PHASE 2: ASSESSING OPPORTUNITY PATHWAYS

In Phase 2, the leadership team will coordinate analysis of energy solutions to realize the vision from Phase 1. Depending on the vision, the solution sets may go beyond electricity to include transportation energy use, water use, and land use planning.

The purpose of this analysis is to provide the community with options and flexibility. The energy transition cannot be accomplished all at once, and circumstances will develop that will change what constitutes the best next step in the transition. At the end of Phase 2, the community will have assessed possible solutions and refined a few practical pathways to realizing the vision laid out in Phase 1.

Phase 2 Describes How To:

- ☐ 2.1 Detail the Current Energy System
- ☐ 2.2 Compare the Current System with the Vision Statement to Reveal Pathways
- ☐ 2.3 Develop Energy System Plans
- ☐ 2.4 Specify Policy, Market, and Operational Barriers and Enablers to Realizing the Vision

2.1 Detail Current Energy System

To ascertain which changes need to be made to realize the vision, the leadership team must establish an accurate description of the current energy system, relying on technical experts to collect and analyze the best available data. This includes a baseline of supply and demand, the state of energy infrastructure, current energy activities and relationships, and energy resource assessments.

2.1.1 Establish an Energy Baseline

An energy baseline is established by collecting information on energy consumption—by sector and time of year—and energy production, including fuel sources and heat rates. It also includes information about line losses, remaining useful life of assets, common end-use behaviors, and peak loads. Essentially, a baseline includes all the information that explains the current energy system production levels and costs. Compiling and analyzing this information may take some time depending on how much information is available.

2.1.2 Catalogue Current Energy Activities and Institutional Relationships, Including Public-Private Partnerships

With the stakeholder analysis from Phases 0 and 1, the leadership team, or working groups if available, should build a catalogue of current energy activities and institutional relationships. This should include incentive programs, policies, and regulations; bilateral or multilateral development partners; and agencies responsible for permitting new energy projects, including building energy efficiency equipment. The catalogue will be a useful reference for shaping opportunity pathways, and as the resulting new programs and policies are defined.

2.1.3 Conduct Energy Resource Assessments, Including Demand-Side Resources

Resource assessments estimate the technical and economic potential of various energy sources, including energy efficiency. These studies can indicate the relative importance of energy sources and where the most promising initial site-specific analysis could take place, which is useful to shaping opportunity pathways. For example, a resource assessment will provide data necessary for estimating how much wind energy could be incorporated into a given pathway.

2.2 Compare the Current System With the Vision Statement to Reveal Pathways

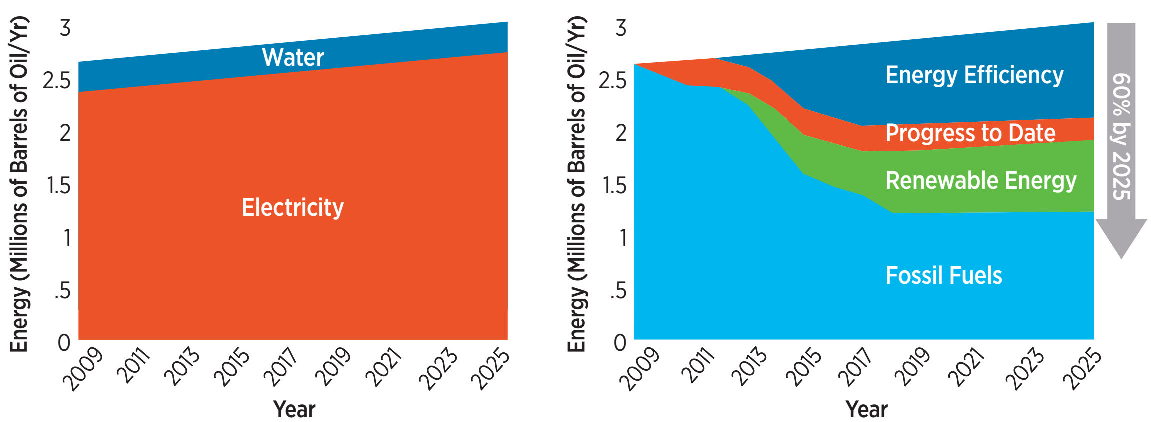
With an accurate profile of the current state of the energy system, the community can measure and quantify the changes that need to be made to realize the vision. This quantification informs overarching numerical targets—such as a 70% reduction in fossil fuel use or deploying clean energy to meet 75% of energy needs—which may add detail to the Phase 1 vision.

A comparison to the baseline also allows the community to identify specific, practical opportunity pathways to realize the vision. For example, if the vision calls for fuel diversity, a comparison with the baseline can show different mixes of fuel conversion, new renewable generation, and efficiency that would eliminate dependency on any one fuel.

2.2.1 Wedge Analysis

A wedge analysis breaks down the total amount of change needed or expected from "business as usual" into the sectors or activities that will drive that change. When shown as a graph similar to the figure below, the different components of change look like wedges. The wedge analysis describes how change will be achieved, and facilitates communication of pathways to stakeholders.

Business As Usual Versus 60% By 2025



2.2.2 Strengths-Weaknesses-Opportunities-Threats Analysis

A Strengths-Weaknesses-Opportunities-Threats (SWOT) analysis is a tool that can help the group explore the factors that will impact the success or failure in meeting the outlined objectives. Typically, the SWOT is compiled into a 2×2 matrix, with strengths and weaknesses describing the characteristics of the people involved and resources at hand, and opportunities and threats describing the external or environmental factors. Beyond simply thinking through these factors, completing a SWOT analysis makes it easier to pair strengths with opportunities, as well as weaknesses with threats, to evaluate the relative merits of pathways from the current energy system to the energy system described in the vision statement. The SWOT framework can also provide structure to stakeholder engagement, with one intended outcome to collect SWOT information from stakeholders for the leadership team to compile.

SWOT Matrix

Strengths	Weaknesses
Opportunities	**Threats**

2.2.3 Critical Path Analysis

Another analytical tool that may aid in the evaluation of pathways between the current system and the vision statement is critical path analysis. While a formal critical path analysis connects all tasks in a given project by their sequence and duration, the basic framework may be applied in Phase 2 to specify the changes and activities that must take place along a given pathway to realize the vision statement.

For example, before building energy use can be reduced, measurements need to be made via an energy audit, and before an audit can be done, a building owner must want an audit and a trained auditor must be available. Also, capable installers and energy-saving equipment must be available. Each of these activities takes time and some must be done in a specific sequence before the objective of reducing building energy use is attained.

2.3 Develop Energy System Plans

No single planning strategy fits all energy transition visions, but all are based on articulating pathways from the baseline to the future energy system as described in the vision statement. Plans that include energy system elements serve to link the Phase 1 vision to the project selection in Phase 3, and inform decisions about near-term investments in human or financial capital. Depending on the planning components, various stakeholders may take ownership of plans or aspects of plans; thus, integrating stakeholder engagement can facilitate timely, comprehensive planning.

2.3.1 Draft an Integrated Resource Plan

The key plan to assessing opportunity pathways is the Integrated Resource Plan (IRP) for the electricity system. The purpose of an IRP is to specify a portfolio of supply and demand resources that balances risks with anticipated costs and benefits, including environmental and social considerations, over the next 15–20 years. The IRP is typically developed by a utility (or utilities) with public input, and guides near-term investment decisions to develop the portfolio.

IRPs are created by comparing the anticipated electricity system needs, costs, and risks in future energy scenarios. The comparisons are made by changing assumptions about costs, benefits, and risks over the next 15–20 years. The government's role is to approve the assumptions, data quality, and the conclusions drawn from them, following thorough review.

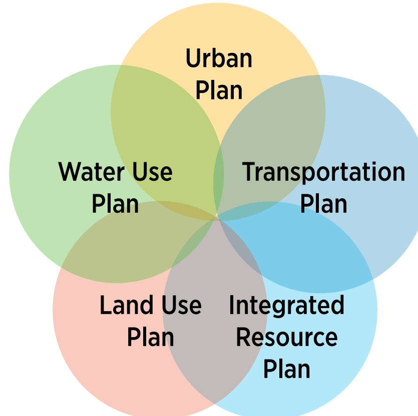
The IRP process involves extensive public participation, data collection, and analysis. IRPs consider all critical components of supply and demand. Some examples include:

- Market segments (e.g., residential, commercial, industrial) and size
- Fuel costs and reliability of supply
- Supply generation and delivery options
- Maintenance and capital investment schedule
- Energy efficiency and demand-side resources
- Legal or regulatory requirements
- Environmental and social objectives.

Although the planning horizon for an IRP is typically 15–20 years, utilities often update an IRP every two to three years to account for changing circumstances.

2.3.2 Complete Other Planning Components as Needed

Similar in principle to integrated resource planning, other planning components that involve energy are intended to estimate the benefits and costs of other courses of action. For transportation, elements related to energy include fueling infrastructure, public transportation, and fleet purchase policies. Land use policies impact siting of new generation assets, and water use plans influence the relative merits of generation technologies. Communities may want to integrate other planning elements into the assessments of energy opportunity pathways in Phase 2.



An energy transition may involve several interrelated plans.

2.4 Specify Policy, Market, and Operational Barriers and Enablers to Realizing the Vision

Now that pathways to realizing the vision have been assessed, the leadership team should identify specific barriers and enablers along those pathways. Barriers are policy, operational, and demand challenges that would prevent or inhibit progress along a particular pathway, such as:

- Initial capital costs
- Unclear permitting requirements
- Utility rate structures
- Lack of consumer awareness
- Inadequate credit or project repayment history
- Misaligned electricity production incentives
- Overlapping governmental responsibilities over energy
- Access to land
- Lack of necessary skills in the workforce.

Enablers, by contrast, facilitate progress along a particular pathway, and can include:

- Political commitment
- Transparent planning and resource allocation decisions
- Support from community leaders
- Public interest
- Experience with public-private partnerships
- Well-trained construction and/or utility workforce
- Capital investments that have been recouped and are ready for replacement
- Specialized university training courses and expertise
- Advanced utility metering and billing infrastructure.

Workers install a 10-kilowatt wind turbine at the St. Croix Reformed Church and Kindshill School in St. Croix. *Photo from Don Buchanan, VIEO, NREL 20418*

It is impossible to accurately describe barriers and enablers to realizing the vision without knowing what changes need to be made.

With possible pathways in mind, these barriers can be assessed for their true impact on a successful transition, and resources can be devoted to addressing these barriers as necessary. Specifying barriers and enablers to pathways is the final step in assessing the relative costs, benefits, and risks between them. The community is ready to begin allocating resources in Phase 3.

The optimal mix of policy and operational changes will depend on local conditions. While it is extremely helpful to examine the policy components of success in other jurisdictions, the combination of policy and operational changes needed in any one place must be tailored to local needs and institutions in order to be most effective. Stakeholders will have valuable input on how to minimize barriers and make use of enablers in order to arrive at the right mix of policy and operational changes.

2.5 Phase 2 Resources

Lessons Learned

- Assessing Pathways in the U.S. Virgin Islands and Hawaiʻi
- High Penetration Solar Distributed Generation Study on Oahu
- Assessing Pathways in Aruba

Worksheet

- Strengths-Weaknesses-Opportunities-Threats Matrix

Sample

- Integrated Resource Plan Objectives

Information Resources

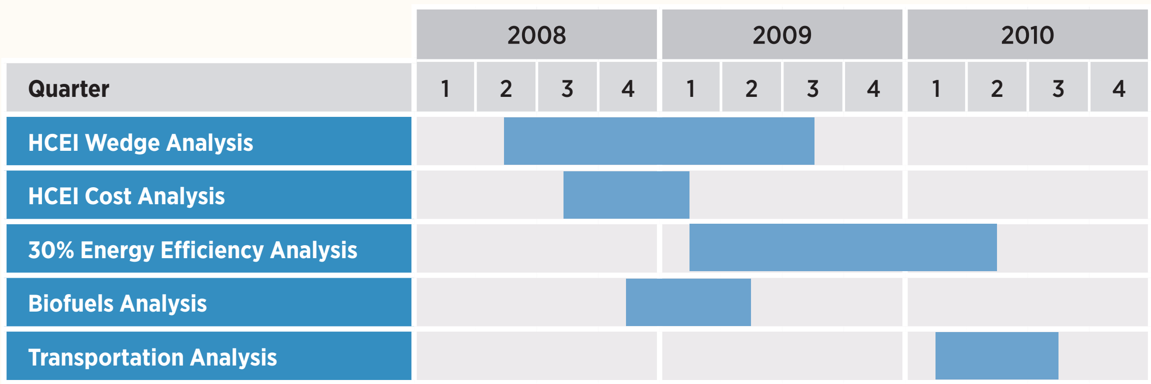
LESSONS LEARNED

Assessing Pathways in the U.S. Virgin Islands and Hawai‘i

Challenge

When setting energy goals, a common challenge is measuring success toward meeting those goals. Establishing an energy baseline enables more informed energy decision-making and provides a way to measure progress toward meeting goals. A key step in developing a road map to meet clean energy goals is determining which energy efficiency and renewable energy technologies the market will support and best use available resources.

Hawai‘i Clean Energy Initiative Scenario Analysis Timeline



Solution

Scenario analyses in the U.S. Virgin Islands (USVI) examined factors such as comparing business as usual versus deploying an aggressive mix of energy efficiency and renewable energy to achieve the territory’s goal of 60% clean energy by 2025. In Hawai‘i, the U.S. Department of Energy (DOE) assisted with various scenarios to achieve the state’s goal of 70% clean energy by 2030. In both instances, the work:

- Facilitated discussion among key stakeholders
- Identified potential policy options and evaluated their impacts on reaching the goal
- Presented possible pathways to attain the goal based on available technologies
- Evaluated capital costs
- Provided technology and market information to help key stakeholders make more informed decisions about next steps
- Conducted feasibility studies to determine which energy efficiency and renewable energy technologies to deploy to meet the goals
- As part of the USVI Energy Road Map, DOE evaluated the cost and energy savings that would be achieved through end-use, residential, and government and business energy efficiency actions. Various renewable energy resources and costs, including solar, wind, biomass, landfill gas, and waste-to-energy were also assessed.

Additional factors that were included in the scenario analysis for the USVI included:

- Grid integration
- Land constraints
- Policy considerations (regulatory processes and building codes)
- Financing issues (up-front versus long-term project development costs)
- Cultural sensitivities (aesthetic concerns and resistance to change).

As in the USVI and Hawai‘i, the data and analyses in Phase 2 are key to charting realistic pathways to transition from the current energy system.

The Energy Mix Needed to Meet USVI's 60% Clean Energy By 2025 Goal

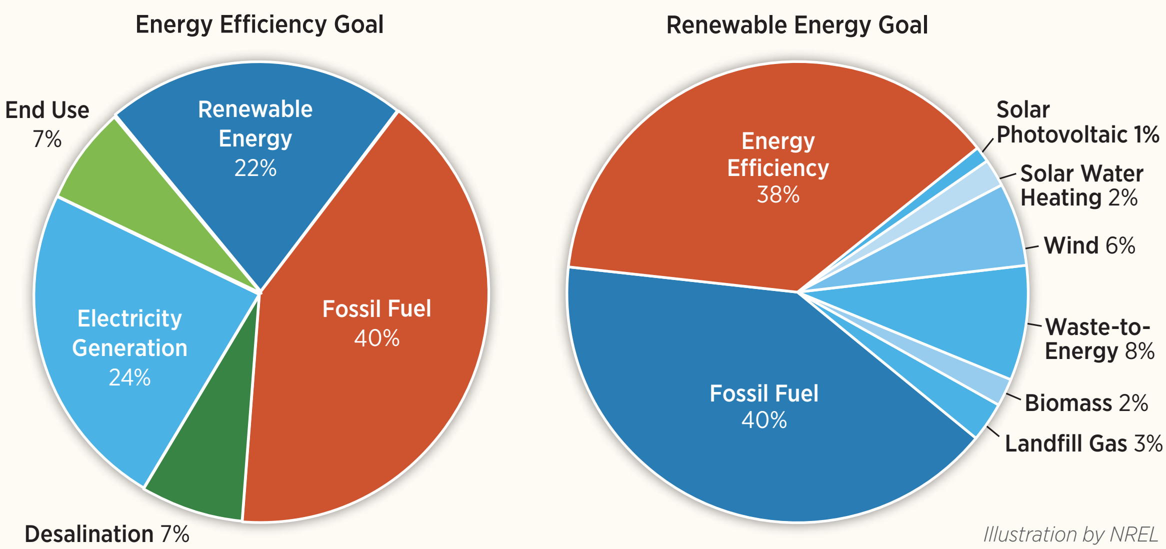


Illustration by NREL

LESSONS LEARNED

High Penetration Solar Distributed Generation Study on Oahu

In 2008, the Hawai'i Clean Energy Initiative (HCEI) set a goal of reaching 70% clean energy by 2030. In order to complement energy efficiency targets, the state of Hawai'i developed requirements to generate 40% of its energy from renewable resources by 2030.

In support of HCEI and the 40% renewable resource goal, the U.S. Department of Energy (DOE) and the Hawai'ian Electric Company (HECO) focused on developing strategies to allow increased photovoltaic (PV) penetration levels on distribution systems, laying the foundation for integrating high levels of distributed PV. These studies relied on the expertise of the National Renewable Energy Laboratory, General Electric, BEW Engineering, and others.

The rooftop solar PV on Hawai'i's Mauna Lani Bay Hotel generates 75 kW of electricity. *Photo from SunPower, NREL 06430*

Challenge

The main objective of the project was to construct, calibrate, and validate one high penetration renewable generator distribution feeder circuit on Oahu's electricity grid to understand the impact on the entire electric power system.

Solution

To start the effort, the team developed a low-voltage electricity distribution circuit model incorporating high penetration levels (more than 15% of the annual peak load) of PV, including data from the substation to the end-use load as well as PV inverter characteristics. The study expanded upon a previous one by enhancing the model's ability to identify the impact on technical performance and operations on Oahu's electricity grid.

During the course of the study, the team evaluated critical issues and mitigation strategies for achieving increased penetration of PV on the HECO electricity grid, including:

- Levels of PV installation protection schemes and how they were impacted
- Reverse power flow impacts on feeder circuits
- Capacitor operations, load tap changers, and voltage regulation on feeders.

At the conclusion of the study, systems planning improvements and modifications, as well as strategic options for mitigation, were presented to HECO. The identified solutions were also coupled as potential reasons to make changes to interconnection rules such as *HECO–Hawai'ian Electric Rule No. 14H–Interconnection of Distributed Generating Facilities Operating in Parallel with The Company's Electric System*.

Although the results of the study and final recommendations were valid only for the particular feeder analyzed, the methodology was replicable on other feeders. Thanks to a standardized process detailing the considerations the utility should review—whether at a single site level or a cluster level—future studies can employ the same methodology.

Key Takeaway: Studies Find High Levels of Wind and Solar Attainable

The project discussed here was part of a larger, more comprehensive effort by DOE and the Hawai'ian utilities to identify ways to increase wind and solar penetration across the islands. Two studies were conducted over the course of several years, each reviewing various scenarios.

The Oahu Wind Integration and Transmission Study was meant to help stakeholders, especially the utility and the State, understand the costs and operating impacts of significant amounts of wind power on their island grids, and plan for future transmission to accommodate this power. The Hawai'i Solar Integration Study detailed the effects of high penetrations of solar and wind energy on the technical operations of the Maui and Oahu grids. Because those two islands already had significant wind and solar power feeding their electricity grids, the utilities on each island wanted to understand how to better operate their systems with more renewable and distributed energy. Both studies found that although renewable generation changes grid dynamics, these resources can be successfully integrated with the right approach.

The studies described here helped decision makers anticipate and plan for this high-penetration solar reality. Today, Hawai'i has one of the highest penetrations of distributed solar in the United States with 1 in 10 homes using solar.

Engaging Stakeholders Leads to Better Studies, Integrated Planning

As part of several studies conducted in 2009 that looked at ways to integrate more solar and wind on the Hawai'ian Islands (including the high penetration solar study mentioned here), the HCEI leadership team convened key stakeholders from the beginning of the project. For two studies in particular, the Oahu Wind Integration Study and the Hawai'i Solar Integration Study, a technical review committee (TRC) was developed. TRC members were regional, national, and international technical experts with substantial experience in power systems, renewable energy, direct-current cable systems, island grids, and wind and solar integration. TRC members provided a technical review of each study's methods, assumptions, preliminary results, gaps, overlaps, data needs, and timelines at in-person meetings during each project. Each TRC reviewed the studies and made recommendations, but the Hawai'ian utilities had final decision-making authority for their projects and next steps.

LESSONS LEARNED

Assessing Pathways in Aruba

In 2010, Prime Minister Eman of Aruba expressed an ambitious goal: to transition Aruba to 100% renewable energy by 2020. Aruba offers a valuable example of how to approach vision and goal setting for an energy project or initiative.

Challenge

Strong tourism and growth in the hospitality industry are boosting economic development for the island of Aruba. However, like many islands and remote locations, Aruba must import thousands of barrels of fuel oil per day to sustain its economy. In 2012, Aruba consumed more than 4,000 barrels of oil per day for electricity and water production.

To meet the prime minister's vision of transitioning off fossil fuels by 2020, the Aruban government and the local utility, WEB Aruba, developed an integrated strategy for sustainable, affordable, and reliable energy.

Solution

The first step was to develop an integrated, multisector, sustainable development strategy in collaboration with the private sector, nongovernmental and government organizations, and individuals. Partners that have committed to the project and are helping Aruba realize its vision include the Carbon War Room, Harvard University, former Vice President Al Gore, and Delft University of Technology.

Through the Green Aruba Forum, the Government of Aruba assembled sector-specific teams of technical experts to examine the current status of Aruba's economic sectors responsible for most of the island's fuel consumption, and to offer a range of possible strategies for addressing the key challenges to sustainable growth in those sectors.

The technical teams focused on three sectors—energy, transportation, and the built environment—to identify pressing challenges and potential opportunities. This work included assessments of renewable energy and energy efficiency opportunities, and wind, solar, and storage options.

The teams also pinpointed possible actions that Aruba might take in the near term to realize its vision, and highlighted some opportunities, which include sectors that require long-term planning, as well as an analysis of technologies still under development.

"Our goal is an ambitious one: to increase the social, environmental, and economic resilience of Aruba through an efficient use of natural resources and an implementation of projects that will create and sustain high-quality local jobs for current and future generations. Ultimately, we hope that Aruba will become the model for a low-carbon, sustainable, and prosperous economy that can be replicated in other island nations."

—Aruba Prime Minister Mike Eman

The findings are summarized in the research report, *Smart Growth Pathways: Building a Green Platform for Sustainable Aruba,*[1] which provides an overview of the work that has been done to date by these technical teams to translate Aruba's goals into tangible plans of action.

Aruba has already made significant progress on the path to sustainability. The island's 30-megawatt (MW) Vader Piet wind farm generates approximately 18%[2] of Aruba's annual electricity, and another 24-MW Urirama wind farm is in development. Other planned projects include a 3.5-MW grid-tied solar PV installation at the airport, a waste-to-energy plant, grid storage, and demand response options. Aruba is also electrifying its public transportation sector, with the first electric bus put into service in 2013.

Key Takeaways

An actionable plan is critical to achieving the vision of a sustainable future. For Aruba, and other similar locations, this involves reducing carbon dioxide emissions to open new channels for environmentally sustainable economic growth, creating local job opportunities, and enhancing the health and well-being of the island's residents and visitors.

[1] Carbon War Room. *http://www.carbonwarroom.com/sites/default/files/reports/CWR_SGP_Download_singless.pdf*.

[2] Source: NuCapital. Accessed Aug. 7, 2014. *http://nucapitalsvcs.com/index.php/projects/27-nuvader-piet-beheer-nv-aruba*.

Worksheet: Strengths-Weaknesses-Opportunities-Threats Matrix

Strengths	Weaknesses
Opportunities	**Threats**

Sample: Integrated Resource Plan Objectives

Objective	Nature of the Objective
Reliable Electric Service	Serving consumers with minimal disruptions in electric service
Electrification	Providing electric service to those without convenient access to electricity is a common objective in developing countries
Minimize Environmental Impacts	Reducing the impacts of electricity generation (and energy use in general) is a goal that has received increasing attention in recent years. Environmental impacts on the global, regional, and local scales can be considered
Energy Security	Reducing the vulnerability of electricity generation (and the energy sector in general) to disruptions in supply caused by events outside the country
Use of Local Resources	Using more local resources to provide electricity services—including both domestic fuels and domestically manufactured technologies—is of interest in many countries. This objective may overlap with energy security objectives
Diversify Supply	Diversification may entail using several types of generation facilities, different types of fuels and resources, or using fuels from different suppliers
Increase Efficiency	Increasing the efficiency of electricity generation, transmission, distribution and use may be an objective in and of itself
Minimize Costs	Cost minimization is a key impetus for pursuing IRP, and a key objective in planning. The costs to be minimized can be costs to the utility, costs to society as a whole (which may include environmental costs), costs to customers, capital costs, foreign exchange costs, or other costs
Provide Social Benefits	Providing the social benefits of electrification to more people (for example, refrigeration and light for rural health clinics and schools, or light, radio, and television for domestic use). Conversely, social harms, as from relocation of households impacted by power project development, are to be prevented or minimized
Provide Local Employment	Resource choices have different effects upon local employment. IRP objectives can include increasing local employment related to the electricity sector, and increasing employment in the economy at large
Acquire Technology and Expertise	A utility (or country) may wish to use certain types of supply project development in order to acquire expertise in building and using the technologies involved
Retain Flexibility	Developing plans that are flexible enough to be modified when costs, political situations, economic outlook, or other conditions change

Source: *Best Practices Guide: Integrated Resource Planning For Electricity*, U.S. Agency for International Development (2009)

Information Resources for Phase 2

These information resources and useful links are illustrative, not comprehensive.

Baseline Energy Performance of New York State Government Buildings (NY 2013). This report demonstrates how energy baseline information can be collected, analyzed, and presented.

Best Practices Guide: Integrated Resource Planning For Electricity (United States Agency for International Development 2009). This publication provides the analytical framework and methods to execute integrated resource planning.

Best Practices in Electric Utility Integrated Resource Planning (Regulatory Assistance Project 2013). This guide uses case studies to examine different approaches to Integrated Resource Plans (IRPs).

Caribbean Sustainable Energy Roadmap (Caribbean Community Secretariat 2013). This publication provides a comprehensive overview of the regional energy situation, in light of regional priorities on sustainable energy.

Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (Intergovernmental Panel on Climate Change 2007). This report describes mitigation options in energy supply, transport, buildings, industry, agriculture, forestry and waste management, with one additional chapter dealing with the cross-sectoral issues.

Encouraging Renewable Energy Development: A Handbook for International Energy Regulators (National Association of Regulatory Utility Commissioners 2011). This guide seeks to help international regulators navigate the policy landscape for large scale renewable deployment.

Energy Baseline Methodologies for Industrial Facilities (Northwest Energy Efficiency Alliance 2013). This publication covers how to establish and document an energy baseline.

Evaluating Policies in Support of the Deployment of Renewable Power (International Renewable Energy Agency 2012). This brief at examines criteria to evaluate the performance of a number of renewable energy policies.

Hawai'i Clean Energy Initiative (HCEI) Scenario Analysis: Quantitative Estimates Used to Facilitate Working Group Discussions (2008–2010). This analysis provided Hawai'i with the foundation to describe and assess pathways to realize its clean energy vision.

The Body of Knowledge on Infrastructure Regulation (*http://regulationbodyofknowledge.org/*) from the Public Utilities Research Center provides links to a large library addressing the regulatory treatment of infrastructure, an extensive glossary, and self-testing features to facilitate learning.

The Competition Reform Web Resource (*http://www.oecd.org/daf/competition/reforms/*) from the Organization for Economic Co-Operation and Development provides governments information to assess their own policies for opportunities to enhance competition.

The Context Sensitive Solutions Resource Center (*http://contextsensitivesolutions.org/*) from the U.S. Department of Transportation offers insights on infrastructure planning, in the context of transportation planning.

The Cost of Renewable Energy Spreadsheet Tool (CREST) is an economic cash flow model designed to assess project economics under various policy support structures.

The Developing a Greenhouse Gas Inventory Web resource (*http://www.epa.gov/statelocalclimate/local/activities/ghg-inventory.html*) from the U.S. Environmental Protection Agency includes steps on completing a greenhouse gas inventory.

The Energy Regulators Regional Association (ERRA) E-Library (*http://www.erranet.org/Library*) provides information and data related to energy regulation.

The Energy System and Scenario Analysis Toolkit (*http://en.openei.org/wiki/Energy_System_and_Scenario_Analysis_Toolkit*) collects a variety of different tools to assist with modeling and analyzing an energy system.

The Hawai'i Clean Energy Initiative website (*http://www.Hawai'icleanenergyinitiative.org*) contains the latest information and analysis on many clean energy efforts in Hawai'i.

The International Council for Local Environmental Initiatives Toolkit (*http://www.icleiusa.org/action-center/tools*) provides tools to help complete an emissions inventory.

The **RETScreen website** (*http://www.retscreen.net*) and software provide a decision support tool to evaluate distributed energy project feasibility and performance.

The State and Local Energy Efficiency Action Network (*https://www4.eere.energy.gov/seeaction/*) offers resources, discussion forums, and technical assistance to state and local decision makers as they provide low-cost, reliable energy to their communities through energy efficiency.

The **Sustainable Energy Regulation and Policymaking for Africa** website (*http://africa-toolkit.reeep.org/*) from the United Nations Industrial Development Organization contains a variety of information on shaping energy policy.

Using Integrated Resource Planning to Encourage Investment in Cost-Effective Energy Efficiency Measures (U.S. Department of Energy 2011). This publication covers the planning issues of particular relevance to including demand-side resources in IRPs.