Defining the Integrated Process

A GPIC Inter-Task Workshop

Organized by:

Design Tools and Processes

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At Building 101

Philadelphia Navy Yard

GPICHUB™

Greater Philadelphia Innovation Cluster for Energy-Efficient Buildings

A U.S. DOE Energy Innovation Hub

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Wednesday October 12 10:00 am to 4:00 pm Building 101 Navy Yard, Philadelphia AGENDA	**Defining the Integrated Process:** A GPIC Inter-Task Workshop
9:00 am – 10:00 am	Continental Breakfast
10:00 am – 10:30 am	**Kickoff**
	Introductions *John Messner* Agenda Overview *Robert Leicht* Workshop Goals *Muscoe Martin*
10:30 am – 12:00 pm	**Session 1: Defining the Integrated Processes for Energy Efficient buildings- Muscoe Martin**
	Breakout into 5-6 person groups with facilitator
12:00 pm – 1:00 pm	**Working Lunch / Small Group Reports**
	5 minute reports & open feedback on themes
1:00 pm – 2:30 pm	**Session 2: Integrated Lifecycle Process Decisions - Rob Leicht**
1:00—1:15	Identifying Critical Points of Integration
1:15—2:15	Breakout to smaller Phases • Supporting Analyses / Tasks • Critical Decisions • Tools to support Decision Making
2:15—2:30	Reports & Feedback on Decisions / Integration Points
2:30 pm – 2:45 pm	**Break**
2:45 pm – 3:45 pm	**Session 3: Integrating GPIC Research with the Lifecycle Process - John Messner**
	• Identify related research tasks • Linking research with Lifecycle Report Back & Discuss
3:45 p.m. –4:15 p.m.	**Summary and Discussion**
	• Working Definition Discussion • Process Model Wrap-up • Next Steps

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1 Workshop Overview

The purpose of this workshop was to bring together representatives from all of the tasks and from industry to develop a common understanding of ***Integration*** for GPIC, particularly as it relates to the ***lifecycle*** of a facility. The goal of this workshop was to develop the essential activities and interrelationship of tasks for the GPIC Energy Efficient Building Hub as they relate to the lifecycle of a building from planning through to operations.

The **goals** for the workshop which led to the breakout sessions were:
1. Defining the Integrated Process for Energy Retrofits;
2. Planning the ideal process;
    A. Defining critical integration points and decisions;
    B. Defining the analyses and tools needed to support those decisions;
3. Defining the relationship of the ongoing GPIC research efforts to the integrated process.

The following sessions will work to fulfill these goals:
Session 1: Defining the Integrated Process for Energy Efficient Retrofits: A key concern of all the GPIC task groups is the importance of an "integrated process" for planning, design, manufacturing, construction, and operation of energy efficient buildings. The purpose of this session was to develop the understanding and interaction needed for this integrated process. The focus was to generate attributes and definitions which can be used to develop a working definition of the Integrated Process.

Session 2: Integrated Lifecycle Process Decisions: Current process models demonstrate outcomes at the project level but do not represent the activities which need to take place at a systems level or more specific to energy decisions. The outcome of this section of the workshop will be used to identify the integration which needs to be planned for systems and energy decisions and provide a means for teams to plan the needed scenarios and process attributes to make those decisions in an integrated fashion. The activities identified will be used to help refine the specific process for energy use and system level interactions specific to a Lifecycle approach for high performance buildings and energy retrofits.

Session 3: Integrate GPIC Tasks into the Lifecycle Process: Focusing on defining the barriers and challenges in implementing the integrated processes specific to the needed decisions which have been defined, this session focused on identifying the current relation of GPIC research to the integrated process and work to identify the opportunities of current GPIC activities to provide direct support for the elements defined and areas for future work.

2 Integrated Lifecycle Process Decisions – Session 1

It is a stated assumption of GPIC that integrated design and delivery processes are needed to deliver higher levels of Energy Efficient Buildings. However, there is not yet a shared definition of what we (GPIC) mean by "integrated." This session was intended to begin to develop this consensus definition.

2.1 Goals:

- Describe the attributes of a fully integrated commercial building design for the GPIC region, assuming a systems approach. This should include consideration of all aspects of a building's design that could affect its energy consumption including building envelope, fenestration, lighting, HVAC systems, operations, etc.
- Identify the necessary components and characteristics of the design and delivery process that can deliver that integrated, energy efficient building.
- Identify ways to adapt this process for smaller scope retrofit projects.

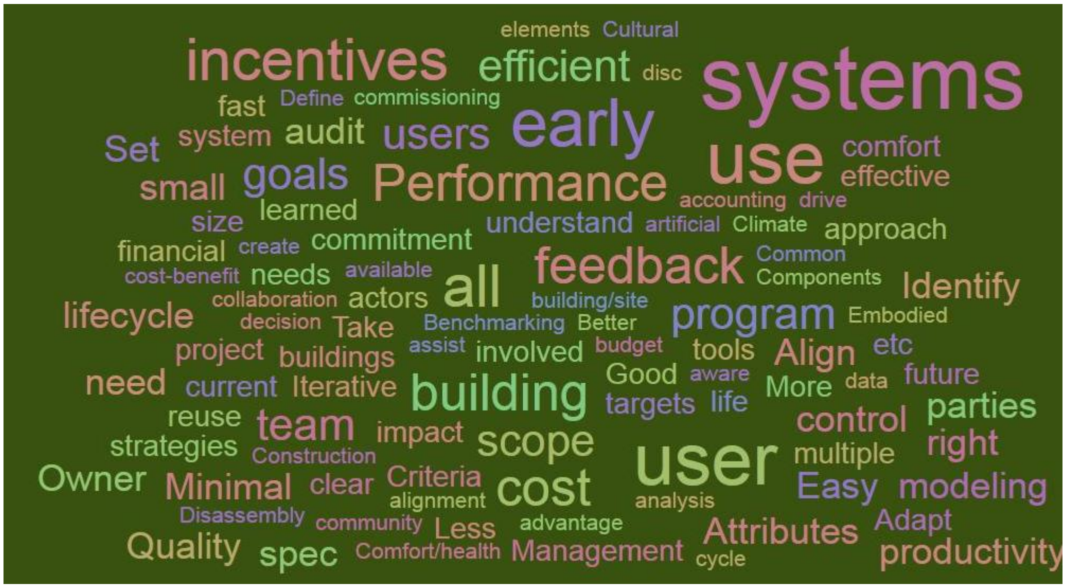
2.2 Questions:

- What are the key attributes of a fully integrated energy efficient commercial building in the GPIC region?
- Based on the answers to the previous question, what are the necessary components of a design and construction process that can deliver an integrated project?
- How can this process be adapted for renovation and retrofit projects of limited scope?

2.3 Discussion Summary

For the first session, the large group was divided into six small break-out groups composed of representatives from the various task groups and industry sectors. The groups were given the task of defining the key attributes/components are necessary to design a fully integrated energy efficient project.

The word cluster diagram shown below was created from the "flip chart" notes from the breakout groups from the morning session. The size of each word is a reflection of the frequency that each term or concept was mentioned in the various group reports.



Using the frequency of the concepts mentioned, several common themes emerged:

- EARLY input on design from full team members
- SYSTEMS approach to design
- ITERATIVE process (not linear)
- Involve building USERS (in design and in building operations)
- FEEDBACK (to design/construction teams, to owners, to users)
- PERFORMANCE measurement & benchmarking
- Must make FINANCIAL sense

2.4 Discussion Keywords

The following are keywords that the participants discussed for the three discussion questions:

- **Q1: What are the key attributes of a fully integrated energy efficient commercial building in the GPIC region?**
    - User
        - Fits user needs
        - Adopt to change (user/ condition/ needs)
        - Productivity
        - Comfort / Health
        - Practical / Usable
        - Productive
        - Indoor Air Quality
        - Materials Used

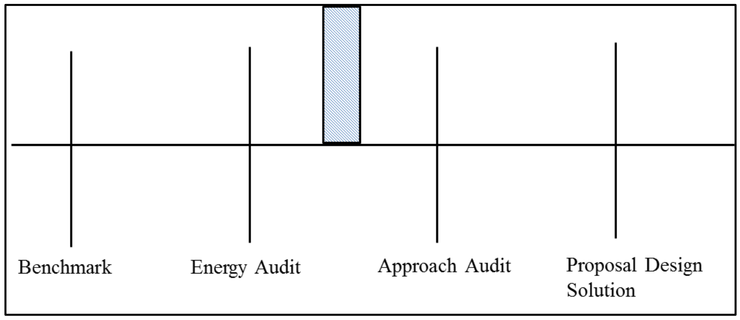
        - Daylighting makes people happy but consumes more energy, how to optimize human comfort with minimum resources use
        - Feedback to users: The users should get the feedback on the energy and other resource consumption. That will educate those who have no technical background. The feedback should be as simple as possible. Without feedback the user will not know his consumption.
        - Considers all current & future users (Occupants/Operators/Future occupants etc)
        - Uncertainty due to uncertain human behavior
        - Design intend vs human behavior, desire to control system, human pursue comfort
        - New or existing renovation building renovation. Feedback from occupants is important factor. Human factor.
    - Systems
        - Interactions of systems/function
        - Interrelated and optimized systems
        - Take the advantage of natural opportunity
        - Adopt and Upgrade
        - LCC effectiveness
        - Embodied energy / reuse
        - Look into systems for energy generation
        - Architectures integrated with systems
        - Energy systems integrated with function
        - Simultaneity
        - Sensibility / inevitableness of design
    - Process:
        - Less painful information exchange
        - Common goal: The participants in the process should have a common goal.
        - Lifecycle collaboration with other teams
        - Integration over time
    - Operation
        - Easy to drive / operator & user
        - Measurable
        - User components
        - Efficient operations (As standard as possible)
        - Continuous commissioning through operation
            - Will the system work in the same way even after 5 or 10 years?
            - Who is responsible? The user? The owner?
    - Cost:
        - Lifecycle cost: Low maintenance, Good commissioning
        - Careful, cost effective selection of Energy Efficient alternatives

        - Embodied energy
    - Project Team
        - Takes a team to achieve: Takes outside people (surrounding community).
        - Agency encourage reuse
        - Integrating goal from different teams, seamless coordination in terms of systems, buildings, and projects.
        - Architecture integrated with systems, lifecycle coordination among activities, people and systems
    - Adaptability
    - Surrounding
        - Good fit with surroundings – The Impact of the built environment on its surroundings.
        - A “look” to them – How are they different from the other buildings (which are not energy efficient)?
        - Benchmarking of similar buildings: Mindful of current use
    - Context
        - Defined goals & objectives
        - Energy conservation is not the only goal, integrated goals of stakeholders, human factor, feedback, uncertainty
        - Environments
        - Verifiable energy use: There should be a metric where the energy usage can be monitored and verified.
        - We need to define the goals and the intends of the buildings

- **Q2: Based on the answers to the previous question, what are the necessary components of a design and construction process that can deliver an integrated project?**
    - Stakeholders and Resources
        - Identify all actors
        - Owner, designer, user, contractor, operator, inspectors, code
        - Strong leader/champion
        - Need people who understand integrated design
        - Better players on issues
        - Full support of owner
        - Right team organized in right way
        - Face to face
        - Trust → taking risks
        - Actors understand their role/roles of others
        - Active community of practice
        - Co-location of the team

        - Identify resources for successful integrations
        - Early involvement of partners
        - Continuous collaboration of partners
        - Commitment- Owner and team synergies
    - Communication (common language)
    - Feedback and Knowledge
        - Feedbacks from all actors
        - Lessons learned
        - Get knowledge to team (right time)
        - Feedback mechanism to design from operations for lessons learned (Automated data collection; training; planning)
        - Early Feedback drives decision
        - Designing feedback mechanism to users (Should impact behavior & attitude)
    - Process
        - Iterative/Not linear
        - Integrated design & delivery of whole process
        - More efficient (Workflow, Faster iteration, Quick decisions/approvals, access to growing knowledge base)
        - Reusable components to process
        - Repeatable Process
        - IPD Incentives: Performance Target
        - Contracting project delivery
    - Goals and Objectives
        - Common goal
        - Set Goal Early- Benchmark
    - Evaluation, Research, Simulation and Analysis
        - Identify gaps in responsibilities & fill them
        - Simulation (multi-level)
        - Cost Model
        - Evaluation of end users needs and capabilities
        - Research and understanding
    - Systems
        - Adaptable building systems which can be adjusted to suit the varying potential building loads
        - Balance the building automation and end user control of the building
        - Understand unique aspect VS. Reusable/ Standard elements
    - Verification (throughout the lifecycle of a building) not only post-occupancy phase
    - Transparent
    - Tools

        - Good tools (Accurate answers; Not proprietary/Open architecture; Validated; Readily available; Interoperable)
        - User interface: proper education and tools to allow building users to be able to adjust the building to their individual needs while remaining conscious of their personal impact on the buildings overall energy consumption
    - Program
        - Program- Needs- flexibility- criteria challenge
        - Make sure when developing the building program, take sufficient account of the variation of the building occupancy
    - Climate Factor
    - Code checking. Working with code and policy makers early on in the project
- **Q3: How can this process be adapted for renovation and retrofit projects of limited scope?**
    - Difficult to see
        - Must keep financial case up front
        - Easy to use, lifecycle financial modeling & communication tools
    - Leverage available incentives: Incentives from the government will help.
    - Quick feasibility survey (What can and cannot be done; Identify unique aspects reusable)
    - Audit investment grade energy (on a limited budget)
    - Scalability of process (How do we perform small project with similar, scaled process)
    - Be mindful of current system status
    - Find best target buildings
    - Inform owners: Owner feedback reports
        - By system
        - By energy consumption
        - Identify suggested actions
    - User survey
    - How do we get small (big) firms to get beyond lighting/HVAC only



- The figure above shows a barrier between energy audit and the approach. Energy audits are done just for the sake of the task and no importance is given to the systems approach. Possible solutions include:
    - Evaluate history /lessons learned
    - Faster/Easier integrated system approach
    - Rapid development of models
    - Collection testing data
    - Government incentives for integrated system audit
- Identify the most effective decision
- Assessment and Audit
- Future- criteria- incentives
- Database for Best Practices
- Open source Modeling
- Integrated processes allow every one to be involved in the project as early as possible
- Integrated processes should allow innovative financial arrangement
- Integrated processes should be simple and easy to understand integrated contract

2.5 Lessons learned

From the discussions of the individual groups, common conclusions include:

- Need clearly defined goals
- Working with code and policy makers early on in the project
- Evaluation of end users needs and capabilities
- Adaptable building systems which can be adjusted to suit the varying potential building loads
- User interface: proper education and tools to allow building users to be able to adjust the building to their individual needs while remaining conscious of their personal impact on the buildings overall energy consumption

- Continuous commissioning is very important, as the building may not function in the same way after 5 or 10 years.
- Feedback to the user helps in educating the user.
- The barrier between the energy audit and the system approach should be removed. The purpose is not being served.
- The design team should maintain a database where they can record the performance of the buildings they designed.
- The roles and responsibility of everyone in the process should be well defined. The inter relationship/interdependence of each discipline should be clear. The user/owner should also be aware of his role.
- Incentives encourage the participants.

3 Integrated Lifecycle Process Decisions – Session 2

This session built upon the morning's discussion to focus on taking integrated practice to the next level of detail by identifying the process points, where teams can apply integrated practices to improve the lifecycle based decision making for energy efficient retrofits. The session was broken up into stages with increasing detail of the points, decisions, tasks, and tools needed to effectively pursue an integrated lifecycle approach.

3.1 Goals:

- To identify critical points of integration and decision making for the Integrated Building Lifecycle Process Model
- To develop the flow of critical decisions, integration points, and handoffs to support a lifecycle approach to Integrated building design, construction, and operations
- To identify barriers and challenges in implementing integrated practices or make integrated decisions
- To discuss solutions for the possible barriers and challenges

3.2 Questions:

- What are the critical integration topics / meetings that allow and enable a truly integrated process?
- What are unique meetings or integration points for retrofit projects?
- What tasks need to take place outside or in support of these integrated practices?
- What decisions are made within these integrated meetings or charrettes?
- What tasks take place within these meetings / charrettes to enable the decision making?
- What tools, real time information, or methods are needed to make these integrated meetings more effective or valuable?
- What are current challenges or barriers to fully implementing these charrettes / integration meetings?
- What skill sets or competencies are needed to make these decisions?

3.3 Discussions

Discussions in this session mainly focused on the early conceptual design and programming phases. The mapping that took place was re-formatted electronically with the three group processes shown in the appendix. Group members spent considerable amount of time discussing detailed issues in the process. Each charrette is considered as an integrated decision-making point. The following are the process steps identified:

- **Understanding the project**
  The first step in the process should concern the review of the existing conditions of the building and site using the energy audit tools. Prior to the first charrette, environmental performance target and benchmarks for evaluating success should be clearly defined. However, several specific questions regarding the energy audit remain to be addressed in the process such as:
    - When should energy audits take place;
    - Should the performance target be determined before the audit;
    - What data already exists;
    - What is the data collection and data analysis process;

  Following the first design charrette, it is important to assess needs and opportunities. The reason is that quite often owners are reluctant to spend early in the project on the design and instead will go directly to the vendors. Thus, assessing the needs is critical.

- **Defining project design goals and collaboration protocol**
  Defining the project program; design principles; and energy environment outcome resulting in a "go/no go" decision should precede the second charrette. At this stage, the appropriate level of BIM use should be defined as well.
  The second charrette should lead to a holistic assessment of design options resulting in one selected design option based on a determined energy performance.
  Defining goals is also a continuous process and evolves with the project. For example, in the pre-design phase energy modeling may serve to determine the desired outcome and consequently define or refine the goal. Defining project goals involves identifying specific objectives with varying priorities and may involve consideration of issues such as:
    - Setting energy performance
    - Evaluating the function
    - Defining team players and roles
    - Defining user expectations
    - Aligning expectations
    - Developing the assessment program
    - Developing communication protocols

- **Program development and system design options**

The next step and level of detail in the integrated process considers the program development and the definition of the intent and criteria for *building systems*. Prior to a schematic design charrette, this initial systems design charrette would serve to identify building systems and potential strategies while validating assumptions regarding cost and energy. In this stage, the project scope should be defined through identifying mechanical systems and potential improvements of the architectural building envelope. To make the decision among different options, few tasks identified to take place at this stage include:

- Identifying parameters and constraints (e.g. building codes, funding requirements, co-agencies, etc.)
- Real time cost analysis and estimating of lifecycle and operational costs;
- Energy performance analysis of different design options;
- Cost feasibility studies of system options;
- Constructability reviews

Subsequently, the development of the *project execution plan* would serve to identify necessary expertise and technologies along with roles and responsibilities to address each task requirements. For example, when analyzing energy performance of different options, the use of an analysis tool such as energy simulation or a spreadsheet will greatly depend on the time, cost, and the assessment method. Defining appropriate metrics (e.g. units, consumption) is thus critical from the perspective of how the data is collected and by whom.

- **Reviewing design options in schematic design (SD) phase**

  The next decision process concerns the review and critique of various design options to determine which design meets the goal. The *design assessment review* is an iterative and interactive process which compares alternative outcomes and defines the next steps in the process. Following the design options review charrette in the schematic design phase, the most optimal systems design option is selected for further development at a more detailed level. The number of design options in the retrofit projects may be limited to begin with, due to the existing site and building conditions. The *design selection* at this stage is still at the conceptual or schematic design phase where the actual systems design is yet to be developed based on the performance requirements.

- **Reviewing design options in design development (DD) phase**

  The design options review charrette in the design development phase progresses towards the system component level in which system/element mockups are developed and reviewed before full implementation. This iterative process focuses on a more detailed review of selected options where energy analyses from the conceptual stage can be revisited for refined testing and modifications. One potential issue may be the knowledgeable cost estimates for design options at this stage.

- **Build and Operations and Maintenance phase**
  The integrated process should be continued during and after the construction of the building. When the building is in use, the building should be monitored and the building operations should be verified properly in order to give feedbacks to the design and construction team. The team can check the operation feedbacks against the original goals and objectives to identify the underperformance and the needed improvement. Those feedbacks can also guide the future design and construction.

Lastly, some of the tools and resources identified to help make decisions in the retrofit projects include:

- Energy modeling tools early in the process which can help defining project goals and comparing energy performance of alternative design options;
- Modeling and simulating various project aspects such as building operation; scenarios of potential uses in a retrofit building; building cost model; interaction between different systems (lighting, HVAC);
- Model database/storage, for example IFC model server; maintaining a calibrated model;
- Monitoring tools within the building; and
- Data accessibility options through other forms such as mobile device applications or similar.

4 Integrate GPIC Tasks into the Lifecycle Process – Session 3

This session focused on integrating GPIC research tasks into the Building Life cycle Process. The focus of this session was on identifying how the research tasks can support the key decision points throughout the building lifecycle process (Planning, Design, Construction and Operation), discussing links and relationships between the GPIC tasks and the decision points, how to better support the process through the GPIC tasks, and identifying barriers and challenges in implementing GPIC tasks or possible solutions for them.

4.1 Goals:

- To integrate GPIC tasks into the Integrated Building Lifecycle Process Model
- To develop links and relationships among GPIC tasks throughout the lifecycle of a building
- To identify barriers and challenges in implementing GPIC tasks
- To discuss solutions for the possible barriers and challenges

4.2 Questions:

- In the Systems level, what are the key activities in the building lifecycle process model?
- What are the needs for key decision-making points which relate to research topics?
- What are the key inputs and outputs of the key decision making points? How can these be improved or facilitated from the research?
- What are the current areas of impact of the GPIC research tasks on the Building Lifecycle?
- What phase or activity can GPIC research activities be linked to?
- What broad tools or methods are needed to further these integrated practices which may not be currently represented in the GPIC tasks?

4.3 Discussions

In Session 3, the three groups formed in Session 2 gathered together again and discussed research opportunities and barriers that need to be investigated to integrate the GPIC tasks into the integrated building lifecycle process. The following are summaries of the research opportunities and barriers identified during the discussion.

Constraints: Constraints are caused from diverse sources. Some of the most common constraints discussed include human-related constraints such as geographical separation among project team members, conflicts with government requirements, and scale /

schedule constraints. In addition, from the perspective of existing facilities and their occupants, the following questions could be constraints for renovation projects:

- If the facilities is already occupied? If so, do the occupants need to be temporarily re-located?
- When only some portion of the building is renovated, how to handle discomfort and productivity of the occupants who have to continue to occupy the building during the renovation?

Communication: As the members of the GPIC project are from diverse disciplines, communication among the members could be challenging. The terms used in one discipline can often refer to something different in another discipline. Speaking the same language is one of the essential factors for exchanging and sharing information correctly, which is crucial in collaborative research projects, especially when integrated building processes are applied.

Cost, Payback, Financial Incentives: There is little data available about regional best practice of energy efficient building renovation projects. In particular, financial incentives for applying the GPIC tasks as well as disincentives need to be investigated in terms of payback money and time required. In order to facilitate the dissemination of the integrated building lifecycle process approach, adequate amounts of incentives should be assigned to each stakeholder, including architects and contractors. Conducting case studies could be one approach to investigate and collect data about the project cost, payback and a possible amount of incentives and disincentives. Furthermore, a tool that shows incentives with various levels of design and energy conservation criteria needs to be developed as well.

Facilities and Systems: From the perspectives of facilities and systems, the discussions concluded that the following need to be investigated:

- Whether existing systems are re-usable?
- How much information is available in terms of sub-metering? How much time is allocated to the process of sub-metering?
- Finding improvements regarding cost- effective and least disruptive technologies
- Is energy storage a critical point?
- What are the energy resources? How does this influence the rest of the project? Does it have an effect on the systems that are selected? Alternative energy systems versus more energy efficient systems within a building?

Simulation and Analysis: Simulations and analyses have become increasingly important, as it is difficult to estimate the scope of work until this preliminary work shows current conditions of the existing building, and tradeoffs and behaviors of different design options. Although it is often time-consuming processes and thus hard to estimate all the possible options, the following are discussed as the types of simulations and analyses that should be considered:

- Audit component of retrofit building
- Estimate potential impacts of retrofit buildings on surrounding buildings
- Conduct site and context analyses to see their influences to the design of the retrofit building
- Investigate methods to measure the impact of the retrofit building on the environment from various perspectives including the buildings energy consumption and carbon footprint

Process: The discussions on integrated processes can conclude that the concept is not clearly understood by stakeholders yet and also that the stakeholders need to ask the right questions at the right time throughout the process. In order to increase the use of the integrated building lifecycle process, what is needed is a momentum that leads to new integrated delivery procedures. Actual methods to change each individual's view to the integrated project delivery process could be a key research area.

Building Information Modeling: The ownership of BIM models should be clearly specified.

Education: In addition to educating and training project stakeholders, the importance of educating future stakeholders, especially K-12 and college students, was discussed. The development of educational games could be an effective approach. The success of this educational game depends on how well the approach leverages with the existing energy-related education and training curriculum for higher-educational students and also on how intuitive the contents can be delivered to K-12 students. Contents to effectively convey the core concept and principles, diverse methods for energy savings should be developed according in diverse ranges of difficulty.

5 Outcomes and Lessons Learned

From the discussions had during the three sessions, we have identified core components of the integrated building lifecycle process by comparing the process maps developed by the three groups. Within each process map, we have also identified key integration points, key decisions made at each integration point, activities to support the key decisions and tools used to conduct the activities.

5.1 Key integration points and activities / tasks associated with each point

The following is a list of key integration points (bullets in bold), activities and tasks associated with each integration point, inputs and tools used to conduct the activities.

- **Establish and Prioritize Goals**
  - Owner / User inputs
  - Develop clear and specific environment performance targets
  - Know building identification
- **Establish Baselines / Metrics: Audit and survey existing building**
  - Document existing conditions
  - Baseline modeling (Existing Energy, Geo-Special, etc)
  - Potential effects on surrounding
  - Infrastructure assessment
  - Existing building assessment
    - HVAC
    - Water, Lighting
    - Energy Bill
    - Exploratory Demolition
    - Climate Analysis
  - Establish benchmarks for assessing success
  - Know building identification
  - Tools:
    - Site Scanning (ex., laser-scanned point-clouds)
    - BIM Modeling (As-Is)
    - Metering using sensors
- **Analysis of Data**
  - Decision-making points
    - Regulatory conformance: Does it conform to Code?
  - Tools:
    - Data mining tools
    - Data visualization tools
- **Project Definition & Design Goals / Principles**

  - Decision-making points
    - Go / No-Go Decisions need to be clearly identified
  - Define project program
  - Define design principles
  - Estimate energy/environment outcomes
  - Establish appropriate level of BIM use
- **Identify Opportunities and Constraints**
  - Define program intent/criteria for systems
  - Validate assumptions for finances, energy, other identified critical goals
  - Assess design options holistically
  - Narrow design options for further development
  - Set goals for energy performance
- **Define Scope**
  - Decision-making points
    - Reuse old systems or switch to all new systems
    - Develop GPIC prototype?
  - Consider energy storage feasibility
  - Catalog energy resources (future)
  - Smart grid
  - Analyze differences between conventional systems and new GPIC prototypes
  - Provide additional details (full spectrum)
- **Define Expertise and Roles**
- **Review/Critique Design Options (SD Phase)**
  - Develop project execution plan
  - Identify the level of service or technology needed
  - Iterative cost estimate
  - Energy/cost feasibility study of system options
  - Layout play options
  - Estimate lifecycle and operational cost
  - Analyze design options
- **Loop: Review/Critique Design Options and Design Selection (DD Phase)**
  - Decision-making points
    - Does the system (product) meet the goals and requirements?
    - Cost analysis: Is it within the budget?
    - Performance analysis: Does the system use less energy or reduce CO_2?
    - Confirm or modify systems for full implement?
  - Pricing

    - Prototyping simulation modeling
    - System / element mockup & review
    - Energy model
    - Measuring and verification
    - Tools:
        - Simulation tools
        - BIM
- **Define Construction Scope**
    - Decision-making point
        - Notice to Proceed
    - Verify scope aligns with goals
- **Build**
    - Trade coordination
    - Pre-installation Meetings
    - Mock-ups
    - Quality verification
    - Commissioning
    - Tools:
        - Tablet PC (tough book)
        - Pre-Functional Test Procedures
        - Functional Performance Test Procedures
        - Laser Scanner (As-Built QC/QA)
- **Construction Progress Meeting**
    - Tools
        - BIM
- **Sign-Off**
    - Tools:
        - Record documents (for building operations)
- **Operations Evaluation**
    - Measure and verify
    - Tools:
        - Knowledge base

5.2 Lessons learned

Sessions 2 and 3 were more open ended in terms of the direction of the outcomes than the first session. It seemed as though the workshop attendees had a difficult time defining the actual process for designing, building and constructing a fully integrated building. There were disagreements about where various steps fell, how an integrated building design and construction differs from a traditional building and what tools were necessary for an integrated building design and delivery. While the results of this exercise varied greatly between the three groups, this exercise clearly illustrated a few critical points:

- A lack of process transparency: When dealing with integrated buildings there is currently a lot of uncertainty surrounding when each tasks should be completed. The development of process maps that clearly show what integration needs to be happening throughout the building design and construction would help make the processes clear to all involved resulting in more streamlined efforts focused on agreed upon goals.
- The need for integrated project teams: The workshop attendees came from various backgrounds with regards to their involvement with building delivery. The individuals' inability to define aspects of the process that they are not directly involved with showed the lack of a clear understanding of "other" stakeholder's roles in a building design and construction process, clearly indicating a critical barrier in understanding of how they could better work together in an integrated setting
- There was also a general lack of agreement within the individual teams regarding what deliverables were essential to an integrated building and when these deliverables should be completed.

6 Concluding summary

The goal of the workshop was to bring together representatives from all of the GPIC tasks and from the industry, and to discuss 1) definitions and core elements of integrated processes for energy efficient retrofit projects, 2) key decision-making points and supporting activities for each decision-making point within the integrated lifecycle process, and 3) research opportunities and barriers of integration of GPIC tasks into the lifecycle process.

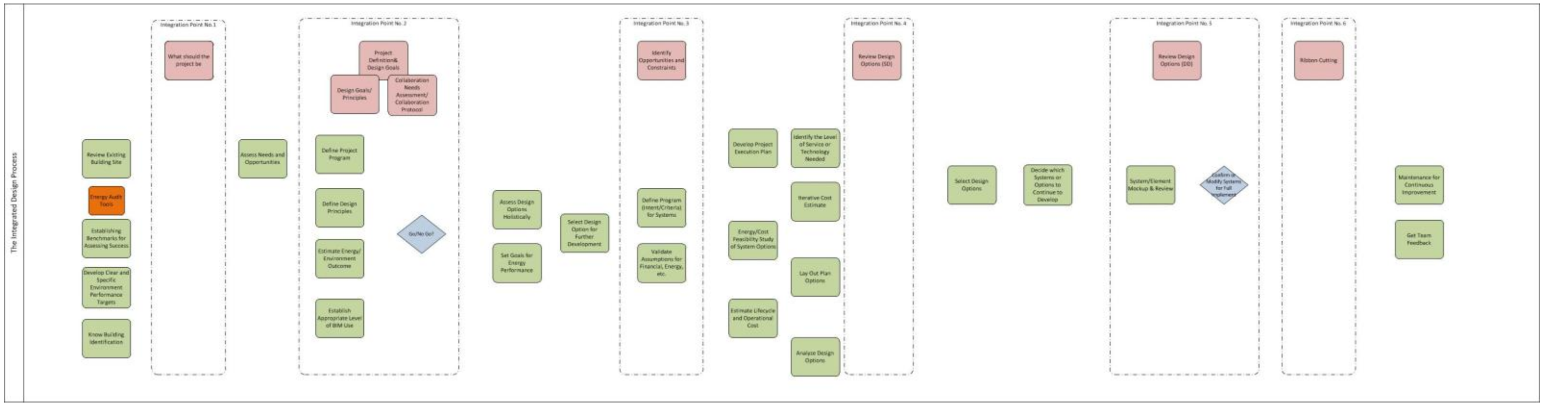
In Session 1, the workshop attendees discussed components and attributes of an integrated building design process and methods to adapt the process for energy efficient retrofit projects. The key attributes discussed include user's comfort and productivity as well as associated human behaviors; system-related attributes such as interactions, optimizations, adoptability, energy use and reuse and sensibilities; lifecycle collaboration with other stakeholders in the process; clearly defined goals and objectives on energy conservation and environmental sustainability. The core components of the design and construction process to deliver an integrated project include actors and their feedbacks as well as clearly defined roles and commitment; common goals and objectives and financial benefits; good tools and models for analysis and simulation; trust to take risks. The methods discussed include quick feasibility and user surveys, appropriate auditing and assessment, database for best practices, and open-source modeling.

The topic of Session 2 was the identification of integration points and key decisions made in each integration point, activities to support the decision-making and tools used to conduct the activities. The various tasks identified some consistent integration points in addition to some variations in needed team collaboration. The first integration point aims to review and assess conditions of the existing building and its surroundings using auditing results if exist. During the second integration point, team members define the project goals and scope. Then, system-level detailed programs and a project execution plan are developed in the third integration point. In this phase, specific metrics are established and roles and responsibilities of team members are defined. The next integration point is design review charrettes: schematic design review and design options review. In this phase, various design options are reviewed using simulation and analysis tools to narrow and then select the design that meets the project goal(s). Once construction/renovation starts, construction progress monitoring and system performance assessment are conducted as necessary.

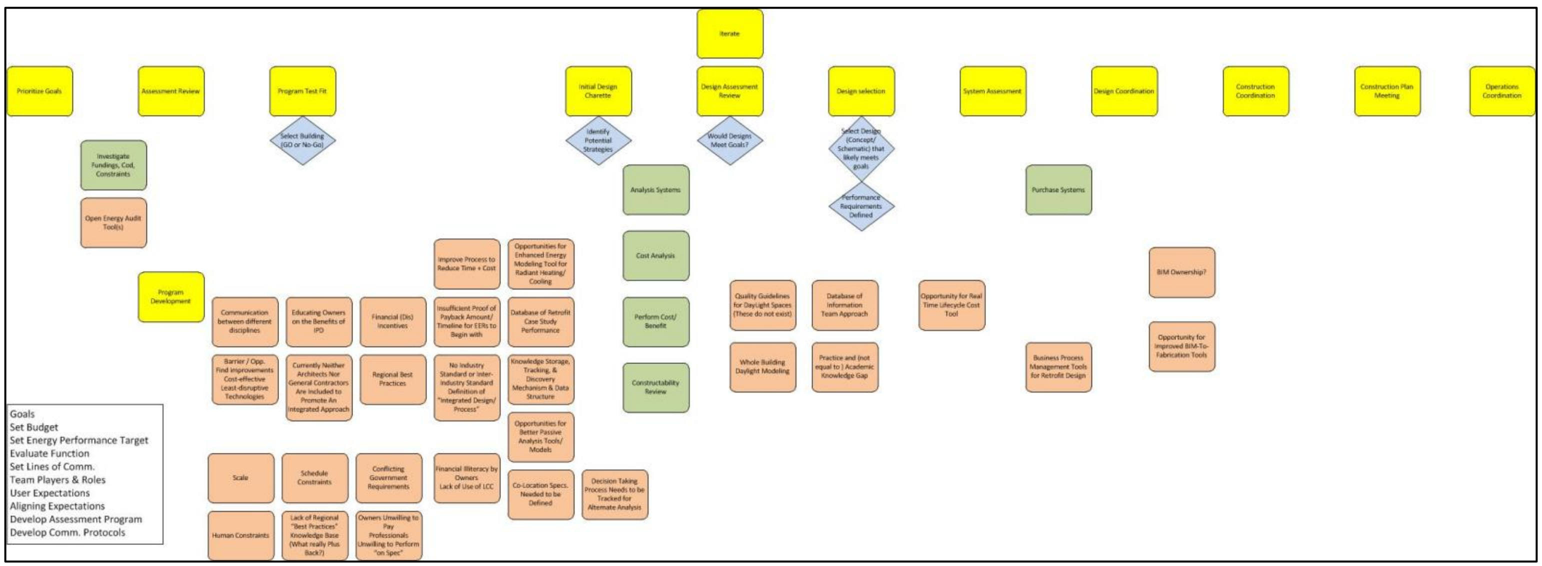
Research opportunities and barriers discussed in Session 3 included constraints from stakeholders such as difficulties in communication and knowledge sharing caused by geographical separation and different languages and formats, conflicts with policies and codes, and schedule and budget constraints. The uncertainty caused by little available data about actual cost, payback and incentives also makes the owner hesitate to invest for energy efficient building renovation. Analyses on the conditions of the existing building and simulations with various design options help estimate the scope of work and paybacks. Furthermore, in addition to the discussion on the use of building information models for those analyses and simulation, the ownership of the model was also discussed.

Appendix. Integrated Design Process Maps

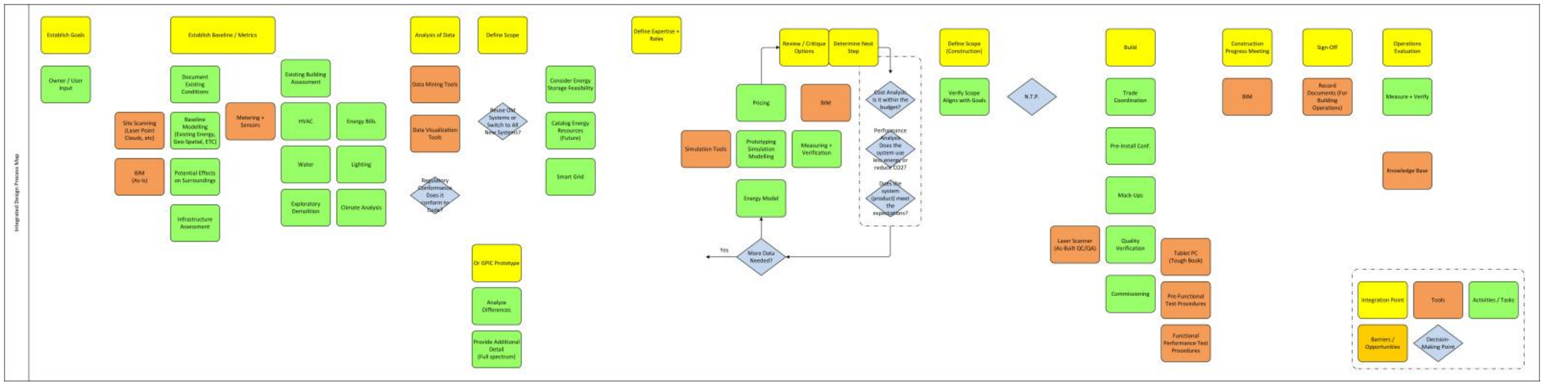
Process #1



Process #2



Process #3


Integrated Design Process Map
Establish Goals
Owner / User Input
Establish Baseline / Metrics
Document Existing Conditions
Site Scanning (Laser Point Clouds, etc)
Baseline Modelling (Existing Energy, Geo-Spatial, ETC)
Metering + Sensors
BIM (As-Is)
Potential Effects on Surroundings
Infrastructure Assessment
Existing Building Assessment
HVAC
Energy Bills
Water
Lighting
Exploratory Demolition
Climate Analysis
Analysis of Data
Data Mining Tools
Data Visualization Tools
Regulatory Conformance Does it conform to Code?
Define Scope
Reuse Old Systems or Switch to All New Systems?
Consider Energy Storage Feasibility
Catalog Energy Resources (Future)
Smart Grid
Or GPIC Prototype
Analyze Differences
Provide Additional Detail (Full spectrum)
Define Expertise + Roles
Review / Critique Options
Determine Next Step
Pricing
BIM
Simulation Tools
Prototyping Simulation Modelling
Measuring + Verification
Energy Model
Cost Analysis Is it within the budget?
Performance Analysis Does the system use less energy or reduce CO2?
Does the system (product) meet the expectations?
Yes
More Data Needed?
Define Scope (Construction)
Verify Scope Aligns with Goals
N.T.P.
Build
Trade Coordination
Pre-Install Conf.
Mock-Ups
Laser Scanner (As-Built QC/QA)
Quality Verification
Tablet PC (Tough Book)
Commissioning
Pre-Functional Test Procedures
Functional Performance Test Procedures
Construction Progress Meeting
BIM
Sign-Off
Record Documents (For Building Operations)
Operations Evaluation
Measure + Verify
Knowledge Base
Integration Point
Tools
Activities / Tasks
Barriers / Opportunities
Decision-Making Point