Integrating Renewable Energy Systems in Buildings

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ASHRAE Region IX CRC

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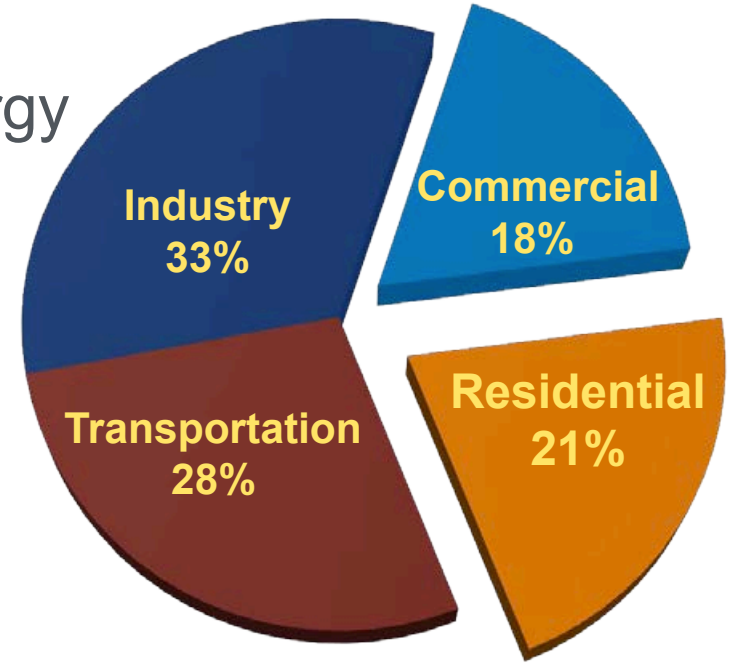


Presentation Overview

- Introduction
- RE Project Steps
- Budgeting
- Q and A

Why Integrate RE Systems in Buildings?

- Buildings account for 40% of U.S. annual energy consumption
- Most of world energy consumption is from fossil fuels
- 75% to 80% of the buildings that will exist in 2030 already exist today
- National and local energy policy moving towards requiring clean energy solutions



U.S. Buildings Prime Energy Consumption

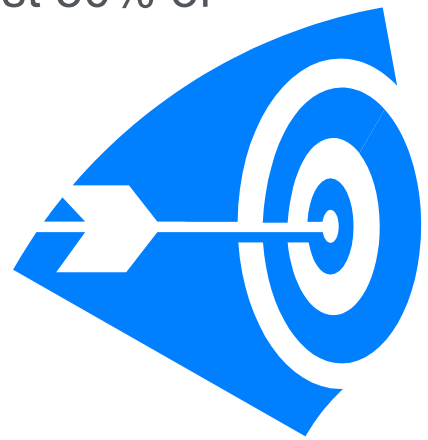
Sources: U.S. DOE, *Buildings Energy Data Book*, 2009 and EIA, *International Energy Statistics*

Getting Started

- Define your goals and objectives for energy efficiency and renewable energy use
  - Reduce peak demand, save money, make money, provide a good example, etc.
- Do an energy audit
  - Understand how the building uses energy and how to reduce total energy consumption
- Enlist help
  - Within your organization, private firms, utility, etc.
- Start to assess potential for renewable technologies
  - Refer to next slide

Project Energy Targets are Essential

- Energy targets need to be included and given priority within the program, for example:
  - Energy use should be at least 40% below the baseline of energy use for a building at applicable codes
  - Renewable energy usage must account for at least 50% of building energy use



- Better to specify targets for energy use rather than specifying certain technologies
  - Gives design team more flexibility
  - Possible to reach same goals at less cost

- Prioritize energy goals within the program
  - Prioritization now helps ensure renewable energy is not dropped during value engineering

Assess Potential for RE Technologies

- Available RE resource at or near the building site
  - Resource maps
- Available area for siting of the RE technology
  - Building roofs, parking shading structures, open land
- Cost of energy purchased from the electrical or thermal energy provider for the building
  - Utility bill information
- Available incentives for offsetting the installation cost of the RE system
  - DSIRE (www.dsire-usa.org)
- Local regulations affecting RE systems
- Desire to preserve/not alter existing architectural features
- Characteristics of energy profiles RE installation will offset
  - Software tools for modeling building energy consumption and RE system contributions

Energy Efficiency First

- Energy savings = $$$ savings
- Applicable to many operations
- Often short payback
- Non-energy benefits
  - Water savings
  - Reduced O & M costs
- $1 invested in energy efficiency saves at least $2 in renewable energy

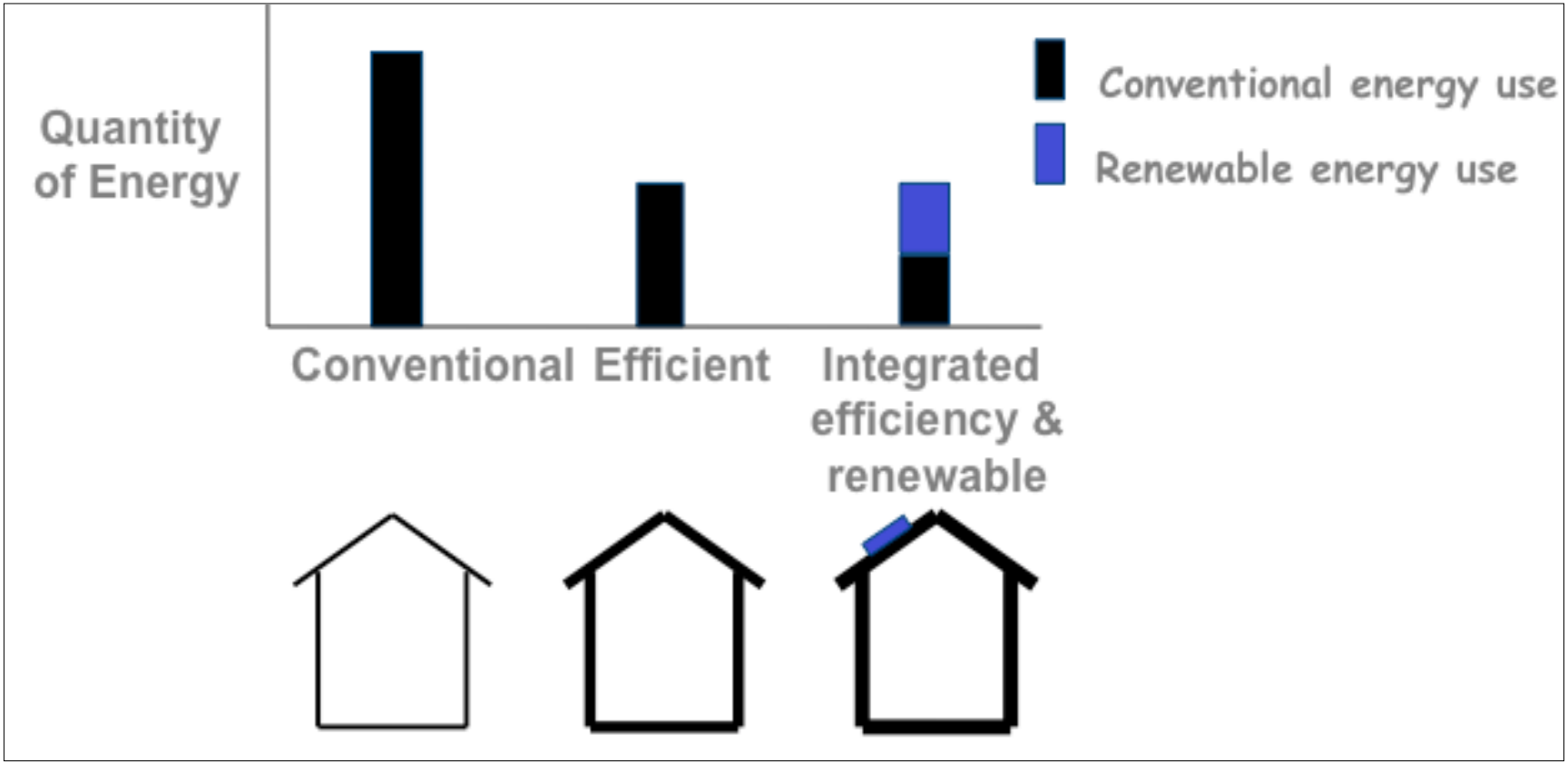
Reduce energy loads through:

- Efficient building envelope
- Building orientation
- Renewable energy (architectural):
  - Daylighting
  - Passive solar heating
  - Cooling load avoidance

Meet remaining loads with:

- Efficient HVAC & lighting equipment
- Renewable energy (building equipment):
  - Solar thermal: water heating, transpired collectors
  - Solar electric: photovoltaics, wind
  - Geothermal heat pumps

Combining EE and RE

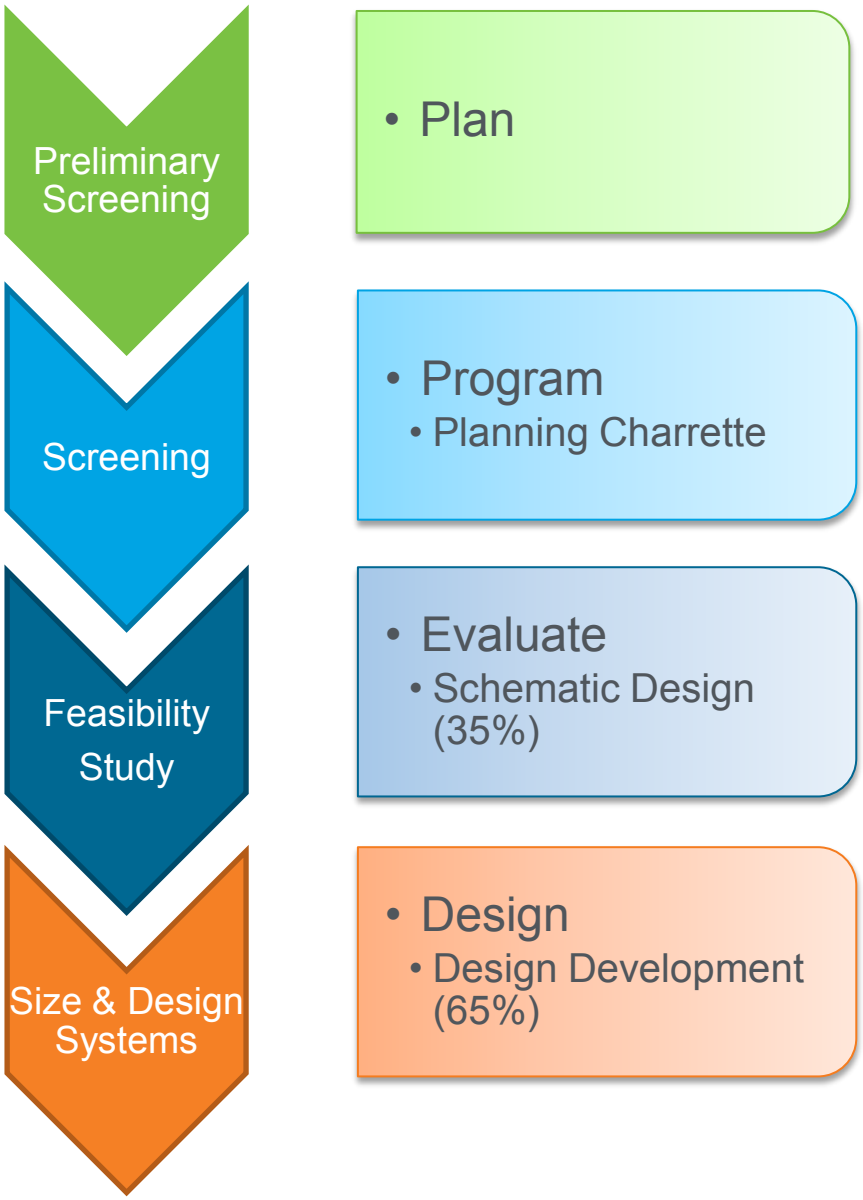


Source: National Renewable Energy Laboratory

Key Project Success Factors

- Goal: Narrow the RE options to technologies best suited to a specific construction project
- Consider renewable energy for every project
  - Almost any location can use renewable energy technologies
- Start EARLY to assess the potential for renewable energy
  - Start in early planning phase
  - Looking at renewable energy early keeps most **cost-effective** options open
  - If wait until after siting and orientation to consider, many options are lost or become more expensive

Renewable Energy Project Steps



Preliminary Screening

• Planning

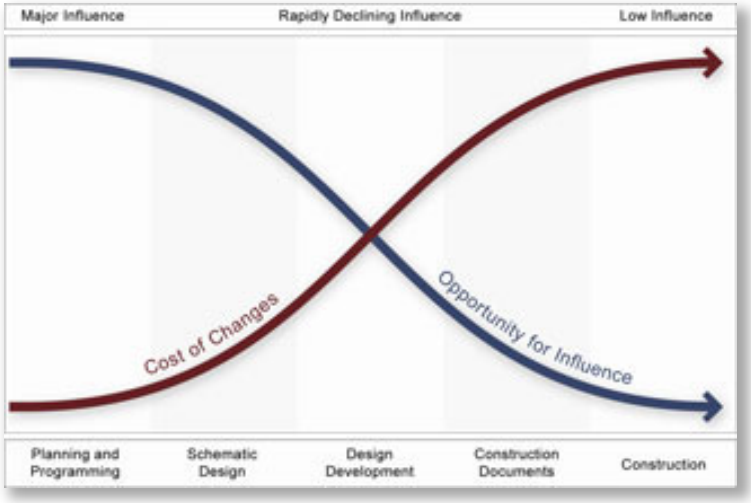
- **What:** Identify categories of renewable energy technologies to consider further
  - Availability of renewable energy resources
  - Ability to connect to grid
- **When:** As soon as a project and site are under consideration for new construction or major renovations to existing building
- **Why:** Decide which technologies are worth investigating
  - Can inform site selection and building design
- **Who:** Can be completed at the organization/building owner level with simple training, often potential design team members conduct screening

Preliminary Screening

• Planning for Renewable Energy

- Upfront planning will cost a bit extra, but can lead to long-term savings
  - Meet requirements with cheaper, more effective energy solutions

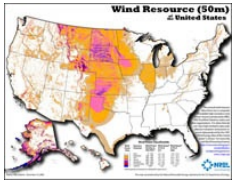
- Now is the time to think about renewable energy!
  - Considering energy now keeps options open and costs down
  - Renewable energy should be a factor in site selection
  - Understanding energy use in master planning can open up options

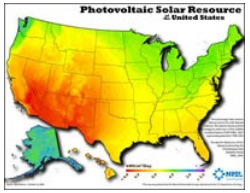


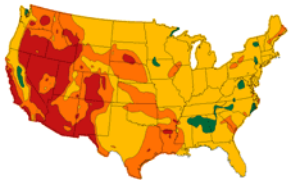
Preliminary Screening

• Factors to Consider

- Renewable Energy Resources
  - Refers to the amount of energy that can be captured
  - Resource maps provide guidance (U.S. resource maps available at www.nrel.gov/renewable_resources/)



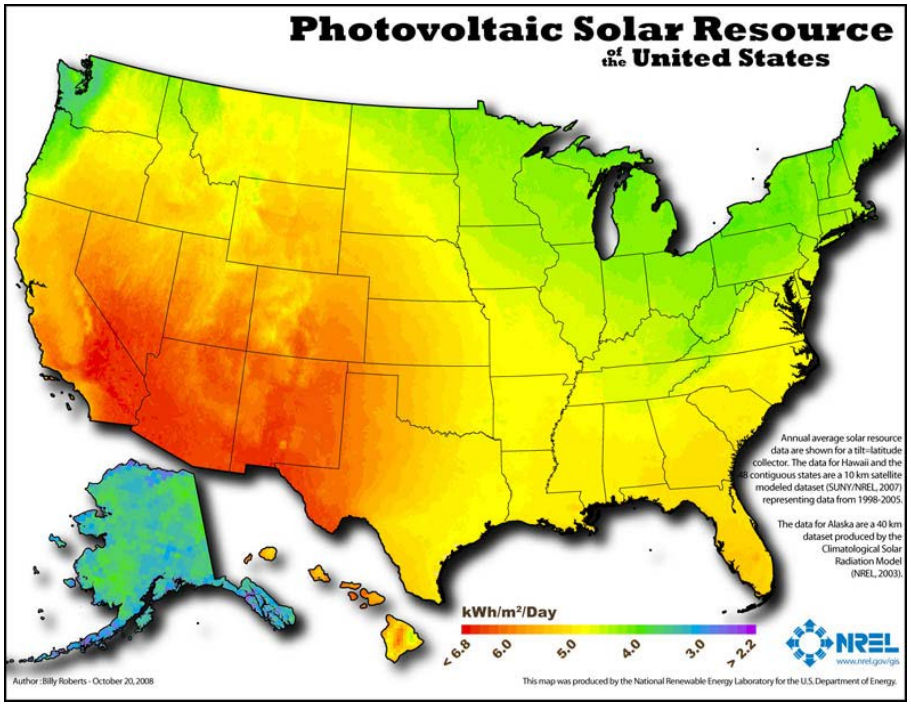




- Ability to Connect to Grid
  - Electric technologies typically must be connected to the utility grid
  - Legal ability to connect a system to the utility grid is very important
    - Referred to as “interconnection”
    - DSIRE (www.dsire-usa.org) provides a map of interconnection policies by state

Preliminary Screening

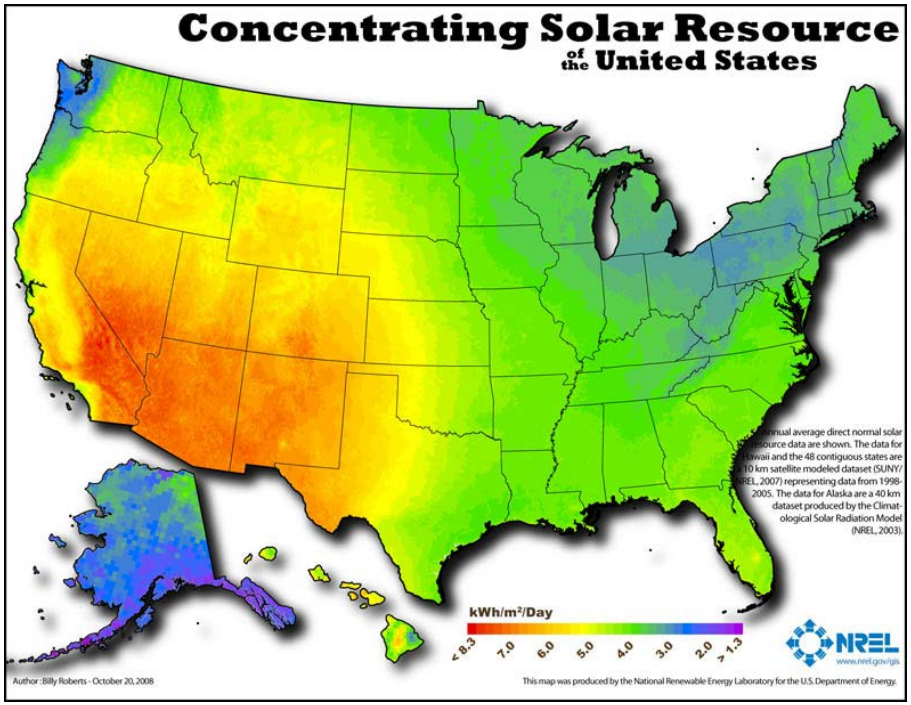
• Solar



- Solar
  - Map useful for most technologies
    - Photovoltaics, Solar Water Heating, Solar Ventilation Preheating, Passive Solar Heating, Daylighting,
  - Local energy costs, incentives, and utility policies affect the economics of these technologies as much as the resource
  - Consider these technologies at least through screening

Preliminary Screening

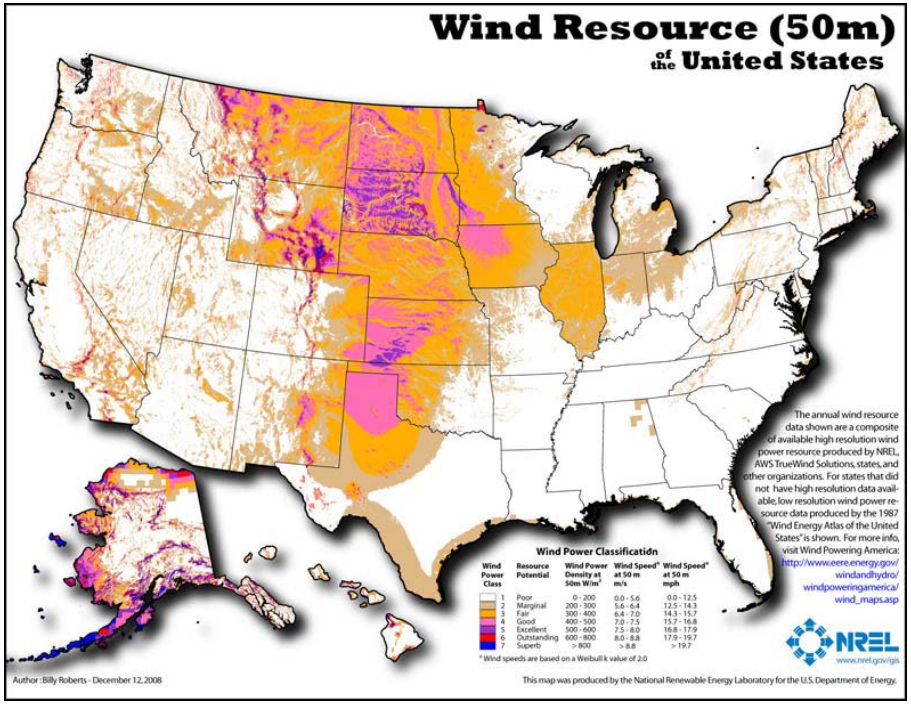
• Concentrating Solar



- Concentrating Solar
  - Concentrators can only use direct radiation from the sun
  - Drop CSP from consideration if the site is not in the southwest

Preliminary Screening

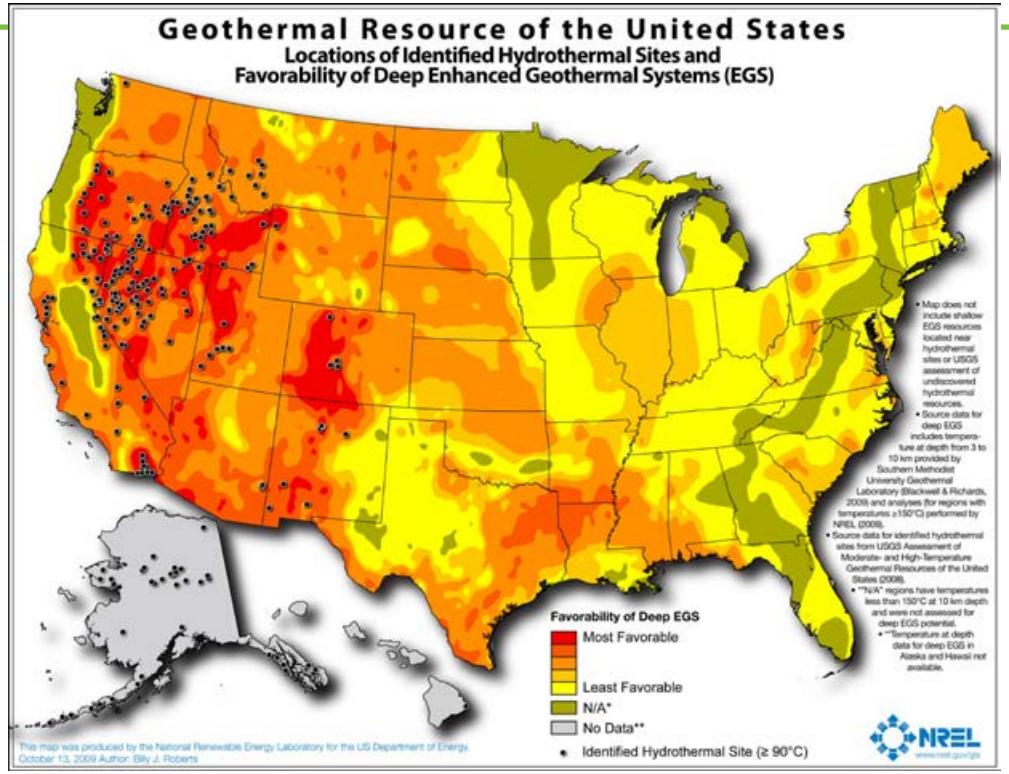
• Wind



- Wind
  - Must assess local wind resource, as the local resource varies greatly from the averages shown in wind resource maps
  - Orange (Class 3): Consider small wind (100kW or less), or large low-wind speed turbines
  - Pink (Class 4): Consider larger, utility-scale turbines (100kW to MW)

Preliminary Screening

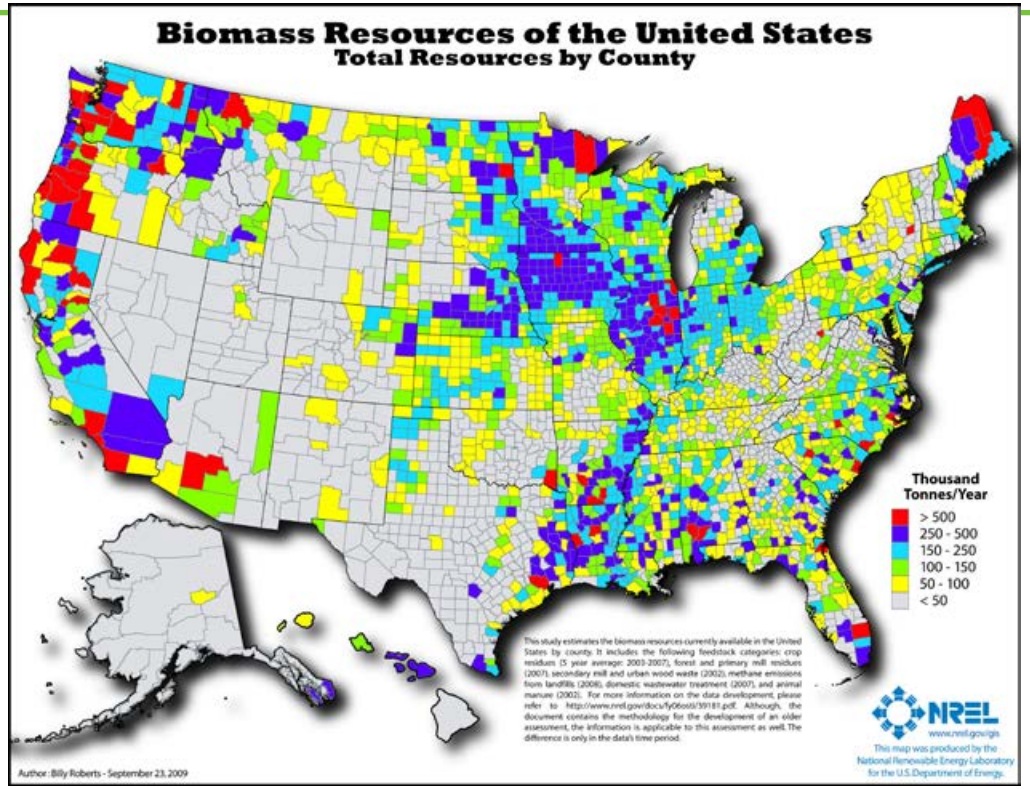
• Geothermal



- Geothermal
  - Geothermal (ground source) heat pumps can be implemented anywhere
  - Geothermal direct heat requires high temperature resources
    - Orange and red colors indicate favorable locations
    - Presence of nearby hot springs an indicator
  - Geothermal electric: only if large power needs and very high temperature

Preliminary Screening

• Biomass



- Biomass
  - If there is a permanent, steady stream of biomass resource within a 50-mile radius, consider this resource further
  - Consult a local expert if the map reveals limited or no biomass resources for the site
  - Especially good for Combined Heat and Power needs

Preliminary Screening

• Ocean & Hydropower

- **Ocean**
  - Remove ocean power technologies from consideration if the site is not adjacent to the ocean.
  - Hawaii: ocean thermal energy conversion is a potential energy technology
  - Pacific Northwest or the Atlantic Northeast: tidal energy is a potential technology

- **Hydropower**
  - FERC simplified rules available for systems under 5MW located at an existing non-power dam.
  - The Bureau of Reclamation produced an assessment in March 2011identifying 70 sites with potential for additional hydropower.
    - http://www.usbr.gov/power/AssessmentReport/Assessmentlistof70sitesbystate.pdf
  - If the site is close to one of these facilities, hydropower could be a viable technology.

Preliminary Screening

•Connecting to the Grid

DSIRE™
Database of State Incentives for Renewables & Efficiency

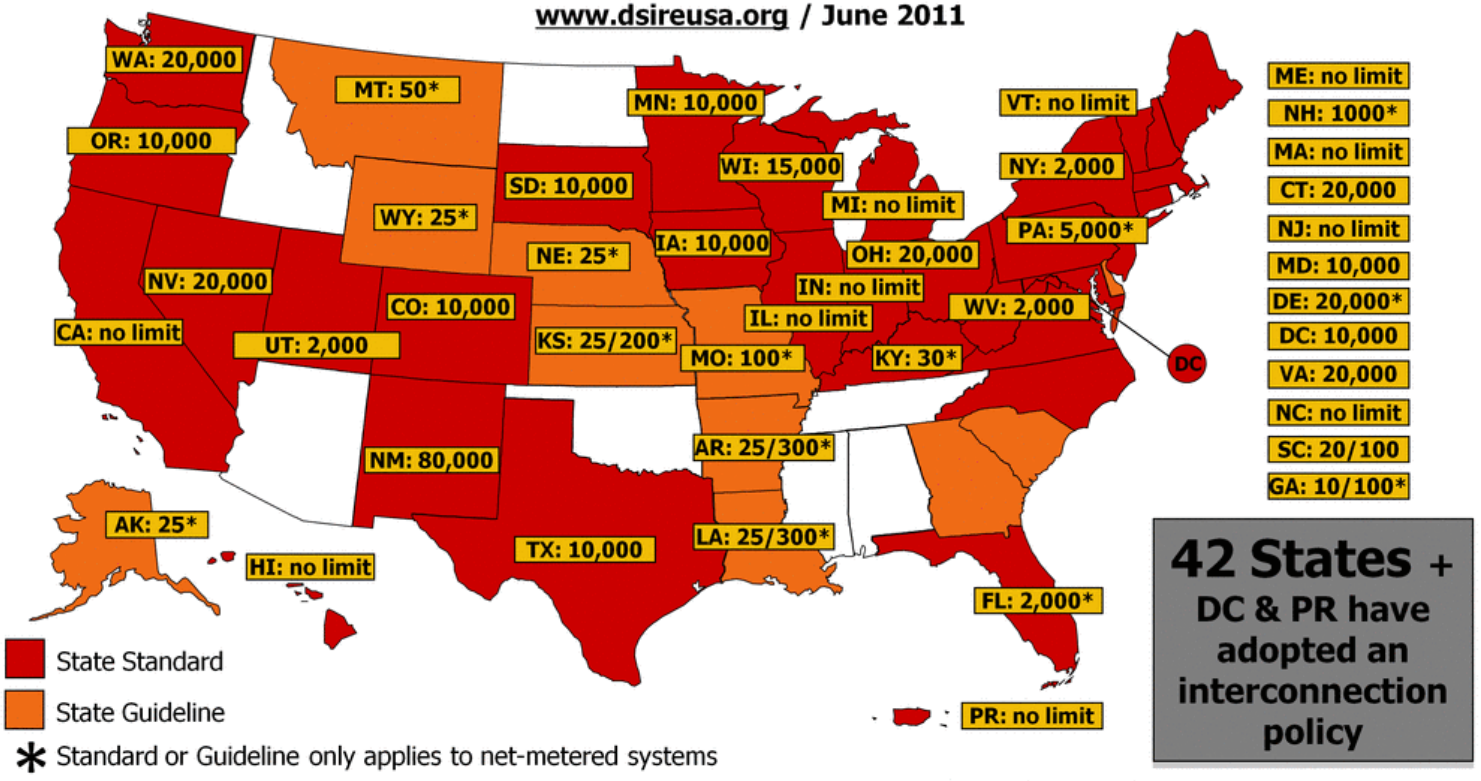
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

IREC Interstate Renewable Energy Council

North Carolina Solar Center

Interconnection Policies

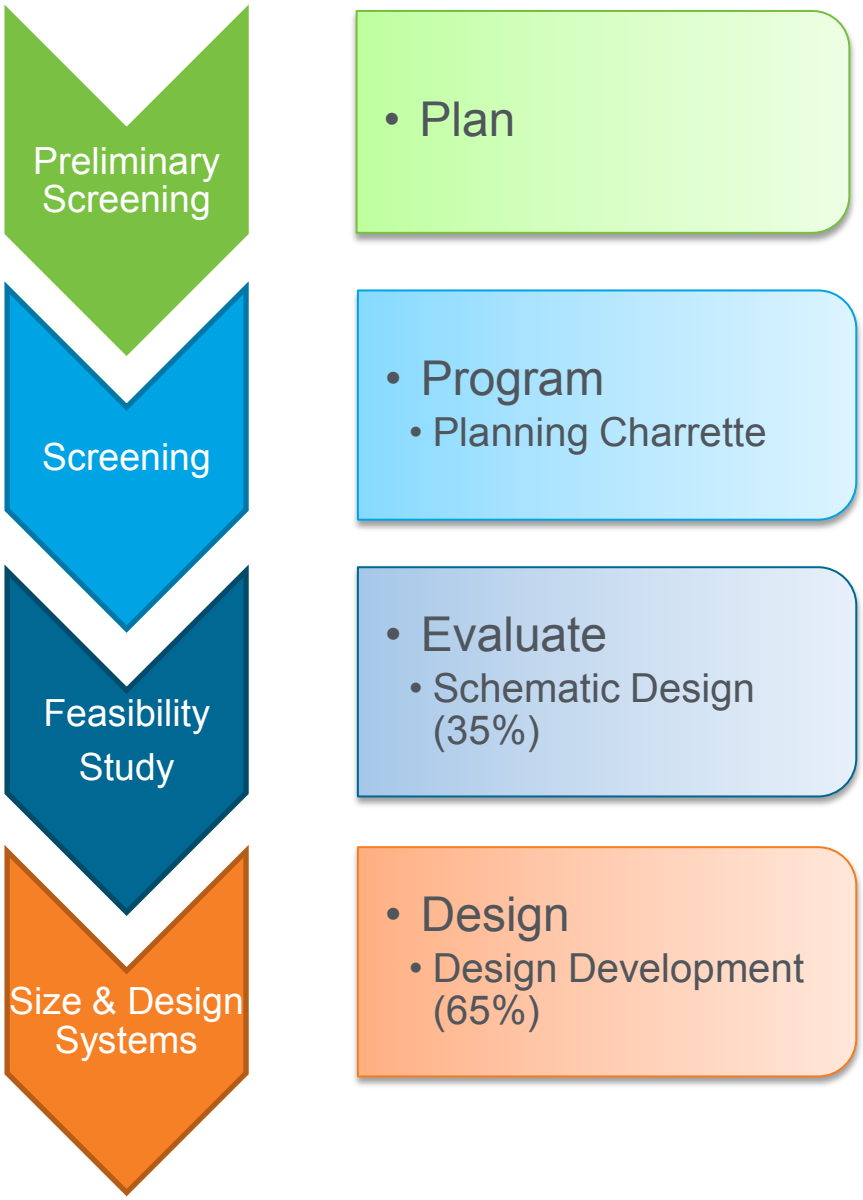
www.dsireusa.org / June 2011



42 States + DC & PR have adopted an interconnection policy

Notes: Numbers indicate system capacity limit in kW. Some state limits vary by customer type (e.g., residential/non-residential). "No limit" means that there is no stated maximum size for individual systems. Other limits may apply. Generally, state interconnection standards apply only to investor-owned utilities.

Renewable Energy Project Steps



Screening

• Programming

- **What:** Further details to factor into planning that defines the project scope
  - Preliminary estimates on system outputs and economics
  - Policy or technical limitations on use
  - Ranking or recommendations for which systems to consider further
- **When:** Early in programming phase, before planning/design charrettes
- **Why:** Further narrow the list of possible technology options to consider integrating into design
  - Information is vital to early design decisions and energy performance goals
  - Useful for creating early budget requests
- **Who:** Usually performed by an outside party (not building owner), independent RE expert/team, or design team member with RE expertise
  - Project energy lead should oversee screening
  - Organization should stipulate specific expertise required from screening team

Screening

• Process

- **Resources** available to the site
  - Analyze data to determine estimated energy at the site for various renewable energy options
  - Assessment tools
    - PVWatts
    - RETScreen
- **Economics** of renewable energy systems
  - Renewable energy costs
  - Existing energy costs
  - Incentives
  - Policies for electricity systems, net metering, etc.
- **Limitations** on use
  - Technical or policy issues that may preclude use

Screening

• Common Technologies

Start with the most common renewable energy technologies.

- **Solar Water Heating**
  - Simple and most effective where existing energy costs are high – especially if electric.
  - Other factors are solar resource and available incentives
  - Required in EISA at 30% of facility needs if cost-effective
  - For renovations, easier if the facility is solar ready or renovation allows for piping and roof loads.

- **Photovoltaics (PV)**
  - Simplest renewable electricity option for a building.
  - Costs can be higher so often dependent on local policies and incentives
  - For renovations, the use of PV depends on the roof strength or other space

- **Solar Ventilation Air Preheating**
  - Can be very cost-effective in heating load dominated climates.
  - Most effective in new construction, but can be used in renovations if a south-facing wall is available.
  - Most effective where large amounts of air are needed.

Screening

• Common Technologies, cont.

Each site is unique and most-effective technologies will vary.

- **Geothermal Heat Pumps**
  - Very effective in mixed climates
  - Best economics where electricity costs are low/moderate.
  - Site must have available land for the ground loops
  - In new construction, loops can be done in conjunction with foundation work or parking lot.

- **Geothermal Direct Heat**
  - **Needs specific resource**
  - Available resource is less common – typically in the western U.S.
  - Best for buildings with heating loads due to climate or process needs
  - Can be a cost-effective and consistent energy source

- **Wind**
  - **Needs specific resource**
  - Site near facility and provides power directly to building
  - Needs a site with an appropriate wind resource and few obstructions.
  - Best if can be sited 150-200m from any occupied facility
  - Cost effectiveness of wind depends on:
    - local wind resource,
    - price of grid-supplied electricity,
    - available incentives, and
    - the local policies on interconnection, net metering and zoning.

Screening

• Other Opportunities

Investigate the site to see if other options are a surprising fit.



- Other technologies include:
  - Biogas
  - Biomass Heat
  - Biomass Power
  - Geothermal Electric
  - Hydroelectric
  - Hydrogen and Fuel Cells
  - Ocean

Screening

• Technology Resource

Overview available of each renewable energy technology at www.wbdg.org/resources/

- Introduction
- Description
  - Overview of the system
  - How does it work
  - Current types/costs of technology
- Application
  - Best applications
  - Economics
  - Assessing resource availability
  - Design considerations
  - Operation and maintenance
  - Special considerations
- Relevant Codes and Standards
- Resources

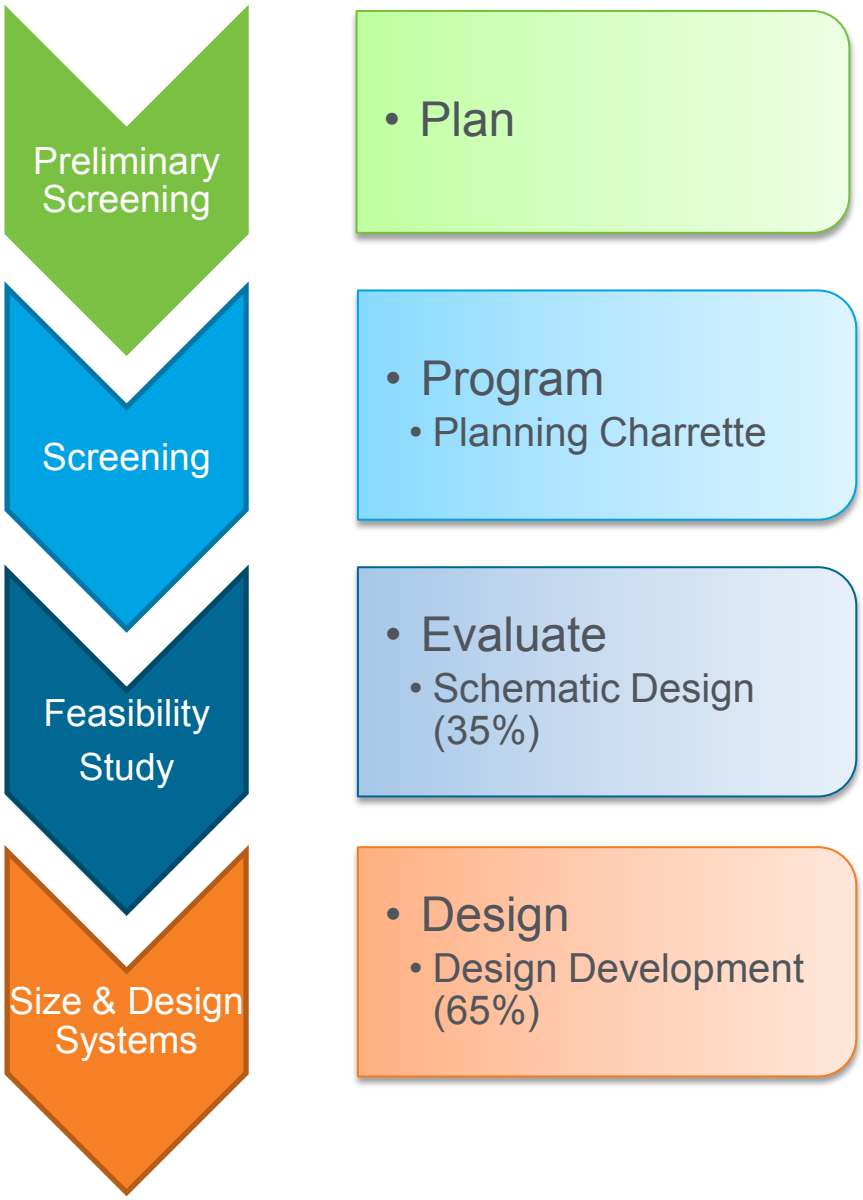


Screening

• RE Electric System Considerations

- Screening should assess impact of various policies for renewable electricity options
  - Interconnection: Governs how renewable electricity technology will connect to the grid
  - Net Metering: Allows the flow of electricity both to and from the customer
    - Extremely important to the economics of a renewable energy system
  - Time-of-Use Rates: Day/Night and seasonal rates charged by utility
  - Feed-In Tariffs: Long-term financial incentives to customers who generate electricity with renewable technologies

Renewable Energy Project Steps



Feasibility Study

• Evaluate Viable RE Options

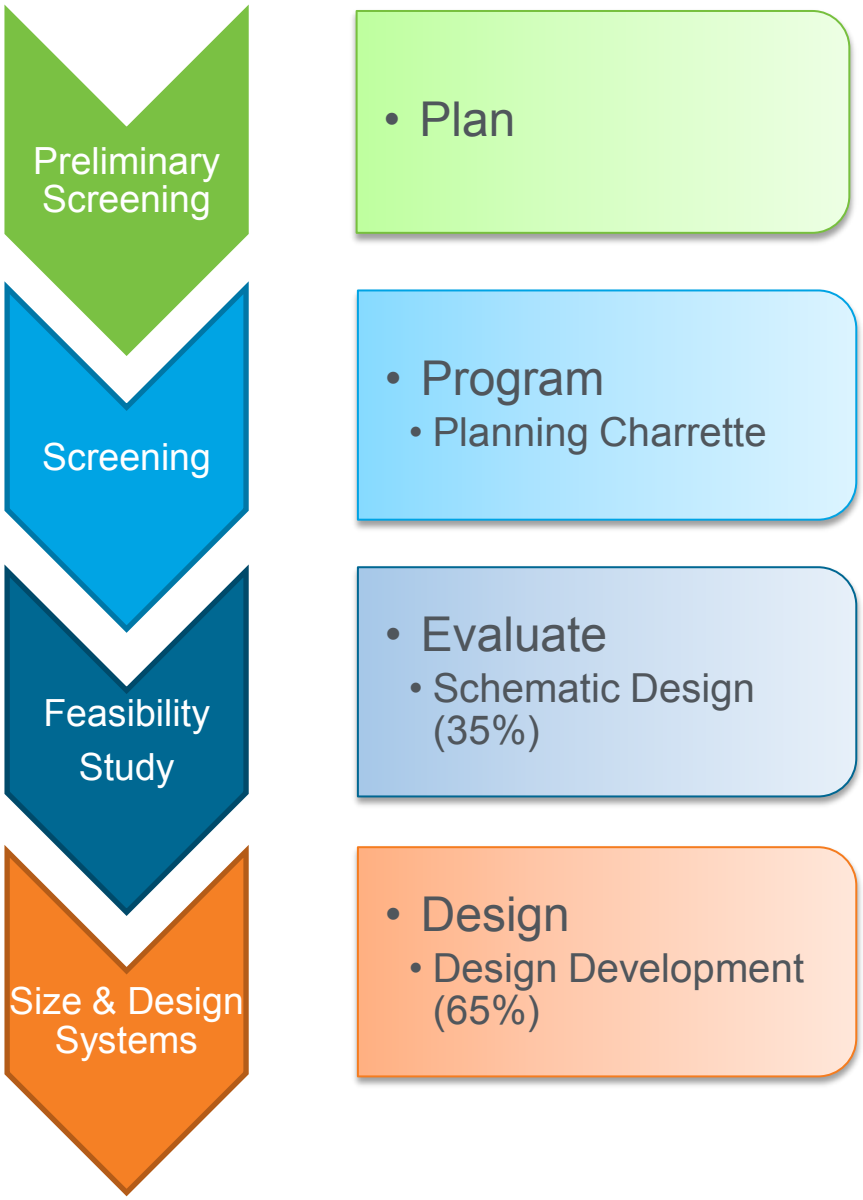
- What: Detailed review of technical and economic viability of each renewable energy technology option
- When: By Schematic Design (35%) phase of building design
- Why: Select which set of technologies best meet project goals/needs
  - Choose between technologies and types
- Who: Performed by a team of independent renewable energy experts
  - Typically commissioned by design team
  - Can be A&E firm or sub with expertise
  - Project energy lead involvement recommended

Feasibility Study

• Process

- Deeper review of screening issues
  - Revised assessment based on additional project details
  - Detailed resource assessment
    - Specific options for system siting/orientation
  - Expected cost savings
    - Include utility incentives and tariffs
    - Look at various ownership models
- Review options within technology
  - Technology Types
  - Manufacturers
  - Economics and availability
- Details on NEPA, permitting, and zoning issues
- Best technologies to meet energy needs of facility
  - Energy modeling of various technology options

Renewable Energy Project Steps



Size and Design Systems

• System Design

- What: Final design based on range of factors
  - Available space in design
  - Building energy loads and demands
  - Utility requirements
  - Applicable codes and standards
  - Availability of equipment
- When: During the Design Development (65%) phase of building design
- Why: Defines specific technologies to be included in the new construction or major retrofit process
- Who: Depends on technology
  - Must have specific expertise in renewable energy technology under design
    - Can be A&E firm or sub with expertise
    - Can be renewable energy contractors in conjunction with A&E firm
    - Can use performance-based EPC subcontracts
  - Must coordinate with remainder of design project

Budgeting: Estimating RE Costs

- RE technologies typically require large capital investments, making it **crucial** to consider them early

- Budget should include:
  - Increased costs of upfront planning, programming and integrated design
  - Costs for potential renewable energy technologies

- Rough Estimate: Sustainable Planning/Design
  - Organizations should plan for an additional 4.5% of the overall planning and design budget
    - 3% for high-performance construction (e.g., to obtain a LEED rating)
    - 1.5% for significant integrated renewable energy

Budgeting: Estimating RE Costs

- Renewable energy technology costs
  - Initial equipment and installation
  - Operations & maintenance
  - Replacement for system components
  - Useful life of the system



- Resource for real-world cost estimates for actual RE systems
    - Photovoltaics
    - Solar water heating
    - Solar ventilation pre-heat
    - Wind
    - Biomass
  - http://www.nrel.gov/analysis/tech_cost_dg.html
  - The guide also adds real-world estimates for geothermal heat pumps and skylights

Budgeting: Life-cycle Cost Analysis

- Decisions for renewable energy are often tied to life-cycle cost effectiveness of renewable energy installation
- LCCA estimates how the up-front cost of the equipment is spread through the life of the equipment
  - Building Life-Cycle Cost (BLCC) software helps decision make economic calculations
    - http://www1.eere.energy.gov/femp/information/download_blcc.html
- Early LCCA enables an organization to justify renewable energy for a project
  - Use to include a placeholder in budget for renewable energy costs
  - Should include enough RE to coordinate with energy goals/requirements
  - Expect that mix of RE technologies will change in process

Life-cycle Cost Analysis for RE

- Quantify the economic benefits of renewable energy systems in the LCCA
  - Include energy production from the system and energy offset
  - Consider renewable energy certificates, incentives and project funding options to improve the economic picture
- Preliminary LCCA should not be used to “reject” any RE technologies
- Life-cycle cost effectiveness should be reassessed throughout the various stages of design
  - Later LCCA done by design team
  - Key to accuracy is in the assumptions
  - Project energy lead serves as the organization’s “check”

Renewable Energy Budget Strategies

- Renewable Energy Project Funding
  - Organizations trying to stretch their capital budget should investigate renewable energy project funding options
    - Energy Savings Performance Contracts
    - On-Site Renewable Power Purchase Agreements
    - Utility Energy Service Contracts
  - Matching available funding tools with specific project needs can make the difference between an unfunded project and a successful project

- Phasing Implementation of Renewable Energy
  - Integrating renewable energy into the project design but delaying the purchase/installation of some systems can relieve budget pressures

RE Project Funding Options

- Energy Savings Performance Contracts
  - Agreement between an organization and an energy service company
  - Service company designs, purchases, and installs energy conservation measures at the organization's facilities
  - Potential to vary ownership of RE system in certain cases
  - can be designed solely for RE projects or combine RE with EE measures to increase savings investment

- On-Site Renewable Power Purchase Agreements
  - A renewable electricity system is sited and installed at an organization's facility but is owned by a separate entity
  - Organization pays to purchase power generated by the renewable energy system
  - Developer is responsible for project design, production and maintenance
  - Developer can takes advantage of tax credits and other incentives to lower system life-cycle cost
  - Specific language needs to be added to the agreement if a PPA is used to integrate RE into larger building construction projects (need to ensure design coordination and clarify project boundaries and responsibilities)

- Utility Energy Service Contracts
  - Programs vary by utility and can vary dramatically – range from rebate programs to full, turnkey project implementation programs
  - UESC contracts are not available from all utilities, and are not available to all projects

Phasing RE Implementation

- If conventional or other renewable energy funding cannot be procured, organizations may “phase” renewable energy into their project
  - Lay the groundwork and infrastructure now preparing for RE in the future
- Phasing allows organizations to access RE later
  - Changes in incentives or policies can make a system cost-effective overnight
- It is vital that renewable energy still be assessed and integrated into design, particularly concerning the building envelope

Regardless of current economics, all building should be built to accommodate future renewable energy.

Phasing RE Implementation: Solar Ready

- Phasing RE implementation is particularly important for solar technologies
  - Avoid shading
  - Roof strength to hold solar system
  - Include inexpensive elements (conduit/piping) during construction
- Solar technology cost-effectiveness is mostly a factor of rates, policies and incentives
  - Change can turnaround economics overnight
- This decision does not require immediate renewable energy use but keeps it from being precluded – now or in the future
- More information in *Solar Ready Buildings Planning Guide*
  - http://www.nrel.gov/docs/fy10osti/46078.pdf

Thank You

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