Planning-Barriers-Solutions for Data Center Project Development

Better Buildings Summit
May 27-29, 2015

Lawrence Livermore National Laboratory (LLNL) Data Center Sustainability Master Plan

LLNL Data Center Consolidation Initiative

May 26, 2015

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LLNL Data Center Sustainability Master Plan

- LLNL Sitewide Sustainability Plan developed in 2009
- Data Center Achievements
  - DOE FEMP 2009 Energy Award
  - B453 LEED Gold Certified 2009
  - B451 LEED Silver Certified 2011
  - B112 Silicon Valley Leadership Group Recognition 2012
    - Lawrence Berkeley Laboratory
    - Romonet
    - Syska Hennessey
  - B112 Uptime Green IT Nominee 2013
  - Fed Tech Magazine Highlight 2013
  - DOE Sustainability Award 2015

Master Plan Core Competencies

- Benchmarking
- Computational fluid dynamics
- LEED certifications
- Consolidations
- Liquid cooling advances
- Innovative electrical and mechanical distribution
- Metering and sub-metering
- Lighting control systems
- Integrated control systems
- Lower power usage effectiveness (PUE)
- Power management systems

LLNL Sustainability Data Center Mission

Continue to develop projects to improve optimization of LLNL's data centers and reduce energy intensity

Data Center Consolidation Goals

- Increase efficiencies and decrease redundant labor support
- Reduce footprint, water usage and energy intensity site wide
- Reduce facility and network infrastructure
- Repurpose redundant equipment
- Clear out spaces that are not properly utilized
- Right size server maintenance contracts
- Standardize IT support model to “One Lab”
- Continue to virtualize services

- Address FY 2012 DOE Sustainability Requirements
  - Data Center: > 500SF and > 1 server
  - Fully meter by FY15 all enduring data centers
  - Obtain a LLNL site wide weighted average PUE of 1.4 by FY15
    - Consolidation provides $40M cost avoidance to achieve metering requirements

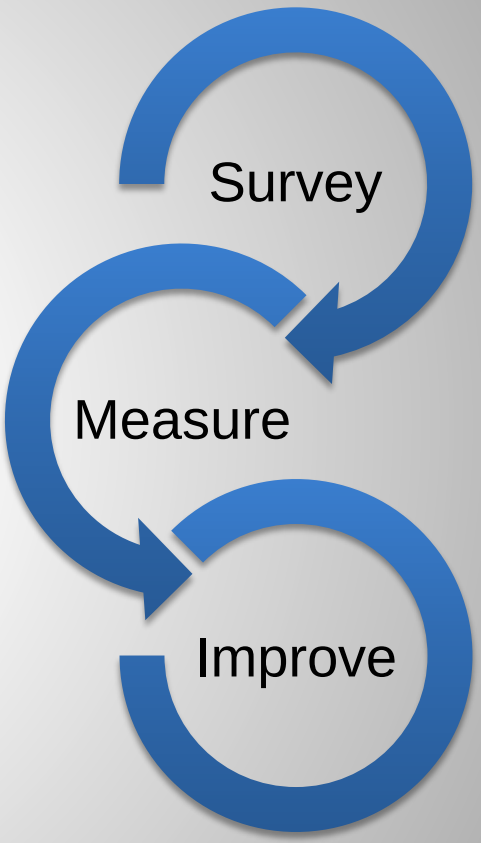
Site Wide Data Center Survey Results and Status

- Initial Condition - 61 rooms in 29 facilities identified and surveyed in one square mile
  - High Performance Computing (HPC)
    - 17 rooms
  - Enterprise Computing
    - 44 rooms

- 36 Rooms have been shutdown to date since 2011
  - Consolidated into enduring facilities
  - Virtualized various applications
  - Nearly 30K SF total space shutdown (Nearly 10K SF cold and dark and balanced repurposed)
  - Nearly $400K annual energy savings
  - Nearly $60K annual maintenance savings on cold and dark rooms
  - Over 500 servers consolidated into B-112 Enterprise Data Center
  - Achieved the site wide PUE of 1.4 Goal
  - Many metering and sub-metering projects underway

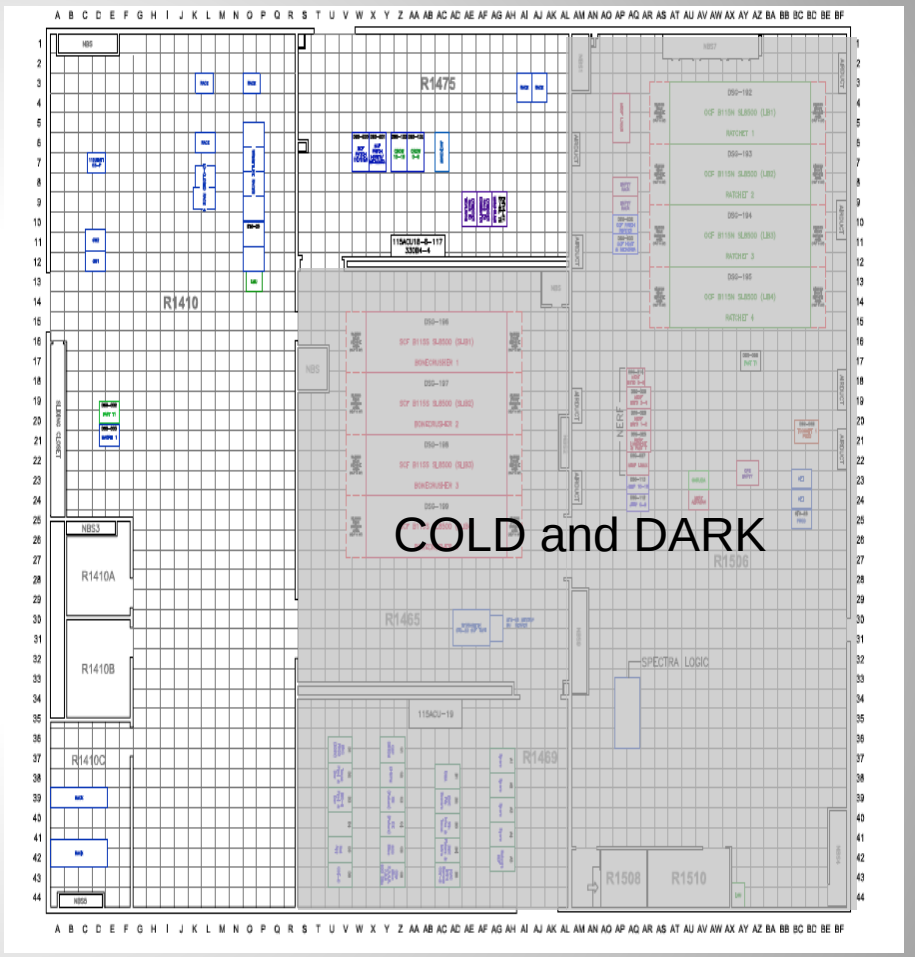
Added Benefits of Consolidation

- **Standardize:** Reduce labor costs resulting from fewer facilities and configurations
- **Virtualize:** Reduce costs for hardware, space and utilities
- **Software:** Reduce licensing costs for unused licenses
- **Hardware:** Better accountability of assets
- **Security:** Timely system patches
- **Best Practices from IT Community**
  - Reduce costs for paid vendor technical support
  - Reduce costs for training, especially with travel
- **Integrated Systems Management**
  - Reduce personnel costs
  - Lower utility costs
- **Vendor Financing (Managed Lifecycle and Leasing)**
  - Conserves expenditures by spreading purchase cost over time



FY 14 - FY15
Enterprise/HPC Data Center Consolidation Efforts

- B-115
  - HPC has outgrown facility and consolidated to other Livermore Computing facilities
  - Identified as enduring for Enterprise Computing until other more efficient facilities can be constructed
  - FY14
    - Repurposed equipment from closed data centers
  - FY15 Remainder of consolidation
    - Only two rooms will remain in service, others are now cold and dark



LLNL Data Center Consolidation Lessons Learned

Master Plan Core Competencies

- Benchmarking
- Computational fluid dynamics
- LEED certifications
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- Laboratory “Mission” comes first
- Understand the obstacles and challenges
- Develop a strategic vision
- Obtain senior management support
- Provide continual leadership
- Remain patient
- Stay focused
- Continue to survey, measure and improve

Successful Next Generation Data Center Sustainability Requires Continual Collaboration

- LLNL co-chairs the EEHPC Working Group
  - Drives implementation of energy conservation measures and energy efficient design in HPC through workshops, papers, subgroups and various focus areas with other national laboratories and industrial partners
    - Annual SC Workshop – SC15 with be the 6th Annual All Day Workshop
    - Papers
      - Energy Efficient High Performance Computing Power Measurement Methodology
      - Liquid Cooling Guidelines
      - General Recommendations for High Performance Computing Data Center Energy Management Dashboard Display
      - TUE Beyond PUE – A New Metric for Data Center Efficiency
      - ASHRAE TC 9.9 – 2011 – Thermal Guidelines for Liquid Cooling of Data Processing Environments
- October 2014 Green Grid Forum – Next Gen Data Centers and the Smart Grid
- November 2014 Silicon Valley Leadership Group Workshop – Future of HPC Centers and the Electric Grid
- January 2015 DOE/LLNL Better Building Challenge

DOE – Better Building Challenge Program

- With “Low hanging fruit” gone from consolidations, effort will evolve into a broader institutional phase under DOE’s Better Building Challenge program led by Doug East, LLNL CIO
  - Demand for computing grew over the past few decades resulting in small data centers around LLNL to meet programmatic needs, often located in closets or buildings with inefficient heating and cooling
- The Better Building Challenge is a partnership between LLNL and DOE
  - LLNL to reduce energy intensity of data centers by 20% within 10 years
  - DOE provides technical expertise, training and host of “best practices
- CIO Statement

  “Now we need to take a more institutional approach and to conduct an education campaign to show the advantages of consolidating into a professionally managed data center. Centralizing equipment in efficient data centers makes business sense and has the potential to save research programs money — resources that could be redirected to science.”

Questions

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Lawrence Livermore
National Laboratory

Planning-Barriers-Solutions for Data Center Project Development

A Tale of Two Centers

David G. Oshinski

Corporate Director of Construction

The Home Depot

May 27, 2015

Atlanta Location and Size

- 39,000 sq. floor out of a 1.7 million sq. ft. set of buildings

Austin Location and Size

- **120,000 sq. ft. building with offices and call center**
- **Data Center 53,000 sq. ft. of building**

ISSUES

Atlanta Store Support Center

- Cold air flowing 24/7
- Heat Exchanger not working
- Continually adding new equipment increasing energy load

Austin Data Center

- 15 year old air cooled units
- No backup system.
- Economizers not working
- Old R22 refrigerant in units

THE FIX

Re-Work Atlanta

- **Install Cold Aisle Containment**

- **Install Cold Aisle Containment**

REPAIR THE HEAT EXCHANGER

Re-Work Austin

- Decommission 19 DX Units

- Install One 800 Ton Water
- Cooled Chiller Tower

REPAIR ECONOMIZERS

Re-Work Austin

- Install Central Plant

- Install 3 Back-up
- 450 ton Air Cooled Chillers

BACKUP WILL BE N + 2

How We Did It

- Had Consultants do a Study
- Requested Funding From Leadership
- 2 Separate Projects, 2 Separate Requests
- Atlanta Went to Corporate Facilities
- Austin Went to IT

Expected Completion

- **Atlanta is complete, Except***

  ***We are always adding new equipment.**

- **Austin will be on line by the end of September 2015.**

- **Working through separate metering.**

We have seen significant savings in energy at Atlanta

Thank You

Planning, Barriers, Solutions for Data Center Project Development

DIGITAL REALTY
Data Center Solutions

9 June 2015

Table of contents

Digital Realty Overview (NYSE: DLR)
World's Largest Data Center REIT

- One of the 20 largest publicly-traded U.S. REITs(1)
- Equity market capitalization of approximately $9.2 billion(2)
- Diversified portfolio of properties and tenants, located in over 30 markets throughout North America, Europe, Asia and Australia(3)
  - 131 properties
  - 250+ suites (many totally discrete)
  - 24.6 million rentable square feet
    - Includes 1.3 million square feet of active development and 1.2 million square feet held for future development
- High quality tenant base – approximately 2,000 leases with 600+ tenants, including leading global companies across various industries
- Over a decade of experience providing data center solutions

1) U.S. REITs with RMZ. Source: companies' financials based on latest public filings. Based on equity market capitalization as of February 18, 2015
2) Based on closing common stock price of $67.58 as of February 18, 2015 and weighted average common stock and units outstanding as of December 31, 2014.
3) As od December 31, 2014. Includes investments in fourteen unconsolidated joint ventures.

Example clients
Trusted by leading organizations worldwide

ENTERPRISE

Atlantic Health System
Deutsche Bank
NetApp
pepsi
VISA
ARM
Cigna
JPMorganChase

COLOCATION & CLOUD, MSPS AND SYSTEMS INTEGRATORS

Capgemini
CONSULTING. TECHNOLOGY. OUTSOURCING
EQUINIX
rackspace HOSTING
TelecityGroup
where content meets connectivity
CenturyLink
GOGRID
IBM
SINGLEHOP

NETWORK PROVIDERS

at&t
BT
TATA
TATA COMMUNICATIONS
Bouygues Telecom
NTT Communications
verizon

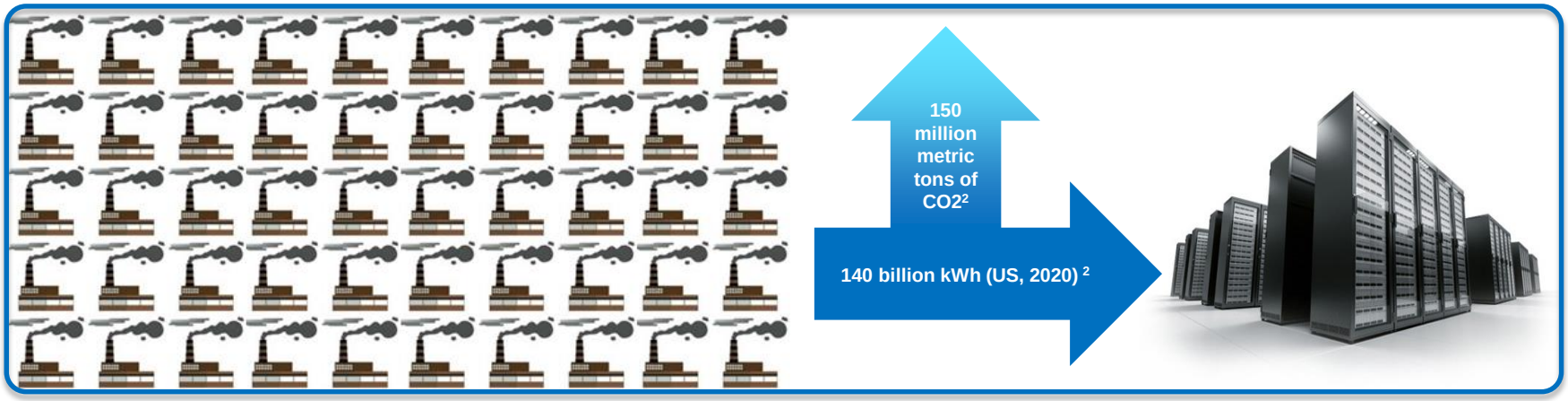
Example clients
Trusted by leading organizations worldwide

ENTERPRISE

COLOCATION & CLOUD, MSPS AND SYSTEMS INTEGRATORS

Drivers of Sustainability
Industry Impact

- If worldwide data centers were a country, they would be the globe's 12th largest consumer of electricity, ranking between Spain and Italy(1)
- U.S. data centers could slash electricity consumption by as much as 40 percent and save $3.8 billion if half of the savings potential from adopting energy efficiency best practices were realized.(3)



1. DCD Intelligence Report, Powering the Data Center, April 2013, http://www.dcd-intelligence.com/Products-Services/Powering-the-Datacenter.
2. National Resources Defense Council, Data Center Efficiency Assessment Issue Brief, August 2014
3. E.R. Masanet et al., "Estimating the Energy Use and Efficiency Potential of U.S. Data Centers," Proceedings of the IEEE 99, No. 8 (August 2011): 1440-1453.

Clean Start
Clean Start℠ Program

- Clean energy certificate purchasing program
- Reduces carbon footprint of client data centers
- Providing clients clean energy for 12 months at no incremental cost over the cost of traditional non-renewable energy.
- Digital will provide renewable energy certificates (RECs) or their equivalent commensurate with the electricity consumed by the client for 12 months following the commencement of a qualified lease.
- Each REC represents 1 megawatt hour of power generated from renewable sources.
- Exploring portfolio-scale opportunities to reduce carbon emissions and improve energy efficiency

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Better Buildings Data Center Challenge

Better Buildings Challenge
Overview

- How is Digital involved?
  - Digital has publically committed to reduce our “non-IT energy intensity”, within a 20MW sub-portfolio of properties, by 20% over 10 years.

Total kW	PUE	IT kW	Non-IT kW	20% of Non-IT kW	20% Reduction Equivalent kWh	20% Reduction Annual kWh Goal	20% Reduction Annual kW Goal
20,000	1.50	13,333	6,667	1,333	11,680,000	1,168,000	133
	2.00	10,000	10,000	2,000	17,520,000	1,752,000	200
	2.50	8,000	12,000	2,400	21,024,000	2,102,400	240
	3.00	6,667	13,333	2,667	23,360,000	2,336,000	267

  - Digital is one of (20) initial program participants.
    - (13) Public and Federal Data Centers + (7) Private Data Centers
    - Total initial program pledge = 90MW
      - DLR is approx. 22% of total initial commitment.

Planning, Barriers, Solutions

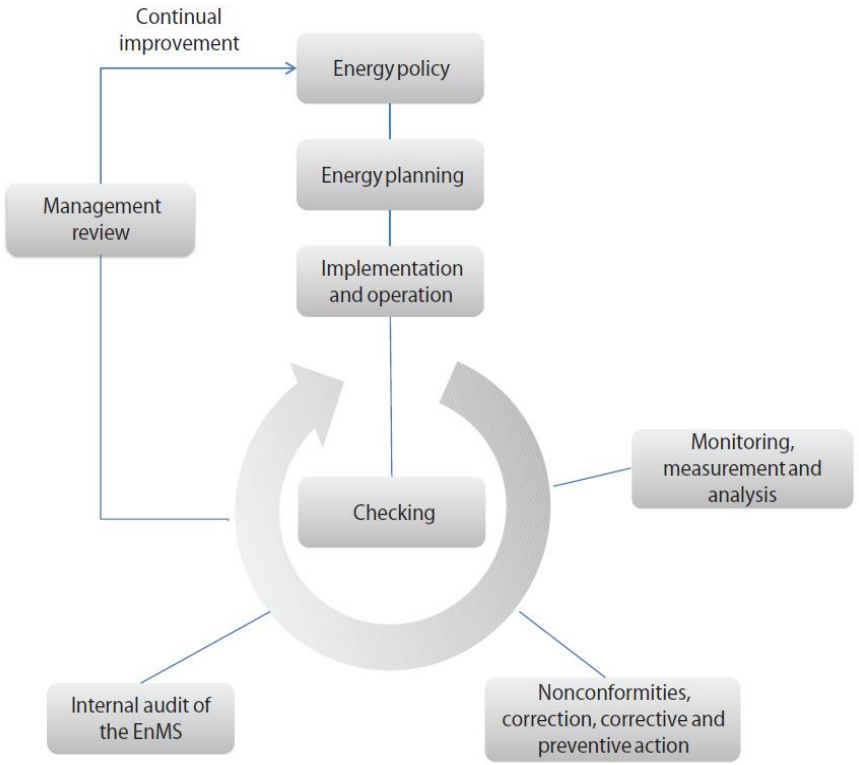
Energy Management
Program Overview – Process (ISO 50001)

1) **Plan:** Conduct the energy review and establish the baseline, key performance indicators (KPI's), objectives, targets and action plans necessary to deliver results that will improve energy performance in accordance with the customer's and/or organization's objectives.

2) **Do:** Implement the energy management action plan(s).

3) **Check:** Monitor and measure processes and the key characteristics of operations that determine energy performance against the energy objectives, and report the results.

4) **Act:** Take actions to continually improve energy performance and the overall Energy Management Program.



Energy Management
Planning

- Low/no cost ECO's – Air and tile management, raising set points, etc.
  - Assess risk
- 2015-2019 Capital Projects with attractive ECO potential
  - Financial modeling for both ROI and IRR.
- Attractive utility rebate and incentive availability
- Customer engagement/interest and support
- Current or planned connectivity with Digital's DCIM tool: Envision
- Cross function buy-in; Customer/IT, Asset Management, Technical Operations, Property Management, Legal, etc.

Planning, Barriers, Solutions
Barriers

- Utility pass-through
  - Most of Digital's customers pay 100% of their utility consumption
    - Why Invest in energy upgrades if Digital doesn't see a benefit?
      - Support customers with in-house energy expertise (whose core business is IT/compute and not data center facilities)
      - Varying financial models for energy conservation opportunities
- Light speed growth
  - Some customers literally can't grow fast enough. Energy takes a back seat to growth (and reliability).
- SLA's
  - Legacy SLA's (ASHRAE 2008 Recommended)
    - Narrow temperature and humidity bands – not much wiggle room. Needs to change to facilitate improved efficiency.
- Resource availability and prioritization – i.e. lack of manpower.
- Cultural Challenges
  - High awareness, Low implementation
    - "I understand the idea and potential benefits of Energy Management, but…."
- Raising temps reduces thermal ride through and increases risk. (True? How is this assessed?)
  - Newer IT equipment specs, ASHRAE X-factor, temperature excursions, current air management, etc
- Who pays for it?

Planning, Barriers, Solutions
Solutions

- You can't manage what you don't measure……i.e. **Data**…..more is better
  - Gather baseline energy consumption data
  - Understand how and where data is taken and recorded
    - Instantaneous monthly kW values
    - Dedicated vs. Shared infrastructure
      - i.e. accounting for chiller plant energy consumption

- Re-aligning legacy designs to accommodate customer IT deployments
  - Average UPS utilization is approx. 35%
  - Tuning Data Center Mechanical Infrastructure to more closely match IT loads.

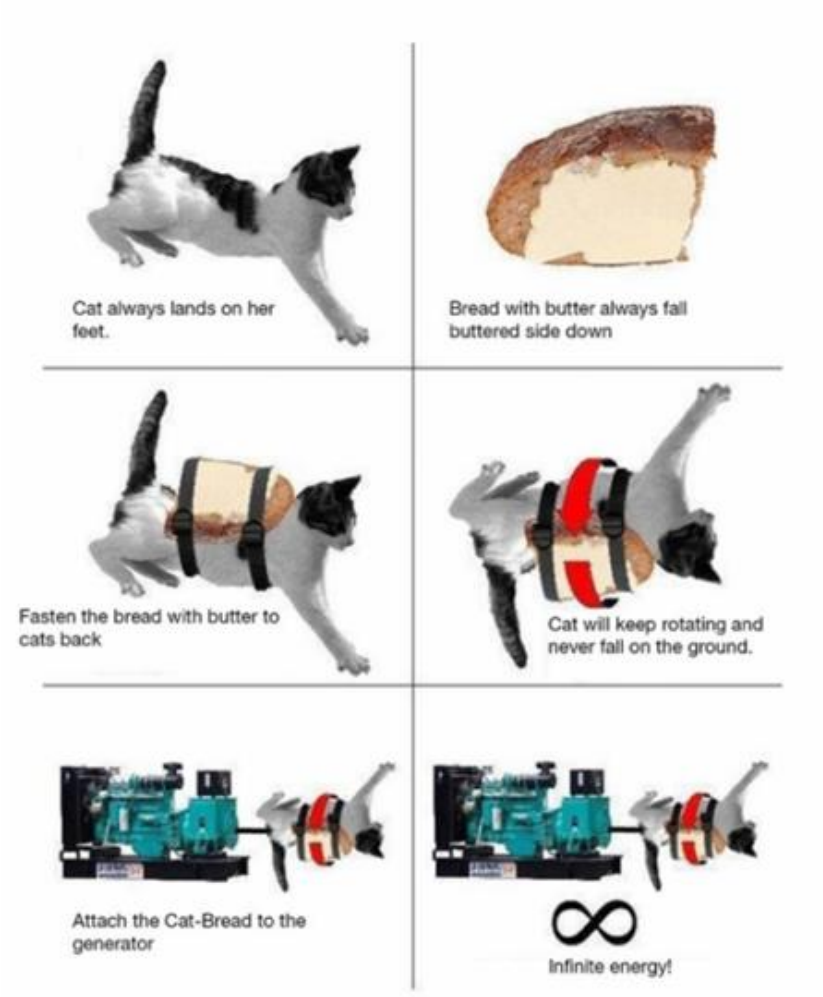
- SLA amendments
  - Moving from 2008 recommended to 2011 recommended and allowable (and beyond).

Planning, Barriers, Solutions
Solutions

- Evaluate opportunities and limitations as they relate to business and customer needs.
  - Identify, Analyze, Prioritize, Implement (Practically)

- Educate, empower and reward individuals
  - Accountability

Planning, Barriers, Solutions
Solutions



Example Life Cycle Analysis

Example Life Cycle Analysis
Air Cooled Chiller Replacements

EXISTING CONDITIONS

- Air Cooled chillers at end of life (15-20yrs)
- Pit application resulting in high levels of recirculation air = equipment deration.
- Legacy site with 42°F Chilled water supply (+30% glycol).
- Adjacent to residential (sound constraints)
- High water costs

ANALYSIS

- Define life cycle (15 yrs)
- Determine cost of capital (hurdle rate)
- Research incentives/rebates
- Define Schedule (seasonal implications)
  - Equipment lead times
- Evaluate replacement options
  - Water cooled
  - Economizers
- Build energy models (bin data)
- Calculate Life Cycle and IRR

Example Life Cycle Analysis
Air Cooled Chiller Replacement

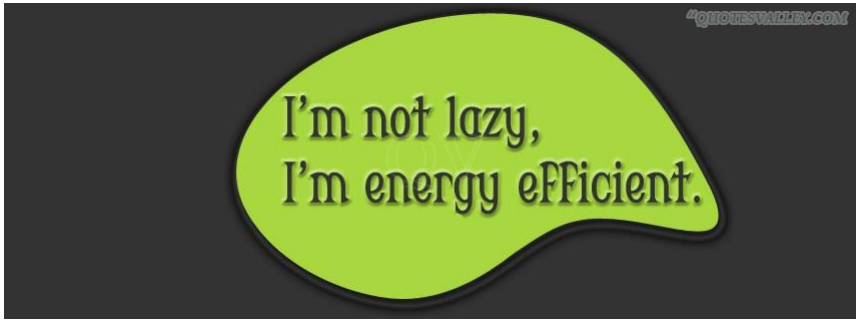
Systems	CHW Operating Temps	Investment Differential	Annual OM&R	Annual Water	Annual Elec. Energy	(N)PV Life Cycle	IRR	SIR	Simple Payback
	(°F)	($)	($)	($)	($)	($)			(years)
Baseline	42/54	Base	$10,000	n/a	$807,676	$8,631,058	Base	Base	Base
Trane high efficiency air cooled chiller	48/60				$758,462	$8,205,746			
Alternative 1A	42/54	+ $43,400	$45,500	n/a	$647,961	$7,564,204	368.0%	25.6	0.3
Daikin high efficiency VFD air cooled chiller	48/60				$579,569	$6,973,156	412.0%	29.4	0.2
Alternative 1B	42/54	+ $14,000	$45,500	n/a	$760,610	$8,508,325	336.0%	9.8	0.3
York high efficiency VFD air cooled chiller	48/60				$671,831	$7,741,091	619.0%	34.2	0.2
Alternative 2	42/54	+ $2,285,047	$47,600	n/a	$666,732	$9,984,044	-1.0%	0.4	17.2
Motivaire high efficiency air cooled chiller with integral free cooling coil	48/60				$586,783	$9,293,119	2.0%	0.5	13.3
Alternative 3	42/54	+ $805,000	$49,000	$29,950	$628,616	$8,185,245	21.0%	1.3	5.3
Liebert AFC air cooled chiller with integral economizer coil and adiabatic pre-cooling	48/60			$32,206	$581,740	$7,780,139	21.0%	1.5	4.6
Alternative 4	42/54	+ $1,197,000	$20,000	n/a	$672,612	$8,736,885	7.0%	0.9	8.9
Trane high efficiency air cooled chiller with integral economizer coil	48/60				$557,838	$7,738,095	15.0%	1.4	5.9

Notes:

1. SIR (Savings to Investment Ratio): SIR lower than one is not cost effective.
2. An annual escalation rate was assumed at 2%.
3. NPV assumed a discount rate of xx%.
4. The net present value (NPV) is the value (the gain minus the cost) of an investment in today's dollars over some specified time period. If the investment has a positive NPV, it is generally considered beneficial.
5. The internal rate of return (IRR) is the annual yield from a project, usually expressed as a percentage of the total amount invested; the compound rate of interest which, when used to discount cash flows, will result in zero net savings. If the IRR is greater than the investor's stated discount rate, the measure is considered beneficial.

Value Add:

- Rebate/incentive cost offsets
- Help reduce customers annual OpEx
- DLR Opportunity COst
- Help reduce DLR annual OpEx
  - Increase NOI
  - Net Value Creation
- Reduce stranded cooling capacity
- Reduce maintenance costs
- Keep competitive advantage
- Improve corporate carbon footprint



DIGITAL REALTY
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