Title
A Path to Successful Energy Retrofits: Early Collaboration through Integrated Project Delivery Teams

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Disclaimer

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A Path to Successful Energy Retrofits: Early Collaboration through Integrated Project Delivery Teams

About This Guide

This document guides you through a process for the early design phases of retrofit projects to help you mitigate frustrations commonly experienced by building owners and designers. It outlines the value of forming an integrated project delivery team and developing a communication and information-sharing infrastructure that fosters collaboration. This guide does not present a complete process for designing an energy retrofit for a building. Instead, it focuses on the early design phase tasks related to developing and selecting energy efficiency measures (EEMs) that benefit from collaboration, and highlights the resulting advantages.

Who will find this document useful?

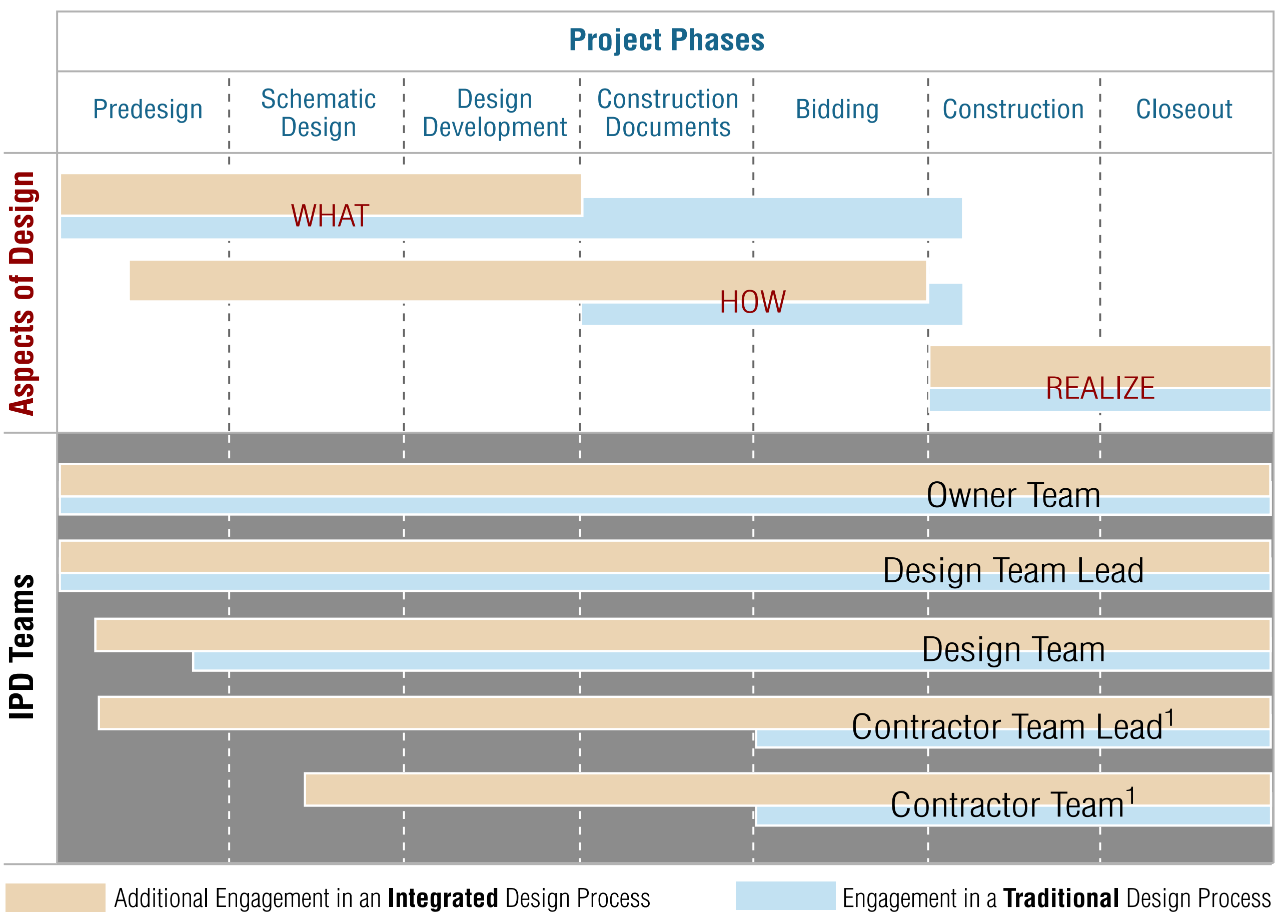
- Building architects
- Building designers
- Building owners
  (in particular, the processes presented in Figure 4 and Figure 5)

While it is difficult to assign costs and benefits to changes in processes, experience provides some insight. Transitioning from a “traditional” project delivery structure to an “integrated” project delivery structure (shown in **Figure 1**) generally *does not cost more*. Rather, *costs are shifted*: costs typically incurred in the construction phase of a project may be shifted into the design phase of a project. As a result, the overall project costs are reduced, through savings in construction insurance, reduced operational costs, and reduced maintenance costs [1]. Previous work shows that early collaboration and integrated project delivery teams can reduce the time to complete a project by 5-10% [2] that in part contribute to cost savings of up to 18% [1]. Integrated project delivery teams are required to achieve deep energy savings vings greater than 20% in existing buildings), due to the need for interconnectivity between building systems [3]. Because deep energy retrofits require integrated project delivery teams, this guide presents an integrated design process to help you reach your deep energy targets.

INTEGRATED PROJECT DELIVERY TEAM

Integrated project delivery teams, or IPD teams, have become increasingly popular in the Architecture-Engineering-Construction industry and indeed, it seems integrated design is the only way to achieve deep energy savings in existing buildings that meet increasingly stringent codes and cost constraints. Institutions such as the American Institute of Architects (AIA), the American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE), and the National Institute of Building Science, have developed guidance on IPD teams and processes [3-5].

Ideal IPD teams differ from traditional design teams in terms of when the team is formed and how the team communicates. IPD teams are formed earlier in the design process than traditional design teams, and they tend to have non-hierarchical, “flat” (or “matrix”) organizational structures that facilitate regular and open communication. **Figure 1** shows the different timelines for forming traditional and integrated project delivery teams, illustrated by blue and peach lines, respectively, and highlights differences in team focus during different project phases [4]. Note in the traditional design process, the team focuses on defining the “What”—that is, defining what the owner’s requirements are and the general shape of the building that will meet these requirements—for much of the process. By contrast, in an integrated design process, the team focuses more on the “How”—determining details of how the building systems will integrate to meet the owner’s requirements. Moreover, team members engage earlier in the integrated design process, so the “What” and the “How” reflect the collaborative effort of more team members.



[1]Contractor Team Lead and Contractor Team engagement shown for the Integrated Design Process is the earliest they may become involved (ideal scenario). Projects can still be successful if these stakeholders are engaged later (e.g., in Schematic Design or Design Development) if constructability or cost effectiveness issues are less present.

Figure 1: Timeline for forming Traditional and Integrated Project Delivery Teams (Adapted from [4])

Note the differences between traditional and integrated project delivery teams, displayed in Figure 1. IPD teams form earlier, allowing them to collaborate on design development from the project outset. Moreover, engaging the contractor team earlier allows the team to anticipate and design for potential construction issues. When the team designs with construction in mind, it is more likely that the design will be realized (that is, the building will be built as designed). In the best case scenario, the building users and building engineers would also be consulted during the design process as part of the owner team (building owner, occupants, operators...), to facilitate information sharing during the design phase. This communication allows the designers to share their intent with building users (both occupants and operators) and hear operational barriers and training required to ensure implementation of that design intent. During this exchange, the design team and the owner team may uncover any serious roadblocks to the project's success and determine a plan to remove or work around them.

Figure 2 shows the difference in team structure. A word of caution: teams may call themselves integrated, but if they are not openly sharing information and collaborating across disciplines and teams, they may not be as integrated as their name or structure suggests. Similarly, some "traditional" project teams will form later in the design process and retain a hierarchical organizational structure, yet still share information, communicate, and provide some of the benefits of an integrated project delivery team. Generally speaking, teams integrate best when they come together early and collaborate openly and often.

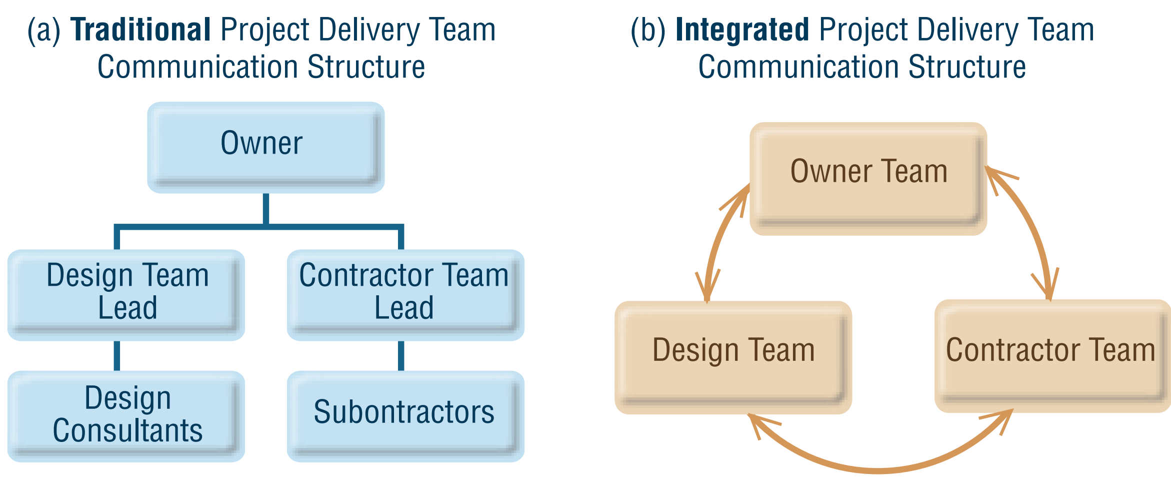


Figure 2: Traditional vs. Integrated Project Team Structure

Beyond hiring the team early, it is critical to establish a relationship that fosters communication and collaboration. To do so, implement the project structure in **Figure 2b**. This structure allows different team members to communicate directly rather than through the design team lead, as is the norm in the traditional project delivery structure. In removing this hierarchy, information flows more readily through the team and facilitates new interactions that could result in synergistic design options that serve multiple functions across disciplines. Information also flows more readily within teams: the teams in **Figure 2b** are often more internally integrated as well, as described by ASHRAE [6]. By allowing team members to share information with each other directly, IPD teams eliminate time spent by the Design Team Lead and Contractor Team Lead "directing traffic" and allow that time to be spent in more fruitful pursuits (like designing the retrofit!). It is critical to establish communication processes and expectations early to ensure that the team really collaborates. When information is not shared, team members must make assumptions and design their system independently, which may eliminate the possibility of synergy between systems, and in turn, lead to cost and schedule overruns and poor energy performance.

IPD TEAM MEMBERS Involved in the Early Design Process for Your Low-Energy Retrofit

Designing your retrofit project involves many tasks, beginning with setting your energy goals, and ending with the design for a new, lower-energy space. This document focuses on the early design phase, where decisions are made that can have major cost, schedule, and energy implications later in the project. This document specifically addresses those tasks in early design related to developing and selecting energy efficiency measures (EEMs) that require collaboration. Two processes are presented, one for the more common scenario where the project team does not have sufficient energy use data (likely sourced from the building's energy management or control system) to reliably estimate the energy savings from implementing EEMs, and another for teams who have granular energy use data at the end-use level. In either case, the same project team members must be involved, namely, the owner, the architect, the energy analyst and mechanical designer, and the M&V Consultant. Note these team members are essential to the tasks presented—other IPD team members, including the contractor team and members of the design and owner teams may also be involved in complex projects, where input from additional team members may be required to ensure EEM feasibility. Each of the team members required for EEM development and selection is described in more detail below.

Owner

The owner commissions the design and construction of a retrofit and selects a team to perform these tasks. Typically, the owner sets the building program and sets energy targets that steer the design. The owner works with the Design Team, the Contractor Team, and others to ensure the retrofit designed and built meets the owner's project requirements.

Architect

The architect often plays the role of "project coordinator" and as such, may be best able to develop synergies between different designers and engineers to develop low-energy designs for various building systems. The architect is also able to coordinate overall programming and architectural design efforts to meet the project's energy goals.

Energy Analyst & Mechanical Designer

The energy analyst & mechanical designer is most typically found in the mechanical engineering firm, but could be contracted from a separate energy analysis firm. This person (or group) is responsible for developing, refining, and analyzing the energy model(s) for the project. This person (group) and the mechanical designer work with the M&V Consultant and other IPD team members to understand how the existing building uses energy, and works with the owner, architect, and other IPD team members to develop, model, and analyze a set of energy efficiency measures (EEMs) to meet the project's energy goals.

Measurement & Verification (M&V) Consultant

The measurement & verification (M&V) consultant is responsible for measuring energy consumption in the existing building. Depending on the project, the M&V Consultant may also help to develop the set of EEMs for the retrofit. The M&V consultant is also responsible for measuring energy consumption after the building retrofit is complete, to verify the energy savings.

Determining Which EARLY DESIGN PROCESS is Right for Your Low-Energy Retrofit Project

This document presents two early design processes for a low-energy retrofit project. The first, shown in **Figure 4**, is for teams who do not have granular energy use data at the end-use level sufficient to determine the energy performance of specific building systems. The second, **Figure 5**, is for teams who have enough submetered, granular end-use energy consumption data to reliably predict the energy savings from various energy efficiency measures (EEMs). The IPD team should determine together whether sufficient data is available and select their process accordingly. **Figure 3** can help you determine how to navigate the remainder of this guide and determine which process to use. If you are unsure of which process to use, use **Figure 4**.

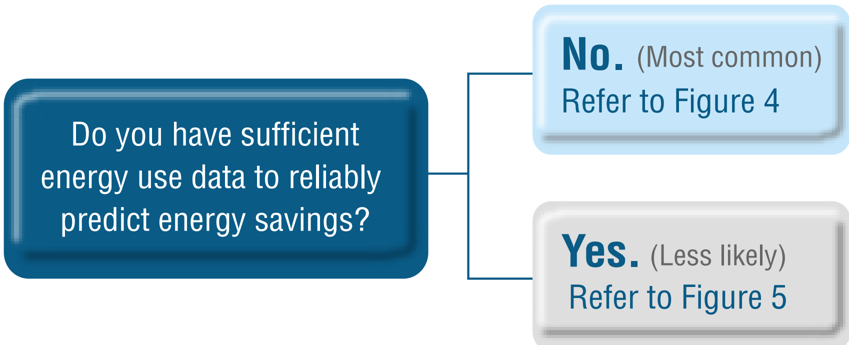


Figure 3: Flowchart to determine which Early Design Process is right for your Low-Energy Retrofit Project

It is more common that teams *will not* have sufficient data at the outset of the project. Note that when sufficient data is not available to reliably predict energy savings, a walkthrough of the existing building can provide enough information to begin to develop a list of EEMs that may be effective. Teams may opt to implement the procedure described in the ASHRAE Auditing Guide [7] to identify efficiency opportunities during the walkthrough. Data collection efforts (to support *how effective* the EEMs will be) can begin in parallel with compiling a list of potential EEMs.

EARLY DESIGN PROCESS for Low-Energy Retrofit when Additional Data Collection is Required

Figure 4 shows tasks for the early design of a low-energy retrofit project, highlighting IPD team member collaboration. If an IPD team that is effectively communicating undertakes these tasks, they can collaborate to maximize the energy savings from the retrofit. For example, the architect, the energy analyst & mechanical designer, and the owner can develop a set of EEMs that improve building energy performance and can take measures to support persistant savings over time, including occupant engagement, operator training, and standardized building operation processes. In the event that the parties were not communicating, EEMs may be selected that require changes in building operation; however, if the building operators and occupants are unaware of these required changes, actual energy savings may be less than predicted. **Figure 4** shows IPD team members along the left side (described in more detail in the previous section), and tasks in boxes.

As previously stated, the tasks shown are only those related to EEM development and selection in early design and that require collaboration; many more tasks are required for early design and even more are required for completing your retrofit project, so you may want to use this map as a starting point for developing a full map and schedule for your project. Note that in this map, time progresses from left to right. It is critical that one task be complete before another begins. There will likely be cause to revisit certain tasks as new information becomes available, but every effort should be made to complete a task before moving on to the next.

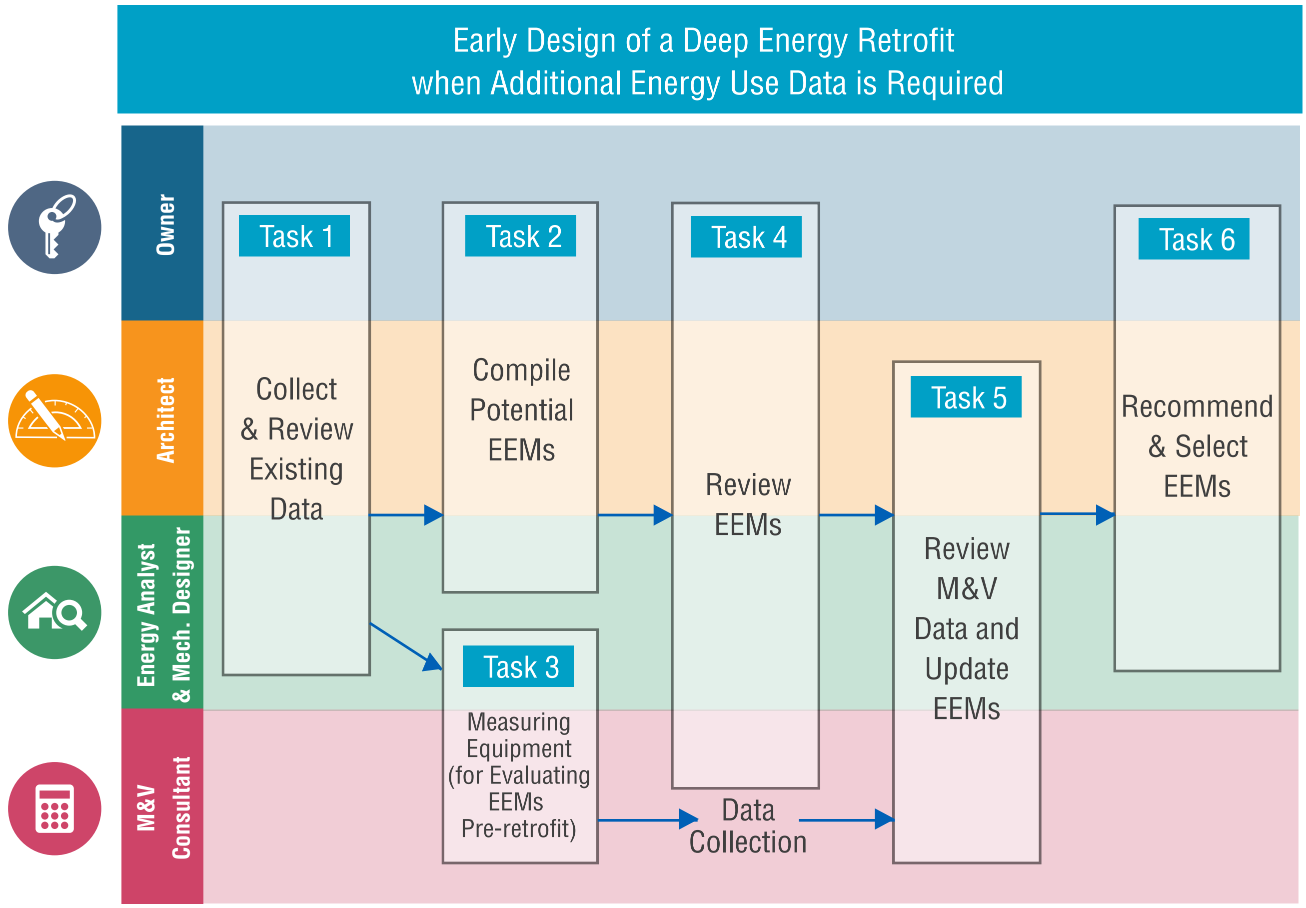


Figure 4: Early Design Process for Deep Energy Retrofit when Additional Energy Use Data is Required

Task 1: Collect & Review Existing Data

This task involves the owner, the architect, and the energy analyst & mechanical designer collecting consumption data for all energy sources flowing to the building from whatever sources are available (for example, utility bills, commissioning report(s), available metered data, and/or benchmarked data). This data is collected to understand the "energy picture" for the building. The more data available, the clearer this picture will be. Any data available about how the energy is used at the end-use level (for lighting, for plug loads, for HVAC, etc.) will help the architect and the energy analyst & mechanical designer understand how the building operates, which in turn allows the team to better understand the metering needs and potential areas for improvement. If you are unfamiliar with benchmarking, consider using ENERGY STAR [8] or EnergyIQ [9] to benchmark your building's energy performance using utility bill data.

Questions to consider during this task:

1. What are the energy sources for the building?
2. What is the consumption, according to utility bills, from each source?
3. What is the consumption overall and at the end-use level according to metered data and/or any commissioning and benchmarking reports for the building?

Task 2: Compile Potential EEMs

This task involves the owner, the architect, and the energy analyst & mechanical designer compiling a list of potential EEMs that may be effective based on the reviewed energy data. To develop the list of potential EEMs, the IPD team reviews the preliminary energy model (developed by the energy analyst & mechanical designer in the course of tasks not shown in **Figure 4**) as well as data from a building walkthough and the collected energy use data to understand which existing building systems are least efficient in terms of energy consumption. These inefficient systems represent opportunities for energy efficiency measures (EEMs). The IPD team can begin brainstorming a list of EEMs to help achieve your energy goals and that may be cost-effective for your building.

Questions to consider during this task:

1. Which current building systems are least efficient?
2. What EEMs may be cost-effective for this building?
3. Do the EEMs support the energy goals?

Task 3: Select Measuring Equipment

This task involves the energy analyst and the M&V consultant. They will work together to determine what equipment requires additional metering – focusing on systems that seem inefficient based on data from Task 1 and the preliminary energy model (developed by the energy analyst in a task not shown in **Figure 4**). The energy analyst and M&V consultant will determine what metering equipment must be installed at what location to collect data relevant for determining the efficacy of EEMs. It is critical that this list be determined before data collection begins. Otherwise, unnecessary meters may be ordered, or worse, the appropriate meters may not be ordered. This task will yield a list of equipment requiring additional metering and determine which points (what data and from what location), as well as which meters, are required.

Questions to consider during this task:

1. Which equipment or systems will require additional energy metering?
2. What data points are needed that require additional metering?
3. What metering equipment is required to collect data about each point of interest?
4. Where should we install meters to collect this data?
5. What are the data logging requirements for the measurements (e.g., accuracy, sample rate, etc.)?

Task 4: Review EEMs

This task requires involvement of the owner, architect, energy analyst & mechanical designer, and M&V consultant, though it is often helpful to include other IPD team members as well (e.g., cost estimator, contractor team). Typically, this task is completed via a presentation from the design team to the owner. The design team will present the preliminary energy analysis, detailing how much energy is consumed by each of the current building systems, as well as a list of EEMs that can help to achieve the energy goals for the building. The presentation of EEMs should include estimated energy benefits (in terms of energy savings and energy cost savings) as well as estimated costs of the EEMs. The goal of this task is to weed out any EEMs or packages of EEMs that should not be candidates for inclusion in the final building design. During this task, you should approach costs as the owner does, for example from a life cycle perspective, or from a cost-benefit analysis.

Questions to consider during this task:

1. What are the energy and energy cost savings associated with each EEM proposed for the building?
2. What are the capital costs associated with each EEM proposed for the building?
3. What is the return on investment of the EEMs?
4. What cost effectiveness metrics were used (life cycle cost, first cost, etc.)?
5. Are there any ancillary benefits (e.g., improved lighting quality, thermal comfort) or deterrents to the EEMs?

Task 5: Review M&V Data & Update EEMs

This task involves the architect, energy analyst & mechanical designer, and the M&V consultant. Note that this task requires the collection of data as identified in Task 3 and shown in **Figure 4** as the 'Data Collection' arrow connecting Task 3 to Task 5. Based on this data, members of the IPD team can calibrate the preliminary energy model to ensure the model better reflects actual conditions in the building. This allows the entire IPD team to better understand energy use in the building and therefore better understand which EEMs may be most effective. As part of this task, the IPD team should also update the projected energy and cost savings associated with each of the proposed EEMs (developed in Task 4) to reflect metered data. Based on the review of the EEMs with the owner (Task 4), IPD team members can narrow down the list of EEMs to determine which warrant further study. This can be done in a variety of ways. The team may choose to prioritize EEMs based on a combination of first costs, projected savings, projected utility bill savings, payback period, or other criteria.

Questions to consider during this task:

1. Is the energy consumption and savings predicted by the model reasonable given the metered data?
2. Considering metered data, are there any changes in the energy savings associated with each EEM proposed for the building?
3. What are the energy savings estimates associated with each EEM proposed for the building (from the energy model)?
4. Considering metered data, are there any changes to the utility bill savings associated with each EEM proposed for the building?
5. What are the updated utility bill savings associated with each EEM proposed for the building?

Task 6: Recommend & Select EEMs

This task involves the owner, the architect, and the energy analyst & mechanical designer. Based on M&V data and revised energy and cost savings associated with each EEM (from Task 5), the owner, the architect, the energy analyst & mechanical designer refine the list of EEMs down to a list proposed for inclusion into the retrofit project. Note the final list of EEMs may include most of those originally selected for further study (in Task 4) or it may comprise only a subset. This final list reflects the architect and energy analysts' recommendations given energy goals, cost constraints, payback constraints, and any other requirements identified by the owner. This list of EEMs is generally provided to the owner as a narrative and a presentation, with the owner making a final selection to proceed into design, construction, and operations (including post-retrofit M&V).

Questions to consider during this task:

1. How did the architect and energy analyst & mechanical designer select the EEMs they recommend to improve energy performance?
2. What are the EEMs recommended for inclusion in the retrofit project?

3. What are the energy and cost savings associated with each of the recommended EEMs?
4. What EEMs should be selected to meet overall goals of the project?

EARLY DESIGN PROCESS for Low-Energy Retrofit When You Have Sufficient Data

Like **Figure 4**, **Figure 5** presents those tasks for early design of a low-energy retrofit project highlighting IPD team member collaboration. However, this process applies when sufficient data is available to evaluate the efficacy of EEMs. This data is typically from the energy management and control system, the energy information system, utility bills, or a combination thereof. As previously described, if an IPD team that is effectively communicating undertakes these tasks, they can collaborate to maximize the energy savings for the existing building. For example, the architect, the mechanical designer, and the owner can use existing data to quickly determine which systems are underperforming and focus efforts on those systems from the outset. In the event that the parties were not communicating, data sharing would take additional time and delay the design efforts and may mask some opportunities for energy performance improvement.

As with **Figure 4**, **Figure 5** shows IPD team members along the left side (described in more detail in the "IPD Team Members Involved in the Early Design Process for your Low-Energy Retrofit" section), and tasks in boxes. The tasks shown are only those which are directly related to early design of EEMs that require collaboration; many more tasks are required for early design and even more are required for completing your retrofit project, so you may want to use this map as a starting point for developing a full map and schedule for your project. Note that in this map, time progresses from left to right. It is critical that one task be complete before another begins. There will likely be cause to revisit certain tasks as new information becomes available, but every effort should be made to complete a task before moving on to the next.

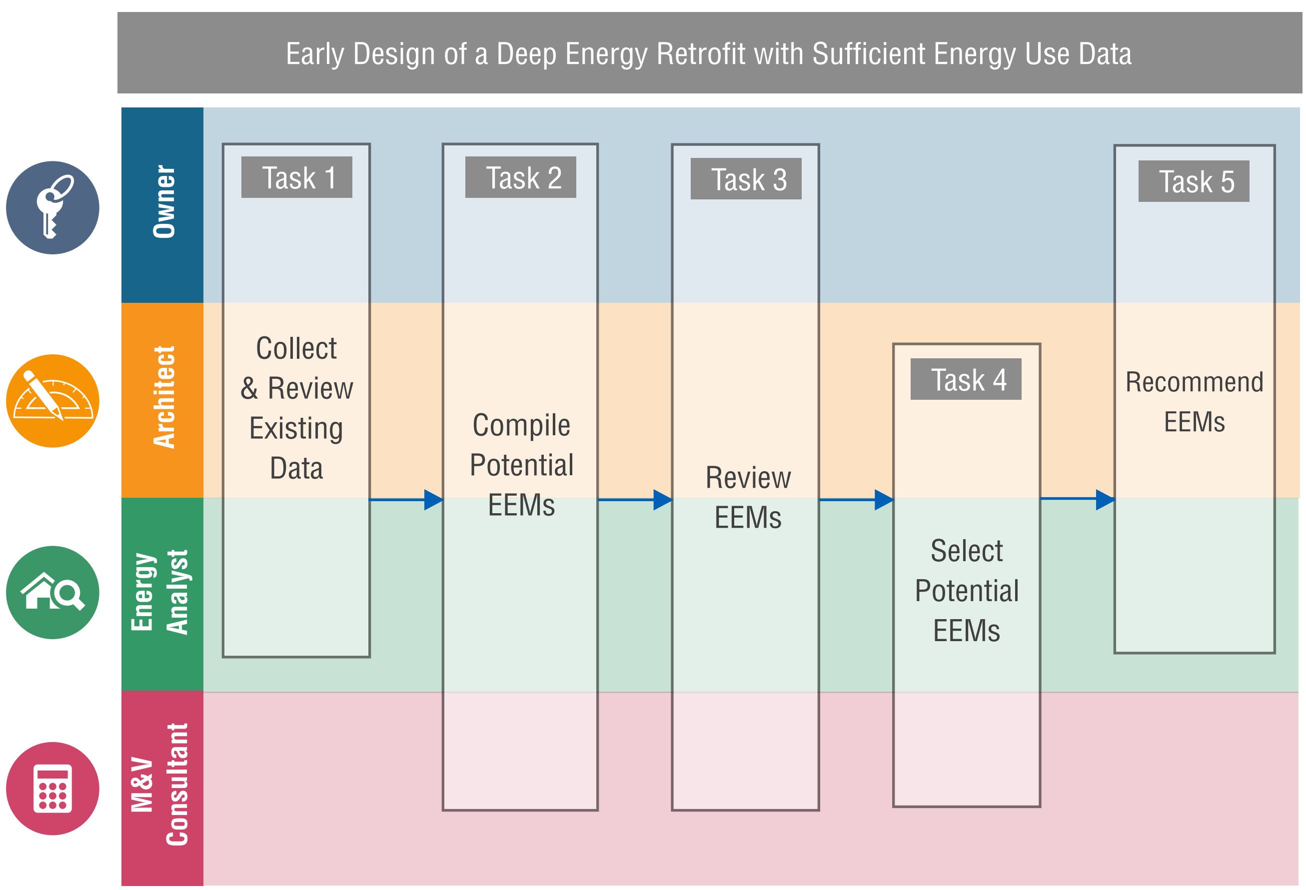


Figure 5: Early Design Process for Deep Energy Retrofit when Sufficient Energy Use Data is Available

Task 1: Collect & Review Existing Data

This task involves the owner, the architect, the energy analyst & mechanical designer collecting consumption data for all energy sources flowing to the building, from the energy management and control system, the energy information system, or other data sources (e.g., utility bills, commissioning report(s), and/or benchmarked data). The more data available, the better the understanding of current energy performance and ability to evaluate EEMs. Submetered data, for lighting, plug loads, HVAC, etc., will help the architect and the energy analyst & mechanical designer understand how the building operates, which in turn allows the team to better understand the potential areas for improvement. If your building is not already benchmarked, consider using ENERGY STAR [8] or EnergyIQ [9] to benchmark building energy performance and determine opportunities for improving it.

Questions to consider during this task:

1. What are the energy sources for the building?
2. What is the consumption, according to energy use data, from each source?
3. What is the consumption overall and at the end-use level according to metered data and/or any commissioning or benchmarking reports for the building?

Task 2: Compile Potential EEMs

This task involves the owner, the architect, and the energy analyst & mechanical designer compiling a list of potential EEMs that may be effective based on energy consumption data. To develop the list of potential EEMs, the IPD team reviews the data alongside the preliminary energy model (developed by the energy analyst in the course of tasks not shown in Figure 5) to understand which existing building systems are least efficient. The IPD team can then begin brainstorming a list of EEMs to help cost-effectively achieve the project's energy goals.

Questions to consider during this task:

1. Which current building systems are least efficient?
2. What EEMs may be cost-effective for this building?
3. Do the EEMs support the energy goals?

Task 3: Review EEMs

This task requires involvement of the owner, architect, energy analyst & mechanical designer, and M&V consultant, though it is often helpful to include other IPD team members as well (e.g., cost estimator, contractor team). Typically, this task is completed via a presentation from the design team to the owner. The design team will present the preliminary energy analysis, detailing how much energy is consumed by each of the current building systems, as well as a list of EEMs that can help to achieve the energy goals for the building. The presentation of EEMs should include estimated energy benefits (in terms of energy consumption and cost savings) as well as estimated costs of the EEMs. The goal of this task is to weed out any EEMs or packages of EEMs that should not be candidates for inclusion in the final building design. During this task, you should approach costs as the owner does, from a life cycle perspective, or from a cost-benefit analysis.

Questions to consider during this task:

1. What are the energy savings associated with each EEM proposed for the building?

2. What are the capital costs associated with each EEM proposed for the building?
3. What is the return on investment of the EEMs?
4. What cost effectiveness metrics were used (life cycle cost, first cost, etc.)?
5. Are there any ancillary benefits (e.g., improved lighting quality, thermal comfort) or deterrents to the EEMs?

Task 4: Select Potential EEMs

This task involves the owner, the architect, the energy analyst, and the M&V consultant. Based on the review of the EEMs with the owner, IPD team members can narrow down the list of EEMs to determine which warrant further study. This can be done in a variety of ways. The team may choose to prioritize EEMs based on first costs, projected savings, projected utility bill savings, payback period, or other criteria.

Questions to consider during this task:

1. How do we prioritize EEMs to determine those that warrant further study?
2. Which EEMs warrant further study?
3. What data do we need to decide which EEMs should be included in the project?

Task 5: Recommend & Select EEMs

This task involves the architect and the energy analyst. Based on data and revised energy and cost savings associated with each EEM that warranted further study based on Task 4, the architect and the energy analyst refine the list of EEMs down to a list proposed for inclusion into the retrofit project. Note the final list of EEMs may include most of those originally selected for further study (in Task 4) or it may comprise only a subset. This final list reflects the architect and energy analysts' recommendations given energy goals, cost constraints, payback constraints, and any other requirements identified by the owner. This list of EEMs is generally provided to the owner as a narrative and a presentation.

Questions to consider during this task:

1. How did the architect and energy analyst select the EEMs they recommend to improve energy performance?
2. What are the EEMs recommended for inclusion in the retrofit project?
3. What are the energy and cost savings associated with each of the recommended EEMs?

BEYOND EARLY DESIGN

Going forward from the tasks outlined in this document into design, construction, and operations, you should maintain the IPD team structure and the communications among team members. Communication helps reduce the need for re-work during design and construction, so it is critical that it be maintained throughout the project. The tasks illustrated here show the team members that must be included in a given task, but there may be value to including others in these tasks. As your project progresses, include IPD team members in decisions that impact their work to ensure best success with your low-energy retrofit project.

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The Commercial Building Partnerships

The Commercial Building Partnerships Program was developed the by U.S. Department of Energy (DOE) to assist companies and organizations that design, build, own, manage, or operate portfolios of buildings. DOE offers technical assistance and guidance on implementing energy efficient technologies to transform commercial buildings. Companies and organizations work with DOE, national laboratories, and private-sector experts (including design and technical) to achieve optimal energy savings within their budget. The goal is to achieve whole building energy savings of 30% or better in retrofits and 50% or better in new construction compared to the minimally code compliant ASHRAE Standard 90.1-2007 baseline.

DOE National Laboratories identify the best strategies for meeting energy saving goals by running performance reviews, modeling, and recommending designs that can be replicated for future projects. Collected data provides the operational and cost data needed to make a solid business case for investment in high-performance buildings. These findings will enable replication throughout building portfolios and the commercial building sector at large, strengthening the participant's position as a leader in energy conservation by influencing others in the commercial building sector.

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