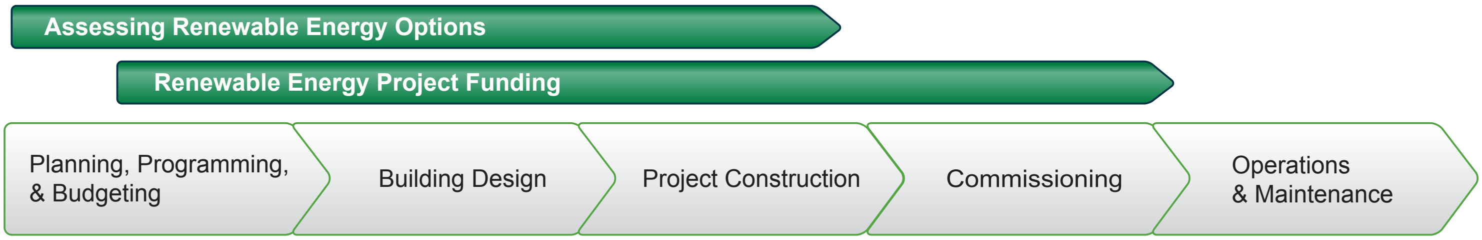
Guide to Integrating Renewable Energy in Federal Construction



Developed by the U.S. Department of Energy (DOE) Federal Energy Management Program (FEMP), the "Guide to Integrating Renewable Energy into Federal Construction" helps Federal agencies understand renewable energy options, select appropriate types of renewable energy technologies, and integrate these technologies into all phases of new construction or major renovation projects.

This PDF is a printed version of the online guide. This guide is structured to address renewable energy considerations at each stage of the construction process.

Guide to Integrating Renewable Energy in Federal Construction

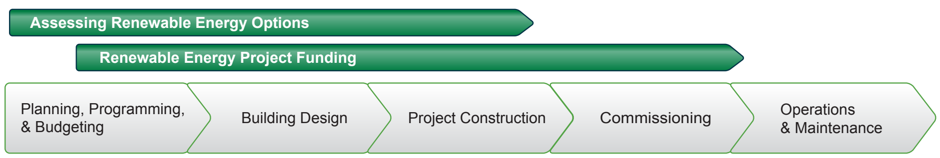
FEMP Federal Energy Management Program

Guide to Integrating Renewable Energy in Federal Construction

Developed by the U.S. Department of Energy (DOE) Federal Energy Management Program (FEMP), the “Guide to Integrating Renewable Energy into Federal Construction” helps Federal agencies understand renewable energy options, select appropriate types of renewable energy technologies, and integrate these technologies into all phases of new construction or major renovation projects.

To reduce costs and increase options, renewable energy should be considered from the very beginning of a construction project as well as at every stage of the project process from planning to operation.

Depicted in the chart below, this guide is structured to address renewable energy considerations at each stage of the construction process.



Technology pages, containing details on each renewable energy technology, including design, cost, life-cycle, and other key issues, are available for this guide through the whole building design guide.

This guide also provides introductory information on why Federal agencies should consider renewable energy, specific guidance on major renovations, and guidance and resources for training and outreach for projects that use renewable energy.

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Introduction to Integrating Renewable Energy into Federal Construction

The introduction to this guide outlines key topics that led to the development of the Guide to Integrating Renewable Energy into Federal Construction. It discusses:

- **Benefits of Renewable Energy Use:** Renewable energy technologies have wide ranging benefits, including economic development and job creation, national security, price stability and environmental improvement.
- **Meeting Federal Renewable Energy Requirements:** A range of legislation and executive orders have stipulated wide-ranging renewable energy requirements and goals that apply to new construction and major renovation projects. Currently, for example, all Federal agencies are required to meet a portion of their energy needs with renewable energy. Integration of renewables into these projects can help agencies comply with all the requirements.
- **Leading By Example:** The Federal government is the nation's largest energy consumer. Operating more than 500,000 facilities comprising of more than 3 billion square feet, the government spends approximately $7 billion annually on energy for these facilities. As such, the Federal government has a tremendous opportunity and clear responsibility to lead by example in adopting sustainable practices to help transform the market. The Buildings Energy Data Book outlines energy use across the Federal sector.
- **Whole Building Project Approach:** The principles of a whole-building design approach are incorporated throughout this guide, including communication between disciplines and integrated design. All systems within a building are viewed as interrelated. In the same way, renewable energy should be viewed as a secondary technology to energy efficiency. The first approach to energy should be to reduce energy use where possible followed by looking for opportunities to produce the remaining energy needed with renewable energy technologies.
- **Renewable Energy Certificates:** Renewable energy can be sold as two distinct products: the actual energy produced from a renewable energy project and the "renewable energy certificate" (REC) which puts a value on the environmental benefits, such as reduced emissions, from the project. To meet Federal renewable energy requirements, agencies can purchase RECs through the market or they can keep or trade RECs associated with an on-site renewable energy project.
- **Technology Resources:** To complement the guide, resource pages were specifically developed for each qualifying renewable energy technology. These technology resource pages contain specific details on each renewable energy technology, including design, cost, life-cycle, and other key issues.

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Guide to Integrating Renewable Energy in Federal Construction

Renewable Energy Benefits

Renewable energy generates a range of benefits at the local, state, regional, national, and global levels. It uses natural resources, reduces greenhouse gas emissions, reduces U.S. dependence on foreign energy sources, and increases Federal energy security by minimizing Federal facility dependence on a vulnerable electricity grid. Renewable energy can also furnish long-term price stability as they rarely depend on costly fuel sources.

The environmental benefits of renewable energy technologies are extensive. For example, if a renewable energy system were installed on a typical 10,000-square foot office building to offset all electricity use (e.g., heating and cooling), avoided carbon emissions would roughly equal the combustion of more than 300,000 gallons of gasoline over a 25-year system life.

Renewable energy also supports economic development through job growth. The U.S. Treasury reports that, in the first 18 months of the renewable energy tax grant program that started in 2009, the manufacture and construction of solar projects that received funds under the program supported approximately 20,000 U.S. jobs in the solar industry alone.

The cost of renewable energy technologies continues to decrease. At the same time, performance continues to increase. Technologies that were once limited to niche applications are now often competitive with traditional energy sources.

The Federal government has an opportunity to transform markets by integrating renewable energy into sustainable building design and construction projects. More information on these opportunities is available in the Federal leading by example section.

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Meeting Federal Renewable Energy Requirements

The way renewable energy is counted toward Federal requirements influences how renewable energy should be treated in new construction and major renovation projects. It is important to have a fundamental understanding of Federal energy and environmental requirements, and the role of renewable energy in meeting successful compliance. This section details Federal renewable energy requirements and how renewable energy is credited.

- Energy Policy Act of 2005
- Executive Order 13423
- Energy Independence and Security Act of 2007
- Executive Order 13514
- Goal Summary
- Notice of Proposed Rulemaking: Energy Efficiency and Sustainable Design Standards for New Federal Buildings
- Notice of Proposed Rulemaking: Fossil Fuel Generated Energy Consumption Reduction for New Federal Buildings and Major Renovations

The following content is intended as reference only. It is recommended that Federal agencies refer to the full text of each law or executive order for more details. Links to these laws and executive orders are provided below.

Renewable Energy Working Group

To help Federal agencies decipher the complexities of renewable energy requirements, FEMP created renewable energy guidance on EPAct 2005 and E.O. 13423 issues. This guidance was developed in conjunction with the Renewable Energy Working Group (REWG). Created to provide a forum for Federal agencies and renewable energy industry experts to exchange ideas and information on renewable energy, the REWG is also charged with developing guidance on Federal renewable energy requirements.

The REWG includes more than 100 Federal agency representatives, DOE programs, and the renewable energy industry members.

EPAct 2005 Section 203 defines “renewable energy” as electric energy generated from solar, wind, biomass, landfill gas, ocean (including tidal, wave, current, and thermal), geothermal, municipal solid waste, or new hydroelectric generation capacity achieved from increased efficiency or additions of new capacity at an existing hydroelectric project. According to FEMP’s Renewable Energy Guidance, hydrokinetic (or run of the river) also qualifies.

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Energy Policy Act of 2005

Section 203 of the Energy Policy Act of 2005 (EPACT 2005) requires the following amounts of total electricity consumed by the Federal government be supplied by renewable energy so long as it is economically feasible and technically practicable:

- Not less than 3% in fiscal years (FY) 2007 to 2009
- Not less than 5% in FY 2010 to 2012
- Not less than 7.5% in FY 2013 and thereafter.

For renewable energy to comply with the provisions of EPAct 2005, the purchase of renewable energy must be separate from normal energy purchases. Renewable energy that is part of the existing mix of electricity supplied by the local utility or that is used to meet state renewable portfolios standards does not count towards this goal.

In addition to EPAct 2005 requirements, some agencies have set higher standards. For example, the Department of Defense (DOD) National Defense Reauthorization Act of 2007 (revised in 2010) sets the goal that DOD must produce or procure of 25% of facility energy use from renewable resources by 2025. The Bureau of Land Management (BLM) has a production goal of 10,000 MW by 2015. EPAct 2005 and individual agency goals must be considered throughout all phases of new construction and major renovation projects for the renewable energy technologies being integrated to maximize credit agencies receive under various requirements.

Bonus Provision

It is important to note that EPAct 2005 has a bonus provision that allows Federal agencies to double count renewable energy if it is produced on site or on Federal or Native American land and used at a Federal facility. Biomass generation on Federal or Native American lands qualifies even in cases when fuel supply comes from other locations. The bonus provision applies to electric projects only and for new projects placed in service after January 1, 1999. It is important to note that to “use” renewable energy, in compliance with the law, means the agency must consume renewable energy to count it toward the goal.

Renewable electricity is not considered used if it is simply produced on a Federal site and sold into the utility grid without being connected to a Federal facility and offsetting some of its power requirements. The renewable energy certificates (RECs) for the power must be retained or traded for other RECs to meet the bonus provision.

It is important to note that EPAct 2005 is a goal that affects everyone. It only counts electric generation and agencies must use the renewable energy, not just have someone produce it on agency land. EPAct 2005 Section 203PDF defines renewable energy goals for the Federal sector in detail.

Executive Order 13423

Executive Order (E.O.) 13423 reinforces Federal renewable goals. Specifically, the order mandates that at least half of renewable energy used by the Federal government must come from new renewable sources (in service after January 1, 1999). Systems that are rebuilt, refurbished, or modified significantly at 80% or greater of original costs are considered "new."

Non-electric renewable resources (e.g., solar water heating, mechanical, daylighting, etc.) can be used to meet this requirement, but the entire EPAct 2005 goal must be met with renewable electricity. Thermal includes solar water heating, solar ventilation pre-heat, ground source heat pumps, biomass heating/cooling, ocean or geothermal thermal. Mechanical includes pumps driven by wind or qualifying hydroelectric.

Maximizing Credits

While EPAct 2005 and E.O. 13423 are separate and contain their own set of requirements, the two do overlap. For example, new electric capacity counts toward both EPAct 2005 and E.O. 13423. New non-electric capacity counts toward E.O. 13423, but does not count toward EPAct 2005. Scenarios for meeting requirements of both directives are illustrated in the table below.

Possible Options for Meeting EPAct 2005 and E.O. 13423 FY 2010 Renewable Energy Goals

	One Possible Option		Another Possible Option	
EPAct: 5% of electricity from renewables by FY 2010	5%	Electric	5%	Electric
E.O. 13423: 50% of renewable energy must be "new"	2.5%	Half of above electric is a "new"	0%	"New" electric
	0%	"New" thermal, mechanical, daylighting	2.5%	"New" thermal, mechanical, daylighting
EPAct and E.O. 13423 goals met	Yes		Yes	
Total renewable energy produced	5%		7.5%	

Energy Independence and Security Act 2007

The Energy Independence and Security Act of 2007 (EISA 2007) contains Federal requirements specifically directed at new construction and major renovation projects. It requires 30% of hot water demand in new Federal buildings and major renovations be supplied by with solar hot water equipment provided it is life-cycle cost effective or has a savings-to-investment ratio (SIR) greater than one.

EISA 2007 also requires fossil fuel consumption relative to 2003 to be reduced as outlined in the bullets below. Adoption of renewable energy technologies will play a critical role in achieving these reduction targets.

- 55% by FY 2010
- 65% by FY 2015
- 80% by FY 2020
- 100% by FY 2030

Executive Order 13514

E.O. 13514 establishes multiple regulations for new construction and major renovation projects under the Guiding Principles for New Construction and Major Renovations, which direct implementation of high performance sustainable building design, construction, operation management and maintenance, and deconstruction. A requirement within E.O. 13514 that is relative to renewable energy is ensuring all new Federal buildings, entering the design phase in 2020 or later, are designed to achieve zero net energy by 2030. While energy efficiency is key to reducing energy consumption within a structure, renewable energy is necessary to supply any additional electricity and thermal needs to achieve zero net energy.

E.O. 13514 requires agencies to reduce greenhouse gas (GHG) emissions, which translates into a need to reduce fossil fuel energy use. Renewable energy will help meet GHG reduction targets and requirements as they emit low or no GHGs. Guidance is available to agencies for establishing GHG baselines and target goals.

Federal Renewable Energy Goal Summary

The following chart summarizes Federal Renewable Energy goals:

Regulation	Produce, Use, or Both	Requirement	Agencies Covered
EPAct 2005 Federal use goal	Use, Electric	3% in FY 2007 to 2009 5% in FY 2010 to 2012 Not less than 7.5% in FY 2013 and thereafter	All
E.O. 13423	Produce or Use, All renewable energy	50% of EPAct 2005 Federal goal from "new" sources	All
DOD National Defense Reauthorization Act of 2007	Produce or Use, All renewable energy	25% of electricity by 2025	DOD
EPAct 2005 BLM production goal	Produce, Electric	10,000 MW by 2015	BLM
EISA 2007 solar hot water requirement	Use, Solar water heating	30% of hot water needs in all new building or major renovations	All

Notice of Proposed Rulemaking: Energy Efficiency and Sustainable Design Standards for New Federal Buildings

On May 28, 2010, the U.S. Department of Energy (DOE) Office of Energy Efficiency and Renewable Energy (EERE) issued a Notice of Proposed Rulemaking (NOPR), 10 CFR 433 and 435PDF. The NOPR was issued to implement provisions of the National Energy Conservation Policy Act (NECPA) as amended by EPAct 2005 that required DOE to establish revised performance standards for the new construction and major renovation of Federal buildings. In addition, provisions of EISA 2007 are considered.

The NOPR is applicable to new Federal buildings, which are defined as any building constructed by, or for the use of, any Federal agency, including buildings built for the purpose of being leased by a Federal agency, and privatized military housing.

It also applies to buildings undergoing major renovations, which are defined as changes to a building that provide significant opportunities for substantial improvement in the sustainable design elements covered in this rule, including energy efficiency and renewable energy. DOE also included in the definition of any renovation that exceeds 25% of the replacement value of the building is to be considered a major renovation.

Within the NOPR, sections specifically focused on renewable energy technologies exist. Although the final rule has not been issued, it is important to be aware of potential requirements that could impact projects. A summary of the applicable NOPR sections for new Federal commercial and multi-family high-rise residential buildings are:

- 433.4 (d) Solar Hot Water: Section 523 or EISA requires 30% of hot water demand in new Federal buildings or Federal buildings undergoing major renovations to be met by solar hot water heaters if life-cycle cost effective. DOE interprets Section 523 to include all hot water usage in the building, including hot water used for restrooms, janitorial closets, food handling facilities, and laundry facilities. Agencies should calculate the total hot water load for the building and then determine if it is life-cycle cost effective to use solar hot water systems to meet 30% of the annual demand.

- 433.6 (f) (1) Sustainable Design Principles for Siting, Design, and Construction; Renewable energy: Federal agencies must implement renewable energy generation projects on agency property for agency use when life-cycle cost effective.

- 435.2 Definitions: Major renovation means changes to a building that provide significant opportunities for substantial improvement in energy efficiency. This may include but is not limited to replacement of the HVAC system, the lighting system, the building envelope, and other components of the building that have a major impact on energy usage. Major renovation also includes a renovation of any kind with a cost exceeding 25% of the replacement value of the building.

  New Federal building means any new building (including a complete replacement of and existing building from the foundation up) to be constructed by, or for the use of, any Federal agency. This includes buildings built for the purpose of being leased by a Federal agency, and privatized military housing. Criteria is being considered for leased buildings by limiting new leased buildings to occurrences where the Federal agency has significant control over building design (lease-constructs).

Extent Practicable: Actions need to be implemented unless an Agency determines that:

- Full implementation would prevent the building or facility from fulfilling a key design or function objective.
- Necessary products or materials cannot be commercially procured in timely fashion.
- Net increases in total project life-cycle costs are very large.
- Initial funding required to integrate features to comply with this rule exceeds 3% of total first costs.

Sustainable design principles will apply to the extent practicable for (1) buildings for which the Administrator of the U.S. General Services Administration (GSA) is required to submit a prospectus to Congress, and/or (2) a building or major renovation for which the construction cost is at least $2.5 million (in 2007 dollars adjusted for inflation). For buildings not fitting into these two categories, sustainable design principles would apply only to the extent they are life-cycle cost effective. To demonstrate life-cycle cost effectiveness, proposing agencies would be permitted to use one of four methods listed in 10 CFR Part 436:

- Lower life-cycle costs
- Positive net savings
- Savings-to-investment ratio (SIR) estimated to be greater than one
- Adjusted internal rate of return that is estimated to be greater than the FEMP discount rate

Notice of Proposed Rulemaking: Fossil Fuel Generated Energy Consumption Reduction for New Federal Buildings and Major Renovations

On October 15, 2010, DOE published a NOPR (10 CFR 433 and 435)PDF to implement Energy Conservation and Production Act (ECPA) provisions as amended by EISA 2007 that require DOE to establish revised performance standards for the construction of all new Federal buildings, including commercial buildings, multi-family high-rise residential buildings and low-rise residential buildings. The NOPR specifically addresses the reduction of fossil fuel generated energy consumption in new Federal buildings and major renovations.

The proposed rule would revise Federal building energy efficiency performance standards for achieving reductions in fossil fuel generated energy consumption and clarify which building types are covered and excluded by the standards. Is also establishes a methodology for compliance, including calculation of the maximum allowable fossil fuel generated energy consumption based on building type and how fossil fuel consumption resulting from electricity usage should be considered.

EISA 2007 Section 433(a) directed DOE to establish regulations that revise Federal building energy efficiency performance standards originally defined in ECPA Section 305 to require public buildings to reduce energy consumption (based on a FY 2003 baseline) in graduated percentages ranging from 55% to 100% over a specified time period beginning in FY 2010 and ending in FY 2030.

In addition, for the purpose of definition, the NOPR is applicable to any building to be constructed by, or for the use of, any Federal agency. In a separate rulemaking, DOE is proposing that the term include buildings built for lease by a Federal agency and privatized military housing.

A major renovation is defined as changes to a building that provide significant opportunities for substantial improvement in energy efficiency. This may include, but is not limited to, replacement of the HVAC system, the lighting system, the building envelope, and other components of the building that have a major impact on energy usage. Major renovation also includes a renovation of any kind with a cost exceeding 25% of the replacement value of the building.

A section focused on renewable energy certificates (RECs) and power purchase agreements (PPAs) to help offset fossil fuel energy generated consumption is included within the NOPR. Although the final rule has not been issued, it is important for agencies to be aware of potential requirements that could impact projects.

A summary of the applicable NOPR sections for new Federal commercial buildings and major renovations includes:

- To meet the maximum allowable fossil fuel generated energy consumption requirements, fossil fuel generated energy consumption could be offset with use of energy created from other sources, including renewable energy. DOE also recognizes there may be physical limitations to the amount of on-site renewable electricity that can be produced, and it may be more affordable in some cases for an agency to purchase electricity from centralized renewable energy generation facilities. As an example, ASHRAE Standard 189.1–2009 has an on-site renewable energy requirement but allows the use of RECs as an alternative to meet the requirement.

- However, there are concerns that purchase of renewable energy generated electricity via RECs or direct PPAs may simply reduce the amount of renewable energy available for purchase by other entities within the U.S. and may not necessarily lead to an overall decrease in domestic fossil fuel generated energy consumption. In addition, unlike PPAs, RECs do not involve a long-term binding agreement and can readily be cancelled.

  The use of RECs is being phased out by January 2012 as a way to meet the renewable energy consumption levels established under EPAct 2005 and E.O. 13423. Therefore, DOE is leaning to a preference of allowing PPAs with a long-term contract to count toward meeting the fossil fuel generated energy consumption reduction requirements, but not allowing RECs. Under this approach, agencies would be allowed to subtract the annual electricity generated by the renewable energy generation facility from the building's annual site electrical energy consumption. The building designer would use this quantity, the net site electrical energy consumption, when calculating the building's fossil fuel generated energy consumption. In effect, the PPAs would help agencies meet the fossil fuel consumption requirements.

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Federal Government: Leading by Example

The Federal government plays a vital role in leading by example in environmental, energy, and economic performance. President Obama stressed this importance on October 5, 2009, by stating:

"As the largest consumer of energy in the U.S. economy, the Federal government can and should lead by example when it comes to creating innovative ways to reduce greenhouse gas emissions, increase energy efficiency, conserve water, reduce waste, and use environmentally-responsible products and technologies."

The U.S. has made a strong and clear commitment to paving the way for the Federal government to actively lead by example in the adoption of clean energy technologies and conservation measures, and drive reduction in greenhouse gas (GHG) emissions. Federal new construction and major renovation projects are a strategic and important way to showcase efforts to lead by example.

Federal Leadership through Policy

Annually, the Federal government consumes approximately 1.6% of all energy used in the U.S. at a cost of $24.5 billion to taxpayers. The majority of this usage and cost, 65%, is attributed to transportation while 30% goes to operating the government's more than 500,000 facilities and buildings. A significant opportunity exists to reduce energy consumption in buildings through the integration of renewable energy technologies in new construction and major renovation projects. In turn, the implementation of these technologies reduces GHG emissions and fossil fuel use.

The Federal government has taken measures over the years to lead by example through adoption of environmentally sound energy management policies directed at the Federal sector. In 2006, Federal agencies demonstrated leadership by creating and signing a Memorandum of Understanding on Federal Leadership in High Performance and Sustainable Buildings. This memorandum set forth specific guiding principles for reduced energy use and other sustainable practices in Federal buildings. In December 2008, the guiding principles were revised to update guidance specific to new construction and major renovations in response to additional executive and legislative energy requirements.

Federal Buildings

The Federal government owns or leases more than 500,000 buildings with more than 3 billion square feet of floor space. These structures affect our natural environment, our economy, and the productivity and health of the workers and visitors that use these buildings.

Most energy consumed by these buildings is produced from non-renewable, fossil fuel resources. Given a declining supply of domestic fossil fuel, security concerns over energy supply disruptions, and the global impact of GHGs, the Federal government has compelling reasons to reduce load, increase efficiency, and use renewable energy resources in facilities of all types.

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Existing efforts to lead by example have already yielded results. Federal energy management over the last two decades resulted in Federal energy use decreasing by 16% from 1985 to 2007 and related carbon emissions from Federal buildings decreasing by 9.4% from 2003 to 2007.

Federal agencies are demonstrating successful efforts by constructing cutting-edge, state-of-the art facilities. These efforts are proving that building integrated renewable technologies are cost effective and deliver optimal performance. These technologies provide many benefits including long-term savings, increased occupant comfort, and a healthier environment.

An example of a new construction building with integrated renewable energy technologies is the Research Support Facility (RSF) located at the National Renewable Energy Laboratory. DOE opened the RSF in June 2010. The Leadership in Energy and Environmental Design (LEED®) Platinum building incorporates a broad range of renewable energy and energy efficiency technologies, serving as a real-life model for how commercial building operators nationwide can cost-effectively reduce energy use and save money on energy bills. For more examples showcasing successful Federal projects, refer to the case studies section.

Whole Building Design Approach

As defined by the Whole Building Design Guide, the goal of whole building design is to create a successful high-performance building by applying an integrated design and team approach to the project during the planning and programming phases. Whole building design has proven to help:

- Reduce project costs
- Increase the probability that project timelines are met
- Ensure systems operate at maximum efficiency

Whether building a new facility or conducting a major renovation on an existing building, the project team must always work with an eye toward planning, designing, constructing, and ultimately operating and maintaining the facility efficiently and cost effectively. The importance of engaging the right people with the required expertise into all phases of the project cannot be overstated. The project should be treated as a collaborative effort, which ensures that systems are designed, sized, installed, and operated, and maintained correctly.

Because renewable energy systems are technically and economically complex and integration of renewable technology in buildings is a relatively new application, it is important to understand the principles, concepts, and proper application of the whole building design method. This section helps agencies understand and use the whole building design process with a specific focus on renewable energy technologies.

- Buildings: Functions and Impacts
- Whole Building Design
- Role of Renewables
- Integrated Design
- Integrated Team
- Overcoming Cost Barriers
- Video Resource

Buildings: Functions and Impacts

Buildings use very large amounts of energy, water, and materials. Data from the U.S. Energy Information Administration (EIA) show that buildings account for nearly half of annual greenhouse gas (GHG) emissions and consume more than two-thirds of the electricity produced in the U.S. The vast majority of this electricity is produced from nonrenewable fossil fuel resources, which are the primary source of GHG emissions.

Buildings are not only required to be sound and secure, they also need to provide a safe and comfortable place for occupants to live and work. Reliable, secure energy supply is critical to the success of most buildings. Occupants are entitled to a healthy environment that fosters productivity. Building owners/operators expect reliable and cost-effective operations for the life of the building. Facilities of all types can meet these goals by reducing energy loads, increasing space and energy efficiency, and using renewable resources.

Whole Building Design

Using the whole building design approach enables a building to meet high-performance goals quickly and cost effectively. It opposes conventional design methods in which project representatives are consulted individually according to phases of a project. It is an innovative practice used for planning and programming through the design, construction, and operations phases of a construction project. Whole building design is a process comprised of two components: the integrated design approach, and the integrated team process.

Role of Renewables

As part of the design and development process, renewable energy technologies should be considered as part of the integrated whole building design. To ensure the most appropriate and economic application of renewable technologies, energy efficiency products and passive renewable designs should be implemented first. They produce significant energy savings, are frequently the most cost-effective measures, and must be incorporated at the earliest stages of design to be effective. Adding active renewable technologies provide further benefits and are needed to achieve net-zero goals, fossil fuel reductions, and reduced GHG emissions. Further information is available on effective design strategies.

When planning to integrate renewable energy technologies into a Federal new construction or major renovation project, the whole building design approach and the Guiding Principles for Sustainable New Construction and Major Renovations are the roadmap for all project phase activities from planning to design to construction to commissioning to operations and maintenance (O&M).

Because buildings are highly complex and specific renewable energy mandates have been established for Federal agencies, the whole building design approach is an essential application for building projects. Using the whole building design approach when developing a new construction or major renovation project ensures that the most appropriate renewable technologies are considered early in the planning process, selected based on specific needs and goals of the project, and sized and sited correctly to suit the building design.

Renewable technologies can serve as multi-purpose components. For example, installing solar photovoltaic (PV) panels on parking structures provides shading to cars and comfort to their occupants, while providing clean electricity. A PV system can reduce fossil fuel use and GHG emissions, and therefore improve environmental quality, human comfort and health, building energy security and supply, and help meet Federal energy requirements.

Integrated Design

Integrated design asks all building stakeholders and the technical planning, design, and construction teams to examine the project objectives, building materials, systems, and assemblies from many different perspectives. This approach differs from the typical planning and design process, which relies on the expertise of specialists who work in a degree of isolation from each other in their respective specialties. An agency should stipulate that its selected design team conduct an integrated design process. Energy efficiency and renewable energy goals need to be included upfront as a key element that the facility design must meet.

Integrated design employs whole systems thinking. It is always collaborative in assessing how one system affects all others. An example is to consider how a passive solar heating system can affect an HVAC system with the goal of minimizing energy consumption. If a building has a good passive high performance envelop with good glazing and passive controls, the energy provided by the sun and saved by the envelope design can reduce heating and cooling requirements for the facility. Accordingly, the facility would require a smaller HVAC system with reduced costs resulting from smaller ducts, fans, pipes, and pumps. Therefore, savings accrued through the smaller HVAC system can be reallocated to the envelope. The entire team needs to participate in the process to understand how one system affects all others to achieve the benefits of integrated design. This process requires more time up front, but brings a payoff by allowing a faster process once the project gets to the construction document phases because problems and solutions were identified in the earlier design phases.

Integrated Design Team

When using the whole building design process, it is important to bring all parties together early in the process to receive as much input as possible from all perspectives. The parties include architects, mechanical engineers, civil engineers, design lighting engineers, daylighting experts, renewable technology experts, other building system designers, and experts in commissioning and O&M.

The design team and all affected stakeholders work together throughout the project phases and evaluate the design for cost, quality-of-life, future flexibility, efficiency, overall environmental impact, productivity, creativity, and how the occupants will be affected. It is critical that the team have an expert, or a sub-team of experts, that are well trained on the complexities of renewable technologies. Although including such experts can increase upfront costs, it also ensures that the most cost-effective and high performing systems are appropriately selected, designed, and installed.

A key point to remember when working within an integrated team environment is that no one person knows as much as the team of experts combined. It is important to get all of the right people together early so that each can provide valuable input that will benefit the project as a whole. Working together early in the planning and design can facilitate knowledge sharing in an integrated approach that enables decisions that change the basic concepts of the building. Collaborative design changes the equation from “either/or” to one of “achieving both, and more.”

Renewable energy systems are complex and it is critical to engage people that understand the correct application, limitations, sizing, design, and installation of systems to ensure they are life-cycle cost effective and operate at optimal efficiency. When acquiring contract services for the project’s architecture and engineering firm, be sure to specify that the design team demonstrate specific renewable energy technology expertise.

It is ideal to identify someone to serve the role of project energy lead. This person should understand the Federal agency’s needs, renewable energy technologies and sustainable building design, and advocate the whole building design system, and be able to build support for energy efficiency and renewable energy in the project. Although adding an additional role to the project can increase costs, the project lead will not only build support for energy efficiency and renewable energy in the project but also ensure appropriate renewable energy and efficiency goals are defined and met along with building requirements.

Overcoming Cost Barriers

The use of renewable energy technologies is often viewed as more expensive when compared to conventional technologies. This has historically been the case, particularly when only initial capital costs are considered. The higher upfront costs are primarily driven by equipment and systems and include additional design expertise. Because most renewable energy technologies do not include any fuel costs and have limited O&M costs, their primary expense will always be in upfront capital costs. As such, decisions made solely on the basis of initial capital costs will not favor renewable energy technologies, which is why life-cycle cost analysis is often stipulated for these decisions.

However, it is also widely recognized that renewable energy technologies offer benefits that conventional energy technologies do not. Economic comparisons may fail to recognize all of the economic benefits of renewable energy. Examples include mitigating potential volatility in cost and availability of conventional fuels as well as operating cost savings and design and capital cost savings that can accrue if an integrated whole building design process is utilized in an effective manner.

Two underlying principles should be observed to ensure that economic analyses provide the best possible comparisons between renewable and conventional energy systems and different renewable energy alternatives.

First, all cost comparisons should be made based on life-cycle costs rather than capital costs alone. This is in line with guidance from the White House Office of Management and Budget (OMB) (OMB Circular No. A-11, Appendix 9, Capital Programming Guide), which applies to all Federal agencies.

Second, cost comparisons should consider all cost impacts associated with the use of renewable and energy technologies, which are not necessarily limited to the obvious impacts on a particular building system. An integrated building design process may result in design alternatives that provide fundamentally different buildings with dissimilar construction materials, configurations, etc. In such instances, comparisons should focus on the total estimated building costs for each design alternative as opposed to simply the comparative costs of the renewable and conventional energy systems.

Video Resource

The Rocky Mountain Institute developed the Performance by Design video showcasing projects based on integrated design and team principles. The video includes interviews with architects, engineers, project managers, and others with roles and responsibilities relevant to project design, construction, and operations. This video is an excellent resource for explaining and illustrating the whole building design approach.

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Technology Resources

To provide detailed information on renewable energy technology options and provide technology resource pages, FEMP partnered with the Whole Building Design Guide, found at: www.wbdg.org

Each of these technology-specific pages provides detailed information on system design and types, best uses, resource assessments, economics, operations and maintenance, and other key considerations. The pages describe the technologies in a context specific to Federal sector applications.

The following renewable energy technology resource pages, which are noted below in the parentheses) on the Whole Building Design Guide site were developed in conjunction with this guide:

- Biomass
  - Biogas (www.wbdg.org/resources/biogas.php)
  - Biomass Heat (www.wbdg.org/resources/biomassheat.php)
  - Biomass Power (www.wbdg.org/resources/biomasselectric.php)
- Geothermal
  - Geothermal Direct Heat (www.wbdg.org/resources/geothermalenergy.php)
  - Geothermal Electric (www.wbdg.org/resources/geothermalelectrictech.php)
  - Ground Source Heat Pump (www.wbdg.org/resources/geothermalheatpumps.php)
- Hydroelectric (www.wbdg.org/resources/hydropower.php)
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  - Solar Water Heating (www.wbdg.org/resources/swheating.php)
- Wind (www.wbdg.org/resources/wind.php)

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Assessing Renewable Energy Options

Federal agencies should assess renewable energy options for each specific project when integrating renewable energy in new building construction or major renovations. This section covers the preliminary screening, screening, feasibility study, and sizing and designing systems phases.

This overview page describes the phases of the renewable energy assessment process that occurs in parallel with the normal development of a project. Links to deeper-level information are also provided to help agencies assess their renewable energy options.

Almost any location can use renewable energy technologies. However, not every form of renewable energy may be practical at a particular site. Determining which technology or combination of technologies is best suited to a specific construction project is done during the assessment process. This section describes the entire assessment process and details how this process fits into the overall construction project timeline. In general, the practicality of most renewable energy technologies increases when considered early in the planning stages of site and building design.

Narrowing the choices of renewable energy options involves several steps:

- Preliminary Screening
- Screening
- Renewable Energy Feasibility Study
- Size and Design Systems

Renewable energy technologies can be considered and incorporated at every stage in the design process. However, significant factors that enable cost-effective and technologically-feasible implementation of renewable technologies are often determined in the early design phases. It is prudent to consider and start analyzing the potential for these technologies in the very early, conceptual stages of design.

Preliminary Screening

The first step in assessing renewable energy options is to conduct a preliminary screening to distinguish between technologies that are worth reviewing and those that should be eliminated without further analysis. This step should occur early in the planning of a construction project. Preliminary screening involves resource maps and other basic tools to choose technologies to pursue further.

Screening

The next step in assessing renewable energy options is a full screening. The screening is usually performed by an outside party or an independent renewable energy expert. It is a review of the possible technology options that identifies dead-ends and further narrows the list to probable technologies for the project. This is a more detailed look at the available resources and a high-level analysis of expected costs and savings, utility considerations, and potential incentives. This screening can also assess each technology's ability to contribute to energy goals and requirements. The agency can analyze specific sites or screen across properties to decide which areas have the greatest renewable energy potential.

Screening should be completed during the programming phase of the project, as it is needed to inform early design decisions and project requirements. It is also very helpful in establishing early budget life-cycle cost estimates for renewable energy.

Renewable Energy Feasibility Study

Once an agency has identified probable technologies, a detailed review of the feasibility and economic viability of each renewable energy technology, also called a renewable energy feasibility study, can determine which renewable energy technologies most effectively meet the agency's energy requirements and goals.

The renewable energy feasibility study takes a deeper look into the remaining technologies to quantify how much energy each technology could produce or offset; reviews details of utility interconnection, tariffs, and revenue; analyzes access to financial incentives as well as project funding models; and reviews National Environmental Policy Act (NEPA) requirements, permitting requirements, and operational costs. This assessment can be accurately conducted only after a potential location has been chosen for the project and initial estimates for energy loads and usage exist. Ideally, the feasibility study is conducted before the schematic design phase.

Size and Design Systems

Following the renewable energy feasibility study, the technologies to be included in the new construction project will be defined and the design team will be ready to size and design the systems. At this point in the process, building energy loads and demands will largely be known. Utility requirements and all applicable codes and standards will also need to be considered and met at this stage. This is the last step in the process of assessing renewable energy options.

Integrating renewable energy into a construction project must be in the hands of renewable energy experts and closely coordinated with the overall project design team.

Assessment Factors

Assessing technology options involves examining several factors:

- Available renewable resources: Renewable energy technologies rely on resources like sunlight, wind, biomass, or heat from the earth. Some technologies require a threshold level of a resource to be feasible or cost effective.
- Available space: Many technologies require additional space, either on a roof or on land, to function properly.
- Technology costs: The cost of any renewable energy technology system is calculated along with its potential energy output to estimate its economic feasibility.
- Energy costs: Estimating the economic feasibility of technologies includes calculating the expected costs of energy to the project that will be offset.
- Ability to connect to the grid: When incorporating an electric power technology system into a project, the system will typically need to be interconnected with the utility power grid. The rules vary by state and utility as to what size and type of technologies can be interconnected economically.
- Agency goals: Agency energy goals are important in assessing various technologies. Federal agencies can set goals or mandates, or they could be required by legislation, to incorporate renewable energy into their energy use portfolio.
- Available incentives: Any financial incentives, such as grants, favorable tariffs, or net metering, can affect the economic feasibility of various technologies.
- Additional Factors: Other considerations that can affect renewable energy decisions include energy security requirements, zoning, permitting, and environmental review requirements.

The depth at which each factor is considered varies depending on whether the analysis is for a preliminary screening, a full screening, or a feasibility study. Project location solidifies a few variables—including renewable resources, land availability, conventional energy cost, available incentives, local net metering, and interconnection policies. In the early design phases, however, several factors are not yet defined and should be considered. These include orientation and siting of a building on a lot, design of a building to optimize access to the renewable resource, and sizing of a renewable energy system to offset an optimum amount of site energy load and to minimize usual energy purchases (while maximizing the applicability of financial incentives, if applicable).

Preliminary Screening

The first step in assessing renewable energy options is to conduct a preliminary screening to decide which technologies are worth investigating and which can be eliminated immediately. Preliminary screening involves using resource maps and other basic tools to choose technologies to pursue further. This should occur in the planning phase and can be completed at the agency level with some simple training. There should be no need to hire an outside consultant at this stage.

When narrowing technology options during this phase of assessment, a range of factors are considered, such as:

- Available Renewable Resources
- Ability to Connect to the Grid

Available Renewable Resources

Renewable energy resources refer to the amount of energy that can be captured for a particular technology, such as how solar energy hits a particular area or how much energy is available in the wind in a specific location. Renewable energy experts have been gathering and refining this data for decades.

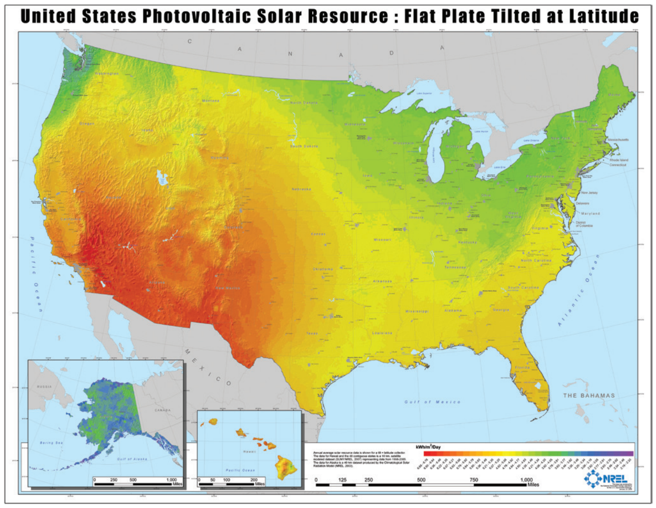
At this stage of assessment, renewable energy resource maps are an easy way to find out what resources are available in your project location. For the preliminary screening, the maps will provide guidance on what technologies should be carried through the next level of assessment.

For more detailed information on any of these or other technologies, see the renewable energy technology resource pages for appropriate technology information.

Solar

The solar photovoltaic (PV) map shows national solar PV resource potential and is useful for most solar technologies, including PV, solar hot water, solar ventilation preheat, passive solar heating, and daylighting. The redder/warmer the color, the better the solar resource. This resource counts both the direct solar radiation that reaches the earth, as well as the reflective solar energy that bounces off the ground or other surfaces.

Although some areas, such as the desert southwest, will produce more energy from solar technologies than other areas, this level of screening cannot rule out solar systems anywhere in the country. Local energy costs, incentives, and utility policies affect the economics of these as much as resource. In general, agencies should consider these technologies, at least through the screening phase, for all new construction projects. Although daylighting and passive solar heating may be more difficult to integrate into a renovation project, these technologies should still be considered.

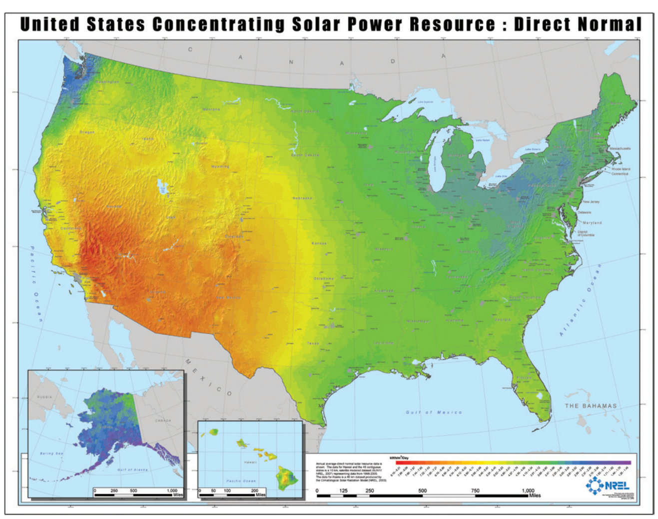


Low Resolution and High Resolution versions are available for download.

Concentrating Solar Power

The concentrating solar power (CSP) map shows the very targeted solar resource potential used in CSP technologies, such as concentrating photovoltaics, concentrating solar power, or concentrating solar thermal. The map shows only the direct radiation from the sun, as concentrating systems cannot make use of any reflective solar energy.

CSP requires at least 6.0 kWh per square meter per day of direct normal solar radiation, which is indicated by the orange color in the resource maps. In general, if the site is in the desert southwest, CSP technologies are feasible. CSP technologies should not be considered if the site is not in the desert southwestern (or in an international location with a resource of this level).



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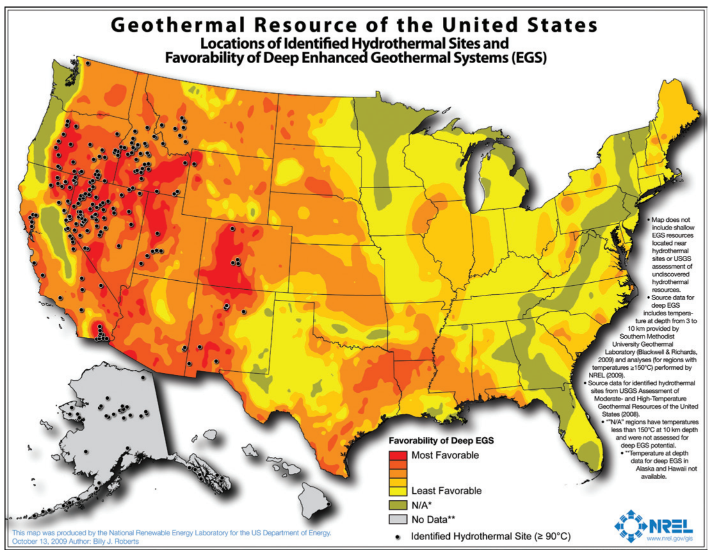
Geothermal

Ground heat pumps can be implemented anywhere in the U.S. and should be considered for any new construction project. Geothermal direct heat technologies require a geothermal resource above 120°F (50°C) located near the site and should be considered if the appropriate resource is available. A geothermal resource above 300°F (150°C) near the site could feasibly be used for geothermal electricity production. However, the scale and cost of such systems means that this should only be considered if the project warrants a utility-scale power project. Most geothermal resources are located in the western U.S.



These maps are available for download.

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The geothermal resource map shows the geothermal resources available in the U.S. Temperature varies by depth, and this map analyzes geothermal resources at depths from three-to-10 kilometers (two-to-six miles). The red and orange colors indicate the most favorable locations for geothermal systems, but the map does not rule out potential locations elsewhere.

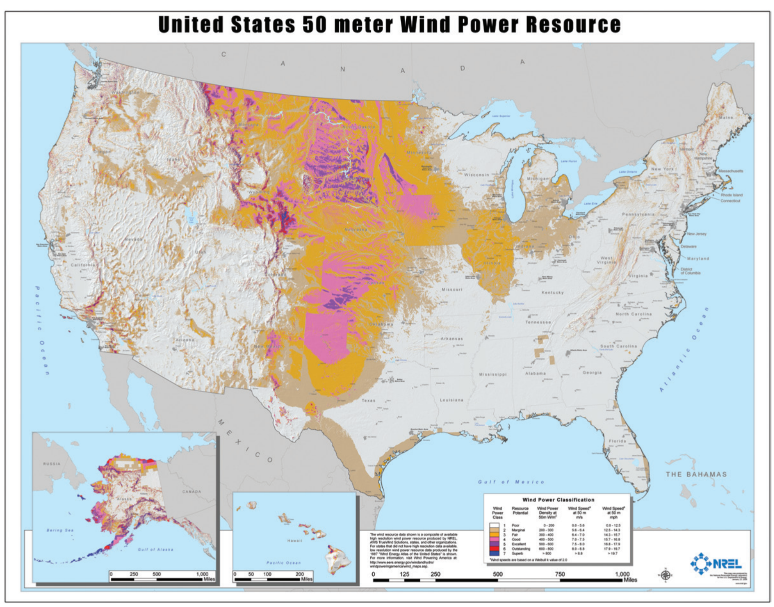
The second map shows regions of known or potential geothermal resources for the West. It also indicates known hot springs and wells, which indicate that geothermally-heated water is present. The nearby presence of hot springs is an encouraging sign for geothermal potential, but the hot springs could be caused by a geothermal resource that is not hot enough for economic energy use in a facility. The presence of many hot springs that are characterized as “hot” (greater than 50°C or 122°F) would be a strong indicator of an area that warrants further investigation for direct heat applications.

Wind

The wind resource map shows national wind resource potential at a tower height of 50 meters above the ground. The higher above the ground, the better the wind resource. Eighty-meter maps are also available. Orange indicates a class 3 wind resource and pink indicates a class 4 wind resource. The darker the color, the better the wind resource.

If the site has a class 3 wind resource, consider small wind turbine (100 kW or less) or large, low-wind speed turbine opportunities. If the site has a class 4 or greater wind resource, wind may be a good option and even larger, utility-scale turbines may provide economic options.

Lower wind resources are less likely to be economically feasible, but should be reviewed if the site is in a class 2 area and there are nearby pockets of class 3 resources.



Low Resolution and High Resolution versions are available for download.

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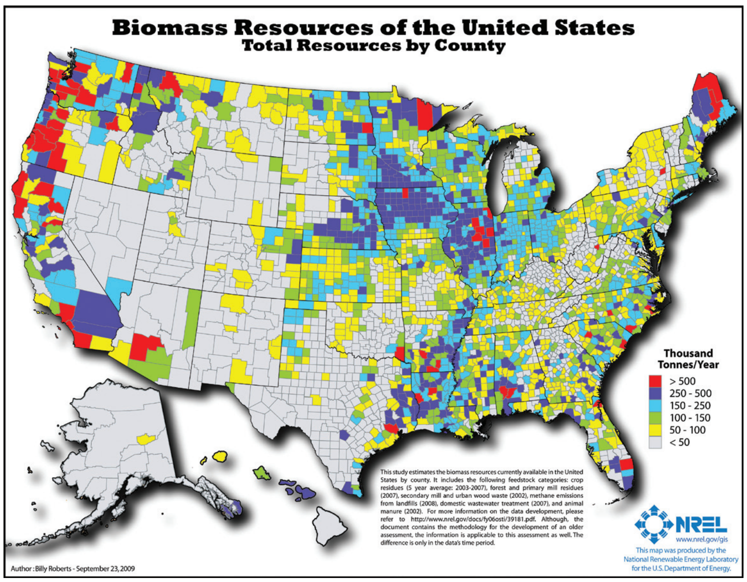
Biomass

Biomass resources are among the hardest to quantify as they can include a range of biomass options, including leftover material from agricultural crops, wood from thinning forests, and even wood waste or municipal solid waste from urban areas. The biomass resource map illustrates the biomass resources available in the U.S. by county. It includes most feedstock categories, but is not all-inclusive for every state, especially Hawaii. Colorado, for example, shows limited resources, but the National Renewable Energy Laboratory (NREL) heats its Research Support Facility partially using a biomass boiler.



This map is available for download.

If there is a permanent, steady stream of biomass resource within a 50-mile radius of the site, biomass opportunities should be considered further. If the map reveals limited or no biomass resources for the site, do not rule out the technology and consult a local expert for more information.

Ocean

Remove ocean power technologies from consideration if the site is not adjacent to the ocean. Ocean thermal energy conversion is a potential energy technology in Hawaii and other tropical island communities. If the site is located on the Pacific Northwest or the Atlantic Northeast, tidal energy is a potential technology and could be considered further for coastal properties.

Hydropower

The Federal Energy Regulatory Commission (FERC) regulates U.S. hydropower resources and provides a simplified process for small and low-impact hydropower projects under 5 MW. The

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Bureau of Reclamation produced a hydropower resource assessment PDF in March 2011, which determined 70 sites with hydropower potential at existing facilities. If the site is close to one of these facilities, hydropower could be a viable technology.

Ability to Connect to Grid

For electricity-generating technologies, such as wind or PV, the renewable energy system typically needs to be connected to the electric utility distribution network or grid to enable the system to integrate safely integrate with the utility grid. The exception to this is a remote facility that gets electricity from on-site sources only and is not served by an electric utility.

The traditional electric utility system and rules were designed for large centralized power plants and not for small on-site power generation by utility customers. As renewable energy and other distributed power technologies have become more cost-effective, many states have developed rules to enable utility customers to interconnect their renewable electricity to the utility grid. These rules often limit the size of the system to be interconnected, and sometimes they do not apply to certain utilities in the state, such as municipal-owned utilities or rural electric cooperatives. Detailed information about these issues is available in the key policies for renewable electricity use section.

The legal ability to connect a renewable energy system to the utility grid is very important to the successful use of renewable electricity technologies. The Database of State Incentives for Renewable Energy (DSIRE) provides a map of interconnection policies by state. The specifications for a successful project are as follows:

- Project is located in a state that has adopted interconnection policies and projects will likely fall within the size limits of the policy.
- Project does not produce electric power.
- Project is not grid connected.

If the project does not fall within successful specifications, the project may still be able to move forward but will require cooperation with utility and/or state authorities to determine the scope of the potential project and any limitations affecting customer-sited generation.

Screening

Screening is typically performed by an outside party or an independent renewable energy expert or team. It is a review of the possible technology options that identifies dead-ends and further narrows the list to probable technologies for the project. A screening provides a preliminary assessment of how much energy could be produced by various renewable energy technologies and conducts a high-level analysis of expected costs and savings, utility considerations, and potential incentives.

Federal agencies can analyze specific sites or conduct an agency-wide screening across properties to decide which areas have the greatest renewable energy potential. When conducted in conjunction with a new construction project or major renovation, an agency should get results from a screening prior to the planning charrette in the programming phase, as the information is vital to early design decisions and energy performance goals. Screening results are also very useful in creating early budget requests that adequately capture the capital costs needed for integrated renewable energy projects.

In a construction project, the designated project energy lead should take responsibility for the screening. This may involve hiring an outside renewable energy firm or assembling a team that has familiarity with each type of renewable energy resource under consideration. The team also needs expertise in resource assessment for each technology, economic evaluation of projects, and policies governing use and size, such as interconnection, net metering, incentives, and project funding mechanisms. Although a screening will add additional costs at the start of a project, it can save time and money in identifying cost-effective options and potential barriers for renewable energy integration. The agency should stipulate specific expertise with each technology identified for consideration during preliminary screening.

Background Project Information

Any information known about the project at this early stage should be provided to the screening team as it may affect the potential for various technologies.

Project location is one important factor. If more than one location is under consideration, the screening may be able to provide a comparison of energy potential. Project type and use are also important as the energy screening for an off-grid visitor's center will look very different than one for a 200,000 square-foot office park. The agency should consider project goals or early limitations on siting or use, as well as specific energy requirements, such as a need for on-site back-up generation.

This background information will be used to generate ballpark estimates of energy use and needs, which will help the team understand the type and scale of technologies to be included in the screening.

Assessing Renewable Energy Resources

The first phase of the screening process is to review the potential renewable energy resources available to the site of the construction project and determine which technologies have viable resources to warrant further evaluation. The resource maps used in the preliminary screening will not be enough for this phase of assessment. Experienced providers will be able to access a variety of data to determine estimated renewable energy production at the site. The screening team will use specific resource assessment tools, such as PVWatts, RETScreen, or data from wind resource models, to get better details on specific production estimates from proposed renewable energy projects. Further information on resource assessment for each technology is available in the renewable energy technology resource pages.

For technologies with enough resource to be a viable option, the team may look at detailed resource data on a daily or even hourly basis to develop specific energy production estimates and to assess their fit with the potential energy needs in the building.

Economics of Renewable Energy Systems

Once developed, the production estimates can be used to conduct an economic evaluation of each technology. A number of issues factor into the economic viability of a renewable energy system, but the primary factors to be looked at in screening are:

- Renewable Energy Costs
- Existing Energy Costs
- Incentives
- Policies for Electricity Systems

It is important to note that the screening only provides a preliminary look at these issues. The actual design and needs of the building are still pending at this stage, and the screening team is only working with generic technology equipment assumptions. Still, this information can be used to understand options and inform early budgets and life-cycle cost analysis.

Renewable Energy Costs

The cost of renewable energy technologies is central to the economic equation for any renewable energy system. Equipment costs alone vary by type of technology, size of system, location, and design. Any renewable energy screening should include early cost estimates, even if they are based on system cost averages or a generic designs. The screening should estimate both costs and production estimates for the same type of system.

Renewable energy technology costs need to include not only the initial cost for equipment and installation, but also operations and maintenance costs and cost of replacing components over the useful system life. For example, an inverter may need to be replaced once or twice during the useful life of a photovoltaic system.

Because early cost estimates are critical to both early planning and budgeting, this guide outlines how to compile life-cycle cost estimates for renewable energy systems. Details are available on the estimating renewable energy costs page.

Existing Energy Costs

To fully understand the economics of any renewable energy system, Federal agencies need cost information for the energy that the renewable energy system will offset. The screening should provide reasonable estimates of the current energy costs. Whereas the price of most renewable energy systems are fixed once they are installed, existing energy costs will vary based on fuel costs and other factors, and they will almost certainly increase over the project life. For ease in using this information in life-cycle cost analysis, the agency should ask the screening team to use projected increases in line with those designated under life-cycle costs analysis regulations.

If the project will be connected to utility services for gas and/or electricity, the first step is to check utility websites for initial rate information to inform cost estimates. Because these rates are often complex, the screening team should include an expert able to decipher the details of local utility tariffs and other information to provide offset energy cost estimates at the utility-level for the expected customer class over the life of the project. In some cases, optional tariffs, such as time-of-use rates, net metering, and other economic incentive rates, need to be assessed to determine the best options for potential renewable energy projects.

If the project is located away from utility services, then the economics are different. Cost estimates can be informed by comparable traditional off-site energy sources such as diesel generators or propane tanks. In these cases, economics should include not only the cost of the equipment, but other factors such as on-site noise and pollution as well as the risks and costs associated with stocking and replenishing on-site fuel sources.

Incentives

Financial incentives offered by Federal and state governments, local utilities, municipalities, and private organizations have a great effect on renewable energy project economics and should be considered even at this early screening stage. Potential incentives could include rebates, loans, tax incentives, grants, bond programs, green building incentives, leasing/lease purchase programs, and performance-based incentives. The Database for State Incentives for Renewables and Efficiency (DSIRE) lists available incentives by state and location.

Economic evaluation of technologies needs to account for the nature of the incentives. Incentives come in a wide variety of types and have a variety of limitations on accessing them. Incentives can be:

- Automatic if the project meets certain criteria
- Restricted to certain size/types of systems
- First-come, first-served for a limited pool of funds
- Competitive in rounds of funding
- Restricted to certain users or owner types (such as rural projects).

In addition, Federal agencies or other public entities cannot directly access tax-related incentives, such as tax credits. Using a different ownership structure for renewable energy project funding could allow an agency to benefit from these tax incentives. A screening should address these options if it has a significant impact on the viability of particular technologies.

Policies for Electricity Systems

A number of key energy policies affect the use of renewable electricity systems at the facility site. The availability and terms of these policies, which vary by state and even utility service territory, can make a major difference in whether certain renewable energy technologies are economic or even viable. These policies include interconnection standards, net metering, time-of-use rates and feed-in tariffs. Detailed information on these policies is available in the key policies for renewable electricity use page.

Agency-Wide Screening

Federal agencies face energy-related requirements on new construction projects and major renovations. These Federal requirements range from reductions in fossil-fuel use to specifying the use of certain renewable energy technologies. As some agencies have already found out, not all sites or construction projects are created equal. Because many of the requirements are agency-wide, an effective and efficient way to meet these requirements is to consider and identify appropriate locations for these technologies across all agency land and building assets.

FEMP can help Federal agencies conduct a renewable energy screening at all of its sites, or just at all of its upcoming construction project locations. Identifying renewable energy potential at an agency-wide level enables an agency to gain a high-level overview of potential opportunities and to provide early screening information to all upcoming projects.

At this stage in the assessment process, a screening report often includes:

- Site location (address or latitude and longitude)
- Estimated site energy cost and use
- Available renewable energy resource by type
- Available financial incentives
- Economic factors and renewable energy technology characteristics.

Other considerations, such as potential available land or roof area, energy security requirements, or net metering limitations, may also be included if available.

Generally, this high-level screening results in a ranked ordering of candidate sites listed in order of potential economic feasibility. This type of analysis is not meant to be definitive, but can serve as a means to identify potential opportunities across an agency or to prioritize sites for more in-depth analysis. When working to incorporate renewable energy technologies into an agency's new building stock, this listing can be used to identify the most promising locations to integrate renewable energy in new construction.

FEMP contacts can offer assistance for conducting an agency-wide renewable energy screening.

Renewable Energy Feasibility Study

After a Federal agency has identified probable technologies through the screening process, a detailed review of the feasibility and economic viability of each renewable energy technology, also called a renewable energy feasibility study, can determine which combination of renewable energy technologies most effectively meet the energy requirements and goals.

When integrating renewable energy into a new construction project or major renovation, this level of renewable energy assessment will typically be commissioned by the design team and should be completed during to the schematic design phase. While a screening looks at the viability of each type of renewable energy, a feasibility study gets into details used to choose technologies and options within a technology type, such as the scale of wind turbine or the type of solar thermal systems to best reach project goals.

The feasibility study takes a deeper look into the remaining technologies to:

- Quantify how much energy each technology could produce or offset, and the value of that energy
- Review details of utility interconnection, tariffs, and revenue
- Analyze access to financial incentives as well as project funding models
- Review National Environmental Policy Act (NEPA) and permitting requirements and operational costs
- Assess economic feasibility with a detailed and credible life-cycle cost analysis according to Federal procedures.

Renewable energy feasibility studies provide technology and financing recommendations an agency or site should pursue. Ultimately, the feasibility study needs to provide enough information for the agency and the design team to make informed decisions about the types of technologies to include in the final project design.

The feasibility study should be performed by an outside party or an independent renewable energy expert. This can be the architecture and engineering (A&E) firm, but it is unlikely that the A&E firm would have the appropriate level of expertise to conduct this type of study. More likely, the A&E firm would hire this out to an objective consultant or team with detailed knowledge of the renewable energy systems under consideration, including technical and design issues, resource assessment, relevant policies and incentives, utility tariffs and interconnections issues, NEPA evaluations, and project funding mechanisms. The entity conducting the study should not be a manufacturer, installer, or organization affiliated with any product or technology under consideration in the project. The project energy lead should be involved in assuring that the feasibility team has the appropriate expertise. In some cases, the agency may arrange to contract these services directly, but the feasibility team must coordinate closely with the A&E firm since feasibility results directly affect design choices.

All renewable energy technologies depend on adequate access to renewable resources to perform optimally. More details are available at this stage on the overall project siting and orientation, so the effect on renewable energy can be assessed in more detail. At the feasibility study stage, it is important to consider not only the types of technologies, but also the specific opportunities for system location and orientation. At this stage, the agency should look at what specifics are needed for optimal production from the renewable energy systems planned for the site.

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A Deeper Look at Screening Issues

The screening, which may be performed by the same group or a different independent renewable energy expert or team, reviews possible technology options and narrowed the list of technologies to probable technologies for the project. The screening also looks at the available resources, potential constraints and risks, expected cost savings, and utility incentives available. The screening is used to inform design requirements, but the feasibility study needs to get to a level of detail to inform the final selection of technologies to meet actual requirements in the most cost-effective manner.

The feasibility study will likely revisit a number of issues looked at during screening, such as resource assessment, technology costs and offset energy savings, interconnection and other policy issues, and available incentives. The feasibility study needs to provide much more precise information based on project and facility specifics and actual technology options. Rather than using estimated offset energy costs, for example, the feasibility study needs to model the full details of the facility's expected energy tariffs and offset energy savings based on net-metering or other revenue streams. These details can be critical to choosing the correct types and sizes of technologies.

Options within Technology

After the renewable energy technologies to be included in a project have been determined, it is time to start considering the types, manufacturers, and sizes of systems needed to accomplish the design criteria. Using photovoltaics as an example, fewer modules made of a higher-efficiency cells (such as single crystalline) would be needed for approximately the same power output as more modules made of a lower-efficiency cell (such as thin film). If a project location is space-constrained, a higher-efficiency and potentially higher-cost module may make the most sense. However, if a project has an abundance of space, a lower-efficiency and less costly module may be most practical.

NEPA, Permitting, and Zoning Issues

In addition to costs and savings from potential renewable energy technologies, the feasibility study should assess the issues and concerns associated with each technology as it relates to compliance with NEPA and all local, state, and Federal zoning and permitting issues.

Many technologies will not have any issues at all, but certain technologies can trigger a number of reviews. For example, wind turbines of a certain height must be cleared by the Federal Aviation Administration to ensure they do not interfere with airport flight patterns. This is not an issue in most cases, but it can prevent the economic use of wind power in certain circumstances.

If a technology is likely to add to the NEPA compliance of the building, that needs to be identified at this stage. This may require including certain renewable energy technologies in public meetings about the building or require working with state, local, or other Federal agencies on review. This also may be a factor in the selection of technologies for the project.

Policies for Renewable Electricity Use

The renewable energy screening should include an assessment of several key utility policies at the facility site. In addition to financial incentives, states and local governments have adopted policies to remove barriers to the use of renewable energy and to facilitate the use of these technologies in a safe and fair manner. These policies are focused on electric-generating technologies and enabling the economic use of on-site power generation at a customer's site.

The screening needs to outline the key provisions at the facility site and assess the impact on the use of these technologies at the site under review. Key policies include:

- Interconnection
- Net Metering
- Time-of-Use Rates
- Feed-In Tariffs

Interconnection

Interconnection standards govern how a renewable electricity technology, such as photovoltaics (PV) or wind, will connect to the power grid. Many states have adopted streamlined interconnection standards that require utilities to let customers connect on-site power systems of a certain type or size. Without these standards, an agency is dependent on cooperation from the local utility to connect a system. Some state policies are only guidelines, and some apply only to investor-owned utilities and not to municipal utilities or rural electric cooperatives.

Interconnection issues can make or break a project. In states without comprehensive interconnection standards in place, it is often more difficult, burdensome, and expensive to connect a system to the grid. In these cases, the interconnection is left to the local utility. Utilities are charged with keeping the power flowing safely to their customers. Any addition to their system, particularly one that they do not control, is often viewed with suspicion.

Lack of utility experience with renewable energy systems, drawn out engineering studies, onerous insurance provisions, or additional non-standard fees can cause havoc with a budget or even put an end to a project. Therefore, interconnection under these circumstances may involve additional work with the utility, additional technical studies, and a fair amount of education of accepted industry standards. On the other hand, high-profile projects, such as a Federal construction project, may interest the utility in enhancing their profile with their customers.

A screening should identify the availability of standardized interconnection with the local utility and detail the specific limitations and requirements. The screening should factor that information into renewable energy types, sizes, and economics. If interconnection is identified as a concern at this stage, the project energy lead and the agency can begin working with the utility early to resolve issues and move forward.

If a new construction or major renovation project is going to be off-grid, or not connected to the utility grid, then interconnection standards do not apply.

Detailed interconnection information is available from the Database of State Incentives for Renewables and Efficiency (DSIRE) website. The site also provides state-by-state details on interconnection standards and guidelines.

Net Metering

For utility customers who generate their own electricity, net metering allows the flow of electricity both to and from the customer. In the simplest cases, the electricity is metered through a simple meter that spins both forwards and backwards depending on the direction power is flowing at the time – either to the customer or back to the utility. When an agency's generation exceeds their usage at a particular site, the excess electricity flows back into the grid for use by other utility customers.

Any power system interconnected to the utility grid is accompanied by a utility tariff or agreement that determines the value of the electricity that the agency provides to the utility. Net metering typically means that any on-site power generation during a billing cycle offsets the electricity charges for that amount of electricity used by the site up to the agency's full electricity usage for that month. In other words, if the meter spins backwards and forwards, the amount left over at the end of the month determines the per kilowatt-hour change that the utility charges the agency, regardless of when the electricity was produced or used. If the agency produces more energy than it uses in a billing cycle, policies vary widely as to how that energy gets valued.

Net metering is extremely important to the economics of a renewable electricity system. It allows the utility to serve as a battery to store excess power generation so it can be used at another time for the same value. Without net metering, for example, an office building with a large photovoltaic system might not use its power over the weekend and would lose most of the value of that electricity. In such cases, renewable energy systems often need to be sized to allow all the energy to be used on site at all times. Renewable energy systems also vary seasonally. A PV system produces the most output during the summary and may line up with air conditioning loads, but a wind system may product its peak power output during winter nights. If a project does not have the ability to net meter with the utility, it dramatically limits the size and type of renewable electricity technologies that can be used.

The screening team needs to look at the provisions of the utility's net metering tariff and determine what types and sizes of renewable energy systems are allowed and economic. Most states require net metering, but these policies vary widely and do not always apply to all utilities within the state. In addition, many policies place limits on the type and size of systems that qualify. All of these issues are critical in determining which technologies should continue to be looked at for the project. Although uncommon, the screening team should pay particular attention to the ownership of renewable energy certificates (RECs) and ensure any utility agreement does not transfer REC ownership without a clear decision by the agency.

In the feasibility study, the team needs to look into the minute details of the net metering and other tariffs with the utility. In some cases, using net metering can preclude the use of other favorable tariffs. Especially because renewable resources vary, the actual renewable energy production versus load of the facility need to be analyzed to determine the likely offset energy savings. In addition, larger facilities typically have two separate components to the utility bill — an electricity charge per kilowatt-hour and a demand charge per kilowatt of peak load. Many renewable energy systems will not offset the latter costs. The details can be extremely important to the economics of these systems, and an expert in this type of analysis needs to review these numbers closely in the feasibility study phase.

Detailed information is available from the DSIRE website. The site also provides state-by-state details on net metering laws and regulations.

Time-of-Use Rates

Time-of-use rates refer to the practice of a utility charging a separate rate for electricity to the same customer based on when the electricity was used (i.e., day/night and seasonal rates). Typically, the production cost of electricity is highest during the daytime peak usage period and low during the night when usage is low. In many climates, time-of-use rates also charge more for summer usage than winter usage since electricity rates peak during times of high air conditioning use.

Time-of-use metering is a significant issue for renewable energy sources since some systems will offset energy at times of peak usage while others might produce more energy during times when it will be credited for less. For example, photovoltaic systems produce energy during the daylight hours and produce the most power during the middle of summer days. These production times largely coincide with the more expensive time-of-use rates for peak periods. Wind power, on the other hand, often produces power overnight and, in many climates, produces the most power in winter months. In this case, even if the price-per-kilowatt from the wind system is lower than the photovoltaic system when the time-of-use rates are considered, the value from the photovoltaic system may be greater. This rate structure varies by utility. Sometimes, time-of-use rates are mandatory while others they are optional or utilities do not offer them at all.

Although time-of-use rates are designed to follow closely the costs facing the utility, they can be used to advantage by certain renewable energy technologies. Photovoltaics are one example, but the economics of other technologies, such as daylighting and solar water heating, can be assisted by time-of-use rates. Other technologies may not fare as well, so the selection and impact of time-of-use rates might be reviewed in the renewable energy screening and assessed in detail in the renewable energy feasibility study. The agency should contact the facility's local utility for details on time-of-use rates and other tariff issues.

Feed-In Tariffs

A feed-in tariff is a state-legislated regulation that encourages new renewable energy development by creating a long-term financial incentive to customers who generate electricity with renewable technologies. This kind of tariff offers a standardized and streamlined process for renewable energy projects under which a utility is required to connect the renewable energy generator to the grid and pay that generator for electricity at a fixed rate for the life of the feed-in tariff contract (typically 10 to 20 years). The goal of a feed-in tariff is to create a robust market for renewable energy with a desired effect of lowering technology costs, increasing development, and potentially paving the way for future growth.

A feed-in tariff policy can be designed to encourage the involvement of different customer classes, generation technologies (e.g., solar, biomass, etc.), and capacity sizes, though they are typically aimed at bigger systems. Feed-in tariffs are a newer policy mechanism, and while a number of states are investigating their use, they are only in effect in a few states as of early 2011. If available, they should be investigated carefully, as the regulations can be complex and have other effects. The renewable energy screening team should investigate the availability of feed-in tariffs for the project and determine if they add any additional economic incentives over other tariff options, such as net metering. For example, Hawaii does not allow both net metering and feed-in tariffs to be applied at the same time, and the choice of tariff must be chosen permanently at the time of interconnection.

DSIRE has more information, state by state, on performance-based incentives such as feed-in tariffs.

The discussion of the various policies for renewable electricity technologies touches on a few of the contracting arrangements that are required with on-site power generation, many of which are new to Federal agencies. Contracting issues with renewable power provides an overview of various agreements that may be involved with a power generation facility integrated into a construction project.

Planning, Programming, and Budgeting

During the initial phases of Federal new construction and major renovation projects, agencies inevitably ask the same question: When in the process should I start considering renewable energy?

The short answer is that it is never too early. Early decisions on goals, siting, budgets, and the members of the project team can greatly affect the agency's ability to effectively integrate energy efficiency and renewable energy into the project. It is important to note that incorporating renewable energy technology is just one of many goals that a successful project must meet, and that compromises may be required to satisfy multiple, competing objectives.

This overview introduces the pre-project planning, programming, and budgeting phases of the project process and provides links to additional information for each phase.

Because each agency uses different terminology for the early stages of project development, this guide uses some general terms for these early activities. This section discusses planning, programming, and budgeting.

The earlier renewable energy is considered, the more cost-effective the opportunities. Source: Whole Building Design Guide and National Institute of Building Services.

- Planning involves the early scoping of a project when an agency is first considering building a new facility or undergoing major renovations on an existing one. This stage includes the community or master planning, site selection, and creation of a planning team, including identifying a project energy load. Planning also refers to the early feasibility and justification. This information is used to develop early budget assessments, preliminary scope, and implementation strategies.
- Programming is the research and decision-making process that defines the scope of work. This phase involves a planning charrette and outlines goals and objectives for the project. This phase results in the initial architectural building program and the project specifications that guide the selection of the design team and proposal.
- Budgeting covers the development and evolution of the project budget within the Federal budget formulation process. This phase is concurrent with the planning and programming phases as it informs and is informed by those activities. Budgeting for renewable energy sources includes economic justifications, incorporation of additional upfront costs, and the development of budget submissions for agency management, interagency review, and, in many cases, Congressional approval.

  The budgeting phase is often discussed using other terms. This phase includes activities like developing a prospectus (for civilian agencies) or a DD Form 1391 (for defense agencies), as well as other agency-specific terms.

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Planning

Energy use should be considered in the earliest stages of pre-project planning when both opportunities and constraints can be identified and evaluated with comparatively few restraints. Energy efficiency and renewable energy choices are integral to a number of other project parameters, such as overall space requirements, site selection, massing, building orientation, and various site planning and architectural considerations. The most cost-effective time to set the direction of a project is during planning. This is the time when tradeoff evaluations and alternative analysis can be performed before too many key project parameters have already been established.

Key Actions in Planning

- Conduct a preliminary review of renewable energy resources available at the site.
- Identify major restrictions to using on-site renewable electricity generation.
- Ensure the planning team includes wide set of disciplines/skills, including renewable energy expertise.
- Identify the agency project energy lead with specific renewable energy skills and experience.
- Identify budget for additional upfront costs associated with integrated design process.

Decisions made in this section also need to inform budgeting decisions.

Once a project's general location is known, the agency can begin to look at renewable energy options available to the project. A preliminary screening, or an early self-assessment, looks at the potential options appropriate to the site. Although this does not give detailed information, it is a first look at the types of renewable resources located near the project. This early knowledge can help the agency understand the impacts of site selection on renewable energy and can highlight which skills might be useful during planning.

Ideally, renewable energy should be considered at the master or community planning stage for an area. If a campus is planned or future expansions are part of a master plan, this could create opportunities for certain renewable energy options, such as central plants of larger-scale technology or district-wide applications. This can offer attractive economics and centralized renewable energy development.

Renewable energy potential should be a factor in site selection. Although other aspects of location may be more important, the renewable energy resources in each location and constraints on the site, such as shading for solar technologies or obstacles to a wind resource, can be valuable selection criteria.

When developing the planning team, the agency should ensure members are familiar with all potential renewable energy options for the site. The team should also include energy

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efficiency expertise, because efficiency should be integrated into a project before renewable energy. Experts in each technology may not be needed at this stage, but the team should include representatives that understand key issues so that renewable energy technologies are appropriately considered and as many options as possible remain available for the subsequent design phase.

More information on the key considerations in establishing the team is available in the planning team section.

First Look at Renewable Energy Options

Project planners should conduct a preliminary review of project energy needs and opportunities when considering renewable energy technologies. This makes energy an integral part of the project, begins the discussion about what renewable technologies may be available to the project. Planning is the time to assess the full project and think innovatively about ways renewable energy can be cost effectively and creatively applied.

Before evaluating renewable energy feasibility, Federal agencies should assess the proposed project and plans to determine at what scale energy technologies should be considered. This assessment should include:

- An evaluation of the scale of energy needs under consideration. For example, laboratories or hospitals have different energy needs than office space or a visitor's center. Although this is a very preliminary look, the scale of the project helps direct the review of renewable resources.
- A review of community or master planning efforts, as well as agency-wide plans for renewable energy, completed or underway. For example, it may not seem appropriate to install a large wind system to power a small office project, but it may save time or money to install the system now if a large campus is planned nearby under the 10-year master plan. That same large wind system may also help meet near-term agency-wide goals for renewable energy.

With a general idea of the type of project and scale of appropriate renewable energy technology, agency staff can easily be trained to conduct a preliminary renewable energy screening that uses resource maps and other basic tools to gain a preliminary look at technologies options for the site. This level of review is very quick, focusing on renewable resource availability and identifying restrictive policies that can affect renewable energy usage. A preliminary renewable energy screening can also rule out some types of technologies. It does not provide an economic assessment of the renewable energy technologies.

Information from the preliminary screening can be used to identify renewable energy skills necessary for the planning team. It can also narrow options moving into a full renewable energy screening. A full screening, conducted by renewable energy experts, provides better information about actual energy production potential at the site and the associated costs. A full screening is needed to inform the remaining planning and programming activities and will include preliminary cost information.

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Planning Team

Planning is the time to bring renewable energy expertise to the table, including a strong renewable energy planning team that will be part of the project though completion. It is important to have a team in place with the skills required to advocate for renewable energy and the agency's best interests throughout the project.

The planning team set the goals and objectives for the project as well as criteria for design team selection and should be convened at the outset of a project and bring together a range of stakeholders and disciplines. Ideally, the entire team should embrace energy efficiency and renewable energy usage. However, team members often have other priorities, and traditional agency stakeholders may lack enough knowledge about renewable energy issues to understand the implications of various early decisions.

Project Energy Lead

High-performance building owners have found that attaining aggressive energy goals requires an informed and active owner. Thus, an agency is far more likely to succeed at energy efficiency and renewable energy goals if an experienced lead is on hand focused on the energy aspects of the project.

The skills required for the project energy lead vary depending on the project scope and the renewable resources under consideration. Generally, this energy lead is an engineer independent of the design firm and renewable energy contractors. This person should function as the building owner's advocate on energy issues. Typically the Project Energy Lead should not be the Leadership in Energy and Environmental Design (LEED®) specialist for the project, but should work in close coordination with that person.

The project energy lead should possess the following (either alone or as a team):

- Extensive experience with renewable energy and energy efficiency technology implementation.
- Full understanding of Federal energy requirements.
- Familiarity with and expertise in all technologies under consideration.
- Experience with energy modeling, including incorporating renewable energy technologies into the models.
- In-depth knowledge of renewable energy policies and incentives, including interconnection and net metering regulations, tariffs, financing options, and available incentives affecting the project.

Once in place, the project energy lead is responsible for keeping the agency's renewable energy needs and goals on track as the project progresses. The energy lead is responsible for:

- Ensuring renewable energy screenings occur.
- Reviewing requests for proposals (RFPs).
- Reviewing designs.
- Representing the agency on both the design review team and the commissioning team.

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It is important that the project energy lead be an independent entity and has only the agency's interests at stake on the project. This ensures that the agency can make informed decisions about renewable energy throughout the evolution of the project. Until integrating renewable energy becomes a building industry standard, there may be situations where either a lack of knowledge, expertise, or commitment on the part of design team may lead to renewable energy being dropped from the project.

The energy lead should be able to review information from the design team to determine if pivotal decision points on renewable energy, such as availability and life-cycle cost effectiveness, are developed appropriately. The energy lead is also invaluable in ensuring proper specifications are included upfront and that winning bidders have sufficient energy efficiency and renewable energy expertise to meet design goals.

An integrated design process has some cost premiums in upfront planning. Adding renewable energy into the process, including a designated project energy lead and renewable energy screening costs, affects the initial planning and design budget. Allocating additional funds for renewable energy screening, planning, and staffing upfront is critical to ensure renewable energy is cost effective and well integrated into the overall project. Funds spent early in the planning process result in cost savings later through less expensive solutions to energy requirements, downsizing related equipment, and reducing long-term operational costs.

Identifying funds for adding specific renewable energy should be done during this phase of pre-project planning and repeated throughout the project as needs.

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Programming

Renewable energy is a key consideration during project programming. As more information about the actual function and needs of the facility becomes available, further decisions can be made about the most appropriate types of renewable energy technologies for the project.

Key Actions in Programming

- Commission a renewable energy screening to assess the options and economics of various technologies.
- Conduct a planning charrette to bring disciplines together to identify project needs and energy opportunities.
- Define and prioritize specific energy-related goals and include them in the building program and requirements for the design team.

The end of this phase results in the creation of the building program, which sets the goals and criteria for the design team. If the desired energy efficiency and renewable energy requirements are clearly included in the program, all the professional disciplines involved in the design process can collaborate to achieve them at minimal cost and disruption. Conversely, decisions made during this phase that do not consider renewable energy goals can prevent potentially cost-effective options from being incorporated into the project.

Programming is the opportune time to gather detailed information on how to determine the viability and value of various renewable energy technologies. This information is extremely valuable in setting energy performance goals for the building and understanding what types of technologies are likely to be incorporated in the project.

Programming also provides detailed information needed to incorporate renewable energy into early budget requests. To do this, a renewable energy screening is recommended. During programming, screening-level data on renewable energy options is used to identify opportunities and narrow the suite of possible technologies. The agency needs to understand the availability and economics of various renewable energy options to inform decisions on energy goals and design requirements. For more information on this step, see the screening section.

As the planning team establishes goals and design objectives for the project, renewable energy should be a clear focus throughout the discussion. With more details available on renewable energy options, it is important to think beyond conventional goals for a project and to develop clear objectives for energy reduction and renewable energy use, including but not limited to those needed to meet Federal energy requirements.

A planning charrette, with a renewable energy component, is recommended at this stage to assemble the planning team to define the criteria to be included in the program. The program should include specific renewable energy criteria for the project, but it is a best practice to define

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energy requirements as targets without specifying specific technologies. This will give the design team more flexibility in choosing the best mix of technologies to meet those requirements.

Energy objectives should be clearly stated and prioritized at this stage so that later design trade-offs do not compromise the economic use of renewable energy technologies. See the establishing design requirement for energy section for more information on how to conduct a planning charrette and formulate renewable energy criteria.

Establishing Design Requirements for Energy

Programming defines details about the project, including square footage, types of building space, and use. The team should make decisions to define the energy needs of the building. Beyond traditional project goals and criteria, the team should also define energy-specific requirements and provisions for integrating renewable energy into the building.

Federal energy requirements should be considered during programming to establish design criteria that meet those requirements. Overall, the programming phase is the time to establish design requirements and criteria that make sure building design meets the agency's energy efficiency and renewable energy use needs. It is also the time to establish selection criteria for architecture and engineering (A&E) procurement and to prioritize energy goals within the program so that renewable energy is prioritized during value engineering.

Planning Charrette

It is a best practice to conduct an early planning charrette for the entire project, informed by the renewable energy screening results and including a specific renewable energy breakout session. The planning charrette should be done during the development of the building program and prior to hiring a design firm.

The planning charrette brings all the disciplines from the planning team, including the project energy lead, together. The result is a well-rounded discussion and evaluation of design requirements and criteria, a more detailed budget, justification for the project, and details to generate specifications for use in procuring design services. It is important that any design consultants brought into the planning stage, even just for early conceptual purposes, have demonstrated renewable energy expertise.

Another best practice is to have renewable energy experts meet separately for an hour or two as a breakout of the planning charrette. Together, renewable energy experts in various disciplines can identify specific elements and criteria for the program that will keep various renewable energy options open. These elements include determining energy-related design requirements; looking at energy use, load reduction, and energy efficiency opportunities; and evaluating technology options and synergies.

To meet energy goals economically, the planning team needs to understand that energy use should drive the structure and form of the building. If this is not accepted, most types of renewable energy will be limited or unavailable. Many building forms can reach the same functional requirements for space usage, but very few forms can maximize the access to renewable energy resources dictated by the orientation and restrictions of nature. Timing is critical for many passive renewable energy technologies, such as daylighting and solar heating, which become impractical if they are not considered before preliminary design.

Building Program

After the planning charrette, design requirements should be added to the program. Energy goals need to be included and given sufficient priority within the program. Examples of energy-related provisions in the architectural program include requirements like:

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- Energy use should be at least 40% below the baseline of energy use for a building built to meet applicable codes.
- Renewable energy usage must account for at least 50% of building energy use.
- Buildings should be designed to meet solar-ready requirements for both photovoltaics and solar thermal systems, regardless of technologies incorporated.
- Rooftops should be kept clear to allow placement of renewable energy technologies.

Additional examples include the following from the Guiding Principles for Federal Leadership In High Performance and Sustainable Buildings:

- **New Construction:** Reduce the energy cost budget by 30% compared to the baseline building performance rating per the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) and the Illuminating Engineering Society of North America (IESNA) Standard 90.1-2010, Energy Standard for Buildings Except Low-Rise Residential.

- **Major Renovations:** Reduce the energy cost budget by 20% below pre-renovations 2003 baseline.

Including specific, prioritized energy requirements in the program creates important guidance for the design team. These provisions add weight to the renewable energy goals and create a clear guidepost to return to repeatedly during scoping changes and design modifications, such as, budget pressures or design decisions might otherwise jeopardize energy goals.

The project energy lead should track the evolution of changes in the project, evaluating how changes affect the needs and design requirements established, and advocating for renewable energy priorities. If the energy provisions are not included and prioritized in the program, other design priorities can easily overtake the energy goals during the trade-offs in the design process.

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Budgeting

Budgeting is done in parallel with planning and programming. Often, the planning stage produces an early economic evaluation of the project that is used in developing either a prospectus or a DD Form 1391. Prospectus and DD Form 1391 are common terms used by civilian and defense agencies, respectively, within the budgeting process.

Key Actions in Budgeting

Include renewable energy specific information into budget request, including:

- Additional planning/design costs.
- Estimated costs for renewable energy technologies.
- Revised project boundary definition (if needed) to enable systems outside the building envelope.
- Conduct early life-cycle cost analysis for renewable energy technologies prior to initial budget request.
- Review and include likely renewable energy project funding options in budget request.
- Decide on need for renewable energy installation phasing.
- Periodically update budget as renewable energy decisions are resolved.

Renewable energy considerations need to be included in the earliest budget planning and development. Many renewable energy technologies have distinct capital costs. This does not mean that renewable energy costs more than typical energy sources, but rather that the costs may be borne upfront and repaid through lower operating costs over the life of the project.

The prospectus or DD1391 establishes the economic feasibility of the project and documents that it is financially beneficial to the agency. The prospectus should include the cost of the measures likely to be included, but more importantly, it should state the savings and added value of those measures. If the earliest budget requests can include realistic placeholders for the renewable energy costs in the project, the process of securing capital for those systems is more efficient.

- Estimating Renewable Energy Costs
- Life-Cycle Cost Analysis
- Renewable Energy Budgeting Strategies
- Project Boundary Definition

Estimating Renewable Energy Costs

When adding renewable energy to either of these processes, the increased costs of upfront planning, programming, and integrated design need to be included. Costs for renewable energy technologies themselves also need to be estimated in the budgeting process. Some renewable energy technologies, such as passive solar, may not add to design costs when considered early in the process. Others, such as photovoltaics, are capital intensive, and may increase costs as much as 10% to 15%. This guide includes more information on the costs associated with integrating renewable energy into a project, including links to specific cost estimates.

Life-Cycle Cost Analysis

The prospectus should describe the business case for optimizing renewable energy in the project, especially since the long-term savings on operational costs will likely accrue to a completely different account than the initial capital expenditures. Both life-cycle cost analysis and a discussion of additional benefits should be included with all of the budget documents.

With cost and savings estimates for renewable energy from screening and the section above, agencies can conduct an early life-cycle cost analysis to provide further justification for the inclusion of renewable energy. If life-cycle cost analysis does not occur until schematic design, then costs for renewable energy may not be justified in the early budget and the agency may later have to force fit renewable energy into established capital budget requests.

Additional information on life-cycle cost analysis is available, including details and tools for conducting life-cycle cost analysis for integrating renewable energy into construction projects.

Note that an agency should not use this preliminary analysis to eliminate renewable technologies from consideration, but rather to provide a better idea of the type and magnitude of technologies that could be available. If life-cycle cost analysis is not favorable for certain technologies, the agency may want to examine additional budgeting strategies for renewable energy or need for meeting Federal renewable energy requirements.

Renewable Energy Budgeting Strategies

If tight budgets are affecting renewable energy adoption, other budgeting strategies could be investigated. These strategies need to be addressed upfront in budget submissions because they affect the overall project. These strategies need to be coordinated with the building program.

One such option is renewable energy project funding, which includes energy savings performance contracts (ESPCs), power purchase agreements (PPAs), or utility energy service contracts (UESCs). These funding mechanisms each have advantages, such as enabling the Federal agency to take advantage of financial incentives not available to government agencies. Each also has limitations and restrictions. The renewable energy project funding page has detailed information.

An additional budget strategy could be to phase the installation of renewable energy development to meet future goals while working within existing budgets. Often referred to as making a building renewable energy ready, this could involve incorporating the future renewable energy projects fully into the building design, but postponing the actual purchase and installation of the equipment. This strategy has advantages and limitations, but phasing renewable energy should not be viewed as option to postpone the integration of renewable energy into the building design. Many economic opportunities are lost if certain elements are not incorporated into the initial building design. The phasing renewable energy implementation page provides additional information.

Project Boundary Definition

Renewable energy technologies might extend geographically beyond the traditional building envelope. For example, a wind turbine on the property, a photovoltaic system on the adjacent parking structure, or a silo for biomass storage might be integral parts of the project's energy system but not located within the boundary typically allowed for authorized use of funding. Because some agency budgets are constrained by a boundary just outside the building envelope it is important to include boundary definitions to accommodate renewable energy in early budget submissions so that authority is part of the project from the beginning.

Estimating Renewable Energy Costs

Some renewable energy measures, such as daylighting, passive solar heating, and cooling load avoidance, do not add much to the cost of a building. However, renewable energy technologies typically require large, additional capital investments with savings accruing over the project's life. It is crucial that these systems are considered early on in the budgeting process.

Early budget requests need to include a set of technologies that could be used to meet the project's design requirements and their associated implementation costs. The design team may respond with a different set of feasible technologies, but it is wise to have an existing placeholder in the budget. Federal agencies can continue to update the budget as decisions are made on the optimal set of renewable energy technologies for the specific project.

This section enables Federal agencies to provide early estimated costs for a specific combination of renewable energy technologies within a project.

- Planning/Design Costs
- Renewable Energy Technology Costs
- Renewable Energy Cost Matrix
- Additional Technology Information

Planning/Design Costs

Leadership in Energy and Environmental Design (LEED®) accredited professionals recommend allocating approximately an additional 3% of the overall planning and design budget for green construction. It is necessary to include an additional premium when integrating renewable energy into a project.

Assuming that renewable energy is being integrated into a sustainable building that already uses an integrated design process, the LEED 3% number incorporates some of the additional required budget needed. Federal agencies likely need to plan for an additional increase of 1.5% (or around 4.5% total) of a traditional planning and design budget for integrated design that includes significant renewable energy use. This is, of course, a rough estimate that can be used for initial budgeting purposes.

Assuming that renewable energy is being integrated into a sustainable building that already uses an integrated design process, the LEED 3% number incorporates some of the additional required budget needed. Federal agencies likely need to plan for an additional increase of 1.5% (or around 4.5% total) of a traditional planning and design budget for integrated design that includes significant renewable energy use. This is, of course, a rough estimate that can be used for initial budgeting purposes.

Renewable Energy Technology Costs

Federal agencies must consider four factors when estimating the cost of integrated renewable energy technologies:

- Initial installation costs
- Operations and maintenance (O&M) costs

- Replacement costs for system components
- Useful life of the system.

Renewable energy is capital intensive taking into account initial costs for equipment and labor. This is a trade-off since renewable energy technologies, with the exception of biomass, do not require fuel and have no associated fuel costs. O&M costs are ongoing throughout the lifetime of the project. Renewable energy technologies may require replacement of certain components over the useful life of the system. On a wind turbine, for example, gearboxes and bearings will need to be refurbished or replaced periodically to ensure that the system runs at maximum capacity for its entire useful life.

Renewable Energy Cost Matrix

Costs and useful life vary by renewable technology. FEMP and the National Renewable Energy Laboratory (NREL) aggregated a range of actual technology system costs into a renewable energy cost matrix to provide real-world estimates for use in planning and budgeting. Current technologies covered in the matrix are photovoltaics, solar hot water, solar ventilated preheat, wind, and biomass technologies. Some of these technologies, such as wind and biomass, are more commonly applied in utility scale applications, so these costs may be slightly lower than a Federal agency may be able to attain.

Additional Technology Information

To assist Federal agencies in estimating early technology costs, FEMP provided available cost information for two additional technologies, geothermal heat pumps and daylighting with skylights that are not currently available in the FEMP cost matrix.

Geothermal Heat Pumps

It is common for the geothermal heat pump industry to refer to costs for the ground source portion of the system on a per ton basis. The table below, although focused on residential-scale

Cost by GHP System Type		
Tons	Total Systems	Heat Pump Only
2	$12,285	$8,400
2.5	$13,483	$7,922
3	$13,719	$9,465
3.5	$13,297	$9,959
4	$13,969	$9,765
5	$16,865	$11,188
Total	$14,278	$9,990

systems, tracks the actual cost of installed geothermal heat pump systems in a 2008 review of the Indiana Residential Geothermal Heat Pump Rebate program.

According to a 2007 report to Congress on the ground-source heat pumps at Department of Defense facilities , O&M costs of geothermal heat pumps at defense facilities was estimated at $7.67 per ton per year. The life-cycle for the heat-pump portion of the system is similar to other heat pumps, but the below ground portion is designed to last 50 years.

Daylighting

Daylighting is the practice of using natural light to illuminate building spaces. Skylights are one effective method used to provide daylighting. They admit more light per unit area than windows and distribute it more evenly over a space.

The table below provides data from the 2008 DOE report entitled Commercial Building Toplighting: Energy Saving Potential and Potential Paths Forward. It provides costs associated with using skylights per square foot of space.

Skylights in conditioned space refers to those used in a typical office space or equivalent usage. An example of skylights in unconditioned space would be a warehouse where part of the steel roofing was replaced with a translucent material to allow daylight into the space.

Skylight cost (conditioned space)	$5.40	$/ft2 floor area
Skylight cost (unconditional space)	$1.50	$/ft2 floor area
Controls Cost (all space)	$0.40	$/ft2 floor area

Life-Cycle Cost Analysis

Life-cycle cost analysis is the process of calculating whether a particular investment, in this case a renewable energy investment, will generate a positive return on investment (ROI) over the life of the technology. It is only as accurate as the estimates and assumptions used in the analysis, but is a useful tool that helps Federal agencies justify whether an investment in renewable energy is appropriate for a project. In fact, many Federal renewable energy requirements are tied to life-cycle cost effectiveness for the specific technology.

Life-cycle cost analysis should be viewed as an ongoing process that starts early in a project and is revisited through all phases of a construction process. To account for the additional up-front costs of renewable energy, life-cycle cost analysis needs to be launched during the early planning phases, ahead of preliminary budget plans, to keep the economic justifications and planning goals consistent with each other. If an agency waits for a hired design team to conduct the first look at economic feasibility of renewable energy, many opportunities may already be lost.

The renewable energy technologies included within the initial budget request need to be consistent with the energy goals and design objectives established during project programming. This gives more justification for the system and establishes a placeholder for the essential size of the renewable energy systems. The specific renewable energy technologies making up the system may change throughout the process, but the magnitude of the request should be consistent with what is required of the architectural and engineering (A&E) team.

It is important not to reject technologies based on early life-cycle cost analysis, but rather use the analysis to inform the ongoing process. Details of resource availability, design, and magnitude of energy savings cannot be fully determined until detailed analysis is conducted in later stages of design.

Life-cycle costs effectiveness should be reassessed throughout the various stages of design. The project energy lead serves as the agency's check in the life-cycle cost analysis system after the initial assessments. The design team takes these assessments into account once they have determined their optimum set of renewable energy technologies, which occurs during schematic design. The project energy lead must ensure the design team is using proper inputs and receiving accurate results. The architectural components and primary energy systems are selected within the design development phase. Some architectural and engineering firms might inadvertently leave these systems out if they do not have the proper experience with the technologies. As such, the agency is well served to have its own expertise to review architectural and engineering assumptions.

Standards for Analysis

Through life-cycle cost analysis, agencies estimate how the up-front cost of the equipment is spread through the life of the equipment. The National Institute of Standards and Technologies (NIST) provides economic parameters for making these assumptions, such as discount rates (time value of money for the Federal government), fuel escalation rates, and general inflation rates to apply to O&M. Agencies still need to understand the specific regulations and tariffs that affect their project, which may override information from NIST.

The Energy Independence and Security Act (EISA) of 2007 changed the life-cycle cost methodology for Federal buildings from 25 years to 40 years, which expands the number of potential cost-effective measures. Extending the useful life of renewable energy systems to

40 years requires proper operations and maintenance (O&M) as well as certain equipment replacements. This is feasible for photovoltaics (PV), wind, ground-source heat pumps, and building integrated technologies like daylighting, passive solar heating, and solar ventilated preheat.

The accepted life-cycle of a solar hot water heater is about 15 years, which is about the same life span as a conventional electric hot water heater. Solar hot water systems that are designed to supply 70% to 80% of the load will reduce cost and will often be life-cycle cost effective.

The Building Life-Cycle Cost (BLCC) software uses the NIST standards to help calculate life-cycle costs, net savings, savings-to-investment ratio (SIR), internal rate of return, and payback period for Federal energy and water conservation projects funded by agencies or through other renewable energy project funding. BLCC also estimates emissions and emission reductions. An energy escalation rate calculator (EERC) computes an average escalation rate when payments are based on energy cost savings.

The economic benefits of renewable energy systems also need to be quantified in the life-cycle cost analysis, including cost savings associated with offset energy use. This analysis is dependent on both a valid estimate of energy production from the system and care should be taken not to use baseline energy tariff numbers, but rather determine the full value of the energy that will be offset by the system. Additional revenue streams, such as renewable energy certificates (RECs), can improve economics. In some cases, an agency may want to sell the RECs from their project, and replace or arbitrage them with less expensive RECs from other renewable energy sources to improve system economics. Other incentives, such as available state or utility rebates or grants, also improve the economic picture.

Additional benefits of renewable energy systems might be factored into the analysis if justified. For some technologies, related non-renewable energy systems may be able to be downsized. Beyond reduced utility payments, renewable energy projects can also provide an opportunity for enhanced green marketing. For example, buildings rated by the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED®) certification process can achieve $11.24 per square foot more in rent than comparable non-LEED buildings and have 3.8% higher occupancy, and sell for $171 per square-foot more than typical properties. Rental rates in ENERGY STAR certified buildings can achieve a $2.38 per square foot premium over comparable non-ENERGY STAR buildings and have 3.6% higher occupancy.

Constructed Costs of a Net-Zero Office Building Facility

Research Support Facility at the National Renewable Energy Laboratory in Golden, Colorado

Operational: August 2010

Constructed cost: $259/ft2 to achieve 50% less energy use than code

Constructed cost of similar office buildings in area: $225 to $300/ft2

Reaching Net-Zero: A 1.27 MW photovoltaic system was added to the project in two phases to bring the system to net-zero. This system was financed through a power purchase agreement and did not add to the constructed cost of the building. If those costs were included in the capital costs, the total constructed cost would have been 291/ft2 to reach net-zero energy use.

Phasing Renewable Energy Implementation

If conventional or other renewable energy funding cannot be procured, or if an agency is working towards a higher goal for renewable energy usage that cannot be met with the current budget, agencies may choose to phase renewable energy into their project. This lays the groundwork and infrastructure now so that some or all of the renewable energy can easily be installed at a later date.

A guide to phasing the development of renewable energy is the Solar Ready Buildings Planning Guide, developed by the National Renewable Energy Laboratory (NREL). The renewable energy project funding page has more information on applicable methods for financing the renewable energy system outside of the traditional budget request for appropriated funds.

Phasing renewable energy projects can be a way for agencies to access renewable energy later, but more economically than trying to add a system to an existing building. However, phasing may mean that the agency is not meeting Federal energy requirements, so budget and requirements need to be balanced. Phasing can be especially useful in cases where a Federal agency wants to exceed current requirements, but cannot reach those goals under existing budgets.

It is vital that renewable energy be assessed and the most viable options be integrated into the larger building design. For projects where it can work well, it is critical for agencies to think through the technologies and needs, particularly concerning the building envelope.

Phasing renewable energy does not mean simply sticking a renewable energy system onto an existing project at a later date. It is a holistic approach that anticipates the future use of renewable energy and integrates certain required elements into the building design that are most efficient to incorporate during the larger construction project. For example, design elements could include specifying the roof structure to hold the load of a photovoltaic system, laying conduit or piping for a future system, or installing sufficient pumping system for a future solar hot water system. All require examining the current design with a vision toward future use.

Certain technologies, such as passive solar heating or daylighting, cannot be separated from the initial design of the building, so phasing is not a good option for these technologies. However, almost any technology can be rendered unavailable to the building if the technology is not assessed and integrated at every stage of the design.

Phasing is not recommended for every project and some opportunities can be lost due to future funding that does not materialize, changes in rates that make projects unpractical, or compliance changes. However, phasing can also prepare a building to take advantage of future markets where energy prices may be volatile and renewable technology costs are much lower. Conventional energy costs rise and fall, but renewable energy resources are relatively constant and predictable, and their costs will continue to decline.

In general, even when other technologies are being used in a project, a best practice is to ensure that the building is designed to accommodate future technology use when a good renewable resource has been identified but not leveraged in the project.

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Renewable Energy Project Funding

Federal energy projects require funding to generate results. Agencies trying to stretch their capital budget for a construction project should investigate renewable energy project funding options outside the traditional appropriated budget process. Carefully matching available funding tools with specific project needs can make the difference between a stalled, unfunded renewable energy project and a successful project that generates energy and cost savings.

Federal agencies may be able to use tools to finance renewable energy facilities outside the capital budget appropriations process or to improve project economics, including:

- Energy Savings Performance Contracts
- On-Site Renewable Power Purchase Agreements
- Utility Energy Services Contracts and Incentive Programs
- Renewable Energy Certificates

Beyond funding mechanisms, many contractual arrangements for renewable power projects are new to Federal agencies. Contracting issues with renewable power provides an overview of various agreements that may be involved with a power generation facility integrated into a construction project.

Energy Savings Performance Contracts

A Federal energy savings performance contract (ESPC) is an agreement between a Federal agency and an energy service company (ESCO) where the service company designs, purchases, and installs energy conservation measures at Federal facilities. The ESCO guarantees savings to the agency, and the agency makes payments to the ESCO based on savings from the energy measures. Payments cannot exceed the savings that the agency realizes from the implemented energy measures.

ESPCs can be designed solely for renewable energy projects or can combine renewable energy with energy efficiency measures to increase the savings-to-investment ratio.

One great advantage of a Federal ESPC contract is that it can have a term of up to 25 years. This is a valuable feature given the often high capital cost of renewable energy, allowing ample time for payments from savings to cover the expenses of financing and maintaining the renewable energy system. This is an advantage of ESPCs over on-site renewable power purchase agreements for civilian agencies.

ESPCs are typically only used for improvements to existing buildings, so these are best used for major renovations. ESPCs can sometimes be used for new construction projects, but the Federal authority required for eligibility is complicated.

Specific information on using an ESPC to integrate renewable energy in Federal construction projects is available on the energy savings performance contract page.

On-Site Renewable Power Purchase Agreements

An on-site renewable power purchase agreement (PPA) is an agreement where a renewable energy system is sited and installed at an agency facility but is owned by a private company, such as a renewable energy developer. The agency agrees to purchase the power generated by the renewable energy system, and the developer is responsible for project equipment purchase, design, installation, output, and maintenance.

PPA projects are often more cost-effective than agency-owned projects when the developer may be able to take advantage of tax credits and other incentives not available to the Federal agency. PPAs are an ideal approach to obtaining renewable energy because the agency pays only for energy generated from the renewable energy system; if the system fails because of problems caused by design flaws, equipment failure, inadequate maintenance, or other problems the agency pays nothing. This removes almost all of the technology risk involved with installing a renewable energy project. The various contracting authorities used for PPAs do not require guaranteed cost savings, as the ESPC authority does, and PPAs are not limited to existing buildings and can be used for new construction.

If an agency uses a PPA to integrate renewable energy into larger building construction projects, specific language needs to be added to the agreement that specifies coordination with the larger project. It is imperative that the renewable energy system design and installation are coordinated and compatible with the overall project.

PPAs for renewable energy are not suitable for all Federal renewable energy projects. A number of concerns need to be addressed that affect Federal agencies, including designation of the ownership of the renewable energy certificates, limitations on length of Federal PPAs, restrictions on private ownership of key equipment on certain military properties, uncertain state and utility policies regarding sale of on-site energy by a third-party, and limited existing experience with PPAs in the Federal sector. Some issues are specific to using a PPA to integrate renewable energy into Federal construction projects. The primary issue with integration is ensuring the close coordination of the design and installation of the renewable energy system with the overall project. Other issues relate to having contractors responsible for management of the Federal facility operations and to the coordination of multiple on-site renewable energy systems in one construction project.

Although PPAs are typically used for electricity generating projects, thermal renewable energy from on-site projects can be purchased through very similar contracts that don't involve the utility issues involved in electricity projects.

More information is available on the PPA page.

Utility Energy Service Contracts and Incentive Programs

Agencies can use utility incentive programs for financing renewable energy projects. These programs can range from rebate programs to full project implementation programs that include financing, project management, and performance assurance—called utility energy service contracts (UESCs). UESCs are one mechanism that an agency and its utility can use for renewable energy projects.

A UESC does not have the same contracting requirements as an ESPC, so UESC authority can be used to finance renewables in new Federal construction as well as in major renovations to existing facilities. It also offers some flexibility in performance assurance. In a UESC, as in an ESPC, the agency pays for the project through avoided cost-savings from energy efficiency improvements or renewable energy generation.

This type of contract depends on the local utility, is not available from all utilities, and is not available to all projects or Federal facilities.

Specific information on using a UESC to integrate renewable energy in Federal construction projects is available on the utility energy service contracts page.

Renewable Energy Certificates

Two separate products exist from electricity produced by renewable energy projects that can be sold together or treated separately. The first product is the electricity, or the actual electrons transferred through the power grid sold on a per kilowatt hour basis. The second product, referred to as the renewable energy certificates (RECs), bundles the environmental benefits of renewable energy, such as reduced emissions, and can be sold or used to meet renewable requirements. These are typically sold on a per megawatt hour basis.

Agencies can purchase RECs to meet renewable energy requirements or they can keep RECs associated with on-site renewable energy project. Since RECs vary in value depending on their location and renewable energy type, agencies can sometimes trade or swap RECs to gain additional revenue for an on-site project. More information on using RECs to meet Federal requirements and trading or swapping RECs is available on the renewable energy certificates.

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Energy Savings Performance Contracts

An energy savings performance contract (ESPC) is a partnership between a Federal agency and an energy service company (ESCO) that enables the agency to achieve energy savings projects with no up-front capital cost and without special appropriations from Congress. Agencies use ESPCs because they deliver guaranteed improvements, savings, and performance. In a Federal construction project, an agency might be able to use an ESPC to fund a particular renewable energy system, or more broadly, to incorporate a range of energy measures.

This page provides targeted guidance for agencies investigating the possibility of using an ESPC to integrate renewable energy into a Federal construction project. Because both renewable energy and new construction are less common for ESPCs, this section discusses three key topics:

- Identifying a Renewable Energy Provider
- Determining Ownership of the Equipment
- Overcoming Restrictions on use for New Construction

General information and FEMP assistance is also available.

Identifying a Renewable Energy Provider

DOE selected 16 ESCOs through a competitive process to implement an indefinite delivery, indefinite quantity (IDIQ) energy savings performance contract. This process streamlines the implementation of an ESPC with one of these providers. However, a site-specific approach may provide more options if an agency is looking specifically at renewable energy as these selections were made based on a wide range of energy conservation measures.

A site-specific approach broadens the field of qualified bidders so that both firms with specialized capabilities and pricing in that particular renewable technology can be brought into consideration. Although one of the 16 pre-qualified providers may also be competitive on a renewable energy system, having access to a wider range of bidders may enable an agency to implement a renewable project at lower cost and with more specific technology expertise.

Determining Ownership of the Equipment

Meeting agency energy goals on a construction project is likely not tied to the ownership of the renewable energy system, but rather the ability to take credit for the renewable energy generated by a system – preferably from one located on the Federal site where the energy is used so the agency can claim the renewable energy goal bonus for a project on Federal land.

The ownership of the renewable energy assets can have a significant impact on the overall economics of the renewable energy systems as certain tax benefits and other financial incentives can be realized by commercial entities but not by Federal entities. Incentives for renewable technologies vary widely from state to state, utility to utility, and even by local area. However, as with tax benefits, the types of owner entities eligible for these benefits are often limited to commercial, industrial, and residential owners. Federal agencies often do not qualify as they do not pay taxes.

Ownership of renewable energy assets by the ESCO can give the agency effective access to these tax benefits and incentives by passing along a lower energy cost to the agency. The ownership treatment of the renewable energy system should be structured to meet the goals of the agency in the most cost-effective manner. If the agency plans for ownership to remain with the ESCO for tax incentive or other financial purposes, the parties should consult a tax attorney to ensure that contract provisions do not limit those incentives.

Ownership of the equipment is a separate issue from ownership of the renewable energy from the system, which can also be important in financing a project and determining its value to the agency. An agency may decide to let the developer own the renewable energy certificates (RECs) from a project if they have a high value at that location in order to reduce the costs of the project. The agency can then work with the developer or pursue a completely separate transaction to acquire low-cost replacement RECs so that it can still claim the bonus for a project on Federal land to satisfy the Federal renewable energy goal, adjust the agency's Scope 2 greenhouse gas (GHG) emissions, and ensure that the project doesn't slow progress toward energy intensity reduction goals. If the agency does not own the RECs from a project or arrange to replace them any energy it receives from the project is not considered renewable and has to be treated as conventional electricity when calculating GHG emissions and energy intensity.

Overcoming Restrictions Use for New Construction

ESPCs have traditionally been used for building retrofits or major renovations and not for energy efficiency or renewable energy in new construction. ESPCs are ideally suited for building retrofits because of the relative ease of creating a baseline of energy usage prior to the installation of efficiency measures.

Experience with using ESPCs to integrate energy efficiency and renewable energy into new Federal construction projects in much more limited. The original statute authorizing ESPCs was not designed with new construction in mind. However, there have been pilot projects utilizing ESPCs for new construction. The General Services Administration (GSA) has pioneered some work in this area with the Evo A. Deconcini U.S. Courthouse and Federal Building in Tucson, Arizona, and again with the FDA White Oaks CampusPDF in Silver Spring, Maryland.

One approach to using ESPCs in new construction is to create a baseline of the building's energy usage using computer building energy models before it is built. This should already be standard modeling that occurs in the integrated design of an energy-efficient building. The modeling can then tailor a scenario that specifically excludes the energy technologies planned for the ESPC. This gives a baseline of energy use and costs for the project without the ESPC measures and represents the existing building. Additional new simulations can then be run with the proposed equipment to determine life-cycle cost effectiveness of the renewable energy and other energy systems.

Another approach is to design the building as renewable energy ready and phase the installation of certain renewable energy systems just after the construction of the building. Planning for the ESPC can be done in parallel with the new construction, but the set of renewable energy and energy efficiency measures planned for inclusion in the ESPC are paid for separately from the original construction.

On-Site Renewable Power Purchase Agreements

An on-site renewable power purchase agreement (PPA) enables Federal agencies to fund a renewable energy project by contracting to purchase the power generated by the system. The renewable energy equipment is installed and owned by a developer but located on-site at the agency facility.

As noted in the renewable energy project funding overview, PPAs provide a range of attractive benefits to Federal agencies trying to access renewable energy. These include no up-front capital costs; the ability to monetize tax incentives; typically a known, long-term energy price; no operations and maintenance (O&M) responsibilities; and minimal risk to the agency. These benefits have all led PPAs to become a major funding vehicle for renewable energy in the U.S.

A number of concerns need to be addressed that affect Federal agencies, including designation of the ownership of the renewable energy certificates (RECs); limitations on length of Federal PPAs; restrictions on private ownership of key equipment on certain military properties; uncertain state and utility policies on third-party ownership of electricity systems; and limited existing experience with PPAs in the Federal sector.

FEMP provides a wide range of information on these issues and the use of PPAs by Federal agencies. This section only discusses a few detailed issues associated with a Federal agency using a PPA for integrating renewable energy into a larger construction project. The primary issue is the coordination of the PPA developer's activities with those of the project design team and contractors. Additional issues can arise in specific instances of having multiple renewable energy systems or transferring site operations to a management and operations (M&O) contractor.

- Coordination of Separate Contracts
- Management and Operations Contractor
- Coordination of Multiple Renewable Electricity Systems

Coordination of Separate Contracts

The developer in a PPA often provides the renewable energy system as a design-build project. Provisions must be included in the agreement like any design-build renewable energy subcontract, requiring participation in the integrated design process and coordination of designs and construction with prime contractors. The project energy lead needs to review the renewable energy system design to ensure elements do not affect other energy issues with the building.

As an example, a Federal laboratory used a PPA to install photovoltaics in conjunction with the construction of a highly energy-efficient building. The renewable energy developer planned to use their standardized design to mount the system to the sloped roof, but the design would have penetrated the additional insulation and thermal barrier of the roof. Both the laboratory and the developer modified their design to resolve the issue. Without coordination, this could have affected the energy performance of the building.

In a construction project, a related concern is that the PPA needs to specify the boundaries of the covered renewable energy system – both for ownership purposes and design responsibility. Details delineating the design and ownership responsibilities need to be very specific, including details as

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specific as the exact location at which ownership of the electric wiring transfers from the renewable energy developer to the agency.

Management and Operations Contractor

If the agency plans to turn the responsibility for facility operations over to an M&O contractor, the agency may not even receive appropriations for power purchases and might be unable to enter into a PPA. If the M&O contractor is the listed utility customer and is responsible for utility payments, it may be necessary or easier for the contractor rather than the agency to enter into the PPA. This is not necessary (or even possible) with all M&O contracts, but the contractor's buy-in is essential if this affects a construction project, so early coordination with the contractor is prudent. If it is then determined that a PPA will be advantageous to the contractor, the details of the contracting can be established.

The challenge for this type of arrangement is usually the term of the M&O contract. The contract will usually be re-competed within 10 years and the contractor cannot sign a longer-term PPA. For the contract to remain in effect beyond the current term, the contract needs to be re-signed for the subsequent M&O contracting period. This is expected in most cases, but it may not be sufficient assurance for the developer or its financiers.

A few approaches have been proposed to resolve this challenge. The developer may be willing to enter a shorter-term PPA, taking the risk that any successor contractor will find the price of power under a successor PPA more attractive than the alternative price of power from the utility. This could be a reasonable risk given historical energy price trends, but the developer will likely want a higher energy price during the shorter contract. The agency could grant the developer a favorable, long-term lease or easement for the system so the right to keep the renewable energy system at the site is clear. This gives the developer access to the successor M&O contractor as a customer for a successor PPA.

Coordination of Multiple Renewable Electricity Systems

In cases where a Federal agency is incorporating multiple renewable electricity technologies into one site, there can be difficulties with coordinating design and accounting for electricity if the ownership is different for the separate systems. Each system must be metered separately.

The various systems need to be designed in a coordinated manner to ensure that they do not negatively affect each other and that interconnection and net metering provisions are still available. The project energy lead should be working with all entities and the utility to identify and resolve any design, utility, or accounting issues.

Guide to Integrating Renewable Energy in Federal Construction

Utility Energy Service Contracts

Utility energy service contracts (UESCs) offer Federal agencies an effective means to implement energy efficiency, renewable energy, and water efficiency projects. In a UESC, a utility arranges funding to cover the capital costs of the project, which are repaid over the contract term from cost savings generated by the energy efficiency measures. With this arrangement, agencies can implement energy improvements with no initial capital investment. UESCs can be used for renewable energy thermal, electric, or combined heat and power projects. The net cost to the Federal agency is minimal, and the agency saves time and resources.

Further information and technical assistance with UESCs is available, including case studies, resources, and contacts to assist Federal agencies with implementation.

An agency integrating renewable electricity generation into its construction project must coordinate with its serving utility to interconnect the system. Because this relationship will already be established, the agency can explore a UESC option if the utility is favorable to the renewable energy project. A UESC is an effective method of contracting for the design, implementation, and financing of on-site renewable energy projects.

As with other financing methods available to Federal agencies, a primary benefit of UESCs is the ability to implement projects without using direct appropriations or through a combination of financing and appropriations. Other benefits include a streamlined contracting process and low finance rates.

Contracting options include a task order under an existing General Services Administration (GSA) utility area-wide contract or a site-specific contract. Both contract types may have terms up to 25 years, but policies vary by agency. Area-wide contracts are blanket contracts, which are essentially indefinite delivery, indefinite quantity (IDIQ) contracts for public utility services. GSA has established more than 150 utility area-wide contracts to provide utility services for Federal facilities around the country.

UESCs can be flexible contracting options. Utilities are interested in varying project sizes, so partnering with the serving utility can facilitate resolution of interconnection issues, and utilities are eligible for renewable investment tax credits if they own the system.

Although the applicable UESC regulations do not require measurement and verification (M&V), it is a requirement under recent Federal guidelines for new construction and major renovations. Systems are likely to be subject to M&V regardless of the UESC requirements, but the responsibility may fall on the agency to implement those measures.

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Renewable Energy Certificates

Two separate products exist from electricity produced by renewable energy projects that can be sold together or treated separately. One is the actual electrons produced, which can either be transferred through the power grid to provide power to utility customers or used off-grid or at a customer site. Although they are not common in the market, Federal renewable energy policy recognizes renewable energy certificates (RECs) from thermal renewable energy projects. For thermal RECs the energy product is British thermal units (BTU).

The second product is the environmental benefits of the renewable energy, typically referred to as a renewable energy certificate, renewable energy credit, or simply by the acronym REC. This applies to both electric and thermal renewable energy.

Some RECs have more value than others, which is dependent on the market terms created by various state and local policies. For example, a solar REC is often worth more than a REC produced from landfill gas. Location, supply, demand, and technology type play an important role in the value of a REC.

This section provides information on using RECs to meet various Federal requirements. The degree to which they will count depends upon the specifics of the project and the requirement. This section also evaluates scenarios focused on actual renewable energy generation, building applications, renewable energy purchases, and RECs.

- Energy Policy Act of 2005 and Executive Order 13423
- Trading and Swapping Renewable Energy Certificates
- Meeting Greenhouse Gas Reduction Goals
- Calculating and Reporting Renewable Energy Certificates

FEMP has created a Quick Guide to Renewable Energy Certificates for Federal agencies, which is available as a PDF on the FEMP website.

Energy Policy Act of 2005 and Executive Order 13423

Renewable energy requirements set in the Energy Policy Act of 2005 (EPAct 2005) and Executive Order (E.O.) 13423 allow REC purchases to represent the equivalent of purchasing and consuming renewable energy. Therefore, RECs can be counted toward renewable energy goals.

Details on how agencies must meet Federal renewable energy requirements is set forth in guidance officially issued by the Secretary of Energy as directed in EPAct 2005. Developed by the Renewable Energy Working Group, this guidance has specific details on how RECs can be used to meet compliance goals. A summary of the REC-specific guidance includes:

- Purchasing renewable energy certificates is equivalent to purchasing and consuming renewable energy and does count toward these requirements.
- RECs from a project must be retained (not claimed by the developer or any other party) by the agency to count toward EPAct 2005 goals. If RECs are not retained by the agency, it cannot claim to be using renewable energy because the right to that claim is transferred to the owner of the RECs.

- The EPAct 2005 bonus for renewable energy from a project on Federal or Native American land is only available if an agency retains the RECs associated with the generation from the project. However, agencies can trade/swap RECs purchased from another source to replace RECs sold to finance an on-site project and still receive the bonus.
- Renewable energy certificates from thermal sources of renewable energy can be counted toward the E.O. 13423 50% new requirement.

Trading and Swapping Renewable Energy Certificates

Trading and swapping of RECs can be considered for projects on Federal or Indian land as it is a method to maximize REC value while still claiming the on-site bonus under EPAct 2005. RECs generated by projects at an agency facility must be retained for an on-site project to count toward a renewable energy goal and receive the on-site bonus, but this does not preclude trading or swapping the project's RECs.

An agency may allow the sale or transfer of RECs from an on-site renewable project to other parties. The agency can then arrange for the purchase of less expensive RECs from other locations and/or renewable resources to replace the RECs from the on-site project. This is considered a REC trade. Since different RECs have different values, a REC trade from a project with high-value RECs can produce a good revenue stream that will increase project cost effectiveness. For example, if a solar REC is sold for $200 per megawatt hour (MWh) and a wind REC is purchased for $15 per MWh, the agency effectively replaced the REC sold and improved project cost effectiveness by $185/MWh. REC sales by an agency are considered disposal of government property, which can be involve a quite complex and time consuming process. Generally agencies that want to benefit from a REC swap allow the developer to retain ownership and dispose of the RECs from a project without the agency ever taking possession. In return the agency can expect the developer to offer a better price just as they would after taking advantage of Federal, state, or local incentives unavailable to the agency directly. Because of the complexities involved in an agency selling RECs, they should consult their attorneys before taking ownership and moving forward with a sale of RECs from a renewable project.

Agencies can also swap RECs between renewable energy projects as long as they stay within the purview of the reporting agency. These swaps do not have to be formally documented. FEMP automatically calculates bonus adjustments if an agency reports enough RECs to swap for the output from renewable energy projects that did not retain RECs. This allows an agency to use RECs purchased from another entity to cover the renewable energy production for an on-site project even when the RECs for the project were not retained. Swaps are not allowed between reporting agencies.

Meeting Greenhouse Gas Reduction Goals

Renewable energy certificates can be used to meet the above Federal requirements and to offset Scope 2 greenhouse gas emissions (GHG). Considered indirect emissions, Scope 2 emissions include those resulting from electricity, heat, or steam purchased by a Federal agency usually from an offsite location. The emissions are considered indirect because they are a consequence of activities occurring within the boundaries of the agency, but are actually emitted by sources owned or controlled by another party.

Calculating and Reporting Renewable Energy Certificates

Agencies must report specific information for them to be RECs applied to offset scope 2 emissions and progress toward the renewable energy goal. The reporting method for GHG calculations is complex, and specific guidance has been developed to assist agencies with accounting and reporting procedures. Agencies must provide the following information on all RECs being applied:

- Type of REC, including renewable energy technology
- Zip Code or eGrid sub-region of the energy generation project producing the REC
- Amount of renewable energy associated with the REC (MWh or BBtu)
- Whether the generator is located on Federal or Indian land
- Whether the generator is grid-connected or off-grid
- The percentage of renewable energy output covered by RECs (always 100% for REC purchases)

The GHG emissions benefit resulting from a REC purchase can be calculated using eGrid. This dataset divides the electric grid into 26 sub-regions with unique emission factors based on the regional electricity generation mix. The location and renewable energy source are important accounting factors. Biomass is assumed to be carbon neutral for purposes of agency GHG reduction targets. The carbon emissions from biomass are reported separately but are not counted against agency emission targets. Nitrous oxide and methane emissions from biomass are a by-product of combustion, so they are considered anthropogenic and are subject to GHG reduction targets. It is important to know the type of biomass used in a project selling RECs and if possible the amount of fuel used by the project because they impact the emission factors. If the amount of fuel is unknown it can be estimated based on typical conversion efficiencies, built into the reporting tool.

Building Design

Integrating renewable energy within Federal new construction or major renovations is critical at each phase of the design process. This overview covers considerations for renewable energy in the design phases of a construction project, including choosing the design team, the design team charrette, preliminary design, schematic design, design development, and construction documents. Information on this page introduces each of the design phases and provides a link to deeper-level information.

Key Actions in Building Design

- Require specific renewable energy experience and skills for design team.
- Prioritize energy-related program requirements and an integrated design process in the RFP.
- Consider strategies for energy efficiency first to optimize renewable energy in design.
- Ensure project energy lead is involved in each phase of design review and has access to data on renewable energy decisions/economics.
- Substantiate performance for each design criterion to ensure established goals are met.
- In value engineering, ensure that renewable energy is not the "easy cut." Assess life-cycle costs and run new energy simulations.

After planning and programming is complete, the project moves into the design phase. In building design, the appropriate people must be at the table and work together in a well-coordinated effort. This begins as soon as project requirements are determined and the team is in place.

Renewable energy considerations must be integrated into each design phase, including:

- Selecting the Design Team
- Design Team Charrette
- Preliminary Design (15%)
- Schematic Design (35%)
- Design Development (65%)
- Construction Documents (100%)

Depending on project needs, the agency could use a conventional design-bid-build or a design-build approach (or acquisition strategy). In both scenarios, attention to assessing the appropriate renewable energy technology and evaluating its integration throughout the design and construction process is critical to ensuring that project goals are met.

The following sections focus on the more common design-bid-build approach. Integrating renewable energy into a design-build (or turnkey) strategy involves a few different approaches, which are covered in the section on design-build projects.

Selecting the Design Team

The first step in designing renewable energy into Federal new construction or major renovations is to identify team members with adequate renewable energy skills and experience. This is necessary at the earliest stage of team selection to ensure renewable energy is properly included and integrated into the project design. Strategies for including those skills vary depending on whether the team is formed from in-house architects and engineers or through a contract with an outside design firm. The agency's project energy lead can be helpful in specifying and reviewing necessary qualifications.

Ideally, the team should have experience with all technologies identified by the renewable energy screening to ensure all viable options are adequately considered. This knowledge should include experience with designing, modeling, and estimating the outputs of the renewable energy systems as well as an understanding of applicable incentives and funding, interconnection requirements, and other issues related to the viability of the technology.

For details on the skills needed and how to specify them for both in-house and procured design services, see selecting the design team section.

Design Team Charrette

After the design team has been selected, the project goals identified during planning and programming must be disseminated to the team members. The information on renewable energy gained from the screening can inform the early discussions on the potential mixes of technologies that could be integrated into the design.

A design charrette facilitates these discussions and allows the entire project team to discuss the options for ensuring that the goals will be met. The charrette is also an opportunity to define team member roles, facilitate coordination, and clarify who has responsibility for particular renewable energy issues.

For more information on team member roles, see the design team charrette section.

Preliminary Design (15%)

During the preliminary design (or early schematic design) phase, which is approximately the first 15% of the building design process, the high-level ideas initiated during project planning and developed in the design team charrette are further refined to incorporate the strategies required to meet the overlying project goals.

Considerations for glazing, wall and roof assemblies, lighting, mechanical, and plumbing systems are evaluated with the concurrent energy analysis. This informs decisions beyond first costs, including durability and long-term energy performance. Early choices for renewable energy technologies can be assessed as part of this analysis.

Schematic Design (35%)

During schematic design, the design team develops a general idea of how the design will be approached along with notes and references on how the proposed renewable energy systems will be incorporated.

Guide to Integrating Renewable Energy in Federal Construction

The schematic design phase is informed by the renewable energy feasibility study, which analyzes the performance, economics, and options of the potential technologies.

During this design phase, the design team selects the set of renewable energy technologies for the project and gets a preliminary idea of appropriate system sizes. The team develops initial energy models to assess technology performance in conjunction with the rest of the building design.

When schematic design is finished, the building design process is approximately 35% complete.

Design Development (65%)

During the design development phase, most of the architectural components and primary energy systems are selected. Energy systems are modeled in greater detail, and renewable energy components are sized and designed in detail. Renewable energy systems should be evaluated again during this phase to ensure project goals are being met and that the systems remain feasible. In this phase, renewable energy system controls should be integrated with the overall building automation systems.

In design development, any comments from the agency are combined during internal collaboration with the architectural and engineering team with regard to meeting the project's goals. One example might be changes to primary building systems that may warrant considering other renewable energy technologies.

When the design development is finished, the building design process is approximately 65% complete.

Construction Documents (100%)

The construction documents phase involves designing and developing the building's architectural and engineering systems to the extent that contractors can bid on the work and construct the project.

If contractor bids exceed those estimated by the design team, value engineering can be used to bring the project back within budget. Although renewable energy systems are an easy target to reduce costs at this phase, opportunities also likely exist within other disciplines. Project energy goals need to be considered throughout the building design phase to ensure renewable energy is not left on the cutting room floor during any cost cutting.

When construction documents are finished, the building design process is considered 100% complete.

Design Team

The success of any building design depends on bringing the right team members onto the project. For projects with integrated renewable energy, any successful design team must bring specific renewable energy experience to the table.

Team experience should not be limited to knowledge of the relevant renewable energy technologies, but should also include how to integrate these systems into a building project, how to properly assess renewable energy, how to incorporate renewable energy into energy simulations, how to leverage policies, incentives and project funding for renewable energy, and how to design successful measurement and verification (M&V) systems. In addition, the design should be accomplished using an integrated design process.

- Procuring Architectural and Engineering Services
- Why Experience is Necessary
- Other Design Team Members

Procuring Architectural and Engineering Services

Whether architectural and engineering (A&E) services are in-house or procured externally, Federal agencies need to specify that these abilities be available in the design team. While some professional accreditations, such as Leadership in Environmental and Energy Design (LEED®), are complimentary, they are not a replacement for demonstrated successful project experience with integrating renewable energy technologies.

Energy-related design requirements and expectations for an integrated design process should also be included in the request for proposals (RFP) for A&E services. If they are not included at this stage, the agency will not have leverage to ensure they are included in the resulting design. Although less common in Federal procurement, provisions allowing for performance-based fees can provide incentives for A&E firms to think outside the box to reach additional energy targets.

The project energy lead can be an invaluable resource in reviewing request for qualifications (RFQ) and RFP documents to ensure they will result in firms with the skill sets necessary and designs needed to meet the project's energy goals.

Prior to finalizing any procurement process, the agency needs to establish selection criteria. While the integration of renewable energy is still a less-common skill for A&E firms, many firms might bid on a project such as this without full understanding of the associated costs or issues. The RFQ should be developed to identify and qualify design teams with specific experience across energy efficiency, renewable energy technologies, and whole building energy simulation experience. Critical to creating a successful project, design team selection should be based on best value rather than simply lowest cost.

If an A&E firm does not have proper experience with the potential renewable technologies designated in the RFP, they should team up with experts with this experience. Simply stating that they will bring on subcontractors with relevant experience is not sufficient.

The proposal should include key personnel on the project, including documented renewable energy experience as well as potential industry certifications.

Since traditional energy simulation models do not easily incorporate renewable energy, the bidding teams should be asked to detail their approach, process, and anticipated software in reaching the correct simulations. Teams should also demonstrate experience with verifying building performance of their built projects to show the ability to benchmark actual energy performance versus design estimates.

The project energy lead should be involved in the review of procurement specifications and should be on the selection committee for the design team. Detailed information on this topic is available in the FEMP guide on the Procurement of Architectural and Engineering Services for Sustainable Buildings.

Why Experience is Necessary

Architects with adequate experience with renewable energy technologies will be able to understand the importance of siting a building and any related renewable energy systems. This includes considering the climate zone, local site characteristics like shading from other structures, and the building's overall environmental impact on the site.

Depending on the project's climate zone, strategies like passive heating and cooling, natural ventilation, wall and roof assemblies, glazing selection, and associated solar control (overhangs, vertical fins) should all be part of the design considerations even before the addition of power generation technologies. The design and integration of renewable energy technologies is a very complex and specific skill, and it is less common to have a designer with skills that span across multiple renewable energy technologies.

Many times, engineers will be asked to design systems to fit into a particular project's architecture as discussed in the various design phases of this guide. Engineers should be familiar with incorporating renewable technologies into projects, but may also rely on the expertise of professionals dealing specifically with any particular technology. While there are opportunities for incorporating design strategies from engineers that can help minimize the project's energy use (thereby increasing the impact potential of any renewable energy technology), having their input early in decision making process will be a benefit to the project moving forward.

From the early stages of a project, experienced energy analysts can provide helpful input on a project design to inform of the impacts of various strategies that can help optimize energy efficiency and renewable energy strategies. Simulation programs, such as, eQUEST (DOE-2) and EnergyPlus, along with other hourly simulation programs are commonly used during this and subsequent phases of the design. A description of these and other simulation programs used in whole building analysis can be found on the EERE building energy software tools directory. Working with architects and engineers allows energy analysts to not only evaluate these strategies, but to also get feedback from these professionals as to potential aesthetic or equipment costs associated with such strategies.

Other Design Team Members

In addition to the outside design firm, it is essential to have members on the design team who will be able to evaluate the progress of each stage of design in reaching the project's energy goals. Other members of the design team include:

- Agency representatives
- Energy project lead
- Architects
- Building siting
- Structural and energy engineers
- Energy analysts
- Commissioning agents

Maintaining communication between and engagement with all team members will help ensure a successful project.

Commissioning agents and building maintenance personnel, in particular, can add value throughout the life of the project if included on the design review team. Since they will play a critical role in ensuring that the building's primary and renewable energy systems are operating as intended and designed, these professionals can provide a wealth of knowledge on issues the design team must consider that may not initially be obvious. Integration of renewable energy system controls into other components of the building system, as well as ongoing maintenance that could result in significant operational costs, are just some of the issues that can be identified and remedied early.

Key Actions in Selecting a Design Team

- Work with project energy lead to include renewable energy provisions when procuring architectural and engineering services. List specific requirements, including:
  - Energy-related requirements from building program.
  - In-depth energy efficiency and renewable expertise on team.
  - Ability to integrate renewable energy and custom control strategies into energy modeling.
  - An integrated design process and coordination with other contractors.
  - History of verifying building performance.
- Determine selection criteria ahead of the RFP, including the ability to judge on best-value versus lowest-cost.
- Create design review team across disciplines, including project energy lead, commissioning agent, and facility staff.

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Design Team Charrette

Holding a design team charrette is a key first step in bringing together the entire design team, including the agency, the winning architectural and engineering (A&E) firm, other design team members, and key experts that can inform the early design process. For renewable energy integration, the agency's project energy lead must be involved at this stage. Bringing the design team members together early is essential in ensuring that design requirements for energy are incorporated into the design efforts moving forward.

A design charrette provides an opportunity for designers, users, and other decision makers to give input on how to best integrate their respective efforts into the project. The design charrette is a process that allows both the agency and the design team to understand the needs and perspectives of all involved parties. Typically, the architect-engineer or design-build team would consult with an independent party to facilitate the charrette. However, this can also be procured by the agency or agency's representative.

Because of the more well-defined scope definition that typically results from a design charrette, project costs can be effectively optimized through reduced design overlaps and associated design and construction costs. Through a charrette and subsequent integrated design process, information received by the design team can best be shared with both the agency and the workers constructing the project. This allows consideration for alternative strategies that serve to meet the project goals, if needed, throughout the design process.

The most common renewable energy technologies and tips for integrating them successfully are outlined within strategies for effective design.

Effective Design Strategies

As described in the Whole Building Design Guide (WBDG), all Federal agencies are required to follow the Guiding Principles for New Construction and Major Renovations, which include considerations for renewable energy. Renewable energy technologies can vary by building type and by climate zone, so Federal agencies should fully assess all options before incorporating them into building design.

The most common renewable energy technology and design strategies include:

- Focus on the efficient use of energy, including natural resources
- Ensure that the building is solar ready
- Consider the most common renewable energy technology options
- Look for additional opportunities

Focus on Energy Efficiency

Energy efficiency and passive renewable energy, such as daylighting and passive solar heating, should be considered prior to active renewable energy technologies as they often provide the most economic options. The WBDG discusses the following considerations to maximize efficient use of energy and natural resources:

- Proper Building Siting: From enabling optimal exposure for roof-mounted photovoltaics (PV) to prevailing wind considerations for natural ventilation and passive cooling, building siting can have significant impacts on energy use and the ability for some renewable energy technologies to be integrated into the project. While primarily applicable to new construction projects, siting should also be considered for major renovation projects to the extent practicable. The WBDG provides more information on proper site selection.

- Roof and Exterior Wall Insulation: Properly selected roof and wall assemblies can reduce heating and cooling loads within a building by effectively decoupling it from the outdoor environment. With decreased building loads, the energy required to condition a building is reduced. This effectively expands opportunities for renewable energy integration and impact. The WBDG provides more information on roof and wall assemblies.

- Climate Responsive Building Design: While windows and associated natural light can enhance space quality within a building, care should be taken to ensure that their benefit is not offset by energy impacts due to increased direct solar gain in the cooling months and thermal losses in the heating months. Climate responsive building design can determine the proper use of techniques to maximize the buildings use of its natural environment. Glazing and window assemblies can be selected to increase beneficial natural light and internal gains, while shading can be used in conjunction with glazing to minimize unwanted solar gains within a space. The WBDG provides more information on passive solar heating and shading.

- Daylighting and Associated Controls: Strategies to incorporate daylighting into design can provide ample natural light and offset energy use associated with artificial light sources. Considerations to maximize the use of daylighting in both new construction and major renovation projects can provide significant energy savings to a project, thereby decreasing building loads and increasing the impact of renewable energy technologies. The WBDG provides more information on daylighting.

- HVAC and Mechanical Systems: Energy associated with heating, ventilation, and air conditioning (HVAC) represents the largest end use within the typical building. Minimizing loads within a building with the strategies discussed above are primary steps in reducing its overall energy use. Local climate conditions along with how the building is expected to operate should be evaluated to ensure cost-effective options for increased energy efficiency are pursued. Increasing energy efficiency within a building is the first step to optimizing renewable energy integration potential. The WBDG provides more information on HVAC and building envelope.

Ensure Buildings are Solar Ready

All facilities should be built to accommodate future renewable energy use, especially solar energy technologies. Making a building solar or renewable energy ready involves designing it to accommodate future PV or solar water heating. This involves ensuring the roof can accommodate the weight of a system and is oriented to take advantage of the solar resource. It also includes adding conduit and plumbing into the walls during construction so that costly retrofits are not required later.

The cost effectiveness of solar technologies often depends more on local policies and incentives than on the available solar resource. A policy change can quickly render a technology cost effective in a matter of weeks if the required building infrastructure is already in place. Therefore, ensuring buildings are solar ready enables future incorporation of renewable energy, even when purchasing and installing the equipment must be postponed. While it will not meet current Federal requirements immediately, this approach can help meet requirements economically by adding renewable energy at a later date. The WBDG provides more information on phasing renewable energy implementation.

Start with the Most Common Renewable Energy Technology Options

Designing to integrate renewable energy requires considering a wide range of renewable technology options. Because economics depend on available resources, existing energy costs, local policies, and incentives, it can be helpful to first consider the technology options that are most often available and cost effective for buildings:

- Solar water heating is a simple technology that is successful in many situations, especially where it offsets electricity or any high energy costs. Where cost effective, Federal requirements call for new construction and major renovations to use solar water heating for 30% of overall facility needs. Cost effectiveness includes factors beyond the cost of the offset energy, including the solar resource and financial incentives available. It is easiest to incorporate solar water heating into a renovation if the facility is solar ready. Otherwise, implementation depends on whether the roof can support the extra load of the system and whether it is possible to install the required pipes and equipment. The WBDG provides more information on solar water heating.

- Photovoltaics are often the simplest renewable electricity option for a building. Prices have historically been higher for PV than other electric technologies, but have been decreasing since 2008. Unless a facility is in an area with costs of electricity, PV cost effectiveness depends on local policies and incentives. Facilities should be designed to be PV ready even if PV is not cost effective at the beginning of a project. Technology advancements and policy changes can quickly render the technology cost effective. For renovations, implementation depends on whether the roof (or other space) can support the extra load of the system. The WBDG provides more information on building-integrated photovoltaics.

- Solar ventilation air preheating is economic in climates with sufficient requirements for heating (heating degree days). It is most effective in new construction, but can be used in renovations if a south-facing wall is available. This is most effective as a preheating technology where large amounts of ventilation air are needed. The WBDG provides more information on solar ventilation air preheating.

- Geothermal heat pumps can be very cost effective in mixed climates that have both heating and cooling loads and where electricity costs are low or moderate. The site must have sufficient available land for the ground loops. However, in new construction, this can be achieved in conjunction with foundation work or can be located under a planned parking lot. The WBDG provides more information on geothermal heat pumps.

Other technologies are also easy to integrate with a project and can be cost effective, but depend on specific resource availability at the site:

- Geothermal direct heat provides a cost effective and relatively simple and consistent energy source for buildings with certain heating loads due to the climate or other process needs. Implementation depends on the availability of a sufficient geothermal resource to provide direct heat for a building, which is less common and typically located in the western U.S. The WBDG provides more information on geothermal direct heat.

- Wind is useful for distributed energy projects and can provide power directly to a facility. Successful implementation requires a site with an appropriate wind resource and few major obstructions. Like PV, the cost effectiveness of wind depends on the local wind resource, the price of grid-supplied electricity, available incentives, local policies on interconnection, net metering, and zoning. To minimize noise concerns, wind turbines are best located where sufficient space separates the turbine from occupied buildings and surrounding neighbors. The distance needed to completely eliminate the wind turbine sound typically requires 150 to 200 meters between the turbine and occupied facilities. The WBDG provides more information on wind.

Look for Additional Opportunities

This guide provides information on a range of additional renewable energy technologies. The use of technologies beyond what is covered is dependent on location, specific resource availability, and the building's energy needs. Projects should quickly screen other technologies to see if conditions exist that may provide a unique opportunity.

As examples, if a facility has an available biomass or geothermal resource and has need for process heat as well as electricity, these renewable resources can each be used in combined heat and power (CHP) applications. A facility with ready access to biogas could also use it to power a fuel cell.

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Preliminary Design (15%)

The preliminary design (15%) phase converts design requirements and design charrette results to an initial design layout. This stage allows for consideration of potentially numerous renewable energy technologies. It may only consist of an overall idea of the building layout along with notes and single-line drawings to represent complicated building systems.

If this initial design layout is done prior to considering renewable energy, many technologies can be effectively eliminated from use. If an agency brings on architects to do this early layout prior to hiring the final design firm, the same rules for renewable experience and knowledge apply to both the conceptual designers and the final design firm.

Energy efficiency should always be considered first as it will often be more cost-effective than adding additional capacity to selected renewable energy technologies. Information from the renewable energy screening should inform which renewable energy technologies are considered for inclusion. The most common renewable energy technologies and tips for integrating them successfully are outlined within strategies for effective design. Regardless of the renewable energy technology being considered, the less energy a building uses the less energy needed from renewable energy systems.

Renewable energy system size and associated cost impacts should be considered when evaluating the inclusion or exclusion and particular design strategy. Strategies that may not appear to be cost effective with the consideration of only cost and direct energy savings may be cost effective with the savings from the reduced renewable energy technology capacity required to meet the project goals. Similarly, design strategies with an energy penalty that may be considered for first-cost savings need to consider any increase in renewable energy technology capacity and associated cost that would be required to maintain the project goals.

Information available to and used by energy analysts of this early stage of the design process can provide insights regarding the potential impact of a given renewable energy technology in helping meet project goals. At this point of the design, information from the energy simulation work can provide valuable feedback on which strategies may be best for a building's architectural and energy-using systems and which renewable energy systems may perform best in conjunction with these strategies. Changes made at this point in the design can be done with little impact to the overall construction schedule or budget.

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Schematic Design (35%)

The schematic design (35%) phase provides an opportunity for the Federal agency and design team to come together and ensure project goals established during programming, discussed during the design charrette, and refined during the preliminary design are represented in the design as it moves forward.

During schematic design, preliminary considerations for potential renewable energy technologies will be primarily based on fuel types available to the project (electricity, natural gas, district steam, etc.), expected project end uses, and overall project goals. Projects with any particular dominant fuel use may find a number of technologies are not feasible in meeting project goals. Feedback from the building energy simulation can be used in preliminary renewable energy system sizing and targeting strategies throughout the design process.

At this point of the design phase, changes are likely to occur as project design components are being refined or new ideas and opportunities are presented for consideration. While deviating from a particular renewable technology needed to meet project goals is not encouraged, changes made to specific technologies during the early stages of the design process allow changes to be integrated with less impact on the subsequent design phases.

The review of these schematic design documents by the integrated design team, including the project energy lead, allows an objective evaluation of the current design and can help ensure that it is on track to meet established project goals. Architectural features, mechanical system design components, and input from others disciplines can lead to design changes that may result in a particular renewable energy technology to be more effective than another in meeting these goals. Any changes should be continually updated and reflected in the energy model being used for the project.

- Results of the Renewable Energy Feasibility Study
- Energy Simulations: Schematic Design vs. Baseline
- Comparing Energy Efficiency and Renewable Energy Measures

Results of the Renewable Energy Feasibility Study

Schematic design is the appropriate time to get detailed information on renewable energy technology options from a renewable energy feasibility study. This study, which should be provided by the architectural and engineering (A&E) firm or their subcontractors, provides in-depth details on energy production, costs, savings and implementation issues associated with specific technology products.

Input from the feasibility study provides detailed reinforcement for the selection of the most effective set of renewable energy technologies for the building. Schematic design is the last opportunity to add any new technologies into consideration, so that information is needed at this point if the feasibility study highlights unexpected potential or concerns with any of the technologies.

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Energy Simulations: Schematic Design vs. Baseline

Engineering calculations and whole building energy simulations should be reviewed for both current design and measures to further increase overall building efficiency. This iterative simulation and review process should occur in all phases of design.

When making energy saving comparisons, a number of ways exist to establish a baseline building and energy case for reference. For new construction projects, building energy simulation methodologies outlined in standards like ASHRAE 90.1 and ASHRAE 189.1 can be used. Publications like ASHRAE's Advanced Energy Design Guides provide guidance for achieving 50% energy savings beyond the minimum requirements of 90.1-2004.

When an existing building is to be renovated, the past energy consumption information of the building can be used. It is suggested that a baseline model incorporating existing design conditions be developed and calibrated to match the existing energy use within a reasonable range when evaluating reductions from the baseline.

Additionally, separate energy simulation files should be preserved at each phase of design that reflects the design documents at that point in time. Any changes that have been incorporated into the current model should be documented with the simulation files. Changes may include operating schedules, architectural components, mechanical system components, or other energy end use systems, including process loads that may not have previously been identified.

For example, a facility that initially included a recreation space with showers and a tempered pool is changed to allow for more office spaces. Due to the high demand for hot water, a solar thermal system was initially chosen to meet the projects renewable goals. With this change characterized by a decrease in hot water demand and an increase in office equipment, it was determined that a photovoltaic system would work best for the project.

Simulations of the current design, along with other design options being considered, can provide critical information to the project as it progresses.

Comparing Energy Efficiency and Renewable Energy Measures

When evaluating design options to meet project energy goals, it is important to consider energy efficiency first in conjunction with potential cost impacts associated with either an increase or decrease in the required capacity of any renewable energy technology. In most cases, energy efficiency can be the most cost-effective option.

Because the renewable energy feasibility study provides specific cost information for a range of technologies, analysts can start to use a levelized cost of energy (LCOE) of renewable energy to determine the most cost-effective steps toward energy goals.

For a given measure, the associated net cost over the expected component life or determined performance period can be converted to a cost/unit energy saved over this time interval. A simple example, assuming constant energy prices and performance over this time interval described this as follows.

Considering electrical energy, an efficiency measure with a cost premium of $50,000 has been shown to save 30,000 kWh per year at a price of $0.10 per kWh. Evaluated over a 20-year period, assuming constant utility cost and component performance, the LCOE for this measure is $0.083 per kWh. The fact that the LCOE is less than the retail cost of energy suggests that this is a favorable measure. This scenario should be compared with any renewable energy system being considered when the total cost of the system is evaluated with the same considerations. Dependent on the project location, utility rates, and incentives for a particular technology, the LCOE for either measure should be compared and evaluated.

Other information, such as de-rating, discount rate, degradation, and maintenance, can be incorporated into LCOE analysis to provide considerations not addressed above. More information on LCOE and other financial evaluation is available from the EERE Office of Planning and Budget Analysis.

Design Development (65%)

The design development (65%) phase is a progression where changes from the schematic design phase are incorporated and further details are developed on building systems. In this phase, the architectural and engineering (A&E) firm typically starts to present overall costs associated with the design. As with the each design phase, the current design will be reviewed by the design team, and the agency should ask the A&E firm to substantiate how the included measures meet design requirements for energy.

Design development is when the size and design of the specific renewable energy technologies is accomplished. It is important to evaluate the design to ensure that the particular technology can be incorporated into the project as intended.

If it has not already occurred, the design team needs to be expanded to include any subcontractors hired by the A&E firm or the agency to handle the design of renewable energy systems.

As the project continues to develop, it is increasingly important to ensure any concerns from all disciplines are discussed and alleviated as changes become increasing likely to affect the project schedule and/or budget. Although some technologies may still be eliminated from consideration for cost or performance issues, no new renewable energy technologies are likely to be added or considered at this phase.

Often, A&E firms will not have the specialized expertise and certifications warranted for designing a particular renewable energy system. The agency or the A&E firm can contract for these services directly through engineering, procurement, and construction (EPC) contracts to have technology specific experts design the renewable systems directly. In these cases, system designs needs to be carefully coordinated with the primary design team to identify any concerns, overlap, or discrepancies. While not exhaustive, some specific items to review include:

- Structural design to ensure it is designed to handle the required photovoltaic or solar hot water panel load for roof-mounted systems.
- Space in mechanical and/or electrical rooms to ensure space for inverters, storage tanks for solar hot water, or any other renewable energy system equipment needed to complete the system has been included.
- Energy simulations to ensure that the associated electrical and thermal demands, usage, and projected costs are aligned with project goals.

While some aspects of the design, including final glazing selections or specific mechanical system components, may yet to be finalized at this point in the design process, many major components will likely be identified. An EPC contract has the advantage of not specifying particular equipment models far ahead of actual installation. In some renewable energy fields, such as photovoltaics, the production and availability of specific models may vary with time but many options are available to produce the same result.

For projects attempting to offset a certain percentage of its annual energy with renewable energy technologies or to meet a specified annual energy use target, it is increasingly important to use targeted engineering calculations or whole building energy simulations to ensure the technology can meet specified project goals.

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Engineering calculations, load sizing output, and/or whole building energy simulations reflecting current design, as well as measures to further increase the overall building efficiency, should be reviewed at this and all other phases of the design process. At this phase of the project, many of the architectural features, mechanical system components, and internal loads have been developed to a point where it is possible to better understand their impact on project goals.

Separate energy simulation files should be preserved at each phase of the design that reflect the design documents at that point in time. Any changes incorporated into the current model should be documented with the simulation files. Changes may include operating schedules, architectural components, mechanical system components, or other energy end use systems, including process loads, that may not have previously been identified.

Construction Documents (100%)

Construction documents (100%) represent the final set of drawings that will be issued for contractors to bid on. At this point, all architectural and engineering systems have been reviewed and designed to ensure that project goals are being met.

A final review with all members participating in previous reviews should be planned to ensure all information from previous design reviews have been incorporated into the construction documents and all other renewable energy integration issues have been resolved before being issued for bid.

At this point, it is expected there will be few, if any, changes to the overall building design. The planned renewable energy technologies will have been evaluated to ensure project goals continue to be met.

Engineering calculations and/or whole building energy simulations reflecting current design, as well as measures to further increase the overall building efficiency, should be reviewed at this and all phases of the design process.

It is suggested that separate energy simulation files be preserved at each phase of design to reflect the design documents at that point in time. Any changes incorporated into the current model should be documented with the simulation files. Changes may include operating schedules, architectural components, mechanical system components, or other energy end use systems, including process loads that may not have been previously identified.

Value Engineering

Pricing will come back to the design team after construction documents are issued for bid to the participating contractors. Contractor bids that fall within the project's planned budget provide the assurance that project goals can be met without additional costs to the project. In cases when all contractor bids are coming in over the project's budget, the design team may need to reevaluate design decisions that may be adding to project costs.

Value engineering describes this scenario, or the process for scaling back design at any phase of the design process, but can be misleading when first-cost is the only consideration used to quantify value. A best practice is to consider life-cycle costs when conducting value engineering and to rerun energy simulations on any proposed cuts or alterations to energy systems. Unintended consequences can be better identified with re-run simulations.

It is easiest to ensure project goals remain in place when these goals are incorporated as a requirement of the project at its inception. Whereas significant costs savings can be realized with the replacement of particular mechanical system components, these typically result in less energy-efficient systems. The impact of the selected renewable energy systems are diminished and could ultimately require a larger system to meet previously defined energy goals for the project. Projected increases in annual energy use and the associated costs, as well as increased renewable energy system capacity to meet established project needs, should be considered when making such value assessments.

With the integrated design team, coming together to review and reevaluate the building as a system can create an opportunity for greater energy efficiency. When components need to be evaluated for cost effectiveness, all systems should be evaluated to determine the most energy-effective way to bring the project within budget while preserving the project's goals. For example, rather than changing the systems designed to handle specific building heating and cooling loads, it may be more cost effective to look at architectural components, including wall assemblies, glazing, and shading strategies that may further reduce equipment size and associated costs.

Design-Build Project Delivery

Renewable energy must be integrated into each of the design phases. Noting that any agency may have specific processes during the development of a construction project, this section discusses key issues in the following phases of the design-build process:

- Planning and Programming
- Request for Qualifications
- Request for Proposal
- Construction Contract
- Design and Build

Integrating renewable energy into design-bid-build strategy involves a few different approaches, which are covered in the main building design section of this guide.

Planning and Programming

The planning and programming phase should look the same regardless of whether the project is design-bid-build or design-build. An early team is brought together for planning, including renewable energy expertise.

Regardless of the project delivery method, the agency still needs a project energy lead with renewable energy expertise to represent the agency's interests throughout the project. The project energy lead should provide oversight and ensure consideration and successful integration of renewable energy technologies throughout the project to meet the project goals. The project energy lead must be independent and unbiased to the technology, but must also understand the range of technical and policy issues that can arise with integrating renewable energy technologies.

After determining the renewable energy potential for the site through a screening, the Federal agency moves into the programming phase. A variety of stakeholders and experts then participate in a planning charrette to establish energy goals and design requirements to be included in the building program. These requirements are prioritized and included in the request for proposal (RFP).

Although the budgeting process in a design-build delivery method may be accelerated, the overall pre-design phases of the project are similar.

Request for Qualifications

Developing the request for qualifications (RFQ) is the first step in allowing the agency to identify design teams that demonstrate the experience necessary to ensure a successful project. The RFQ should clearly identify the necessary qualifications to ensure the successful integration of various renewable energy technologies that may be considered to meet the project goals. The qualifications for a design-build team are the same as the combined qualifications for a design team and a construction team.

Project goals being developed as part of the planning charrette with the agency and selected representatives will ultimately become part of the RFP for selected design teams.

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Request for Proposals

The RFP must be carefully thought out, tested for achievability, and clearly written. Because RFPs for commercial buildings are typically hundreds of pages long, they should also be well organized and easy to navigate. For renewable energy, it is important that clear goals and requirements be laid out for the projects as well as specific requirements for both design teams and construction teams.

A typical design-build RFP contains:

- **Scope of Work:** A narrative describing goals, project intent, and best value recommendations
- **Procedure:** A narrative describing the competitive process, evaluation criteria, and incentives
- **Programming:** Occupancy totals, departmental affinities, parking requirements, etc
- **Performance Specifications:** Technical data, load requirements, energy monitoring systems, etc.

Project goals associated with renewable energy technologies should be addressed in each instance.

From the RFQ submittals received, a selected number of design-build teams will submit proposals identifying the design approach necessary in reaching the project goals. A draft RFP may be first issued to allow the design teams to provide comments on items not addressed initially that may help ensure a successful project regardless of the design team selected. Modifications made to the draft RFP will become the final RFP from which each design team submits their proposal.

Identifying the project goals is necessary for a successful project. With integrating any renewable energy technology, minimizing building loads is a simple and effective way to maximize the impact of any renewable energy technology. Depending on the building type (office, laboratory, warehouse, etc.), considerations like orientation, natural ventilation, and daylighting can have a significant impact on meeting project renewable energy goals. Identifying and prioritizing such requirements, along with performance targets and identified project goals, is necessary to ensure these are included in each proposal.

The Whole Building Design Guide has information on the NAVFAC design-build request for proposal

Construction Contract

In design-build approaches, the agency contracts with a single legal entity, the design-builder, to provide a completed building based on the agency's design criteria. The designer/builder controls both the design and the construction process unlike design-bid-build approaches.

The agency develops a clear, comprehensive RFP that outlines expectations for the project, and the design-builder assumes complete responsibility for delivering the project as specified in the RFP on time and on budget.

In addition to writing a detailed RFP for the building, the agency must hire an experienced, committed design-builder. Although this process is getting easier, it is still a time-consuming task that some agencies find intimidating.

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Because design-build teams with adequate renewable energy experience may not be availability, agencies may want to make sure of a request for qualifications early in the process to identify candidates and available skills. If responses indicate a lack of qualified candidates, the agency could recommend that teams partner with renewable energy experts to expand experience or bolster subsequent proposals. The project energy lead should be closely involved in this entire process to ensure appropriate qualifications are specified and to identify qualification issues as early as possible.

Selecting a design-builder involves:

- Preparing a solicitation for services
- Requiring RFQs from prospective teams
- Evaluating RFQs submittals
- Developing a short list of teams
- Interviewing the short-listed teams
- Preparing a final ranking of the teams
- Negotiating with the highest ranked team

Performance fees or other meaningful financial incentives, both for the finalists in the selection process and for the successful firm throughout the project, are effective tools for supporting positive outcomes. Although they can be difficult in Federal procurement, incentives provide a reason for firms to go above and beyond in reaching ambitious project goals. More information is available in the Whole Building Design Guide's discussion on contracting.

Design and Build

Because design-build does not require a lengthy bidding process before the building contractor joins the team, it is the fastest of the project delivery methods and generally shifts project risks, including scheduling and costs overruns, from the agency to the design-build team. While the design-build team is in the process of developing the final design, it is possible to allow other trades to begin comparing the expected months associated with bids and contract issuance associated with design-bid-build projects.

As discussed in other sections, it is important to develop an energy model early in the process to demonstrate that project goals are attainable. Continually updating the model to reflect changes that occur during the design and construction process ensures performance goals are achievable.

Project Construction

Integrating renewable energy into Federal new construction or major renovations requires effective structuring of the construction team and project schedule. This overview discusses key construction team considerations for renewable energy as well as timing and expectations for the construction phase.

The project construction phase begins after a project is completely designed and the construction documents (100%) have been issued. Construction team skills and experience with renewable energy technologies are crucial during construction, as is how the integration of renewable energy affects the project construction schedule.

Key Actions in Construction

- Use best-value selection criteria for the construction team.
- Require the prime contractor to have experience integrating renewable energy.
- Specify that the construction team demonstrate specific expertise on technologies relevant to the project.
- Require all parties to coordinate during project construction, including the general contractor, subcontractors, and renewable energy installers from external contracts.
- Specify contractor responsibilities for enhanced commissioning, operations, and maintenance materials and training.
- Identify and plan key scheduling issues with various renewable energy technologies.
- Involve building and inspecting officials early and often in the process to familiarize them with systems.
- Keep the project energy lead involved throughout construction, including on any energy system decisions that arise.

Construction Team

If the project is design-bid-build, the construction documents become a bid package for selecting the construction team, which is typically led by a general contractor. If the project is design-build, the general contractor is already in place and renewable energy expertise should have been figured into that selection. Other primary team members include renewable energy subcontractors.

The general contractor manages the entire construction process and ensures the project is built as specified in the construction documents. Although the general contractor might not have specific skills for installing every type of renewable energy technology, basic familiarity with installing and operating the various technologies is important, as is understanding how installation fits within the broader construction process.

Usually, a general contractor uses subcontractors to install the renewable energy systems. Finding an experienced subcontractor can be challenging, and in this case the skills needed to install the system are more important than the lowest price. The agency or architectural and engineering

(A&E) firm may also bring in a subcontractor for renewable energy that handles system design and construction.

Specifying particular expertise and certifications for specific renewable energy systems can ensure that the general contractor brings on subcontractors with significant demonstrated experience on similar projects. Considering the use of specific Engineering, Procurement, and Construction (EPC) contracts for renewable energy systems may increase access to experts and reduce construction delays.

The agency's project energy lead oversees energy systems and issues during construction, as does the commissioning agent. Both must be familiar with renewable energy technologies being installed to manage any problems that arise with design or installation.

For more information on skills and requirements of key project construction players, see the construction team section.

Timing and Expectations

Integrating renewable energy technologies affects the project construction schedule. Many renewable energy contractors are more experienced with standalone projects than with integrating renewable energy technologies within other construction activities, so there may be a learning curve. In addition, projects including renewable energy could require specialized equipment rentals, subcontractor scheduling, equipment staging, and optimal timing of various types of work. It is the general contractor's responsibility to pull together all elements introduced by incorporating renewable energy.

For example, a solar installer could need access to a building roof to install footings prior to the installation of the roofing material. If they do not have access until after roofing is complete, some roofing elements might have to be reinstalled, increasing costs. However, if the solar installer is not available at the proper time, the delay occurs while the roof is in a vulnerable, unfinished state. Each subcontractor's responsibility must be clarified in these instances.

Maintaining the highest quality is fundamental to any successful construction project, as is finishing it on time and within budget. Typically, a monetary incentive is offered to complete tasks ahead of schedule or at a higher quality than standard construction. If used, these incentives can have specific requirements tied to the renewable energy technologies as well.

For more information on key issues surrounding scheduling the installation of various renewable energy technologies during project construction, go to the construction timing and expectations section.

Project Construction Team

Assembling the right project construction team is crucial and begins with the request for proposal (RFP). Federal agencies create and RFP for construction services using construction documents developed during the final stage of building design.

Construction documents are the blueprints on which every project is built and will be used to generate bids for the construction phase of the project. Renewable energy will either be specified in detail in the construction documents, or the design and construction of certain renewable energy systems may be contracted separately with installation coordinated with the larger construction project.

- Selecting the Construction Team
- Roles and Responsibilities

Selecting the Construction Team

The successful contractor should have experience with integrating renewable energy into a larger project. In some markets, this may require the contractor to expand their typical team by partnering with a renewable energy firm. Where renewable energy construction is included in the overall project construction package, the responding team should include members with specific experience and certifications in each of the technologies to be installed.

As with choosing a design team earlier in the project, selection criteria are critical to the successful integration of renewable energy and should be based on best value rather than lowest cost. Otherwise, the proper experience and skills are unlikely to be available to carry out the design correctly.

Cases in which renewable energy contracts may be separate include projects with separate ownership, such as through renewable energy project funding or projects using a renewable energy engineering, procurement, and construction (EPC) contract (or in essence, a design-build contract) specifically for individual renewable energy systems. EPC contracts are often coupled with a performance guarantee so the contract winner must not only design, purchase, and install the system in question, but also guarantee that it will meet certain energy output requirements for the specified term of the contract.

Roles and Responsibilities

The general contractor plays a central role during the project construction phase. The general contractor is responsible for building the project according to the construction documents. The general contractor is chosen early in a project whether the project is design-build or design-bid-build.

When choosing a general contractor, it is important that they demonstrate the ability to carry out projects with renewable energy components. The general contractor should have a portfolio of work involving various renewable energy technologies and should be able to state in writing their capabilities related to renewable energy systems. In some markets, contractors may need to bring on additional resources or partners to meet these requirements, but renewable energy experience is important for integrated renewable energy project success. It is also important that the general

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contractor demonstrate work on projects with major energy efficiency features. Renewable energy is the focus of this guide, but energy efficiency goes hand in hand with renewable energy.

Subcontractors work under the general contractor and perform specialized work that the general contractor does not have the proper skill set to complete. It is common for subcontractors to install renewable energy systems because it typically requires specialized labor. In fact, in many instances, these specialized skills extend to the design of the system as well, and the agency or architectural and engineering (A&E) firm will choose to have renewable energy systems handled by a design-build type of subcontract referred to as an EPC contract. These can also be coupled with performance guarantees so the agency is guaranteed a certain energy performance from the system.

Depending on the region of the U.S., finding a proficient subcontractor can be an issue. It is important that the subcontractor has the preferred certification to install a particular renewable energy system. The following table lists the preferred certification for renewable energy system installers for various technologies.

Preferred Certification for Renewable Energy System Installers

Renewable Energy Technology	Preferred Certification for Installers
Passive Solar Thermal	Passive Solar Certification, Leadership in Energy and Environmental Design (LEED®)
Photovoltaics	North America Board of Certified Energy Practitioners (NABCEP)
Solar Hot Water	North America Board of Certified Energy Practitioners (NABCEP)
Wind	North America Board of Certified Energy Practitioners (NABCEP)
Biomass	Microgeneration Certification Scheme (MCS)
Geothermal Heat Pump	Certified GeoExchange Designer (CGD)

The energy lead needs to stay involved during construction and be a resource for any issues that arise that affect building energy systems. The commissioning agent is also available at this stage to identify integration issues that arise during construction. Both roles should have already been filled by experienced renewable energy professionals.

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Construction Timing and Expectations

Creating a detailed construction schedule that allows all the project elements to be coordinated in a timely manner is fundamental to any successful construction project. The construction schedule should take into account that many tasks cannot be started before others are finished. It should also account for special schedule considerations related to renewable energy systems.

Key elements of most new construction or major renovation projects include landscape, structural, architectural, mechanical, electrical, plumbing, communication systems, and renewable energy systems. Maintaining the highest quality of construction across all elements is fundamental to any successful construction project.

Incentives for the project construction team can be created so that the project is completed on time or ahead of schedule and at the highest level of quality. The incentives typically offered are additional money for completing tasks ahead of schedule and/or at a higher level than standard construction.

- Considerations for Renewable Energy Systems during Construction
- Working with Building and Inspection Officials

Considerations for Renewable Energy Systems during Construction

Renewable energy systems are relatively specialized and can require special considerations during the project construction phase. Often, specialized equipment and labor crews are required to install renewable energy systems. There are also additional scheduling considerations to account for when renewable energy systems are being employed.

The following table lists the specialized equipment, labor, considerations, and scheduling considerations for various renewable energy systems. It is not an exhaustive list, but serves as a starting point.

Renewable Energy Technology	Specialized Equipment	Specialized Labor	Special Considerations	Scheduling Considerations
Passive Solar Thermal		Knowledge of thermal mass/ Trombe walls	• Orientation of building • Shading issues	First renewable energy technology to consider in planning
Roof-Mounted Photovoltaics (PV)	Usually just a forklift, but might required crane on taller buildings	Electrician familiar with DC wiring and PV installation; NABCEP certi-fied installer	• Weight and wind loading issues • Installed on the south with minimal shading	If mounted instead of ballasted, PV footings go in after the roof structure is complete but before actual roofing membrane is installed
Wind	Crane and excavation equipment for larger turbines; special climbing harness	Wind turbine experts; electrician familiar with wind installa-tion and climbing tower	• Excavation for foundation • Surrounding space for tower erection and guy cables, if used • Siting is very specific • Proximity to grid power at correct voltage • NEPA considerations	If mounted instead of ballasted, PV footings go in after the roof structure is complete but before actual roofing membrane is installed
Geothermal	Drilling rig	Plumber, excavator		Larger surface area near project may be unavail-able during certain phases of installation.
Solar Ventilation Preheat		HVAC/ mechanic familiar with solar air systems		Same possible roof mount issues as PV
Solar Water Heating	Forklift	Plumber familiar with solar installation	• Weight and wind-loading issues • Installed on the south with minimal shading • Siting is very specific	Panel footings go in after the roof structure is complete but before actual roofing membrane is installed

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Working with Building and Inspection Officials

Because of their newer and evolving nature, renewable energy technologies are often viewed with suspicion by various building and inspection officials. Costly change orders and work shut downs can be avoided by involving these officials earlier in the planning process, reviewing their often-justified concerns, and making corrections before and during construction. By first respecting the officials' far-reaching authority to completely halt the construction process, everyone involved can avoid creating a situation where the officials ever feel it necessary to fully exercise their power to the detriment of the project.

These building and inspection officials often have extensive knowledge and background in the trades they represent and can become an invaluable design resource to the project instead of an impediment. Because of the incredible variation in types of equipment and systems they must inspect, they generally do not have time to devote to the latest developments in renewable energy technologies. The use of standard building, plumbing, and wiring methods when possible will help build their confidence in the work and alleviate the perception that renewable energy technology is different than other more familiar types of construction. The inspection process can often involve many partial inspections at various stages of construction, so it is important to know the various inspectors, when they will be coming, and what they expect.

It is imperative to have knowledgeable, experienced experts that can amicably deal with the questions and concerns on a timely basis. Design of all renewable energy systems should already comply with all national and local building codes and standards. Any compliance concerns raised by officials should be dealt with seriously to determine if it is a design error. If not, this can be an opportunity to expand the official's knowledge of a new technology.

Knowing in advance what special concerns each particular official may have is also very important. What works in California for example, may well be frowned upon in another jurisdiction, so hiring a contractor with a strong positive relationship with the local authorities can create a much smoother project.

In addition to compliance with building codes and standards, adhering to Occupational Safety and Health Administration (OSHA) standards and maintaining a professional workplace can also improve relationships with inspectors.

Engineering, Procurement, and Construction Contracts and Performance Guarantees

Engineering, procurement, and construction (EPC) contracts with long-term performance guarantees are becoming increasingly popular for some renewable energy technologies, such as commercial-scale photovoltaics systems.

EPC contracts give the owner unprecedented assurance that the system will provide the long-term energy benefits advertised without wasting time and money with the architectural and engineering (A&E) firm or expensive change orders. These performance guarantees cover the entire installation and go way beyond manufacturer warranties that only cover specific parts and not the system as a whole.

EPC and performance guarantee contracts can be a wise choice for many reasons. Often, A&E firms do not have the in-house expertise to understand fully how to specify renewable energy systems. Due to the newer nature of these technologies and the rapidly developing nature of many technologies, this is a specialized field of its own for each renewable technology type. If the A&E firm specifies particular equipment, while it may be feasible, it may not be the optimal design or the most likely to be available at construction.

EPC contracts also provide more flexibility in equipment choices that can reduce change orders and construction delays. For example, many photovoltaic modules change specifications and dimensions on almost a monthly basis. Even the oldest and most reputable manufacturers are working to keep pace with fierce competition in the field today. Given that the modules are the heart of the photovoltaic system, it reasons that specifying a particular module in the construction documents might result in a change order and result in cost over runs and delays by actual construction.

Contractor Benefits

In an EPC contract with a performance guarantee, the contractor has a strong financial incentive to use the most reliable and highest performing equipment and to ensure the highest standards are maintained throughout installation and that any details that could influence long-term performance are addressed. Practices ranging from cherry picking highest output modules to oversizing wiring and conduit to improved operations and maintenance (O&M) plans might not be necessary for inspection or commissioning but can contribute to meeting the contractor's long-term performance liability. These same practices in turn enhance the long-term energy performance to the greater benefit of the facility and those that operate it.

Performance guarantee contracts attract top renewable energy contractors with long-term success in their fields. Less capable or experienced contractors will not savor the extra liability involved, nor will they have the expertise or even access to the top quality equipment necessary to fulfill a performance guarantee.

Contract Provisions

Certain provisions should be included with any EPC contract to ensure coordination and consistency with the remainder of the project. As noted in the selecting the design team section, all contracts and subcontracts related to the project should include provisions requiring participation in the integrated design process including coordination of design with other related aspects of the project.

The EPC contractor needs to work with the A&E firm to understand the building elements that are necessary to the integration of the renewable energy system. In addition, an EPC contract needs provisions to ensure coordination with the larger project construction team. While coordination is important, this type of design and construction contract allows the contractors to do what they do best and frees more of the agency's critical planning resources for other aspects of the project.

Additional provisions standard with other construction contract terms should also be included in the EPC contract. These include requiring the team to perform enhanced commissioning over the first year and developing an O&M manual and training for the system.

Through a combination of EPC contracts combined with long-term performance guarantees, the construction relationship is transformed from being sometimes adversarial to being a win/win situation for everyone involved.

Commissioning

Commissioning renewable energy for new construction projects and major renovations requires special consideration in selecting the commissioning agent and team, developing the specifications, conducting the full commissioning process, and integrating measurement and verification (M&V) systems.

Commissioning can reduce overall costs related to construction deficiencies and ensure more efficient building and systems operation. For new construction projects or major renovations with renewable energy systems, commissioning is critical to the ultimate goal of operating all building systems as safely, optimally, and efficiently as their designers intended.

Key Actions for Commissioning

- Plan and budget for enhanced, independent commissioning to optimize renewable energy under seasonal variations.
- Identify a commissioning agent with demonstrated renewable energy expertise.
- Include the commissioning agent in design review processes to identify issues early.
- Ensure the commissioning agent has access to renewable energy installers and experts throughout the enhanced commissioning process.
- Have facility O&M staff shadow the commissioning agent to learn more about new systems.

Enhanced commissioning, spanning seasonal variations for a year, is recommended for all projects with renewable energy systems and should be considered early in the project development. Basic commissioning ensures that the systems are operational, while enhanced commissioning takes additional steps to investigate and optimize system interactions. Enhanced commissioning not only optimizes energy performance, but it also qualifies for Leadership in Energy and Environmental Design (LEED®) credit.

Through an enhanced commissioning process, the renewable energy system performance and operations are reviewed, enhanced as needed, and verified to ensure they operate seamlessly with other building systems. When renewable energy technologies have seasonal variations in performance, enhanced commissioning optimizes performance for a wide range of operating conditions and not just a single point in time.

Delivering both short- and long-term benefits, enhanced commissioning should be viewed as an investment and not an expense. With renewable energy systems, it ensures not only that the systems are functioning properly, but also that they can be operated in conjunction with other building systems and can maximize performance and savings. Some benefits include:

- Improved energy performance and savings
- Improved occupant comfort, safety, and productivity

- Extended equipment life and reduced warranty claims
- Reduced operations and maintenance (O&M) costs.

This overview discusses how renewable energy considerations should be integrated into the commissioning team, commissioning specifications, and commissioning process. Finally, it discusses the importance of measurement and verification with renewable energy systems.

Commissioning Team

The commissioning team should be formed early in the project. It is critical that skills and technical expertise specific to renewable energy are represented across the team. The commissioning agent is central to an effective commissioning effort, and the agent should have experience with the range of renewable energy technologies and how they are integrated into the building.

The commissioning team must also include experts in each of the renewable energy systems involved and specified as part of any renewable energy subcontractors in construction. In addition to overseeing commissioning of each individual technology, the commissioning agent must be able to assess renewable energy technology performance as part of the overall building operating system.

Timing of the commissioning team selection, particularly the commissioning agent, is also important. Ideally, the commissioning agent should be designated and involved prior to the design development (65%) phase to highlight areas of concern or opportunities for renewable energy system operation and integration.

Budgeting for the commissioning team must be considered early on and must be adequate to cover the commissioning agent's upfront interactions with the design team as well as the additional costs associated with enhanced commissioning. Further information on renewable energy considerations in selecting a commissioning team is available in the commissioning team section.

Commissioning Specifications

When creating specifications for commissioning a facility with integrated renewable energy, the commissioning team must understand how the renewable energy systems integrate with the related infrastructure and equipment. They should plan for the specific impacts that new elements will have on existing building components.

The commissioning team should not only specify the commissioning of renewable energy project individual components, but should also commission all new system controls, the existing building equipment, and the building itself. This helps ensure that renewable energy system performance targets are achieved or exceeded and that the systems work efficiently within the building and its existing equipment and systems.

More information on commissioning specifications is available in the commissioning specifications section.

Commissioning Process

Commissioning is a systematic process consisting of developing system checklists, reviewing designs, testing functional performance, identifying and correcting deficiencies, and developing O&M procedures. When renewable energy technologies are incorporated into a construction project, additional emphasis should be placed on system integration and integrated operations.

Commissioning input in design review can help create an integrated design that operates cohesively. The commissioning team should review design development drafts and construction documents to identify issue with system integration and to focus attention on integration of renewable energy system controls with the building automation systems. This review is critical because efficiencies are lost and costs increase if systems are designed in such a way that the separate components can only work independently.

For most renewable energy projects, functional testing should be scheduled and performed over a longer-term basis. When the expected performance of renewable energy systems varies because of weather patterns or time of year, these systems must be tested under various operating conditions and not simply optimized for a single point in time.

For more information on integrating renewable energy into the entire commissioning process, see the commissioning process section.

Measurement and Verification

For renewable energy systems, measurement and verification systems are crucial for assessing long-term performance, fulfilling Federal reporting requirements, and meeting terms of project funding contracts where applicable.

Developed mostly during the design development phase of a project, M&V systems define project-specific methods and techniques that will be used to verify operation of a variety of systems throughout the project. With regard to renewable energy systems, this can include measuring performance output and assessing it as a function of resource input, or for example, measuring how much energy is produced from a wind system and determining if it is within expected range based on the wind speed at the time.

M&V systems need to be carefully verified during commissioning, including any interactions with building controls. Once verified as accurate at a range of operating conditions, they can be a useful tool in commissioning to get real-time data about the performance of energy systems.

Further information about M&V issues for renewable energy and related protocols is available in the measurement and verification section.

Additional Resources

Additional information is available in the FEMP guide on Commissioning for Federal Facilities: A Practical Guide to Building Commissioning, Recommissioning, and Continuous Commissioning.

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Commissioning Team

Assembling a committed team is a critical part of the commissioning process for renewable energy projects. Members of the team vary based on the size, complexity, and funding mechanism used for the project at hand.

The commissioning team lead is a commissioning agent, an independent agent representing the agency's interests. In addition to the commissioning agent, participants in the commissioning process can include the agency, operations and management (O&M) personnel, contractors, subcontractors, and the architectural and engineering (A&E) firm. The project energy lead should also be an active member of the commissioning team and work closely with the commissioning agent.

Renewable energy projects often require a team of experts in specific renewable energy technologies. Working with the general contractor and any separate engineering, procurement, and construction contractors on scheduling the commissioning agent, who oversees and verifies commissioning performed by the renewable energy installers on each individual system, plans, coordinates, and oversees the commissioning process and takes ownership of the overall energy performance for the facility.

Any construction contracts or subcontracts for renewable energy systems must include a provision that the installers are responsible for conducting commissioning testing and activities under the commissioning agent. It must also stipulate that they are available for seasonal testing required for enhanced commissioning for the first year of the project.

In cases when renewable energy projects are not owned by the agency but are financed through renewable energy project funding, those agreements may stipulate additional or separate commissioning activities by an entity hired by the agency. In such cases, those entities should be on the project commissioning team and efforts coordinated with the project commissioning agent.

Engaging an Independent Commissioning Agent

An independent, third-party commissioning agent brings the most objective perspective to the commissioning process. Appointing a member of the project design team or contractor can create a conflict of interest, as these parties will be tasked with reviewing, testing, and identifying deficiencies in their own work. Designating an independent commissioning agent to conduct enhanced commissioning can also earn Leadership in Energy and Environmental Design (LEED®) credits.

Leading the commissioning process for renewable energy projects requires a great deal of specialized expertise. An independent commissioning agent should have excellent communication skills, experience developing commissioning plans, and demonstrated success in directing the commissioning process.

Renewable energy projects add an additional layer of complexity to these requirements. Ideally, the commissioning agent must be an expert not only in the relevant renewable energy technologies, but also in how they interact with other systems.

The commissioning agent candidates should demonstrate significant hands-on experience with the commissioning or installation of energy efficiency and renewable energy technologies included in the project. Where no candidates can be identified, agencies may want to ensure that an additional independent party, such as the project energy lead, is involved throughout building energy system commissioning.

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Commissioning Specifications

Commissioning specifications outline basic requirements of the commissioning process and detail the roles and responsibilities of each party involved. System checklists, startup requirements, and performance testing procedures are typically included in the specifications to let contractors know what standards are required during the various testing phases involved throughout the commissioning process.

Since renewable energy technologies are changing and developing rapidly, it is critical to have the commissioning specifications developed by a well-informed resource with up-to-date renewable energy expertise. This resource must also have a thorough understanding of how renewable energy systems work together and affect other building systems.

It is ideal to have an independent, third-party commissioning agent develop the specifications in collaboration with the agency and design team. However, in cases when a project has a separate ownership agreement through renewable energy project funding, the renewable energy system commissioning plan may fall to an independent entity. In such cases, the plan should be included or coordinated with the overall project plan.

Developing a Commissioning Scope of Work

A scope of work for commissioning is developed as part of the specification process. For projects with integrated energy efficiency and renewable energy, this scope of work should encompass not only initial commissioning of the building energy systems, but also periodic evaluations at different points throughout the first year to ensure systems perform properly and the building is optimized during all seasonal variations.

The scope of work determines exactly how comprehensive and thorough a commissioning effort will be. For example, a commissioning scope of work for a photovoltaic (PV) system might stipulate that the commissioning agent test each string of PV modules to verify performance.

In some renewable energy projects, ASHRAE commissioning guidelines, Leadership in Energy and Environmental Design (LEED®) requirements, and best practices for commissioning specific renewable energy technologies help drive the scope of work. Reviewing testing and verification resources for specific renewable energy technologies can be helpful in determining what should be included in the scope of work for a commissioning effort.

Since the commissioning agent will typically have a vested interest in developing a scope of work that is as comprehensive and detailed as possible, the agency should be engaged in the development process. Ideally, the commissioning agent and the agency will develop a scope of work that verifies the agency's project requirements within a reasonable budget. This plan should be scoped early with the required budget included as early as possible into budget plans.

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Commissioning Process

The commissioning process is designed to verify that a renewable energy project meets specified agency design, performance, and operational requirements. To ensure that the level and focus of commissioning efforts are appropriate to the scope and complexity of the project, the commissioning planning process should begin at the same time as the design phase of the project.

- Integrating Commissioning Into the Design Process
- Developing a Detailed Commissioning Plan
- Testing Systems and Providing Commissioning Reports
- Performing Enhanced Commissioning
- Delivering Final Documentation

Integrating Commissioning Into the Design Process

The commissioning agent should attend design team meetings, review the project design at various stage of development, and make recommendations to help facilitate commissioning. The commissioning agent will note potential system performance problems, operations and maintenance (O&M) concerns, and other potential issues, depending on the scope of commissioning and the specific renewable energy technologies included in the design.

In the design phase, it is the project energy lead's responsibility to evaluate and discuss all of the commissioning agent's findings on the energy systems with the design team.

Developing a Detailed Commissioning Plan

During the pre-construction phase, the commissioning agent also develops a detailed commissioning plan that outlines the structure and schedule for the commissioning process and allows all participants to anticipate and prepare for milestones throughout the project.

The commissioning plan includes pre-functional checklists and an overview of the functional performance testing procedures performed during the construction phase. In addition to startup and standard operational testing, functional performance testing procedures for renewable energy projects must include seasonal testing to ensure systems perform as specified in all weather conditions and all seasons. The commissioning plan should include follow-up testing for renewable energy systems at a range of seasonal variations.

In some cases, the commissioning agent may be tasked with developing the testing procedures for the project. In others, the commissioning agent may review and accept testing procedures developed by renewable energy contractors or architectural and engineering (A&E) professionals. Especially in the latter case, the commissioning agent needs to verify that these are best practices for that type of system and accurate.

The commissioning plan also typically outlines the O&M training schedule for personnel and lists the warranties and manufacturer literature that will be collected from the contractor in the O&M manual for the project.

The agency may need to facilitate certain activities and procedures described in the commissioning plan, such as planned outages or special access to systems and facilities. The project energy lead should carefully review the plan to confirm that the plan is designed to verify the intended energy performance requirements for the overall building.

Testing Systems and Providing Commissioning Reports

During the construction phase, the commissioning agent should oversee and verify pre-functional and functional performance testing and document all testing procedures performed by project contractors. For renewable energy systems, testing should occur on equipment, measurement and verification systems, and related controls. As testing occurs, the commissioning agent will note deficiencies, work with installing contractors to correct them, and retest the systems. The commissioning agent should provide the agency with weekly commissioning reports that include schedule changes and updates, a list of new and outstanding deficiencies, and a list of deficiencies that have been resolved.

The commissioning agent and installing contractors typically make lower-level decisions about deficiencies and corrections, although the design team or the agency may be consulted. Particularly for decisions on energy-related systems, the project energy lead should be involved. The commissioning agent makes final recommendations to the agency regarding acceptance of each test, and the agency gives final approval to confirm that each test has been successfully completed.

The commissioning agent will also need to review and accept the O&M manuals and training proposed by the construction contractor. Encouraging O&M staff to participate in the various testing and operational phases of commissioning can help staff learn and troubleshoot systems prior to training.

The commissioning agent verifies that the training plan covers all required subject matter and develops criteria for determining successful completion of O&M training. The general contractor and installing contractors typically present the training material with the commissioning agent in attendance.

Performing Enhanced Commissioning

Enhanced commissioning verifies that, once operational, a renewable energy system continues to perform as specified by the design specifications. Enhanced commissioning is required for certain LEED certifications.

For up to a year after system installation, the commissioning agent will perform testing procedures and use measurement and verification (M&V) data to substantiate system performance across seasonal variations. It is important to note that renewable energy system installers should be contracted for the duration of enhanced commissioning to conduct required testing and make any necessary adjustments.

Delivering Final Documentation

The commissioning agent creates a final commissioning report compiling all key commissioning data for the project, including design documents, an updated commissioning plan, signed pre-functional checklists, signed performance test results, and reports on deficiencies, and corrective actions taken.

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Ideally, the commissioning agent also develops a re-commissioning manual that outlines procedures and strategies for conducting periodic commissioning-type reviews of the building systems. This keeps the system performing at optimal levels. Components in the manual can include as-built sequences of operation for all equipment, seasonal start-up and shutdown procedures, recalibration recommendations, and a list of diagnostic tools. The O&M team can use this manual as a guide in performing periodic reviews and ensuring that systems are operating as specified.

Agencies need to stipulate upfront in the contract if they want this information provided specifically by the commissioning agent.

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Measurement and Verification

Measurement and verification (M&V) play a vital role in renewable energy projects. M&V verifies verify that renewable energy technologies successfully meet the energy generation or savings requirements as specified by the agency and the system design.

Federal sustainable building guidelines require M&V systems for sustainable building projects and the use of M&V data for benchmarking systems. However, these systems deliver value well beyond regulatory compliance. They provide measureable, actionable data that allows agencies to optimize equipment and get the most out of renewable energy technology investments.

- Systems for Agency-Funded Projects
- Systems for Projects with Renewable Energy Project Funding
- Versatility of Measurement and Verification output
- Future of Measurement and Verification Systems

Systems for Agency-Funded Projects

For an agency-funded renewable energy project, it is critical that the agency include M&V considerations in the early stages of the project. When selecting a design team, the agency should look for firms with proven experience in implementing M&V systems and accurately measuring energy output in sustainable building projects.

In the project's design requirements, the agency should specify an M&V system that can:

1. Provide operations and maintenance (O&M) staff with real-time logged performance data along with corresponding weather conditions.
2. Predict appropriate system performance based on data that allows O&M personnel to easily verify system performance is within normal range.

Any M&V for renewable energy systems must also measure weather-related data to determine if performance issues are due to current conditions, such as no sunlight, or if an actual problem exists. For example, M&V technology for a photovoltaic (PV) system should measure parameters like solar irradiation levels, temperature, and wind speed. That data should be included in calculating the expected performance range for the system during various conditions.

While measurement and verification systems are usually installed by the contractor as part of the renewable energy system, it is important to have it commissioned by an independent, third-party commissioning agent. Besides confirming proper operation and installation, the commissioning agent must oversee the independent verification of all measured parameters and ensure that the calibration of equipment is adjusted if necessary. Some equipment may need to be re-calibrated on a regular basis by factory-trained personnel to meet required standards. The commissioning agent should also ensure that operational procedures for the M&V system are thoroughly documented and included in the O&M manual.

Systems for Projects with Renewable Energy Project Funding

For a renewable energy project with separate project funding, an M&V system is typically included as part of the arrangement with the energy service company (ESCO) or utility company.

Payments to ESCO are based on energy production or energy savings data produced by the renewable energy system and are recorded based on data from the M&V system.

For example, if an agency used separate project funding for the PV system incorporated into a building construction project, they may not own the system but contract a service provider a certain amount per kilowatt-hour generated from the system. The M&V system provides the energy output readings used to calculate payments to the provider. In this case, the M&V systems will likely be designed, built, and managed by the ESCO. The agency should specify that this M&V system be verified in commissioning and coordinated with other M&V systems in the building as appropriate.

Versatility of Measurement and Verification Output

An M&V system can easily pay for itself. By identifying performance issues, it allows O&M staff to make the adjustments or repairs necessary to optimize performance and maximize savings. Once verified, M&V technology can also help inform commissioning by measuring and providing data on system performance.

Federal objectives for renewable energy technologies include educating the public and building staff to support alternative energy sources. Measurement and verification systems can serve as a powerful tool in this effort. For example, a Federal agency might set up a visitor kiosk with information on the renewable energy technologies incorporated into its facility and include a link to online M&V data on how much energy the technologies are currently generating and over the project's lifetime. Simple metering can even show how many tons of CO2 are being prevented from entering the atmosphere.

Future of Measurement and Verification Systems

Measurement and verification systems are developing at a rapid rate, especially technology that allows facility owners to see the combined functions of all the renewable energy systems on the building. By providing an Internet connection with the M&V systems, the output can be viewed by multiple people in real time. O&M personnel, commissioning agent, the facility manager, and other interested parties can all have password-protected access to view all the system parameters.

Remote monitoring of renewable energy systems allows the use of programmed alarms and even automatic e-mails to be sent when the system is not performing properly. Managing advanced system controls, especially between many different types of equipment, becomes a programming issue rather than a much more expensive hardware issue. Repairs can be made in days instead of months, vastly improving overall energy performance.

Sophisticated M&V systems can also reduce commissioning costs by allowing the commissioning agent to view most system parameters remotely. With extensive data logging capabilities, this new generation of M&V systems provides long-term performance data that is easily imported into spreadsheets for detailed analysis.

Finally, the O&M personnel and the commissioning agent can check the building's operation in a variety of conditions year round without having to be physically present for all operating conditions.

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Operations and Maintenance

Operations and maintenance (O&M) programs are critical to successfully integrating renewable energy into new Federal building construction and major renovations. This overview covers the importance of O&M programs for renewable energy projects, creating a successful O&M program, and identifying the right team to carry out the program. It highlights typical renewable energy issues and recommends following the design, specifications, and recommendations from product manufacturers.

Key Actions in Operations and Maintenance

- Make O&M a priority to protect agency investment.
- Include O&M input in design reviews.
- Require O&M manuals and training as closeout in any construction contracts.
- Provide training so facility staff is comfortable with new technologies.
- Assemble a team of accredited experts in specific renewable energy technologies. This can use a mix of third-party contracts, new hires, and internal training.

Operations and maintenance programs should enhance and optimize the operation of a building and its equipment, such as HVAC, lighting, and renewable energy systems. Proper O&M ensures the building and systems operate safely, reliably, and efficiently. It also ensures that Federal agencies get the most out of renewable energy investment. Reducing inappropriate or premature equipment failure through corrective and preventive maintenance is critical to equipment life expectancy.

O&M requirements and costs should be considered when selecting renewable energy technologies because they affect the budget and may influence design choices. O&M for renewable energy systems could be performed by in-house staff, a third party, or through a project funding agreement, such as an energy savings performance contract (ESPC), utility energy service contract (UESC), or power purchase agreement (PPA).

O&M procedures vary significantly among renewable energy technologies. At one end of the spectrum, passive systems, such as passive heating or daylighting, have little O&M beyond the typical building envelope. More complex renewable energy systems, such as a wind turbine or a biomass heating facility, require detailed and ongoing O&M.

Operations and maintenance budget should be planned appropriately and considered as early as the planning and programming phase. O&M costs typically consist of equipment maintenance costs, such as equipment and parts replacement, and labor costs. Technology-specific procedures and cost information can be found in the technology resource pages.

A well-designed O&M program ensures renewable energy systems and equipment meet expected performance criteria. This prevents renewable energy system failures, which can lead to disruptions and energy production losses. A well-functioning O&M program not only handles complaints; it also formulates proactive responses and correct practices to mitigate problems.

Once the operations and maintenance program is defined in a renewable energy project, a typical O&M process can be applied. The three major components of the O&M program include:

- Operations and Maintenance Manual
- Building a Team
- Training

Operations and Maintenance Manual

An operations and maintenance manual is typically developed by the general contractor and verified by the commissioning agent. It should have customized specifics of the renewable energy system to ensure optimal system production and performance.

Given the complexities of many renewable energy systems, the O&M manual should be thorough and user-friendly, clearly define the roles and responsibilities of O&M staff, and be accessible to all staff. The goal is to support the life-cycle of the system by eliminating unplanned shutdowns and realizing life-cycle cost savings.

The manual typically contains maintenance schedules and checklists, manufacturer installation and maintenance instructions, troubleshooting procedures to solve system malfunction problems, special inspection verification and certificates of completion, and safe operating procedures. Custom-designed renewable energy systems also need full details on the design and operation of the system in addition to manufacturer's literature. Tracking procedures and forms aids in tracking actual equipment performance against expected performance.

More information and details can be found in the operations and maintenance manual section.

Building a Team

Trained and experienced O&M teams are critical to ensuring the operations and maintenance plan for the renewable energy system is implemented systematically and effectively. If an O&M team is not familiar with the renewable energy technologies and their interaction with other building systems, the equipment can be underused and miss performance targets. A mix of training, new hires, and outside contracts may be used to meet experience requirements of the O&M program.

In-house staff should also have a thorough understanding of the O&M procedures, whether it will be performed in-house, outsourced, or included as part of a project funding package. A centralized team serving multiple facilities or campuses can be very cost-effective.

Operations and maintenance staff familiar and experienced with renewable energy technologies should review building designs to identify and resolve O&M issues as early as possible.

More information is available in the operations and maintenance team section.

Training

After renewable energy systems are designed, installed, and commissioned, building O&M staff need training to make sure that the systems function at the highest level. This usually involves hands-on training with the equipment and a full O&M manual that can be used as a daily reference.

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The agency should also look for early opportunities to train key facility staff, including early training on general renewable energy and energy efficiency issues as well as observing commissioning activities to gain hands-on experience with the new systems.

Formal O&M training with construction closeout should cover basic information about the workings of the technology and the amount of energy the system will typically produce. It should also supply practical information on operating and maintaining systems, understanding measurement and verification systems, and troubleshooting any problems. Training should also explain how the renewable energy systems affect and interact with other controls and facility systems.

The level of training required depends on the renewable energy technologies. Some technologies are more involved than others. Checklists for any of the renewable energy technologies help the staff perform routine checks on the system. Refresher training for all renewable energy technologies should be offered to ensure the system operates at the highest level throughout its lifetime and that the staff is kept current. To keep training at the forefront, future training courses should be scheduled early.

For additional information, see the operations and maintenance training section.

Operations and Maintenance Manual

Closeout of the construction phase for renewable energy projects includes the creation of a comprehensive operations and maintenance (O&M) manual. Although specific content varies depending on the size, scope, and complexity of the project, the O&M manual typically includes manufacturer literature, basic operating procedures, troubleshooting techniques, measurement and verification (M&V) system documentation, and maintenance information.

The general contractor should compile O&M documentation, gather as-built drawings for equipment and systems, and take the lead in organizing the manual. The commissioning agent reviews the manual to verify that it includes all necessary documentation, including:

- **Manufacturer Literature:** The general contractor gathers manufacturing literature for all major equipment types used in the project, including any renewable energy components. Manufacturing literature includes contact information for the manufacturer, specifications, warranty information, operational details, parts lists, and safety data.
- **Renewable System Information:** Since most renewable energy systems are designed specifically for the application, manufacturer literature only tells a small portion of the story. The renewable energy contractors responsible for the system should provide details on the components of the system, how they work together, and details on the design.
- **Operating Procedures:** The general contractor or renewable energy system installers should document basic operational procedures for the installed systems, including system start-up and shut-down. The documents should be short and concise with procedures described in plain terms. The procedures can refer the user to manufacturer literature for additional information as necessary. The general contractor should be responsible for providing information on interactions between systems that are not covered in individual component system information.
- **Troubleshooting Techniques:** The general contractor should also document troubleshooting techniques to assist O&M personnel in addressing issues that may arise with the systems they will be maintaining.
- **M&V System Documentation:** The renewable energy system installers should document standard system performance ranges and provide instructions on reading and interpreting M&V data. This may be tied to broader M&V system design from the architectural and engineering (A&E) firm, or it may be part of the individual renewable energy system design.
- **Maintenance Information:** The type of maintenance program required will depend on the renewable energy technologies included in the project. For example, photovoltaic (PV) systems or passive systems such as daylighting typically need very little maintenance but do require periodic inspections. Solar hot water systems require annual maintenance. And, wind turbines require more frequently scheduled maintenance.

The O&M manual should include a maintenance plan with schedules and task descriptions for any regular preventative maintenance that needs to be performed. It should also list any monitoring signals designed to alert O&M staff to the need for corrective maintenance.

Some renewable energy systems may require third-party experts or personnel meeting the manufacturer's certification requirements to perform corrective maintenance. For some systems, this may be required by warranty. The manual should clearly delineate between tasks that O&M staff should perform and tasks that should be performed by experts in the particular renewable energy system.

In the course of maintaining the system, it is important for O&M staff to document any performance issues or out-of-the-ordinary maintenance requirements and add this documentation to the O&M manual. If there is a significant turnover of O&M personnel, this documentation will be critical for new staff members.

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Operations and Maintenance Team

Assembling the right set of skills and resources to operate and maintain a renewable energy system is critical. Renewable energy technologies only perform as specified when managed by a well-trained, highly motivated operations and maintenance (O&M) team.

For a renewable energy project financed through an energy savings performance contract (ESPC) or a power purchase agreement (PPA), primary O&M services are typically delivered as part of the agreement, but in-house staff will need some familiarity with the system. For agency-funded projects, O&M services may be provided by in-house facilities staff, a contracted service provider, or a combination of the two.

Experienced O&M staff can provide valuable input and should be included in design review. During the design phase, O&M personnel not only begin learning about the renewable energy systems to be installed, but can provide design input that will facilitate optimal O&M practices later on. For example, O&M staff can provide recommendations on the placement of walkways or special access needed to service various systems.

Leveraging In-House Personnel

Although some agencies have the opportunity to hire full-time O&M professionals with renewable energy expertise, others have existing facility personnel requiring renewable energy training.

When hiring new facility personnel, agencies can specify minimum experience with renewable energy technologies, especially the ones included in the new facility. Leadership in Energy and Environmental Design (LEED®) certification, particularly the LEED AP Operations and Maintenance credential, can be highly useful for facility staff, and this could help one candidate stand out over others. However, LEED involves a range of sustainable building information and will not necessarily denote any specific experience with or understanding of renewable energy technologies. Although certification as a qualified installer in the relevant renewable energy technologies is not needed for this level of employee, it would certainly be beneficial. The more experience available in-house, the more likely the agency can save money by reducing outside contracts.

Ideally, O&M training begins while the renewable energy project is being commissioned. O&M staff can shadow the commissioning team at key points in the process and start learning about the equipment before it becomes operational. While LEED training for facility staff can help with a broad-based understanding of the range of energy and other sustainable measures built into the facility. It should not be expected to provide specific renewable energy training.

O&M personnel should also receive more structured training at the end of the project's construction phase. In addition to covering basic operations, safety procedures, and troubleshooting techniques, this training should provide an understanding of how the renewable energy system is integrated with surrounding systems and infrastructure. Additionally, it should prepare O&M staff to interpret measurement and verification (M&V) data and incorporate it in their ongoing maintenance programs.

Renewable energy systems typically require specialized O&M training extending beyond the instruction provided during commissioning. In-house staff can receive additional training from renewable energy equipment manufacturers and other external resources.

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Engaging Third-Party Resources

Many agencies contract third-party resources to provide O&M services for their renewable energy systems. By using a third-party operations and maintenance provider, an agency can get specialized renewable energy expertise without investing in extensive staff training. However, some agencies find having an in-house maintenance team on-site at all times more advantageous.

An agency can also choose a phased approach in which a third-party O&M provider serves as a training resource for in-house facilities staff. For example, an agency might set up a one- or two-year contract with a third-party service provider offering the required renewable energy expertise. The regularly scheduled inspections can serve as training sessions for in-house facilities staff and, at the end of the contract, the staff is prepared to take over O&M for the renewable energy system.

Operations and Maintenance Training

To keep a renewable energy system performing at optimal levels, operations and maintenance (O&M) personnel must receive thorough training.

A renewable energy system may be properly installed, but without a robust O&M program in place, it will not perform as specified over the long-term. Even if O&M services are outsourced to a third-party or provided as part of a renewable energy funding arrangement, on-site staff should be trained to perform basic O&M procedures.

Key Actions in O&M Training

- Have O&M staff shadow Commissioning Agent during commissioning for early interaction with new renewable energy equipment.
- Train facility staff fully on O&M manual and building systems, regardless of O&M contracts on renewable energy systems.
- Provide key facility staff with general renewable energy and LEED training prior to building start-up.
- Look for opportunities for O&M staff to learn from external O&M contractors.

Operations and maintenance training is cited as a requirement for construction efforts, but too often, the actual training is provided as an afterthought in the final stages of a project and is poorly coordinated, loosely structured, and lacking well-defined objectives. In many cases, training responsibilities are handed over to contractors who can provide adequate training in the systems they have installed, but fail to explain how these systems should operate in concert with other systems and infrastructure.

Agencies should include detailed provisions in construction contracts that require O&M documentation and training as part of closeout activities.

- Starting Staff Training Early
- Creating a Formal Training Program
- Providing Additional Training

Starting Staff Training Early

As soon as key facility staff is identified for a new construction project or major renovation, the agency should look for opportunities to increase their familiarity with renewable energy and energy efficiency technologies and issues. A range of renewable energy training opportunities are available, and staff could take these prior to building construction. Leadership in Energy and Environmental Design (LEED®) AP Operations and Maintenance certification of at least one member of the facility staff can prove useful in optimizing building system performance and ensuring systems run as intended, but this should not be considered a substitute for training with specific renewable energy systems.

Operations and maintenance training should be a dynamic process intertwined with a larger commissioning effort. Ideally, O&M involvement will begin during the initial stage of the commissioning process with select O&M personnel participating in commissioning team meetings.

The start-up and functional testing procedures performed during the commissioning process also provide good training opportunities for O&M personnel. By shadowing the project team during testing procedures, O&M staff can gain invaluable insight into renewable energy system operations.

Creating a Formal Training Program

In addition to their involvement in key steps throughout the commissioning process, O&M staff should also receive more structured training from the general contractor and other renewable energy installers. At the end of the project construction phase, the general contractor compiles all necessary O&M documentation and, in some projects, collects written training plans from renewable energy installers. Each plan should list the equipment or system covered in the training, intended audience, location of the training, objectives, subjects covered, duration of training on each subject, instructor for each subject, and training methods involved (lecture, site walk-through, etc.).

The general contractor develops an overall training plan and coordinates scheduling for the training. The commissioning agent will review the training plan to verify that content is complete and develop a set of criteria for determining when O&M training has been successfully completed.

The general contractor and renewable energy installers present the training material with the commissioning agent attending all training sessions. Although content will vary based on the renewable energy systems involved, general topic areas for O&M training include:

- **Basic Operations:** Training should reiterate standard operational procedures, including system start-up and shut-down. For renewable energy, the training should discuss the performance variability expected during different weather and seasonal conditions.
- **Health and Safety:** O&M staff are typically accustomed to working with electrical systems, but few have extensive experience with high-voltage direct current (DC). Training for the applicable renewable energy systems should thoroughly cover DC-related safety procedures.
- **Emergency Procedures:** O&M staff members must be taught emergency protocol, including the procedures for emergency system shut-down.
- **Troubleshooting:** Training should cover basic troubleshooting techniques and identify resources for further reference. For renewable energy systems, training should also include information on when to identify the need for outside expertise.
- **Systems Integration:** O&M staff must understand how a renewable energy system integrates with surrounding systems and infrastructure.
- **Measurement and Verification (M&V):** For renewable energy projects, O&M personnel must be trained in the M&V systems used to track output and performance. M&V technology provides data that can guide O&M staff in making the adjustments necessary to optimize equipment.

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Providing Additional Training

Operating and maintaining a renewable energy system requires a specialized set of skills. Depending on the complexity of technology involved, O&M personnel may need additional training or certification from an equipment manufacturer. In these cases, an external O&M contractor might originally be hired, but the facility staff should take every opportunity to learn from external resources. Within a couple years, the in-house staff may be able to achieve certification and take over those responsibilities. Providing advancement or other incentives to employees to reach these new skill levels can benefit both facility staff and the agency.

Additional training is also required whenever there is significant O&M staff turnover. For instance, when a facility's management and operating contract changes hands, an entirely new O&M team might be brought on board. Comprehensive O&M training on the facility and its integrated renewable energy systems should be included as a provision in the new contract.

In addition, if the facility finds itself in a situation where staff turnover has resulted in mostly untrained personnel on the renewable energy systems, the original installers or another team with similar experience should be brought in to re-train the staff and ensure systems are used correctly.

Major Renovations

Major renovations are more constricted in design choices than new construction, but can still offer a wide range of opportunities for integrating renewable energy technologies into the renovation process. During a major Federal building renovation, more design factors may be pre-determined, such as building site and orientation, but a whole building design approach can still offer the most economic and efficient options. Federal agencies are required to incorporate the Guiding Principles for High Performance and Sustainable Buildings within new construction and major renovations. The Guiding Principles are required for any major renovation or repair of Federal buildings, including provisions for including solar water heating and other renewable energy technologies where life-cycle cost effective into different renovation types and special building types.

Project Phases for Major Renovations

The major renovation process still follows the phases of project design and construction, from planning to operations and maintenance. More information on how to integrate renewable energy into the phases of design is discussed in the main portion of this Guide.

Even when only certain portions of a building are undergoing renovation, the design process should approach the renovation as a whole rather than simply as a renovation of a series of sub-systems in a building. All stakeholders, from design professionals to the building occupants, can be included in the design process. Stakeholder involvement ensures successful integration of energy savings measures and inclusion of renewable energy in renovation design.

The renovation team should determine the potential for various types of energy efficiency improvement measures and the renewable energy technologies to fit within the renovation. Certainly the basics of assessing renewable energy options should be followed, but depending on the type of facility areas planned for renovation, certain renewable energy technologies are more likely to be considered. For instance, since daylighting may be considered an energy efficiency measure and a renewable energy measure daylighting may be considered at the earliest stages of project planning. Proper daylighting design may involve renovations to the facility's roof, building envelope, plumbing, electrical system, and interior layout, so would need to be considered early on. Integration of energy efficiency measures and renewable energy into the design must start in the earliest stages of project planning.

Renewable Energy Options by Renovation Type

Different types of renewable energy technologies should be considered based on the type of renovation. As with any sustainable design, energy efficiency of the building should be considered as well.

While some renovations only involve one or a few sub-systems in a building, others are more extensive. Extensive renovations, such as building additions or "down-to-stud" renovations, involve all aspects of a facility. Compliance renovations, such as with asbestos or mildew removal, can open certain opportunities for renewable energy as well.

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Special Building Types

A number of other factors can determine the ability to use renewable energy in a renovation. For instance, certain types of buildings have special energy considerations. The renewable energy opportunities in various Federal special building types such as warehouses and service buildings, hospitals, data centers, laboratories, remote facilities, residential units, and historic buildings can have their own requirements and needs.

Renewable Energy Opportunities by Renovation Type

Renewable energy opportunities should be considered and identified in the earliest stages of Federal project planning and the team should assess the renewable energy options based on the type of renovation for the facility prior to making any significant decisions about the building design and goals.

Integrating renewable energy into major renovations follows the same processes in design as for other construction projects. However, renovations will necessarily be more limited in some design choices related to renewable energy, such as site selection and building orientation. This section of the Guide attempts to give a first step in understanding the considerations when integrating renewable energy into major renovations.

Renewable Energy Options by Renovation Type

	Daylight-ing	Photo-voltaics	Solar Water Heating	Solar Ventilation Air Preheating	Passive Solar Heating	Geo-thermal Heat Pump	Bio-mass	Wind	Renew-able Ready
Lighting	X	X							X
Plumbing			X		X	X			X
Electrical	X	X							X
HVAC			X	X	X	X	X		X
Roof	X	X	X						X
Interior Construc-tion	X		X	X	X				X
Building Envelope	X	X		X	X				X
Utility Service Upgrade		X						X	X
Land-scaping / Parking		X	X			X		X	X
Other	X		X						X

The table shows a variety of renovation types (lighting, plumbing, etc.) and identifies potential renewable energy opportunities. Most likely, any renovation will combine a number of these types of renovations into a larger project. It is important to view the renovation as a whole, rather than as modifications to a variety of sub-systems.

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As part of whole-building design approach the design teams for various components should work together from the earliest stages to identify and capitalize on various energy opportunities.

Each renovation type, including extensive renovations, has further explanation provided about the renewable energy options in design development. This information is not comprehensive, but it can be useful in the screening of technology options that should occur prior to design development. Actual facility loads and system economics will affect which technologies are selected as well.

Even when renewable technologies are not included in a renovation, certain elements can be simply incorporated into the design that would be costly to add later. This keeps the option open for the use of certain renewable energy technologies. This is important since the economics of systems are highly dependent upon external factors, such as government policies and fuel prices, which can change quickly.

Since energy efficiency is often the most effective way to reduce energy costs, each renovation section also includes a brief discussion of energy efficiency measures to be considered in that renovation. While this is not comprehensive, it notes the importance of energy efficiency in sustainable design and provides links to additional resources.

Special Building Renovations

A number of building types have specific energy uses and needs, and as such the renewable opportunities may be different from a typical office building. This section briefly discusses the following Federal building types with specific design considerations for renewable energy: data centers, historic buildings, hospitals, laboratories, remote facilities, residential, and warehouses and service buildings.

Data Centers

Because data centers account for an ever-growing amount of energy consumption, designing high efficiency data centers is both a sustainable and economic option. Coupled with energy efficiency measures, renewable energy technologies can provide some opportunities for data centers. Since many systems require 100% makeup air, solar ventilation preheat can be useful in reducing the conditioning load of a large air turnover. In addition, photovoltaic systems can be specially designed for use in conjunction with uninterruptible power supply (UPS) systems to provide power for critical systems during power outages. More information is available on UPS in electrical renovations. The Federal Energy Management Program also has a range of additional information on energy efficiency in data centers.

Historic Buildings

Integrating renewable energy technologies into historic buildings can be tricky due to the constraints of historic preservation and the condition of the building. However, integrating renewable energy can be done and there are several options.

Hospitals

Hospitals can take advantage of various renewable energy technologies when undergoing a renovation, including solar water heating, geothermal heat pumps, biomass heating, and photovoltaics.

Laboratories

On average, U.S. laboratories use far more energy and water per square foot than office buildings and other facilities. Laboratories for the 21st Century (Labs 21) is a voluntary partnership program dedicated to improving the environmental performance of U.S. laboratories. In addition to a wide range of information on energy efficiency and water conservation, Labs21 has also developed a best practice guide for onsite distributed generation systems for laboratories.

Remote Facilities

Renewable energy can be more cost-effective when a facility is in a remote location, far away from utility transmission lines or fuel sources.

Residential Buildings

The Federal government may need to renovate residential buildings, such as Army barracks and prisons. Renewable energy technologies can be incorporated into these types of renovations.

Warehouses and Service Buildings

Many Federal facilities include warehouses or service buildings used for storage that when renovated can incorporate renewable energy.

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Training

Training is critical to successfully implementing, operating, and maintaining renewable energy systems in new Federal construction or major renovation. This section outlines the different training needs of project management, design, and facility management staff.

Designing and integrating a successful renewable energy project requires training on renewable energy system specifics, especially since systems are specialized components of a building project. Once in place, renewable energy system successful operation relies on the operations and maintenance (O&M) staff, who should fully understand the system and its interaction with other building systems.

Training is necessary at various stages of a new construction or major renovation project to ensure the staff has the right knowledge at the right time. Training needs vary according to staff experience with renewable energy, but key times to consider training are during the conceptual phase, at the start of a project, before the building design phase, and after the project construction phase.

This section introduces training requirements across different groups, including:

- Project Management Staff
- Design Staff
- Operations and Maintenance Staff

Training Federal personnel responsible for building construction recently received additional attention with the passage of the Federal Buildings Personnel Training Act of 2010. This legislation presents an opportunity to increase agency understanding of renewable energy technologies in building construction by specifying additional training opportunities for personnel responsible for building operations, maintenance, energy management, safety, and future performance.

Project Management Staff

Federal agencies should ensure that expertise in renewable energy issues and requirements are well represented across the project management staff prior to new construction and major renovation projects. This is critical to ensure the project is guided by informed decision-makers and that specifications, such as the request for proposals, include the proper language.

Renewable energy systems are becoming more common on buildings, and renewable energy requirements on Federal buildings are becoming more stringent. It is critical to train pertinent staff prior to or very early on in the project planning phase so that they are familiar with the process of incorporating renewables into a building project. For example, agency staff should understand how renewable energy relates to Federal energy requirements. Staff should learn how to conduct a preliminary screening for renewable energy options, and how to initiate a full screening of renewable resources, policies, and economics. Effective training upfront helps ensure technologies deliver the expected value in the finished project.

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For information on training opportunities on renewable energy topics, see the renewable energy training and education section.

Design Staff

If outside architects and engineers design a project, the agency can specify certain renewable energy skills and experience in the procurement process. If in-house staff members design the project, however, they might need specific training on incorporating renewable energy. Even if the design team decides to hire outside assistance with specific renewable energy technologies, the team still must have a working knowledge of technologies that allows them to understand how renewable energy systems interrelate with other building designs and controls.

The design staff must be able to consider all feasible renewable energy technologies and develop and incorporate optimized designs into all aspects of the design process up to and including the construction documents. Well-trained and experienced design staff produce the best designs. Agencies with in-house design staff may want to consider new hires or subcontracts to fill any gaps in experience.

For information on training opportunities on renewable energy topics, see the renewable energy training and education section.

Operations and Maintenance Staff

After renewable energy systems are designed, installed, and commissioned, building O&M staff need training to ensure systems function at the highest level possible. This usually involves hands-on training with the equipment and a full O&M manual that can be used as a daily reference.

Although staff needing training vary from site to site, the facilities staff, building manager, and building energy manager should generally attend at a minimum. The training should cover basic information about the workings of the technology and the amount of energy the renewable energy system typically produces. It should also supply practical information on operating and maintaining systems and troubleshooting any problems. The training should also explain how the renewable energy systems affect and interact with other controls and facility systems.

The level of training required depends on the renewable energy technology. Some technologies are more involved than others. Checklists for any of the renewable energy technologies help staff perform routine checks on the system. Refresher training for all renewable energy technologies should be offered to ensure that the system operates at the highest level throughout its lifetime and that the staff is kept current on the technologies. To keep training at the forefront, future training courses should be scheduled early.

For additional information, see the operations and maintenance training section.

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Outreach

Outreach programs are critical to successfully implementing and using renewable energy systems in new Federal building construction or major renovations. This section covers strategic considerations, building occupant outreach, public outreach, and interagency outreach. Also covered are considerations for agencies developing outreach programs for each primary audience along with links to additional information.

Rather than a "one-size-fits-all" approach, materials and activities should be targeted to three primary audiences: building occupants, the public, and an interagency audience consisting of Federal agencies and organizations planning to construct or renovate similar buildings.

For all audiences, the primary goal of outreach is to increase awareness of and engagement with the new renewable energy technologies to advance their acceptance and adoption.

- Building occupant outreach should focus on both the operation and the benefits of efficiency and renewable energy systems for buildings. This empowers occupants to monitor their energy usage and practice energy conservation behaviors.
- Public outreach should not only educate, but also demonstrate how building integrated renewable energy systems work. Public outreach methods can range from distributing media packages to presenting onsite information with interactive elements.
- Interagency outreach designed to assist Federal agencies with building similar facilities should focus on instructional materials and how-to guides that showcase the successes of the project and describe lessons learned during renewable energy implementations.

Regardless of the target audience, training and outreach programs should present information that encourages people to make informed energy choices in their daily lives. The most effective programs include a blend of educational, instructive, and demonstrative information. They are designed to be flexible—leveraging feedback from the audience and evolving in response to new developments in a highly dynamic industry. Federal agency representatives can maximize these programs by showcasing successes and communicating lessons learned.

Building Occupant Outreach

Energy Awareness programs created through outreach can engage occupants' natural curiosity and interest in their buildings. Educating occupants about the benefits of energy efficiency and renewable energy helps engage them as active participants in energy savings, bringing a higher rate of return on investment for the agency while improving environmental quality and occupant comfort. Federal employees can take immediate action to help reduce energy use and costs. Actions can be as simple as turning off lights when leaving an area for any period of time, to not using copy machines during peak demand.

EPA offers guidelines for energy management to help agencies improve energy and financial performance. EPA also hosts an annual National Building Competition for energy use reduction.

FEMP developed a handbook to help energy managers increase energy awareness and action among employees and building occupants to increase building performance. Agencies can use the Creating an Energy Awareness Program HandbookPDF to gain ideas about successful awareness campaigns. Campaign materials from current and past campaigns can help Federal agencies customize their own energy awareness programs.

Maintaining active participation from building occupants requires ongoing diligence to encourage and reinforce energy-saving behaviors. Some examples of effective educational activities for building occupants include:

- The FEMP You Have the Power energy saving checklist displayed in the office to encourage employee participation
- Installed energy consumption meter displays that show feedback data to building occupants
- Historical energy consumption and renewable energy generation reports for the building that are published and made available to the occupants
- Progress reports on achieving compliance with Federal energy requirements with the renewable energy systems
- Prominently displayed informational posters, educational briefs, and other materials on the renewable energy systems and energy conservation measures available to building occupants.

Public Outreach

Public outreach on major construction projects that incorporate renewable energy can increase awareness of the economic, environmental, and social benefits of renewable energy and energy conservation. Federal agencies have a unique opportunity to demonstrate the potential and capabilities of renewable energy technologies. Showcasing a newly constructed or renovated building that integrates renewable energy technologies, for example, is an optimal education tool as people can discover and experience operating systems in an applied environment. A well-designed and implemented public outreach program is instrumental in encouraging a broad audience to make thoughtful and informed energy choices.

Public outreach programs work best when they are primarily anecdotal instead of technical. Describing sustainable measures and behaviors can influence what people do in their homes and workplaces. A well-designed public education and outreach program could include:

- An interactive environment with educational displays, exhibits, energy generation and consumption monitors, videos, and other materials in an easily accessible public location, such as the NREL Visitor Center.
- Informational tours highlighting the buildings' energy efficiency and renewable energy technologies.
- News articles, press releases, and media events.
- Feature stories in local and national journals, newspapers, and magazines.
- Coverage on local and national broadcast and radio outlets.
- Social network tools and informational videos on websites such as YouTube.
- Fact sheets and case studies.

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- Community events, including those that are environmentally focused, such as Earth Day and Energy Awareness Month. Related activities can include an open house of the facility (where appropriate and in accordance with agency security protocols), or a sponsored booth featuring informational materials and facility experts on hand.
- Information on Federal, state, regional, and local policies that affect research, development, and demonstration of renewable energy technologies.

Interagency Outreach

Outreach materials developed to be shared across Federal agencies should document processes and procedures that went into project planning, development, construction, and commissioning. Information on successes, barriers, challenges, and lessons learned is an invaluable education tool for other agencies planning to construct or renovate similar buildings.

In addition to developing materials that document the history of a project, it's important to develop a plan to disseminate the information. A website, such as this NREL site, is an excellent, easily accessible host to library materials. Conferences that attract a large number of Federal employees, such as GovEnergy, can be an excellent venue for presentations. Publishing articles in journals and magazines that target Federal agencies is another effective method of outreach. Reaching as broad of an audience as possible is key to achieving the highest impact. Examples of outreach materials for Federal agencies include:

- Presentations
- Case studies and fact sheets
- Case studies and fact sheets
- The design-bid-build project manual specific to your project
- An in-depth report of the project from inception to completion, a comprehensive history
- Best practices

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Resources

Case studies and additional resources on implementing renewable energy in Federal new construction and major renovations are available online through downloadable PDFs or websites.

- Case Studies
- Additional Resources

Case Studies

The following case studies are examples of integrating renewable energy into Federal new construction and major renovation projects. Additional renewable energy case studies are also available. To review or download the following case studies please visit: eere.energy.gov/femp/reconstructionguide/case_studies.html

- National Renewable Energy Laboratory (NREL): Research Support Facility
- NREL RSF Webpage
- RSF Fact Sheet
- National Renewable Energy Laboratory: Science and Technology Facility
- Emerson Global Data Center
- Environmental Protection Agency (EPA) Building Region 8
- EPA New England Regional Laboratory
- One and Two Potomac Yard
- NAVFAC Building 33
- EPA Robert S. Kerr Environmental Research CenterPDF
- Alfred A. Arraj U.S. District CourthousePDF
- William J. Clinton Presidential Center
- U.S. EPA National Computer Center

Additional Resources

The following resources are focused on Federal new construction and major renovation projects, sustainable construction, and the role of renewable energy technologies in such facilities. To review or download the following resources please visit: eere.energy.gov/femp/reconstructionguide/additional_resources.html

Resource Guides

- Whole Building Design Guide (WBDG)
- WBDG: New Construction and Major Renovation Guiding Principles (WBDG)
- Leadership in Energy and Environmental Design (LEED) New Construction and Major Renovation Reference Guide
- Greening Federal Facilities: An Energy, Environmental, and Economic Resource Guide for Federal Facility Managers and Designers

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Acknowledgements

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- Lessons Learned from Net Zero Energy Assessments and Renewable Energy Projects at Military Installations
- Low Energy Building Design Guidelines
- Los Alamos National Laboratory (LANL) Sustainable Design Guide
- WBDG Federal Green Construction Guide for Specifiers
- High Performance and Sustainable Buildings Implementation Plan

Renewable Energy Planning

- Guide to Purchasing Green Power
- National Renewable Energy Laboratory (NREL): Solar Ready Buildings Planning Design
- Procuring Solar Energy: A Guide for Federal Facility Decision Makers
- Solar Ready: An Overview of Implementation Practices

Planning

- Handbook for Planning and Conducting Charrettes for High-Performance Projects
- Procurement of Architectural and Engineering Services for Sustainable Buildings: A Guide for Federal Project Managers

Construction

- WBDG: Construction Criteria Base

Operations and Maintenance

- Operations and Maintenance: Best Practices, A Guide to Achieving Operational Efficiency

Commissioning

- Commissioning for Federal Facilities: A Practical Guide to Building Commissioning, Recommissioning, Retro-Commissioning, and Continuous Commissioning
- Continuous Commissioning Guidebook for Federal Energy Managers
- Commissioning for Federal Facilities Handbook and Training

Sample Plans and Documents

- Department of Health and Human Services Sustainable Buildings Implementation Plan
- Department of Interior Federal Leadership in High Performance and Sustainable Buildings Implementation Plan

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