Sustainability Occupant Well Being, and Better Buildings Through Smart Systems

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What’s changed in the last 5 years?

Value proposition

Campuses and labs

General approach to smart buildings

Key takeaways
Autonomous Vehicles
Zero Carbon Buildings
Computing Size, Speed, Costs

IBM World’s Smallest Computer

Microprocessor Clock Speed

Doubling time: 3 years

Year


Logarithmic Plot

$r^2 = 0.9899$
SMART WORLD

LINCOLN CONTINENTAL PERFECT POSITION SEATS

Perfect Position Seats in the Lincoln Continental usher in a new era of wellness and luxury.

Perfect Position Seats are inspired by those used in private aircraft and high-end office furniture. They are offered in several different categories, including 24-way, 30-way, and 36-way models. The 36-way model is available with thigh extensions and available 30-way with thigh extensions and multi-contour functionality.

There are multiple options for personalizing your comfort with the 36-way Perfect Position seat. Here's a look at what can be adjusted:

6 ways to adjust TRACK
4 ways to adjust THIGH SUPPORT
2 ways to adjust RECLINE
4 ways to adjust LUMBAR SUPPORT
2 ways to adjust ALPHA RESTRAINT
2 ways to adjust BACK BOLSTER
4 ways to adjust UPPER BACK BOLSTER SUPPORT
2 ways to adjust CUSHION BOLSTER
4 ways to adjust CUSHION EXTENSION

The upper and lower back supports the shoulders, while the suspension system supports the body. This combination helps prevent stress on the shoulders and neck.

Two extending thigh cushions, each independently adjustable, add further support. The cushions can be extended or moved up or down, allowing the driver to further personalize the adjustments. This provides support for each leg, enabling one leg to be at rest while the other leg is extended for pedal engagement.

The seats are modular, allowing for greater personalization options.

30 points of adjustment

DUMB BUILDINGS

No points of adjustment...
AI / Machine Learning
Americans Care About Climate

407 US #ClimateMayors, representing 70 million Americans, have committed to adopt, honor and uphold the climate goals of the Paris Agreement
Healthy Buildings Are a Top Priority

THE WELL BUILDING STANDARD™
SEVEN CONCEPTS FOR HEALTHIER BUILDINGS

A Program at the Harvard T.H. Chan School of Public Health
Solar and Batteries are Cost Competitive

Figure 29. NREL utility-scale PV system cost benchmark summary (inflation adjusted), 2010–2018
Electric Vehicles are Taking Over
Mobility is Evolving
Resilience and Adaptation Are Becoming Requirements
Value Proposition
Main Value Propositions

1. Streamline maintenance, operations, asset management, and work order management

2. Make better use of existing facilities

3. Set, track, evaluate, and achieve sustainability goals

4. Enhance user experience and engagement
Streamline maintenance, operations, asset management, and work order management
Streamline maintenance, operations, asset management, and work order management

| Criteria                                                                 | YNM | 1   | Y   | N   | 1   | Y   | 1   | Y   | 0   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   |
|-------------------------------------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Data Processing and Back up Hardware                                     | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 0   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 0   | Y   |
| Data Processing and Back up Real time alarm and event messaging        | Y   | 1   | Y   | 1   | Y   | 0   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 0   | Y   | 0.05 | Y   |
| Data Aggregation: Aggregation based on time intervals                   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   |
| Data Aggregation: Aggregation based on location                        | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   |
| Data Aggregation: Aggregation based on occupied/occupied hours          | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   |
| Data Exchange: Available to 3rd party services                           | Y   | 3   | Y   | 3   | Y   | 3   | Y   | 3   | Y   | 3   | Y   | 3   | Y   | 3   | Y   | 3   | Y   | 2   | Y   |
| Data Exchange: Available through REST                                    | Y   | 3   | Y   | 3   | Y   | 3   | Y   | 3   | Y   | 3   | Y   | 3   | Y   | 3   | Y   | 3   | Y   | 2   | Y   |
| Automated Fault Detection and Diagnostic: Machine learning              | Y   | 5   | Y   | 3   | Y   | 5   | Y   | 3   | Y   | 3   | Y   | 3   | Y   | 3   | Y   | 3   | Y   | 2   |
| Automated Fault Detection and Diagnostic: Standard library              | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   |
| Automated Fault Detection and Diagnostic: Rule based alarm definition   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   |
| Automated Fault Detection and Diagnostic: Custom subscribers             | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 0   |
| Automated Fault Detection and Diagnostic: Rule based alarm detection    | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   |
| Automated Fault Detection and Diagnostic: Data driven diagnosis         | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   |
| Automated Fault Detection and Diagnostic: Diagnostics supported by suggested measures or actions | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   |
| Automated Fault Detection and Diagnostic: Provisional deployment         | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   | Y   | 1   |
| Automated Fault Detection and Diagnostic: Pre-authorization              | Y   | 3   | Y   | 3   | Y   | 3   | Y   | 3   | Y   | 3   | Y   | 3   | Y   | 3   | Y   | 3   | Y   | 3   | Y   |

Vendor Background Information (ESGis)
Create Digital Twins of Facilities

- Visualise and gain automated insights to uncover hidden inefficiencies, save energy and reduce costs
- Smart tools to help review data and fill data gaps
- Cross analyse data from different sources in one platform
- Take advantage of continuous fault detection if live data connection is enabled
SMART Energy Management

- FDD
- MBCx
- Real-time M&V
SMART Energy Management

- FDD
- MBCx
- Real-time M&V

SMART Real-Estate Management

- Data driven program development
- Agile workplace management
- Space utilization

SMART User Experience

- Ongoing IEQ & comfort evaluation
- User feedback
- Correlation of user feedback to performance
Make better use of existing facilities

Track and manage existing building utilization and movement

Track and manage IAQ

Track and manage equipment lifespans
RESET IAQ Standard

To maintain RESET™ Air Certification, 90% of daily average results can

**PM2.5**
Particulate Matter

- Acceptable: < 35 µg/m³
- High Performance: < 15 µg/m³

**TVOC**
Total Volatile Organic Compounds

- Acceptable: < 0.5 mg/m³
- High Performance: < 0.4 mg/m³

**CO₂**
Carbon Dioxide

- Acceptable: < 1000 ppm
- High Performance: < 600 ppm

Note: RESET™ continuously tests sensors that detect other parameters of interest such as formaldehyde sensors are proven to meet the RESET™ Air Standard.
Set, track, evaluate, and achieve sustainability goals

Research campuses consume more energy per square foot than most facilities. They also have greater opportunities to reduce energy consumption, implement renewable energy systems, reduce greenhouse gas emissions, and set an example of climate neutrality.

The NREL Climate Neutral Research Campuses web site provides research campuses a five-step process to develop and implement climate action plans.

See: https://www.nrel.gov/climate-neutral/
Is EUI the best we can do?
Is EUI the best we can do?

Y-intercept: How much energy is used when nobody is in the building. Critical vs. non-critical building energy assessment.


R-squared = 0.8394
Slope = 0.0400 kWh/%
It’s Time for Some New Metrics!

How ‘bout: **ON-EUI** – Occupancy Normalized Energy Use Intensity

[Ennui -- A feeling of listlessness and dissatisfaction arising from a lack of occupation or excitement]
Campuses and Labs
Priorities for Labs and Campuses

1. Resilient Operation
2. Aggressive Carbon Reduction Targets
3. Older (and Newer) infrastructure with deferred maintenance
4. A variety of BAS vendors, submeter requirements, etc.
5. Design standards don’t accommodate smart yet
6. Health and human resources is a driver
7. Need for visibility and transparency to engage students
SFO Mapping Example
## SFO Mapping Example

<table>
<thead>
<tr>
<th>NUMBER</th>
<th>BUILDING NAME</th>
<th>EEMS Above the Line</th>
<th>EEMS Below the Line</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>Emergency Rescue Fire Fighting Facility (ERF #3)</td>
<td>2, 6, 8</td>
<td>7</td>
</tr>
<tr>
<td>56</td>
<td>SFIA APOE Facility #2</td>
<td>6, 8</td>
<td>7</td>
</tr>
<tr>
<td>60</td>
<td>SFO IT Data Center</td>
<td>2, 6, 8</td>
<td>7</td>
</tr>
<tr>
<td>100</td>
<td>International Terminal Building (ITB)</td>
<td>2, 6, 8, 11, 12, 17, 18</td>
<td>3, 7, 12, 14, 20, 23</td>
</tr>
<tr>
<td>100A</td>
<td>International Terminal B/A A</td>
<td>2, 6, 8, 11, 18</td>
<td>7, 12, 17, 20, 23</td>
</tr>
<tr>
<td>100G</td>
<td>International Terminal B/A G</td>
<td>2, 6, 8, 11</td>
<td>3, 7, 12, 20</td>
</tr>
<tr>
<td>195</td>
<td>Central Plant - Boiler Plant</td>
<td>10, 15, 22</td>
<td>3, 7</td>
</tr>
<tr>
<td>195</td>
<td>Central Plant - Chiller Plant</td>
<td>4, 5, 9, 13, 16</td>
<td>3, 7, 19</td>
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<tr>
<td>200</td>
<td>Terminal 1 Central</td>
<td>2, 6, 8, 11</td>
<td>7</td>
</tr>
<tr>
<td>200B</td>
<td>Terminal 1 B/A B</td>
<td>2, 6, 8, 11</td>
<td>7</td>
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<tr>
<td>200C</td>
<td>Terminal 1 B/A C</td>
<td>2, 3, 6, 7, 8, 11, 12, 14, 17, 18, 20, 23</td>
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<tr>
<td>250</td>
<td>Terminal 2 Air Traffic Control Tower (ATCT)</td>
<td>2, 6, 8</td>
<td>7</td>
</tr>
<tr>
<td>300</td>
<td>Terminal 2 CENTRAL &amp; B/A D</td>
<td>2, 6, 8, 11, 18</td>
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<tr>
<td>400</td>
<td>Terminal 3 WEST</td>
<td>1, 2, 6, 8, 11</td>
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<tr>
<td>400</td>
<td>Terminal 3 EAST</td>
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<td>7</td>
</tr>
<tr>
<td>400E</td>
<td>Terminal 3 B/A E</td>
<td>2, 6, 8, 11, 18</td>
<td>7</td>
</tr>
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<td>400F</td>
<td>Terminal 3 B/A F</td>
<td>1, 2, 6, 7, 8, 11, 12, 14, 17, 18, 20, 23</td>
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</tr>
<tr>
<td>497</td>
<td>Garage &quot;G&quot; Bart Station and Concourse H</td>
<td>8</td>
<td>7</td>
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<tr>
<td>632</td>
<td>West Cargo Building</td>
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<tr>
<td>674</td>
<td>Consolidated Administration Campus, Museum</td>
<td>2, 6, 8</td>
<td>7</td>
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<tr>
<td>780</td>
<td>Rental Car Center</td>
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<tr>
<td>782</td>
<td>Rental Car QTA</td>
<td>6, 8</td>
<td>7</td>
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<tr>
<td>195</td>
<td>Central Parking Garage</td>
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<td>All</td>
</tr>
<tr>
<td>575</td>
<td>SFO Business Center</td>
<td>None</td>
<td>All</td>
</tr>
</tbody>
</table>
A typical laboratory is 3-4 times more energy intensive than an average commercial building and can account for up to 70% of a campus’ energy footprint, making laboratories a key focal area for energy and carbon management strategies at universities, corporations, national laboratories, hospitals, and federal agencies.
General Approach to Smart Buildings
Currently...

Very BMS Centric
Integrated Approach

1. Identify goals
2. Identify stakeholders
3. Identify processes and systems required to achieve goals
4. Identify data sources necessary to track / manage goals
Goals

- Financial Goals
- Cybersecurity Requirements
- Campus Sustainability Goals
- Campus Health Goals
Stakeholders

- Financial Goals
- Cybersecurity Requirements
- Campus Sustainability Goals
- Campus Health Goals

- IT People
- Facility Manager
- Analysis Team
- Money People
- Building Engineer
- Sustainability Manager
- Health Manager
Data Requirements

- Financial Goals
- Cybersecurity Requirements
- Campus Sustainability Goals
- Campus Health Goals

- IT People
- Facility Manager
- Analysis Team
- Money People
- Building Engineer
- Sustainability Manager
- Health Manager

- Space Planning
- Network Infrastructure
- Work Order Management
- MBCx and M&V
- Environmental Monitoring

- Capital Improvements
- BMS
- Portfolio Manager / Arc
- Data Storage & Analytics

- Occupancy
- Mechanical Equipment
- Panels
- Lighting
- Submeters
- Utility Data
- IAQ
Key Takeaways
Key Takeaways

1. Starting is the hardest part
2. Utilize existing resources and programs – they’re out there!
3. Pilot multiple EMIS’s / FDD tools and understand their capabilities. There are many products, catered to different needs – find what fits.
4. Map to renovation plans, there’s no need to do it all at once
5. Staff accordingly
6. Seek allies within your campus!
7. Iterate on successes and keep building
Thank you!

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