District Energy Performance and Savings

Approaches to Maximize End Use Performance

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Context

District energy is usually the ideal solution for serving thermal and electrical loads in dense environments

District Energy projects are highly scrutinized, and must demonstrate multiple facets of performance for approval

Opportunities for dropping 15 to 25% (or more) of the energy usage in a system likely exist right now!

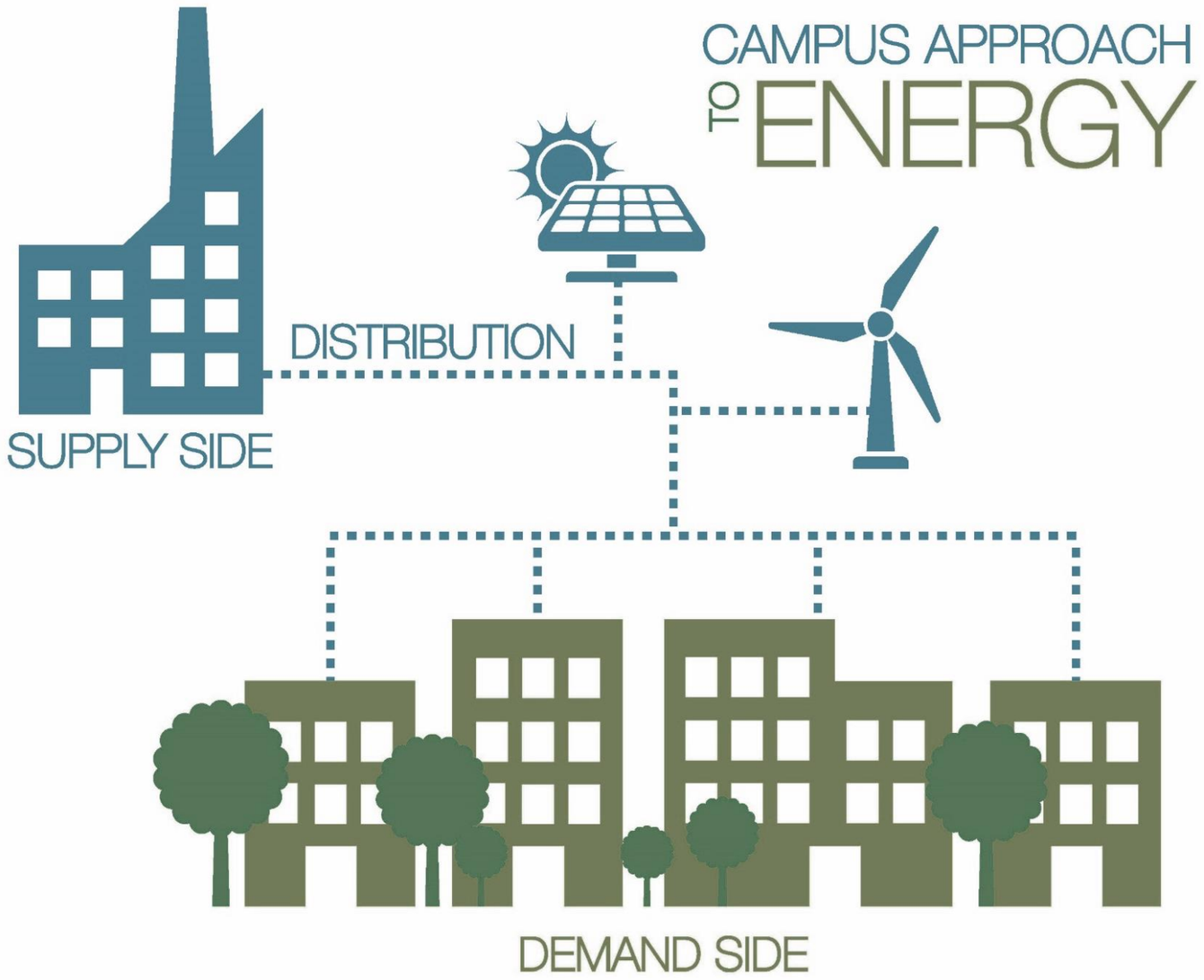
The **Challenge**

Division in ownership

Delegation of responsibility

Air Side **vs.** Plant side

Blissful **ignorance**



The **Opportunity**

Leadership in holistic performance

Demonstration of sustainability

Extend useful capacity of infrastructure

Maximize carbon reduction

Reduce deferred maintenance

Let district energy be the **HERO**

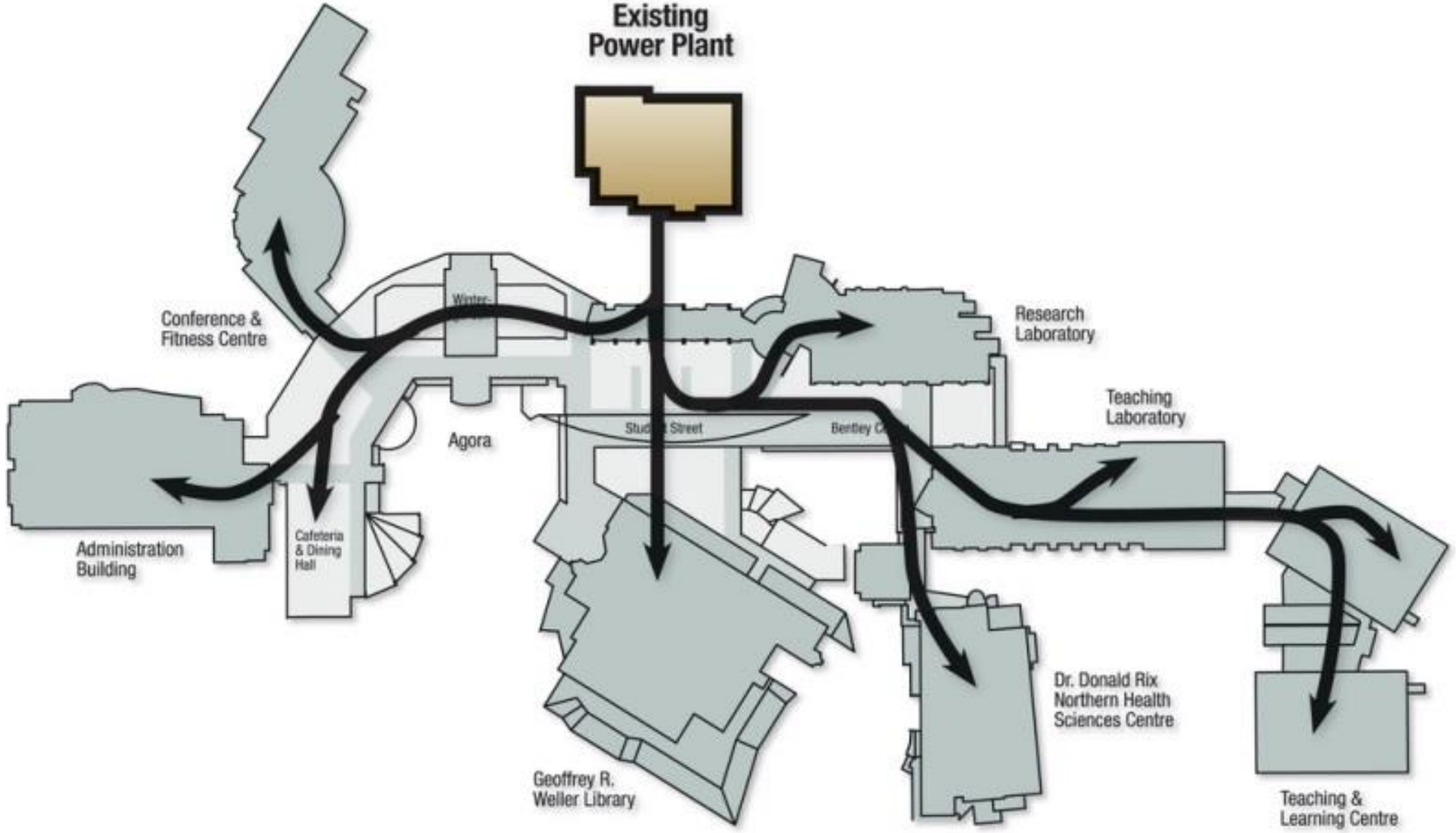
Start Somewhere

Campus/portfolio level energy strategy

Building level energy audits

System retro-commissioning

Evaluate maintenance program



Campus Level **Energy Strategy**

Strategic Energy Plan

Energy Usage Intensity (EUI)

Peer Benchmarking

> **If you don’t know where you’re going, you’ll end up someplace else.**

Scenario Analysis Tool

Robust multi-level calculations

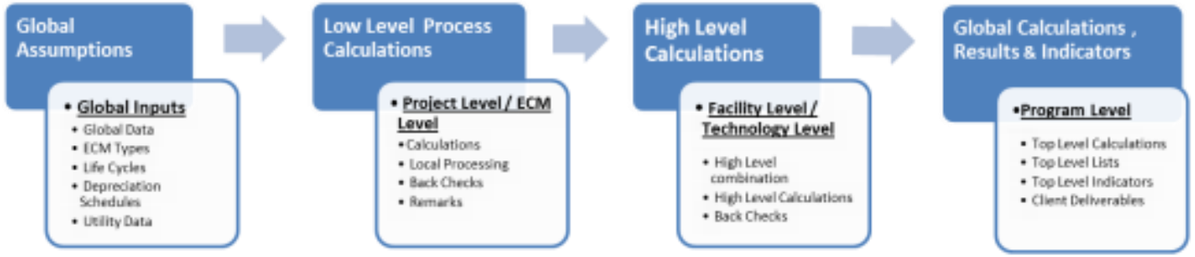
Complex variables – (direct / indirect)

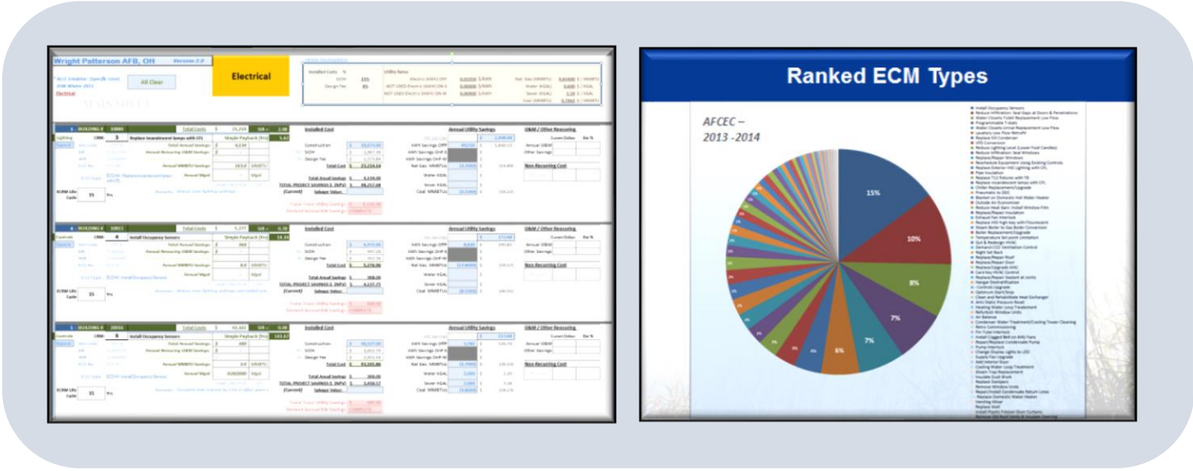
Efficient input variables

- Slider bars, buttons, typed inputs, validation

Intuitive outputs – (quantitative / qualitative)

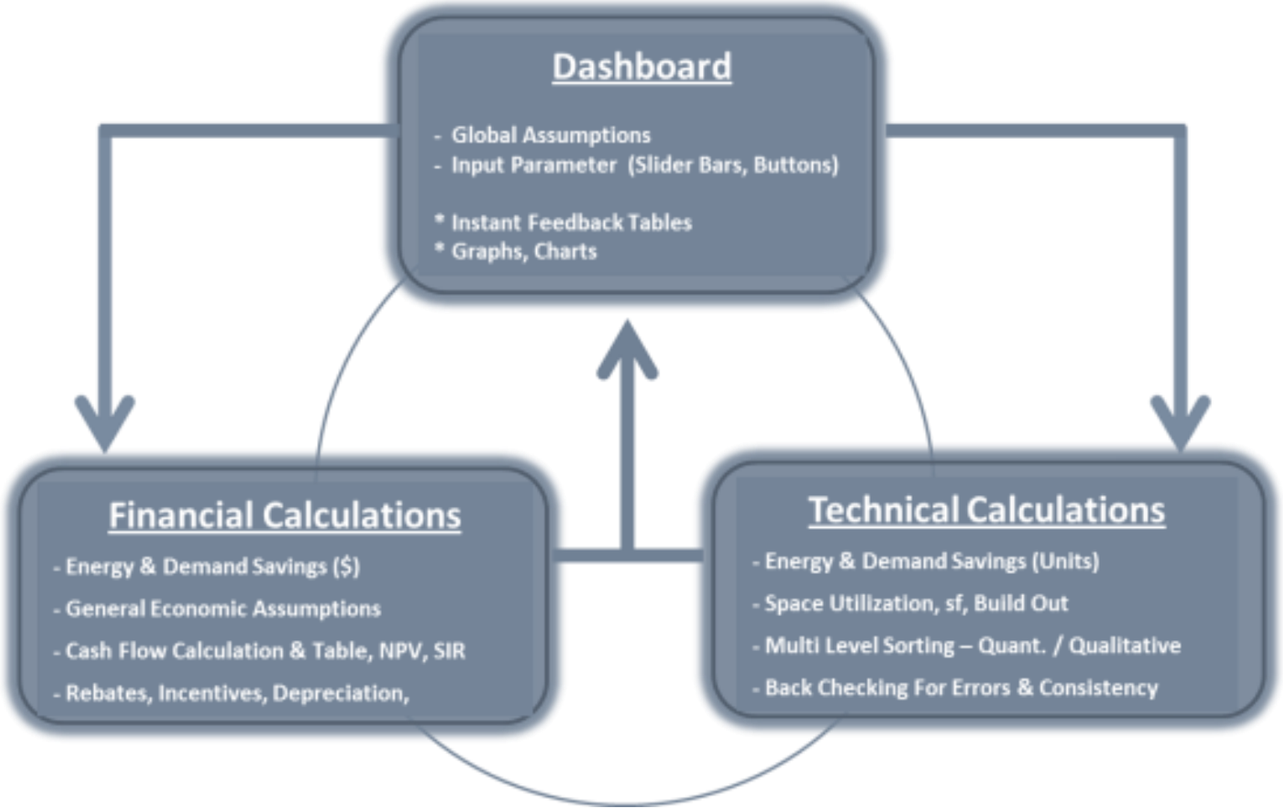
- Meaningful graphs, tables, concise dashboard gauges

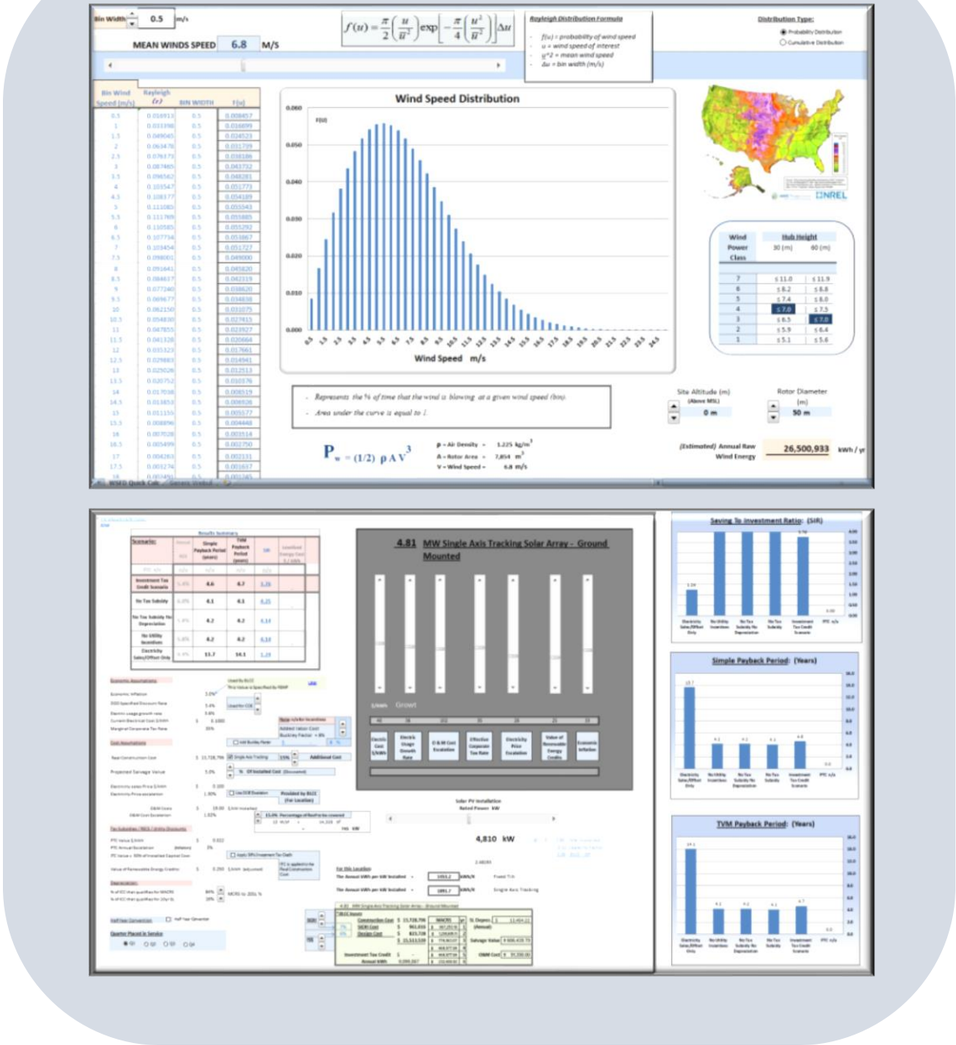




Scenario Analysis Tool

Too much automation can conceal insight…



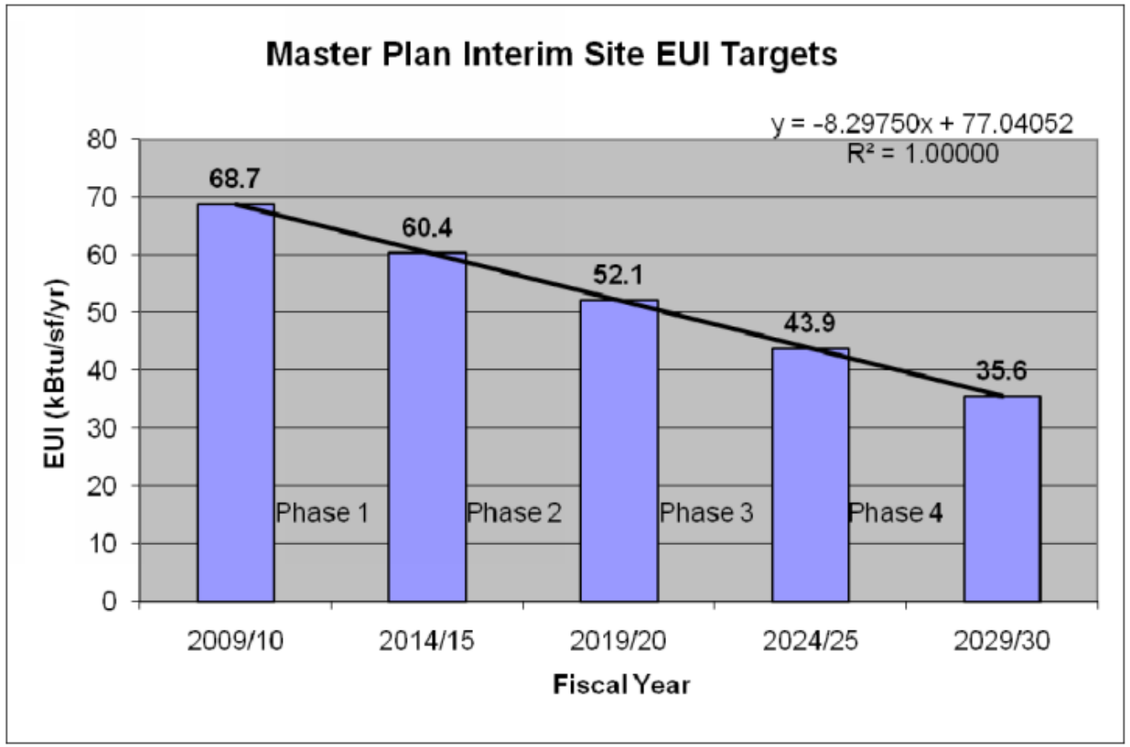


Strategic Energy Plan

Campus Approach

- 2030 Target
- 1990 Energy Usage
- 36% SF Growth

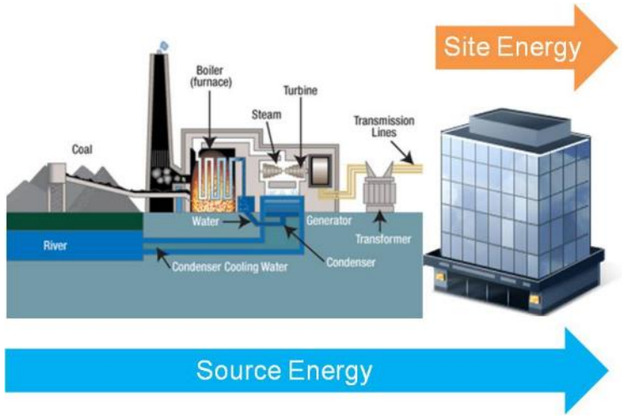
Stage	Year	Floor Area Added per Phase(sf)	Campus Floor Area (sf)	Total Combined Annual Consumption (kBtu/yr)	% Site Energy Change	Site EUI (kBtu/sf/yr)	% EUI Change
Baseline	2009/10	-	3,948,096	271,404,067	-	68.7	-
Phase 1	2014/15	1,114,200	5,062,296	305,993,170	12.74%	60.4	-12.07%
Phase 2	2019/20	285,200	5,347,496	278,861,412	-8.87%	52.1	-13.73%
Phase 3	2024/25	539,000	5,886,496	258,126,031	-7.44%	43.9	-15.91%
Phase 4	2029/30	330,000	6,216,496	221,015,363	-14.38%	35.6	-18.92%



Benchmarking

Energy Usage Intensity (EUI)

$$\frac{Energy}{Square\ Foot}$$



Broad Category	Primary Function	Further Breakdown (where needed)	Source EUI (kBtu/ft²)	Site EUI (kBtu/ft²)	Reference Data Source - Peer Group Comparison
Healthcare	Ambulatory Surgical Center		138.3	62.0	CBECS - Outpatient Healthcare
	Hospital	Hospital (General Medical & Surgical)*	426.9	234.3	Industry Survey
		Other/Specialty Hospital	433.9	206.7	CBECS - Inpatient Healthcare
	Medical Office*		121.7	51.2	CBECS - Medical Office
	Outpatient Rehabilitation/Physical Therapy		138.3	62.0	CBECS - Outpatient Healthcare
	Residential Care Facility		213.2	99.0	Industry Survey
	Senior Care Community*		213.2	99.0	Industry Survey
	Urgent Care/Clinic/Other Outpatient		145.8	64.5	CBECS - Clinic/Outpatient
Lodging/Residential	Barracks*		107.5	57.9	CBECS - Dormitory
	Hotel*		146.7	63.0	CBECS - Hotel & Motel/Inn
	Multifamily Housing*		118.1	59.6	Fannie Mae Industry Survey
	Prison/Incarceration		156.4	69.9	CBECS - Public Order and Safety
	Residence Hall/Dormitory*		107.5	57.9	CBECS - Dormitory
	Residential Care Facility		213.2	99.0	Industry Survey
	Senior Care Community*		213.2	99.0	Industry Survey
	Single Family Home		N/A	N/A	None Available
	Other - Lodging/Residential		143.6	63.6	CBECS - Lodging
Manufacturing/Industrial	Manufacturing/Industrial Plant		N/A	N/A	None Available
Mixed Use	Mixed Use Property		89.3	40.1	CBECS - Other
Office	Medical Office*		121.7	51.2	CBECS - Medical Office
	Office*		116.4	52.9	CBECS - Office & Bank/Financial
	Veterinary Office		145.8	64.5	CBECS - Clinic/Outpatient
Parking	Parking		N/A	N/A	None Available

Goal Setting

Energy efficiency offers the **most affordable opportunity** to reduce carbon footprint

Buildings often have **waste designed-in** – a lot!

Entrenched culture of overdesign and **tolerated energy waste**, defended as “margin of safety” and “best practice”

Concept of **“smart” buildings often oversold**, underdeveloped

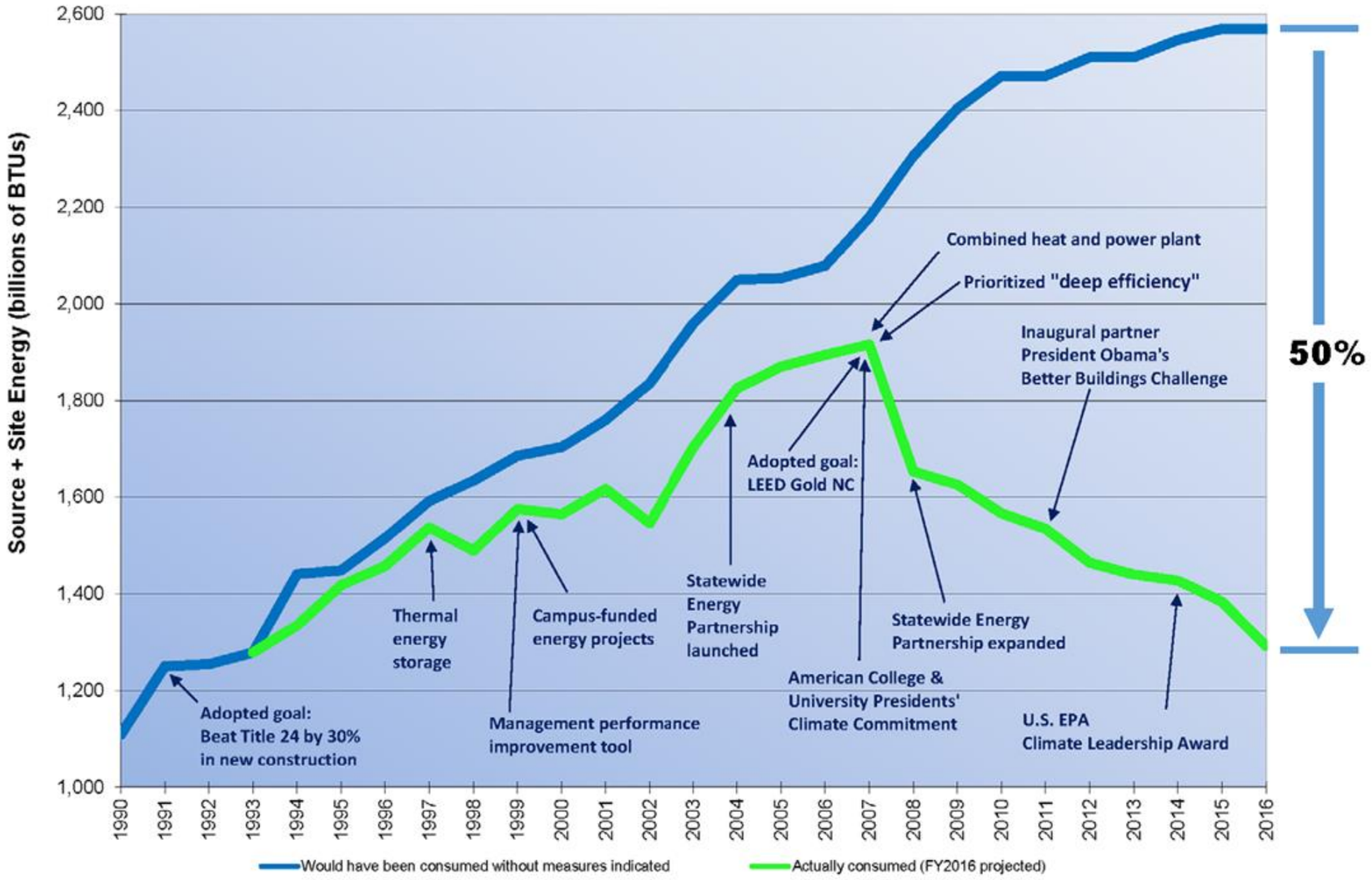
AIM HIGH TO GO LOW!

Attitude Drives Results

UC Example – 50% Reduction Goal

Facility Type	Goal	Realized
Laboratories	50%	61%
Classrooms/Offices	50%	50%
Housing	40%	23%
Lighting	50%	60%
Parking	50%	79%

Attitude Drives Results



Attitude Drives Results

60% of efficiency opportunities were in **buildings**

Challenge all accepted design practices

Use software and sensors to make systems **“smart”**

Whole-building retrofits enable **savings >50%**

Digital-savvy tradespeople essential to keep smart buildings smart

Beliefs and attitudes are as important to success as technology, financing, and management

Building **Energy Audits**

ASHRAE Level 1 Audit

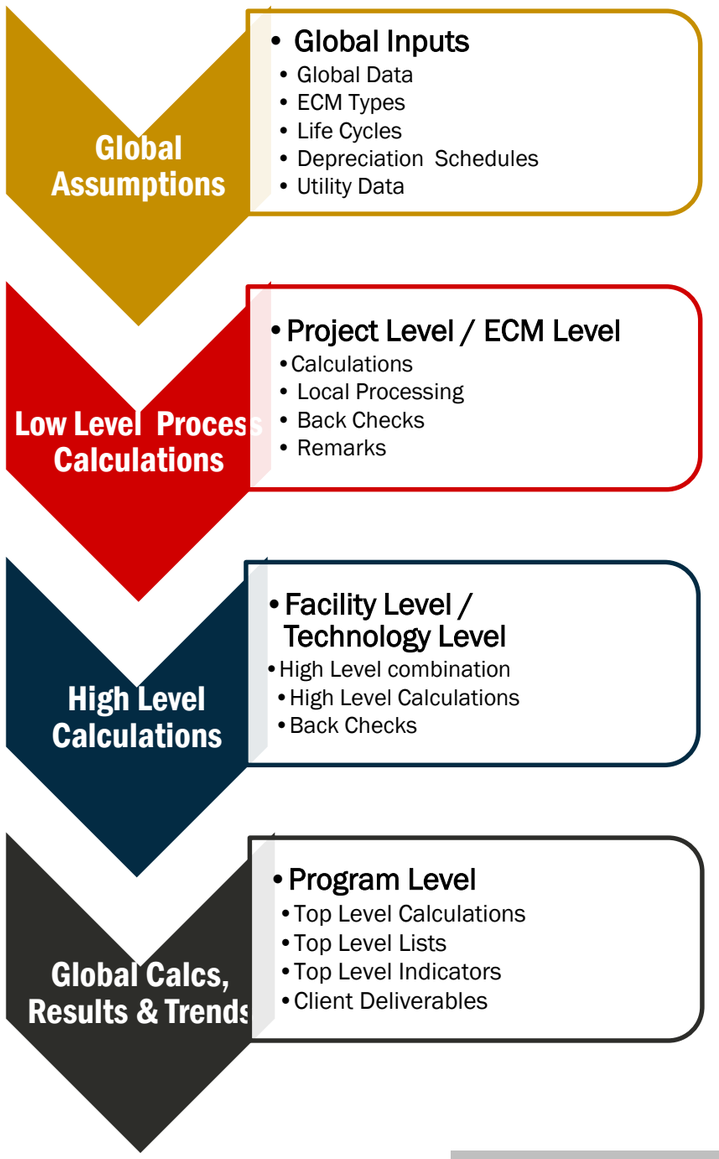
- High-level audit to identify potential energy conservation measures

ASHRAE Level 2 Audit

- Detailed investigation of all energy consuming systems and operations
- Spreadsheet based calculations along with probable cost estimates

ASHRAE Level 3 Audit

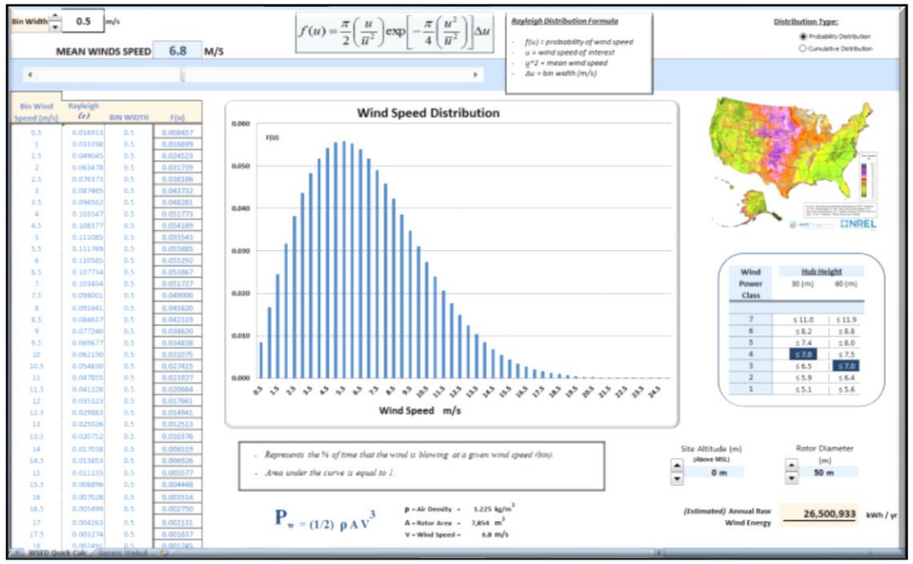
- ECMs developed in detail for accurate cost estimating
- Detailed, hourly based, computer modeling to determine savings

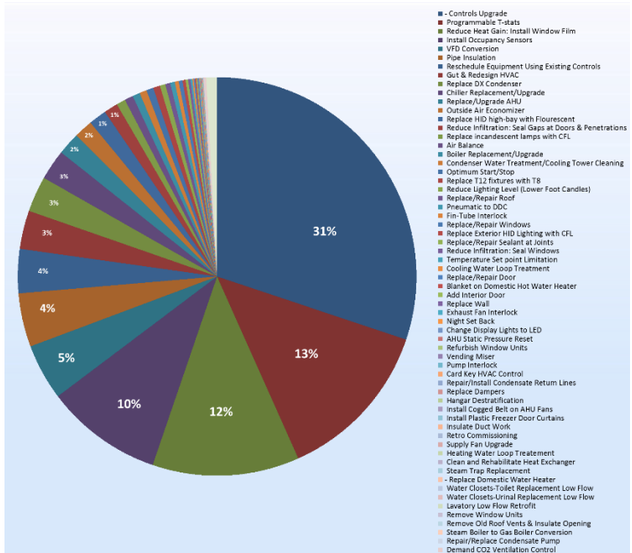


Building **Energy Audits**

Develop list of potential ECMs

- Issues log with recommendations and priority
- Develop description, cost, estimated annual savings and ROI
- Bundle ECM opportunities





Building **Energy Audits**

NAVFAC example

- 10 weeks, 60 auditors
- Average payback 2.7 years

Facility	SF Audited	# Buildings	# ECMs	# Bundles	Total Project
Hill AFB, UT	5.5M	234	670	154	$ 12,553,137
Wright Pat. OH	7.5M	101	625	146	$ 75,623,108
Whiteman, MO	1.2M	27	123	62	$ 11,251,017
TOTALS	**14.2M**	**362**	**1,418**	**362**	**$ 99,427,262**

Building **Retro-Commissioning**

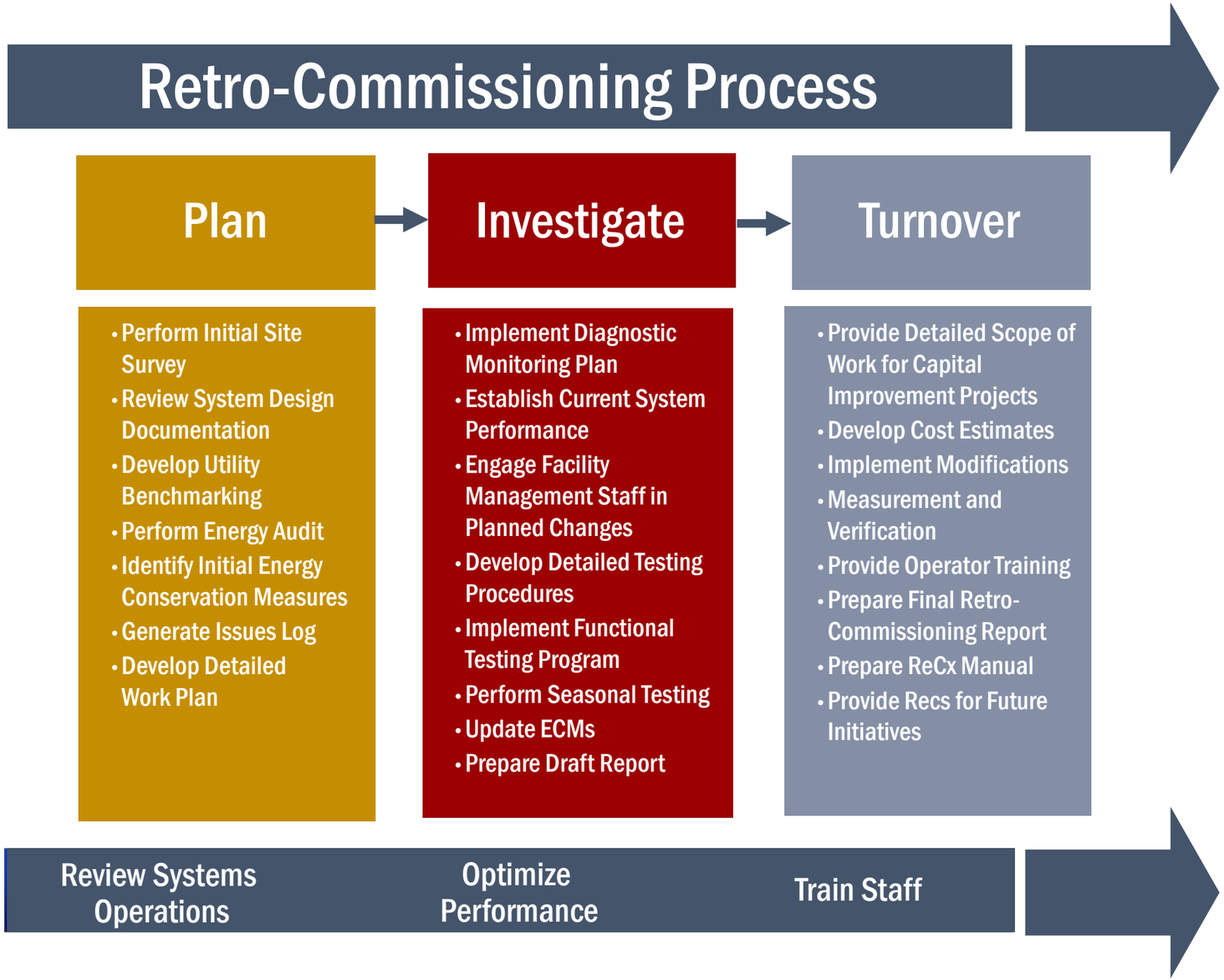
Purpose and Benefits

- Address problems never identified during initial building start-up
- Resolve systemic problems in building operation
- Address environmental deficiencies
- Correct excessive equipment run times due to changes in occupancy or use
- Identify and correct malfunctioning equipment or sensors
- Implement control optimization issues
- Extend equipment life
- Improve operations

RCx **Focus Areas**

- Temperature and humidity sensors out of calibration
- BAS programming vs. actual operation
- Simultaneous heating and cooling
- Correct and efficient air damper sequencing
- Chilled water bypasses and leaks
- Corroded condenser coils
- Incorrect head pressure control and hot gas bypass connections
- Poor equipment access (maintenance)
- Equipment not responding to control system
- Control sequence not operating correctly
- Incorrect cooling load calculations

RCx **Process**


Retro-Commissioning Process
Plan
Investigate
Turnover
• Perform Initial Site Survey
• Review System Design Documentation
• Develop Utility Benchmarking
• Perform Energy Audit
• Identify Initial Energy Conservation Measures
• Generate Issues Log
• Develop Detailed Work Plan
• Implement Diagnostic Monitoring Plan
• Establish Current System Performance
• Engage Facility Management Staff in Planned Changes
• Develop Detailed Testing Procedures
• Implement Functional Testing Program
• Perform Seasonal Testing
• Update ECMs
• Prepare Draft Report
• Provide Detailed Scope of Work for Capital Improvement Projects
• Develop Cost Estimates
• Implement Modifications
• Measurement and Verification
• Provide Operator Training
• Prepare Final Retro-Commissioning Report
• Prepare ReCx Manual
• Provide Recs for Future Initiatives
Review Systems Operations
Optimize Performance
Train Staff

RCx **Process**

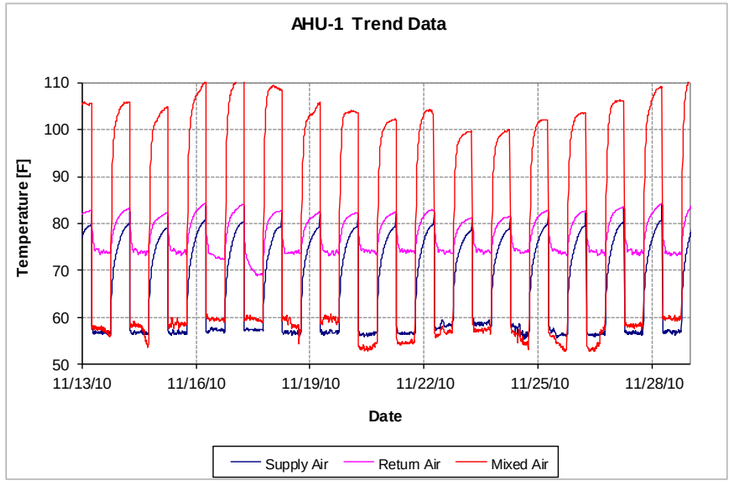
Investigation

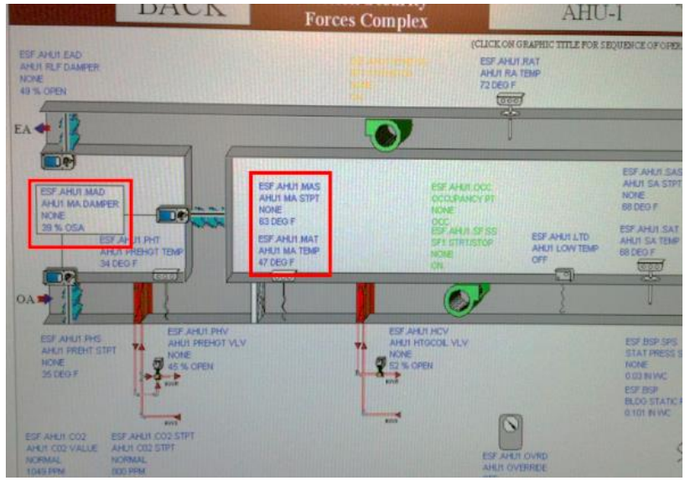
Diagnostic monitoring

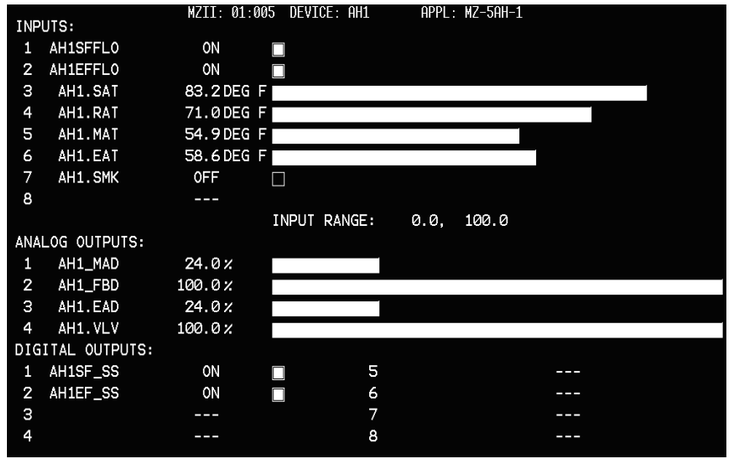
Functional testing

Energy analysis

Implementation







RCx **Lessons Learned**

Inadequate building documentation

Poor access to BAS data

Systems "never ran right from day one"

Zone level **adjustments made** but never tracked

Changes made during **construction**

"Improving performance" may not always reduce energy consumption

RCx **Results**

Our experience: average 15% to 25% savings in energy; can be higher

LBNL study of 643 buildings: over 10,000 energy-related problems, resulting in 16% median whole-building energy savings, with payback of 1.1 years

LBNL: High-Tech building - saved $127,800 Hospital: saved $6,700 – simple payback of 1 year

LBNL: Office - saved $90,900 with immediate payback

Capitalize on the **Opportunity**

- ✓ Develop an energy strategy
- ✓ Benchmark
- ✓ Goal + mind setting
- ✓ Building energy audits
- ✓ Building retro-commissioning

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