Assembly	68	114	82	94
Public Order and Safety	110	97	87	116
Religious Worship	29	37	32	43
Warehouse and Storage	41	38	44	45
Other [3]	150	172	144	164
Vacant	28	21	16	21

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	1992	1995	1999	2003
Total Midwest	91	105	90	99
Education	82	87	79	86
Food Sales	194	Q	Q	219
Food Service	216	173	203	219
Health Care	290	309	167	206
Lodging	152	150	103	109
Mercantile and Service	77	101	81	97
Office	105	112	96	109
Public Assembly	86	113	79	102
Public Order and Safety	Q	99	Q	Q
Religious Worship	35	52	34	53
Warehouse and Storage	60	51	73	75
Other [3]	Q	Q	Q	Q
Vacant	38	Q	Q	Q

109 kBtu/ft2/yr

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Residence Hall Energy Use			
21 Buildings Analyzed			
	EUI (Energy Use Intensity)		
	Baseline (kBtu/SQ FT/yr)	Proposed (kBtu/SQ FT/yr)	Actual (kBtu/SQ FT/Yr)
Low	49	28	76
High	112	79	76
Mean	65	44	76
Average	71	46	76
Cone	**59**	**34**	**76**

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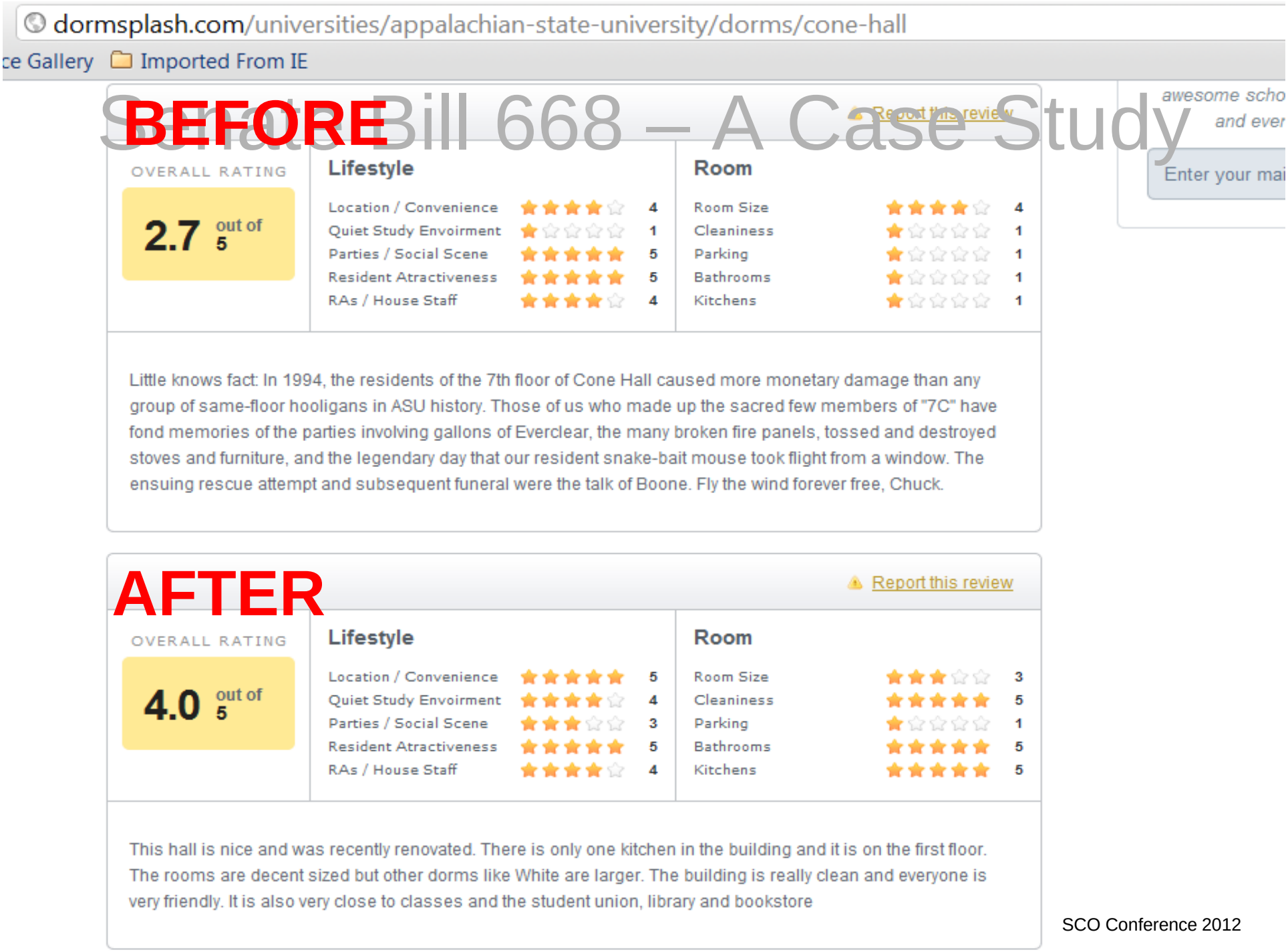
Question:

Was the project a success?

Yes!



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Thank You!

Questions?

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