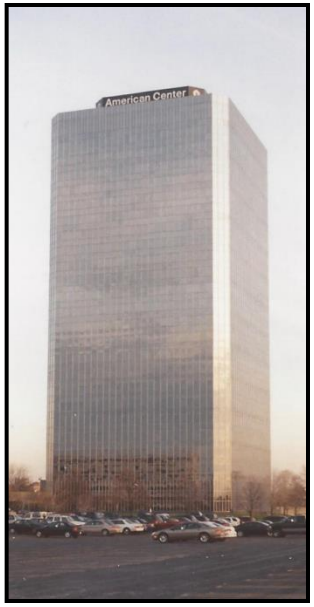
Course Approval **#NY3633**:

This Course has been Evaluated and Approved by The Practicing Institute of Engineering, Inc (PIE) for compliance with the NYS Mandatory Continuing Education requirements for Professional Engineers. Approved for: **1.0 PDH** (Professional Development Hours).

Introduction to the Proper GSHP & Building Commissioning "Process & Basics" - Supporting a wide range of Buildings, Technologies, & Projects - *Including varying types of GSHP Systems*

NY-GEO 2026 Conference - March 24-25, 2026
New York Marriott at the Brooklyn Bridge - Brooklyn, NY



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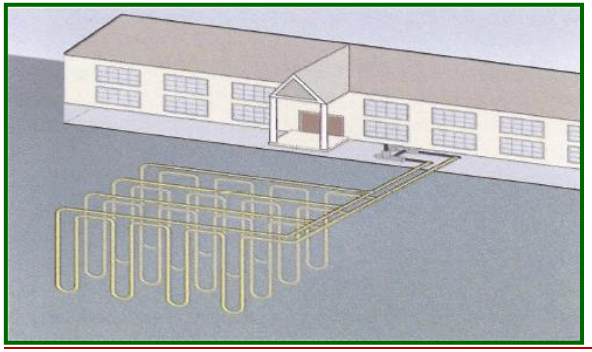

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- No warranty is made as to the suitability of any drawings and/or data for a particular application - each application must be handled separately and based on its own site specific conditions.
- The success of implementing the Commissioning procedures, achieving projected/desired energy and costs savings, and desired project performance, etc. all depend on the quality and completeness of the engineering design, construction, TAB Procedures (Testing, Adjusting and Balancing), proper application of the system commissioning during all project stages, system controls/integration, proper PM, weather, many behavioral/operational factors, and many other factors outside the control of Pyramid EES.
- As such, Pyramid EES does not guarantee project performance and shall in no event be liable should the actual performance (and energy and cost savings) vary from the desired project performance.

Course/Workshop Intended Diverse Audience

- This course primarily caters to Design Engineers, Technicians, Facilities Managers, Construction Contractors, Consultants, Construction Managers, Project Managers, Architects, Specialty MEP Equipment Vendors;
- In addition to other professionals like Scientists, R&D researchers supporting testing and demonstration projects, and energy and climate policy makers.
- All interested in seriously enhancing their knowledge and exposure to a broad spectrum of commissioning procedures supporting a wide range of residential, commercial, industrial, and institutional facilities and master energy and environmental plans in need of a wide range of commissioning types to achieve desired goals.

GSHP Building Commissioning Basics
Course Description

This session presents an overview of the proper commissioning (Cx) process and points out **six (6) types of commissioning processes**, depending on what's required or specified. Outlined will be the **4 proper phases of the Total Cx process** including how to plan for Cx, Cx team's composition and an intro to the required checklists, forms and tests to conduct Cx. Lastly, how to plan for & generate beneficial Cx reports for existing and new buildings and systems targeting high performance.

Course Description (1 of 5)

- This course starts by presenting an overview of the ***proper commissioning (Cx) process*** starting with what is Cx?
- Presents the most known six (6) types of Cx: (1) *Total Cx*, (2) Continuous Cx, (3) Ongoing Cx, (4) Re-Cx, (5) Retro-Cx, & (6) Cx Light or Custom Cx.
- Presents the 4 proper phases of the *Total Cx process*.
- How to plan for Cx.
- The Cx team's composition and their Roles & Responsibilities.
- Intro to the required checklists, forms and tests to conduct Cx.
- How to plan for & generate beneficial Cx report for existing and new buildings and systems targeting high performance.

Topics Covered / Learning Objectives - (2 of 5)

- Understand the ***well-integrated*** and ***holistic*** project development and Cx approaches to support:
- Successful HVAC, MEP and building/process ***automation systems*** (EMS/BMS/SCADA) installations covering a wide variety of conventional, progressive and renewable heating and cooling systems and technologies in varying building types and sizes covering residential, commercial, institutional, industrial facilities (& even laboratories & mission critical facilities!).
- ***Cx*** *is part of successful* ***IDP*** *(Integrated Design Process)*.

Topics Covered / Learning Objectives - (3 of 5)

Be aware of the numerous Commissioning (Cx) ***procedures and requirements*** based on major Cx references including but not limited to:

- **U.S. DOE** (Model Cx Plan - Construction Phase Cx Plan).
- US DOE funded **BCxA** (Building Commissioning Association).
- **ACG** (AABC Cx Group).
- Well-known and widely accepted **ASHRAE** Guideline 0 (The Cx Process) & ASHRAE Guideline 1 (The HVAC Cx Process).
- Numerous respected other resources.
- All coupled and illustrated by the trainer's own in-depth expertise and experience in the field over 3 decades, domestically in the U.S. as well as internationally, supported by real life examples, some were quite painful and expensive.

Topics Covered / Learning Objectives - (4 of 5)

Make a differentiation between ***existing*** and ***new*** building Cx needs:

- Provide an overview of suggested additional sensors to "incorporate" during the design and construction phases to support a new building Total Cx process, then Ongoing Cx moving forward, utilizing valuable built-in and well-thought of sensors for both monitoring based commissioning (MBCx) & M&V (if needed).
- Identify key systems within a facility that are better candidates or higher priorities for commissioning compared to other systems as sorted by their energy use, demand intensities, safety, and critical to facility operation in terms of occupant comfort, productivity, customer revenues, IEQ and safety.

Topics Covered / Learning Objectives - (5 of 5)

- Be aware of a few of the known ***barriers*** impeding implementation of the proper Cx process in numerous projects and know how to avoid them through good customer and project team education.
- Be aware of the proper Cx process from A to Z and see what happens when the proper process was not followed based on multiple real life examples. Some lessons were real painful and expensive!
- ***A Sample of lessons learned categories*** are briefly presented in this Introductory Stage-1a & 1b Courses, but are elaborated on further the "Optional" Stage-2 Detailed Course.

www.HeatSpring.com/Cx

Important Commissioning (Cx) Definitions, Sources & Resources

In general, Commissioning is a systematic process of inspecting and testing building systems to ensure that they are installed properly and operate in accordance with the design intent.

- However, is this definition enough? Ans.: Yes, No, or it really depends?

As such, listed below are General Definitions and elaborations in relation to Commissioning &TAB.

- These definitions are based on industry-accepted standards, and cover **all phases** of the project.
- Quotations below come from *several* valuable ASHRAE (and other) References published over the last 30+ years:

"*Total Building Commissioning Process (TBCxP)*:

Very Important Slide

- **ASHRAE Guideline 0-2005 & 2013 (The Commissioning Process)** defines the **Cx Process** as "*A quality-focused **process** for enhancing the delivery of a project. The process focuses upon verifying and documenting that the facility and all of its systems and assemblies are planned, designed, **installed, tested**, operated, and maintained to meet the Owner's Project Requirements*".

- "The Cx ***Process*** ***begins*** at project inception during the *Predesign Phase* and continues for the life of the facility through the *Occupancy/Operations Phase*. During the Predesign Phase, the OPR are determined and documented by the Cx Team, which includes the Owner, Cx Authority (CxA), design professionals, operation and maintenance personnel, occupants, and users. Throughout each phase of the project, deliverables (drawings, specifications, submittals, construction, training, documentation, etc.) are verified against the OPR".

Total Building Commissioning Process (TBCxP):

Per ASHRAE, The Commissioning Process, also published by NIBS (National Institute of Building Sciences) as Guideline 0, fully supports the **Total** Building Commissioning Process.

Very Important Slide

- Q. What does **Total** Mean?
- **Total = Holistic = Thorough = Complete = Extensive = Multi-Phase = Full 4-Phase Cx Process = Spans from pre-design all the way into occupancy & Operations = The Cadillac = Get it done appropriately & correctly all the way from the project beginning to end, be thorough and do not cut corners.**

The Comprehensive Total Building Commissioning Process (TBCxP) takes place in Four (4) Phases of the project.

Per the ASHRAE **Cx Guidelines**, **Total** Commissioning can take place in **4 Phases**:

1. Cx During Pre-Design Phase.
2. Cx During Design Phase.
3. **Cx During Construction**.
4. Cx During Occupancy & Operations.

ASHRAE Guideline 0-2005 & 2013 (The Commissioning Process) defines the **Cx Process** as "*A quality-focused process for enhancing the delivery of a project. The process focuses upon verifying and documenting that the facility and all of its systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the Owner's Project Requirements*".

Types of Buildings in need of Commissioning:

1. Cx of ***Existing*** Buildings.
2. Cx of ***New*** Buildings.
3. Cx of *Existing* Buildings that are undergoing ***Substantial Renovations***.

Make a differentiation between the 3 building types and determine additional sensors to incorporate during the design and construction phases to support the Total Building Cx Process (TBCxP) for new and substantially renovated buildings and to facilitate Ongoing Cx moving forward in both bldg types using those new built-in sensors for both monitoring based Cx (MBCx) (& M&V if needed).

"Commissioning (or the Commissioning Process):

[FYI - Old Reference Slides Only]

- **ASHRAE Guideline 1-1996 (The HVAC Commissioning Process)** defines the Cx Process as "*the process of ensuring that systems are designed, installed, functionally tested, and capable of being operated and maintained to perform in conformity with the design intent. In this guideline, commissioning begins with planning and includes design, construction, start-up, acceptance and training, and can be applied throughout the life of the building*".

- **FYI - California Commissioning Guide for Existing Buildings** stated that "*Building Commissioning (Cx) is a systematic quality assurance **process** that spans the entire design and construction process. Building commissioning helps ensure that a new building's performance meets owner expectations by verifying and documenting that building systems and components are planned, designed, installed, tested, operated, and maintained to meet the owner's requirements (OPR)*".

Why *Commissioning*?

Question - Why *Commissioning*? (*Geothermal Heat Pump* System Examples)

1. Ensure correct GTHP system *operation, **controls** and **integration*** with existing HVAC systems, energy management and controls system (EMCS), and heat distribution systems.
2. Verify *properly sized System Components (HPs, Pumps, Pipes, and GHX, etc.* and other support systems.
3. Verify the effectiveness and benefits from *GHX Thermal Storage year round*.
4. Support future quantification of energy and cost savings and, performance validation and *measured COPs at varying loads*.

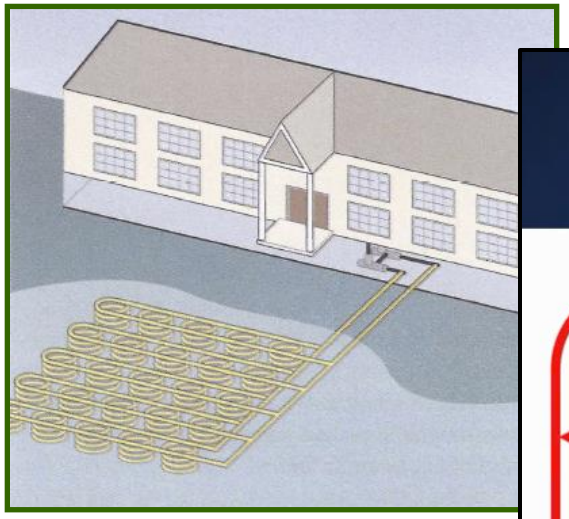
Technology Specific Example

Question - Why *Commissioning*? (*Geothermal Heat Pump* System Examples)

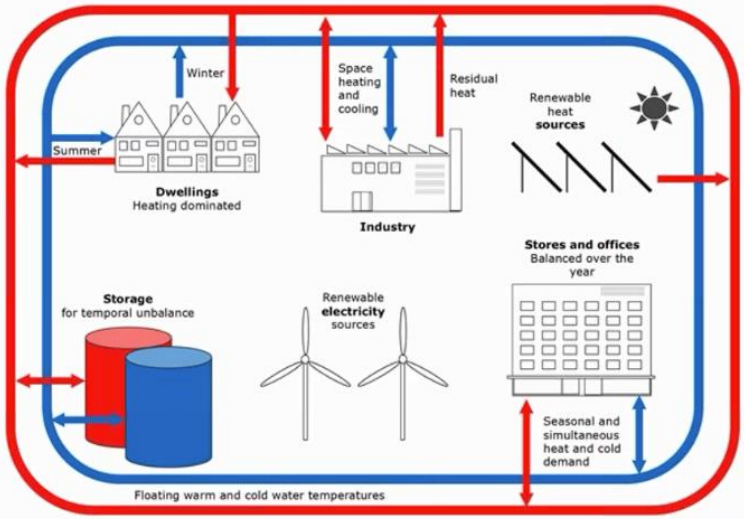
1. Facilitate accurate and fair billing with campus style settings that have *thermal sale agreements*.
2. Ultimate targets to ensure we deliver conditions where "*Ground is warmer in winter and cooler in summer*" without any major deviations.
3. Overall, use your imagination from your own expedience and/or if you review of the detailed lessons learned slides (if you take the Detailed Course Stage-II) and how many problems could have been avoided from the beginning "***IF***" proper Cx was implemented from the beginning, which would have been much less costly than the system corrections that were implemented after a significant amount of system troubleshooting and retro-Commissioning.

Technology Specific Example

Technology Specific Examples

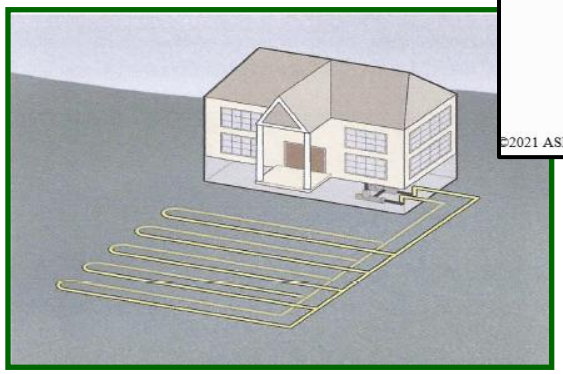


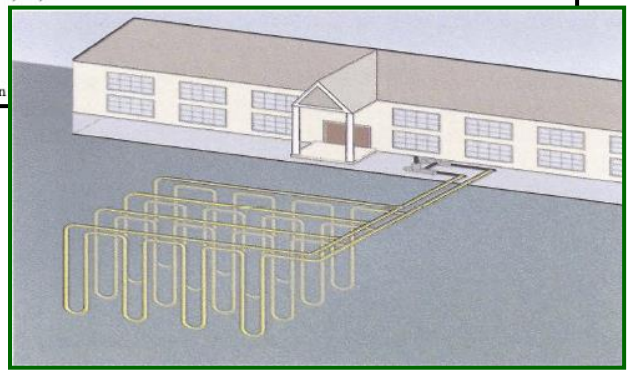
5th Generation District Energy Systems



- District heating and cooling approach using renewable resources
- District heating and cooling components may be decentralized.
- Systems may be bi-directional, close to ground temperature
- Seasonal storage
- All electric. Ideally, no CO_2 produced at sites
- Includes Community Heat Pump Systems

Boesten, S., Ivens, W., Dekker, S. C., and Eijdems, H.: 5th generation district heating and cooling systems as a solution for renewable urban thermal energy supply, Adv. Geosci., 49, 129–136, https://doi.org/10.5194/adgeo-49-129-2019, 2019.





Illustrations Courtesy of *ASHRAE & NYSERDA*

Q/A - Why *Commissioning*? (General to All Systems) (1 of 2)

- ✓ Provide a "**quality-oriented process** for achieving, verifying, and documenting that the performance of facilities, systems, and assemblies meets defined objectives and criteria" (ASHRAE Guideline 0-2005).
- ✓ The purpose of G0-2005 & 2013 is to "describe the Commissioning Process capable of verifying that a facility and its systems meet the Owner's Project Requirements (OPR)" (ASHRAE Guideline 0-2013); & Basis of Design (BOD).

Q/A - Why *Commissioning*? (General to All Systems) (2 of 2)

- ✓ Provide the owner with:
  - ✓ "***Comprehensive quality assurance program***, beginning with the **predesign phase** of the project, continuing through the **design** and **construction** phases, and culminating in sustainable **operation** by the owner's staff".
  - ✓ "Commissioning is a programmed series of quality assurance, documentation, and testing activities that are performed specifically to ensure that the ***finished facility operates as intended***"
  - ✓ (The Bldg Cx Handbook 2nd Edition).

How much does *Commissioning* Cost?

&

How much can *Commissioning* Save?

Q/A - How Much does *Commissioning* Cost? (General to All Systems) (1 of 3)

- ✓ Cx will generally and will definitely add cost to the project's first cost including Cx & TAB, but it will save a lot of energy and money over the building lifecycle cost (BLCC) cost over a 30 to 50 or even a 100 year period.
- ✓ The bottomline is that be aware that "***the cost of building commissioning is less than the cost of not commissioning your new facilities***." (The Bldg Cx Handbook 2nd Edition).

Q/A - How Much does *Commissioning* Cost? (General to All Systems) (2 of 3)

- ✓ Fact - Building commissioning is important for the success of capital construction projects and should be budgeted for during **all** project phases.

- ✓ Cx has an attractive return on investment (ROI) and is much better than a CD.

- ✓ ***Simply, you cannot afford not to Commission***.

Q/A - How Much does *Commissioning* Cost? (General to All Systems) (3 of 3)

- ✓ Cx has numerous benefits, one of which is that it *helps fill gaps* in the needed coordination that generally lacks in many projects and as such *communication and coordination is key* to the success of this Cx process.

- ✓ Cx supports a well-Integrated Design Process (IDP).

Q/A - How Much Can *Commissioning* Save in terms of energy and other non-energy savings? (General to All Systems) (1 of 4)

In 2004, Lawrence Berkeley National Laboratory estimated $18 billion per year of potential savings from commissioning throughout the United States. Simply addressing the top 13 faults in commercial buildings alone has a potential savings of **$3.3 to $17 billion per year**.

Top 13 Faults in Commercial Buildings:

1. Duct Leakage.
2. HVAC system operates continuously during unoccupied period.
3. Lighting system illuminating space during unoccupied period.
4. HVAC system improperly balanced.
5. Improper refrigerant charge.
6. Economizer dampers operating Incorrectly.
7. Insufficient evaporator airflow.
8. Improper controls setup / commissioning.
9. Control component failure or degradation.
10. Software programming errors.
11. Improper controls hardware installation.
12. Air-cooled condenser fouling.
13. Valve leakage.

Q/A - How Much Can *Commissioning* Save in terms of energy and other non-energy savings? (General to All Systems) (2 of 4)

Per US DOE and Pacific Northwest National Lab, a study that included 643 buildings across the U.S. suggests that **correcting the deficiencies** found during the commissioning process resulted in:

- **16%** median whole-building energy savings in existing buildings (Payback times of **1.1 years**).
- **13%** energy savings in new construction (Payback time **4.2 years**).

It also found that projects that incorporated a **thorough commissioning** process attained nearly:

- **Twice** the overall median level of savings.
- **Five times** the savings of the least thorough projects.

Q/A - How Much Can *Commissioning* Save in terms of energy and other non-energy savings? (General to All Systems) (3 of 4)

- Per US DOE and Pacific Northwest National Lab, Energy savings of new building commissioning can be significant.
- Since they depend on several factors, including building type, location, and the scope of the commissioning process, they are usually presented as a range.
- A comprehensive study found the value of energy savings from commissioning to range from **$0.02 - $0.19/sqft**.
- The value of non-energy savings resulting from commissioning to range from **$0.23 - $6.96/sqft**, as shown in the table below.

Savings from Commissioning		
Description	Range of Values	Expected Annual Savings for a Theoretical 100,000 sq. ft. Building
Value of Energy Savings	$0.02 - $0.19/sq. ft.	$2,000 - $19,000
Value of Non-Energy Savings	$0.23 - $6.96/sq. ft.	$23,000 - $696,000

Q/A - How Much Can *Commissioning* Save in terms of energy and other non-energy savings? (General to All Systems) (4 of 4)

- Per US DOE and Pacific Northwest National Lab, through proper commissioning these savings can actually increase over time.
- This may seem counterintuitive, but studies have found that when commissioning includes training, and in some cases, installation of permanent metering and feedback systems, improvements in system performance can persist for years after commissioning.
- Findings reassure building owners that new-construction commissioning can be very effective, durable, and the Cx outcomes will result in savings for the entire life of the building.

Commissioning Process & Key Cx Component Definitions

Cx Plan:

- **ASHRAE Guideline 0-2005 & 2013 (The Commissioning Process)** defines the **Cx Plan** as "*A document that outlines the organization, schedule, allocation of resources, and documentation requirements of the Commissioning Process*".

- **ASHRAE Guideline 1-1996 (The HVAC Commissioning Process)** defines the **Cx Plan** as "*a document defining the commissioning process, which is developed in increasing detail as the project progresses through its various phases*".

***Cx Authority (or Cx Agent)*:**

- **ASHRAE Guideline 0-2005 & 2013 (The Commissioning Process)** defines the **Cx Authority (CxA or CA)** as "*An entity identified by the Owner who **leads**, plans, schedules, and coordinates the commissioning team to implement the Commissioning Process*".
- **ASHRAE Guideline 1-1996 (The HVAC Commissioning Process)** defines the Cx Agent as "*the designated person, company, or agent who **implements** the overall commissioning process*".
- **ASHRAE Standard 202-2013 (Cx Process for Buildings & Systems)** states on Page 27 under Subsection G2.1 that "*The primary role of the CxA is to verify achievement of the OPR throughout the project, from Predesign Phase through Occupancy/Operations Phase. The owner could perform the CxA role*".

Cx Reporting:

ASHRAE Guideline 0-2005 & 2013 (The Commissioning Process) defines:

- **Cx Process Progress Report** - "*A document that details activities completed as part of the Commissioning Process and significant findings from those activities, which is continuously updated during the course of a project. Usually incorporated into the Commissioning Plan as an ongoing appendix*".

- **Cx Process Report** - "*A document that records the activities and results of the Commissioning Process. Usually developed from the final Commissioning Plan with all of its attached annexes*".

Testing, Adjusting, and Balancing (TAB):

ASHRAE Standard 111-2008 (Measurement, Testing, Adjusting and Balancing of Building HVAC Systems):

- PURPOSE of standard - "*To provide uniform procedures for measurement, testing, adjusting, balancing, evaluating, and reporting the performance of building heating, ventilating, and air-conditioning systems in the field*".
- SCOPE of Standard states "*This standard applies to building heating, ventilating, and air-conditioning (HVAC) systems of the **air-moving** and **hydronic** types and their associated heat transfer, distribution, refrigeration, electrical power, and control subsystems*".

ASHRAE, founded in 1894, is a global society advancing human well-being through sustainable technology for the built environment. The Society and its more than 50,000 members worldwide focus on building systems, energy efficiency, indoor air quality, refrigeration and sustainability. Through research, standards writing, publishing, certification and continuing education, ASHRAE *shapes tomorrow's built environment today*. More information can be found at www.ashrae.org/news."

Q. What happens when well-integrated and holistic project development approaches were **not** followed and there was **NO Commissioning**?

List 3 examples.

Issues Summary from Commercial & Residential HVAC/MEP System Troubleshooting (1 of 1)

1. Lack of design review by independent 3rd party, Lack of an Energy Audit before design, Lack of design team training.
2. Inadequate Design, Drawings & Spec details.
3. Oversized Systems & Inadequate Building Insulation.
4. Unclear Roles and Responsibilities (R&R) among project team members during all project phases.
5. Lack of TAB (Test, Adjust and Balance).
6. Lack of Total Cx (Commissioning) process, Issues Logs & Project Coordination Meetings, etc.
7. Issues with *early generation* Equipment reliability & robustness.
8. Lack of complete Control Sequences of Operation (SOO), & Systems integration.

Issues Summary & Highlights of Major Findings (Main Categories - Group 1 of 3):

Technology Specific Example

1. Lack of **TAB** (Test, Adjust and Balance).
2. Lack of **Cx** (Commissioning) process, Issues Logs & Project Coordination Meetings .
3. Lack of complete **Control Sequences of Operation (SOO)**, & Systems **integration**.
4. Inadequate **Designs**, **Drawings** & **Specification** details.
5. Lack of proper **design review by independent 3rd party** & Lack of an **Energy Audit** before design.
6. Numerous **system pressurization**, & **HX** (heat exchanger) location & sizing issues.
7. **Pumping, Piping, Valving, VFD** & other **Hydronic issues**.

Issues Summary & Highlights of Major Findings (Main Categories - Group 2 of 3):

Technology Specific Ex.

8. Incomplete **Pump/Valve Schedules**, & lacking other documentation.
9. No accurate **as-built drawings** *before* & *after* the project.
10. Unclear **Roles and Responsibilities** among project team members during all project phases.
11. Inadequate and Improper **TES (thermal energy storage)** Tanks.
12. Existing Building, System and Central plant problems were not resolved *before adding* GTHPs.
13. Lack of proper building **Peak Heat Load Determination** and H/C **Load Profile** modeling leads to **Oversizing HP & GHX** Issues.

Issues Summary & Highlights of Major Findings (Main Categories - Group 3 of 3):

Technology Specific Ex.

14. Issues with **2&3-way mixing valves** serving BOP.
15. Lack of enough **BTU meters**, **M&V**, & motor status **CTs**.
16. Lack of **PT Ports** makes it impossible to TAB systems and troubleshoot.
17. ESCO, Design Engineer & Installer lack the necessary GTHP (and MEP) system **knowledge & experience**.
18. Issues with **HP reliability** and robustness.
19. **Geothermal Vault**, BOP (Balance of Plant), Boiler **venting**, & Misc other MEP and/or code issues.
20. ESCO Financial Issues; Low Natural Gas Prices?; Any one else to blame?
21. Issues with Certain Government Procurement Processes.

Besides the most thorough and Comprehensive Four (4) Phase Total Building Commissioning Process (TBCxP) listed below,

"Other" varying types & phases of Commissioning include, but are not limited to:

Per the ASHRAE **Cx Guidelines**, Total Commissioning can take place in **4 Phases**:

1. Cx During Pre-Design Phase,
2. Cx During Design Phase,
3. **Cx During Construction**, and
4. Cx During Occupancy & Operations.

ASHRAE Guideline 0-2005 & 2013 (The Commissioning Process) defines the **Cx Process** as "*A quality-focused process for enhancing the delivery of a project. The process focuses upon verifying and documenting that the facility and all of its systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the Owner's Project Requirements*".

Per the ASHRAE **Cx Guidelines**, the "**Other**" varying types of Commissioning include, but are not limited to:

1. **Total Building Cx Process (TBCxP) [Inclusive of all 4 Phases]**.
2. Continuous Cx Process.
3. Ongoing Cx Process (OCx).
4. Re-Cx.
5. **Retro-Cx**.
6. Cx Light (or Custom Cx).

***Commissioning (Other Types)*:**

- **ASHRAE Guideline 0-2005 (The Commissioning Process)** defines the **Continuous Commissioning Process** as "*A continuation of the Commissioning Process well into the Occupancy and Operations Phase to verify that a project continues to meet current and evolving Owner's Project Requirements. Continuous Commissioning Process activities are ongoing for the life of the facility. Also see Ongoing Commissioning Process*".

- **ASHRAE Guideline 0-2005 & 2013 (The Commissioning Process)** defines the **Ongoing Commissioning Process (OCx)** as "*A continuation of the Commissioning Process well into the Occupancy/Operations Phase to verify that a project continues to meet current and evolving Owner's Project Requirements. Ongoing Commissioning Process Activities occur throughout the life of the facility; some of these will be nearly continuous in implementation, and others will be either scheduled or unscheduled (as needed)*".

Commissioning (Other Types):

- **ASHRAE Guideline 0-2005 & 2013 (The Commissioning Process)** defines the **Re-Commissioning** as "*An application of the Commissioning Process requirements to a project that has been delivered using the Commissioning Process. This may be a scheduled recommissioning developed as part of an Ongoing Commissioning Process, or it may be triggered by use change, operations problems, or other needs*".

- **ASHRAE Guideline 0-2005 & 2013 (The Commissioning Process)** defines **Retro-Commissioning** as "*The Commissioning Process applied to an existing facility that was not previously commissioned. This guideline does not specifically address retrocommissioning. However, the same basic process should be followed from Predesign through Occupancy and Operations to optimize the benefits of implementing the Commissioning Process philosophy and practice*".

***Commissioning (Other Types)*:**

- **ASHRAE Guideline 0-2005 & 2013 (The Commissioning Process)** defines the **Basis of Design (BoD)** as "*A document that records the concepts, calculations, decisions, and product selections used to meet the Owner's Project Requirements and to satisfy applicable regulatory requirements, standards, and guidelines. The document includes both narrative descriptions and lists of individual items that support the design process*".

- **ASHRAE Guideline 0-2005 & 2013 (The Commissioning Process)** defines the **Owner's Project Requirements (OPR)** as "*A document that details the functional requirements of a project and the expectations of how it will be used and operated. These include project goals, measurable performance criteria, cost considerations, benchmarks, success criteria, and supporting information. (The term Project Intent is used by some owners for their Commissioning Process Owner's Project Requirements.)*".

Commissioning (Other Types):

USGBC - LEED New Construction (NC) Reference Guide Energy & Atmosphere (EA) Credits Prerequisite 1: Required Point - Fundamental Commissioning of the Building Energy Systems; Completion of the following commissioning process activities by the Design & Cx Team:

1. Designate *qualified* & *independent* **CxA entity** to lead, review & oversee completion of Cx process activities.
2. Owner document the Owner Project Requirements (**OPR**).
3. Design Team develop the Basis of Design Document (**BOD**).
4. CxA develop **Cx Plan**.
5. Design Team to Develop & Incorporate **Cx Requirements** into Construction Documents (**CDs**) i.e., in Specs.
6. Project Team **Implement Cx Plan**.
7. **Verify installation & performance** of commissioned systems.
8. Complete summary **Cx Report**. (Results reported directly to owner)

Commissioning (Other Types):

USGBC - LEED NC Ref. Guide Energy & Atmosphere Credits: ***Optional Credit*** - **Enhanced Commissioning of the Building Energy Systems**. Intent: "Begin the commissioning process ***early*** during the design process and execute additional activities ***after*** system performance verification is completed". Completion of ***more*** Cx process activities by Design & Cx Team:

1. Satisfy all Fundamental Cx Requirements (See earlier slide).
2. CxA complete mid-construction stage Cx Design Review of **OPR** & **BOD**.
3. CxA **back-checks** that the necessary updates were completed in subsequent design submissions.
4. CxA review **contractor submittals** of commissioned systems for compliance with OPR & BOD.
5. Design Team to Develop **System Manual** for operating staff to understand and operate all commissioned systems.
6. Verify completion of all operating personnel (and occupants) **training** completed.
7. CxA to perform a **10 month operations review**.

Commissioning Team Members & Determination of their Roles & Responsibilities

Determination of Roles & Responsibilities

1. Customer, Owner, or Applicant.
2. Project Manager of the Owner (**PM**).
3. Construction Manager (**CM**).
4. Architect, Design engineer of record, (MEP, **E/A** or A/E Firm), with special focus on Mechanical and/or HVAC.
5. General Contractor (**GC**).
6. Mechanical Contractor (**MC** or **MEP**).
7. Test, Adjust & Balance Contractor (**TAB** or **T&B**).
8. Commissioning (**Cx**) Authority (**CxA**), or Cx Oversight Consultant.
9. Specialty Sub-contractors (especially in large projects) such as:
10. Controls Contractor (**CC**) - EMCS Vendor, System Integration Contractor, low voltage contractor.
11. Electrical Contractor (**EC**).
12. M&V Agent, or **M&V** Consultant, or M&V Contractor.
13. HP Manufacturer.
14. HP Testing & HP Cx Contractor.
15. GHX Contractor + Pipe/Grout Manufacturer/Vendor.
16. Other Equipment Manufacturers / Suppliers such as HX, Valves, Underground Pipes, etc.
17. Local authorities or authorities having jurisdiction over the project (needed for obtaining certain permits and/or to ensure compliance with all local codes, rules and regulations),
18. ESCO (Energy Services Company).
19. Funding Agency or Financing Agency.
20. Utility: Elec, Fuel, Nat Gas suppliers.
21. Specialty Consultants (in certain complex projects).

Very Important Slide

The Commissioning Scoping Meeting (1 of 2)

1. The CxA (through the GC or CM) will schedule, plan and conduct a Cx scoping meeting w/ the ***Entire Cx Team***.
2. At the meeting, Cx parties are introduced, Cx process is reviewed, and management and reporting lines are determined.
3. Construction Phase ***Cx Plan*** is reviewed, process questions are addressed, lines of reporting and communication are determined, and the work products list is discussed.
4. Other discussion topics include the general list of each party's responsibilities, responsibility for development of startup plans for each piece of equipment, and the proposed commissioning schedule.

The Commissioning Scoping Meeting (2 of 2)

5. Meeting outcome is that each team member will have a better understanding of the Cx process and of their ***Specific Roles and Responsibilities***.
6. Meeting also provides the CxA with additional information required to finalize the Cx Plan, including the anticipated Cx Schedule & the varying forms.
7. GC, CM or CxA keep notes from Mtg and distribute them to each team member.
8. Prior to this meeting, the CxA is given, by the GC (or CM or A/E), all drawings and specifications and the construction schedule by trade.

Suggested
Issues & Resolution Log
(or Deficiencies Log)
Detailed Layout/Table & Minimum Content Requirements

Issues & Resolution Log (Deficiencies Log) - (1 of 3)

Issues and Resolution Log

Pyramid EES
Energy Engineering Services, PLLC

Facility or Project Name:
Building or Location:
Commissioning Authority (CA or CxA): Pyramid Energy Engineering Services, PLLC (Pyramid EES)

[Updated as of MM/DD/YEAR]

Issue or Item #	System or Equipment & Location	Equipment Type[1]	Project Phase[2]	Date Identified	Initiated by	Issue Description or Deficiency	Issue Class[3]	Responsible Contractors	Recommended Actions	Status (Open or Closed)	Date Resolved[4]	Response by (Name)	Explanation of Correction and Other Notes or Comments	Note #

Notes:

1. **Equipment Type**: Mech, Elec, Ltg, Plumbing, MEP, BOP, Piping, TES Tank, Pellet Storage and Conveyance, BMS, M&V, Boiler Venting/Chimney (Flue Products), Boiler Room Ventilation, General, Building Envelope (Container or MER), Enclosure, Structural, Site, Safety, etc.
2. **Project Phase**: Construction, TAB (0 - 99) then Cx Phases: PFC = prefunctional (100 - 199), S = spot-check of prefunctional testing, FPT = functional testing (200 - 299), TD = trend data (300 - 399), M&V (400 - 499), etc.
3. **Issue Classes**: Energy, IEQ, Operations and Maintenance (O&M), Measurement and Verification = M&V, TAB, Safety, Procedural, Proper Storage of Materials & Equip, Scheduling and Construction Management (CM), PM, QA/QC, Change Orders, Access, Aesthetics, etc.
4. **Date Resolved**: Indicate the date that the issue was resolved or its correction was verified.

Disclaimer - CA (or CxA) assumes no responsibility for how the material in these Cx Issues and Resolution Logs may be utilized by users. The users assume full responsibility for any and all liability that may arise from any reference to, or use of, this material. This log is not intended to capture all issues during construction and Cx as it captures only what CxA and Owner had observed during site visits/inspections. It is the contractors, CM, GC and Design Engineer's full responsibility to ensure that any other unobserved issues are addressed and the project is built and controlled in compliance with the construction documents and following all best practices.

-- END OF LOG --

Use the space below if additional space is needed for NOTES and reference the systems and page numbers from previous in this Issues and Resolution Logs:

Issues & Resolution Log (Deficiencies Log) - (2 of 3)

1. Issue or Item #
2. System or Equipment & Location
3. Equipment Type[1]
4. Project Phase[2]
5. Date Identified
6. Initiated by
7. Issue Description or Deficiency
8. Issue Class[3]
9. Responsible Contractors
10. Recommended Actions
11. Status(Open or Closed)
12. Date Resolved[4]
13. Response by (Name)
14. Explanation of Correction and Other Notes or Comments
15. Note#

1. **<u>Equipment Type</u>**: Mech, Elec, Ltg, Plumbing, MEP, BOP, Piping, TES Tank, Pellet Storage and Conveyance, BMS, M&V, Boiler Venting/Chimney (Flue Products), Boiler Room Ventilation, General, Building Envelope/Enclosure, Structural, Site, Safety, etc.

2. **<u>Project Phase</u>**: Construction & TAB (0 - 99); then Cx Phases: PFC = prefunctional (100 - 199), S = Spot-Check of prefunctional testing, FPT = functional testing (200 - 299), TD = Trend Data (300 - 399), M&V (400 - 499), etc.

3. **<u>Issue Classes</u>**: Energy, IEQ, O&M, M&V, TAB, Safety, Procedural, Proper Storage of Materials & Equip, Scheduling CM, PM, QA/QC, Change Orders, Access, Aesthetics, etc.

4. **<u>Date Resolved</u>**: Indicate the date issue was resolved or its correction was verified.

Issues & Resolution Log (Deficiencies Log) - (3 of 3)

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- -- END OF LOG –
- Use the space below if additional space is needed for NOTES and reference the systems and page numbers from previous in these Issues and Resolution Logs:

Commissioning Schedule & Typical/General Scheduling Issues & Warnings

Cx Scheduling, Issues & Warnings

The following **sequential** priorities shall be followed:

1. Equipment is not "temporarily" started (for heating or cooling) until pre-start checklist items and all manufacturers' pre-start procedures are completed and moisture, dust and other environmental and building integrity issues have been addressed.

2. **Functional testing is not begun until prefunctional checklists, start-up and TAB are completed** for a given system (this does not preclude a phased approach).

3. The controls system and equipment it controls are not functionally tested until all points have been calibrated and pre-functional testing completed.

4. TAB is not performed until the control system has been sufficiently functionally tested by the CC and approved by the GC (or CM), A/E and CxA for TAB work.

Very Important Slide

PDH Questions / Answers for Assessment of Learning

PDH Questions / Answers - (Q/A 1)

- **Q1** - Commissioning is just a quick site visit in the afternoon from 2 to 4 PM, with no need for any preparation or any forms or any formalities; Let's get it over with, quickly and just move on. True or False?

- **A1** - False.

PDH Questions / Answers - (Q/A 2)

- **Q2** - Per the ASHRAE Cx Guidelines, what are the primary Phases for the **Total** Commissioning process?

- **A2** - [1] Cx During **Pre-Design Phase**, [2] Cx During **Design Phase**, [3] Cx During **Construction**, and [4] Cx During **Occupancy & Operations**.
- It is definitely not a quick site visit for casual system testing.

PDH Questions / Answers - (Q/A 3)

- **Q3** - What is one of the best definitions for the Cx Process, and why?

- **A3** - Per ASHRAE Guideline 0-2005 & 2013 (The Commissioning Process), it defines the Cx Process as "A quality-focused process for enhancing the delivery of a project. The process focuses upon verifying and documenting that the facility and all of its systems and assemblies are **planned**, **designed**, **installed**, **tested**, **operated**, and **maintained** to meet the **Owner's Project Requirements**".

PDH Questions / Answers - (Q/A 4)

- **Q4** - How many members are in the Commissioning Team and how often do they need to communicate?

- **A4 -** Varies anywhere from 6 to over 20 depending on the project size, complexity and number of disciplines involved.
  - CxA regularly communicates with all members of the commissioning team, keeping them apprised of commissioning progress and scheduling issues through memos, progress reports, etc.
  - At a minimum, there should be webinars (and/or site visits) every 2 weeks by the GC, PM (and CxA is present) to discuss and *proactively* address all project issues during construction and not wait till the PFC and FPT stages.
  - Early CxA involvement and coordination with all team members is a must.

PDH Questions / Answers - (Q/A 5)

- **Q5** - Can the GC start **FPT** before **PFC** (and why yes or no)?

- **A5 -** The word prefunctional refers to ***before*** functional testing.
  - Prefunctional Performance Checklists/Testing must be successfully completed ***prior to*** formal functional performance testing of equipment or subsystems.
  - PFCs basically document that equipment and systems are properly installed and operational so that functional performance testing ***may proceed without unnecessary delays***.

PDH Questions / Answers - (Q/A 6)

- **Q6** - What are the most important 3 items you gathered from this presentation (besides needing a break or having lunch)?

- **A6** - Must have a full Cx team and their roles and responsibilities all well define upfront.
  - Complete all PFCs well before FPTs
  - Maintain and stay on top of Issues & Resolution Logs (deficiencies log) during ALL project phases and do a great job.
  - Take Cx seriously for the future of your project and *educate* the Owner of the importance of Cx.

PDH Questions / Answers - (Q/A 7)

- **Q7** - What are a few of the most important ASHRAE guidelines and standards that best define and describe the commissioning process?

- **A7** - ASHRAE Guideline 0-2005 & 2013 (**The Commissioning Process**).
- ASHRAE Guideline 1-1996 (**The HVAC Commissioning Process**).
- ASHRAE Guideline 1.1 - 2007 (HVAC&R Technical Requirements for the Commissioning).
- ASHRAE Standard 202-2013 (Cx Process for Buildings & Systems).
- ASHRAE Standard 111-2008 (Measurement, Testing, Adjusting and Balancing of Building HVAC Systems).
- ASHRAE Guidelines 11-2009 (Field testing of HVAC controls components).
- See other Guidelines issues by the Associated Air Balance Council (AABC) or more specifically AABC Commissioning Group (ACG).

- ASHRAE, founded in 1894, is a global society advancing human well-being through sustainable technology for the built environment. The Society and its more than 50,000 members worldwide focus on building systems, energy efficiency, indoor air quality, refrigeration and sustainability. Through research, standards writing, publishing, certification and continuing education, ASHRAE shapes tomorrow's built environment today. More information can be found at www.ashrae.org/news."
- As some of the above tasks were not yet fully completed in this project (TAB and Cx), the above definitions were included to best support and guide the reader of this Presentation (and/or Report) during project next steps.

Multiple Credits

- Credits to NYSERDA and NYS DEC for their significant contributions and facilitating access to key project information at multiple host, test and demonstration sites used to generate valuable lessons learned that were later used to support the development of major parts of this Commissioning training material.
- Additional Photo & Illustration Credits to NYSERDA, NYS DEC, several design engineers, contractors, installers, customers, HVAC/MEP equipment manufacturers, universities, research centers, labs, and several commercial project installations in New York State and elsewhere.
- Thank you all for valuable contributions and for sharing data and valuable content that supported this effort.

Q/A

Thank you all for Attendance and Participation

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Optional/Suggested Commissioning Reference Material & Handouts

Overview of the Construction Phase Commissioning Process

Overview of Commissioning Process - (1 of 4)

1. Cx during construction ***begins*** with a "commissioning scoping meeting", conducted by the CxA preferably within 60 to 90 days of the beginning of construction, where the Cx process is reviewed with Cx team members.
2. Additional meetings will be required throughout construction to plan, coordinate, schedule future activities, and resolve problems. The additional meetings will be scheduled as needed by the GC (or CM).
3. Equipment documentation shall be submitted to the CxA during normal submittals, including detailed start-up procedures.
4. The CxA develops (and/or oversees the development of) prefunctional checklists (PFC) and submits blank forms to the GC (or CM) for assignment and distribution to the subcontractors. Subcontractors shall *properly and thoroughly* complete **FPCs** during the start-up process.

Overview of Commissioning Process - (2 of 4)

5. In general, the checkout and performance verification proceeds from simple to complex; from component level to equipment to systems and intersystem levels. Prefunctional checklists must be completed and returned to the CxA ***before*** functional testing begins.

6. Contractors, under their own direction and/or preferably via schedule coordination with the GC (or CM), execute and document the prefunctional checklists (PFC) and perform start-up and initial checkout. The GC or CM (and at times the CxA for selected equipment) document the completion of the PFCs and startup procedures according to the approved plans and using the PFC forms provided by the CxA and whatever other sources of documentation and forms they desire to use for best documentation. This may require the presence of the CxA as a witness upon start-up of selected equipment.

Overview of Commissioning Process - (3 of 4)

7. CxA develops (and/or oversees the development of) specific equipment and system functional performance test (**FPT**) procedures and forms.
8. FPTs are executed by the contractors and the appropriate forms are properly completed under the guidance (and/or the direction) of the CxA. The Contractors (and/or CM/GC) properly and thoroughly document the functional performance test results using the appropriate forms provided by the CxA for the CxA's review. Any deficiencies are recorded by the CxA (and/or the Contractors or CM) on the **Commissioning Issues Log**.
9. Items of non-compliance in material, installation, or setup are corrected at the contractor's expense, and the deficient system will be *retested*.
10. CxA (and CM) review O&M documentation for completeness.

Overview of Commissioning Process - (4 of 4)

11. Contractors submit to the CxA through the GC (or CM) *training plans*, and the CxA reviews and pre-approves training plans before training by the contractors can proceed. The GC (or CM) coordinates any training provided by the contractors. The CxA verifies that training was completed as required.

12. Seasonal or other deferred testing is conducted, as specified or required.

13. CxA prepares a final report to document the results of the commissioning process.

14. CxA returns to the site approximately 8 to 10 months into the 12-month warranty period to review current building and system operation with facility staff and address the any conditions or outstanding issues related to the owner's project requirements.

15. CxA develops a re-commissioning management manual for the owner, as needed.

Q/A

Thank you all for Attendance and Participation

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End