



U.S. Department of Energy  
Energy Efficiency and Renewable Energy



# Building Commissioning

Presented by  
H. Jay Enck  
Commissioning & Green Building Services, Inc.  
[WWW.CxGBS.com](http://WWW.CxGBS.com)





# What is Commissioning?

- Commissioning “is a systematic process of assuring that a building performs in accordance with the design intent and the Owner’s operational needs”
- Inspired by the Navy practice of a “shake down” cruise
- Simply stated, commissioning is making sure the owner gets what they paid for and the building runs right



# 1988-Caribbean Beach Resort Walt Disney World



- 2112 rooms
- \$5.5 M Problems Before Opening Day (HVAC & Envelope)



# 1991-Omni Hotel Charleston, S.C.



- HVAC/Envelope Problems Occurred Immediately After Opening
- \$10+ M Fix



# 1993-Martin County Courthouse Stuart, FL



- Building problems led to evacuation
- \$15+ M in repairs (original cost = \$11M)



# 1997-Marriott Hotel Kansas City



- Problems began during first summer's operation
- \$2 M Repairs



# 1995-Hale Koa Hotel Honolulu Hawaii

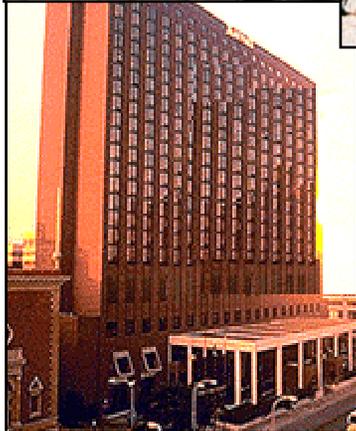


- Moisture & mildew problems started immediately after opening
- \$6.5 M HVAC fix



# Common Themes

- In every case the buildings were T&B-without finding (or correcting) problems
  - In every case the problems could have been predicted in the design stage.
    - In every case the changes needed to prevent these failures would not have cost more money or added to the schedule
    - In every case building commissioning would have prevented these problems.







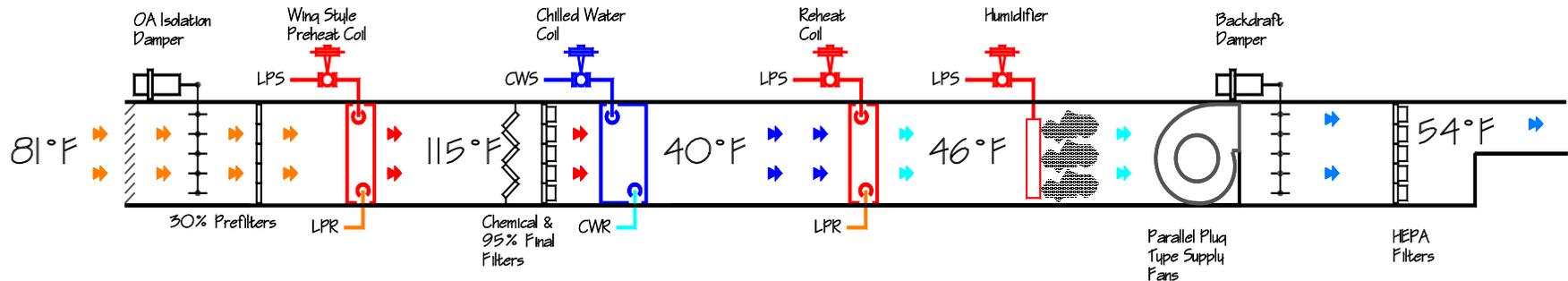
# Poor Performing Buildings



- Extensive water intrusion
- Storm water system not effectively removing rain water
- HVAC system not providing fresh air as designed
- Poor indoor air quality
- \$2M+ in repairs



# Which Design Intent are you Trying to Meet ?



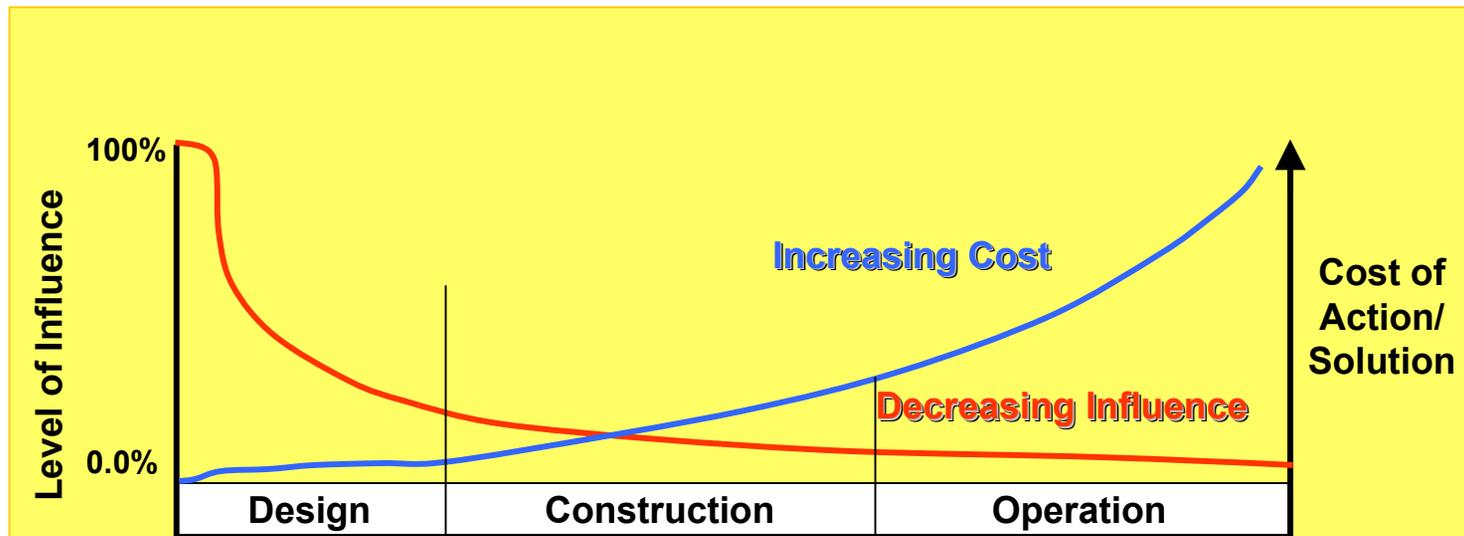
**Space conditions on spec at  $68^{\circ}\text{F} \pm 1\text{-}1/2^{\circ}\text{F}$ ,  
 $45\% \pm 5\%$  relative humidity.**

**Entropy of the Universe – Going Up!**



# Benefits of This Approach

- Reduces risk of building system failure
- Focuses owner and project team on critical issues while there is still an opportunity to correct
- Verifies performance for life of building
- Reduces risk and cost



Source: Adapted from Quality in the Constructed Project, American Society of Civil Engineers, 1988.



# A Win-Win Activity

- Commissioning is facilitation:
  - anticipating problems
  - working to find solutions
  - following through to get results
  - helping everyone win
- Lowers the total cost of ownership
  - Minimizes post occupancy administration
  - Minimizes initial O&M effort
  - Lowers operating costs
  - Improves owners image in the eyes of the occupants & their parents



# Southeast University's Business School



- Completed in 1997
- 123,053 Sq Ft
- Selected For LEED-EB
  - “Good Building”
  - “Has Many Green Features”
- Only 13 Work Orders Recorded – No Significant Issues
- No Known Occupant Complaints
- Energy Usage Monitored Since Completion
- Considered One of University’s “Best”



# University Business School



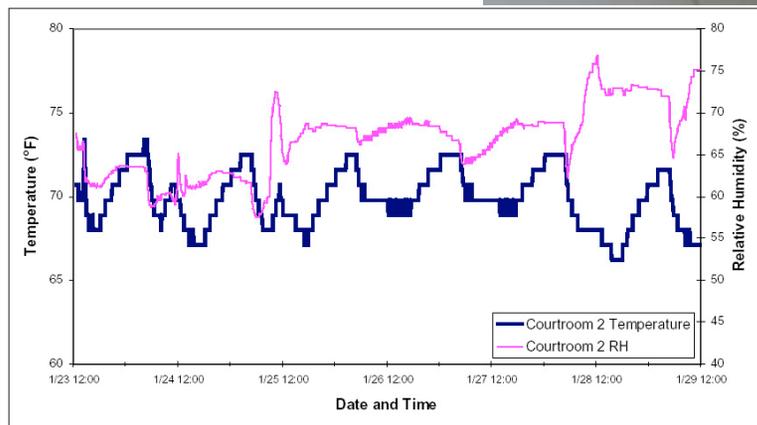
- Estimated HVAC System Consuming +50% More Energy Than Required
  - Negatively Pressurized
  - Make-up Air Restricted
  - VFD Fans Operating at Higher Than Necessary Static Pressure
- Overall Utility Consumption Estimated 35% to 40% More Than Required
  - Operating 24/7/365



# Holistic Commissioning Process

## – Forensic Based

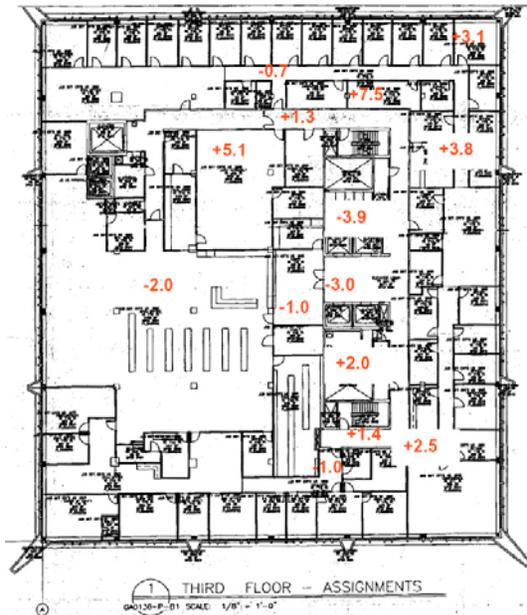
- Moisture Intrusion
- Energy Efficiency
- O&M Issues





# Holistic Commissioning Process

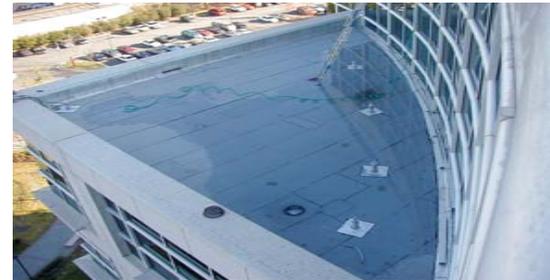
- Design Review
  - Vapor Transmission
  - Rain Water Intrusion
  - Negative Pressurization





# Holistic Commissioning Process

- Performance Verification
  - Building Envelop
  - MEP
    - Trending
    - Thermograph
    - Pressure Mapping
  - Emergency Conditions





# Commissioning Process

- Commissioning helps owners' improve performance in proportion to Cx effort
- Even the best commissioning requires follow-through after occupancy
- Changes after occupancy include:
  - O&M staff overrides features they does not understand
  - Sensor failure
  - Control modifications
  - Tenant retrofits



# Performance Tools

- Measurement & Verification
  - Benchmark for the operational staff to judge performance
  - Establishes action parameters
  - Isolates problem
  - Using Cx procedures to corrects problem for Life of Facility



# What Does Cx Really Mean?

- Involving all stakeholders from users, operations, and construction to clearly define the needs and requirements of the facility.
- Collaborative team effort to reduce design, construction, and operational problems resulting in higher occupant satisfaction and building performance
- Balances competing interests in Owner's favor



# What Does Cx Really Mean?

- Identify and resolve problems early while designers and contractors are engaged
  - Create a comfortable, safe workplace
  - Deliver energy-efficient buildings through testing and verification that systems work as intended
- Ensure a smooth transition to building occupancy & operation through training and documentation
- Performance for the life of the facility



# Facing the Human Costs and Resulting Liability Issues

- Operational and warranty costs have convince many owners to commission their facilities
- On average, people spend about 90% of their time indoors - National Safety Council.
- Pollutant levels inside can be two to five times higher outdoors –EPA
- Sources of pollutants including mold and mildew, chemicals, cleaning products, pesticides, and particulate concentrations



# Commissioning Important for Schools

- Schools at Risk for IAQ Problems
  - High Occupant Densities
  - Susceptible Population
  - Cookie Cutter Design
  - Often Minimal Maintenance



# Phases of Commissioning

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## 1. Pre-Design

Preparation of Owner's Project Requirements. OPR details the functional requirements of the project and expectations of how it will perform.

## 2. Design

Integrate commissioning into specifications defining roles & responsibilities of project team. Reviews accessibility, performance, coordination, sustainability goals, maintenance and operation training, and design intent.

## 3. Construction

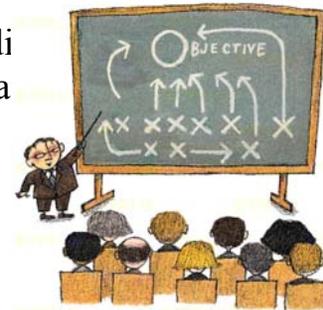
Identify issues that affect ability to maintain facility, installation practices that could jeopardize performance, construction practices that could affect indoor air quality, assist team identify and resolve problems while resources are still on site.

## 4. Acceptance & Warranty Phases

Verify performance all equipment, systems and subsystems, assist with O&M staff training, provide recommissioning manual. During warranty phase conduct seasonal testing and monitor performance.

## 5. Measurement & Verification and Re-Commissioning as Needed

Provide software tools and train O&M staff on their use for benchmarking building performance for energy, water consumption, & other metrics. Re-commission as needed.





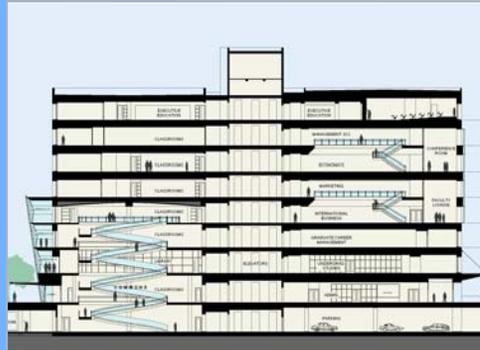
# Integrated System Approach

## ELECTRICAL

- Lighting & Power
- Energy Consumption
- Fire & Life Safety

## PLUMBING SYSTEM

- Storm Water
- Water & Sewer
- Water Efficiency



## STRUCTURAL

- Wind & Seismic Loads
- Flexibility
- Floor Load

## BUILDING ENVELOPE

- Weather Barriers
- Air Barriers
- Vapor Retarders
- Fenestration

## HVAC SYSTEM

- Proper Selection & Sizing
- Sufficient Run Time
- Adequate Pressurization & Ventilation



# Systems to be Commissioned

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- Originally, HVAC Systems
- Now, Whole Building Commissioning
  - HVAC
  - Envelope
  - Electrical

Other Systems May Include:

- Roof Structure & Insulation
- Fire /Life Safety
- Energy Management
- DDC Controls
- Technology Package
- Lighting
- Security Systems



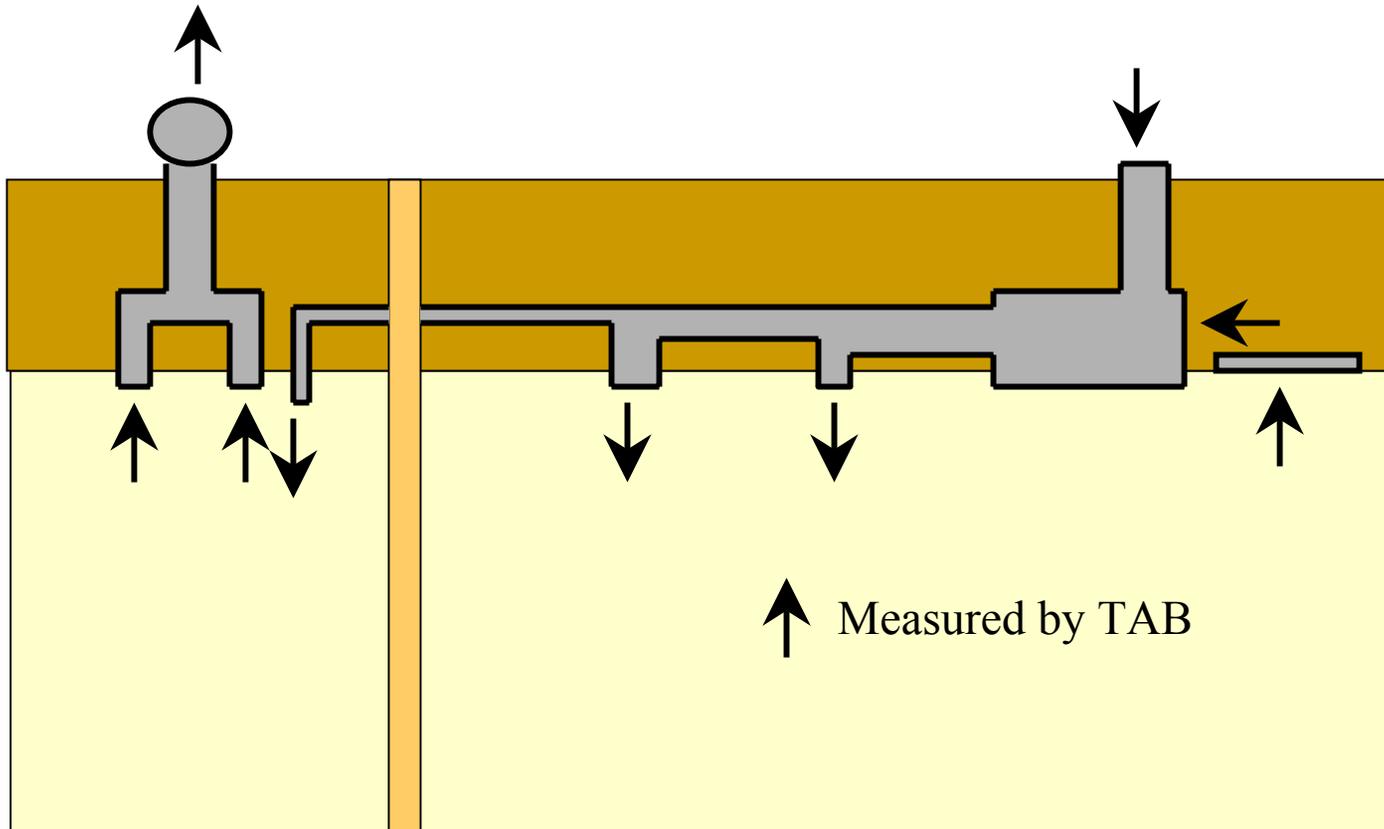


# Whole Building Commissioning

- Sometimes Commissioning is limited to MEP or even just Mechanical (HVAC) System
- We recommend Whole Building Commissioning that includes Envelope
- Envelope Commissioning test for moisture infiltration
- Moisture Problems lead to damage as well as mold and mildew problems
- Test & Balance Can be Part of Commissioning
- Test & Balance not a substitute for Commissioning

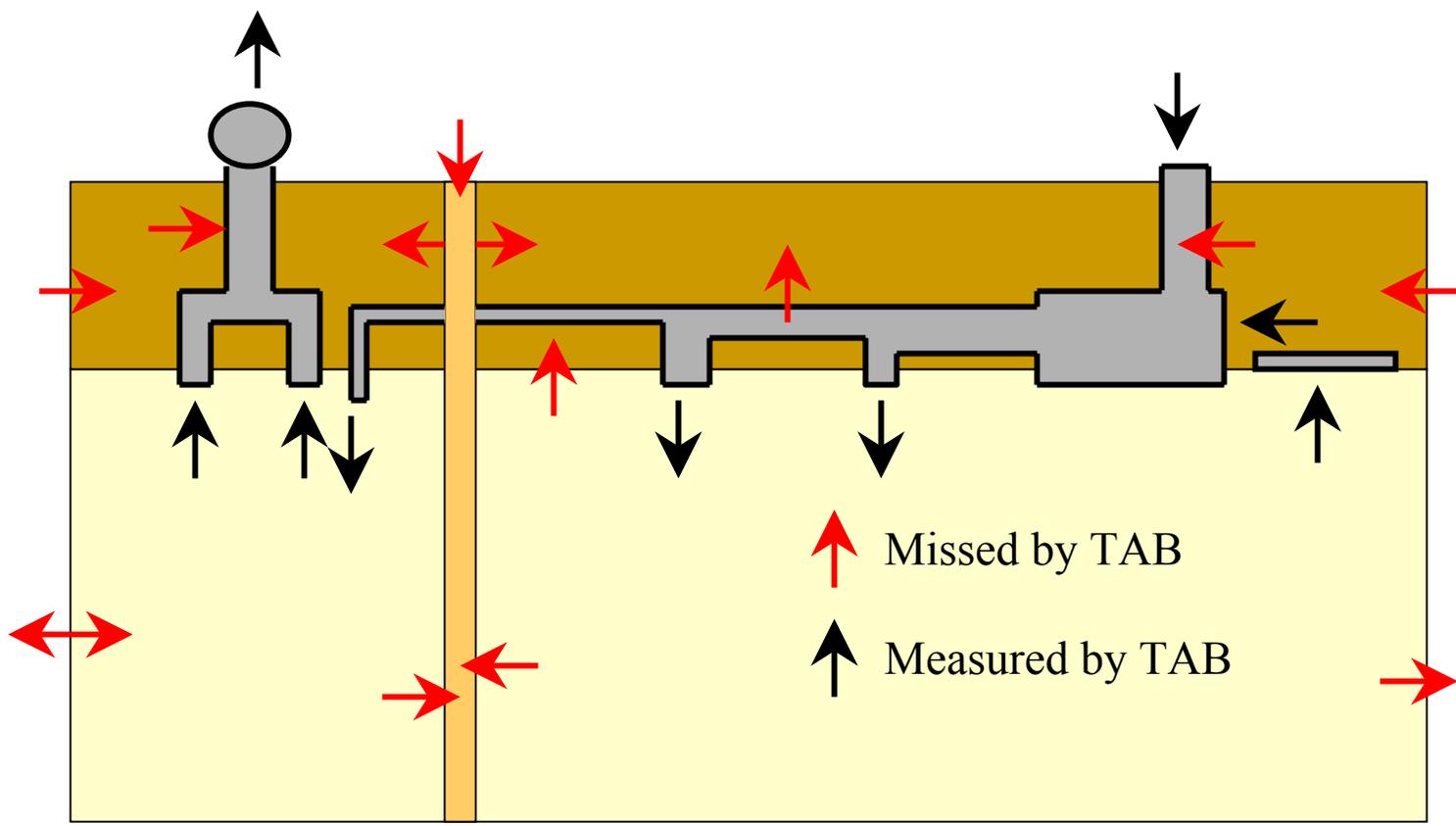


# Airflow Test and Balancing





# TAB Often Misses





# Example Commissioning Checklists

**COMMISSIONING CHECK SHEET  
SCREW CHILLER  
OPERATIONAL PERFORMANCE TEST (OPT)**

Project \_\_\_\_\_  
Equipment Tag \_\_\_\_\_  
System \_\_\_\_\_

Test Date \_\_\_\_\_  
Location \_\_\_\_\_  
Dwg. No. \_\_\_\_\_

Description	Design Data	Verification
<b>Phase II Start Up (OPT)</b>		
<b>Chiller Barrel</b>		
Check Chilled Water Flow		
Verify DP Drop		
<b>Condenser Barrel</b>		
Check Condenser Water Flow		
Verify DP Drop		
<b>Compressors</b>		
Vibration Isolational Functional		
Crank Case Heater Operational		
Voltage		
Phase		
Jog for Rotation		
Amps		
Verify Overload Size and Setting		
Verify Oil Setting HP/LP		





# Problem and Resolution Examples

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- Proprietary Control Solutions
- Pump Seals
- Control Calibration
- Control Sequence Deficiencies
- Slag in CW / HW Loop
- Boiler Tube Rust
- Bypass Valves
- Freeze Stats
- Side Stream Filters
- Outside Air Mix





# Deliverables to the Customer

- Documentation
  - ✓ Performance
  - ✓ Issues
  - ✓ Training
- Training
  - ✓ O & M
  - ✓ M & V
- Tools
  - ✓ Benchmarking
  - ✓ Re-commissioning manual
- Assistance
  - ✓ Problem resolution
  - ✓ Monitoring performance





# Recommissioning

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Applied to the existing building's HVAC, controls, and electrical systems.

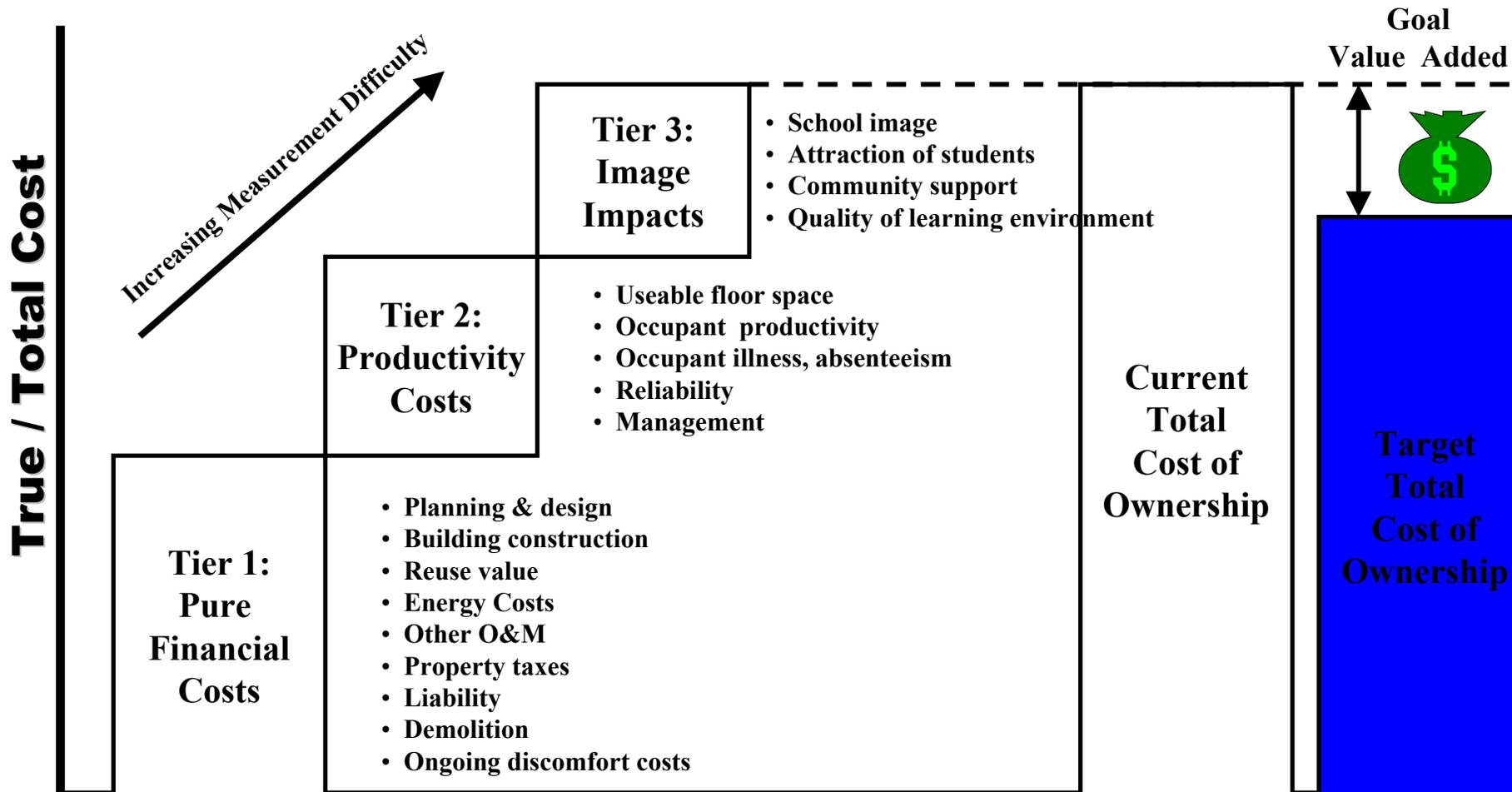
*Also called "Building Tune-Up."*

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# TCO consists of several tiers of costs





# Why Commissioning?

- Reduces the Owner's Total Cost of Ownership
- Pays for itself with improved operations, avoided problems, better IAQ and energy efficiency
- Reduced risk, fewer change orders, improved energy efficiency & lower operating costs
- Reduced administrative effort dealing with design or contractor problems during warranty and inconvenience of call backs and repairs
- Conservation of O&M resources and lower O&M costs
- Commissioning – a small investment with a big payback