GovEnergy
www.govenergy.gov
The Premier Energy Training Workshop and Trade Show for Federal Agencies

A River of Energy Solutions

Designing Laboratories for Conservation, Sustainability & Efficiency

Session 1: Specialty Buildings Track

HDR

Agenda

- Introduction
- Building Typology
  - Laboratory Characteristics and Environmental Demands
- Key Guidelines & Requirements
  - Federal & Other
- Laboratory Solutions
- Case Studies
  - Brookhaven, USAMRIID & Georgia Tech
- The Future
- Q&A

Opportunity

'With Great Power Comes Great Responsibility…'

-Ben Parker, Peter Parker's uncle

-Author Stan Lee

Because Laboratories inherently require so much energy and many resources, they provide the greatest opportunity to become sustainable

GovEnergy
www.govenergy.gov

Building Typology: Laboratory

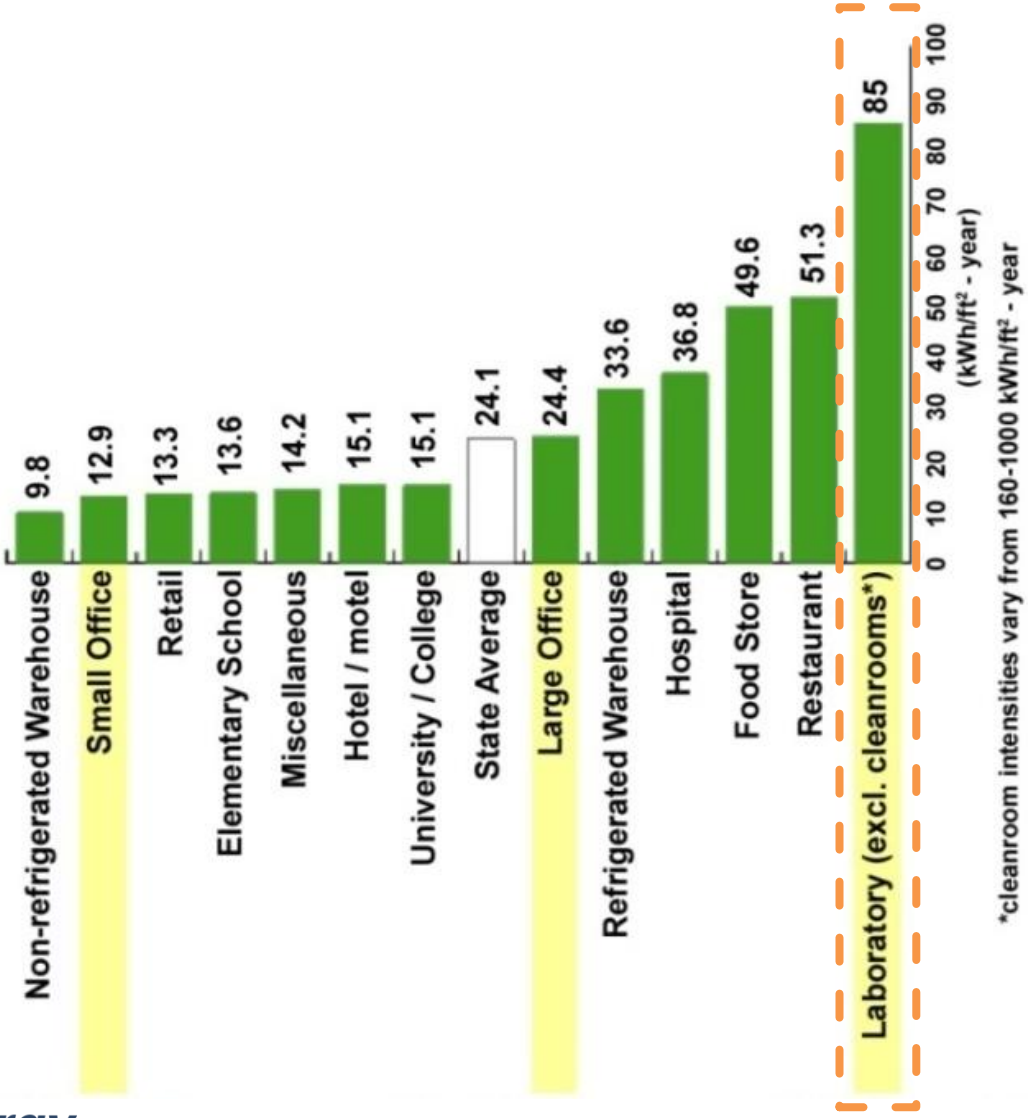
Laboratories are Inherently Energy Hogs

- Typical Laboratories use 4 >10 times as much energy and water as an office building
- Specialty Laboratories can use significantly more energy and water as an office building.
- One 6 foot fume hood consumes as much energy annually as a 2,500 square foot home.
- The rigors of scientific research often limit sustainable material selections that better utilize natural resources.

It is our responsibility to minimize Laboratory Facility impact on the environment while providing a safe, effective research atmosphere.

GovEnergy
www.govenergy.gov

Building Typology: Laboratory



GovEnergy
www.govenergy.gov

Building Typology: Laboratory

4 Main Laboratory Types:

- ***Life Science*** – Biomedical Research Facilities composed of biology laboratory, heavy vivarium & administrative functions
- ***Chemical*** – Scientific Research Facilities dominated by chemical use composed of laboratory, vivarium & administrative functions
- ***Physical Science*** – Nanotechnology, Physics and Particle Science Research Facilities, composed of laboratory, clean room & administrative functions
- ***Electronic*** – Software and Electronics Research Facilities, composed of bench electronics labs, clean rooms & administrative functions.

Building Typology: Environmental Demand

	Heat/Cool	Electricity	Water	Materials
Life Science	4	3	5	5
Chemistry	5	4	3	5
Physical Science	3	4	2	3
Electronic	3	4	2	3
Office Building	1	1	1	1

Scale:	1	2	3	4	5

Least → Greatest

GovEnergy
www.govenergy.gov

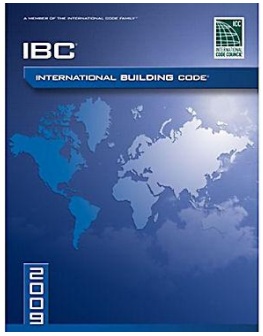
Current Guidance

LABS FOR THE 21ST CENTURY®

LEED
LEADERSHIP IN ENERGY & ENVIRONMENTAL DESIGN

GSA U.S. General Services Administration

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy



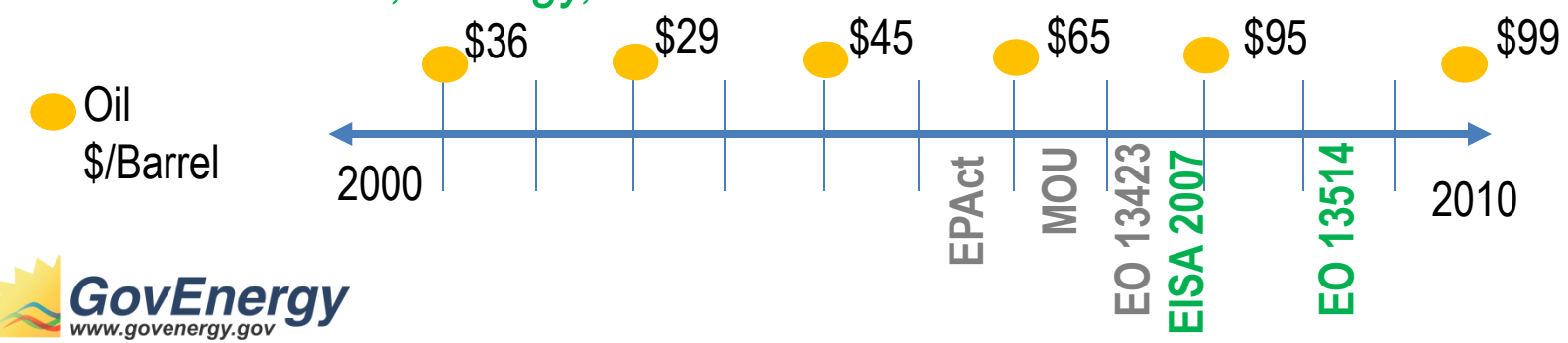
ASHRAE
Advancing HVAC&R to serve humanity and promote a sustainable world

Current legislation & guidance proactively addresses the built environment, anticipating environmental climate change.

Key Federal Guidelines: History

Federal Mandates for Sustainability

- **EPAct** Energy Policy Act of 2005
- **EO 13423** Executive Order 13423, Strengthening Federal Environmental, Energy, and Transportation Management of 2007
- **MOU** Memorandum of Understanding, Federal Leadership in High Performance and Sustainable Buildings, January 2006
- ***EISA 2007*** *Energy Independence and Security Act of 2007*
- ***EO 13514*** *Executive Order 13514, Federal Leadership in Environmental, Energy, and Economic Performance*



GovEnergy
www.govenergy.gov

EISA 2007 Relevance to Laboratories

Energy Reduction Goals for Federal Buildings

- Energy Reduction Goals from the 2003 baseline:
  - 18% / 2011
  - 21% / 2012
  - 24% / 2013
  - 30% / 2015

Why Does this Matter?

- Laboratory system design requirements can constrain solutions that maximize energy reduction goals:
  - ventilation
  - pressurization
  - zoning
  - IHS

Aligns with AIA 2030 Challenge & Living Building Challenge goals

GovEnergy
www.govenergy.gov

EISA 2007 Relevance to Laboratories

Performance Standards for New Building & Major Renovation

- Fossil fuel generated energy consumption reduced from the 2003 baseline:
  - 65% / 2015
  - 80% / 2020
  - 90% / 2025
  - 100% / 2030
- 30% of hot water demand provided from solar energy
- Technology Incentives include LED Lighting & Geothermal Heat Pumps

Why Does this Matter?

- Regional Energy Opportunities not always aligned with Scientific Hubs
  - Solar power in the southwest; biodefense initiatives central to DC
  - Encourages the Scientific community to push innovative solutions where research is not compromised

GovEnergy
www.govenergy.gov

EISA 2007 Relevance to Laboratories

Facility Management/Benchmarking & Metering

- Full commissioning and benchmarking of the building & key equipment
- Metering all utilities required by October 2016
- Funding flexibility allows Agencies to pursue any source of funding

High Performance Buildings

- Federal Green Building Performance - Comply with OMB scorecard

Why Does this Matter?

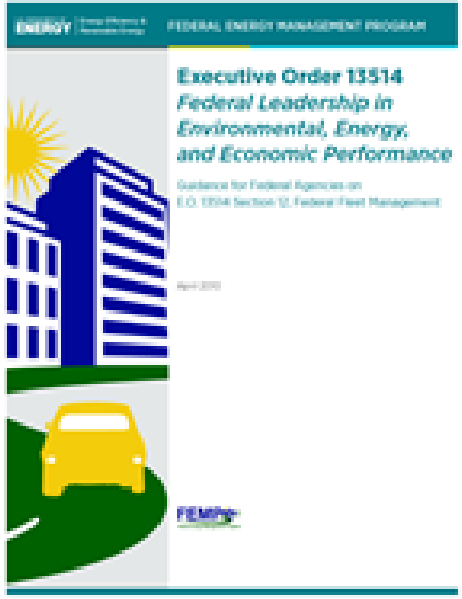
- Verify & monitor performance
  - Integral & Inherent to Laboratory Best Practices

GovEnergy
www.govenergy.gov

EO 13514 2009 Relevance to Laboratories

Key Take-Aways:

- Reduce Potable, Industrial & Landscaping Water Consumption 26% by 2020
- Implement High Performance Sustainable Federal Design Standards in 15% of Agency buildings by 2015; 100% of design by 2020.
- Align with local planning for renewable energy
- Include energy impacts in EIS documentation



Why Does this Matter?

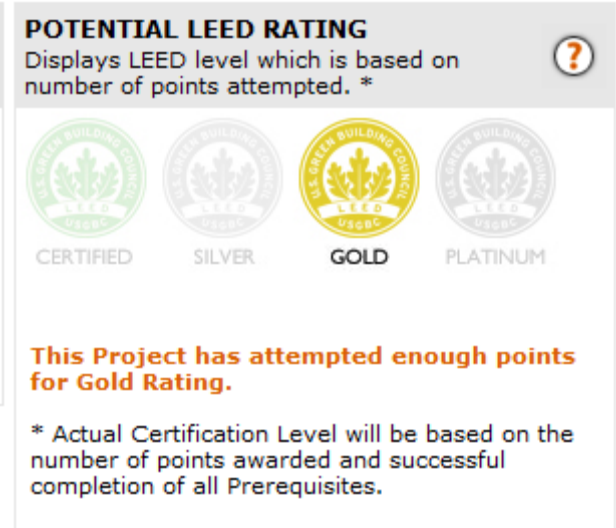
- Ups the ante with aggressive timelines and expectations
- Requires greater front end thought & solutions as to building system design

GovEnergy
www.govenergy.gov

Other Key Guidelines: LEED

- Leadership in Energy and Environmental Design (LEED) is an internationally recognized green building certification system developed by the U.S. Green Building Council (USGBC); March 2000
- LEED promotes sustainable building and development practices; aligned with the Federal requirements.
- A ***broader reach*** to elements considered sustainable and creates a ***holistic approach*** not just to energy but also environmental impact.

There is no specific category for Laboratories which are typically submitted under New Construction or Existing Buildings



How Does LEED Challenge Lab Design?

Category	Challenge
Sustainable Sites	Greater reliance on design solution to capture points and meet project goal
Water Efficiency	Greater Consumption = Greater Opportunity
Energy & Atmosphere	Design requirements such as pressurization create innovative system configurations
Materials & Resources	Opportunity to develop new materials which meet scientific requirements
Indoor Air Quality	Labs inherently excel as result of 100% exhaust requirements
Innovation & Design Process	Significant points possible above current limit

Other Key Guidelines: Labs 21

Labs21® is a **voluntary partnership program** dedicated to improving the **environmental performance** of U.S. laboratories.

Over a decade, Labs 21 has been a Leader in the Safe, Sustainable, Functional, Energy Efficient design and operation of Laboratories.

Aligned with the USGBC LEED process & implemented Environmental Performance Criteria (EPC) 2.2 :

Provides additional key guidance in:

- Water Efficiency
- Energy & Atmosphere
- Materials & Resources
- Indoor Environmental Quality

LABS FOR THE 21ST CENTURY

labs for the 21st century

Laboratory Solutions

Heat/Cool

Energy Drivers	Employed Techniques
Ventilation	Air to Air Heat Recovery
	Customized Delivery of Heating & Cooling
	Ventilation Optimization; VAV Fumehoods
	Eliminate Simultaneous Heat/Cool

Energy Drivers	Employed Techniques
Space Load	Energy Star Rated Equipment
	Local Capture of Heat
	Direct or Customized Delivery of Heating & Cooling

Energy Drivers	Employed Techniques
Exterior Envelope	Transmission Reduction; Insulated Envelope
	Glass Shading Coefficient
	Passive Solar Gain & Daylighting

Laboratory Solutions

Electricity

Energy Drivers	Employed Techniques
MEP Systems	Equipment Selection & Systems Configuration
	High Efficiency Motors
	Equipment & Systems Control

Energy Drivers	Employed Techniques
Lab Equipment & Lighting	Energy Star Rated Equipment
	Daylighting, Task Lighting & Occupancy Based Controls

Energy Drivers	Employed Techniques
Source Generation	Photovoltaics
	Green Power Suppliers; Wind & Solar
	Cogen

GovEnergy
www.govenergy.gov

Laboratory Solutions

Water

Energy Drivers	Employed Techniques
Site	Landscaping & Stormwater solutions that naturally process stormwater & avoid irrigation

Energy Drivers	Employed Techniques
Administrative	Low Flow Fixtures & Waterless urinals
	Gray water systems; user specific

Energy Drivers	Employed Techniques
Scientific/Process	Low Flow Fixtures
	Low Flow & Managed Scientific Equipment
	Multiple cooling loops employ closed loop systems
	Cascading use from lab equipment to other

Laboratory Solutions

Materials

Energy Drivers	Employed Techniques
Sourcing	Renewable & Recyclable Materials
	Local & Regional Selection

Energy Drivers	Employed Techniques
Installation	No/Low VOC offgasing

Energy Drivers	Employed Techniques
Selection	Maximize material choices in non-laboratory spaces
	Consider alternative materials as appropriate
	Reuse strategies

Case Studies

Brookhaven National Labs, DOE

- Center for Functional Nano-materials (BNL CFN), Upton, NY

U. S. Army Medical Institutes of Infectious Diseases (USAMRIID)

- Biomedical Research Laboratory, Ft. Detrick, MD

Georgia Institute of Technology,

- Carbon-Neutral Energy Solutions Laboratory, Atlanta, GA

Case Study 1: Brookhaven

Center for Functional Nano-materials (BNL CFN)

- 88,000 gSF Energy Related Interdisciplinary Science, 1 of 5 National Nano-material Centers.
- $38.5M Construction Cost
- Scientific Focus on Nanoscale Research
- Achieved LEED Silver certification

Case Study 1: Brookhaven

Key Program Elements:

- Advanced Microscopy & Photo-emission Spectrometry
- Large Flexible Labs, Diverse Chemical & Physical Research (Wet, Dry & Analytical)
- Ultra-Low Vibration labs with isolated structure & Pneumatic vibration isolation
- Clean Rooms

Case Study 1: Brookhaven Results

- **Air-side Energy Recovery** (single stage) via Run-around Loop: 28-30% by overall BTU, 17,8% by $
- **Radiant cooling** walls reducing ventilation energy
- Large Flexible Labs **with VAV laboratory exhaust** = real-time flow reduction
- **Envelope & Daylighting** modeling for quality of life and lighting energy conservation: 77% of functional space has >2% daylighting

GovEnergy
www.govenergy.gov

Case Study 1: Brookhaven Results

- "**Brownfield"** site & 23% of 10 acre parcel preserved from development for next 40 years
- Retained more than 85% as **Open Space**
- Employs Stormwater on-site quantity & quality treatment with **Biofiltration basin**
- Water use reduction 47% over EPACT 1992 baseline with **waterless urinals & low flow fixtures**

- 27% of materials by cost were **regionally extracted and manufactured;** 10% of materials were **recycled**
- LEED Innovation credit for Exemplary Performance

Case Study 1: Brookhaven Lessons Learned Opportunities

- **Why not Gold?**
  - Federal Guidelines and funding changed dramatically during project design and construction. Project success was proactively defined as LEED Silver.
  - Funding drove LEED success. ***Value Engineering had significant impact on heat recovery and AHU strategies.***
- Moving forward Brookhaven has incorporated DOE expectations proactively, aligning funding & design to achieve LEED Gold.

Case Study 2: USAMRIID

U.S. Army Medical Institutes of Infectious Diseases (USAMRIID)

- 865,000 gSF Nation's newest and largest high containment research facility designing treatments for the world's most dangerous Infectious Diseases
- $680M Construction Cost
- Biomedical Research Facility
- Currently tracking LEED Gold (v2.2) during Construction

Case Study 2: USAMRIID

Key Program Elements:

- Biocontainment (A)BSL-2, 3E & 4 focused on Vaccine and Therapeutic discovery
- Virology & Bacteriology Biology Labs
- Unique Medicinal Chemistry, clean room and NMR components
- Large & Small Animal Vivarium with transgenic, barrier, aerobiology, imaging and telemetry
- Administrative & Office to support over 950 researchers & support staff

Case Study 2: USAMRIID Results

- **Solar Thermal** resulted in 75%reduction of domestic & BSL-2 lab hot water
- **Flash Steam Recovery** saving 6.3% of MPS
- **Multi-layer energy recovery system** AHU with VFD cascading recovery at dual duct = 65% savings
- **CVRH to Dual Duct** eliminated simultaneous heating & cooling

- **Daylighting Control** & Manual Override in Labs
- BSL-2 & Administration **60% daylighting & views**; resulted in 6% reduction in lighting from baseline
- **Cooling Energy Savings** resulted in 2.5MW

GovEnergy
www.govenergy.gov

Case Study 2: USAMRIID Results

- Customized Approach to **Process/Laboratory Equipment Cooling**
- Process Equipment **water reutilized** in cooling tower to eliminate process water to drain
- Water Saving features on **Vivarium Equipment**
- **Low Flow Fixtures** in Administration & Labs
- Water efficient landscaping with **no irrigation**

- **Exterior material selection**, including white roof resulted in significant energy reduction
- **Rubber Flooring** in BSL-2 Laboratories
- Currently 30% of materials are **recycled content** & **20% regional material** sourced

GovEnergy
www.govenergy.gov

Case Study 2: USAMRIID Lessons Learned Opportunities

- Lost Opportunity for **Lighting Pollution Reduction Credit** as result of site security lighting requirements that could be gained with a campus wide lighting masterplan
- Rethink **Innovative Wastewater Technologies**
- Existing CUP prohibited **on-site generation** through photovoltaics or other; potential 1-3 credits
- Potential innovation credit; **LED or high performance lighting** in vivariums and labs.
- **Increase recycled content** considered

Case Study 3: Georgia Tech

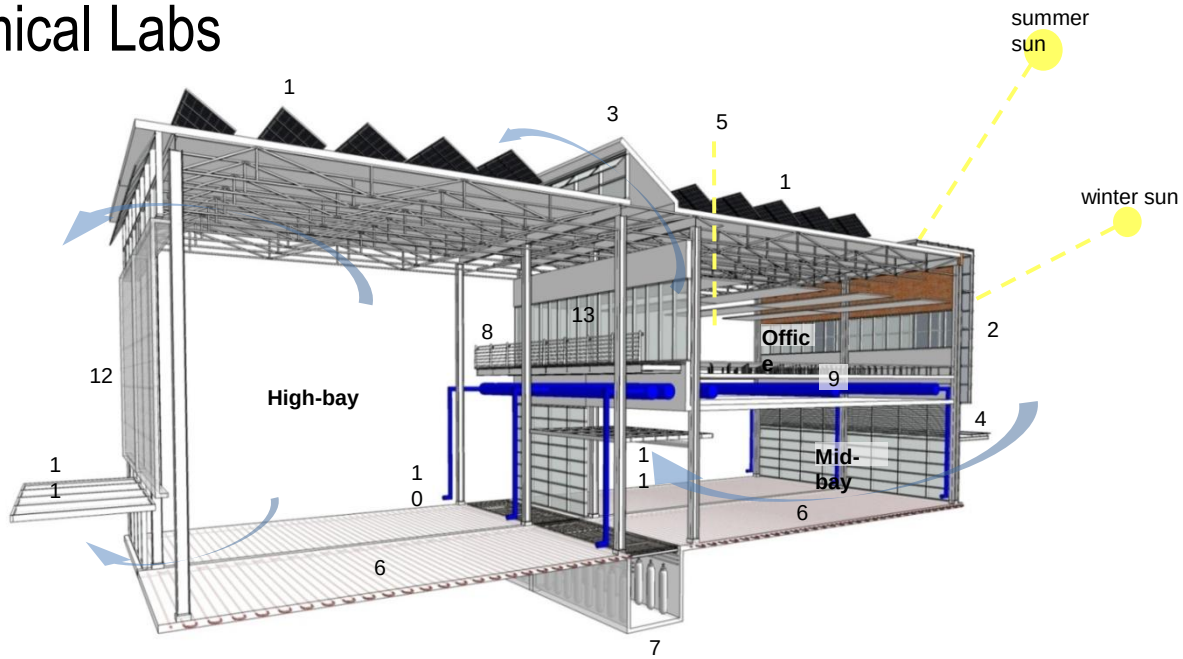
Carbon-Neutral Energy Solutions Laboratory

- 35,000 gSF Energy Solutions Laboratory
- $23.5M Construction Cost
- Combustion, Gasification & CO2 Capture Research
- Currently tracking LEED Platinum during Construction
- **"Carbon Neutral" Zero Energy Building (ZEB) was the primary project goal**

Case Study 3: Georgia Tech

Key Program Elements:

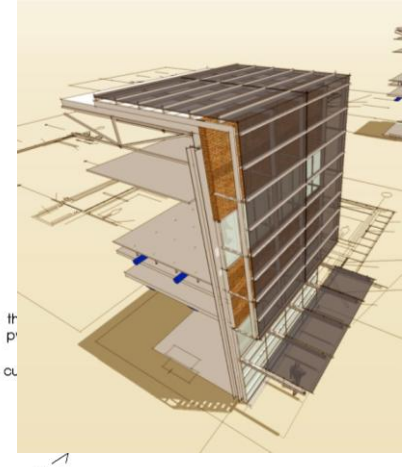
- Flexible Industrial High-Bay Lab
- Refined Mid-Bay Labs with individual environmental control
- High Pressure Fuel Research (1,000 psi) with High Exhaust
- Combustion & Chemical Labs

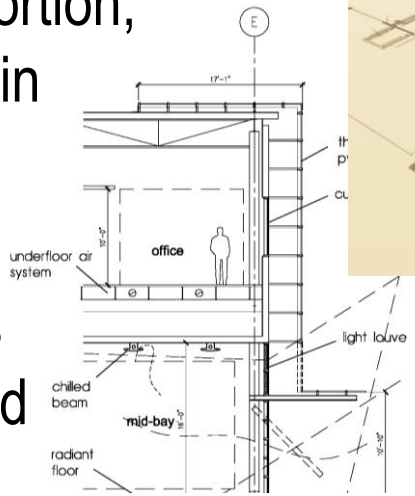


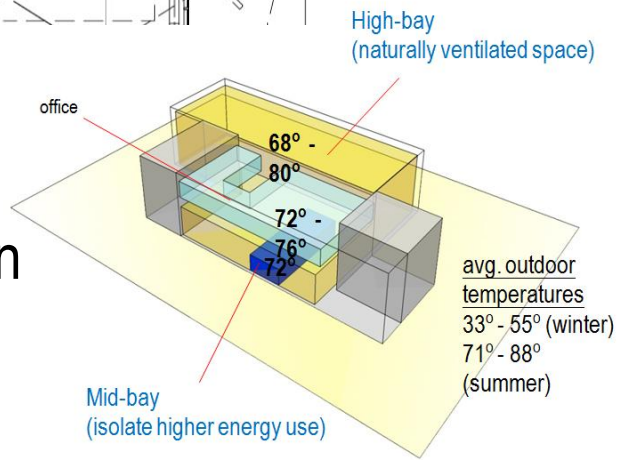
Case Study 3: Georgia Tech

How ZEB drove the design?

- **Physical Attributes:** Orientation, Proportion, Shape & Exterior solution that resulted in extremely efficient envelope layout
- **Program Alignment**: Segregation of elements ganged environmental pieces together & isolated the most constrained elements
- **System Innovations**: Holistic approach to design created a balanced effort between energy reduction and renewable generation







GovEnergy
www.govenergy.gov

Case Study 3: Georgia Tech Results

- 147 tons of **CO2 saved** annually
- **Forced Natural Ventilation** in high-bay
- Optimized **Air Change Rates** in Labs, **Point of Use Exhaust**

- **Collect 367 MWh/yr production** through PV panel
- 32% annual lighting energy use reduction through **Daylighting, LED task lighting and lighting control**
- North side **Kalwall**

Case Study 3: Georgia Tech Results

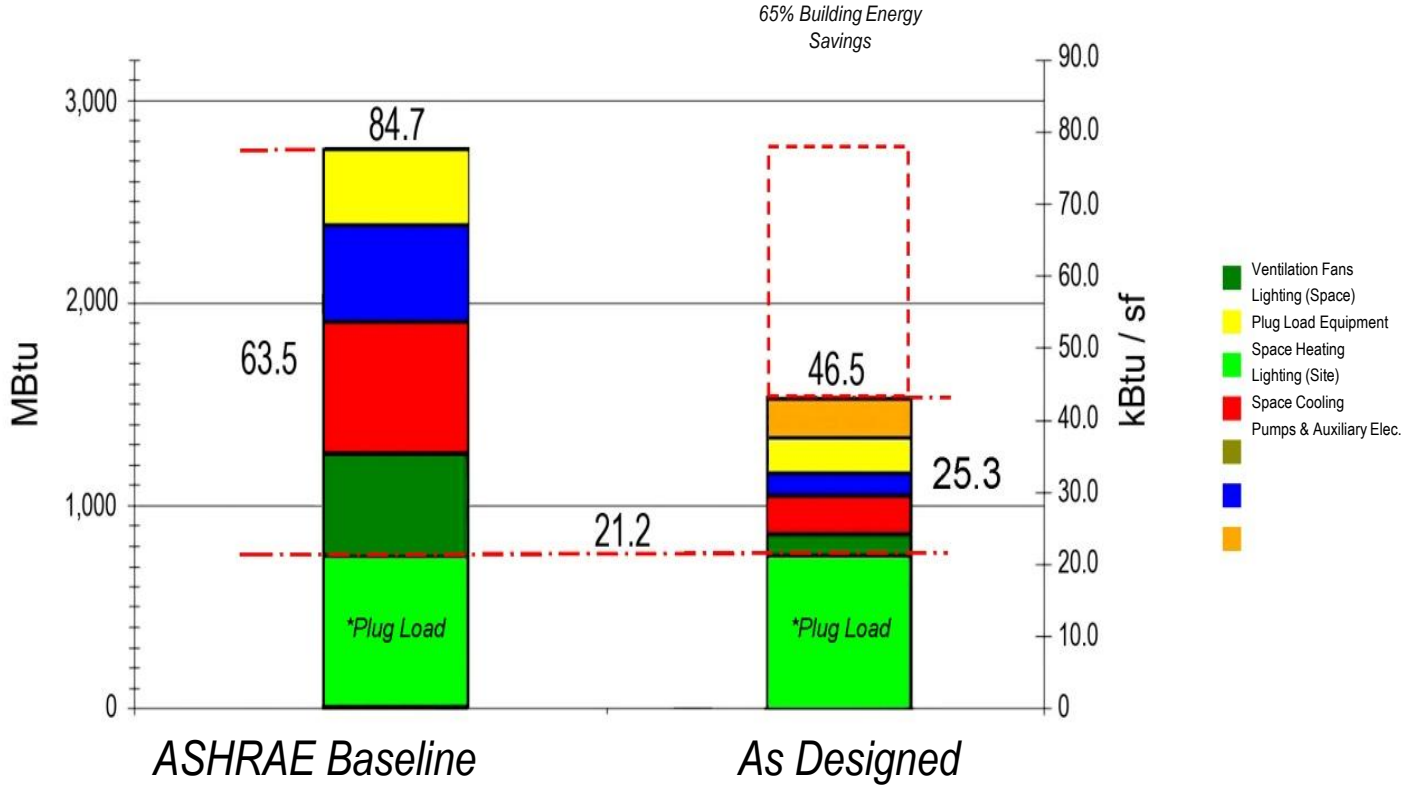
- 85% savings on **rain harvesting** (11,000 gallons) eliminates site storm water management
- **Low Flow Fixtures & Point of Use** Domestic Hot Water Heaters
- **PV Parking Canopy dual functioned** to provide significant shading while generating electricity

- **Salvaged Brick** exterior
- **PV Wall Panels** generate electricity while reducing cooling load
- **Demountable Interior Partitions** reducing long term material use and cost

GovEnergy
www.govenergy.gov

Case Study 3: Georgia Tech Lessons Learned Opportunities

- Designed project achieves 65% energy savings over the baseline.
- Captures solar energy to eliminate reliance on fossil fuels



GovEnergy
www.govenergy.gov

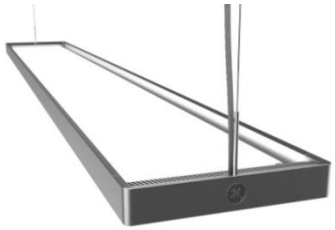
Case Study What If's

What would it take to meet 2015 reduction goals?

- 30% Solar/Water
- 30% Energy
- 65% Fossil Fuel

Example Technologies:

- Additional Air System Energy Recovery
- Dual Duct or Tempered Supply System
- Auto Hood Sash Positioners
- Advanced Occupancy Sensors
- Solar Photovoltaic's
- LED or high performance lighting
- Modest Supplemental Cogeneration



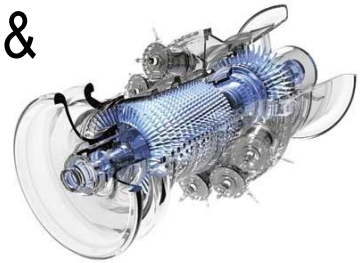
Case Study What If's

What would it take to meet 2030 reduction goals?

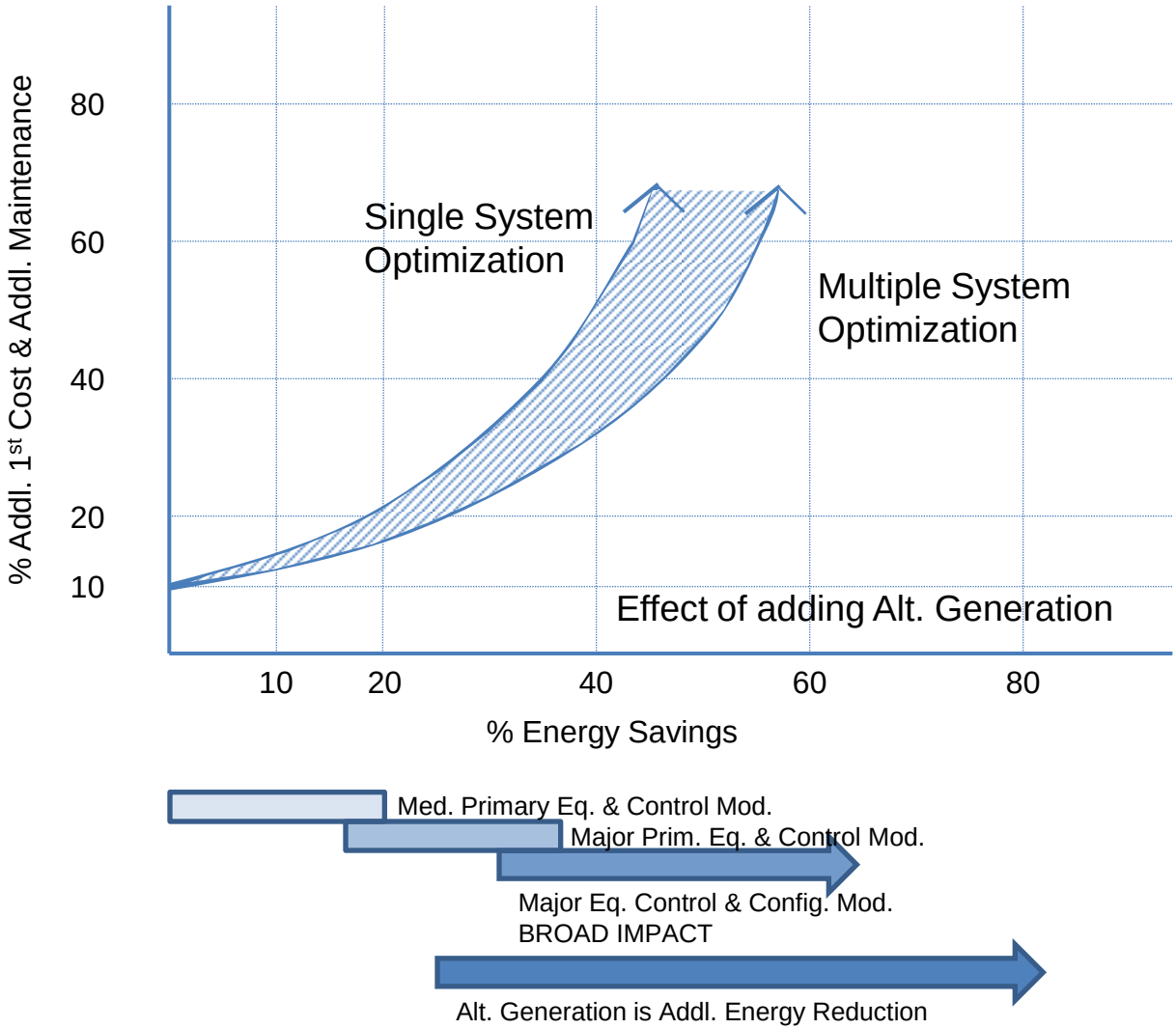
- 30% Solar/Water
- 30% Energy
- 100% Fossil Fuel – *The real challenge*

Example Technologies:

- Buy Green Energy from the Grid
- Additional Solar Photovoltaic's
- Cogeneration utilizing Bio-Fuels and/or CO_2 scrubbing
- Regional Opportunities of Wind & High Temperature Solar



Solution-to-Cost Sweet Spot



GovEnergy
www.govenergy.gov

The Future

What else could be done to meet 2030 reduction goals?

- **Fusion-Triggered Fission**
- **Solar Gasoline**
- **Quantum Photovoltaics**
- Heat Engines
- Shock-Wave Auto Engine
- **Magnetic Air Conditioners**
- Clean(er) Coal

Questions?

Liz Cook

HDR, Inc.

(609) 791-7326

Elizabeth.Cook@HDRINC.com

Rob Consalvo

HDR, Inc.

(609) 791-7151

Robert.Consalvo@HDRINC.com