


Epsten Group
High-Performance Building Specialists



**APPROACHING NET ZERO –
LESSONS LEARNED AND LEADING QUESTIONS**
Dagmar B. Epsten, AIA, LEED Fellow

www.epstengroup.com

Epsten Group

A Net Zero Pavilion – Das Haus

Solar Decathlon in Washington DC

- Team Germany (Technische Universität Darmstadt – TUD):
 - Winner in 2007
 - Winner in 2009

Leading to Das Haus, Exhibit Pavilion

- North American tour organized by German Chamber Network, Deutsch- Amerikanische Handelskammer = AHK
 - AHK USA and AHK Canada
- Supported by Germany's
 - Federal Ministry of Economics and Technology and
 - Federal Ministry of Transport, Building and Urban Affairs
- An Initiative of Germany's
 - Energy Efficiency Export Initiative and
 - Renewable Energies Export Initiative




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A Net Zero Pavilion – Das Haus

Das Haus October 2011 – Nov 2012

- Previously "Casa Alamana"
Sao Paolo to Mexico City, 13 counties in 16 months, started in April 2010
- Refurbished in Miami
- North American Tour**
 - [Atlanta](#) 10.17.11–10.26.11
 - [Houston](#) 11.8.11 – 11.17.11
 - [Phoenix](#) January 2012
 - [San Francisco](#) February 2012
 - [Vancouver](#) March 2012
 - [Toronto](#) April 2012
 - [Montreal](#) May 2012
 - [Boston](#) June 2012
 - [New York](#) July 2012
 - [Washington DC](#) August 2012
 - [Chicago](#) September 2012
 - [Denver](#) November 2012




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A Net Zero Pavilion – Das Haus

Das Haus - approx. 33' x 33' - 3 Elements

- COVERED MEETING AREA**
 - Open-air covered central meeting area (with exhibits)
- TECHNOLOGY AREA**
 - Technology section with batteries for PVs and with wall section exhibits
- ENCLOSED ROOM**
 - A superinsulated room container (kitchen & dining)



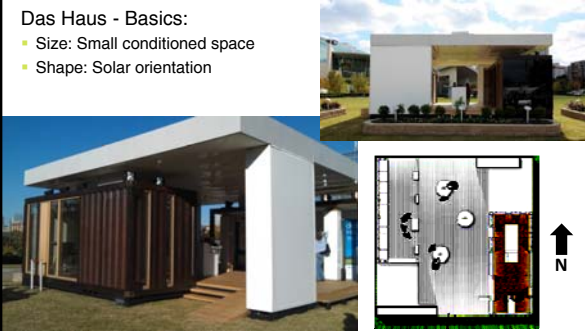
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A Net Zero Pavilion – Das Haus

Das Haus - Basics:

- Size: Small conditioned space
- Shape: Solar orientation



Source: HHS Planer + Architekten AG 5

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A Net Zero Pavilion – Das Haus

Das Haus - Technologies

- Envelope
- Lighting & Equipment
- HVAC
- Photovoltaics/Solar



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A Net Zero Pavilion – Das Haus 

Das Haus - Technologies

- Envelope
 - Vacuum insulated panel systems (8 to 10 time higher R-value, 2 layers)
 - Passive House triple-pane windows with insulated oak frames
 - Vacuum-insulated door, ventilation panel
 - Exhibit of other advanced wall construction materials, including louvers





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A Net Zero Pavilion – Das Haus 

Das Haus - Technologies

- Lighting & Equipment
 - LED lighting systems
 - high-efficiency appliances



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A Net Zero Pavilion – Das Haus 

Das Haus – Technologies

- HVAC – mini split heat pump system
 - Interior insulated compact unit w/ heat recovery delivering supply air near floor, exhaust air to roof.
 - External inverter-controlled compressor inverter allows variable rotational speed of compressor




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A Net Zero Pavilion – Das Haus 

Das Haus - Technologies:


- Photovoltaics/Solar (1.89 kWp)
 - 8 building-integrated CIS* thin-film PV & insulation wall panels (0.5 kWp)
 - Thin film CIS* photovoltaic roof modules (1.05 kWp)
 - PV louvered panel systems (0.34 kWp)
 - For storage: Battery systems

*CIS = Copper-Indium-Selenide








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A Net Zero Pavilion – das Haus 

Das Haus - Process



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Approaching Net Zero 




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Approaching Net Zero

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- Buildings are key in the pursuit of energy conservation
- Buildings consume 49% of the energy produced in the United States
 - Transportation: 28.2%
 - Industry: 22.7%

(Source: US Energy Information Administration)




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Approaching Net Zero

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- Increased emphasis on energy conservation is due to:
 - Environmental concerns (global climate change)
 - Strategic concerns (instability in oil-rich regions)
 - Economic concerns (increased energy costs)




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- Reducing electric consumption from the grid also saves water
 - 89% of power plants in the U.S. are thermoelectric power plants (use evaporation to remove heat from cooling tower water)
 - As a national average, 2 gallons of water are used to produce 1 kWh of electricity.

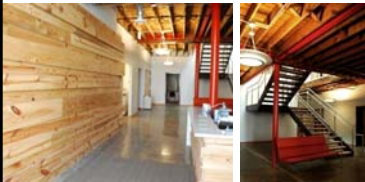


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Approaching Net Zero

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- Optimize all energy uses
 - Occupancy (Energy & Water)
 - Materials (Life Cycle Analysis for LCA)
 - Transportation





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Approaching Net Zero

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How does the government lead?
U.S. Federal Government Goals:

- Design all **new** Federal buildings to zero-net-energy by FY 2030
- GSA will continue to use LEED certification.
- 50%+ of GSA **historic** building renovations to achieve LEED Gold+ by FY 2015.
- GSA will review existing frameworks, incl. Living Building Challenge
- GSA will test **16 new technologies** in the Green Proving Ground program




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Approaching Net Zero

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- New Construction (process for Renovations is similar)
- The basics:
 - Minimize conditioned space needs
 - Solar Orientation and Shape (new construction)
- Technologies:
 - Optimize the thermal properties of the building envelope
 - Simple lighting and controls strategies ("the low-hanging fruit")
 - Install efficient mechanical systems
 - Install renewable energy systems




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Basics: Size - Lesson Learned

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- Internet and telecommuting has been a transportation innovation
- Work from home, with less office space
- Need more mixed-use space
- Public transportation requires density and destinations






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Basics: Size - Leading Questions

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*How many people per square foot? Per square mile?
How much energy/water/materials?*


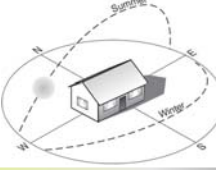
Energy/Water/Material	People	Energy Use
		
Per Person Or Per Square Foot	Per Square Foot	Per Heating/Cooling Degree Day

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Shape - Lessons Learned

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- Joint Forces Readiness Center**
Montgomery, AL
(pursuing LEED-NC 2.2 Gold)
 - Building elongated east to west
 - Water-source heat pumps
 - Partial underfloor ventilation
 - 363.3 kW PV system
 - Predicted energy reduction 36.5%


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Shape - Leading Questions

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How will this shape buildings?

- Solar orientation
- Building massing, height, roof area
- Glazing areas, shading

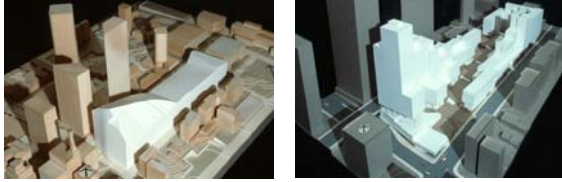


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Shape - Leading Questions

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**How will this shape cities?
Without access to the sun, can we use it?**



Ralph L. Knowles, 1999




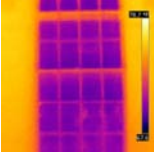
Solar Access Envelope as zoning device – will determine shapes & sites

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Envelope - Lessons Learned

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- 3 improvement areas
 - Insulation**
(R-value or U-value)
 - Air-tightness** (incl. water resistance)
Install complete air barrier
 - Radiation**
Shading/ Solar Heat Gain Factor/
Reflectivity (in or out)

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Envelope - Lessons Learned

Roofing - Radiation: Light-colored roofing




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Envelope - Lessons Learned

Glazing

- Insulation:** Insulate opaque glass, reduce glazing, gas-filled voids in new windows (argon), films
- Airtightness:** Sealants
- Radiation:** Add overhangs or screens, high-efficiency glazing, coatings (low-e), films





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Envelope - Lessons Learned

The Edge
Atlanta, Georgia
LEED Platinum, 4 Green Globes

- Wall insulation upgraded to R-22 with spray-applied insulation for air barrier
- New windows with double or triple glazing and shading on South and East
- Roof insulation upgraded to R-32
- TPO Roof


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Approaching Net Zero

GSA Category	GSA Technology	GSA Project Description
1 Building Envelope	High R Value Windows	Curtain wall system, R-5 (Energy Star is R3)
2 Building Envelope	Smart Windows	Compare electrochromic windows* with thermotropic organic polymer "window filler"***

*** electrochromic windows:**

- varied tinting values, 2% to 60%, via electronic controls
- require a controlled power source integrated into the frame
- provides local occupant control




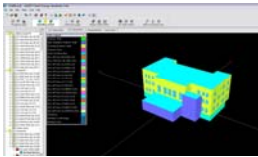
**** thermotropic organic polymer "window filler"**

- darkens as surface temperature increases
- does not provide local occupant control

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Envelope - Leading Questions

- Thickness? Site boundaries? Interior space encroachments?
- Priorities for historical buildings?
- Glazing size reductions? Strategic locations?
- Selective glazing?
- Airlocks?

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Lighting & Equipment - Lessons Learned

Simple lighting and controls strategies are "the low-hanging fruit" of energy optimization

- From T-12 or Incandescent to T-8 or better or LED
- Occupancy Sensors
- Daylighting Sensors
- Wireless, addressable lighting controls
 - Personal control and task tuning
 - Smart time scheduling and load shedding




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Lighting & Equipment - Lessons Learned

- The Edge**
Atlanta, Georgia
LEED Platinum, 4 Green Globes
- Lighting loads reduced to **0.69 W/sf** with
 - Daylighting
 - Daylight-responsive dimming
 - T-8 fluorescent lights
 - Occupancy sensors



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Lighting & Equipment - Leading Questions

GSA Category	GSA Technology	GSA Project Description
3 Lighting	Low Ambient / Task Lighting	Integrated daylighting systems and occupant control
4 Lighting	Integrated Daylighting Systems	Expanded digital lighting control w/ daylighting harvesting
5 Metering	Plug Load Reduction	Submetering equipment with dashboard for occupants





Photo: Duke Energy Center
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Lighting & Equipment - Leading Questions


- LED? Cost?
- New technologies?
- Daylight with selective glazing?
- Occupancy sensors?
- New refrigerants?
- Heat capture/exchange?
- Equipment/pipe insulation?



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HVAC - Lessons Learned

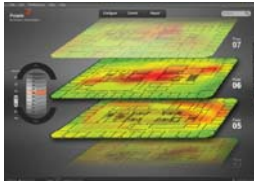
- Energy Savings Measures To Consider For New Designs**
 - Cooling and Heating Efficiency
 - Variable Speed Motors
 - Economizer
 - Energy Recovery
 - Ground Source Heat Pumps
 - Geothermal Systems
 - Variable Refrigerant Systems
 - Temperature Reset Controls
 - Variable Speed Chillers
 - Condensing Boilers
 - Displacement Ventilation
 - Chilled Beams
 - Solar: Thermal & Electric
 - Renewable Technology



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HVAC - Lessons Learned

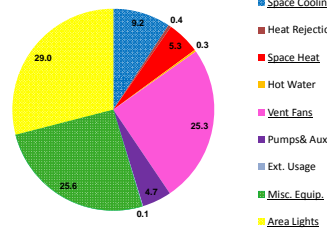
- System Retrofits**
 - Ground Source Heat Pumps
 - Variable Refrigerant Systems
 - DDC Reset and Setback Strategies
 - Air and Water Side Economizer Modes
 - Demand Response
 - Natural Ventilation
 - Scheduling & Behavioral Modification



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HVAC - Lessons Learned

Systems Annual Electricity Consumption by End Use (%)




End Use	Percentage (%)
Space Cooling	29.0
Heat Rejection	9.2
Space Heat	0.4
Hot Water	5.3
Vent Fans	0.3
Pumps & Aux.	25.3
Ext. Usage	4.7
Misc. Equip.	0.1
Area Lights	25.6

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HVAC - Lessons Learned

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- **233 North Michigan Avenue**
Chicago, Illinois
LEED-O+M Silver 2010
 - Originally "Two Illinois Center", designed 1967 by famous modernist architect Ludwig Mies van der Rohe, completed 1973
 - Energy Star Rating of 89 based on actual utility/energy use data




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HVAC - Lessons Learned

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- **UGA Sanford Hall**
Athens, Georgia
- Original Construction 1996A
- Recommendations
 - T12 to T8 lighting (2-yr ROI)
 - Optimize CHWS operation (3-yr ROI)
 - Repair/Optimize airside economizer (2.3-yr ROI)



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Approaching Net Zero

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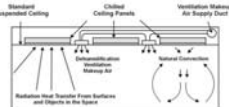

GSA Category	GSA Technology	GSA Project Description
6 HVAC	Wireless Mesh Sensor Network	For active monitoring of temperature in multiple locations
7 HVAC	Magnetic Bearing Compressor	Frictionless which increases efficiency at part load conditions
8 HVAC	Variable Refrigerant Flow	Enables use of different evaporators for ind. comfort control
9 HVAC	Variable-Speed Chiller Plant Control	Optimizes the plant as a system
10 HVAC	Condensing Boilers	Extracts additional heat from the waste gases
11 HVAC	Commercial Ground-Source Heat Pump	Centralized water to water ground source heat pump systems
12 HVAC	Chilled Beams	Primary source of conditioning using efficient thermal transfer rate of water
13 Water	Non-chemical water treatment	For cooling towers; reduce water consumption, energy, chemical discharge

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HVAC - Leading Questions

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- Passive House?
- Chilled Beams?

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PVs/Solar - Lessons Learned

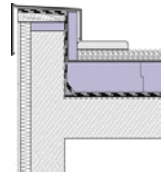

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Roofing including Re-roofing

Photovoltaics

along with

- Added insulation
- Light-colored membrane
- Roof monitors/ skylights
- Green roof
- Solar water heating systems






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PVs/Solar - Lessons Learned

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- **The Edge**
Atlanta, Georgia
LEED Platinum, 4 Green Globes
 - Installed a 5.0 kW thin-film photovoltaic system on the roof





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PVs/Solar - Lessons Learned

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- Capitalize on load reductions from other energy optimization techniques
- Solar water heating
 - has the fastest payback and
 - works well in buildings with high domestic hot water use (residential-type uses)
- Consider the impact of new roof loads on existing structural systems
 - Panelized vs. Thin-film photovoltaic systems



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PVs/Solar - Lessons Learned

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**Non-roof surfaces:
Integrated photovoltaics**




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PVs/Solar - Lessons Learned

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- Types of Arrays
 - Crystalline Panel
 - Crystalline Panel with solar tracking
 - Thin film
- Typical Installation Costs
 - Turn-key costs vary across the nation
 - 2010 national average: \$6.2/watt (17% below 2009 national average)
 - 2011 numbers indicate a further 11% reduction in installed costs
 - Economies of scale play a large role
 - Thin Film is slightly more expensive in typical ≤ 1000 kw arrays, but added costs is offset by not needing to enhance structure in existing buildings




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PVs/Solar - Lessons Learned

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- Payback periods
 - Typically longer than solar thermal systems
- Rebate & tax incentive programs
 - DSIRE (database of state incentives for renewables & efficiency) for residential and commercial properties
 - 30% federal credit, potentially state credit
 - 179D tax deduction for energy efficient commercial buildings

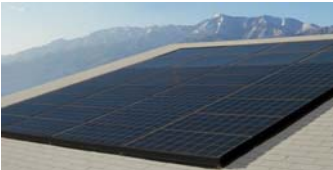


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Approaching Net Zero

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GSA Category	GSA Technology	GSA Project Description
1 Water Heating	PV with Solar Water Heating	Roof PVs with thermal heat extractor panels beneath, in same footprint
1 Power Generation	Photovoltaics	High efficiency solar panels for 2 MW/yr; research 4 types of solar technology
1 Policy	Net Metering	Building qualified with Federal Energy Regulatory Commission (FERC)

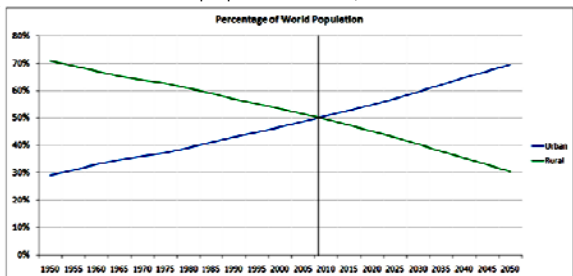


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PVs/Solar-Leading Questions

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How will this shape cities?
More people are urbanized, trend continues



Percentage of World Population

Urban Rural


Data Source: United Nations, <http://esa.un.org/unwp/2004data.asp>

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PVs/Solar - Leading Questions

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- Increased efficiencies in operation? Beyond copper indium gallium selenide (CIGS)?
- Increased efficiencies in manufacturing?
- Competitiveness to nuclear, "clean" coal, biomass?
- Innovative Product Technology: Solar Shingles



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Process – Lessons Learned

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- It is important to plan for appropriate validation strategies**
- New buildings:**
 - Energy Modeling
 - Commissioning (Systems and Envelope)
 - Measurement and Verification
 - Benchmarking
 - Certification




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Process – Lessons Learned

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- Foyer Zug Offices for Credit Suisse**
Zug, Switzerland
Pursuing LEED-CS 2009 Platinum
- 2 new office buildings
- Very efficient:
 - Curtain Wall Systems,
 - Radiant Cooling,
 - District Ground-Source Heat Pump
- Energy Modeling**
 - 29.4% reduction predicted (11 points in LEED-CS 2009)

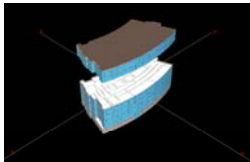


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Process – Lessons Learned

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- CDC Building 24**
 - Centers for Disease Control, Atlanta, Georgia
 - Pursuing LEED-NC 2.2 Gold
 - 12-story, 312,000SF office building
- Energy Modeling**
 - Feasibility Study of PVs, life-cycle costing
 - Optimization of Energy Efficiency Measures
 - Energy Model showed over 30% energy reduction (EPA 2005 requirements)




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Process - Lessons Learned

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- Existing Buildings**
- Optimization through step-by-step process:
 - Energy Audits**
 - Retro-Commissioning**
 - Retro-Commissioning Mechanical Systems
 - Retro-Commissioning Building Envelopes




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Process – Lessons Learned

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- Commissioning**
- Systematic process of ensuring:
 - Owner's Project Requirements are met
 - Design Intent has been achieved
- Envelope and MEP Systems Commissioning is recommended
- Process includes:
 - Design Review
 - Installation verification
 - Comprehensive functional testing
 - Proper owner training
 - Deficiency tracking and resolution
 - Warranty




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Process - Lessons Learned

Envelope Commissioning

- Water resistance/ Airtightness
- Thermal performance
- Radiation




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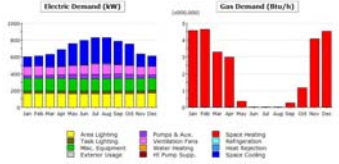
Process – Lessons Learned

Measuring & Verification:

- Meter and monitor energy performance & benchmark
- Identify and address most costly or inefficient systems
- Sub-metering by system type
 - Lighting
 - HVAC
 - Plug Loads

Predictive Analytics

- Identify issues prior to malfunction
- Faults monetized based on energy consumed
- Improve asset life cycle
- Persistent savings




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Process – Lessons Learned

Measurement and Verification Plan (M&V Plan)

- Set of agreed-upon metrics to
 - establish baseline performance and
 - verify actual energy savings
- Typically based upon International Performance Measurement & Verification Protocol (IPMVP)




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Process – Lessons Learned

Benchmarking

- Energy Star to monitor and benchmark energy performance
 - EPA reports 83,000 buildings benchmarked
 - Incorporated into LEED-O+M
 - A joint program of EPA and DOE




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Process – Lessons Learned

Certification

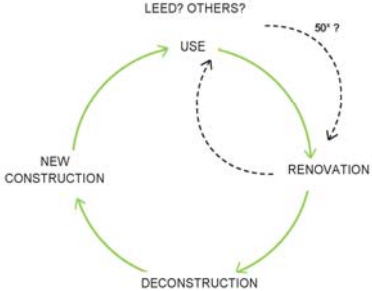
- LEED is a rating system that focuses on a wide range of environmental impacts, including energy issues
- The LEED-NC 2009 Rating System emphasizes energy performance incl. reporting



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Process – Leading Questions

How do we close and lengthen the building life-cycle?



LEED? OTHERS? 50' ?

50 Years?
100 Years?
500 Years?

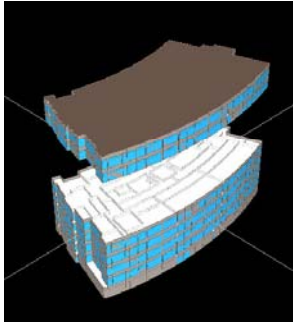
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Process – Leading Questions

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How do we optimize?

- Whole building operating energy
- Wind & air pressure
- Rain deposition patterns
- Vapor diffusion
- Water Infiltration
- Air leakage
- Cavity pressure equalization
- Capillary moisture
- Effects of salts and surfactants
- Latent heat & phase change in materials
- Thermal mass
- Radiation - light and heat (daylighting)
- Heat conduction
- Convection
- Shading patterns



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Process – Leading Questions

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Germany's contributions?

Das Haus - Technologies

- Envelope
- Lighting & Equipment
- HVAC
- Photovoltaics/Solar



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Process – Leading Questions

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How do we achieve innovation?

GSA Category	GSA Technology	GSA Project Description
1 Building Envelope	High R Value Windows	Curtain wall system
2 Building Envelope	Smart Windows	Compare electrochromic windows with polymer "window filler"
3 Lighting	Low Ambient / Task Lighting	Integrated daylighting systems and occupant control
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14 Water Heating	PV with Solar Water Heating	Roof PVs with thermal heat exchanger panels beneath in same footprint
15 Power Generation	Photovoltaics	High efficiency solar panels for 2 MW/yr; research 4 types of solar technology
16 Policy	Net Metering	Building qualified, Federal Energy Regulatory Commission (FERC)

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Process – Leading Questions

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North America Germany

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Dagmar B. Epsten, AIA, CxA, CCS,
LEED Fellow,
LEED® AP BD+C, O+M, ND, ID+C, Homes

President, Epsten Group
404-577-0370
depsten@epstengroup.com

Architects, Engineers, Consultants
www.epstengroup.com



in@epstengroup.com
399 Edgewood Avenue, Atlanta, GA 30312
p (404) 577-0370 • f (404) 577-1739
www.epstengroup.com