Chapter 3
Climate Change Policy as a Catalyst for Sustainable Energy Practice: Examples from Mainland Ecuador and the Galapagos

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Context

In 2011, Ecuador's National Electricity Board (CONELEC) identified Ecuador's electricity generation sources as: "Hydroelectric: 60.18%, Thermoelectric: 31.94%, Other renewable sources: 0.82%, Imported electricity: 7.05%" (Villa Romero 2013). While hydroelectricity has a relatively low carbon footprint, it can also be susceptible to regional droughts, rainfall variability, and climate change impacts affecting rainfall amounts and seasonal precipitation patterns. For example, Ecuador experienced unusually low rainfall in 2011, which resulted in low reservoir levels which in turn resulted in rolling electricity outages affecting over one million people in in different quadrants of the capital city of Quito. Similarly, the amount of glacial meltwater sources available to Empresa Eléctrica Quito decreased by 50% between 1978 and 2008 (Villa Romero 2013).

Through "Decree 1815" Ecuador established a National Strategy for Climate Change to identify climate change actions for the period 2012–2025 (Nachmany et al. 2015, p. 3). Ecuador's related National Plan for Good Living (2013–2017) (Republic of Ecuador 2013) includes strategies for climate change adaptation and mitigation in partnership with Ecuador's National Environmental Policy. Objective 10 of this National Plan promotes diversification of energy mix within the context of the National Climate Change Strategy (Nachmany et al. 2015, p. 5). The intention is "to reduce net emissions through increased efficiency in production of electricity"

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through the development of renewable energies (Nachmany et al. 2015). In an effort to diversify the electricity generation grid mix with more sources of renewable energy, CONELEC initiated Regulation 004/11 in 2011, which is a feed-in tariff to support the development of "solar photovoltaic, wind, geothermal, biomass, biogas, and hydro-energy" (Nachmany et al. 2015). This competitive concession contracting was intended to secure renewable electricity production from alternative sources using 20-year government contracts as an incentive for development.

Case One: A Radical Approach to Solar Energy Development

In 2010, Radical Energy, a Canadian solar photovoltaic company specializing in the development of solar projects from the idea stage to the operational stage, undertook development planning for two large-scale solar power projects in Ecuador. These two projects (Cóndor Solar and Solarconnection) had a combined planned capacity of 63.5 MWp/3 MWac. Although these projects were ultimately not constructed, their history provides important lessons useful for other locations interested in developing sustainable energy projects. Specifically, Radical Energy's planning and development approach was based on three fundamental principles:

- Produce ethical returns for investors.
- Focus on environment, health, and sustainability.
- Ensure maximum social benefits and knowledge transfer.

The initial land area planned for both projects was 147 hectares (ha) which is roughly equivalent in size to 133 soccer fields. The area chosen was dry with poor potential for agricultural production. According to software calculations using RETScreen and PVSyst, the annual electricity generation would be 106 GWh (196,000 MWh), which was equivalent to an annual electrical load of approximately 100,000 households in northern Ecuador.

Project planning included approximately 211,000 three hundred watt solar panels connected to a 69 kV distribution line bisecting the project area. As planned, the two projects would offset an estimated 47,000 tonnes of CO_2 annually based on the 2011 carbon intensity of the Ecuadorian grid. This would be equivalent to removing 8,700 mid-sized cars from the road or 4,392 hectares of forest absorbing CO_2 annually. Projected employment opportunities generated by Cóndor Solar and Solarconnection development included 500–700 jobs over a 7–10-month construction period and 15–25 full-time positions post-construction related to site security, panel washing, and general systems monitoring and maintenance.

The total capital expenditure estimated for project construction was $212 million in United States currency. In order to fund project construction, an international financial consortium was created which involved companies from Spain

(Solarpack Technologies, SENER Engineering), the United States (Sunwize Technologies), and Canada (Radical Energy, Solexica Development Corporation, JCM Capital). Approximately $8.5 million was initially raised to cover land purchases, legal expenses, government performance bonds, operational costs, and bank due diligence costs. Three international banks were involved in project financial planning including the Inter-American Development Bank, Proparco (a private arm of the French Development Bank), and the FMO (a private arm of the Dutch Development Bank).

Community and environmental investments of $200,000 annually for the duration of the 20-year concession contract were included in the project development plan. With an estimated project life of 35 years, this would produce $6 million in the first 20 years and considerably more once project ownership transferred to the government of Ecuador after year 20. These monies would be created by electricity revenues and intended to support education through scholarships and small business development through micro-finance loans, as well as other environmental conservation and direct investment community projects. Although these community and environmental monies were never realized because the projects were not constructed, during the planning phase, the development consortium did donate $40,000 to an organic farming NGO working adjacent to the planned projects.

Solar Project Development Phases

The role of Radical Energy included project originator, planner, and developer. Radical investigated, planned, and developed project plans to the point where the projects were able to attract financing, engineering, procurement, and construction partners and ultimately project buyers. The scope of services and activities handled by Radical Energy was multifaceted and required a very broad understanding of all aspects of energy project development including legal, policy, environmental regulations, and stakeholder relations in addition to engineering, finance, and construction. Radical Energy's phases of solar project development planning are identified below, but in practice they frequently overlapped and were iterative because of feedback from various phases:

- Market assessment and research
- Project site investigation and development planning
- Technology and equipment investigation and procurement
- Partnership development and financing
- Procurement, construction contracting, and labor force recruiting
- Project ownership transition (on-going operations and maintenance logistics)

Market Assessment and Research

Radical Energy's activities in this phase focused on two key activities: pre-feasibility analyses of a project's specific financial, regulatory, and legal requirements, and identification of country-specific risks and strategies to avoid, transfer, or mitigate for investors and developers. As the project development planner, Radical Energy analyzed several sources of solar data utilizing global horizontal irradiance as the key indicator. Using these results, the areas with the best solar irradiation were cross-referenced with the location of electrical distribution and transmission lines. Results were then used with RETScreen software to run a financial analysis of the project's siting and estimated annual electrical generation.

Project Site Investigation and Development Planning

This phase involved the following major activities: investigate alternative development sites, site selection, negotiate a land control contract, initiate contact and plan for community and social engagement, and conduct social and environmental impact scoping. Although government information sources were used to map the location of distribution and transmission lines, Radical Energy's on-the-ground Geographic Positioning System (GPS) cross-checks found this mapping information to be inaccurate by several kilometers. Because of the significant challenge of finding a large enough area to accommodate both projects, Radical Energy personnel used a local taxi truck fitted with a camera and GPS to find potential sites and confirm the locations of electrical lines. Finally, property of sufficient size for a 69 kV distribution line running through it was identified as having sufficient capacity to transport future solar electricity production.

Radical Energy executives had learned one very important aspect of sustainable energy project planning while participating in the Sustainable Energy Development (SEDV) Master of Science Program delivered cooperatively by the University of Calgary and the Universidad San Francisco de Quito in Quito, Ecuador. This was the importance of stakeholder and community engagement in project development. Acquiring stakeholder buy-in and support early in the project planning process was crucial to moving forward with the projects. Radical began engaging with almost all stakeholders 2 years before planned construction, and the company used the International Finance Corporation's (IFC) Performance Standards on Environmental and Social Sustainability (updated from 2006) to plan and manage interactions with the local communities and for the environmental impact assessment of the project (IFC 2012). This process created strong relationships with stakeholders including numerous government departments; formal and informal consultations with aboriginal communities; and women's groups, local community councils, and the neighboring organic farming NGO. An Inter-American Development Bank (IDP) specialist who was assigned to review the project work commented on it as being one of the best engagement processes they had reviewed in Latin America (Dick 2014).

Technology, Equipment Investigation, and Procurement

The engineering analysis in this phase involved several steps: grid connection viability, technology and equipment selection, procurement, and systems engineering. The purpose of grid connection viability was to determine if the Cóndor Solar and Solarconnection projects could connect with existing transmission and distribution lines and transport the electricity into the local grid. Activities included analysis of transmission and distribution interconnection requirements, a preliminary grid capacity analysis, and negotiations for solar project interconnections with the local electrical grid infrastructure.

Based on the results of this analysis, Radical Energy and its partners then investigated suitable solar PV technology options for the project site. With a consideration for cost-effectiveness, activities included consultation with engineering procurement and construction firms; negotiation, audit, signing of purchase contracts; and finalizing selection of technology and engineering firms for construction and installation. System engineering activities included utilizing expertise from solar engineers to design the final electrical schematics and layout for both projects and obtain final approvals from government authorities.

Partnership Development and Financing

Radical Energy investigated suitable partners to share both the operational and financial risk for project development. Activities involved strategic partner identification, which included preparing project portfolios, audits, and negotiating investment contracts with the assistance of legal experts. Lender identification required developing project marketing, financial prospectus material, and specific information for bank officials. Equity investors identification involved working through due diligence reviews of financial and project information with private equity investors.

Procurement, Labor Force Recruitment, and Construction Contracting

Before necessary equipment and materials can be purchased and construction can begin, all applicable laws and policies must be met. All legal documentation required must be completed for project approval including local permitting and zoning requirements. Establishing and maintaining strong government connections were critical in working through all the requirements for final project approvals prior to proceeding with procurement and contracting. Specifically, two onsite archeological studies, a forestry license to move harvested trees offsite, solar interconnection approvals with the local electricity grid distribution company, a social environmental assessment study, full project design approvals, and construction approvals were all required prior to project construction contracting.

Project Ownership Transition (On-Going Operations and Maintenance Logistics)

Upon completion, project assets were expected to be transferred to an asset holder. Planning for this transfer requires ensuring the project is functioning as an autonomous electricity generating plant and fully operational under a local operations and maintenance company.

Solar Development Lessons Learned

The Cóndor Solar and Solarconnection projects were not completed for political reasons beyond Radical Energy's control. However, the experience with the planning for these two solar projects provided some important lessons specifically related to government policy and community and stakeholder engagement.

Government policy and related incentives while intended to support solar energy development also add a significant degree of risk and uncertainty to infrastructure projects like Radical Energy's two solar projects. Such risks are difficult to mitigate in the planning and development stage, and it is not uncommon for government policy to change in the middle of development, which in turn, completely changes the economic viability of a project. Because all the phases of solar project development as outlined above can take many years to fully implement, it is critical that policy in force at the time of project planning be grandfathered to enable project completion. This situation is not unique to Ecuador or developing countries. For example, both Spain and the provincial government of Ontario in Canada have had policy changes that caused not only projects but a fledgling solar industry sector to falter or fail to reach full potential (Fraser Institute 2012; McKitrick and Adams 2014). In order for government policy to support the growth of and transition to renewable energy, "TLC" (transparency, longevity, and certainty) is required (Deutsche Bank 2009, p. 4). Sustainable energy development projects require years of planning work and millions of dollars in investment and legal agreements before construction can begin and power generated. By creating long-term, transparent policy and regulations to support this investment of time and money, investors and the public can be confident that investment dollars can be repaid from long-term electricity sales revenues.

Engagement with stakeholders, especially with communities geographically located near the project is a valuable social learning experience at all stages of project development. Honesty, transparency, and relationships built on trust over time are essential throughout the entire project engagement process. However, there is a risk that some project information may receive a negative response from stakeholders that could jeopardize the project. As well, project personnel may not always be pleased with what they hear in the engagement process, but concerns and motivations of the community will help them to understand their own project better. Ultimately, the objective is to get the project implemented and address stakeholders' concerns early in project development. All types of engagement processes, from large town hall meetings to smaller meetings with community leaders, small group discussion groups, informal votes, and prioritization of alternatives, can occur during the stakeholder engagement process. Although input can range from useful, well-thought-out comments to angry off-topic attacks, it is all part of the learning process. Community meetings help to convey how company investments might be allocated to create a sense of trust between project developers and the community. An open dialogue can assist in forging a bond that can help a project get through some difficult times. Initially, it would seem that a large-scale solar project would be an easier sell to a community than a large-scale open pit mine or even a wind power project. But, based on Radical Energy's project development experience, in any type of project, stakeholders want to be treated as if they are important and part of the process (Dick 2017). Stakeholder influence and opposition can cancel a project, cause delays, or change government policy. Therefore, although community and stakeholder engagement takes time and money, it is fundamental to successful sustainable energy project development.

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Case Two: Adding Energy Efficiency into the Energy Mix

In 2016, graduate students from the Sustainable Energy Development Master of Science degree program at the University of Calgary undertook internships in the Galapagos. They worked on a project in the community of Puerto Ayora and the Island of Santa Cruz initially started by the World Wildlife Fund and the Republic of Ecuador's Ministry of Tourism in the Galapagos. They undertook energy and water audits of a sample of tourist hotels to help identify where energy efficiency could be improved to better manage growing energy demands from increasing land-based tourism pressures. The results of these audits which included interviews with hotel managers and staff and lessons learned from these results are described as follows.

Energy Audit Results

Figures 3.1 and 3.2 compare the audit results for three medium hotels (MSH) and three small hostels (SSH). Results have been separated into high and low tourist season estimates and low-, medium- and high-energy consumption categories using

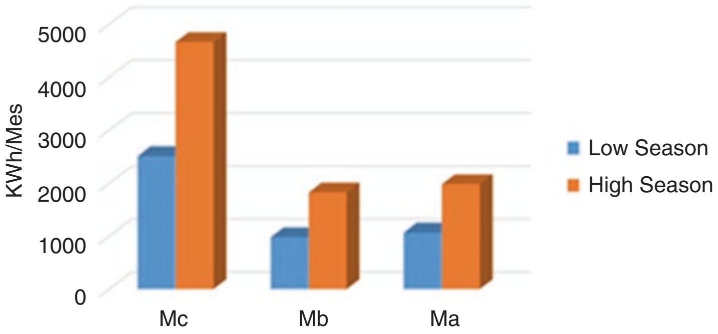

Fig. 3.1 Energy audit comparisons of medium-sized and small-sized hotels

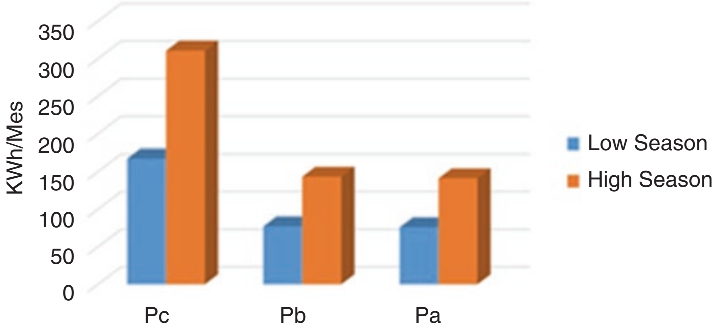

Fig. 3.2 Comparison of small-sized hotels energy use in high and low tourist seasons

median values from the range of audit results. The total kWh/month for the MSH far exceeds the SSH total because of the greater number of energy services provided by the MSH such as air conditioning, mini-refrigerators, and larger buildings with significantly more lighting in hallways, staircases, lounges, and lobbies, which all contribute to higher electricity consumption.

The two outliers in each figure (Pc and Mc) are the result of their higher electricity consumption due to air conditioning. Specifically, Pcs offered air conditioning in more rooms than the other hostels. Mc's high electricity use was due to the type of air conditioners used. The air conditioner units in Mc were rated at 3500 W in all the guest rooms that were assessed. This is a significantly higher power rating for new AC units than observed in other hotels and rated at 1100–1200 W. In examining the three major electricity consuming devices in Fig. 3.3, AC consumed 43%, ceiling lighting 41%, and refrigeration (including freezers) 16% of the total electricity consumed by all six hotels combined.

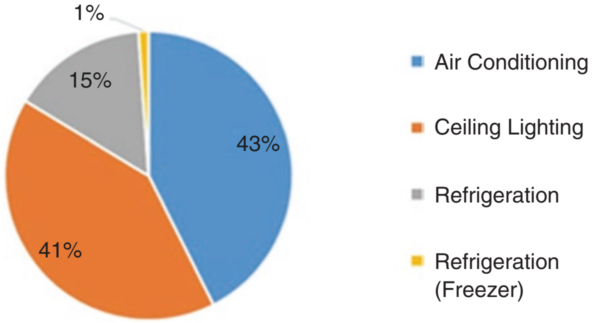

Fig. 3.3 Total electricity use by device type

Lighting

From the overall energy consumption audit of the six assessed hotels, ceiling lighting contributed 41% of the energy use per year. If all the light bulbs in the six hotels were replaced by light emitting diode (LED) bulbs, lower energy consumption could be achieved. Only one of the six hotels has switched from compact fluorescent light (CFL) and incandescent to LED for communal areas. Table 3.1 compares the three lighting types used in the hotels audited. The specifications for the light bulbs in Table 3.1 are based on retail prices and bulb types available in hardware stores in Puerto Ayora and Santa Cruz, and prices are in US Dollars.

The six hotels use less than 10% incandescent light bulbs. The transition from incandescent lights to CFL bulbs resulted from a previous best practices program implemented by the World Wildlife Fund (WWF) and Ecuador's Ministry of Tourism (WWF Program Galapagos 2013) to promote ecotourism on the Islands. A similar program could phase out CFL use, as LED bulbs use approximately 50% less energy. Given the current energy mix in the Galapagos is approximately 70% diesel, greenhouse gas (GHG) reduction and energy conservation are important (Dove 2014).

Potential LED Savings

Table 3.2 illustrates the range of savings possible if all six of the sample hotels transitioned to using LED light bulbs. The assumptions used in generating Table 3.2 include the following: lights are on in hotel communal areas 4 h/day; lights are on in guest rooms 3 h/day; there is an emission factor of 0.96 kg CO_2/kWh which would require 13 kg CO_2/3-year to offset emissions; and energy mix is assumed constant for the lifetime of the LED bulbs.

As illustrated in Table 3.2, the potential savings per year of LED bulbs is significant. A medium hotel could save an estimated US$400 to US$530 per year and a small hostel an estimated US$70 to US$130 per year with the payback period ranging from 1 to 2 years.

Table 3.1 Comparison of three types of hotel light bulbs

Per bulb	LED	CFL	Incandescent
Power	8.5 W	20 W	40 W
Price	\$7~\$10	\$4–\$6	\$2~\$4
Life-span	25,000–50,000 h	8000–10,000 h	1200–3000 h
Environmental impact	–	Contains mercury	Creates more waste

Table 3.2 Range of potential savings from LED light bulbs

Potential savings	Combined total
Utility money saved per year (USD)	1056
Money saved on maintenance/year (USD)	610
Total money saved/year (USD)	1666
Diesel saved/year (L)	3749
CO_2 emissions offset (ton/year)	7
CO_2 emissions offset in lifetime (ton)	130
Trees required to offset the emissions	551

Air Conditioning

Air conditioning (AC) was the highest energy-consuming device in the hotel audit using 43% of energy consumed. Most hotels in Galápagos do not have building designs that incorporate shading, thermal mass, or natural ventilation. Hot season temperatures can extend from January into July (Charles Darwin Foundation 2016). Audit results found that fans were not considered as a viable alternative to AC in hotels. AC units used are relatively new (2013) and have different function modes. However, interviews with the hotel managers suggest these energy saving features are not being used. The International Energy Agency (IEA) suggests (IEA 2013, p. 3): "In hot climates, the energy savings potential from reduced energy needs for cooling are estimated at between 10% and 40%. More than 40% of the savings expected in heating and cooling energy demand under a low carbon scenario can be directly attributable to improvements in the building envelope."

To reduce electricity consumption rates and decrease tourist sector carbon footprints, both hotel owners and tourists need to embrace an energy conservation attitude. AC units need to be set at an appropriate level. In the Galápagos, AC can be preset in different modes during the year to work optimally in each season. There is also a fan function that can be used to reduces electricity consumption of AC units by 85%. Many international hotels encourage their customers to save water and energy through educational initiatives such as sustainability labeling, and this can be done in the Galapagos.

Table 3.3 Potential savings from proper sealing of windows and doors

Number of assessed ACs	73
Average of energy consumed by ACs in assessed hotels (kWh/y)	99,808
Energy saved by proper sealing	20%
Average of energy saved in ACs at assessed hotels (kWh/y)	19,962
Potential US$ saved	1996

Table 3.4 Reduced energy use from fans

Number of assessed ACs	73
Average of energy used for ACs in assessed hotels (kWh/y)	99,808
Energy reduced by using a fan instead of an AC	85%
Average of energy saved in ACs at assessed hotels (kWh/y)	16,967
Potential US$ saved	1,697

Improving Sealing

The Energy Star program (2009) states the properly sealed rooms could save could save almost 20% in energy costs. Table 3.3 illustrates the potential energy savings from proper sealing of hotel windows and doors for the six hotels audited which could provide a potential saving of 19,962 kWh/y which is equivalent to US$1996 in savings.

The Rainforest Alliance (n.d.) has suggested that fan use represents only 15% of AC energy requirements. The increased use of fans instead of AC units could reduce hotel energy use as illustrated in Table 3.4, which indicates that fans could reduce AC energy consumption by 20% on an annual basis.

If these assumptions and numbers can be extrapolated to include all the hotels in the Galapagos, then the potential reduction in energy use could have a significant impact. Increasing the efficiency of energy use is an important component of a sustainable energy mix transition in the Galapagos.

The Water-Energy Nexus

Water and energy use are connected. Energy is required for the collection, treatment, distribution, pumping, and heating of potable water. Energy consumption related to water use ranges from 4% to 19% of electricity consumption (Copeland 2014). Energy use related to water use in the Galapagos has not been calculated but is an overlooked aspect of energy management on the Islands. Increasing population growth and land-based tourism has increased water use significantly and specifically in Santa Cruz. The municipal water supply in Santa Cruz is currently at capacity.

Water Audit Results

The same six hotels involved in the energy audit process were also involved in a water use audit. The water audit included the following: bathroom faucets, showerheads, toilets, laundry facilities, kitchen facilities, outdoor landscape irrigation purposes, housekeeping and maintenance, pool, and spa facilities. Audit results identified the areas with the highest water saving potential. Strategies for water savings were provided to each hotel, and a small report and discussion held with hotel staff on implementing the strategies for water savings, which can increase the energy efficiency of hotel operations. Water-saving opportunities and estimated savings are projected in Table 3.5. It should be noted that water consumption in guest bathrooms is very dependent on the occupancy rate and the water consumption behavior of guests. For the purposes of Table 3.5, high season is assumed to be from December to July at 65% occupancy, and low season is assumed to be from August to November at 35% occupancy. The towel and linen reuse assumes 10% reuse by guests. Water consumption in guest bathrooms is very dependent on the occupancy rate and the water consumption behavior of guests. As illustrated in Table 3.5, the potential water savings in small hotels translates into approximately the volume of one to two domestic swimming pools. Water saving in medium hotels translates to roughly the volume of three to seven domestic swimming pools.

Table 3.5 Water-saving opportunities

Low-cost water-saving actions	High efficiency faucet aerators	Low-flow showerheads	Repairing leaking toilets	Towel and linen reuse program	
Approximate cost across hotel (US$)	5–10 per faucet	15–75 per shower	50–125 per toilet	Cost of printing signage	Total estimated water-saving opportunities
Annual water savings in a small hotel (liters)	4,700–12,000	34,000–64,000	7,000–14,000	5,400–7,300	51,000–97,000
Annual water savings in a medium hotel (liters)	25,000–145,000	48,000–96,000	100,000–200,000	23,000–32,000	196,000–473,000

Desalination Water Treatment Plant

In 2016, a reverse osmosis desalination plant became operational on the Galapagos Island of Santa Cruz. The desalination plant produces safe water low in chloride content that is distributed throughout the Island. However, a desalinization plant has significant costs and energy demands (Reyes et al. 2015). The demand for desalinization plant water is highest for residential and hotel use (Reyes et al. 2015). The desalination process requires significantly more energy than other water treatment methods. The process generally requires three steps: (1) the pretreatment of the reverse osmosis membranes, (2) the reverse osmosis process, and (3) the posttreatment of the permeable membrane. The highest energy consumption is usually in the reverse osmosis step (WRA 2011).

Increasing Efficiency for the Energy-Water Nexus

Behavioral change is key to lowering energy and water consumption. Creating greater awareness about the importance of energy efficiency and the water-energy nexus for sustainable energy mix in fragile environments is important in dealing with population growth and increasing tourism pressure in the Galapagos. Table 3.6 identifies specific actions to improve performance. Each hotel audited was provided with specific recommendations customized to their performance and needs.

Table 3.6 Specific actions to improve energy and energy-water nexus efficiency

• General suggestions	• Train employees to conserve energy and water
	• Induce behavioral changes in the tourists
	• Informative and accurate signage for “save energy and water”
	• Automatic key cards, external switches
• Air conditioning	• Clean filters
	• Proper insulation
	• Promote use of fan feature in ACs
• Refrigeration	• Proper sealing on door
	• Located in cool place, distance from the wall
	• Discourage empty refrigerators
• Lighting	• Encourage use of LED bulbs
	• Use of clean bulbs
	• Use of reflectors, open lamps to improve illumination
	• Use of external lights
• Water conservation	Install low-flow toilets and showerheads
	Repair leaking toilets
	Install aerators in faucets
	Utilize a towel and linen reuse program

Lessons Learned

The results of the energy and water audits from this small sample of hotels in the Galapagos Islands suggest that low-cost efficiency upgrades and minor maintenance of devices could improve energy efficiency and in the process save energy and money. Energy efficiency is necessary for the Galapagos Islands to transition to a sustainable energy mix. Energy efficiency that reduces energy demand makes this transition more feasible. There are numerous energy efficiency opportunities in the areas of AC, refrigeration, and lighting which can contribute to cumulative energy savings for Galapagos. Creating shared value among institutions, businesses, and consumers is pivotal to implementing these measures. Audit results suggest there is a lack of knowledge and tools available to businesses for implementing efficiency measures. Opportunities exist for educational initiatives to fill this gap. Additional initiatives can be directed at influencing tourist behavior. Together these initiatives have the potential to advance sustainable energy use.

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Conclusions

Both the solar energy project case and the energy efficiency audit project demonstrate a variety of lessons learned and critical factors influencing sustainable energy mix development. Both the production of new renewable energy generating capacity and improving the efficiency of existing energy use are components of developing sustainable energy mix options in specific circumstances. While technological innovation plays a key role in developing sustainable energy, both of the cases reviewed here illustrate the importance of policy innovation and social learning through engagement and behavior change as having an equally key role in sustainable energy mix development.

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