ELEVATING LABORATORY PERFORMANCE USING INTEGRATIVE DESIGN + BUILDING SCIENCE TOOLS

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Brian Turner, PE, CEM, BEMP
LEARNING OBJECTIVES

1. Understand integrative design and how it can be better embedded in the design process to facilitate sustainable decisions during programming and throughout the design process.

2. Develop an understanding of some of the building science tools used to determine high-performance sustainable decisions.

3. Recognize strategies for reducing energy in labs and for monitoring other metrics such as water, habitat and materials that are a part of the integrative process.

4. Develop an understanding of the roles between design team members and how architects and engineers to best enable confident performance decisions by the owner.
ELEVATING LABORATORY PERFORMANCE USING INTEGRATIVE DESIGN + BUILDING SCIENCE TOOLS

Integrative Design + Building Science
Embedding ID and Building Science in Firm
Embedding ID in Project Process
Integrative Design in Practice
WHY INTEGRATIVE DESIGN?
WHAT IS INTEGRATIVE DESIGN?

HIGH-PERFORMANCE
STRATEGIC COLLABORATION EARLY
ENERGY - WATER - MATERIALS - HABITAT
WHAT IS INTEGRATIVE DESIGN?

“...A process that seeks designs that are cost effective over short and long terms... by engaging all project team members in an intentional process of discovering mutual beneficial synergies between systems and components to elevate building performance and human performance and environmental benefits are achieved.”

- ANSI IP 2012
## TRADITIONAL DESIGN PROCESS

<table>
<thead>
<tr>
<th>PreDesign</th>
<th>Design and Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conceptual Design</td>
<td>Schematic Design</td>
</tr>
<tr>
<td>Design Development</td>
<td>Construction Documents</td>
</tr>
<tr>
<td>Bidding and Construction</td>
<td></td>
</tr>
</tbody>
</table>

- VE: Value Engineering
- CVO: Continuous Value Optimization
INTEGRATIVE DESIGN PROCESS
Climate Summit

What if it's a big hoax and we create a better world for nothing?

- Energy independence
- Preserve rainforests
- Sustainability
- Green jobs
- Livable cities
- Renewables
- Clean water, air
- Healthy children
- Etc. Etc.

CLARK NEXSEN
Global Temperature Projections for various RCP Scenarios

RCP8.5
Business-as-usual
2.2 trillion tons carbon

RCP6.0
Emissions peak 2060
1.6 trillion tons carbon

RCP4.5
Emissions peak 2040-50
1.3 trillion tons carbon

RCP2.6 (1.5°C)
0.53 trillion tons carbon
Zero CO₂ emissions ~2050

Source: Architecture 2030; Adapted from IPCC Fifth Assessment Report, 2013
Representative Concentration Pathways (RCP), temperature projections for SRES scenarios and the RCPs.
EMBEDDING ID IN FIRM
EMBEDDING INTEGRATIVE DESIGN IN FIRM

INCORPORATE INTO VISION

SIGN ONTO 2030 CHALLENGE

INCORPORATE INTO STRATEGIC PLAN

EMBED IN PERFORMANCE REVIEWS

INCORPORATE INTO OFFICE OPERATIONS

IMPROVE KNOWLEDGE ACROSS ALL DISCIPLINES
PARTNER. DISCOVER. TRANSFORM.

“Together we discover, inspire, and shape ideas that transform our world”
A CATALYST TO IMPROVE OUR INTEGRATED DESIGN PROCESS

MERGING OF VISION AND IDEAS WITH METRICS AND PERFORMANCE

PREDICTED ENERGY USE INTENSITY (pEUI)
2030 COMMITMENT

TRACK PERFORMANCE - pEUI

ANNUAL SUSTAINABILITY REPORT

ACTION PLAN

The 2030 Challenge

Source: ©2010 2030, Inc. / Architecture 2030. All Rights Reserved.
*Using no fossil fuel GHG-emitting energy to operate.
2030 COMMITMENT

DEVELOP TOOLS AND RESOURCES FOR INTEGRATED DESIGN PROCESS

TRACK pEUI THROUGHOUT PROJECT

ESTABLISH KNOWLEDGE NETWORK

INTEGRATED DESIGN LEAD FOR EACH PROJECT

DEVELOP BEST PRACTICES BY PROJECT TYPE
2030 COMMITMENT

DEVELOP TOOLS AND RESOURCES FOR INTEGRATED DESIGN PROCESS

TRACK pEUI THROUGHOUT PROJECT

ESTABLISH KNOWLEDGE NETWORK

INTEGRATED DESIGN LEAD FOR EACH PROJECT

DEVELOP BEST PRACTICES BY PROJECT TYPE
2030 COMMITTMENT

DEVELOP TOOLS AND RESOURCES FOR INTEGRATED DESIGN PROCESS

TRACK pEUI THROUGHOUT PROJECT

ESTABLISH KNOWLEDGE NETWORK

INTEGRATED DESIGN LEAD FOR EACH PROJECT

DEVELOP BEST PRACTICES BY PROJECT TYPE
### pEUI TRACKING BY PROJECT TYPE

<table>
<thead>
<tr>
<th>Project Type</th>
<th>pEUI</th>
<th>baseline EUI</th>
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<tbody>
<tr>
<td>1937 Federal Building Renovation</td>
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<tr>
<td>EDRU Technical Services Building</td>
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<tr>
<td>Reno Bldg 599 Energetics Lab</td>
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<td></td>
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<tr>
<td>RTI Heron Building AMSE Lab Renovation</td>
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<tr>
<td>Germanna Phase II</td>
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<tr>
<td>Argo Therapeutics Manufacturing Bldg</td>
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<tr>
<td>BCS Greenhouse 5</td>
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<tr>
<td>Bradburn Pharma Manufacturing Bldg</td>
<td></td>
<td></td>
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<tr>
<td>UHCC New Science Building</td>
<td></td>
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<tr>
<td>Vertical Lift Test facility</td>
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**CLARK Nexsen**
EMBEDDING ID IN DESIGN PROCESS
KEYS TO EMBEDDING INTEGRATIVE DESIGN IN PROCESS

IDENTIFY INTEGRATIVE DESIGN LEAD

SET PERFORMANCE ID GOALS EARLY

PROJECT MANAGEMENT

ENGAGE WITH BUILDING SCIENCE GROUP

TRACK pEUI THROUGHOUT PROJECT

TRACK ALL ID METRICS
KEYS TO EMBEDDING INTEGRATIVE DESIGN IN PROCESS

IDENTIFY INTEGRATIVE DESIGN LEAD

SET PERFORMANCE ID GOALS EARLY

PROJECT MANAGEMENT

ENGAGE WITH BUILDING SCIENCE GROUP

TRACK pEUI THROUGHOUT PROJECT

TRACK ALL ID METRICS
AIA
COTE Top Ten

“This toolkit is not a resource for the 1% of projects to achieve 100%, but for 100% of projects to achieve substantially better outcomes.”
PROJECT GOALS TRACKED IN VISION AND INTRANET
AIA 2030 + LABS 21 - ESTABLISH ENERGY GOAL EARLY

<table>
<thead>
<tr>
<th>Use Types *</th>
<th>Area (GSF)</th>
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<tbody>
<tr>
<td>Education - College/University (campus)</td>
<td>48655.0</td>
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<td>Office - Small (less than 10,000 sf)</td>
<td>3925.0</td>
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<td>Public Assembly - Recreation</td>
<td>26406.0</td>
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<tr>
<td>Storage - General</td>
<td>11793.0</td>
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Total: 90.8K

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<th></th>
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<tbody>
<tr>
<td></td>
<td>kBtu/sf/yr</td>
<td>kBtu/sf/yr</td>
<td>kBtu/sf/yr</td>
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<td>26.0</td>
<td>7.8</td>
<td>0.80</td>
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WEIGHTED 89.8 27.0 1.11
PROJECT PROCESS + ENGAGEMENT WITH BUILDING SCIENCE GROUP

Engage Energy Modeler

Climate & Site Analysis

Energy Benchmarking

Energy Charrette

Document Energy Goals

Track throughout process
# ENERGY MODELING TOOLS

<table>
<thead>
<tr>
<th>DESIGN + EARLY ANALYSIS</th>
<th>Pre-Schematic</th>
<th>Schematic Design</th>
<th>Design Development</th>
<th>Construction Documents</th>
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<tr>
<td>![Logo 1] + ![Logo 2]</td>
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<tr>
<td>![Logo 3] + ![Logo 4]</td>
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<tr>
<td>![Logo 5] + ![Logo 6] + ![Logo 7]</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

| ENERGY ANALYSIS/COMPLIANCE MODELING   |               |                  |                    |                        |
| IES                                    |               |                  |                    |                        |
| ![Logo 8]                              |               |                  |                    |                        |
| ![Logo 9]                              |               |                  |                    |                        |

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**CLARK NEXSEN**
INTEGRATIVE DESIGN IN PRACTICE
**GOALS:**

- Capture rainwater
- Treat 100% stormwater
- Treat 100% wastewater
- Minimize energy – 35%
- Maximize daylight
- Use geothermal
CSI
RESEARCH BUILDING

GOALS:
CAPTURE RAINWATER
TREAT 100% STORMWATER
TREAT 100% WASTEWATER
MINIMIZE ENERGY – 35%
MAXIMIZE DAYLIGHT
USE GEOTHERMAL
CSI RESEARCH BUILDING

GOALS:
CAPTURE RAINWATER
TREAT 100% STORMWATER
TREAT 100% WASTEWATER
MINIMIZE ENERGY – 35%
MAXIMIZE DAYLIGHT
USE GEOTHERMAL
GOALS:
CAPTURE RAINWATER
TREAT 100% STORMWATER
TREAT 100% WASTEWATER
USE GEOTHERMAL
MINIMIZE ENERGY – 35%
MAXIMIZE DAYLIGHT

BIOCLIMATIC DESIGN
CSI
RESEARCH BUILDING

GOALS:
CAPTURE RAINWATER
TREAT 100% STORMWATER
TREAT 100% WASTEWATER
USE GEOTHERMAL
MINIMIZE ENERGY – 35%
MAXIMIZE DAYLIGHT

ENERGY FLOWS AND ENERGY FUTURE
CSI RESEARCH BUILDING

GOALS:
CAPTURE RAINWATER
TREAT 100% STORMWATER
TREAT 100% WASTEWATER
USE GEOTHERMAL
MINIMIZE ENERGY – 35%
MAXIMIZE DAYLIGHT

CLARK Nexsen
LIGHT + AIR
CSI
RESEARCH BUILDING

GOALS:
CAPTURE RAINWATER
TREAT 100% STORMWATER
TREAT 100% WASTEWATER
MINIMIZE ENERGY – 35%
MAXIMIZE DAYLIGHT
USE GEOTHERMAL

GEOTHERMAL HVAC SYSTEM
ORIGINAL DESIGN
CLOSED LOOP SYSTEM
230 WELLS
MODULAR HEAT PUMP
VAV AIR HANDLING UNITS
VAV AND CAV TERMINAL UNITS
CSI
RESEARCH BUILDING

GOALS:
CAPTURE RAINWATER
TREAT 100% STORMWATER
TREAT 100% WASTEWATER
MINIMIZE ENERGY – 35%
MAXIMIZE DAYLIGHT
USE GEOTHERMAL
CSI
RESEARCH BUILDING

GOALS:
CAPTURE RAINWATER
TREAT 100% STORMWATER
TREAT 100% WASTEWATER
MINIMIZE ENERGY – 35%
MAXIMIZE DAYLIGHT
USE GEOTHERMAL

CLARK Nexsen
CSI
RESEARCH BUILDING

GOALS:
CAPTURE RAINWATER
TREAT 100% STORMWATER
TREAT 100% WASTEWATER
MINIMIZE ENERGY – 35%
MAXIMIZE DAYLIGHT
USE GEOTHERMAL
CSI
RESEARCH BUILDING

GOALS:

CAPTURE RAINWATER
TREAT 100% STORMWATER
TREAT 100% WASTEWATER
USE GEOTHERMAL
MINIMIZE ENERGY – 35%
MAXIMIZE DAYLIGHT

WATER CYCLE
CSI
RESEARCH BUILDING

GOALS:
CAPTURE RAINWATER
TREAT 100% STORMWATER
TREAT 100% WASTEWATER
USE GEOTHERMAL
MINIMIZE ENERGY – 35%
MAXIMIZE DAYLIGHT

WATER CYCLE

75% reduction of water use in all fixtures
Source: LEED Credit IE3

60% of water is graywater
Source: LEED Credit IE3

CLARK NexSEN
CSI RESEARCH BUILDING

GOALS:
CAPTURE RAINWATER
TREAT 100% STORMWATER
TREAT 100% WASTEWATER
MINIMIZE ENERGY – 35%
MAXIMIZE DAYLIGHT
USE GEOTHERMAL
MINIMIZE CARBON FOOTPRINT

MATERIALS + CONSTRUCTION

22% of material content is recycled
47% materials are extracted, harvested and manufactured within 500 miles
CSI
RESEARCH BUILDING

GOALS:
CAPTURE RAINWATER
TREAT 100% STORMWATER
TREAT 100% WASTEWATER
MINIMIZE ENERGY – 35%
MAXIMIZE DAYLIGHT
USE GEOTHERMAL
MINIMIZE CARBON FOOTPRINT

MATERIALS + CONSTRUCTION
38% less energy from baseline, pEUI=63
45% reduction of potable water use
90% occupied spaces with daylight
95% occupied spaces with views
100% stormwater managed on site
100% wastewater managed on site

LEED Gold
UNCC
CHEMISTRY BUILDING

GOALS:
MINIMIZE ENERGY
MINIMIZE FUME HOOD LOADS
HIGH-PERFORMANCE ENVELOPE
MAXIMIZE DAYLIGHT
UTILIZE HEAT RECOVERY
HEATING, 45%
COOLING, 6%
FANS & PUMPS, 23%
EQUIPMENT, 16%
LIGHTING, 9%
OTHER, 1%

175 NC State Mandate for Science Buildings
LABORATORY BUILDINGS | ENERGY CONSERVATION MEASURES

**COOLING**
- Chilled water cooling
- Reduces solar load (shading)
- High-efficiency chillers
- Comparative enthalpy economizers
- Supply air temperature reset

**HEATING**
- Exhaust air energy recovery
- Heat recovery chillers
- Reduced infiltration
- Improved envelope insulation
- High performance glazing

**FANS**
- Filtered fume hoods
- Demand-controlled ventilation
- Static pressure reset
- High-efficiency fan motors
- Low-pressure duct design

**WATER HEATING**
- Low-flow domestic fixtures
- Condensing hot water heaters

**LIGHTING**
- LED fixtures
- Occupancy sensors
- Daylight harvesting

**PLUG LOADS**
- Automatic receptacle shutoff
REDUCE DEMAND | FUME HOODS

- TOTAL HOOD COUNT = 94
  - 89 6'-hoods
  - 25 4'-hoods
- Use high performance hoods
- Lower face velocity
  - 100 fpm typical EHS standard
  - 80 fpm was accepted with ability to reduce in the future as standards change
- Reduce sash heights in teaching labs from 18” to 15”
Most HVAC savings are associated with heat recovery in the three main AHUs and the use of zone supplemental cooling (reduces ventilation loads).
ENVELOPE – TRIPLE PANE GLAZING

TRIPLE PANE w/ ARGON
U-VALUE: 0.27
SHGC: 0.16

3.5" INSULATION
R-VALUE: 15

ENVELOPE DESIGN ALLOWED FOR THE
ELIMINATION OF PERIMETER HEAT
## ENERGY PERFORMANCE

**175 EUI NC State Mandate for Science Buildings**

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Design</th>
<th>Savings</th>
<th>% Reduction</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site Energy</td>
<td>22,622 MBtu</td>
<td>19,417 MBtu</td>
<td>3,205 MBtu</td>
<td><strong>14.2%</strong></td>
<td>≥15% Reduction</td>
</tr>
<tr>
<td>Site EUI</td>
<td>197.5 kBtu/ft²</td>
<td><strong>169.5 kBtu/ft²</strong></td>
<td>28.0 kBtu/ft²</td>
<td><strong>14.2%</strong></td>
<td>≤175 kBtu/ft²</td>
</tr>
<tr>
<td>Energy Value</td>
<td>$241,206</td>
<td>$225,645</td>
<td>$15,562</td>
<td>6.5%</td>
<td>None*</td>
</tr>
<tr>
<td>Water Use</td>
<td>3.671 MG</td>
<td>3.091 MG</td>
<td>0.580 MG</td>
<td><strong>15.8%</strong></td>
<td>≥20% Reduction</td>
</tr>
</tbody>
</table>

*There are no specific requirements for energy cost reductions, but the 6.5% cost reduction will result in 12 Green Globes points under 3.3.1.1.2.
NC STATE
CIVIL ENGINEERING LAB BUILDING

GOALS:
TREAT STORMWATER
MINIMIZE ENERGY
MAXIMIZE DAYLIGHT
SMART BUILDING
GOALS:
TREAT STORMWATER
MINIMIZE ENERGY
MAXIMIZE DAYLIGHT
SMART BUILDING

NC STATE
CIVIL ENGINEERING LAB BUILDING

CLARK NexSEN
GOALS:
TREAT STORMWATER
MINIMIZE ENERGY
MAXIMIZE DAYLIGHT
SMART BUILDING

Level 1 - Control glare in the entry and in the Structural lab, increase daylight on the perimeter spaces if possible by adding clerestory windows near grade, similar to what is has been done on the east (oval side)

Level 2 - The south side needs extreme solar control as there is extreme amounts of glare. The east and west sides also need solar control to reduce glare. This will decrease the daylighting in these classroom type spaces. Care will be taken to try to make it so light continues to shine deep into these rooms while reducing glare and solar gain.
NC STATE
CIVIL ENGINEERING LAB BUILDING

GOALS:
TREAT STORMWATER
MINIMIZE ENERGY
MAXIMIZE DAYLIGHT
SMART BUILDING

CLARK NEXSEN

Monthly Solar Irradiation Per Facade
Workflow

Geometries modeled in Rhino

Daylight/energy simulations in Diva for Rhino

Results displayed in Human UI
NC STATE
CIVIL ENGINEERING LAB BUILDING

GOALS:
TREAT STORMWATER
MINIMIZE ENERGY
MAXIMIZE DAYLIGHT
SMART BUILDING

CLARK NexSEN
QUESTIONS/COMMENTS

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