Chapter 7

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Renewable Energy and Energy Efficiency

Preamble

It has long been recognised that the sustainable supply of energy services is an imperative: it delineates the viable developmental options that any sovereign island nation can select as it caters to its current and future generations. Energy services – **the appropriate use of energy to achieve desired productive outputs** – plays a crucial role in facilitating the implementation of nation-specific options for all small island developing states (SIDS) regions (Caribbean, Pacific and African and Indian Ocean SIDS).

Implicit in the sustainable development of SIDS are global economic issues for which SIDS have special vulnerabilities, as already identified in the Barbados Programme of Action (BPOA) (Annex I, Part One, IV). Some of the strategies for economic success and indeed survival are:

- the production of value-added products as a competitive alternative to high volumes and low prices,
- niche marketing as a competitive strategy,
- producing an educated, skilled and trainable workforce to attract higher paying jobs and technologically driven markets,
- efficiency, productivity and energy conservation to maximise foreign exchange earnings and retention, while improving self reliance, and
- import substitution and improving energy security.[1]

The development of viable industries is also a critical insert to sustainable economic development. All these strategies are energy dependent.

Sustainable social targets for SIDS are also energy driven to a large degree. For instance, the following targets are all energy reliant:

- strategies for improving the quality of life, including modern, convenient and safe energy supplies,
- less labour-intensive tasks,
- modern transportation services,
- up-to-date, effective health services,
- improved life expectancy,
- facilitating effective education,
- reducing poverty and improving national security,
- increasing food supplies, and
- providing recreational or inspirational settings conducive to emotional health.

Environmental health also depends on sustainable and cost-competitive energy options, through the careful selection of mechanisation for sustainable livelihoods, energy resources with fewer environmental aspects, lower and reversible impacts, and a reduced need for end-of-pipe treatment. At the same time, energy options used for addressing environmental impacts should produce economic, energetic and productive collaterals. As BPOA suggests (Annex I, Part One, III, 1, 2 and 3), many of the global phenomena (such as global climate change and sea-level rise) affecting SIDS are energy derived and exogenous, so collaboration in global energy strategies is a proactive stance. If the Millennium Development Goals (MDGs) are used as a template for SIDS against which the importance of energy can be measured (as rehearsed above), it becomes apparent that the eight developmental goals encapsulating economic, social and environmental issues, cannot be achieved by 2015[2] without securing adequate energy services in the short term.

Driving forces for implementing non-conventional energy options

The growing need for adequate energy services has been somewhat stymied, as the conventional fossil fuels upon which SIDS have depended are rapidly failing in supply volumes, stability of affordable prices and reliability of supplies.

The global scenario affects energy security for SIDS on the supply side. World supply/demand forecasts[3] a demand of 87.8 million barrels per day (bpd) by 2011; however, by June 2010 supplies of only 86.1 million bpd were being produced. This represents a 1.7 million bpd supply shortfall, which could easily be exacerbated by the average global demand growth of approximately 2 per cent. We now live in the reality of the Oil Peak[4] where the rate of new discoveries and production is lagging behind the rate at which we consume these fossil fuels. Supply issues are aggravated by:

- diminishing OPEC[5] spare capacity,
- greater demand for higher environmental and performance specifications, as proportionately more heavy and medium sour crude are found,
- decline of major non-OPEC production such as North Sea, US Gulf of Mexico (GOM) and Alaska,
- volatile geopolitical and unpredictable weather incidents disrupting supplies,
- rapid economic growth of developing and industrialised nations, and
- aged infrastructure and decline in new exploration and refinery investments.

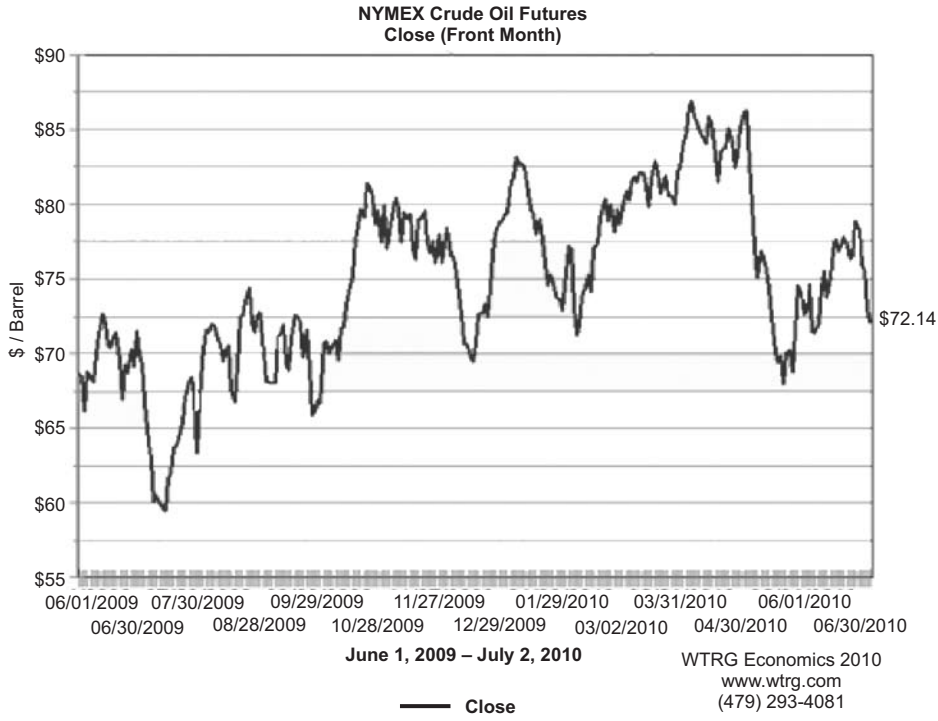

Figure 7.1 NYMEX crude oil futures (front month)
Source: WTRG Economics, www.wtrg.com [last accessed August 2010].

These factors have not only caused oil prices to break old thresholds (e.g. US$94.53 per oil barrel [bbl] 31 October 2007, NYMEX WTI for December 2007[6]) but have also created a new threshold of US$100/bbl and sustained new price floors of US$30–35/bbl. After declining to around US$40/bbl at the height of the global financial crisis, oil prices are on the increase, reaching US$80.87/bbl by 3 March 2010 (see figure 7.1). Now more than ever, SIDS are reminded that 'Energy dependence is a major source of economic vulnerability' (Mauritius Strategy, para. 41).

These volatile fossil fuel prices have wreaked havoc for national development planning and economic strategies. In Jamaica for instance, approximately 90 per cent of the energy mix comes from imported energy. Jamaica's current ability to meet developmental targets is therefore severely hampered by the consumption of 65–70 per cent of its export foreign exchange earnings, or more than 15 per cent of its GDP, to import more than 25.7 million bbls of petroleum products. Similarly, up to 40 per cent of national budgets and 46 per cent of total national revenues of the Pacific islands go to importing fossil fuels (His Excellency Ambassador Enele S Sopoaga).

Natural gas, a long-term more price-stable product has surrendered to the vicissitudes of price movements, reaching as high as US$15 per one million British thermal units (mmbtu) in early 2006, and declining to US$8.33 per mmbtu[7] 31 October 2007. However, following the global financial crisis, natural gas prices have declined. By 3 March 2010, natural gas was US$4.78 per mmbtu (see figure 7.2).

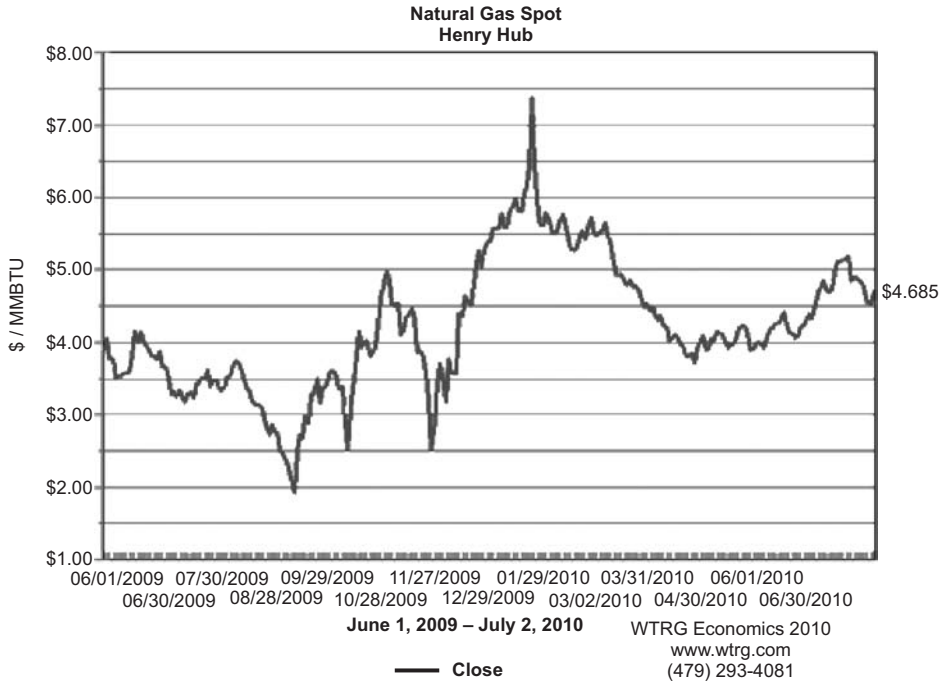

Figure 7.2 Natural Gas Spot: Henry Hub
Source: WTRG Economics, www.wtrg.com [last accessed August 2010].

Though more steady in the market, coal prices have also raised dramatically to US$70.50 per metric ton (mt) CIF (cost, insurance and freight). Coal prices were significantly influenced by the European heat wave in August 2006.

Continued dependence on fossil fuels is therefore contrary to energy security, because their supply is finite and there is unpredictability in pricing over long periods. Additionally, there are growing quality constraints as regional and international fuel harmonisation and clean fuel trends change (e.g. reduction of fuel sulphur to 0.5 per cent for power generation, 30 parts per million (ppm) for gasoline and 15ppm for diesel: US, Department of Energy, 2010).

As stated by the Executive Secretary, United Nations Framework Convention on Climate Change (2007): 'The IPCC found that climate change is unequivocal and is caused largely by human activities that release greenhouse gases'. International efforts have been galvanised to stem global warming (e.g. Joint Implementation [JI] projects and Clean Development Mechanisms [CDMs], with their agro- or forestry-based closed carbon loops and wind power generation) and these in turn have raised the demand for renewable energy options, non-petroleum fuels or fuel blend compromises (e.g. biofuels). Stand-alone or distributed solar photovoltaic generation systems have also become a preferred option, as they are cleaner, less impacting and more viable. In this context, SIDS must focus on the areas of greatest energy demand and implement renewable energy technology(ies) (RET)[8] and energy efficiency and conservation (EE&C)[9] initiatives.

The strategic sustainable development of SIDS therefore lies first in the concurrent and strategic actions of (i) reducing the rate of growth of energy consumption (energy conservation), and (ii) producing more high-value outputs from less energy (energy efficiency). This is a short-term and

sustainable solution for working towards full energy security, global competitiveness and achieving rapid social and economic development against the backdrop of global energy events. Finances could initially be focused on making early, large energy savings on the supply side to large-scale commercial and industrial sectors, which skew national energy demand (e.g. heat and power demands by hotels, sugar cane processing and minerals), followed by transportation and domestic consumers. The proportion of energy cost relative to total production cost in the cement industry, for example, is approximately 55 per cent; however, the potential energy savings could be 10–50 per cent, depending on the EE&C application (Wright, 2003). In Jamaica, where the cement industry is responsible for coal imports equivalent to 1.2 per cent of national energy consumption, energy efficiency becomes an opportunity for significant savings. Similarly, bauxite/alumina processing in the country consumes more than 36 per cent of petroleum imports and is responsible for a 50 per cent increase in energy intensity. Transportation, commercial and residential buildings may consume in the order of 20 per cent and 30 per cent of the energy use in island economies.

Second, the strategic sustainable development of SIDS should involve short-term application of renewable energy technologies (e.g. cogeneration and biofuels), to provide the additional energy required to close the gap between the current energy baseline demand and the future demands. In the short- to long-term, renewables should also be used as a strategic option to replace fossil fuels when old systems are to be decommissioned and in meeting graduated fuel switching, especially in industry and transportation. Using concepts of import substitution (Bruton, 1998) and applying them to energy security would suggest that SIDS must protect their economies from the harmful dependence on imported energy, by harnessing an array of indigenous energy options to replace what they may otherwise import. The emphasis should be on increased energy self-reliance, as opposed to exclusion of imports, as energy demand and supply need to be met if development is to be continuous.

Intra-regional collaboration and effective national policies are also crucial to accelerate implementation across SIDS in a region.

Energy status of SIDS

With few exceptions, SIDS from the Caribbean to the Pacific are predominantly energy (petroleum) importers, and therefore energy insecure. Islands approaching 'sustainable energy island' status may include Faeroe Island, Denmark, with wind supplying 100 per cent of electricity, Yakushima, Japan, with more than 80 per cent of its electricity coming from RET, especially hydro (56 megawatts [MW]), Dominica with 45 per cent hydro (220MW) and Guadeloupe utilising wind (2MW) and geothermal (5MW) potentials. To lesser degrees, Dominica's hydro resources (7.6MW) provide more than 50 per cent of the total energy supplied to the national grid, and in the French overseas departments (Guadeloupe, Martinique, Réunion Island and French Guiana) 45 per cent of fuel imports are from fossil fuels, the balance from RET, including wind and hydropower.

More typical, though, is a low energy security predicated on fossil fuel imports. In CARICOM, hydrocarbons accounted for around 95 per cent of total primary energy supply, with renewables accounting for approximately 5 per cent of total primary energy supply (Detlef and Coviello, 2005; CARICOM Energy Policy, 2007). The US Virgin Islands depends on imported energy for 99 per cent of its demands, while in some Pacific islands, petroleum products accounted for almost 80 per cent of primary commercial energy consumption, while RETs – mostly hydro – contribute to less than 10 per cent of the islands' energy use (South Pacific Regional Energy Programme [SPREP], 2005). The economic costs for not using indigenous renewable energy are inflationary prices induced

by imported energy costs, and reduced price competitiveness in global markets. The social cost is stagnation in health services, education and security, as debt repayment consumes a greater portion of government national spending. The environmental challenge, meanwhile, is the failure to arrest natural resource damage induced by the transportation, storage and use of fossil fuels.

SIDS such as Jamaica and Grenada hope to improve energy security rapidly from potential oil and gas finds, while others such as Trinidad, Cuba and Barbados hope to augment their current petroleum resources through new exploration campaigns within their territories. However, these options for energy security are highly risky and expensive: prospects are assumed to be minor, and do not easily attract early investments from oil and gas companies with the requisite financial and technical resources to make such options a present reality. Although new finds should not be excluded, EE&C and RET remain the certain near-future option for SIDS. Energy security should therefore include utilising localised wind, geothermal and biomass options, proven successful for industrial, commercial and domestic uses, and petroleum for existing infrastructure. Solar and hydro will also be critical resources in meeting domestic and commercial demand.

Energy efficiency and conservation – the first line of defence

Overall, the rationale for applying EE&C initiatives is aligned to the **'Basis for Action'** of the BPOA (Annex II, Chapter VII, paragraph 36) and part of the **'new ethic of conservation and stewardship'** endorsed by the Resolution of the UN Millennium Declaration (Resolution 55/2 Paragraph 23, September 2000). Generally, energy management also reduces SIDS's exposure to increases in energy prices, an external threat to sustained development.

Energy efficiency and conservation using renewables or non-renewables is an immediate to long-term strategy for SIDS to improve their market competitiveness. As energy prices increase, there is an external opportunity for energy-efficient sectors within SIDS to maintain or increase production levels and profitability against less efficient counterparts (Wright, 2003). Efficient operations also lead to less environmental aspects and impacts, as pollution prevention and reduction techniques are successfully applied. Appropriate technologies and best practices for EE&C can often be implemented within 1–2 years, as opposed to some large-scale RET projects which may require 2–4 years from feasibility study to operation. Energy efficiency and conservation not only reduce expenditure (thus diverting monies to other key areas of national development such as education, health and social services), but also contribute to the achievement of productivity which meets international benchmarks.

Energy efficiency and conservation gains can be most dramatic for SIDS with high energy costs (e.g. the Caribbean mean average of US$0.17 per kilowatt hour [kWh]; Escalante, 2003), high industrial energy demands and vulnerabilities to oil price shocks. Recently, the European Commission (EC) announced that a new liberalised market-access regime through Economic Partnership Agreements (EPAs), including all African, Caribbean and Pacific Group of States (ACP) products, would replace the EU/ACP sugar protocol as of 1 January 2008. This means a new external threat, for some Caribbean sugar producers (an important sector with high heat and power demands) may experience a 'sudden' 37 per cent price cut, market uncertainties and heightened competition with the entry into the EU market of new lower-cost ACP producers. Applied competence in onsite cogeneration and trigeneration[10] in the sugar cane industries of SIDS could be a potential internal strength to increase overall factory efficiencies up to 80 per cent, reduce costs, provide additional income streams and, at a minimum, maintain their place in the market. Incentives for EE&C in the CARICOM cane industry alone could mean saving more than 125,000 jobs and income of

approximately US$300 million/annum. An efficient industry could continue to empower men and women (who work in the industry), combat poverty and provide young people with decent and productive jobs (UN Millennium Declaration Resolution 55/2, paragraph 20, September 2000).

The hotel industry is a major foreign exchange earner for SIDS, and also has potential for significant gains. Energy accounts for more than 70 per cent of the total utility costs at typical hotels, with equipment, appliances, air-conditioning and lighting being significant contributors (Escalante, 2003). With simple, inexpensive devices and practices, such as monitoring energy use, insulation, use of natural ventilation and lighting, occupancy sensors, compact fluorescent lamps, maintenance and insulation, hotels can reduce electricity consumption per guest per night by 10–24 per cent and up to 19 per cent of the hotel's total electricity use. These savings can occur in 18 months, with some payback periods as short as 4 months depending on the intervention. These savings extrapolated over the gamut of hotels in any one small island state redounds easily to a significant national gain.

Potential savings for industrial and commercial consumers are easily achieved through energy monitoring (10 per cent), corrective and preventive maintenance (15–20 per cent), awareness (10 per cent), reduced air infiltration into conditioned spaces (10 per cent) and energy-efficient lighting and retrofits (40 per cent) (Haughton, 2003). For utilities, savings can be made from the supply side by reducing generation and transmission losses (16 to 20 per cent in the Caribbean). The main consumers of electricity should also be targeted for special EE&C programmes – for example, the National Water Commission in Jamaica, which consumes on average 47 per cent of the government's electricity usage. At the residential level, town houses could be designed and sold with EE&C features as standard (e.g. the Doric Residential Complex in Jamaica), with homeowners standing to reap quantifiable savings.

With other sectors, such as transportation, consuming as much as a quarter of imported fossil fuels, interventions must transform cultural barriers over time. Air transportation may impact SIDS less than ground transportation, as airline fuel supplies are distributed over their various international ports of call, fuel costs are borne mainly by international carriers (except for some national and regional carriers e.g. Air Jamaica, Caribbean Airlines and Singapore Airlines) and in some SIDS the percentage consumption is relatively low (approx. 6 per cent of total in Jamaica, compared with road and rail of 24 per cent). The association of mass transport with a lower quality of life and of large engine private vehicles with the converse, plus the slow uptake on information technology (IT) competences for servicing complex computer-controlled engines, presents a challenge. In this context, attempts at improving mass transit efficiencies (e.g. fuel switching to natural gas), introducing car-pooling and vehicle fleet shifts towards electric, hybrid or flexi-fuel vehicles may be unsuccessful. Projections for improving this sector must be realistically weighed in the cultural setting, and more familiar options such as the use of biodiesel and bioethanol fuel blends may have more success for fossil fuel import substitution efforts (e.g. coconut oil use in the Pacific islands). Other measures, such as linking duties with engine size and rated fuel mileage, lower toll/road charges for utilising optimal seating capacities and congestion charges in cities, may induce EE&C practices on the part of motorists. Where possible, national airlines should purchase/lease efficient aircrafts (e.g. the Airbus A350 and Boeing 787 are said to be 15 per cent more efficient than their predecessors) and should ensure optimal bookings per flight.

Extremely important in cost savings for implementing EE&C is an 'upstream' approach, creating opportunities by incorporating EE&C designs into original building design to enhance comfort, safety and productivity. Energy Efficiency Building Codes (EEBC) (e.g. EEBC-94, finalised and approved as a voluntary standard in Jamaica with funding from the World Bank and the Canadian

International Development Agency [CIDA]) or the Leadership in Energy Efficiency Design (LEED) protocol are important tools to facilitate opportunities and rewards for the building industry and private sector entities. Such tools are said to be able to reduce energy consumption by 30–36 per cent per annum and shave electricity peak demands by 24–29 per cent, with only an initial 5 per cent increase in building cost. Another upstream approach is the creation of a demand for energy saving opportunities, with the engagement of more energy saving companies (ESCOs) and energy auditors. ESCOs, in particular, are driven by performance contracts to generate quantifiable energy or other savings for their client, the basis on which they are remunerated. Hilton hotel chains within Barbados, The Bahamas, St Lucia and Puerto Rico, have benefited from the energy management interventions of ESCOs.

Downstream energy auditing is also a valuable tool for identifying opportunities for real savings and for setting and recommending achievable EE&C targets. Such tools could be recommended for implementation throughout SIDS. Also on the downstream side, the retrofit markets can have fast uptake (e.g. CFL lamps, water savers and motion sensors), where tax and other incentives are applied and public education is dynamic (radio, TV, road shows etc.)

With the current cost of capital, competition for developmental funds and reducing the unit cost of production in the global marketplace, collaboration among regional SIDS becomes critical in order to fast-track the application of best practices in energy efficiency cost effectively. Pacific energy ministers (Communiqué, Pacific Energy Ministers, 2007) agreed and affirmed that it was necessary to share experiences, develop expertise and competencies in EE&C, collaborate in programmes, projects and standard setting, in order to eliminate duplication and accelerate implementation to reduce energy dependence on external sources. In CARICOM, member states have embraced the need to collaborate on regional energy efficiency, institutional networks, testing facilities, training and capacity building, and to develop regional public sector energy efficiency programmes. In this context, a CARICOM Charter on Energy Efficiency has also been propagated.

Island-specific initiatives such as policy, energy legislative frameworks, programmes and incentives are also needed to encourage cost-effective and energy-efficient initiatives at the national level, as recognised by the Pacific energy ministers. It was also recognised that a private sector–government partnership is needed to drive major opportunities for energy efficiency from the power companies (Communiqué, Pacific Energy Ministers, 2007). The Pacific Islands Energy for Sustainable Development (PIESD), by targeting the power utilities of 14 South Pacific ACP members, aims to decrease costs and fuel consumption and improve the efficiency of power production, transmission and distribution with a target of 30 per cent reduction in losses using supply side management (SSM) projects (Fairbaim, 2004). Within the utilities, SSM plans would be developed, appropriate cost-effective power system equipment would be identified and staff capacity building would be implemented. Within CARICOM, member states have also committed to promoting high-efficiency power generation technologies (including combined cycle and cogeneration) and observances of best practice industry standards, with the aim of reducing system losses in generation, transmission and distribution (CARICOM Energy Policy, 2007).

Status and potential for renewable energy technology use in SIDS

Globally, renewable energy investments continue to increase, amounting to more than US$38 billion in 2005.[11] For 2005, among the power generation options, installed capacity for hydro was 930 gigawatts (GW; 4 per cent growth), biomass power was 1GW (50–100 per cent growth) and grid-connected solar stood at 3.1GW (55 per cent growth). Wind capacity attained 74GW in

2006 (25 per cent growth over the previous year) (International Network for Sustainable Energy [INFORSE], 2007). Globally, biodiesel production has risen to 3.9 billion litres (a growth of 85 per cent in 2005) and bioethanol to 33 billion litres (8 per cent growth). For renewable heating and power options, geothermal resources were 28 gigawatts thermal (GWth) at the end of 2005 (a 9 per cent increase) and solar water heating achieved 23 per cent growth from 2004 to 88GWth (REN21, update 2006).

In the context of this favourable global growth rate, the potential for harnessing and proliferation of RET in island states has to be carefully examined against the background of available natural resources. Most SIDS have varied but limited endowments of renewable resources, and may not have the potential to harness more than 25–30 per cent RET towards their national energy mix. This was acknowledged in the BPOA (Annex II, Chapter VII, paragraph 37). It is important to integrate EE&C outcomes when considering RET. Otherwise they cannot be considered truly sustainable, and could be potentially as damaging to economies and the environment as those that use non-renewable resources.

Renewable energy technologies for SIDS, such as solar, biogas, biomass and wind, when implemented with EE&C considerations allow for the avoidance or removal of greenhouse gases (GHG), effluents and solid wastes during operation. During operation, fuelwood plantations supplementing sugar cane bagasse can facilitate 110 per cent carbon capture, biogas can reduce methane (a GHG) escape to the atmosphere and no emission is produced by wind. Cognisant of our global village, such applications are supportive of the spirit of the Kyoto Protocol now ratified by 175 countries, including SIDS such as St Lucia, Cook Islands, Fiji Islands and Cuba (23 October 2007). The Protocol has created a unique opportunity for project financing for SIDS via the Clean Development Mechanisms (CDM), by raising the bargaining power of SIDS (grouped or individually) in partnerships with industrialised countries needing to meet their obligations (UN Millennium Declaration Resolution 55/2, paragraph 23, September 2000).

Possibly the most prolific application of RET and a competitive strength for tropical SIDS is solar energy.[12] With declining photovoltaic (PV) module costs (approx 30–60 per cent of total system costs), at prices around US$5.50 per peak watt (Department of Business, Economic Development and Tourism [DBEDT], 2006), PV systems can be applied unrestricted for Pacific, Caribbean, African and Indian SIDS, utilising building roofs and ground spaces. The French overseas departments have already installed 3MW of PV, with a clear potential to increase output. In Hawaii, 309kW of PV has been installed on the Ford Island's Building in Oahu for the Navy, while 25 public schools have received rooftop PV systems (Oahu, Maui, Hawaii's Big Island) and 209kW was installed at the Parker Ranch. All the systems were grid tied (*Star Bulletin*, 2007; Power Technology.com, 2007),[13] in addition to several thousands that are in remote subdivisions and not serviced by the utility grid. A projection of several thousand new homes in Hawaii are to have solar panels installed over the next few years, totalling 6MW (some were installed in 2006) and a commercial 167kW-generation plant is to be installed on the roof of the Hawaiian Electronic Company's Archer Sub-station, servicing up to 200 homes (*Star Bulletin*, 2007). The ADMIRE programme[14] in Marshall Islands, targets more than 2,000 PV installations with some currently installed on Wothoo and Wodmej. These installations have already improved academic performance in schools and the productivity of fishermen and women (Global Sustainable Energy Island Initiative [GSEII], 2007). Solar PV has proved to be a solution for rural electrification challenges, where it may be expensive to extend the grid for small dispersed homes in small communities. For rural communities, PV facilitates the introduction of more modern amenities, improved security and community activities, as lighting options potentially increase productive hours and income generation, especially if electricity co-operatives are established.

Solar thermal, the most widely used RET application in the Caribbean (especially solar water heaters [SWH]), is one of the best commercial opportunities for SIDS. Barbados has developed its SWH industry, encouraging its manufacturers (e.g. Solar Dynamics, SunPower and AquaSol) distributors and retailers. More than 40,000 solar water heaters have been installed in homes, commercial businesses and hotels in Barbados. For hospitals needing large volumes of hot water and power, and where the tourism industry is significant (such as in Jamaica, Barbados, Mauritius and Seychelles) economies of scale generate the most meaningful cost savings and avoided fuel imports. Hotels and bed and breakfast accommodations, depending on size and season, may spend approximately 20–30 per cent of electricity costs on water heating (East Harbour Management Services [EHMS], 2003). Domestic payback periods may be around 3–4 years, but commercial utilisation may be 2–3 years, especially when electricity heating is replaced.

Islands with a large landmass, highly varied topography and elevations, and limited karst rocks, tend to have some hydropower resources. Cuba (57MW), Dominica (220MW), Dominica (7.6MW) and Fiji (90MW), by virtue of their topography, geology and landmass, have adequate rainfall and can utilise dams and run-of-the-river type mini-hydropower systems. The theoretical potential of these islands (e.g. Dominica 25MW, Jamaica 82MW, Fiji 400MW, Cuba 650MW, and Dominica 1,800MW) are constrained by competing social uses, ecological water demands and insufficient technical information for analysis of potential.

Larger mountainous SIDS (e.g. Jamaica), the smaller islands of the Lesser Antilles (e.g. Curacao and Bonaire) and the Windward Islands (e.g. St Lucia and St Vincent) are geographically positioned to take advantage of localised wind sources (e.g. sea and land breeze and mountain and valley winds), and those generated by prevailing trade winds blowing east to west. Others, such as Cape Verde and some Pacific Islands, are also able to utilise wind potentials. For example, Hawaii's mountainous topography and strategic location within the northern Pacific Trade Wind belt creates an excellent wind resource, and several megawatts of wind power have been installed at Kahuku, Lalamilo and South Point on Hawaii Island (Jensen, 2000). Location and topographical features are internal strengths for isolated SIDS, enabling some to bypass the disadvantage of not being able to utilise cross-border electricity export to improve energy security, due to the water barrier and distances between islands.

Geothermal is an important heat and power source for industrial applications, and therefore may be significant in displacing fossil fuel consumption (and import) for heat and power generation. Commercial and industrial geothermal potentials are restricted mainly to SIDS on volcanic ridges of an archipelago (e.g. Guadeloupe 5MW), where tectonic plates are spreading or colliding. Puna, on Hawaii Island at the edge of the Kilauea volcano, is said to have one of the most significant geothermal resources at 676°F (358°C).

Commercial biomass fuel plantations (e.g. cane, corn and sorghum for bioethanol; Jatropa and coconuts for biodiesel; trees for fuelwood) are mostly suited for larger SIDS (e.g. Mauritius, Cuba and Dominica), as dedicated crops require contiguous land space to minimise transportation costs, and to obtain economies of scale for production and maintenance costs if they are to be viable. Smaller SIDS also face dwindling land with competition from housing, landfills and demand for open spaces. Pre-existing competence in large-scale mono-crops production with power generation (e.g. sugar cane in Mauritius and Fiji), is also important in the application of biomass fuels. Also for cane, some capital infrastructural costs have been written off or reduced over years of operations, potentially reducing costs for biomass power generation. Cellulosic feedstocks (as opposed to edible crops) grown on marginal lands, with increased CO_2 sequestration and lower fertiliser costs, can increase ethanol production. In conjunction with newer conversion technologies, these cellulosic

feedstocks, such as switchgrass, miscanthus or sorghum, may yield a total of 2,000 gallons (gal) per acre (assuming 20 tons harvested per acre), while edible corns may yield about 900 gal of ethanol/acre (*The Green Chip Review*, 2007).

Biogas, though a technology that has been proved for heat and power generation, is not a significant option for the national energy mix, as centralised effluent flows are typically small and often do not justify the capital costs. Larger potentials, such as the Soapberry Wastewater project (Jamaica), will treat in excess of 20,000 imperial gallons of wastewater/day, utilising state-of-the-art biological aerobic technology (Kelly, 2006). When considering the sustainability issues of biofuels, therefore, other aspects should be taken into account, such as opportunity costs (especially for export crops), reduction of food crops and the energy needed to produce the biofuels.

Advance technologies such as Ocean Thermal Energy Conversion (OTEC), may be considered by SIDS with steep island shelves and sufficient water temperature differentials near shore. Open-cycle OTEC has been demonstrated in Cuba, and closed- and open-cycle OTEC in Hawaii (52kW and 210kW at Keahole Point). Possibly such cutting edge technologies, which have not yet been proved convincingly, could be reserved until less expensive, proved technologies have been used.

From this menu of indigenous energy resources, RET applications should be customised to fit local conditions. 'Rubber stamping' is inappropriate. The best use applications of renewable energy technologies, and those with the greatest impact over the next decade, will probably be for commercial power generation and ground transportation (biomass-cogeneration will be important if SIDS remain in the sugar cane industry). The current Caribbean Basin Initiative arrangements and regional and international fuel harmonisation trends will provide support for biofuels for transport. Domestic and commercial use of SWH could also be important, as will small amounts of PV. In the meanwhile, some SIDS are aggressively exploring their petroleum potentials to achieve greater energy security and reduce energy imports as part of a holistic and viable solution.

Barriers for implementing RET and EE&C

There are several issues that negatively affect the implementation and proliferation of RET and EE&C. For example:

- Inadequate policy support
- Absence of a dedicated and empowered champion for RET and EE&C
- Absence of appropriate financing and accounting practices
- Inadequate expertise in resource mobilisation
- Cross-sectoral issues
- Public education and public awareness
- Influence of utilities
- Competition for scarce resources
- Scale of resources

Inadequate policy support

Without an energy policy, there will be little investment in RET and EE&C. In the last 3–5 years, there has been a concerted effort to develop (or document) local renewable energy policies or energy policies that have committed sections for RET and EE. A few examples of such efforts include:

- Jamaica – revising the Jamaica Energy Sector Policy 2006 and a completed study on 'Renewable Energies Potential in Jamaica' (Detlef and Coviello, 2005)
- Cuba – Law of the Environment, with encouragement for renewable energy and an 'Energy Revolution'
- Barbados – comprehensive energy policy with recent updates

Regional efforts have produced, for example, a draft CARICOM Energy Policy (2007).

Effective energy policies promoting RET and EE&C could include some or all of the following components, where possible:

- Planning and evaluation tools, such as energy forecasting and energy balancing.
- Clear legislative and regulatory directives.
- Offering various financial incentives for RET & EE&C to all sectors, including equity with existing incentives (such as subsidies) already offered to existing users of conventional fuel. Differential taxation based on levels of energy efficiency, availability and appropriateness may also be offered.
- Contractually linked/binding specific targets for RET and EE&C applications, especially for the heat and power sectors, including cogeneration and combined cycle technologies.
- Power generation incentives, including feed-in tariffs, capital subsidies/grants/rebates, special duty and tax concessions/credits.
- Net metering and net billing options for small distributed generation applications.
- Reduced or weighted influence of utilities in bid evaluation and selection for new generation.
- Public education, including development of a trained and skilled workforce.
- Encouraging the development of market mechanisms for GHG emission reduction.
- Special financing mechanisms for all sectors, including residential users.
- Stimulation of upstream RET and EE&C demands (e.g. EEBC as a regulatory standard).
- Updated and appropriate emissions and fuel quality standards for all sectors.
- Using RET for rural electrification.
- Developing appropriate models for energy sector liberalisation, decentralisation and privatisation.
- Using full-cost accounting and benefit–cost to evaluate proposed new installations. Accounting should also consider all aspects of sustainability.

The successful effects of clear policies and political will be the proliferation of RET and EE&C nationwide, as can be seen from the Cuban and Japanese cases. The Cuban Energy Revolution (a government policy) facilitated savings of approximately US$1 billion per year from RET, including 1,000MW of wind, solar and hydro power, the increased use of energy-saving fluorescent light bulbs and low-energy household appliances. Already 7,000 solar panels have been installed, and PV modules are being manufactured and exported. Electricity prices were also revalued to better reflect the cost of production through raised and stratified tariffs pegged to consumption, thus creating a conservation incentive (James, 2007).

Japanese energy policies were developed for the country's multiple islands (432 inhabited islands of 6,852). In Miyaki, Yakushima and Hachijo-jima Islands in the early 1990s, the Enetopia Island Plan, Zero Emission Vision and Clean Energy Model Island for the 21st Century, facilitated the implementation of 1.75MW wind, 0.75MW solar PV, 56.5MW hydro and 3.3MW geothermal, plus

the importation of six electric vehicles. The Ministry of International Trade and Industry (MITI), implementing its national policy mandate through a unique quasi government entity – the New Energy and Industrial Technology Development Organization (NEDO) – utilised a rotation of private sector and public sector employees to implement a Ten Thousand Roofs Programme under 'Project Sunshine'. Components of the programme included:

- An installation grant collected through an electricity surcharge.
- Voluntary purchases of excess grid-provided electricity by the utility at the retail price of electricity.
- That businesses could apply to NEDO for a grant under a programme funded to the value of 1.12 billion yen (US$9.5 million) to subsidise the installation of new technologies.
- Tariffs linked to consumption.
- Fiscal support for residential PV systems, covering 50 per cent of the cost of PV modules, peripheral equipment, distribution lines and installation work.
- Homeowners having access to the New Energy Foundation (government) for subsidies and a grant (one-third of the purchase and installation costs) if they satisfied the requirements (e.g. having an approved grid connection). The programme budget would pay for roughly 10,000 residential installations.
- Subsidies were granted for wind power, cogeneration, waste power and other 'new energies' (dispensed by NEDO) up to one-third of the total installation cost. Local governments are eligible for comparable subsidies under a parallel programme, also administered by NEDO.

Supporting laws in both the Cuban and Japanese cases included:

- deployment of renewable technologies under the Law on Special Measures to Promote Use of New Energies (New Energy Law) 1997 for promoting wind, solar, ocean, hydro, geothermal and waste energy, and
- energy efficiency (Law Concerning the Rational Use of Energy), which promoted energy conservation, as well as tax incentives for energy efficient equipment and public education.

Absence of a dedicated and empowered champion for RET and EE

The strategy of an 'Internal Catalyst'[15] (internal to the sovereign state) is a proved means to achieve policy targets for RET and EE&C and sustainable consumption and production targets. Without a sustained (long-term, more than 10 years) agency 'genetically linked' to the governments of SIDS to drive the objectives, neither a surge in implementation nor a cultural shift will be achieved. Commitment and dedication must be **endogenous** factors for sustainability. On one hand, the private sector grapples with some inherent conflicts of profit objectives versus satisfying environmental and social responsibility. On the other hand, central governments are driven towards development of social, environmental and political agendas against the background of limited economic resources. Non-governmental organisations (NGOs) and civil society, meanwhile, have neither sufficient policy legislative influence nor the funding to achieve a sustained outcome. The profile of the champion or internal catalyst is therefore a hybrid with government origins, given private sector decision-making power and financing and the liberty to lobby for civil society. This internal catalyst must have a clear transforming vision to catalyse sustainable consumption and production imperatives.

In Jamaica's case, the champion was the Petroleum Corporation of Jamaica (PCJ), in Japan it was NEDO and in the French overseas departments it was ADEME.[16] The PCJ has the mandate in

law for implementing Jamaica's national energy policy; it owns the nation's petroleum refinery (Petrojam Ltd) and petroleum marketing subsidiary (Petcom) (both competing with private sector entities). It is also the regulator of the current campaigns for oil and gas exploration. It lobbies for a reduction in Jamaica's high-energy intensity, improvements in energy security and utilisation of supply- and demand-side management techniques to increase energy self-reliance. PCJ's achievements are as follows:

- implemented Wigton Wind Farms (the Caribbean region's largest wind farm, with 23 wind turbines, each producing 900kW),
- implemented energy-efficiency and conservation programmes in government hospitals, including full-scale energy audits (US$93,000, from UNDP funding), installed 3kW of PV (utilising government and UNDP funding) and designed efficient air conditioning and lighting systems and rehabilitated SWH systems (costing US$14,000),
- established a National Energy Efficiency Fund (US$10,000, with Inter-American Development Bank [IADB] assistance),
- implemented capacity-building programmes for secondary, tertiary and professional education levels,
- revised the Jamaica Energy Sector Policy, incorporating RET and EE&C components,
- through Petrojam, produced 40 million gallons/year of fuel-grade ethanol and ran an ethanol in gasoline trial as part of a plan to replace Methyl Tertiary Butyl Ether (MTBE),
- commissioned 500 solar water heaters in residential complexes and more than 77 solar street lights island-wide,
- donated more than 2,200 compact fluorescent lamps (CFLs) to government entities, and in a joint programme with the Government of Cuba donated approximately 4 million bulbs island-wide, and
- implemented 13 ha of fuel wood plantation and nursery.

The RET and EE&C champion for the French overseas departments is ADEME, a public agency under three ministries, committed to energy, research and the environment. It collaborates closely with public sector partners on research and industry, the European Commission for market incentives and various councils for local implementation. Under this structure, ADEME has had successful interventions in EE&C, GHG abatement and development of RET, with legal obligations in place to meet energy-efficiency targets using 'White Certificates'. Under the Energy Law 2000, there were guarantees for purchases and feed-in tariffs for projects (amounting to more than 12MW). Market incentives and subsidies include PV subsidies up to 80 per cent of investment costs, and income tax reductions of 40 per cent for purchases, up to 40 per cent for investment in domestic SWH systems and up to 60 per cent for larger collective systems. Biogas and biofuels subsidies can be obtained for 20 to 30 per cent of investment costs and competitive calls for tender on power generation from offshore wind, biomass and biogas electricity.

Where there is no internal catalyst or champion for RET and EE&C, such successes are not likely to occur or be sustained.

Absence of appropriate financing and accounting practices

The cost of renewable energy technologies cannot be measured truthfully by monetised values alone, but must also incorporate the emergent negative and positive externalities. Whereas the capital outlay for RET options may be considered more expensive than for traditional fossil fuels,

full-cost accounting methods (considering associated fuel generation, transport, storage, use and disposal issues) show that renewables are as competitive over the full life cycle of the fuel. Triple bottom line and benefit–cost analysis are now showing that real power generation costs, (considering externalities, embedded subsidies and life-cycle costs) demonstrate an equitable economic basis for selecting renewable fuels as viable options. Care must be applied to avoid seemingly financially viable experimental RET and EE&C projects, which later need to be either subsidised or have fossil fuels used to augment fuel supplies. Green funding, third-party financing and other financial mechanisms for renewables should be considered equitable and valid commercial mechanisms compared with the more than 4 billion Canadian dollar (C$) subsidy to the Canadian oil and gas industry,[17] and annual subsidies and other external costs of more than US$1 trillion related to the upstream and downstream gasoline life cycle in the USA.[18] In this context, Jamaica's 20.7MW wind farm receiving a grant of US$7 million to achieve 5.6 cents/kWh plus an estimated income of US$3.1 million between 2004 and 2012 for Certified Emissions Reductions (CERs), is competitive on equitable terms with a fossil option. Interestingly, the typical threshold of 5–7 cents/kWh for acceptance of some power generation projects using fossil fuels does not reflect the electricity prices of 20–35 cents/kWh experienced in many SIDS.

Biomass using fuel cane, bagasse cogeneration and bioethanol production will be critical for improving the US$300 million earnings and saving 125,000 jobs in the cane industry in CARICOM. Currently in Jamaica, wet ethanol is imported for the production and export of 100 million gallons of fuel-grade anhydrous bioethanol (60 million gallons from Jamaica Broilers Group Ltd – a private sector agro-industry). Local production of feedstock is the route to optimise social and economic gains. Prices are increasing from 85 cents/gallon in Brazil to US$1.9/gallon in the USA and US$2.8/gallon in Hawaii (with production incentives and tax credits equal to about 4 cents/gallon),[19] making bioethanol more lucrative as a fuel.

In this context, special low-cost loan facilities should be made for RET and EE&C applications, which recognise the cost savings in externalities, import substitution, potential for economic gains such as with CERs, and employment benefits. Energy saving companies (ESCOs) could also be utilised to create value-added linkages between improved efficiencies and investment dollars. The French overseas departments have utilised innovative fiscal incentives to proliferate wind and solar technologies. Long-term domestic loan facilities could be made available to residential users (e.g. in Jamaica, the National Housing Trust [quasi-government] and Victoria Mutual Building Society [private sector] offer low-interest, long-term loans for solar water heating [SWH]). As a tool to encourage serious EE&C applications, banks could consider energy audits before granting loans to business operations (e.g. in Barbados). Government fiscal support to local industries could also include concessions, duty-free import of SWH materials and partial- or full-tax deductions to consumers for the cost of the heaters (UNDESA, 2005). Barbados has now become the largest CARICOM producer of SWH, and in terms of number of installed units per capita (1 unit per 18 households). Energy funds on a revolving basis can assist in providing capacity building in energy efficiency technologies, support small-sized projects and drive market development. Special financiers such as E+Co can provide equity, loans, security and lines of credit from start-up through to implementation of RET and EE&C projects. Funds are available to ESCOs, financiers and end-users.

Whereas SIDS are often funded from external sources, we need to ensure that national priorities/drivers have sufficient weighting for selecting projects and fiscal incentives. The agreements of the Caribbean Single Market and Economy, growing support for PetroCaribe (a petroleum arrangement with Venezuela) and a suspension of the Common External Tariff in the Caribbean region, are

opportunities to explore the concept of bundling of CDM projects to attain critical CER mass to enter the commodities market.

Some regional funding options may potentially reduce energy security. Currently, Jamaica has three major petroleum arrangements with Venezuela: the Caracas Accord, PetroCaribe and a refinery upgrade programme, in which the Venezuelan company Petróleos de Venezuela S A (PDVSA) is a significant shareholder. A fourth arrangement may emerge in the form of a proposal for supply of liquefied natural gas (LNG). This means that Jamaica could stabilise its energy needs in the near future and have some economic gains; however, it would have to become significantly dependent on one source.

Inadequate expertise for resource mobilisation

In the case of funding from the European Union of 200 million euro through the EU Energy Initiative, it was reported that the process for application was so complex for SIDS that only 10 per cent were able to apply, and that the countries that applied had to have European consultancies (GSEII, 2007). Available funding that does not have simplified procedures for proposal preparation or special assistance as part of the funding offer, presents a barrier to the proliferation of RET. Capacity building is also needed to develop engineering designs and modelling for project proposals, feasibility studies and business plans that are specifically suited for the peculiarities of SIDS.

Historically, SIDS's economies used to be managed on an expense budget as the offshore interests of empires, instead of on a zero budget basis, and this may have reduced innovativeness to source funds. Many SIDS are trailing behind European and North American states in terms of their resource mobilisation abilities. On the other hand, some SIDS have developed the competence and expertise to access CDM financing for projects. Sustainable Energy Limited (SEL) negotiated CER carbon credits with the Netherlands-based ABN-Ambro for its Wainikasou and Vaturu hydro projects in Fiji. Jamaica's Wigton Wind Farms obtained a Oret/Miliev grant from the Dutch government under the Dutch Development and Environment Related Export Transactions Programme. Where experience has been gained, countries should make their expertise available to other SIDS,, as a benevolent gesture but also to attract further funding to their regions by developing a positive investment climate for developed and industrial nations seeking locations for projects.

Cross-sectoral issues

Traditionally, synergies were not created between different sectors that generated and those that consumed energy. As a result, industries often had main income streams which were isolated from other income streams across sectors, and the countries were unable to maximise the benefits of cumulative production. For example, the sugar cane industry could be used to produce ethanol and cogeneration power to be consumed by the power, spirits and transportation sectors, so creating employment in each sector. Similarly, waste disposal in landfills could be transformed into sources for energy. New technology has now made it possible to produce ethanol from cellulosic wood mass in a second-generation biomass-to-liquids technology, thereby utilising waste biomass from forestry, agricultural processes and/or the furniture industry (James, 2007). The production of biodiesel (using Jatropa curca) in Dominica or the more than 100,000 gallons of coconut-based biodiesel from the Tobolar coconut industry (GSEII, 2007) can provide a much-needed transportation fuel. This would reduce the volume of imported diesel fuel, reduce sulphur emissions (providing environmental benefits), while at the same time presenting employment opportunities in agriculture, processing and export. Hydropower can provide for irrigation, domestic

water and power (e.g. the proposed Blue Mountain Multipurpose Scheme – Water for the Kingston Metropolitan Area [KMA], 20MW and irrigation).

Public education and public awareness

When consumers are unaware of measurable benefits, they will continue to follow familiar customs and habits. Therefore, the end-user must understand the specific and general benefits of RET and EE&C, and where possible receive measurable gains. With the hotel industry example (see above), staff awareness of the EE&C technologies and practices was sufficient to generate a 10 per cent saving in energy costs. Critical too is the fact that shareholders of companies in SIDS may not be as aware or sensitive to environmental or EE&C matters as their European lobbyists and shareholders are. Corporate bodies have therefore continued to make key decisions based on financial criteria, and annual reports and audits are often devoid of environmental or social reporting. National decision-makers must therefore continuously inform their publics about opportunities and benefits for using RET and EE&C for a number of reasons:

- The shift to RET and EE&C is a cultural one in many cases. Cultural shifts may occur in the short term, but for it to be sustained, behaviour must be reinforced continuously.
- Advantages gained for conventional fuels (lowered prices or the addition of new fuels to the energy mix, such as natural gas) may cause a de-emphasis on renewables and EE&C. If these advantages are lost, then it is often difficult to regain the momentum regarding EE&C and the benefits of using indigenous energy sources.
- Younger generations emerge providing a window of opportunity to create a sustainable cultural pattern.
- Technologies are changing rapidly and the benefits should be grasped to maximise on new opportunities.
- Much investment has been sunk in existing fossil technologies. However, on expiration of the useful life of equipment, opportunities will emerge for new investments. Local and foreign investors should have appropriate knowledge to make the decision that yields the most optimal results (taking the social, economic and environmental benefits in account).

Public education should include a range of informal to formal educational options (e.g. workshops, academic programmes) suitable to targeted audiences in a manner that is culturally acceptable. Education should deliver information, and also develop competence for sustainability (e.g. programmes that are focused on regional institutions).

Influence of utilities

Another barrier faced by RET for power generation applications is the influence of power generation and transmission companies. Whereas there have been various degrees of privatisation, unbundling of monopolies and deregulation of the power sector in many SIDS, utilities continue to have licences for large blocks of electricity supply and usually all of transmission. This is often a default position, where some SIDS's total power demand is not sufficient to make generation commercially viable for multiples of generators and dividing transmission would be unwieldy to manage. This exerts an unusual influence on regulators and energy ministries to provide special considerations to technical and fuel preferences of the operators over large blocks of generation using 'familiar' conventional fuel technologies. In some cases, the utility company is a deciding member of bodies selecting new generation proposals. Energy efficiency may be seen by some to be contrary to the core business of energy supply, and often EE&C are valuable only in periods when expansion is not

economically feasible and buffer capacity is approaching critical lows. While recognising the limits for competition in SIDS, it is also important that government interventions and mandates lead the way for national benefits, with the utilities acting in a supportive role.

Competition for scarce resources

The demand for renewable fuel sources often competes with other social, economic or environmental demands, and may naturally limit which RET which can be implemented. The diffused nature of the renewable energy sources (such as solar and wind), as compared with the more energy-dense fossil fuels, also means that RETs typically need to concentrate the energy source (using large volumes of water, hectares of space or multiples of turbines) before they can be applied in commercial settings. The competition for resources is therefore often heightened, meaning that sometimes conventional, energy-dense fuels are selected over RETs. For example, hydropower considerations must now reserve 'environmental' and 'social' water demands (i.e. minimum volume flows needed to maintain healthy ecosystem functions, social use or recreational benefits) as stipulated by water resources management agencies. This can affect economic viability projections. Biomass plantations may compete with high-valued crops for land, and wind farm sites may compete with aesthetic features, especially if coastal.

Scale of resources

With SIDS's small populations, limited land space and limited surface water, often the resources that are available for renewable options are small compared with those of industrialised nations. For centralised power generation, utilising waste-to-energy (WTE) technologies and others, the small populations consuming power and producing wastes may not have the economies of scale to make investment attractive. Numerous feasibility assessments of the potential for using Jamaica's 900,000 tonnes of waste each year have determined this to be too small to fuel a commercially attractive power generator system. Technologically advanced smaller modular systems can now utilise as little as 250,000 tons per year at an investment of US$1,967 per kW to warrant WTE power generation.

Other

Finally in the considerations for utilising RET and EE&C, the gains should be considered in terms of the national benefits. For example, solar water heater incentives in Barbados facilitated the avoidance of fossil fuel imports of 33,000 tonnes of fuel/year, a saving of about US$6.5 million (assuming a price of US$25/bbl of oil and population of 260,000). For the English-speaking Caribbean, this would be a saving of US$125 million/year (assuming a population of 5 million) (INFORSE, 2007). A SWH of 100 litres has the capability of preventing emission of 1.5 tonnes of carbon dioxide/year, and 1,000 such units can shave 1MW of peak loading. The Wigton Wind Farm, meanwhile, is estimated to save 52,540 metric tonnes CO_2 equivalent per annum. The local environment and utilities (both private and public) would benefit from differed installation of additional peak load capacity, where RET are used.

Conclusion

Various regional and international accords have captured the challenges and plights of SIDS, and have also provided useful frameworks for sustained development. To sufficiently fast-track the development of SIDS to the level of equitable partners on a global platform – increasing wealth,

improving the quality of life and sustaining vulnerable environments, while avoiding development mistakes of the past – SIDS must be selective in strategies that move them towards energy security and independence. Full appraisal and development of local resources is paramount, to gradually replace imported energy used for long-term investments in heat, light and power generation. An emphasis could be placed on valuable local sectors that can experience transformation in the short term, for the preservation of key economic earners, cultural heritage and environments. Energy options that facilitate early shifts in national energy mix towards dependence on sustainable indigenous energy resources should also be pursued with alacrity.

The 'litmus test' of energy efficiency should be applied to energy options that could be administered within a paradigm shift towards achieving, and subsequently raising, the benchmark for energy use. Energy efficiency therefore becomes the first criteria for successfully reducing the energy appetite of SIDS, so as to achieve optimal gains from any energy security advances gained.

The endowments of renewable energy options are diverse, in spite of possible limitations for use depending on surface and subsurface features of the environment, geographic location and resource mobilisation opportunities. The optimal combination and proportion in the energy mix for a particular sovereign state is best identified after rigorous economic, social and environmental considerations are applied, and after conventional options are compared on the same platform considering externalities, social, economic and environmental impacts. Tested and approved appropriate technologies should be a priority relative to new and future-edge trial technologies, to avoid expenditure of time and funds on unsuccessful attempts.

After the long-standing use of conventional energy resources, full-cost accounting methods and access to special project funding are considered to be critical for levelling the conditions for application of EE&C and RET in SIDS. Building competences for resource mobilisation and project development will be important in this effort, and collaboration between experienced nations and their neighbours will accelerate this transition.

National policies should be so crafted and communicated to achieve these ends, with support from regional policies to encourage means of collaboration and support between sovereign states within a region, to achieve their transformational targets. Strategic buy-in by corporate 'citizens', special interest groups and the population at large becomes important for successful change, and so is an important part of the state communication process. Without a dedicated and empowered champion for RET and EE&C, efforts towards transformation may be weak and diffused at best, or costly and unsuccessful. However, there may be sufficient examples within Caribbean, Asian, Pacific and other SIDS to facilitate transformation within each. Awareness and knowledge has grown among SIDS; however, various methods for informing the public and decision-makers should be continuous, deliberately designed, implemented and sustained for a transforming and lasting impact.

Distinct internal strengths for SIDS to develop RET-based project initiatives that can attract special funding include location, geology, even climates and the global efforts to reduce GHG. However, the historical barriers discussed above, and limited resources such as land and water, have proved to be a challenge for most SIDS to overcome. Despite this, clear policy directives and planning tools can lead to the necessary solutions. In the near future, some SIDS will have to decide if their cane industry can survive under favourable market terms with bioethanol and cogeneration as sweeteners; others will attempt to make biofuels and cogeneration the determining factor.

The future for the sustainable development of SIDS using RET and EE&C as platforms is favourable, but will require clear vision, early action and a tenacious determination to succeed.

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Notes

1. Energy security: the appropriate blend of energy forms, in adequate quantities, at affordable competitive costs, in a timely manner, meeting quality and functionality requirements from a strategic blend of suppliers (supply buffer). More recently the dimension of reducing acceptable or irreversible environmental impacts over the long term has been added to address sustainable development requirements.
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4. Colin Campbell indicated that an Oil Peak would be evidenced 2006–2015.
5. OPEC – Organisation of Petroleum Exporting Countries.
6. Source: graph from *Energy Economics Newsletter*, 2007.
7. *Energy Economics Newsletter,* available at: http://www.wtrg.com/index.html#Crude [last accessed 4 July 2010]
8. Renewable energy: an energy source which is not depleted after its use or which may be replenished at an equal or faster rate than its consumption.
9. Energy efficiency: increasing or maintaining the overall output of an activity while reducing or sustaining the required energy input over time. Conservation: reduction or avoidance of energy loss or wastage in the generation of an output.
10. Cogeneration is the simultaneous production, usually of heat and power, from a single energy input; trigeneration is similar, with heat, mechanical and power being the outputs.
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